SYSTEMS

Evaluation, Measurement, and Verification
Final Report

HEED: Home Energy Efficient Design
A Statewide Tool for Residential Ratepayers

CPUC Reference Numbers 1067-04 and 1068-04

May 19, 2006

Program Administrator:

Professor Murray Milne
Department of Architecture and Urban Design
University of California at Los Angeles
Los Angeles, California 90095
(310) 206-7021
Fax: (310) 825-8959

**CALMAC
Study ID**

UCL0001.01

Evaluation Contractor:

Aloha Systems, Inc.
14801 Comet Street
Irvine, California 92604
(949) 851-2221
Fax: (949) 851-5008

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The Home Energy Efficiency Design (HEED) software was developed by the Department of Architecture and Urban Design at the University of California at Los Angeles (UCLA) to calculate and explore the energy savings options available when considering the building, improvement, or repair of homes. It is available free for download from the internet. During the 2002-03 program year the software was developed for use within the Southern California Edison service territory. The 2004-05 HEED program expanded its scope to include the Pacific Gas and Electric and San Diego Gas and Electric service territories. The software was also updated to incorporate new developments and standards; to make it more informative, comprehensive, and user-friendly; and to be available in Spanish as well as English.

Originally the target audience for users of the software included people such as "do-it-yourself" homeowners making modifications to their homes. In the early stages of the 2004-05 program, the implementers realized that it is best suited for a more professional target audience including architects, engineers, contractors, and consultants. Promotion of the program thus moved away from mass market advertising of its availability on the internet toward promotion of training workshops through technical societies and utility energy centers.

The program met its goals. Since it was classified as an "information only" program, actual energy savings were not calculated or evaluated. There were specific target goals included in the program implementation plan, and the program met those goals as delineated in this report.

The program was well received and considered useful and informative by its users.

Continued promotion of the program to professional users would be beneficial. There is also a need to review and modify it from time to time to make sure that its available options are kept up to date and current. Many users suggested that it be expanded to include small commercial buildings. While this can be done with the existing software, and the ways of doing it are explained in detail by documentation provided by the implementer, incorporation of commercial structures and uses in the manner of easy selection presently provided for residences would be a useful expansion. We thus see continued benefit from on-going funding of this program and its evolution.

INTRODUCTION

The Home Energy Efficiency Design (HEED) program developed and distributed free informational software that allows investor-owned utility (IOU) ratepayers in the state of California to calculate and explore the energy savings options available to them when considering the building, improvement, or repair of their homes. The main goal of the software is to point out specific ways to reduce energy use. The HEED software also facilitates the calculation of energy and cost savings through an individualized process that accounts for a wide array of parameters including climate zone, the electricity rate specific to their utility service territory, and home square footage and design parameters. The HEED program began as a study at the University of California at Los Angeles (UCLA) for the Southern California Edison service territory and was expanded to serve the San Diego Gas and Electric and Pacific Gas and Electric territories as well.

DISCUSSION OF CPUC OBJECTIVES

This project was "information-only," so the measurement of direct demand reduction and energy savings was not required because there was no actual hardware installation occurring. During our process and customer satisfaction evaluation, we asked participants a series of questions including whether they have modified behavior, modified repair/renovation/building plans, or otherwise done anything to reduce energy consumption as a result of their use of the HEED software.

The CPUC has set out certain guidelines that direct the EM&V process of information-only programs. The CPUC's specific information-only objectives, from Chapter 6 of the *Energy Efficiency Policy Manual*, were covered in this plan as discussed below:

Providing up-front market assessments and baseline analysis. For the HEED software EM&V, the baseline analysis was a matter of assessing initial market conditions as well as awareness in the home building/renovation community. We conducted email surveys of HEED software users and on-site surveys of HEED informational workshop participants. This helped determine the baseline of awareness, how the users heard about HEED, and the level of utilization of the software's resources. We also inquired as to whether they used similar software tools available from other sources.

A survey of true non-participants was considered beyond the budgetary scope of this evaluation. The non-participant population was very large, but reaching people who had heard of HEED but not chosen to download it would have been extremely difficult. "Never heard about it" clearly would have dominated a non-participant survey asking why they did not use HEED.

Originally the target audience for the program included nonprofessional users such as do-it-yourself homeowners. With this in mind, we proposed evaluating semi-participants – those people who had downloaded the software but not fully used it. We had planned to assess the reasons that prevented the would-be users from actually benefiting from the program. (We expected the main reason to be the complexity and difficulty of using the software.) However, the implementers realized that the true target audience was made up of professionals such as architects, engineers, contractors, and consultants. These users included two groups – those who simply downloaded the software (and possibly instruction materials) from the UCLA website, and those who attended hands-on presentations. There was no realistic means to survey professionals who had heard about HEED and chose not to use it. Likewise, with the limited evaluation budget there was no practical means of representatively surveying the people who downloaded the software but had no other interaction with the implementers.[1] Our research therefore focused on those people who used the program rather than those who did not.

