**Building America Whole Building Research Projects**

# FINAL REPORT NEBRASKA STATE ENERGY PROJECT RESEARCH

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# Introduction

The National Renewable Energy Laboratory (NREL) is the technical field manager for the U.S. Department of Energy's (DOE) Building America Program (BAP). The goal of the BAP is to develop innovative system engineering approaches to advanced housing that will enable the U.S. housing industry to deliver affordable and environmentally sensitive housing while maintaining profitability and competitiveness of homebuilders and product suppliers.

The Consortium for Advanced Residential Buildings (CARB), led by Steven Winter Associates, is one of five Building America teams working throughout the country. For innovative building energy technologies to be viable candidates over conventional approaches, it must be demonstrated that they can cost-effectively increase overall product value and quality while significantly reducing energy use and use of raw materials.

The long-term energy related goal of NREL/DOE's Building America Program is to reduce total energy use in new housing by an average of 60% and existing housing by an average of 30%. In FY04, the teams targeted 40% energy savings through energy efficiency improvements in new housing. Reductions in all energy end uses were required to meet these goals, including reductions in: space conditioning loads, water heating loads, lighting loads and plug loads. At a minimum, systems engineering research projects included in the program targeted 40% energy savings in new buildings when compared to the "Building America Research Benchmark Definition".

This is the final report on the Nebraska State Energy Project, for which Building America provided technical support to the Nebraska Energy Office. The mission of the Nebraska Energy Office (NEO) is to promote the efficient, economic and environmentally responsible use of energy. The NEO has been a leader in many of Nebraska's progressive and successful initiatives, including sustainable and green programs. Targeting energy-efficiency in housing, the NEO seeks to demonstrate that affordable housing can be designed and constructed to reduce operating costs for low-income families, while maintaining comfort, healthy indoor air quality, and durability.

To achieve this goal, the NEO partnered with the Consortium for Advanced Residential Buildings (CARB) to design and construct an affordable and energy-efficient prototype home. The requirements of the Nebraska Certified Green Building Homes Program (NCGBHP) were used as the basis for the prototype design. This program sets energy and environmental standards for new construction. With a desire to impact the state's first time home buyer affordable housing market, keeping first costs low is a key component of the project. With the guidance of CARB and the Building America program, the demonstration home built in Lincoln serves as a replicable example of energy-efficient, affordable housing.

This home will become Nebraska's benchmark for truly affordable housing. Using Building America's research, technology implementation, and technical support, the home was designed and value-engineered to be an affordable Nebraska Green Built Home. The project was documented to create a building system performance package with complete specifications. This package will be proposed to the Governor, Legislature and the building industry as the State's standard for the construction of homes in the first time home buyer, affordable housing market.

NEO/CARB Prototype

## Project Time Line

| | |
|---|---|
| May 29, 2004 | Sent Preliminary Construction Drawings and Specs to NEO for Review |
| July 13, 2004 | Sent Revised Construction Drawings to NEO for Bldg. Department Review |
| August 4-5, 2004 | Contractor Meeting held by CARB in Lincoln, Nebraska |
| August 19, 2004 | Contractor Bid Submission Deadline |
| Late August 2004 | Contractor Selection Deadline (Ken Inness was chosen) |
| September 23, 2004 | Excavation Start Date |
| Sept 27 - Oct 1, 2004 | Foundation Formed, Poured, and Stripped |
| November 1-4, 2004 | Advanced Framing, CARB onsite |
| December 6, 2004 | Spray-Foam applied to Rim/Band Joist (Eco-Green Enterprises, LLC) |
| December 7, 2004 | Air-Sealing of the Home, CARB onsite |
| December 7, 2004 | Home Tour for Nebraska State Home Builders Association, CARB onsite |
| December 6-8, 2004 | Mechanical Installation, CARB onsite (Bryant Heating and Air) |
| December 14, 2004 | Blown-In Wall Insulation |
| January 15, 2005 | CARB Spoke with Lincoln Mechanical Contractor to Resolve Code Issues |
| February 4, 2005 | Home Completion Date |
| February 7-11, 2005 | Home Open for Showing |
| February 16, 2005 | Final Performance Testing by CARB |
| February 17, 2005 | Home Tour for Students of Local Technical College, CARB and NEO |
| March 1-31, 2005 | Home Open for Showing |
| May 8-15, 2005 | Parade of Homes Event |
| TBD | Ribbon-Cutting Event |

