

## HEEDING THE NEEDS OF HOME IMPROVEMENT DECISION-MAKERS

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### ABSTRACT

*Over \$7,500,000,000 in Building Permits for Residential Alterations and Additions are issued to Californians every year. A least double this amount of work is done without a permit by do-it-yourselfers and informal subcontractors.. Nationally this represents over \$300 billion in economic activity annually. If this huge group of homeowners can be shown the economic benefits of investing even a tiny fraction of these funds in energy efficiency improvements, the potential impact on our nation's energy consumption could be immense.*

*The problem is how to reach this particular group of consumers, and how to answer their questions that apply to their own specific home. They need a decision-making tool that shows exactly how much money they will save with each different option in their own unique situation.*

*This paper analyzes the huge economic leverage of this particular group of homeowners, discusses the kinds of decision-making tools they need, describes a software tool that meets their specific needs, and proposes a simple strategy for homeowner-initiated deployment that will be much less costly than trying to drive this market to higher efficiency through regulation, legislation, or rebates.*

### 1. THE MARKET

In Los Angeles County alone over \$775,000,000 in Building Permits were issued for Residential Alterations and Additions. A huge amount of additional work is done

without a building permit by do-it-yourself homeowners and informal subcontractors, at least doubling this total. Nationally this amounts to well over \$300 billion in economic activity. The Home Improvement Research Institute (HIRI) says that nationally over \$200 billion is spent for residential home improvement products alone. Over \$10 billion of this is for replacement windows, a segment that is growing rapidly.<sup>1</sup>

Almost 75% of energy consumed in residential buildings is in homes that are over 25 years old, most of which will need some type of repair or remodeling work in the next few years. In these older homes, many components are beginning to reach the end of their useful life cycle. For example, ORNL estimates that nationally 1.3 million homes that will undergo siding replacement this next year where a 10% improvement in energy efficiency would yield 0.15 quads over 10 years.<sup>2</sup>

If this huge group of home improvement decision-makers can be shown the economic benefits of investing even a tiny fraction of their funds in energy efficiency improvements, the annual potential impact on our nation's energy consumption would be immense. The problem is how to reach this particular group of consumers, and how to answer questions that apply to their specific homes.

### 2. THE CONSTITUENCY

This Do-It-Yourselfer market<sup>3</sup> is made up of a variety of sub-groups that might be called:

- Style/Trend Setters: who tend to be indifferent to initial costs, long term savings, or energy issues.

- Minimal Maintenance: who try to solve immediate problems, are most concerned with first cost, and probably will only respond to point-of-sale energy messages.
- Confused Novice: who are worried by sales pitches or advice from friends and need basic information of the kind provided by utility hot lines or on-line programs like HIT or HES (see Table 1).
- Frugal Handyman: who are concerned about both first cost and long term payoff, as well as energy conservation.
- Type-A Homeowner: who seek the highest quality materials, products, workmanship, and energy efficiency, and tend to subcontract most work.
- Hard Core DIYers: who are willing to take on any job, no matter how difficult, and for whom technical complexity is no problem.

The latter three types are likely to do some research in order to discover the best alternative solutions to their problem. All are interested in energy efficiency.

Fortunately, this particular group tends to be quite knowledgeable about how their house is constructed and maintained. For example they know if their attic is insulated and whether their floor is a slab or raised. They know their home's square footage and the direction it faces and they are easily capable of measuring the size of their windows.

### 3. REACHING THIS CONSTITUENCY

Reaching this particular group of consumers is extremely difficult because they are so diverse and disaggregated. They are not part of a trade group or profession that has a newsletter or regular meetings. They do not show up at national conferences. They are made up of a number of different sub-groups, each needing slightly different kinds of information (see Table 1). Many of them speak Spanish. Women play a major role in decisions about how these remodeling funds are spent, that has been largely underestimated according to the Home Improvement Research Institute (HIRI). Interestingly, one of the few things they all have in common is that they all receive a bill from their local utility every month and most by now have access to the Internet, which opens a strategy for reaching this constituency.

### 4. NEEDS OF THIS CONSTITUENCY

Looking not too far into the future, DIYers will turn more frequently to the internet for help in making Home Improvement decisions. For the beginners and energy novices, there are a number of web sites offering generalized energy saving tips and on-line audits (see Table 1). At the other end of the spectrum there are many

engineering-oriented programs for energy consultants and technically inclined architects.

