



**Center for Energy, Economic & Environmental Policy**  
Edward J. Bloustein School of Planning and Public Policy  
Rutgers, The State University of New Jersey  
33 Livingston Avenue • Suite 190 • New Brunswick • New Jersey 08901-1958  
732/932-5475, Ext. 720 • FAX: 732/932-0934

## **Evaluation of Home Energy Audit Tools**

**Prepared by:**  
**The Center for Energy, Economic and Environmental Policy**

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## Executive Summary

In March of 2003, the staff of the Board of Public Utilities (“Board staff”) commenced a review of the overall administrative structure of the New Jersey Clean Energy Program and of the specific programs being administered by the utilities. In discussions with the utilities, Board staff raised concerns regarding the need to expend funds on a residential home audit program given the availability of free residential home energy audits through a number of vendors including the US Department of Energy (DOE) and the US Environmental Protection Agency (EPA). In January of 2004, the Center for Energy, Economic and Environmental Policy (CEEPP) at Rutgers Bloustein School of Public Policy and Planning was engaged by the Board of Public Utilities (the “Board”) to perform an evaluation of residential home energy audit tools.

The evaluation was conducted by CEEPP in three stages. The first stage was a review of relevant literature on the topic of residential energy audits and a review of similar evaluations performed by other entities. In the second stage of the evaluation we conducted a high level overview of four audit tools available on the Internet. The overview included a review of the audit tools to determine ease of use, energy usage outputs, energy saving recommendations, links to other useful sites and usefulness of any reports produced by the audit tool. In the third stage of the evaluation we prepared a comparison of the audit tools identified above.

A report prepared by the US Department of Energy’s Lawrence Berkeley National Laboratory (LBNL) discussed below notes that there exists 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. The LBNL 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 following residential home energy audit tools were evaluated by CEEPP:

1. Home Energy Checkup; sponsored by the Alliance to Save Energy;
2. Home Energy Advisor; sponsored by the US EPA;
3. Home Energy Saver; sponsored by the US DOE and US EPA; and
4. Home Analyzer; sponsored by NEXUS and currently utilized by the New Jersey Clean Energy Program.

This report includes an overview of each of the audit tools evaluated. The report also includes a comparison of the various attributes of each of the tools.

### *Overview of the Audit Tools*

The Home Energy Checkup is a tool that is designed for educational purposes only. It is not designed to provide a homeowner with specific recommendations regarding potential energy saving measures but instead provides very generic information regarding ways to reduce energy usage. The other tools evaluated allow users to input information more specific to their homes and the recommendations are more tailored to the user’s home.

The Home Energy Advisor is an easy to use tool that provides the user with recommendations regarding ways to save energy that are tailored to the specified home. It provides simplified results based on high level inputs regarding the home and its occupants. The audit requires the user to input minimal information specific to the home using instead default values specific to the area. The tool is linked to promoting the use of ENERGY STAR products with the majority of the recommendations being to consider ENERGY STAR products when replacing an existing product. The tool has links to several helpful pages that provided additional information to assist the user in evaluating the costs and savings associated with the energy saving recommendations.

Like the Home Energy Advisor, the Home Energy Saver provides the user with recommendations regarding ways to save energy that are tailored to the specified home. It includes links to other sources of information to help users assess the costs and benefits of implementing the recommendations. The first two levels of detail offered by the Home Energy Saver were easy to use. The evaluator found the third level of detail difficult to use and it took significantly more time to complete than the other audit tools. The tool apparently utilizes the same default values and calculations as the Home Energy Advisor since both produced identical estimates of costs and savings for the first level of detail and similar estimates for the second level of detail. The Home Energy Saver produced some estimates of usage and savings that were questionable.

The Home Analyzer is organized in such a manner that, with a small time investment, users can see results quickly, and need not complete an entire analysis to obtain meaningful answers. This is done by presenting the user with fourteen easy-to-answer questions that allows them to build a “profile” of their home. This process, which took the evaluator less than five minutes to complete, allows the user to then view a list of potential energy savings measures, which can be further refined by continuing the analysis. The user is quickly able to see how their home compares to other similar homes in the area.

The four residential home energy audits evaluated by CEEEP are all useful tools that were designed for different purposes. The Home Energy Checkup was designed as a simple educational tool that is intended to provide the user with generic information regarding ways to save energy. It is not designed to provide users with information specific to their home. The Home Energy Advisor and the Home Energy Saver were both designed as tools to be used nationally. As such, they have limited ability to be modified to add features potentially desired by the New Jersey Clean Energy Program.

CEEEP believes that the Home Analyzer audit tool currently utilized by the New Jersey Clean Energy Program has more depth and robustness than the other tools evaluated and that it offers several advantages over the other tools assessed. First, the Home Analyzer provided the best balance between soliciting information that would tailor the results to the sample home without requiring an excessive level of detail. The tool includes as a default value actual energy costs for the sponsoring utilities that serve homes in the area specified. While the Home Energy Advisor and Home Energy Saver allow the user to input actual energy costs, by including actual energy costs as a default value, the Home Analyzer gives the user more precise inputs without requiring the user to obtain actual energy costs on their own. The Home Energy Advisor also averages

weather information from multiple weather stations which results in more accurate weather inputs than the other tools.

If the Office of Clean Energy is simply looking for a high level educational tool, it could provide links to the Alliance to Save Energy's Home Energy Checkup. If the Office of Clean Energy is looking for a web-based audit tool that provides users with estimates of energy usage and potential areas of savings, the free tools are sufficient for this purpose. The tools could be linked to the New Jersey Clean Energy Program web-site giving the user access to a simple tool (Home Energy Advisor) or a more detailed tool (Home Energy Saver). However, the Home Analyzer utilized information more specific to the home and provided recommendations more specific to the home being assessed.

What differentiates the Home Analyzer from the other tools are the additional features that it offers that are aimed at getting the user to implement the recommended measures. The following identifies some of the additional features offered by the Home Analyzer that are not available through the Home Energy Checkup, the Home Energy Advisor or the Home Energy Saver:

#### *Adaptability*

The Home Analyzer offers the ability to develop a tool that meets the specific needs of the New Jersey Clean Energy Program. The other tools are national tools which are by design general in nature.

#### *Customer Access*

The Home Analyzer is available to users that do not have Internet access through a paper audit or CD ROM and also has a version available in Spanish.

#### *Customer Information*

The Home Analyzer program can provide the Office of Clean Energy with information concerning usage, home profiling information and can provide customers with customized messages to increase the chance of measures being implemented.

#### *Call Center*

The Home Analyzer includes a call center that fulfills requests for paper-surveys, fields phone calls from consumers either asking for help completing the paper survey or to help understand the results report, directs consumers on how to begin the implementation process of the recommended energy savings measures and provides consumers with the necessary information or paper work needed to take advantage of the programs and services being offered by the New Jersey Clean Energy Program.

#### *Maintenance and Upgrades*

The local rates for the sponsoring utilities are maintained and kept up to date by Nexus project managers.

#### *Market Research*

Nexus has provided the Board with some data on consumers that have utilized either the on-line or paper application. This type of data analysis has potential for both designing programs and targeting consumers for particular programs.

Significantly, the Home Analyzer is also the only audit tool that requires funding from the New Jersey Clean Energy Program. In 2002, \$963,000 was expended on the program. Of this amount, \$562,000 was for direct audit costs with the remainder expended on related costs such as administration, sales, marketing and promotions, training and market research. In 2002, 4,706 paper audits were completed, 15,922 on-line audits were performed and 2,807 CD ROMs were mailed to customers for a total of 23,435 audits assuming each customer that received a CD ROM performed an audit. The overall cost per audit performed was approximately \$41 and the direct cost per audit excluding the other related costs identified above was approximately \$24 per audit. The average cost per audit will drop as more audits are performed since a significant portion of the overall cost is the fixed monthly payment.