## Preliminary Design Review

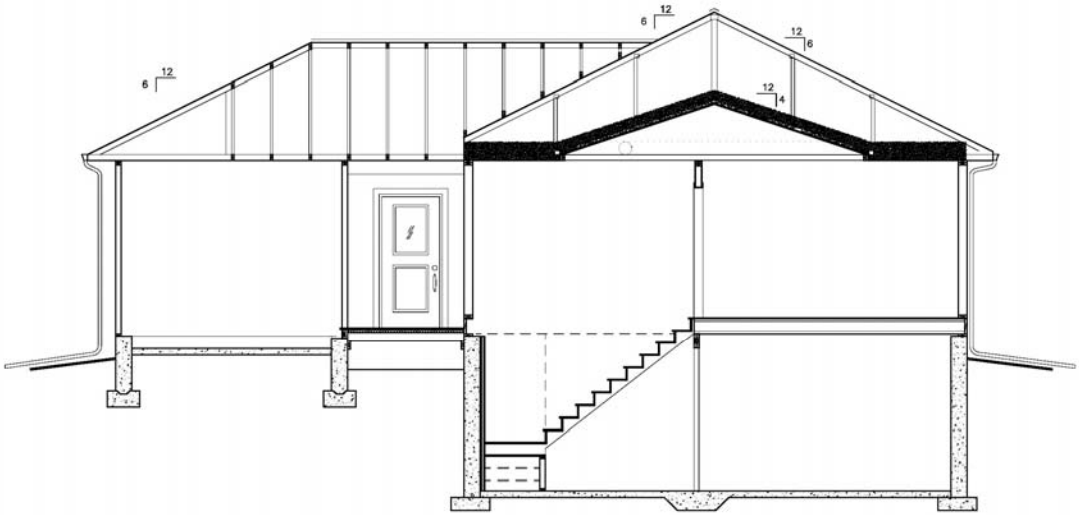
CARB worked with the NEO to develop plans that would meet the needs of first time homebuyers, be replicable throughout the state, comply with the local codes for Lincoln, and achieve high energy performance. The NEO worked with the Building Department to review the design drawings provided by CARB for code compliance. After all of the code issues were resolved, a revised set of plans was provided to local contractors to obtain cost estimates. Ken Inness, of Inness II Homes, was selected as the contractor for this prototype. A veteran homebuilder, Ken's interest and enthusiasm largely contributed to the success of this project.

