MONTAGE BUILDERS

NORTHERN FOREST

“THE MONTAGE”

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EXECUTIVE SUMMARY

This report presents the final design by Montage Builders – Northern Forest for the US DOE Challenge Home Student Design Competition, 2014.

Montage Builders – Northern Forest is an integrative project team of thirteen students from the State University of New York College of Environmental Science and Forestry, Onondaga Community College, and Syracuse University. We have designed a single family dwelling that satisfies the DOE competition's criteria and aligns with our collective mission: to design a home that meets the needs of middle class Central New Yorkers by providing a healthy living environment, financial resilience, and social equality.

Even though our project is based on a single site in the city of Syracuse, we've developed the plans with the intent to be "shovel ready" for local builders; keeping the construction means and methods within their skill set has remained a fundamental aspect of our design. By combining Building America's research findings, best practice solutions, and regionally specific building science principles with a local aesthetic and constructability, we have created a model of success for Syracuse.

The Montage, an American Craftsman style house, offers a winning combination of the movement's local and historical relevance, commitment to natural materials and a desirable aesthetic. The style's inherent use of natural and honest materials bolsters our commitment to occupant health, affordability, and environmental responsibility. Furthermore, the design of a timeless well-established look that compliments the local vernacular of the neighborhood creates curb appeal, an essential ingredient of the home's financial resilience.

Resource efficiency further contributes to the financial viability of *The Montage*. With passive heating, cooling, and natural daylighting; ENERGY STAR fixtures and appliances; a well insulated, air-sealed, and durable envelope; cutting-edge high-efficiency HVAC equipment; and a compact domestic hot water distribution design, we offer the owner a substantial reduction in utility costs compared to a typical home.

The Montage's high performance package exemplifies our deliberate decision not to use fossil fuels, and our utilization of available solar energy culminate to form a resilient Net-Zero Energy home. This as well as our durability features and disaster preparedness ensure that *The Montage* will have a positive lasting impact for centuries.

Finally, while durability, constructability, aesthetics, and resource efficiency are paramount, people are at the heart of our design. Simply, our house enables and empowers people. Incorporating visitability features that allow occupants to age in place, recover from an unexpected injury, and invite friends with a variety of physical abilities to participate in the preparation of a meal, and deep conversations distinguishes this house from its less socially conscious counterparts. We hope to assert the notion that the built environment can perpetuate social change.

OUR MISSION

Montage Builders – Northern Forest strives to design and build regionally appropriate and truly sustainable homes for our community though holistic thinking and collaboration.

OUR PHILOSOPHY

We reach beyond energy savings and creating equity for homeowners to enhance the world, our neighborhoods, as well as the financial and physical well being of communities, families, and individuals.

Truly sustainable buildings are part of a dynamic equilibrium between the structure, its occupants, the environment, and the economy. They have the ability to adapt according to occupants changing needs, provide safety and livable shelter during extreme weather conditions, yield a positive impact on occupant and environmental health, are financially viable to construct as well maintain long term, and offer beauty.

Houses, when designed and built for people, speak to us. We wish to engage our neighbors in a conversation about energy efficiency, community, and sustainability. Ultimately, thorough education and awareness, we hope to inspire a change in what home buyers expect from a house.

WHO WE ARE

We are the next generation of builders and designers responding to today's demands with tomorrow in mind.

OUR NAME

Montage, a combination of different elements that forms a unified whole, references our teams diverse multi-cultural and multi-generational aggregation of perspectives and experiences, which is the key for the success of our design.

Northern Forest acknowledges the importance of regionally specific design and the default (pre-development) landscape of our region - used for accurate site ecosystem service assessment.

MONTAGE BUILDERS TEAM

A COLLABORATIVE TEAM OF

State University of New York - College of Environmental Science and Forestry

Department of Sustainable Construction Management and Engineering

Onondaga Community College

Department of Architecture and Interior Design

Syracuse University

L.C. Smith College of Engineering

Each of the departments has an emphasis on building science in the program coursework and research.

The *Department of Sustainable Construction Management and Engineering* offers a Bachelor of Science degree in Construction Management, which prepares students for a wide variety of professional careers in the construction industry. The department has integrated building science in the following courses:

CME 342 - Light Construction

This course combines the information on light frame structural systems (traditional and advanced framing) with building science principles for proper envelope design. The last third of the course focuses exclusively on thermal, moisture, and infiltration control of the envelope. The course culminates in the students selecting an alternative construction approach (Rammed earth, Straw bale, SIPs, Stacked log, ICF, etc.) and evaluating it based on the structural, thermal, moisture and infiltration control characteristics.

CME 305 Sustainable Energy Systems for Building

This course studies the technology, economics, and environmental impacts of both building-scale renewable energy sources, as well as energy conservation measures. The students perform a series of exercises to evaluate methods of energy harvest as well as conservation at a building scale. The course culminates in each student selecting an existing building and determining the set of most cost-effective measures to retrofit the building to net zero energy.

CME 304 Environmental Performance Measures for Building

This course is an overview of environmental and energy metrics used by the construction industry. Systems covered include LEED, ICC 700, IGCC, Energy Star, Passivhaus, Living Building Challenge, Green Globes, BEES, and Athena Ecocalculator. Emphasis is placed on understanding how to quantify energy and environmental impacts, both during design as well as construction and operation

CME 215 Introduction to Sustainable Construction

This course is an introductory course to the field of sustainable construction, both at the commercial and residential levels. The course covers new materials and methods of green construction. The course includes basic concepts of building science and a brief introduction to ratings systems like LEED.

CME 332 Mechanical and Electrical Equipment

This course provides technical understanding of the function of building mechanical systems. Concepts of thermal comfort, heat transfer, and building performance metrics form the basis for the course. Individual system operation (mechanical, electrical, and plumbing) and components are covered. Description of commissioning and on-going measurement and verification are included.

CME 565 Sustainable Innovations in Residential Construction

This course provides an integrated approach to the understanding of the construction process. The course uses the principles of building science, ecology, and biomimicry as the basis for helping the student develop a holistic approach to the construction process. The course culminates in a project where students teams work to evaluate actual projects on a sustainable basis, and assist the owners in understanding the requirements to attain green building and energy incentives offered by State and Federal governments.

The Department of *Architecture and Interior Design at Onondaga Community College* offers an Associate of Science Degree in Architecture Technology. The degree program prepares students for careers in the design and construction industry. The program stresses the fundamentals with four-semester, studio-course sequences in design and drafting. Courses in residential (wood frame) and commercial (masonry and steel) construction materials and methods are required companions to the drafting courses. Building science principles guide much of the decision-making as the students design and develop building plans and details for semester-long projects.

Sustainability and green building design concepts are infused in every course we teach and BuildingAmerica and Building Science Corp. information resources are utilized in the teaching and learning process.

Two courses in particular address and focus on high performance residential building design:

ARH 144 Introduction to Sustainable Construction

Covers the theory and principles of innovative sustainable construction with a focus on residential construction. The course takes an integrated design and ecological systems approach to high performance green building. Students learn how to reduce the ecological impact of the built environment using cutting-edge best practices. Topics include climate change, green building principles, performance standards and measurements, and rating systems including LEED® for Homes, EnergyStar, and HERS. Cost, life cycle assessment, energy efficiency, renewable energy and solar elements, and valuing "natural capital" are discussed. Instruction includes field trips to HP homes and students work in teams and develop case study reports.

ARH 244 Residential Energy Performance

A fundamental study of energy efficiency and building science with an emphasis on residential energy performance and analysis. Topics include basic energy principles; building thermal boundary; and the control of air, heat, and moisture. The interaction of building components with environmental factors is essential to the discussion. Efficiency strategies for lighting, appliances,

heating, cooling, and water heating are introduced. Strategies for dealing with home health, air quality, and combustion safety problems are discussed. Fundamentals of building inspection and diagnosis are covered, including the use of the blower-door, duct-blaster, manometer, infrared camera, smoke generator and other testing equipment. Instruction includes two four-hour field experiences.

High performance commercial-sector green building design is also covered in:

ARH 263 Green Building Rating Systems

Acquaints the student with rating systems that seek to define and measure sustainable, high-performing "green" buildings. Focus is on the U.S. Green Building Council's LEED® Green Building Rating System portfolio of rating products and the major LEED credit categories including sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, regional priorities, and innovative design. Course content includes an introduction to sustainability; core concepts; the integrative design approach; the LEED certification process; and credit intents, requirements, and strategies. Aspiring candidates for the GBCI LEED(R) Green Associate examination find the course useful. The course includes field trips to LEED registered and certified projects.

Other technology related courses include computer graphics, structures, mechanical and electrical systems, building codes, and office practice.

The Department of *Mechanical and Aerospace Engineering* at Syracuse University offers a Bachelors of Science degree in Mechanical Engineering, and performs world-class research at the Building Energy and Environmental Systems Laboratory. The mission of the BEESL includes advancing the science and developing innovative technologies in the areas of indoor environmental quality (IEQ), building energy efficiency (BEE) and building protections. The Building Envelope Systems Test Laboratory, a part of this work, performs research on the infiltration performance of multiple wall assembly types. Other research areas include:

- Indoor pollutant sources and sinks such as building materials and furnishings, office machines, consumer products, etc.
- Combined air, heat, moisture and contaminant transport through building envelopes. Interactions between indoor, outdoor environments and HVAC systems/components.
- Room air and contaminant distributions in personal/task, displacement, or mixing ventilations.
- Air and contaminant transports in multi-zone buildings and building dynamics.
- Air filtration/purification technologies for gas and particulate contaminants including stand-alone room air cleaners and those installed in HVAC ducts.
- Building envelope systems (walls and window assemblies) performance for thermal and moisture control performance.
- Comprehensive Instrumentation for Material Characterization, including thermal moisture, pollutant transport and storage properties.
- Sensitivity, accuracy and reliability of environmental sensors and control systems.
- Ambient air samplers, industrial hygiene monitors, indoor air quality monitors and sensors, thermal comfort monitors and occupational protective equipment and materials.

QUALIFICATIONS

As lead faculty member for the competition team, I, Paul Crovella, certify that all the construction-major students have satisfied the EEBA coursework. These members are:

Michelle Tinner

Michael Walczyk

David Wallace

Andrew Kenneally

Zhaozhou Meng

Sarnai Davaadagva

Jeff Chen

Peter LaCongo

Jacek Bartczak

Gamika Korale

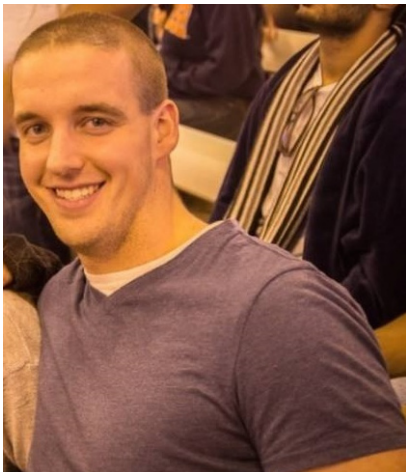
Brent Crump

STUDENT TEAM MEMBERS

MICHELLE TINNER - TEAM LEAD

SUNY- ESF, Masters Student
Sustainable Construction Management

"For me, the richness of participating in this competition lies in the hurdles we encounter along the way and in the collaboration through which we arrive at holistic solutions."



MICHAEL WALCZYK

SUNY- ESF, Junior
Construction Management

"Building sustainably is similar to eating right. We have the knowledge of what is healthy, tools to inform us, ability to be proactive and adaptive, and the materials to be environmentally friendly. Now, we just need to combine all these ingredients in the right order to create a home that will leave little to no impact on the environment. This challenge allows me to be a part of a design team whose purpose is to do just that."

PETER LACONGO

SUNY- ESF, Senior
Construction Management

"The best part about working on a project like this is the fact that you have the opportunity to learn lessons that you would otherwise never learn in school."

STUDENT TEAM MEMBERS

SARNAI DAVAADAGVA

SUNY-ESF, Senior
Environmental Science

"When I first arrived at SUNY ESF, I knew I wanted to make the world a better place, but I didn't know how to do it. Being part of the Montage Builders - Northern Forest sustainable design team has given me the tools and direction necessary to achieve my goal. I look forward to carrying the knowledge I gain from this team-work experience forward into my career as a green building professional."

GAMIKA KORALE

SUNY-ESF, Senior
Construction Management

"The unremitting negative impacts towards the environment with the advancement of industries continue to hinder the fruitfulness of the environment. The sustainable improvements made towards commercial construction alone may not indentify the effects caused by deleterious practices and therefore makes it crucial to synchronize sustainability within residential construction. This competition caters towards the promotion of the science of sustainability and highlights both the environmental and financial lucrativeness present in "green homes" and is therefore my personal vision towards this competition."

BRENT CRUMP

SUNY-ESF, Senior
Construction Management

"Collaboration between designers and builders, who fully believe in sustainability, is integral to reversing the harmful effects poor design and construction have placed on both the environment and human health and welfare."

STUDENT TEAM MEMBERS

ADAM SCALISI

SUNY-ESF, Senior
Landscape Architecture

"The landscape architecture field is rapidly changing as we are being charged with employing landscapes that are functional on far more levels than an aesthetic one. When looking at a design project we have to consider not only aesthetics but also ecological, economic, and social impacts which makes our field far more integral and versatile than it has ever been before. This competition is a platform to display that our landscapes can be working landscapes at all scales, including individual residences."

DAVID WALLACE

Onondaga Community College
A.A.S. Architectural Technology

"What is "Green" Architecture other than low emissive material choices and creating a smaller environmental footprint? I believe we must think of "Green" Architecture as changing the human interaction within the building they live and work in everyday. I joined this project to further my knowledge in how to do just that."

ANDREW KENNEALLY

Onondaga Community College
A.A.S. Architectural Technology

"This competition enabled us to work with students from a number of different disciplines as well as utilize the knowledge we acquired in the classroom to productively deliver an efficient solution to a real world issue."

STUDENT TEAM MEMBERS

JACEK BARTCZAK

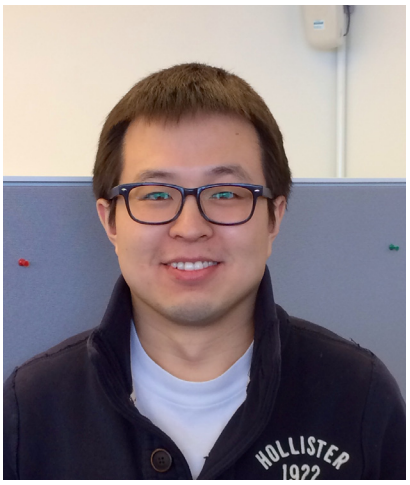
Onondaga Community College
A.A.S. Architectural Technology

"Sustainability is the keystone of doing good for the planet. By helping to progress sustainability in construction we are bettering our environment today, as well as for future generations."

JEFF CHEN

Syracuse University, Graduate Student
Civil/Construction engineering and sustainable infrastructure management

"As a structural designer, construction manager, and sustainability enthusiast, I believe that structure provides the skeleton, management offers the procedure, and sustainable thoughts put the soul into a building."



ZHAUZHOU MENG

Syracuse University, Graduate Student
Mechanical and Aerospace Engineering

"The residential sector is responsible for approximately 21% of the total energy consumption in the U.S. As an engineer, I'm interested in reducing that load and bringing sustainable design to everyone's daily life. Through deliberate and thoughtful actions, we can live better while using less energy. This competition is a great way to learn, to practice, and to realize sustainable design."

STUDENT TEAM MEMBERS

TALIA HORNER

Syracuse University, Senior
Industrial and Interaction Design

"Creating a sustainable future is one of the greatest challenges we face today, but with interdisciplinary collaboration and efficient design, I believe we can make great changes regarding the impact the built environment has on the world today."

STUDENT CONTRIBUTERS

KRYSTAL TYRRELL

Onondaga Community College
A.A.S. Architectural Technology and Interior Design

ELIZABETH ORR

SUNY-ESF
Environmental Science

FACULTY ADVISORS

KENNETH BOBIS

AIA, LEED AP BD+C
Faculty Advisor,
Montage Builders –
Northern Forest

"It is most gratifying to know that the students who make up the Montage Builders Team are keenly aware of the "inconvenient truth" about our planet and they have embraced the Challenge Home competition knowing that it is a meaningful and tangible way for them to make a positive impact toward a sustainable future."

PAUL CROVELLA

PE, LEED AP BD+C
Faculty Advisor,
Montage Builders –
Northern Forest

"I chose to work on the Challenge Home competition because it offers the opportunity to make a change in our community. The change will be seen in the buildings that are built, but more importantly it will be embodied in the beliefs and aspirations developed by those involved. For me, the result of the Challenge Home competition will never be fully captured in a single structure, but rather forever shared by the community and individuals involved in the work."

KEVIN STACK

Faculty Advisor, Montage Builders – Northern Forest

"My participation has allowed me to witness firsthand the passion and inner strength exhibited by a diverse team of students from multiple disciplines, most of whom have just met. "Best learning experience ever" is just one of the many, many positive comments I've heard from the students. As a builder their commitment inspires me to continue my quest to "the race to zero energy". "

INDUSTRY ADVISORS

CHRIS STRAILE
Home Energy Technical Advisor, Syracuse Center of Excellence in Energy and Environmental Systems

HILLARY MANSUR
Construction Manager, Home Headquarters

ESTHER GREENHOUSE
Principal - Esther Greenhouse Enabling Design

MICHELLE POPCUN
Licensed Real Estate Agent, RealtyUSA

NATE WALKER
Vice President, Solvay Bank

MARK HARRINGTON
Builder, Harrington Homes

TEDD BENSON
Owner, Bensonwood Homes

EDWARD WHITAKER
Owner, Green Thermal Systems

JOE SALIBRA
Sales Representative, Superior Walls of Upstate New York

COMMUNITY ADVISORS

PASTER FRED MANNARA
Most Holy Rosary Church

DESIGN GOALS

DESIGN TOUCHSTONES // Design and Construction Goals

The Montage, our evolved adaptation of a local and timeless traditional house design for our specific climate, was created using seven team-defined touchstones critical to sustainability. These touchstones reciprocate and reinforce themselves – success in one will lead to or amplify success in another.


RESILIENT


HEALTHY


LOCAL


EFFICIENT


TIMELESS


BEAUTIFUL


HONEST

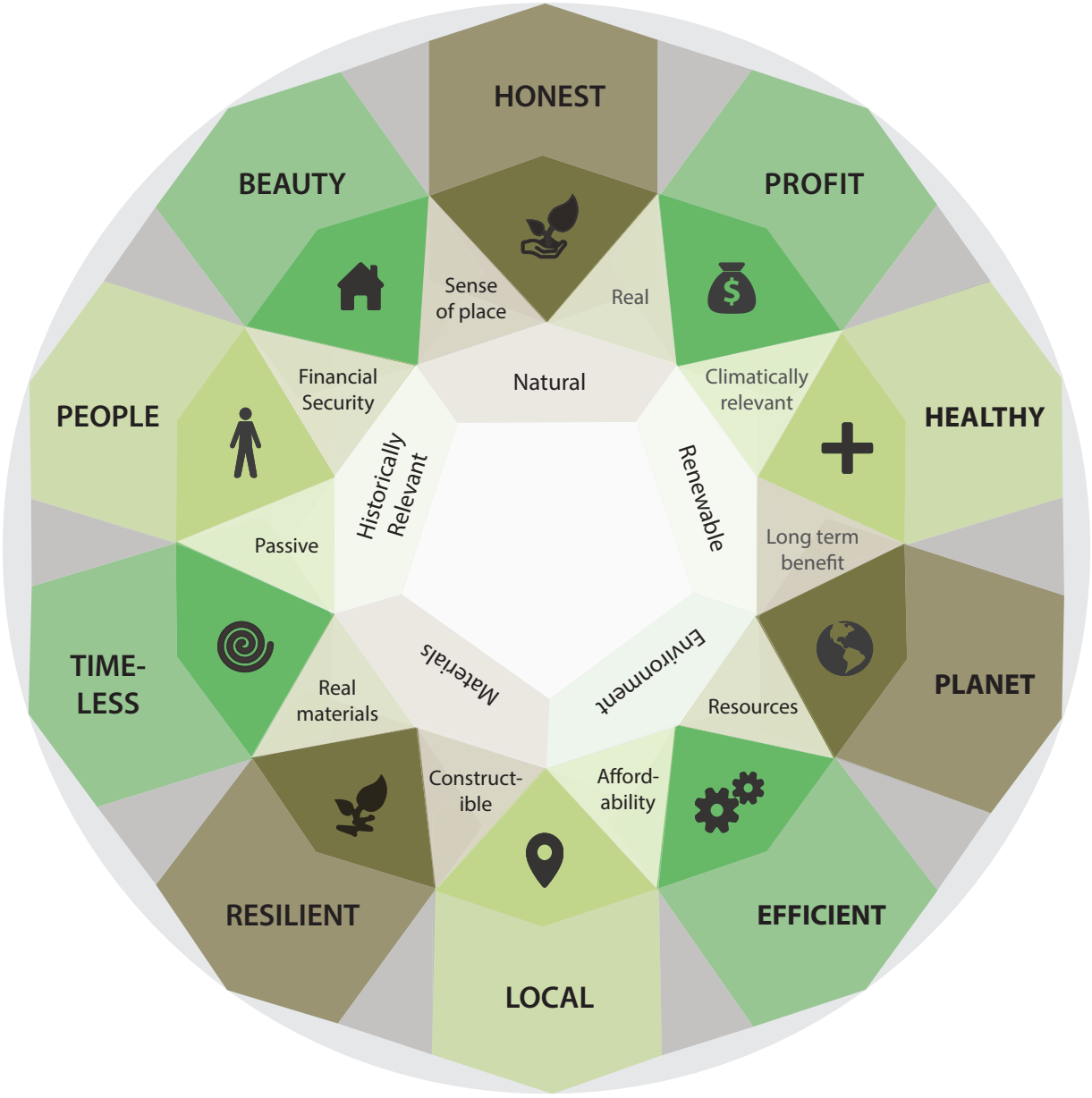
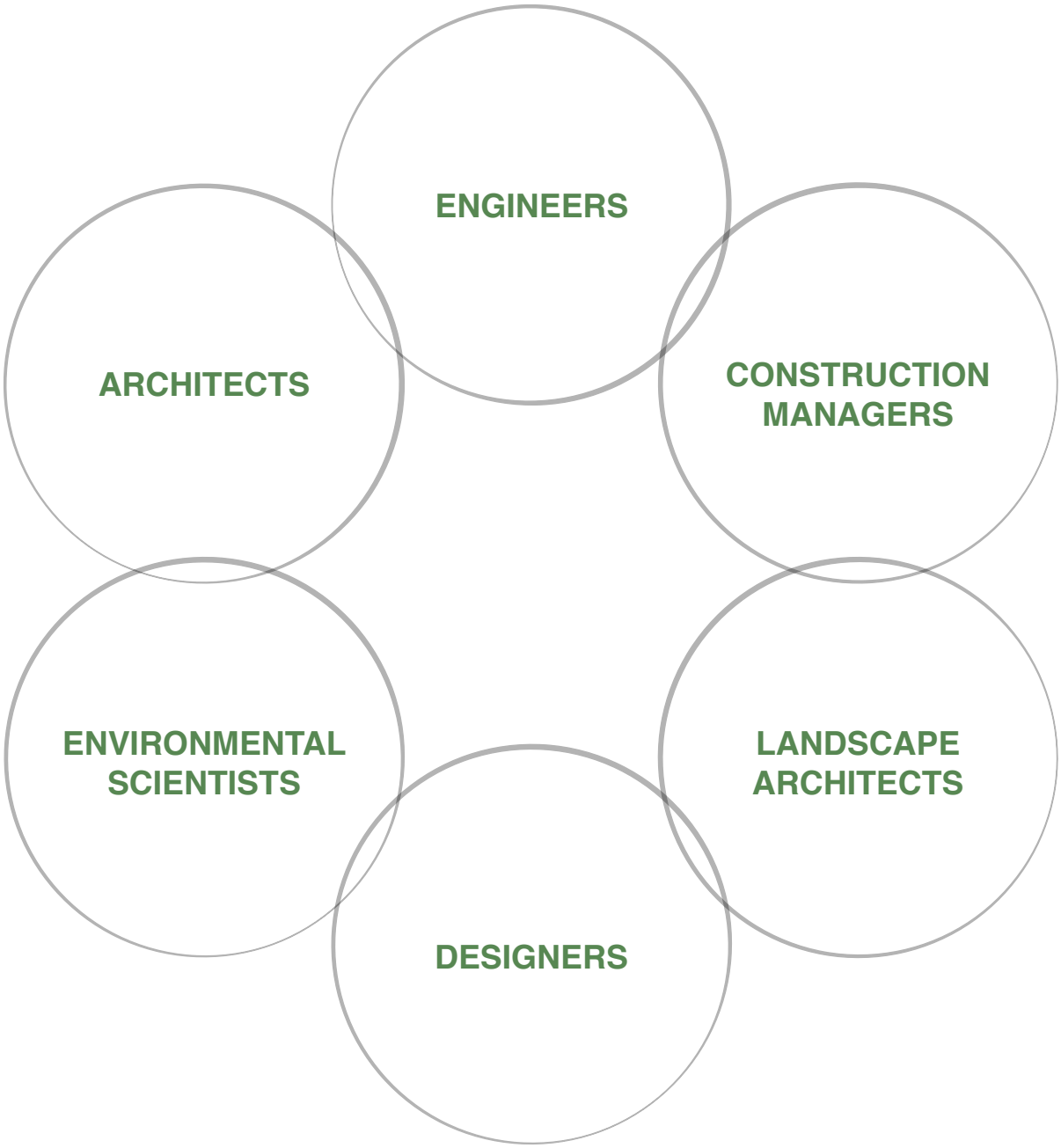


Figure 1: Touchstones Connection Diagram

By combining durability and passive measures with efficient envelope, heating, ventilation, lighting, and domestic hot water distribution strategies, we have achieved our goal of meeting the US DOE Challenge Home and ENERGY STAR criteria, earning a HERS Index of 43. With the addition of solar thermal and solar electric, we reach a HERS Index of -5 while remaining within our budget, limiting the cash outflow, and improving the equity for the future occupant. Using a building systems approach to optimize and infuse the measures selected and their relationships with respect to durability, performance, and finance lead to the affordable, micro-load, and Net-Zero design of *The Montage*.

While our seven sustainability touchstones achieve the high-performance nature of our design, they were conceived with a bigger picture in mind. Ecology's seventh-generation concept inspired us to consider the long term effects of our actions and the importance of resilience, health, location, efficiency, timelessness, beauty, and honesty for people, the planet, and profit centuries down the road. Outcomes we couldn't have reached without an equally sustainable collaboration process.

INTEGRATED DESIGN PROCESS



Our team, Montage Builders – Northern Forest, is a diverse group of undergraduate, graduate, and PhD students who came together in response to a call from Professor Paul Corvella, our lead faculty advisor. We represent seven different fields of study and three different educational institutions, exemplifying cross pollination collaboration. Many of us did not know each other before the project began; therefore, defining an effective structure of cooperation and decision-making was essential for the success of our integrated design process. We utilized a weighted decision matrix to mold and enhance our design choices, allowing us to achieve a multi-generational legacy in the shape of a building.

The decision matrix kept us in line with our commitment to people and the environment despite the pressures of working with a realistic budget. Figure 3 below demonstrates the level of care and consideration with which we approached this project.

Above Grade Walls

Weight:	14.9	13	14.7	15.2	13.9	13.8	10	15.3	11.4	11.7	14.1	13.7	13.9	
Attribute:	Design Challenge	Budget	Build-ability	Indoor Air Quality	Water MGMT	Visit-ablity	Net-Zero	Climate Change	Supply Chain (local vs non local)	Recycled / Recycl-able	Dur-ability	Resilience/ Passive Survivablity	No/Low Environ-mental Toxicity	
2x6 Wall @ 24" O.C. 5.5" Blown Cellulose, 4" XPS	90%	70%	85%	75%	97%	0%	92%	60%	70%	75%	90%	90%	65%	Score:
Score:	13.41	9.1	12.495	11.4	13.483	0	9.2	9.18	7.98	8.775	12.69	12.33	9.035	129.08

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2x6 Wall @ 24" O.C. 5.5" Blown Cellulose, 4" Polyiso-cyanurate	92%	60%	85%	82%	97%	0%	95%	94%	70%	74%	90%	91%	96%	Score:
Score:	13.708	7.8	12.495	12.464	13.483	0	9.5	14.382	7.98	8.658	12.69	12.467	13.344	138.97

Figure 3: Montage Weighted Decision Matrix – Wall Systems

About Global Warming Potential (GWP): According to a study conducted by Alex Wilson, the "lifetime GWP" (embodied GWP and GWP related to the blowing agent used) of extruded polystyrene (XPS) insulation is 56 times greater than that of polyisocyanurate insulation. Adding four inches of XPS rigid insulation to the exterior of a 2x6 wall system insulated with cellulose results in a payback period (energy saved by the insulation to offset the greenhouse gas emissions resulting from the use of that insulation) of 65 years in Climate Zone 5. If polyisocyanurate is used instead, the payback period is only 2.7 years.[1]

Our team, Montage Builders – Northern Forest, is a diverse group of undergraduate, graduate, and PhD students who came together in response to a call from Professor Paul Corvella, our lead faculty advisor. We represent seven different fields of study and three different educational institutions, exemplifying cross pollination collaboration. Many of us did not know each other before the project began; therefore, defining an effective structure of cooperation and decision-making was essential for the success of our integrated design process. We utilized a weighted decision matrix to mold and enhance our design choices, allowing us to achieve a multi-generational legacy in the shape of a building.

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Score:	13.41	9.1	12.495	11.4	13.483	0	9.2	9.18	7.98	8.775	12.69	12.33	9.035	**129.08**

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Score:	13.708	7.8	12.495	12.464	13.483	0	9.5	14.382	7.98	8.658	12.69	12.467	13.344	**138.97**

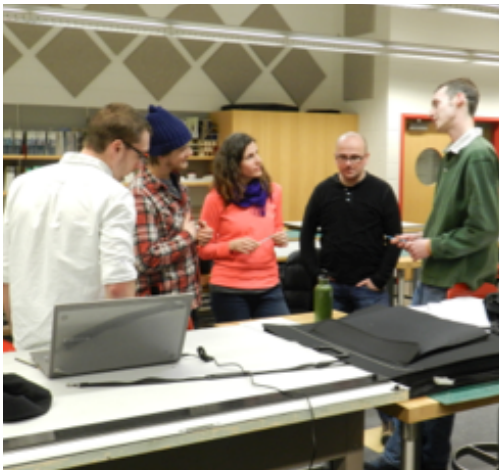
Figure 3: Montage Weighted Decision Matrix – Wall Systems

About Global Warming Potential (GWP): According to a study conducted by Alex Wilson, the "lifetime GWP" (embodied GWP and GWP related to the blowing agent used) of extruded polystyrene (XPS) insulation is 56 times greater than that of polyisocyanurate insulation. Adding four inches of XPS rigid insulation to the exterior of a 2x6 wall system insulated with cellulose results in a payback period (energy saved by the insulation to offset the greenhouse gas emissions resulting from the use of that insulation) of 65 years in Climate Zone 5. If polyisocyanurate is used instead, the payback period is only 2.7 years.[1]

Additionally, dynamic Governance, a tool used to structure effective communication, collaboration, and shared leadership was used to facilitate our meetings. Similar to the whole-system's approach we used to design The Montage, dynamic governance offered a holistic solution, making the team better than the sum of its parts by helping us tap into the collective intelligence of our group.

