ENERGY PERFORMANCE REMODELING

Case Study:

Habitat for Humanity Montgomery County (HFH-MC) Montgomery County, MD

Habitat for Humanity Montgomery County (HFH-MC) worked in conjunction with Montgomery County, MD to purchase 12 older, unoccupied homes in a residential neighborhood. HFH-MC with its team of professionals and volunteers remodeled the homes, delivering 12 fully renovated, energy efficient homes ready for occupancy. The goals of the remodeling project include advancing affordability, enhancing safety, improving durability, lowering the energy cost, and adhering to schedule and budget. As part of this project, HFH-MC partnered with the NAHB Research Center through the Department of Energy's (DOE's) Building America Program. The intent of the partnership was to address the opportunities to significantly enhance the energy efficiency in whole house renovation projects while improving indoor environmental quality and avoiding future moisture problems. Additional support for the development of energy efficient upgrades was provided by the American Chemistry Council (ACC). Specific insulating materials for energy efficient upgrades were donated by DOW Building Solutions through its partnership with Habitat for Humanity.

The 12 homes in the project are outlined below. The homes were predominantly built in the 1950's of block and brick wall construction and with basement foundations. One important focus of this project was on achieving significant improvements in the energy performance of the building enclosure by increasing insulation levels and reducing air leakage.

House	Year Built	Style	Foundation	Framing	Conditioned Floor Area
Dauphine Street	1956	Split Foyer	Walkout	Block	2,098 sqft
Jeffry Street	1959	Split Foyer	Walkout	Block	2,067 sqft
Harrell Street	1953	Ranch	Basement	Block	2,431 sqft
Hathaway Drive	1950	Ranch	Crawlspace	Block	1,256 sqft
Denley Road	1950	Cape Cod	Basement	Block	2,575 sqft
Denley Place	1950	Ranch	Basement	Block	1,872 sqft
Farthing Drive	1953	Ranch	Basement	Block	2,148 sqft
Goodhill Road	1953	Ranch	Basement	Block	1,872 sqft
Middle Road	1946	Ranch	Basement	Frame	1,760 sqft
Pittson Road	1958	Split level	Basement	Frame/Block	1,872 sqft
Ivy Glen Road	1946	Two Story	Basement	Frame	2,052 sqft
Napier Street	1955	Split Level	Crawlspace	Block	1,764 sqft

Remodeling Construction Process:

HFH-MC has a unique construction process with a heavy reliance on volunteers to carry out most of the remodeling and construction tasks. The volunteer activities are coordinated on a daily basis, with the work segmented into discrete tasks 3-4 hours in duration and often include time to instruct/train volunteer workers. In addition, building materials are organized per work segment and the selection of building materials often depends on availability as materials are frequently donated by manufacturers. Finally, the home remodels must be completed for immediate sale.

The NAHB Research Center's role in HFH-MC's remodeling project included observing the remodeling process, reviewing for durability & energy efficiency opportunities, obtaining "test-in"

Case Study:

Habitat for Humanity Montgomery County (HFH-MC) Montgomery County, MD

and "test-out" energy performance data where possible, detailing efficiency enhancements (including moisture, health, and safety considerations), identifying products and methods for increased energy efficiency, documenting the process as implemented, modeling energy savings, and cataloging construction details for future retrofit projects.

HFH-MC's approach for remodeling these homes included removing interior wall finishes from exterior walls, adding/increasing insulation (in foundation, above grade walls, and ceiling), replacing windows, upgrading electric including rewiring, replacing most plumbing and all fixtures, and evaluating HVAC equipment and ducts for continued use or replacement.

In conjunction with HFH-MC staff, the NAHB Research Center assessed the HFH-MC remodeling process for opportunities to enhance the energy efficiency, durability, and indoor air quality of the remodels. Through this evaluation, the following energy features were identified as enhancements for implementation in this and future HFH-MC projects:

- Replace windows with ENERGY STAR or higher energy performance units and install per manufacturer's recommendations
- Air-seal openings at the floor and ceiling where existing walls were removed
- Air-seal band joist areas and penetrations to the outdoors
- Air-seal cantilever overhangs, including solid blocking
- Block and air-seal chases and bulkheads that open to the attic
- Relocate supply and return ducts from exterior walls to interior walls or floors
- Ensure low resistance return air paths for all rooms (for example, ducted returns or baffled transfer grilles)
- Install programmable thermostats
- Duct kitchen and bath exhaust fans to the outdoors
- Install ENERGY STAR refrigerators, dishwashers, and clothes washers
- Install ENERGY STAR bulbs
- Broom sweep all areas of the home after demolition to improve effectiveness of air sealing, worker safety, and indoor air quality
- Confirm that downspouts adequately direct rain water away from house, ground is graded away from house, and sump pumps are operating properly

Energy Performance Remodeling Details:

A significant advancement in the energy performance of these older homes was HFH-MC's development of details for upgrading the insulation of the existing block and brick and existing frame walls. For the block walls, the original R-4.7 walls were upgraded to R-20 walls (R value is provided on a whole-wall basis). The wall upgrade process included 1) removing the drywall and furring strips, 2) attaching 1" rigid foam adjacent to the block and air-seal, 3) constructing a 2x4 wall on the interior of the rigid foam, 4) insulating the 2x4 cavity with R-13 batt insulation, 5) installing drywall and painting the interior walls as depicted in the photo sequence below.