The decision as to which audit tool to utilize is a policy decision that should be based on an assessment of the value of the additional benefits of the Home Analyzer compared to the additional costs in light of program objectives.

#### *Recommendations*

1. *The Office of Clean Energy needs to define what it is looking for in a residential home energy audit:*

All of the tools evaluated were useful for the purposes for which they were designed. The Office of Clean Energy needs to determine whether the tool is intended solely to educate consumers regarding the benefits of installing energy efficiency measures or is intended to motivate customers to implement recommended measures and to participate in other New Jersey Clean Energy Programs.

If the Office of Clean Energy determines that it wants to offer a tool with a high likelihood of motivating customers to implement the recommended measures, the Home Analyzer offers several features that the other tools do not that are aimed at motivating customers to implement recommended measures. The benefits of the additional features offered by the Home Analyzer should be assessed against the additional costs.

2. *If the Office of Clean Energy decides to continue with the Home Analyzer, it should be expanded to include all customers in the State:*

The audit should be expanded to include customers of Rockland Electric and the municipal and cooperative utilities in the State.

3. *Include Available New Jersey Clean Energy Program Incentives in the Audit Recommendations*

Three of the audit tools provided links to the New Jersey Clean Energy Program web-site where the user could obtain additional information regarding incentives available to help offset the costs of implementing the recommendations. However, this requires the user to

search the web-site to find out if incentives are available for a specific recommendation. Rather than providing links to the web-sites that have information concerning available incentives, having the information included in the tool would provide a much more useful link to the programs.

4. *Provide On-line Access to Customer Bills*

Three of the tools allow customers to input specific energy usage information. However, such information is not readily available unless the customer has saved twelve months worth of utility/energy bills. Allowing the user to download past electric and gas bills would greatly simplify the process and allow the user to obtain more personalized and accurate results.

5. *Assess the number of customers that implement recommended measures*

The Board should perform an additional evaluation next year to determine the number of customers that install measures recommended by the audit.

## Background

By Order dated March 9, 2001, the New Jersey Board of Public Utilities (the “Board”) directed the state’s seven natural gas and electric utilities to administer and implement a number of energy efficiency and renewable energy programs. One of the programs the utilities were directed to administer was a residential home energy audit then known as the Residential Retrofit Program.

In July of 2001, the utilities commenced implementation of a statewide residential home energy audit available to all of their customers at no charge. The utilities engaged NEXUS Energy through a competitive solicitation to deliver the audit to customers. The audit was available through access to a web based tool, a CD ROM for customers without web access and a paper audit/report for customers without computer access.

In 2001, \$1.257 million was expended on the program and 7,223 audits were performed. A significant portion of the expenditures were one time program start-up costs. In 2002, \$963,000 was expended on the program. Of this amount, \$562,000 was for direct audit costs with the remainder expended on related costs such as administration, sales, marketing and promotions, training and market research. In 2002, 4,706 paper audits were completed, 15,922 on-line audits were performed and 2,807 CD ROMs were mailed to customers for a total of 23,435 audits assuming each customer that received a CD ROM performed an audit. The overall cost per audit performed was approximately \$41 and the direct cost per audit excluding the other related costs identified above was approximately \$24 per audit.

In March of 2003, Board staff commenced a review of the overall administrative structure of the New Jersey Clean Energy Program and of the specific programs being administered by the utilities. In discussions with the utilities, Board staff raised concerns regarding the need to expend funds on a residential home audit program given the availability of free residential home energy audits through a number of vendors including the US Department of Energy (DOE) and the US Environmental Protection Agency (EPA). In May of 2003, pursuant to an Order of the Board, the Residential Retrofit Program was discontinued.

The Electric Discount and Energy Competition Act (EDECA) mandated a four year freeze on electric utility rates that expired on July 31, 2003. In July of 2003, the Board was in the final phases of its consideration of petitions to raise rates filed by the State’s four investor owned electric utilities to become effective at the expiration of the rate freeze. The rate increases that resulted from these petitions were effective as of August 1, 2003.

Commissioners and Board staff have commented that they are concerned with the impacts of these rate increases on customers and explored various avenues for providing customers with tools to help mitigate the impacts of the rate increases. One of the tools that was considered was providing customers with information that could assist them with reducing their energy usage thereby lowering their bills. The Board expressed an interest in providing customers with such information in a timely fashion, that is, coincident with the announcement of the rate increases.



Based on discussion between the Utilities and Board Staff, it was agreed that given the recent experience of NEXUS Energy in delivering a residential home energy audit in NJ, they were the only realistic option for having a residential home energy audit up and running at the time the rate increases were announced. Therefore, their contract was extended and the residential energy audit became available to customers again in September of 2003.

While the Board authorized the restart of the audit program for the reasons identified above, Board staff remained concerned that a similar audit could be delivered to customers at little or no cost to the New Jersey Clean Energy Program. Therefore, the program was extended for three months, with a three month renewal option, pending an evaluation of the residential home energy audit program.

In January of 2004, the Center for Energy, Economic and Environmental Policy (CEEEP) at Rutgers Bloustein School of Public Policy and Planning was engaged by the Board to perform an evaluation of residential home energy audit tools. The audit evaluation is described in the Evaluation Description that follows.

## Evaluation Description

The genesis of this evaluation is the Office of Clean Energy's desire for a comparison of the costs and features of various residential energy audit tools. As such, CEEEP performed a high level overview of various residential audit tools. Specifically, CEEEP compared the residential audit tool currently utilized in NJ with several of the free audit tools available. The comparison involved a single evaluator inputting standard values for a single home, running these inputs through all of the options available for each of the tools, and comparing the results.

The evaluation was conducted in three stages. The first stage was a review of relevant literature on the topic of residential energy audits and a review of similar evaluations performed by other entities. Specifically, we reviewed and summarized an analysis performed by Evan Mills at the Lawrence Berkeley National Laboratory entitled "*Review and Comparison of Web- and Disk-based Tools for Residential Energy Analysis*", September 2002; and, a study performed by John Westerman of SAIC for the California Energy Commission entitled "*Home Energy Analysis Software Study*", November, 2001.

In the second stage of the evaluation we conducted a high level overview of four audit tools available on the Internet. The overview included a review of the audit tools to determine ease of use, energy usage outputs, energy saving recommendations, links to other useful sites and usefulness of any reports produced by the audit tool. Our evaluation did not include an assessment of the accuracy of the estimates or the software or assumptions used to calculate energy usage or energy savings assumptions.

The following residential home energy audit tools were reviewed:

1. Home Energy Checkup; sponsored by the Alliance to Save Energy
2. Home Energy Advisor; sponsored by the US EPA;
3. Home Energy Saver; sponsored by the US DOE and US EPA; and
4. Home Analyzer; sponsored by NEXUS and currently utilized by the New Jersey Clean Energy Program

In the third stage of the evaluation we prepared a comparison of the audit tools identified above. The evaluator input variables for a single home in NJ and compared estimates of energy usage, energy savings, recommended measures and links to other useful sites.

## Review of Relevant Studies

In this section CEEEP will review an analysis performed by Evan Mills from the Lawrence Berkeley National Laboratory (LBNL) in his report entitled “*Review and Comparison of Web- and Disk- Based Tools for Residential Energy Analysis*”, September 2002 (the LBNL Report) and, a study performed by John Westerman of SAIC for the California Energy Commission entitled “*Home Energy Analysis Software Study*”, November, 2001. The Executive Summary of the LBNL Report, which sets out many of the issues faced when evaluating residential home energy audit tools, is included in this Report as Appendix A.

