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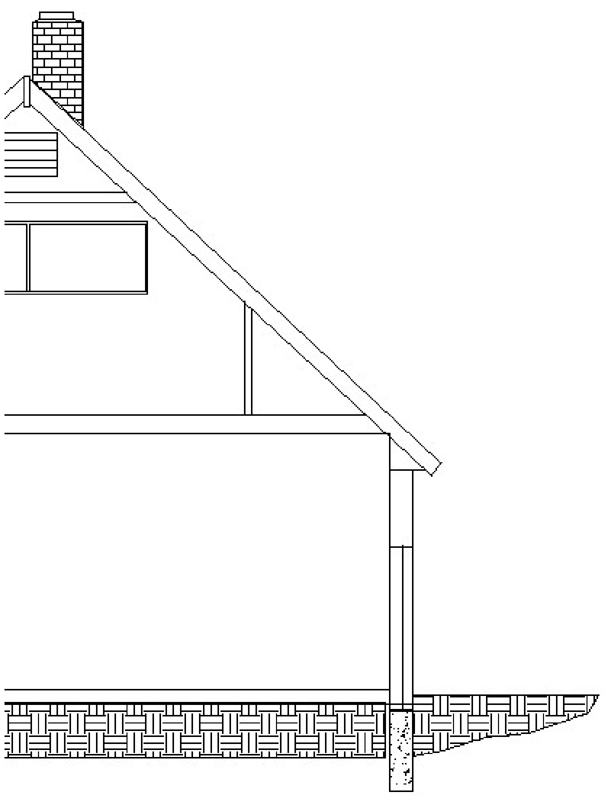
Langhorne PA

Evaluating Levittown Pennsylvania Homes for Energy Savings – Part 1

A Case Study in evaluating the potential for energy conservation in existing tract housing developments.



Evaluating Levittown, Pennsylvania Homes for Energy Savings, Part I

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KC Environmental, Inc.

January 2008

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This study was funded wholly by KC Environmental, Inc.

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Acknowledgements

Special thanks to Stephen Rees, Curator of the Levittown Archive at the Bucks County Levittown Regional Library for the loan of materials; S. David Marable, Proprietor of Levittown Exhibit Center North for a copy of the "Levittowner" drawings; and Ted Inoue of ETC Creations, LLC for energy modeling review, consulting and thermographic analysis.

Executive Summary

Buildings in general and residential buildings in particular consume a significant amount of the energy used in the United States. The housing stock in the US is large, with over 124 million units, many of which were built in eras of inexpensive energy without energy conservation as a priority. Environmental and economic realities have caused many to take a hard look at the present level of energy use in existing housing to develop practical and affordable means to conserve energy. This study was conducted to that end.

Levittown, Pennsylvania is one of the 3 major suburban communities developed by Levitt and Sons from the late 1940s through to the early 1960s. Levittown, New York was the first of these developments which began in the late forties. Levittown, Pennsylvania construction began in the early fifties followed by Levittown, New Jersey (renamed as Willingboro) in the late fifties. These homes were all slab on grade, wood frame construction homes common to the era. The techniques and methods used by Levitt were emulated in many developments throughout the country. This case study reviewed Levittown, Pennsylvania housing examples to determine if significant energy savings could be achieved. Heat loss estimates were prepared using standard estimating techniques for a selected housing model as designed and constructed. These estimates served as the baseline. Estimates were then prepared for an upgraded version of the home based on assumed upgrades that have been used to various degrees in many of the current Levittown homes. Comparison of the estimates indicates that savings of 40% or more of heating costs are possible with the expectation of additional electrical energy savings during the cooling period.

This study is expected to be followed by a more detailed review of a selected home using blower door testing and thermographic analysis. Heat loss estimates will be prepared for each of the housing models to provide a basis for estimating the potential energy savings across the entire development.

Background

Buildings in United States consume 40 % of the total amount of energy used annually[1] and this consumption accounts for roughly $2/3^{rds}$ of the electricity produced nationally. Consumption is expected to grow.[2] It surprises some that the amount of energy use attributed to buildings (40%) exceeds that of transportation (28%), but given that much of the energy used in our buildings is delivered in the form of electricity, it is less noticeable as discrete packets of energy than are cars, gas stations and tank trucks. The recent drive for efficiency and sustainability in building design produced significant advances in building science, technology, and construction practices leading to the development of green building technology. Green building practices and technology can produce homes that are extremely energy efficient when due care is given toward the integration of efficiency and sustainability in all aspects of design and construction. New building concepts integrate what has been known for centuries about the placement of buildings in a given environment with new and emerging technology that maximizes efficiency and comfort.

A rapid and large scale reduction in residential building energy consumption is not likely without significant effort and investment focused on the existing housing stock. The residential building stock in the United States is extensive. The most recent estimates put the number of housing units at over 124 million.[3] Housing is being added at the pace of almost 1.5 million units annually. A portion of the new housing construction is the result of expansion in the housing market while some can be attributed to the replacement of existing buildings. The rate of replacement roughly determines the rate at which older, less energy efficient buildings are being replaced.

Much of the nation's housing was built at a time when energy resources were cheap and plentiful. Figure 1 illustrates the estimated distribution of housing in the US according to the year it was built. The vintage distribution indicates that almost $1/3^{rd}$ of US housing

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[1] US Department of Energy, 2007 Buildings Energy Data Book.
[2] US Department of Energy, Energy Information Agency, Annual Energy Outlook, 2003.
[3] American Housing Survey, 2005; U.S. Department of Housing and Urban Development and U.S. Census Bureau.

was built before 1960 and is nearing a minimum age of 50 years. Just over 1/2 of the housing was built before 1975 and at a minimum is now over 30 years old. Even after the "energy crisis" of the 1970s, new housing construction was not universally optimized for energy efficiency so a large part of the remaining housing is not considered highly energy efficient by current practices. As indicated in Figure 2, the energy use per household steadily dropped through the 1980s and then began to rise to pre-WWII levels. The increase in home square footage and the proliferation of electronic appliances is largely responsible for the increase.