Providing ongoing feedback and corrective and constructive guidance regarding the implementation of the programs. Aloha Systems personnel were in frequent and ongoing communication with UCLA personnel throughout the two-year program period. Furthermore, one or more of our staff people observed some of the user workshops. These workshops introduced the HEED software to architects, designers, and others interested in home design and instructed them how to effectively use it.

When we observed such an event, we provided a written report to UCLA personnel assessing the event from the standpoint of ways we believed the processes or effectiveness of the workshops could have been improved. These assessments and observations included general commentary on the actual operation and program documents as well as passing on of anecdotal information gathered from participants. We also sent email surveys to all of the participants in all of the workshops.

Measuring indicators of the effectiveness of specific programs, including testing of the assumptions that underlie the program theory and approach. The HEED program theory assumed the program would make customers (1) aware of the HEED software, (2) induce them to use the software, and (3) implement energy efficiency recommendations provided by the software.

Actual use of the software was evaluated with surveys that ask customers who have downloaded the software whether or not they actually used the software. These participants were also asked what actual or planned energy efficiency modifications were or will be made as a result of their using the HEED software.

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[1] The *only* information we had on these people was an email address. Therefore the only possible way to contact them would be through email. With the abundance of spam, we considered it highly unlikely that an accurate and representative survey could be conducted among people who had downloaded this software, perhaps weeks or even months previously, and then never used it. Many of them might have even forgotten downloading it, and a significant number would have deleted the survey as spam without ever considering it.

Assessing the overall levels of performance and success of the program. The overall performance and success of the HEED program was based upon the ability of the software to teach residential designers, builders, and homeowners about a home's energy use and to inspire them to consider energy efficiency when planning a new house or a remodel or addition to an existing house. Through our survey of participating customers, we assessed what portion of the customers felt they have learned something about energy efficiency through the program and, furthermore, what percentage of participants actually planned on making any physical changes as a result of their new awareness.

Informing decisions regarding compensation and final payments. The information we analyzed and present will enable UCLA and the CPUC to accurately determine whether the program has met its stated objectives.

Helping to assess whether there is a continuing need for the program. We analyzed the marketing strategies and the opinions reported by the rate paying customers who used the HEED software to assess whether there was a continuing need for the program. We provided recommendations of areas where the project could have been improved for greater success in the future.

DISCUSSION OF SPECIFIC PROJECT COMPONENTS

Aloha Systems evaluated the effectiveness of the HEED program (*i.e.*, the information/marketing program, not the computer software itself). In particular, we set out to consider the following questions:

- Was the program implemented as designed?

- Were there any changes in the design over the year?

- Is the target audience being reached?

- Are there any recommended changes in the program design for the next program period?

Surveys

We distributed hard copy and/or electronic surveys to 100% of the participants in the HEED workshops. Because the workshops were introductory in nature, we relied upon email surveys sent a few weeks after the workshop in order to gather information about the participants' actual use of the software after the workshop. We also were given copies of the written surveys distributed by the various workshop hosts (*e.g.*, utility energy centers).

These surveys were generically used for many programs and focused on presentation satisfaction, while our electronic survey focused on the actual use of the HEED software.

We had originally considered sending electronic surveys to all of the people who downloaded HEED from the internet. We found this to be both tedious and unreliable. Because the information we were seeking required the person to have actually used (or attempted to use) the software, the survey would have to be done after a reasonable period of time (at least a week but more meaningfully one or more months). Because of the high incidence of spam that nearly everyone receives by email, it was not possible to gather responses that could represent the population of those who downloaded the software. Thus this methodology could potentially (with a great amount of interest) have mimicked the survey of workshop attendees – *i.e.* those people with a high level of interest in the program – it would have been virtually impossible to ascertain such nuances as (1) those who downloaded the software and never even tried to use it, (2) those who tried to use the software but found it too confusing or tedious, (3) those who liked the software but didn't really do anything with it, and even (4) those who used the software continuously but simply deleted or didn't bother to respond to the email survey.

This change in research focus also reflects the realization of the program implementers that the target audience for the software is much more professional than originally anticipated. The tool is far too complex to interest the average do-it-yourself homeowner to evaluate windows or insulation prior to going to a home improvement store. Thus the workshop participants, reached through various professional communities, were the most important points of dissemination.

We therefore concentrated on those people who attended workshops. In addition to collecting descriptive information about the residential rate paying participant (renter, homeowner, consultant, etc.) and the participant's location, we asked the participants the following:

- How did you hear about HEED?

- Had you used HEED prior to coming to the workshop?

- Which similar software programs do you use, if any?

- How far into the software analysis did you get?

- Did you learn anything at the workshop?

- Will you share what you learned about HEED with others?

- Do you feel HEED is effective in improving a home's energy efficiency?

- Did you take any action as a result of running HEED?

- Do you plan to use HEED again?

- What did you like and dislike about it?

- How would you improve the software program?

