Customizing HEED for a Small Utility District

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ABSTRACT:

In California, the four largest utilities serve 80 percent of the State’s residential customers, while over 40 small utility districts serve the rest of the population. These smaller utilities individually do not have the economic leverage to provide their customers with the large array of ratepayer support tools offered by the big four. But their customers struggle with the same problems, such as how to make cost-effective energy efficient decisions when repairing or remodeling their homes, or how to evaluate different options when comparing potential new home purchases.

The 472,666 residential ratepayers in the Sacramento Municipal Utility District (SMUD) spend almost two billion dollars per year on new homes and on residential remodeling and repairs. If these homeowners can be shown the economic benefits of investing even a tiny fraction of these funds to make their homes more energy efficient, the potential impact on SMUD’s energy consumption patterns would be significant. The problem is how to reach this particular group of ratepayers, and how to answer questions that apply to their specific homes.

HEED (Home Energy Efficient Design) is a free homeowner-friendly design tool that shows the energy implications of new construction and remodeling decisions. A custom version of HEED was developed at UCLA to address SMUD’s rate structures, climate data, and home construction practices. It will be made available on SMUD’s web site.

1. Helping SMUD Ratepayers Improve Their Home’s Energy Efficiency

There is a large custom home market in Sacramento and endless activity in the remodeling and additions sector. Sacramento County issues over $128 million in Building Permits for Residential Alterations and Additions every year (see Table 1). At least three times this amount of work is done by do-it-yourselfers and informal subcontractors without permits, bringing the total to roughly half a billion dollars annually. New Single Family Home Construction accounts for another $1.4 billion annually. All this money comes out of the pocket of the 472,666 residential ratepayers in the Sacramento Municipal Utility District (SMUD).

Giving these homeowners an easy way to visualize the economic benefits of investing some of their funds in energy efficiency improvements to their own homes will in turn have a significant impact on SMUD’s energy consumption patterns. The problem is how to reach the particular group of SMUD ratepayers who are about to make these decisions, and how to answer questions that apply to their own particular homes.

<table>
<thead>
<tr>
<th>Table 1: Residential Building Permits Issued in Sacramento County</th>
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<tbody>
<tr>
<td>New Single Family</td>
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<td>New Multi-Family</td>
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<tr>
<td>Alterations and Additions</td>
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<td>Total Residential Building Permits</td>
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(Construction Industry Research Board, May 2002).
SMUD currently offers incentives to new home builders to construct SMUD Advantage Homes that exceed California’s Title 24 energy standards by 35%. The incentives go to the builders in the form of Hookup Fee discounts when they make a subdivision application for electric service. The SMUD Advantage Home Program has been available to builders since 1992, and now over 40,000 Advantage homes exist in Sacramento County.

To predict energy savings for Title 24 Energy Code compliance on these production home subdivisions, mechanical contractors and energy consultants perform energy simulations using complex and costly software programs. Individual homeowners and small builders need a simple, easy-to-use tool that is equally accurate to help them quantify the energy impact of all their design and construction decisions. SMUD wanted to give these people a free “what if” tool that can quickly calculate the energy savings of alternative strategies in their new home construction and remodeling projects.

An increasing number of SMUD ratepayers get their hands dirty on “home makeovers,” and seek answers to their questions relating to energy savings in their construction projects. They often contact SMUD staff and seek the resources of the SMUD Energy and Technology Center. SMUD offers some classes on weekends and evenings to educate customers about efficient home design and construction. However helpful the classes may be, attendees always require more specific assistance with their particular project. SMUD employs three residential energy specialists in the new construction group, but they are generally inundated with the 6,000 SMUD Advantage homes built per year. One architect is also on staff who is knowledgeable about residential design and offers his experience as time permits, however his main expertise and effort is assigned to commercial daylighting simulations. HEED is thought to be the needed extra resource to augment SMUD staff.

Fig. 1 Floor Planner: HEED allows users to draw in their floor plan by selecting the “building” icon, then click and drag to fill in squares on a four-foot module. This example shows the lower floor of a three story home with a driveway and garage on the north.
On a daily basis, the typical questions that are asked relate to things like the benefits and payback for a particular efficiency strategy. These include windows and their placement, glass tints and coatings, wall and roof insulation values, radiant barrier benefits, and air conditioner efficiencies and system options. SMUD staff will offer information about all of these features but does not have the resources to run energy simulations to give each customer individualized detailed payback information. The first cost of any strategy greatly affects the decision to implement an efficiency measure. It is important to quantify the long-term financial benefits for a strategy to be implemented. It is also equally important to simulate indoor environmental comfort. SMUD needed an easy tool that could be used by anyone, that could answer the energy questions quickly. SMUD found that HEED not only answered energy savings questions but also calculated indoor air temperatures. HEED served the need of the basic user but would also be very beneficial for the architectural design community doing sophisticated passive solar design.