The LBNL Report notes that there exists 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 LBNL 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 the LBNL evaluation, automatically translate into a “better” or “more accurate” tool.

LBNL concluded that 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. 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.

For the tools that LBNL 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. 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).

The most thorough prior review of residential home energy audit tools appears to be a study performed by John Westerman of SAIC for the California Energy Commission entitled “*Home Energy Analysis Software Study*”, November, 2001 (the CEC Report). Although only eight residential tools were evaluated by Westerman, 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. The tools evaluated by CEEEP will be assessed against the features recommended by Westerman.

The CEC Report concluded that the most comprehensive and useful tool that was evaluated was the Home Improvement Tool provided by the EPA which is now the Home Energy Advisor. The CEC Report found that this tool requires only a general level of knowledge by the user and provides ranked results through a limited number of user inputs (34 questions).

The LBNL Report identifies a number of problems with the accuracy of the results of the residential energy tools. The types of inaccuracies identified in the report include:

- Accuracy or incompleteness of the algorithms
- Accuracy of savings calculations
- Errors in programming
- Completeness or representiveness of user-specified options
- User misunderstandings
- Weather and weather-normalization
- Inter-tool differences

CEEPP did not attempt ascertain the accuracy of the results of the residential energy audit tools. CEEPP did, however, evaluate the level of detail the tools allowed the user to input concerning the home and its occupants.

The two reports reviewed above provide guidance that assisted CEEPP in its evaluation. The reports identify the Home Energy Advisor and the Home Energy Saver as the most comprehensive and useful tools. These two tools were evaluated. The reports also identify “Best Practices” that were incorporated in part by CEEPP into the framework of the evaluation.

## Overview of Residential Home Energy Audit Tools

The LBNL Report noted that there are essentially three classes of whole-house residential energy tools: those developed and hosted by government or non-profit entities for the public interest purposes (energy and environment education, etc.); those developed by individual utilities, typically focused on a single fuel for local customers and designed to be ultra-simplified (single-screen of inputs); and those developed by private vendors and deployed to utilities or individuals under licensing agreements, or some other business arrangement. The CEC Report concluded that the most comprehensive and useful tool that was evaluated was the Home Improvement Tool provided by the EPA which is now the Home Energy Advisor.

CEEEP performed a high level overview of four residential home energy audit tools. The overview included a review of the audit tools to determine ease of use, energy usage outputs, energy saving recommendations, links to other useful sites and usefulness of any reports produced by the audit tool. Our evaluation did not include an assessment of the accuracy of the estimates or the software or assumptions used to calculate energy usage or energy savings assumptions.

The following residential home energy audit tools were reviewed:

1. Home Energy Checkup; sponsored by the Alliance to Save Energy
2. Home Energy Advisor; sponsored by the US EPA;
3. Home Energy Saver; sponsored by the US DOE and US EPA;
4. Home Analyzer; currently utilized by the New Jersey Clean Energy Program; and

The Home Energy Checkup was reviewed at the request of Board staff. The Home Energy Saver and Home Energy Advisor were selected for review for two key reasons. First, they were developed by federal agencies, DOE and EPA, and are therefore presumed to be unbiased. Second, they have been identified in the LBNL and CEC evaluations as the most comprehensive and useful tools. The Home Analyzer was selected since it is the tool currently utilized in NJ and is therefore the tool against which the other tools will be measured.

The comparison of the audit tools is based on multiple visits to the web site that hosts each tool by an individual evaluator. Inputs were for a single home specified by the evaluator. We also took into consideration and included in the overview of each of the audit tools the assessment of the tools included in the LBNL Report.

The next section summarizes the results of our assessment of the residential energy audit tools.

## ***Home Energy Checkup***

The Home Energy Checkup is easily accessed through the Alliance to Save Energy web-site. The tool is designed for educational purposes only. It is not designed to provide a homeowner with specific recommendations regarding potential energy saving measures but instead provides very generic information regarding ways to reduce energy usage.

The Home Energy Checkup allows the user to specify only low/medium/high for home attributes such as level of insulation, windows, lighting, etc. The tool also allows the user to input weather zones with the nearest to this area being “Mid-Atlantic.” The tool allows the user to input only low/medium/high for fuel costs.

The tool allows the user to select these attributes for either an existing home or for an efficient home. It calculates estimated energy costs for the existing and efficient home with the difference being the savings.

The tool offers very high level recommendations regarding measures the user should consider. For example, it recommends calling your local utility or a local contractor for more information. It has minimal links to other useful web-sites. No reports are generated by the audit tool.

The other audit tools evaluated below, including the free audit tools, provide significantly more accurate and detailed information to the user than the Home Energy Checkup. Therefore, CEEEP recommends that the Home Energy Checkup not be considered further as a tool to be used by the New Jersey Clean Energy Program. For this reason, CEEEP did not include the Home Energy Checkup in its comparison of the audit tools set out below.

## ***Home Energy Advisor***

LBNL developed the Home Energy Saver on behalf of US DOE and US EPA. However, a representative of LBNL indicated that at some point the needs of DOE and EPA diverged and that LBNL was asked by EPA to develop a simpler tool designed to meet its specific needs. The Home Energy Advisor was developed by LBNL to meet the specific needs of EPA.

The Home Energy Advisor was accessed both through the EPA's web-site and by doing a search for "Home Energy Advisor." Accessing it through the EPA web-site required the evaluator to search several pages and topics before locating the tool.

The Home Energy Advisor audit commences with the user inputting their zip-code. The tool produces an estimate of the annual energy cost for a typical home in the user's area and for a typical energy efficient home in the area. For the zip-code input by the evaluator the tool estimated annual energy costs to be \$2,616 for a typical home and \$1,568 for an energy efficient home

The tool then asks the user questions concerning the characteristics of the home and its occupants including when the home was built (by decade, pre-1960 for everything built prior to 1960), how many stories is the home and the number of occupants by various age categories. The tool includes default prices for various fuels and allows the user to input actual fuel costs. The default prices were \$0.104/kwh, \$0.747/therm of natural gas and \$1.488/gallon of oil.

The tool then asks a number of questions regarding the homes structure such as square footage, type of foundation, are walls/floors/ceilings insulated (yes/no/I don't know), types of windows and proportion of windows on each side of the home, source of heating and cooling, use and type of thermostat, age of appliances, ranking of the top three types of lighting fixtures and range of number of hours used per day and whether appliances and lights are ENERGY STAR labeled. The tool allows the user to input utility bills to make the recommendations more realistic.

The tool then calculates an estimate of the annual energy cost for the home, the annual energy cost for the home if the top five recommendations are implemented with the difference being the potential savings. For the sample home used by the evaluator the tool estimated annual energy costs to be \$3,529, the annual energy costs with the upgrades to be \$2,720 and the potential savings to be \$809. The actual energy costs for the home were \$2448.

The tool breaks down the annual energy use by six categories: heating, cooling, water heating, appliances, lighting and miscellaneous. The tool estimates the annual energy cost for each of these categories with and without the recommended upgrades. The tool provides a listing of the typical cost to operate various household appliances broken down by monthly and annual expenditures and cost per use.

The tool then shows potential upgrades to the home based on the inputs provided by the user. For the sample home used by the evaluator, the audit recommended ten upgrades plus four additional energy saving recommendations. Ten of the fourteen recommendations were simply

to choose an ENERGY STAR labeled model when replacing a specific appliance or windows. The other four recommendations were to have a professional seal air leaks and to insulate walls, ceilings and the floor above the basement to a specified level of insulation.