Case Study:

Habitat for Humanity Montgomery County (HFH-MC) Montgomery County, MD

1) remove drywall

2) install rigid foam & air-seal

3) construct 2x4 wall

4) insulate 2x4 wall

5) finish interior walls

Figure 1 - HFH-MC Block Wall Remodeling Process

Removal of the original wall coverings revealed large gaps between the floor and the wall structure as well as the ceiling framing and the wall structure (note that these deficiencies are not typical in standard construction methods today). These areas can be sealed with a combination of rigid foam panels that provide the primary air barrier and spray foam products that expand to fill the remaining gaps. This detail is less prone to moisture problems since it adds moisture-resistant insulation adjacent to the block wall but still allows the wall to breathe allowing moisture vapor to pass through the materials as needed.

Similar to the insulation upgrade details developed for the block homes, wall insulation details were developed for the frame home remodels. One approach that avoids demolition of interior wall coverings includes installation of 1”-thick exterior rigid insulation on the exterior sheathing surface. This approach is practical in remodeling projects where the siding is replaced. This

Case Study:

Habitat for Humanity Montgomery County (HFH-MC) Montgomery County, MD

approach can upgrade the whole wall R-value from R-11.8 (R13 batts in standard 2x4 framing) to approximately R-17.4. The second upgrade approach for frame homes includes constructing a 2x4 wall on the inside of the existing 2x4 wall and insulating both walls to R-13 in the cavity resulting in a whole wall R-value of R-20.2. These approaches allow much higher performing wall systems and when the interior coverings are removed, can provide additional opportunities for air sealing and relocating ducts into conditioned space where appropriate. In addition, any utilities located in the exterior walls can also be upgraded and relocated into conditioned space more easily.

In addition to upgrading the insulation in the walls, air sealing details were another important aspect of improving the energy performance of these homes.

Figure 2 - Cantilever Floor Section Air Sealing

Figure 3 – Cantilever Foam Air Barrier Over Wall and Foam Sealed Edges

While it is possible to identify air leakage paths for individual homes through blower door testing and other measures, the goal was to identify common problem areas that can be air sealed in multiple homes in a standardized manner without testing each one as part of the air sealing process. The NAHB Research Center developed a list of areas needing consideration for air sealing for the types of homes included in this project:

- Floor and foundation wall intersection,
- Rim/band joist areas,
- Ceiling and wall intersections,
- Wire and pipe plate penetrations,
- Sloped ceiling/wall interface,
- Balloon-framed gable end wall/ceiling interfaces,
- Cantilevered floors,
- Gable walls adjacent to main house walls in split-level designs,
- Attic hatch covers,
- Duct and chimney chases,
- Wall top plates at attic, and
- New openings created by the retrofit, such as: door and window openings, through-wall penetrations, story-to-story penetrations

Details for air sealing measures were developed and applied throughout the remodels with varying success. Difficulties were found with the lack of experience to identify air-sealing locations, in the lack of experience with use of spray applied foams, and in some cases, the timing of the air sealing

application relative to the installation of framing, insulation, or other materials. In other cases air sealing was difficult due to the large amount of dirt and debris, for example, in the band-joist area where successful application of sealants was limited. Numerous additional details need to be developed to address air sealing in a reliable and consistent manner including specification of appropriate materials and installation instructions. Additional ventilation needed in conjunction with air sealing details was planned for in the use of bath and other exhaust fans, although none of the homes resulted in extremely air-tight enclosures. While upgrades to the HVAC system were considered, the cost of replacement was beyond the planned scope of the remodeling effort and HFH-MC generally kept the original system in place if it was in good working order.

Energy Performance Remodeling Details:

The estimated energy efficiency improvements from energy simulations for the homes in the project ranged from 9% to 38% over the existing condition of the homes. Throughout the project, many of the lessons learned in the overall remodeling process and for individual home details will provide a base of experience for future projects

One significant result of the energy analysis is that nearly all the homes achieve a HERS index of 100, demonstrating that the implemented energy efficiency measures brought 1950's era homes up to the energy performance of 2004 energy code minimum homes (the baseline for the HERS index). The largest improvement achieved a HERS Index of 80 - a 20% more efficient home than the base code home. The table below summarizes the estimated performance.