2. Creating the SMUD version of HEED

SMUD asked UCLA to build a version of HEED specifically for small builders, contractors, architects and their more knowledgeable residential customers. They asked for a number of additional new features addressing their district’s particular needs.

HEED (Home Energy Efficient Design) is a free user friendly energy design tool that was created initially to help residential ratepayers in the Southern California Edison (SCE) service territory make energy efficient design decisions when choosing repair and remodeling options, or when buying or designing a new home. In anticipation of serving other constituencies, HEED was programmed in a modular fashion that makes it relatively efficient to add in new capabilities including different rate structures and climate data for other utility districts.

Previous ASES papers illustrated how HEED lets ratepayers quickly draw in their own home’s floorplan (by filling squares in a checkerboard), then define their windows and drag them to the correct location on each elevation. A 3-D image of their home can be clicked and rotated to its exact compass heading. Ratepayers can easily describe their home’s construction by choosing from lists of building components like floors, roof, insulation, etc. Then they can very quickly run through half a dozen “what if” possibilities in a few minutes, and at each step see bar charts showing differences in their annual energy bills compared to a Title 24 home, using their local utility’s actual rate structures (Fig. 7 and 8). HEED is designed to be extremely easy for ratepayers to understand and simple to use, but it is actually driven by a very sophisticated hourly heat balance algorithm. HEED has been validated using ASHRAE’s Bestest procedure against the results of programs like DOE-2 and Blast. Recently HEED’s ability to predict indoor air temperatures has been validated using a set of full height test cells.

HEED starts by asking the user four facts about their home (zipcode, square footage, number of stories, and building type), and then it automatically designs a home that meets the California Energy Code (Title 24) for their climate zone. It next designs Scheme 2 that is more energy efficient. Together these two act as benchmarks to help users evaluate their own designs and revisions. Note that individual components, like walls or windows need not meet Title 24 prescriptive standards, as long as the new home’s overall energy consumption is less than the performance of Scheme 1, the Code Compliant version.

3. New Features Added to HEED for SMUD Ratepayers:

Climate Data: All of SMUD’s zipcodes and the weather data for Sacramento’s Climate Zone 12 were added to HEED’s database. Incidentally, an additional feature was added that allows climate data for over 500 stations around the world to be loaded directly from the EnergyPlus web site, via the hotlink in the HEED web page.

<table>
<thead>
<tr>
<th>Electric Rates for Sacramento Municipal Utility District</th>
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<tbody>
<tr>
<td>5.00</td>
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<tr>
<td>6.1299</td>
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<tr>
<td>7.14231</td>
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<td>11</td>
</tr>
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<td>4</td>
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<td>0.00325</td>
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Fig. 2: SMUD’s Electric Rates Screen
Electric Rates: New Electrical Rates screens were added to display SMUD’s Residential Rates (Fig. 2). This means that once SMUD ratepayers have typed in their zipcode, all their utility rates and climate data is loaded automatically.

Fuel Rates: In Sacramento, natural gas is provided to most of SMUD’s customers by Pacific Gas and Electric. Therefore a new PG&E gas rates screen was also created. Also the options of propane and heating oil were added, which are common alternatives in the more rural sections of the SMUD service territory (Fig. 3). All these electrical rates and gas rates can be changed by the user on the screen.

Level of Insulation: Because this tool is intended to help homeowners who are making remodeling and repair decisions for existing homes, there is a screen that lets them choose different levels of insulation depending on the year when their home was built (Fig. 5). Other options allow for older uninsulated homes that were partially updated by adding attic or floor insulation, which are two common do-it-yourself projects.

Radiant Barriers in Roofs: Reflective Foil Radiant Barriers are required in Sacramento’s climate zone if the Prescriptive approach is used for energy compliance. However, the large majority of new homes use the Performance approach to comply with Title 24 and many do not incorporate radiant barriers. A new set of options for roof construction now automatically includes radiant barriers, but the user is given the option here to include or omit them (Fig. 5). The user must then use other strategies to meet or exceed the performance of the Title 24 Code compliant building.