Green building construction currently represents a small but growing fraction of the housing market with much of the focus on new construction. With an existing housing stock of 124 million units, and with an attrition rate of 0.6%,[4] over 150 years would be required to replace older homes with energy efficient models provided all builders and all home owners chose that option – an unlikely expectation. If timely advances are to be made in reducing residential energy consumption, remodeling of existing homes has to be a significant component of the overall effort.

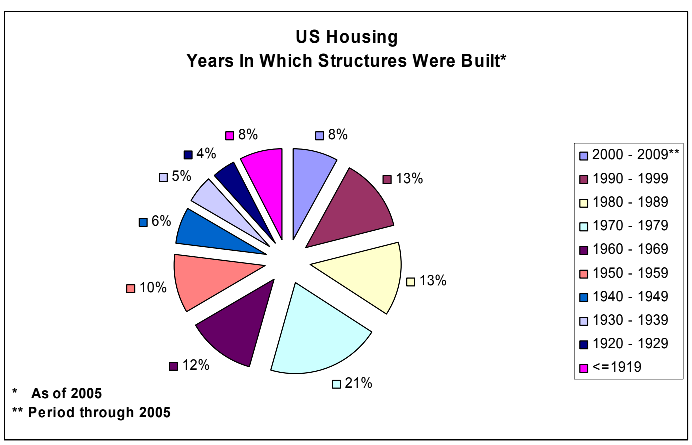

Figure 1: Age distribution of housing in the US.[5]

[4] Assumes ½ of new construction is attributed to replacement.
[5] American Housing Survey, 2005; U.S. Department of Housing and Urban Development and U.S. Census Bureau.

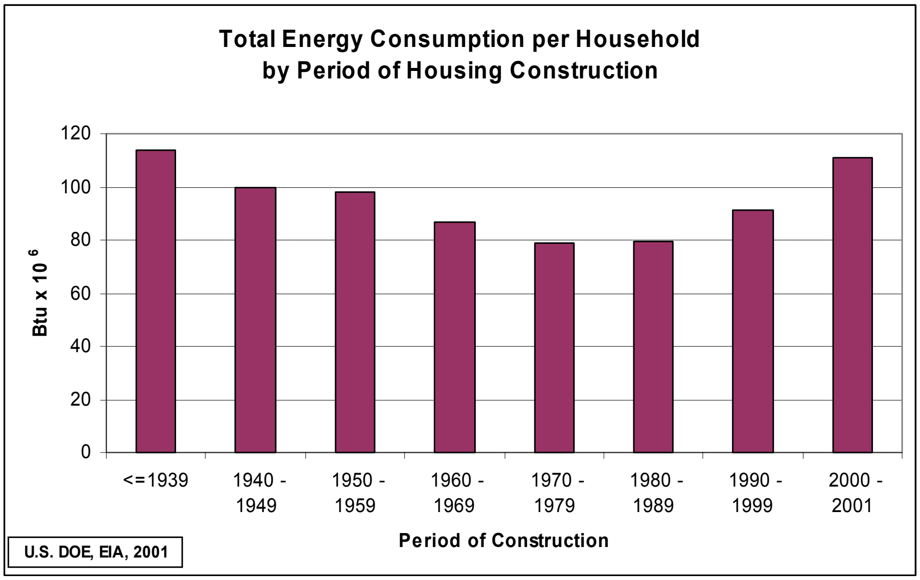

Figure 2: Household energy consumption by period of construction

Levittown, Pennsylvania is a good example of the style of development that took place from the late 1940s through to the early 1970s. Approximately 17,300 single family homes were built throughout the 1950's on 5,500 acres that spanned four existing political jurisdictions in Lower Bucks County: Bristol Township, Falls Township, Middletown Township and Tullytown Borough. See Figure 3. As indicated in Figure 4, the political jurisdictions that contain Levittown housing are significantly represented and in some cases dominated by 1950's era housing.

Figure 3: Aerial view of Levittown from the 1960's with portions of Bristol, Falls and Middletown Townships. From the *ASRO* collection.

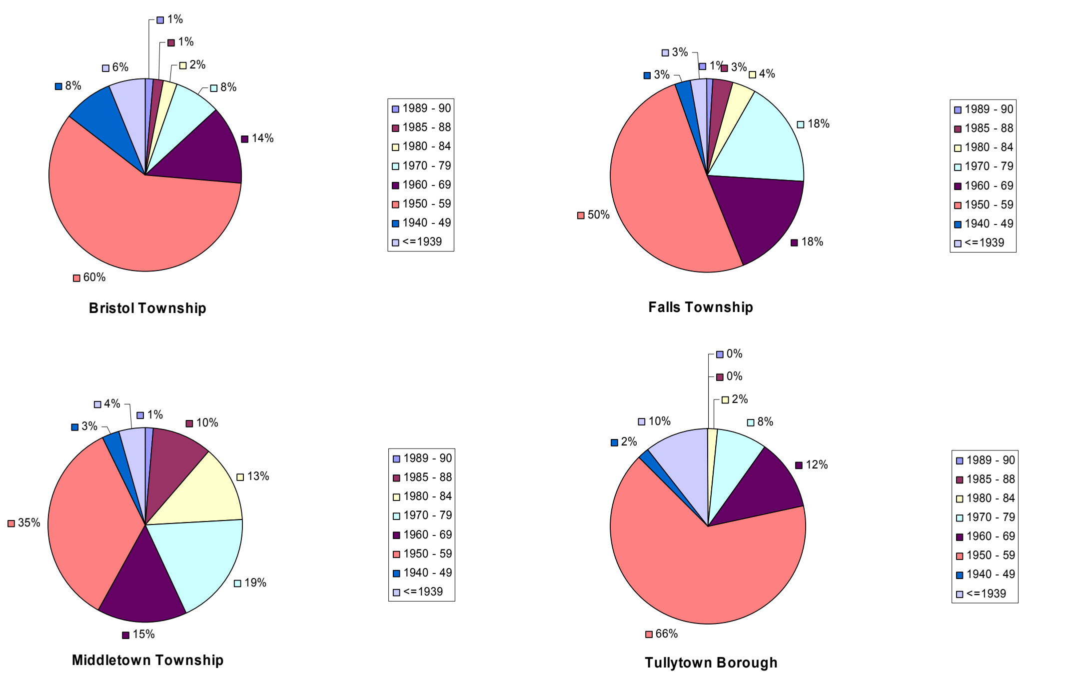

Figure 4: Housing era distribution for Bristol Township, Falls Township, Middletown Township and Tullytown Borough, as of 1990. (PSDC)[6]