The tool then produces a detailed upgrade report. For the upgrades selected by the user, the report estimates the annual bill savings, the estimated cost, the return on investment, the payback period in years and associated environmental benefits. The report also provides a breakdown of the cost to implement the measure, the annual and lifetime savings, the return on investment and the payback period. The report provides a detailed description of the recommended measure, purchasing tips and links to other sites if the user desires more information on the topic or information on specific equipment. This information includes a list of dealers that carry ENERGY STAR equipment, ENERGY STAR product lists as well as information on how to properly size equipment.

The final page of the audit provides links to general information to help the user get started in locating information about energy efficiency upgrades. This page includes a link to the New Jersey Clean Energy Program web-site.

The LBNL Report noted that the Home Energy Advisor was the only tool reviewed that has a flexible and detailed cost-effectiveness evaluation module and that it was the only tool allowing specification of ENERGY STAR efficiency levels. LBNL found that the Home Energy Advisor had the most extensive recommendations and cost effectiveness information of any of the tools evaluated. LBNL also noted that the tool had a highly simplified building description.

The CEC Report noted that the favorable features of the tool are as follows:

1. Graphic representation of the annual energy cost for the house modeled with the top 5 energy upgrades
1. A table presenting a breakdown of annual energy usage for the house with the top 5 energy upgrades in the following categories: heating; cooling; water heating; appliances; lighting; and, miscellaneous
2. Listing of the top 5 upgrades in order of the highest return on investment
3. Detailed upgrade report: Economic benefits (annual cost savings, lifetime energy cost savings, upgrade cost, return on investment, simple payback); Additional benefits; Upgrade description; Purchasing tips; and, web links.



## ***Home Energy Saver***

Like the Home Energy Advisor, the Home Energy Saver is designed to help consumers identify the best ways to save energy in their homes and find the resources to make the savings happen. The Home Energy Saver was the first Internet-based tool for calculating energy use in residential buildings. The project is sponsored by the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (EPA), as part of the national ENERGY STAR Program for improving energy efficiency in homes. The Home Energy Saver includes an option that is not included in the Home Energy Advisor that allows the user to input more detailed information concerning the home.

The Home Energy Saver quickly computes a home's energy use on-line. By changing one or more features of the modeled home, users can estimate how much energy and money can be saved and how much pollution can be prevented by implementing energy-efficiency improvements. All end uses (heating, cooling, major appliances, lighting, and miscellaneous uses) are included. A detailed description of the underlying calculation methods and data is provided in a report.

The Home Energy Saver calculates energy use and savings opportunities based on a detailed description of the home provided by the user. Users can begin the process by entering their zip code, and in turn receive instant initial estimates. By providing more information about the home the user will receive increasingly customized results along with energy-saving upgrade recommendations.

The tool calculates heating and cooling consumption using the DOE-2 building simulation program (version 2.1E), developed by the U.S. Department of Energy. The program performs a full annual simulation for a typical weather year (involving 8760 hourly calculations) in about 10-20 seconds, after the user assembles the necessary information describing their home. Users can choose from 2 weather locations in NJ, Newark or Atlantic City. DOE-2 performs a series of calculations, but the web-based user interface is relatively simple and results are distilled into a useful form. Default energy prices for each fuel and state are also available, or users can enter a specific price of their choosing.

The Energy Advisor calculates domestic water heating energy consumption. Users can see how household size, age of occupants, equipment efficiencies, and water inlet temperatures affect bottom-line energy costs.

By entering the number and approximate age of their major appliances, users can estimate their energy consumption, based on historic sales-weighted efficiency data. A module is also included to estimate energy consumption and savings opportunities for lighting and dozens of miscellaneous gas and electric appliances, with default values based on data compiled over the years by LBNL researchers.

In addition to calculating energy use on-line, other features of the Home Energy Saver; such as the Making it Happen and Energy Librarian modules, connect users to an expanding array of

"how-to" information resources throughout the Internet. These modules help users successfully capitalize on the energy savings opportunities identified by the Energy Advisor module. These modules offer a host of links to practical information, including lists of specific efficient products, tips about selecting a good contractor and to information on what assistance your utility might have to offer. The site also features an extensive glossary and frequently-asked questions module.

The audit commences with the user inputting their zip-code. Based on the zip-code, the tool estimates the annual energy cost for an average home and an energy efficient home in the area and breaks down the usage into six categories: heating; cooling; water heating; major appliances; lighting; and small appliances.

The audit then offers more detailed energy cost estimates and energy saving recommendations. The user is asked eighteen questions regarding the home and its occupants including the age and size of the home, insulation levels, appliance types, number and location of windows and number of occupants by age level. The tool includes default energy prices and also allows the user to input actual energy costs.

The third level of detail allows the user to input more specific information concerning the home. The information is broken down by six categories as follows and each of these categories includes several subcategories:

- general information and energy prices
- heating and cooling
- major appliances
- small appliances
- water heating
- lighting

Inputting the requested information for the detailed audit was somewhat cumbersome. The tool did not take the user through the various inputs smoothly but instead required the user to click on over 25 categories, input the requested information and save the answers and to click on the next category for which the user wanted to submit information. Much of the information requested was unknown to the evaluator at the time of the audit and would have required the user to obtain additional information such as measuring the area of windows on each side of the home. The tool does include default values if the user does not input information specific to their home.

For the sample home used by the evaluator the Home Energy Saver estimated, for an "average" home with the specified attributes, annual energy costs for each of the three levels of detail as follows:

Based on area code:	Average Home; \$2,617; Efficient Home; \$1,568
1 <sup>st</sup> level of detail:	Average Home; \$2,963; Efficient Home; \$1,568
Detailed inputs:	Average Home; \$3,247; Efficient Home; \$1,568

Actual energy costs for the home were \$2448.

The tool then offered suggested upgrades to the home. The recommendations from the first level of detail included installation of a programmable thermostat. This recommendation was not included in the detailed audit report since the user had input that the home already has this measure. All of the other recommendations were the same for both reports.

Three of the recommendations were to upgrade insulation in the ceiling, walls and floors. Six of the recommendations were to choose an ENERGY STAR labeled model when replacing various appliances or windows. The tool recommended air sealing, sealing duct joints, wrapping the water heater and replacing high use lights with compact fluorescents.

The user can click on the specific recommendations to receive additional information. This page provided the evaluator with recommendations on suggested levels of insulation, appliances and lighting. This page was also linked to other pages that provided information on purchasing, installation, financing, products and other useful sources of information including a link to the New Jersey Clean Energy program web-site.

The LBNL Report found that the Home Energy Saver included more end-use flexibility in building descriptions than the other tools evaluated and that it included more decision support content than the other tools. LBNL also found that it was relatively time consuming to complete the detailed audit and that the user interface lacked interest.

## ***Home Analyzer***

The Home Analyzer is the residential home energy audit tool currently utilized by the New Jersey Clean Energy Program. The tool is offered through a licensing agreement with NEXUS Energy. NEXUS Energy was selected to provide this service through a competitive solicitation issued by the State's utilities in 2001.

The audit tool is currently available through two mediums: on the web either through the New Jersey Clean Energy Program web site or through the individual utility web sites and a paper audit is available for customers without access to a computer. The paper audit produces a report sent to customers based on input provided by the customer. It was available on CD ROM for customers without internet access although this feature has been discontinued.

The audit is supported by an 800 number hotline managed by Honeywell DMC. Customers can call up the 800 number and ask questions regarding how to implement any of the energy savings measures recommended by the audit or to receive information on other New Jersey Clean Energy Programs available that may offer incentives to reduce the costs of the recommended measures.

