

# **Review and Comparison of Web- and Disk-based Tools for Residential Energy Analysis**

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September 5, 2002  
(Rev. October 23, 2002)

LBNL-50950

This work was supported by the Assistant Secretary for Energy Efficiency and Renewable Energy, Building Technologies Program, U.S. Department of Energy, under Contract No. DE-AC03-76SF00098.



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# 1 EXECUTIVE SUMMARY

There exist hundreds of building energy software tools, both web- and disk-based. These tools exhibit considerable range in approach and creativity, with some being highly specialized and others able to consider the building as a whole. However, users are faced with a dizzying array of choices and, often, conflicting results. The fragmentation of development and deployment efforts has hampered tool quality and market penetration.

The purpose of this review is to provide information for defining the desired characteristics of residential energy tools, and to encourage future tool development that improves on current practice. This project entails (1) creating a framework for describing possible technical and functional characteristics of such tools, (2) mapping existing tools onto this framework, (3) exploring issues of tool accuracy, and (4) identifying “best practice” and strategic opportunities for tool design.

We evaluated 50 web-based residential calculators, 21 of which we regard as “whole-house” tools (i.e., covering a range of end uses). Of the whole-house tools, 13 provide open-ended energy calculations, 5 normalize the results to actual costs (a.k.a “bill-disaggregation tools”), and 3 provide both options. Across the whole-house tools, we found a range of 5 to 58 house-descriptive features (out of 68 identified in our framework) and 2 to 41 analytical and decision-support features (55 possible).

We also evaluated 15 disk-based residential calculators, six of which are whole-house tools. Of these tools, 11 provide open-ended calculations, 1 normalizes the results to actual costs, and 3 provide both options. These tools offered ranges of 18 to 58 technical features (70 possible) and 10 to 40 user- and decision-support features (56 possible).

The comparison shows that such tools can employ many approaches and levels of detail. Some tools require a relatively small number of well-considered inputs while others ask a myriad of questions and still miss key issues. The value of detail has a lot to do with the type of question(s) being asked by the user (e.g., the availability of dozens of miscellaneous appliances is immaterial for a user attempting to evaluate the potential for space-heating savings by installing a new furnace). More detail does not, according to our evaluation, automatically translate into a “better” or “more accurate” tool.

Efforts to quantify and compare the “accuracy” of these tools are difficult at best, and prior tool-comparison studies have not undertaken this in a meaningful way. The ability to evaluate accuracy is inherently limited by the availability of measured data. Furthermore, certain tool outputs can only be measured against “actual” values that are themselves calculated (e.g., HVAC sizing), while others are rarely if ever available (e.g., measured energy use or savings for specific measures). Similarly challenging is to understand the sources of inaccuracies. There are many ways in which quantitative errors can occur in tools, ranging from programming errors to problems inherent in a tool’s design. Due to hidden assumptions and non-variable

“defaults”, most tools cannot be fully tested across the desirable range of building configurations, operating conditions, weather locations, etc.

Many factors conspire to confound performance comparisons *among* tools. Differences in inputs can range from weather city, to types of HVAC systems, to appliance characteristics, to occupant-driven effects such as thermostat management. Differences in *results* would thus no doubt emerge from an extensive comparative exercise, but the *sources* or *implications* of these differences for the purposes of accuracy evaluation or tool development would remain largely unidentifiable (especially given the paucity of technical documentation available for most tools).

For the tools that we tested, the predicted energy bills for a single test building ranged widely (by nearly a factor of three), and far more so at the end-use level. Most tools over-predicted energy bills and all over-predicted consumption. Variability was lower among disk-based tools, but they more significantly over-predicted actual use. The deviations (over-predictions) we observed from actual bills corresponded to up to \$1400 per year (approx. 250% of the actual bills).

For bill-disaggregation tools, wherein the results are forced to equal actual bills, the accuracy issue shifts to whether or not the total is properly attributed to the various end uses and to whether savings calculations are done accurately (a challenge that demands relatively rare end-use data). Here, too, we observed a number of dubious results.

Energy savings estimates automatically generated by the web-based tools varied from \$46/year (5% of predicted use) to \$625/year (52% of predicted use). The estimates reflect widely different packages of measures proposed by the tools, and thus a diversity of “messages” sent to users about the opportunities for saving energy.

Lay users would likely experience even more variability in results, due to the many technical judgments required to translate actual building characteristics and occupancy patterns into tool inputs.

Based on spot checks, we also discovered a remarkable number of results that suggest errors in programming or algorithm accuracy. More systematic studies need to be done in order to draw firm conclusions about tool accuracy.

There are numerous potential avenues for improvement of residential energy tools. For example, many provide only estimates of existing energy bills and no recommendations or estimates of potential savings, and fewer still provide cost-effectiveness or emissions analysis. Few web- or disk-based tools offer substantial qualitative content to support decision-making based on quantitative results. Only one of the web-based tools is suitable for professional audiences, while all of the disk-based tools are directed toward professional audiences and—due to their complexity—none are suited for use by consumers.

Various important building science issues and energy efficiency features cannot be sufficiently well evaluated using existing tools (e.g., peak power, IR reflective roofing, high-R perimeter attic insulation, thermal comfort, advanced crawlspace/foundations, advanced thermal distribution modeling, early appliance retirement).

Synthesizing the information gathered, we developed best-practice guidelines that may be useful to developers of residential-energy tools. These include:

- Targeting & Usability – we suggest carefully identifying and serving diverse audiences and their equally diverse needs, providing qualitative decision-support information (in addition to calculations), keeping information and data current, fostering linkages among an every-growing proliferation of tools, and focusing on user convenience. Analytical results (e.g., benchmarking) and “what-if” capabilities are more helpful for users than raw data outputs.
- Technical Features & Rigor – we suggest maximizing the applicable geographic range of tools (weather conditions), ensuring technical rigor (e.g., modeling of interactions) while providing for the modeling of occupant effects, open-ended energy calculations as well as results that are normalized to user-entered billing history, incorporating means for users to appreciate the uncertainties embodied in the results, and ensuring quality control to remove errors from the design and programming of tools.
- Platform – web-based tools offer considerable advantages over disk-based tools. Among these, are platform independence (PC, MAC, Unix), lower cost of distribution, ease of updates, and the ability to implement links to a growing array of related resources elsewhere on the internet.
- Strategic Considerations – future efforts could encourage heightened objectivity, technical inclusiveness, and accuracy, and improved transparency and documentation of assumptions. There is tremendous fragmentation and redundancy (as well as disparate results) among tools currently in use. Efforts should be made to unify existing disparate public and private development initiatives and focus scarce development resources into higher-quality and more reliable tools.

## 2 HOME ENERGY ANALYSIS SOFTWARE AND AUDITS

In their ideal form, building energy tools enable users to accurately and cost-effectively evaluate energy use and savings opportunities as well as non-energy issues such as those having to do with cost, environment, comfort, safety, and aesthetics (Mills and Rosenfeld 1994). Generic building blocks include the core simulation engines, coupled with user interfaces, and supported with data on weather and component properties. The long-term vision is one involving virtual (collaborative) “life-cycle” building tools that simulate actual buildings and their construction coupled with intelligent systems that monitor and archive building performance and feed the results back to the simulation tools that in turn grow more refined by operating on better empirical data (Bazjanac and Crawley 1999).

The origins of building energy software trace back to the 1970s, when development of the first simulation engines began. Prior to that time, energy audits had been conducted by hand and at significant cost. In the 1980s, the first-generation of simulation-based analysis and design tools came into use by researchers and consultants. The 1990s were marked by tool improvements and a rapid diversification of tools targeted at a broader range of users, including commercial and residential consumers, and the advent of web-based tools. In parallel with these technical developments was a perhaps 500-fold reduction in the cost of delivering tool-based audits.<sup>1</sup>

Persistent barriers to the mainstream adoption of building energy tools include the time required to use them, processing the often-extensive outputs, and then evaluating strategies for reducing energy use below the performance level predicted for the existing or baseline building. This can require the use of multiple tools and multiple “runs” to evaluate alternate scenarios. Compounding the problem are user-interface and performance irregularities stemming from the relatively low level of investment in developing and maintaining these tools.

The small market for building energy tools has led to low investment in tool development, by software industry standards. Development teams typically number from one to five people, versus one to two hundred even for considerably simpler mainstream consumer software (e.g., checkbook-balancing tools). Numerous evident bugs and runtime instabilities evidence a lack of sufficient resources for quality assurance.

Despite the steady improvements over time, residential energy tools (as well as non-residential ones) have attained very low market penetration. This has been partly ascribed to the extensive fragmentation of development and deployment efforts (as evidenced by the hundreds of tools in existence), resulting in a proliferation of tools each with a low user base. The argument has been made for unifying the currently disparate development efforts into a more focused and collaborative initiative (Papamichael and Pal 2002). This is particularly desirable given the high historic level of public-sector funding for tool development.

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<sup>1</sup> According to Michaels (2000) the evolution from the early computer-based residential audits to the emerging email-based audits has seen a cost reduction from approximately \$250/home to \$0.50/home. The cost reductions were due to a combination of lower computing costs, reduced human labor, and increased participation rates.



### 3 PRIOR SOFTWARE REVIEWS

Mills and Ritschard (1987) previously evaluated disk-based tools applicable to multifamily buildings for DOE. Few if any of these tools still exist, or they have evolved considerably since the original review. Home Energy Magazine has published various articles, each of which looks at a handful of tools (e.g., Hunter 1998). The Electric Power Research Institute commissioned a proprietary review of four web calculators in 1998 (EPRI 1998).

The most thorough prior study of this kind appears to be a review conducted for the California Energy Commission (Westerman 2001). Although only eight residential tools were evaluated (two disk-based and six web-based),<sup>2</sup> the information collected was more detailed than prior studies. The study concluded that a tool should provide three kinds of recommendations (1) no-cost options such as behavioral changes, (2) envelope measures applicable during remodeling, and (3) equipment retrofits. The report lists non-energy benefits and case studies as additional information that tools should offer, as well as multiple user levels, recallable results, comparisons between multiple scenarios, and the ability to evaluate single measures (i.e., without having to do a whole-house survey). Westerman also emphasizes the importance of tools that “educate” the user (i.e., not just generate numbers). The study concluded that no single tool “consisted of all the desirable features and functionality”. Two additional related criticisms of all the tools were that the recommendations are often vague and don’t specify the exact efficiency level that consumers should select, and that some give ranges (instead of point values) for results but do not assist the user in understanding the underlying uncertainties. According to the study, the most comprehensive and useful tools were the Home Improvement Tool (now called the Home Energy Advisor) and the Home Energy Saver.

While not a critical review, The U.S. Department of Energy’s Building Energy Software Tools Directory (Crawley 1998) is a rich compilation of tools and developer-provided information per a standard format. LBNL also maintains an on-line list of buildings energy software tools (LBNL 2002).

The current study expands and improves on past efforts in several ways:

- A more current and larger number of web- and disk-based tools are evaluated with more systematic and exhaustive side-by-side comparisons.
- More emphasis is placed on evaluating the reasonableness and accuracy of tool outputs.
- An improved framework is established for evaluating and testing the tools.
- Recommendations are provided for best-practice tool design.

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<sup>2</sup> These tools are Home Improvement Tool (now Home Energy Advisor), Home Energy Saver, HomeEnergy Software, Home Energy Efficiency Design, SMUD’s Home Energy Analysis, SDG&E’s On-Line Energy Profile, SCE’s On-Line Home Energy Survey, and PG&E’s Home Energy Survey.

## 4 METHODOLOGY

To identify residential tools for evaluation, we conducted web- and literature searches, including review of the above-mentioned prior work. The disk-based tools were selected in Spring 2002 from the on-line version of DOE's *Building Energy Software Tool Directory* (Crawley 1998). The selected tools were cataloged and reviewed for useful features, methods of presentation, interface design concepts, etc. From this main set, the subset with a “whole-house” orientation were identified and evaluated in considerably more depth. To be included in the “whole-house” detailed review, a tool must consider the full range of residential energy end uses and fuels.

All tools are listed in Tables 1 and 2.<sup>3</sup> Most of the tools identified were developed in the U.S., and some in Canada. The few European tools identified were either not available in English or did not seem applicable to U.S. conditions.

Our methodology for collecting and comparing information on the web- and disk-based tools evaluated expands significantly on that used by Mills and Ritschard (1987). A detailed matrix was set up to capture, as comprehensively as possible, the house and household description, output, and user-support features, and analytical methods used by each tool. The range of user needs and the corresponding presence of these features in the tools examined informed decisions about which features to record in the matrix. Summary information is presented in Tables 3 and 4, and the complete matrices of features appear in Appendices 1 and 2.<sup>4</sup> No one tool possessed all possible features.

We determined how many inputs were possible for each tool. There are various ways to define an “input”. Some prior studies have used “number of questions (e.g. Westerman 2001), but individual questions typically seek multiple pieces of information. We found it more meaningful to include the actual number of pieces of information that a user might have to enter. Numbers of inputs and input screens are systematically higher for the disk-based tools, which are due to their professional target audiences and correspondingly greater sophistication, especially concerning extensive materials and component libraries in which multiple characteristics of multiple items can be specified by the user.

Our entries for many of the features are simple “yes” or “no” answers, corresponding to their presence or absence in a given tool. However, a fair number of entries are tallies or other more specific information. Additionally, the matrix captures organizational and proprietary information about the tools and their developers. Caution must be exercised in interpreting “yes/no” entries in the matrix. For example, the ATCO tool has two implicit HVAC efficiency options as a function of vintage (e.g. 60% efficiency for “old”) whereas the Home Energy Saver

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<sup>3</sup> Due to cost or other constraints, test or demonstration versions were used in some cases.

<sup>4</sup> One tool, the “The EnergyCheckup HERS Server” from GeoPraxis was not made available to LBNL for review. Information shown in this report was provided by the developers.

Table 1. Complete list of web-based tools.

| Tool Name                                      | Developer   | Web Site  | Electric  |               |             |      | Other                        | Method(s): Bill Disaggregation Engineering Calc Simulation Watts x Hours Lookup  | Comments |
|--|---|---|-----------|---------------|-------------|------|------------------------------|--|----------|
|  |   |   | Consu-mer | Profes-sional | Whole House | Only |                              |  |          |
| Appliance Calculator                           | San Diego Gas & Electric Co                               | <a href="http://www2.sdge.com/energycalculator/sdga_energy_calculator.cfm">http://www2.sdge.com/energycalculator/sdga_energy_calculator.cfm</a>                                   | •         |               | •           |      | WxH                          | Ultra simplified   |          |
| Appliance Energy Estimator                     | Southern California Edison                                | <a href="https://www.sce.com/002_sava_energy/002b2_estimator.shtml">https://www.sce.com/002_sava_energy/002b2_estimator.shtml</a>   | •         |               | •           |      | WxH                          | Very similar to PG&E's Ecalc   |          |
| ATCO Energy Sense House                        | Atco Gas (Canada)   | <a href="http://www.atcogas.com/customer_services/Calculator/Design/works.htm">http://www.atcogas.com/customer_services/Calculator/Design/works.htm</a>                           | •         |               | •           |      | WxH                          | Included in "Whole-House" tool review  |          |
| BEACON   | Oarsman   | <a href="http://www.oarsman.com">www.oarsman.com</a>  | •         |               | •           |      |                              | Included in "Whole-House" tool review  |          |
| Chicopee Electric Light Department             | Chicopee Electric Light Department                        | <a href="http://www.ceid.com/PS/ECal/ECalculator.html">http://www.ceid.com/PS/ECal/ECalculator.html</a>   | •         |               | •           |      | WxH                          | Ultra simplified   |          |
| City of Oxford Electric Energy Calculator      |   | <a href="http://www.energyright.com/oxfordel/calculator/index.htm">http://www.energyright.com/oxfordel/calculator/index.htm</a>   | •         |               | •           |      | WxH                          | Ultra simplified   |          |
| Comfort Check                                  | Enercom & Nicor   | <a href="http://www.comfortcheck.com/">http://www.comfortcheck.com/</a>   | •         |               | •           |      |                              | Tool unstable and appears under construction. Developers did not respond to email queries. Dropped from whole-house list.  |          |
| Ecalc  | Pacific Gas & Electric Company                            | <a href="http://www.pge.com/ecalc/">http://www.pge.com/ecalc/</a>   | •         |               | •           |      | WxH                          | Included in "Whole-House" tool review  |          |
| ELPC Pollution Calculator                      | ELPC  | <a href="http://www.elpc.org/polCalc/">http://www.elpc.org/polCalc/</a>   | •         |               |             | •    |                              | Specialized Calculator: Energy-related pollution for specific utilities and home size  |          |
| Energy Calculator                              | Niagra Mohawk   | <a href="http://www.niagaramohawk.com/house/enrhome/calculator.asp">http://www.niagaramohawk.com/house/enrhome/calculator.asp</a>   | •         |               | •           |      |                              | Ultra simplified   |          |
| Energy Calculator                              | Electric Power Research Institute                         | <a href="http://www.energyint.com/ec/">http://www.energyint.com/ec/</a>   | •         |               | •           |      | WxH                          | Association with EPRI is unclear.  |          |
| EnergyCheckup.com                              | GeoPraxis   | <a href="http://www.energycheckup.com/content/homeowner.asp">http://www.energycheckup.com/content/homeowner.asp</a>   | •         |               | •           |      | L                            | Tool incomplete (under construction) and site intermittently available   |          |
| EnergyCheckup.com HERS version                 | GeoPraxis   | no URL provided by developer  | •         |               | •           |      | E, S, WxH, L                 | Developer did not provide URL for evaluation   |          |
| EnergyGuide                                    | Nexus   | <a href="http://www.energyguide.com">http://www.energyguide.com</a>   | •         |               | •           |      |                              | See Whole-house Tool Notes   |          |
| Environment - Energy Calculator                | BC Hydro  | <a href="http://www.bchydro.com/environment/whatyoucan/energy.html">http://www.bchydro.com/environment/whatyoucan/energy.html</a>   | •         |               |             | •    |                              | Very efficient and educational emissions calculator, allowing Canadians to compare their emissions (and electricity generating mix) to typical values in other provinces.  |          |
| EPEN Energy Conversions Calculator             | US Department of Energy                                   | <a href="http://analysis.eren.doe.gov/aec99/energyCalculator.html">http://analysis.eren.doe.gov/aec99/energyCalculator.html</a>   |           | •             |             | •    |                              | Convenient calculator for making unit conversions used in energy and policy analysis.  |          |
| Find Out About Your Electricity                | Environmental Defense                                     | <a href="http://www.environmentaldefense.org/programs/Energy/green_power/x_calculator.html">http://www.environmentaldefense.org/programs/Energy/green_power/x_calculator.html</a> | •         |               |             | •    |                              | Emissions calculator, map-driven   |          |
| Home Energy Advisor (EPA/LBNL)                 | USEPA/Lawrence Berkeley National Lab                      | <a href="http://HomeImprovementTool.lbl.gov">http://HomeImprovementTool.lbl.gov</a>   | •         |               | •           |      | B, E, S, WxH, L              | Included in "Whole-House" tool review  |          |
| Home Energy Analysis (SMUD)                    | Sacramento Municipal Utility District                     | <a href="http://www.smud.org/home/customer_services.html">http://www.smud.org/home/customer_services.html</a>   | •         |               | •           |      |                              | Based on Nexus Energyguide   |          |
| Home Energy Audit                              | Texas-New Mexico Power Company                            | <a href="http://www.tnpe.com/energy_homeaudit.asp">http://www.tnpe.com/energy_homeaudit.asp</a>   | •         |               |             | •    |                              | Content only. Recommendations tailored to the user based on checklist selections.  |          |
| Home Energy Calculator                         | Central Main Power Company                                | <a href="http://www.cmpco.com/EnergyCalculator/input.html">http://www.cmpco.com/EnergyCalculator/input.html</a>   | •         |               | •           |      | WxH                          | Particularly flexible inputs.  |          |
| Home Energy Checkup                            | Alliance to Save Energy                                   | <a href="http://www.ase.org/checkup/home/main.html">http://www.ase.org/checkup/home/main.html</a>   | •         |               | •           |      | L                            | Included in "Whole-House" tool review  |          |
| Home Energy Saver                              | USDOE/Lawrence Berkeley National Lab                      | <a href="http://HomeEnergySaver.lbl.gov">http://HomeEnergySaver.lbl.gov</a>   | •         | •             | •           |      | E, S, WxH, L                 | Included in "Whole-House" tool review  |          |
| Home Energy Survey                             | Electrotek Concepts                                       | <a href="http://ipirba.electrotek.com/webapp/REBA/HomeEnergySurvey">http://ipirba.electrotek.com/webapp/REBA/HomeEnergySurvey</a>   | •         |               | •           |      |                              | Included in "Whole-House" tool review  |          |
| Home Energy Survey                             | Pacific Gas & Electric Company                            | <a href="http://www.pge.com/003_sava_energy/003a_res/003a2b_home_survey.shtml">http://www.pge.com/003_sava_energy/003a_res/003a2b_home_survey.shtml</a>                           | •         |               | •           |      |                              | Included in "Whole-House" tool review  |          |
| Home View                                      | Volt VIEWtech   | <a href="http://voltviewtech.com/homeview.htm">http://voltviewtech.com/homeview.htm</a>   | •         |               | •           |      | Modified degraded method     | Included in "Whole-House" tool review  |          |
| Watts On Schools                               | American Electric Power                                   | <a href="http://www.wattsonschools.com/calculator.htm">http://www.wattsonschools.com/calculator.htm</a>   | •         |               |             | •    |                              | Energy conversion factors. Useful for educational purposes.  |          |
| KCPCL Electricity Calculator                   | Kansas City Power & Light                                 | <a href="http://www.kcpcl.com/calc/index.html">http://www.kcpcl.com/calc/index.html</a>   | •         |               | •           |      |                              | Included in "Whole-House" tool review  |          |
| KUA Electricity Calculator                     | Kissimmee Utility   | <a href="http://www.kua.com/support/utility/">http://www.kua.com/support/utility/</a>   | •         |               | •           |      |                              | Electric only; watts x hours calculations (210 questions)  |          |
| My Home  | Green Mountain Power                                      | <a href="http://www.gmpvt.com/energy101/myhome.shtml#">http://www.gmpvt.com/energy101/myhome.shtml#</a>   | •         |               | •           | •    |                              | Included in "Whole-House" tool review  |          |
| On-Line Energy Profile                         | San Diego Gas & Electric                                  | <a href="http://www2.sdge.com/SDGEBes/index.asp">http://www2.sdge.com/SDGEBes/index.asp</a>   | •         |               | •           |      |                              | Based on Enercom "Residential On-Line Energy Audit" (see below)  |          |
| On-Line Home Energy Audit                      | International Council for Local Environmental Initiatives | <a href="http://www.iclei.org/audit/index.htm">http://www.iclei.org/audit/index.htm</a>   | •         |               | •           |      |                              | Included in "Whole-House" tool review  |          |
| On-line Home Energy Survey                     | Southern California Edison                                | <a href="https://xensecure.xenergy.com/clients/sce/production/recap.nsf">https://xensecure.xenergy.com/clients/sce/production/recap.nsf</a>                                       | •         |               | •           | •    |                              | Included in "Whole-House" tool review  |          |
| ORNL Calculators                               | Oak Ridge National Laboratory                             | <a href="http://www.ornl.gov/roofs+walls/">http://www.ornl.gov/roofs+walls/</a>   | •         | •             |             | •    | E                            | Specialized calculators for system r-value calculation; r-value recommendation; moisture; radiant barrier selection. Would be good additions/links to whole-building tools for professionals                       |          |
| Personal Energy Profiler                       | United Illuminating                                       | <a href="http://darth.uinet.com/home.asp">http://darth.uinet.com/home.asp</a>   | •         |               | •           | •    |                              | EnergyDepot. Account number required   |          |
| PowerSmart Home; PowerSmart Business           | BC Hydro  | <a href="http://eww.bchydro.bc.ca/cgi-bin/cgi-bin/building.cgi">http://eww.bchydro.bc.ca/cgi-bin/cgi-bin/building.cgi</a>   | •         |               | •           | •    |                              | Provided by EnergyDepot  |          |
| PSNH Electricity Calculator                    | Public Service of New Hampshire                           | <a href="http://www.psnh.com/cshome/calculator.html">http://www.psnh.com/cshome/calculator.html</a>   | •         |               | •           |      | WxH                          | Ultra simplified Watts x hours calculator  |          |
| PVWatts  | National Renewable Energy Laboratory                      | <a href="http://rredc.nrel.gov/solar/codes_algs/PVWATTS/">http://rredc.nrel.gov/solar/codes_algs/PVWATTS/</a>   | •         |               |             | •    |                              | Solar electric calculator  |          |
| Radon Project                                  | Columbia University & Lawrence Berkeley National Lab      | <a href="http://www.stat.columbia.edu/radon/">http://www.stat.columbia.edu/radon/</a>   | •         |               |             | •    |                              | Interactive Radon Risk Test and other information  |          |
| Residential Calculator                         | Utilities   | <a href="http://buckeye.apogee.net/rescalc/">http://buckeye.apogee.net/rescalc/</a>   | •         |               | •           |      | WxH                          | Included in "Whole-House" tool review  |          |
| Residential Energy Bill Analyzer               | Florida Power Corporation                                 | <a href="http://www.fpc.com/cfusion/home/energy.cfm">http://www.fpc.com/cfusion/home/energy.cfm</a>   | •         |               | •           |      |                              | Included in "Whole-House" tool review  |          |
| Residential Energy Bill Analyzer               | Electrotek Concepts                                       | <a href="http://www.pqssoft.com/reba/example/index.htm">http://www.pqssoft.com/reba/example/index.htm</a>   | •         |               | •           |      |                              | Included in "Whole-House" tool review  |          |
| Residential On-Line Energy Audit               | Enercom   | <a href="http://www.energydepot.com/etour">http://www.energydepot.com/etour</a>   | •         |               | •           |      |                              | Included in "Whole-House" tool review  |          |
| Residential Ventilation Calculator             | Lawrence Berkeley National Laboratory                     | <a href="http://epb1.lbl.gov/ventilation/program.html">http://epb1.lbl.gov/ventilation/program.html</a>   |           | •             |             | •    |                              | Specialized Calculator: computes ventilation parameters, including effective leakage area, normalized leakage area, ACH, ASHRAE Leakage Class, and compliance with ASHRAE standards for ventilation and tightness. |          |
| RP&L Energy Calculator                         | Richmond Power & Light                                    | <a href="http://www.rp-l.com/calculator.htm">http://www.rp-l.com/calculator.htm</a>   | •         |               | •           |      | WxH                          | Simplified   |          |
| Solar Energy Calculator                        | Iowa Energy Center  | <a href="http://www.energy.iastate.edu/solarcalculator/index.htm">http://www.energy.iastate.edu/solarcalculator/index.htm</a>   | •         |               |             | •    |                              | Home solar electric and water-heating calculator   |          |
| Torchiere energy cost and payback              | Lawrence Berkeley National Laboratory                     | <a href="http://eaid.lbl.gov/BTP/LSR/projects/torchiere/torchmain.html">http://eaid.lbl.gov/BTP/LSR/projects/torchiere/torchmain.html</a>   | •         |               |             | •    | WxH                          | Halogen torchiere retrofits  |          |
| Twenty Percent Solution                        | Lawrence Berkeley National Laboratory                     | <a href="http://savepower.lbl.gov">http://savepower.lbl.gov</a>   | •         |               | •           |      | E, S, WxH, L                 | Focus on summertime peak power savings in Calif.   |          |
| Western Massachusetts Online Energy Calculator | Western Massachusetts Electric Co.                        | <a href="http://www.wmeco.com/online/calculator.asp">http://www.wmeco.com/online/calculator.asp</a>   | •         |               | •           |      | WxH                          | Highly simplified. No grand total.   |          |
| Your California Home                           | GeoPraxis   | <a href="http://www.idea-server.com/cahome/">http://www.idea-server.com/cahome/</a>   | •         |               | •           |      | Lookups based on simulations | Included in "Whole-House" tool review  |          |