But there is a gap for the people in between: DIYers, home buyers, homeowners contracting major upgrades, home builders, and designers. These people need a tool that is fast, easy to use, accurate, and automatically loads all the data needed for their home (local utility rates, building materials, and local weather).<sup>4</sup> But most important, this tool must be free, because these homeowners are not willing to purchase and learn to use the more complex computer programs used by energy professionals.

This decision-making tool must show exactly how much money they will save in energy costs with each different option applied to their own unique home. For example, will they save more money by investing in a patio awning or a more efficient air conditioner? Will they save more by insulating their attic compared to installing tinted double glazed windows? (for the answers see Table 2)

This level of detail is why this tool must go beyond the very general kinds of energy advice and the entry-level home surveys that are currently available. This tool must be usable at the very beginning of the project when only a few facts are known, because this is when all the most important design decisions (mistakes) are made that effect the home's energy consumption.

If each homeowner can be shown the economic benefits of investing even a small fraction of his or her own funds in energy efficiency improvements, the potential impact on energy consumption at the national scale would be huge.

### 6. A TOOL THAT MEETS THESE NEEDS

HEED<sup>5</sup>, Home Energy Efficient Design, was recently developed to meet this specific set of needs. It can accommodate all kinds of dwellings including single family detached homes, townhouses, condominiums, or apartment houses with exterior or interior hallways.

HEED uses a number of unique features to let homeowners easily and quickly sketch in all the important information about their home. Allowing these kinds of input details helps reassure them that the output results accurately reflect their own particular house's performance.

This high level of precision is essential in order to encourage homeowners to trust in the future economic payoffs of the energy efficiency investments they are making today. For example, glazing has by far the greatest impact on a home's energy performance, therefore it is essential for an energy design tool to allow homeowners to input the actual dimensions and orientation of all their

Table 1: Filling the Gap in the Needs of Home Improvement Decision-makers

Currently there is a gap in the kinds of tools available to consumers who are making critical decisions about the \$300 billion spent annually for residential alterations and addition. Notice there are many excellent tools available for novices at one end of the spectrum, and for energy specialists at the other end. However there are no tools specifically intended for home improvement decision-makers in the middle ranging from the more knowledgeable Do-It-Yourselfers to Designers looking for a “Day-One” tool.

<b>Type of Consumer</b>	<b>Existing Residential Energy Programs</b> (most available on-line from Utilities or DOE)	<b>How the Proposed New Tool for Home Energy Efficient Design Fills this Gap</b>
<b>Initial Consumer Contact:</b> Consumer Energy Center	Energy Saving Tips, Energy Conservation Best Practices, Home Energy Surveys	
<b>Energy Novice:</b> with Basic Questions, Seeking Information about Generic Homes	Online Energy Audit, HIT Home Improvement Tool HES Home Energy Saver	
<b>Do-It-Yourselfers:</b> About to Make Repair, Redesign, or Remodeling Decisions for their own particular Home		This tool shows in detail the annual savings in utility costs for each proposed change to each uniquely different home
<b>Homeowners Contracting for Major Upgrades:</b> Needing a Way to Validate the Claims of Home Remodeling Contractors.		This tool shows bar charts comparing up to nine different design alternatives in terms of their home’s annual energy costs
<b>Prospective Home Buyers:</b> Want to Compare the Energy Costs of Different New or Used Homes		This tool allows different homes in different zipcodes to be accurately simulated using local utility rates and local climate data
<b>Home Builders:</b> Need a Graphic Tool to Show Potential Customers How Various Upgrades Will Make Their Homes More Energy Efficient, or Why Their Home Out-Performs the Competition		This tool has over two dozen different graphic outputs showing many different ways to evaluate a home’s performance, including indoor air temperatures, and hourly costs of furnace, air conditioner, fans, appliances, and daylighting
<b>Architects, Interior Designers,</b> (and also Beginning Students): Need an Intuitive, Easy-to-Use Tool to Help Them on “Day One” to Design a Better Home, along with Graphics to Communicate its Energy Performance to their Clients		This tool provides many Advanced Design options appealing to design professionals, including 3-D plots comparing the performance of different schemes as they evolve and a series of 3-D bar charts showing dozens of other variables
<b>Energy Consultants, Engineers, and Technically Inclined Architects</b> (and also Advanced Students): Use Powerful and Complex Software Primarily for Mechanical Systems Design and Code Compliance When the Building is Well Along in Design	DOE-2*, Energy-10*, EnergyPlus, Energy-Pro*, E-Quest, GreenDesignTools*, MicroPas*, VisualDOE*, (*Costs range \$250 - \$1600)	

home's windows and sun shading. It must also allow them to input the data from the Energy Star sticker on the windows they are thinking about buying (U factor, Transmissivity, and Solar Heat Gain Coefficient), or the dimensions of the patio awning they are considering, or the R-value of the attic Insulation that is being proposed.