Wall Construction Options: Many new wall details have been added to the basic Wall screen based on construction practices common in SMUD’s climate zone (Fig. 6). If the user selected a wall system that will not accommodate the level of insulation initially selected, then the expert system automatically changes it to the next better assembly. For example, if the user selected the insulation level to meet the current energy code in Sacramento’s climate zone, and then selected 2x4 stud construction, the expert system will change it to R19 insulation. This is because a 4-inch deep stud space will only hold up to R13 insulation, but the prescriptive code requires R19 in Sacramento’s Climate Zone 12. The same thing happens if the user had clicked on a filled-core concrete block wall, which would be changed to block with exterior polystyrene foam.

Complex Floor Plans: HEED has been modified to accommodate floor plans that have a different footprint on each floor level (Fig. 1). Now users can easily create the floorplan of their own house by simply clicking on squares and filling in a checkerboard, then clicking on the Up or Down button to fill in the other floors. As before, neighbors and garages can be added at any floor, either attached or free standing.

Window Glazing and Frame Options: Additional types of glass and the options for either aluminum frames or non-metallic frames (wood or vinyl) have been added per ASHRAE® options (Fig. 4). These are basic radio-button lists that allow users to simply click on any window assembly they wish. However, if they have the actual NFRC (National Fenestration Rating Council) sticker data from a manufactured window they are considering using, it can be added on the Advanced Window screen for up to 25 different windows.

Spanish Language Version: HEED is one of the few Energy Efficiency software programs that are available in either English or Spanish. Therefore all this new material has been translated into Spanish and added to the final full function Spanish version of HEED.
Frame Type:
- Aluminum without a thermal break, Operable Window
- Wood or Vinyl Operable Window

Glass in Wood or Vinyl Frame Window:
- Energy Code Minimum Hypothetical for Climate Zone 12
  - Clear Single Pane 1/8" glass in wooden frame (U= 0.89 SHGC= 0.64 Tvis= 0.66)
  - Clear Double Pane in wood/vinyl frame (U= 0.51 SHGC= 0.52 Tvis= 0.57)
  - Clear Double Pane Low-E in wood/vinyl frame (U= 0.40 SHGC= 0.42 Tvis= 0.63)
  - Clear Double Pane Low-E squared in wood/vinyl frame (U= 0.39 SHGC= 0.28 Tvis= 0.61)
  - Clear Argon filled Double Pane Low-E squared wood/vinyl frame (U= 0.36 SHGC= 0.28 Tvis= 0.64)
  - Tinted Double Pane in wood/vinyl frame (U= 0.51 SHGC= 0.38 Tvis= 0.49)
  - Tinted Double Pane Low-E in wood/vinyl frame (U= 0.40 SHGC= 0.36 Tvis= 0.45)
  - Tinted Double Pane Low-E squared in wood/vinyl frame (U= 0.39 SHGC= 0.21 Tvis= 0.33)
  - Tinted Double Pane Reflective (SS) in wood/vinyl frame (U= 0.51 SHGC= 0.13 Tvis= 0.08)
  - Clear Triple Pane in wood/vinyl frame (U= 0.39 SHGC= 0.46 Tvis= 0.51)

Note: Values from ASHRAE 2001 Ch 30; double and Triple glazing has 1/4" glass with a 1/2" air space.
Tinted Double glazing has blue/green on the exterior with clear on interior, SS is Stainless Steel.
You must list all values for any other airtight windows assemblies on the Advanced Windows screen.

Level of Insulation:
- No Insulation: House Built pre-1950s (Wall R=0, Ceiling R=0, Floor R=0)
- Insulated Attic Only to Current Code level (Wall R=0, Ceiling R=8, Floor R=0)
- Insulated Attic and Partial Floor (to Current Code) (Wall R=0, Ceiling R=9, Floor R=13)
- Insulation Build before Energy Code in 1975 (Wall R=7, Ceiling R=11, Floor R=0)
- Early Energy Code (Wall R=8, Ceiling R=11, Floor R=11)
- Current Energy Code (2001) for Climate Zone 12 (Wall R=19, Ceiling R=30, Floor R=19)
- Insulation Upgrade to 1.5 times Current Code
- Super Insulation to 2 times Current Code
- Current Energy Code with Heavy Mass Walls (Wall R=12, Ceiling R=19, Floor R=38)

Reflective Foil Radiant Barriers (in Attics only)
- Radiant Barrier installed in Attic (shiny surface facing into vented attic above insulation in ceiling)
or in Flat Roof (shiny surface facing into a vented air space above insulation)
- No Radiant Barrier in Attic or Flat Roof (or upstairs is an occupied unit: see roof screen)

Note: In this Climate Zone the Code Package C and D requires a Radiant Barrier in Attics.