## Prototype Design

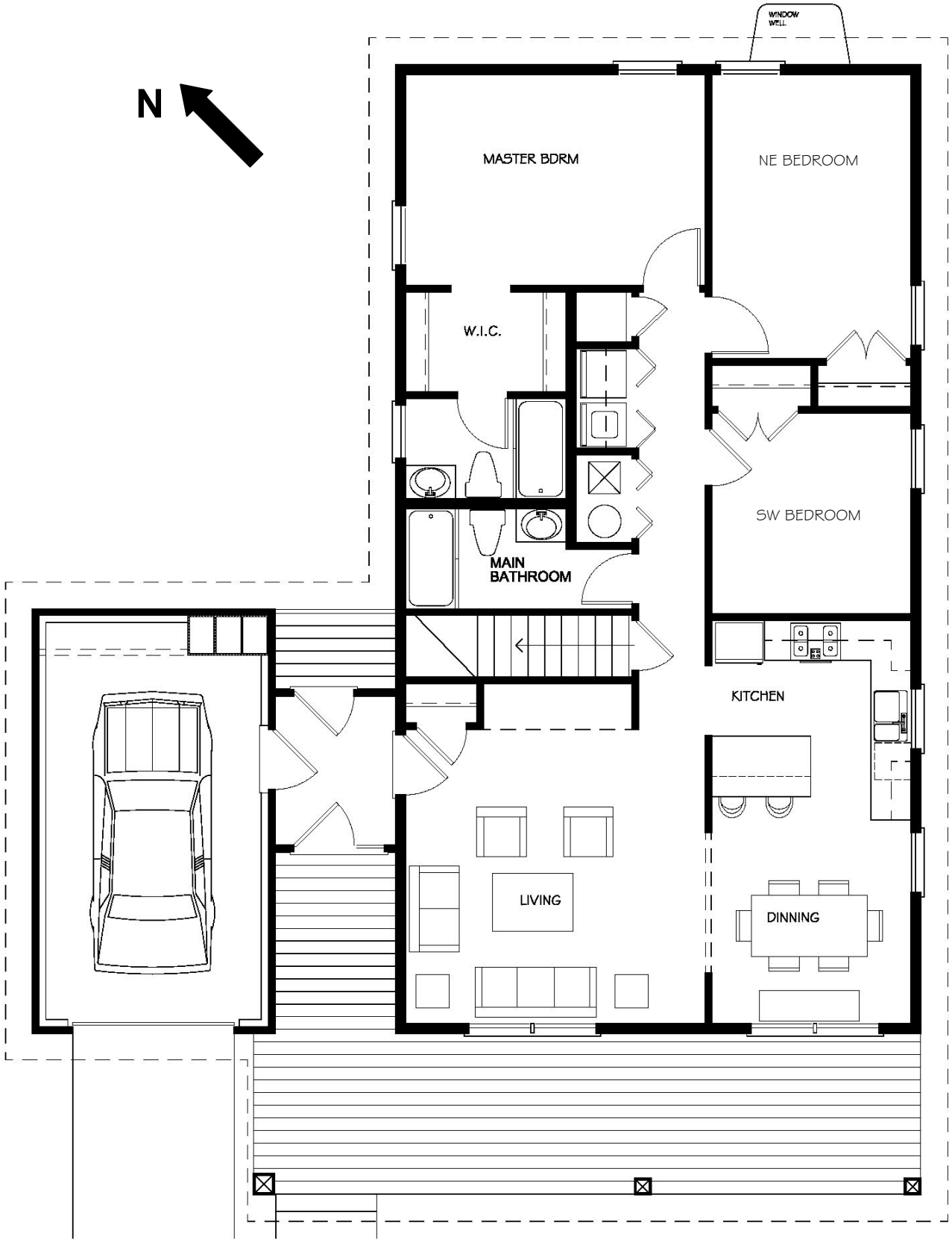
The elevation, section, and plan on the following pages show the design of the demonstration home that was built at 2410 SW Paul Whitehead Lane; Lincoln, NE. It is a single story home that can be built on either a basement or a slab on grade. With approximately 1,250 $ft^2$ of living space, the layout includes: three bedrooms, two baths, a living room, a separate dining room adjacent to the kitchen, and a washer and dryer located on the first floor.

One unique feature of this house is the plenum truss, designed to accommodate the home's supply air ductwork. As shown in the section, the plenum was designed into the roof trusses and provides a space to run ductwork. By insulating over the plenum, the ducts remain in the conditioned space without the added cost of soffits and dropped ceilings.

