Direct Testimony

Of

David Brightwell
Economic Analyst

Policy Program
Energy Division
Illinois Commerce Commission

Petition Pursuant to Rider EEP of Schedule of Rates for Gas Service to Initiate a

Proceeding to Determine the Accuracy of the Rider EEP Reconciliation

Statement

North Shore Gas Company and

The Peoples Gas Light and Coke Company

Docket Nos. 09-0436/09-0437 Consolidated

April 6, 2010

Contents

I. WITNESS QUALIFICATIONS 1

II. PURPOSE OF TESTIMONY 2

III. FUNDAMENTAL ISSUES OF COST EFFECTIVENESS: 5

IV. TANKLESS WATER HEATERS, HIGH EFFICIENCY CLOTHES WASHERS, AND WALL INSULATION. 13

V. SUMMARY 19

I. Witness Qualifications

Q. Please state your name, job title and business address.

A. My name is David Brightwell. I am an Economic Analyst in the Policy Program of the Energy Division of the Illinois Commerce Commission ("Commission"). My business address is 527 East Capitol Avenue, Springfield, Illinois 62701.

Q. Please describe your educational background.

A. I received a Ph.D. in economics from Texas A&M University in 2008. My major fields of study were industrial organization and labor economics, and my minor field was econometrics. I received a bachelor's degree in political science in 1992 and a master's degree in applied economics in 2002 from Illinois State University.

Q. Please describe your work background.

A. I have been employed as an Economic Analyst with the Commission since June 2008. I have focused on energy efficiency and smart grid related issues at the Commission. Staff has a non-voting role in the Peoples/ North Shore Gas Energy Efficiency Program's Governance Board. Since approximately January 2009, I have been a regular participant in both the Board meetings and the Operating Committee meetings. From 2002-2008, I attended Texas A&M University. While attending Texas A&M, I was a teaching assistant for my dissertation advisor Professor John Moroney for the 2002-2003, 2003-2004, and 2006-2007 academic

years and his research assistant in the summer 2003 semester. As a research assistant, I performed econometric analysis for the book *Energy and Sustainable Development in Mexico* written by John Moroney and Flory Dieck-Assad. I was the instructor for various economic classes from the 2004 summer semester through the 2007-2008 school years. From 2000-2002, I served as a graduate assistant for David Loomis at Illinois State University.

Q. Have you previously testified before the Commission?

A. Yes. I provided testimony in Docket Nos. 08-0363 and 09-0247.

II. Purpose of Testimony

Q. What is the purpose of your testimony in this proceeding?

A. I reviewed the prudence of expenditures collected through Rider EEP for the energy efficiency plan the Commission approved in the Peoples/North Shore Gas 2007 rate case.(Final Order 07-0241/0242c Pages 183-184, February 4, 2008). Based on my review I am recommending that the Commission disallow $45,584.35 dollars that were collected by North Shore Gas Company ("North Shore" or the "Company") through Rider EEP and $100,419.93 that were collected by The Peoples Gas Light and Coke Company ("Peoples Gas" or the "Company") through Rider EEP . This money was spent on rebates for three measures that were not

economically justified: wall insulation, tankless water heaters and high efficiency clothes washers.

Q. What Criteria does the Commission use to determine prudence?

A. The Commission has defined prudence as:

> […] that standard of care which a reasonable person would be expected to exercise under the circumstances encountered by utility management at the time decisions had to made. In determining whether or not a judgment was prudently made, only those facts available at the time the judgment was exercised can be considered. Hindsight review is impermissible.
>
> Imprudence cannot be sustained by substituting one's judgment for that of another. The prudence standard recognizes that reasonable persons can have honest differences of opinion without one or the other necessarily being 'imprudent'." (Commission v. Commonwealth Edison Company, Docket No. 84-0395, Final Order dated October 7, 1987, page 17).

Q. Please describe the energy efficiency plan.

A. The Companies, in their 2007 rate cases, petitioned the Commission to establish a Governance Board that approved the use of up to $7.5 million in ratepayer funds for the purpose of energy efficiency. The Companies' petition recommended a Board that would consist of five members: one from Peoples/N Shore Gas, one from an environmental group, one from a consumer group representing North Shore

customers, one from a consumer group representing Peoples Gas customers, and one representing the City of Chicago. The Commission approved the Board structure because it "[…] should ensure independence from the Utilities and will likely result in representation of all or substantially all relevant interests. " The Commission also stated that "[w]ith proper independent governance and oversight, and with the selection of appropriate, cost-effective efficiency measures, the Commission believes that the proposed programs will make a significant positive contribution to the benefit of all ratepayers. There is no reference in the order to preapproval of any particular measure or rebate values. The Commission left this to the Governance Board with a reference to cost-effective efficiency measures. .(Final Order 07-0241/0242c Pages 183-184, February 4, 2008).

Q. Why should the Companies be held responsible for the prudency of decisions made by an independent Governance Board?

A. The Companies are the parties who filed this plan and recommended the independent Governance Board. Since they filed the plan, the risk of imprudence should be their responsibility not the ratepayers.

Q. Please describe the format of your testimony.

A. In section III, I describe some fundamentals of the cost effectiveness analysis. Specifically, I address two measures of cost effectiveness - the Total Resource Cost ("TRC") test and the Program Administration Cost ("PAC") test. After I

describe these tests, I explain why the TRC is the preferable test for evaluating cost effectiveness.

I then explain some terms used in the TRC evaluation such as free riders, spillover, and net to gross ratio and use this information to explain program level analysis that leads me to recommend that recovery of expenditures for each of these measures be disallowed.

In section IV, I address specific flaws in the analysis of each measure. Section V summarizes and concludes my testimony.

III. <u>Fundamental Issues of Cost Effectiveness:</u>

Q. What is the basis for your recommendations?

A. Wall insulation, tankless water heaters and high efficiency clothes washers were included in a rebate program known as the "Retailer and Measure Rebate Program." The Companies provide a description of this program in their testimony (PGL EX. 2.0 pp. 6-9, NS Ex. 2.0 pp. 6-9). I do not believe inclusion of costs for these measures is justified because the measures either failed a Total Resource Cost test ("TRC") or passed under unreasonable and unjustifiable assumptions.

Q. Please explain the Total Resource Cost test used by the Companies.

A. The TRC is a measure of cost effectiveness. It evaluates the incremental benefits of a measure to both the utility and the customer and compares it to the incremental costs to implement the measure. In the cases of high efficiency clothes washers, tankless water heaters, and wall insulation, the benefits are the present value of the incremental savings that are received in comparison to a baseline piece of equipment or standard. The costs include the cost of the equipment and labor. The costs are also calculated as incremental to the costs associated with a baseline piece of equipment or standard. (Companies Responses to Staff DR DAB 1.01)

Q. Please provide an example.

A. Suppose there is some piece of equipment called a standard widget that has a one-year life and uses 86 therms per year. Its cost $30 for the equipment and $10 for the labor to install it. Natural gas is expected to sell at $1/therm. There is an alternative piece of equipment called an efficient widget that serves the same function. It also has a one year life. It cost $35 for the equipment. Installation is a bit more labor intensive and costs $12. The efficient widget only uses 65 therms per year.

In this scenario, the total cost for the standard widget is $40 and it is $47 for the efficient widget. The gas used by the standard widget costs the customer $86 and

the efficient widget uses $65 in natural gas for the year. This means there are $21 in incremental benefits ($86- $65) and $7 ($47-$40) in incremental cost. The TRC value in this example is 3.0 (21/7), meaning that each incremental dollar spent on the efficient widget yields $3 in additional savings compared to the standard widget.

Q. How do the actual calculations differ from your example?

A. Obviously this is a very simplified example. All measures in the actual program have savings that accrue over several years. These savings are discounted to determine a present value. This requires forecasts of future prices as well as an estimate of the discount rate. Avoided costs for other resources are also included. Depending on the measure, there can be increased or decreased electric and/or water use. These avoided costs are also included.

Q. Are any other methods used to evaluate the cost effectiveness of a measure?

A. Yes. In addition to the TRC, the Program Administration Cost test ("PAC") is used by the Chicagoland[1] Board as a metric. In the PAC test, the benefits are the present value of the avoided gas costs. The cost is the rebate that is being provided by the utility or program (Company responses to Staff DRs PGL DAB 1.04 and NS DAB 1.04). In the previous example, if the utility provided a $2 rebate for

[1] The Energy Efficiency Program markets itself as Chicagoland Gas Savings. The Chicagoland Board is its governing body.

the widget, the PAC would be 10.5 ($21 in avoided gas cost/$2 in cost to the program). The PAC does not include any customer cost for installing a measure; nor does it include the avoided costs of electric, water.

Q. Above, you note that wall insulation, tankless water heaters, and high efficiency clothes washers either failed the TRC test or would have failed it under reasonable assumptions. Have you formed an opinion on whether the TRC is a better criterion than the PAC to determine if an expenditure is prudent?

A. Yes I have. In my opinion the TRC is a better criterion than the PAC to determine if an expenditure is prudent. The TRC estimates incremental costs for both the utility and the customer installing the measure. It then compares it to the incremental avoided costs for both the customer and the utility to determine the savings. It essentially estimates the private benefits of all savings to the costs to all parties that are necessary to achieve those savings. If the TRC is above 1, it means that the benefits that accrue to all parties exceed the costs that accrue to all parties.

The PAC only measures the costs and benefits to one party, the utility or program. A PAC greater than 1 means the measure's commodity savings were greater than the costs to the program.

It is very possible to justify a measure based on the PAC that has a TRC less than 1. The program only needs to lower its incentive level for a measure to raise its

PAC. However, the total cost of the measure stays the same. It's just that the remainder of the cost is paid by other parties.

Consider the widget example used above. If the utility provides a $5 rebate, the PAC is 4.2 ($21/$5). If the rebate is $4, the PAC is 5.25. Regardless of the rebate level the TRC is 3. The total incremental savings are $21 and the total incremental costs are $7.

Again I should point out that this is a simplification because the only incremental savings in the widget example were avoided natural gas costs. If the efficient widget saved $3 in electricity as well the TRC would be 3.43 ($24/$7). This additional $3 in avoided electric costs would not be reflected in the PAC test. Likewise, if part of the gas savings resulted because the efficient widget used $3 more in electricity, this would be reflected in the TRC test but not the PAC test.

Overall, the TRC is a more comprehensive measure of the benefits and costs that accrue to all parties.

Q. Are there any reasons that a measure with a TRC less than 1 should be included in a program?

A. Yes. A measure can potentially have high spillovers. Spillovers are the greater awareness of energy efficiency, which encourages investments in energy efficiency projects that do not directly receive incentives from the program caused just by the

presence of the measure. This is effectively a “loss leader.” Other examples of loss leaders include a store advertising soft drinks for a price below cost in order to draw customers who will in turn purchase other items or a casino comping a hotel room in expectation that the loss will be more than offset in gaming revenues.

Another reason to include a measure with a TRC less than 1 is that there can be synergies achieved by installing multiple measures at the same time. For example, much of the cost involved in a direct install program is the labor for the workers doing the installation. When multiple measures such as shower heads and faucet aerators are bundled together, there is only one service call. The additional time associated with installing an additional measure is negligible so that it barely contributes to the overall cost.

Q. Does the cost effectiveness analysis performed for the Chicagoland Board indicate that wall insulation, tankless water heaters or high efficiency clothes washers have a high degree of spillover?