6 Pennsylvania State Data Center, Housing Characteristics – 1990.

Levittown was intended to satisfy the pent up demand for housing that existed after WWII. All Levittown housing was slab-on-grade, wood-frame construction; it was built quickly and efficiently using adapted production line methods little seen in the residential construction industry at the time. Levittown homes were equipped with oil-fired hot water radiant heating systems at a time when residential heating fuel costs averaged less than 16 cents per gallon.[7] A limited number of housing models were produced with some type variation within models. Much has been written about Levittown, both praising and criticizing the project. One aspect that is not debated is that it was affordable housing that served the needs of the area's middle class. It continues to do so today. Now after 50 years, the housing that Levitt built is still in demand and is being remodeled at a rapid pace. As a result, it represents an ideal case to evaluate the challenges and opportunities encountered in efforts to remodel green.

There are key improvement areas where existing home owners can have an impact and accomplish measurable energy savings. These include the general areas summarized below:

- Space Heating/Cooling
    - infiltration/exfiltration
    - thermostats
    - insulation
    - windows
- Appliance and Lighting Electrical Use
- Hot Water Heating

<u>Space Heating/Cooling</u>

Space heating and cooling represent about 1/3rd of the overall energy used in a home. In the Southeast Pennsylvania region, heating is the dominant requirement October through May while cooling occurs mainly during August and early September. Managing the heat loss during the heating season is a major concern and the rate at which a building looses heat is usually determined during the design and construction of the structure. After the

[7] US Department of Energy, Energy Information Agency, Annual Energy Review, 1995 (DOE/EIA-0384(95)).

fact, home owners can focus on particular areas that will bring the greatest return on investment either directly through energy savings, building comfort or both.

<u>Infiltration/Exfiltration</u>

One of the largest factors that impacts the amount of energy used to heat or cool a home is the uncontrolled movement of air into (infiltration) or out of (exfiltration) the building. Older homes tend to be 'drafty' – an indication that uncontrolled air movement is occurring through the space. Air leakage can occur in a variety of places: around window and door framing, along the sill plate, at framing corners, along wall headers, through plumbing and electrical penetrations and through poorly sealed window units among others. Fireplaces can also be a major source of energy loss due to air movement up the chimney. Current construction techniques and materials have been designed to limit this potential. House wrap is used to seal the exterior wall and framing surfaces, gaskets and caulking are used liberally, insulation and sealing around window and door framing is standard and fireplace enclosures and inserts are common. These were not universal practices in the 1950s.

External wall sheathing on the Levitt homes was wrapped using asphalt felt paper with a 6" overlap. The wrap acted both as a weather resistive barrier and a sealer. The wrap was generally cut along the window frames and not wrapped through as in most new construction practices. Nonetheless, window frames were caulked to limit moisture and air penetration. The window units included seals around the glazing and closure points, but for the sliding units, the panes often did not have a snug fit in the aluminum guide channel and would rattle in a stiff wind. Generally, no penetrations through the wall headers for electrical wire routing were sealed and no gaskets were used for electrical outlets. No sealant is evident along the sill plates. Shimmed areas around the door and window frames were not always sealed or insulated.

Fireplaces were included in multiple housing models (Colonial, Country Clubber, and Levittowner). They were equipped with a flue damper but were otherwise open style fireplaces. These fireplaces, i.e., those not fitted with enclosures or equipped with inserts, can be very inefficient and draw a great deal of air and energy out of the home. The damper must be open while an active fire is burning and long after while the embers cool. Much more air is pulled out of the room than is necessary to support combustion, so not only is energy lost while a fire is actively burning, but also long after during cool-down – as long as the damper is open. Many Levittown home owners have retrofitted their fireplaces with enclosures or inserts which provide control over the amount of air drawn into the fireplace thereby controlling the amount of heat from inside the building that is drafted up the chimney. For those that have not already done so, upgrade of the fireplace represents an energy savings potential.

Thermostats

The original thermostats in the Levittown homes were simple ON/OFF devices. Once set, it stayed at that setting until someone reset it. The development of programmable thermostats today permits the use of settings for every day of the week and for multiple times during the day. In essence it allows the occupant to establish the comfort temperature level when they are actually in the home and to change it for those periods when they are out or when comfort needs change (such as at night). Programmable thermostats save energy both in fuel and in electricity and are easily installed to upgrade Levittown homes.

Insulation

The six basic models of Levittown homes[8] included 3 inches of batt insulation in the walls and in the attic. Unlike similar homes in Levittown, NY the edge of the concrete floor slab was also insulated to limit heat loss from the heated floor.[9] See Figure 5. However, the insulation depth to the top of the footer is much less than is recommended by current practices which require insulation along the foundation wall to the footer. The houses all lack insulation beneath the slab – a significant oversight for homes originally heated by radiant coils in the concrete floor slab. For some models that exhibited Cape Cod styling with a finished second floor (i.e., Jubilee and optionally Country Clubber,

[8] Models included Colonial, Country Clubber, Jubilee, Levittowner, Pennsylvanian and Rancher.
[9] Holohan, Dan, Radiant Reflections, Old House Journal Online http://www.oldhousejournal.net/magazine/2005/nov/Radiant_Reflections.lasso.

Pennsylvanian and Rancher models), construction required knee walls that intercepted the slope of the roof line. See Figure 6.

