# High Performance Home Case Study


## Gerber Homes

Gerber HOMES

*We Build Dreams.*
*Families Live Them.*

ROCHESTER HOME BUILDERS' ASSOCIATION INC

NEWPORT VENTURES

NYSERDA

# High Performance Housing with Gerber Homes: A Case Study

## About the Challenge

The New York State Energy Research Development Authority conceived the High Performance Residential Development Challenge as a program to provide builders with incentives and expertise in building higher energy efficient homes. The HPRDC set a target goal of energy efficiency at 65% or better than homes built to the 2004 International Energy Conservation Code – far beyond what builders typically build today. Newport Ventures served as a building consultant in the project, modeling builders' reference homes and working with builders to redesign the plans for energy efficiency. Focus was given to the building envelope and mechanical systems, and incremental costs of energy efficiency improvements were quantified to estimate benefits. Finally, short term energy tests and long term energy monitoring were conducted to enable comparison of the finished product to the model.

## About the Builder

Gerber Homes, Inc., a family owned and operated home building business, has been building and renovating homes in the Greater Rochester area for more than 45 years. Having built over 2000 homes, with at least 250 of those being Energy Star, Gerber Homes prides itself on being on the cutting edge of energy efficiency.

Gerber's focus on energy efficiency started in the 1970's, when the company was trying to find a way to reduce their customer's expensive electric heating bills. They suspected that if they could build a better insulated home, the unavoidable heating bills would be much lower. Gerber began increasing the insulation in the homes and tracking the effects on their customer's monthly utility bills. The extra insulation that was put in the attics and walls during this time resulted in a significant utility cost savings and is used as one of their many standards in all of their home building to this day.

Once word of the results spread, the public was eager to build their own "extra insulated home". It wasn't long before other area builders were making similar changes to meet the new demand. Gerber Homes has continued this innovative thinking over the last 45 years, assessing obstacles, researching and testing options, and collaboratively sharing their results.

Gerber's target market includes first time home buyers, empty nesters, retirees and those moving up to a larger home. Most of their homes, which are typically ranch style, are between 1400 and 3500 square feet. They are considered a custom builder of affordable housing for those of all ages and circumstances. Their target market has expressed an interest in 'in-law' capable ranch homes to enable care of their elderly family members that are also low maintenance, and highly energy efficient.

The Design Home

Gerber Homes' response to the challenge was an enthusiastic one, as they identified this as an opportunity to learn more about energy efficient systems and their associated costs and benefits. For this project, Gerber selected a 2004 sq ft model which was to be showcased in the Rochester Homebuilders Association's 2008 Homearama. Newport Ventures, a building and technology consulting firm, provided design and energy consulting services for Gerber Homes.

Starting with Gerber's baseline systems, Newport recommended multiple building systems to result in a design that modeled to be 61% more energy efficient than a home built to the 2007 New York Energy Conservation Construction Code. Primarily, the design focuses on improving the energy performance of the walls and ceiling to ensure that the home performs well for its entire life. Secondarily, the super-insulated home incorporates a very energy efficient mechanical ventilation system and heating and cooling system. The house finishes out its energy efficiency package through specification of high efficiency appliances and lighting. Gerber's *Build-Green, Live-Green* home is one of seven homes throughout the state built in partnership with Newport Ventures and NYSERDA to provide advanced energy efficient homes.

**Marketing**
Energy efficient features that are behind the wall or tucked away in mechanical rooms can be hard to sell. That is why Gerber decided to show an unfinished home at the Rochester HBA Homearama. While other builders were focusing on finishes, Gerber was showing off their super-insulated building envelope. Letting potential home buyers touch and feel a product really makes a difference. Gerber believes that effective market penetration of energy efficient technologies for the home can only come about by involving both the manufacturer and the builder in marketing directly to the consumer.