A. No. The cost effectiveness analysis was done with net to gross ratio assumptions performed at the program level not the measure level. A net to gross ratio measures the total savings that are attributable to the level at which the assumption was made. Since this analysis was performed at the program level it is not possible to disentangle the net to gross ratio for any given measure in the rebate program.

Q. Please explain a net to gross ratio.

A. The net to gross ratio considers both spillovers and free riders. A free rider is a rebate recipient who would install the measure with no rebate. A free rider is a problem because it costs the program money, but the customer did not need the encouragement. Thus, the energy savings should not be attributed to the program because they would have occurred even in the absence of the program.

To illustrate the idea of a net to gross ratio, suppose there is a rebate program for only the efficient widgets described earlier. If the program offers incentives for 1000 widgets, the gross savings is 21,000 therms (21 therms for each of the 1000 widgets). If 40% of the rebate recipients are free riders then 8,400 of these therms (0.4*21,000) would have been saved without any program. If the program increased the awareness of energy efficiency and led others to buy efficient widgets or other measures without program money that saved 6,000 therms, then those 6,000 therms are the spillover. The net savings are 18,600 therms (the 21,000 gross therms – 8,400 therms going to free riders + the 6,000 therms due to spillover). The net to gross ratio is then 0.886 (18,600/21,000). The TRC for any particular widget is 3.0 but for the entirety of the widgets receiving rebates in this program the TRC is 2.66 (.886*3).

Since the Chicagoland analysis considered net to gross ratios at the program level, it is not possible to disentangle the net to gross ratio for any particular measure. To my knowledge, the Board made no attempt to examine the net to gross individually for wall insulation, tankless water heaters, or high efficiency clothes washers. Therefore it is unreasonable to assume there is a higher net to gross ratio for any of these measures than there is for the overall rebate program. The Board's cost effectiveness analysis did not justify inclusion of these measures.

Q. Do these measures have synergies that make it advantageous to bundle them with other measures?

A. No. There is also nothing about these measures that leads me to believe there are synergies associated with installing them jointly. Each measure appears to take a different type of labor to install and can be done at different times. An expert at installing a tankless water heater most likely does not regularly install wall insulation and there is little specialized labor involved with installing a clothes washer.

Q. The TRC for each individual measure is less than 1 but the overall TRC for the rebate program is greater than 1. Isn't this sufficient to justify all three measures?

A. No. As stated above, there may be reasons to consider measures that are not individually cost effective. However, the company has not provided sufficient justification for these measures. If these rebates are viewed as energy efficiency

investments, then the Chicagoland Board is promoting investments that its own analysis either shows to lose money or should have shown to lose money if it was done properly.

Peoples Gas and North Shore and the Chicagoland Board made assumptions about spillover and free riders to determine the net to gross ratio in its cost effectiveness analysis. At no time did they investigate the particular spillover for any of these measures to determine if there were extenuating circumstances that should lead to a higher net to gross ratio for any particular measure. Effectively each of these measures was determined to cost more to implement than was saved over their lifetime and the program used ratepayer provided funds to encourage consumer investments that were expected to lose money.

IV. Tankless water heaters, high efficiency clothes washers, and wall insulation.

Q. Why do you recommend that expenditures for high efficiency clothes washers be disallowed?

A. The reason for this disallowance is that the cost effectiveness analysis performed for the Chicagoland Board showed that the TRC for this measure was 0.94[2]. This means that for every dollar that is spent on this measure only 94 cents in gas,

[2] On April 22, 2009, I was sent cost-effectiveness analysis materials by Lorna Rushforth of RSG, the program implementer for the rebate program. The analysis I was sent through that request indicated a TRC of 0.91 for clothes washers.

electric, water were saved. (PGL DAB 1.02 Attach 06 in response to Staff DR DAB 1.02), The Companies responses to Staff DR DAB PGL 2.02 and DAB NS 2.02 argue that clothes washers are a frequently used energy efficiency measure that provide awareness and acceptance of energy efficiency. However, the Companies did not provide any studies or evaluations from other energy efficiency programs that support this assumption. The Companies also contradict this assumption by applying 0.8 as the default net-to-gross ratio for the measure. Apparently no real analysis was performed that indicated that the net to gross ratio applied to the rebate program was unreasonably low for this measure. So the Companies' own analysis indicates that promotion of clothes washers was unjustified.

Q. How much is the disallowance for this measure?

A. According to the Companies, expenditure on rebates for high efficiency clothes washers in program year 1 was $24,600 by North Shore and $32,100 by Peoples Gas (Companies Responses to Staff DRs DAB NS 2.01 and DAB PGL 2.01). These amounts should be disallowed for clothes washers. These disallowances are for expenses related to SC1 customers.

Q. Why do you recommend that expenditures for wall insulation be disallowed?

A. The initial cost effectiveness calculations that were performed indicated the TRC for wall insulation was 2.5 (PGL DAB 1.02 Attach 06 in response to Staff DR DAB 1.02). This would indicate that every dollar spent on wall insulation saved $2.50 in energy costs. However, this analysis assumed that any customer installing wall insulation would do so as part of a larger remodeling project and therefore there was no incremental labor cost associated with installing the wall insulation. As a result, the cost per square foot of wall insulation was determined to be $0.35. I do not believe a reasonable person would conclude this was a reasonable assumption for modeling the measure's cost effectiveness.

Q. Why do you believe this was an unreasonable assumption?

A. There are several reasons for my opinion. First, the program established a trade ally network to promote its energy efficiency rebates. The trade ally network basically consists of vendors, retailers, and contractors who sell and/or install energy efficiency measures including wall insulation. I do not believe it is reasonable to assume there will be no labor cost associated with installing wall insulation while simultaneously promoting the program to contractors who will be performing the labor to install the measure.

Second, the Companies provided work papers for its original cost effectiveness (PGL DAB 1.02 Attach 04). These work papers show that there was sufficient

reason to suspect the cost of $0.35 per square foot was unreasonably low. Reference 3 of this work paper includes a link to the modeling work papers which describe the software and modeling procedures used to model energy savings. (Attachment 1) Page 6 of Attachment 1 refers to recent retrofit projects that were done locally by the Chicago green bungalow initiative and cites a report of the results.

The green bungalow initiative reports the retrofit results for four bungalows in the City of Chicago. The retrofits took about a year to complete beginning in the fall of 2001 (Attachment 2, page 3). Three of the retrofits included adding wall insulation in existing walls. The report indicates the costs for work done in 2001-2002 ranged from $0.82 to $1.35 per square foot (Attachment 2, pages 5, 7, and 9). Given inflation, a reasonable person would conclude the price per square foot would be higher in 2008 and 2009 a full six years after these installations took place.

Q. How much is the disallowance for wall insulation?

A. The Companies indicate that North Shore spent $12,184.35 and Peoples Gas spent $52,719.93 (Companies Responses to Staff DRs DAB NS 2.01 and DAB PGL 2.01) on rebates. These amounts should not be recovered from ratepayers through Rider EEP. These expenses are relevant for SC1 customers.

Q. Why do you recommend a disallowance for tankless water heaters?

A. The Companies' original analysis indicated that tankless water heaters have a TRC of 1.01[3] (PGL DAB 1.02 Attach 06 in response to Staff DR DAB 1.02). This means that each dollar spent on tankless water heaters saves $1.01 in resources. However, the analysis failed to consider that tankless water heaters require either a medium pressure gas system or a booster to work properly. About half of Peoples Gas service territory has a low pressure system and the costs of boosters were not included in the analysis. I believe the Governance Board approved this measure without knowing that tankless water heaters were not designed to work in much of Peoples Gas service territory without additional equipment. However, this information was easily available shortly after the launch of the program. In fact, Salvatore Marano who submitted prefiled testimony dated February 25, 2009 on behalf of Peoples Gas in its last rate case testified about the system requirements for tankless water heaters.

Q Are there any additional reasons why this upgrade to a newer and more modern infrastructure system needs to be accelerated?

A Benefits of the medium-pressure system would include Incremental services made possible by the medium-pressure system's ability to accommodate technologies and appliances not available through the current low-pressure system, including access to many high-efficiency appliances. In the relatively near

[3] According to the Companies responses to Staff DR DAB 1.02 the TRC was 0.78 (see PGL DAB 1.02 Attach 06). However, Lorna Rushforth of RSG emailed me the original cost effectiveness analysis on April 22, 2009. RSG is the rebate program implementer hired by the Chicagoland Board. The materials sent by Ms. Rushforth indicate a TRC of 1.01 for tankless water heaters.

> future, the residential low-pressure system may not be able to serve standard residential appliances, if as expected; they require 6" of water column pressure at the burner tip. The lack of a medium-pressure system would cause customers in Chicago to forego consumer options or require more expensive special orders.
>
> In addition, a medium-pressure system will allow Chicagoans to install higher efficiency appliances. The following higher efficiency appliances require inlet pressures that in many cases would require either a customer-installed booster or PGL's provision of a medium-pressure system:
>
> - Tankless water heaters;
> - Fan assisted heaters;
> - Home generators; and
> - Commercial-grade cooking appliances.

(Docket 09-0166/0167 consolidated, PGL EX. SDM 1.0 REV., page 38-39 February 25, 2009)

According to the Companies, the program began a quick launch of its rebates programs January 1, 2009 (PGL Ex. 2.1, page 3). I believe the Company and Chicagoland Governance Board had a responsibility to know operating requirements of the equipment if they were going to spend ratepayer funds to promote its purchase. The evidence was readily available to the Company less than two months from the launch of the program and no revisions were made.

Q. How much is the disallowance for tankless water heaters?

A. According to the Companies, North Shore Gas provided $8,800 and Peoples Gas provided $15,600 (Companies Responses to Staff DRs DAB NS 2.01 and

DAB PGL 2.01) in rebates to SC1 customers. These amounts should be disallowed.

V. **Summary**

Q. Please summarize your testimony.

A. The Peoples Gas and North Shore energy efficiency program provided rebates for three measures that were not cost effective and that reasonable persons should conclude were not cost effective. These measures were tankless water heaters, wall insulation, and high efficiency clothes washers.

At no time did the cost effectiveness analysis ever determine that clothes washers were a cost effective measure. Tankless water heaters and wall insulation were determined to be cost effective. However, these determinations were based on unreasonable assumptions that should have been known to be unreasonable at the time they were made.

The assumption about wall insulation was that no incremental labor would be used to install the insulation. However, the program promoted wall insulation rebates to contractors who were installing the insulation. The cost effectiveness analysis for tankless water heaters failed to consider that boosters would be required to properly operate the equipment in much of Peoples Gas service territory because it is a low pressure system. The program had a responsibility to know the operating

requirements for equipment for which it was spending ratepayer funds to encourage its customers to buy, had this evidence within two months of the launch of the program and did not use the information to modify the program in a timely manner.

The disallowance that I recommend is $100,419.93 for the SC1 portion of Rider EEP for Peoples Gas and $45,584.35 for the SC1 portion of Rider EEP for North Shore. This is broken down for Peoples Gas as $15,600 for tankless water heaters, $52,719.93 for wall insulation and $32,100 for clothes washers. For North Shore the break down is $8,800, $12,184.35, and $24,600 for tankless water heaters, wall insulation, and clothes washers respectively.