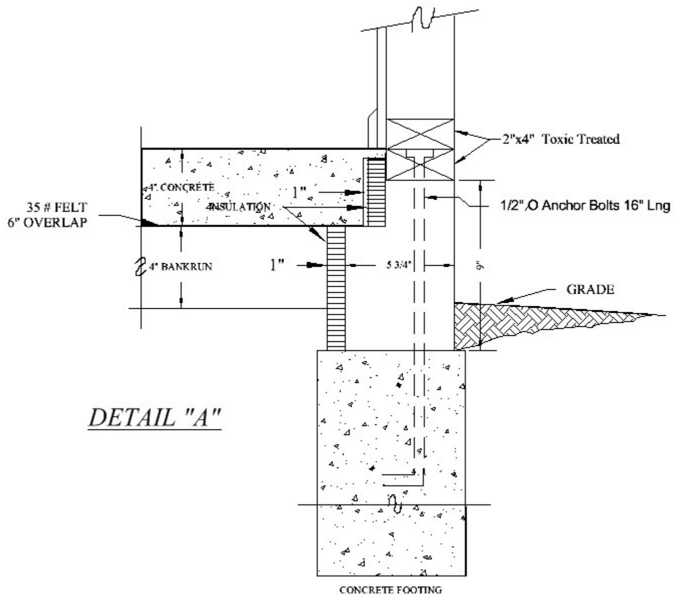

Figure 5: Slab Insulation detail; Levitt Country Clubber

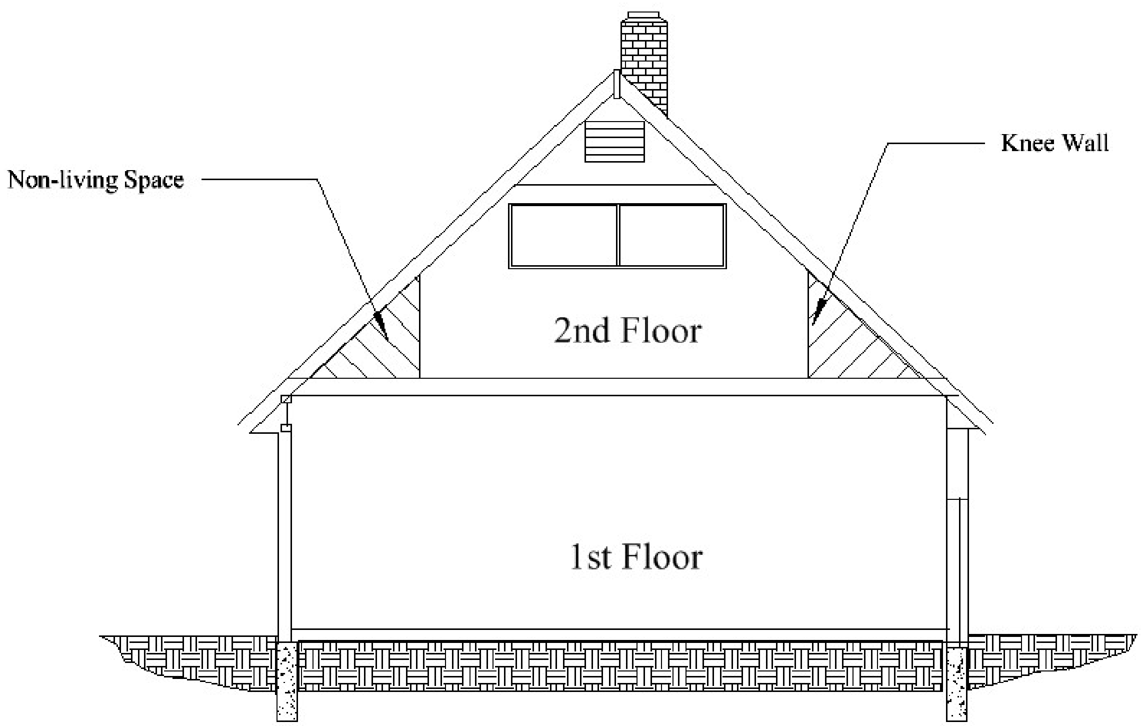

Figure 6: Knee wall illustration.

To as practical a degree as possible, it is desirable to insulate and seal the entire "envelope" that surrounds the living space in the house. For the Levittown series that may have had a Cape Cod aspect with a finished second floor, the envelope outline looks like Figure 7. The A-frame construction required insulation along a portion of the roof line which, as a matter of convenience and cost savings extended down to the first floor ceiling. In doing so, non-living space behind the second floor knee wall was heated due to transfer through the knee wall and the ceiling below. Insulation along the roof line was stapled in place to the roof rafters. Over time, due to the effects of gravity and embrittlement of the Kraft paper facing, insulation can pull away and sag leaving a direct conduit for heat loss to the upper attic and out through the eave vent. See Figure 8. Since this happens in unseen areas of the home it can go unnoticed but clues are not hard to find as you travel around Levittown on a frosty morning. See Figure 9. Current practice uses twine or similar support in a shoe string pattern across rafters to support insulation in the rafter bays.