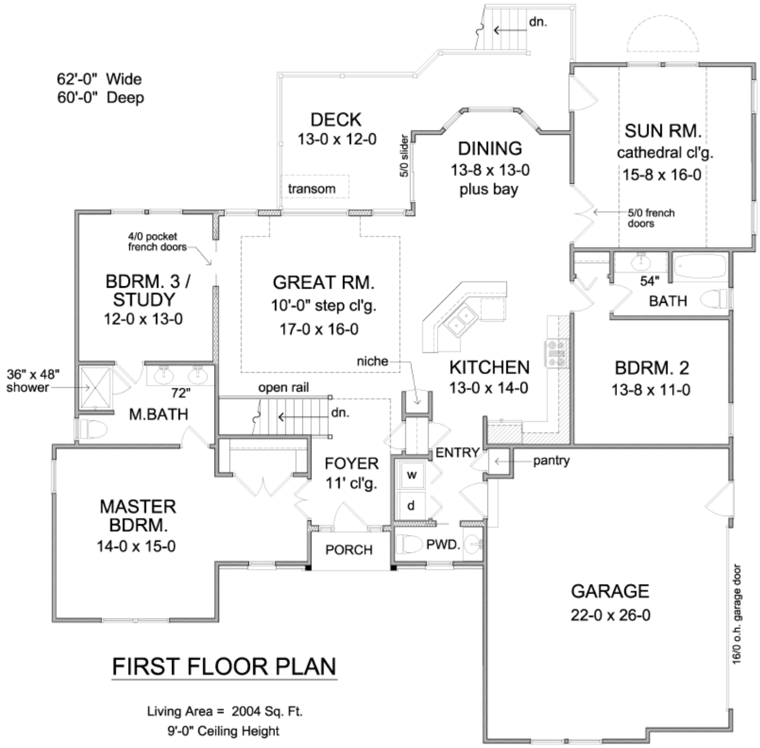
A press conference was held in conjunction with the Homearama on June 17, 2008. The Governor proclaimed the day Energy Efficiency Day.

*Peter Douglas of NYSERDA presents the Governor's proclamation to Gerber Homes founder, Bruce Gerber.*

| Measure | Gerber's Reference Home | Gerber's Design Home | Incremental Cost | Expected Single Measure Savings |
|---|---|---|---|---|
| Ceiling Insulation | R-42 Blown Cellulose | R-50 Blown Cellulose + Raised Hell Truss | $500 | $19 |
| Above Grade Walls | 2x4, 19.2 inches on center, R-13 cavity | 2x4, 19.2 inches on center, R-18 closed cell spray foam cavity insulation, 2" R-10 exterior continuous foam insulation | $7295 | $149 |
| Below Grade Walls | Precast concrete walls with integral R-5 continuous interior foam insulation | Precast concrete walls with integral R-12.5 continuous interior foam insulation + R-21 cavity insulation | $2400 | $267 |
| Domestic Water Heating | 40 gallon, 62% EF, natural gas-fired tank | 82% EF natural gas-fired tankless unit | $721 | $62 |
| Space Heating and Cooling | 92 AFUE furnace, SEER 13 AC | Ground Source Heat Pump | $16,520 | $722 |
| Mechanical Ventilation | Exhaust MV at 100 cfm, 110 Watts | ASHRAE 62.2 compliant Heat Recovery Ventilator | $2,800 | $59 |
| Lighting | 10% fluorescents | 63% fluorescents | $300 | $56 |
| Total Incremental Costs & Expected Savings | | | $30,536 | $1128 |
| HERS Score | 85.8 | 92.4 | | |

Table 1. Baseline home and design home comparisons.

**Figure 1. Front Elevation of Gerber's *Build-Green, Live-Green* Homerama Home located at 11 Tea Olive Lane, Magnolia Manor, Rochester, NY**




In February 2008, Gerber Homes received their building permit and broke ground on their project home.