Meetings, first biweekly then weekly, were held with all team members, faculty advisors, and our two core industry advisors. We used these three-hour blocks of time to work through design challenges, update each other on progress, and develop strategies for moving forward. Despite difficult decisions; intense workloads; and at times, different opinions, our fostered team-spirit remained strong, yielding a supportive and productive learning experience for all members of Montage Builders – Northern Forest.






Figures 4: Montage Team Meetings

DESIGN GOALS // The race to zero

At our first official meeting each team member contributed three goals that inspired them to participate in the project and listed the categories of the competition they were most interested in. Regarding their input and appreciating the value of team work, we assigned various responsibilities to three sub-groups. We condensed the goals down to what are now our guiding sustainability touchstones and used them to define our target for performance.

As a group, we reached beyond the initial performance goals of A HERS Index of 50 or lower, staying true to our touchstones, and staying affordable for median income families in Syracuse, NY. In addition to adhering to DOE Challenge Home and ENERGY STAR requirements, we committed to achieving ICC 700, LEED for Homes, EPA WaterSense, EPA IndoorAirPlus and IBHS Fortified certifications. Our design theoretically achieves all of these certifications and reaches a projected HERS Index of 44. As a baseline for comparison, we also modeled The Montage to meet the current Energy Conservation Construction Code of New York State; this model only "earned" a HERS Index of 89.

THE MONTAGE

US DOE Challenge Home

ENERGY STAR
Certified New Home:

HERS Index without Renewables:
44

With Renewables:
-5

The Montage meets the minimum criteria for:

EPA Indoor airPlus

ENERGY STAR

IBHS Fortified for Safer Living

ICC 700 Score

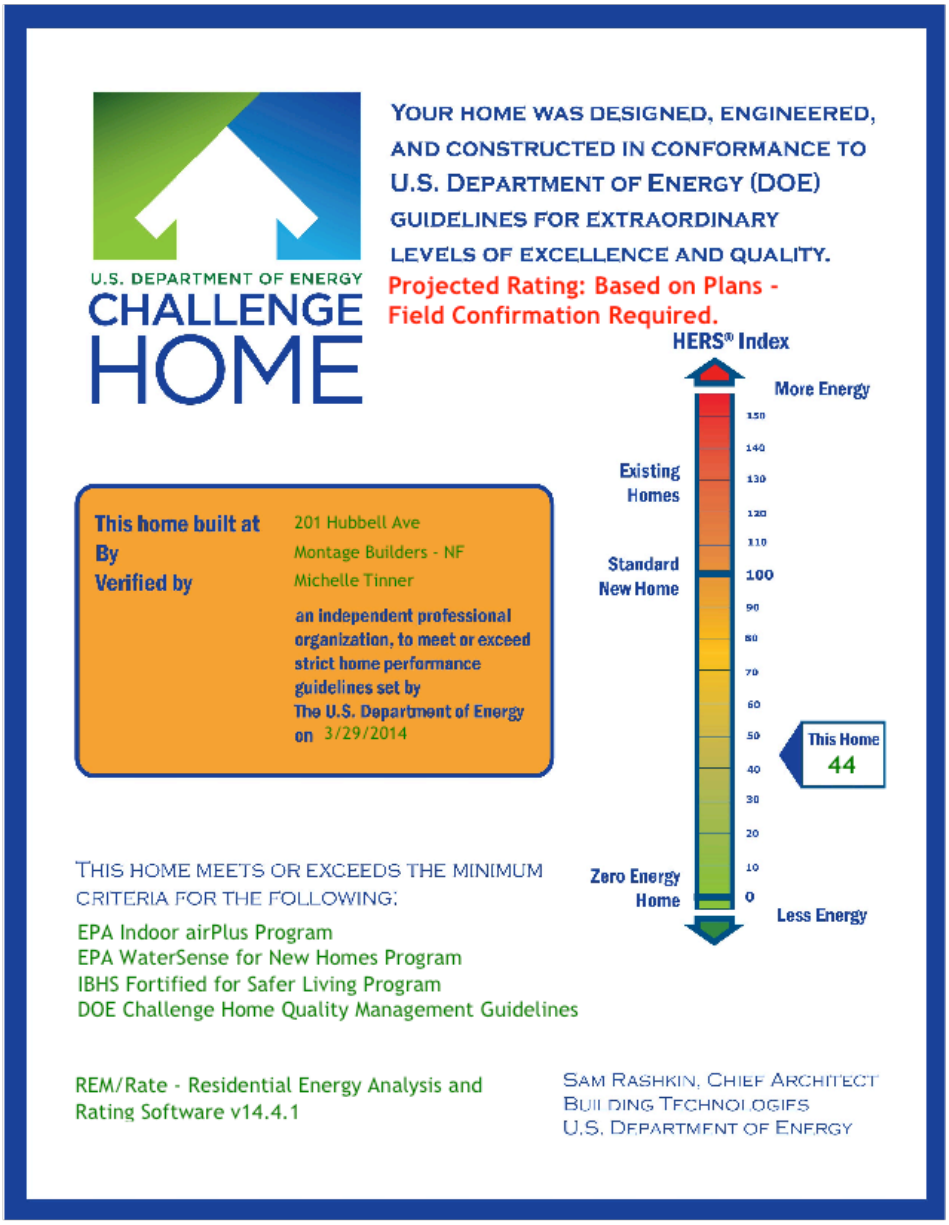
EPA WaterSense

LEED for Homes: Platinum

Seeking an exemplary model and framework for local builders, although important, budget took a slight backseat to environment, health, water-management, visitability, and durability goals. Return to Figure 3 to view the weights in our decision matrix for details. By not compromising quality for cost yet remaining committed to delivering a design that is *still* affordable to the local community, we ended up with the best possible house at the lowest possible cost. To build The Montage is an appropriate and smart economic decision for a family earning $65,800 annually; this is the median family income of Syracuse.

A 450 square foot solar photovoltaic system and a 96 square foot solar hot water heating system are incorporated into our budget at a cost estimated at $15,000 after tax credits and local incentives. With these renewable systems *The Montage* reaches an impressive HERS Index of -5. Taking into account the 3.5% energy cost inflation rate, we encourage the solar systems investment right up front as it is within the budget and will save the homeowner $84,365 over the course of thirty years.

The Montage: *No Solar*



ENERGY STAR® CERTIFIED NEW HOME

Projected Rating: Based on Plans - Field Confirmation Required.

Builder Name: Montage Builders - NF
Permit Date/Number:
Home Address: 201 Hubbell Ave
Syracyse , NY 13207

Rating Company: MBT Design
Rater Identification Number: 2636162
Rating Date: 3/17/14
Version: 3.0

Standard Features of an ENERGY STAR Certified New Home

Your ENERGY STAR certified new home has been designed, constructed, and independently verified to meet rigorous requirements for energy efficiency set by the U.S. Environmental Protection Agency (EPA), including:

Thermal Enclosure System

A complete thermal enclosure system that includes comprehensive air sealing, quality-installed insulation and high-performing windows to deliver improved comfort and lower utility bills.

Air Infiltration Test: **Htg: 1.00 Clg: 1.00 ACH50**

Primary Insulation Levels:
Ceiling: R-60.0 **FndWall: R-21.3**
AGWall: R-46.0 **Slab: R-41.3**

Primary Window Efficiency:
U-Value: 0.300, SHGC: 0.300

Water Management System

A comprehensive water management system to protect roofs, walls, and foundations.

Flashing, a drainage plane, and site grading to move water from the roof to the ground and then away from the home.

Water-resistant materials on below-grade walls and underneath slabs to reduce the potential for water entering into the home.

Management of moisture levels in building materials during construction.

Heating, Cooling, and Ventilation System

A high-efficiency heating, cooling system, and ventilation system that is designed and installed for optimal performance.

Total Duct Leakage:
NA

Duct Leakage to Outdoors:
NA

Primary Heating (System Type • Fuel Type • Efficiency):
Air-source heat pump, Electric, 3.7 COP.

Primary Cooling (System Type • Fuel Type • Efficiency):
None

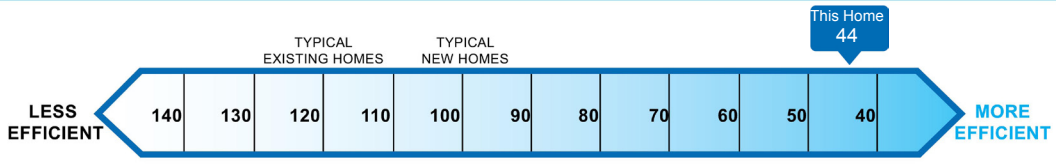
Energy Efficient Lighting and Appliances

Energy efficient products to help reduce utility bills, while providing high-quality performance.

ENERGY STAR Qualified Lighting: **100%**

ENERGY STAR Qualified Appliances and Fans:
Refrigerators: 1 **Dishwashers: 1**
Ceiling Fans: 2 **Exhaust Fans: 1**

Primary Water Heater (System Type • Fuel Type • Efficiency):
Heat pump, Electric, 2.00 EF, 80.0 Gal.



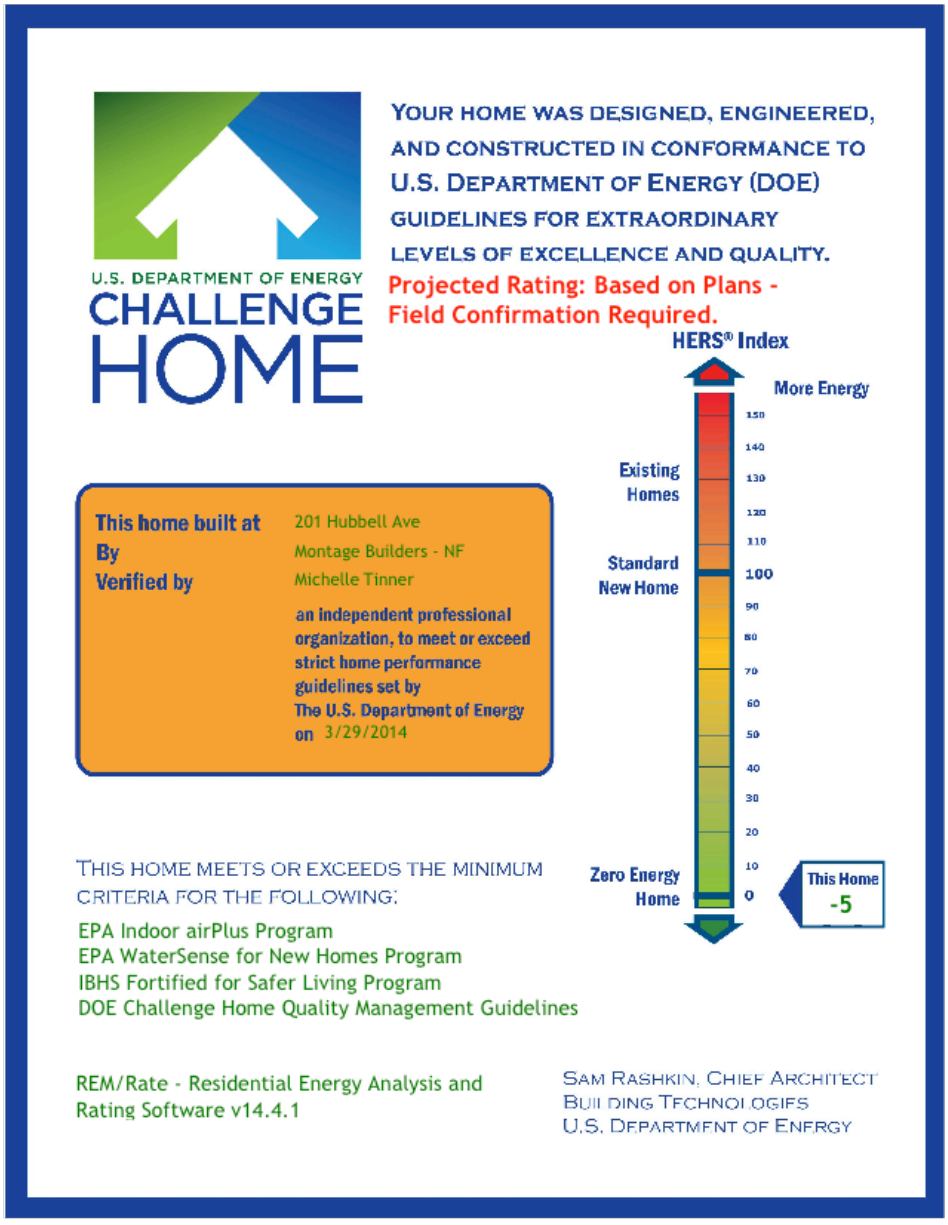
HERS® Index

The certificate provides a summary of the major energy efficiency and other construction features that contribute to this home earning the ENERGY STAR, including its Home Energy Rating System(HERS) score, as determined through independent inspection and verification performed by a trained professional. The home Energy Rating System is a nationally-recognized uniform measurement of the energy efficiency of homes.

Note that when a home contains multiple performance levels for a particular feature (e.g., window efficiency or insulation levels), the predominant value is shown. Also, homes may be certified to earn the ENERGY STAR using a sampling protocol, whereby one home is randomly selected from a set of homes for representative inspections and testing. In such cases, the features found in each home within the set are intended to meet or exceed the values presented on this certificate. The actual values for your home may differ, but offer equivalent or better performance.

Learn more at www.energystargov/homefeatures

The Montage: *Solar PV and Solar Thermal*



ENERGY STAR® CERTIFIED NEW HOME

Projected Rating: Based on Plans - Field Confirmation Required.

Builder Name: Montage Builders - NF
Permit Date/Number:
Home Address: 201 Hubbell Ave
Syracyse , NY 13207

Rating Company: MBT Design
Rater Identification Number: 2636162
Rating Date: 3/17/14
Version: 3.0

Standard Features of an ENERGY STAR Certified New Home

Your ENERGY STAR certified new home has been designed, constructed, and independently verified to meet rigorous requirements for energy efficiency set by the U.S. Environmental Protection Agency (EPA), including:

Thermal Enclosure System

A complete thermal enclosure system that includes comprehensive air sealing, quality-installed insulation and high-performing windows to deliver improved comfort and lower utility bills.

Air Infiltration Test: **Htg: 1.00 Clg: 1.00 ACH50**

Primary Insulation Levels:
Ceiling: R-60.0 **FndWall: R-21.3**
AGWall: R-45.3 **Slab: R-41.3**

Primary Window Efficiency:
U-Value: 0.300, SHGC: 0.300

Water Management System

A comprehensive water management system to protect roofs, walls, and foundations.

Flashing, a drainage plane, and site grading to move water from the roof to the ground and then away from the home.

Water-resistant materials on below-grade walls and underneath slabs to reduce the potential for water entering into the home.

Management of moisture levels in building materials during construction.

Heating, Cooling, and Ventilation System

A high-efficiency heating, cooling system, and ventilation system that is designed and installed for optimal performance.

Total Duct Leakage:
NA

Duct Leakage to Outdoors:
NA

Primary Heating (System Type • Fuel Type • Efficiency):
Air-source heat pump, Electric, 3.7 COP.

Primary Cooling (System Type • Fuel Type • Efficiency):
None

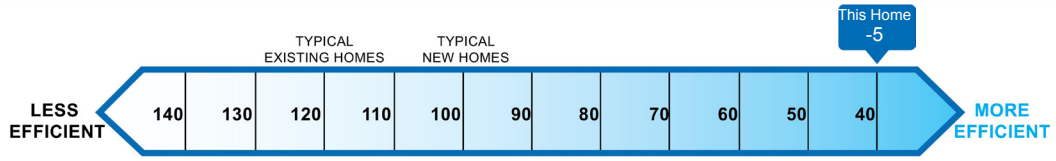
Energy Efficient Lighting and Appliances

Energy efficient products to help reduce utility bills, while providing high-quality performance.

ENERGY STAR Qualified Lighting: **100%**

ENERGY STAR Qualified Appliances and Fans:
Refrigerators: 1 **Dishwashers: 1**
Ceiling Fans: 2 **Exhaust Fans: 1**

Primary Water Heater (System Type • Fuel Type • Efficiency):
Heat pump, Electric, 2.00 EF, 80.0 Gal.



HERS® Index

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Learn more at www.energystargov/homefeatures

PERFORMANCE GOALS

With our long-term positive impact goal in mind, we focused first on one hundred plus year components to reduce the building's load while optimizing rapidly evolving "plug and play" mechanical systems. Designing an envelope according to Building Science Corporation's 5-10-20-40-60 principle, eliminating thermal bridging, addressing air infiltration and durability by specifying complete and user-friendly flashing details, and integrating pest management resulted in a high-performance envelope.

By maximizing the performance of the envelope, we minimized the need for space conditioning. A Daikin Altherma air to water heat pump system will satisfy the 14,000 Btu/h design heating load as well as all domestic hot water needs. Compared to our baseline model of *The Montage*, which is "built" to meet the current Energy Conservation Construction Code of New York State, our super insulated and air-sealed building enclosure combined with the high efficiency heat pump will reduce energy use by 41.3 percent and avoid 6.1 tons of carbon dioxide from being released. By adding a PV array and active solar, we prevent the consumption of energy by 109% and the release of 9.4 tons of carbon per year.

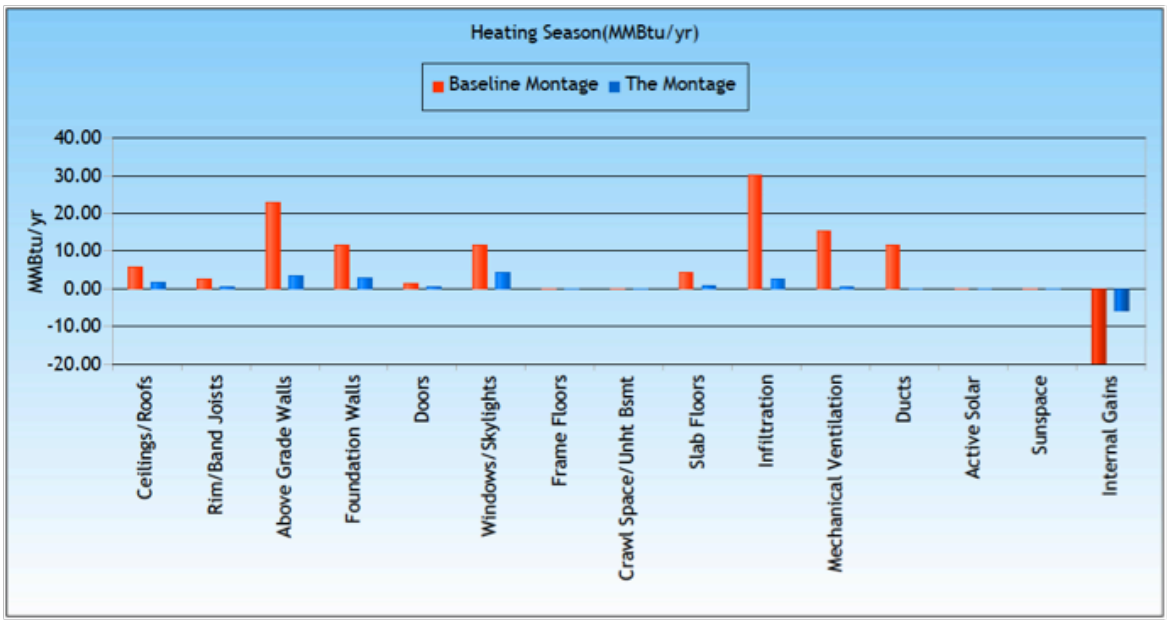


Figure 5: Two Building Report, Montage v.s. Baseline Montage. Generated in REM Rate.

Montage Builders – Northern Forest strives to be part of the movement that brings energy efficient homes to mainstream America. Affordability, comfort, health, indoor environmental quality, and aesthetics are essential for the success of this mission. *The Montage* was designed with great consideration to an occupant's comfort and needs. In conjunction with radiant floor distribution, through the wall HRV units will be used to provide ventilation without introducing raw Upstate New York winter air. This measure adds to the overall efficiency of the house and therefore its financial viability; however, more importantly, it encapsulates a healthy indoor environment.

ARCHITECTURAL GOALS

From an architectural standpoint, indoor environmental health is supported by the use of all hard flooring, natural materials, low VOC paints and adhesives, window placement and sizing for optimal natural ventilation and natural lighting, an all LED lighting design that ensures appropriate work surface illumination levels, detachment of the garage, and the integration of universal design features that enable people with varying physical abilities and elderly occupants as their needs change. Furthermore, while maintaining the characteristics of an American Craftsman style home, Net-Zero energy and water readiness, water management, and passive solar were designed into *The Montage*.

Figures 6: Images of similar American Craftsman style homes in Syracuse

The American Craftsman style fits in with the pattern language of the Strathmore neighborhood in Syracuse where our selected lot, 201 Hubbell Ave, is located. Capitalizing on the lot's elongated west facing orientation, the house was designed for maximum solar exposure along the south side of our gabled roof; solar exposure also influenced window placement and shading.

Figures 7: Artistic Renderings of The Montage; exterior, master bedroom and living room

Our architectural choices also inform the constructability of *The Montage*. By utilizing readily available materials, a foundation that can be placed in a single day, methods local builders are familiar with, and standard window sizes, we have increased the probability of local builders taking advantage of our design, especially with additional perks being simplified and reduced-cost maintenance.

ENVIRONMENTAL GOALS

According to the EPA, energy supply; commercial and residential buildings; and waste and wastewater contribute a massive 37% of global carbon emissions released into the environment.[2] To drastically limit fuel use and emissions associated with typical homes, efficient use of materials and resources have curtailed the overall environmental impact of *The Montage*. We've applied advanced framing, a compact domestic hot water distribution system, and a LEAN Construction Control Plan as material and time saving components.

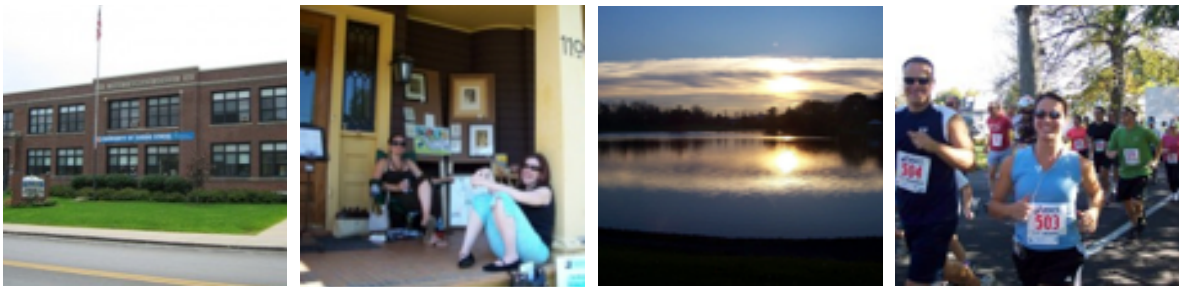
As mentioned earlier, we are building a house with the intention for it to

last hundreds of years; however, we recognize that homes sometimes get torn down prematurely. To address this and minimize waste we planned for deconstruction. The Superior Wall Plus foundation, hardwood floors, fasteners, lumber, and insulation can all be disassembled and used again. Other materials like gypsum wall board are recyclable, too. Yet and hopefully, the house benefits from our designed rehabilitation considerations for a *long* time before the destruction process benefits ever kick in.

With the city's help, we've addressed Syracuse's long-standing issues with their combined sewer and storm water management system. Thanks to a generous grant from the *Save the Rain* program (Appendix 1), we were able to expand upon our original on-site storm water management plan, protecting Onondaga Lake from further pollutants. At our site, storm water runoff is first minimized with the use of permeable pavement on the driveway. Remaining storm water is diverted to rain gardens and a cistern. These gardens constitute a comprehensive local plant list to restore ecosystem services by sequestrating carbon, evapotranspiring water and creating a habitat for wildlife. Finally, a rain garden between the sidewalk and the street will divert storm water from the road.

SOCIAL GOALS

Like a recirculating range hood, the residues of and policies from the inequitable National Housing Act of 1934 continue to disenfranchise neighborhoods in Syracuse and keep people spread out in suburbia. In opposition to this trend, we chose a lot from the Greater Syracuse Land Bank to reinvest in dense communities and give back to neglected neighborhoods. Hubbell Ave, on the edge of the Strathmore neighborhood, is in a two block transition zone between a thriving community and a struggling one. By selecting this location and moving reinvestment and change toward a place in need, *The Montage* offers close proximity (within half a mile) to a strong community as well as valuable resources, such as Onondaga Park, Hiawatha Lake, and Most Holy Rosary Parish. For a brief history of Syracuse and the Strathmore neighborhood see Appendix 2.



Figures 8: Strathmore Neighborhood: Roberts School, Art on Porches, Hiawatha Lake, and Park Run. [3]

We hope our project proves to be a catalyst for change with our eye for biophilic beauty, financial stability, and social well-being: biophilic beauty exemplified by garden space and green space for people; financial stability maintained through energy monitoring and bill mitigation; and social well-being provided by a house built to endure and handle super storms. With these occupant characteristics, *The Montage* owners embark on a synergistic relationship (a whole systems approach) with their livable space. An approach and change welcomed by the Greater Strathmore Neighborhood Association and our community advisor Father Fred of Most Holy Rosary.

BUILDING SYSTEMS APPROACH

In the *Builder's Guide to Cold Climates*, Joe Lstiburek writes, "a house is a complex interrelated system of people, the building itself, and the environment." Montage Builders – Northern Forest recognizes the importance of a building systems approach to construction, understanding that each and every assembly along with their elements, the element's sub-systems, and the sub-system's components are related. Seemingly minute changes to a sub-system component (for example, selecting different finishes) can severely affect the performance and durability of the entire assembly; the functionality of other assemblies and systems; and therefore the entire home.[4]

Designing building assemblies and systems in isolation from one another is detrimental and naïve. A strong understanding of building science principles, management provisions, and an integrative designing process are critical when we bring different trades and specialist together. Our decisions and attention to detail have already proven useful—we hold a non-binding contract (Appendix 3) for *The Montage* to be built, a testament to our team-work, the Building America's research, and the DOE's guidance.

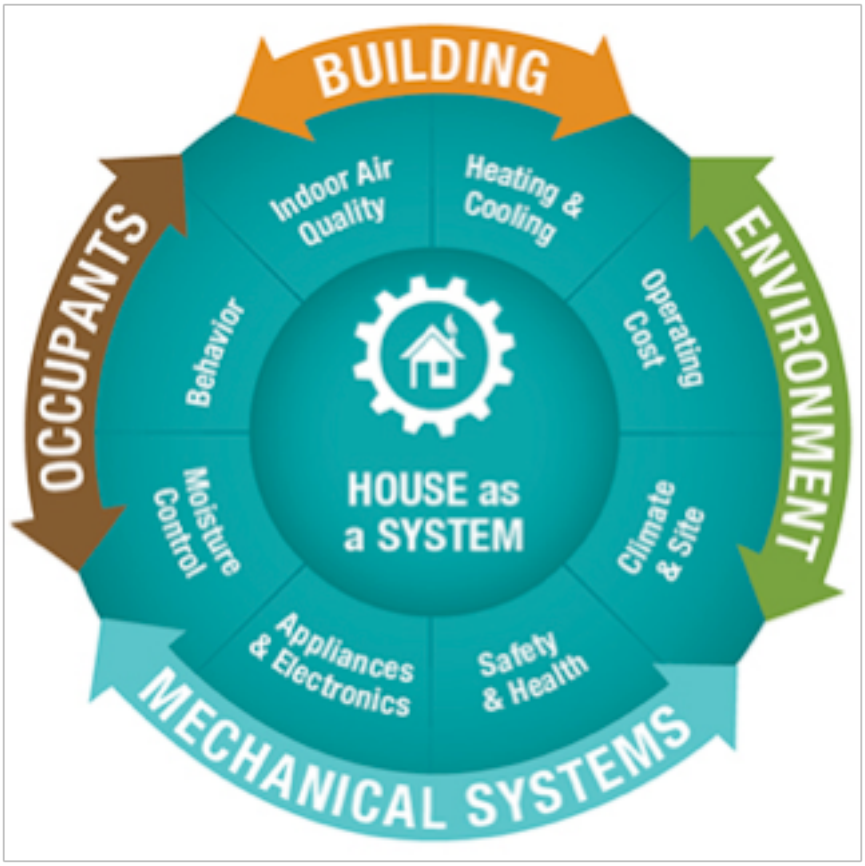


Figure 9: House as a System . [5]

WORKS CITED

[1] Wilson, Alex. "Avoiding the Global Warming Impact of Insulation." *BuildingGreen*. 1 June 2010. Web. 21 Jan. 2014.

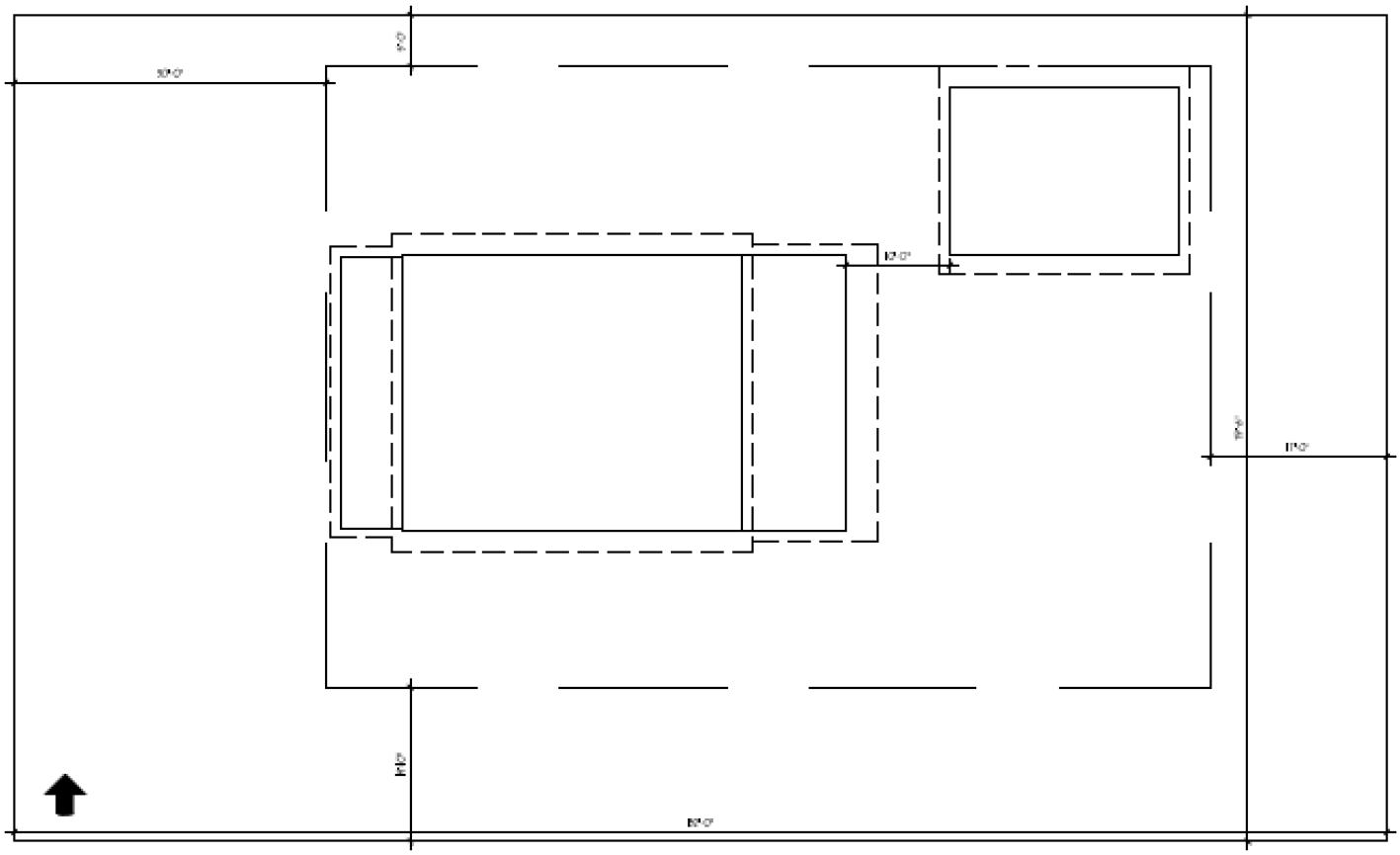
[2] "Global Greenhouse Gas Emissions Data." *EPA*. 20 March 2014.