Nebraska Prototype Elevation




Nebraska Prototype Section

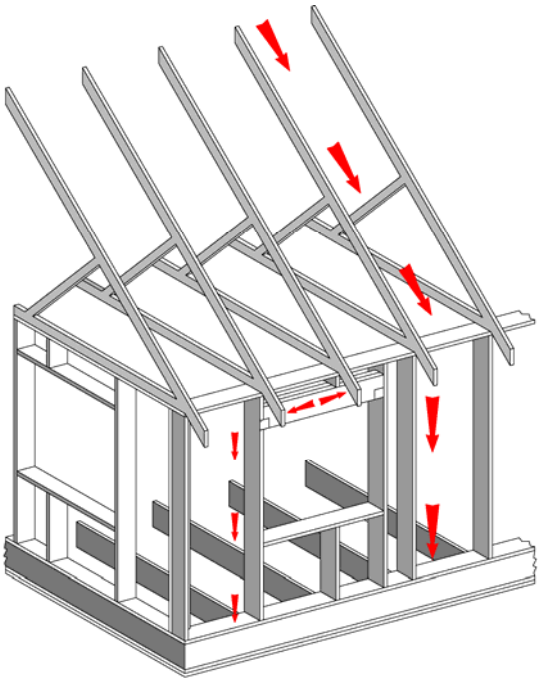



Nebraska Prototype Floor Plan

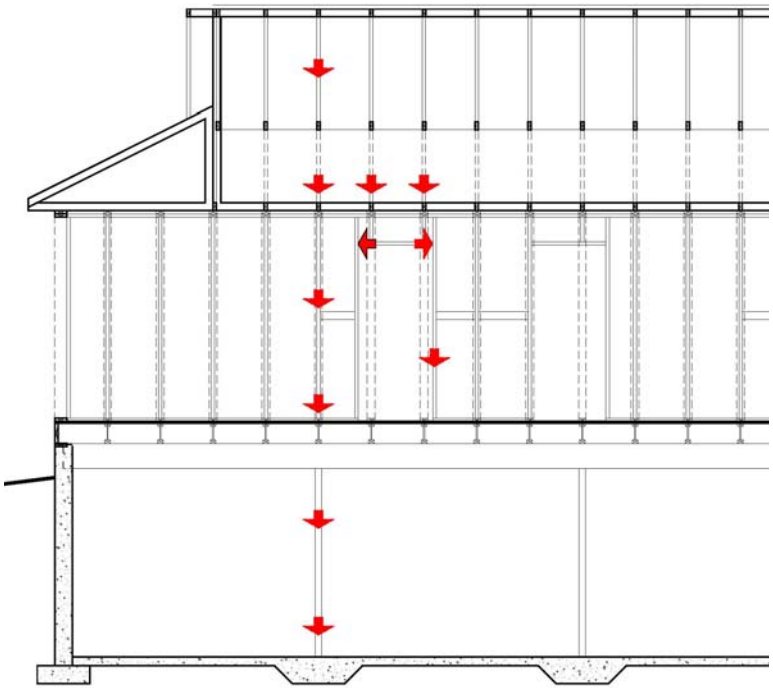
# Advanced Framing

A key part of keeping this project affordable was the implementation of Advanced Framing Techniques, also known as Optimum Value Engineering (OVE). OVE refers to framing techniques that reduce the amount of lumber used to build the home while maintaining the structural integrity of the building. Using OVE techniques results in lower material and labor costs and improved energy performance for the building. Framers unfamiliar with the techniques typically need training and more planning is required when using these techniques.