**Figure 2. First Floor Plan Gerber's *Build-Green, Live-Green* Home.**

Systems targeted for energy-efficiency improvements included:

**Basement Walls:** Energy simulation modeling shows that a typical new NY home's standard basement wall system can account for as much as 27% of the home's heat loss. The Build Green. Live Green's advanced basement wall system is projected to save 14% of the entire home's energy use compared to a standard basement wall system. To achieve a super-insulated basement, Superior Walls' pre-cast concrete walls


**Figure 3. Superior Walls Basement Walls**

with integrated
R-12.5 continuous insulation provided the support. Then Owens Corning's high-density R-21 fiberglass insulation was installed in the wall cavities. Because the basement is unfinished, Owens Corning's permeable house wrap, PINKWRAP®, was specified as the interior finish for its clean and non-abrasive surface that far outperforms code requirements for flame spread and smoke developed index.

Constructability Issues

Typically, unfinished basements of new homes in NY are provided with several supply registers to at least semi-condition a storage space. What starts as a storage space is generally transformed into a fully conditioned, finished space at some point in the future. With only two choices for characterizing the space within energy modeling software (conditioned or unconditioned), the most logical choice was to treat the basement as conditioned. This modeling assumption revealed that there were significant efficiency gains to be had over standard insulation practice in the basement – up to 14% energy savings in this case by going from an R-5 Superior Wall to a whole wall R-value of R-33.5. While this seems like low fruit on the energy efficiency tree, there is a wide chasm between specifying a system and actually achieving it.

Insulating and air sealing an unfinished basement can be a challenge. When a contractor thinks basement insulation, he typically thinks R-11, hanging 4' down from the sill plate of a poured concrete or concrete masonry foundation wall. The Gerber home called for precast concrete walls with integrated and continuous polyisocyanurate foam at R-12.5. To boost the whole wall R-value to R-33.5, the specification called for installation of R-21 in the 2x6 cavities of the precast concrete wall. What seemed like it should take a couple simple steps turned into several. Un-faced fiberglass batts would need to be used to meet the smoke density and flame spread requirements of code. Though the un-faced batts conformed to code, local building code inspectors asked that a finish layer be applied over the batts due to concerns about ambient fibers. Because kraft faced batts would not meet smoke and flame requirements of code, a foil or poly scrim kraft is generally used for this application. Non-perforated scrim kraft finishes have a very low permeability (~0.02 perms) that do not permit the wall to dry to the interior when there is bulk moisture penetration. Owens Corning, who supplied the R-21 batt, suggested their PINKWRAP housewrap product for the finish, which provides a higher perm while performing far better than code requirements as related to smoke and flame. Ultimately, code officials rejected the house wrap as an interior finish due to the product not being labeled as an interior wrap, and the builder was forced to settle for a PSK finish for the below grade walls.

When it came time to actually install the batts, insulation installers were faced with highly irregular stud spacing in the precast concrete walls. "Standard" stud spacing within the walls was given as 24 inches on center, meaning the standard cavity was 19.75 inches wide, once stud width and foam board insulation were accounted for. A large number of the cavities were much smaller than the 19.75 inches – at dimensions of 11 or 9 or 7 inches, which would require trimming all batts to various dimensions to avoid compression and to maintain their rated R-value. All said, the low hanging fruit of basement insulation required coordination between manufacturers, code official, builder, and contractor, with the final installed system unable to provide the same performance as the specified system, due to building official concerns over product labeling.

**Above Grade Walls:** Energy losses through above grade walls account for about 15-25% of the heat load of a typical NY home. To reduce expected heat loss, the first step was to reduce the amount of framing in the wall, by spacing the studs at 19.2 inches on center (the diamond mark on a tape measurer), and using ladder blocking and two stud corners. Reducing the framing members in this fashion means more insulation can be installed in the walls. The Gerber home has both continuous exterior insulation and interior wall-cavity insulation on above-grade walls. Two-inch Dow Styrofoam, rated at R-10, was installed on the outside of the OSB structural sheathing. To help provide a tighter wall assembly while increasing insulation, BASF Comfort Foam was sprayed in all cavities and along band joists, providing a cavity insulation R-value of 18.3. Together, these measures are projected to reduce the home's total energy use by 8%. Improved air sealing resulting from these measures could increase the projected energy savings by another 3%.

