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Analysis of Illinois Home Performance with ENERGY STAR® Measure Packages

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Partnership for Advanced Residential Retrofit

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Definitions

AFUE	Annual fuel utilization efficiency
ALA	Approximate leakage area
Ameren Illinois	Illinois investor-owned utility
BEopt™	Building Energy Optimization software
BPI	Building Performance Institute, Inc.
Btu	British thermal unit
CNT Energy	A nonprofit running a portfolio of Chicagoland energy efficiency programs
DOE	U.S. Department of Energy
EI2	Energy Impact Illinois
EF	Energy factor
EUI	Energy use intensity
IECC	International Energy Conservation Code
IHP	Illinois Home Performance with ENERGY STAR
MEEA	Midwest Energy Efficiency Alliance
PARR	Partnership for Advanced Residential Retrofit
PC	Participating contractor
SEER	Seasonal energy efficiency ratio

Executive Summary

Through the Chicagoland Single Family Housing Characterization and Retrofit Prioritization report, the Partnership for Advanced Residential Retrofit (PARR) characterized 15 housing types (groups) in the Chicagoland region based on assessor data, utility billing history, and available data from prior energy efficiency programs (Spanier et al. 2012). Within these 15 groups, a subset showed the greatest opportunity for energy savings based on BEopt Version 1.1 modeling of potential energy efficiency package options and the percent of the housing stock represented by each group. In this PARR project, collected field data from a whole-home program in Illinois are utilized to compare marketplace-installed measures to the energy saving optimal packages previously developed for the 15 housing types. Housing type, existing conditions, energy efficiency measures installed, and retrofit cost information were collected from 19 homes that participated in the Illinois Home Performance with ENERGY STAR® (IHP) program in 2012, representing eight of the characterized housing groups. Of these homes, two were selected for further case study analysis to provide an illustration of the differences between optimal and actually installed measures. Taken together, the two selected case study homes are representative of 34.8% of the Chicagoland residential building stock. In one instance, actual installed measures from IHP closely matched optimal recommended measures. For the other case study, installed measures and normative measures did not match, resulting in a missed opportunity.

Overall, PARR finds that homeowners in northern Illinois are not installing BEopt-defined energy-saving optimal measure packages. Specifically, homeowners are installing measures that have an installed cost that is more than twice the cost of BEopt-recommended measure packages. PARR investigates the missed energy savings opportunities as well as homeowner choices leading to the installation of suboptimal measure packages. These reasons included market conditions, utility rebate programs, home performance program design, education, and a history of envelope improvement measures. This study has found that cost may be only one consideration for homeowners, as many choose to invest heavily in home energy retrofits rather than selecting cost-optimal packages. For instance, a homeowner may find greater value in comfort than in cost effectiveness; therefore, the homeowner will choose measures that maximize comfort. Another important finding of this study is that modeled energy savings may be comparable between cost-optimized measures and measures actually selected in the field. While savings are comparable, costs are not.

This project provides Building America with important insights into the marketability of specific energy efficiency packages. IHP relies upon private home performance contractor and energy auditor companies to not only perform the analysis and upgrade work, but also to sell the job to the homeowner, who has the final say in exactly what improvement work is completed. As such, no matter how cost effective or optimal a retrofit solution package is deemed to be, it will not be implemented unless the local contractor community is skilled in appealing to the homeowners' needs, which often focus on improved comfort or safety rather than energy savings. In the IHP program design, contractors present homeowners with a scope of work derived from an energy audit, while never presenting homeowners with BEopt optimal package recommendations. Energy savings achieved through the IHP program are largely the result of interactions between the homeowner and contractor; therefore, BEopt's sequential search for cost-optimal packages is not in alignment with how retrofit scopes of work are actually derived by homeowner-contractor

interactions. While it may be useful to know what cost-optimal or near-optimal packages are, optimality—at least not cost optimality—is not what drives decision-making.

The results of this research summarize the current retrofit practices under IHP and highlight the missed opportunities from failing to install the measure packages as originally put forth by PARR for targeted housing types. The content presented in this report is directed toward—and applicable to—energy efficiency program designers, researchers, utilities, and building science professionals.

1 Introduction

1.1 Background

The Chicago metropolitan region contains a dense population of old, energy-intensive housing that is costly for homeowners to maintain and, in many cases, drafty and uncomfortable (Spanier et al. 2012). Comprehensive home energy upgrades, implemented by local contractors and energy auditors, have the potential to keep housing affordable, improve comfort, and preserve the existing housing stock. However, the energy upgrade industry is still nascent in northern Illinois. Large-scale programmatic efforts, such as Illinois Home Performance with ENERGY STAR® (IHP) program and associated electricity and natural gas utility programs, have only just begun. Most home performance contractors complete a limited number of retrofits each year due to either their company's small size or IHP retrofitting is supplemental to their core business. In alignment with national trends (Bianchi 2011), homeowner knowledge on the subject is low and, correspondingly, homeowner demand is limited to a handful of first adopters.

Building off of other recent research (Polly et al. 2011), the Partnership for Advanced Residential Retrofit (PARR) has identified standardized retrofit measure packages tailored to certain housing types as a tool that may aid the industry in overcoming these challenges and help move the local market toward large-scale retrofit implementation (Polly et al. 2011; Spanier et al. 2012). This previous PARR research found that use of a standardized set of retrofits, specific to housing type, can result in 11%–28% energy savings (Spanier et al. 2012). However, before moving forward with recommended standard packages, it is necessary to assess which retrofit packages are actually being chosen and why the homeowner chooses them.

The U.S. Department of Energy's (DOE) National Renewable Energy Laboratory has developed Building Energy Optimization (BEopt™) software to identify cost-optimal residential efficiency packages that are specific to individual housing types. BEopt modeling software simulations account for the home's size, architecture, occupancy, vintage, location, and utility rates. One important function of BEopt modeling software is that it takes a systems-integrated approach rather than basing energy savings on additive individual retrofit measures. This BEopt software assumption is important, because it accounts for the additional benefit and energy savings associated with system-level retrofits (Hendron and Engebrecht 2010). The system-level interactions of these simulation inputs result in residential retrofit recommendations involving the home thermal envelope, equipment, construction materials, and construction practices. Residential retrofit optimization conducted during BEopt software simulation is based on data gathered in a stepwise process with the intention of utilizing and applying the best available information and data.

A number of issues limit the real world applicability of BEopt's approach to retrofit package selection, including the pre-existing conditions, outside the scope of simulation software that impact retrofit measure selection include occupant vacancy duration, contractor-specific skillsets, code and building regulations, and assessment of livable space. Previous studies have found that BEopt simulation recommendations are confounded by software assumption limitations and real-world influences (DOE, 2009a, 2009b; Donnelly and Mahle 2012). There is also evidence that the exact retrofit measure implemented is largely based on factors other than cost effectiveness. An important motivating factor, cited in several case studies by contractors, is that existing homes vary greatly in their physical characteristics (DOE 2009a, 2009b; USDA 2012).

The primary objective of BEopt is to maximize energy reductions while minimizing costs; however, case studies have found that contractors and occupants are motivated by objectives beyond just cost effectiveness. Case studies representative of multiple housing types and geographic locations have found an intrinsic objective of improving energy efficiency (DOE 2009a, 2009b; Donnelly and Mahle 2012). Additional goals, stated by contractors and homeowners, include sustainability, operational affordability, durability, safety, comfort, and lifestyle. The numerous goals, beyond cost effectiveness, help guide the decision-making surrounding residential energy efficiency retrofit measure selection. In addition to contractor and home occupant goals, the decision of what to retrofit can also be impacted by financial factors outside of direct costs and energy saving financial benefits. One case study in Pittsburgh, Pennsylvania noted that "Federal Tax Credits" and "State Incentive Programs" motivate homeowners to implement costly retrofit measures such as equipment and window replacements (DOE 2009b).

Because of the variations in pre-existing conditions for residential buildings and competing homeowner motivations, it is important to identify measures that are actually being installed in the field. This report also attempts to investigate the reasons homeowners are not electing to install BEopt optimal packages.