Workshop Commentary

Six workshops were held in various locations in California. We attended and observed two of these workshops to provide direct first-hand assessment and constructive commentary. At the workshops we attended, we also discussed the program with some attendees and gathered their thoughts, opinions, and recommendations through an informal process. This information was incorporated into our feedback provided to the program implementers.

Software Review and Validation

Several of our employees used the HEED software to model their own homes and/or hypothetical design homes. In the process of doing this, we noted issues and provided comments back to the implementer. A few times we provided points that could help make the software more useful. We never noticed any technical errors.

Validation of the HEED software, its design, and external verification of its results with another source was specifically beyond the scope of this EM&V project. During the course of our evaluation we became very familiar with the program. We were prepared to discuss any situations where we believed the results generated were inaccurate or unclear, but we did not encounter any such findings. However, we did not attempt to make an exhaustive demonstration of the software or compare its results with those of other energy software packages. HEED had previously been validated using ASHRAE Standard 140 (BestTest). The report of the validation, "HEED Validated Against the ASHRAE/ BESTEST Standard" by Grace Tsai and Murray Milne, is available for download on the HEED website, http://www2.aud.ucla.edu/heed/binaries/HEED_BESTTEST.pdf.

Energy Savings Estimates

The program was classified as "information only" by the CPUC. An accurate evaluation of the actual energy savings achieved through it was therefore not a requirement of the evaluation report. While a few users did report specific actions they took, it was neither feasible nor required to estimate either the quantity of energy efficiency measures taken because of using HEED or the energy savings achieved by installing those measures.

RESULTS

Peformance Goals

       The program met its official performance goals, which are listed in the program implementation plan spreadsheets on the "other performance goals" tab. Our commentary on the specific goals follows here, with the goals printed in italics beginning each paragraph, and our commentary as to their completion following.

       Develop the new Economic Payoff spreadsheet screen and calculation procedure. These revisions were completed by the implementers. We observed the "Economic Analysis" screen in the software and consider it easy to understand.

       Expand the built-in Energy Efficiency Strategies information in "Help" to explain PG&E rates and climate design. We found the "Help" section of the "Electric Rates" and "Fuel Rates" screens under "Advanced" to contain well-stated definitions of such general concepts as baseline tiers, rate zones, and time-of-use periods. The "Help" screen does not specifically explain how PG&E's rates were designed based on climate, but it does explain the general concept that the quantity of baseline usage for any given customer is dependent upon the climate zone in which the home is located. We believe this meets the intent of this performance goal. In fact, we believe it serves the public *better* than a fully detailed explanation of any particular utility's rate design.

       Develop a new screen to let homeowners draw in windows and doors of any rectangular size and shape. This was done. The "Window/Sunshade/Door Design" screen under "Advanced" lets individual windows, skylights, and doors be entered. Several parameters can be specified including height and width, U-factor, direction, tilt, and even information about draperies. Although only rectangular windows can be entered, windows of any odd shape could be easily approximated, presumably with quite great accuracy.

       Expand built-in "Advice" feature by adding the web sites, rebate programs, and other background information. The "Advice" tab brings up succinct information about several energy uses and efficiency measures. The first section explains the HEED program. Links are provided to 54 related websites from government agencies, utilities, professional organizations, and businesses, including all four major California investor-owned energy utilities. While the "Advice" section does not specifically discuss other utility programs such as Express Efficiency, information about those programs is available to customers by clicking on the website of their own utility.

Develop the Expanded Pitched Roof algorithm and accompanying graphic screens. This was recently completed and is now available in the most recent version of the software available through the website as of April 13, 2006.

Develop the Basements thermal performance algorithm and accompanying graphic screens. This was completed. "Basement" is one of the selections available for selection of floor type on the "Floors" screen.

Post the latest upgrade Beta Test version of HEED on the web site. The HEED website, www.aud.ucla.edu/heed, contains the current version as well as the prior two versions of the software. They are easy to download. The website is referenced on the Department of Energy's Energy Efficiency and Renewable Energy website (www.eere.energy.gov) and is also relatively easy to find through search engines.

Develop new display screen and calculation algorithms to compute furnace and air conditioner capacity per Manual J. These revisions were reported as completed by the implementers.

Staff hands-on workshops. Six workshops were prepared and conducted by the implementers.

Revise HEED as necessary to accommodate proposed revisions in the 2005 version of Title 24. These revisions were reported as completed by the implementers. A brief review of the software for window design seemed to match the fenestration requirements of the 2005 version of Title 24.   A comprehensive verification and comparison is beyond the scope of our evaluation.

Create new Energy Savings Design screen to give suggestions tailored for each ratepayer's climate, building type, and utility. This was recently completed and is now available in the most recent version of the software available through the website. It is the third screen available under the "Basic" tab.

Translate all new material added to HEED into Spanish to update the current Spanish versions. We reviewed the Spanish version and it appears similar to the English version. Verifying the exact translation is beyond the scope of our evaluation. We entered equivalent data in the English and Spanish versions and received the same energy use numbers in return, so the mathematical algorithms appear equivalent. (An exhaustive comparison of Spanish and English results is also beyond the scope of our evaluation.)