The Home Analyzer was easily reached on the New Jersey Clean Energy Program web site. The tool is accessible by simply clicking on the Residential tab and then the Home Energy Analysis tab. Clicking the "Get Started" tab begins the audit.

The tool then asks the user to click on your utility company's logo. The tool includes the logo for the six gas and electric companies that sponsor the audit (it does not include an icon for Rockland Electric or any of the municipal or cooperative utilities). NEXUS has indicated that a user not served by any of the six utilities could still use the audit, however, the default values for energy costs would be based on state averages as opposed to actual costs for customers served by one of the utilities that sponsor the audit. Customers served by two of the utilities can select either utility to start the process.

The welcome page requires the input of only the customer's zip code and offers several options. For a whole house analysis the customer can select either the fast track or the detailed track.

## ***Appliance Calculators***

The customer can select from several calculators that enable the customer to obtain information on the energy use of a specific appliance. The calculators available are: washer, cooling, heating, refrigerator, dryer, water heater, system (new heating or cooling system), room ac and thermostat.

These calculators allow a customer quick access to information concerning a specific appliance without requiring the user to perform the full audit. For example, if a customer is thinking about installing a new furnace, they can access the heating calculator. After answering eight questions such as type and age of the existing boiler and square footage and age of the home, the calculator calculates the costs and savings that can be achieved by installing a new boiler (it does not specify the efficiency of the new boiler). It also provides other tips on how to reduce heating

costs such as look for the ENERGY STAR label if you are buying a new boiler. Similar calculations and tips are provided by accessing the other calculators available for other appliances.

#### *Fast Track Audit*

The fast track asks fourteen questions regarding the characteristics of the home and its occupants and the type of fuels used. The tool then provides a range of annual energy costs and the average annual energy cost for similar homes. For the sample home used by the evaluator, the tool estimated a range of annual energy costs from \$2,246 to \$5,205 with an average of \$3,726 (actual costs for the sample home were \$2,448).

The fast track audit then provides recommendations on a number of ways to save energy. For the sample home used by the evaluator, the audit recommended four savings options; control air leakage; install a programmable thermostat and maintain the heating system; turn off lights when not in use and install compact fluorescent bulbs in high use areas; and insulate the water heater tank.

The tool provided a range for the annual savings and estimated cost to install these measures. For example, the tool estimated that the cost to install compact fluorescent bulbs ranges from \$42 to \$70 and that the savings would be from \$20 to \$33 per year and from \$88 to \$147 over the lifetime of the measure.

#### *Detailed Audit*

The detailed audit commences with the same fourteen questions asked in the fast track audit. The tool then brings the user to a page that estimates the average annual energy cost for a similar home, an estimate of the monthly energy cost for a similar home and a breakdown of energy cost by appliance. This page also has links to the New Jersey Clean Energy Program web site that provides information on available incentives.

The audit provides the user with the opportunity to provide more detailed information concerning the home. The next level of detail asks the user to identify the number and types of appliances used in the home. As information is provided on the number and types of appliances, the tool updates the estimates of annual energy costs for the sample home and updates the allocation of those costs to the various appliances for which information was provided.

The tool then offers some quick options for saving energy. For the sample home used by the evaluator, the tool recommended the replacement of 25% of the most frequently used light bulbs with compact fluorescents. The tool also suggested the user could save up to \$243 per year on heating costs and asked for more detail on the heating system and home weatherization.

The next level of detail requests information from the user for the following home characteristics:

- Weatherization
  - Ceiling or attic insulation
  - Wall insulation
  - Storm windows/double pane windows

- Heating
  - Type and age of heating system, high or standard efficiency, electronic ignition, number of zones, how often the system is serviced, and whether you have programmable thermostats
  - Secondary heating systems
  - Thermostat settings
- Cooling
  - Types (central or window, size of unit(s), age, efficiency, temperature settings, usage patterns)
- Hot water and laundry
  - Dishwasher age, size, usage
  - Clothes washer age, size, type, usage
  - Clothes dryer age, type, usage
  - Water heater age, type, size, efficiency, temperature setting, insulation blanket
  - Number of showers/baths per week
- Food storage
  - Type, size, age of refrigerators and freezers
- Lighting
  - Number of lights by type, most common wattage (ranges by type and usage, does not ask to specify each light)
  - Hours of use
- Other appliances
  - Offers inputs on over 20 other appliances

After the user has input the more detailed information for each of the home characteristic categories identified above, the audit tool provides a number of suggestions regarding ways to save energy. Energy saving suggestions are provided under four subheadings for each home appliance or character identified above:

- Low/no cost
- Needs investment
- Tips, and
- Not cost justified

Upon completion of the audit, the tool produces a Home Energy Analysis Report. The report lists graphically the annual energy use of each appliance sorting from highest to lowest use. The Report then lists all of the recommendations regarding ways to save energy. The recommendations include a description of the recommended action, an estimate of the costs and savings and an estimate of CO<sub>2</sub> and water use reductions that would result from implementation of the measure.

## **Comparison of Audit Tools**

The following summarizes the evaluators experience with the three audit tools discussed above for the sample home used.

## *Ease of Use*

Each of the audit tools was easily accessible on the Internet and had easy to follow directions. Each of the tools required the user to know certain information regarding their home and utilized default values if the user did not specify an input. As the user moved to a higher level of detail, more information was required to tailor the audit to the home being assessed such as types and sizes of windows and appliances.

The Home Energy Advisor does not offer the user the option to perform an assessment of the home utilizing detailed inputs. It bases estimates on answers to some basic questions and does not provide an opportunity to input more detailed information. The evaluator found the detailed track for the Home Analyzer to be the most user friendly. The detailed track for the Home Energy Saver was difficult to navigate and took much longer to complete than the Home Energy Advisor.

## *Levels of Detail*

The Home Energy Advisor offers two levels of detail. The first provides information based on zip-code only and the second based on inputs regarding the characteristics of the home and its occupants.

The Home Energy Saver offers three levels of detail. The first provides information based on zip-code only, the second based on inputs regarding the characteristics of the home and its occupants and the third based on highly detailed inputs regarding the home and appliances.

The Home Analyzer offers three levels of detail. The first provides information based on inputs regarding the characteristics of the home and its occupants. The second allows the user to obtain information regarding a specific appliance by clicking on one of the various appliance calculators. This tool was the only one that allowed the user to obtain information on a specific appliance without having to go through the whole house analysis. For example, if the user only wanted information on central air or lighting, the user could click on the calculator for that appliance. The third level of detail is based on detailed inputs regarding the home and appliances.

## *Precision of Inputs*

The Home Energy Advisor requested information regarding the home. It allows the user to select either Newark or Atlantic City for the climate most similar to your home. Some of the information requested was general in nature such as what year was the home built and how many levels are there in the home but allowed the user to input only the decade the home was built or before 1960 for any home built before 1960. For information regarding insulation it allowed the user to answer only yes, no or I don't know. It allowed the user to input square footage of the home. It allowed the user to input the types of windows and what portion (%) of the windows is on each side of the home. With regard to cooling it asked only what type of cooling was used and do you use more than one of the cooling sources specified. For the sample home that uses room air conditioners it did not specify information regarding the number of units, sizes or efficiency. With regard to appliances, the tool requested the year the appliance was built and whether or not it was ENERGY STAR labeled. With regard to lighting, it asked the user to rank

the top three types of fixtures used and to provide a range regarding the number of hours each type of fixture is on each day. The tool provided default values for fuel prices and allowed the user to specify other fuel prices.