In specifying an above grade wall with continuous extruded polystyrene on the exterior and high density spray foam in the interior cavities, it was crucial to detail the flashing around windows and penetrations to avoid future problems with bulk water movement through the assembly. Joints and seams of exterior foam board were taped to result in a code compliant weather barrier, and a Dow representative was on-site to ensure that manufacturer's flashing instructions were followed explicitly during the installation.

**Figure 4. Dow Styrofoam for exterior continuous insulation**

**Figure 5. BASF Comfort Foam cavity insulation**

**Domestic Hot Water**: Standard natural gas fired hot water storage tanks have inefficiencies associated with heating water in a tank—waiting to be used. Tankless water heaters eliminate these standby heat losses because tankless water heaters only heat water when needed. The Takagi TK3 tankless water heater was selected for this project to decrease energy consumption and costs. With an Energy Factor of 0.83, energy savings are expected to be 3% of whole-house energy use, saving approximately $62 annually off of natural gas bills. The unit was mounted on an exterior wall to avoid incremental costs associated with long gas line runs and venting.

**Mechanical Ventilation:** Tight, energy efficient homes need to have ventilation systems that ensure adequate indoor air quality is maintained. Fresh air ventilation systems that use heat exchangers can use less energy than typical exhaust only systems. Broan's HRV100 heat exchanging system was used in this home because it is extremely energy-efficient and satisfies the fresh indoor air quality needs of the home. Compared to a typical exhaust only system, the Broan HRV100 is expected to save 3% of the home's total energy use.

A builder has several options for installing an HRV in selecting the supply and return streams, setting ventilation rates and times, and providing variable controls. The simplest installation typically involves pulling from the central duct return plenum and supplying fresh air to the supply plenum of the furnace. Pulling from the furnace's return plenum and supplying to the return plenum can also be done but generally requires that the central blower operates in tandem with the HRV to avoid short-circuiting ventilation air. This configuration can result in severe energy penalties, especially if configured to run continuously.

For the Gerber home, the "Cadillac" of all installations was selected – a system configured to pull from the three bathrooms in the home and supply to the return plenum of the central duct. Though a smaller model HRV could have been selected to provide the target ventilation rate (based on ASHRAE 62.2 levels), a larger volume unit was selected to permit the HRV to operate at lower speeds and higher efficacies. Variable fan speed and humidistat controls were installed in the bathrooms to boost the HRV from low to high speed during high demand events. With the unit sized to pull over twice the targeted air flow of the home, it was expected that it would operate on medium speed. Field measurements of air flow taken with a digital thermo anemometer (Dwyer Series 471), resulted in fan speeds that fell short of design levels. Though the digital thermo anemometer was selected for its reputed high accuracy, field measurements showed a high degree of variability based on position within the duct. For this reason, no measurements are reported here. Nevertheless, based on low numbers that were reported by the anemometer, the HRV was left on the high speed setting to maximize flow through the ducts.

It is suspected that the layout of the HRV supply and return ducts contributed to the low flow measurements recorded. This was especially true of the return side of the HRV, which consisted of a 6" flex duct with runs from 3 bathrooms. The longest of these runs was 80 feet and included eight 90 degree bends, one 180 degree bend, and one tee. The HRV's supply duct was characterized by 32 feet of 6" flex duct, two 90 degree bends, and two 45 degree bends.

The lesson learned from this install is that what looks good on paper doesn't always play well in the field. The simple solution may be the best, and placement of the HRV and its ducting system should be done through balancing considerations of both anticipated expansion/basement finishing as well as performance of the unit. Further, actual supply and return flow rates of these units can be expected to fall far short of manufacturer's published data due to high static pressure associated with typical installations.