The Spanish and English versions cannot be run concurrently. If one is open, the other one gives a notice that the application is already running. Additionally, while switching back and forth between the Spanish and English versions, we found overlap. We do not anticipate many users switching back and forth, and furthermore do not have a particular belief as to whether this overlap is a benefit, a hindrance, or a combination of both. The test homes we input in English were "Home of Mark" and the equivalent test homes we input in Spanish were "*Vivienda de Mario*." After using (and closing) the Spanish version, then opening the English version and telling it to "use the initial design," the English version labeled it "*Mi primer diseño*" and "*Vivienda de Mario*." (Our Spanish-speaking employees also wonder why the software uses *vivienda* rather than *casa* to mean "house.")

This language confusion, while probably not a significant user problem since few if any users will repeatedly switch between Spanish and English, appears to demonstrate that the Spanish version is programmatically a duplicate of the English, which is a *desired* goal of the translation.

Expand Help and Advice to act as the users' manual and technical support manual. The help and advice aspects of the program appear comprehensive and useful.

Translate the new Help and Advice content into Spanish, which acts as the Spanish users' manual and technical support. The Spanish version contains a comprehensive help menu.

Hold Spanish language workshops if requested. None were requested or held. The fact that the software user base evolved toward the level of the professional designer, as opposed to the average homeowner, markedly decreased the target audience for workshops in any language and made non-English workshops unnecessary.

Work with EM&V consultant to establish ratepayer attitudes toward HEED. We provided on-going feedback to the implementers as we gathered it and always felt that they were interested in and receptive of this information.

Validate HEED using ASHRAE Standard 140 (Best Test). This had already been done on the earlier (SCE-only) version of the software. The implementers indicate that validation will be completed on the new version before May 15, 2006. Technical validation or assessment of the software was specifically beyond the scope of our EM&V work.

Provide copies of HEED to be downloaded directly from the SDG&E and/or PG&E servers if requested. This was not requested by the utilities.

Provide master CD of self-installing version of HEED that can be copied and distributed by SDG&E and/or PG&E if requested. This was not requested by the utilities.

Program Design and Target Audience

When the program and the evaluation plan were initially developed, there was an underlying assumption that non-professional people would use the software, including residential customers who may be considering remodeling their house, changing windows or doors, adding appliances or insulation, etc.

It clearly is true that the software *could* be used by such a person. We as evaluators believe that it would give very useful information to a person under such use. It would accurately answer the question, for example, as to how much energy would be saved in a house if the homeowner replaced the existing windows with any number of various types of more efficient windows that are available. From there, the homeowner could make a cost-effectiveness comparison and determine what model of new window would be best based upon energy savings, initial cost, etc.

However, in the course of continued development, the implementers found that the software was much more appealing to professional energy analysts – architects, engineers, energy raters, contractors, consultants, etc. This is an assessment with which we thoroughly agree. Because of its comprehensive nature, attention to detail, and striving toward accuracy, the casual amateur is almost necessarily excluded from the population of likely users. For some of these people it is a matter of technical competence. For others it is a matter of practicality – "Do I really want to draw a floor plan of my house, gather details about my HVAC system, wall and ceiling insulation, and existing windows simply to decide which new windows to install or even whether I should install them?" For many, the answer to this question is simply, "No." The value of the information received is not worth the cost of gathering data, learning the software, and inputting the information.

Bearing this in mind, the implementers decided to pursue the technical users. This has given them the freedom, in a sense, to expand the ability of the software to explore the details of design even more comprehensively. In the beginning of the program while reviewing initial versions of the software, we anticipated this perception of complexity by nonprofessionals and laud the implementers for incorporating it by letting their program, its development, and its marketing evolve toward a professional audience. The HEED program has demonstrated the value of allowing an energy efficiency program to evolve and adapt itself as it moves forward.

The promotion of the program likewise moved away from methods to reach the general home remodeling population – utility bill inserts, websites, etc. – and on toward reaching the professional population. Outreach was particularly geared toward professional societies (the American Institute of Architects in particular) and the utility-sponsored energy efficiency training centers.

The software continues to be modified for a variety of reasons. As new products become available, they must be incorporated into the scope of possibilities. As utility rates

change, the new rates must be entered into the energy cost calculations. As energy efficiency standards and codes change, the flags and warnings about designs that do not meet code must be modified.

An additional modification planned by the implementers but not germane to the SPC-funded program is the expansion of the software's capabilities to cover homes located outside of California. The 2003 version of the software covered the SCE service territory. The present version covers all zip codes within California. Some users desire to be able to use it for non-California locations as well.

Users and Workshops

From January 1, 2004, through January 1, 2006, there were 4,455 unique downloads of the software. For the two-year "contract period" beginning April 15, 2004, and ending April 15, 2006, there have been 4,804 unique downloads as of April 7, 2006. A "unique download" means to one email address and excludes multiple downloads by the same email address (such users of older versions downloading newer versions).