[3] "Strathmore." *Greater Strathmore Neighborhood Association RSS*. Web. 29 Mar. 2014.

[4] Joseph Lstiburek. "The Builder's Guide to Cold Climates." The Taunton Press, Inc., 2000.

[5] "House as a System: The Whole-Systems Approach to Energy Efficiency." *Conservation Services Group Inc*. Web. 29 Mar. 2014.

SITE PLAN

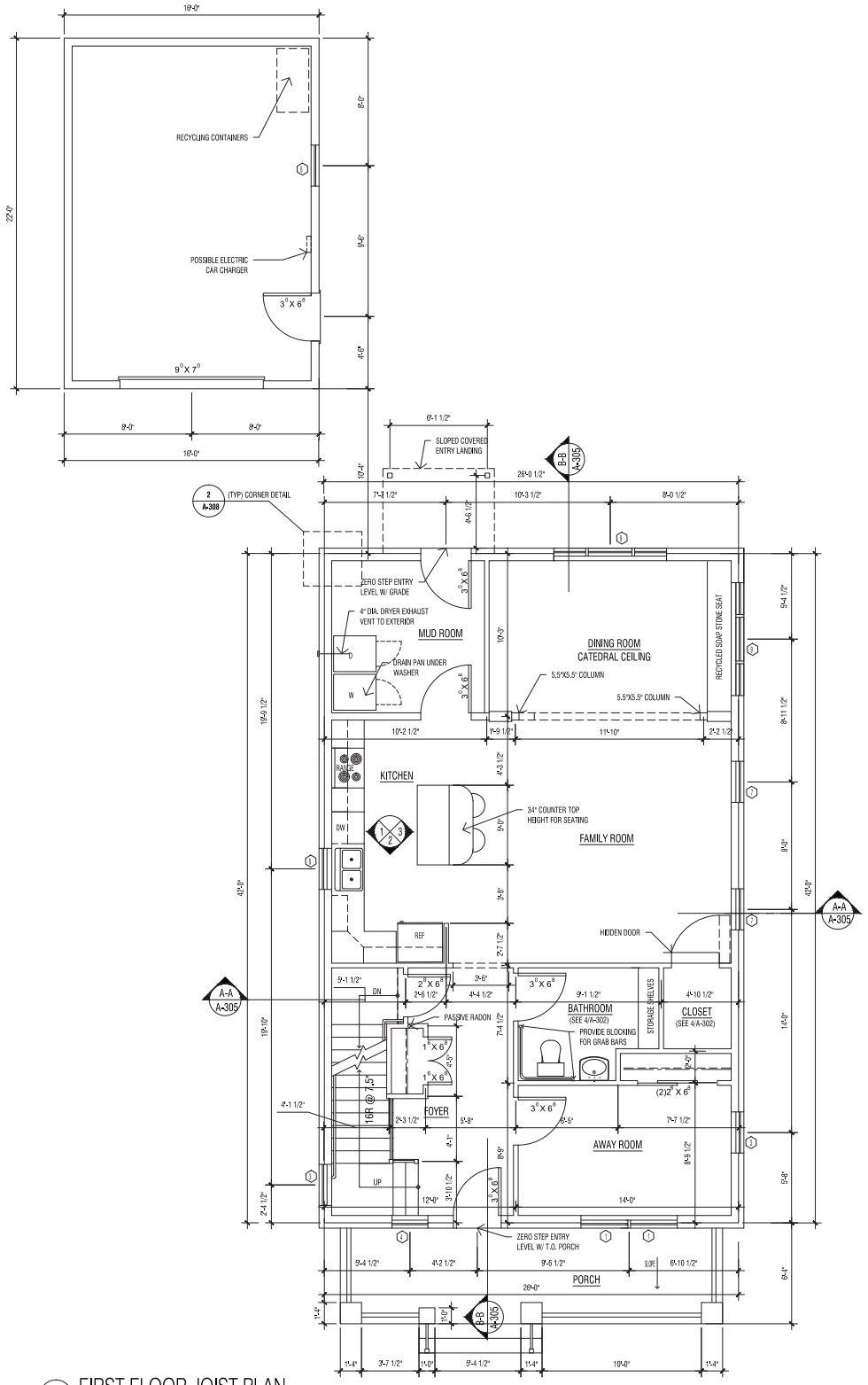


SITE PLAN

SITE PLAN • REVISION 23MAR2014
• THE SMALL DASHED LINES REPRESENT PROPOSED OVERHANGS
- THE SOLID LINES REPRESENT THE BUILDINGS FOOTPRINT ON THE LOT
• THE LARGE DASHED LINES REPRESENT THE ZONING OFFSETS

FLOOR PLANS

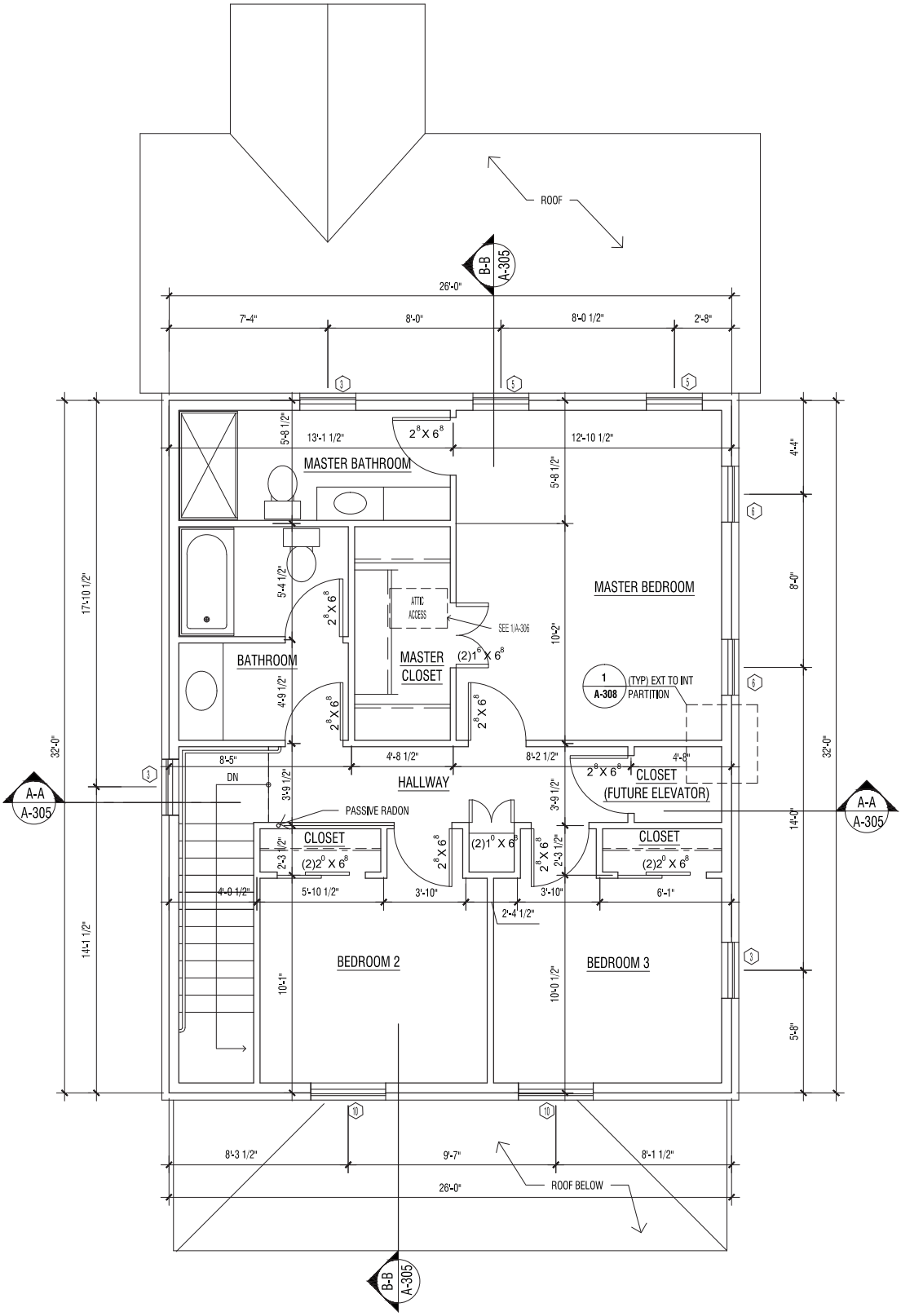
FIRST FLOOR PLAN



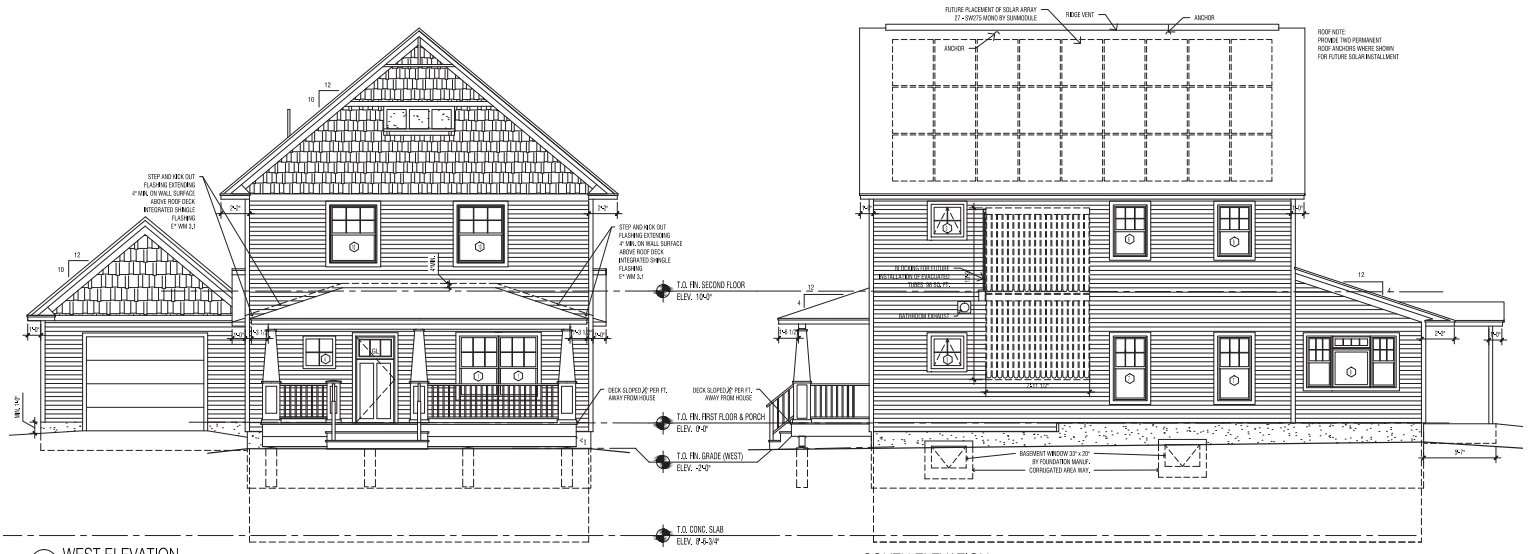
FIRST FLOOR JOIST PLAN
1/4" = 1'-0"

FLOOR PLANS

SECOND FLOOR PLAN

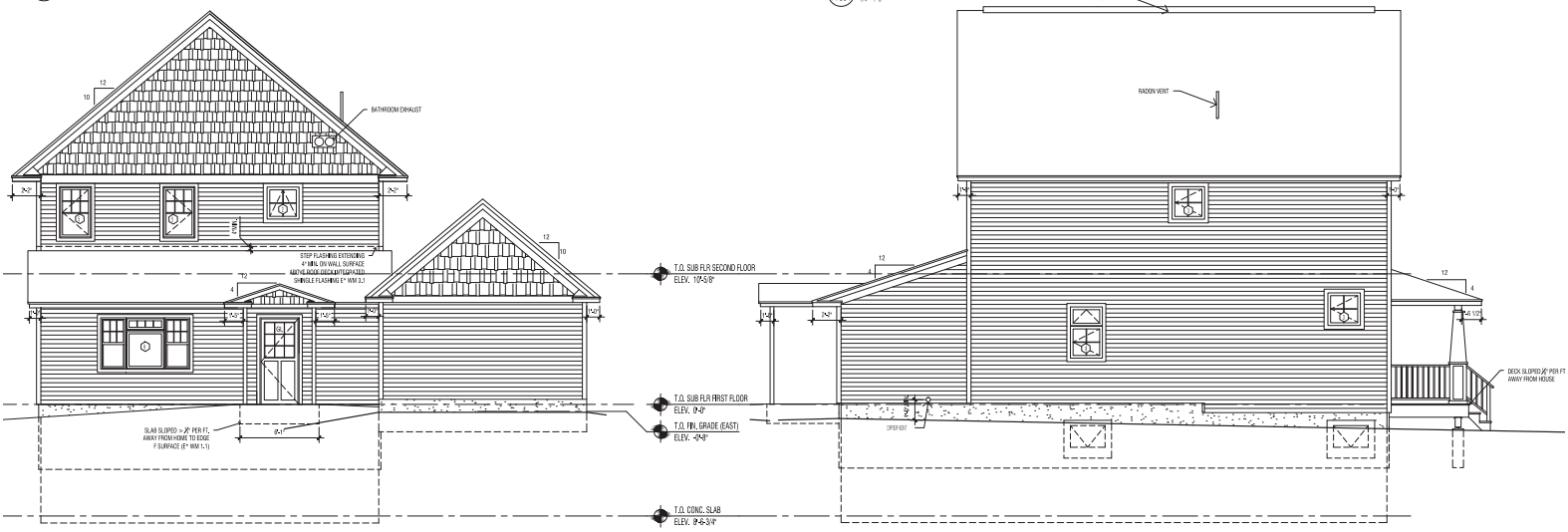


ELEVATIONS



A A-304 WEST ELEVATION 1/4" = 1'-0"

B A-304 SOUTH ELEVATION 1/4" = 1'-0"



C A-304 EAST ELEVATION 1/4" = 1'-0"

D A-304 NORTH ELEVATION 1/4" = 1'-0"

ABOUT ADVANCED FRAMING

Advanced Framing[1] in *The Montage*

After researching, we employed the National Renewable Energy Laboratory's advanced framing for *The Montage*. Advanced framing, also called Optimal Value Engineering (OVE), reduces lumber use, minimizes wood waste, and maximizes structures' thermal efficiencies while maintaining a structure's integrity and building code requirements. Conveniently, advanced framing expedites construction because everything is planned, drawn, and laid out in the design phase.

The Montage's structural members are vertically aligned with the same spacing for studs, floor I-joists, and roof trusses, known as a stack frame. This style of framing provides better overall structural integrity since gravity loads bear directly on members below and allow for the use of a single top plate. Our framing also uses header hangers, allowing us to eliminate jack studs and save wood. We're excited about using advanced framing because it insists on 24 inch on center modular framing, which allows for a reduced amount of material; it also reduced our cost of labor and amount of generated waste. Less waste relinquishes our need to cut down trees to manufacture construction materials, which reflects positively on our human endeavor and our ecosystem's health.

When crunching some numbers with *The Montage*, we were pleasantly surprised by how many studs we could save. Using structural-rated wood materials to their full approved capacities, optimizing our layout for efficient material use with 2x6s 24" O.C. for the exterior walls and 2x4s 24" O.C. for the interior walls, omitting jack studs, eliminating double top plates, using one stud to connect interior framing to exterior framing and constructing two-stud corners saved us about one hundred and forty-six 8ft studs. An added bonus to this framing method is that it eliminates structural materials where nonstructural materials are adequate, so we didn't have to put headers above openings in non-bearing walls, which saved us five headers. Similar wood saving benefits continued with our placement of our windows.

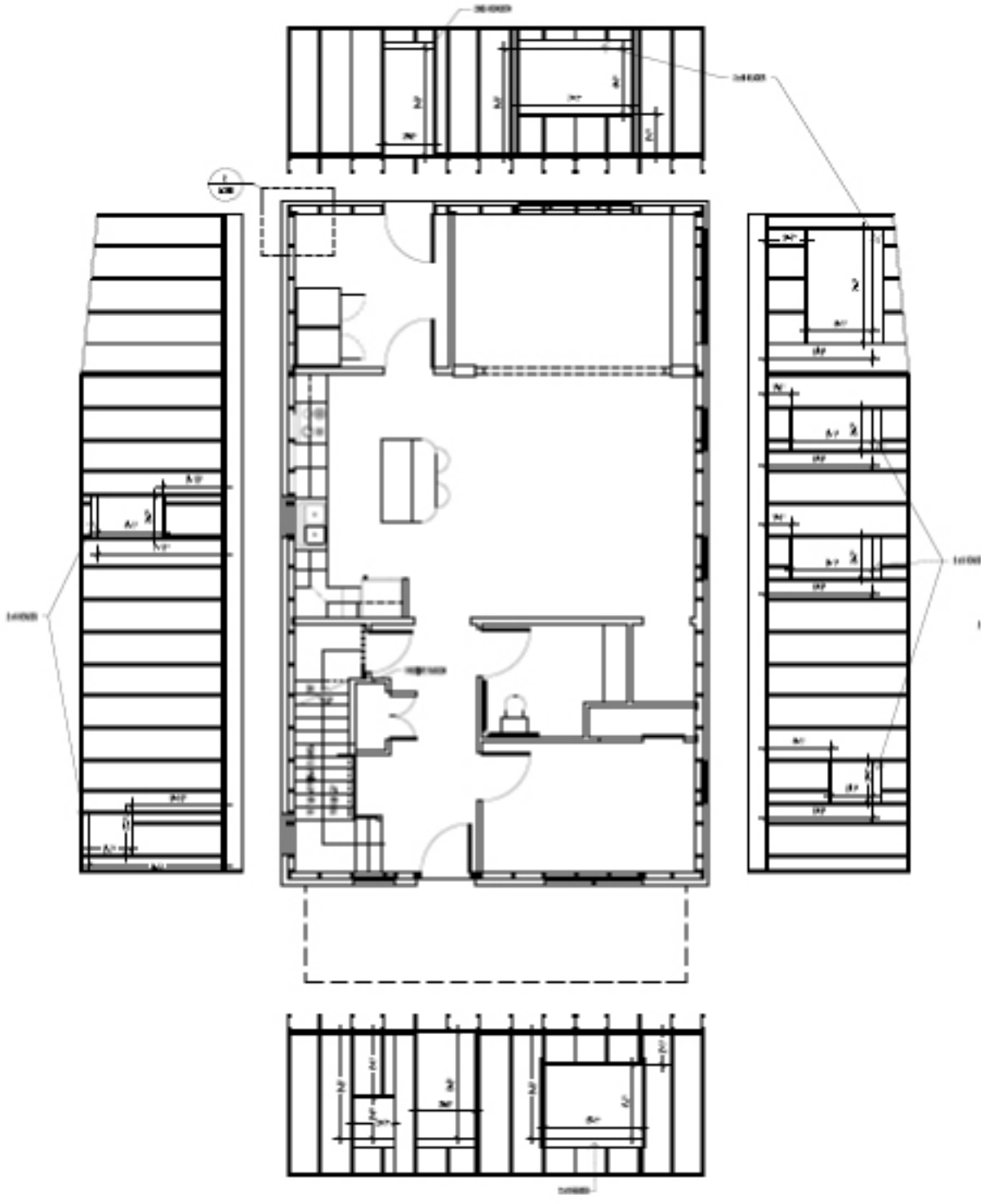
For our design we used Andersen A-series windows. Our windows were sized and placed to fall in alignment with our stud structure, adhering to advanced framing principles. With comfort of the occupants and need to reduce their energy use in mind, windows were placed across from each other where possible to promote natural ventilation, provide the most daylight, and meet egress requirements. Similar to passive solar design,

we oriented our house to supplement our frame design's efficiencies. On the second floor, window glazing is shaded with our roof overhangs. To provide shading for the 1st floor, deciduous trees were carefully placed on the site. Our seasonal considerations continued when planning for the colder months.

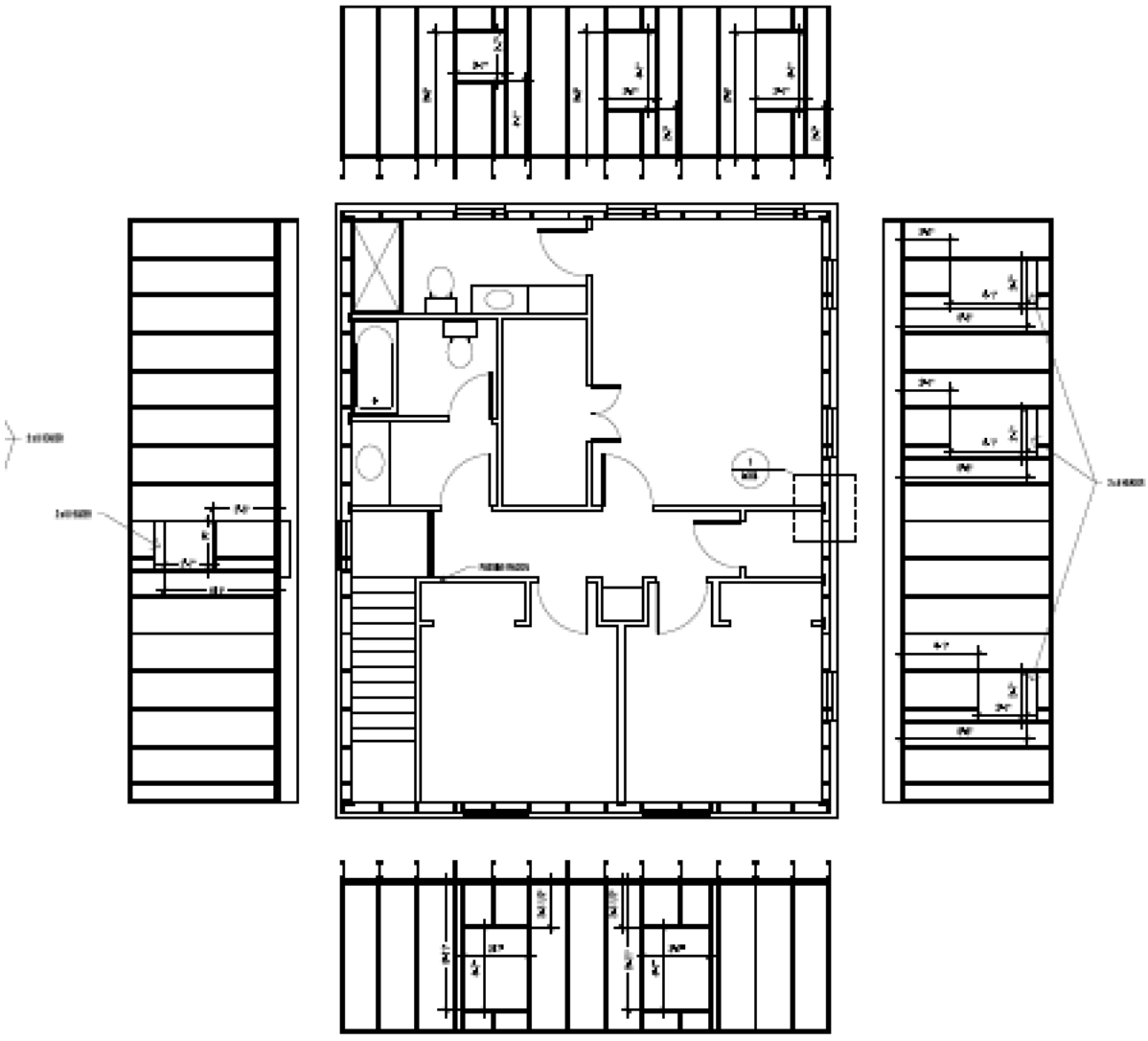
The science behind advanced framing's tighter envelope is encouraging for Syracuse's tough winter season. Using 24" O.C. 2x6 framing gave our building a stronger R-value by having more space for insulation while simultaneously reducing thermal bridging. To further reduce thermal bridging, we added two layers of polyisocyanurate on the outside of the sheathing in our design. As dictated by this approach, we used two stud corners and gave them an additional nailer to provide a continuous surface for attaching and sealing the drywall. Implementing this framing method requires a few techniques, but they're intuitive, cost-effective, and easy to adapt and replicate on any site, ensuring the use of our design for further jobsites and more importantly, our occupants' comfort and safety by having a strong structured, weather resistant, energy efficient, resilient, and durable home, which supplements our design team's touchstones.

WORKS CITED

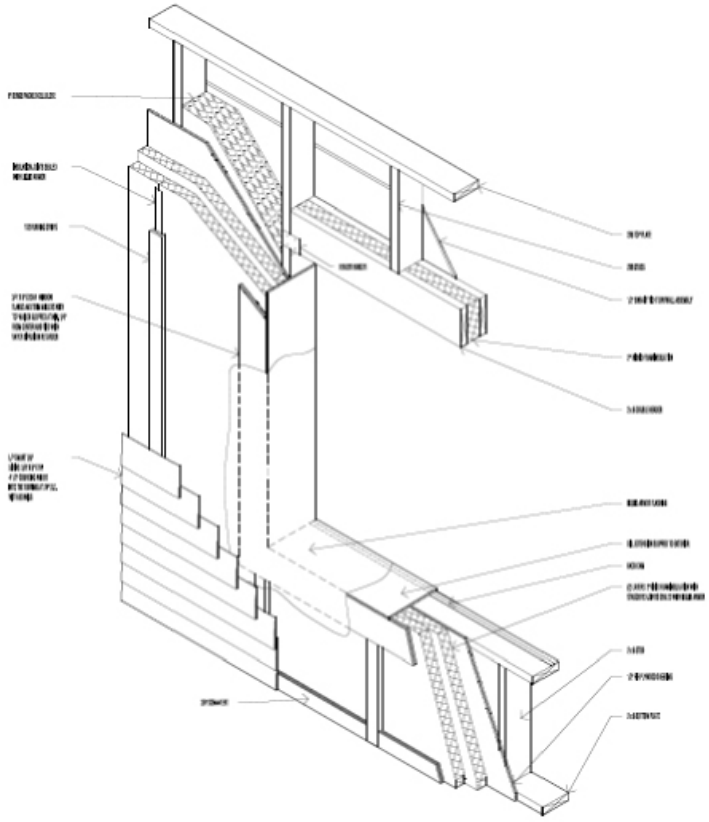
[1] "Advanced Wall Framing Fact Sheet." *National Renewable Energy Laboratory*. 2000. 2 March 2014. <*http://www.nrel.gov/docs/fy01osti/26449.pdf*>.