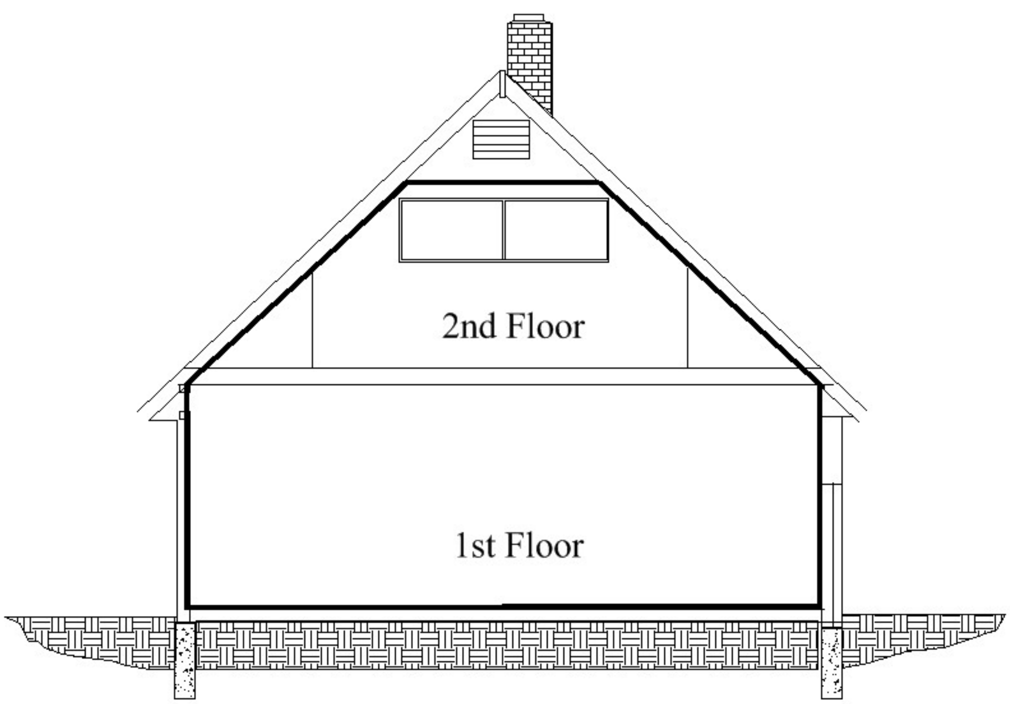

Figure 7: The Building Envelope.

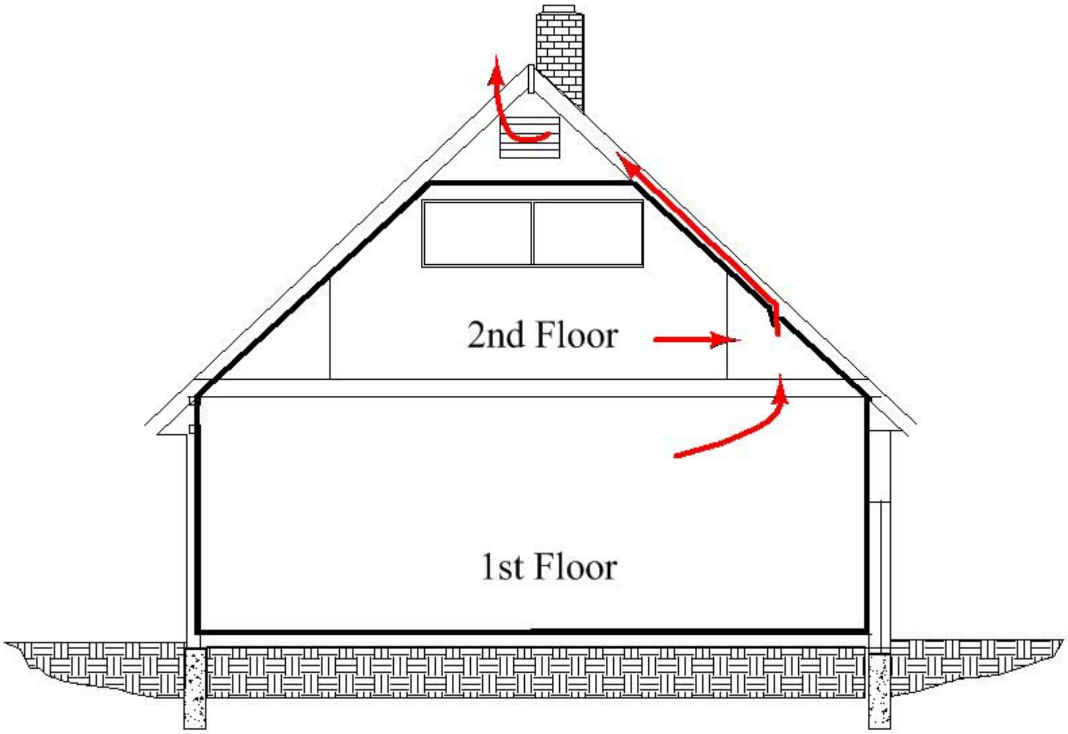

Figure 8: Heat loss through sagging insulation.

Figure 9: Photo of Levittown roof with heat loss patterns.

Opportunities exist to improve the insulation of those Levittown homes that have not already done so to reduce the heat loss and cost of seasonal heating and cooling. These opportunities in order of their lowest cost and difficulty include:

- Attic
- Walls
- Floor

Attic

Insulation in many models originally consisted of 3 inches of batt insulation laid between the joists in the attic. Notations on drawings for the Levittowner also indicate that 3½ inches of blown insulation was planned for that model. This amount of insulation is equivalent to an R value of 11 to 13, well below current recommendations for a minimum R-38.

R-Value
A material's resistance to heat flow.
Higher R values indicate a higher resistance to heat flow.

R Values for some common materials are below:

Material	R-Value
Plywood, 1/2"	0.63
Plywood, 3/4"	0.94
Drywall, 1/2"	0.45
Fiberglass Batt, 3 1/2" Standard Density	11
Fiberglass Batt, 3 1/2" Medium Density	13
Fiberglass Batt, 3 1/2" High Density	15
Window, Single Pane	0.91
Window, Single Pane w/Storm	2.0

Recent model energy codes seek to achieve an R-49 for Southeast Pennsylvania[10]. Adding insulation to the attic is relatively simple. Additional batts can be laid between the joists until you reach the top of the joist. Another layer can then be placed across the joists until there is enough to achieve a minimum R-38.[11] Alternatively, insulation can be blown in place to the desired height, again when possible, enough should be added to cover the joists.

[10] U.S. Department of Energy, Office of Building Technology, Technology Fact Sheet: Ceilings and Attics.
[11] Placing insulation to cover the joists helps to lessen the effect of thermal bridging. The wood joists, typically 2 x 6 or 2 x 8, are in direct contact with the heated ceiling in the living space below and conduct heat to the attic. In essence, they act as a bridge directly to the attic. Depending on the dimensions and spacing, thermal bridging can reduce the R value of the surface by 10% or more.