Six workshops were conducted. They were attended by a total of 115 people. We sent an email survey to all 115 attendees, and 44 returned it. Similar written surveys were also distributed in some of the sessions, and 26 people returned the written survey. Nine people responded to both the email and written survey, meaning that a total of 61 people responded to surveys, representing 53% of the attendees.

Fifty-four (89%) of the 61 respondents had not used HEED prior to attending the workshop. Six indicated they had used it before and one didn't recall. The following table shows the utility service territory of the attendees based upon the 44 responses to the email survey. (Only the email survey was distributed to all participants, so inclusion of the written sample would bias this response toward the local utility of that workshop.)

Utility Service Territory	Quantity	Percent
San Diego Gas & Electric	10	23%
Pacific Gas & Electric	11	25%
Southern California Edison	13	30%
Elsewhere in California	3	7%
U.S. Outside of California*	5	11%
In Another County	1	2%
No Answer	1	2%

* The first seminar was conducted at a technical conference in Orlando, Florida.

The following table shows the occupations of the 61 people who responded to the surveys. The totals exceed 61 because the email survey allowed multiple answers.

Self-Description as User	Quantity	Percent*
Architect or Designer	21	34%
Energy Consultant	18	30%
Engineer	5	8%
Teacher/Instructor	7	11%
Contractor	4	7%
Do-It-Yourself-Type Homeowner	7	11%
Call-In-Professional-Type Homeowner	2	3%
Renter	2	3%
Student	3	5%
Other	5	8%

* This totals greater than 100%. There was no requirement that only one answer
be given, and some people checked more than one answer.

The following table shows how the 44 people who responded to the email survey learned about HEED. This question was not asked in the written survey.

How They First Heard About HEED	Quantity	Percent*
Workshop Advertisement	19	43%
Word of Mouth	7	16%
Technical Society or Journal	6	14%
Heard it Mentioned in a Presentation	4	9%
Utility Information	3	7%
Internet	2	4%
Other	3	7%

Forty-seven (77%) of the 61 respondents do not use any type of software similar to HEED. Three did not answer the question. Of the eleven (18%) that did use another software, the following table lists the programs and the number of respondents who indicated that they used them. (Those who did use other software often used more than one program.)

Other Software Programs Used	Quantity	Percent
DOE-2	1	2%
E-Quest	3	5%
Energy 10	5	8%
EnergyPro	3	5%
MicroPas	3	5%
ResCheck	2	3%
Other*	5	8%

   * Presumably "other" does *not* include EcoTect, EnergyPlus, Energy Scheming,
     GreenDesign, Home Energy Saver, or RemDesign, all of which were listed as
     possible responses, but not selected by any of the respondents

Attitudes and Opinions from the Email Survey

The surveys of workshop participants delved into the user's thoughts regarding the software as well as what actions are likely to be taken.

All of the respondents believe that HEED is effective in improving a home's energy efficiency.

Only one of the 44 respondents said he did not like the program. In saying "No," this person commented that it was "very hard to model the building accurately and not useful for non-residential buildings."

Likewise, only one respondent (a different one) said he did not learn anything from the workshop. Some of the people commented on what they learned. Some of the things learned were the basic ideas that HEED exists and that modifications can improve energy efficiency. Other comments were very specific and/or interesting, including the following:

- Using the program illustrated important design features that help in energy efficiency.

- I noted benefits for specific energy efficiency strategies.

- I was surprised by how much cooling load can be reduced.

- I learned a bunch of energy saving tricks.

- I learned that the software won't run in MAC OSX 10.28.

- There is a point of diminishing returns for the rectangular shape of the building, long and narrow has a balance point for proportions.

- Bright people can make complicated things simple enough.

- I learned how hard it is to model buildings but how valuable it can be.

We asked the attendees what they liked the best about the software and what they liked the least. Graphics/visuals (25%) and ease of use (18%) were the dominant responses to the open-ended question about what people liked the most. In addition to ease of use and the graphics and visuals that were mentioned multiple times, some of the things liked the most include the following:

- The ability to identify specific property characteristics

- The ability to play with various inputs and get quick results

- The ability to see the influence of specific strategies

- The program's total interactivity

- Looking at "what-if" changes

- The adaptability to user experience and knowledge

- The graphic display of results and cost output makes for good client presentation

- The speed of calculations

- The applicability to residential or small commercial[2]

- 3D charts

- The ability to incorporate passive strategies

- Integrated windows with the façade and the elevation of the solar heating, night losses, etc.

- The ability to add overhands and other shading features

- Siting the building at any direction

- The ability to enter broadscope data for quick comparisons or detailed data for careful review

- The ease in being able to generate multiple case studies where you can modify components and use HEED as a tool to compare performance of the models

- The varying level of complexity based on how in depth you want to go

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[2] This specifically contradicts the person who complained that it can only be used on residential structures. In fact HEED can be used on small commercial structures if the user forces them into a house-like model, and this was explained at some of the seminars. HEED does, however, remain designed for residential settings and applies the residential building standards, so a commercial modeling is only an approximation that can give some sense of the value of changing different parameters.