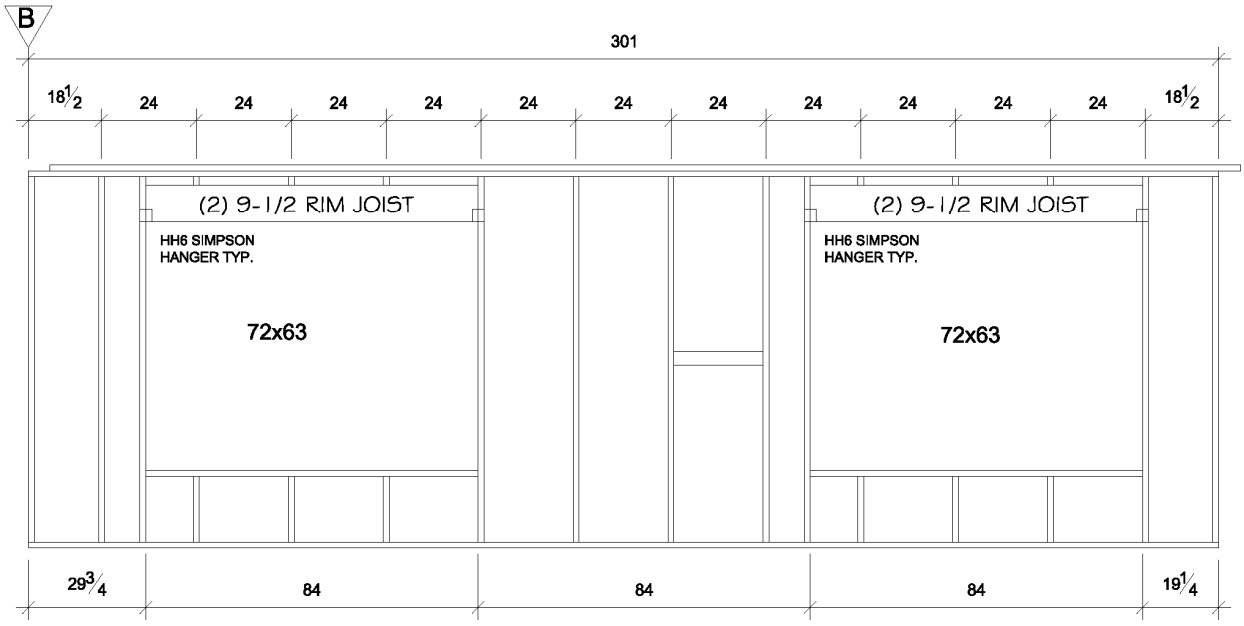
By incorporating OVE Framing techniques, the layout was simplified and the materials used to frame the prototype were reduced. The plan was designed on a 24" grid, which optimized the use of all sheet materials, such as drywall and oriented strand board (OSB), and coordinated with the spacing of the framing. The walls were framed at 24" on center (OC), rather than the standard practice of 16" OC. As shown in the previous building section, a plenum space was designed into the roof trusses. This plenum, used to carry the HVAC ductwork, was coordinated with the advanced framing layout to simplify both the framing and mechanical systems.



As shown in the diagram on the right, inline framing was used to provide a direct load path from the roof to the foundation. CARB worked with the NEO architect to: rationalize the floor plan for the 24" on center (OC) grid, size and locate the required vertical mechanical chases, and develop a full set of advanced framing drawings. Window, door, and bearing wall locations were shifted to fit into the 24" OC module, as shown below. To maintain the alignment all the way to the foundation, the roof trusses and floor joists were also spaced at 24" OC. The increased spacing reduced the number of floor trusses required. A sample of the advanced framing drawings is shown on the following page.



Other advanced framing strategies included header hangers over the windows to eliminate the need for jack studs, open 2-stud corners, and ladders for intersecting walls. These strategies all reduced lumber while increasing the free wall area for insulation, improving the overall U-value of the wall assembly.




Sample Advanced Framing Elevation

11-1/4" Engineered Floor Joists at 24" OC

End of Day 1: Decking Done, Walls Begun

Header Hangers replace Jack Studs at Windows
Note the reduction in Framing Members

End of Day 2: Walls/Exterior Sheathing Complete
Note the Ladder Bracing and 24" Grid Layout

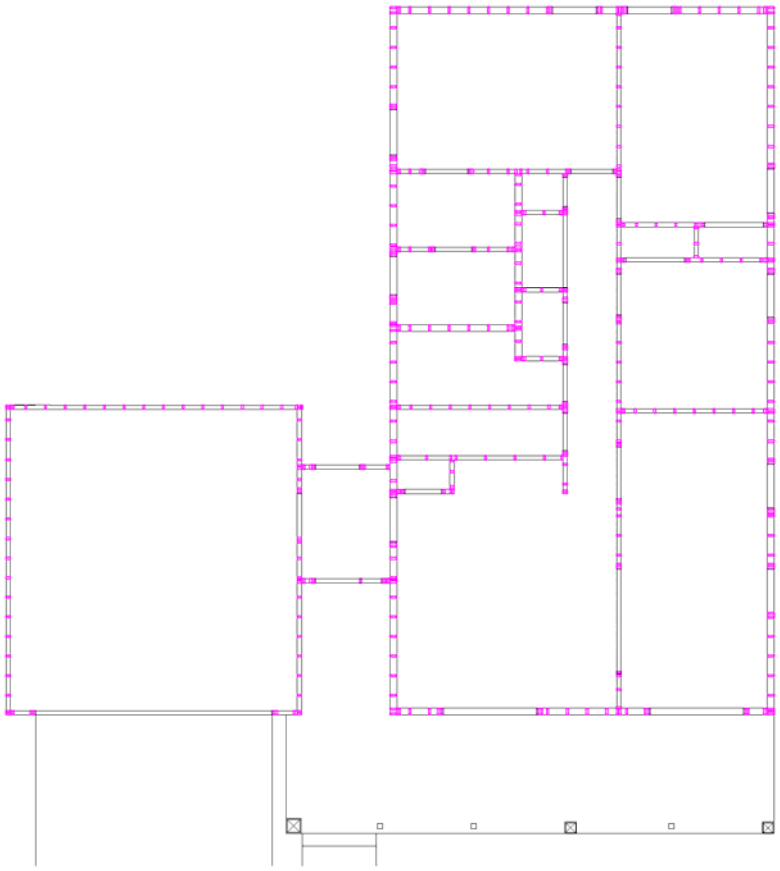
Weather Resistant Barrier and Roof Trusses
Note Roof Trusses spaced at 24” OC