1.2 Illinois Home Performance

Over the past two years, Midwest Energy Efficiency Alliance (MEEA) has led the development of a statewide Home Performance with ENERGY STAR program in Illinois (IHP). IHP connects homeowners with qualified contractors and energy auditors who assess the "performance" of existing homes and perform targeted renovations that result in energy savings and improved comfort, safety, and durability. IHP is a process, as well as a set of contractor and performance standards, used by a variety of utility and nonprofit residential programs across Illinois. Currently, IHP program providers include Energy Impact Illinois (EI2), Ameren Illinois, ComEd and Nicor Gas, Delta Weatherization, and the Historic Chicago Bungalow Association. For this report, PARR is including 19 cases that resulted in IHP certification through EI2 and Ameren Illinois' programs. An IHP energy upgrade addresses issues such as drafts, rooms that are too hot or cold, and high energy bills. There are three steps:

1. Pinpoint areas to be fixed through a comprehensive energy audit.
2. Make targeted improvements identified during the audit, such as air sealing, duct sealing, installing insulation, and repairing or replacing heating and cooling equipment.
3. Run tests to verify improvements are working as intended.

IHP takes a systems-based building science approach to home energy upgrades. The first step is a comprehensive home energy assessment that specifies how to address comfort issues and save energy. Next, qualified and approved contractors perform the improvements, which often include sealing up drafts and ductwork, installing wall and attic insulation, and tuning up or replacing heating and cooling equipment. IHP specifies that the home energy upgrades should be completed following Building Performance Institute (BPI) standards, which include health and safety considerations as well as sound building science principles. Homeowners receive documentation of the assessment, completed upgrades, and a "test-out," which provides verified data on the home's improved performance and results in statewide IHP certification. Furthermore, a quality assurance program allows contractors to hone their crafts, improve customer satisfaction, and provide homeowners the confidence that home improvements have been completed properly.

The decision to participate in the IHP program eventually must be made by the homeowner. Specific measure selection, required to qualify for IHP, is also the homeowner's decision. Homeowners often choose which home energy improvements to make based on local rebate packages, the specific contractor, and the measure price. In the E12 program, homeowners can receive rebates of 70% off of their total project cost (up to $1,750) on insulation and air sealing measures. If a homeowner chooses to forgo air sealing and insulation entirely in favor of other cost-effective measures, he or she would not be eligible for the enticing rebate offer. Thus, most homeowners primarily choose to air seal and insulate their homes because of the financial incentive, and beyond these two measures they make secondary decisions about the other measures that a contractor proposes. The impact of measure-specific incentives and differences in measure pricing is important to process because homeowners may not be presented with background information about measure cost effectiveness.

Homeowners that complete an IHP job are awarded IHP Silver or Gold Certificates from the State of Illinois. These certificates detail improvements made and are recognized in the Northern Illinois Multiple Listing Services for reference at home sale. The net result is that during resale northern Illinois residents can capture some of the value they have invested in making their homes safer, more comfortable and more energy efficient.

IHP offers homeowners a variety of resources, including an online energy profile tool, building science hotline, listing of qualified contractors, and Gold and Silver Certificates of Completion. Visit www.IllinoisHomePerformance.org for more information.

1.3 Housing Stock

PARR's Chicagoland Single Family Housing Characterization and Retrofit Prioritization project identified 15 single-family home housing types that are abundant in Cook County, Illinois (see Table 1). A subset of three housing types was identified as the most promising for development of standardized measure packages due to their high energy saving potential, defined as annual source energy savings multiplied by the total number of houses of that type in the population. See Appendix B for details on the three housing types and their optimal measure packages; Appendix D provides background demographic information for Cook County. This project applied and refined previous work by comparing the findings to home retrofits completed in the field.

While the earlier report focused solely on Cook County, this project expanded the research area to EI2's and Ameren Illinois' program territory. Because some of Ameren Illinois' territory extends into southern Illinois, only homes from Ameren Illinois' northern regions were included. All homes were from International Energy Conservation Code (IECC) climate zone 5. Due to the potentially small sample size of retrofits, PARR did not want to unnecessarily limit the data by restricting the project to one county.

Table 1. Chicago Housing Group Characteristics (Spanier et al. 2012)

Chicago Single Family Housing Characteristics					
Housing Groups	Description	Mean Sqrft	Mean kWh	Mean therms	% pop
1	Brick, 1978-present, 1 to 1.5 stories	1741	8887	1077	2.5%
2	Brick, 1978-present, split level	1404	10076	1205	1.9%
3	Brick, 1978-present, 2 stories	2506	12482	1446	4.7%
4	Brick, 1942-1978, 1 to 1.5 stories	1217	8859	1212	17.9%
5	Brick, pre 1978, Split level	1299	9643	1344	6.1%
6	Brick, 1942 - 1978, 2 stories	2059	11714	1553	4.8%
7	Brick, pre-1942, 1 to 1.5 stories	1141	8927	1141	11.6%
8	Brick, pre-1942, 2 stories	1884	11062	1757	4.1%
9	Frame, 1978 - present, 1 to 1.5 stories	1801	9719	1217	1.7%
10	Frame, all years, split level	1349	9321	1480	2.1%
11	Frame, 1978 - present, 2 stories	3178	14914	1749	1.1%
12	Frame, 1942 - 1978, 1 to 1.5 stories	1185	8483	1268	23.6%
13	Frame, 1942 - 1978, 2 stories	1586	9802	1467	3.8%
14	Frame, pre-1942, 1 to 1.5 stories	1254	9050	1608	11.2%
15	Frame, pre-1942, 2 stories	2058	9050	1608	2.9%

1.4 Relevance to Building America's Goals

This project addresses Building America's objective of creating a market-ready strategy to increase uptake of retrofits. Further understanding of installed retrofit packages, and the opportunity to make them more optimal, may be useful for three separate groups:

- Energy efficiency programs, to assist in fine-tuning homeowner incentives and targeting likely retrofit candidates with tailored marketing
- Home performance contractors and energy auditors, to support refining and streamlining processes for assessment and improvement work
- Homeowners, to aid understanding of retrofit processes and projected outcomes.

The data generated in this project are specifically relevant to the country's cold climate regions, categorized by abundant housing type. Chicagoland single-family homes encompass all cold-climate architectural styles and were largely built before energy efficiency was an important consideration. The top three housing types alone represent the potential for savings of more than 100 million therms of source energy, if each were to be retrofitted following the PARR's earlier recommended measure packages (Spanier 2012).

1.5 Program Impacts

One of the program benefits is an increase in comfort for occupants. It is commonly held knowledge among practicing home performance companies that comfort issues drive consumer interest (Mills and Rosenfeld 1996). Furthermore, even with the availability of rebates, homeowners provide the majority of financing for home energy upgrades through IHP. As such, it was expected going into this research that homeowners would select a variety of energy efficiency measures, and that these measures would not necessarily align with BEopt-predicted optimal measure packages. Cost assumptions for BEopt modeling have been taken from the National Residential Efficiency Measures Database. The retrofits might have also included measures that hold high value among homeowners but are not always cost-effective, such as windows.

In addition to energy efficiency, occupant comfort, health, and safety are also important program benefits. Regarding occupant health and safety, IHP's structure and guidelines have made these a key focus by requiring pre- and post-retrofit combustion safety testing following BPI Building Analyst and Envelope standards.

Finally, an important homeowner benefit under IHP was the third-party administered IHP with ENERGY STAR Gold or Silver Certificate of Completion, which documented the measure improvements and expected savings of a project and was capable of being listed on the Chicagoland Multiple Listings Service. The certificates and the requirements to earn an IHP certificate had been developed by MEEA in consultation with the major Illinois utilities.

By increasing the cost effectiveness of retrofits and streamlining program resources, value is provided to participants. Varying levels of homeowner investment costs and benefits associated with home residential retrofit measures determined the cost effectiveness. Cost effectiveness can impact the homeowner's decision-making process and the measures selected and implemented during the retrofit. Increasing cost effectiveness and process efficiencies for residential retrofits in northern Illinois was an important component of this project. Data surrounding potential barriers, such as measure cost effectiveness, could help inform decisions related to home energy efficiency retrofits.

2 Research Methodology

2.1 Research Questions

- What are the characteristics of retrofits currently occurring under the IHP program in northern Illinois?
- Which measures or packages are commonly purchased in the field and how do these compare with the modeled optimal packages?
- How much money are homeowners willing to invest in an energy upgrade and does this restrain the recommended standard retrofit package?
- Based on field data, does PARR need to revise its pre-retrofit case, cost, or other assumptions used in the original models for the top three targeted housing types?
- How close are modeled energy savings estimates to actuals, for three case studies?
- Are energy efficiency measure packages developed from empirical data and simulation appropriate for abundant Midwest housing types?

