Table 2. Nebraska Certified Green Building Homes Checklist Summary

	Category	Options (Pts Scored / Minimum)	Description
1	Lot and Siting	3/2	Recycled Decking Material, Covered porch on south side, Covered outdoor living area (10% of living area)
2	Waste Reduction & Recycling	2/2	Built-in recycling center w/ 3+ bins, Construction waste recycling program
3	Foundation	4/2	Poly vapor barrier under slab, 20% local fly ash in concrete, non-leaching damp proofing, Aluminum foundation forms used
4	Building Envelope Design	9/5	Exceeded IECC 2003 by 30% (HERS 86), air infiltration barrier, Blower Door test at completion, Air Sealing, 100% of south glass shaded (June-Aug), glazing on all elevations < 6% of total finished floor area, south glass area <10% of finished floor area, energy heel trusses, natural day light entering space from 2 sides of rooms in over 60% of livable floor area
5	Exterior Walls	3/2	Locally produced brick, light colored exterior siding, recycled content sheathing (OSB)
6	Insulation	3/1	Soy-based spray insulation (CFC/HCFC-free), Thermax & Optima Insulation (Formaldehyde-free), Fiberglass with 15% recycled content
7	Roof Materials & Construction	3/2	30-year roof material, Light colored roof, vented roof cavity
8	Indoor Air Quality	4/2	Backdraft dampers & timer switches on all bath fans, sealed-combustion gas furnace, power-vented water heater, radon mitigation and sealed sump pit installed
9	Doors	1/1	Recycled-content interior doors
10	Windows	5/2	Low e/Argon Windows (U=0.33), Vinyl frames, Window glazing exceeds R-3, No metal-framed windows in home, light-colored window treatments
11	Structural Frame	4/3	Limited large dimension lumber, Engineered wood “I” joists for floor, Roof trusses, OVE framing techniques
12	Mechanical Equipment & Design	7/7	SEER 12 A/C, Direct-Vent Furnace (94.3% AFUE), Programmable Thermostat, Ductwork sealed with Mastic, Mechanical zoning for every 1500 ft^2, air handling unit located within 15% of the horizontal center of the living space, all ductwork within the conditioned space
13	Water & Water Heating Equipment	10/8	Energy Factor of 0.61, ½” insulation on all hot water lines, heat traps installed on all hot and cold connections to water heater, low flow shower heads, low flush toilets, power-vented water heater, lawn seeded with grass that requires less water, copper piping used for potable water lines, No garbage disposal (to encourage composting)
14	Finishes and Adhesives	3/2	Low VOC interior paint, Gypsum wallboard with least toxic joint compound, carpeting tacked rather than glued
15	Appliances	2/1	Energy-Star rated dishwasher, Built-in microwave oven provided
16	Lighting	8/8	Fluorescent lighting in kitchen and baths, switches for most efficient lighting located nearest doors, All exterior lighting is photocell controlled, No recessed can lights (unless IC rated), Light colored interiors and floor coverings, CFL light fixtures for at least 50% of fixtures
17	Cabinetry and Trim	2/2	Finger-jointed trim, Urea formaldehyde-free products throughout
18	Finish Floor	2/2	Recycled-content carpet pad, recycled-content carpet
	Total	**75/54**	

Prototype Features

As outlined in the preceding specifications table, this prototype features a number of upgrades and new technologies. For the Nebraska Energy Office, this prototype was an opportunity to learn more about the Building America "Systems Approach" to design and the opportunities for cost shifting. Although this home includes a high performance envelope and upgraded mechanical equipment, the construction costs had to be consistent with affordable housing in the Lincoln area. Some areas of interest are highlighted below.

Foundation Insulation

CARB has been performing on-going basement insulation testing in a home in Chicago, Ill. Results of this testing show that interior rigid insulation strategies perform well. Two inches of foiled-faced polyisocyanurate, non-HCFC, closed-cell rigid foam insulation (R-6.5/inch) were installed on the interior side of the foundation walls.