*Table 2. Complete list of disk-based tools*

| Tool Name             | Developer                          | Web Site  | Consumer | Professional | Whole-House | Envelope/HVAC Only | Comments   |
|-----------------------|------------------------------------|---|----------|--------------|-------------|--------------------|--|
| AkWarm                | Alaska Housing Finance Corporation | <a href="http://www.absn.com/index.cfm?fuseaction=akwarm">http://www.absn.com/index.cfm?fuseaction=akwarm</a>                       |          | •            | •           |                    | Heating simulation tool for Alaskan locations only; treats a few other appliances. |
| BTU Analysis REG      | Enchanted Tree Software            |   |          | •            |             | •                  | calculator.  |
| Energy-10             | NREL, LBNL                         | <a href="http://www.sbicouncil.org/enTen/index.html">http://www.sbicouncil.org/enTen/index.html</a>                                 |          | •            |             | •                  | Simplified, commercial-building-oriented heating and cooling simulation tool.      |
| ENERPASS              | Emermodal Engineering              |   |          | •            |             | •                  | DOS-based commercial-building-oriented heating and cooling simulation tool.        |
| EZDOE*                | Elite Software                     | <a href="http://www.elitesoft.com/web/hvacr/elite_ezdoe_info.html">http://www.elitesoft.com/web/hvacr/elite_ezdoe_info.html</a>     |          | •            |             | •                  | building-oriented heating and cooling simulation tool.                             |
| E-Z Heatloss*         | Thomas & Associates                | <a href="http://www.thomasandassoc.com/heatloss.htm">http://www.thomasandassoc.com/heatloss.htm</a>                                 |          | •            |             | •                  | Design heating and cooling load calculator.  |
| HOT2000               | Natural Resources Canada           | <a href="http://www.buildingsgroup.nrcan.gc.ca/hot2k_supmain_e.html">http://www.buildingsgroup.nrcan.gc.ca/hot2k_supmain_e.html</a> |          | •            | •           |                    | Heating and cooling calculation tool; treats a few other appliances.               |
| J-Works               | MicroWorks, Inc.                   | <a href="http://www.microworksinc.com/jwkinfo.html">http://www.microworksinc.com/jwkinfo.html</a>                                   |          | •            |             | •                  | Design heating and cooling load calculator.  |
| MECcheck              | U.S. Department of Energy          | <a href="http://www.energycodes.gov/meccheck/">http://www.energycodes.gov/meccheck/</a>   |          | •            |             | •                  | Energy code compliance tool.   |
| Micropas*             | Enercomp, Inc.                     | <a href="http://www.micropas.com/">http://www.micropas.com/</a>   |          | •            |             | •                  | simulation and energy code compliance tool for Californian locations only.         |
| NEAT                  | Oak Ridge National Laboratory      |   |          | •            |             |                    | Heating and cooling simulation and retrofit tool; treats a few other appliances.   |
| REM/Rate (Simplified) | Architectural Energy Corporation   |   |          | •            | •           |                    | Simplified heating and cooling simulation and home energy rating tool.             |
| REM/Rate (Detailed)   | Architectural Energy Corporation   |   |          | •            |             |                    | home energy rating tool; treats many other appliances.                             |
| ResRatePro            | Florida Solar Energy Center        | <a href="http://www.fsec.ucf.edu/ratings/software/professional.htm">http://www.fsec.ucf.edu/ratings/software/professional.htm</a>   |          | •            |             |                    | and home energy rating tool; treats a few other appliances.                        |
| TREAT**               | Taitem Engineering                 | <a href="http://www.buildingperformance.net/index-nn.asp">http://www.buildingperformance.net/index-nn.asp</a>                       |          | •            |             |                    | Heating and cooling simulation tool; treats many other appliances.                 |
| VisualDOE*            | Eley Associates                    | <a href="http://www.eley.com/gdt/visualdoe/index.htm">http://www.eley.com/gdt/visualdoe/index.htm</a>                               |          | •            |             | •                  | DOE-2-based, commercial-building-oriented heating and cooling simulation tool.     |

Table 3. Meta-evaluation: Web-based tools

|  | ATCO Energy Sense House      | BEACON (Oarsman)     | Ecalc. (PG&E)       | Energy Calculator (Niagara Mohawk) | Energy Calculator (EPRI) | Energy Checkup.co (GeoPraxis)         | Energy Checkup "HERS Server" (GeoPraxis) | EnergyGuide [Fast Track] (Nexus) | EnergyGuide [Detailed] (Nexus) | EnergyGuide [Full] (Nexus) | Home Energy Advisor (EPA/LBNL) | Home Energy Checklist (ASE) |
|--|------------------------------|----------------------|---------------------|------------------------------------|--------------------------|---------------------------------------|--|----------------------------------|--------------------------------|----------------------------|--------------------------------|-----------------------------|
| • Ease of use/speed of calculations  | Somewhat Difficult/Very Fast | Reasonable/Very Slow | Efficient/Very Fast | Efficient/Very Fast                | Cumbersome/Very Fast     | Not functioning at time of evaluation | Not made available for evaluation        | Reasonable/Slow                  | Somewhat Difficult/Slow        | Cumbersome/Very Slow       | Efficient/Fast                 | Efficient/Very Fast         |
| • Overall suitability for building envelope/HVAC analysis                      | Very Low                     | Low                  | Very Low            | Very Low                           | Very Low                 | Not functioning at time of evaluation | Not made available for evaluation        | Very Low                         | Very Low                       | Low                        | Moderate                       | Low                         |
| • Overall suitability for appliance analysis                                   | Moderate                     | High                 | High                | Low                                | Moderate                 | Not functioning at time of evaluation | Not made available for evaluation        | Very Low                         | Moderate                       | High                       | Moderate                       | Low                         |
| • Overall suitability for occupant effect analysis                             | Moderate                     | Low                  | Low                 | Very low                           | Moderate                 | Not functioning at time of evaluation | Not made available for evaluation        | Very low                         | Very low                       | Good                       | Moderate                       | None                        |
| • Overall helpfulness of outputs and other information in supporting decisions | Low                          | None                 | Low                 | Very Low                           | None                     | Not functioning at time of evaluation | Not made available for evaluation        | Moderate                         | Moderate                       | Moderate                   | Moderate                       | Moderate                    |

|  | Home Energy Saver [Simple] - (LBNL/DOE) | Home Energy Saver [Middle] - (LBNL/DOE) | Home Energy Saver [Full] (LBNL/DOE) | Home Energy Survey (PG&E) | HomeVIEW (VoitVIEW) | KCPL Electricity Calculator (KCPL) | My Home (GMP/Red-Wire) | On-Line Home Energy Audit (ICLEI) | On-Line Home Energy Survey (SCE) | Residential Calculator (Buckeye) | Residential Energy Bill Analyzer (Electrotek) | Residential On Line Energy Audit (Enercom) | Your California Home [Quick Survey] (GeoPraxis) | Your California Home [Expert] (GeoPraxis) |
|--|---|---|-------------------------------------|---------------------------|---------------------|------------------------------------|------------------------|-----------------------------------|----------------------------------|----------------------------------|---|--|---|---|
| • Ease of use/speed of calculations  | Efficient/Very Fast                     | Efficient/Fast                          | Reasonable/Fast                     | Cumbersome/Fast           | Efficient/Slow      | Somewhat Difficult/Very Fast       | Cumbersome/Very Fast   | Efficient/Very Fast               | Reasonable/Very Slow             | Efficient/Fast                   | Reasonable/Fast                               | Reasonable/Acceptable                      | Somewhat Difficult/Slow                         | Reasonable/Very Slow                      |
| • Overall suitability for building envelope/HVAC analysis                      | Very Low                                | Moderate                                | High                                | Low                       | High                | Very Low                           | Very Low               | Moderate                          | Low                              | Very Low                         | Low   | High                                       | Very Low  | Moderate                                  |
| • Overall suitability for appliance analysis                                   | Low                                     | Low                                     | High                                | High                      | High                | Moderate                           | Moderate               | Very Low                          | High                             | Low                              | High  | High                                       | None  | Moderate                                  |
| • Overall suitability for occupant effect analysis                             | Low                                     | Low                                     | High                                | Moderate                  | Moderate            | Moderate                           | Moderate               | Low                               | High                             | Low                              | High  | Moderate                                   | None  | High                                      |
| • Overall helpfulness of outputs and other information in supporting decisions | Moderate                                | Moderate                                | Moderate                            | Moderate                  | Low                 | Low                                | None                   | Low                               | Low                              | Low                              | Low   | Moderate                                   | Low   | Low                                       |

**Table 4. Meta-evaluation: Disk-based tools.**

|  | <b>AkWarm</b>            | <b>BTU Analysis REG</b>  | <b>Energy-10</b>          | <b>ENERPASS</b>         | <b>EZDOE</b> | <b>E-Z Heatloss</b>      | <b>HOT2000</b>      | <b>J-Works</b>                      |
|--|--------------------------|--------------------------|---------------------------|-------------------------|--------------|--------------------------|---------------------|-------------------------------------|
| • Ease of use/speed of calculations  | Reasonable/<br>Very Fast | Reasonable/<br>Very Fast | Reasonable/<br>Acceptable | Cumbersome/Very<br>Slow | Cumbersome/? | Reasonable/<br>Very Fast | Cumbersome/<br>Fast | Somewhat<br>Difficult/<br>Very Fast |
| • Overall suitability for building envelope/HVAC analysis                      | Moderate                 | Moderate                 | Moderate                  | Moderate                | Moderate     | Moderate                 | Moderate            | Moderate                            |
| • Overall suitability for appliance analysis                                   | Low                      | Very Low                 | Very Low                  | Very Low                | Very Low     | Very Low                 | Moderate            | None                                |
| • Overall suitability for occupant effect analysis                             | Very Low                 | Very Low                 | Moderate                  | High                    | Moderate     | Low                      | Moderate            | Very Low                            |
| • Overall helpfulness of outputs and other information in supporting decisions | Moderate                 | Moderate                 | Moderate                  | Moderate                | Moderate     | Low                      | Moderate            | Moderate                            |

|  | <b>MECcheck</b>          | <b>Micropas</b>           | <b>NEAT</b>                    | <b>REM/Rate (Simplified)</b> | <b>REM/Rate (Detailed)</b> | <b>ResRatePro</b>  | <b>TREAT</b>             | <b>VisualDOE</b>    |
|--|--------------------------|---------------------------|--------------------------------|------------------------------|----------------------------|--------------------|--------------------------|---------------------|
| • Ease of use/speed of calculations  | Reasonable/<br>Very Fast | Reasonable/<br>Acceptable | Somewhat<br>Difficult/<br>Fast | Reasonable/Fast              | Reasonable/Fast            | Reasonable/<br>low | Cumbersome/<br>Very Slow | Cumbersome/<br>Slow |
| • Overall suitability for building envelope/HVAC analysis                      | Moderate                 | Moderate                  | Moderate                       | Moderate                     | High                       | High               | High                     | Moderate            |
| • Overall suitability for appliance analysis                                   | None                     | None                      | Moderate                       | Very Low                     | High                       | Moderate           | High                     | Low                 |
| • Overall suitability for occupant effect analysis                             | None                     | Very Low                  | Moderate                       | Low                          | Moderate                   | Moderate           | High                     | Moderate            |
| • Overall helpfulness of outputs and other information in supporting decisions | Moderate                 | Low                       | Moderate                       | Moderate                     | Moderate                   | High               | Low                      | Moderate            |

has a large number unique efficiency levels as a function of exact age of system. Both, however, receive a “yes” answer in the matrix.

A draft master matrix (per Appendices 1 and 2) was sent to each tool developer for review and provision of missing information. Developers were allowed 3 weeks to respond. Additional email correspondence took place on a case-by-case basis, and developers were generally cooperative. Of the twenty one web-based tools, responses were received for nine. Twelve of the fifteen disk-based tool developers responded.

The numbers of technical (including house and household description) and decision-support (including calculational methodology, output, and user-support) features were tallied for each tool to glean overall ideas about comprehensiveness and ease of use.<sup>5</sup>

We have made no effort to “weight” the various answers. Clearly some features are more important than others in affecting energy use (e.g., floor area is more important than whether a foundation is insulated), as well as in a relative sense depending on the intended use.

In cases where a tool offered two or more significantly different levels of input detail, the modes were catalogued and tested separately.

Toward the goal of understanding and comparing the tools’ predictive power, we chose real homes for which we had actual consumption data and a detailed description of characteristics and occupant behavior. The web-based tools were evaluated against a test house in San Francisco, CA, and the disk-based tools were evaluated against a test house in Toledo, Ohio. We compared the tool results to the test houses and to each other. The choice of two test houses allowed us to explore different climates, and the California home had an extensive (8-year) billing history while the Ohio home had detailed end-use energy estimates against which to compare the tools.

While this is not a comprehensive accuracy evaluation; the results are useful in demonstrating the variations among tools and the need for more exhaustive validation efforts. Lacking was sub-metered end-use data to compare against the end-use predictions from the various tools.

Lastly, it is important to keep in mind that the tools evaluated, especially those that are web-based, are under continuous development. Only those features available to users at the time of the evaluation (Spring 2002) were recorded. Exact version numbers are included in the matrices, where available. Additionally, for those web-based tools with implementations at multiple utility web sites, features may vary from one site to another.

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<sup>5</sup> Web-based evaluations of speed and performance were conducted on DSL or faster connections. The disk-based tools were evaluated using a PC equipped under Windows with an x86Family 6 Model 8 Stepping 10 Intel ~356 processor.

## 5 FINDINGS

### 5.1 Existing Tools Exhibit Considerable Range & Creativity

Our review shows that there are many approaches to the design of residential energy tools and levels of detail that can be offered to users. More detail (questions asked) does not, however, automatically translate into a “better”, more thorough, or more accurate tool. As suggested by a comparison of Figures 1 and 2, some tools require a relatively small number of well-considered inputs while others ask a proliferation of questions and still miss key issues. For example, the Kansas City Power and Light’s web-based tool asks 198 questions, but only encompasses 30 of the 124 potential features itemized in Appendix 1.<sup>6</sup>

The value of detail has a lot to do with the type of question(s) being asked by the user (e.g., the availability of dozens of miscellaneous appliances is immaterial for a user attempting to evaluate their potential for space-heating savings by installing a new furnace). Some tools were severely limited to a single fuel and/or climate, while others were quite flexible in this regard.

Some technical differences in tools are not readily discernible from our summary matrices. For example, among those tools in which insulation is indicated as a variable, some denote this as either a “yes” (presence) or “no” (absence) question, while others allow users to specify exact R-values. Similarly, some tools may have “yes/no” formats for programmable thermostats, while others provide a detailed programming interface with user-defined hourly and daily set-points. Many tools use “pull-down” menus from which a user selects a range instead of a discrete answer, e.g., house size 1000-1499 square feet. Such formulations obviously invite inaccuracies for users for whom the actual value is not in the middle of the range.<sup>7</sup>

Similarly, the tools varied in their usability (e.g. approachability, navigability, wait time, etc.). Some had very elegant and easy-to-navigate interfaces while others were cumbersome (e.g., many screens, poor text legibility). Some were able to collect large amounts of information via a simple interface, while others had elaborate interfaces that did a poor job of collecting information.

Three of the disk-based tools provide design heating and cooling load calculations only; as many as eight others provide this type of calculation as part of their repertoire. Six of the disk-based tools calculate consumption for a few to many non-space-conditioning household appliances; thus, they can be termed “whole-house” tools. Several of the tools provide the user the opportunity to compare a base-case house with one outfitted with one or more energy efficiency measures.

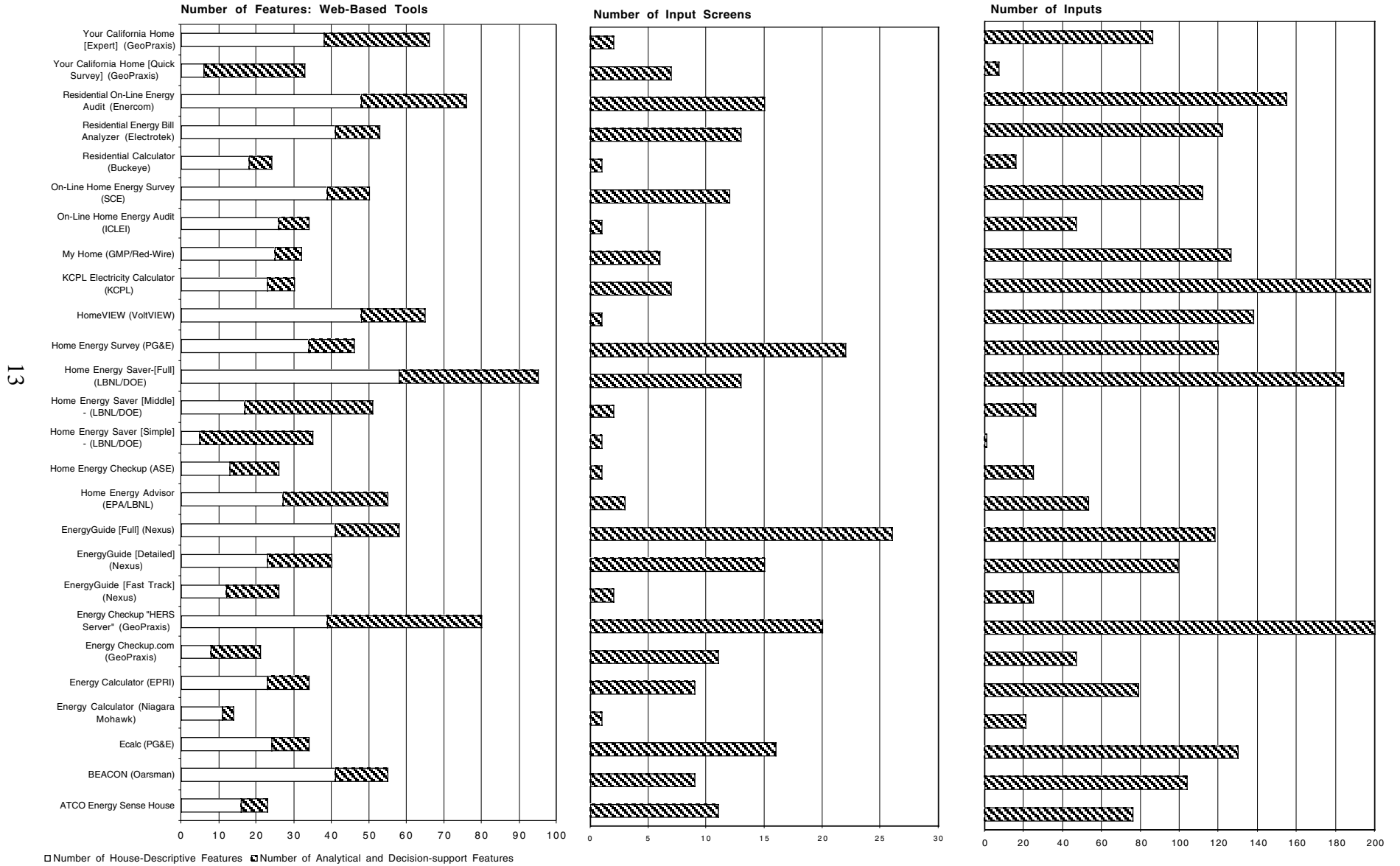
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<sup>6</sup> The EPRI tool is another example that appears to be very extensive (9 input screens and 79 questions), yet is in fact very inflexible and full of embedded assumptions. For example, the efficiencies of heating systems and many other appliances are fixed, and by having the user enter “number of hours per year use of heating system” the building size, geometry, and envelope characteristics are entirely bypassed.