Q. Does this conclude your testimony?

A. Yes.

DRAFT DOCUMENT

ENERGY SAVING MEASURES
PEOPLE'S GAS PROJECT

ENERGY MODELING OF A CHICAGO RESIDENTIAL HOME

USING

TREAT™ - TARGETED RESIDENTIAL ENERGY ANALYSIS TOOLS

CNT ENERGY

Working Document V. 001

Study by

Anne Evens Director
Larry Kotewa PE
Michael Whelton PhD

Contributions by

16th January 2009.

INTRODUCTION

This research describes an energy modeling methodology that represents the energy use in a typical single family home. In particular the study focuses on the development of an energy modeling process for a Chicago bungalow.

Based on this methodology a platform is established for the prediction of energy savings by which designed energy saving measures can be analyzed. The energy model provides a systems analysis for the various improvement initiatives and a cost benefit analysis for each improvement measure.

The study provides supporting data for the development of the People's gas rebate program for energy efficient residential housing measures. The paper documents predicted costs of improvement measures and the associated energy savings for the Retailer Program and the Furnace Program as established by People's Gas.

OUTLINE OF STUDY OBJECTIVES

The objectives of the study are summarized as follows:

1. Establishment of an operational framework for energy modeling of residential homes.
2. Selection of a particular building type to act as baseline model for energy savings;
3. Establishment and compilation of energy model data;
    - Weather data;
    - Physical building and energy systems and;
    - Energy billing data.
4. Development of a baseline model using TREAT™ – Targeted Residential Energy Analysis Tools.
5. Design of energy saving measures.
6. Energy savings predictions of standard replacement of systems and high efficiency replacement of systems.

7. Development of results and concluding remarks.

Figure 1 describes the energy modeling process that was established to support the measures design for the energy efficiency program.

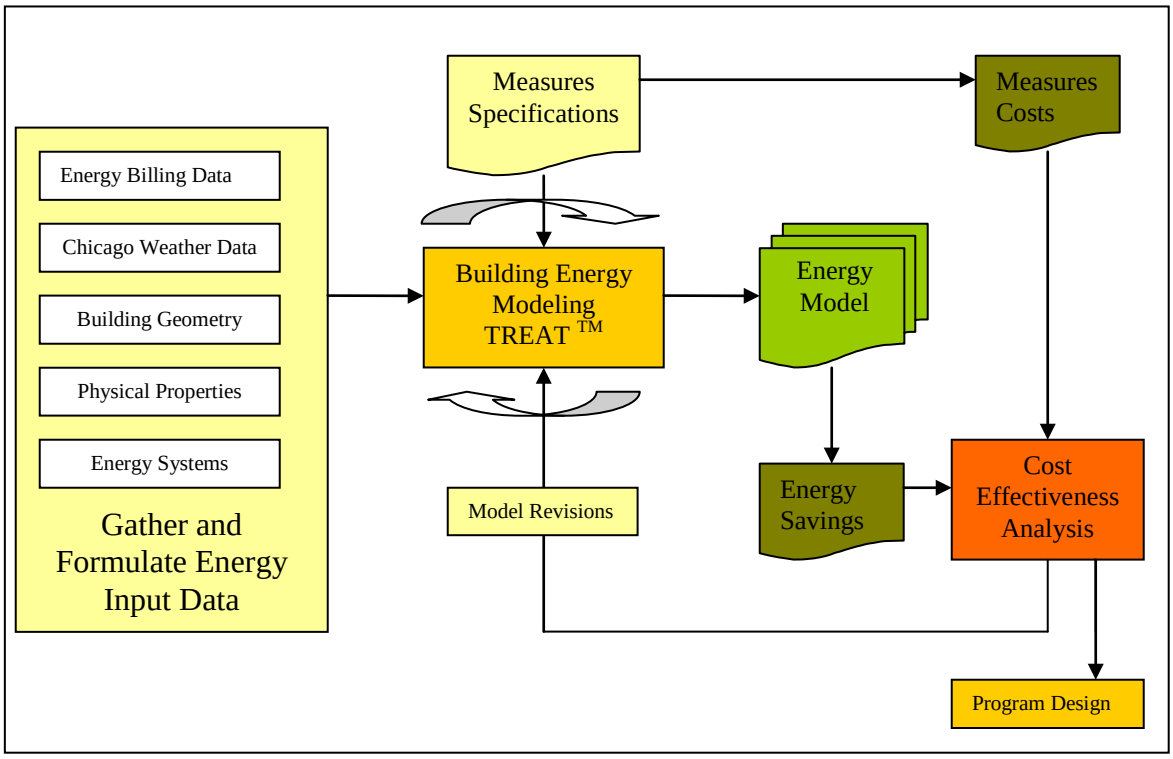


Figure 1 Energy Modeling Framework as an Input Output System

ENERGY MODELING APPROACH

The energy use of a residential home is specific to the nature and condition of the physical building system, the energy systems performance, weather conditions and user behavior. In terms of energy savings, measures related to weatherization e.g. insulation, and heating systems - furnaces and boilers, are directly associated with the relationship of the physical model, the weather data, the billing data. Other energy saving measures such as appliances e.g. clothes washers and water heaters are primarily user behavior related and product performance related, and savings are less determined by weather, location, and physical building properties.

Computational energy modeling is an established approach[1] to predicting energy use in buildings. TREAT™ is an energy modeling software program that computes energy use in single or multi-family buildings[2]. TREAT conforms to the Home Energy Rating System Building Energy Simulation Test[3], which supports the certification of energy simulation programs in the USA.

The software was chosen as a modeling environment given its ability to model residential energy use and to model costs of improvement strategies such as systems replacements and physical enhancements to the building fabric.

The modeling strategy is limited in terms of encapsulating the range of variability that the Chicago residential housing stock displays. Therefore experiential based choices were made with respect to the selection of the most common type of residential home and the physical properties of the home.

DEVELOPMENT OF ENERGY BILLING DATA PROFILES

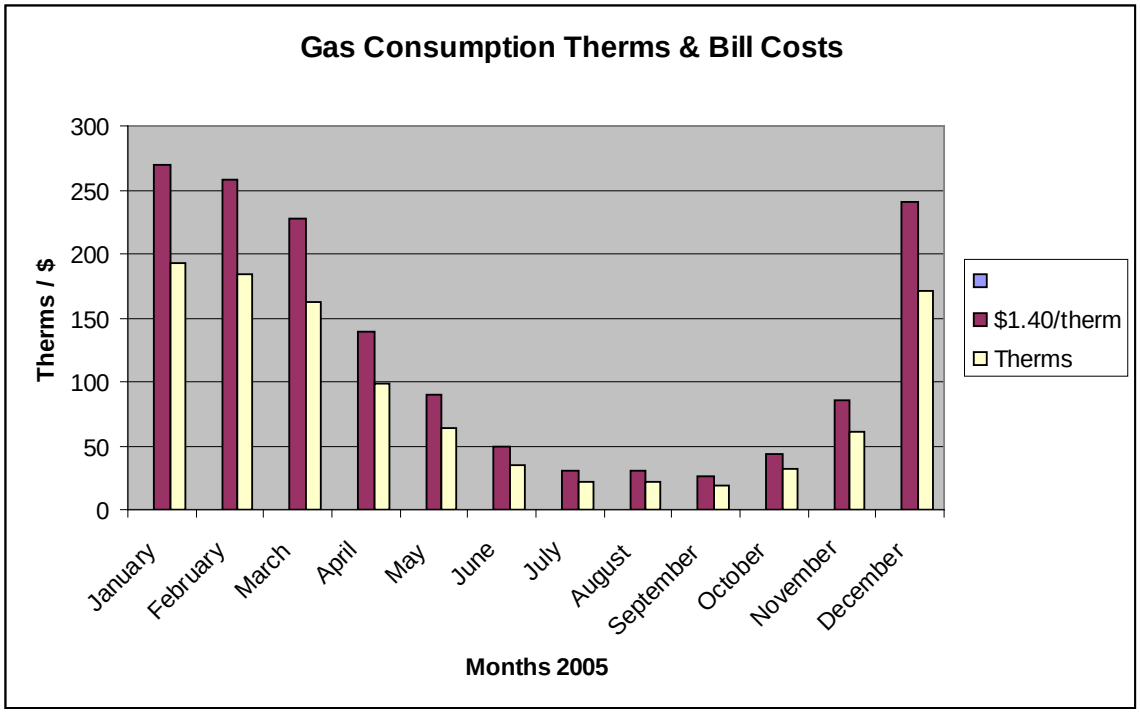
An energy use profile for both gas and electricity was created from data compiled by City of Chicago Utility companies and further developed by CNT Energy[4]. Figure 2 illustrates the energy profiles for average gas and electricity use for residential homes in the City of Chicago for 2005.

WEATHER DATA

TREAT utilizes daily temperatures to model heating and cooling loads and subsequent energy use. Temperatures for the Chicago area[5] were used in the analyses.

---

[1] http://www.doe2.com/
[2] http://treatsoftware.psdconsulting.com/user_manuals.html
[3] http://www.nrel.gov/docs/legosti/fy96/7332b.pdf
[4] CNT Energy: internal document wrt energy data.
[5] Temperature Location: http://www.engr.udayton.edu/faculty/jkissock/gsod/ILCHICAG.txt



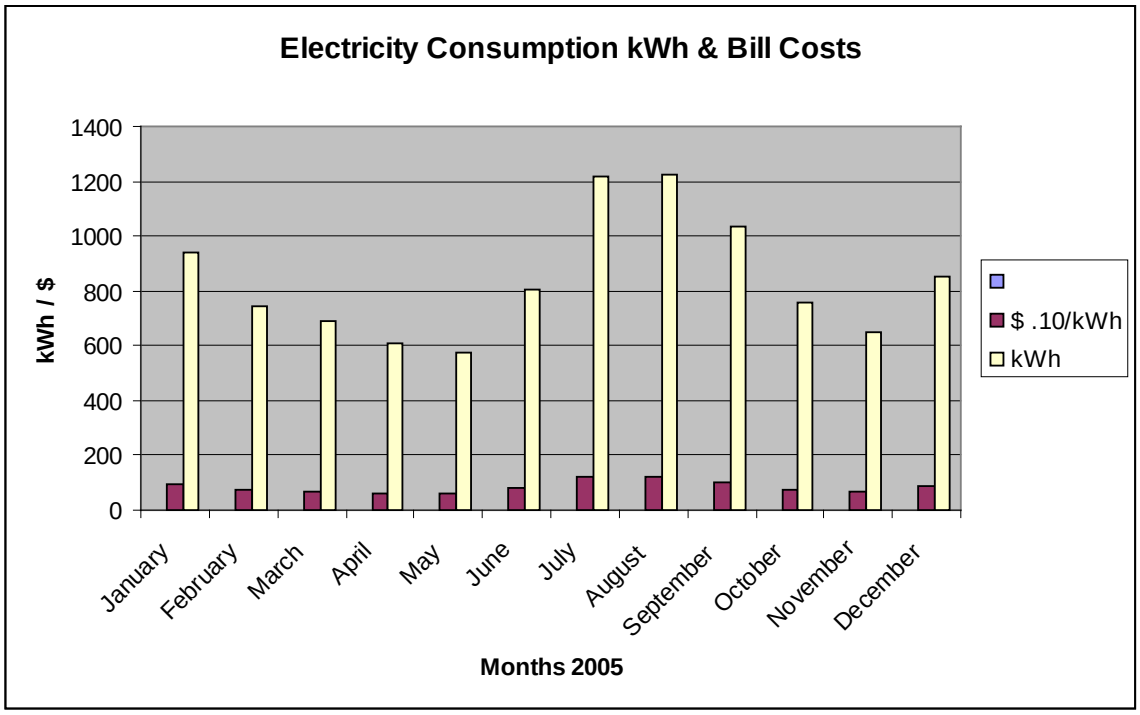


Figure 2 City of Chicago Residential Energy Use Profiles

BUILDING TYPE SELECTION AND GEOMETRY

The methodology centers on the development of an energy use model for a typical residential home in the City of Chicago. Examples of recent and local energy retrofit projects in the City of Chicago include the Chicago green bungalow initiative[6] and Comed's Energy Efficiency Showcase[7].