The Home Energy Saver requested information regarding the home. It allows the user to select either Newark or Atlantic City for the climate most similar to your home. For the second level of detail described above, the tool asks the age of the home (allows input of actual year, the square footage of the home, how many levels the home is and the orientation of the home. It allowed the user to input specific levels of insulation for the roof but only allowed yes or no/don't know for wall insulation. It allowed the user to input the types of appliances in the home but no detail regarding the size age or efficiency of the appliances. For the sample home, it allowed the user to input only that it had room ac, it did not allow the user to input the number, size or efficiency of the units. It allowed the user to input the number of windows on each side of the home but did not ask what type of windows were installed. Like the other tools, it included default values for fuel prices and allowed the user to input actual energy prices. The second level of detail did not allow the user to input actual energy usage although the third level of detail did.

The Home Analyzer requests information regarding the home. For the first level of detail described above it starts with information concerning the type of home, i.e. single family, townhouse duplex, etc. and asks how many levels the home is. It asks how old the home is but allows only ranges such as 5-9, 10-15 or over 40. It asks whether the home has an attic and whether it has a heated or unheated basement. It asks how many rooms there are in the house and whether the rooms are above, below or average in size. It then estimates the square footage of the home or allows the user to input the actual square footage if known. It asks for the type of heating system and fuel used for heating. For the sample home it allowed the user to input the number of room ac units. The Home Analyzer has built in actual utility tariff prices for each zip-code.

The Home Energy Saver and the Home Analyzer both provide the user with the opportunity to input more detailed information concerning the home and appliances. As stated above, while both tools allow for the input of detailed information, the evaluator found the Home Analyzer to be much more user friendly and took much less time to input the details concerning the home.

All three tools allow the user to input specific energy usage from utility bills. This would eliminate the need to estimate the energy usage of the home although the errors could still occur in the allocation of the user's energy usage to various usage categories such as heating and cooling and appliances and in estimating energy costs if inaccurate prices are utilized. In the case of the evaluator, usage information was not readily available. The user needed to contact the utilities that serve the home and request usage information. The information was received through the mail approximately one week later.

### *Comparison of Usage Estimates*

The actual energy cost for the sample home for the previous twelve months was \$2,448. Actual energy costs will vary with usage which is affected by weather and energy costs which have increased in NJ in the past twelve months. Each of the tools included guidance to instruct the



user that the estimated energy costs were representative of the sample home and that actual energy costs could vary from the estimates. The following sets out the estimates of energy usage that each of the tools produced for the different levels of detail:

### Estimates of Annual Energy Costs

	Home Energy Advisor	Home Energy Saver	Home Analyzer
Level of Detail	Estimated annual energy costs		
zip-code/default values	\$2,616	\$2,617	NA
2 <sup>nd</sup> level of detail	\$3,529	\$2,963	\$2,246 to \$5,205 Ave: \$3,726
Detailed inputs	NA	\$3,247	\$2,010

### Estimates of Annual Potential Savings

	Home Energy Advisor	Home Energy Saver	Home Analyzer
Level of Detail	Estimated annual savings		
zip-code/default values	\$1,048	\$1049	NA
2 <sup>nd</sup> level of detail	\$809	\$1,395	Up to \$1,480
Detailed inputs	NA	\$1,859	Provided as a range for each measure recommended

### Recommendations and Savings Estimates

#### Home Energy Advisor

Recommendation	Estimated Cost	Annual bill savings
Have a professional seal your homes air leaks	\$250 to \$750	\$809
When replacing your gas water heater, choose an energy efficient model	\$0 to \$200	\$21
Insulate exterior walls to R-11	\$1,049 to \$2,449	\$419
Insulate your ceiling to at least R-38	\$325 to \$516	\$89
When replacing your dishwasher, choose an ENERGY STAR labeled model	\$0 to \$70	\$6
When replacing your gas boiler, choose an ENERGY STAR labeled model	\$800 to \$1,100	\$131
Insulate the floor above your basement to at least R-19	\$363 to \$746	\$71
When replacing windows, choose an ENERGY STAR labeled windows	\$749 to \$2,248	\$128
When replacing your secondary refrigerator, choose an ENERGY STAR labeled model	\$0 to \$1000	\$17
When replacing your secondary	\$0 to \$1000	\$17

refrigerator, choose an ENERGY STAR labeled model		
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The Home Analyzer produces a detailed, printable report that provides information regarding of the energy saving recommendations.

### Home Energy Saver

The Home Energy Saver produced the following recommendations for the version utilizing the inputs for the second level of detail described above:

Upgrade ceiling insulation to at least R-38
Upgrade wall insulation to at least R-11
Insulate floor over basement to at least R-19
When replacing windows choose windows with low-E-glass
Air sealing can reduce energy use for heating and cooling
Choose an ENERGY STAR labeled model when replacing your furnace
Choose an ENERGY STAR labeled model when replacing you're your room air conditioner
Seal duct joints with mastic or high quality duct tape. Insulate ducts in unconditioned spaces
Wrap your water heater to reduce your water heating costs
Choose an ENERGY STAR labeled model when replacing your dishwasher
Choose an ENERGY STAR labeled model when replacing your clothes washer
Replace TVs and VCRs with ENERGY STAR labeled models
Replace high use lights with fluorescent or compact fluorescent fixtures
Install a programmable thermostat

The Home Energy Saver did not provide information concerning the cost of the measures but instead had links to other sites with this information. As is evident in the table below, the Home Energy Saver produced some questionable energy cost and savings estimates. For example, the tool estimated that the sample home defined by the evaluator had annual heating costs equal to \$2,477 and an energy efficient home would have an annual heating cost of \$337 suggesting the user could reduce heating costs by over 85% by implementing the suggested measures. With regard to the potential savings, the Home Energy Saver provided a comparison of the sample home to an energy efficient home as follows:

	Heating	Cooling	Water heating	Major appliances	Lighting	Small appliances
Your house	\$2477	\$35	\$193	\$385	\$211	\$127
Energy efficient house	\$337	\$251	\$135	\$318	\$53	\$474

The more detailed version of the Home Energy Saver produced the same recommendations with the exception of the recommendation to install a programmable thermostat. This

recommendation was eliminated since the detailed version picked up that the sample home already had programmable thermostats.

## Home Analyzer

The Fast Track audit produced the following recommendations:

Energy Category	Annual Savings	Lifetime Savings	Savings Options
Weatherization	\$156 - \$260	\$2,123 - \$3,538	Control air leakage
Heating & Cooling	\$10 - \$175	\$358 - \$596	Install programmable thermostat Maintain heating system
Lighting	\$23 - \$38	\$123 - \$205	Turn off lights when not in use Use compact fluorescent bulbs in high use lamps
Water Heating	\$2 - \$3	\$12 - \$20	Insulate water heater tank

The tool allows the user to click on the recommendation to receive additional information regarding the recommended measure. As noted above, the Home Analyzer allows the user to obtain recommendations on a specific measure by clicking on the calculator for that measure without going through the whole house analysis.

The detailed audit walks the user through several screens such as appliance energy use, weatherization, heating and cooling. As the user finishes inputting the information for each screen, the tool produces recommendations for ways to save energy for the area being assessed. The tool offers recommendations in four categories: Low/No Cost; Needs Investment; Tips; and Not Cost-justified. It provides estimates for the costs to install the measure and the resultant savings. The tool produces a report at the end of the detailed audit that summarizes the recommended ways to save energy.

## Costs

The Home Energy Advisor and the Home Energy Saver are available at no cost to either the user or the New Jersey Clean Energy Program.

The Home Analyzer is available at no cost to the user. The cost to the New Jersey Clean Energy Program includes both a fixed monthly fee plus an incremental charge per audit performed. Therefore, the average cost per audit is a function of the number of audits performed. Assuming that 5,000 paper audits and 15,000 on-line audits were performed in a year, which is approximately the number of audits performed in 2002, the average cost per audit would be approximately \$21.