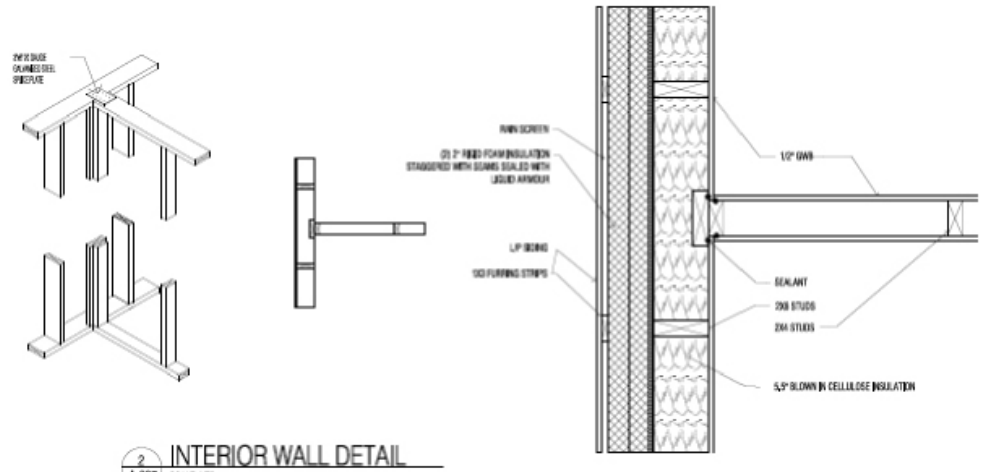
FIRST FLOOR FRAMING PLAN



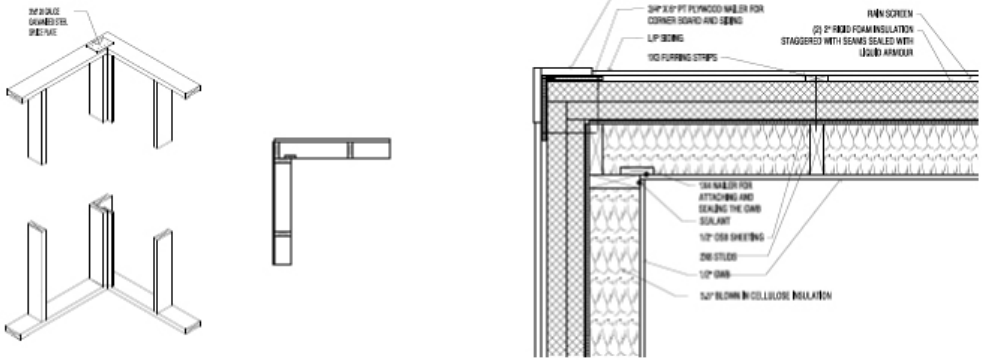
SECOND FLOOR FRAMING PLAN



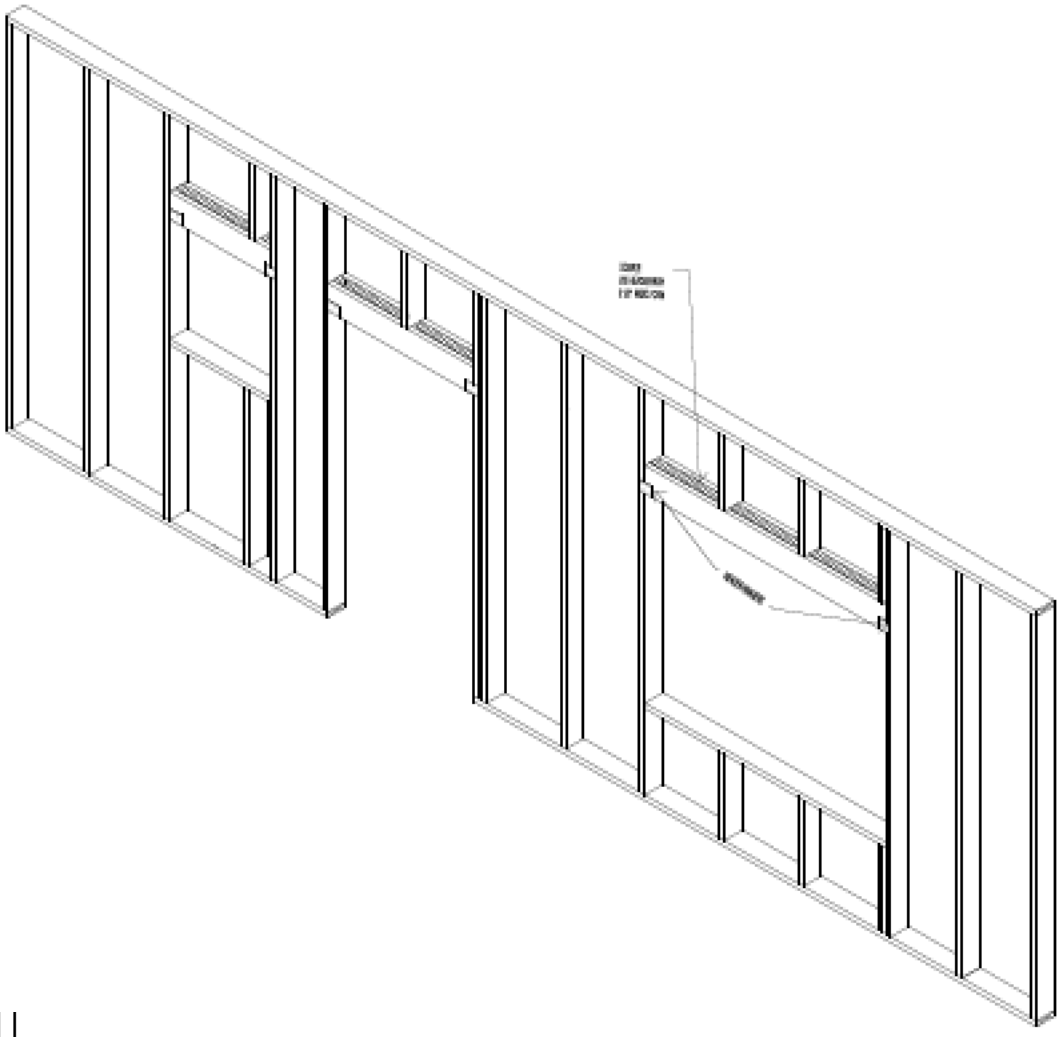
5 A-307 WALL ASSEMBLY DETAIL
SCALE: NTS

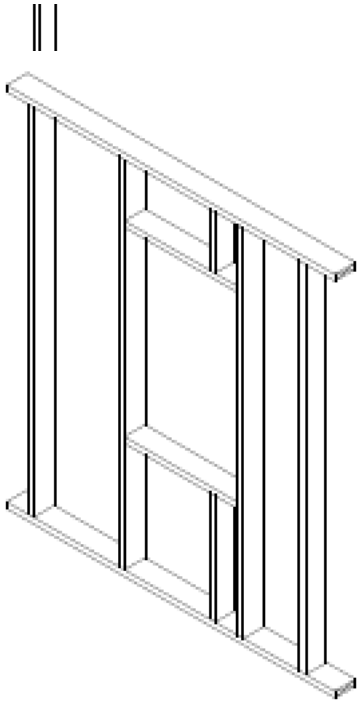


2 A-307 INTERIOR WALL DETAIL
SCALE: NTS

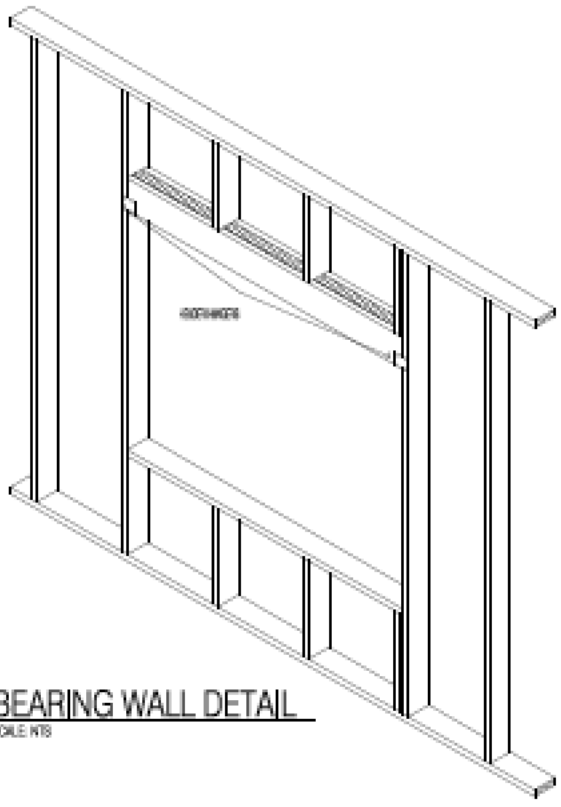


1 A-307 EXTERIOR CORNER DETAIL
SCALE: NTS





NON-BEARING WALL DETAIL
4 / A-307 SCALE: NTS



BEARING WALL DETAIL
3 / A-307 SCALE: NTS

ABOUT VISITABILITY

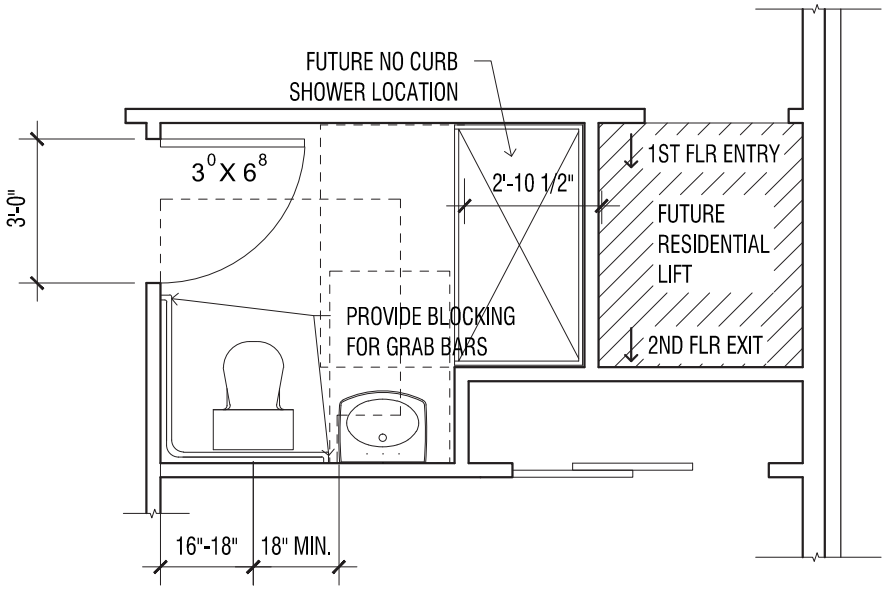
Visitability is referred to as basic home access. Eleanor Smith defined it on the website Concrete Change (www.concretechange.org) as "a movement to change home construction practices so that virtually all new (single family) homes, whether or not designated for residents who currently have disabilities, offer a few specific features that make the home easier for people who develop a mobility impairment to live in and visit." With the guidance of Esther Greenhouse, Enabling Design Advisor, we incorporated visitability into *The Montage*.

The basic but essential features that visitability promotes and requires are: thirty-two inch clear openings throughout the entire first floor, at least one zero step entry, and access to a half bath on the first floor (preferably a full). We accomplished those and the location of our zero step entry is located at the back entrance allowing direct access to the garage and yard. But we went a step further by providing zero step access to the front porch as well as allowing an occupant with impaired mobility the ability to enjoy all of the features that a front porch offers, including a sense of community and security. This also allows the occupant the option of adding a ramp to the front porch if the occupant ever needed. Additional universal features we've supplied within our design are electrical receptacles that are greater than fifteen inches off of the finished floor and electrical switches that are at a height of forty-four inches from the finished floor.

In addition to visitability features we have included features of what we'd like to call "adaptability." These include an easy transition for the half bath on the first floor to become a full bath by providing plumbing to the location during initial construction and blocking in the walls for grab bars as well. Also we have sized the away room for transition, providing a closet which could allow an occupant the ability to reside/ live entirely on the first floor.

We made our design visitable and adaptable for many reasons. One major reason was the growing number of city ordinances mandating the implementation of visitability in new construction. Additionally, by having our design visitable, we potentially increase the marketing ability, allowing a broader range of consumers to purchase the house. Visitability design also makes a simpler circulation path throughout the house for every individual with everyday activities. Finally, as Montage Builders, we wanted to make a statement. We believe incorporating these principles is a testament to a powerful value: acceptance; we take pride in a building that exemplifies this value.

VISITABILITY



CONSTRUCTION COST

With an unlimited budget, it is fairly simple to build an extremely energy efficient house. Unfortunately, this is not the case for most people. We based our budget for *The Montage* on the median family income, $65,800, for our area, Syracuse, NY. This dictated the maximum construction cost for our project to be $240,000. We quickly realized that this is not as much money as it seems to be.

PROCESS

In order to meet this goal, we designed our home to our ideal standards and then had to dial our plans back selectively in order to meet the budgetary constraints. Selecting areas in which to cut costs is no simple task when each element seems just as important as the next. Montage Builders – Northern Forest utilized a weighted decision matrix in order to help with the decision making process. By comparing a number of different factors, just one of them being cost, we were able to effectively make decisions that kept the budget in mind without sacrificing our design values.

After the design was complete, we performed a quantity take off for all aspects of the project. Through a collaborative effort, MB-NF utilized local builders and suppliers to obtain material and labor quotes for all elements of the project and then selected the best fit for our design.

REDUCING COSTS

Montage Builders – Northern Forest developed a LEAN Construction Control Plan as another strategy to reduce costs. By implementing this plan, it enables us to save money in material, labor, and rework. These savings help to offset any added costs for high-efficiency systems and additional measures taken to increase the overall performance of *The Montage*.

CHALLENGES

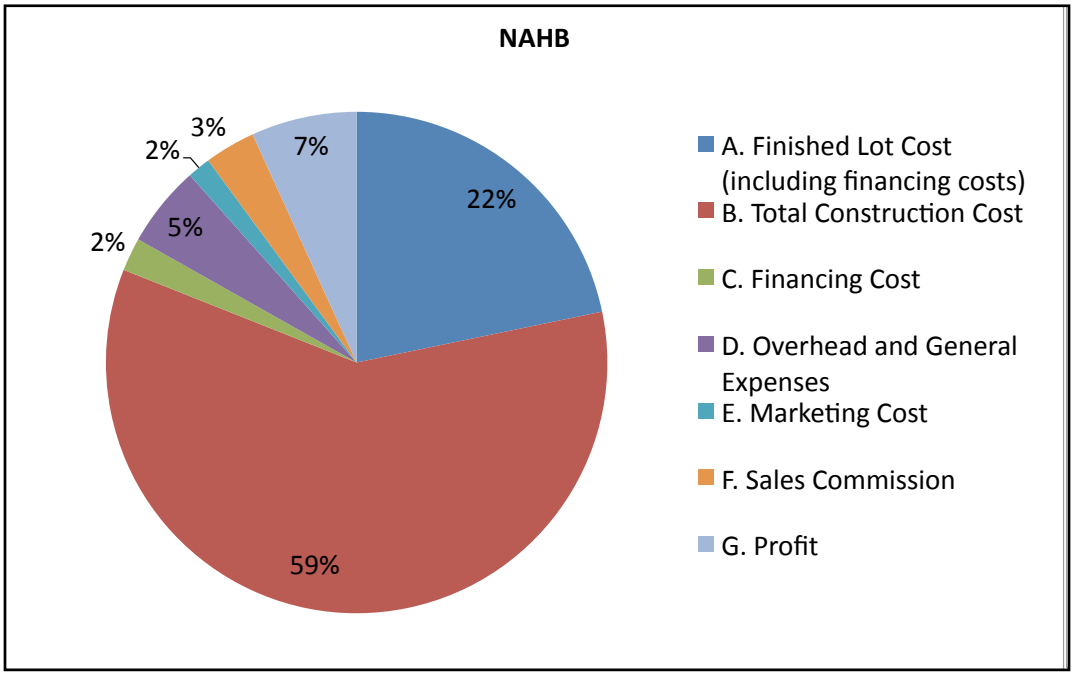
Obtaining pricing for each individual element of *The Montage* proved to be a challenging aspect of the project that we at Montage Builders – Northern Forest overcame. Our industry and faculty advisors connected us with

honest, dependable contractors and suppliers who were willing to work with us and donate their time in order to support us with our project. A local builder, Harrington Homes, was a great help in providing realistic numbers for labor and material costs.

Additionally, the team utilized local resources like The 2014 Home and Garden Show. This proved to be a valuable resource because it enabled us to speak face-to-face with product suppliers and local contractors about our specific needs for the project. We at Montage Builders – Northern Forest like to practice "listen twice as much as you speak."

Single Family Price and Cost Breakdowns 2011 National Results						
	Average Lot Size	20,614 SF	Lot Size	10,494 SF		
	Average Finished Area	2,311 SF	Finished Area	1927 SF		
I. Sales Price Breakdown	**Average**	**Share of Price**	**The Montage**	**Share of Price**	**% Difference**	**$ Difference**
A. Finished Lot Cost (including financing costs)	$67,551.00	21.7%	$21,700.00	6.7%	-15.0%	-$45,851.00
B. Total Construction Cost	$184,125.00	59.3%	$243,082.10	75.5%	16.2%	$58,957.10
C. Financing Cost	$6,669.00	2.1%	$6,710.01	2.1%	-0.1%	$41.01
D. Overhead and General Expenses	$16,306.00	5.2%	$16,615.25	5.2%	-0.1%	$309.25
E. Marketing Cost	$4,645.00	1.5%	$1,597.62	0.5%	-1.0%	-$3,047.38
F. Sales Commission	$10,174.00	3.3%	$10,544.30	3.3%	0.0%	$370.30
G. Profit	$21,148.00	6.8%	$21,727.64	6.7%	-0.1%	$579.64
Total Sales Price	**$310,618.00**	**100.0%**	**$321,976.92**	**100.0%**	**0.0%**	**$11,358.92**
Cost/SF	**$134.41**		**$167.09**			**$32.68**
II. Construction Cost Breakdown	**Average**	**Share of Construction Cost**	**The Montage**	**Share of Construction Cost**	**% Difference**	**$ Difference**
Building Permit Fees	$3,107.00	1.7%	$3,205.25	1.3%	-0.4%	$98.25
Survey	$0.00	0.0%	$500.00	0.2%	0.2%	$500.00
Impact Fee	$2,850.00	1.5%	$0.00	0.0%	-1.5%	-$2,850.00
Water and Sewer Inspection	$2,952.00	1.6%	$0.00	0.0%	-1.6%	-$2,952.00
Excavation, Foundation, and Backfill	$17,034.00	9.2%	$24,426.40	10.0%	0.9%	$7,392.40
Steel	$1,012.00	0.5%	$96.88	0.0%	-0.5%	-$915.12
Framing, Sheathing, and Trusses	$27,046.00	14.6%	$24,371.27	10.0%	-4.6%	-$2,674.73
Windows	$6,148.00	3.3%	$11,147.61	4.6%	1.3%	$4,999.61
Exterior Doors	$2,150.00	1.2%	$1,362.26	0.6%	-0.6%	-$787.74
Interior Doors and Hardware	$2,883.00	1.6%	$2,195.46	0.9%	-0.7%	-$687.54
Stairs	$1,052.00	0.6%	$5,273.00	2.2%	1.6%	$4,221.00
Roofing	$5,256.00	2.8%	$9,690.30	4.0%	1.2%	$4,434.30
Siding	$8,739.00	4.7%	$14,771.23	6.1%	1.4%	$6,032.23
Gutters and Downspouts	$870.00	0.5%	$0.00	0.0%	-0.5%	-$870.00
Plumbing	$10,990.00	5.9%	$16,766.73	6.9%	1.0%	$5,776.73
Electrical Wiring	$8,034.00	4.3%	$8,900.00	3.7%	-0.7%	$866.00
Lighting Fixtures	$2,193.00	1.2%	$2,172.39	0.9%	-0.3%	-$20.61
HVAC	$8,760.00	4.7%	$17,725.25	7.3%	2.6%	$8,965.25
Insulation	$3,399.00	1.8%	$13,570.20	5.6%	3.7%	$10,171.20
Drywall	$8,125.00	4.4%	$8,600.00	3.5%	-0.8%	$475.00
Painting	$6,005.00	3.2%	$9,000.00	3.7%	0.5%	$2,995.00
Cabinets and Countertops	$10,395.00	5.6%	$8,568.00	3.5%	-2.1%	-$1,827.00
Appliances	$3,619.00	2.0%	$1,716.72	0.7%	-1.2%	-$1,902.28
Flooring	$8,363.00	4.5%	$9,730.50	4.0%	-0.5%	$1,367.50
Trim Material	$3,736.00	2.0%	$11,993.56	4.9%	2.9%	$8,257.56
Landscaping	$6,491.00	3.5%	$489.59	0.2%	-3.3%	-$6,001.41
Wood Deck	$1,918.00	1.0%	$3,707.00	1.5%	0.5%	$1,789.00
Driveway	$2,729.00	1.5%	$0.00	0.0%	-1.5%	-$2,729.00
Solar PV	$0.00	0.0%	$22,100.00	9.1%	9.1%	$22,100.00
Rating Fees	$0.00	0.0%	$1,150.00	0.5%	0.5%	$1,150.00
Contingency	$0.00	0.0%	$7,000.00	2.9%	2.9%	$7,000.00
Other	$19,487.00	10.5%	$2,852.50	1.2%	-9.3%	-$16,634.50
Total	**$185,343.00**	**100.0%**	**$243,082.10**	**100.0%**		**$57,739.10**

Figure 1: 2011 NAHB vs. The Montage



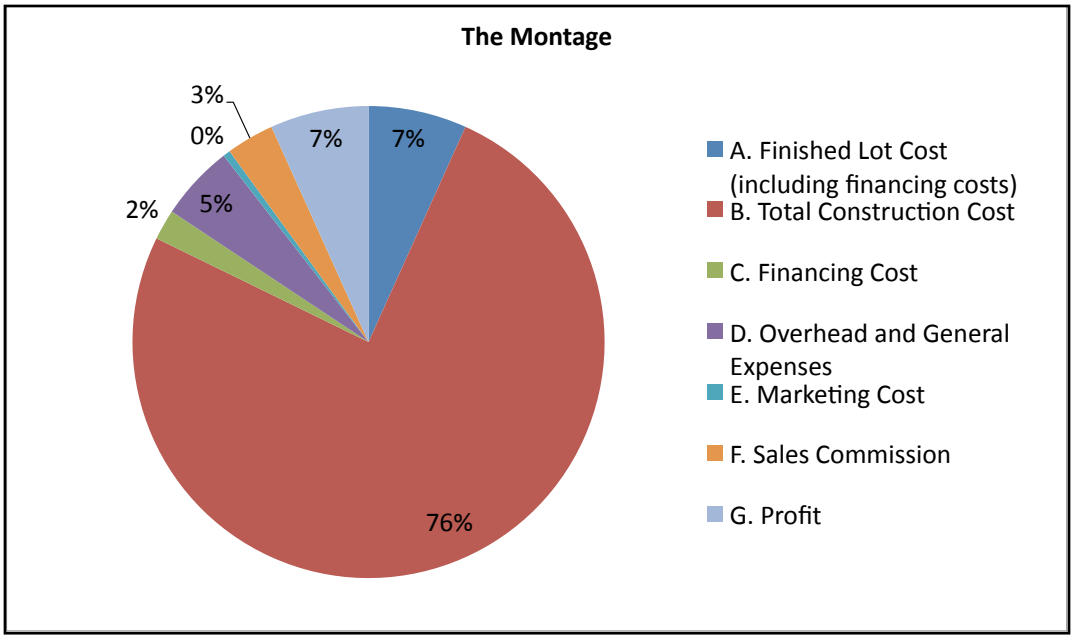


Figure 2: Sales Price Breakdown

FINANCIAL ANALYSIS

The financial analysis has been based on the total construction cost and related soft costs for the construction and sale of The Montage. These costs include but are not limited to: financing costs, overhead, profit, marketing costs, applicable taxes, applicable incentives, rebates and appropriate inflation rates.

We have outlined two options for the homeowner: a Net-Zero ready home with the ability to add a photovoltaic system (PV system) and a Net-Zero home with PV installed. Utility cost savings through a 30 year period, return on investment, net present value of the home, and simple payback periods for the PV system have been provided for the client, both in graphic and numeric form.

The Montage has been designed to achieve LEED-H Platinum certification; this certification presents unique incentives applicable in Syracuse, NY. The structure of the mortgage is presented in order to better understand the feasibility of building and selling/owning this home with current interest rates. Vice President Nathan Walker from Solvay Bank located at 1537 Milton Ave, Solvay, NY 13209 has validated our assertions.

MORTGAGE LAYOUT WITHOUT PV

The mortgage layout for the home has been analyzed with a uniquely created amortization table. The table analyzes the payments for a total of 360 months (30 Year- fixed rate), presenting to a client payment dates, current rates of interest, payment, interest portion, principle portion, and the principle balance to evaluate the investment throughout its payment period. A down payment of 20% of the median family income has been included in the analysis. The rate of tax increase is capped at 2.0 % in NYS.

First Payment Date	01-Jan-15
Principal Amount	282, 761.01
Term in Months	360
Beginning Interest Rate	4.50%
Payment	$1,432.71

Financial Projections for Net-Zero Ready Home

LOAN AMORTIZATION CALCULATOR

Assumptions:

	First Payment Date		01-Jan-15
	Principal Amount:	--->	282,761.01
	Term in months:	--->	360
	Beginning Interest Rate:	--->	4.50%
	Payment:	--->	$1,432.71

Amortization Table:

Payment Number	Payment Date	Current Rate	Payment	Interest Portion	Principal Portion	Principal Balance
1	01-Jan-15	4.50%	$1,432.71	$1,060.35	$372.35	$282,388.66
2	01-Feb-15	4.50%	1432.71	1058.96	373.75	282,014.91
3	01-Mar-15	4.50%	1432.71	1057.56	375.15	281,639.76
4	01-Apr-15	4.50%	1432.71	1056.15	376.56	281,263.20
5	01-May-15	4.50%	1432.71	1054.74	377.97	280,885.22
6	01-Jun-15	4.50%	1432.71	1053.32	379.39	280,505.84

Figure 1: Montage Builders: Loan Amortization Calculator Net-Zero ready Layout

The financial parameters used for the cash outflow layout analysis:

Value of Home	=	$ 295,921
Down Payment (20% of MFI)	=	$ 13,160 (Median Family Income of Syracuse: $ 65,800)
First Payment Date	=	January 1st 2015
2014 City and School Taxes Syracuse	=	$ 7,571 inflated @ 2% for 30 Years
2014 County Tax Syracuse	=	$ 3,410 inflated @ 2% for 30 Years
2014 County Water Tax Syracuse	=	$ 12 inflated @ 2% for 30 Years
Utility Cost without PV Year 1	=	$1,273 inflated @ 6% for 30 Years
Mortgage Insurance Year 1	=	$ 1,645 2.5% of MFI inflated @ 2% for 30 Years

The complete cash outflow layout diagram:

30 years →

Montage Builders Financial Analysis			Year	1	2
Total Value of Home/Total Value of Home with DSIRE exemption			**295,921**	285,772	
Down payment			(13,160)		
Principal			(282,761)	(4,562)	(4,771)
Interest			(233,014)	(12,631)	(12,421)
Tax benefit of interest			30%	3,726	3,664
2014 City and School Taxes			2.0%	(7,571)	(7,723)
LEED Tax SYR exemption				7,571	7,723
County Tax			2.0%	(3,410.0)	(3,478)
County Water Tax			2.0%	(12)	(12)
Tax benefit of RE Taxes				1,006	1,026
Utility costs			6.0%	(1,273)	(1,349)
Mortage Insurance			0.0%	$ (1,645.00)	(1,645)
Home Owner Insurance Insurance			2.5%	$ (427.00)	(438)
Cash Outflow After Taxes			$ (13,160.00)	$ (19,227.55)	$ (19,424.75)
Cash Outflow Before Taxes	NPV	8%	(266,667)	$ (23,959.62)	$ (24,115.12)
Mortage Payment			515,775	17,192.50	17,192.50
Remaining Payments				$ 843,836.89	$ 824,412.14
One time Cash Payment Incentive				$ 5,582.00	
Monthly Household debt			2.5%	$ (329.00)	(337)
Affordable Cash Outflow	38% of MFI		2.5%	$ 25,004.00	25,629
Dollars below afforable Cost Savings				$ 6,297.38	$ 1,176.76

Figure 2: Montage Builders Financial Analysis

The energy costs for the United States have experienced an escalation rate of about 7% within the last 10 years and 5% within the last 20 years; however, the escalation rate forecasts an escalation of about 15.07% for the next year with a Historical Data Test Forecast Accuracy of 12.62%[1] . Therefore a nominal and probable rate of 3.5 % above inflation has been applied for energy cost escalation within this investigation. View Figure 4 to see mortgage payments with a PV system.

The payment elements for a mortgage without a PV system:

Total Yearly Payment			$ 28,768.81	Average Payment for 30 years
Total Monthly Payment			$ 2,397.40	Based on average total yearly Payment
Total of 360 Payments			$ 515,775.07	
Total Cash Outflow			$ 863,064.43	Including all elements
Type of Payment	**Total**	**Yearly**	**Monthly**	
Total Interest Paid	$ 233,014.05	$ 7,767.14	$ 647.26	
Total City and School Taxes Paid	$ 208,371.12	$ 6,945.70	$ 578.81	
Total Utility Cost	$ 100,641.07	$ 3,354.70	$ 279.56	
Total Insurance Cost	$ 18,746.45	$ 624.88	$ 52.07	

Figure 3: Payment Elements for a Mortgage without PV

The cost of the total interest paid at 4.5%, total city and school taxes, and insurance costs have been broken down into three different time elements to better understand the costs that are associated with this house over time. This home has an average utilities price the first year of $106.08 per month, according to our Remrate analysis for Syracuse with 6803 heating degree days.[2] This is an affordable amount for a home owner with a median family income of $65,800. In addition the first year monthly mortgage payment is approximately $1,432.

MORTGAGE LAYOUT WITH PV

The same amortization table explained and referred in Figure 2 has been used to evaluate the mortgage layout for a home with the inclusion of a photovoltaic system at the additional cost of $22,100 (before incentives). This option was found to produce 9 year simple payback, so we have provided comparisons illustrating the cash outflow and mortgage layouts to better understand the possible advantages and financial constraints of the two alternatives.

First Payment Date	01-Jan-15
Principal Amount	308, 816.91
Term in Months	360
Beginning Interest Rate	4.50%
Payment	$1,564.73

Financial Projections for Net-Zero Ready Home

LOAN AMORTIZATION CALCULATOR

First Payment Date		01-Jan-15
Principal Amount:	--->	308,816.91
Term in months:	--->	360
Beginning Interest Rate:	--->	4.50%
Payment:	--->	$1,564.73

Amortization Table:

Payment Number	Payment Date	Current Rate	Payment	Interest Portion	Principal Portion	Principal Balance
1	01-Jan-15	4.50%	$1,564.73	$1,158.06	$406.67	$308,410.25
2	01-Feb-15	4.50%	1564.73	1156.54	408.19	308,002.06
3	01-Mar-15	4.50%	1564.73	1155.01	409.72	307,592.33
4	01-Apr-15	4.50%	1564.73	1153.47	411.26	307,181.07
5	01-May-15	4.50%	1564.73	1151.93	412.80	306,768.27
6	01-Jun-15	4.50%	1564.73	1150.38	414.35	306,353.93

Figure 4: Montage Builders: Loan Amortization Calculator Net-Zero Layout

The financial parameters used for the cash outflow layout analysis:

Value of Home	=	$ 321,976.91
Down Payment (20% of MFI)	=	$ 13,160 (Median Family Income of Syracuse: $ 65,800)
First Payment Date	=	January 1st 2015
2014 City and School Taxes Syracuse	=	$ 7,676 inflated @ 2% for 30 Years
2014 County Tax Syracuse	=	$ 3,457 inflated @ 2% for 30 Years
2014 County Water Tax Syracuse	=	$ 12.28 inflated @ 2% for 30
Utility Cost without PV Year 1	=	$30 inflated @ 6% for 30 Years (Service Charges after)
Home owner Insurance Year 1	=	$ 427.28 2.5% of MFI inflated @ 2% for 30 Years

Montage Builders Financial Analysis			Year	1	2	3
Total Value of Home/Total Value of Home with DSIRE exemption			**321,976.91**	**289,728**		
Down payment			(13,160)			
Principal			(308,817)	$ (4,981.92)	(5,211)	(5,450)
Interest			(254,486)	$ (13,794.84)	(13,566)	(13,327)
Tax benefit of interest			30%	$ 4,069.48	4,002	3,931
2014 City and School Taxes			2.0%	$ (7,676.02)	(7,830)	(7,986)
LEED Tax SYR exemption				$ 7,676.02	7,830	7,986
County Tax			2.0%	$ (3,457.21)	(3,526)	(3,597)
County Water Tax			2.0%	$ (12.28)	(13)	(13)
Tax benefit of RE Taxes				$ 1,019.88	$ 1,040.27	$ 1,061.08
Utility costs (Economy+Energy)			6.0%	$ (30.00)	(32)	(34)
Mortage Insurance			0.0%	$ (1,645.00)	(1,645)	(1,645)
Home Owner Insurance			2.5%	$ (427.28)	(438)	(449)
Cash Outflow After Taxes			$ (13,160.00)	$ (19,259.18)	$ (19,388.17)	$ (19,521.61)
Cash Outflow Before Taxes	NPV	8%	(328,608)	$ (24,348.53)	$ (24,430.40)	$ (24,514.04)
Mortage Payment			563,303	$ 18,776.76	18,776.76	18,776.76
Remaining Payments				$ 801,517.16	$ 782,128.99	$ 762,607.38
One time cash payment (incentive)				$ 15,482.00		
Monthly Household debt			2.5%	$ (329.00)	(337)	(346)
Affordable Cash Outflow	38% of MFI		2.5%	$ 25,004.00	25,629	26,270
Dollars below afforable Cost Savings				$ 15,808.47	$ 861.47	$ 1,410.13

Figure 5: Montage Builders: Home Ownership Affordability Analysis & Study

A cost comparison between the Home Ownership affordability cost and the actual predicted costs before taxes, while taking into consideration the monthly household debt for this home have been evaluated and included within this study. Therefore the actual dollar savings may be significantly greater when considering the tax benefits that are applicable

The cost of the total interest paid at 4.5%, total city and school taxes, and insurance costs have been broken down into three different time elements in this home. This home has an average utilities price of only $6.59 per month, and lower monthly mortgage payments than the home without PV.