## 6. UNIQUE FEATURES OF HEED

One of HEED's unique features is that instead of requiring the homeowner to load in every detail of their home from scratch, it starts by asking just four questions, and with this information automatically creates a complete basecase house that Meets the California Energy Code. This building follows the required modeling assumptions of California's Residential Alternative Calculation Method (ACM).

Next HEED automatically creates Scheme 2, a More Energy Efficient house of the same size. For the home's latitude and climate, HEED chooses the optimum Energy Efficiency strategies including thermal mass, percent glazing on each orientation, shading, and ventilation cooling strategies.

HEED's most unique feature is the extremely intuitive interface. For example HEED is the only homeowner-friendly program currently available that lets users:

- draw in their actual floorplan using an easy fill-in-the-squares drawing technique,
- click on a 3-D image of their house to rotate it to its exact orientation,
- drag and drop their actual windows to the correct location on each facade,
- automatically attach garages their home, or neighboring units to townhouses or apartments,
- select from simple checklists the wall, roof, and floor construction, glass type, insulation, and heating and cooling equipment, etc.

Another of HEED's unique features is that it calculates indoor electric lighting levels for each hour of the year as a function outdoor illumination, window size, orientation, and room depth. All of this is used to calculate how the home's electric lighting load is reduced by daylight availability. In many California climates, electric lighting is one of the major categories of energy consumption.

Yet another of HEED's unique features is the fact that it can address occupant comfort by plotting average Indoor Temperature. It is important to test this issue when the homeowner is considering eliminating the air conditioner in favor of a whole house fan.

HEED is the only energy design tool available in both English and Spanish.

## 7. VALIDATION

While HEED is extremely easy for homeowners to understand and use, it is actually driven by a very sophisticated hourly heat-balance simulation, similar to the approach used by EnergyPlus. HEED has been validated using the ASHRAE/BESTEST Procedure compared to the results of programs like DOE-2 and Blast.<sup>6</sup> HEED is the result of more than \$575,000 of research contracts and over 20 years of development work.

## 8. A WORKED EXAMPLE OF HEED:

The following worked example shows that HEED is an easy-to-use tool that tells homeowners exactly how much money they will save each year on their gas and electric bills by making various home remodeling improvements.

Assume Mr. and Ms. Ratepayer have decided to invest some money in improvements for their 1960s tract home. HEED starts by asking them four basic questions about their home: the building type, square footage, number of stories, and zipcode. With this it automatically finds the local utility rates and hourly climate data. It then designs two basecase homes; Scheme 1 Meets the Energy Code, and Scheme 2 More Energy Efficient (about 30% better).

Next HEED makes a copy and prompts Mr. and Ms. Ratepayer to change this new Scheme 3 to represent their own house as built. So now Mr. and Ms. Ratepayer draw in their own house by clicking on squares in the Floorplanner grid. They also rotate it to the correct orientation, and click and drag their windows to the correct location on each facade. Finally they describe its construction by selecting from lists of different options.

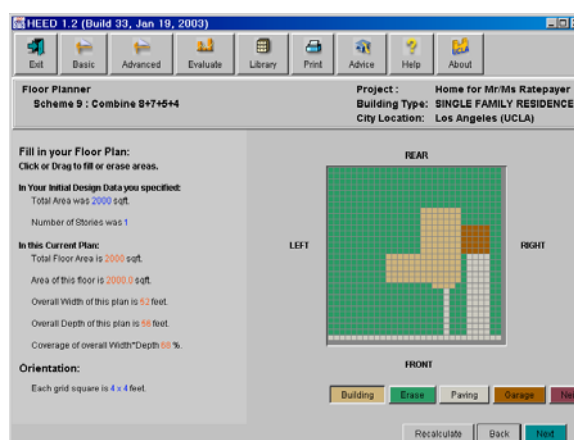


Fig. 1: In this typical example, Mr. and Ms. Ratepayer used the **Floor Planner** screen to draw in their own home by simply clicking on squares in the grid. Here they have drawn in their typical L-shaped 1960s tract house with an attached garage shown in brown.