## *Summary of Comparison of Residential Home Energy Audit Tools*

The Home Energy Advisor requests only basic information regarding the home. It is a highly simplified tool and as such, the estimates of annual energy costs and potential savings by definition are based on averages rather than information specific to the home being analyzed.

Therefore, this tool has the least likelihood of accurately predicting energy costs and savings unless the user chooses the option that allows them to input both actual energy usage and costs. Six of the ten recommendations were to choose an ENERGY STAR labeled appliance or window when replacing an existing one. The Home Energy Advisor was the only tool that estimated a return on investment for the recommended energy saving measures.

The Home Energy Saver has three options for the level of detail. The first level uses the zip-code input by the user and default inputs for the characteristics of the home. This level of detail produced the same estimates as the Home Energy Advisor. The third level of detail produced some questionable estimates. For example, the tool estimated that the sample home defined by the evaluator had annual heating costs equal to \$2,477 and an energy efficient home would have an annual heating cost of \$337 suggesting the user could reduce heating costs by over 85% by implementing the suggested measures. The tool also estimated, in the second level of detail, that the sample home had annual cooling costs equal to \$8. As noted above, the tool allowed the user to input only that the home had room air conditioning. The evaluator found the third level of detail difficult to use and it took significantly more time to complete than the others.

The Home Analyzer utilizes actual utility costs for the zip-code provided and uses weather information averaged from multiple sites in NJ as opposed to the other tools that have default costs that appear to be well below actual costs in NJ and weather information for Newark and Atlantic City only. This adds a level of precision to the energy cost and savings estimates when compared to the other tools. The Home Analyzer Fast Track is more tailored to the specifics of the user's home without having to go through a detailed input process and the detailed track produces even more accurate recommendations using a relatively quick and easy to use process.

## Audit Tool Comparison Matrix

The following matrix provides a comparison of the various features of the residential audit tools evaluated by CEEEP:

<b>Comparison of Residential Audit Tool Features</b>			
<b>Audit Tool Feature</b>	<b>Home Energy Advisor</b>	<b>Home Energy Saver</b>	<b>Home Analyzer</b>
<b>Ease of Use</b>			
Default level	excellent	excellent	NA
1 <sup>st</sup> level of detail	excellent	excellent	excellent
Detailed version	NA	poor	excellent
<b>Levels of Detail</b>	2	3	2
Whole house	Y	Y	Y
Ability to assess specific appliance	N	N	Y
<b>Precision of Inputs</b>			
# weather sites	2	2	Averages multiple sites
Default fuel prices	general	general	actual utility prices
Ability to enter actual usage	Y	Y	Y
Home characteristics	good	better	best
<b>Cost/Savings Estimates</b>			
Annual energy cost (actual \$2,448) Default values	\$2,617	\$2,617	NA
1 <sup>st</sup> level of Detail	\$3,529	\$2,963	Range provided Ave: \$3,726
Detailed audit	NA	\$3,247	\$2,010
Estimated savings			
Default values	\$1,048 total, provided estimate for each measure	\$1,049 total, plus estimate for each measure	NA
1 <sup>st</sup> level of detail	\$809 total, plus estimate for each measure	\$1,395 total, plus estimate for each measure	Up to \$1,480
Detailed audit	NA	\$1,859 total, plus estimate for each measure	Provided a range for each measure
<b>Recommendations</b>	Many were general in nature such as consider ENERGY STAR products; descriptions of measures included; ROI provided	Many were general in nature such as consider ENERGY STAR products: descriptions of measures included	Specific to home; descriptions of measures included

## LBNL Report - Best Practices

The LBNL Report identifies best practices for the development of residential energy tools. The following assesses the extent to which each of the audit tools incorporates the best practices identified in the LBNL Report:

### *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).

*CEEEP Assessment: All three tools had a version that provided lay people with simple answers. The Home Energy Saver and Home Analyzer provided the user with simple answers based on more detailed inputs. Only the Home Analyzer allowed the user to obtain information regarding a specific appliance without going through the whole house audit.*

- Qualitative Decision Support – 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.

*CEEEP Assessment: the Home Advisor did the best job of tailoring the audit to the specifics of the home without requiring the user to obtain or input overly detailed information. All three tools provided information regarding non-energy benefits.*

- Interconnections among Tools – Comprehensive tools can benefit from providing links to specialized tools rather than reinventing each and every possible function.

*CEEEP Assessment: the Home Energy Saver was the only tool assessed that provided links to specialized tools.*

- 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.

*CEEEP Assessment: The Home Energy Advisor and Home Energy Saver tools require users to remember a six-digit Session Identification Number to recall the previously entered data. The Home Advisor stores a consumer’s information automatically. A consumer can return at a*

*later date to look at different information without the need of passwords or user ID's and all previously entered information is pre-populated.*

- Currency – Tools must be regularly updated to enable modeling of new technologies, relevant default information (e.g., energy prices), etc.

*CEEEP Assessment: all of the tools evaluated periodically update inputs. Only the Home Analyzer includes updated specific utility energy costs*

### *Technical Features & Rigor*

- 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.

*CEEEP Assessment: the Home Energy Advisor and Home Energy Saver use two weather locations, Newark and Atlantic City. The Home Analyzer uses three weather zones that average multiple weather locations and inputs weather information based on zip-code. NEXUS has indicated that the Home Analyzer is being updated to tie a customer's zip-code to the closest weather station.*

- Format – Some users prefer open-ended energy analysis, while others seek bill disaggregation, or both.

*CEEEP Assessment: all three tools provided both*

- Uncertainty Analysis – Tools should help users deal quantitatively and qualitatively with the issues of uncertainty inherent in the results.

*CEEEP Assessment: all three tools explained the uncertainty in the results*

## Best Practices Matrix

The following matrix compares whether each of the audit tools evaluated incorporates the applicable “Best Practices” identified above as well as those identified in the CEC report;

<b>Best Practices Matrix</b>			
<b>Best Practice</b>	<b>Home Energy Advisor</b>	<b>Home Energy Saver</b>	<b>Home Analyzer</b>
<b>Targeting and Usability</b>			
Whole house	Y	Y	Y
Ability to evaluate a single measure	N	N	Y
<b>Convenience</b>			
Saves results	with I.D. #	with I.D. #	automatic
<b>Geographic Range</b>			
Need to accommodate a range of climates	2 weather zones	2 weather zones	Multiple weather zones
Need to accommodate a range of building types	N	N	Y
<b>Types of Recommendations</b>			
No cost options	N	N	Y
Envelope measures applicable during remodeling	Y	Y	Y
Equipment retrofits	Y	Y	Y
<b>Includes non-energy benefits</b>	Y	N	Y
<b>Includes Detailed Report</b>	Y	N	Y
<b>Educates consumers</b>	Y	Y	Y
<b>Includes multiple user levels</b>	N	Y	Y
<b>Comparisons between multiple scenarios</b>	N	Y	Y



## Conclusion

The Home Energy Advisor, while a useful and easy to use tool, provides only highly simplified results based on high level inputs regarding the home and its occupants. The audit utilizes minimal information specific to the home using instead default values specific to the area. The tool is linked to promoting the use of ENERGY STAR products with the majority of the recommendations being to consider ENERGY STAR products when replacing an existing product. The tool has links to several helpful pages that provided additional information to assist the user in evaluating the costs and savings associated with the energy saving recommendations.