For this discussion, the space behind the second floor knee wall was also considered as attic space. There are two approaches to consider as illustrated in Figure 10: a) remove the existing insulation from between the rafters from the top of the knee wall to the ceiling and replace with high density (R-26) batting that is appropriately supported to avoid future sagging, or b) leave the existing insulation in place and insulate the back side of the knee wall (R-15 or higher)[12] and the exposed area of the ceiling (R-38 to R-49).

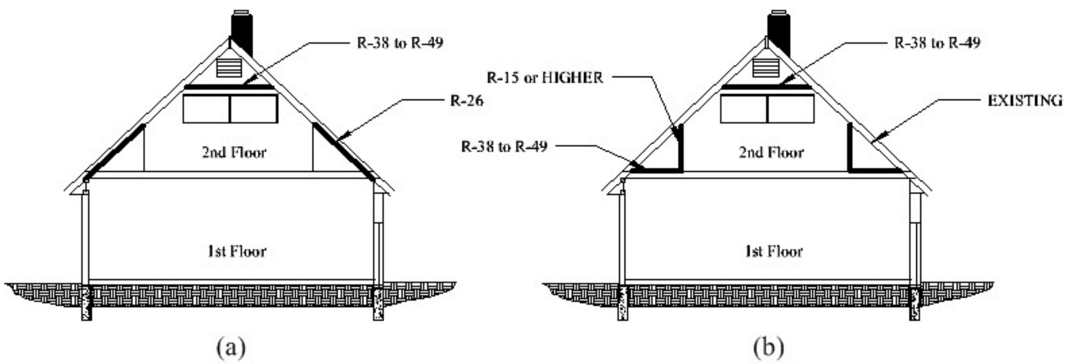

Figure 10: Insulation options around the knee wall area.

Walls

Unless drywall is being removed for an interior renovation, the existing 3inch insulation batting can't be removed to make full use of the 3 ½ inch wall cavity.[13] If removing drywall is intended multiple options exist for upgrading the insulation using either batting or spray foam products. Batting can be added by most homeowners in do-it-yourself (DIY) projects. Although R-13 fiberglass batts are available in most Pennsylvania home centers for the standard 3½ inch wall cavity, high density R-15 batting is also available

[12] Since there is really no conceptual difference between the knee wall losses and the ceiling losses, it is desirable to bring the knee wall insulation value up to par with the ceiling. With a 2 x 4 stud wall, the use of 4.5 inches of spray foam, covering the studs with 1 inch, will bring the wall up to ~ R-30.
[13] Some soft expansion foam products could conceivably be used with batts in place.

on request. Spray foam requires professional installation using commercial equipment. Although it's not available for DIY projects, it can be applied quickly by professionals to achieve a higher R-value in the 3½ inch wall and will seal the wall far better than can be done with batting insulation alone.

For much of the remodeling that occurs in Levittown, wall insulation is improved from the outside when the house receives new siding. Rigid insulation in the form of polyisocyanurate or styrofoam sheets is typically installed beneath siding as an added layer of insulation. A ½ inch sheet product has an R-3 rating, which when added to the existing R-11 wall results in a nominal R-14 rating. Because these insulation sheets are installed over the exterior wall surface, the effects of thermal bridging from the 2 x 4 wall studs are avoided for this layer.

Floor

The original Levittown radiant heating system made use of copper tubing imbedded in the concrete floor. Hot water circulated through this tubing and heated the entire floor slab which in turn radiated heat into the living spaces. However, given the lack of insulation beneath the slab, heat was also exchanged with the underlying soil resulting in the loss of heat outside of the envelope. There are no easy or inexpensive solutions to this problem.

The insulation of the foundation wall or installation of an insulation baffle around the perimeter of the house is a technical possibility, but the feasibility is questionable. The baffle (see Figure-11) helps to insulate outright, but it also helps to shed water away from the foundation. Moisture has a significant impact on heat transfer efficiency – lower moisture results in lower heat loss.

Oddly, many Levittown home owners installed wall to wall carpeting in their homes. For those that continue to use the original radiant heat system, this has the effect of adding an insulation layer between the occupants and the heat source resulting in reduced overall heating efficiency. Removal of the carpet will translate directly into energy and fuel savings.

Many Levittown homeowners have replaced the radiant system due to leaks in the imbedded copper piping that could not be economically repaired. The most popular conversions appear to use baseboard hydronic radiators with the existing oil fired hot water boiler. The relocation of the heat source from the slab also reduces the heat loss through the slab. In the event that conversions of this kind are done, insulation in the form of underlayment sheet products can be added on top of the concrete floor slab prior to the installation of tile, carpet or wood flooring.

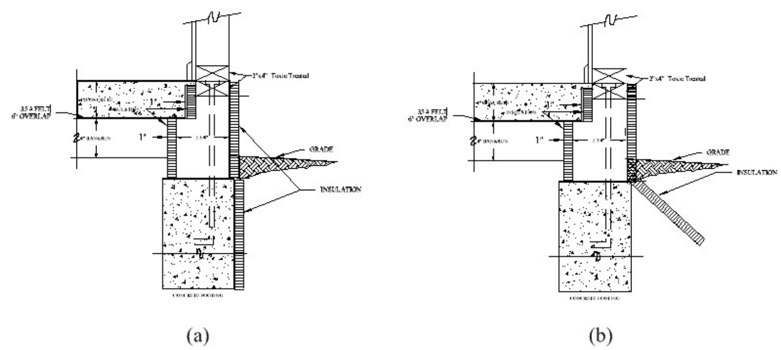

Figure 11: Foundation insulation options. [14]

Windows and Patio Doors

Windows are a major source of heat loss in a home. For Levittown era homes this is particularly true. The basic window used in most of the Levittown homes was a single pane and aluminum framed unit. Glass has a very low insulation value and aluminum is a rather good heat conductor which efficiently conducts heat out of the home. Storm windows, also constructed of aluminum framed–single panes were included. These

[14] Note that insulation along the outside of the foundation can mask the presence of termites. Regular inspections must be performed.

helped to lessen the wind effects on the primary window. On very cold winter days, it was not unusual to see frost form on the inside window surface in humid areas of the house such as in bathrooms and kitchen.