SOFT COST ANALYSIS

The soft cost for this project has been based on the percentage breakdowns as per information from the *National Home Builders'* "Single Family Price and Cost Breakdown 2011 National Results." The percentages have been retrieved and customized to suit and cater to the requirements of *The Montage*. The lot cost is based on actual Syracuse Land Bank values as explained in the introduction.

Item name	%	With PV	Without PV	Comments
Finished Lot Cost	6.7%	$ 21,700.00	$ 21,700.00	6000 Connection fees
Total Construction Cost	75.5%	$ 243,082.10	$ 220,982.10	
Financing Cost	2.1%	$ 6,710.01	$ 6,245.91	
Overhead and General Expenses	5.2%	$ 16,615.25	$ 15,466.05	
Marketing Cost	0.5%	$ 1,597.62	$ 1,487.12	
Sales Commisssion	3.3%	$ 10,544.30	$ 9,815.00	
Profit	6.8%	$ 21,727.64	$ 20,224.84	
	100%	$ 321,976.91	$ 295,921.01	

Figure 6: The Breakdown

	PV	Solar Thermal	Total
Without Incentives	$ 22,100.00	$ 10,149.00	$ 32,249.00
Incentive Amount	$ 9,900.00	$ 4,149.00	$ 14,049.00
With Incentives	$ 12,200.00	$ 6,000.00	$ 18,200.00

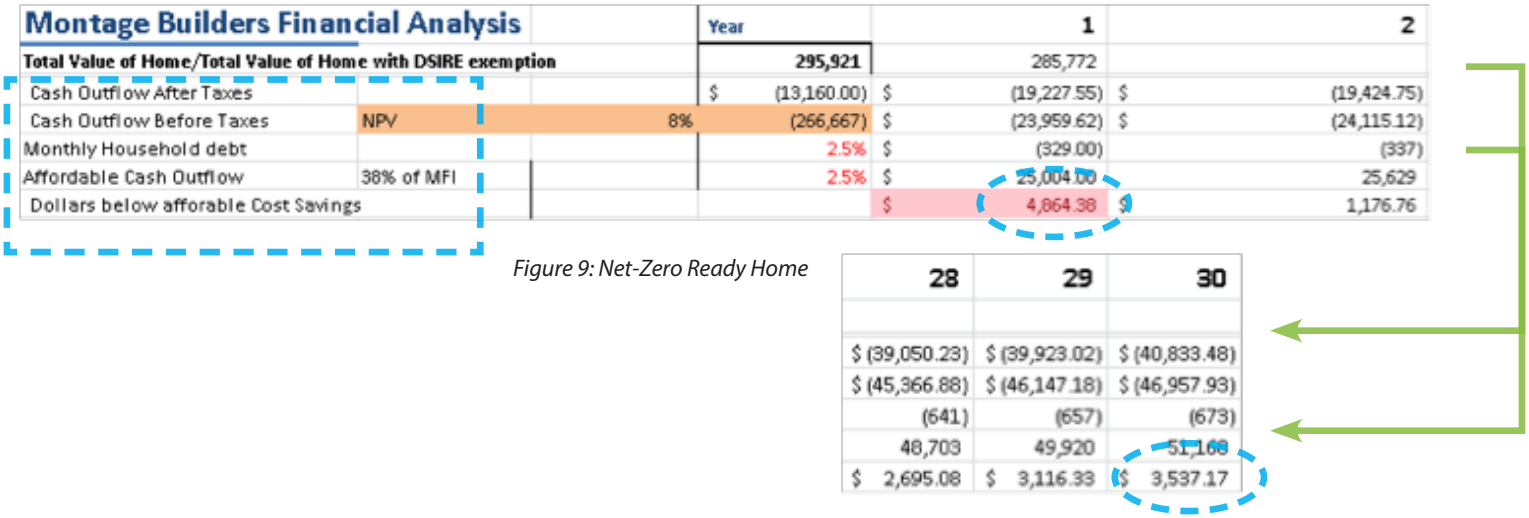
Figure 7: The Renewable on-site Energy sources Price Breakdown

	Yearly	Monthly
Utility Cost	$ 1,257.00	$ 104.75
Utlities with PV	$ 110.00	$ 9.17
Utility Cost for Solar DHW	$ 1,147.00	$ 95.58
Utlities with PV and Solar DHW	$ 30.00	$ 2.50

Figure 8: The energy consumption breakdown as per data From (Remrate)

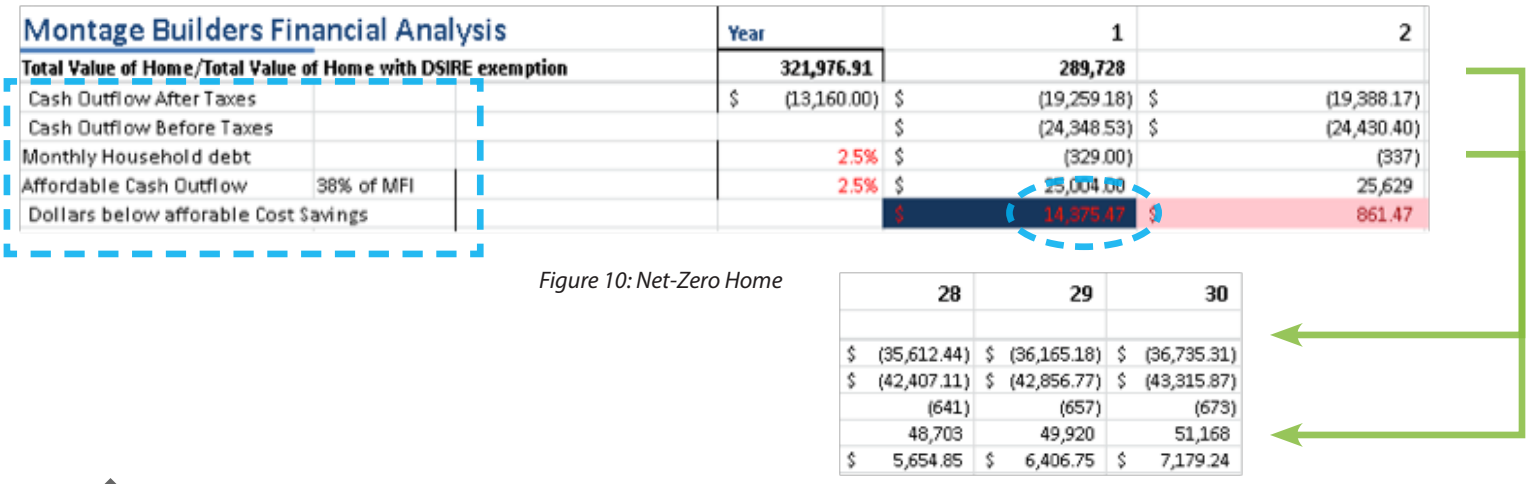
CHALLENGE PARAMETERS VS. SCHEDULED VALUES

The maximum allowable home ownership affordability as per parameters presented by the challenge was 38% of the median family income (MFI), which includes the principle, interest, property taxes, home insurances, and utilities. Within the analysis done for this home the total cash outflow that was predicted for the home with the PV system has been compared to the allowable home ownership value. Thus, potential savings of the Net- Zero home for the first year is calculated to be $14,375.47 with the DSIRE one time incentive for solar thermal DHW and PV systems. Cost savings for the second year are $861.47 with utility costs and savings escalating as indicated earlier.



Montage Builders Financial Analysis			Year	1	2	28	29	30
Total Value of Home/Total Value of Home with DSIRE exemption			295,921	285,772				
Cash Outflow After Taxes			$ (13,160.00)	$ (19,227.55)	$ (19,424.75)	$ (39,050.23)	$ (39,923.02)	$ (40,833.48)
Cash Outflow Before Taxes	NPV	8%	(266,667)	$ (23,959.62)	$ (24,115.12)	$ (45,366.88)	$ (46,147.18)	$ (46,957.93)
Monthly Household debt			2.5%	$ (329.00)	(337)	(641)	(657)	(673)
Affordable Cash Outflow	38% of MFI		2.5%	$ 25,004.00	25,629	48,703	49,920	51,168
Dollars below afforable Cost Savings				$ 4,864.38	1,176.76	$ 2,695.08	$ 3,116.33	$ 3,537.17

Figure 9: Net-Zero Ready Home



Montage Builders Financial Analysis			Year	1	2	28	29	30
Total Value of Home/Total Value of Home with DSIRE exemption			321,976.91	289,728				
Cash Outflow After Taxes			$ (13,160.00)	$ (19,259.18)	$ (19,388.17)	$ (35,612.44)	$ (36,165.18)	$ (36,735.31)
Cash Outflow Before Taxes				$ (24,348.53)	$ (24,430.40)	$ (42,407.11)	$ (42,856.77)	$ (43,315.87)
Monthly Household debt			2.5%	$ (329.00)	(337)	(641)	(657)	(673)
Affordable Cash Outflow	38% of MFI		2.5%	$ 25,004.00	25,629	48,703	49,920	51,168
Dollars below afforable Cost Savings				$ 14,375.47	861.47	$ 5,654.85	$ 6,406.75	$ 7,179.24

Figure 10: Net-Zero Home

Within this study the applicable monthly household debt allocated at 0.5% of MFI was added to the total cash outflow and deducted from the affordable cash outflow while being inflated equally at 2.5 % in order to provide uniformity and to create realistic figures that reflect the economical inflations that should be applied when performing calculations over an allocated time period.

CASH OUTFLOW COMPARISON

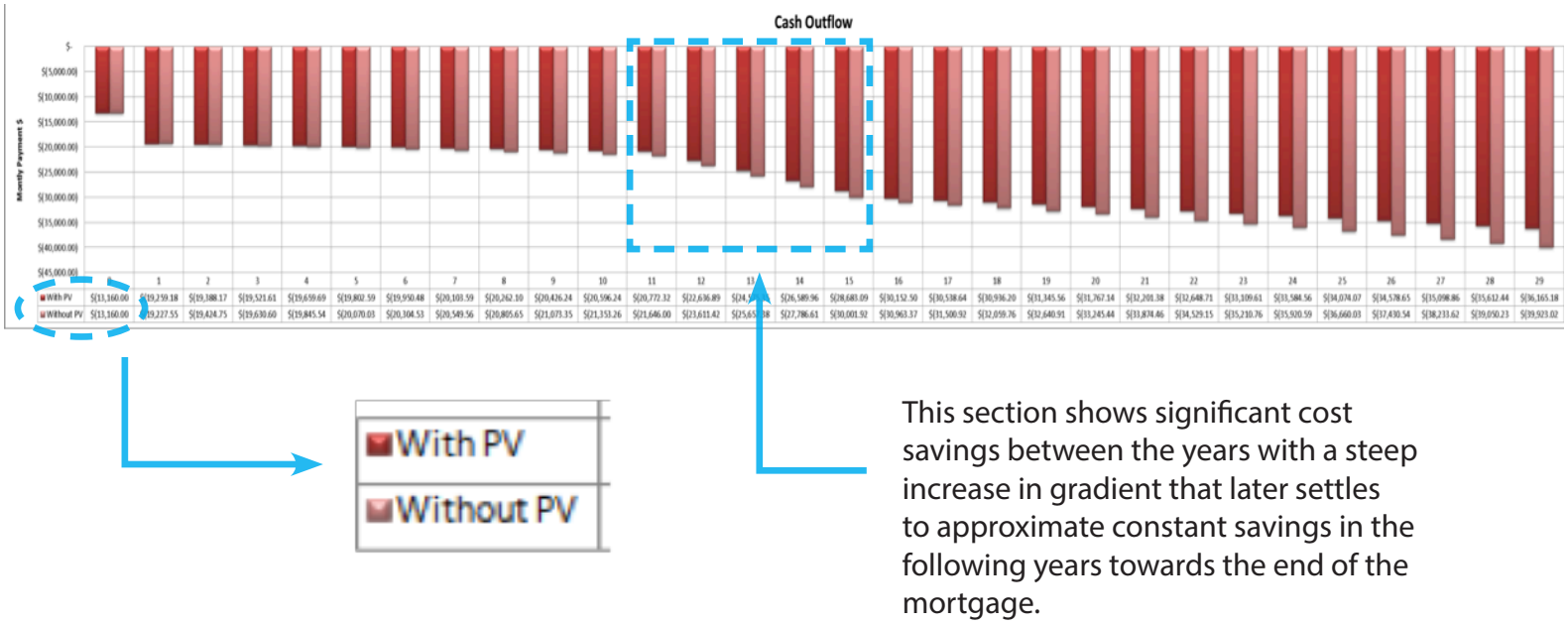


Figure 11: Cash Outflow Comparison Chart

Figure 11 illustrates the comparison between the total cash outflows of the two choices available to a potential home buyer. Year zero includes the down payment scheduled for the purchase of the home that is equal due to it being based on the MFI.

While keeping in mind that the value of the home with PV is $22,100 greater than its counterpart, the utility cost savings have created tremendous savings causing the total cash outflow of the home (over 30 years) with PV less than the home without PV. In addition it is visible that with time the cost savings increase.

MORTGAGE SETTLEMENT LAYOUT

The chart below illustrates the mortgage settlement layout showing a potential home buyer the rate at which the settlements will be made, thus providing a coherent understanding of the ability to settle the payment with the given parameters while highlighting the practicality of owning the home under the given values. In addition, this allows the owner to critically identify a year or range of years and understand the remaining payments that will be outstanding within that particular time frame. A home owner may be looking to retire or may have a child attending college, so this layout enables the client to evaluate the mortgage that will remain for this home at the time in order to make a proficient well informed decision.

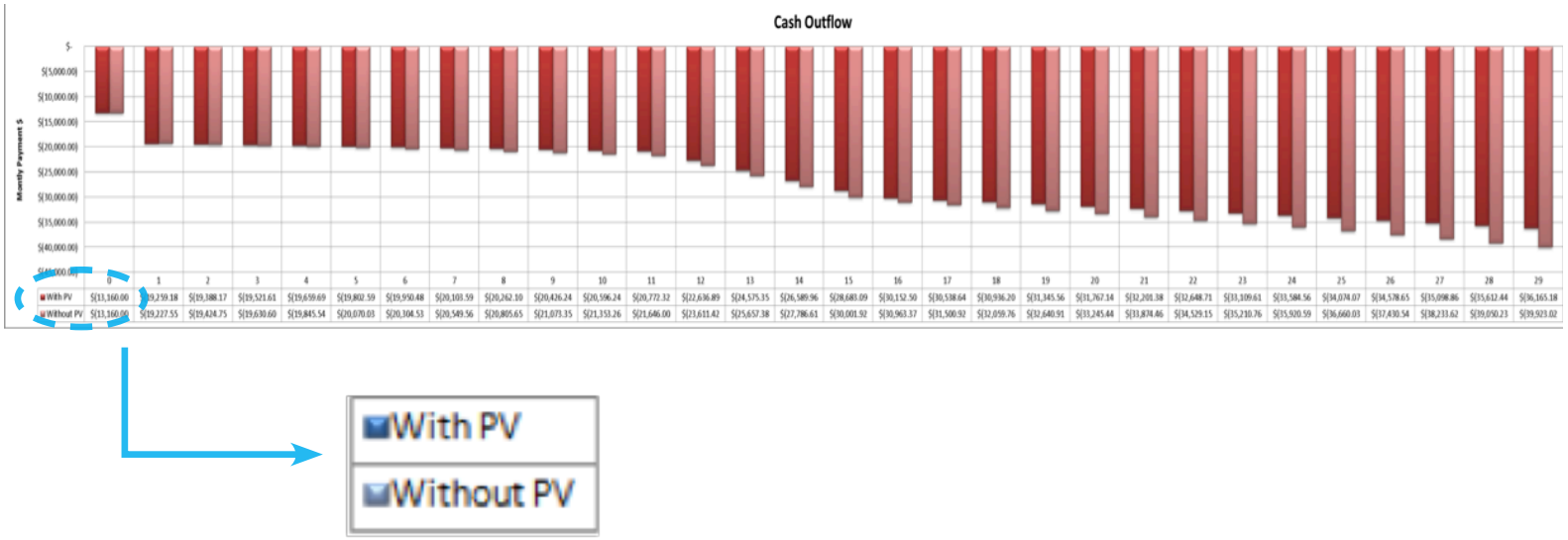


Figure 12: Mortgage Settlement Layout Chart

APPLICABLE TAXES AND RELATED EXEMPTIONS

The following taxes applicable to Syracuse have been considered:

1. County Tax
2. City tax
3. School Tax
4. County Water Tax.

The rates used were retrieved fromOn.Gov.net.[3]

City	2014 County Rate	2014 City Rate	2014 School Rate	2014 County Water	Total City Rate
City of Syracuse	11.9326	9.1384	17.3555	0.0424	38.4689

Figure 13: City of Syracuse Taxes

The tax calculation has been done by multiplying the value of the asset (the value of the home) by the tax rate and dividing it by a 1000. In addition, the taxes have been inflated at a uniform level of 2% over the 30 year period to reflect state law.

Applicable Tax = (Value of home x Adjustment Factor) /1000

Montage Builders Financial Analysis	Year	1	30
Total Value of Home/Total Value of Home with DSIRE exemption	**295,921**	285,772	
Down payment	(13,160)		
Principal	(282,761)	(4,562)	(16,781)
Interest	(233,014)	(12,631)	(412)
Tax benefit of interest	30%	3,726	121
2014 City and School Taxes	2.0%	(7,571)	(14,030)
LEED Tax SYR excemption		7,571	-
County Tax	2.0%	(3,410.0)	(6,319)
County Water Tax	2.0%	(12)	
Tax benefit of RE Taxes		1,006	6,003

Figure 14: Inflation with and without PV

Figure 14 illustrates the inflation that has occurred within the home without PV and with PV from Year 1 of purchase to Year 30 at settlement. The differences are often significant and both choices have no exemptions as per incentives and rebates currently available.

STATE INCENTIVES FOR RENEWABLES AND EFFICIENCY

In addition an incentive for New York State defined as "Local Option - Solar, Wind & Biomass Energy Systems Exemption" has been used. This incentive exempts the home owner from the asset value appraisal that will occur when both the Solar Thermal DHW system and the PV system are installed. The installation of renewables raises the asset's value by a total of $32,249. Therefore the property tax for this value will be exempted at 100% for the first fifteen years. The incentive is available to be reviewed on DSIRE.[4]

LEED TAX EXEMPTION

Taking into consideration that the structure is designed to achieve LEED Platinum regardless of the inclusion of the PV system, the following exemptions available to homes in Syracuse will be applicable to this home.

What does LEED-certified mean?

LEED refers to the Leadership in Energy and Environmental Design Building Rating System published by the United States Green Building Council. New one- and two-family residences certified by a LEED-accredited professional will receive additional years of exemption.

CITY/SCHOOL TAX EXEMPTION SCHEDULE FOR LEED-CERTIFIED HOUSES

YEARS	SILVER	GOLD	PLATINUM
1-8	100%	100%	100%
9	80%	100%	100%
10	60%	80%	100%
11	40%	60%	100%
12	20%	40%	75%
13	–	20%	50%
14	–	–	25%

What taxes are reduced by the exemption?

City and School taxes due to the value added by the construction. County taxes are not reduced by it.

Figure 15: LEED Tax Exemptions

Given this exemption the necessary adjustments have been made to both choices in order to produce stringently accurate results.

Montage Builders Financial Analysis	Year	1	11	12	13	14	15
Total Value of Home/Total Value of Home with DSIRE exemption	295,921	285,772					
Down payment	(13,160)						
Principal	(282,761)	(4,562)	(7,148)	(7,476)	(7,820)	(8,179)	(8,555)
Interest	(233,014)	(12,631)	(10,045)	(9,716)	(9,373)	(9,013)	(8,638)
Tax benefit of interest	30%	3,726	2,963	2,866	2,765	2,659	2,548
2014 City and School Taxes	2.0%	(7,571)	(9,229)	(9,414)	(9,602)	(9,794)	(9,990)
LEED Tax SYR exemption		7,571	9,229	7,060	4,801	2,449	
County Tax	2.0%	(3,410.0)	(4,157)	(4,240)	(4,325)	(4,411)	(4,499)
County Water Tax	2.0%	(12)	(15)	(15)	(15)	(16)	(16)
Tax benefit of RE Taxes		1,006	1,226	1,945	2,692	3,468	4,274

Figure 16: LEED Exemption Included

The city and school taxes have been 100% exempted from the payment cash flow for the first eleven years, whereas the exemption gradually decreases from 75% in the 12th year to 25% in the 14th Year. No exemptions are thereby applied to the 15th year and all taxes are applicable.

UTILITIES COST SAVING BEHAVIOR REFLECTING VARIOUS INFLATION RATES

The investment and its return may vary depending on the different inflation rates that can be associated with cost savings. Given the energy inflation rates associated to the prices, the cost savings have been calculated under three scenarios to outline the baseline cost savings and compare the figures to probable inflation rates. In order to cater to this requirement, cost savings made in energy with the inclusion of a PV system have been compared to the cost of energy at the absence of a PV system at the various inflation rates shown in Figure 17.

Montage Builders Financial Analysis				Year	1	2	3	4	5
Utility Payback period analysis									
				Inflation %					
Cost of PV					$ 12,200.00	(With Rebates)			
Utility Cost Without PV				2.5%	$ 1,273.00	1,305	1,337	1,371	1,405
				6.0%	$ 1,273.00	1,349	1,430	1,516	1,607
				9.5%	$ 1,273.00	1,394	1,526	1,671	1,830
Utility Cost With PV	0% energy inflation + 2.5% Economy Inflation			2.5%	$ 206.00	211	216	222	227
Cost Savings					$ 1,067.00	$ 1,093.68	$ 1,121.02	$ 1,149.04	$ 1,177.77
Total Energy Cost Savings					$ 46,844.18				
Payback Period	11 Years	$ 13,319.86							
ROI		123%	20 Year Period						
		284%	30 Year Period						
Utility Cost With PV	3.5% energy inflation + 2.5% Economy Inflation			6.0%	$ 206.00	218	231	245	260
Cost Savings					$ 1,067.00	$ 1,131.02	$ 1,198.88	$ 1,270.81	$ 1,347.06
Total Energy Cost Savings					$ 84,355.08				
Payback Period	9 Years	$ 12,261.23							
ROI		222%	20 Year Period						
		591%	30 Year Period						
Utility Cost With PV	7% energy inflation + 2.5% Economy Inflation			9.5%	$ 206.00	226	247	270	296
Cost Savings					$ 1,067.00	$ 1,168.37	$ 1,279.36	$ 1,400.90	$ 1,533.98
Total Energy Cost Savings					$ 159,716.56				
Payback Period	8.5 Years	$ 11,982.62							
ROI		373%	20 Year Period						
		1209%	30 Year Period						

Figure 17: Utility Payback Period Analysis

The Energy Costs for the United States has experienced an inflation rate of about 7% within the last 10 years and 5% within the last 20 years. However the inflation rate forecasts an inflation of about 15.07% for the next year with a Historical Data Test Forecast Accuracy of 12.62%[5] . Therefore a nominal and probable rate of 3.5 % has been applied for energy inflation within this investigation.

While the differences in the payback periods may not be significant, this is mainly due to the limiation of the investment and its size. As shown in the below Figure 18, if a larger investment was to be made, there are potentially larger savings towards the latter margin of the 30 year period and therefore would have provided much better impactive payback periods when comparing the three scenarios; however and regardless, while inflation will undoubedtly occur, the choice of comparing the savings with no inflation demonstrates a baseline savings of above $45,000 with no inflation considered whatsoever. Therefore when syrcronizing the actual behaviour of money through the two inflation rates, signifcant savings are reached which allows the reader or potential home owner to predict cost savings between $80,000 and $160,000 considering the adjusment factor of the Historical Data Test Forecast Accuracy lacking stringent accuracy within its predictions.

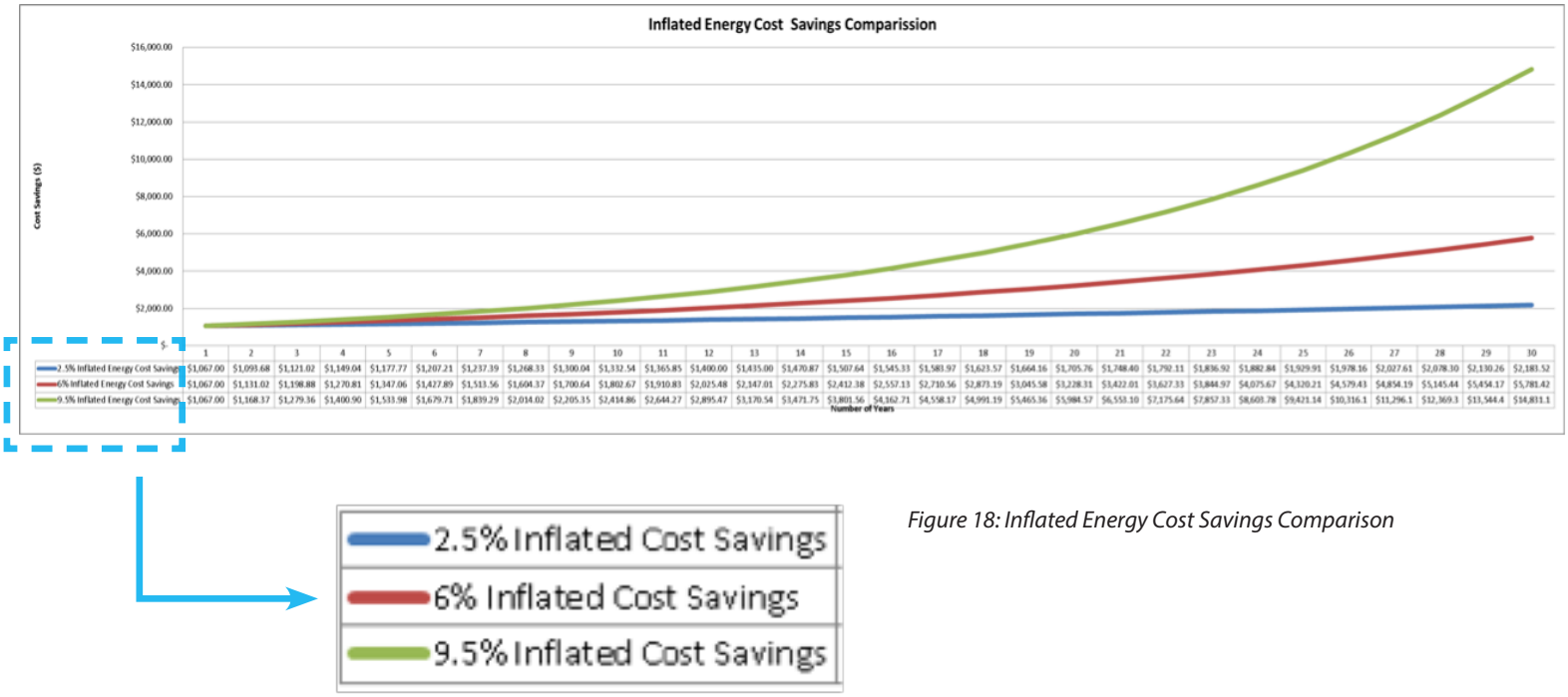


Figure 18: Inflated Energy Cost Savings Comparison

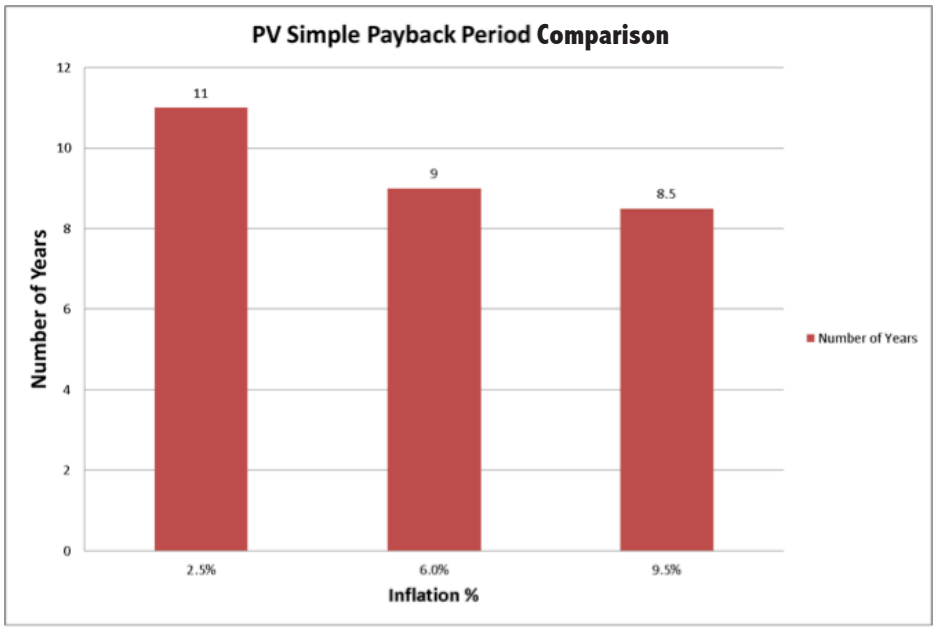


Figure 19: PV Simple Payback Period Comparison Chart

As explained above, Figure 19 shows an owner the payback periods on the investment that is to be made on the PV system. While the three inflation rates bring about 2 years of reductions in between them, additional costs such as maintenance if at all has not been included. However given that PV systems have potential in being low maintenance sources, the integrity of these calculations remain approximate.