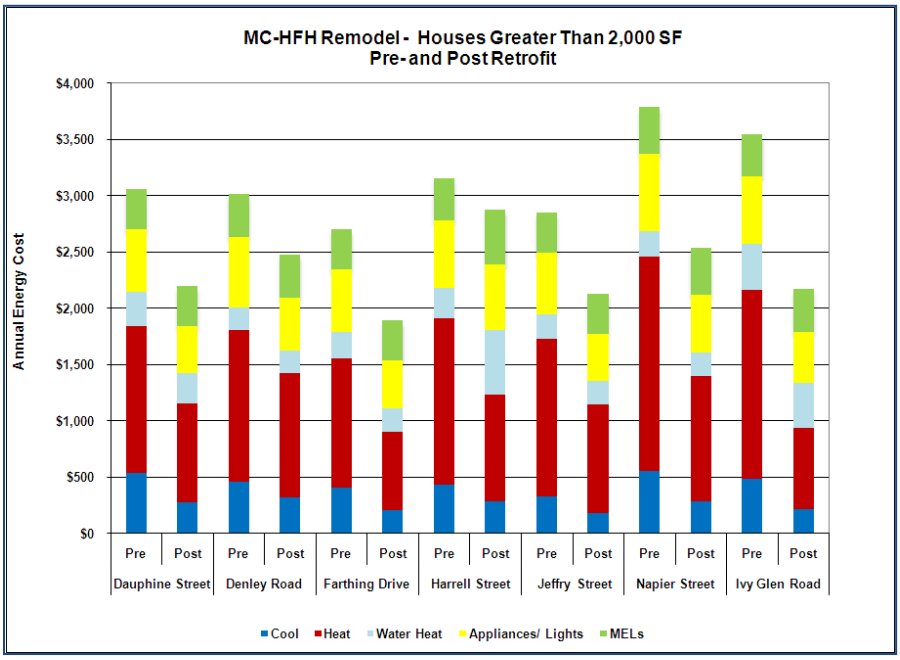
House	Year Built[A]	Style	Source Energy Savings Post-Retrofit (MBtu/yr)	Source Energy Consumption Reduction (%)	HERS Index Estimate after Remodel	Notes
Dauphine Street	1956	Split Foyer	66.50	28.13%	103	C
Jeffry Street	1959	Split Foyer	56.19	25.44%	96	C
Harrell Street	1953	Ranch	22.58	9.24%	90	E
Hathaway Drive	1950	Ranch	74.76	24.65%	100	C
Denley Road	1950	Cape Cod	41.23	17.71%	94	B
Denley Place	1950	Ranch	86.67	38.36%	83	
Farthing Drive	1953	Ranch	63.11	30.18%	85	C
Goodhill Road	1953	Ranch	64.58	31.32%	86	D
Middle Road	1946	Ranch	42.14	18.23%	110	C
Pittson Road	1958	Split level	78.30	27.90%	99	C
Ivy Glen Road	1946	Two Story	107.20	39.12%	80	
Napier Street	1955	Split Level	97.39	33.21%	101	D

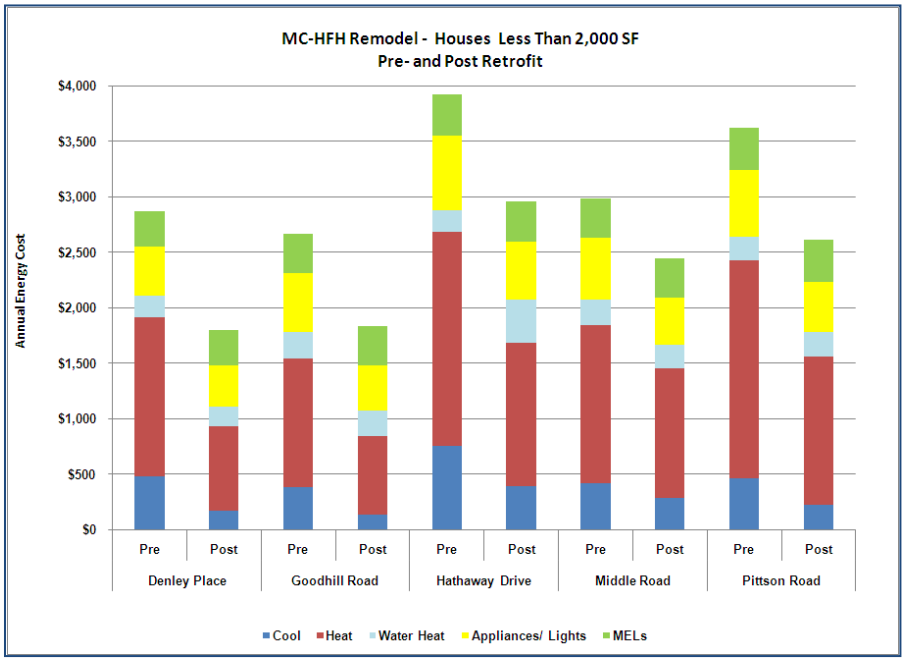
[A] From tax records
[B] HVAC equipment was upgraded in the Pre-Retrofit condition – 13 SEER A/C, 92% furnace, 62%PV DHW
[C] Old HVAC equipment was retained (Dauphine – 8 SEER A/C, 71% furnace, DHW 0.50); (Middle - 9 SEER A/C, 74% furnace, 63%PV DHW)
[D] Goodhill upgraded A/C only (13 SEER), Napier upgraded to 80% Furnace and 13 SEER A/C
[E] This house retained the same conditioned square footage in the pre- and post-remodel, but increased from 3 to 5 bedrooms and 1 to 2 baths. HVAC equipment was not upgraded (13 SEER, 80% furnace). DHW was switched from 0.53 gas to 80 gallon electric 0.86 EF.