2.2 Data Collection and Analysis

This research was based on data collected by MEEA from actual retrofits documented under the IHP program. MEEA had included data from 19 retrofits within northern Illinois. These data included pre- and post-retrofit information ranging from year built to the before and after building infiltration rate. See Appendix C for a listing of all data points collected through IHP. Nearly all of the information required for the first step of this project had been collected through IHP's normal procedures in concert with EI2 or Ameren Illinois, local program providers. The data and process flow was as follows:

- IHP participating contractor (PC)[1] engaged with a homeowner to complete an initial audit, sold a retrofit package that addressed the homeowners motivating issues (comfort issues, high energy bills, etc.), and completed an audit and retrofit following BPI Building Analyst and Envelope Standards.
- IHP PC submitted a work scope and a completed test-out reporting form to the local program provider.
- The program provider reviewed the file for errors and sent a quality assurance staff person to the job site for an onsite inspection, following IHP standards. If errors, mistakes, or issues were identified, the contractor had to correct the mistakes.
- Upon satisfactory completion of quality assurance, the program provider sent corresponding qualitative and quantitative data along with quality assurance notes to MEEA, who performed a final review.
- MEEA then issued an IHP Silver or Gold Certificate of Completion to the homeowner on behalf of the State of Illinois.

[1] In order to participate in IHP, a contractor or auditor must meet the following requirements: BPI Building Analyst and BPI Envelope certifications, liability and workers compensation insurance, valid business license, and business and customer references. For more information, visit www.IllinoisHomePerformance.org/contractors.

The data associated with this project were organized as a matrix spreadsheet, with columns that corresponded to each retrofit and rows that corresponded with retrofit data categories. Through direct inquiry with contractors, MEEA was able to collect and populate the spreadsheet with the necessary data that went above and beyond the standard IHP data points. The two case study homes were chosen because they offered robust retrofit measure descriptive data and illustrated one home that closely followed recommended optimal measures and one that did not.

3 Results

This study collected and evaluated data from 19 homes that had undergone IHP retrofits in northern Illinois. Of those 19 homes, two case studies had been chosen because they represented prevalent housing types in the Chicagoland area and corresponded with high estimated annual savings potential. Furthermore, the two case studies highlighted one home where installed measures closely matched recommended measures and another where the installed measures differed from optimal measures.

Specifically, the two housing groups evaluated were groups 12 and 14: homes in housing group 12 were frame, 1942–1978, and 1–1½ stories; homes in housing group 14 were frame, pre-1942, and 1–1½ stories. These two home categories comprised approximately 34.8% of the total Chicagoland home inventory evaluated in the Chicagoland report.

Homes that underwent the IHP program were subjected to a three-step process that involved a pre-retrofit audit, upgrade selection and implementation, and a post-retrofit audit. The home's pre-retrofit audit evaluated multiple aspects of the home and identified problem areas. After the initial audit the homeowner was provided with a detailed report listing the recommended upgrades and the potential energy savings. The homeowner then selected the desired upgrade package. Finally, once the upgrades were completed, the house would be audited to verify the upgrade efficacy and the potential energy savings.

3.1 Illinois Home Performance with ENERGY STAR Housing Types

IHP launched in November 2011 with its first program provider, EI2, a Better Buildings program. Though IHP was designed as a statewide program, each program territory would launch at separate times. Ameren Illinois' Warm Neighbors Cool Friends program and Home Energy Performance program launched in late summer 2012, and data from their homes are included in this report. ComEd and Nicor Gas's Home Energy Savings program also launched in late summer 2012, but as of this publishing, no homes had received IHP certification through the Home Energy Savings program. Peoples Gas and North Shore Gas were not yet IHP program providers, though through a partnership with E12, homeowners in their territory could participate in IHP. Because of these varied launch dates, the majority of the homes that had gone through IHP have come from the E12 program territory, covering the seven counties around the City of Chicago plus the City of Rockford. It would be expected that housing types would go through IHP in similar percentages to the representative housing stock, not having accounted for economic factors that could have correlated to type and size of home and propensity to invest in an energy upgrade. IHP is a market-based program and requires homeowners to make the investment decisions on home energy upgrades.

Because the sample size was small, it appeared that IHP jobs were distributed roughly along the same lines as the percentage of housing types (see Table 2). Housing group 4 represented 17.9% of the housing population, and five number four IHP types accounted for 26.3% of the IHP jobs. Less common homes have yet to go through IHP. PARR would expect that in the coming year, as more than 200 homes participate in IHP, PARR will be able to identify trends that more closely mirror percentage of housing population.

Table 2. IHP Participating Homes Housing Group Breakdown

Frequency of IHP Homes in Chicagoland Types			
Groups	Descriptive	% of pop	Homes
1	Brick, 1978-present, 1 to 1.5 stories	2.5%	
2	Brick, 1978-present, split level	1.9%	
3	Brick, 1978-present, 2 stories	4.7%	
4	Brick, 1942-1978, 1 to 1.5 stories	17.9%	5
5	Brick, pre 1978, Split level	6.1%	
6	Brick, 1942 - 1978, 2 stories	4.8%	
7	Brick, pre-1942, 1 to 1.5 stories	11.6%	1
8	Brick, pre-1942, 2 stories	4.1%	1
9	Frame, 1978 - present, 1 to 1.5 stories	1.7%	
10	Frame, all years, split level	2.1%	1
11	Frame, 1978 - present, 2 stories	1.1%	
12	Frame, 1942 - 1978, 1 to 1.5 stories	23.6%	3
13	Frame, 1942 - 1978, 2 stories	3.8%	2
14	Frame, pre-1942, 1 to 1.5 stories	11.2%	2
15	Frame, pre-1942, 2 stories	2.9%	2
Total			17

**note: 2 IHP homes were unable to be categorized*

3.2 Measure Packages Installed Through Illinois Home Performance with ENERGY STAR and Comparison to BEopt Optimal Measures

BEopt optimal measure packages as described in the previous Chicagoland report are listed in Appendix B for the 15 different housing types. Individual measures range from increasing attic insulation to R-38 or R-49, tightening up the house through air sealing, installing new high-efficiency boilers and furnaces, and installing new water heaters. One to four measures were recommended per housing type. Table 3 illustrates the frequency with which each measure category was recommended by BEopt.

Table 3. BEopt-Recommended Upgrade Measure Category Frequency

Category	Frequency
Infiltration	12
Unfinished Attic	10
Furnace/Boiler	9
Water Heater	10

Given that these measures were modeled to be the most cost optimal, PARR would have expected that homeowners, with the primary goal of maximizing cost effectiveness, would elect to install these measures in their homes. PARR did not find this to be the case. Individual upgrade measure recommendations and homeowner upgrade selections frequency diverged from what was modeled as optimal (Table 4). This was also true of recommendations in the initial home audit, suggesting that contractors played a large part in determining installed measures.

PARR found that 17 out of 19 homes had air sealing performed and 16 out of 19 homes had attic insulation installed. Three homes received duct sealing, while six homes received new windows. One home had a heat recovery ventilator installed. In eight of the 19 homes, heating, ventilation, and air conditioning equipment was upgraded. One area that significantly differed from the BEopt-optimized measures was water heater replacement. No IHP homes installed new water heaters (Appendix A).

Table 4. IHP Upgrade Measure Frequency Summary

Upgrade measure	Rank	Frequency
Air sealing	1	17
Attic insulation: R>38	2	10
HVAC equipment replacement	3.5	8
Ventilation upgrade	3.5	8
1st floor perimeter walls: R-11	5	7
Technology/window upgrade	6	6
Attic insulation: R-35 - 38	7	5
Basement perimeter walls: R>11	8	4
Duct sealing	9.5	3
Basement perimeter walls: R-11	9.5	3
Crawlspace insulation: R<35	11	2
Crawlspace insulation: R-35	13	1
Installation of HRV	13	1
2nd Floor Wall insulation	13	1
Moisture sealing	15.5	0
Knee Wall R-13	15.5	0

Overall, homeowners spent $127,252 on completing the 19 retrofits. Individual retrofits ranged from $3,392 to $11,630, with the average approximately $6,700. Most of the audits were included in the pricing for the retrofit, or were included as a program provider cost in the case of Ameren Illinois. In the six instances where the audit was separately charged, the audit price ranged from $300 to $699, with an average price of $470. Program provider rebates were not available for all homes, specifically the first six homes through IHP outside of the City of Rockford. In Rockford, typical rebates were $2,000, and rebates for subsequent non-Rockford homes were slightly less than that. Still, homeowners bore a significant portion of the cost associated with completing retrofits.