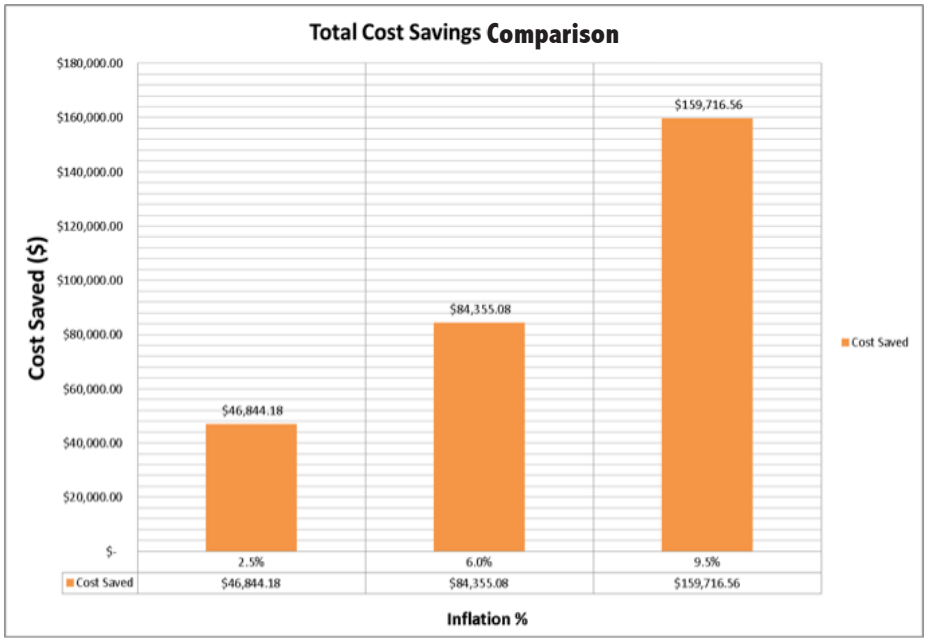
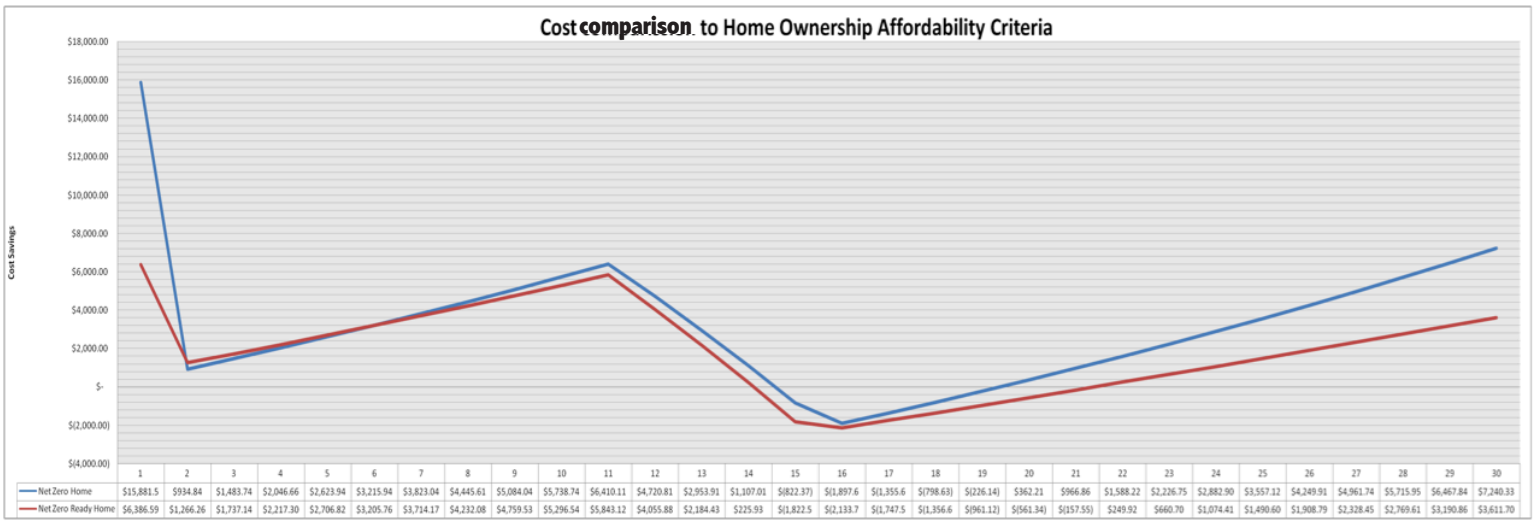


Figure 20: Total Cost Savings Comparison Chart

This diagram shows the significant differences in the cost savings when comparing the three scenarios. While there is a baseline of over $40,000 without recognizing inflation, nominal increases of inflation create even larger savings.

As per Figure 21 the first time incentive stated provides a potential home owner of the Net-Zero home savings of up to approximately $14,375.47. Even though cost savings experience a negative within years 15 to 19, this deficit is due to the end of the LEED exemptions, a total of $5,100, as described in Figure 18. Nonetheless, the opportunity created upfront provides a funding volume that will cater to this nominal deficit experienced in the negative flow years; however, the net cost savings for this period created will be $10,500, which was calculated by deducting the total cost deficit from the upfront cost savings created by the investment.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Net Zero Home	$15,881.5	$934.84	$1,483.74	$2,046.66	$2,623.94	$3,215.94	$3,823.04	$4,445.61	$5,084.04	$5,738.74	$6,410.11	$4,720.81	$2,953.91	$1,107.01	$(822.37)	$(1,897.6	$(1,355.6	$(798.63)	$(226.14)	$362.21	$966.86	$1,588.22	$2,226.75	$2,882.90	$3,557.12	$4,249.91	$4,961.74	$5,715.95	$6,467.84	$7,240.33
Net Zero Ready Home	$6,386.59	$1,266.26	$1,737.14	$2,217.30	$2,706.82	$3,205.76	$3,714.17	$4,232.08	$4,759.53	$5,296.54	$5,843.12	$4,055.88	$2,184.43	$225.93	$(1,822.5	$(2,133.7	$(1,747.5	$(1,356.6	$(961.12)	$(561.34)	$(157.55)	$249.92	$660.70	$1,074.41	$1,490.60	$1,908.79	$2,328.45	$2,769.61	$3,190.86	$3,611.70

Figure 21: Cost Comparison to Home Ownership Affordability Criteria

FINANCIAL SWOT ANALYSIS

STRENGTHS

- Significant Cost Savings through Utilities
- Market Adaptability (Regionally Appropriate)
- Net Zero Energy
- Lucrative Payback Periods
- Tax Exemptions in place for high performance
- Sound Financial Investment with Minimal Risk
- Bank loan Friendly

WEAKNESS

- Real Estate Appraisal
- Lack of Recognition of High Performance Homes related to first costs
- Durability measures are not fully recognized by the Insurance industry

OPPORTUNITIES

- Higher Market Resale Value
- Sustainable Long Life Span
- Future oriented LEED or Energy Friendly Exemptions / incentives
- Additional Tax Benefits
- Income alternative (Energy to Grid)

THREATS

- Financial Overuns
- Financial Incentives tied to green rating programs may sunset in the near future

Figure 22: Overall Review and Analysis

FINANCIAL ANALYSIS OVERVIEW

Figure 22 depicts the financial opportunities and constraints that will be experienced by a potential home owner of *The Montage*. In comparison to the increasing median family incomes experienced in developing cities, Syracuse remains at a comparatively low MFI of $65,800; however, we met the challenge of providing the average home owner of Syracuse with a Net-Zero home at a 7% energy inflation rate with the specified PITIU of 38% of the MFI identified as the Home Ownership Affordability Cost value.

According to Green Home Builders and Remodelers Study at the National Association of Home Builders (NAHB), Green homes are to grow between 29% and 38% of the market by 2016. The same study done by NAHB in conjunction with McGraw Hill states that 46% of builders and remodelers find that "building green" makes it easier to market themselves in a down economy. Currently, an overwhelming 71% of firms are dedicated to green home building. Given this information, this home will additionally have a higher resale value than an average home of the similar area footage and be a marketable asset to its potential owner.

The data furnished from the analysis confirms that a Net-Zero home has much greater financial opportunity with significant cost savings that can be achieved with the inclusion of the PV system. In addition while the choice may be more favorable when reviewed by financial institutions, its cash outflow values are lower than the values expected of a Net-Zero ready home. *The Montage* PV return on Investment is 1209% over 30 years at 7% energy inflation. The installation of the PV system is recommended by the team as a financially viable investment for a potential home owner in Syracuse with incomes similar to rates discussed.

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[3] "County/Town Tax Rates." On.Gov.net. 2 March 2014. Web. <http://www.ongov.net/rpts/countyTownTaxRates.html>.

[4] "Local Option – Solar, Wind and Biomass Energy Systems Exemption." DSIRE. 2 March 2014. Web. <http://www.dsireusa.org/>.

[5] "USA Energy Inflation Forecast." Forecast Chart. 13 Mar. 2014. Web. <*http://www.forecast-chart.com/inflation-usa-energy.htm)*>.

ENVELOPE DURABILITY

Durability is a key component to ensuring the longevity of buildings. It adds lifetime value to *The Montage* and reduces operation and maintenance costs. To guarantee that *The Montage* is a long-standing durable structure free of any major issues that provides a quality and healthy living environment for 100 or more years requires an intricate understanding of the core principles of building science supplemented with the use of proven research findings and best practice solutions. It is also imperative that these principles can be easily applied and replicated by everyday contractors.

Above Grade Walls														
Weight:	14.9	13	14.7	15.2	13.9	13.8	10	15.3	11.4	11.7	14.1	13.7	13.9	
Attribute:	Design Challenge	Budget	Build-ability	Indoor Air Quality	Water MGMT	Visit-ablity	Net-Zero	Climate Change	Supply Chain (local vs non local)	Recycled / Recycl-able	Dur-ability	Resilience/ Passive Survivablity	No/Low Environ-mental Toxicity	
2x6 Wall @ 24" O.C. 5.5" Blown Cellulose, 4" XPS	90%	70%	85%	75%	97%	0%	92%	60%	70%	75%	90%	90%	65%	Score:
Score:	13.41	9.1	12.495	11.4	13.483	0	9.2	9.18	7.98	8.775	12.69	12.33	9.035	129.08
Weight:	14.9	13	14.7	15.2	13.9	13.8	10	15.3	11.4	11.7	14.1	13.7	13.9	
Attribute:	Design Challenge	Budget	Build-ability	Indoor Air Quality	Water MGMT	Visit-ablity	Net-Zero	Climate Change	Supply Chain (local vs non local)	Recycled / Recycl-able	Dur-ability	Resilience/ Passive Survivablity	No/Low Environ-mental Toxicity	
2x6 Wall @ 24" O.C. 5.5" Blown Cellulose, 4" Polyiso-cyanurate	92%	60%	85%	82%	97%	0%	95%	94%	70%	74%	90%	91%	96%	Score:
Score:	13.708	7.8	12.495	12.464	13.483	0	9.5	14.382	7.98	8.658	12.69	12.467	13.344	138.97

Because there's only one chance to make it right, the building envelope is arguably the most important piece to creating a durable, healthy, and energy efficient home. This is why our team conducted research, worked closely with local builders, and spent many hours discussing various strategies. We put just about every wall system we could think of through our decision matrix before arriving at our 2x6 wall covered with 4" of polyisocyanurate. What we concluded with was a strong envelope that manages the environmental challenges of our climate as well as occupant induced stressors, while keeping it manageable for constructability purposes.

Literature such as Dr. Joseph Lstiburek's Builder's Guide to Cold Climates[1] was utilized and played an integral role in shaping our design details. By understanding the science behind how our building acts, we can effectively manage moisture movement as well as heat and air flow throughout our home. Other key factors that drove our design for *The Montage* included traditional ecological knowledge, common sense, and past experiences with less durable buildings.

Relating to durability, an interesting aspect of this project was the overlap between program requirements. By meeting ENERGY STAR requirements, we found that it took little additional effort to meet the requirements of LEED-H, ICC700, and the FORTIFIED standard. This demonstrates how we benefited from Biomimicry's concept of redundancy. The overlap between programs ensured that *The Montage* was built to the highest standards and no stone was left unturned.

FOUNDATION

DRAINAGE AND RADON

- No on site backfill is specified in the design of The Montage in order to ensure reduced hydraulic pressure and efficient drainage around the perimeter of the house
- All backfill and hard surfaces are sloped at a minimum ½" per foot away from the home
- Perimeter drains are located on the exterior of our foundation walls and are specified to be located below the bottom of the basement concrete slab
- Interior drains are included in the design and are to be piped to a strategically located sump pump. The sump will be piped to our cistern which is located nearby with an overflow strategy that directs excess water to an onsite infiltration area
- The Montage is equipped with a passive radon mitigation system. The The sump pump cover is specified to be mechanically fastened and gasketed which will prevent radon gases from seeping into the home

FOUNDATION SYSTEM

- Superior Walls promote LEAN construction processes that speed up construction time and reduce labor costs
- They support design for disassembly and deconstruction and are able to be reused potentially in the future
- Direct wood to concrete connections are separated by a sill sealer and/or an EPDM membrane, as specified on the drawings, in order to manage any moisture that could possibly wick up into our wall system through capillary action

WALL SYSTEM

The characteristics of our wall system meet Sam Rashkin's definition of a "Super Insulation" wall system as defined in his paper, *The Road to Carbon Neutral: Energy Star for Homes and Beyond*.[2] *The Montage's* walls meet all five of the criteria outlined in the paper and are listed below.

- Zero-tolerance Installation
- Air Tightness
- Thermal Bridging
- Complete air barrier
- Provides 50% to 100% more R-value than minimum code requirements

Please reference "Design Goals" for detailed information about advanced framing in *The Montage*.

INSULATION

Our insulation strategy was based off Dr. Joseph Lstiburek's 10-20-40-60 rule.

- **Slab**: R-20, 4" Rigid EPS beneath entire slab
- **Foundation:** R-26, Superior Walls Xi Plus, 2" Exterior XPS 4' below grade
- **Wall Assembly:** R-45, 5 ½" Blown Cellulose, 4" Rigid Polyisocyanurate
    - (2) 2" layers, staggered and sealed at each layer
- **Ceiling:** R-60, 18" Blown Cellulose
    - All top plates that intersect attic plane air sealed
    - Insulation baffle spray foamed in place
    - SIPs Panel attic access hatch with weather-stripping and mechanical latches
- **Rim and band joists:**
    - Insulated with closed cell spray foam

With the spray foam contractor on site, *The Montage* will be air sealed, which will then be verified by a blower door test prior to the installation of blown cellulose and drywall.

- Construction is not to proceed until an acceptable infiltration number is achieved

The ENERGY STAR Version 3 Thermal Enclosure Checklist and Water Management Checklist were followed when designing *The Montage*.

- Thermal bridging through studs is virtually eliminated by applying 2 layers of rigid Polyisocyanurate over wall assembly
- Raised heel energy trusses allow insulation to be installed to the full required R-value at the eaves
- Exterior polyisocyanurate extends to the underside of the roof deck and doubles as an insulation baffle, which will prevent wind-washing of the cellulose

AIR BARRIER

We used innovative new products such as DOW Liquid Armor in conjunction with DOW Tuff-R rigid polyisocyanurate in order to form the air barrier on *The Montage*. Rigid air barriers are more durable than other strategies. By using DOW Liquid Armor, a fluid applied weather resistive barrier, we eliminated the need to depend on tape for the lifetime of *The Montage*. All rough openings will be treated with the liquid armor prior to installation of windows and doors, and again after the element is installed.

To preview DOW Liquid armor:
https://www.youtube.com/watch?v=Z4vbNlxxzXg&feature=youtu.be

By stopping the air flow, we also stop the majority of moisture movement. Careful attention was paid to where moisture would go if it did get into the wall. Class III interior paint with the appropriate perm rating was specified to permit drying to the inside of the assembly.

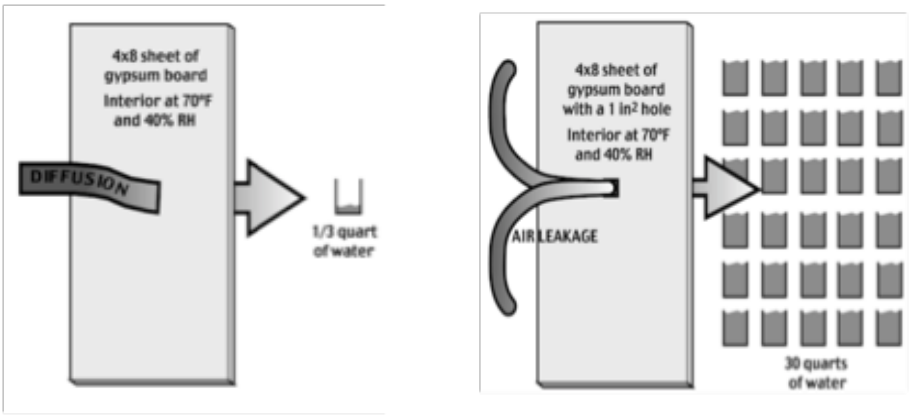


Figure 2: Moisture Movement Comparison (Lstiburek, Joseph)

SIDING AND RAIN SCREEN

The rainscreen detailing on *The Montage* includes 1x3 wood furring strips with Cor-A-Vent and pest screens at the top and bottom of the assembly. By furring out the siding, it will contribute to the lifetime of our LP Smartside cladding. The airspace will allow the siding to dry efficiently and as Alex Wilson mentioned in his most recent blog, *Lessons from Our House That Could Be Applied More Affordably* [3],

> "We spent a little more installing strapping over the exterior sheathing so that the siding will have an air space behind it, but the cost is low enough and the durability benefits great enough that this should be standard practice today. We will save thousands of dollars over the years by having to paint the siding only every 15-20 years (I predict), instead of as often as every five years, and a big part of the difference is the rainscreen detail." (Wilson, Alex)

Our siding was ordered pre-primed to ensure coverage on all six surfaces. Likewise, the cedar shingles to be used on gable ends are specified to be primed on all six sides prior to installation. Additionally, all cut sides are to be sealed before installation.

TRADITIONAL ECOLOGICAL KNOWLEDGE

By studying moisture management strategies on buildings from over 100 years ago (lower left), we learned to simply show the water where to go, rather than believe we could completely block it out.

Figure 3: Hundred Plus year old barn

Figure 4: Example of its place behind the exterior cladding in this assembly

For windows located well below any overhangs, we sloped our plywood nailers at a minimum ¼" per foot (above right), then integrated them into our drainage plane assembly. This simple, timeless strategy is an effective and dependable method for managing moisture in a critical location.

ROOF & WALL GEOMETRY

Simple rooflines fit the pattern language of the neighborhood that our home was designed for; this is one of the reasons why complicated roof lines were strictly avoided in our design. By using simple rooflines, we also minimize critical wall to roof connections. We followed this approach with the geometry of our walls also, to minimize waste. The most efficient buildings, like *The Montage*, are those with simple geometry. Anywhere that there was a wall to roof connection, the appropriate flashing details were provided. Kick-out flashings are specified where necessary to comply with the ENERGY STAR water management checklist.

Covered entryways were provided at all exterior doors in order to divert any water or ice away from the entryway and prevent splash up. Properly sized overhangs, according to the winter and summer sun angles, with gutters are specified to manage runoff water from the roofline. The gutters are diverted to a cistern and rain barrels, and any overflow is then piped to infiltration basins located on site. This ensures that there will be efficient drainage and no standing water on our site.

FLOORING

- Zero carpet design, all hard surface flooring
- Hardwood floors can be cleaned more efficiently and can last the lifetime of *The Montage*, unlike carpet
- Wood is a sustainable resource that grows where we live, The Northern Forest, and can be refinished a few times throughout the life of *The Montage*
- This durability strategy is also recognized in LEED Homes rating system

INTEGRATIVE PEST MANAGEMENT

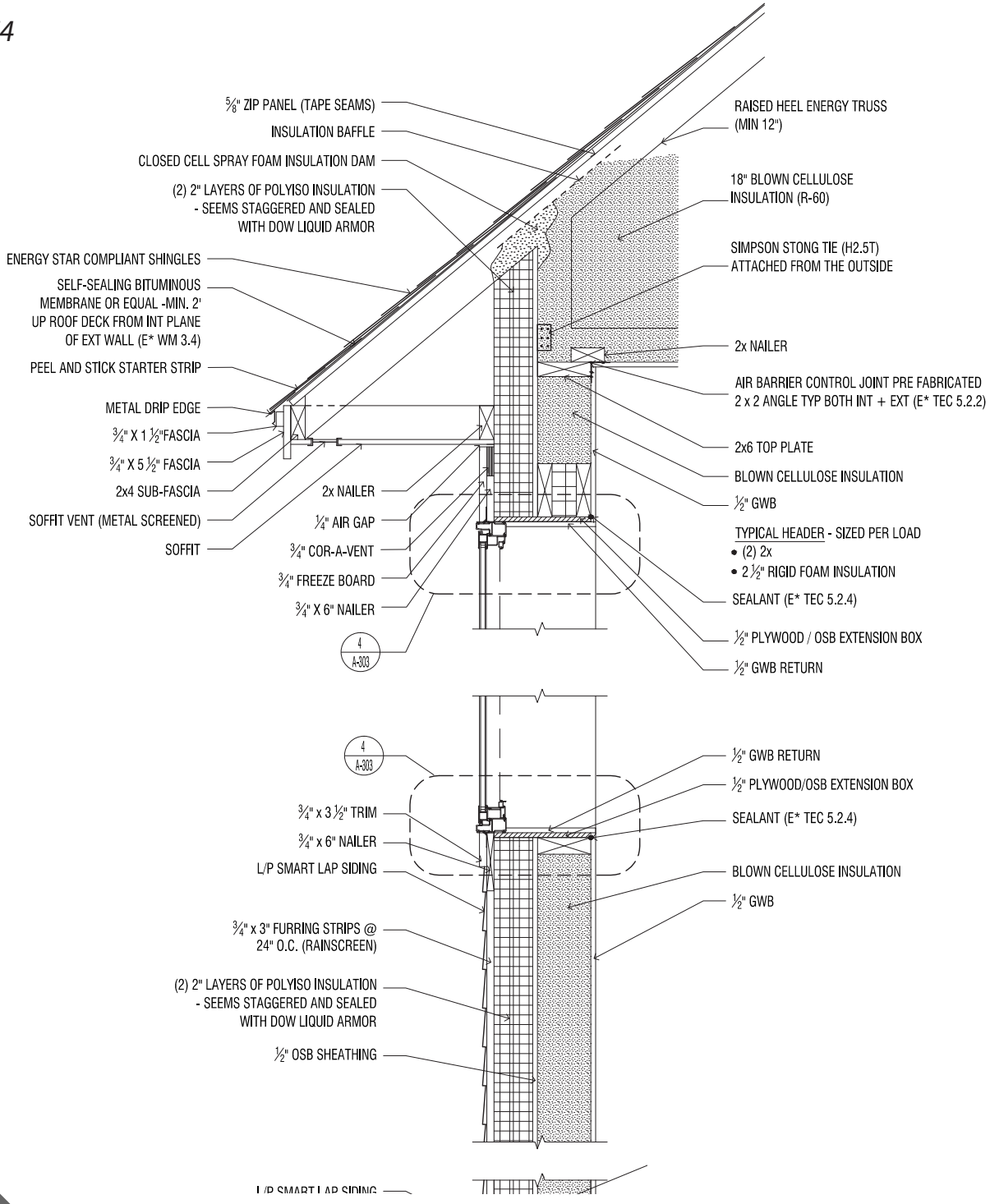
Although termites are not recognized as a major concern at this time in our climate, we adapted our design in anticipation of them being here in the very near future. A two foot gravel strip lines the perimeter of our house in

order to deter the termites away from *The Montage*. We also incorporated a termite shield at the top of the foundation as an added measure. These measures also decrease or eliminate the need to use pesticides.

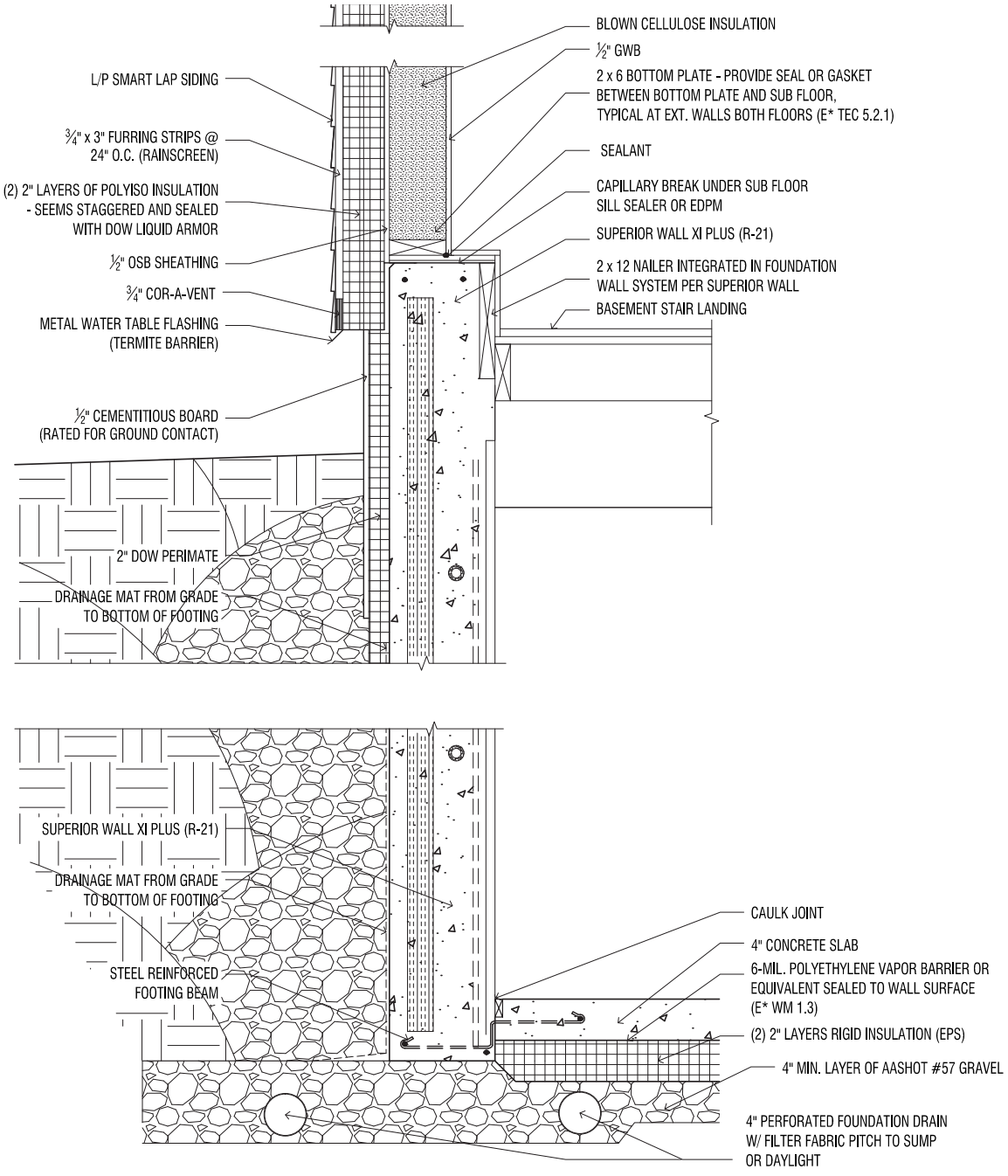
The two foot gravel strip also confirms that all mature landscaping will be kept a minimum of 24" away from *The Montage*, as specified in LEED for Homes. The last benefit of this gravel strip is that it will prevent rainwater from splashing onto *The Montage's* siding.

KEY EXTERIOR WALL SECTIONS

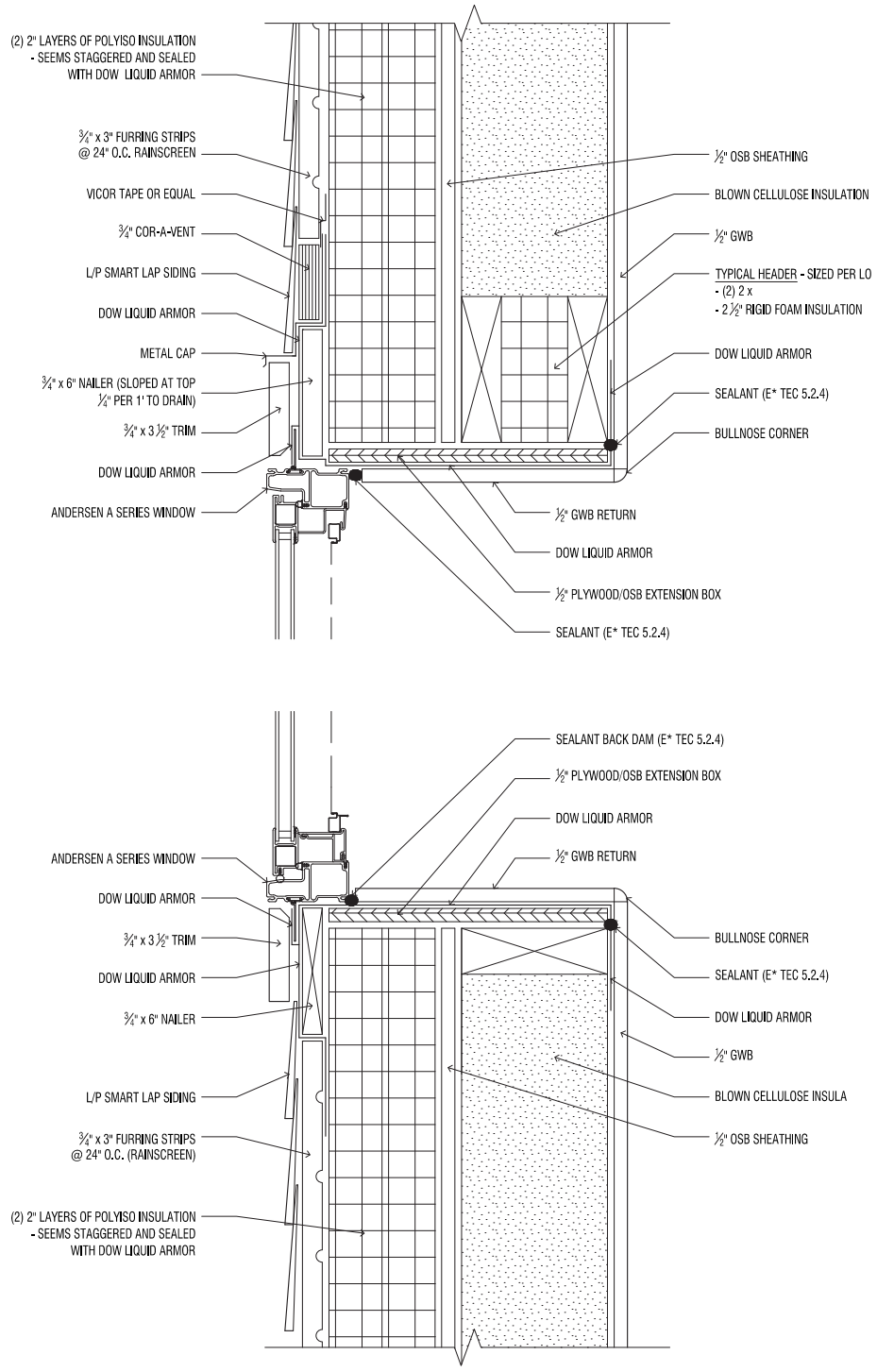
TOP OF WALL SECTION



BOTTOM OF WALL SECTION



WINDOW DETAIL



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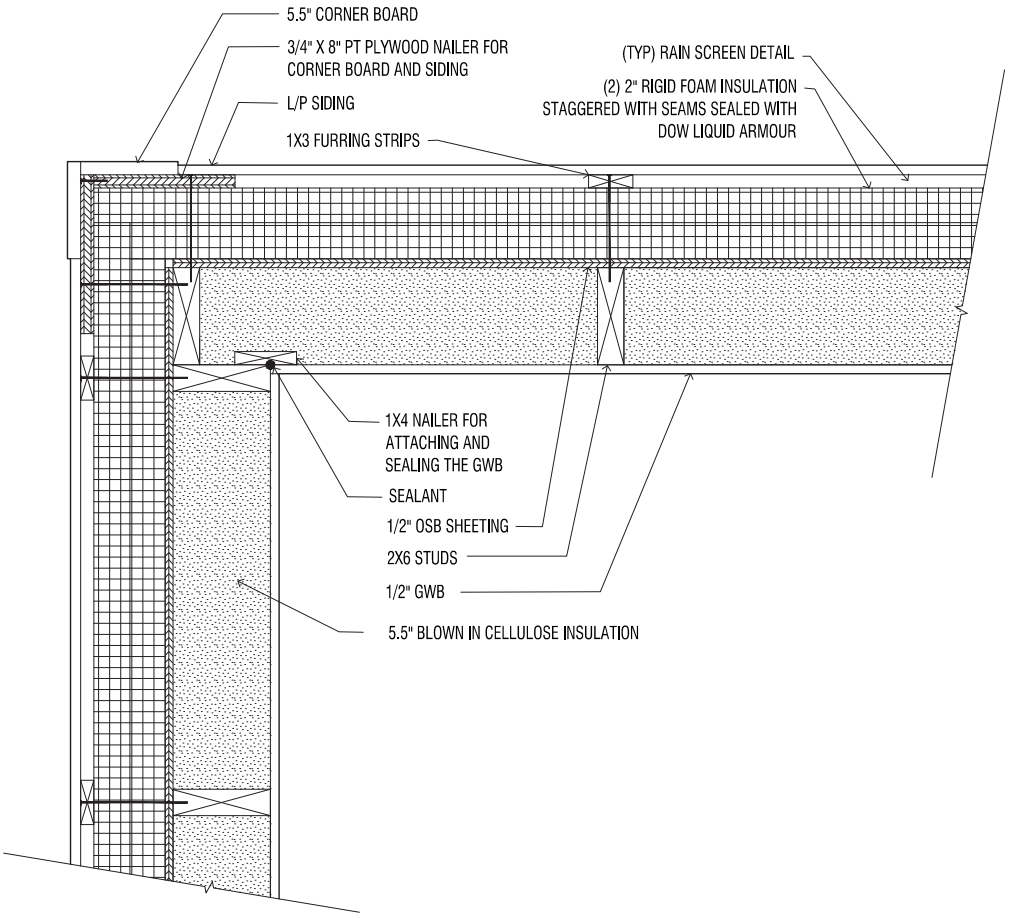
WINDOW SILL & HEAD DETAIL

3" = 1'-0"

CORNER DETAIL



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A-309

EXTERIOR CORNER DETAIL

1-1/2" = 1'-0"

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[2] Rashkin, Sam, Glenn Chinery, David Meisegeier, and Dean Gamble. "The Road to Carbon Neutral: ENERGY STAR for Homes and Beyond." *ACEEE Summer Study on Energy Efficiency in Buildings* (2008): Web.