Figure 3 illustrates a massing model of a Chicago bungalow describing the geometrical parameters used to model physical properties of the building. The models are a representation of a typical building type and are limited with respect being fully representative of all residential building sets. Further model sets are necessary for broader representation.

Table 1 lists the general physical description for the model.

Table 1 General Properties of Building Type

Building Properties	Description	Variations Modeled
Building Type	Single Family Home (Chicago Bungalow)	
Size and Spaces	1400 sq ft Footprint, 1 story and basement, unused attic space	
Construction	Brick Frame	
Conditioned Spaces	Conditioned 1St Floor and Basement	
Window Types	Glazing 12 # 3'x5' single pane windows.	
Air Infiltration	Very Leaky Building	
Insulation:	None	
Heating Systems	Gas Air Furnace – 80% Eff	Gas Water Boiler – 80% Eff
Air Conditioning	Window Units	

[6] http://egov.cityofchicago.org/webportal/COCWebPortal/COC_ATTACH/GreenBungalowRpt.pdf http://egov.cityofchicago.org/webportal/COCWebPortal/COC_ATTACH/bungalow_energy_analysis_2004.pdf

[7] http://www.exeloncorp.com/NR/rdonlyres/FB49B9EB-870A-46DB-B273-DA724AD24EDF/2790/ChicagoBungalowEnergySavingsEstimates.pdf

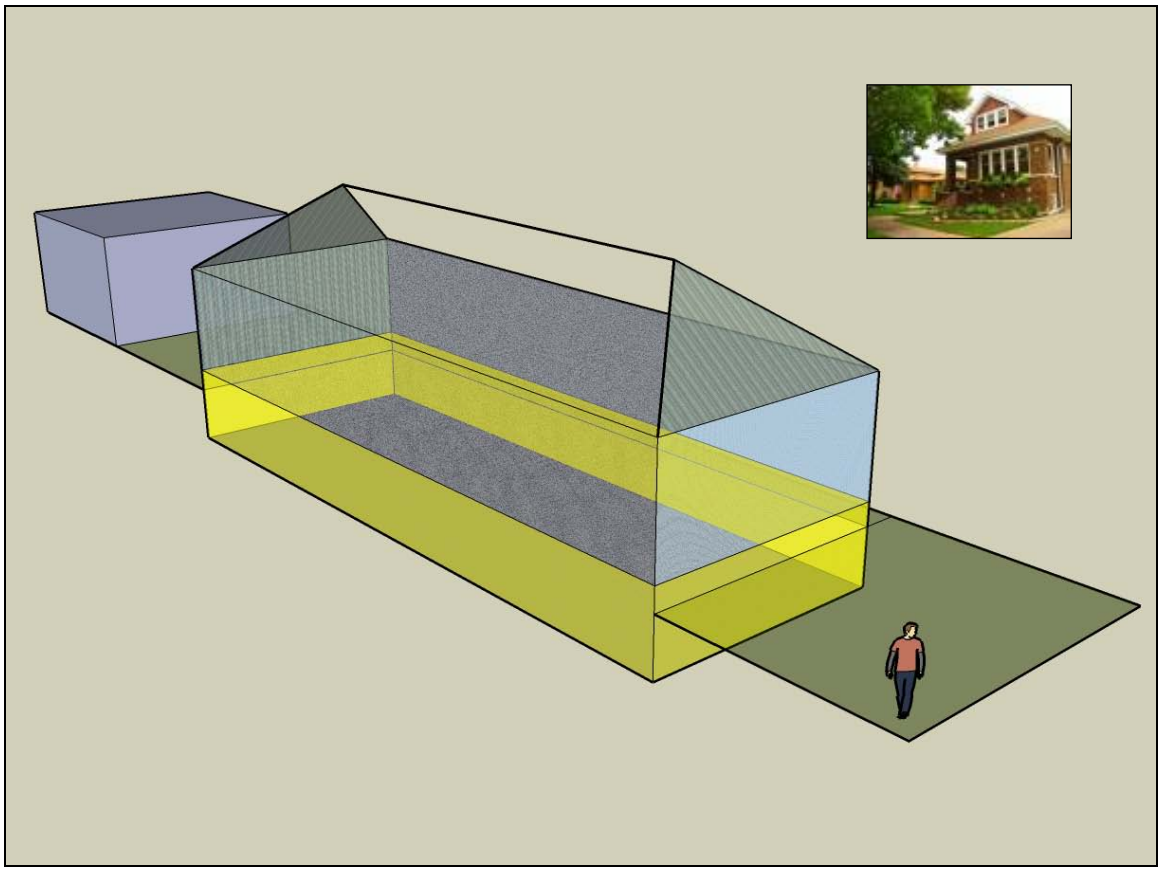


Figure 3 Chicago Bungalow Massing Model (Sketch Up™ 3d View).

MODEL DEVELOPMENT

Figure 4 illustrates the modeling environment and user interface for data input. Each segment comprises of information necessary to establish a realistic model of the building. The TREAT™ user manual (See Ref 2) further describes the system framework and modeling environment.

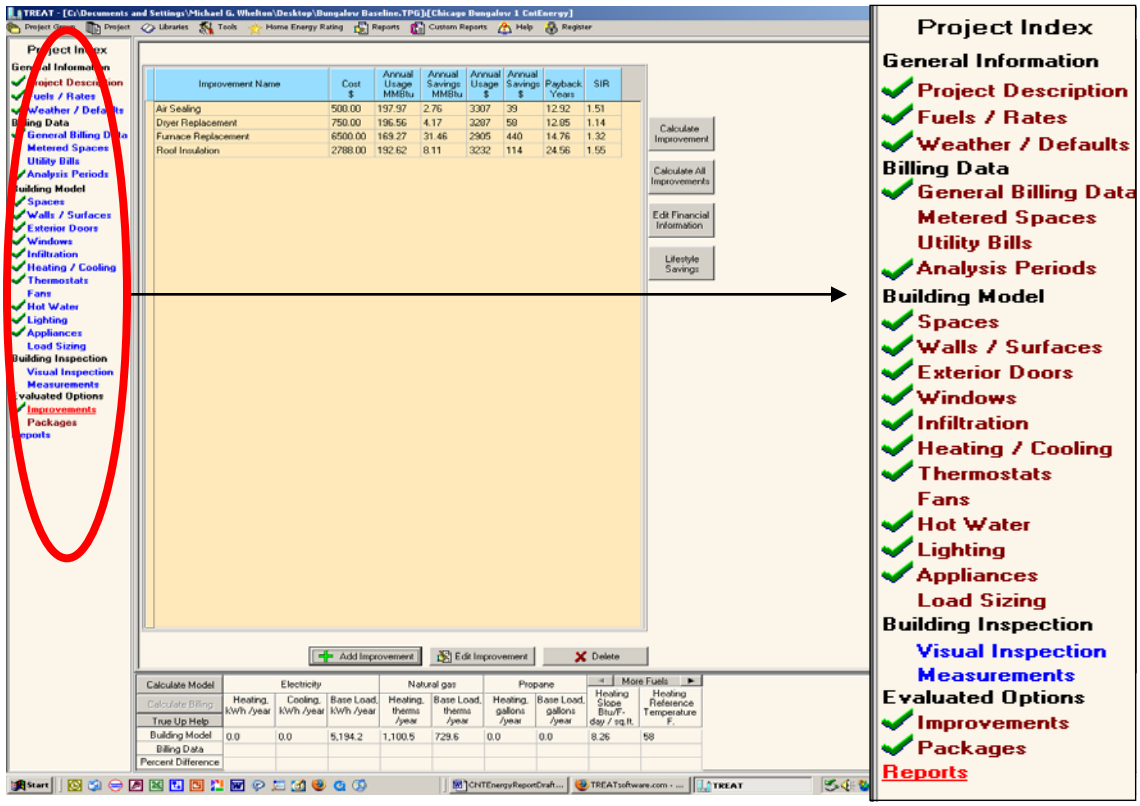


Figure 4 TREAT™ User Interface for Modeling Parameters

POSITIONING ENERGY USE MODEL IN HOUSING STOCK

TREAT calibrates the computational energy model with actual billing data as seen in Figure 2. The energy model was calibrated to model residential homes that depict high energy use intensity. Figure 5 illustrates the range of housing stock that the model intends to represent, and where energy efficiency measures can provide the greatest opportunity for energy savings.

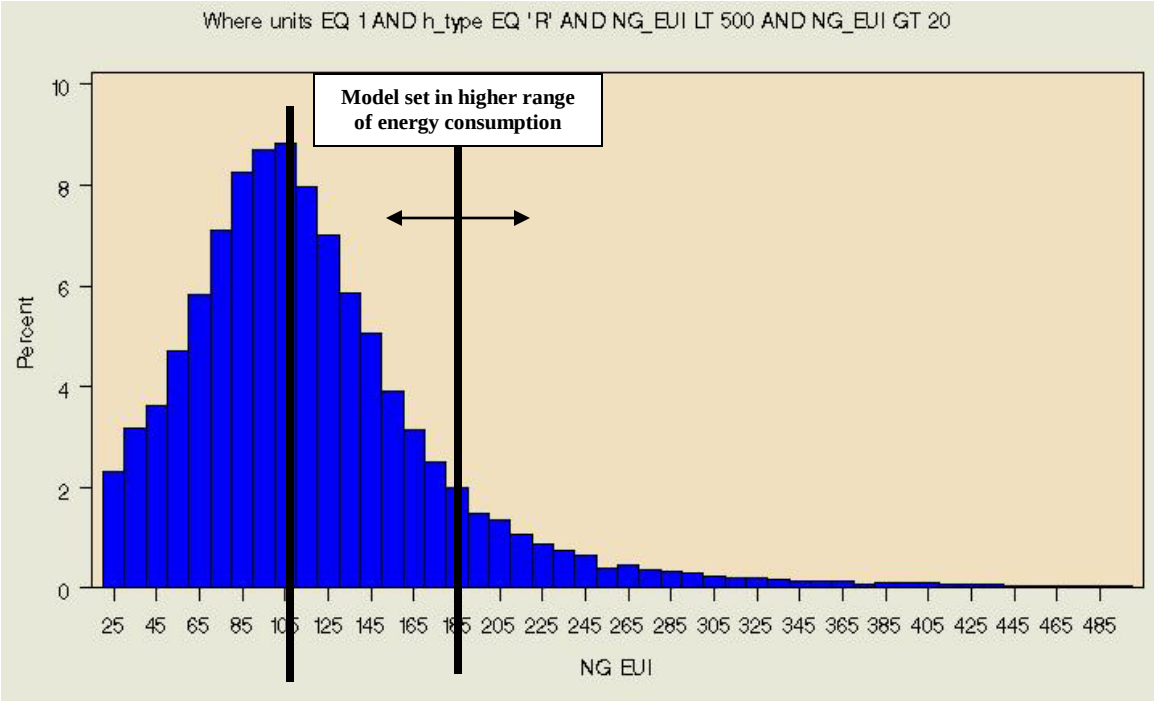


Figure 5 Illustration of Energy Model Range of Representation

MEASURES DEVELOPMENT

Table 2 outlines the measures that were identified for modeling energy savings.