3.3 Case Study Homes

From the sample of 19 homes, PARR had selected two case study homes to describe what was typically happening in these homes. These homes were in Rockford and Berwyn, Illinois and the work was performed by two different companies that completed both the audit and the retrofit. Both homes went through the EI2 program to receive their IHP Silver Certifications, and both homes received onsite quality assurance through EI2. Table 5 shows the selected case study homes as they matched up to their respective housing groups, 12 and 14 (Table 5).

Table 5. Case Study and Home Group Characteristics

Case Study and Home Group Characteristics				
	CS A	HG 12	CS B	HG14
Housing Group	12	12	14	14
Location	Rockford, IL		Berwyn, IL	
Year Built	1966	1942-1978	1911	pre-1942
Conditioned Space (sq ft)	1600	1185	1468	1254
Construction	Frame	Frame	Frame	Frame

3.1.1 Case Study A: Housing Group 12, Rockford, Illinois

(Google)

Figure 1. Case Study A: (L) Rockford, Illinois; (R) model housing group 12

Case Study A (CS-A) was chosen because it offered the PARR team the most comprehensive retrofit package and descriptive data currently available for housing group 12. The home chosen for CS-A was a 1,600-ft^2, single-family, one-story ranch home, built in 1966, and located in Rockford, Illinois. The pre-retrofit audit found an air infiltration rate of 2,906 CFM50 and no attic insulation. This level of pre-retrofit air leakage allowed the PARR team to categorize CS-A as leaky in the BEopt model. The IHP PC noted that CS-A had an 80 annual fuel utilization efficiency (AFUE) gas forced-air furnace, a 13 seasonal energy efficiency ratio (SEER), 24.0 kBtu/h central air conditioner and a gas water heater with an energy factor (EF) rating of 0.51. Pre-retrofit utility bill analysis from February 2010 to January 2012 showed a total energy use intensity (EUI) (normalizing heating/cooling only; kBtu/ft^2/yr) of 91.2 with 72% gas and 28% electricity. The weather-normalized heating was 865 therms and the weather-normalized cooling was 1,641 kWh according to PARR's pre-retrofit utility bill analysis conducted by CNT Energy. PARR separated baseload energy use from heating and cooling load energy use using a regression model based on heating and cooling degree days. The heating and cooling energy use only was then weather normalized to ensure comparisons to future energy use or other normalized models was as accurate as possible.

The initial audit recommended several envelope upgrades. Subsequently, the homeowners chose to perform air sealing, resulting in a 35% reduction in air leakage, increased the attic floor insulation to R-50, and performed duct sealing. Reducing the home's air leakage will reduce heating and cooling losses and improve the overall indoor air quality. Duct sealing will aid in the reduction of the amount of conditioned air lost to unconditioned space and therefore reduce the total energy consumption. Installing attic insulation to R-50 would improve the home's comfort, reduce heat losses, and reduce overall energy costs. The audit cost $300 and took 3.5 hours to complete. The total cost of the project was $4,723 and was completed in 70 hours.

In this instance, PARR had a case study that closely followed the BEopt recommendations for housing group 12. BEopt recommended a one-step air infiltration upgrade from leaky to typical and the addition of ceiling insulation to R49, however BEopt did not recommend changes to furnace or water heater equipment.

Both REM Design and BEopt can help develop scopes of work for builders; however, they do so differently. One tool that IHP contractors utilize to estimate energy savings is REM Design. REM Design differs from BEopt because it is designed for use by homebuilders and remodelers. REM Design modeling analysis performed by the IHP PC showed estimated reductions in the annual heating load of 44.2%, and the cooling load of 23.0%. Post-retrofit blower door testing found that the air infiltration rate was reduced by 35% from 2,906 CFM50 to 1,881 CFM50. The implemented upgrades had been projected to save 38% of the total energy consumption based on REM Design. Specifically, the upgrades had been estimated to reduce electricity consumption by 18% and gas consumption by 37%/yr. The predicted reduction in energy consumption would result in an estimated savings of $747 annually (Table 6). The PC estimated the improvements would save 2,230 kWh/yr and 413 therms/yr from REM Design models.

Table 6. Case Study A: Pre-Retrofit, BEopt Cost-Optimal Measures, and IHP-Installed Measures

Category	Pre-Retrofit	BEopt Upgrade	IHP Upgrade
Infiltration	Leaky	Typical	Tighter
Unfinished Attic	Ceiling R19 fiberglass blown-in, vented	Ceiling R49 fiberglass blown-in, vented	Ceiling R50 fiberglass blown-in, vented
Duct	Typical, uninsulated	None	Tight, uninsulated

For this homeowner, one of the primary motivating factors behind deciding to invest in an energy upgrade was the environmental impact. The homeowners specifically asked the PC to provide an estimate of the carbon reduction resulting from the improvements. The PC commented that these homeowners "knew they would save money but were amazed at the comfort level change in their home. They commented on not having to put a sweater on in the morning while reading the paper with coffee." The homeowners followed the recommendations of the PC as laid out in the REM Design runs. The PC believed that these specific measure improvements would generate the most savings for the investment.

Figure 2. Case Study B: (L) Berwyn, Illinois; (R) model housing group 14

3.1.2 Case Study B: Housing Group 14, Berwyn, Illinois

This particular home was chosen for use as a case study because it offered the PARR team the most comprehensive retrofit package and descriptive data currently available for housing group 14, and it illustrated an instance where the installed measures differed from BEopt's recommendation. The home chosen for Case Study B (CS-B) was a 1,468-ft^2, single-family 1½-story bungalow, built in 1911, and located in Berwyn, Illinois. Pre-retrofit testing found that CS-B had an air infiltration rate of 5,130 CFM50, poor wall insulation, an unknown level of attic insulation, and limited air sealing. This level of pre-retrofit air leakage allowed the PARR team to categorize pre-retrofit CS-B as leaky. Comprehensive furnace data were not available; however, the home auditor noted that the furnace was a newer gas forced-air, Bryant furnace with an ENERGY STAR rating. PARR had estimated that this furnace was a condensing unit between 90%–97% efficient as measured by AFUE. The home auditor also noted that the home had an older central air conditioner and a newer gas water heater. Pre-retrofit utility bill analysis from February 2011 to January 2012 showed a total EUI (normalizing heating/cooling load only; kBtu/ft^2/yr) of 142.0, 84% gas, 16% electric. The weather-normalized heating load was 1,611 therms, while the weather-normalized cooling load was 2,660 kWh.

The initial audit recommended that this home undergo several upgrades involving its thermal envelope. Subsequently, the homeowners chose to air seal, increase the exterior wall and basement insulation to R-11, and insulate the crawlspace to R-35. Improvements in the home's air sealing will help reduce heating and cooling losses and improve the overall indoor air quality. Upgrades in the home's exterior wall, crawlspace, and basement insulation served many functions in addition to improving the comfort of a home. Increasing insulation levels reduced the amount of heat that could potentially be lost though portions of a home's thermal envelope that had been insufficiently insulated. Proper insulation levels in conjunction with air sealing reduced the loss of conditioned air and thereby reduced the energy requirement for heated conditioned spaces, reducing energy costs. In addition, adequate insulation prevents the loss of structural stability due to rot created when warm moist air meets cold surfaces causing condensation on wooden surfaces. The audit cost was included in the overall price of the project and took approximately 4 h to complete. The total project cost was $8,605 and took 30 h.

The post-retrofit audit of CS-B showed modeled and estimated reductions in energy consumption and air infiltration. Post-retrofit blower door testing found that the air infiltration rate had been reduced by 40% from 5,130 CFM50 to 3,070 CFM50. Specifically, the upgrades were estimated to reduce electricity consumption by 8% and gas consumption by 41%. These percent reductions were equivalent to reductions of approximately 611 kWh of electricity and 826 therms of gas. The predicted reduction in energy consumption would result in an estimated savings of $722 annually (Table 9).