[3] Wilson, Alex. "Lessons From Our House That Could Be Applied More Affordably." *GreenBuildingAdvisor.com*. N.p., 20 Mar. 2014. Web. 23 Mar. 2014.

IAQ EVALUATION

The Montage, designed to ENERGY STAR and EPA Indoor airPLUS standards, provides a healthy and supportive indoor environment for its occupants.

People spend the majority of their time indoors and efficient homes are built with super tight enclosures; therefore, indoor air quality is a critical piece of the building systems approach. In fact, because houses are dwellings for people, human health should represent the bottom line and trump all else when it comes to the built environment. Without the natural air changes we are accustomed to in older inefficient homes, pollutants and allergens must be removed using mechanical ventilation. Drawing on Biomimicry's principles of redundancy, we've eliminated pollutants at the source, incorporated balanced mechanical ventilation, and installed operable windows positioned for ideal cross ventilation, maximizing a powerful defense against potential pollutants for occupants of *The Montage*.

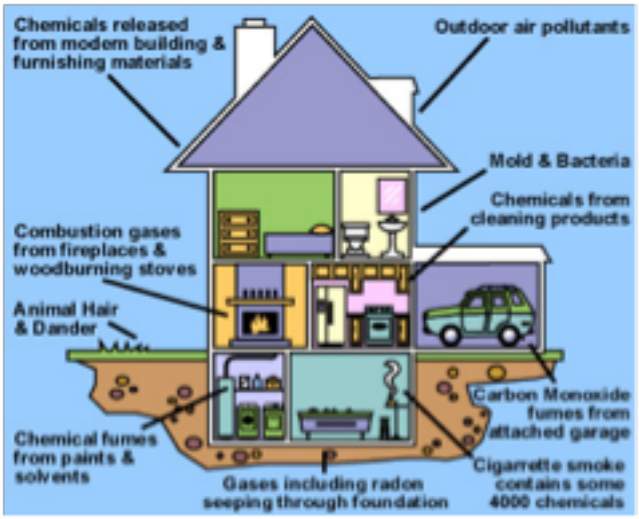

Figure 1: EPA, Indoor Air Pollutant Diagram. [1]

REMOVING POLLUTANTS AT THE SOURCE

Pollen, dust, radon, volatile organic chemicals, carbon monoxide, moisture, mold, and toxic building materials represent just some of the potential pollutants of the indoor environment. The most effective and fail-safe way to control these pollutants resides at the source. We have detached our garage, eliminated the use of combustion appliances, installed a passive radon vent, addressed interior and exterior moisture related risks, selected native plants for landscaping and to obviate fertilizers, and increased the "clean-ability" of the house by avoiding wall to wall carpeting.

DESIGN CONSIDERATIONS

Although favorable regarding our budget, we eliminated exhaust only and supply only ventilation as options early on. Exhaust only ventilation places the house under a negative pressure drawing in air from the paths of least resistance. This increases the likelihood of bringing in outdoor pollutants like pollen, dust, car exhaust, and soil gasses. Supply only ventilation was insufficient as well because we didn't have a ducted heating system that the unit could be tied into. Bringing in unconditioned air from outside would clearly have created a comfort issue in our climate.

Using a heat recovery ventilator (HRV) was our best option. Benefits of this system include a reduction in the heat load, increased comfort, and filtration of pollutants. Unfortunately, the cost, approximately $5,000 – 7,000 installed, was above the price range we allotted for ventilation. We continued to search for more options, finally arriving at the Lunos e2 decentralized heat recovery ventilator system.

WHOLE HOUSE BALANCED VENTILATION

We've addressed all ENERGY STAR and EPA Indoor airPLUS requirements in our design according to program specifications. To meet the ENERGY STAR whole house mechanical ventilation requirement, ASHRAE Standard 62.2, which calls for continuous ventilation at a rate of 49 Cubic Feet per Minute (CFM) in our case, we specified three sets (two per set) of Lunos e2 decentralized HRVs. Equipped with a merv 10 filter, a 60-70% efficient unit that removes particles as fine as milled flour, and a regenerative ceramic heat exchanger, these through the wall units are 90.6% efficient at heat and 20-30% efficient at humidity recovery.[2]

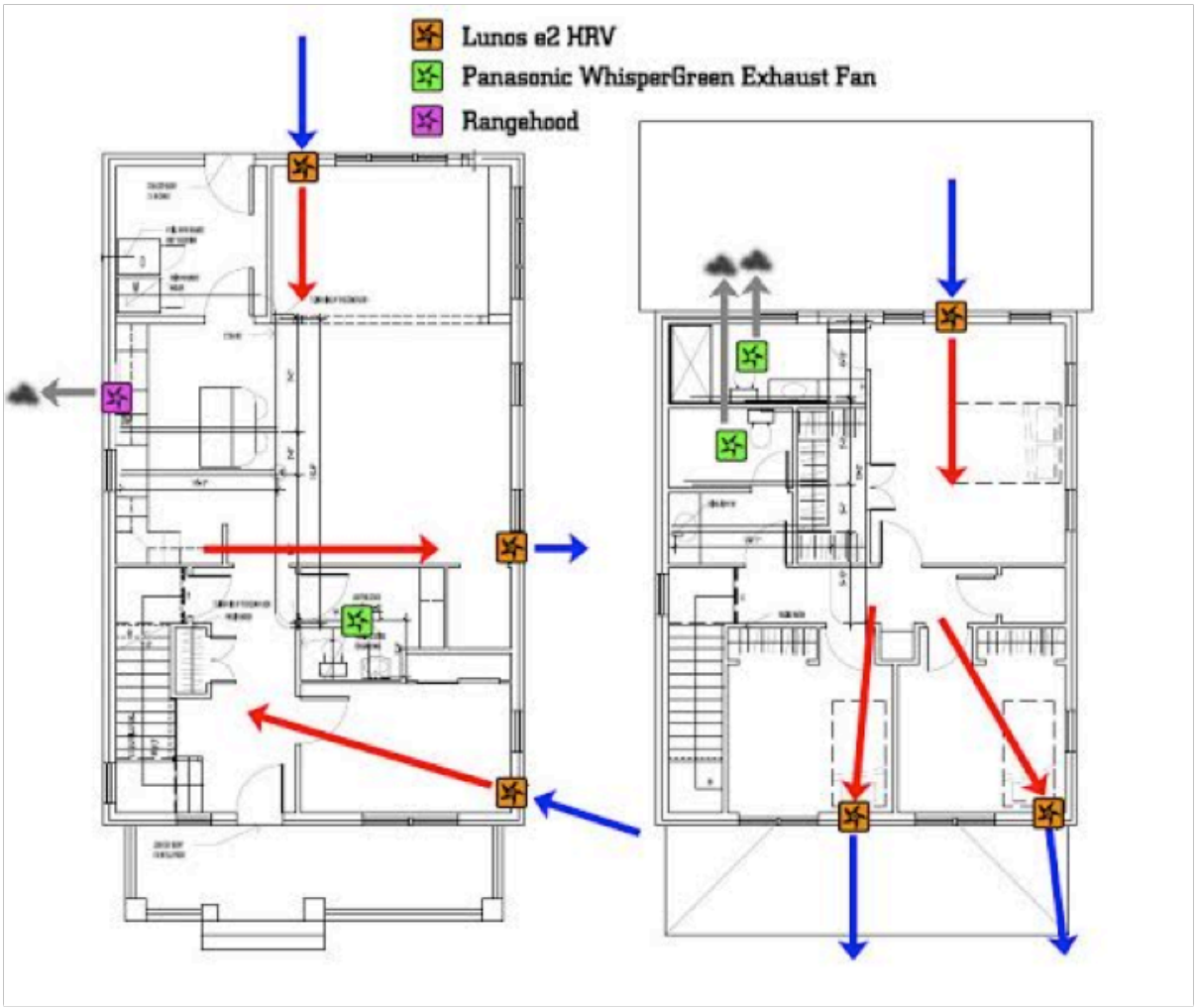

Figure 2: Montage Ventilation

We assert air only goes where it is told to go. By strategically placing Lunos e2 HRV fans in all bedrooms, the away room, family room, and dining room, we have ensured that all major living areas of the home are continually washed with fresh air. The Lunos e2 fans operate tandem. While one brings in supply air, the other exhausts stale air, see Figure 3. These units are charged by holding the outgoing indoor air for seventy seconds after which they reverse flow and bring in outdoor air, transferring the stored heat. Three stages of operation at nine, eighteen, and twenty-two CFM make it possible to ramp the units up or down as needed. These fans are engineered for quiet operation, remaining under one sone at their highest capacity.

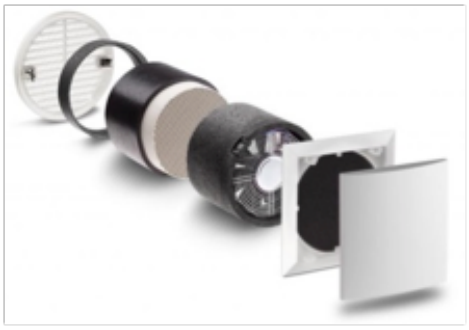

Figure 3: Lunos e2 HRV [4]

The fan set serving the family and dining room will be linked to one set of controllers, and the four remaining fans serving the bed and away rooms to another set. As per the manufacturer's recommendation, the controls will be simple low-voltage rocker switches, enabling occupant override.

Figure 4: Low-voltage rocker switches for Lunos e2 HRV [5]

Creating six holes in our envelope was a concern that we addressed in our durability details by specifying Roflex 150 airtight gaskets, Figure 5, to be installed, taped on all four sides with each Lunos e2 unit as per the manufacture's specifications.

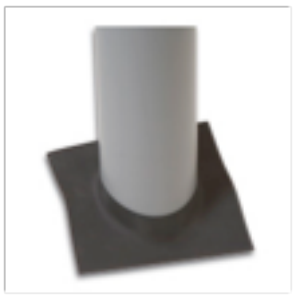

Figure 5: Roflex 150 airtight sleeve that fits Lunos e2 units [6]

LOCAL EXHAUST VENTILATION

80 CFM capacity Panasonic WhisperGreen exhaust fans will provide intermittent local exhaust ventilation for all three bathrooms. These units are equipped with SmartFlow Optimim CFM Technology which adjusts the fan speed according to static pressure in the ducts to reach the desired ventilation rate, which is in our case 50 CFM. In addition to making sure duct runs to the outside are as short and straight as possible, we elected to increase the diameter of the R-4 insulated flex duct from four to six inches to help the already quiet and efficient ENERGY STAR qualified fan run as resourcefully as possible.[7]

Figure 6: Panasonic WhisperGreen bathroom exhaust fan [8]

Although a CustomVent™ Variable Speed Control makes it possible to run the fans continuously at a low level is available, to support the efficiency of the Lunos e2 HRV units the fans will be programmed to remain off unless the occupant calls for ventilation. This also greatly reduces the risk of drawing in pollutants due to a negative pressure in the home. For complete moisture removal from the bathrooms, a High/Low delay timer will be set to run for an additional fifteen minutes after the switch is turned off.

As per ASHRAE Standard 62.2, a 100 CFM minimum capacity range hood exhaust fan vented to the outside will be used to remove moisture, odors, and other indoor air contaminants right from the source.

Extinguishing pollutant sources when possible while complying with ENERGY STAR and EPA Indoor airPlus requirements and meeting ASHRAE Standard 62.2 using the Lunos e2 HRV units in conjunction the Panasonic WhisperGreen bathroom reinforces our holistic approach to building and design. Our strategy does not only address health, it relinquishes the need for ductwork deals with cost and efficient use of materials and energy. See Appendix 1 for Indoor airPlus certificate and checklist.

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SPACE CONDITIONING

Comprehensive design comes from understanding design conditions. First, we looked at the typical household energy use in New York State for a baseline comparison to our project. According to our sustainability touchstones and calculated loads, we selected our heating system by comparing the following system types: a conventional furnace; a clean and efficient electrical mini-split system; and the cutting-edge, all-in-one, and air-to-water Daikin Altherma heat pump, which integrates space conditioning and domestic hot water heating.

AVERAGE HOUSEHOLD ENERGY USE IN NEW YORK STATE

"New York households consume an average of 103 million Btu per year (15% more than the U.S. average). Since the weather in New York is cooler than most other areas of the United States, space heating (56%) makes up a greater portion of energy use in homes compared to the U.S. average, and air conditioning makes up only 1% of energy use."[1] Syracuse is in Central New York and climate zone five.

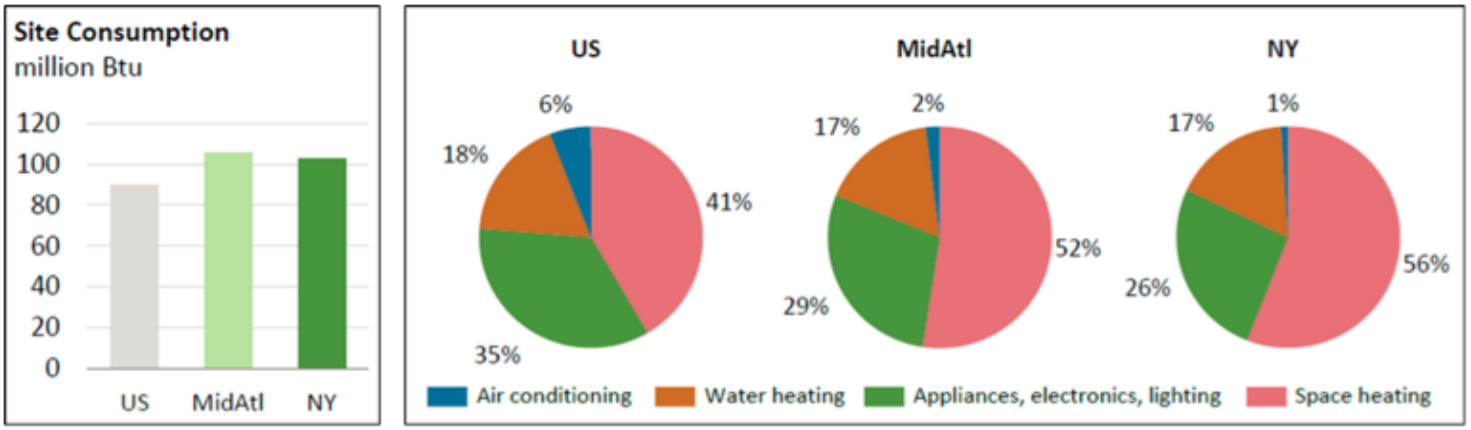
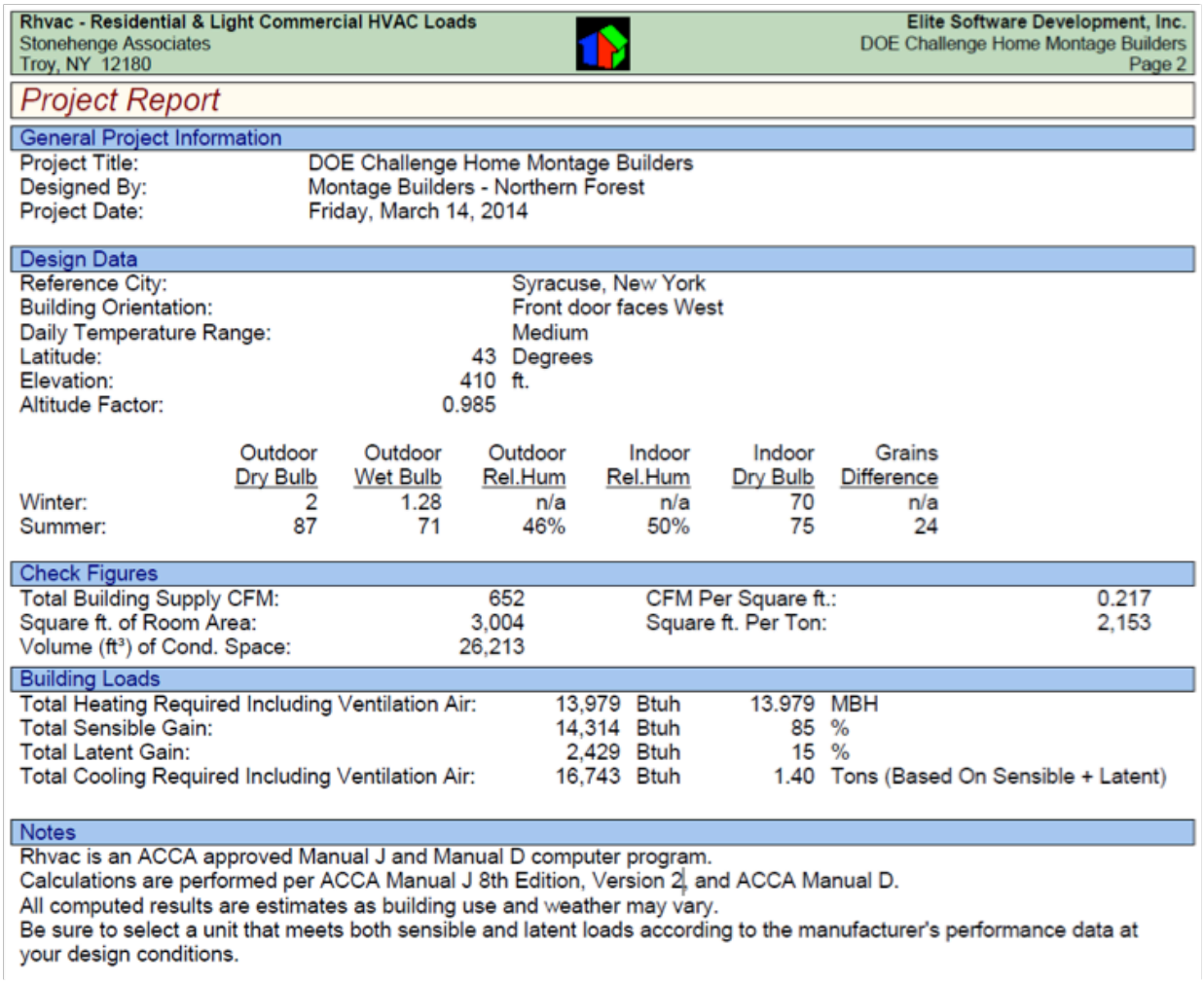


Figure 1: Site energy consumption & consumption by end use [2]

DESIGN LOADS AND PRINCIPLES

DESIGN LOADS

We used Air Conditioning Contractors of America's (ACCA) approved software Elite Software - *Rhvac* for Manual J, D, and S calculations (8th Edition, Version 2). A summary of the Manual J is shown in Figure 2. For the full report, see Appendix 1. This report shows that our design has a heat load 13,979 Btu/h and a cooling load of 16,743 Btu/h.



Rhvac - Residential & Light Commercial HVAC Loads
Stonehenge Associates
Troy, NY 12180

Elite Software Development, Inc.
DOE Challenge Home Montage Builders
Page 2

Project Report

General Project Information

Project Title:	DOE Challenge Home Montage Builders
Designed By:	Montage Builders - Northern Forest
Project Date:	Friday, March 14, 2014

Design Data

Reference City:		Syracuse, New York
Building Orientation:		Front door faces West
Daily Temperature Range:		Medium
Latitude:	43	Degrees
Elevation:	410	ft.
Altitude Factor:	0.985	

	Outdoor Dry Bulb	Outdoor Wet Bulb	Outdoor Rel.Hum	Indoor Rel.Hum	Indoor Dry Bulb	Grains Difference
Winter:	2	1.28	n/a	n/a	70	n/a
Summer:	87	71	46%	50%	75	24

Check Figures

Total Building Supply CFM:	652	CFM Per Square ft.:	0.217
Square ft. of Room Area:	3,004	Square ft. Per Ton:	2,153
Volume (ft³) of Cond. Space:	26,213		

Building Loads

Total Heating Required Including Ventilation Air:	13,979	Btuh	13.979	MBH
Total Sensible Gain:	14,314	Btuh	85	%
Total Latent Gain:	2,429	Btuh	15	%
Total Cooling Required Including Ventilation Air:	16,743	Btuh	1.40	Tons (Based On Sensible + Latent)

Notes

Rhvac is an ACCA approved Manual J and Manual D computer program.
Calculations are performed per ACCA Manual J 8th Edition, Version 2, and ACCA Manual D.
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 according to the manufacturer's performance data at your design conditions.

Figure 2: R-hvac Manual J Summary

Although our cooling design load is higher than our heating load, we chose not to provide cooling for *The Montage* because we have designed it with optimal window placement according to the prevailing wind direction for cross ventilation, heat recovery ventilators, as well as ceiling fans. Moving air makes people feel up to six degrees cooler than what the ambient temperature is. Furthermore, the design conditions are rarely reached as the projected cooling costs in REM Rate at only $49 per year demonstrate, see Figure 3.

Annual Energy Costs ($/yr)

Heating	330
Cooling	49

Annual Consumption (MMBtu/yr)

Heating	11.3
Cooling	1.7

Figure 3: Cooling energy consumption and cost

Detailed heating and cooling composition pie charts are shown in Figure 4.

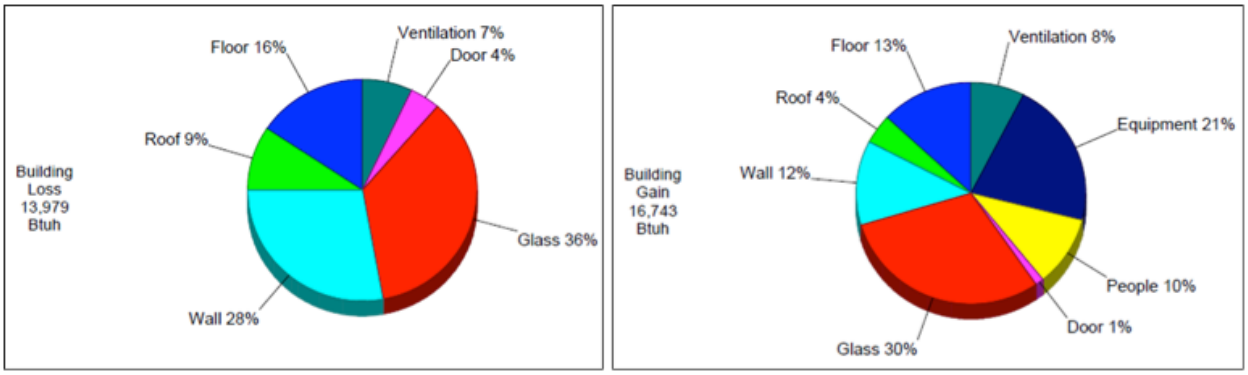


Figure 4: The Montage heating and cooling load composition

DESIGN PRINCIPLES

Wanting to achieve the same design objectives for our heating system as for the project as a whole, we looked for a system that would provide high indoor quality while consuming very little energy and being environmentally friendly. Based on our touchstones, we set the following goals:

- Provide comfortable and safe indoor conditions by sizing equipment properly and avoiding the use of combustion appliances.
- Keep it affordable – low installation cost, low operation cost, and low maintenance cost.
- Use a high efficiency system to reduce energy consumption.
- Avoid natural gas to not support hydrofracking, an issue we are very familiar with locally.
- Use a system that is easily integrated into a Net-Zero design.

HVAC SYSTEM SELECTION

EQUIPMENT SELECTION

The traditional gas furnace was eliminated as it uses gas which is not renewable and also not compatible with our mission toward Net-Zero energy. In addition, it is a combustion appliance which has negative health implications, especially in tight homes like *The Montage*. A furnace has a low initial installation cost but a much higher operational cost (about 15.9%) when compared to a Daikin Altherma. See the comparison shown in Figure 5.

Weather:Syracuse, NY
The Montage
DOE House no Solar 0323.blg

Builder
Montage Builders - NF

Heating Season(MMBtu/yr)	The Montage - Nat Gas	The Montage	Savings	%Saved
Ceilings/Roofs	3.1	3.1	0.0	0.0%
Rim/Band Joists	0.9	0.9	-0.0	-0.0%
Above Grade Walls	6.4	6.4	0.0	0.1%
Foundation Walls	5.7	5.7	0.0	0.1%
Doors	1.1	1.1	-0.0	-0.0%
Windows/Skylights	7.6	8.8	-1.2	-16.1%
Frame Floors	0.0	0.0		
Crawl Space/Unht Bsmt	0.0	0.0		
Slab Floors	2.2	2.2	-0.0	-0.0%
Infiltration	4.8	4.8	-0.0	-0.0%
Mechanical Ventilation	1.3	1.3	-0.0	-0.0%
Ducts	5.5	0.0	5.5	100.0%
Active Solar	0.0	0.0		
Sunspace	0.0	0.0		
Internal Gains	-11.0	-11.1	0.1	0.8%
Total	27.5	23.1	4.4	15.9%

Figure 5: Heating energy use comparison of traditional furnace and Daikin Altherma

Because group source heat pumps are proven to be efficient in our climate, we took the time to compare their benefits to those of air source heat pumps. We looked at the following factors.[3]

- **Installation Cost** - air source system has a lower installation cost compared to ground source.
- **COP** - air source system has very good COP's 2.2 – 3.4 although it is lower than ground source.
- **Operational Cost** - air source system has very similar operating costs due to ground source pumping requirement.
- **Maintenance, Repair, and Troubleshooting** - All components of the air source system are above ground and accessible; therefore, compared to a ground source system, they are easier to maintain.

Once we settled on using an air-source heat pump, we did a juxtaposed a mini-split system and the Daikin Altherma. Mini-split systems are widely used due to their low initial cost and flexibility. For instance, a mini-split can provide heating and cooling capacity all in one and heads can be easily configured to meet various room requirements. However, it can't provide domestic hot water and areas far from the head may have poor thermal comfort conditions. In contrast, the Daikin Altherma is an air to water heat pump which can provide heating, cooling, as well as domestic hot water and it has a distribution system for maximum comfort. Additionally, it is easily integrated with a solar thermal system through the use of a "combi" tank or pre-heat tank. Their comparisons are listed in the table in Figure 6. Finally, we selected the Daikin Altherma for its all-encompassing proficiencies.

Daikin Altherma	Mini Split
Install cost	Install cost +++
Versatility +	Versatility -
DHW ++	DHW --
Whole House Comfort +++	Whole house Comfort ---
TOU Rates +	TOU Rates --
Off peak rates +	Off Peak Rates --
Storage Compatibility ++	Storage Compatibility --
COP ++	COP +++
PV Offset to Zero - retrofit +++	PV offset to zero - retrofit +
PV Offset to Zero – New +++	PV Offset to Zero – New ++

Figure 6: Daikin Alterhma & Mini Split systems comparison table[4]

A schematic of a Daikin Altherma system integrated with solar thermal is shown in Figure 7.

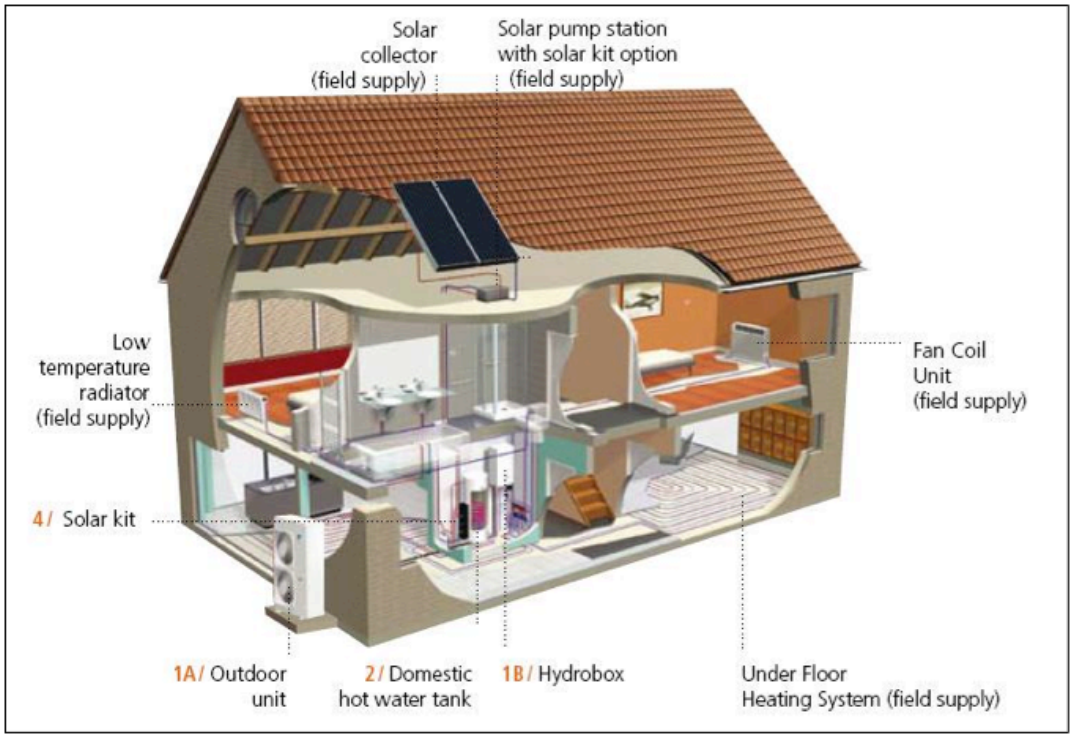


Figure 7: Daikin Altherma system[5]

EQUIPMENT SELECTION

We choose to use hydronic distribution instead of air distribution due to its increased delivery efficiency. Using the Daikin Altherma Simulator V4.0.0, we evaluated three hydronic distribution types as listed in the table in Figure 8. Because Warmboard Radiant has a high seasonal coefficient of performance (COP) and low operational cost we wanted to select it; however, its initial installation cost was out of our budget. We solved this problem by using a local builder's method of "making our own," shown in Figure 9.