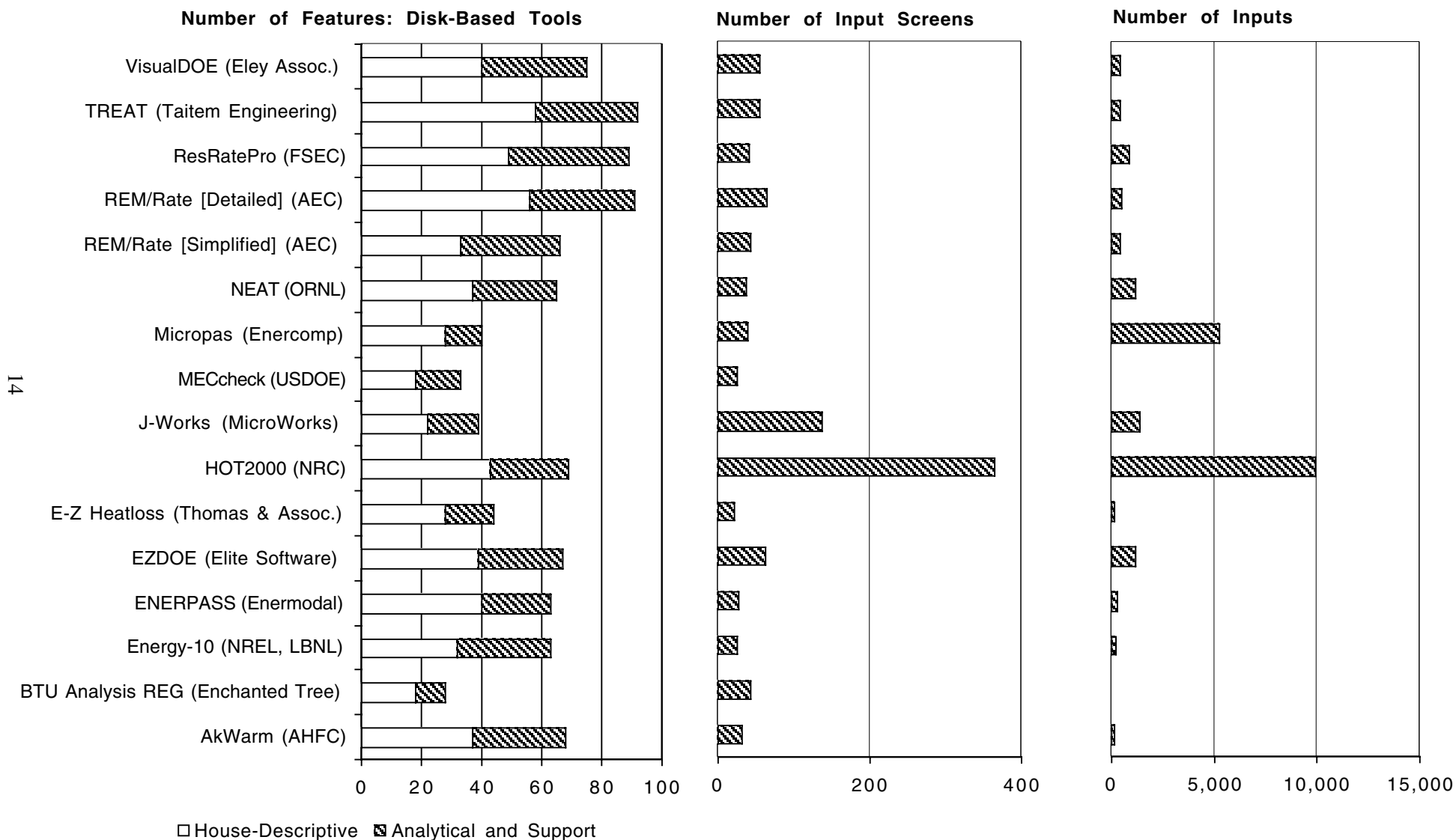
<sup>7</sup> Moreover, it is probably not apparent to the lay user that the middle of the range is used in the calculation.



Figure 1a-c. Features, input screens, and inputs vary widely: Web-based tools.



*Figure 2a-c. Features, input screens, and inputs vary widely: Disk-based tools.*



Considerable creativity is demonstrated in the design of many existing tools. Even tools that are not particularly comprehensive have things to offer. For example:

- One of the most simple in design is also one of the more intriguing—The “Ecalc” tool from Pacific Gas & Electric Company. An austere single screen contains 130 user inputs, including 41 miscellaneous uses (more than most tools). Nearly every end use offers usage-driven variables (occupant effects) and the assumptions are completely explicit. User feedback is instantaneous. Yet this tool also has significant deficiencies, including no building size/climate/envelope variables, no energy savings analysis or decision-support information. This tool also exemplifies the potential for inadvertent user error, e.g. arising from ambiguity about whether specified hours of use apply to a season or to an entire year. If the latter, then the user is implicitly required to perform a very technically challenging “weighting” process in order to determine their input values.
- Electrotek’s Residential Energy Bill Analyzer is an example of a single-fuel tool (reflecting the single-fuel focus of its purveyor).<sup>8</sup> It has a simple interface (18 questions) and gives quick and clear results, but with many limitations.
- Kansas City Power and Light’s calculator is one of the only tools that allows users to vary the electrical demand (watts) and utilization of every single end use, and to create new end uses by specifying wattage and utilization; and it provides instantaneous feedback (calculation) of electricity costs for each end use. It uses a refreshingly different approach to organizing the questions by offering categories such as “entertainment” and “comfort”, rather than the traditional (and rather dry) “HVAC”, “Appliances”, etc, and has more miscellaneous end uses (62) than any other tool in our evaluation. However, the tool only handles electricity, is only applicable to two states, and does not allow for electricity prices to be varied. Its calculations are limited to a simplified “watts x hours” method, and the tool is very cumbersome to navigate. This tool is a prime example of the non-correlation between detail and tool quality. With nearly 200 questions in all, a comparison of Figures 1 and 2 shows that it misses an extraordinary amount of important information.
- The Residential Calculator tool handles all fuels and gives results by fuel and end use, cost, and energy. With only 16 questions, completing the building description is quick. Predictive power is highly dubious, as suggested by a 100% over-prediction of our test home.

Only one web-based tool is suitable for professional audiences, as opposed to all of the disk-based tools. This is a somewhat subjective determination. We based our judgment on a tool’s technical depth and flexibility, e.g., in modeling specific equipment efficiencies, complex building geometries, a wide range of climates, and providing sufficiently detailed outputs for a professional user’s needs.

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<sup>8</sup> We were directed to a prototype interface developed for Florida Power for our evaluation.

## 5.2 Specialized Tools Can Augment Whole-House Tools in Useful Ways

We identified a number of specialized residential energy tools (these are included in Tables 1 and 2), which offer useful techniques and services that complement what was found in the more comprehensive whole-house tools. These include:

- EREN’s Energy Conversions Calculator is a clever and convenient calculator to convert among energy units and to do “what-ifs” with nationwide statistics.
- MECheck is used for building energy code compliance.
- Several disk-based tools (BTU Analysis REG, E-Z Heatloss, and J-Works) are intended for heating and cooling load calculations only.
- ORNL offers calculators for determining the R-value of an assembly of envelope materials, recommending insulation levels by region, and investigating moisture-control in low-sloped roofing.
- LBNL’s Residential Ventilation Calculator, computes ventilation parameters, including effective leakage area, normalized leakage area, air-change rate, ASHRAE Leakage Class, and compliance with ASHRAE standards for ventilation and tightness.
- LBNL’s Torchiere Lighting Calculator is an example of focusing on a specific end use to minimize demands on the consumer’s time and produce answers quickly. EDF has a similar map-driven calculator for the US.
- Environmental Law and Policy Center’s Pollution Calculator has very simplified inputs, but well-designed outputs and visualization (plus links) oriented to the consumer. Another clever pollution calculator is offered by BC Hydro, and allows users to benchmark their pollution to that from homes in other provinces. See also the Environment-Energy Calculator (BC Hydro).
- Some tools, such as the Home Energy Audit from Texas-New Mexico Power Co., deliver qualitative information (recommendations) based on user-supplied answers to checklist questions.
- We identified only one calculator that focuses on “peak” electricity savings. The 20% Solution web site provides quick estimates of summertime electricity savings across five California climate zones and for five building types.

While the diversity of specialized tools offer valuable features to users, it is disadvantageous that they are not interoperable, e.g. similar information must be re-entered for each tool and the results are not coordinated or integrated.

### 5.3 Users Face Bewildering Choices and Often-Confusing Questions

There are today hundreds of web- and disk-based energy tools. Approximately 220 were listed in DOE's Building Energy Tools Directory as of Spring 2002. The "Whole-Buildings" subset breaks down as follows: Simulation: 74, Load Calculation: 59, Retrofit: 31. These subsets are not mutually exclusive.

The first web-based energy calculator was the Home Energy Saver, developed in the mid-1990s. There ensued a rapid proliferation of web-based energy calculators. There has since been considerable consolidation; many web-based tools have vanished from the Internet. The (often unanticipated) cost of building and maintaining these sites is no doubt a factor in this trend (Primen 2002).

A potential source of confusion for users, many tools use similar or identical nomenclature especially "Energy Advisor" or "Home Energy Advisor" for the calculator and "Energy Library" or "Energy Librarian" for links. Even the names or acronyms of the tools are identical in some cases.

There are essentially three classes of whole-house residential energy tools:

1. Those developed and hosted by government or non-profit entities for the public interest purposes (energy and environment education, etc.) Examples include: Home Energy Advisor (LBNL/EPA); Home Energy Checkup (ASE); Home Energy Saver (LBNL); and On-Line Home Energy Audit (ICLEI).
2. Those developed by individual utilities, typically focused on a single fuel for local customers and designed to be ultra-simplified (single-screen of inputs). Examples include: Chicopee Electric Light (Mass); City of Oxford (Mississippi)<sup>9</sup>; and Public Service of New Hampshire.
3. Those developed by private vendors and deployed to utilities or individuals under licensing agreements, or some other business arrangement. Web-based examples include: EnergyDepot (Enercom); EnergyGuide (Nexus); Home View (Volt VIEWtech); and Oarsman. Most disk-based tools fall under this category.

In the course of this study, we identified 50 web-based residential calculators, 21 of which can be considered "whole-house" tools.<sup>10</sup> Of the whole-house tools, 13 provide open-ended energy calculations, 5 normalize the results to actual costs (a.k.a "bill disaggregation tools"), and 3 provide both options. Across the whole-house web tools, we found a range of 5 to 58 house-

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<sup>9</sup> In this case, the utility using the calculator to persuade consumers that it costs little to *add* end uses and use more electricity. There are other cases where gas utilities use their calculators encourage fuel-switching by oil customers.

<sup>10</sup> One web-based tool, EnergyCheckup.com, was not fully functional and the developers did not respond to our queries.

descriptive features (68 possible) and 2 to 41 analytical and decision-support features (55 possible). See Appendices 1 and 2 for details.

We also evaluated 15 disk-based residential calculators.<sup>11</sup> These tools offers ranges of 18 to 58 technical features (70 possible) and 10 to 40 user- and decision-support features (56 possible). Of these tools, 11 provide open-ended energy calculations, 1 normalizes the results to actual costs (a.k.a “bill disaggregation tools”), and 3 provide both options.

The disk-based tools contain 21 to 364 input screens and 45 to 9,870 inputs, far more than the corresponding numbers for web-based tools.<sup>12</sup> Despite the large numbers of potential inputs, limitations in the designs of some of the disk-based tools limit users' abilities to model their homes with the desired level of detail. The limiting of house geometries to a six-surface box shape is an example of this shortcoming.

The tools exhibit a large range in analytical scope. It was surprising how few enable the evaluation of certain key energy issues and opportunities, e.g. ducts, advanced windows, cool roofs, programmable thermostats, or peak demand, and how few address indoor air quality considerations and other non-energy benefits of energy efficiency. Most tools, however, give considerable (and appropriate) attention to miscellaneous energy end uses. Various important building science issues and energy efficiency features cannot be sufficiently well evaluated using any of the existing tools (e.g., peak power, IR reflective roofing, high-R perimeter attic insulation, thermal comfort, advanced crawlspace/foundations, advanced thermal distribution modeling, early appliance retirement). Few tools offer substantial content (either local or via links to useful web sites).

Many tools provide estimates of existing energy costs but no recommendations or estimates of potential savings, and fewer still address cost-effectiveness or emissions analysis (even superficially). Where available, most savings recommendations are spotty, with a large focus on low/no cost measures (often focusing on appliance usage) and less on investments in better equipment or envelopes. Most recommendations are illustrative rather than comprehensive, e.g. SCE’s On-Line Home Energy Survey only suggest caulking & weatherstripping, CFLs, and occupancy sensors for outdoor lighting for our test house.

The formulation of questions is a central issue—as will be discussed below in the section treating the question of accuracy—and is often done in a way that is likely to be confusing for lay users. In one of many examples, one tool asks for hours per day refrigerator usage (default is 24), while another asks the same question and defaults at 5 hours, and yet another asks for hours/month and the default value offered is 335 ( $24 \times 30 = 720$ ). Similar problems with hours-of-use questions are exhibited for other end uses in many tools. In the EPRI tool, users are

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<sup>11</sup> Although only six of the fifteen met our definition of “whole-house” tools, we included all the tools in the detailed analysis.

<sup>12</sup> Note that the numbers of inputs could not be tallied on a rigorously consistent basis because some of the tools incorporate libraries of construction materials, windows, HVAC systems, utility rates, etc., that can be augmented and are almost infinitely variable.

asked to enter the number of hours their heating system operates in each year. Even an energy expert would not likely be able to make an accurate guess at this value. In yet another example, one tool asks for total lighting hours aggregated by bulb type. This is unreasonably challenging question for the typical consumer and invites poor estimates and thus poor results.

A valuable feature of some web-based tools (and all disk-based tools) is the ability for users to return to a previous session. In some cases (e.g. Residential On-Line Energy Audit; EnergyGuide), however, it is difficult or impossible to start with a “blank” building description because the tool recognizes the returning user.

As will be discussed below, energy use estimates generated by these tools can vary by several-fold. This is of considerable concern given that lay and even professional users have limited ability to judge the merits of a given tool.

#### **5.4 Web- and Disk-based Tools Differ Considerably**

Several of the disk-based tools (and none of the web-based tools) are intended primarily for non-residential applications. All of the disk-based tools are suitable for professional users, compared to only one of the web-based tools.

The level of detail varies accordingly, with up to 200 possible input questions among the web-based tools versus a maximum approaching 10,000 for the disk-based tools.

The disk-based tools offer correspondingly greater choice and control over building characteristics, system sizing, weather location, outputs, etc. However, the disk-based tools generally offer a narrower end-use coverage and thus there are fewer (in comparison to the web-based tools) that qualified for the “whole-house” designation used in this study. None of the disk-based tools offer recommendations on no-cost energy-saving measures, while most of the web-based tools do so. Few of the disk-based tools offer a cost-effectiveness protocol for evaluating energy retrofit measures, whereas most of the web-based tools do.

Perhaps counter-intuitively, the web-based tools are more sophisticated in some areas. For example, they more frequently provide vintage-dependent defaults for appliance and equipment efficiencies.

The distribution of disk-based tools is naturally narrower than that of web-based tools. With one exception, the disk-based tools had between 50 and 2300 copies in circulation. (MECheck had 25,000 copies in circulation.) The web-based tools are more accessible to anyone using the Internet, and, among those we evaluated, receive up to 250,000 visitors per year. None of the disk-based tools work on a Macintosh platform; all of the web-based tools are by definition platform-independent.

The web-based tools are (by definition) free to users, whereas, with a few exceptions, a fee is required to acquire the disk-based ones. In some cases, however, web-based tools are limited to customers of specific utilities.

Only one of the tools contain features for quantifying indoor air quality.

With one exception, all disk-based tools we examined provide documentation making their embedded assumptions and methods transparent, whereas only one web-based tool does so.

## 5.5 Evaluating Accuracy is an Elusive Goal

The question of tool “accuracy” is a complex and multi-faceted one. The ability to evaluate accuracy is inherently limited by the availability of measured data, and manipulations of that data (e.g., weather normalization) to facilitate meaningful comparisons to tool outputs. Certain tool outputs can only be measured against “actual” values that are themselves calculated (e.g., HVAC sizing), while others are rarely if ever available (e.g., measured energy use or savings for specific measures). Similarly challenging is to understand the sources of inaccuracies. As described below, there are many ways in which quantitative errors can occur in tools, ranging from programming errors to problems inherent in a tool’s design.

### 5.5.1 Types of Accuracy Problems

Conducting analytical inter-comparisons of residential energy tools raises a number of complicated issues, and the question of “accuracy” has multiple definitions. Inter-comparison of tool results is more approachable. Almost every tool we examined contained a prominent disclaimer regarding the accuracy of the results. Spot checks of many tools revealed questions about algorithm accuracy, errors in programming, house characterizations that invite user errors, and other analytical problems.

There are several potential sources of inaccuracy in the results produced by a given tool. The specific illustrations provided below are based on spot checks rather than exhaustive trials of each tool.

- **Accuracy or Incompleteness of Algorithms** – A given tool’s underlying engineering calculations or simulation techniques may contain inaccuracies. Pinpointing the source of such a problem can be virtually impossible for outside reviewers who do not have access to technical documentation and underlying source code and assumptions. Only two of the tools we evaluated offered documentation of the technical assumptions, and each was incomplete.
- **Accuracy of Savings Calculations** – Even if baseline calculations were accurate, savings calculations may not be. Finding measured data with which to validate savings calculations is far more problematic than finding measured data to validate baseline bills. Ideally, data are needed for savings estimates in each end use. Some of the savings estimates we encountered when running our test homes were implausible. One tool estimated the annual savings for a



water heater blanket at questionably low values of \$2/year, and at \$4/year for reducing the water heater temperature. Another tool reported only \$2/year annual savings for duct insulation. When testing another tool, going from zero ceiling insulation to “R20-30” resulted in \$12/year HVAC savings, and going from “never” changing the air-conditioner filter to changing “every 3 months” resulted in no change in HVAC costs. When specifying a 10 to 15 year-old standard non-ENERGY STAR model washer in one tool, it predicted only \$2/year savings for upgrading (same answer for hot or cold wash temperature and independent of the number of loads washed). Another tool classified all clothes washers as “energy efficient”, irrespective of the age (up to 27 years) input by the user.

- **Errors in Programming** – As one indication of such problems, in several instances changes to inputs did not result in changes in predicted energy use. When examining one tool, we noted that energy bills decreased when the water-heater thermostat was *increased* from the 130 to 140 degree range to the 140 to 150 degree range, and were virtually the same from the “Low: below 120 degrees” setting to the “Very high: over 150 degrees” setting. Similarly, energy use increased with decreasing shower length. Computer energy use increased only \$2/year when utilization inputs for use were changed from “a little” to “a lot”.

We noticed several web-based tools in which the results did not always equal the sum of the individual end uses. In another example, the tool did not show any differences in energy bills as a function of house size (we tested a range of 1000 to 1500 square feet to 2000 to 2500 square feet). Another tool failed to capture the impact of roof insulation when both roof and attic insulation are specified for an unconditioned attic, and greenhouse-gas emissions calculated by that tool do not always increase when energy use increases.

Bill disaggregation tools provide special challenges. One tool reported increased heating use (\$1119 vs \$992) when a smaller home size (1000 to 1499 sq ft versus 2000-2499 sq. ft) was specified. Also counterintuitive, lighting energy use was identical in the two homes. The same problems were observed in another tool, where in fact lighting energy use increased with decreasing house size. This bill-disaggregation tool also computed the same baseline air conditioning use for SEERs 6 to 16, perhaps an artifact of inflexible values for other end uses and an actual energy bill that must be matched.

- **Completeness or Representiveness of User-Specifiable Options** – If a tool excludes miscellaneous uses, for example, results can easily be 20 to 30% lower than utility bills for this reason alone. Half of the tools we tested reported miscellaneous energy at less than 10% of total bills – a highly unlikely scenario – and in one case completely excluded it. Other examples include lack of provision for more than one refrigerator, values specified as a range (e.g., floor area), or that otherwise don’t fit reality (e.g., different walls have different R-values). One tool relies solely on defaulted building descriptions keyed to the user-entered zip code, and thus the resulting defaults will inevitably fail to fully represent the actual home in question (e.g., attribution of cooling energy use where none may exist in fact). Another tool does not allow fractional hours of use for many miscellaneous appliances (e.g., toasters,

microwaves) – this can lead to over-prediction of energy costs. Another does not allow furnace efficiencies below 78%.

Many of the disk-based tools we identified are limited in scope, typically to only HVAC end uses, load (and not energy) calculations, etc. (Table 2).

Particular issues arise when users attempt to model non-typical homes or usage patterns. Cases involving particularly low- or high-energy-use homes are most likely to exhibit under/overestimation of results (except, of course, when using bill-disaggregation tools). For example, extreme high or low thermostat settings will lead to actual bills that differ from those predicted by tools that don't allow for explicit entry of thermostat settings. Problems can also arise, for example, in tools that specify ranges for inputs, such as a vintage range of "before or later than 1993" for appliance efficiency, implying only two possible "average" efficiency options based on the user answer, where in fact the user could have an ancient appliance or a brand-new premium-efficiency model.

- **User Misunderstandings** – The interface design and questions formulated by some of the tools could lead to input errors or poor house descriptions that significantly affect the results. These potential problems fall into two categories. "Hidden" options—those discretely placed in rather long pull-down menus or activated by the selection of related "lead-in" options—can easily go unnoticed. "Surrogate" inputs can also trigger unnoticed and undesired calculational paths. In one tool, a request for the number of bedrooms, rather than the number of occupants, in a house is an example of such a surrogate input.