As shown on the right, the insulation extended from the bottom of the truss cords down to the floor. Each seam was sealed with metal tape to prevent air movement behind the insulation. This strategy is simple to install and provides a high insulating value for the basement walls, while reducing concern about moisture problems. By insulating the walls, the entire basement becomes conditioned space.

Spray-Foam Insulation

The rim joists in this home were insulated with Insulgreen, a spray-in-place high density soy-based foam insulation product. Produced in Nebraska, this insulation material is made of soy bean by-products and is CFC, HCFC, and Formaldehyde free. These characteristics made it an excellent insulation choice to comply with the Nebraska Green Program. In addition to having a high insulating value (R-6. 5/inch), this product is impermeable to moisture and creates a strong air barrier.

Controlling air and moisture problems is extremely important, particularly at the foundation. Typically in Nebraska, builders install batt insulation at the rim joist. Moisture migrates up from the concrete foundation, where it can collect in the fiberglass batt. This reduces the effective R-value of the insulation and results in moisture accumulation behind the batt. The impermeable foam mitigates these moisture concerns. As shown in the photographs below, the rigid insulation applied to the walls provides a lip hold the spray-foam in place. The spray-foam insulation also provides a tight seal around any penetrations.

Tightly sealing all penetrations

Applying Spray-foam to the band joist

Spray-foam was also used to insulate the window headers. The use of window header clips is one of the advanced framing techniques implemented in this home. These clips reduce the amount of lumber over the windows, leaving a cavity that can be insulated. Spray-foam is a simple way to get a high insulation R-value in this often overlooked part of the building envelope. Since the contractor was already on-site, it added very little cost to the project.

CARB also requested that the insulation contractor seal the plenum truss with spray-foam. The plenum truss, which will be discussed in greater detail in a subsequent section of this report, was not built according to the original design specifications. The sheathing material specified was not available locally, so the builder was forced to experiment with readily available products. Unfortunately, the result was less than satisfactory for both CARB and the builder. To add rigidity and provide a tight air seal, CARB suggested applying a thin layer of spray-foam over the top of the entire plenum. Although this was an expensive fix, it is part of the learning curve associated with any new technology. In the end, it was a successful solution to an unexpected problem.

Insulating the window headers

Sealing up the plenum truss

Air-Sealing

CARB worked with the builder to educate him about the importance of air sealing the home. The builder went to great lengths to make sure the home was well-sealed. As shown in the photographs below, all exterior penetrations were foamed or caulked to reduce air infiltration. The top and bottom plates of all walls were also caulked to reduce infiltration. This excellent air sealing job, in conjunction with the spray-foam insulation discussed previously, resulted in a tight building envelope.


Caulking the Top Plate


Sealing the Bottom Plate & airtight electrical boxes

Builder sealing around windows

The materials used to seal the house

Blown-In Fiberglass Insulation

As standard practice in Nebraska, exterior walls are framed with 2x4 lumber at 16 inches on center and insulated with R-13 fiberglass batt insulation. Through the use of advanced framing techniques, including 2x6 walls at 24 inches on center, the overall R-value of the envelope is greatly increased. Gaps and compressions in batt insulation can reduce the R-value of the insulation and create potential cold spots, impacting durability and occupant comfort. Blown-in insulation systems conform to each cavity, eliminating these gaps and cracks. Blown-in systems not only ensure proper installation without third-party monitoring, they have the added benefit of increased air sealing and higher R-values. The blown-in insulation specified for this project has a rating of R-22. The images below show the installation process.