Walls:
- Stucco or Brick on 2x4 Wood Stubs at 16" with Plaster Board Interior
- Wood or Vinyl Siding on 2x4 Wood Stubs at 16", Plaster Board Interior
- Stucco or Brick on 2x6 Wood Stubs at 24", with Plaster Board Interior
- Wood or Vinyl Siding on 2x6 Wood Stubs at 24", Plaster Board Interior
- Stucco, Vinyl, or Wood, 1"-Polyethylene/Plywood,2x4 Wood Stubs at 16", Plaster Board
- Stucco, Vinyl, or Wood, 1"-Polyethylene/Plywood,2x6 Wood Stubs at 24", Plaster Board
- Stucco on 4-1/2" SIPs Panels (OSB, 3-1/2" Polyurethane, OSB), Plaster Board
- Stucco on 8"Concrete Block, Insulation, 2x4 Stud Wall, Plaster Board (acts like low mass)
- Stucco on 8"Concrete Block, Insulation filled cores, Exposed or Plasterboard
- Wood or Vinyl Siding, Foil, Air Space, 8"Concrete Block, Exposed or Plasterboard
- Stucco, 2"-Polyethylene on 8" Hollow Concrete Block, Exposed or Plasterboard
- Stucco, 2"-Polyethylene on 8" Solid Concrete or Block, Exposed or Plasterboard
- Stucco, Uninsulated Concrete Form Wall, Plaster Board Interior
- Solid 8" Masonry Wall, uninsulated, Exposed Inside and Out (does not meet code)

Note: "*" means thickness can increase if required by the Insulation screen or to meet local Energy Code.
If the Insulation in the selected Wall assembly cannot meet what is required on the Insulation screen, it will be automatically changed to a better Wall assembly.
Fig. 7: Energy Costs Bar Chart shows the cost of Electricity (blue) and Gas (red) for a SMUD ratepayer.

Summary Table: The Summary Table shows the user exactly how much money each of their different designs will save compared to Scheme 1, the Title 24 Basecase Home (Fig. 8). This is especially helpful for those builders interested in the SMUD Advantage Homes Incentives, because it shows which combinations of design features can achieve the desired 35% improvement above Title 24.

4. Deployment:

User Support: Simply providing a new tool does not guarantee that it will have a significant impact. Users have all kinds of questions; some extremely simple and others complex enough to require a revision in the program. That is why UCLA will staff an email User Support Hot-Line for SMUD ratepayers.

Web Site Delivery: This new SMUD version of HEED will be hosted on UCLA’s Energy-Design-Tools web site (both English and Spanish versions) where it can be downloaded at no cost by SMUD ratepayers, and to which it can be transparently linked from SMUD’s own web sites.

Workshops and Media: In addition, a series of workshops are also planned in SMUD’s Energy & Technology Center who serve various SMUD user constituencies. Bill stuffers and stories in local media can help jumpstart user acceptance.

ACKNOWLEDGEMENTS:

These new additions to HEED were developed by the UCLA Energy Design Tools Group under contract to the Sacramento Municipal Utility District, and are now available to all users. The original version of HEED was supported by the California Public Utilities Commission, under a contract administered by Southern California Edison, Gregg Ander Manager, in association with CTG Energetics, Malcolm Lewis President. We wish to thank all our many beta-testers around the country for their comments and suggestions.

1 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


4 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, (see “BestTest Validation” on HEED web site)

5 “Automatic Sun Shades, An Experimental Study”, Pablo LaRoche and Murray Milne, Proceedings of ASES 2004, American Solar Energy Society

6 A file in the download folder called READ-USA.TXT explains how to use weather data directly from the EnergyPlus web site for over 500 locations throughout the world. HEED, Home Energy Efficient Design, is available at no cost on www.aud.ucla.edu/heed

7 ASHRAE Handbook of Fundamentals, Tables 4 and 13, Chapter 30, 2001