Wordings of input questions can confuse or mislead users, resulting in inappropriate building description information and thus inaccurate results. For example, many tools ask for "hours of operation" for various appliances and it is often unclear whether to provide annual or seasonal averages (in the case of space conditioning questions) or 24 hours/day in the case of refrigerators. Several tools ask for annual hours of operation for furnaces; another asks for hours of operation of almost every end use including water heaters, furnace fans, and freezers. As another example, prediction of energy costs (bills) requires that the user make an accurate estimate of the weighted-average energy prices. One tool reports identical results for "ceiling insulation – yes" and "- don't know". Users would be less likely to be confused or suspect the accuracy of the tool were the option worded "yes/don't know".

- **Weather and Weather-normalization** – One practical barrier to accuracy evaluation is that not all tools can be run in all climates. For example, in the case of the tools we examined, 10 of the 22 web-based tools and 5 of the 16 disk-based tools could not be run in the selected cities. We found only one tool that applies weather normalization techniques to help reduce the apparent errors that would result from applying the tool to an actual year's billing data that may be higher or lower than the long-term average.
- **Inter-tool Differences** – The aforementioned factors conspire to confound comparisons *among* tools. Differences in inputs can range from weather city, to types of HVAC systems,

to appliance characteristics, to occupant-driven effects such as thermostat management. Differences in *results* would thus no doubt emerge from an extensive comparative exercise, but the *sources* or *implications* of these differences for the purposes of accuracy evaluation or tool development would remain largely unidentifiable (especially given the paucity of technical documentation available for most tools).

Illustrations of relevant differences in ways in which tools describe a home (and hence predetermine the results) include:

- Many tools give results only in dollars, and thus the accuracy of energy (and/or fuel-specific) estimates can not be determined unless energy price/tariff assumptions are explicitly documented, allowing energy use to be “backed out” of the results.
- Some tools allow users to specify exact window types, orientations, and sizes, while others use only the number of windows.
- Some tools allow fractional hours for lighting (down to 15 minutes), while others have a minimum of one hour per bulb per day).
- Some tools have "either/or" question formats, while others accept specific inputs, e.g. manual versus programmable thermostats, versus explicitly defined programmable thermostats.

Another uncertainty associated with accuracy analysis is that different users would arrive at different results, given the many judgments entailed in describing a real home to a necessarily simplified tool.

Further complications apply in the case of bill-disaggregation tools. The question of whole-house “predictive” ability is moot, since such tools by definition agree with actual bills. In this case, the accuracy issue shifts to one of end-use predictive power, i.e., the correct allocation of total bills to actual end uses. As noted above, some bill-disaggregation tools exhibited problems when submitted to spot tests. The scarcity of good end-use data makes it difficult to validate such tools.

#### 5.5.2 Accuracy Evaluation Test Case: Web-Based Tools

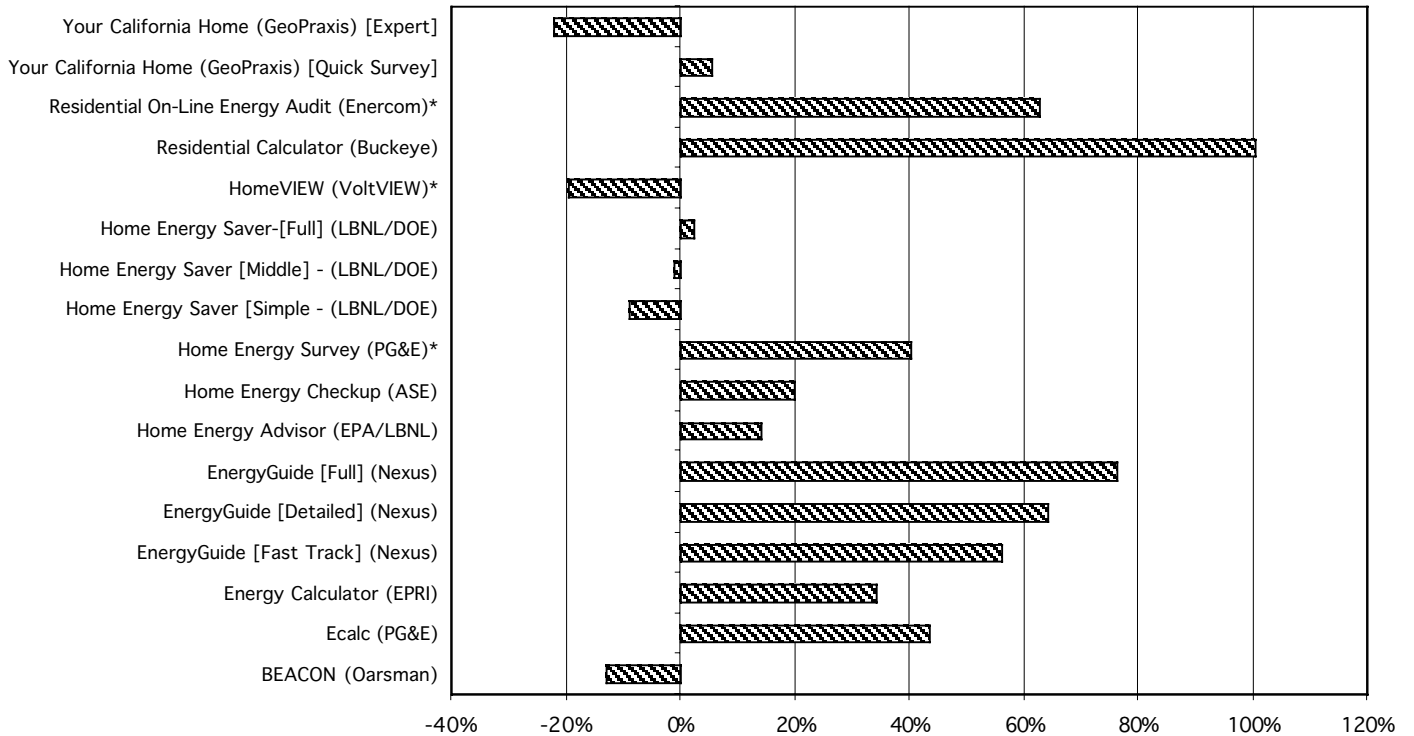
We evaluated those web-based tools with which it was possible to analyze homes in the climate of our first benchmark home (San Francisco Bay Area). All in all, 12 tools were included in this part of the accuracy evaluation.

The results are shown in Figures 3 and 4.

Bill-disaggregation tools were included that would run with only one month of data (in which case we picked August). In one such case (PG&E’s Home Energy Survey), because the tool

**Figure 3. Predicted versus actual annual energy bills vary widely: Web-based tools**

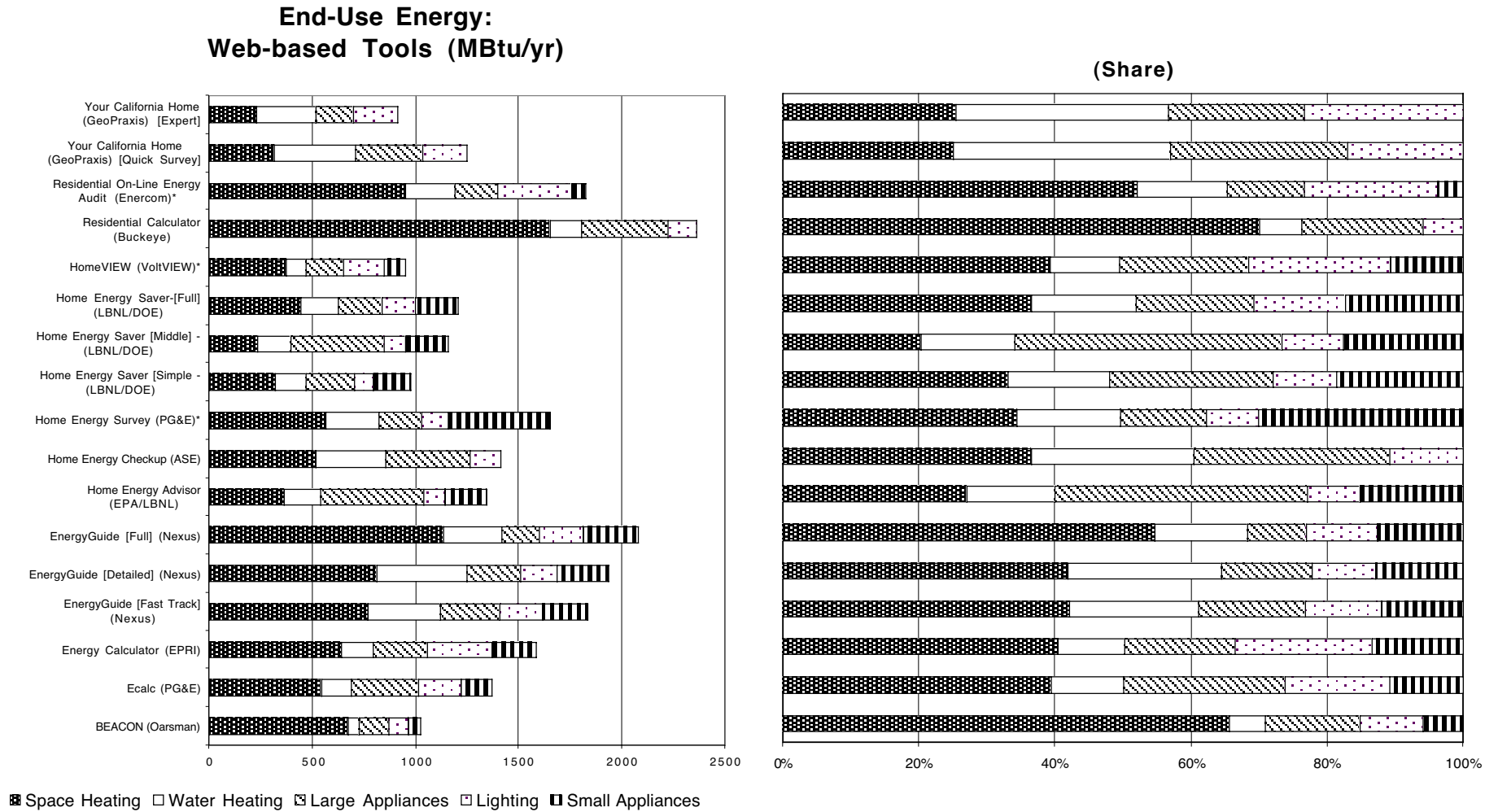
### Deviation of Predicted Bills from Actual: Web-based Tools



**Notes:**

- Actual: \$1179/year (8-year weather average)
- EnergyGuide: Initial estimates were \$2566 (Fastrack) and \$3283 (Detailed). Subsequent visit yielded lower outputs (shown here) for same inputs.
- Enercom: Base tool uses Riverside's energy prices. Results shown here adjusted for actual rates. Bill disaggregation module supplied only with August data.
- PG&E: Subtotals disagree with grand total by 30%.
- Residential Calculator (Buckeye): Results adjusted to reflect actual energy prices.

Figure 4a-b. Predicted energy use and end-use breakdowns vary widely: Web-based tools.



used only the prior year's billing data—and that year happened to be a particularly high-use year—the tool yielded results 40% higher than the long-term (8-year) actual billing average.

The results demonstrated considerable variability around the expected results (Table 5a):

- Predicted energy bills varied from 25% below to 100% above the actual (\$1179/year).
- All tools over-predicted energy use by a significant margin (by up to a factor of 2.4). The variability was higher when examined at the end-use level, e.g. a factor of 8 in water heating energy and a factor of 7 for space heating energy.
- Energy savings estimates automatically generated by the tools varied from \$46/year (5% of predicted use) to \$625/year (50% of predicted use) (Figure 5). Each tool has a different set of decision rules for including recommendations (often non-systematic and non-comprehensive), and thus the issue here is not one of accuracy as much as conveying vastly different information to consumers.

### *5.5.3 Accuracy Evaluation Test Case: Disk-Based Tools*

Because of the limitations of demonstration versions and available weather data, only six of the disk-based tools could be test run meaningfully with the second benchmark house, which was located in Ohio. Figures 6 and 7 show sample calculation results.

The availability of estimates for actual end-use consumption also allowed us to compare tool end-use predictions.

The results showed similar variability as was seen for the web-based tools (Table 5b):

- Predicted energy bills varied from 2.1 to 2.4-fold above the actual (\$969/year).
- All tools over-predicted energy use by a significant margin (by up to a factor of 2.8). The variability was higher when examined at the end-use level, e.g. a factor of 5.4 in air conditioning energy and a factor of 3.8 for water heating energy.
- Design load predictions varied by factors of 1.5 for both heating and cooling (Figure 8). (None of the web tools produce design load recommendations.)
- None of the tools generate automatic retrofit recommendations.

*Tables 5a and 5b. Ranges of annual results for the web- and disk-based tools.*

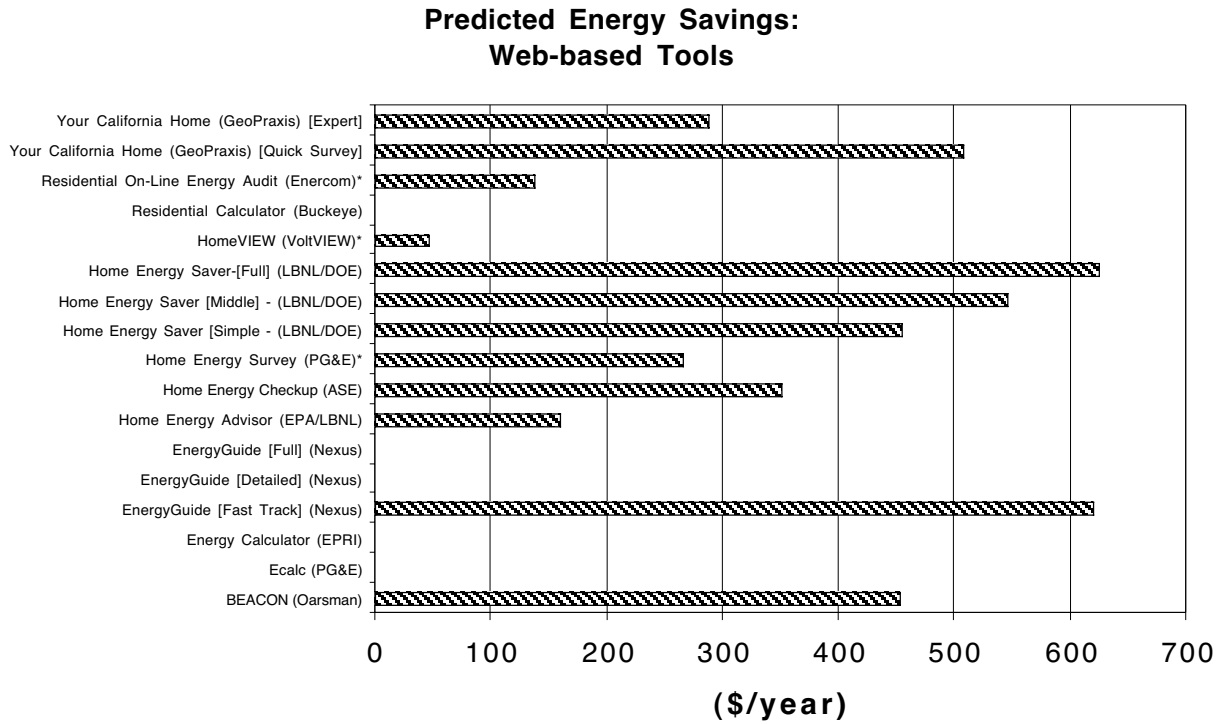
| <b>Web-based tools</b>  | Energy Use (MBTU) |              | Energy Cost (\$) |                | Share of Total Bill (%) |            |
|-------------------------|-------------------|--------------|------------------|----------------|-------------------------|------------|
|                         | Min               | Max          | Min              | Max            | Min                     | Max        |
| <b>Actual</b>           | <b>1 2 9</b>      |              | <b>1 1 7 9</b>   |                | <b>- -</b>              |            |
| <b>Total Predicted*</b> | <b>1 5 2</b>      | <b>3 0 9</b> | <b>9 1 6</b>     | <b>2 3 6 1</b> | <b>- -</b>              | <b>- -</b> |
| Space Heating           | 36                | 254          | 231              | 1653           | 20%                     | 70%        |
| Water Heating           | 8                 | 67           | 97               | 437            | 5%                      | 32%        |
| Major Appliances        | - -               | - -          | 179              | 500            | 11%                     | 39%        |
| Lighting                | 8                 | 30           | 91               | 359            | 6%                      | 23%        |
| Small Appliances        | 0                 | 42           | 0                | 497            | 0%                      | 30%        |

\*Includes only those twelve tools that attempt to predict whole-house energy use.

| <b>Disk-based tools</b>    | Energy Use (MBTU) |              | Actual (MBTU) | Energy Cost (\$) |                 | Share of Total Bill (%) |            |
|----------------------------|-------------------|--------------|---------------|------------------|-----------------|-------------------------|------------|
|                            | Min               | Max          |               | Min              | Max             | Min                     | Max        |
| <b>Actual</b>              | <b>1 0 1</b>      |              |               | <b>9 6 9</b>     |                 | <b>- -</b>              |            |
| <b>Total Predicted*</b>    | <b>2 3 7</b>      | <b>2 8 2</b> | <b>1 0 1</b>  | <b>2, 0 2 9</b>  | <b>2, 3 6 1</b> | <b>- -</b>              | <b>- -</b> |
| Space Heating              | 154               | 192          | 36            | 1,143            | 1,467           | 52%                     | 61%        |
| Cooling                    | 5                 | 27           | 6             | 55               | 324             | 2%                      | 16%        |
| Water Heating              | 8                 | 30           | 11            | 58               | 216             | 3%                      | 9%         |
| Major Appliances           | 16                | 50           | 18            | 164              | 585             | 7%                      | 28%        |
| Lighting                   | 7                 | 13           | 5             | 81               | 149             | 4%                      | 6%         |
| Small Appliances           | 19                | 29           | 24            | 222              | 339             | 11%                     | 16%        |
| Design Heating Load (BTUh) | 48,406            | 70,313       | - -           | - -              | - -             | - -                     | - -        |
| Design Cooling Load (BTUh) | 16,132            | 24,617       | - -           | - -              | - -             | - -                     | - -        |

\*Includes only those six tools that predict whole-house energy use.

*Figure 5. Predicted annual energy savings defaults vary widely among the web-based tools.*



\* Bill disaggregation tool. We provided one month's data, where 12-months was not required.



**Figure 6.** Predicted versus actual annual energy bills vary widely: Disk-based tools

Note: Actual = \$969/year Agreement = 0% deviation

### Deviation of Predicted Bills from Actual: Disk-based Tools

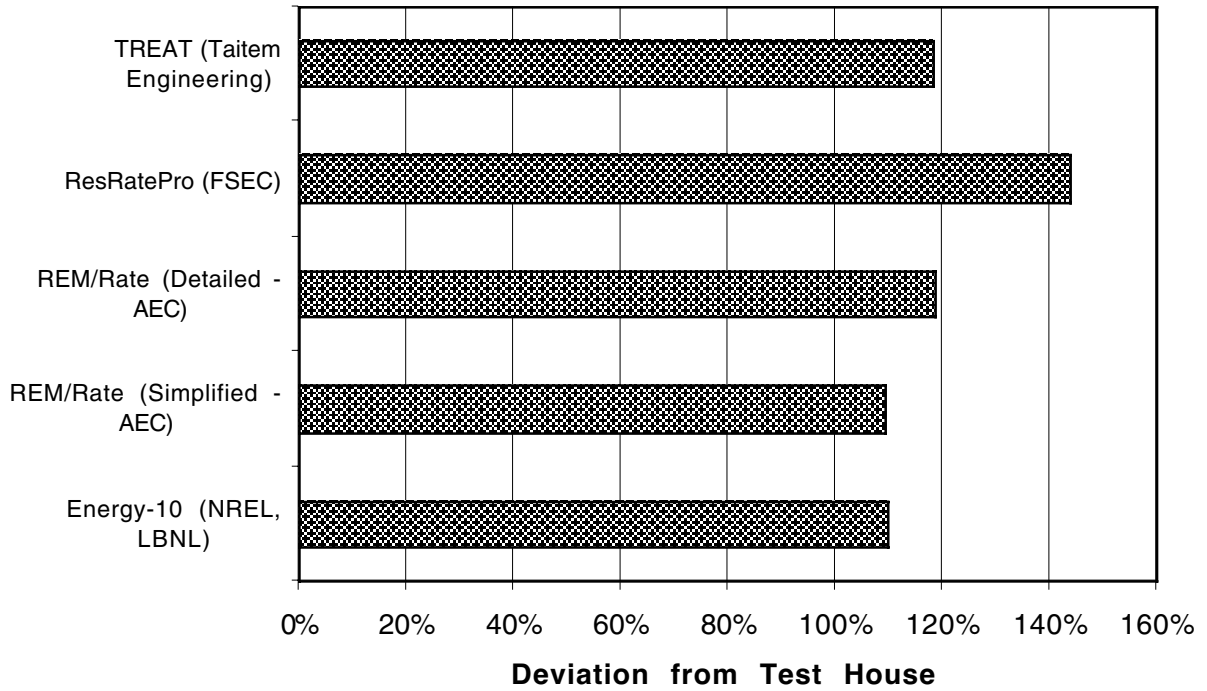


Figure 7. Predicted energy use and end-use breakdowns vary widely: Disk-based tools