Table 2 Residential Housing Energy Saving Measures

Measure Name/Description
1. Ceiling Insulation (R-38)
2. Wall Insulation (R-11)
3. ENERGY STAR Clothes Washers (Energy Star: MEF >/= 1.72 and WF </=8.0)
4. Storage Water Heater (Energy Star: EF >/= 0.62)
5. Tankless Water Heater (Energy Star: EF >/= 0.82)
6. Gas Condensing Water Heater (Energy Star: EF >/= 0.80)
7. 92-93% AFUE, High Efficiency Gas Furnace
8. 94+% AFUE, High Efficiency Gas Furnace
9. High efficiency gas boiler 85% Eff.
10. High efficiency gas boiler 95% Eff.

RESULTS

The energy model was further developed to model the improvement measures as set out in Table 3. The model set a baseline case, a standard measures replacement case and a high efficiency measures replacement case. The differential results between the standard case and high efficiency case shown in Table 4 were used as inputs to the cost effectiveness assessment process as shown in Figure 1. Table 5 summarizes the costs per unit for the final selected measures.

CONCLUDING REMARKS AND FURTHER DEVELOPMENT

The following projects are identified to further improve the quality of the modeling process:

- Analyze billing data by location to establish energy usage and costs for specific building types. Set up data sets with GIS applications;
- Gather field data on physical building properties wrt building system R-values;
- Develop a database of measures costs for improved modeling and potential budget management of energy retrofit projects;
- Explore the use of Monte Carlo simulation as a means of modeling cost variability of energy saving measures;
- Improve “model and feedback” cycle with project stakeholders, i.e. create smaller batch sizes of “model”, rapid development and feedback cycle to improve rates of learning;
- Determine benchmarks for cost effectiveness of measures; and
- Seek post-program feedback to test performance of results.
- Collaborate with energy efficiency program partners to implement the above.

Table 3 Baseline, Standard and High Efficiency Cases

Measure Name/Description High Efficiency Case	**Measure life (yrs) *Source DEER***	**Unit Sizes - Physical Building Model**	**Units**	**Baseline Case Assumptions**	**Standard Case Assumptions**
Ceiling Insulation (R-38) Contractor Installed Cellulose	20	1400	Square foot	No Insulation Exists	No Insulation Added
Wall Insulation (R-11) Self Install Batts	20	3366	Square foot	No Insulation Exists	No Insulation Added
ENERGY STAR Clothes Washers (Energy Star: MEF >/= 1.72 and WF </=8.0)	11	1	Per home	Gas Water Heating Older>1994	Conventional Washer Unit
Storage Water Heater (Energy Star: EF >/= 0.62)	11	1	Per home	SWH 40 Gallon Eff 70%	SWH 40 Gallon EF 59
Tankless Water Heater (Energy Star: EF >/= 0.82)	20	1	Per home	SWH 40 Gallon Eff 70%	Basic Tankless EF 59
Gas Condensing Water Heater (Energy Star: EF >/= 0.80)	11	1	Per home	SWH 40 Gallon Eff 70%	Basic Gas Condensing EF 59
92-93% AFUE, High Efficiency Gas Furnace	20	1	Per home	80% Eff	80 % Eff
94+% AFUE, High Efficiency Gas Furnace	20	1	Per home	80% Eff	80 % Eff
High efficiency gas boiler 85% Eff.	20	1	Per home	80% Eff	80 % Eff
High efficiency gas boiler 95% Eff.	20	1	Per home	80% Eff	80% Eff

Table 4 Measures Costs and Energy Savings

Measure Name/Description	Units	Standard Unit Cost $/Unit	Standard Gross Therm Savings/yr/unit	Standard kWh/yr Savings/yr/Unit	Standard Total Home Cost $ for Measure	High Eff Upgrade Total Cost $/Unit *	Incremental measure cost from Standard to High Eff ($) / Unit	Total Home Cost - Differiential from Standard Cost to High Eff ($)	Gross therm savings/yr	kWh Savings/yr	High Eff. Therm savings/yr/unit	High Eff. kWh Savings/yr/unit
Ceiling Insulation (R-38) Contractor Installed Cellulose	Square foot	0	0	0	0	3.00	3.00	4200.00	467.00	970	0.33	0.69
Wall Insulation (R-11) Self Install Batts	Square foot	0	0	0	0	0.35	0.35	1178.10	275.00	-313	0.08	-0.09
ENERGY STAR Clothes Washers (Energy Star: MEF >/= 1.72 and WF </=8.0)	Per home	400	na	na	400	700.00	300.00	300.00	11.76	25.87	11.76	25.87
Storage Water Heater (Energy Star: EF >/= 0.62)	Per home	600	57	11	600	900.00	300.00	300.00	42.00	3	42.00	3.00
Tankless Water Heater (Energy Star: EF >/= 0.82)	Per home	1200	57	11	1200	1500.00	300.00	300.00	115.00	6	115.00	6.00
Gas Condensing Water Heater (Energy Star: EF >/= 0.80)	Per home	800	57	11	800	1000.00	200.00	200.00	110.00	6	110.00	6.00
92-93% AFUE, High Efficiency Gas Furnace	Per home	2500	0	0	2500	3500.00	1000.00	1000.00	97.00	0	97.00	0.00
94+% AFUE, High Efficiency Gas Furnace	Per home	2500	0	0	2500	4000.00	1500.00	1500.00	130.00	0	130.00	0.00
High efficiency gas boiler 85% Eff.	Per home	3500	0	0	3500	4500.00	1000.00	1000.00	170.00	0	170.00	0.00
High efficiency gas boiler 95% Eff.	Per home	3500	0	0	3500	5000.00	1500.00	1500.00	256.00	0	256.00	0.00

Table 5 Full Measures Costs Data Per Unit

Measure Name/Description	Unit Sizes - Physical Building Model	Units	Standard Unit Cost $/Unit	High Eff Upgrade Cost $/Unit	CNT Energy Internal References & Online Resources
Ceiling Insulation (R-49): Fiberglass Batts Self Installed	1400.00	Square foot	NA	1.00	http://www.homedepot.com/webapp/wcs/stores/servlet/Navigation?Ntk=AllProps&N=10000003+90234+527411&storeId=10051&catalogId=10053&langId=-1 http://www.greenbeaninsulation.com/investment-returns.html COST PER SQ FT FOR FOAM- full installation varies in cost from $1.30-$1.90 per sqft COST PER SQ FT FOR CELLULOSE- full installation for blow-in cellulose usually ranges from $0.75-$0.95 per sqft for R-30 in attics, R-15 in walls. DRILL & FILL in existing wall cavities usually ranges from $1.25-$1.50/sqft. http://www.jea.com/about/pub/downloads/AtticInsulationUpgrade.pdf http://www.accuspect.com/cost.asp Insulation Insulate open attic to modern standards $1 - $1.50 / sq. ft. Blow insulation into flat roof, cathedral ceiling or wall cavity $2 - $3.50 /sq. ft. Lump Sum: 1,800-$2,500 single family (From Kevin at Delta) typically $2/sqft.
Ceiling Insulation (R-49) contractor installed (Blown Cellulose)	1400.00	Square foot	NA	3.50	
Ceiling Insulation (R-38): Fiberglass Batts Self Installed	1400.00	Square foot	NA	0.80	
Ceiling Insulation (R-38) contractor installed (Blown Cellulose)	1400.00	Square foot	NA	3.00	
Ceiling Insulation (R-30): Fiberglass Batts Self Installed	1400.00	Square foot	NA	0.52	
Ceiling Insulation (R-30) contractor installed (Blown Cellulose)	1400.00	Square foot	NA	2.75	
Wall Insulation (R-11): self-installed (batting or rigid)	3366.00	Square foot	NA	0.35	
Wall Insulation (R-11): contractor installed (spray foam)	3366.00	Square foot	NA	2.25	
Wall Insulation (R-19): self-installed (batting or rigid)	3366.00	Square foot	NA	0.40	
Wall Insulation (R-19): contractor installed (spray foam)	3366.00	Square foot	NA	2.50	
Hot water pipe insulation (Domestic Hot Water only)	200.00	Per linear foot	NA	1.00	http://www.leaningpinesoftware.com/hot_water_pipes.shtml - R-4 used in Model http://www.northwesternenergy.com/documents/E+Programs/E+NaturalGasRebate-Equipment.pdf rebate info, insulating pipe.
Low E double pane windows (ENERGY STAR: U-Factor <= 0.35)	180.00	Square foot	20	33.33	http://www.homedepot.com/webapp/wcs/stores/servlet/ProductDisplay?storeId=10051&langId=-1&catalogId=10&productId=100081911&N=10000003+500324+10234013 http://www.homedepot.com/webapp/wcs/stores/servlet/ProductDisplay?storeId=10051&productId=100547854&langId=-1&catalogId=10
ENERGY STAR Doors (ENERGY STAR: U-Factor <= 0.35)	19.50	Square foot	20	60.61	http://www.housingprohome.com/thermatru_entry.html

TABLE 5 CONTD. **Measure Name/Description**	**Unit Sizes - Physical Building Model**	**Units**	**Standard Unit Cost $/Unit**	**High Eff Upgrade Cost $/Unit**	**CNT Energy Internal References & Online Resources**
ENERGY STAR Clothes Washers (Energy Star: MEF >/= 1.72 and WF </=8.0)	1.00	Per unit	400	700.00	http://www.sears.com/shc/s/s_10153_12605_Appliances_Washers+%26+Dryers_View+All+Washers?filter=Energy+Star+Compliant|Yes http://www.energystar.gov/index.cfm?c=clotheswash.pr_crit_clothes_washers See Washer Calc sheet
Storage Water Heater (Energy Star: EF >/= 0.62)	1.00	Per unit	600	900.00	Plumbing Contractor (Mobile Plumbing): Input $1000 High Eff Model Comed Cares Cost Report - $1550 http://www.homedepot.com/webapp/wcs/stores/servlet/ProductDisplay?storeId=10051&langId=-1&catalogId=10053&productId=100627491 http://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/WaterHeater_ProgramRequirements_2008.pdf http://www.consumerreports.org/cro/appliances/heating-cooling-and-air/water-heaters/tankless-water-heaters/overview/tankless-water-heaters-ov.htm http://www.energystar.gov/index.cfm?fuseaction=gas_tankless.display_products_html http://www.energystar.gov/index.cfm?fuseaction=gas_storage.display_products_html EF Conventional Water Heaters .59
Tankless Water Heater (Energy Star: EF >/= 0.82)	1.00	Per unit	1200	1500.00	
Gas Condensing Water Heater (Energy Star: EF >/= 0.80)	1.00	Per unit	800	1000.00	
92-93% AFUE, High Efficiency Gas Furnace	1.00	Per home	2500	3500.00	Comfortable Air Corp: $2000 basic model, $2500 - $3500 90+% eff Kevin from Delta Institute: Budget for $2200 - $3000 basic models, All Temp Contractor (Rachel Cnt Contractor): $4225 92% eff. Single Family Home Quotation Comfortable Air Corp: Budget for Boilers: $3500-$3800 basic model, $5000 95% eff Kevin Dick at Delta Institute: Budget for $4500 for Boiler Replacement Other: Comed Cares Cost Report $8100 Other: Chicago Bungalow $4800
94+% AFUE, High Efficiency Gas Furnace	1.00	Per home	2500	4000.00	
High efficiency gas boiler 85% Eff.	1.00	Per home	3500	4500.00	
High efficiency gas boiler 95% Eff.	1.00	Per home	3500	5000.00	

The Chicago Green Bungalow Initiative

6421 S. Fairfield
6423 S. Fairfield
6425 S. Fairfield
6448 S. Fairfield

January, 2004

by the
Chicago Department of the Environment

Richard M. Daley, Mayor

Introduction

The Chicago bungalow has played a defining role in the history of many Chicago neighborhoods. Between 1900 and 1940, this middle class home with its solid exterior and comparatively spacious rooms served developing communities as Chicago spread out from its industrial and commercial core. More than 80,000 bungalows were built[1]. Often entire blocks were developed in the Chicago bungalow style, and they continue to stand – housing current residents while connecting communities to their past.