Case Study:

Habitat for Humanity Montgomery County (HFH-MC) Montgomery County, MD

Graphically, these energy performance remodeling results are detailed in the two figures below.





Case Study:

Habitat for Humanity Montgomery County (HFH-MC) Montgomery County, MD

NAHB Research Center
400 Prince George's Blvd
Upper Marlboro, MD 20774
Phone: (301) 249-4000
Toll Free: (800) 638-8556
Fax: (301) 430-6180
Corporate site:
www.nahbrc.com
Technical Resources:
www.toolbase.org

Habitat for Humanity Montgomery County
9110 Gaither Road
Gaithersburg, MD 20877
Phone: (301) 990-0014
Fax: (301) 990-7536
Website:
http://habitat.montgomery.md.us

U.S. Department of Energy Building America Program
1000 Independence Ave SW
Washington, DC 20585
Phone: (202) 586-5000
Fax: (202) 586-4403
Website:
www1.eere.energy.gov/buildings/building_america/

American Chemistry Council Plastics Division
700 Second St., NE
Washington, DC 20002
Phone: (202) 249-7000
Fax: (202) 249-6100
Website:
www.americanchemistry.com/s_plastics

Summary:

Habitat for Humanity Montgomery County's process for home remodeling has unique aspects that require special planning considering volunteers and donated materials as well as goals of affordability, durability, and energy efficiency. The initial assessment of twelve 1950's era homes in Montgomery County, MD, as with all older homes, required specific attention to uncommon features.

The 12 remodels addressed installing or upgrading insulation in exterior walls to substantially improve the energy efficiency of the 10 block and the 2 wood-framed houses. Successfully implemented measures included the use of rigid foam panels installed on the interior face of exterior block walls in combination with new interior framing and fiberglass cavity insulation. The foam panel provides a thermal break and enhanced air sealing capability. This retrofit strategy is beneficial for both above- and below-grade block walls. In addition, HFH-MC made significant progress identifying and addressing air leakage pathways in older homes where the construction methods and details often resulted in large air infiltration areas. Air sealing was accomplished by using a combination of rigid and spray foam products, which both also provide additional insulation value. In addition to air sealing, ventilation approaches included multiple exhaust fans ducted to the exterior for the purpose of indoor air quality, health, and safety. The energy performance of the remodeled homes shows that meeting modern energy code ratings is achievable through upgrading the building enclosure in even 60 and 70 year old homes.

Next Steps:

The next steps as part of the Building America program will include development of additional best practices, details, training, etc for energy efficiency improvements and durability to provide specific solutions for houses of this vintage and construction type. A more definitive assessment procedure based on house design and location is needed to improve and simplify the selection of energy performance remodeling upgrades (i.e., foundation, wall & roof insulation, duct assessment and sealing, etc.). As part of the assessment, an integrated analysis of whole-house investment opportunities is needed to enable prioritization of available energy efficiency upgrades based on cost and energy savings. Products and installation guidelines are also necessary to provide energy efficiency upgrade opportunities in existing homes for both the professional remodeler and the DIY markets.

Specific areas where additional detailed information is needed as learned from the HFH-MC remodels include air sealing assessment and product selection as well as HVAC assessment and upgrade options. The air sealing details need focused development including work procedures/instructions for volunteers (i.e., DIY market). Guidance also needs to be developed regarding how to determine when to upgrade/replace an existing HVAC system and how to improve the duct system. Research efforts should continue to develop product options, design details, and application details, as well as work scopes and activities, for incorporating energy efficiency measures into remodeling projects. Habitat for Humanity Montgomery County is currently planning additional renovation projects that could provide the opportunity to advance the development of energy performance remodeling for affordable homes in Maryland.