End-Use Energy: Disk-based Tools

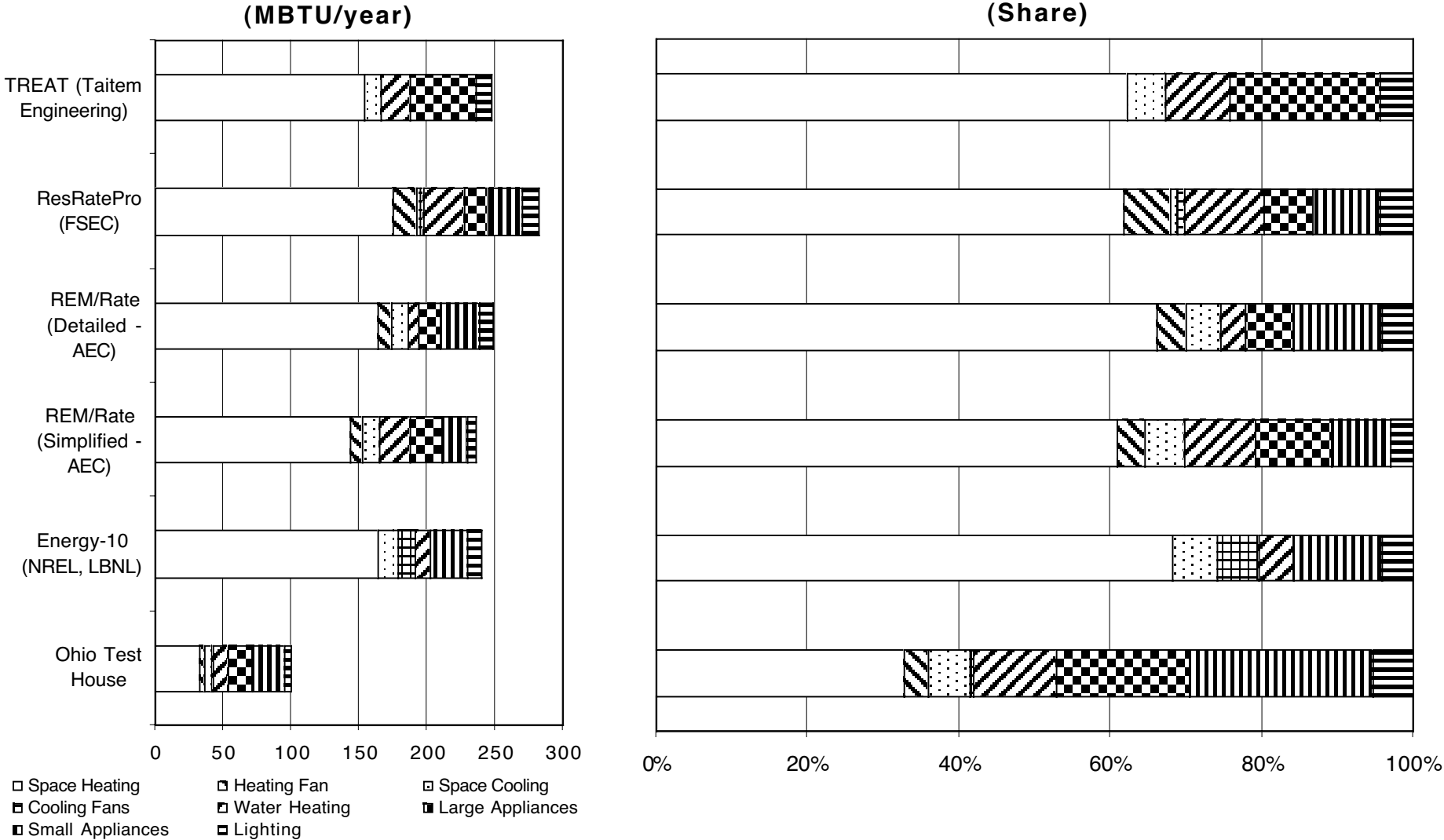
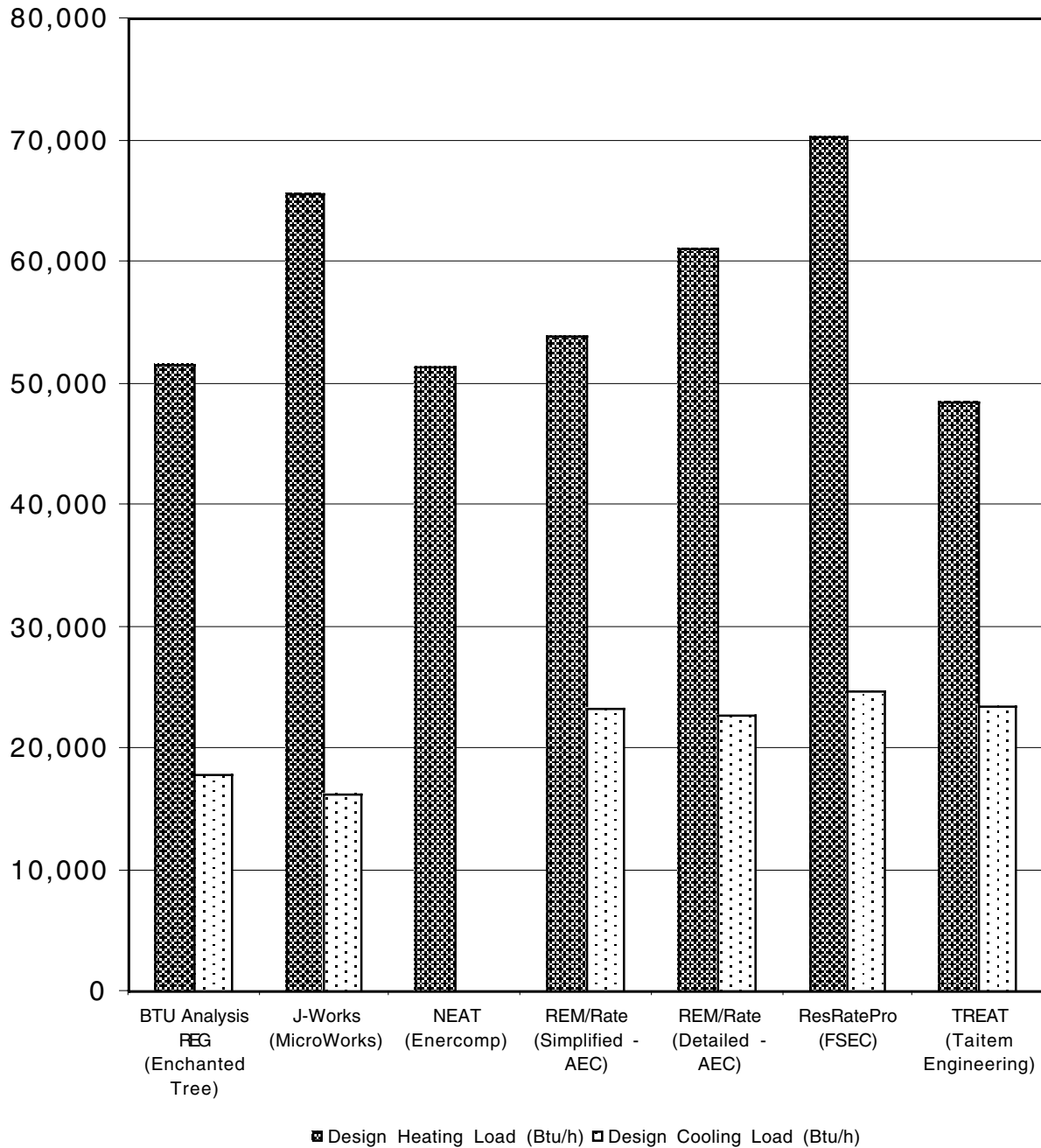


Figure 8. Predicted design loads vary widely.

### Design Loads (BTU-h): Disk-based Tools



Although sub-metered heating and cooling energy use was not available for the test house, detailed estimates of end-use energy consumption can be compared to the disaggregated utility data, and the results are somewhat disturbing. In particular, the space-heating consumption is over-predicted by a factor of 4 or 5 across the board.

#### 5.5.4 Summary

Limitations of this exercise include the fact that only two buildings were studied, and without the full spectrum of potential end uses (one test house was located in a non-air-conditioning climate). Also, the analysis was performed by experienced modelers; lay users might not achieve the same results given the difficulties in interpreting what is being asked or in how to gather or otherwise provide the proper input. Results for lay users are likely to exhibit even wider variability.

While Figures 3 and 6 suggest that some tools appear to be more “accurate” than others, the many above-mentioned caveats apply. A readily apparent question is that of fortuitous agreement with actual bills as opposed to genuine accuracy. For example, the “middle” version of the Home Energy Saver provides slightly “better” results than the “detailed” version. This is not because the former provides better modeling than the detailed tool, but rather that inaccuracies have fortuitously cancelled out. Similarly, the Home Energy Checkup provides results relatively close to actual, however, this is clearly fortuitous given that this tool is based on a very approximate “lookup” process using national survey data. The actual house, for example, has electricity prices a full 50% higher than the Home Energy Checkup’s (invariable) energy prices.

Note also that most results are above those of the actual test house bills. One would expect a more random distribution of over- and under-prediction.

Some web-based tools were not very stable, i.e., they delivered different results when the homes were rerun without changing the building description or when saved runs were recalled subsequent to the initial session.

In order to conduct more comprehensive accuracy evaluations the following would be required:

#### Test Homes & Measured Data

1. A statistically representative series of test homes (to compensate for fortuitous agreement and accurately characterize the target population) representing a wide range of: climates, HVAC types, envelope characteristics, and occupant utilization effects.
2. Detailed whole-house *and* end-use sub-metering for test homes for typical weather year.
3. Measured energy savings (at the end-use level) for a variety of retrofits for a typical weather year.

### Tool Features & Methods

1. Inputs (and underlying modeling features) must allow for testing of features of interest (e.g., house size/type, window types, insulation levels, utilization patterns, roof color, etc.).
2. Relevant outputs must be provided (e.g., energy, energy cost, fuel-specific sub-totals, peak power, etc.– all at a whole-house and end-use level). In fact, none of the whole-house tools we evaluated provides all of these outputs.
3. Corresponding outputs for a range of retrofits.
4. In order to understand the sources of errors, extensive documentation would have to be available.
5. Method for correcting actual-year consumption data to long-term average weather assumed in the tool.

### Test Methods

1. A useful “validation” exercise must also evaluate the methods used to determine savings estimates, and to find errors in the code. As noted above, numerous dubious estimates were noted during our review.
2. Using a variety of testers (including lay users and contractors/professionals) to run the tests.

This list is not comprehensive, but indicates the considerable effort required. We estimate that at least 138 runs of each tool would be required for HVAC and domestic hot water alone; the multiplicative combination of these could be quite large.<sup>13</sup> Furthermore, note that fulfillment of the above list would make most of the existing tools ineligible for evaluation. Conversely, conducting such an analysis limited to the least common denominator required for all tools to qualify would result in such a highly “denatured” analysis (because very few parameters could be tested) as to have little value or meaning.

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<sup>13</sup> For example: climate (cold/hot-dry/hot-humid/mixed), building type (sfd/mfd), efficiency level (inefficient/typical/efficient), HVAC types (furn/CAC/heat pump/boiler/evaporative cooler), leakage (hi/low/average), foundation/basement ((un)vented crawlspace/(un)conditioned basement), roof color (light/medium/dark), orientation (N/S/E/W), bill disaggregation (on/off), insulation (walls/floor/roof), windows (single/double/triple), thermostat (two points per period – day/night), occupants (1/2/3), water heater temperature settings (low/med/high). We recommend having at least three testers for each tool (analyst/contractor/consumer) to help discern problems associated with interpreting the questions and intended responses.

## 6 DEFINING BEST PRACTICE

Specifying the desired characteristics of residential energy tools should be grounded in social science as well as engineering. None of the tools we evaluated offer all desirable features. Westerman (2001) arrived at the same conclusion. There are many potential avenues for improvement in the existing web-based tools. For example (and surprisingly), many provide only estimates of existing energy bills and no recommendations or estimates of potential savings, and fewer still address cost-effectiveness or emissions analysis (even superficially). Few tools offer substantial decision-support content. Based on our review, we offer the following topics for consideration by future tool developers.

### 6.1 Targeting & Usability

- Diversity of Audiences – Interface options (inputs/outputs) should be tailored for a diversity of user audiences, which could range from consumers, to educators, to policymakers, to home remodelers and energy auditors. For example, one user might simply (and only) want to know the difference in energy use between microwave and standard ovens (“what-if” analysis), while another might be designing an entire home from the ground up. Similarly, some users are lay people who want simple answers to simple questions, while others are building professionals who want detailed technical analysis (e.g., HVAC sizing information or analysis evaluation of changes in roof reflectivity). Outputs can include annual/monthly/hourly timesteps; energy/cost; upgrade costs/savings; emissions; or non-energy benefits. Many users require help in evaluating the results (e.g., via benchmarking their home against typical or efficient homes). Your California Home (by GeoPraxis) offers a good example of a simplified “hub” with a minimum of questions, and an “Expert” option to “drill down” and specify greater detail on any feature in order to refine the results.
- Qualitative Decision Support – No tool evaluated does an adequate job of guiding the consumer in making complex choices among multiple options. A clear example concerns windows. The tools—if they treat windows at all—assume that the user knows which type of window to specify and will enter the proper corresponding technical specs for the purposes of making the calculation. Qualitative “Decision Trees” should be offered for a variety of end uses. Non-energy benefits are also an important and often overlooked contribution to consumer decision-making.
- Interconnections among Tools – Comprehensive tools can benefit from providing links to specialized tools rather than reinventing each and every possible function.
- Convenience – Many users wish to save results and return at a future date or have access to building characteristic description sets for meaningful baselines. These could include prototype “old”, “typical new (code)”, and “efficient” packages.
- Currency – Tools must be regularly updated to enable modeling of new technologies, relevant default information (e.g., energy prices), etc.

## 6.2 Technical Features & Rigor

- Whole-House Perspective – For tools attempting to predict energy use and savings at the whole-house level, it is important that a host of interactions are properly modeled. These include the role of equipment in generating internal heat gains and the subsequent influence on heating and cooling loads and HVAC sizing.
- Geographic Range – Tools need to accommodate a range of climates (weather zones) and building types (single- vs. multi-family, etc) and weather-normalization techniques so that results reflect long-term averages.
- Technical Rigor & Occupancy Effects – Users expect that a tool’s underlying technical methods (e.g., refrigerator energy use as function of vintage and size) as well as occupant effects (e.g., water consumption, thermostat management, lifestyle) are realistic.
- Format – Some users prefer open-ended energy analysis, while others seek bill disaggregation, or both.
- Uncertainty Analysis – Tools should help users deal quantitatively and qualitatively with the issues of uncertainty inherent in the results.
- Quality Control – One definition of accuracy—the correct utilization of user-specified inputs to arrive at a result—should be expected of all tools. The Building Energy Simulation TEST (BESTEST) project provides a method for evaluating tool accuracy, although it focuses only on building envelope performance, and may require modification to a tool’s source code in order to be used (USDOE 2000).

## 6.3 Strategic Considerations

- Objectivity and Inclusiveness– Consumers require tools that embed technology and fuel neutrality, coupled with credible analysis.
- Transparency – Tools should be fully documented and preferably based on non-proprietary assumptions/algorithms.
- Choice of Web- and/or Disk-based Format – Web-based tools have many advantages including development and maintenance cost efficiency, cross-platform compatibility, easier versioning, a large potential user base, and ability to easily link users to decision-support information elsewhere on the Internet. Disk-based tools, alternatively, may be more stable, and may appear to some users to have more intrinsic value to users than web-based tools. However, it is unlikely that consumer audiences would pay for disk-based tools.
- Integration vs. Fragmentation – As noted above, there already exists a bewildering proliferation of tools. Users would benefit from an integrated “Toolkit” using consistent

underlying data and assumptions that serve a range of interfaces and specialized modules for different audiences. This would also help reduce the wide variability in results that consumers will receive if using a variety of tools, while more efficiently allocating the scarce resources available for tool development.

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# APPENDICES: Detailed Tool Characteristics

Appendix 1. Web-based Energy Calculators: Detailed Characterization

| DESCRIPTOR, FEATURE, OR OPTION                            | DEFINITION OF FEATURE OR OPTION   | Energy Calculator (Niagara Mohawk) | Energy Calculator (EPR) | Energy Checkup.com (GeoPraxis) | Energy Checkup.co (HERS Server) | EnergyGuide (Fast Track)        | EnergyGuide (Detailed Nexus) | EnergyGuide (Full Nexus)     | Home Energy Advisor (EPA/LBNL) | Home Energy Checkup (ASE)      | Home Energy Saver (SimpleLBNL/DOE)          | Home Energy (Middle) - Save (Full LBNL/DOE) | Home Energy Survey (PG&E)   | HomeVIEW Calculator (KCP&L) | My Home (GMP/RedWire)        | On-Line Energy Audit (ICLEI) | On-Line Energy Survey (SCE)             | Residential Energy Calculator (Buckeye)   | Residential Energy Bill Analyzer (Enecom) | Residential On-Line Energy Audit (Enecom) | Your California Quick Survey (Expert) |    |
|---|---|------------------------------------|-------------------------|--------------------------------|---------------------------------|---------------------------------|------------------------------|------------------------------|--------------------------------|--------------------------------|---|---|-----------------------------|-----------------------------|------------------------------|------------------------------|---|---|---|---|---------------------------------------|----|
| <b>Number of House-Descriptive Features</b>               | HVAC, appliances, occupant behavior   | 16                                 | 41                      | 24                             | 11                              | 23                              | 41                           | 27                           | 13                             | 5                              | 17  | 34  | 23                          | 25                          | 26                           | 39                           | 18                                      | 41  | 48  | 6   | 38                                    |    |
| <b>Number of Analytical and Decision-support Features</b> | Features: analytical methods, outputs, user support   | 7                                  | 14                      | 10                             | 3                               | 11                              | 13                           | 28                           | 13                             | 30                             | 34  | 37  | 12                          | 7                           | 7                            | 8                            | 11                                      | 6   | 12  | 28  | 27                                    | 28 |
| <b>Total Number of Features</b>                           | Features: all   | 23                                 | 55                      | 34                             | 14                              | 34                              | 54                           | 55                           | 26                             | 35                             | 51  | 95  | 46                          | 30                          | 32                           | 34                           | 50                                      | 24  | 53  | 76  | 33                                    | 66 |
| <b>General Information</b>                                |   |                                    |                         |                                |                                 |                                 |                              |                              |                                |                                |   |   |                             |                             |                              |                              |   |   |   |   |                                       |    |
| • Developer/inch  | Organization developing the tool.   | ATCO Gas & Electric                | ATCO Gas & Electric     | ATCO Gas & Electric            | Energy Checkup.com (GeoPraxis)  | Energy Checkup.co (HERS Server) | EnergyGuide (Fast Track)     | EnergyGuide (Detailed Nexus) | EnergyGuide (Full Nexus)       | Home Energy Advisor (EPA/LBNL) | Home Energy (Middle) - Save (Full LBNL/DOE) | Home Energy Survey (PG&E)                   | HomeVIEW Calculator (KCP&L) | My Home (GMP/RedWire)       | On-Line Energy Audit (ICLEI) | On-Line Energy Survey (SCE)  | Residential Energy Calculator (Buckeye) | Residential Energy Bill Analyzer (Enecom) | Residential On-Line Energy Audit (Enecom) | Your California Quick Survey (Expert)     |                                       |    |
| • Developer responded to survey results                   | Developer provided missing information and/or verified results.   | •                                  | •                       | •                              | •                               | •                               | •                            | •                            | •                              | •                              | •   | •   | •                           | •                           | •                            | •                            | •                                       | •   | •   | •   | •                                     |    |
| • Cost to end-user  | Licensing cost (e.g., to utility host).   | none                               | none                    | none                           | yes to inspectors & consumers   | none                            | none                         | none                         | none                           | none                           | none  | none  | none                        | none                        | none                         | none                         | none                                    | none                                      | none                                      | none                                      | none                                  |    |
| • Commercial/e-commerce content                           | Tool offers products or services for sale (yes (Y/no), no (N)).   | no                                 | no                      | no                             | •                               | •                               | •                            | •                            | •                              | •                              | •   | •   | •                           | •                           | •                            | •                            | •                                       | •   | •   | •   | •                                     |    |
| • Privacy statement                                       | Tool has written privacy protection notice (yes (Y/no), no (N)).  | no                                 | •                       | •                              | •                               | •                               | •                            | •                            | •                              | •                              | •   | •   | •                           | •                           | •                            | •                            | •                                       | •   | •   | •   | •                                     |    |
| • Non-proprietary   | Tool is open source/available at no charge (yes (Y/no), no (N)).  | no                                 | no                      | no                             | no                              | no                              | no                           | no                           | •                              | •                              | •   | •   | •                           | •                           | •                            | •                            | •                                       | •   | •   | •   | •                                     |    |
| • User base   | Proprietary sites typically are licensed for use in past year (not page views or hits).   | 4,500                              | ?                       | ?                              | 800                             | 27,000+                         | ?                            | ?                            | 51,429                         | ?                              | 294,000                                     | 294,000                                     | ?                           | Proprietary                 | ?                            | ?                            | ?                                       | 4 utilities                               | 65 utilities                              | 100                                       | 100                                   |    |
| • Audience(s)   | Targeted for consumers (yes (Y/no), no (N)).  | •                                  | •                       | •                              | •                               | •                               | •                            | •                            | •                              | •                              | •   | •   | •                           | •                           | •                            | •                            | •                                       | •   | •   | •   | •                                     |    |
| - Consumer  | Contains sufficient technical depth and flexibility to be useful to professionals (yes (Y/no), no (N)).                                       | no                                 | no                      | no                             | ?                               | no                              | no                           | no                           | no                             | no                             | no  | no  | no                          | no                          | no                           | no                           | no                                      | no  | no  | no  | no                                    |    |
| - Professional  | Results not linked or limited to utility bill total (yes (Y/no), no (N)).   | •                                  | •                       | •                              | •                               | •                               | •                            | •                            | •                              | •                              | •   | •   | •                           | •                           | •                            | •                            | •                                       | •   | •   | •   | •                                     |    |
| • Types of tool   | Outputs can be scaled to other utility bill types (Y/no), no (N).   | no                                 | no                      | no                             | no                              | no                              | no                           | no                           | no                             | no                             | no  | no  | no                          | no                          | no                           | no                           | no                                      | no  | no  | no  | no                                    |    |
| - Bill disaggregation                                     | Number of discrete levels of input detail.  | 1                                  | 1                       | 1                              | 1                               | 2                               | 3                            | 3                            | 3                              | 3                              | 3   | 3   | 3                           | 1                           | 1                            | 1                            | 1                                       | 1   | 1   | 1   | 2                                     |    |
| • User level(s)   | Number of users that must or can be viewed, even if no input is required or permitted.  | 11                                 | 9                       | 16                             | 1                               | 9                               | 11                           | 20                           | 2                              | 15                             | 26  | 3   | 1                           | 1                           | 1                            | 12                           | 1                                       | 13  | 15  | 7   | 2                                     |    |
| • Inputs  | Number of items that can be specified by the user, including radio buttons and checkboxes, but excluding sliders, refrigerators and freezers. | 76                                 | 104                     | 130                            | 21                              | 79                              | 47                           | 200                          | 25                             | 99                             | 118   | 53  | 25                          | 1                           | 26                           | 184                          | 120                                     | 138                                       | 198                                       | 122                                       | 155                                   |    |
| • Ease of use/ speed of calculations                      | Ease of use: Cumbersome; Somewhat Difficult; Reasonable; Easy; Very Easy; Show/Slow; Acceptable; Fast; Very Fast.                             | Somewhat Difficult                 | Reasonable              | Efficient                      | Very Fast                       | Very Fast                       | Very Fast                    | Very Fast                    | Very Fast                      | Very Fast                      | Very Fast                                   | Very Fast                                   | Very Fast                   | Very Fast                   | Very Fast                    | Very Fast                    | Very Fast                               | Very Fast                                 | Very Fast                                 | Very Fast                                 | Very Slow                             |    |