The Chicago bungalow has been defined as a blend of the Prairie School architectural style developed in the work of Louis Sullivan and Frank Lloyd Wright and the Arts and Crafts movement. As in Prairie School homes, the Chicago bungalow has low pitched roofs, wide eave overhangs, long horizontal lines, massive masonry supports, and earth-toned or contrasting colors. The Arts and Crafts movement promoted homes as private and individualized retreats from the hectic pace of city life. Following this principle, each bungalow has unique features that personalize the residence. As a result, one can look at a block of Chicago bungalows and quickly see both the common features and the difference that each house presents.

Also important to the Prairie School and the Arts and Craft style was a connection to nature and the environment. The *Chicago Green Bungalow Initiative* built on this connection by examining how sustainable products can be used in the renovation and landscaping of Chicago bungalows. Sustainable product choices included recycled insulating materials, low-volatile organic compound (low VOC) paints, and water conserving landscape features.

In addition to choosing sustainable products for renovation and maintenance, the *Chicago Green Bungalow Initiative* made energy efficiency a priority. Energy efficiency reduces the operating costs of these homes and will enable families of moderate income to afford these houses for another century. Energy efficiency is also a proven strategy for pollution prevention.

This report summarizes the *Chicago Green Bungalow Initiative* Program and outcomes. Goals of the *Initiative* as well as background information are presented. The design strategy and the energy efficiency and sustainable features of each bungalow are described. Energy savings and costs for the energy measures and sustainable products are then shown.

It is hoped that the *Chicago Green Bungalow Initiative* and this summary report will provide bungalow owners with ideas on how their homes can be modified for today's lifestyles in a sustainable fashion while remaining true to the original spirit of the bungalow design.

[1] - "The Chicago Bungalow" by Dominic A. Pacyga and Charles Shanabruch

Project Background

The *Chicago Green Bungalow Initiative* was a pilot program sponsored by the City of Chicago. Goals of the *Initiative* were to:

- Demonstrate creative methods of rehabbing bungalows that appeal to contemporary homeowners while preserving the historic character of the homes;
- Demonstrate innovative energy efficient and environmentally sustainable techniques;
- Encourage homeownership in the Chicago Lawn/Gage Park neighborhoods through visible neighborhood revitalization;
- Strengthen the cohesiveness of the neighborhood through a variety of streetscape improvements; and
- Promote the results of the *Chicago Green Bungalow Initiative* to bungalow owners and design professionals.

The following groups worked together to help guide the *Chicago Green Bungalow Initiative*.

- City of Chicago Department of Environment
- City of Chicago Department of Housing
- U.S. Department of Housing and Urban Development
- Neighborhood Housing Services – Chicago Lawn
- Neighborhood Housing Services Redevelopment Corporation
- Southwest Home Equity Assurance Program
- Greater Southwest Development Corporation
- Chicago Chapter American Institute of Architects
- Historic Chicago Bungalow Association

A project architect was hired and a "Green Team" was assembled to help guide the process with respect to architecture, design, sustainability, energy efficiency, landscaping and urban design.

Design Process

The 6400 block of South Fairfield was selected by the partners as a model block for the *Chicago Green Bungalow Initiative*. Four abandoned bungalows were acquired by the Neighborhood Housing Services. Themes, or "types", were developed around each bungalow on which the rehab work would be based.

A group of bungalow homeowners and professionals gathered for a half day charette in April 2001 to begin the design process. The purpose of the charette was to gather and exchange ideas on creating adaptable, energy efficient and "green" Chicago bungalows. Groups were formed and given a bungalow type on which to focus. The results of each group were presented to the participants, summarized and then given to the architect for incorporation into the design of each bungalow.

The four bungalow types that grew out of this process were:
- Handicap Accessible
- Home Office
- Young Professionals
- Classic Restoration

Rehab work scopes and construction documents were prepared for each bungalow. An energy efficient strategy was designed for each bungalow in keeping with the rehab work scope. Appropriate sustainable materials were then chosen for each design. Rehab work began in the fall of 2001 and was completed a year later. The bungalows were purchased and occupied in November 2002. Heating bills for the 2002-2003 heating season were acquired in the spring of 2003 to determine energy savings.

The following section describes the design, energy efficiency strategy and sustainable features of each bungalow. Costs and energy savings are also shown.

6421 S. Fairfield (Handicap Accessible)

Design

The home at 6421 S. Fairfield was rehabbed with accessibility in mind. A 500 ft^2 addition was added to the back of the home that includes an 11.5' x 10' master bedroom. A laundry room, wheel chair lift and a wide corridor leading to the new rear deck are part of the addition. The addition was built over a conditioned crawl space. Total square footage is 1,400 ft^2.

The existing kitchen and bathroom were demolished and rebuilt to accommodate a wheel chair. The existing two bedrooms, living room and dining room were refinished. Existing walls and mechanicals in the conditioned basement were removed.

The existing building was in fairly good shape. The plaster and lath were in good shape, requiring patching and painting. New windows were installed. New plumbing, electrical and a new heating system were part of the rehab work scope.

1st Floor Plan

Energy Measures

The following energy measures were included in the rehab work scope.

- foam insulation (R4) injected between plaster and brick on exterior walls
- R18 sidewall insulation in the addition
- R43 attic insulation
- R10 basement and crawl space foundation wall insulation
- new double-glazed low-E windows (old pulley wells filled with foam insulation)
- ground source heat pump for space heating and domestic hot water (electric back-up)
- bathroom and kitchen exhaust fans vented to the outside

Green Building Products

- low-VOC paints throughout
- cork floor in master bedroom
- linoleum in hallway and kitchen
- ceramic tile in bathroom
- recycled gypsum board used throughout
- copper-treated lumber used for rear deck
- cement board siding used on garage

Foam Insulation

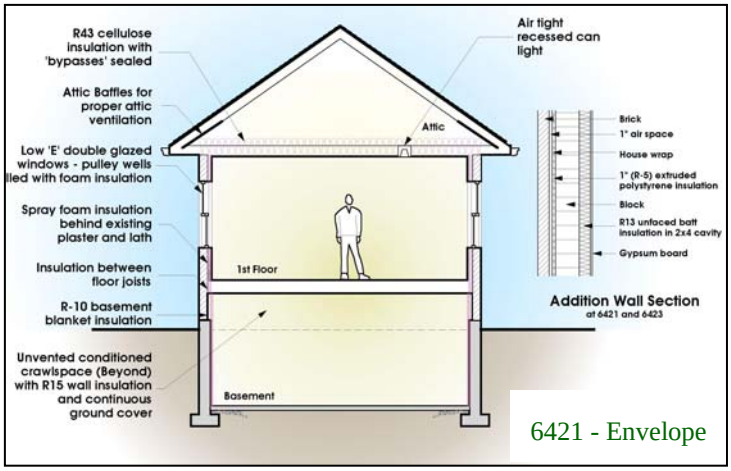
Actual Energy Costs over Typical Rehab Energy Costs- 6421 S. Fairfield (1,400 ft^2)

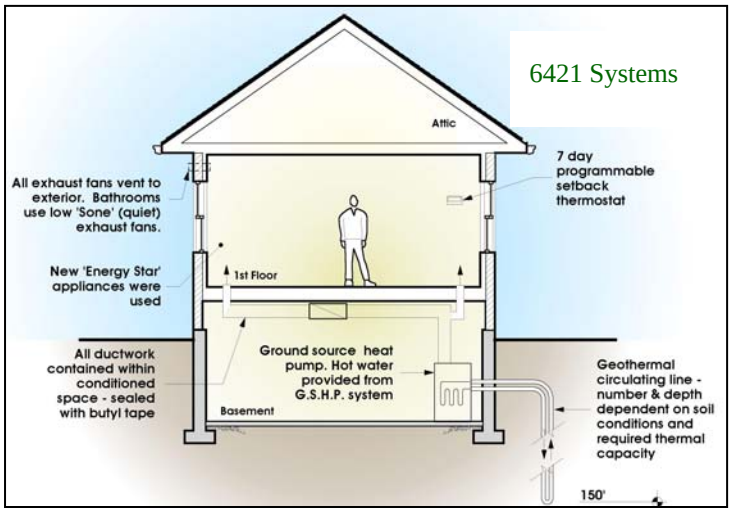
Energy Measure	Typical Rehab	Actual Rehab	Additional Cost	Unit Cost
Attic Insulation	R30	R43	$230	$0.17/$ft^2$
Wall Insulation (existing walls)	None	R4 (injected foam)	$900	$0.82/$ft^2$
Wall Insulation (addition)	R13 batts	R13 batts + 1" insulated foam board	$400	$0.68/$ft^2$
Basement/Crawl Space Wall Insulation	None	R10 blanket & R15 in crawl space	$1,200	$1.00/$ft^2$
Windows	New Double Glazed	New Double Glazed with low-E coating	$370	$2.00/$ft^2$
Furnace	Standard 80%	Ground Source Heat Pump	$10,000	
Water Heater	Standard Natural Draft			

Total Rehab Cost: $192,958 ($137.82/ft^2)
Total Additional Energy Cost: $13,100 ($9.36/ft^2)
Percent Increase: 6.8%

Actual Space Heating Energy Savings:
$1,073/year

Monthly Energy Savings:
$89/month





6423 S. Fairfield (Home Office)

Design

The interior of the home was in poor condition that warranted a "gut rehab". Plaster and lath was removed from all walls exposing all studs and the masonry exterior walls. A 262 ft^2 space that can be used as a home office was added to the back of the home over a slab-on-grade. The home office area has a separate entrance and is connected to a kitchenette and bathroom in the partially finished basement. Total square footage is 1,300 ft^2.

Many opportunities are present in a "gut rehab" to include energy efficient building measures. Those opportunities were captured in the rehab of this bungalow.