Some housing models (Country Clubber, Colonial) included sliding glass doors along the back side of the house that provided access to the back yard and patio – or 'terrace' as Levitt termed it. These were visually appealing and allowed a lot of light into the house. For the Country Clubber, these doors included one unit with 2 – 4 foot wide panels in the dining room and another with 4 – 4 foot wide panels in the living room. Collectively they constituted 24 linear feet of 'glass wall' along the back of the house. They are double paned and aluminum framed units which can be a significant source of heat loss from the home.

Window replacement is a typical upgrade for these homes that can have a significant benefit. Window replacement is often done when siding is added because exterior window trim can be done at the same time. However, window replacement can be done at any time as a separate project often by do-it-yourselfers. When windows are replaced, Energy Star rated units should be used. These units are estimated to be twice more efficient than the original models.

Replacement of the patio doors can also dramatically reduce heat loss and improve the comfort level of the home. They enhance the beauty of the room and bring light into the home. See Figure 12. Words of caution for home owners contemplating a DIY approach – these doors are very heavy and assistance is necessary to remove and replace these units.

Figure 12: Country Clubber with Energy Star rated replacement patio doors.

Courtesy of David and Janice Johnson.

Appliance and Lighting Electrical Use

Levittown homes were originally equipped with electric appliances: ranges, ovens, washing machines and dryers. Some models even included the option for central air conditioning. Most of these appliances and systems have long since been replaced.

Built-in lighting was minimal – decorative surface mounted can type ceiling lights were installed in the kitchens and baths while bell shaped high hat fixtures were used for hallway and entrance lighting. Some models also included a drop fixture for the formal dining area. All lighting used incandescent lamps.

These homes were built before the widespread use of hair dryers, microwave ovens, instant-on televisions, window air conditioners and computers. Over the years since original construction, more electrical demand has been accommodated by upgrades to the electrical service to the home. It is reasonable to assume that electrical demand has only increased since these homes were built. Nevertheless, conservation and savings are possible.[15]

[15] It is noteworthy that Pennsylvania initiated deregulation of power utilities in 1996. Price caps now in place are due to expire in the PECO service region on 12/31/10. Prices in other states and regions that have

Household appliances and equipment have been the focus of federal programs for some time. The federal Energy Star program has been integral in the development of energy efficiency standards and certifications for a wide variety of products including appliances, heating and cooling equipment, windows, doors, insulation, home electronics and more. When replacements are contemplated, Energy Star rated products should be considered.

Incandescent bulbs currently in use in fixtures and plug-in lamps throughout the home can all be replaced with compact fluorescent bulbs (CFLs). These bulbs are rated up to 75% more efficient than standard incandescent bulbs and will last longer.[16]

Hot Water Heating

Hot water heating is among the highest energy uses in a home, responsible for up to 13% of the total household consumption.[17] In Levittown era homes, hot water is produced by passing a water supply through a coil installed in the heating boiler. This strategy requires the heating system to be on and up to temperature at all times in the event hot water is called for. Estimated thermal losses when the boiler is in stand-by mode were reported for the Levittowner model to be 8,000 btu/hr.[18]

The heating season for the Levittown, Pennsylvania area falls roughly between October 15th and May 15th of the following year leaving the remaining time when the boiler is not required to supply heat to the home. During the remaining five months of the year, the heating system is in stand-by mode for hot water production. Some homeowners have added stand alone hot water heaters for other reasons – mainly because the existing coil insert did not keep up with the demand of a household getting ready for work and school at the same time. This supplemental hot water heater allowed the homeowner to switch

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already deregulated experienced increases, some as high as 70%. This significantly increases consumer costs and the need to conserve to maintain a household budget.

[16] US EPA and US DOE, Energy Star @ http://www.energystar.gov/index.cfm?c=cfls.pr_cfls.

[17] U.S. Department of Energy, Energy Efficiency and Renewable Energy, Building Energy Data Book, 2005.

[18] Levittowner Plans, Levitt & Sons.

off the heating system at the end of the season and turn it back on again in October. Others have removed or bypassed the coil altogether and rely solely on a stand alone water heater as in most newer homes. In the event that a stand alone hot water heater installation is contemplated, consider the following:

- Consider purchasing an Energy Star rated unit appropriately sized for household needs.
- Add timer controls to produce hot water only when needed, often allowing off-peak energy use.[19]

Other options also exist. Some replacement oil-fired boilers incorporate hot water heating with a storage tank into their design and shut themselves down when heat is not called for, thereby significantly reducing stand-by losses. These compact units are now showing up in Levittown homes.

Many homes have also converted to the use of heat pumps to take advantage of the potential for air conditioning using the same system. Electric hot water heaters with timer controls and tankless units can be used if these heating system approaches are adopted.

Heat Loss Estimates

Heat loss estimates were prepared based on procedures outlined by ACCA[20] for a Levittown home as originally constructed (baseline) and again with modifications discussed above to permit a comparison. The following sections discuss these estimates.

Heat Losses – Baseline Case as Designed/Constructed – 1950s era.

Heat loss calculations were prepared for a Country Clubber model home with a completed second floor. The home living space inside the "envelope" is estimated to be 2,460 ft^2. Temperature conditions adopted as the basis for estimates were 14 ^oF outside

[19] Smart metering is under active consideration as a state-wide option in Pennsylvania and is in use in some areas now (California, New York, Texas). PECO and PP&L use Smart Metering for load planning now. In the future when full deregulation of the industry takes place, consumer costs for electricity could fluctuate with the demand on an hourly basis. Electrical use during off-peak periods could result in cost savings if household uses were appropriately timed and configured.