Filling the Cavity

Insulated Wall Section

Insulation Truck

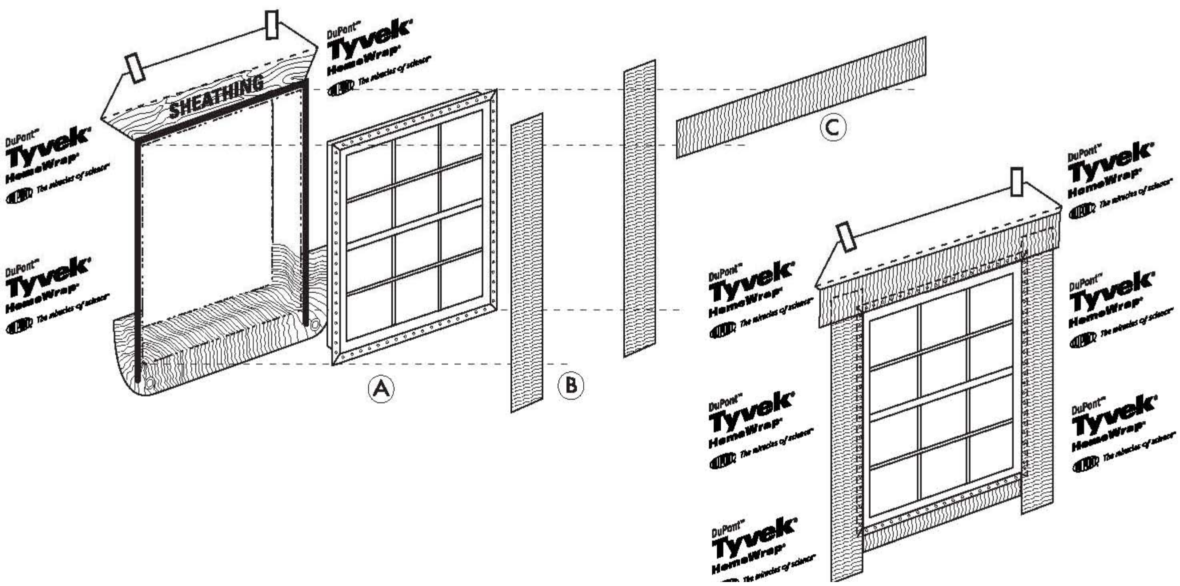
Windows

In the prototype, the builder installed Simonton ProFinish Contractor Series, Single-Hung, Vinyl, low e, argon-filled windows with grids (U = 0.33, SHGC = 0.28). A requirement of the Green Building Program, these high performance windows have many benefits. The low e coating reduces the solar heat gains, resulting in a smaller cooling load and allowing the designer to down-size cooling equipment. The lower thermal transmission also decreases the heating losses and increases comfort within the spaces. Since high performance windows were used, it was not necessary to have heating and cooling supply registers under each window. This allowed the diffusers to be kept in board, aiding in the compact duct design.