1st Floor Plan

Energy Features

- blown rock wool insulation in 2" x 4" exterior wall framing (R15)
- R18 wall insulation in addition
- R43 attic insulation
- R13 basement wall insulation
- R10 full slab-on-grade insulation
- new double glazed low-E windows (old pulley wells packed with insulation)
- air sealing
- radiant floor in home office
- direct vent sealed combustion combination space and water heating furnace (90% efficient)
- bathroom and kitchen exhaust fans vented to the outside

Combination Heating System

Green Features

- natural slate tiles in home office
- linoleum in kitchen
- recycled content gypsum board
- low-VOC paints & stains
- rubber flooring in finished part of basement
- cement board siding used on garage

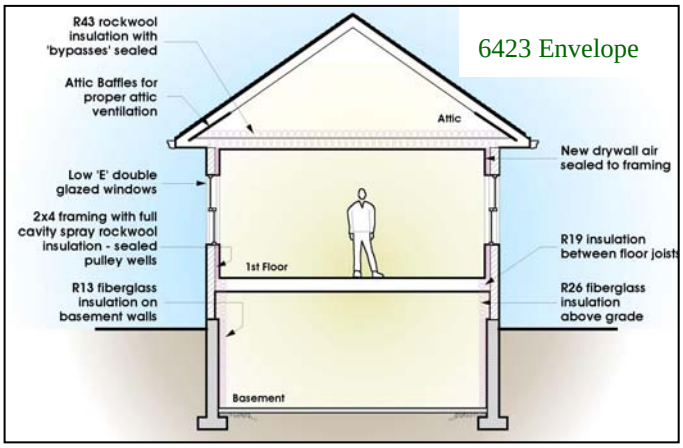
Actual Energy Costs over Typical Rehab Energy Costs- 6423 S. Fairfield (1,300 ft^2)

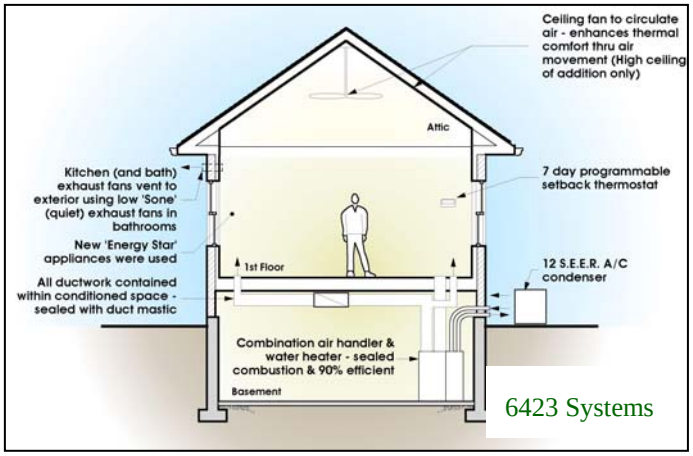
Energy Measure	Typical Rehab	Actual Rehab	Additional Cost	Unit Cost
Attic Insulation	R30	R43	$180	$0.17/$ft^2$
Wall Insulation (existing walls)	R9	R15 (blown rock wool)	$1,060	$1.02/$ft^2$
Wall Insulation (addition)	R13 batts	R13 batts + 1" insulated foam board	$500	$0.82/$ft^2$
Basement Insulation	None	R13 batts	$400	$0.50/$ft^2$
Slab Insulation	R10 perimeter	R10 full slab	$400	$1.54/$ft^2$
Windows	New Double Glazed	New Double Glazed with low-E coating	$640	$2.00/$ft^2$
Furnace	Standard 80%	Combination Heating System	$2,000	
Water Heater	Standard Natural Draft			

Total Rehab Cost:	$220,425	($169.56/$ft^2$)
Total Additional Energy Cost:	$5,180	($3.98/$ft^2$)
Percent Increase:	2.4%	

Actual Space Heating Energy Savings:
$709/year

Monthly Energy Savings:
$59/month



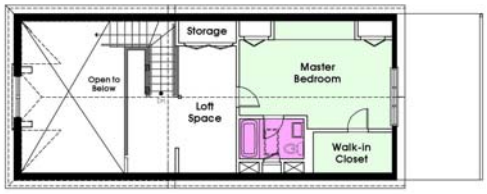


6425 S. Fairfield (Young Professional)

Design

The interior of this home was in poor condition requiring a "gut rehab". A section of the roof was raised and a master bedroom suite was added to the second floor. The ceiling over the living room was removed and the roof was finished as a cathedral ceiling. The basement was finished as living space. Total square footage is 1,644 ft^2.

The "gut rehab" permitted a wide range of energy measures to be included as part of the rehab, resulting in significant energy savings.



2nd Floor Plan

1st Floor Plan

Energy Features

- blown rock wool insulation in 2" x 4" exterior wall framing on first floor (R15)
- R43 attic insulation
- R10 basement wall insulation
- 2nd floor: R18 in knee walls and R21 in rafter cavity
- new double glazed low-E windows (old pulley wells packed with insulation)
- air sealing
- direct vent sealed combustion furnace (94% efficient)
- electric water heater
- 2.4 kw photovoltaic system on roof
- bathroom and kitchen exhaust fans vented to the outside

Spray Rock Wool Insulation

Green Features

- recycled plastic content carpet
- recycled content gypsum board
- low-VOC paints & stains
- cement board siding used on garage
- plantings on garage ("green roof")

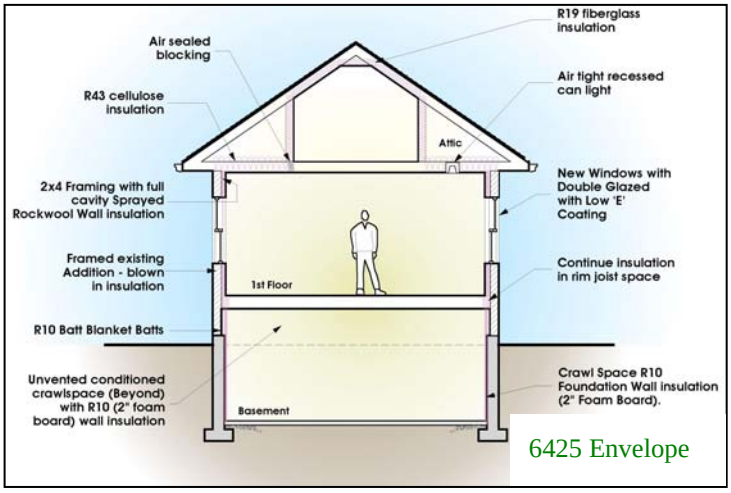
Actual Energy Costs over Typical Rehab Energy Costs- 6425 S. Fairfield (1,644 ft^2)

Energy Measure	Typical Rehab	Actual Rehab	Additional Cost	Unit Cost
Attic Insulation	R30	R43	$100	$0.17/$ft^2$
Wall Insulation (existing walls)	R9	R15 (blown rock wool)	$1,300	$1.35/$ft^2$
Batt Insulation	Knee walls: R11 rafter cavity: R19	Knee walls: R18 Rafter cavity: R21	$1,100	$0.95/$ft^2$
Basement Insulation	None	R10 blanket	$1,000	$1.00/$ft^2$
Windows	New Double Glazed	New Double Glazed with low-E coating	$475	$2.00/$ft^2$
Furnace	Standard 80%	94% Efficient	$600	

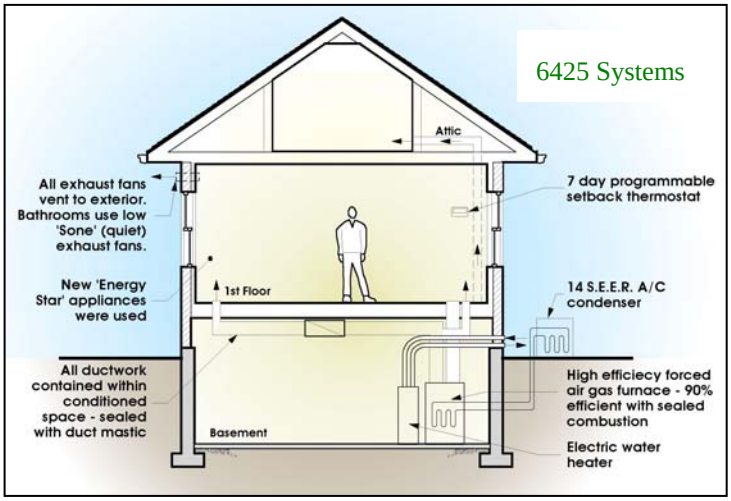
Total Rehab Cost:	$175,200	($106.57/$ft^2$)
Total Additional Energy Cost:	$4,575	($2.78/$ft^2$)
Percent Increase:	2.6%	

Actual Space Heating Energy Savings:
$849/year

Monthly Energy Savings:
$71/month



6425 Envelope

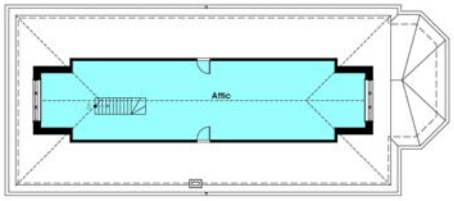


6425 Systems

6448 S. Fairfield (Classic Bungalow)

Design

The home was in fairly good shape. A number of historic features, such as doors, windows and trim were preserved and restored as part of the rehab. The attic was framed and insulated with denim insulation (but not heated) and can be finished as living space at some future point. Total square footage is 1,268 ft6^2.



Attic Plan

1st Floor Plan

Despite limited opportunities for including energy measures, significant energy savings were achieved. Foundation insulation, attic insulation, a new energy efficient boiler, an instantaneous water heater and limited air sealing were installed. Sidewalls were not insulated nor were the windows replaced.

Energy Features

- R43 attic insulation
- R10 foundation wall insulation
- R13 denim insulation in 2nd floor expansion
- single-glazed low-E storm windows (added over existing windows)
- sealed combustion boiler (88% efficient)
- instantaneous water heater (68% efficient)
- new high velocity central air conditioning
- bathroom and kitchen exhaust fans vented to the outside

Cotton insulation in knee wall

Green Features

- recycled content gypsum board
- low-VOC paints & stains
- restored and repaired stained glass windows, bookcase, fireplace mantel, light fixtures and doo
- cement board siding used on garage

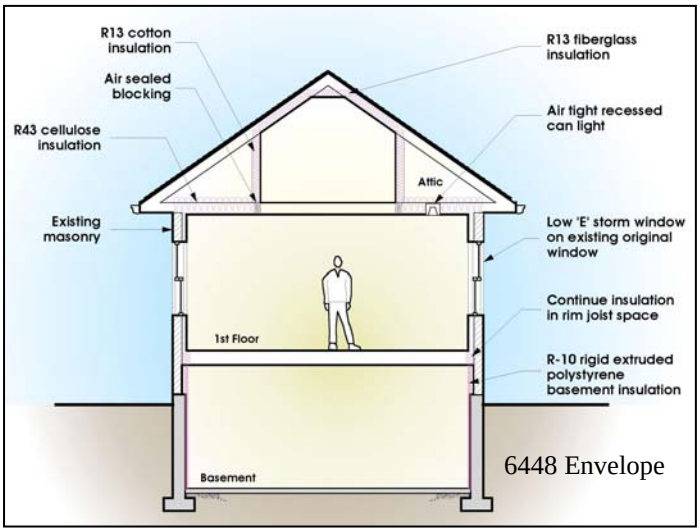
Actual Energy Costs over Typical Rehab Energy Costs- 6448 S. Fairfield (1,268 ft^2)