- Using the design of the energy efficiency in walls and windows in order to minimize the heat lost in HVAC

- Being able to look at the detail of how components such as walls and windows perform throughout the course of different periods of time and seasons.

Twenty-three (52%) of the respondents either said "nothing" or left blank the question about what they liked least, indicating that the program was generally very well received. Some of the things cited, such as pitched roofs and Title 24 compliance, have been addressed in later versions of the software. Most of the other comments were not highly negative, but tended to point out minor shortcomings, including the following:

- Incomplete because of no water heating

- Limited choices in mechanical systems

- Limited building materials selection (mentioned three times)

- Limitations of the 4x4 building blocks

- The floor plan layout is very orthogonal and the toggling on and off of little squares seems a little antiquated

- More opportunity in commercial applications (mentioned twice)

- No time-of-use analysis

- All units of output are dollars

- No weather files for locations outside of California

- Some parts are not so user-friendly

- "I'm not sure yet how to mine the data to get at the roots of what is going on. Adding thermal mass, how to do it, and what to use to evaluate it."

Attitudes and Opinions from the Written Survey

Unlike the open-ended email survey, the written survey provided an interval scale for responses to various questions. The results presented include all 26 respondents, including the nine who completed the written survey and also responded to the email survey. The responses are provided in the same order as on the questionnaire.

Paraphrased Question	Mean	5 Descriptor	1 Descriptor
User friendliness of HEED	5.0	Excellent	Poor
Ability of instructor to answer questions	5.0	Excellent	Poor
Impression of the speaker *(see following)*	5.0	Too Complex	Too Simplistic
Complexity of the program	4.1	Too Complex	Too Simplistic
Availability of input data	4.8	Very Easily Available	Highly Unavailable
Usefulness in building design/remodel	4.9	Highly Useful	Highly Useless
Customer demand for energy-efficient bldgs	4.8	Very High	Very Low
Personal interest in decreasing energy use	4.9	Very High	Very Low
Overall satisfaction with HEED software	4.8	Highly Satisfied	Highly unsatisfied
Likelihood participant will share what learned	4.4	Highly Likely	Highly Unlikely
Overall satisfaction with training workshop	4.8	Highly Satisfied	Highly unsatisfied
Description of participant's computer skills	4.8	Advanced	Poor

We are not convinced that the response for "Impression of the speaker" was answered in the manner intended. The questionnaire provided descriptors for the "1" and "5" response for each question, as well as for middle numbers on some questions. The previous two questions had been "5-Excellent, 1-Poor" questions. Although the "Too Complex" label is clear above the 5, we are not sure that it was noticed. Rather, we believe that at least some (if not all) of the respondents may have been still thinking "excellent." Our intent was for this question to address specifically whether the speaker's delivery was at the proper level of technical detail, but sense that we actually measured overall satisfaction with the speaker. A rating of 5.0, meaning that every respondent called the speaker "too complex" is inconsistent with the very high overall satisfaction ratings presented throughout this particular survey.

We asked the written survey participants, "What was your first impression of HEED?" The question was open-ended and did not suggest any terms. The majority of

responses were some version of a positive attribute. The key words with their frequency of use is as follows:

- Awesome (1)
- Great (6)
- Interesting (4)
- Neat (1)
- Simple (4)
- Smart (1)

Among the other more detailed responses were the following:

- It is a good idea to help save energy.
- I thought it was a good idea for home owners.
- I thought it would be complicated, but with time it was real simple to use.
- It seemed complex but wasn't.
- [It was] difficult but got easer.
- I thought it would be difficult.
- [I was] skeptical of the ease of use.
- [I was] thinking it was like the rest of the other programs.

We also asked these participants, "Which features of the program were of most interest to you?" Most of the responses grouped into four basic areas:

- All/everything (5)
- Design process (4)
- Ease of use (5)
- Layout (4)

Additional responses included the following:

- Buttons
- Window demos
- Openings like doors and windows
- Graphs and diagrams

- The creative control of how the design will be

- Good visualization of input and output data

- The design of the energy efficiency in walls and windows in order to minimize the heat lost in HVAC

- The ability to identify specific property characteristics

Planned Actions

Nineteen (43%) of the respondents indicated that they had run HEED more than once. Eight (18%) said they had "made a number of different design changes" and eight said they "made simple design changes." The question allowed multiple answers, and many people checked several. Only seven of the respondents indicated that they had not really worked much with the software (or left the answer blank), which means that 84% of the respondents worked with the software after they came back from the workshop.[3]

Thirty-nine (89%) of the respondents plan to use the HEED software again.