Appendix 1. Web-based Energy Calculators: Detailed Characterization

| DESCRIPTION, FEATURE, OR OPTION               | ATCO Energy Sense (Beacon House)  | Eclic (Gerrman) (PG&E) | Energy Calculator (Niagara Mohawk) | Energy Calculator (EPR) | Energy Checkup (GeoPraxis) | Energy Checkup.co "HERS Server" | EnergyGuide (Nexus) | EnergyGuide (Full) (Nexus) | Energy Advisor (EPA/BLM) | Home Energy Saver (Simple) | Home Energy (Middle) - Save (Full) (LBNL/DOE) | Home Energy Survey (PG&E) | HomeVIEW Calculator (KCP) | My Home Energy (GMP/Red-Wire) | On-Line Home Energy Survey (SCE) | Residential Energy Audit (BUckeye) | Residential Energy Audit (Ewincom) | Residential On-Line Energy Audit (Ewincom) | Your California Home [Quick Survey] (Expert) | Your California Home [GeoPraxis] |
|---|---|------------------------|------------------------------------|-------------------------|----------------------------|---------------------------------|---------------------|----------------------------|--------------------------|----------------------------|---|---------------------------|---------------------------|-------------------------------|----------------------------------|------------------------------------|------------------------------------|--|--|----------------------------------|
| <b>Technical Features-- General Building</b>  |   |                        |                                    |                         |                            |                                 |                     |                            |                          |                            |   |                           |                           |                               |                                  |                                    |                                    |  |  |                                  |
| • Age of house                                | Can be specified (Yes) (Y/no)   | *                      | no                                 | no                      | ?                          | *                               | *                   | *                          | *                        | no                         | *   | *                         | *                         | no                            | *                                | *                                  | *                                  | *  | *  | *                                |
| • Building type(s)                            | Can be modeled (Yes) (Y/no)   | *                      | *                                  | *                       | *                          | *                               | *                   | *                          | *                        | *                          | *   | *                         | *                         | *                             | *                                | *                                  | *                                  | *  | *  | *                                |
| - Single-family detached                      | Can be modeled (Yes) (Y/no)   | *                      | *                                  | *                       | *                          | *                               | *                   | *                          | *                        | *                          | *   | *                         | *                         | *                             | *                                | *                                  | *                                  | *  | *  | *                                |
| - Townhouse                                   | Can be modeled (Yes) (Y/no)   | no                     | no                                 | no                      | no                         | no                              | no                  | no                         | no                       | no                         | no  | no                        | no                        | no                            | no                               | no                                 | no                                 | no   | no   |                                  |
| - Apartment building                          | Must be able to model multizone HVAC systems.   | no                     | no                                 | no                      | no                         | no                              | no                  | no                         | no                       | no                         | no  | no                        | no                        | no                            | no                               | no                                 | no                                 | no   | no   |                                  |
| - Mobile home                                 | Can be modeled (Yes) (Y/no)   | no                     | no                                 | no                      | no                         | no                              | no                  | no                         | no                       | no                         | no  | no                        | no                        | no                            | no                               | no                                 | no                                 | no   | no   |                                  |
| • Room additions                              | Unique features (e.g., fireplace, bay window, trapezoid bay window, room level) (Yes) (Y/no)      | no                     | no                                 | no                      | no                         | no                              | no                  | no                         | no                       | no                         | no  | no                        | no                        | no                            | no                               | no                                 | no                                 | no   | no   |                                  |
| • House geometry                              | House shape and dimensions can be specified   | no                     | no                                 | no                      | ?                          | *                               | *                   | *                          | *                        | no                         | *   | *                         | *                         | no                            | *                                | *                                  | *                                  | *  | *  |                                  |
| • House orientation                           | Compass direction of front of house or components can be specified (Yes) (Y/no)                   | no                     | no                                 | no                      | ?                          | *                               | *                   | *                          | *                        | no                         | *   | *                         | *                         | no                            | *                                | *                                  | *                                  | *  | *  |                                  |
| • Number of stories                           | Can be specified (Yes) (Y/no)   | no                     | no                                 | no                      | ?                          | *                               | *                   | *                          | *                        | no                         | *   | *                         | *                         | no                            | *                                | *                                  | *                                  | *  | *  |                                  |
| • Floor area                                  | Can be specified (Yes) (Y/no)   | no                     | no                                 | no                      | ?                          | *                               | *                   | *                          | *                        | no                         | *   | *                         | *                         | no                            | *                                | *                                  | *                                  | *  | *  |                                  |
| • Ceiling height                              | Can be specified (Yes) (Y/no)   | no                     | no                                 | no                      | ?                          | *                               | *                   | *                          | *                        | no                         | *   | *                         | *                         | no                            | *                                | *                                  | *                                  | *  | *  |                                  |
| • Exterior shading                            | Dimensions of neighboring buildings, overhangs, or trees that shade can be specified (Yes) (Y/no) | no                     | no                                 | no                      | ?                          | *                               | *                   | *                          | *                        | no                         | *   | *                         | *                         | no                            | *                                | *                                  | *                                  | *  | *  |                                  |
| <b>Technical Features-- Building Envelope</b> |   |                        |                                    |                         |                            |                                 |                     |                            |                          |                            |   |                           |                           |                               |                                  |                                    |                                    |  |  |                                  |
| • Foundation type                             | Can be specified (Yes) (Y/no)   | no                     | no                                 | no                      | ?                          | *                               | *                   | *                          | *                        | no                         | *   | *                         | *                         | no                            | *                                | *                                  | *                                  | *  | *  |                                  |
| • Wall exterior construction type             | Can be specified (Yes) (Y/no)   | no                     | no                                 | no                      | ?                          | *                               | *                   | *                          | *                        | no                         | *   | *                         | *                         | no                            | *                                | *                                  | *                                  | *  | *  |                                  |
| • Daps  | Number and/or type of doors can be specified (Yes) (Y/no)   | no                     | no                                 | no                      | ?                          | no                              | no                  | no                         | no                       | no                         | no  | no                        | no                        | no                            | no                               | no                                 | no                                 | no   | no   |                                  |
| • Insulation levels                           | Can be specified (Yes) (Y/no)   | no                     | no                                 | no                      | ?                          | *                               | *                   | *                          | *                        | no                         | *   | *                         | *                         | no                            | *                                | *                                  | *                                  | *  | *  |                                  |
| - Foundation                                  | Can be specified (Yes) (Y/no)   | no                     | no                                 | no                      | ?                          | *                               | *                   | *                          | *                        | no                         | *   | *                         | *                         | no                            | *                                | *                                  | *                                  | *  | *  |                                  |
| - Floors                                      | Can be specified (Yes) (Y/no)   | no                     | no                                 | no                      | ?                          | *                               | *                   | *                          | *                        | no                         | *   | *                         | *                         | no                            | *                                | *                                  | *                                  | *  | *  |                                  |
| - Walls                                       | Can be specified (Yes) (Y/no)   | no                     | no                                 | no                      | ?                          | *                               | *                   | *                          | *                        | no                         | *   | *                         | *                         | no                            | *                                | *                                  | *                                  | *  | *  |                                  |
| - Ceiling                                     | Can be specified (Yes) (Y/no)   | no                     | no                                 | no                      | ?                          | *                               | *                   | *                          | *                        | no                         | *   | *                         | *                         | no                            | *                                | *                                  | *                                  | *  | *  |                                  |
| - Roof  | Can be specified (Yes) (Y/no)   | no                     | no                                 | no                      | ?                          | *                               | *                   | *                          | *                        | no                         | *   | *                         | *                         | no                            | *                                | *                                  | *                                  | *  | *  |                                  |
| • Roof color, reflectance, or absorptance     | Can be specified (Yes) (Y/no)   | no                     | no                                 | no                      | ?                          | *                               | *                   | *                          | *                        | no                         | *   | *                         | *                         | no                            | *                                | *                                  | *                                  | *  | *  |                                  |
| • Window area                                 | Window size can be specified (Yes) (Y/no)   | no                     | no                                 | no                      | ?                          | *                               | *                   | *                          | *                        | no                         | *   | *                         | *                         | no                            | *                                | *                                  | *                                  | *  | *  |                                  |
| • Gas/ignite type                             | Number of combinations. Can be specified (Yes) (Y/no)   | 0                      | 6                                  | 0                       | ?                          | ?                               | 0                   | 3                          | 6                        | 3                          | 0   | 17                        | 2                         | 4                             | 0                                | 50                                 | 0                                  | 3  | 0  |                                  |
| • Skylights                                   | Can be specified (Yes) (Y/no)   | no                     | no                                 | no                      | ?                          | no                              | no                  | no                         | no                       | no                         | no  | no                        | no                        | no                            | no                               | no                                 | no                                 | no   | no   |                                  |
| • Leakage (airtightness)                      | Can be specified (Yes) (Y/no)   | no                     | no                                 | no                      | ?                          | *                               | *                   | *                          | *                        | no                         | *   | *                         | *                         | no                            | *                                | *                                  | *                                  | *  | *  |                                  |
| • Leakage (blower door data)                  | Can be specified (Yes) (Y/no)   | no                     | no                                 | no                      | ?                          | *                               | *                   | *                          | *                        | no                         | *   | *                         | *                         | no                            | *                                | *                                  | *                                  | *  | *  |                                  |
| • Caulking and weatherstripping               | Can be specified (Yes) (Y/no)   | no                     | no                                 | no                      | ?                          | no                              | no                  | no                         | no                       | no                         | *   | *                         | *                         | no                            | *                                | *                                  | *                                  | *  | *  |                                  |



Appendix 1. Web-based Energy Calculators: Detailed Characterization

| DESCRIPTOR, FEATURE, OR OPTION                           | DEFINITION OF OR OPTION  | ATCO Energy Sense House (BACON) | Eclic (Niagara Mohawk) | Energy Calculator (EPRI) | Energy Checkup.com (GeoPraxis) | Energy Checkup.com "HERS Server"      | EnergyGuide (Nexus) | EnergyGuide (Full Detailed) | EnergyGuide (Nexus) | Home Energy Advisor (EPALBHL) | Home Energy Checkup (ASE) | Home Energy Saver (Simple) | Home Energy (Middle) | Home Energy (Save-Full) | Home Energy Survey (PG&E) | HomeVIEW Calculator (KCPPL) | My Home Energy Audit (GMP/Red-Wire) | On-Line Home Energy Survey (SCE) | On-Line Home Energy Audit (ICLEI) | Residential Energy Bill Analyzer (Electrek) | Residential On-Line Energy Audit (Eiwincom) | Your California Home [Quick Survey] (Expert) |      |
|--|--|---------------------------------|------------------------|--------------------------|--------------------------------|---------------------------------------|---------------------|-----------------------------|---------------------|-------------------------------|---------------------------|----------------------------|----------------------|-------------------------|---------------------------|-----------------------------|-------------------------------------|----------------------------------|-----------------------------------|---|---|--|------|
| <b>Technical Features-- Occupant Effects</b>             |  |                                 |                        |                          |                                |                                       |                     |                             |                     |                               |                           |                            |                      |                         |                           |                             |                                     |                                  |                                   |   |   |  |      |
| • Number of occupants                                    | Can be specified (yes (Y/no).  | •                               | •                      | •                        | •                              | •                                     | •                   | •                           | •                   | •                             | •                         | •                          | •                    | •                       | •                         | •                           | •                                   | •                                | •                                 | •   | •   | •  |      |
| • Ages of occupants                                      | Can be specified (yes (Y/no).  | no                              | no                     | no                       | ?                              | no                                    | no                  | no                          | no                  | •                             | no                        | no                         | •                    | no                      | no                        | no                          | •                                   | no                               | no                                | •   | no  | •  |      |
| • Occupants home during day                              | Can be specified (yes (Y/no).  | no                              | no                     | no                       | no                             | no                                    | no                  | no                          | no                  | no                            | no                        | no                         | no                   | no                      | no                        | no                          | no                                  | no                               | no                                | no  | no  | no   |      |
| • Adjustable window insulation                           | Can specify energy use with and without movable window insulation (yes (Y/no).                         | no                              | no                     | no                       | ?                              | no                                    | no                  | no                          | no                  | no                            | no                        | no                         | no                   | no                      | no                        | no                          | no                                  | no                               | no                                | no  | no  | no   |      |
| • Thermostat type(s)                                     | Fixed thermostat setting can be specified (yes (Y/no).   | no                              | •                      | no                       | ?                              | •                                     | no                  | no                          | no                  | •                             | no                        | no                         | •                    | no                      | no                        | no                          | •                                   | no                               | no                                | •   | no  | •  |      |
| - Standard   | Manual nighttime setback   | no                              | no                     | no                       | no                             | no                                    | no                  | no                          | no                  | •                             | no                        | no                         | •                    | no                      | no                        | no                          | •                                   | no                               | no                                | •   | no  | •  |      |
| - Setback option   | Can be specified (yes (Y/no).  | no                              | no                     | no                       | no                             | no                                    | no                  | no                          | no                  | •                             | no                        | no                         | •                    | no                      | no                        | no                          | •                                   | no                               | no                                | •   | no  | •  |      |
| - Programmable   | Thermostat can be specified (yes (Y/no).   | no                              | no                     | no                       | ?                              | •                                     | no                  | no                          | no                  | no                            | no                        | no                         | no                   | no                      | no                        | no                          | no                                  | no                               | no                                | no  | no  | no   |      |
| • Zone heating/cooling                                   | Allows for heating/cooling of zones (yes (Y/no).   | no                              | no                     | no                       | ?                              | no                                    | no                  | no                          | no                  | no                            | no                        | no                         | no                   | no                      | no                        | no                          | no                                  | no                               | no                                | no  | no  | no   |      |
| • Water heater setting                                   | Allows for setting of water heater temperature or setting (e.g., medium) can be specified (yes (Y/no). | no                              | •                      | no                       | ?                              | no                                    | no                  | no                          | no                  | no                            | no                        | no                         | no                   | no                      | no                        | no                          | no                                  | no                               | no                                | no  | no  | no   |      |
| • Tap water consumption                                  | Accounts for occupant water use (e.g., low-flow showerheads) (yes (Y/no).                              | no                              | no                     | no                       | ?                              | •                                     | no                  | no                          | no                  | •                             | no                        | no                         | •                    | no                      | no                        | no                          | •                                   | no                               | no                                | •   | no  | no   |      |
| • Use of cooking appliances                              | Allows for variation of hours of use (yes (Y/no).  | no                              | no                     | no                       | ?                              | no                                    | no                  | no                          | no                  | no                            | no                        | no                         | no                   | no                      | no                        | no                          | no                                  | no                               | no                                | no  | no  | no   |      |
| • Use of dish- and clothes-washing appliances            | Allows for variation of numbers of loads, temperature settings, etc. (yes (Y/no).                      | •                               | •                      | no                       | ?                              | no                                    | no                  | no                          | no                  | no                            | no                        | no                         | no                   | no                      | no                        | no                          | no                                  | no                               | no                                | no  | no  | no   |      |
| • Use of clothes line                                    | Can be specified (yes (Y/no).  | no                              | no                     | no                       | no                             | no                                    | no                  | no                          | no                  | no                            | no                        | no                         | no                   | no                      | no                        | no                          | no                                  | no                               | no                                | no  | no  | no   |      |
| • Use of miscellaneous appliances                        | Allows for variation of hours of use (yes (Y/no).  | •                               | •                      | no                       | ?                              | no                                    | no                  | no                          | no                  | no                            | no                        | no                         | no                   | no                      | no                        | no                          | no                                  | no                               | no                                | no  | no  | no   |      |
| • Use of lights  | Allows for variation of hours of use (yes (Y/no).  | •                               | •                      | no                       | ?                              | no                                    | no                  | no                          | no                  | no                            | no                        | no                         | no                   | no                      | no                        | no                          | no                                  | no                               | no                                | no  | no  | no   |      |
| • Overall suitability for occupant effect analysis       | Overall efficacy of feature of this type: None, Very Low, Low, Moderate, High.                         | Low                             | Very low               | Moderate                 | Moderate                       | Not functioning at time of evaluation | Very low            | Good                        | Very low            | Moderate                      | None                      | Low                        | Low                  | High                    | Moderate                  | Moderate                    | Moderate                            | Low                              | High                              | Low   | Moderate                                    | None   | High |
| <b>Technical Features-- IAQ</b>                          |  |                                 |                        |                          |                                |                                       |                     |                             |                     |                               |                           |                            |                      |                         |                           |                             |                                     |                                  |                                   |   |   |  |      |
| • Calculations   | Calculates indoor environment metrics (e.g., indoor pollution, humidity) (yes (Y/no).                  | no                              | no                     | no                       | no                             | no                                    | no                  | no                          | no                  | no                            | no                        | no                         | no                   | no                      | no                        | no                          | no                                  | no                               | no                                | no  | no  | no   | no   |
| • Content  | Can be included in IAQ issues (yes (Y/no).   | no                              | no                     | no                       | •                              | no                                    | no                  | no                          | no                  | no                            | no                        | no                         | no                   | no                      | no                        | no                          | no                                  | no                               | no                                | no  | no  | no   | no   |
| <b>Technical Features-- Economic Analysis</b>            |  |                                 |                        |                          |                                |                                       |                     |                             |                     |                               |                           |                            |                      |                         |                           |                             |                                     |                                  |                                   |   |   |  |      |
| • Variable energy prices                                 | Can be specified or revised (yes (Y/no).   | no                              | •                      | •                        | ?                              | no                                    | no                  | no                          | no                  | •                             | LMH                       | no                         | •                    | no                      | no                        | no                          | no                                  | no                               | no                                | some  | •   | no   | no   |
| • Variable energy tariffs (e.g., block rates, TOU rates) | Can be specified (e.g., included block rates) (yes (Y/no).   | no                              | •                      | no                       | ?                              | no                                    | no                  | no                          | no                  | no                            | no                        | no                         | no                   | no                      | no                        | no                          | no                                  | no                               | no                                | some  | •   | no   | no   |
| • Cost-effectiveness indicator(s)                        | LCC  | no                              | no                     | no                       | no                             | no                                    | no                  | no                          | no                  | no                            | no                        | no                         | no                   | no                      | no                        | no                          | no                                  | no                               | no                                | no  | no  | no   | no   |
| • #NAME?   | Outputs include this type of analysis (yes (Y/no).   | no                              | no                     | no                       | no                             | no                                    | no                  | no                          | no                  | no                            | no                        | no                         | no                   | no                      | no                        | no                          | no                                  | no                               | no                                | no  | no  | no   | no   |
| - PBT  | Outputs include this type of analysis (yes (Y/no).   | no                              | no                     | no                       | no                             | no                                    | no                  | no                          | no                  | no                            | no                        | no                         | no                   | no                      | no                        | no                          | no                                  | no                               | no                                | no  | no  | no   | no   |
| - Other  | Outputs include this type of analysis (yes (Y/no).   | no                              | no                     | no                       | no                             | no                                    | no                  | no                          | no                  | no                            | no                        | no                         | no                   | no                      | no                        | no                          | no                                  | no                               | no                                | no  | no  | no   | no   |
| • Rebates, tax incentives, etc.                          | Can be included in calculation (yes (Y/no).  | no                              | no                     | no                       | financing                      | •                                     | no                  | no                          | no                  | no                            | no                        | no                         | no                   | no                      | no                        | no                          | no                                  | no                               | no                                | no  | no  | no   | no   |
| • Early appliance retirement                             | Can be specified (yes (Y/no).  | no                              | no                     | no                       | ?                              | •                                     | no                  | no                          | no                  | no                            | no                        | no                         | no                   | no                      | no                        | no                          | no                                  | no                               | no                                | no  | no  | no   | no   |

Appendix 1. Web-based Energy Calculators: Detailed Characterization

| DESCRIPTION, FEATURE, OR OPTION                       | DEFINITION OF DESCRIPTOR, FEATURE, OR OPTION  | ATCO Energy Sense House (Gerrman) (PG&E) | Energy Calculator (Niagara Mohawk) | Energy Calculator (EPR) | Energy Checkup.com (GeoPraxis) | Energy Checkup.co "HERS Server" | EnergyGuide (Nexus) | EnergyGuide (Full) (Nexus) | Home Energy Advisor (EPALBHL) | Home Energy Checkup (ASE) | Homes Energy Saver (Simple) (LBNL/DOE) | Home Energy (Middle) (LBNL/DOE) | Home Energy Survey (Full) (LBNL/DOE) | Home Energy Survey (PG&E) | HomeVIEW Calculator (KCP) | My Home Energy Calculator (GMP/Red-Wire) | On-Line Home Energy Audit (ICLE) | On-Line Home Energy Survey (SCE) | Residential Energy Bill Analyzer (Elocrotek) | Residential On-Line Energy Audit (Elocrotek) | Residential Energy Audit (Elocrotek) | Year California Home Energy Survey (GeoPraxis) |
|---|---|--|------------------------------------|-------------------------|--------------------------------|---------------------------------|---------------------|----------------------------|-------------------------------|---------------------------|--|---------------------------------|--------------------------------------|---------------------------|---------------------------|--|----------------------------------|----------------------------------|--|--|--------------------------------------|--|
| <b>Energy Analysis Methods and Details</b>            |   |  |                                    |                         |                                |                                 |                     |                            |                               |                           |  |                                 |                                      |                           |                           |  |                                  |                                  |  |  |                                      |  |
| - Simulation  | Calculational method used in tool (Yes (Y/no))  | no                                       | no                                 | no                      | no                             | no                              | ?                   | ?                          | ?                             | no                        | no                                     | no                              | no                                   | no                        | no                        | no                                       | ?                                | no                               | no   | no   | no                                   | no   |
| - Engineering estimates                               | Calculational method used in tool (Yes (Y/no))  | no                                       | no                                 | no                      | no                             | no                              | ?                   | ?                          | ?                             | no                        | no                                     | no                              | no                                   | no                        | no                        | no                                       | ?                                | no                               | no   | no   | no                                   | no   |
| - Walks X hours                                       | Basic power X use (Yes (Y/no))  | no                                       | no                                 | no                      | no                             | no                              | ?                   | ?                          | ?                             | no                        | no                                     | no                              | no                                   | no                        | no                        | no                                       | ?                                | no                               | no   | no   | no                                   | no   |
| - Survey data/knowledge                               | Color-coded (Yes (Y/no))  | no                                       | no                                 | no                      | no                             | no                              | ?                   | ?                          | ?                             | no                        | no                                     | no                              | no                                   | no                        | no                        | no                                       | ?                                | no                               | no   | no   | no                                   | no   |
| - Weather locations                                   | Number of cities or regions. Load calculations take into account weather (Yes (Y/no))   | no                                       | no                                 | no                      | no                             | no                              | ?                   | ?                          | ?                             | no                        | no                                     | no                              | no                                   | no                        | no                        | no                                       | ?                                | no                               | no   | no   | no                                   | no   |
| - Solar gains   | Load calculations take into account weather (Yes (Y/no))  | no                                       | no                                 | no                      | no                             | no                              | ?                   | ?                          | ?                             | no                        | no                                     | no                              | no                                   | no                        | no                        | no                                       | ?                                | no                               | no   | no   | no                                   | no   |
| - Internal gains                                      | Heating energy calculation takes account of "heat" from appliances (Yes (Y/no))   | no                                       | no                                 | no                      | no                             | no                              | ?                   | ?                          | ?                             | no                        | no                                     | no                              | no                                   | no                        | no                        | no                                       | ?                                | no                               | no   | no   | no                                   | no   |
| - Internal gains includes occupancy                   | HVAC energy is influenced by internal gains from appliances or people (Yes (Y/no))  | no                                       | no                                 | no                      | no                             | no                              | ?                   | ?                          | ?                             | no                        | no                                     | no                              | no                                   | no                        | no                        | no                                       | ?                                | no                               | no   | no   | no                                   | no   |
| - Internal gains influence HVAC                       | Calculates whole-house lighting energy based on lamps, hours of use   | no                                       | no                                 | no                      | no                             | no                              | ?                   | ?                          | ?                             | no                        | no                                     | no                              | no                                   | no                        | no                        | no                                       | ?                                | no                               | no   | no   | no                                   | no   |
| - Aggregate analysis                                  | Calculates whole-house lighting energy and presents data on a disaggregated basis. Savings for specific measures take into account system-level interactions (Yes (Y/no)) | no                                       | no                                 | no                      | no                             | no                              | ?                   | ?                          | ?                             | no                        | no                                     | no                              | no                                   | no                        | no                        | no                                       | ?                                | no                               | no   | no   | no                                   | no   |
| - Room-by-room or fixture-by-fixture                  | Calculates whole-house lighting energy and presents data on a disaggregated basis. Savings for specific measures take into account system-level interactions (Yes (Y/no)) | no                                       | no                                 | no                      | no                             | no                              | ?                   | ?                          | ?                             | no                        | no                                     | no                              | no                                   | no                        | no                        | no                                       | ?                                | no                               | no   | no   | no                                   | no   |
| - Retrofits/savings calculations include interactions | Hourly, Daily, Monthly, Annual. Documentation of technical assumptions used in tool (Yes (Y/no))  | no                                       | no                                 | no                      | no                             | no                              | ?                   | ?                          | ?                             | no                        | no                                     | no                              | no                                   | no                        | no                        | no                                       | ?                                | no                               | no   | no   | no                                   | no   |
| - Calculation time-step                               | Hourly, Daily, Monthly, Annual. Documentation of technical assumptions used in tool (Yes (Y/no))  | M  | D                                  | A                       | A                              | H                               | A                   | A, M                       | A, M                          | H                         | H                                      | H                               | H                                    | H, A                      | M                         | A  | A                                | M                                | A  | D  | A, D, M                              | H, A   |
| - Transparency of assumptions and methods             | Documentation of technical assumptions used in tool (Yes (Y/no))  | no                                       | no                                 | no                      | no                             | no                              | ?                   | ?                          | ?                             | no                        | no                                     | no                              | no                                   | no                        | no                        | no                                       | ?                                | no                               | no   | no   | no                                   | no   |
| <b>Defaults</b>                                       |   |  |                                    |                         |                                |                                 |                     |                            |                               |                           |  |                                 |                                      |                           |                           |  |                                  |                                  |  |  |                                      |  |
| - Location-dependent defaults                         | Default insulation levels, energy prices, etc. are location-specific (Yes (Y/no))   | no                                       | no                                 | no                      | no                             | no                              | ?                   | ?                          | ?                             | no                        | no                                     | no                              | no                                   | no                        | no                        | no                                       | ?                                | no                               | no   | no   | no                                   | no   |
| - Pre-defined prototype library                       | Defaults are building energy-specific (Yes (Y/no))  | no                                       | no                                 | no                      | no                             | no                              | ?                   | ?                          | ?                             | no                        | no                                     | no                              | no                                   | no                        | no                        | no                                       | ?                                | no                               | no   | no   | no                                   | no   |
| - HVAC-vintage-driven defaults                        | Default equipment efficiencies are a function of vintage (Yes (Y/no))   | no                                       | no                                 | no                      | no                             | no                              | ?                   | ?                          | ?                             | no                        | no                                     | no                              | no                                   | no                        | no                        | no                                       | ?                                | no                               | no   | no   | no                                   | no   |
| - Appliance-vintage-dependent defaults                | Default end-use consumption is a function of appliance age (Yes (Y/no))   | no                                       | no                                 | no                      | no                             | no                              | ?                   | ?                          | ?                             | no                        | no                                     | no                              | no                                   | no                        | no                        | no                                       | ?                                | no                               | no   | no   | no                                   | no   |