End of Day 3: Plenum Trusses Set

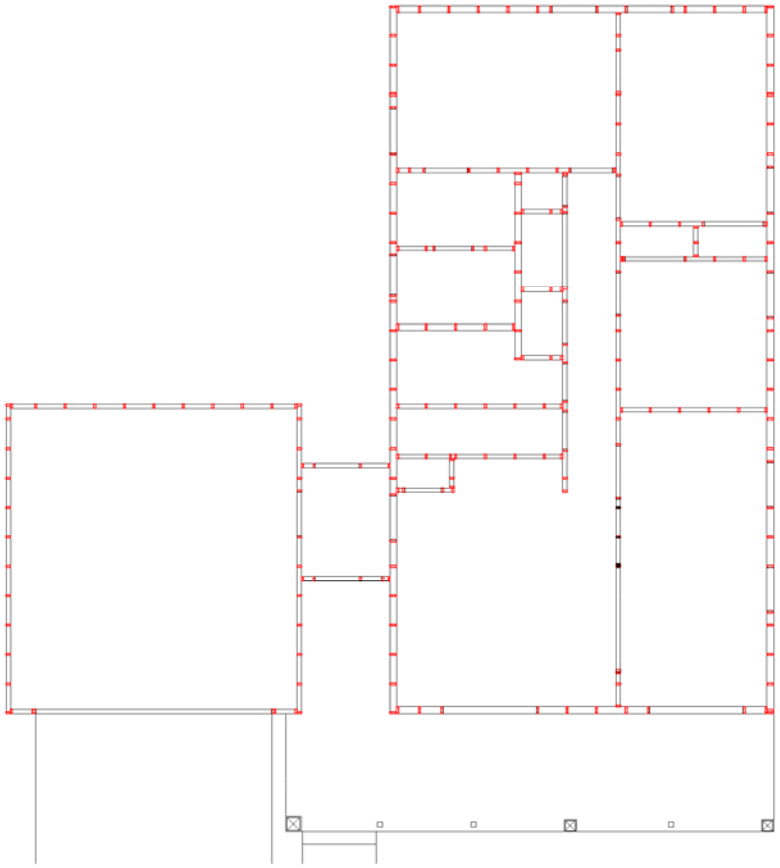
2x6 Exterior Walls with Double Top Plate

End of Day 4: Garage & House Framed

Through the use of Advanced Framing Techniques, CARB calculated a savings in wall lumber of 38% over the standard practice of 16 inch on center framing. At 16” OC, the house would have required 1,761 board feet of lumber. Shifting to 24” OC, the lumber was reduced to 1,082 board feet. Similarly, there were savings associated with shifting the floor joist spacing from 16 to 24 inches on center. As standard practice, this home would be built with 9-1/4” TJIs at 16” OC and require 1,066 linear feet. For the prototype, the home was built with 11-1/4” TJIs at 24” OC. The required linear feet of TJIs dropped to 650, a 39% reduction in lumber. The drawings on the following page show the difference in lumber density found when switching from 16” OC to 24” OC and implementing OVE framing.



16” OC Framing



24” OC OVE Framing