**Figure 6. Broan HRV100h for indoor air quality. Note the two 180 degree bends in the supply and return ducts on the right hand side.**

**CFLs for Lighting**: Changing out inefficient incandescent lights for fluorescent lights can be one of the most cost effective methods for saving energy. The Build Green. Live Green home exclusively uses compact fluorescents and pin-based fluorescent lighting. This single measure is expected to reduce the home's energy use by 3%.

Though the focus of this project was not on lighting, specification of energy efficient lighting can provide an excellent return on investment for home owners. HERS modeling showed that the effect on the HERS score of specifying a 100% fluorescent and compact fluorescent package for the Gerber home came to an increase of one full point over the base case of 10% fluorescent and compact fluorescent package. The builder agreed to specify a 100% CFL and fluorescent package for the home and Newport did not provide any further support in this area, as NYSERDA stressed that lighting and appliances should not be the focus of the project.

When the final walk-through was done, there was only one CFL in the home. When the builder was alerted to this, a punch-list employee was sent to buy and install CFL bulbs. Screw-in CFLs were placed in all fixtures that were easily reachable and that would accommodate the standard base sizing. This amounted to 63% of all lighting for the home. Unfortunately, no consideration was given to placing dimmable CFLs in dimmable light switches, so the CFLs in these circuits performed poorly, flickering regularly. CFLs installed in pendant lighting over the kitchen island were longer than their shades, resulting in an uncomfortable glare. CFLs in recessed cans were not of the flood-light variety, and their appearance could be described as awkward at best. Finally, no CFLs were installed in the candelabra light fixtures, as the punch-list employee was unable to locate these at the local hardware store. All told, a little planning would have gone a long way in specifying the CFLs. A 100% fluorescent lighting package is possible, but requires specification of the right bulb for the right fixture.

**Heating and Cooling**: The minimum code compliant furnace in New York has an efficiency of 80 percent, while the minimum efficiency air conditioner is rated as a SEER

13. The Gerber home uses a ground source heat pump to improve the home's heating and cooling energy efficiency. Water Furnace Envision's high efficiency ground source heat pump is expected to provide between a 40 percent to 45 percent reduction in total energy use from a baseline code compliant home.

**Figure 7. Excavating for the horizontal geothermal loop field. A horizontal installation was selected as a more affordable alternative to a vertical loop field.**

To install a GSHP, Gerber needed to look beyond their typical HVAC contractors. In established relationships with contractors, both builders and contractors have mutual expectations of responsibilities, regardless of what is stated in a contract. Gerber was surprised to learn that a few items that were typically provided by their HVAC contractor were not considered to be within the scope of services offered by the geothermal contractor. For example, Gerber expected that the geothermal HVAC contractor would vent the range hood and also run gas lines. These items were not in the HVAC contractor's contract, so Gerber the cost to Gerber was approximately $600 for these services. The lesson here is that to ensure a fair comparison between alternate technologies and contractors, a full scope of services should be outlined within the contract. Identifying responsibilities up front can save big headaches and budget overruns down the road.

**Attic Insulation:** For this high performance home, the attic's insulation value was specified at R-50, achieved with blown cellulose and raised heel trusses, which permit insulation to be blown all the way to the eaves, providing excellent coverage of the top plate. This measure is expected to result in a savings in whole-house energy use of 0.4%. Further, a weather-stripped foam board cover was specified for the attic access to reduce infiltration and improve thermal performance.

An on-site inspection revealed that attic insulation, which should be about 14.5 inches deep at a typical value of R-3.5/inch, was installed in many areas at 13" deep or less – based on the rulers provided along the trusses. This means that some areas are an R-7 to R-10 less that specified, unless this blow is of higher density than typical. We were told by the HERS rater that this is typical, and that an average number is taken for the install. Based on the average depth of the insulation, the rater listed the R-value at R-50. Also, the inspection revealed that no foam cover or weather stripping was provided at the attic hatch. The home managed to score 2.5 ACH @ 50 Pa without this measure and several other air sealing measures, meaning that a lower score could have been possible with better follow-through on specified measures. Ultimately, the rater adjusted the blower door infiltration number to 2.0 ACH @ 50 Pa once these measures were addressed.