	Low temp Baseboard	**Staple-up Radiant**	**Warmboard Radiant**
Required heating capacity	14979 BTU/h	14979 BTU/h	14979 BTU/h
Energy consumption heating	3824 kWh	3199 kWh	2402 kWh
Energy cost heating	570 $	477 $	358 $
Spare cap. in heating, including BUH	19777 BTU/h	20029 BTU/h	21490 BTU/h
Seasonal COP	2.3	2.8	3.7
Required cooling capacity	16743 BTU/h	16743 BTU/h	17 BTU/h
Energy consumption cooling	1210 kWh	1210 kWh	1 kWh
Energy cost cooling	180 $	180 $	0 $
Spare cap. in cooling	10700 BTU/h	10700 BTU/h	17 BTU/h
Annualized EER	10.9	10.9	11.5
SEER	17.7	17.7	18.6

Figure 8: Distribution systems comparison table

Figure 9: Heating distribution system on the floor

SYSTEM OPERATION

To control the Dakin Altherma heating system, we have selected a self-learning Nest thermostat (Figure 10). With auto schedule, the Nest learns each time it is used and adapts to the occupant's schedule automatically, and unlike a regular programmable thermostat, the Nest self-adjusts as the occupant's schedule changes. Doing this, it can reduce the annual energy use of a household by up to 20%. Furthermore, the Nest has a *System Match* feature where it activates custom energy-savings depending on the heating distribution systems used. Most other thermostats are made for forced air systems only.

Figure 10: Nest Thermostat

MAINTENANCE SUMMARY

The occupants will follow the manufacture manual to operate and maintain the Daikin system.

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[4] Reference: Mr. Ed Whitaker, *DOE Challenge Home Workshop.*

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DOMESTIC HOT WATER

Domestic hot water consumption has been known to account for up to 15% of the electricity used in residences and is typically the second largest use of energy in a home.1 In energy efficient homes, the domestic hot water energy use can have an even greater impact on energy demand, as a tight envelope requires far less energy to condition spaces. Studies have shown that the typical American home wastes roughly 3,650 gallons of water per year waiting for hot water to arrive.2 These staggering numbers show the importance of designing efficient domestic hot water systems.

For *The Montage*, we chose to design the domestic hot water system based on the guiding principles of reducing demand losses, stand-by losses, and distribution losses, directly relating to our touchstone of efficiency. To achieve sufficient reductions in these areas, we chose to use the WaterSense New Homes Specification, LEED for homes V2008, specifying ENERGY STAR appliances where applicable, and following the ICC-700 National Green Building Standard® to guide our design. Our design goal was to design a water efficient system using improved technologies that deliver equal or better service with less water.

ENERGY EFFICIENT STRATEGIES

REDUCING DEMAND LOSSES

Reducing hot water demand has been the most challenging part of the project. How much hot water is used can vary greatly depending on the occupant. It is imperative to educate the homeowner on strategies to use less water. Some strategies we chose to educate the owner with are:

- Only running washing machines when full.
- Not running the faucet while brushing teeth.
- Keep a pitcher of water in the fridge instead of running the tap.
- Easy access hot water turn off switch to turn off hot water heater when away for extended periods of time.
- Incorporating a Pressure Reducing valve to ensure the water supply is below 60 psi.

REDUCING STAND-BY LOSSES

Strategies for reducing stand-by losses include:

- Insulating solar hot water heater with an R-15 insulating blanket completely surrounding the tank.
    - Expected savings = 150 – 450 kWh annually.[3]
- Raising solar hot water heater off the basement floor on an insulated platform.
- Sizing solar hot water heater correctly.
- Setting solar hot water heater to heat water to 120 degrees F and verifying temperature at fixtures
    - Expected Savings = 100 – 200 kWh annually.[3]
- Utilizing a drain-water heat recovery system to raise temperature of incoming water before reaching the solar hot water heater. Second floor shower drains will have a separate line from the toilet, sharing a common vent above the wet line of the system.

REDUCING DISTRIBUTION LOSSES

Reducing distribution losses was the area that we were able to make the greatest positive impact in. Strategies for reducing distribution losses include:

- Demand Initiated Recirculation System
  - Designing recirculation loop to be within 40'+ (2x ceiling height).
  - Designing branch lines from recirculation loop to be less than 10 feet and ½" diameter.
  - ACT D'MAND C3-100 Recirculation Pump (received Certificate of Recognition by the US Department of Energy). Deposits ambient temperate water back into solar hot water heater (less than 0.6 gallons) while delivering hot water to fixtures. See Figure 1 below for estimated wait times.
  - Push-Button initiated instead of sensor initiated. A person may enter the bathroom for reasons other than hot water.
  - All piping is located within conditioned space.
  - Insulating hot and cold water lines to R-4.6. Insulating cold water lines ensures condensation will not form on tubing within conditioned spaces. Properly installing insulation on all piping elbows to tightly adhere to 90 degree bend.
  - Specifying WaterSense approved aerators at fixtures.
  - Specifying WaterSense approved fixtures.
  - Planned grey water lines for future ease of adaption.
  - Specifying Energy Star Dish Washer that uses less than 6.0 gallons per cycle.
  - Specifying Energy Star Clothes Washer with and MEF>2.0 and WF<5.5.

FIXTURE	PIPE DIAMETER	WATER CAPACITY (oz/ft)	PIPE LENGTH (ft)	WATER VOLUME (gal)	FLOW RATE (gpm)	HW WAIT TIME (s)
Kitchen Sink	1/2"	1.31	9.92	0.10	2.2	2.77
Bathroom Sink	1/2"	1.31	8.08	0.08	1.5	3.31
Bathroom Sink	1/2"	1.31	2.00	0.02	1.5	0.82
Shower	1/2"	1.31	10.00	0.10	2.0	3.07
Bath	1/2"	1.31	8.75	0.09	2.0	2.69
Bathroom Sink	1/2"	1.31	10.00	0.10	1.5	4.09

Figure 1: Estimated Domestic Hot Water Wait Times

Sample HW Wait Time Calculation:

Water Volume in Branch(gal) = (Water Capacity(oz/ft)*Pipe Length(ft))/128(oz/gal)
HW Wait Time(s) = Water Volume(gal)/Flow Rate(gpm)*60s

Homeowner Operation & Maintenance Checklist

Quarterly		Date last completed			
PLUMBING					
Faucets and shower heads	Check interior and exterior faucets for leaks. Clean aerators. Replace washers if necessary.				
Drains	Ensure speed of drainage is adequate				
Drains	Clean with baking soda. Pour water down unused drains.				
Pipes	Inspect visible pipes for leaks.				
Kitchen and bathroom cabinets	Check under and around for leaks.				
Toilets	Check for stability and leaks.				
Solar Hot Water Heater	Check area around water heater for leaks. If you have hard water, drain 1-2 gallons water.				
Fixture Areas	Look for loose tiles (moisture may be present)				
SHW System	Clean dust off solar collectors				
Pressure Relief Valve	Make sure it is not stuck open or closed				
SHW System	Check nuts and bolts attaching collectors to structure for tightness				
Penetrations	Ensure flashing and sealant around penetrations is in good condition				
Supply	Test Water Pressure				
Fall		Date last completed			
Plumbing shut-off valves	Inspect for proper operation.				
Outside faucets	Drain				
Solar Hot Water Heater	Flush out hot water to remove accumulated sediment.				
Faucet aerators	Check for proper flow of water. If the flow is reduced, clean the aerator screens. During the first two months, the faucet aerators could require more frequent cleaning.				
Spring		Date last completed			
Solar Hot Water Heater	Flush out hot water to remove accumulated sediment.				
3-5 years		Date last completed			
Domestic Hot Water Loop	Circulate mild acidic solution (vinegar) to avoid scaling				
Solar Hot Water Heater	Inspect anode				

Figure 3: Homeowner Operation & Maintenance Checklist

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LIGHTING AND APPLIANCES

DESIGNING LIGHTING TO OUR SURROUNDINGS

Our lighting analysis combined several crucial building components: passive lighting; room occupancy times and duration; amount of time spent in the room; lighting level requirements; source of electrical production; energy use; number of fixtures; and method of monitoring and control.

When designing the lighting for *The Montage*, we tried to keep the natural light level of our local environment, the "Northern Forest." The light from our Northern Forest can best be described as warm and comfortable but not overbearing. It should feel inviting and have plenty of natural sunlight without glare as if the sunlight is just breaking through the top of the trees and hitting the ground, allowing for a constant soft stream of light to fill the home. It was essential to make sure the home had visible access to the outside to maximize the amount of natural light and views from light inside.

By strategically placing the majority of the windows on the southern exposure, the home will receive the most natural light possible when the sun is at its lowest point in the sky during the winter months. This will occur during the morning and evening hours, which is also when the home will be at its highest usage by the occupants. Placing the windows in this way ensures that the homeowner will be able to manage the amount of natural vs. artificial light they want in various rooms during different times of the year. By reducing the need for artificial light by replacing it with natural light to help maintain proper lighting levels throughout the day, we will reduce energy costs.

We researched extensively natural versus artificial lighting sources and their effects on happiness and health. You can learn more about the effects of natural vs. artificial light at HealthStatus.com.[1] Additional information about the health effects are contained in E.O. Wilson's book *Biophillia*.[2]

MANAGEMENT OF NATURAL VS. ARTIFICIAL LIGHTING FOR HEALTH BENEFITS

Improper management of light in a home, whether it is too much light or too little, can be harmful to the occupant's health. With too much natural light, occupants would constantly close the blinds and rely completely on the use of artificial light. By relying solely on artificial light, the occupant would reduce the ability of the occupant to stay healthy as well as restrict their visible comfort by not being able to look out the windows.

As the sun moves across the sky, the southern house orientation will allow the most light through its windows therefore permit the maximum passive lighting. Deciduous trees will give protection during the summer and allow more light through during winter.

Figure 3: Homeowner Operation & Maintenance Checklist

The occupancy of rooms at specific times of the day represents another factor that played a serious role in our design. Designing large, open spaces with lightly colored reflective ceilings and walls allow *The Montage* to reflect the most natural light into the home compared to small rooms with dark colored walls. This allows the home to maximize the amount of natural lumens per square foot in each room and use the least number of fixtures to provide the required light levels. Reducing the reliance

on artificial light also reduces the cooling load. This will ensure a warm, comfortable atmosphere, which is a vital part of our lighting analysis and design as well as energy management.

Room Occupancy times with Lighting Levels

Location	Estimated Time of Occupancy	Lumens Present
Dining Room	7am-9am & 5pm-7pm	3200
Living Room	5pm - 10pm	4000
ADA Bed	8pm - 12am & 6am-9am	1600
1st Bed	8pm - 12am & 6am-9am	1600
2nd Bed	8pm - 12am & 6am-9am	1600
Master Bed	8pm - 12am & 6am-9am	2400
ADA Bath	8pm - 12am & 6am-9am	3200
Guest bath	8pm - 12am & 6am-9am	3200
Master Bath	8pm - 12am & 6am-9am	3200
Hallway	8pm - 12am & 6am-9am	2400
Stairs	8pm - 12am & 6am-9am	1600
Kitchen	7am-9am & 5pm-7pm	5680
Mud room	7am-9am & 7pm - 11pm	800
Foyer	8pm - 12am & 6am-9am	1600

Figure 2: Rooms with Lighting Levels

LIGHTING ENERGY COMPARISON

The lighting type was a major determining factor in our lighting analysis because a well-lit home while using the most energy efficient products was an important concept towards changing the way we build homes. During the initial comparison of lighting types, we looked at three main sources of light: incandescent (as a control), compact florescent lighting (CFL), and light emitting diode (LED).

Comparison Point	LED	CFL	Incandescent
Watt Bulb (or Equivalent)	60	60	60
Lumens/Watt	88	57	13
Lumens	800	800	780
Avg. Cost	$ 14.00	$ 9.00	$ 0.75
Energy Consumption (watts/hr.)	9	14	60
Average lifespan (LS) (Hours)	30,000	10,000	2,000
Average Use per day (hrs.)	3	3	3
Yearly Energy use (kWh)	10.0	15.4	65.7
Comparison Point	**LED**	**CFL**	**Incandescent**
Avg. LS in Years	27.4	9.1	1.8
Energy used over Bulb LS (kWh)	272.7	140.4	120
Cost per kWh	$ 0.145	$ 0.145	$ 0.145
Energy cost over bulb LS	$ 39.55	$ 20.35	$ 17.40
Yearly Energy Cost	$ 1.44	$ 2.23	$ 9.53
Bulbs required to meet LED LS	1	3	15
Bulbs cost over LED LS	$ 14.00	$ 27.00	$ 11.25
Energy consumed to meet LED LS (kWh)	272.7	421.1	1800
Total Energy Cost compared to LED LS	$ 39.55	$ 61.05	$ 261.00
Total Cost plus cost of bulb	$ 53.55	$ 88.05	$ 272.25
Estimated environmental impact by recycling mercury in bulb	0%	25%	0%
Return on investment	35.40%	33.17%	4.31%

Figure 3: Bulb Type Comparison

Based on the information in the chart above, we were able to conclude the best return on investment was from LED fixtures/bulbs because the energy use over time and environmental impact was less compared to recycling the mercury content found in CFLs. Energy-wise CFLs are significantly more efficient than incandescent bulbs, but we questioned the benefit of increasing energy savings at the cost of allowing mercury into the home. In every standard CFL bulb (60W Equivalent), there is 5mg of mercury.

For homeowners the danger of mercury in CFLs is serious and requires specific measures to dispose of properly. "Do no harm," human health, and performance are priorities when designing our lighting system. It is our belief that the increase in safety by using LEDs outweighs the cost savings from CFLs.

Therefore, we implemented all ENERGY STAR LED fixtures and bulbs into our lighting design. Using LED lighting reduces our home's overall energy consumption, making it much easier to achieve Net-Zero due to a reduced electrical load.

LIGHTING FOR TIMES OF OCCUPANCY

Understanding the times of the day a room is occupied is important while designing the lighting infrastructure. As the amount of time a household spends in a room increases, the reliance on electrical energy also increases. For example, members of a household will spend more time in the kitchen and living room compared to the bathroom, thus placing a higher emphasis on electrical energy needed to supply these rooms.

By maximizing the amount of light by proper window orientation, ample fixtures, and dimmable switches we have given the home owner the ability to change the lighting mood to their preferred setting in high use areas.

HIGH USE ROOM MANAGEMENT

High use rooms in The Montage have dimming switches incorporated to manage energy use. Individual Lutron dimming switches will allow the homeowner to adjust the light in several rooms such as the living room and dining room. From an energy management perspective, this is a great way to give the homeowner the ability to control lighting levels when full density light can be overwhelming since every installed Lutron Dimmable switch automatically reduces the load of a lighting circuit by 5%. See Appendix 1 for more details.

TASK LIGHTING ANALYSIS: REFERENCE FIGURE 4 FOR DETAILED ROOM INFORMATION

KITCHEN

The lighting design of the kitchen involves several recessed down lights illuminating the area between the island and the main counter. Under cabinet LED lights illuminate countertops, giving a generous amount of task lighting. The appeal of our design is based around the practicality of installation as well as simplicity of our design, keeping it manageable, efficient, cost effective, and universal.

BATHROOM

All of the bathrooms contain two simple fixtures that are ENERGY STAR rated with LED bulbs: one vanity fixture and one fan light. These two fixtures provide ample lumens for the bathrooms with three LED efficient bulbs in each.

FRONT PORCH

The Montage's front porch has three main fixtures: two LED surface mounted fixtures that will illuminate the porch and one LED wall mounted security light. The two surface mounted fixtures will create a warm and inviting atmosphere. The wall mounted LED light will be controlled by a separate switch and has several illuminates the front porch and mitigate home intrusions because it's a well-lit area.

MUD ROOM TO GARAGE EXTERIOR LIGHTING

On the exterior of *The Montage's* mud room, next to the door an essential lighting design has been implemented: two LED wall mounted fixtures. These fixtures will be controlled from both inside the house as well as from inside the garage for ease of visible access into the home, ADA Compliance, safety, and security.

MASTER BEDROOM CONTROL LIGHTING

A safety feature our team implemented into *The Montage* is a lighting control switch in the master bedroom. The lighting control switch controls LED exterior lights along the back entrance of the house and driveway. This is primarily useful for security so that the occupant can illuminate the outside of the house without needing to walk downstairs in the event of an emergency or if someone arrives home late.

Location	SQ FT of Area	Lumens Present	Required Foot-candles	Montage Foot-candles
Dining Room	119.3	3200	10 to 20	26.8
Living Room	237	4000	20 to 55	16.9
ADA Bed	107.8	1600	10 to 20	14.8
1st Bed	119.1	1600	10 to 20	13.4
2nd Bed	119.1	1600	10 to 20	13.4
Master Bed	184.5	2400	10 to 20	13.0
ADA Bath	73.2	3200	10 to 20	43.7
Guest bath	68	3200	10 to 20	47.1
Master Bath	62.5	3200	10 to 20	51.2
Hallway	71.7	2400	10 to 20	33.5
Stairs	50	1600	20 to 30	32.0
Kitchen	138.4	5680	20 to 55	41.0
Mud room	67.1	800	10 to 20	11.9
Foyer	86.7	1600	10 to 20	18.5

LIGHTING ENERGY USE ANALYSIS

Understanding the times of the day a room is occupied is important while designing the lighting infrastructure. As the amount of time a household spends in a room increases, the reliance on electrical energy also increases. For example, members of a household will spend more time in the kitchen and living room compared to the bathroom, thus placing a higher emphasis on electrical energy needed to supply these rooms.

By maximizing the amount of light by proper window orientation, ample fixtures, and dimmable switches we have given the home owner the ability to change the lighting mood to their preferred setting in high use areas.

Lighting	units	Watts	hrs/day	Watts/ unit/ day	Total Watts per all fixture Type	kWh per day	Days in Year	Total kWh/year
Flushmounted Surface Light (LED & ES) (Type D)	5	18	8	144	720	0.72	365	262.8
Flushmounted CFL Globe Light (LED & ES) (Type C)	8	26	8	208	1664	1.66	365	607.36
Bathroom vanity Lights (LED) (Type B)	3	24	3	72	216	0.22	365	78.84
6" LED Recessed Downlight (Type I)	2	20	8	160	320	0.32	365	116.8
LED Light with Fan (Type A)	2	10	8	80	160	0.16	365	58.4
Light Socket w/ LED Bulb (60W LED $13.97) (Type F)	12	9	4	36	432	0.43	365	157.68
70CFM Exhaust Fan W/LED Light (Type E)	3	26	4	104	312	0.31	365	113.88
Exterior Wall Lighting LED (Type G)	3	10	4	40	120	0.12	365	43.8
LED Motion sensor lighting (Type L)	2	26	3	78	156	0.16	365	56.94
LED Dining room & Island Light (Type J)	2	20	8	160	320	0.32	365	116.8
12" LED Snap Lights (Type H)	7	3	8	24	168	0.17	365	61.32
LED Front Porch Light (Type K)	2	8.3	4	33.2	66.4	0.07	365	24.24
							Total kWh	1698.86
							Cost/ kWh	$ 0.145
							Total Cost	$ 246.33

Figure 5: Light Energy Analysis

Our predicted kWh analysis of the lighting system estimated that the annual amount of energy needed to power our LED lighting system would be approximately 1,700 kWh/ yr.

EDUCATION BY HOME ENERGY MANAGEMENT SYSTEMS (HEMS)

In order to educate and consciously inform the homeowner in real-time about their energy use we have implemented The Total Energy Detective (TED). The Energy Detective is a home energy management system that displays energy usage on a computer screen (Appendix 2). It is an inexpensive and efficient method to manage energy in a simple and easy to understand format. A real-time graph of the amount of energy *The Montage* uses will be displayed while computing the cost of current and future energy bills. The TED system monitor software can be installed on your home computer where you can monitor, record, and view data on your desktop or laptop.

APPLIANCES

Only ENERGY STAR appliances are specified for *The Montage*. These appliances will use less energy than conventional appliances. The figures can be seen below in Figure 6.

Appliance	Size	kWh/yr.	ENERGY STAR Compliant	Characteristics
Range/oven	4.9 cu. Ft.	varies (~985)	Yes	Black
Dishwasher	24"	264	Yes	Stainless Steel
Refrigerator/Freezer	25.2 cu. Ft.	481	Yes	Stainless Steel
Microwave/Range fan	24"	varies (~306)	Yes	Stainless Steel
Washer/dryer	Not Inc.	800	Yes	Predictable Energy Use
Estimated kWh/yr.		2224		
Cost/kWh		$ 0.145		
Total Cost		$ 322.48		

Figure 6: Appliance Energy Analysis

Furthermore, to achieve Net-Zero, it's beneficial to have all electric appliances, allowing the PV system to offset all appliance use. The anticipated load for all appliances is 2225kWh/yr. This includes all installed and any future appliances such as a washer or dryer.

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[1] "Artificial Light and Health." *HealthStatus.com*. 29 Feb. 2014. Web. <http://www.healthstatus.com/health_blog/wellness/artificial-light-and-health/ >.

[2] Wilson, Edward. *Biophillia*. 1984.

[3] "Top 10 Benefits of Light Control." *Lutron.com*. 12 Dec. 2014. Web. <http://www.lutron.com/en-US/Education-Training/Pages/LCE/GreenBenefits.aspx>.

ZERO NET ENERGY USE

GENERAL HOUSE DESIGN MODIFICATIONS

In a recent blog post, *These Ain't Yer Grandpappy's Heat Pumps*, Allison Bails sums it up best, "Build an all-electric, micro-load home, add enough photovoltaic modules, and voilà, you're at net zero energy use, producing as much as you use."[1] This is exactly the approach we took to achieving Net-Zero with The *Montage*. We focused first on reducing our load by maximizing our envelope's efficiency. Then we selected ENERGY STAR lighting and appliances as well as the Daikin Altherma, a combined space conditioning and domestic hot water system, which is easily integrated with solar thermal.

PV Shading Array Diagram

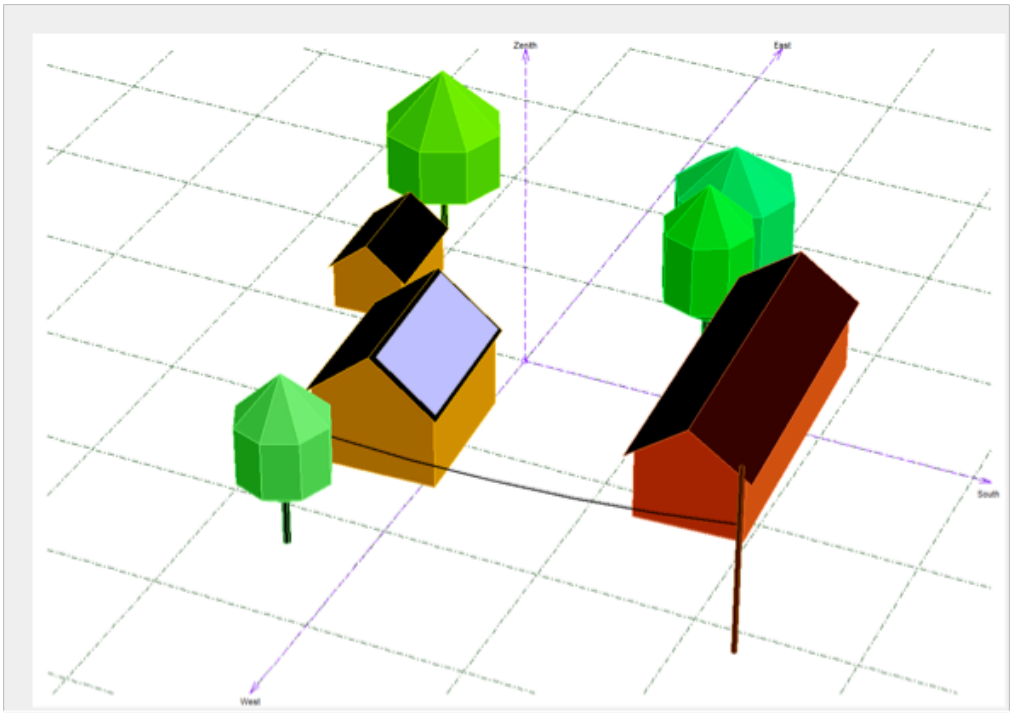

Figure 1: Solar PV Shading Array

HOME ENERGY MANAGEMENT

Figure 2: TED display

We incorporated *The Total Energy Detective (TED)* Electricity Monitor into our design. This system provides the homeowner with the ability to monitor real-time energy use of the following components: lighting, heating, PV production, and appliances. Naturally, it empowers the owner to alter his behavior should he see the need. According to the manufacturer, using a TED system will save a homeowner anywhere from 5 – 30% on his electricity bill, a significant contribution toward lowering the total load and enabling a PV system to cover it fully.[2]

THE TED SYSTEM BENEFITS OVERVIEW

- *Solar* – TED records production and consumption detail as well as showing net monitoring.
- The average TED user saves 5 – 30% off his electricity bill.
- Being 99% accurate, TED will provide exportable data.
- Affordable – the average TED user finds the unit to pay for itself within a year.
- TED helps users discover energy hogs and phantom loads.
- Allows users to predict their monthly bills using local utility rates.[3]

HEATING SYSTEM MANAGEMENT

As mentioned and outlined in our space conditioning section, we chose the Nest thermostat to regulate our heating system and reduce heating cost by 20%, an efficient measure to assist our Net-Zero achievement.

THE MONTAGE ENERGY CONSUMPTION ANALYSIS:

***The Montage's* Estimated Total Energy Consumption**		
***does not include water heating cost**		
Component	**kWh/yr.**	**Cost**
Lighting	1700	$ 246.50
ENERGY STAR Appliances	2225	$ 322.63
Electrical Load	2075	$ 300.88
Heating System	2400	$ 348.00
PV Production	-8400	$ (1,218)
Total Energy	0	$ 0.00

Figure 3: The Montage's estimated total energy consumption

RENEWABLE ENERGY SYSTEM SELECTION

To ensure an appropriate renewable energy system selection for *The Montage* at 201 Hubbell Ave, we conducted research, studied the site using a solar site assessment tool (SSAT), and spoke with local contractors about the potential for wind, geothermal, and solar at our location. According to our lot conditions, budget, and goals, we determined a combination of solar PV and solar thermal to be our best option.

Please note that the site specific data is missing because of the EPA's system failure. This tool has been down for several weeks and if there are any concerns on the site specific data anyone may contact James Critchfield from the EPA at (202-343-9442) who is in charge of the system. He would be happy to answer any of your questions or concerns about Northern Forests Solar Site Assessment.

SOLAR ELECTRIC SYSTEM

To provide solar photovoltaic readiness, we followed the Environmental Protection Agency's (EPA) Solar Photovoltaic (PV) Renewable Energy Ready Home specifications (RERH) and filled out the corresponding checklist (Appendix 1,2). Our design meets all of the requirements, for example meeting the minimum dead-load specification for the roof.

The total proposed size of *The Montage's* photovoltaic system is 8kW covering 450 sq. ft of its south facing roof (177° azimuth). It will consist of twenty-seven 275 watt panels that have the production capabilities of 8,400 kWh – 8,840 kWh per year. According to our quote from CNY Solar, the system will cost roughly $12,200 after all state and federal incentives have been applied. Applying a rate of $0.15 per kWh, this system will offset $1,147 of our projected $1,257 annual utility costs.

PV System Financial Analysis		
Cost of System	**$12,200.00**	
Energy Production kWh/yr		8400
Cost of kWh	$	0.15
Utility Cost w/o PV	$	1,257.00
Total Cost With PV	$	110.00
Total Savings	$	1,147.00
Payback of PV System (Years)		10.6

Figure 4: PV System Financial Analysis

This system will be controlled by two string inverters, a Sunny Boy 5000 and a Sunny Boy 3000. The two inverters will be installed in the basement on a 4' x 8' sheet of plywood and fed into a 70 amp breaker in a 225 amp panel box. We used string inverters over micro inverters because they are compatible with a future battery back-up system.

MAINTENANCE OF PHOTOVOLTAIC SYSTEM

Homeowner Photovoltaic Operational Maintenance Checklist					
Quarterly	**Home Owner Inspection**	**Date**	**Date2**	**Date3**	**Date4**
	Remove all debris from top of panels (Branches, leaves, snow, ice etc.) If you feel comfortable (Safety First)				
	Wash all dirt off of panels either in the morning or at night (During mid-day could crack panels)				
	Do not use detergent when washing (WATER ONLY)				
	Inspect Roof Anchors for potential rust (Needs replacement)				
	Inspect for cracks, chips and discoloration in panel and note location for future inspection (This is to ensure the problem does not develop further).				

Yearly	**Installer Inspection Points**	**Date**	**Notes**
	Call and schedule an annual inspection from installer to cover the potential following components:		
	Panel defects and efficiency		
	Exterior Wiring and conduit attachments		

	Anchor bolts (RUST)		
	Panel framework and integrity		
	Inverter efficiency		
	Leaks in battery		
	Storing efficiency of battery		
	Connection with battery		
	Connection with Panel Box		

Figure 5: PV Homeowner Maintenance Checklist

SOLAR THERMAL

With 2x6 studs, The Montage is equipped to support the additional load of a solar thermal system on its south facing wall. This placement was chosen according to the advice of Gary Klein who urged us to make sure the system would not produce more than needed during the summer. Overhangs and deciduous trees will shade the array during the hot summer months; in the winter, when the sun is lower in the sky and leaves are off of the trees, they will be fully exposed.

A solar thermal evacuated tube system was selected and sized to reduce the domestic hot water load for *The Montage*. By adding the system to our already very reduced utility cost, we offer the owner an estimated monthly utility cost of $2. We followed the EPA's Solar Water Heating (SWH) Renewable Energy Ready Home specifications (RERH) and filled out the corresponding checklist (Appendix 3,4) The checklist covers all relevant solar data such as azimuth of the system, potential tilt, size of system, location of system, and any solar shading. This system will offset most of *The Montage*'s hot water production.

Solar Thermal Financial Analysis	
Cost of System (No Incentives)	**$6,000**
Cost of System (With incentives)	$ 1800
Estimated Total kWh Savings/yr.	552 kWh
Cost of kWh	$ 0.15
Total Cost Savings/yr.	$ 80
Payback in Years (No incentives)	75
Payback in Years (With incentives)	22.5

Figure 6: Solar Thermal Financial Analysis

MAINTENANCE OF SOLAR THERMAL:

- Make sure there are no leaks in the system.
- Clean any debris form the surface of the collectors regularly.
- Ensure your pump is working (cost to replace $200-300 and lasts about 10 years).
- Have the collector serviced or checked by the installer every year.
- TED helps users discover energy hogs and phantom loads.
- Touch the tubes while the system is on to ensure it is warming the water.

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[1] Bails, Allison. " *These Ain't Yer Grandpappy's Heat Pumps*." Energy Vanguard Blog. Web. 29 Mar. 2014.

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CONSTRUCTION DOCUMENTS

See Construction Documents Folder

THANK YOU!