[20] Air Conditioning Contractors of America, Residential Load Calculation, Manual J, 7th ed., 2005.

and 70 ^{o}F inside resulting in a differential temperature of 56 ^{o}F. Results of the estimates are summarized below in Table 1.

Table 1: Estimate of heat losses for an original Country Clubber.

Category	Area ft^2	Linear ft	Air Flow CFM	Loss BTU/hr
Windows	191	-	-	6,967
Doors	192	-	-	7,431
Walls	1,738	-	-	6,340
Slab Edge		178.5	-	7,262
Ceilings	523	-	-	2,579
Roofs	619	-	-	2,495
Infiltration		-	427	26,304
Total				**59,376**

The total heat loss for the home is estimated to be nearly 59,400 BTU/hr. Figure 13 shown below illustrates the heat loss distribution graphically. As indicated, this estimate is dominated by infiltration losses that account for 44% of the heat loss from the home. Nearly half of this heat loss is attributed to the fireplace. It is noteworthy that the glass patio doors emit more heat than all of the windows combined and the concrete slab emits more heat than all of the walls combined. Although the estimates indicate relatively high losses from the home much of the loss is in areas that are subject to control by homeowners.

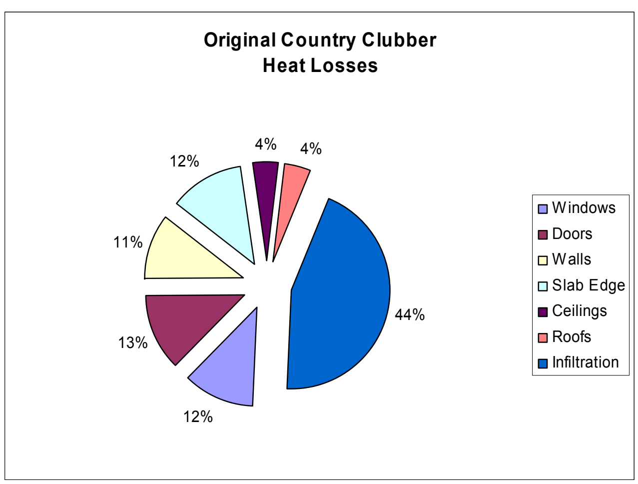

Figure 13: Distribution of heat losses from an original Country Clubber model.

Heat Losses – Upgraded Conditions

Heat loss estimates were prepared for the upgraded version of the same home model. For these estimates, the following formed the basis:

- An upgrade to a programmable thermostat was included that permitted lowering temperature settings during the day (while at work) and at night (while asleep). For estimating purposes, 65°F was selected as the setback temperature for a duration of 12 hours per day.
- Windows were upgraded to vinyl framed, doubled glazed, argon filled, low-e, Energy Star rated units with a U factor of 0.235 BTU/ft^2 °F•hr. It is noted that windows with a higher efficiency rating are available.
- Sliding glass patio doors were upgraded to vinyl clad, double glazed, argon filled, low-e, Energy Star rated units with a U factor of 0.33 BTU/ft^2 °F•hr (See Figure 12).
- Walls were upgraded by the addition of 1/2 inches of polyisocyanurate rigid insulation under new vinyl siding. The original R-11 walls were not upgraded for these estimates. It is noted that further energy savings could be realized if the wall insulation is upgrade during more intensive remodeling.
- The slab remained unchanged for these estimates. Insulation of the slab foundation is considered intensive and has not been included herein.
- Ceiling insulation was upgraded to R-38. A further upgrade to current recommendations of R-49 will provide greater efficiency.
- Roof insulation was upgraded along the 2nd floor slope to R-26 within the 2 x 8 roof rafters.
- Infiltration factors were chosen to represent "good" sealing conditions for the building envelope given the window and door replacements, insulation and siding addition and an assumption of aggressive caulking. The fireplace is assumed to be fitted with an enclosure.

The results of the estimates for the above upgrade conditions are summarized below in Table 2. A comparison with original based estimates indicates that heat losses are reduced by over 40%. Further reductions are achievable by upgrading wall insulation during remodeling, adding foundation insulation, bringing ceiling insulation to R-49 and selecting triple pane Energy Star rated replacement windows.

Table 2: Estimate of heat losses for an upgraded Country Clubber

Category	Area ft^2	Linear ft	Air Flow CFM	Loss BTU/hr
Windows	191	-	-	2,550
Doors	192	-	-	3,739
Walls	1,738	-	-	4,906
Slab Edge		178.5	-	6,938
Ceilings	523	-	-	644
Roofs	619	-	-	1,324
Infiltration		-	230	13,531
Total				**33,632**

The energy savings resulting from the upgraded unit, projected over an entire heating season with 5180 heating degree days (HDD) in the Southwest Pennsylvania Region translate to seasonal fuel savings of nearly 450 gallons. At fuel costs approaching $3/gallon the estimated cost savings is $1,350.

Additional savings, not estimated above would also be realized in the cooling season with the reduction of electrical air conditioning costs. Since air conditioning is not uniformly installed in Levittown homes these estimates have not been made here.

Summary

Whether motivated by environmental concerns, or cost, remodeling of older homes to achieve energy conservation and sustainable efficiency must occur if timely reductions in our national energy consumption are to be realized. This study focused on evaluating the potential to achieve energy savings for 1950's era housing. It served to illustrate the challenges and opportunities to improve residential energy efficiency for existing homes. Potential energy savings associated with reduced heat losses exceeded 40%. Improvements made to these homes are also expected to be applicable to a large number of the existing homes in the U.S. This study illustrates that significant energy savings can be realized for older homes, using existing technology and without extensive rebuilding. Additional savings are also possible.

The Next Step

A blower door test coupled with a thermographic evaluation is planned for a second phase of study for a Levittown home. The blower door test essentially pulls air from the house and creates a slight vacuum that induces air to move into the house from the outside through whatever cracks or crevices exist. It essentially simulates the infiltration of cold air into the house with a stiff breeze. An infrared camera is then used to survey the home to locate the major locations where heat loss is occurring. The results of this testing will be discussed in the next phase.