Weather-Resistant Barrier Installed

Simonton Window

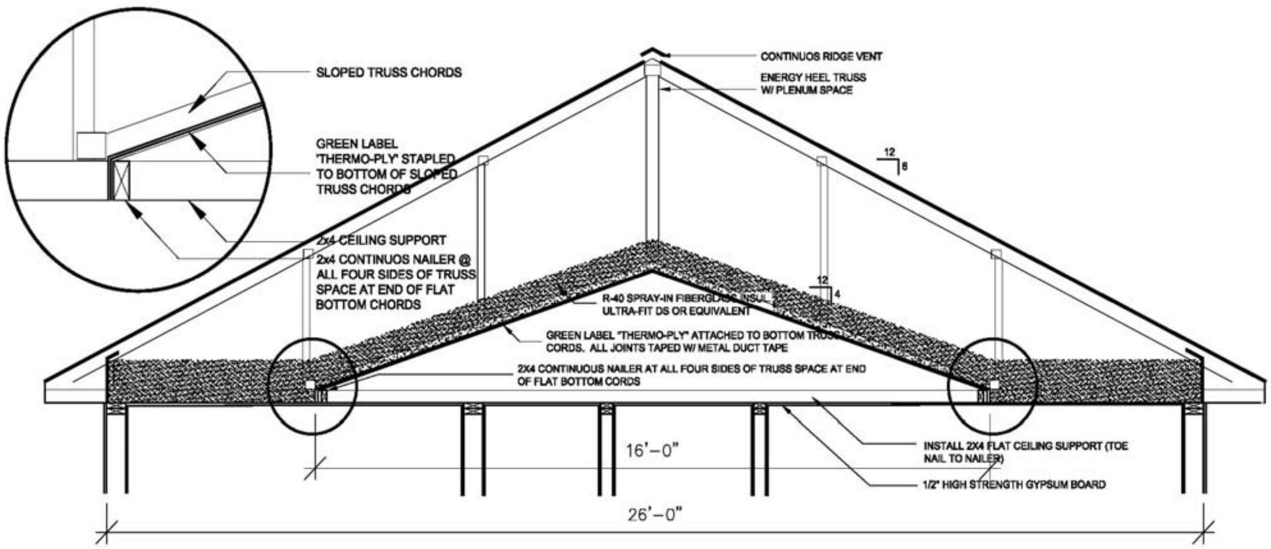
CARB also made recommendations for flashing the windows. This home was covered with house wrap to provide a weather-resistant barrier. As a best practice, CARB recommended the flashing detail specified by one of the house wrap manufacturers, which prevents moisture intrusion by shingling. As shown in the detail below: butyl tape is applied to the bottom of the window opening, the window is installed, the sides are sealed with butyl tape, the house wrap is folded over the top of the window and secured in place.



Manufacturer's recommended window flashing detail

Plenum Truss

A key component of the prototype design is the plenum truss, which enables the design to be replicable for homes built on either a basement or a slab on grade. Using specially designed scissor trusses for the roof system, a cavity was created to house the ductwork. With careful insulation and air sealing practices, the plenum became part of the conditioned space. This added flexibility to the floor plan, while increasing the energy efficiency of the air distribution system by allowing the ducts to remain in the conditioned space. The need for soffits and dropped ceilings was eliminated and the aesthetics of the home were not impacted by the duct system. In addition, this home can be built on either a basement or slab on grade without changing the duct layout. See the plenum elevation detail below.