As we mentioned earlier, the information about actions taken or planned to be taken is relatively weak because of the nature of both the software and our ability to conduct the survey. HEED is a tool that is learned and then, most likely, applied at a later date. We attempted to conduct the survey soon enough after participating in the workshop to evaluate opinions based upon recent memories but late enough to have given at least some of the participants an opportunity to work with the software on their own. Nonetheless, we did not expect any significant number of respondents to have already made physical changes to a home as a result of using the HEED software.

Actions Taken	Quantity	Percent*
It was a useful learning experience	26	59%
Change my energy use behavior	7	16%
Purchased energy efficient lights/appliances	3	7%
Made building maintenance improvements	2	4%
Made remodeling changes	4	9%
Made project changes with a contractor	2	4%
Made building design changes	6	14%
Used for training/consulting	2	4%
Interested to use in the future	4	9%
Nothing changed	4	9%

* This totals 135%. There was no requirement that only one answer be given, and some people checked more than one answer.

PG&E Survey

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[3] While we believe this is very significant, we also believe there could be a bias in this with respect to the total population of workshop attendees. The people who took the time and interest to continue to use and/or explore the HEED software were probably more likely to respond to the survey.

PG&E gave a written survey to the participants at the training session held in its facility. The results were overwhelming supportive of the class. Fourteen participants responded. The following table shows the mean result on a scale of 1-5, where 5 represented "excellent" and 4 represented "very good." (Almost all of the answers given were either 4 or 5. No value less than 3 was recorded.)

Paraphrased Question	Mean
Overall satisfaction with the course	4.6
Instructor's knowledge of the subject matter	4.9
Instructor's ability to respond to questions and give examples	4.9
Information at a level that was easy to use and understand	4.7
Practice exercises and their applicability to your job	4.2
Length of the course	4.2
PRIOR ability to perform tasks required for the course (0-100)	38.2
POST ability to perform these tasks (0-100 scale)	73.2

Sempra Survey

Sempra gave a written survey to the participants at the training session held in its facility. The results were also very supportive of the class. Twenty-three participants responded. The following table shows the mean result on a scale of 1-5.

Paraphrased Question	Mean
Overall satisfaction with the course	4.4
Satisfaction with the speaker (Murray Milne)	4.6
Helpfulness of handouts/materials	4.3
Right amount of time was allocated for the seminar	4.3
Seminar met my expectations	4.4
Seminar will help me in my job	4.4

RECOMMENDATIONS

Our first impression of HEED was that it was too complex for the then-target audience of do-it-yourself residential customers. We therefore commend the implementers for realizing this and adjusting their strategy for promoting the program. The usefulness of the HEED software lies within its ability to simply and accurately model a variety of different components of a house. Simplifying it to the point of making it readily usable to the average residential customer, or even the average "do-it-yourself-type" residential customer, would have seriously hindered its ability to handle the complex situations that make it useful to its professional audience.

This evaluator (a 50-year-old engineer) originally thought the software was too artistic in its design. While entering numbers into tables comes easily, drawing with little squares was not something that was readily appealing, perhaps because I am not an architect and/or because I did not grow up with graphic-interface computing. However, this initial roadblock was easily overcome by attending one of the presentations and actually playing with the software. Furthermore, this opinion was not shared by the software's users. On the contrary, the graphics of the program were frequently cited as one of its best features. We thus commend the HEED developers in their work in this arena and posit that perhaps this is one of the reasons why the program *is* so appealing to architects and home designers, so we encourage them to continue in this format with any enhancements that may be made.

Two recommendations occasionally came up from participants regarding the limitations of the software. The first is its limitation to residential buildings. The second is its limitation to California. The HEED website contains downloadable reports that explain exactly how to model commercial buildings and also how to download and import weather data for anywhere in the world. Also, the utility rate screens allow manual input, so any utility's rate could be put into the program. Thus, for the ardent and savvy user, both of these limitations have already been addressed.

Commercial Buildings. We believe that expansion of the software's ability to cover commercial buildings is a desirable and appropriate use of California public goods charge (PGC) money. To some extent the general lessons a designer can learn from iterative runs of a home's design can be extended into the commercial setting. On the other hand, the specifics of a building's savings, and the cost-effectiveness of various specific measures, particularly with respect to viable alternatives, are dependent on the finer details of the structure and its occupancy. So the software can serve as a general learning tool applicable to commercial building design, but cannot easily serve as a useful tool to *optimize* the design of any specific building. Developing a version for commercial buildings would obviously assist in the commercial sector. It probably would increase the use of the residential version of HEED as well, simply because many designers work with both types of building. If they had one software program that is easy to use in both sectors, they would be more likely to use it.

Non-California Locations. Extension of the program to non-California locations would also be useful to the nation and the world. We do not see that this would be an appropriate expenditure of California's PGC money, but certainly encourage the implementers to seek other sources of funding for that expansion.

Continuous Updating.   Clearly there is a need for continuous updating and modification of the software. One vital force driving the need to update is the change in building codes and standards. These changes tend to happen in discrete intervals and are therefore easy to track. Obviously when these changes are made by the Energy Commission or other authority, the software needs to be updated to incorporate the change.