BEopt modeling of this housing group was different than what occurred in CS-B. In this instance, the homeowners invested in air sealing, insulated the first-floor perimeter walls to R-11, and insulated the basement walls to R-11. For this housing type, BEopt recommended a one-step air infiltration upgrade from very leaky to leaky, adding R-38 insulation to the attic, installing a 95% AFUE furnace, and installing a 0.67 premium gas water heater.

CS-B's homeowners were motivated to invest in an energy upgrade primarily because of comfort issues. Specifically, they wanted to keep a room in their attic warm throughout the winter. The PC said that they could address their comfort issues and would use diagnostic testing to verify their improvements. The homeowners were very happy with their results, saying "the energy improvements have made the temperature throughout our home much more stable, which is extremely important to us with our new baby, and we're already seeing lower energy bills. We're very happy to have had this work done." Subsequently, these homeowners have sold their home.

As part of selling the project, the audit report included an approximate leakage area (ALA) that characterized the air infiltration rate in more relatable terms. The auditor estimated that the homeowners had an ALA equivalent to leaving a 3.5-ft^2 window open in their home 24 hours per day. This type of analogy helps homeowners better understand the problems of air infiltration, and helps contractors sell air sealing measures to homeowners.

3.2 Quantifying the Missed Opportunity

3.2.1 Case Study Home Demographics and Modeling Assumptions

BEopt software modeling was intended to identify cost-optimal energy efficiency packages based on the building design. This project utilized BEopt to determine how current retrofit practices compared to the cost-optimal retrofit package. BEopt could also help identify potential missed opportunities. The two case study homes in this project were assessed using BEopt software. House structure comparison showed some discrepancies between PARR BEopt modeling and field houses. Specifically, variance between actual houses and house groupings was accommodated by running the modeling software with the real home size and the average housing group home size.

The BEopt models for these two housing groups were slightly revised to match the field data:

A) Group 12: 1,600 ft^2, frame, 1942–1978, 1–1½ stories

B) Group 14: 1,468 ft^2, frame, Pre-1942, 1–1½ stories with attic and crawlspace at basement.

Case Study A and Case Study B were modeled under housing types 12 and 14 using BEopt under three scenarios:

- Pre-retrofit- models case study homes with original construction characteristics for the housing type
- BEopt Upgrade—models case study home as if BEopt-proposed optimization measures were installed
- IHP Upgrade—models the case study homes based on IHP-installed upgrades.

The case study home sizes that underwent BEopt analysis were different from the PARR BEopt modeling sizes (Spanier 2012). In order to make the comparisons with PARR BEopt-proposed modeling results, three scenarios were run separately with the real house size and PARR BEopt modeling size. The modeling scenarios were BEopt house before retrofit package install, BEopt upgrade, and actual IHP upgrade. This assemblage of scenarios allowed for establishment of baseline energy usage, energy use after cost-optimal measure installation, and energy use after actual IHP measure installation. Individual descriptive data for each case study home group are listed on the following pages:

3.2.1.1 Case Study A: Group 12: Frame, 1942–1978, 1–1½ Stories (No Split Level)

Real square footage: 1,600
PARR BEopt square footage: 1,176

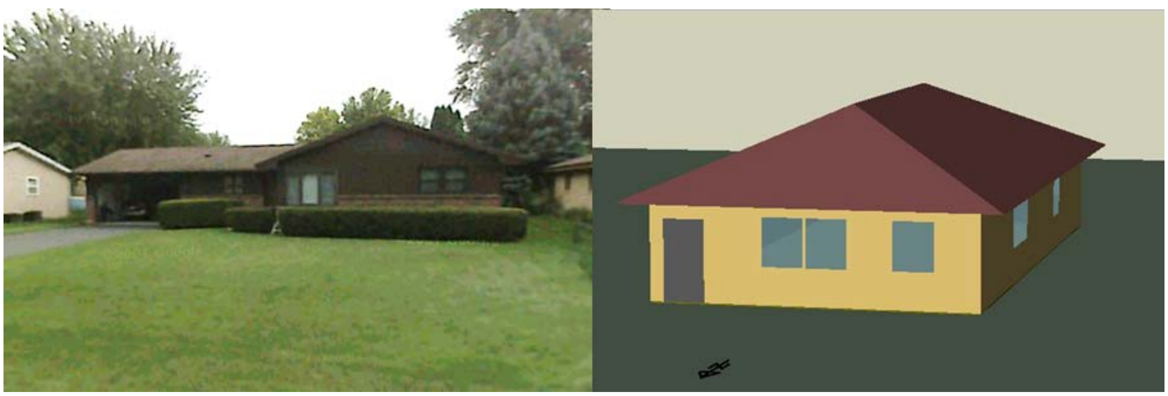

Figure 3. Case Study A: Case home and BEopt software image

3.2.1.2 Case Study B: Group 14: Frame, Pre-1942, 1–1½ Stories (With Attic and Crawlspace for Basement)

Real square footage: 1,468
PARR BEopt square footage: 1,248

Figure 4. Case Study B: Case home and BEopt software image

Table 7. Case Study B: Pre-Retrofit, BEopt Cost-Optimal Measures and IHP Installed Measures

Category	Pre-Retrofit	BEopt Upgrade	IHP Upgrade
Infiltration	Very leaky	Leaky	Tight
Unfinished Attic	Floored R3 roof insulation unvented	Ceiling R38 fiberglass blown-in, vented	None
Furnace/Boiler	Gas, 80% AFUE boiler	Gas, 95% AFUE boiler	None
Water Heater	Gas 0.54 EF	Gas premium (0.67 EF)	None
Unfinished Basement		None	Wall 8-ft R-11 rigid, R-35 insulated added to crawlspace underneath kitchen
Wall, Wood Stud		None	R11 batts, 2 × 4, 16 in. on center

3.2.2 Energy Consumption

Table 8. Pre-Retrofit, IHP, and BEopt: Therms and All Scenarios Therms and EUI (kBtu/ft²/year)

			Case Study A	Case Study B
EUI	Pre-retrofit	Total	164.4	188.5
	IHP	Total	132	145
		% Δ	20%	23%
	BEopt	Total	144	150.3
		% Δ	12%	20%
Therms	Pre-retrofit	Total	1459	1582
	IHP	Total	1033	1011
		% Δ	29%	36%
	BEopt	Total	1191	1075
		% Δ	18%	32%