Appendix 1. Web-based Energy Calculators: Detailed Characterization

| DESCRIPTION, FEATURE, OR OPTION  | DEFINITION OF DESCRIPTION, FEATURE, OR OPTION   | ATCO Energy Sense (Beaman) (PG&E) Mohawk | Energy Calculator (Niagara Mohawk) | Energy Calculator (Epic) | Energy Checkup (EPRI) (GeoPraxis) | Energy Checkup (HERS Server) | Energy Checkup (HERS Server) | Energy Guide (Full) (Nexus) | Energy Guide (Detailed) (Nexus) | Energy Tracker (Nexus) | Energy Tracker (Nexus) | Energy Advisor (Full) (EPALBHL) | Home Energy Checkup (ASE) | Home Energy Checkup (Simple) (LBNL/DOE) | Home Energy Checkup (Middle) (LBNL/DOE) | Home Energy Checkup (Full) (LBNL/DOE) | Home Energy Survey (PG&E) | Home Energy Survey (PG&E) | HomeVIEW Calculator (KCP&L) | My Home (GMP/Red-Wire) | On-Line Energy Audit (SCE) | On-Line Energy Calculator (BUckeye) (Enecom) | Residential Energy Bill Analyzer (Enecom) | Residential On-Line Energy Audit (Enecom) | California Home Energy Survey (GeoPraxis) | Your California Home Energy Survey (GeoPraxis) |
|--|---|--|------------------------------------|--------------------------|-----------------------------------|------------------------------|------------------------------|-----------------------------|---------------------------------|------------------------|------------------------|---------------------------------|---------------------------|---|---|---------------------------------------|---------------------------|---------------------------|-----------------------------|------------------------|----------------------------|--|---|---|---|--|
| <b>Outputs</b>   |   |  |                                    |                          |                                   |                              |                              |                             |                                 |                        |                        |                                 |                           |   |   |                                       |                           |                           |                             |                        |                            |  |   |   |   |  |
| • Energy consumption   | Outputs include this information (yes (y/no), no (n))   | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • Peak electricity demand  | Outputs include this information (yes (y/no), no (n))   | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • Energy savings   | Outputs include this information (yes (y/no), no (n))   | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • Energy cost/savings  | Outputs include this information (yes (y/no), no (n))   | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • Cost by fuel type  | Outputs include this information (yes (y/no), no (n))   | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • End-use breakdowns   | Outputs include this information (yes (y/no), no (n))   | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • Retrofit recommendations   | Outputs include this information (yes (y/no), no (n))   | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • Cost-associated measures   | Outputs include this information (yes (y/no), no (n))   | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • Ranking of measures  | Outputs include this information (yes (y/no), no (n))   | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • Flexibility of benefit cost assumptions                                      | Key inputs (e.g., measure costs) can be specified (yes (y/no), no (n))  | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • Benchmarking   | Outputs include this information (yes (y/no), no (n))   | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • Run comparisons  | Separate run results can be compared on same output information (yes (y/no), no (n))                                    | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • HVAC system sizing   | Outputs include this information (yes (y/no), no (n))   | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • Water consumption  | Outputs include this information (yes (y/no), no (n))   | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • Emissions  | Outputs include this information (yes (y/no), no (n))   | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • Output time-step   | Time-step for outputs: Hourly, Daily, Monthly, Quarterly, Annually  | M  | A                                  | A                        | A                                 | H,D,M,A                      | A                            | A                           | A                               | A                      | A                      | A                               | A                         | A                                       | A                                       | A                                     | A                         | A                         | A                           | A                      | M                          | A  | M   | A   | A   | A  |
| • Graphical outputs  | Outputs include this information (yes (y/no), no (n))   | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • Stored/retrievable runs  | Previous runs can be re-used (yes (y/no), no (n))   | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| <b>User and Decision-Support Services</b>                                      |   |  |                                    |                          |                                   |                              |                              |                             |                                 |                        |                        |                                 |                           |   |   |                                       |                           |                           |                             |                        |                            |  |   |   |   |  |
| • On-site text-based content   | Presence of feature or content (yes (y/no), no (n))   | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • FAQs   | Number: 0   | 0  | 0                                  | 0                        | 0                                 | 0                            | 0                            | 0                           | 0                               | 0                      | 0                      | 0                               | 0                         | 0                                       | 0                                       | 0                                     | 0                         | 0                         | 0                           | 0                      | 0                          | 0  | 0   | 0   | 0   | 0  |
| • Glossary   | Presence of feature or content (yes (y/no), no (n))   | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • General program help   | Presence of feature or content (yes (y/no), no (n))   | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • Context-sensitive help   | Presence of feature or content (yes (y/no), no (n))   | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • Site search  | Presence of feature or content (yes (y/no), no (n))   | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • Case studies   | Presence of feature or content (yes (y/no), no (n))   | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • Non-energy benefits  | Presence of feature or content (yes (y/no), no (n))   | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • Links to external energy-related Web sites                                   | Number: 0   | 0  | 0                                  | 0                        | 0                                 | 0                            | 0                            | 0                           | 0                               | 0                      | 0                      | 0                               | 0                         | 0                                       | 0                                       | 0                                     | 0                         | 0                         | 0                           | 0                      | 0                          | 0  | 0   | 0   | 0   | 0  |
| • E-mail support   | Feature is supported for the tool (yes (y/no), no (n))  | no                                       | no                                 | no                       | no                                | no                           | no                           | no                          | no                              | no                     | no                     | no                              | no                        | no                                      | no                                      | no                                    | no                        | no                        | no                          | no                     | no                         | no   | no  | no  | no  | no   |
| • Overall helpfulness of outputs and other information in supporting decisions | Overall helpfulness of outputs and other information in supporting decisions (this type: Very Low, Low, Moderate, High) | Low                                      | None                               | Low                      | None                              | None                         | None                         | Moderate                    | Moderate                        | Moderate               | Moderate               | Moderate                        | Moderate                  | Moderate                                | Moderate                                | Moderate                              | Moderate                  | Moderate                  | Low                         | None                   | Low                        | Low  | Moderate                                  | Low                                       | Low                                       | Low  |

# WEB-BASED RESIDENTIAL ENERGY CALCULATORS: Additional Notes

The following descriptive information primarily augments that in the detailed matrix, and provides clarifying information where noted in the matrix.

## ATCO Energy Sense House (Atco Gas, Canada)

[http://www.atcogas.com/customer\\_services/Calculator/Design/works.html](http://www.atcogas.com/customer_services/Calculator/Design/works.html)

[EnergySense@atco.com](mailto:EnergySense@atco.com)

### Special Features:

- Very appealing and dynamic interface
- Results constantly visible and updated
- Every question has a default

### Weaknesses:

- Many simplifications

### Notes:

## BEACON (Oarsman)

<http://audit.btutilities.com>

[support@oarsman.com](mailto:support@oarsman.com)

Michael Davis

### Special Features:

- One of the few sites that explicitly recognizes interactions in its savings calculation reports.
- Also available as disk-based tool

### Weaknesses:

- Site unstable. Often fails to save data or perform calculations.
- Cannot be used in Netscape (only Internet Explorer)
- Questionable outputs. Stated \$4/year savings for reducing water heater temperature and \$2/year for water heater blanket.
- Forms were not coherent (questions were largely masked). Reported to tool host; no response received.
- Most inputs specified as ranges
- Window area or number not asked, just overall size (small, medium, large)
- User cannot go back and change inputs after reaching results page
- Energy prices cannot be varied. Assumes gas at \$4.35/ccf. Electric price unknown. We have been pointed to another version where prices can be varied. Will evaluate for the final report.
- Very few measures included in the retrofit recommendations (ranked by energy savings)

### Calculations:

- Very long calculation run time (~5 minutes)

### Notes:

- Also found under "EnergyBill.com", "BEACON" calculator
- Test site is a version of the product licensed to Bryan Texas Utilities. Set zip code to actual zip when registering. Another version can be found at: <http://cps.oarsman.com>
- Also available in identical disk-based version

## Ecalc (PG&E)

<http://www.pge.com/ecalc/>

[pecinfo@pge.com](mailto:pecinfo@pge.com)

### Special Features:

- One of the most simple in design. In an austere single screen it contained 130 user inputs, including 41 miscellaneous uses (more than most sites). Nearly every end use offered usage-driven variables (occupant effects) and the assumptions were completely explicit.

- Nearly every end use offered usage-driven variables (occupant effects) and the assumptions were completely explicit.
- Feedback was instantaneous.

**Weaknesses:**

- Significant deficiencies, including no building size/climate/envelope variables, no energy savings analysis or decision-support information. This site also exemplifies the potential for inadvertent user error, e.g. arising from ambiguity about whether specified hours of use apply to a season or to an entire year. If the latter, then the user is implicitly required to perform a very technically challenging “weighting” process in selecting inputs.
- Report will not print
- Site repeatedly crashes browser
- Not stated what weather zone (within the large PG&E service territory) is assumed.
- Disregards climate, building envelope, building size, and energy-savings calcs
- Very limited vintage-specific inputs

**Calculations:**

- Subtotals disagree with grand total by 30%!

**Notes:**

## Energy Calculator (EPRI)

<http://www.energyint.com/ec>

[rtidball@energyint.com](mailto:rtidball@energyint.com)

**Special Features:**

- Immediate calcs, with explicit utilization assumptions shown
- Separates gas and electricity from relevant end uses (e.g. furnaces)

**Weaknesses:**

- Does not sum results (requires tedious spreadsheet)
- Difficult to specify many inputs (e.g. hours per year of furnace operation)
- Difficult to extrapolate some results to annual numbers

**Notes:**

## Energy Calculator (Niagra Mohawk)

<http://www.niagaramohawk.com/house/enrghome/calculator.asp>

[customeremail@niagaramohawk.com](mailto:customeremail@niagaramohawk.com)

**Special Features:**

**Weaknesses:**

Only applicable to NiMo customers

**Notes:**

## EnergyCheckup.com (GeoPraxis)

<http://www.energycheckup.com/content/homeowner.asp>

[John Kennedy <jfk@geopraxis.com>](mailto:John.Kennedy@geopraxis.com)

**Special Features:**

**Weaknesses:**

Tool is under construction; many features (end uses) not working.

**Notes:**

Unclear what the "HERS" version is. Developer did not provide URL for our evaluation. All answers are developer-provided, without LBNL verification.

## EnergyGuide (Nexus)

<http://www.energyguide.com/>

[info@energyguide.com](mailto:info@energyguide.com)

**Special Features:**



- Extensive reports, although often confusing
- Saves final report on local computer as an html file, which can be opened without re-entering the site.
- Benchmarking feature
- Groups recommendations by "Low/No" cost, "Needs Investment", "Tips", and "Not Cost- Justified"
- Links to contractors, energy providers, etc.
- Separate calculators for fridges, washers, and room ac not evaluated.

### **Weaknesses:**

- Confusing navigation environment, and text legibility poor (especially with AOL browser).
- Heavily e-commerce oriented, e.g. lighting results include bulb purchasing information; offers to change energy provider
- Limited value to HVAC sizing module, as it does not account for internal load variations.
- Retrofit recommendations included zero-savings measures (heat pump) and evidenced some inconsistencies from other parts of the site (e.g. the lighting module suggested replacing 10 lamps; the main site said there were no applicable retrofits). \$15-\$25 cost estimate for duct sealing dubious. Faucet aerators show no water savings.

### **Calculations:**

- The site generated different results on each visit
- Spot checks of reasonableness indicated multiple problems with calculations
- In some runs, the sum of the end-use totals was significantly (up to one-third) less than the grand total reported by the tool.
- Whole-house savings can only be determined from the "Fast Track" version, because for the other two levels results are given measure-by-measure (not accounting for interactions).

### **Notes:**

- Utilities pay license fee for use; free to utility customers
- Electricity savings, emissions and payback time are provided for the refrigerator and washer mini-calculators

## **Home Energy Advisor (EPA/LBNL)**

<http://hit.lbl.gov>

[Mjpinckard@lbl.gov](mailto:Mjpinckard@lbl.gov)

### **Special Features:**

- Only tool reviewed that has flexible and detailed cost-effectiveness evaluation module.
- Only tool allowing specification of ENERGY STAR efficiency levels
- Utility bill calibration optional.
- Most extensive recommendations and cost-effectiveness information of any tool reviewed

### **Weaknesses:**

- Highly simplified (limited) building description, e.g. "are your walls insulated? Yes/no/don't know"
- Output is only graphical and limited, with no tabular information.

### **Notes:**

- Formerly the "Home Improvement Tool". Now integrated with EPA's Home Improvement Toolbox, which contains other relevant modules, including a home benchmarking tool (the Home Energy Yardstick) and information on non-energy issues (e.g. indoor air quality)
- Discussion is underway to merge this site with the Home Energy Saver.
- Utility bill calibration was suppressed during the energy calculation.
- Number of screens and questions noted excludes utility bill input screen

## **Home Energy Checkup (ASE)**

<http://www.ase.org/checkup/home/main.html>

[info@ase.org](mailto:info@ase.org)

### **Special Features:**

- Instantaneous feedback for any change of measures.
- Very limited building description

### **Weaknesses:**

- Inputs are ranges rather than point values.

### **Calculations:**

- based on lookups from surveys; highly approximate

- misc end uses not recognized

**Notes:**

## Home Energy Saver (LBNL/DOE)

<http://HomeEnergySaver.lbl.gov>

[Emills@lbl.gov](mailto:Emills@lbl.gov)

### Special Features:

- Three increasingly detailed user levels
- More end-use specificity and flexibility in bldg. description than other sites reviewed
- Far more decision support content and web links than other calculators.
- Only tool reviewed with documented assumptions and calculation methods
- Only tool reviewed that reports water consumption

### Weaknesses:

- User interface lacks interest
- Many appliances lack vintage variable
- Relatively time consuming to complete detailed audit
- Features for professional users could be more extensive

**Notes:**

## Home Energy Survey (PG&E)

[http://www.pge.com/003\\_save\\_energy/003a\\_res/003a2b\\_home\\_survey.shtml](http://www.pge.com/003_save_energy/003a_res/003a2b_home_survey.shtml)

[pecinfo@pge.com](mailto:pecinfo@pge.com)

### Special Features:

### Weaknesses:

- Requires PG&E Account number to use
- Tedious data entry (22 input screens) and no navigation

**Notes:**

## Home View (Volt VIEWtech)

<http://voltviewtech.com/homeview.htm>

[DMitchell@voltview.com](mailto:DMitchell@voltview.com) or [orjmclain@voltview.com](mailto:orjmclain@voltview.com)

Debbie Mitchell

### Special Features:

- Many recommendations, but few quantified

### Weaknesses:

- Only two savings recommendations were quantified: heating/cooling and hot water
- Specific recommendations do not appear to be linked to actual home description (e.g. specified water heater wrap, but the tool recommended wrapping water heater)

**Notes:**

- Window area not asked, just number of windows
- Energy prices can be varied on versions implemented by specific utilities and, to some, extent, tariff structure
- Number of weather locations depends on utility hosting the site

## KCPL Electricity Calculator (Kansas City Power and Light)

<http://www.kcpl.com/calc/index.html>

[comments@kcpl.com](mailto:comments@kcpl.com)

### Special Features:

- User can vary wattage and hours of use for all end uses
- Interesting grouping of end uses (e.g. "Entertainment")
- Extensive coverage of miscellaneous appliances
- instant feedback for each end use

### Weaknesses:

- Electricity only

- Limited to two states (Kansas & Missouri)
- Site not stable
- Difficult to navigate: must follow prescribed, linear pathway.

**Notes:**

## My Home (Green Mountain Power)

<http://www.gmpvt.com/energy101/myhome.shtml>  
[rnadworny@KSVC.com](mailto:rnadworny@KSVC.com)

### Special Features:

- Clever interface; fun to use (but gimmicky and time-consuming)

### Weaknesses:

- Calculations independent of house size
- Walls are movable, but this appears to have no effect on energy use
- Electric Only
- Meaning of hours of use unclear (annual average; seasonal)
- Long wait times to load home or change to different floor

**Notes:**

- Very new tool

## On-Line Home Energy Audit (ICLEI)

<http://www.iclei.org/audit/index.htm>  
[sbaird@iclei.org](mailto:sbaird@iclei.org)

Stuart Baird

### Special Features:

### Weaknesses:

- Tailored strictly for Ontario Canada
- Functionality uncertain: e.g. varying utility bill did not influence results
- Results only apply to heating, although questions are asked about other end uses.
- CFLs not an option; no lamp under 60watts can be specified. Minimum furnace efficiency is 78%.

**Notes:**

- ICLEI = The International Council for Local Environmental Initiatives
- Beta version

## On-Line Home Energy Survey (SCE)

<https://xensecure.xenergy.com/clients/sce/production/recap.nsf>  
[tdietz@xenergy.com](mailto:tdietz@xenergy.com)

Travis Dietz

### Special Features:

- Interesting occupant-related questions such as % of year house occupied, and number of people home during day. Percentage of the time during that heating and cooling equipment (including fans) is used. Clothesline. Number of refrigerators *plugged in*. Numbers of meals prepared at home. Few/some/most of the lights on when someone home.
- Nice/clean interface; easy to navigate.
- Only tool that asked about time of day of appliance use (clotheswashers and dryers, showers/baths, spas, pool filters).
- Only tool that appears to let the presence of a solar water heater affect the calculation.
- Downloadable report

### Weaknesses:

- Requires SCE account number to use
- Asks many fuel-dependent questions, but only provides answers for electricity use.
- Savings tips are extremely limited and non-comprehensive (caulk and weatherstrip, CFLs, and motion sensors for outdoor lighting)
- "View Report" option failed about half the time, forcing re-initiation of session.

**Notes:**

## Residential Energy Bill Analyzer (Electrotek)

<http://www.pqsoft.com/reba/example/index.htm>

Sandy Smith

[sandy@electrotek.com](mailto:sandy@electrotek.com)

### Special Features:

- Attractive interface
- Results show on every page, including "unallocated" portion of actual bill (it's a bill-disaggreg program)
- Allows user to do what-if's on every single question (appliance choice and utilization)
- Allows for multiple air conditioners, water heaters, etc.
- Asks about maintenance (e.g. changing filters)
- Can view results for single month or entire year, by end use
- Uses Princeton Scorekeeping Method (PRISM) to weather-normalize utility bills

### Weaknesses:

- Bill disaggregation only
- Awkward end-use definitions (heating and cooling combined; laundry and cooking not included in "appliances")
- Recommendations for HVAC limited to 0&M. Rec's generally weak (e.g. use glass baking dishes to save cooking energy).
- Only applicable to one climate (verify)
- Requires viewing 5 screens before getting to home input area
- Heating cannot be specified without air conditioning
- Does not allow fractional weekly hours of use for cooking appliances (include toaster oven, microwave)
- Most result graphics print poorly, or not at all

### Calculations:

- Very high "unassigned" proportion of total bill (+40%)

- Numerous apparent weaknesses in methodology: lighting use and heat/cool INCREASE with decreased floor area

### Notes:

- Has been implemented on 4 utility websites
- Viewed version implemented on FP&L's website. Did not include certain features mentioned in a spec provided by the developers.
- Some utility versions have TOU prices and tariff-specific rate structures
- Developers very responsive to questions
- See <http://www.pqsoft.com/reba/about.htm> for technical info
- Version evaluated had an interface called "Home Energy Survey", developed for FP&L. See <http://fplreba.electrotek.com/webapp/REBA/HomeEnergySurvey>

## Residential Energy Calculator (Buckeye)

<http://buckeye.apogee.net/rescalc/>

[webmaster@apogee.net](mailto:webmaster@apogee.net)

### Special Features:

- Can send results via email
- Highly simple input environment (only one screen and 16 questions)

### Weaknesses:

- Vastly simplified

### Calculations:

- Results adjusted to reflect actual energy prices

### Notes:

- Contacted developers with questions about climate

## Residential Online Energy Audit (Enercom)

[www.energydepot.com/hometown/riverside\\_res](http://www.energydepot.com/hometown/riverside_res)

Al Lemmer

[lemmera@enercomusa.com](mailto:lemmera@enercomusa.com)

### **Special Features:**

- Convenient appliance-specific calculators.
- Nice feature letting user specify "other" end uses (watts, hours used, fuel, etc.).
- Extensive FAQs (100 questions)
- Very thorough context-sensitive help
- Utility bill calibration is optional

### **Weaknesses:**

- Some changes to selections (e.g. heating system type) were not saved.
- Many inputs are ranges rather than point values.
- Text legibility poor (small font size).
- Relatively time consuming to complete detailed audit
- Requires that range and oven use same fuel

### **Calculations:**

- Developers instructed us to use Riverside utilities version of tool and test home's zip code
- Initial run contained major error (\$7000 electricity bill). Was difficult to locate source of bad input.
- Grand total is approximately 5% higher than the sum of end-use subtotal consumption values.
- Base tool uses Riverside's energy prices. Results shown in prediction check adjusted for actual rates for test house. Bill disaggregation module supplied only with August data.