<u>Assessing the Home's Performance</u>

Short term energy monitoring (STEM) tests can be an effective tool to estimate the heating energy use or thermal performance of homes. The resources, effort, and associated expense of these tests vary greatly. Because the NYSERDA HPRDC project seeks to identify cost effective means to demonstrate energy conservation measures in homes, focus was maintained on cost effective, non-invasive STEM testing methods to relate the effectiveness of these measures.

The first STEM test on the Gerber home included four testing points:

- Envelope heat flux measurements
- Duct distribution system effectiveness
- Envelope air infiltration
- Infrared imagery

**Test conditions**

The Gerber home was completed and sold in July, 2008. Because the home owners planned to move into the home in July, it was necessary to perform the STEM test during the summer – resulting in less than ideal conditions. Due to weather constraints (e.g. high outdoor ambient temperatures), the home was heated to 90 degrees to ensure that a significant temperature gradient existed across the envelope. This temperature gradient was necessary to produce meaningful infrared imagery and heat flux measurements. A delta T of at least 20 degrees was maintained across the envelope for the STEM test. Wind conditions were negligible.

**Envelope Heat Flux Measurements**

To compare actual values versus expected values of envelope performance, heat flux measurements were taken at various locations to obtain real-time data on the heat transfer performance of the walls and ceiling. ASTM standards C1046[1] and C1155[2] offer standard practices for this method and were used to guide the measurement and calculation procedures.

*Results*

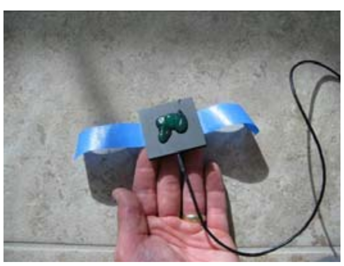


Figure 1: Heat flux sensor with conductive paste.

In theory, heat flux measurements should be a very useful tool in assessing the thermal resistance of the building envelope, but test results were highly variable and problematic. Sensors were affected by convective currents and even proximity to radiant heat emitted from technicians. Further, these sensors require steady state, one-dimensional flows of heat and extended periods of measurements if these flows are not steady-state. Given program constraints and due to the variability of the results, the heat flux sensors were determined to be an inappropriate method for quantifying envelope performance.

**Duct System Distribution Effectiveness**

For each home in the project, duct location is restricted to conditioned space only. Because all leakage is within conditioned space, duct leakage to the outside is

[1] ASTM C 1046-95(2007) Standard Practice for In-Situ Measurement of Heat Flux and Temperature on Building Envelope Components

[2] ASTM C 1155-95(2007) Standard Practice for Determining Thermal Resistance of Building Envelope Components from the In-Situ Data

negligible. However, to assess the overall performance of the duct system, pressure differentials were taken between rooms and common areas with doors shut and open to gauge air distribution effectiveness.

*Results*

Differential pressure measurements between rooms and common areas were low, meaning that the distribution effectiveness was satisfactory, Results are presented in Table 1.

Table 1. Pressure differentials between individual rooms and the first floor common area (kitchen/living room/dining room). Pressure differentials were measured with the HRV operating.

| DeltaP (Pascals) | Room |
|---|---|
| 1.9 | Master Bedroom |
| 0.1 | Master Bathroom |
| 0 | Bedroom 3 |
| 0.1 | Powder Room |
| -0.3 | Bedroom 2 |
| 0.4 | Bath in BDRM 2 |
| 0.1 | Sun Room |
| -1.8 | Basement |

**Envelope Air Infiltration**

Tighter homes consume less energy through reduction of unwanted convective heat loss and gain. A blower door test was conducted on the home to quantify air infiltration. This value can used to calibrate models of the home to better estimate expected heating and cooling energy use.

Figure 5. Blower door test.