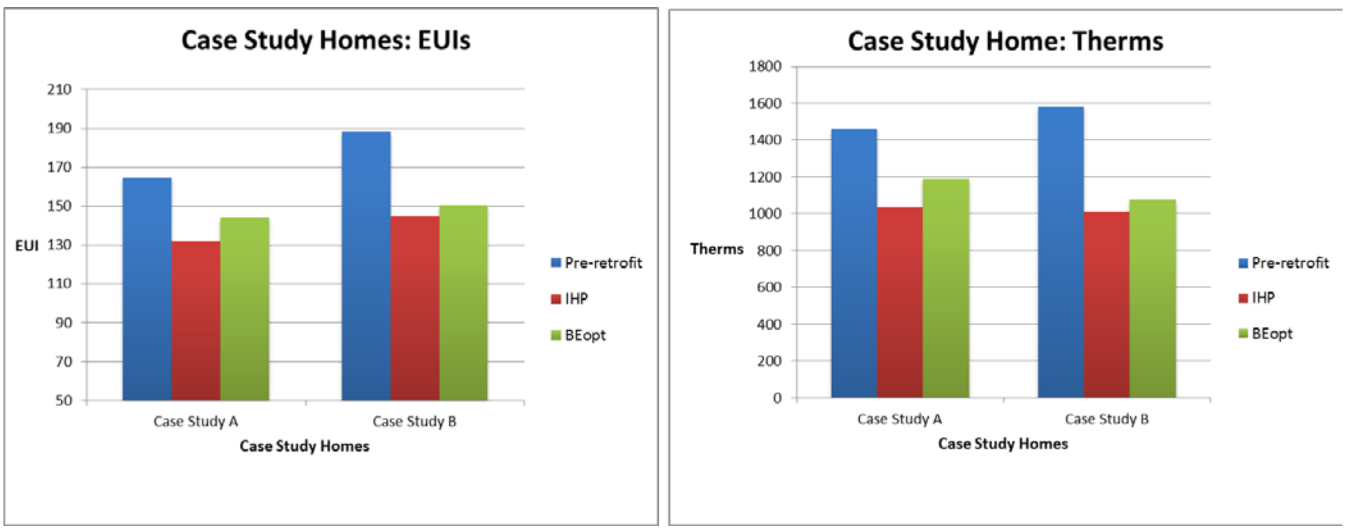

Figure 5. Case study home scenarios: therms and EUI

The simulated energy data presented above highlight the differences between the three modeled scenarios. In using the square footage as found in the field for the three cases, the EUIs decreased for CS-A and CS-B by installing BEopt-recommended measures, and were further reduced with the IHP field-installed measures (Figure 5). The difference in percent EUI reduction between IHP and BEopt retrofit measures is 8% for Case Study A and 3% for Case Study B (Table 8). IHP field-installed measures have a greater percentage drop for CS-A than for CS-B, which is surprising considering the similarity in measures. The CS-A IHP Update case included slightly more attic insulation and performed duct sealing. These two measures correspond with a drop from the BEopt pre-retrofit case value of 164.4 to 132 for the IHP retrofit and 144 in the BEopt retrofit (Table 8). In CS-B, the EUI started at 188.5 in the BEopt pre-retrofit case, dropped to 150.3 in the BEopt retrofit, and further to 145 in the IHP retrofit

(Table 8). For CS-B it is interesting to note that a similar level of savings was achieved with a different set of measures. The CS-B IHP Update case did not include furnace and water heater equipment replacements, but this case did include basement insulation and improved wall insulation.

Both case study homes exhibited similar trends for annualized therms (Figure 5). Case Study A and Case Study B showed 11% and 4% difference in percent therm reductions, respectively (Table 8). Interestingly, BEopt modeled a 426 therm/yr reduction in going from the pre-retrofit case to the IHP update case for CS-A. The IHP PC modeled a 413 therm/yr reduction from baseline using REM Design. For CS-B, BEopt predicted a 571 therm/yr reduction, while the IHP PC suggested an 826 annualized therm reduction using HES Pro.

3.3 Cost Effectiveness

Data corresponding to home energy retrofit cost effectiveness are important, because they present information regarding how long it takes for a homeowner to recoup retrofit expenditures from realized energy savings. BEopt software models, cost-optimal retrofits, and real-world home energy retrofits can be motivated by factors other than just cost (DOE 2009a, 2009b; Donnelly and Mahle 2012). There is a significant difference between the installed cost associated with the IHP retrofit and the BEopt-modeled retrofit (Table 9). Specifically, each case study home retrofit has an installed cost that is more than twice the BEopt-installed cost. However, the magnitude of installed cost differences does not correspond to financial savings associated with a reduction in energy consumption (Table 9). High retrofit installation costs that do not correspond with savings result in a longer payback time. Both case study homes show that the BEopt retrofit modeled payback time is significantly shorter than an IHP retrofit (Table 9).

Table 9. Cost Effective Results From All Scenarios—BEopt Upgrade and IHP Update

	Square Footage		Utility Bill ($/yr)			Utility Saves ($/yr)		Installed Cost ($)		Simple Payback Years	
GROUP	BEopt	IHP	BEopt, Pre-Retrofit	BEopt	IHP	BEopt	IHP	BEopt	IHP	BEopt	IHP
12	1,600	1,600	2,081	1,844	1,704	237	377	2,192	5,259	9.2	13.9
14	1,468	1,468	2,182	1,771	1,714	411	468	2,583	10,108	6.3	21.6

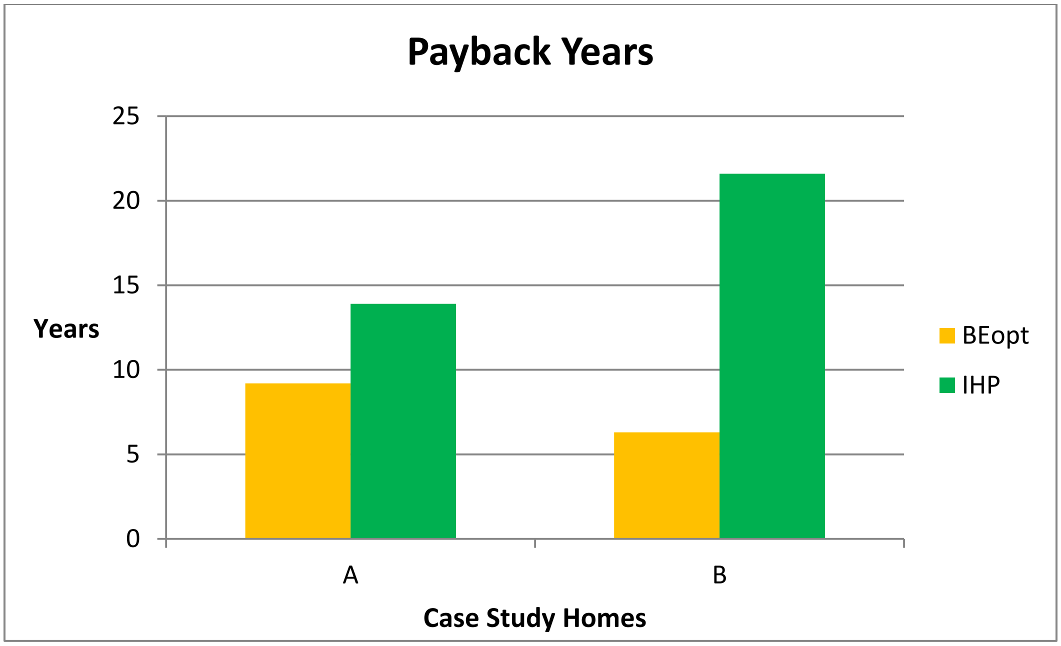

Figure 6. IHP and BEopt payback years

4 Discussion

This study collected data on homes that participated in the IHP program, grouped the field homes into 15 previously defined housing types, and took an in-depth look at how BEopt cost-optimized retrofits compare to what was installed under the IHP program. Through the analysis of qualitative and quantitative data, this study has been able to answer the research questions below and provide insights into how model-driven home retrofits differ from retrofits that are currently being performed.

- What are the characteristics of retrofits currently occurring under the IHP program in northern Illinois?
- Which measures or packages are commonly purchased in the field and how do they compare with the modeled optimal packages?
- How much money are homeowners willing to invest in an energy upgrade and does this restrain the recommended standard retrofit package?
- Based on field data, does PARR need to revise its pre-retrofit case, cost, or other assumptions used in the original models for the top three targeted housing types?
- How close are modeled energy savings estimates to actuals, for three case studies?
- Are energy efficiency measure packages developed from empirical data and simulation appropriate for abundant Midwest housing types?

In the IHP program to date, there appears to be more uniformity in measure selection than what would be expected given the different housing types. Instead of installing BEopt cost-optimal measure packages, homeowners are selecting other measures, most with an emphasis on envelope improvements. Additionally, it appears that homeowners are willing to make a significant investment in home energy retrofits, suggesting that price may not be the greatest deterrent to widespread adoption. Another important consideration is that BEopt cost assumptions are derived from the National Residential Efficiency Measures Database. This database provides unified national cost averages; therefore, the costs encountered in northern Illinois might differ from the national average values.

Many factors influence the decisions of homeowners in measure package selection. First, program design plays a large role. Through IHP, homeowners are presented with a scope of work derived from the audit and not from BEopt measure packages. This means that homeowners may never be presented with a cost-optimal choice. Further, by establishing certain requirements for participation of both homeowners and contractors, some measures are intentionally or unintentionally emphasized over others in their presentation to homeowners. Available rebates and other incentives also guide homeowners to make certain measure-level decisions. Homeowners face several competing motivations, such as comfort, safety, durability, aesthetics, and resale value (DOE, 2009a, 2009b; Donnelly and Mahle 2012). Contractors influence measure-level decisions via framing, and even through their specific points of departure into the whole-home space. Insulation contractors turned building scientists favor envelope measures, as legacy HVAC whole-home contractors prefer mechanical upgrades. While homeowners are saving energy through IHP, they could be doing so in a more cost-effective manner.