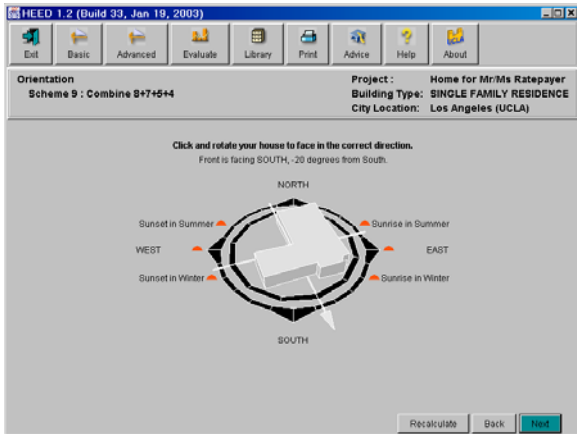


Fig.2: On this **Orientation** screen the Mr. and Ms. Ratepayer clicked on the arrowhead and rotated their home around to its correct compass heading.

After they complete describing “Scheme 3, Home as Built”, they begin creating other new schemes by simply clicking on "Copy" and changing the different attribute of their house that they wished to test. Mr. and Ms. Ratepayer are considering a number of different home improvement options so they added each one to a copy of their original tract house. For example they tried comparing the cost savings of weather-stripping, a high efficiency air conditioner, double pane tinted windows, awnings to shade patio sliding glass doors, installing attic insulation, and the final scheme combines their choice of four of these do-it-yourself (DIY) projects.

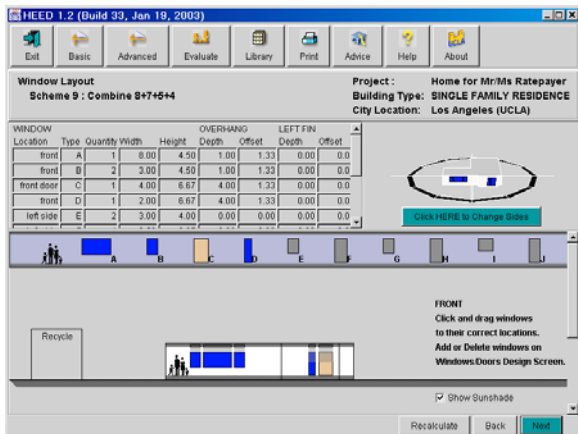


Fig.3: On this **Window Layout** screen the homeowners can click and drag their windows and doors to the correct location on each facade. By clicking on the green bar (center-right) the building will rotate to show all four sides plus the roof.

In this way HEED delivers detailed energy efficiency comparisons personalized to each ratepayer’s unique home and the specific design options they are interested in.

The Energy Costs bar chart shows their home’s annual utility bills. The first two schemes are created automatically by HEED to give a basecase point of reference:

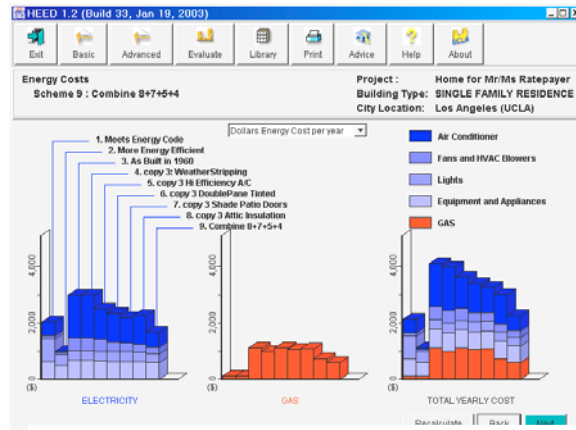


Fig.4: The **Energy Costs** bar chart shows the reductions in Electricity (left), Gas (center), and Total Yearly Cost (right) for each of the following schemes:

1. Meets Energy Code (designed by HEED)
2. More Energy Efficient (also by HEED)
3. Home As Built in 1960  
(as drawn in by the homeowners)
4. Copy of 3: Weather-Stripping
5. Copy of 3: Hi Efficiency Air Conditioner
6. Copy of 3: Double Pane Tinted Windows
7. Copy of 3: Shades for Patio Sliders
8. Copy of 3: Install Attic Insulation
9. Combine Schemes 8+7+5+4

The graph shows that these home improvements would make their home use about the same amount of energy as a home of the same size that meets the current California Energy Code (compare Scheme 9 vs. Scheme 1).