Results

Typically, new single family detached construction results in infiltration levels of 5-7 air changes per hour (ACH) at 50 Pascals. With high density spray foam used to seal the above grade walls, band joists, and penetrations, this home was expected to perform much better than a standard home. The blower door test was subcontracted to a HERS rater who reported an infiltration rate of 2.0 ACH at 50 Pa for the home.

**Infrared Thermography**

Infrared imagery can be used to gauge the quality of insulation installation and air sealing of a home. For the infrared imagery to be useful, a significant temperature gradient should be maintained across the envelope (e.g. 20 deg F or greater). ASTM C 1060[3] provides guidance for producing and interpreting thermal imagery of buildings.

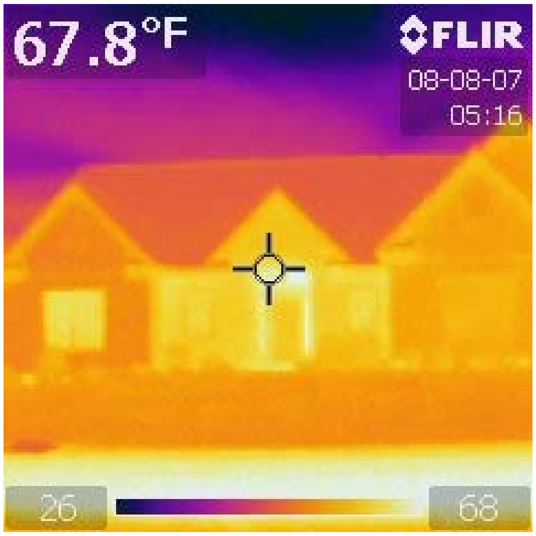
*Results*

Because the Gerber home STEM test was conducted in July, the thermostat was set to 90 deg to maintain a delta T of at least 20 degrees across the envelope. The home was held at this temperature for a several hours before the thermal images were taken at 5am. Taking the pictures at night helped reduce the effect of solar gain on the envelope.

The images from the Gerber home tell more from what are not seen than what are seen. What are not seen are framing members in the walls, gaps in insulation, or cold corners. At the time of the STEM test, the basement insulation had not been completed, so the

[3] ASTM C 1060-90(2003) – Standard Practice for Thermographic Inspection of Insulation Installations in Envelope Cavities of Frame Buildings.

rear view of the house clearly demonstrates higher temperatures on the foundation wall than on the above grade wall. Warmer temperatures are also observed along the top plate of the above grade wall and at windows. Overall, the images reveal no insulation deficiencies in the areas insulated. Because there were no occupied homes near the Gerber home that would permit heating to 90 deg F, there was no control home for comparison.



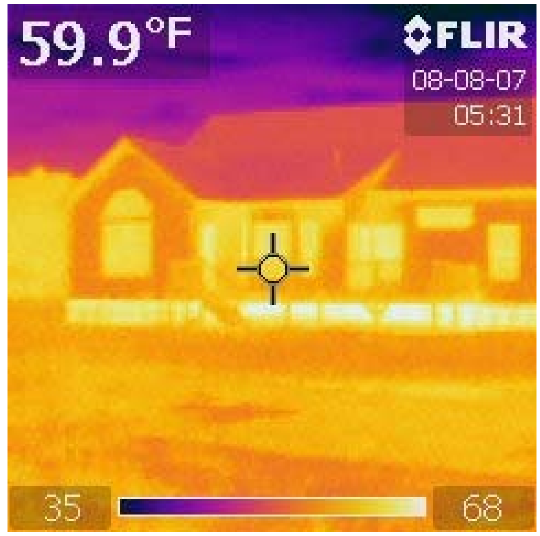




Figure 6. Infrared images of the Gerber home. The left picture is of the front of the home and the right is of the rear. Notice the higher temperatures of the uninsulated basement wall, which was insulated the morning after the test. The light color around the door is from the sidelites and transom windows.

**Utility Bill Analysis**

Natural gas and electricity utility bills will be collected for one year.