Certainly, many of the homeowner retrofit decisions were affected by available incentives. From when IHP launched in November 2011 until June 2012, EI2 was the only operating IHP program provider. The program's service territory covered the seven counties around the city of Chicago and the city of Rockford. In the seven counties around Chicago, no rebates were available to homeowners. The only incentive was that they would receive an IHP Silver or Gold Certificate that could be listed on the local MLS when they went to sell their home, allowing homeowners to regain some of their investment in increasing the safety, comfort, and durability of their homes. In Rockford, however, there was a tiered rebate structure based on modeling. For homes that achieved 15% energy savings as modeled through REM Design, homeowners were eligible for a $1,000 rebate from the Better Buildings Neighborhood program. If homeowners achieved 20% they were eligible for $1,200 back, and they were eligible for up to a $2,000 rebate for modeling 30% energy savings. Of the nine homes that participated in IHP during that period, three were from Rockford, and the rest were from the seven counties. Two of the Rockford homes added new 95 AFUE furnaces and 13 SEER central air conditioner, while the third was CS-A. The other homes in that time frame conducted air sealing and installed insulation, when no financial incentive was available to them. This could have been due to the fact that the contractors in the Rockford area, while having BPI certifications, were from the HVAC industry, whereas contractors in the Chicago area tended to have a longer history with whole home work. Larger datasets will lend further clarity to these associations.

In June 2012, two things changed. First, qualifications for obtaining an IHP Silver Certificate went from demonstrating 15% modeled energy savings to additionally allowing a prescriptive path. The prescriptive approach allowed for a 30% reduction in air leakage combined with installing attic insulation to IECC levels to qualify. At the same time, EI2 teamed up with the local investor owned utilities to provide combined incentives. In Peoples Gas and North Shore Gas territories, homeowners could receive $0.30/ft^2$ and $0.10/ft^2$, respectively, for bringing attic insulation that was below R-19 up to the IECC level for northern Illinois of R-38. This rebate was available to everyone who used an IHP PC, but it did not necessitate that the homeowner participate in IHP. Doing so would require them to perform a diagnostic energy audit, follow BPI Building Analyst and Envelope standards, and perform a test-out with quality assurance. BPI BA+E standards require that air sealing is performed prior to attic insulation being installed. If homeowners wanted to complete these measures, there was an additional EI2 incentive that, combined with the attic insulation rebates, would cover 70% of the work up to $1,750 as long as an IHP Silver Certificate was achieved. This subsequently skewed the financial benefits of installing air sealing and attic insulation. Indeed, air sealing was performed in all 10 homes and completed after this June change went into effect.

In the fall of 2012, Ameren Illinois began offering IHP in both its moderate income program, Warm Neighbors, Cool Friends, and its market-based program, Home Energy Performance. Through the Home Energy Performance program, homeowners can receive air/duct sealing up to $1,200, attic insulation up to $1,400, rim joist insulation up to $400, and wall insulation up to $2,400. These rebates, too, affected decisions made by homeowners on what they wanted done in their homes. It may be interesting, for future analysis, to change BEopt cost assumptions to reflect available incentives in different geographic regions in northern Illinois.

Aside from the prescriptive IHP Silver path that specifically requires air sealing and attic insulation, the IHP Silver modeling path (where any and all measures that result in at least 15%

modeled energy savings are incentivized) and the IHP Gold path (Appendix E), also affect measure selection. The primary building science requirement for IHP PCs is BPI's Building Analyst and Envelope Professional certification. These certifications place an emphasis on combustion safety testing, but also on writing a scope of work in the proper load order. The result is that if insulation is going to be installed, there must be air sealing performed, according to the Building Airflow Standard, beforehand. While a best practice is to use a blower door to guide air sealing, the requirement is for accurate before-and-after numbers.

From conversations with homeowners who have gone through the Illinois Home Performance program, and with IHP PCs, it is not just financial considerations that must be weighed in determining whether or not to do a home performance upgrade, and which measures to include. Many homeowners are motivated by comfort issues, and successful IHP PCs are adept at selling comfort fixes. One PC ranks comfort, savings, and resale value as the top three selling points when closing an IHP job. Simply, homeowners do not have access to BEopt and make decisions on more than just cost effectiveness. This information indicates that homeowners place significant value on benefits other than just financial savings gained through reduced energy consumption.

Finally, homeowners are finding that there are multiple ways to achieve moderate energy savings. Whether going with the BEopt-recommended upgrades or the PC-recommended upgrades, homeowners will begin to see reductions in their energy consumption. Some measures will no doubt be more cost effective than others, but selected measures must address the homeowners' primary motivating factors for purchasing upgrades. While it might not always make economic sense, homeowners are adept at weighing a multitude of variables in their consumption decisions and choosing what works best for them. Another important consideration in residential energy efficiency retrofits is the complexity of residential energy systems. Depending on the homeowner objectives and the pre-existing home conditions, there are multiple pathways to achieve energy savings goals. This study has shed some light on how real-world home conditions can impact exact measure selection and actualized energy savings. Although costs vary significantly, evidence suggests that homeowners are likely to work with their contractor to customize their home's energy efficiency retrofit.

5 Conclusion

The PARR Northern Illinois Single Family Housing Retrofit Case Studies project collected data on homes that participated in the IHP program, grouped them into 15 previously defined housing types, and compared installed measures with BEopt-defined energy-saving optimal measure packages. IHP homeowners in northern Illinois are installing a variety of measures, but the majority of installed measures are focused on attic insulation and air sealing. This measure selection reflects the current financial incentive environment and program design specifics. BEopt software modeling can provide the most cost-effective measure installation, but multiple other factors—economics, homeowner preference, rebates, structure characteristics, and others—can impact what is actually installed in the home. In fact, comparison between BEopt modeled savings and the two IHP retrofits has shown that IHP retrofits result in lower energy consumption than BEopt-modeled energy consumption.

Energy efficiency measure packages developed from empirical data, simulations, and model recommendations are a good place to begin making informed retrofit decisions; however, evidence suggests that numerous other factors will shape the eventual retrofit measure selection decision.

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Appendix A: Supplementary Data

Upgrade measure	SO1	CSA	CSB	S-02	S-04	S-06	S-07	S-08	S-09	S-10	S-11	S-12	S-13	G-01	G-02	S-15	G-03	G-04	G-05	Frequency	Rank
Housing Group #	14	12	14	15	12	12	10	4	4	8	13	4			4	15	4	7	13		
Air sealing	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x	17	1
Duct sealing		x						x											x	3	9.5
Moisture sealing																				0	15.5
1st floor perimeter walls: R-11			x	x									x	x			x	x	x	7	5
Basement perimeter walls: R-11	x		x											x						3	9.5
Basement perimeter walls: R>11				x		x											x		x	4	8
Crawlspace insulation: R<35					x									x						2	11
Crawlspace insulation: R-35			x																	1	13
Attic insulation: R-35 - 38	x			x	x	x	x													5	7
Attic insulation: R>38		x								x	x	x	x	x	x	x	x		x	10	2
HVAC equipment replacement								x	x			x	x	x			x	x	x	8	3.5
Ventilation upgrade	x			x		x					x		x		x	x			x	8	3.5
Technology/window upgrade					x					x		x	x				x	x		6	6
Installation of HRV															x					1	13
Knee Wall R-13																				0	15.5
2nd Floor Wall insulation																x				1	13
Total upgrades	4	3	4	5	4	4	2	2	1	3	3	4	6	6	4	4	6	4	7		

Table 10. Individual IHP Retrofit Measure Selection

Appendix B: Chicagoland Single Family Housing Characterization Findings

PARR's Chicagoland Single Family Housing Characterization determined three common housing types (groups) to be the best candidates for energy savings through retrofit:

1. Group 14—Wood frame pre-1942 construction 1–1½ stories
2. Group 12—Brick (double brick) pre-1942 construction 1–1½ stories
3. Table 11 outlines the optimal cost-effective measure package for each group, as determined by the study.