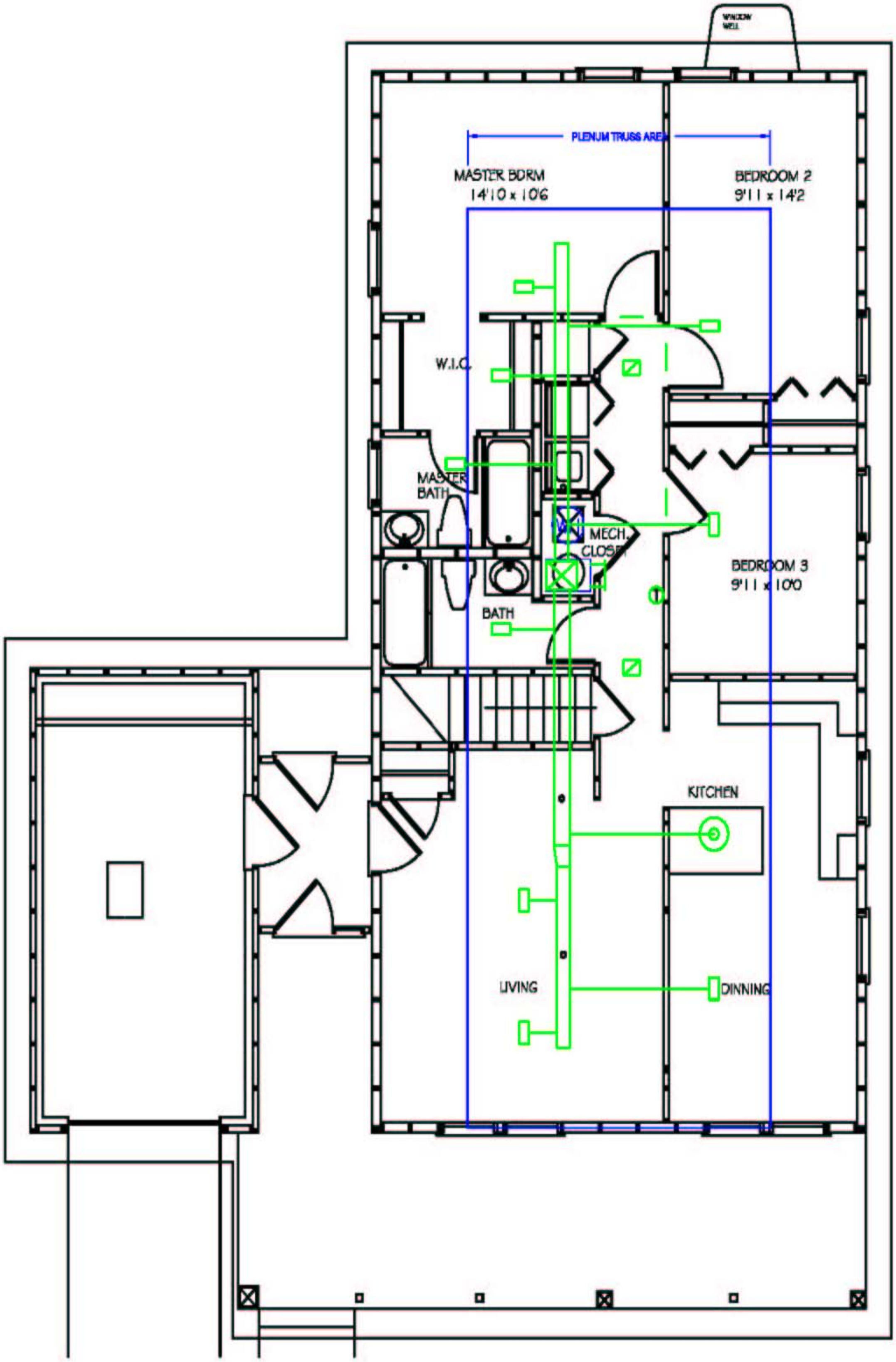


Plenum Truss Detail

As discussed previously, there were some problems obtaining the appropriate materials to construct the ceiling of the truss. In the original design, CARB specified “Thermo-Ply” sheathing for the rigid material attached to the bottom side of the upper truss cords. Typically used as a structural sheathing, Thermo-Ply is comprised of fiberboard with foil on two sides. CARB specified this material because it was lightweight and inexpensive, could be sealed to prevent air leakage, and had a fire rating. Unfortunately, Thermo-Ply was not available locally.

Instead, the builder installed a radiant barrier material with two layers of barrier bubble film laminated between two layers of foil. Although this material had foil to provide the necessary fire rating, it was extremely difficult to air seal. In addition, it lacked the rigidity necessary to adhere it to the truss chords. To rectify the problems with air sealing and add structural stability, CARB recommended the top surface of the plenum be coated with spray-foam. As discussed earlier, this solved the problem and ensured the plenum was tightly air sealed.

The floor plan on the following page shows the plenum in plan view outlined in blue. The ductwork, shown in green, fits neatly and compactly into the plenum. CARB coordinated the compact duct design with the plenum truss design. Pictures of the completed truss are also included in this section.