Energy Measure	Typical Rehab	Actual Rehab	Additional Cost	Unit Cost
Attic Insulation	R30	R43	$120	$0.17/$ft^2$
Wall Insulation	None	None	$0	$0
Knee Walls	R13	R13 denim insulation	$125	$0.25/$ft^2$
Basement Insulation	None	R10 foam board	$1,445	$1.50/$ft^2$
Windows	Typical triple-track storms	Low-E storm	$700	$2.00/$ft^2$
Boiler	Standard 80%	88% Efficient	$1,000	

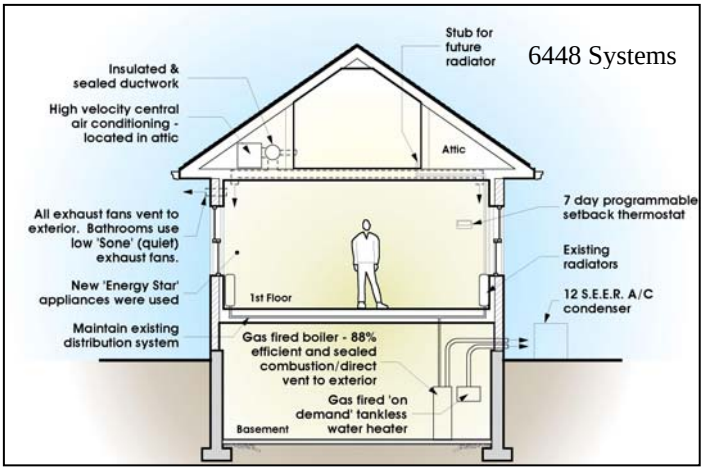
Total Rehab Cost:	$131,153	($103.43/$ft^2$)
Total Additional Energy Cost:	$3,390	($2.67/$ft^2$)
Percent Increase:	2.6%	

Actual Space Heating Energy Savings:
$574/year

Monthly Energy Savings:
$48/month



6448 Envelope



6448 Systems

Estimated Energy Savings and Actual Energy Savings

Estimated savings versus actual energy savings are shown in the Table 1. Actual savings were greater than the estimated savings in 6423 and 6448. Actual savings were less than estimated at 6421 and 6425.

Table 1

	Estimated Energy Savings	Actual Energy Savings
6421 S. Fairfield	68%	56%
6423 S. Fairfield	51%	61%
6425 S. Fairfield	72%	69%
6448 S. Fairfield	38%	47%

Cost Effectiveness

Cost differences between the "typical rehab" and the "energy efficient rehab" were obtained for each of the four bungalows. Energy savings for each bungalow were compared to the additional costs for the energy measures to determine cost effectiveness. Cost effectiveness is shown three different ways; payback, life cycle and cash flow.

- *Payback*

Payback is the number of years it takes for the energy savings to pay for the energy measures - the lower the payback, better the cost effectiveness. It is determined by dividing the energy savings into the cost of the energy measures. It does not account for inflation or increased cost of energy. Paybacks for the four bungalows ranged from 5.4 years to 12.2 years.

- *Life Cycle*

Life cycle accounts for the increased cost of energy over time. Life cycle indicates how many times over an energy measure pays for itself over 20 years– the higher the life cycle, the more cost effective. An energy measure with a life cycle of 1.0 will pay for itself once over 20 years. Any measure with a life cycle greater than 1.0 is cost effective; any measure with a life cycle of less than 1.0 is not cost effective as it will never pay for itself. Life cycles for the four bungalows ranged from 2.82 to 1.12.

Paybacks and life cycles for the four bungalows are shown in Table 2.

Table 2

	Annual Savings	Payback	Life Cycle Savings
6421 S. Fairfield	$1,073	12.2 years	1.12
6423 S. Fairfield	$709	7.3 years	2.08
6425 S. Fairfield	$849	5.4 years	2.82
6448 S. Fairfield	$574	5.9 years	2.57

- *Cash Flow*

The cost to finance the energy work is subtracted from the monthly energy savings to determine cash flow. If the monthly energy savings are greater than the monthly financing costs, there is a positive cash flow. That is, the owner uses the energy savings to pay the monthly finance charges and still has money remaining. The more money remaining, the greater the cash flow. If the monthly finance charges exceed the monthly energy savings, there is a negative cash flow. That is, the energy savings do not cover the additional financing costs.

Cash flow for the four bungalows was determined for two financing scenarios. First, it was assumed that money to pay for the energy measures was borrowed over 30 years at 6.5%. Under these terms, the monthly finance charge is $6.32 for every $1,000 borrowed. The second scenario assumed the money was borrowed over 15 years at 5.5% which translates to a monthly finance charge of $8.17 for every $1,000 borrowed.

Cash flow for the four bungalows with 30 year financing is shown in Table 3. Table 4 shows cash flow with 15 year financing.

Table 3

	Additional Cost for Energy Measures	Monthly Savings	Monthly Cost to Finance 30 yrs	Net Cash Flow
6421	$13,100	$89	$82.79	+ $6.21
6423	$5,180	$59	$32.74	+ $26.26
6425	$4,575	$71	$28.91	+ $42.09
6448	$3,390	$48	$21.42	+ $26.58

Table 4

	Additional Cost for Energy Measures	Monthly Savings	Monthly Cost to Finance 15 yrs	Net Cash Flow
6421	$13,100	$89	$107.03	- $18.03
6423	$5,180	$59	$42.32	+ $16.68
6425	$4,575	$71	$37.37	+ $33.63
6448	$3,390	$48	$27.70	+ $20.30

Home Energy Ratings

Home Energy Ratings (HERS) were done for each bungalow. HERS measure the home's energy characteristics, including insulation levels, window efficiency, heating, cooling and water heating system efficiency. A point score between 0 and 100 (0 represents the least energy efficient home possible and 100 represents the most energy efficient home possible). To be an *Energy Star*® home, the home must receive a HERS score of at least 86. A rating of 80 indicates the home meets the International Energy Conservation Code (IECC).

Each bungalow received two ratings. The first rating was based upon the "typical" rehab shown previously for each bungalow. The second rating was based on the actual rehab that includes the energy efficient measures. The ratings for each bungalow are shown in Table 5.

All of the homes meet the IECC with the energy efficient measures included. The home at 6425 reached *Energy Star*® status with 6423 falling slightly below. Both of the homes received a gut rehab. Both 6421 and 6446 received moderate rehabs and were able to meet the IECC.

Table 5

	Rehab Type	Typical Rehab	Actual Rehab
6421 (accessible)	moderate	63.1	81.2
6423 (home office)	"gut"	59.4	85.1
6425 (young professional)	"gut"	64.4	86.5
6448 (classic)	patch & paint	68.0	80.9

Bungalow Vendor List

The following consultants, subcontractors and suppliers are people and companies that worked directly on the *Chicago Green Bungalow Initiative*. The City of Chicago and the Department of the Environment do not explicitly or implicitly recommend these firms or individuals. Please feel free to investigate and compare those listed here with others in similar trades and fields.

It is always a good idea to obtain a number of bids for each part of the work, or, if a general contractor is involved, bids from different general contractors. Obtaining three bids is good practice. It allows a comparison between the bidders instead of only finding out who has a high bid and who has a low bid. Make sure that the bidders are all providing bids on the same items. Pay attention to what is excluded from the bid as well as what is included.

Heating

- Geothermal
  HVAC & Geotech Systems
  1927 Tanglewood Dr., #3A
  Glenview, IL 60025
  847/410-0180

- Lennox/Complete Heat
  Rival Mechanical Systems
  4418 N. Milwaukee
  Chicago, IL 60625
  773/286-2557

Insulation

- Insulation – *Retrofoam*
  American Thermal Seal Insulation
  1103 N. 31st St.
  Melrose Park, IL 60160
  708/865-2800

- Insulation – *Rockwool*
  Soto Insulation
  1929 W. 43rd St.
  Chicago, IL 60609
  773/471-6030

- Insulation – *Ultra Touch Recycled Denim*
  Advance Fiber
  4710 Interstate Dr.
  Cincinnati, OH 45246
  513/860-4446

- Styrofoam *Wall Mate*
  Dow Chemical Company
  200 Larkin Center
  Midland, MI 48674
  800/232-2436

Landscape

- Trench Drains
  WRD
  445 N. Sacramento
  Chicago, IL 60612
  773/722-9870

Consultants

- Architect
  Sonoc Architects
  735 W. Division
  Chicago, IL 60610
  312/266-5954

- Developer/General Contractor
  Neighborhood Housing Services
  11001 S. Michigan
  Chicago, IL 60622
  773/568-1020

- Landscape design
  Conservation Design Forum
  375 W. First St.
  Elmhurst, IL 60126
  630/559-2000

- 'Green Team'
  Thomas Forman, ADPSR
  Chicago Associates Planners and Architects
  773/929-7974

  Jeanne Gang, AIA
  Studio Gang
  773/929-7974

  Nathan Kipnis, AIA
  Nathan Kipnis Architects, Inc.
  847/864-9650

  Paul Knight, Architect
  Domus PLUS
  708/386-0345

Landscape Installation

- **WRD Environmental**
  445 N. Sacramento
  Chicago, IL 60612
  773/722-9870

Green Roof

- **Voltaire's Garden**
  1955 N. Leavitt St.
  Chicago, IL 60647
  773/278-6850

Masonry

- **Miron Construction**
  421 N. Rose Avenue
  Park Ridge, IL 60068
  847/823-2733

Security

- **Protection One**
  600 Hunter Drive Suite 101
  Oak Brook, IL 60523
  708/288-8383

Solar Panels

- **Spire Solar**
  455 N. Sacramento
  Chicago, IL 60612
  773/533-2151

Stained Glass

- **B & G Stained Glass Studio**
  4795 S. Archer
  Chicago, IL
  773/843-0558

Product Suppliers

- *Antique Lighting*
  Heritage Company
  151 N. Edwards
  Kalamazoo, MI 49006
  616/385-1004

- *General*
  Home Depot
  1232 W. North Ave.
  Chicago, IL 60622
  773/486-9200

  Menard's
  2601 N. Clybourn
  Chicago, IL
  773/880-5954

  Hyde Park Building Supply
  4630 S. Cottage Grove
  Chicago, IL 60632
  773/268-5500

- *Carpet, Recycled Content*
  Mohawk 'Kids at Play'
  L & S Carpet
  4701 N. Milwaukee
  Chicago, IL 60630
  773/777-5415

- *Drywall, Recycled Content*
  Sises Material Products
  2601 W. 9th Ave.
  Gary, IN 46404
  219/949-7436

- *Doors, Interior and Exterior*
  Simpson Door 'Bungalow Series'
  800/952-4057
  Supplier: Lee Lumber

- *Ceramic & Linoleum*
  Century Tile
  8181 S. Cicero
  Chicago, IL
  312/733-9709

  Ceramic Tile
  Apex Floor Covering
  1714 S. Halstead
  Chicago, IL 60616
  312/733-9707

- *Kitchen Cabinets*
  Advanced Cabinet Corp.
  1458 N. Lemoyne Ave.
  Chicago, IL
  773/378-7800

- *Lumber*
  Cementitious Siding
  Shannon Lumber
  4540 W. Belmont
  Chicago, IL
  773/286-4512

  Copper Treated Decking
  Hines Lumber
  For Nearest Location:
  888/334-4637

- *Paint – Low V.O.C. (Muralo Brand)*
  Hi Grade
  1300 S. Wabash
  Chicago, IL 60605
  312/663-0700

- *Plumbing – Tankless Water Heater*
  Banner Supply
  7255 S. Cottage Grove
  Chicago, IL 60619
  773/483-4900