Table 11. Cost-Effective Measure Package per Housing Type

Housing Group	Infiltration	Unfinished Attic	Furnace Boiler	Water Heater
1	No change	Ceiling R49 Fiberglass Blown-In, Vented	No change	No change
2	Tight	Ceiling R38 Fiberglass Blown-In, Vented	No change	Gas Premium (0.67 EF)
3	Tight	No change	No change	Gas Premium (0.67 EF)
4	Typical	No change	No change	Gas Premium (0.67 EF)
5	Typical	Ceiling R38 Fiberglass Blown-In, Vented	Gas, AFUE 92.5% Furnace	No change
6	No change	Ceiling R38 Fiberglass Blown-In, Vented	Gas, AFUE 92.5% Furnace	Gas Premium (0.67 EF)
7	Leaky	No change	Gas, 95% AFUE Boiler	Gas Premium (0.67 EF)
8	Typical	Ceiling R30 Fiberglass Blown-In, Vented	Gas, 95% AFUE Boiler	Gas Premium (0.67 EF)
9	No change	No change	Gas, AFUE 92.5% Furnace	No change
10	Leaky	Ceiling R38 Fiberglass Blown-In, Vented, Roof R19 Fiberglass,	Gas, 95% AFUE Boiler	Gas Premium (0.67 EF)
11	Tight	No change	No change	Gas Premium (0.67 EF)
12	Typical	Ceiling R49 Fiberglass Blown-In, Vented	No change	No change
13	Typical	Ceiling R38 Fiberglass Blown-In, Vented	Gas, AFUE 92.5% Furnace	No change
14	Leaky	Ceiling R38 Fiberglass Blown-In, Vented	Gas, 95% AFUE Boiler	Gas Premium (0.67 EF)
15	Typical	Ceiling R38 Fiberglass Blown-In, Vented	Gas, 95% AFUE Boiler	Gas Premium (0.67 EF)

Appendix C: Illinois Home Performance Dataset

List of Data Received by MEEA for Each IHP Job

Illinois Home Performance Data Collection Requirements MEEA 2-9-2012, updated 6-7-2012

Homeowner information

Full address

Building volume, including the basement (cubic ft)

Year home was built

Number of stories / home type

Audit information

Date of audit

Auditor company name (must be current IHP PC or IHP Program Provider representative)

Hours spent on audit

Cost of audit, if not included in retrofit cost

Initial building infiltration rate (CFM50)

Gas/propane line examined & all leaks marked for repair (Y/N)

Carbon monoxide measurements taken & actions completed as necessary following BPI BA standard (Y/N)

Spillage test results (Pass/Fail for each relevant appliance, following BPI BA standard)

Draft test results (Pass/Fail for each relevant appliance, following BPI BA standard)

Worst case depressurization (Pass/Fail per BPI BA limits)

Copy of audit report that has been shared with homeowner (should include info on existing HVAC equipment and insulation type & locations)

Retrofit information

Date retrofit began

Date retrofit completed

Hours spent on retrofit

Contractor company name (must be current IHP PC)

In each instance of insulation installation, air sealing was completed prior to installing insulation (Y/N)

Mechanical ventilation installed in compliance with ASHRAE 62.2 2007? (Y/N, if Y provide brief description) (Gold Cert requires)

Airsealing completed? (Y/N, if Y provide short description) ("Checklist Track" Silver Cert & Gold Cert require 4 ACH50 -OR- ≥30% reduction)

Duct sealing completed? (Y/N, if Y provide final leakage rate, which is calculated by dividing sum of supply and return leakage by fan flow) (Gold Cert requires duct leakage rate of ≤10% when ductwork is not fully within pressure boundary)

Wall insulation installed? (Y/N, if Y supply R-value) (Gold Cert requires R≥13 in all perimeter walls)

Attic insulation installed? Y/N, if Y supply R-value. (Gold Cert requires R≥49t; "Checklist Track" Silver Cert requires insulation to meet or exceed current state or local code, whichever is higher)

Basement/crawlspace insulation installed? (Y/N, if Y supply R-value(s)) (Gold Cert requires R≥30 for unconditioned basements -OR- R≥10 continuous / R≥13 cavity for conditioned basements)

Heating equipment (furnace/boiler) installed? (Y/N, if Y provide AFUE, model #, and whether or not it is ENERGY STAR qualified) (Gold Cert requires ENERGY STAR qualified HVAC)

Cooling equipment (central or window AC unit(s)/heat pump) installed? (Y/N, if Y provide SEER, condenser & evaporator model #s, and whether or not it is ENERGY STAR qualified) (Gold Cert requires ENERGY STAR qualified HVAC)

Other improvement(s) (provide brief description(s))

Total cost for retrofit

Test-out information

Date of test-out

Company name (must be current IHP PC)

Final building infiltration rate (CFM50)

Carbon monoxide measurements taken & actions completed as necessary following BPI BA standard (Y/N)

Spillage test results (Pass/Fail for each relevant appliance, following BPI BA standard)

Draft test results (Pass/Fail for each relevant appliance, following BPI BA standard)

Worst case depressurization (Pass/Fail per BPI BA limits)

Estimated total electricity savings per year (kWh, %) ("Modeled Energy Savings Track" Silver Cert requires 15% total predicted annual energy savings)

Estimated total natural gas savings per year (therm, %) ("Modeled Energy Savings Track" Silver Cert requires 15% total predicted annual energy savings)

Estimated annual cost savings ($)

Name of software used to make these estimations, if applicable

Quality assurance information

Name of program provider

Date of file review

Date of quality assurance field inspection, if applicable

Field inspection results, if applicable (Pass/Fail)

Notes

The above list is the complete set of data required by MEEA in order to (a) include each retrofit in our Illinois Home Performance DOE HPwES reporting and (b) craft the homeowner's Certificate of Completion, which will be signed by DCEO. This data should be sent to MEEA by the local IHP Program Provider.

Appendix D: Cook County Single-Family Housing and Demographics

Table 12. List of Housing and Demographics Information

Cook County Single Family Housing & Demographics	
Size	1635 square miles
Households	Nearly 2 million
Single family Homes (n)	Nearly 1.1 million
Size of homes (median)	1,629 square feet
Year built (median)	1956
Construction type	Masonry 38% Frame 58% Other 4%
Household annual income (median)	$59,903
Heating Systems	85% gas forced air, 15% hot water/steam
Central Air Conditioning penetration	40%

Appendix E: IHP Certificate Requirements

Earning the IHP Silver Certificate

- ☐ Retrofit achieves a minimum of **15% modeled total energy savings**, as compared to the baseline determined during the home energy assessment.*

  -OR-
- ☐ Retrofit includes the following two components, at a minimum:

  A. **Building infiltration rate**: 4 ACH50 –OR –30% reduction below baseline. Must follow BPI Building Airflow Standard requirements and

  B. **Attic insulation**: R-value increased to the level specified in the current state or local code, whichever is higher.

*NOTE: When pursuing the modeled savings track, the post-retrofit modeled total energy use figure must be clearly stated in the test-out report and must reflect savings predicted from the actual installed improvements, not the improvement package recommended in the audit (if these two differ). The test-out report must include annual kWh and therms savings, % total savings, and total estimated $ savings resulting from the retrofit.

Earning the IHP Gold Certificate

Each of the following performance metrics is met:

- ☐ **Ventilation: Meets requirements set forth in ASHRAE 62.2 2007**
- ☐ **Building infiltration rate: 4 ACH50 –OR – 30% reduction below baseline**
  - NOTE: If multiple IHP home improvement projects have been undertaken at a single residence, the air leakage rate baseline is determined by *first* IHP home energy assessment. This will ensure a homeowner is not penalized for completing some air sealing in their achievement of the Silver Certificate, should they later aim to achieve the Gold Certificate.

As well as four out of the five metrics listed below:

- ☐ **Ducts: When partially or fully outside the conditioned space, leakage rate is sum of supply and return leakage to outside divided by fan flow ≤ 10%** (see BPI Envelope standard, pg7) – OR – **Ducts are fully inside the home's pressure boundary**
- ☐ **Wall insulation: R≥13 in all perimeter walls**
- ☐ **Attic insulation: R-value as specified in the current state or local code, whichever is higher.**
- ☐ **Basement/crawlspace insulation: If unconditioned, floor insulation R≥30 –**OR – **If conditioned, wall insulation R≥10 continuous or R≥13 cavity**; in either instance, must be installed with proper air sealing and venting so as to avoid moisture problems.
- ☐ **Heating and cooling equipment: ENERGY STAR qualified, subject to manufacturer installation specifications**

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