Plan View of Plenum Truss and Duct Design

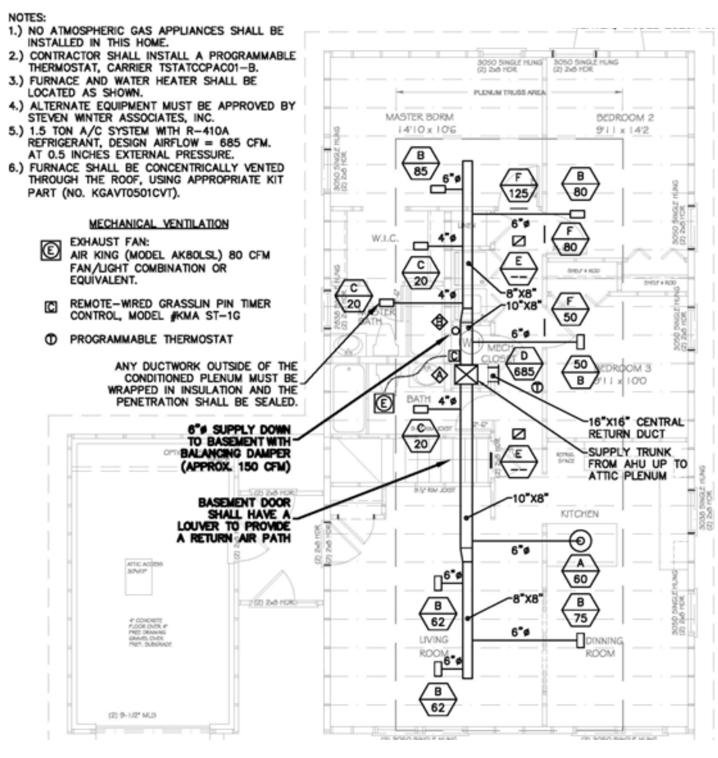

Underside of Plenum Truss with Foil-faced Bubble material exposed


End of Plenum Truss with Spray-foam sealing the gable ends and top surface

Compact Duct System

As previously discussed, this home features a compact duct system integrated into both the plenum truss and architectural designs. As part of the demonstration project, the HVAC layout was designed for a home that could be built on either a slab or a full basement. To meet this unique requirement, all the ductwork was designed into the plenum truss overhead and the supply registers were placed in the ceiling. In a home with a full basement, like the prototype, the ductwork and equipment could easily be located in the basement and floor registers could be used as an alternative.

CARB performed energy modeling, sized and specified the mechanical equipment, designed the duct layout, and provided detailed HVAC drawings. Using Wrightsuite Residential software (version 5.9), the HVAC system and ductwork were sized according to Manual J load calculation procedures. The system was designed to minimize ductwork, keep all ducts within the conditioned space, and provide balanced supply and return airflows. A mechanical closet was provided on the main floor for supply trunks and the central return, eliminating the need for ductwork in exterior walls. No panned ductwork was permitted and the system was sealed with mastic to reduce duct leakage. As shown in the photographs below, the home has a single central return on the 1st floor and transfer grilles from each of the bedrooms.



HVAC Drawings & Specifications by CARB

Overhead Supply Branch

Main Supply Trunks

HVAC Closet & Low Central Return

Over Door Transfer Grilles

3-Way Supply Register

Duct Sealing with Mastic
For this home, the mechanical contractor agreed to seal all the ductwork with mastic. This is a requirement of the Nebraska Certified Green Building Homes Program and a new requirement under the 2003 International Energy Conservation Code (2003 IECC). CARB was onsite to oversee the duct system installation and sealing. Unfortunately, the return plenum was not sealed prior to installation and was difficult to seal after the fact. While onsite, CARB had an opportunity to discuss the new requirement for mastic in the 2003 IECC with some HVAC contractors. In general, the HVAC contractors seemed doubtful that this requirement will be enforced. However, they were quick to point out their willingness to adopt the new practices, as long as the builders are prepared to pay for the additional labor hours.

Even with the duct sealing, the finished HVAC system for this home was assembled very quickly. The return plenum and unit had been installed during a previous visit. All the supply ductwork was installed and sealed by a single technician in less than two days. The process would probably have gone faster with an additional set of hands, since much of the work was done in the trusses overhead. However, the system was simple to install and the technician had no complaints. See photos of the mastic below.

Mastic-Sealed Vertical Supply Plenum and Horizontal Trunks

Sealed Side and Bottom Branch Take-Offs

Applying Mastic over Fiberglass Mesh Tape to seal a curved supply branch

Materials: Mesh Tape, a Paint Brush, Bucket of Mastic, and a roll of Insulation Wrap