### **Notes:**

- Uses modified degree-data method for heat/cool calculations
- Used demo site for evaluation
- Utilities pay license fee for use; free to utility customers.
- Showed only \$2/year savings from duct sealing/insulation

## **Your California Home (GeoPraxis/CEC)**

<http://www.idea-server.com/cahome/>

John Kennedy

[jfk@Geopraxis.com](mailto:jfk@Geopraxis.com)

### **Special Features:**

- Two user levels (uncommon feature among the tools reviewed)
- Good transition between simple and detailed input environments

### **Weaknesses:**

- Bugged down when trying to revise answers in the quick version
- Quick version has one input page per question -- many screens. Awkward javascript rollovers; difficult to use.
- Seeing end-use breakdowns or savings estimates requires mousing over icons of the various appliances. No comprehensive report.
- California-specific
- Tool does not allow use of "back" button

### **Calculations:**

- Based on look-up analysis using previous DOE-2 runs
- Extremely long run time for "Expert" version (6 minutes)
- "Quick Answer version" froze and would not give results ("Javascript error") and retrofit results not available on site. Developers discovered an error and repaired the site in response to our query.
- Predicted cost is lower for larger house (quick version)

### **Notes:**

- Formidable licensing agreement to be read before calculation will run
- Help email feature did not work



Appendix 2. Disk-based Energy Calculator: Detailed Characterization

| Descriptor, Feature, or Option                            | ANW:m (CHF) | BTU Analysis REG (Enriched) (Tons) | Energy-10 (MREL, (Enriched)) (LBN) | ENERPASS (Enriched) | EZDOE (Elite Software) (E-Z) | Heatloss (Thomas) (H) | HOT2000 (MRC) (M) | i-Works (MicroWorks) (M) | MEChce K (MicroWorks) (M) | Microspas (Eiterom) (M) | NEAT (CHN) (M) | REMRate (Simplified) (AEC) (M) | REMRate (Detailed) (AEC) (M) | ReRatePro (PSEC) (M) | TREAT (Tham Engineering) (M) | VisualDOE (Elite) (M) |
|---|-------------|------------------------------------|------------------------------------|---------------------|------------------------------|-----------------------|-------------------|--------------------------|---------------------------|-------------------------|----------------|--------------------------------|------------------------------|----------------------|------------------------------|-----------------------|
| <b>Technical Features—HVAC Systems</b>                    |             |                                    |                                    |                     |                              |                       |                   |                          |                           |                         |                |                                |                              |                      |                              |                       |
| • Heating system type(s)                                  | 15          | 0                                  | 6                                  | 9                   | 6                            | 4                     | 23                | 0                        | 4                         | 4                       | 28             | 12                             | 12                           | 9                    | 13                           | 9                     |
| • Cooling system type(s)                                  | 0           | 0                                  | 2                                  | 2                   | 2                            | 0                     | 4                 | 0                        | 2                         | 4                       | 4              | 7                              | 7                            | 4                    | 1                            | 4                     |
| • Secondary heating                                       | •           | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • HVAC system efficiency                                  | •           | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Duct location/insulation/sealing                        | •           | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Ceiling fans  | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Mechanical fans   | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Overall suitability for building envelope/HVAC analysis | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| <b>Technical Features—Major Appliances</b>                |             |                                    |                                    |                     |                              |                       |                   |                          |                           |                         |                |                                |                              |                      |                              |                       |
| • Water heating   | 13          | 0                                  | 0                                  | 3                   | 1                            | 0                     | 5                 | 0                        | 0                         | 2                       | 2              | 18                             | 18                           | 3                    | 3                            | 4                     |
| • Types   | 3           | 0                                  | 0                                  | 3                   | 1                            | 0                     | 5                 | 0                        | 0                         | 2                       | 2              | 5                              | 5                            | 3                    | 3                            | 4                     |
| • Solar water heating                                     | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Variables (e.g., support, recovery factor)              | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Water conservation options                              | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Refrigerator  | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Refrigerator and freezer sizes                          | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Multiple refrigerators and/or freezers                  | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Stove   | •           | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Dishwasher  | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Dishwasher  | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Clothes washer  | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Clothes dryer   | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Hot/tub or spa  | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| <b>Technical Features—Miscellaneous End Uses</b>          |             |                                    |                                    |                     |                              |                       |                   |                          |                           |                         |                |                                |                              |                      |                              |                       |
| • Miscellaneous end uses (gas and electric)               | 0           | 0                                  | 0                                  | 0                   | 0                            | 0                     | 0                 | 0                        | 0                         | 0                       | 0              | 0                              | 0                            | 1                    | 2                            | 24                    |
| • Usage-driven end uses                                   | 0           | 0                                  | 0                                  | 0                   | 0                            | 0                     | 0                 | 0                        | 0                         | 0                       | 0              | 0                              | 0                            | 1                    | 2                            | 24                    |
| • Miscellaneous gas end uses                              | •           | •                                  | •                                  | •                   | •                            | •                     | •                 | •                        | •                         | •                       | •              | •                              | •                            | •                    | •                            | •                     |
| • Module to describe generic appliances                   | •           | •                                  | •                                  | •                   | •                            | •                     | •                 | •                        | •                         | •                       | •              | •                              | •                            | •                    | •                            | •                     |
| <b>Technical Features—Occupant Effects</b>                |             |                                    |                                    |                     |                              |                       |                   |                          |                           |                         |                |                                |                              |                      |                              |                       |
| • Overall suitability for appliance analysis              | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Low, Moderate, High                                     | L           | VL                                 | VL                                 | VL                  | VL                           | VL                    | M                 | N                        | N                         | N                       | M              | VL                             | H                            | M                    | H                            | L                     |
| • Can be specified (yes (y/no))                           | •           | •                                  | •                                  | •                   | •                            | •                     | •                 | •                        | •                         | •                       | •              | •                              | •                            | •                    | •                            | •                     |
| • Anns of occupants                                       | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Occupants home during day                               | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Movable window insulation                               | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Movable window shades                                   | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Thermostat type(s)                                      | •           | •                                  | •                                  | •                   | •                            | •                     | •                 | •                        | •                         | •                       | •              | •                              | •                            | •                    | •                            | •                     |
| • Standard  | •           | •                                  | •                                  | •                   | •                            | •                     | •                 | •                        | •                         | •                       | •              | •                              | •                            | •                    | •                            | •                     |
| • Setback option  | •           | •                                  | •                                  | •                   | •                            | •                     | •                 | •                        | •                         | •                       | •              | •                              | •                            | •                    | •                            | •                     |
| • Programmable  | •           | •                                  | •                                  | •                   | •                            | •                     | •                 | •                        | •                         | •                       | •              | •                              | •                            | •                    | •                            | •                     |
| • Zone heating/cooling                                    | •           | •                                  | •                                  | •                   | •                            | •                     | •                 | •                        | •                         | •                       | •              | •                              | •                            | •                    | •                            | •                     |
| • Water heater setting                                    | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Tap water consumption                                   | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Use of cooking appliances                               | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Use of dish- and clothes-washing appliances             | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Use of clothes line                                     | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Use of miscellaneous appliances                         | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Use of lights   | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Overall suitability for occupant effect analysis        | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Low, Moderate, High                                     | VL          | VL                                 | M                                  | H                   | M                            | L                     | M                 | VL                       | N                         | VL                      | M              | M                              | M                            | M                    | H                            | M                     |
| <b>Technical Features—IAQ</b>                             |             |                                    |                                    |                     |                              |                       |                   |                          |                           |                         |                |                                |                              |                      |                              |                       |
| • Calculations  | •           | •                                  | •                                  | •                   | •                            | •                     | •                 | •                        | •                         | •                       | •              | •                              | •                            | •                    | •                            | •                     |
| • Comfort   | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Others information (text on IAQ issues) (yes (y/no))    | •           | •                                  | •                                  | •                   | •                            | •                     | •                 | •                        | •                         | •                       | •              | •                              | •                            | •                    | •                            | •                     |
| <b>Technical Features—Economic Analysis</b>               |             |                                    |                                    |                     |                              |                       |                   |                          |                           |                         |                |                                |                              |                      |                              |                       |
| • Overall suitability for economic analysis               | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Variable energy tariffs (e.g., block rates, TOU rates)  | •           | •                                  | •                                  | •                   | •                            | •                     | •                 | •                        | •                         | •                       | •              | •                              | •                            | •                    | •                            | •                     |
| • Cost-effectiveness indicators                           | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • LCC   | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • IRR?  | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • PBT?  | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |
| • Other   | SIR         | no                                 | no                                 | no                  | no                           | no                    | no                | no                       | no                        | no                      | SIR            | SIR                            | SIR                          | SIR                  | SIR                          | no                    |
| • Rebates, tax incentives, etc.                           | •           | •                                  | •                                  | •                   | •                            | •                     | •                 | •                        | •                         | •                       | •              | •                              | •                            | •                    | •                            | •                     |
| • Early appliance retirement                              | no          | no                                 | •                                  | •                   | •                            | no                    | •                 | no                       | no                        | no                      | •              | •                              | •                            | •                    | •                            | •                     |

Appendix 2. Disk-based Energy Calculator: Detailed Characterization

| DESCRIPTION: FEATURE, OR OPTION                                      | DEFINITION OF DESCRIPTION: FEATURE, OR OPTION  | BTU Analysis (Akwarm (AHC)) | Energy-10 (REG (Enhanced Tree)) | ENERPASS (Enermodal Software) | EZDOE (Elite Software & Assoc.) | Heatloss (Thomas Hott2000 (MicroWorks)) | J-Works (MicroWorks) | MEChc (USDOE) | Microppas (Enercom p) | NEAT (ORNL) | REMRate (Simplified) (AEC) | REMRate (Detailed) (AEC) | ResRatePro (FSEC) | TREAT (Talem Engineering) | VisualDOE (Eley Assoc.) |
|--|--|-----------------------------|---------------------------------|-------------------------------|---------------------------------|---|----------------------|---------------|-----------------------|-------------|----------------------------|--------------------------|-------------------|---------------------------|-------------------------|
| <b>Energy Analysis Methods and Details</b>                           |  |                             |                                 |                               |                                 |   |                      |               |                       |             |                            |                          |                   |                           |                         |
| Type of calculation(s)   | Calculated method used in tool (yes (y)/no (n))  | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Engineering estimates  | Calculated method used in tool (yes (y)/no (n))  | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Watts X hours  | Basic power X use calculation (yes (y)/no (n))   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Survey data/lookups  | Number of calculation methods used in tool (yes (y)/no (n))  | 274                         | 0                               | 239                           | 111                             | 250                                     | 0                    | 91            | 754                   | 16          | 216                        | 403                      | 239               | 239                       | 256                     |
| Weather locations  | Number of calculation methods used in tool (yes (y)/no (n))  | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Solar gains  | Weather locations take into account solar heat gains (yes (y)/no (n))  | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Internal gains   | Load calculations take into account heat from occupants (yes (y)/no (n))   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Occupants  | Load calculations take into account heat from appliances (yes (y)/no (n))  | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Appliances   | Calculates whole-house lighting energy based on user inputs (e.g., number of lamps, hours of use).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Lighting   | Calculates whole-house lighting energy and presents results on a disaggregated basis.  | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Aggregate analysis   | Savings for specific measures take into account system-level interactions with other measures (e.g., lighting savings result in lower cooling loads and interactions). | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Room-by-room or fixture-by-fixture                                   | Time-step for calculations: Hourly, Daily, Monthly, Annual.  | A                           | A                               | H                             | H                               | H                                       | A                    | M             | A                     | M           | A                          | Seasonal                 | Seasonal          | H                         | H, M, A                 |
| Retrofit/savings calculations include interactions                   | Documentation of technical assumptions/data used in tool (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Calculation time-step  | Default includes typical energy prices, etc., are location-specific (yes (y)/no (n)).  | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Transparency of assumptions and methods                              | Default equipment efficiencies are a function of age (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Location-dependent defaults  | Default end-use consumption is a function of appliance age (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Pre-defined prototype library  | Outputs include this information (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| HVAC-vintage-driven defaults   | Outputs include this information (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Appliance-vintage-dependent defaults                                 | Outputs include this information (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Energy consumption   | Outputs include this information (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Peak electricity demand  | Outputs include this information (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Energy savings   | Outputs include this information (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Energy conservation  | Outputs include this information (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Cost by fuel type  | Outputs include this information (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| End-use breakdowns   | Outputs include this information (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Retrofit recommendations   | Key inputs (e.g., measure costs) can be specified (yes (y)/no (n)).  | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Non-cost measures  | Outputs include this information (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Ranking of measures  | Outputs include this information (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Flexibility of retrofit cost assumptions                             | Outputs include this information (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Benchmarking   | Outputs include this information (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Run comparisons  | Outputs include this information (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| HVAC system sizing   | Outputs include this information (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Water consumption  | Outputs include this information (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Emissions  | Time-step for outputs: Hourly, Daily, Monthly, Annual.   | M, A                        | A                               | H, M, A                       | D, M, A                         | H, D, M, A                              | A                    | M, A          | A                     | A           | A                          | A                        | H, M, A           | M, A                      | H, M, A                 |
| Output time-step   | Previous runs can be reused (yes (y)/no (n)).  | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Graphical outputs  | Presence of feature or content (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Stored/retrievable runs  | Presence of feature or content (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Internal tool-based content  | Presence of feature or content (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Global   | Presence of feature or content (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| General program help   | Presence of feature or content (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Context-sensitive help   | Presence of feature or content (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Help search  | Presence of feature or content (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Help search and output sets  | Presence of feature or content (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Case studies   | Presence of feature or content (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Non-energy benefits  | Presence of feature or content (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Links to external energy-related Web sites                           | Presence of feature or content (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Email support  | Presence of feature or content (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |
| Consistency of outputs and other information in supporting decisions | Presence of feature or content (yes (y)/no (n)).   | no                          | no                              | no                            | no                              | no                                      | no                   | no            | no                    | no          | no                         | no                       | no                | no                        | no                      |



# **DISK-BASED RESIDENTIAL ENERGY CALCULATORS: Additional Notes**

**The following descriptive information primarily augments that in the detailed matrix, and provides clarifying information where noted in the matrix.**

## **AkWarm (Alaska Housing Finance Corporation)**

### **Special Features:**

- Partially a home energy rating tool.
- Has straightforward input style.
- Contains revisable, expandable wall, window, heating system, etc., libraries.

### **Limitations:**

- Considers Alaskan locations only.
- Does not consider cooling loads and systems.

### **Notes:**

- Numbers of input screens and inputs recorded include specification of one of each component type.
- Although number of stories cannot be specified, building height can be specified.
- Although dimensions of shading objects cannot be specified, generic exterior shading can be specified.

## **BTU Analysis REG (Enchanted Tree Software)**

### **Special Features:**

- Has simplified, one-question-per-screen input style.

### **Limitations:**

- Calculates HVAC equipment sizes only.
- Requires significant preparation of inputs prior to entry.
- Some input descriptions potentially misleading.

### **Notes:**

## **Energy-10 (NREL, LBNL)**

### **Special Features:**

- Cost reduced to \$50 with \$200 educational discount.
- Contains revisable, expandable materials and glazing libraries.
- Can model thermal mass, photovoltaic system.

### **Limitations:**

- Primarily a commercial building tool.
- Strictly a design option comparison tool.
- Input limitations affect calculational precision.

### **Notes:**

- Number of inputs recorded includes revision of one material type and one glazing type.
- Number of glazing/frame combinations recorded for residential building specification.

## **ENERPASS (Enermodal Engineering)**

### **Special Features:**

- Very large numbers of zones, walls, doors, windows, heating systems, etc., can be specified.

### **Limitations:**

- Additional weather data beyond first three location files cost extra.
- Operates in DOS window.
- Despite instructions, problematic to run.

### **Notes:**

- Numbers of input screens and inputs recorded include specification of one of each component type.

## **EZDOE (Elite Software)**

### **Special Features:**

- Uses DOE-2.
- Very large numbers of schedules, glass types, spaces, walls, windows, materials, etc., can be specified
- Can model trombe wall.

### **Limitations:**

- Primarily a commercial building tool.
- Operates in DOS window.
- Appears not to run properly under Windows platform.

### **Notes:**

- Demo version of tool evaluated.
- Numbers of input screens and inputs recorded include specification of one of each component type.
- Additional international weather data beyond 250 U.S. and Canadian location files can be downloaded from Elite Software's Web site.

## **E-Z Heatloss (Thomas & Associates)**

### **Special Features:**

- Very large numbers of rooms, walls, doors, windows, etc., can be specified.

### **Limitations:**

- Calculates annual design heating and cooling loads only.
- Crashes easily with improper inputs.
- Results dependent on user-specified anticipated annual heating and cooling hours.

### **Notes:**

- Demo version of tool evaluated.
- Numbers of input screens and inputs recorded include specification of one of each component type.
- Although dimensions of shading objects cannot be specified, generic exterior shading can be specified.

## **HOT2000 (Natural Resources Canada)**

### **Special Features:**

- Contains very large, revisable, expandable wall, window, etc., libraries.

### **Limitations:**

- Considers Canadian and some other locations.

### **Notes:**

- Numbers of input screens and inputs recorded include revision of all components originally included in
- Additional weather data can be defined by knowledgeable users.
- Features to be added in near-future versions of tool:
  - Duct location/insulation/sealing;
  - Retrofit measure interactions;
  - Retrofit recommendations;
  - Case studies.

## **J-Works (MicroWorks, Inc.)**

### **Special Features:**

- Cost reduced to \$180 with \$45 educational discount.
- Maximum of 33 rooms can be specified.

### **Limitations:**

- Calculates annual design heating and cooling loads only.
- Does not allow backtracking to previous input screens to revise inputs before run.
- Crashes easily with improper inputs.
- Input limitations affect calculational precision.

### **Notes:**

- Numbers of input screens and inputs recorded for maximum specification of 33 rooms.

## **MECcheck (U.S. Department of Energy)**

### **Special Features:**

- Free.
- Very large numbers of walls, doors, windows, etc., can be specified.

### **Limitations:**

- Strictly an energy code compliance tool.

### **Notes:**

- Number of inputs recorded includes specification of one of each component type.

## **Micropas (Enercomp)**

### **Special Features:**

- Has straightforward input style.
- Large numbers of walls, windows, heating and cooling systems, etc., can be specified.
- Can model gas heat pump, hydronic heating system, thermal mass, sunspace.

### **Limitations:**

- Strictly an energy code compliance tool.
- Considers Californian locations only.
- Operates in DOS window.

### **Notes:**

- Demo version of tool evaluated.
- Number of inputs recorded for minimum specification of one zone, maximum specification of other components.
- Additional weather data beyond 16 Californian location files can be obtained with research version of tool.
- Additional features apparently available in research version of tool.

## **NEAT (Oak Ridge National Laboratory)**

### **Special Features:**

- Very large numbers of walls, doors, windows, etc., can be specified.
- Can model evaporative cooler.

### **Limitations:**

- No established means of distribution to private sector.
- Strictly a retrofit tool.
- Entry of some component characteristics awkward.

### **Notes:**

- Numbers of input screens and inputs recorded include specification of one of each component type.

## **REM/Rate (Architectural Energy Corporation)**

### **Special Features:**

- Partially an energy code compliance tool.
- Partially a home energy rating tool.
- Contains revisable, expandable wall, window, heating system, etc., libraries.
- Can model thermal mass, ground-source heat pump, dual-fuel heat pump, active solar system, photovoltaic system, sunspace.

### **Limitations:**

- User must enter measured or estimated power draw of appliances to obtain calculation of appliance energy consumption.

### **Notes:**

- Numbers of input screens and inputs recorded include specification of one of each component type.
- Although number of occupants cannot be specified, number of bedrooms can be specified.

## **ResRatePro (Florida Solar Energy Center)**

### **Special Features:**

- Partially a home energy rating tool.
- Uses DOE-2.
- Very large numbers of floors, ceilings, walls, doors, windows, etc., can be specified.
- Can model gas heat pump, ground-source heat pump, hydronic heating system, sunspace.

### **Limitations:**

#### **Notes:**

- Cost of other versions of tool \$199 and \$299.
- Numbers of input screens and inputs recorded include specification of one of each component type.
- Features to be added in near-future versions of tool:
  - Apartment buildings;
  - House geometry;
  - Zone heating/cooling;
  - Energy tariffs;
  - Peak electricity demand.

## **TREAT (Taitem Engineering)**

### **Special Features:**

- Has straightforward input style.
- Contains revisable, expandable utility/fuel type, wall, window, heating system, etc., libraries.
- Can model ground-source heat pump, groundwater-source heat pump.

### **Limitations:**

- Input limitations affect calculational precision.
- Gives no screen feedback for aborted runs.
- Appears to contain calculational errors.

#### **Notes:**

- Beta test version of tool evaluated.
- Numbers of input screens and inputs recorded include specification of one of each component type.
- Although dimensions of shading objects cannot be specified, generic overhangs can be specified.
- Some calculation options apparently not implemented in beta test version of tool.
- First commercial version of tool to be released in fall 2002.
- Cost of commercial version of tool \$500 (single-family model) and \$1,500 (multifamily model).
- Features to be added in near-future versions of tool:
  - Age of house;
  - Foundation type;
  - Foundation insulation level;
  - Roof color;
  - Room air conditioners;
  - IAQ calculations;
  - Peak electricity demand;
  - No-cost retrofit measures;
  - Run comparisons;
  - FAQs;
  - Glossary;
  - General program help;
  - Help search;
  - Example input and output sets;
  - Non-energy benefits.

## **VisualDOE (Eley Associates)**

### **Special Features:**

- Cost reduced 60% with educational discount.
- Partially an energy code compliance tool.
- Uses DOE-2.
- Contains revisable, expandable glazing, window, materials, construction, etc., libraries.