## 9. FINDING THE COST EFFECTIVE OPTIONS

The final step is for Mr. and Ms. Ratepayer to get estimates of the costs of doing these remodeling projects. A visit to the local home center outlet will yield accurate estimates for the Do-It-Yourself (DIY) options. Estimates for the contracted work would mean phone calls to local contractors in the Yellow Pages. In the next version of HEED these values can be loaded into a Cost Effectiveness Spreadsheet (Table 2). To calculate the years it will take to pay back the investment, the estimated cost is divided by the annual energy savings. Anything less than about 7 years is considered a very good investment (equivalent to about 10% annual rate of return).

	Options Tested	Annual Energy Costs	Savings Compared to Scheme 3	Estimated Costs of Improvements		Years to Pay Back Annual Energy Savings	
				DIY	Contracted	DIY	Contracted
3.	Home As Built in 1960	\$4066	-				
4.	Copy 3: Weather-stripping	\$3950	\$116	\$200	\$500	2	5
5.	Copy 3: Hi Efficiency A/C	\$3601	\$465	\$2500	\$4000	5	9
6.	Copy 3: Double Pane Tinted	\$3377	\$689	-	\$8000	-	(12)
7.	Copy 3: Shade Patio Doors	\$3233	\$833	\$800	\$1600	1	2
8.	Copy 3: Attic Insulation	\$2977	\$1089	\$1000	\$2000	1	2
9.	Combine 8+7+5+4	\$2255	\$1811	\$4500	\$8000	2.5	4.5

Table 2: These estimates show that Scheme 9, the Combination of the four Do-It-Yourself projects, would pay for themselves in only 2.5 years, a wonderful investment in any economy. Even if Mr. and Ms. Ratepayer contracted out this work they would get a 4.5 year payback, still a very sound investment. (This economic analysis is a mockup of one of the new functions that will be added in the proposed new HEED-2)

The best single option for Mr. and Ms. Ratepayer is (8.) to Install Attic Insulation; it will save them \$1089 per year in total gas and electric bills compared to (3.) their Home As Built. Based on estimates they received for installing this attic insulation, this project would have a 2 year payback if they contracted it out, or a one year payback if they did it themselves.

When they combed this with three other DIY options, it yields a total annual savings of \$1811 and a 2.5 year payback, which is an excellent return on investment. Even if they decide to contract out this work it would have a 4.5 year payback, still a very attractive investment.

## 10. DEPLOYMENT

Encouraging homeowners to use a free tool like HEED to calculate their long-term savings with different home improvement options is much less costly than trying to drive this market segment to higher efficiency through enforcing stronger regulations, legislating required changes, or paying rebates.

The solution is advertising. The objective is to make homeowners aware of HEED's availability and to encourage them to download a copy onto their home computer. One simple way to initiate this is to include information in the utility bill stuffer that every homeowner receives monthly. Another strategy is to include a link to the UCLA site on utility web sites. Customer support is provided by UCLA we maintain an email Hot Line to answer user queries, along with a file of Frequently Asked Questions.

To date over 2700 copies of the beta test version of HEED have been downloaded in response to requests initiated by potential users from around the world. This makes HEED one of the top two or three most widely used 'whole house' design tools.<sup>7</sup>

## ACKNOWLEDGEMENTS:

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<sup>1</sup> Home Tech Online, [www.hometechonline.com/handyman](http://www.hometechonline.com/handyman)

<sup>2</sup> "Supplying Energy Efficiency to Existing Residential Buildings; By Integrating HVAC and Envelope Repair, Replacement, and Renovation", Jeff Christian, Oak Ridge National Laboratory

<sup>3</sup> The growth in the Home Improvement Industry has been fueled by the Baby Boomers, who have been a major factor in the rise of home center outlets: Home Improvement Research Institute (HIRI), [www.hiri.org](http://www.hiri.org)

<sup>4</sup> "Barriers in Developing and Using Simulation-Based Decision Support Software", Papamichael, K., et.al, Proceedings of the ACEEE 2002 Summer Study on Energy Efficiency in Buildings, Asilomar

<sup>5</sup> HEED, Home Energy Efficient Design, is available at no cost on [www.aud.ucla.edu/heed](http://www.aud.ucla.edu/heed) (a file called READ-USA.TXT explains how to use this version in locations outside Southern California.)

<sup>6</sup> HEED produces valid heating and cooling results for 28 different test buildings using ASHRAE's "Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs", (ANSI/ASHRAE Standard 140-2001) Grace Tsai, et.al. (see report on HEED web site)

<sup>7</sup> "Review and Comparison of Web- and Disk Based Tools for Residential Energy Analysis", Evan Mills, Lawrence Berkeley Laboratory, 2002