The continuous evolution of technology creates another need for updating of the software, the available design options, and their underlying parameters. Unlike building standards, this happens slowly and could easily be overlooked.   We encourage the implementers that they keep abreast of technology and its developments, making additions and changes to the software as appropriate. We recommend on-going funding from PGC funds or elsewhere to enable this work.

Time-of-Use Analysis.   One of the users pointed out that the software does not have time-of-use analysis. The vast majority of residential customers do not have time-of-use rates, so at this point in time such information would not contribute to either the annual energy savings or the cost savings of a particular design.   However, this situation is changing, and demand response is becoming more of an issue. Expansion of the model to include time-of-use analysis should be seriously considered.

We realize that this is much more complex than simply adding a TOU utility rate structure and basic information such as when a home is occupied and when the residents do laundry.   Various design features – insulation, fenestration, etc. – have time delay components that could alter the load profile of a home even without a change in occupant behavior, and these load profile changes vary from one climate zone to another. Nonetheless, as addressing critical peak power demand becomes ever more important in California and elsewhere, including time-of-use analysis is a noble goal and worthy extension of this program. Perhaps funding from demand response programs could be used for this effort.

More Options.   Some users mentioned various types of enhancements such as additional mechanical system options and a greater variety of building materials.   The importance of addressing these additions depends on two factors: (a) the realistic frequency in which the unmodeled equipment is actually used in homes and (b) how closely the unavailable equipment can be modeled by choosing a similar piece of equipment from the available list. An analysis of this is beyond the scope of our study. We do point out that it is unreasonable to expect a modeling program such as HEED to be able to address every possible situation with absolute accuracy. Nonetheless, it could benefit the program for the implementers to review the available options with this thought in mind and see if there are a few additions that they feel would be helpful.

Energy Units.   Another respondent complained that the outputs are in dollars. We agree that using dollars clouds the issues of energy efficiency and utility rates. Since the rate is unchanged for a given house, the influence of rates (and their current accuracy in the software) tends to wash out when comparing different designs. The output graphs currently give three options: (1) dollars per year, (2) percent of the first design, and (3) dollars per square foot per year. Allowing a fourth option, "kWh or therms per year" would allow users to use energy units rather than financial units if they so choose. We suspect that many users would choose to use energy units. Furthermore, we believe that using energy units

mentally assists designers to think about energy at a conscious level. When designing a home they'll start thinking about kilowatt-hours and therms rather than just dollars. We therefore recommend that future versions of the software allow the user to select energy units for the comparison graphs.

Solar Energy. The implementer hopes to add components to allow the software to assess photovoltaics and/or solar hot water heating. We agree that this would be beneficial and would assist the state in the endeavors of the Million Solar Roofs initiative. We believe that this would be an appropriate use of energy efficiency and/or demand response public goods funds.

Graphic Color Scheme. The comparison colors of the 3D time-of-day/month-of-year graphs have different values on the two charts for comparison. For example, purple might represent 9-12 kBTU/h on the left and 8-10 kBTU/h on the right. While this strategy maintains the full color spread on each graph, it decreases the ability to immediately compare the two strategies through visual means. We suggest exploring the use of the same color ranges for both graphs on each comparison (not necessarily the same scheme for *all* graphs, but for any two that are presented side-by-side). We do not necessarily claim that this is better, as it could produce some graphs that are boring or monochromatic. What we do recommend is that a group of users be shown the two options and asked about their preferences.

A similar observation is that each color is assigned a specific value range, but these ranges are obviously generated by a computer. We recommend rounder ranges. Compare, for example, the following actual observation and our recommendation:

Color	Observed	Recommended
Purple	9.21 to 12.24	>9
Magenta	6.18 to 9.21	6 to 9
Green	3.15 to 6.18	3 to 6
Blue	0.12 to 3.15	0 to 3
Navy	-2.91 to 0.12	-3 to 0

Finding the Website. HEED is easily found by search engines such as Google so long as one uses extra terms such as "HEED home energy." We are therefore surprised that it is relatively difficult to find from either the main UCLA website (www.ucla.edu) or the department's website (www.aud.ucla.edu). Even the search "HEED home energy" on the UCLA homepage search brought up over a hundred results, mostly papers written by professors that had no relationship to the HEED program but merely contain the word *heed*. We believe a direct link, at least from the department's www.aud.ucla.edu homepage should be provided.

CONCLUSIONS

The HEED program implemented by the UCLA Department of Architecture and Urban Design accomplished the tasks specified in the program implementation plan.

The program was well received by the target audience of architects, engineers, and other design professionals. The users liked the program and they felt the instructional seminars were done well.

Funding should be made available for some ongoing development. At the least, there should be sufficient funding available to allow the implementers to update the software as technology and/or regulation continue to modify the available and appropriate technology options to be included in the analyses. There also appears to be a desire for and usefulness of a version of the software dedicated to small commercial structures and occupancies.