The Home Energy Saver was also a useful tool with the first two levels of detail being rather easy to use. The tool apparently utilizes the same default values and calculations as the Home Energy Advisor since both produced identical estimates of costs and savings for the first level of detail and similar estimates for the second level of detail. The Home Energy Saver detailed audit module produced estimates of usage and savings that were questionable. For example, the tool estimated that the sample home defined by the evaluator had annual heating costs equal to \$2,061 and an energy efficient home would have an annual heating cost of \$337 suggesting the user could reduce heating costs by approximately 85% by implementing the suggested measures. The tool also estimated that the sample home had annual cooling costs equal to \$8. As noted above, the tool allowed the user to input only that the home had room air conditioning but did not allow the user to input the number of units or the size or efficiency of the units. The evaluator found the third level of detail difficult to use and it took significantly more time to complete than the others.

The Home Analyzer is organized in such a manner that, with a small time investment, users can see results quickly, and need not complete an entire analysis to obtain meaningful answers. This is done by presenting the user with fourteen easy-to-answer questions that allows them to build a “profile” of their home. This process, which took the evaluator less than five minutes to complete, allows the user to then view a list of potential energy savings measures, which can be further refined by continuing the analysis. The user is quickly able to see how their home compares to other similar homes in the area.

The Home Analyzer takes the consumer from a home profile to a compare my home section, which then leads to a choice of detailed question on a variety of end-uses (heating, cooling, weatherization, hot water, etc.). The user can then choose which end-use group to look at first and the corresponding energy savings measures associated with that end-use. Additionally, the energy savings recommendations are laid out in a user-friendly, tabbed table format. Each tab allows the user to see measures that have virtually no implementation costs, measures which require an investment and others that may not be cost-justified.

CEEEP believes that the Home Analyzer audit tool currently utilized by the New Jersey Clean Energy Program has more depth and robustness than the other tools evaluated and that it offers several advantages over the other tools. First, the tool provided the best balance between soliciting information that would tailor the results to the sample home without requiring an

excessive level of detail. The tool includes as a default value actual energy costs for the utilities that serve homes in the area specified by the user and provides more specific weather information than the other tools.

If the Office of Clean Energy is simply looking for a high level educational tool, it could provide links to the Alliance to Save Energy's Home Energy Checkup. If the Office of Clean Energy is looking for a web-based audit tool that provides users with estimates of energy usage and potential areas of savings based on non-home specific default values, the free tools are sufficient for this purpose. The tools could be linked to the New Jersey Clean Energy Program web-site giving the user access to a simple tool (Home Energy Advisor) or a more detailed tool (Home Energy Saver). However, the Home Analyzer utilized information more specific to the home and provided recommendations more specific to the home being assessed.

However, what differentiates the Home Analyzer from the other tools are the additional features that it offers that are aimed at getting the user to implement the recommended measures. The following identifies some of the additional features offered by the Home Analyzer that are not available through the Home Energy Advisor or the Home Energy Saver:

#### *Adaptability*

The Home Analyzer offers ability to adapt the tool to meet the specific needs of the New Jersey Clean Energy Program. The other tools are national tools which are by design general in nature. While they may offer some opportunity to tailor the product to New Jersey, the Home Analyzer is by design one that offers the ability to develop a product that meets program needs and the Home Analyzer offers a staff dedicated to design such features.

#### *Customer Access*

The Home Analyzer is available to users that do not have Internet access. Based on statistics provided by Nexus, of the 23,435 consumers who performed a home energy analysis in 2002, 15,922 used the on-line audit, 4,706 paper audits were performed and 2,807 customers were mailed a CD ROM. To further broaden the reach to all consumers in NJ, Nexus is also able to provide a Spanish language version of both the on-line and paper-based energy tools.

#### *Customer Information*

The Home Analyzer program can provide the Office of Clean Energy with information such as:

- Traffic reports that provide details on the number of on-line users, time spent in the applications, pages that were viewed, etc.
- Home profiling information which can be extracted and summarized in an aggregate form to better help program managers design new programs and services that best fit the needs of the typical residence in New Jersey;
- With permission from the consumer, home profiling information can also be used to tailor personalized e-mail messages detailing new programs and services the consumer qualifies for but might not have been available when they had performed their on-line analysis.

#### *Call Center*

The call center that is included as part of the fees for the Home Advisor performs the following functions:

- Fulfills requests for the paper-survey;
- Processes returned surveys;
- Fields phone calls from consumers either asking for help completing the paper survey or to help understand the results report;
- Directs consumers on how to begin the implementation process of the recommended energy savings measures;
- Provides consumers with the necessary information or paper work needed to take advantage of the programs and services being offered by New Jersey.

The call center number is currently not included anywhere on the on-line audit (it is on the audit home page but does not appear anywhere once the audit is started). It would be helpful to include this number as part of the on-line audit for any customers that may have additional questions that are not answered through the audit process.

#### *Maintenance and Upgrades*

The rates of the utilities that sponsor the audit are maintained and kept up to date by Nexus project managers.

#### *Market Research*

Nexus has provided the Board with some data on consumers that have utilized either the on-line or paper application. This type of data analysis has potential for both designing programs and targeting consumers for particular programs.

Based on the above, the Home Analyzer compares favorably to the other tools in terms of ease of use and it utilizes default values more closely tied to the actual home being assessed. It was very user friendly and provided recommendations more tailored to the home as compared to the other tools that provided general recommendations such as look at ENERGY STAR products when replacing an appliance. The Home Analyzer includes several features identified above that are not available through the other audit tools. The Home Analyzer offers significant opportunity for improvement by taking advantage of several of the available features that are not currently utilized.

Significantly, the Home Analyzer is also the only audit tool that requires funding from the New Jersey Clean Energy Program. In 2002, \$963,000 was expended on the program. Of this amount, \$562,000 was for direct audit costs with the remainder expended on related costs such as administration, sales, marketing and promotions, training and market research. In 2002, 4,706 paper audits were completed, 15,922 on-line audits were performed and 2,807 CD ROMs were mailed to customers for a total of 23,435 audits assuming each customer that received a CD ROM performed an audit. The overall cost per audit performed was approximately \$41 and the direct cost per audit excluding the other costs identified above was approximately \$24 per audit. The average cost per audit will drop as more audits are performed since a significant portion of the overall cost is the fixed monthly payment.

NEXUS has provided CEEEP with the current costs for the audit. Based on the current cost levels, if approximately 15,000 on-line and 5,000 paper audits were to be performed in a year, which is approximately the number of audits performed in 2002, the annual costs for the tool would be approximately \$418,000. The cost per audit at this level is approximately \$21.

The decision as to which audit tool to utilize is a policy decision that should be based on an assessment of the additional benefits of the NEXUS audit as described above compared to the additional costs.

### *Recommendations*

1. *The Office of Clean Energy needs to define what it is looking for in a residential home energy audit:*

All of the tools evaluated were useful for the purposes for which they were designed. The Office of Clean Energy needs to determine whether the tool is intended solely to educate consumers regarding the benefits of installing energy efficiency measures or is intended to motivate customers to implement recommended measures and to participate in other New Jersey Clean Energy Programs.

If the Office of Clean Energy determines that it wants to offer a tool with a high likelihood of motivating customers to implement the recommended measures, the Home Analyzer offers several features that the other tools do not that are aimed at motivating customers to implement recommended measures. The benefits of the additional features offered by the Home Analyzer should be assessed against the additional costs.

2. *If the Office of Clean Energy decides to continue with the Home Analyzer, it should be expanded to include all customers in the State:*

The audit should be expanded to include customers of Rockland Electric and the municipal and cooperative utilities in the State.

3. *Include Available New Jersey Clean Energy Program Incentives in Audit Recommendations*

Three of the audit tools provided links to the New Jersey Clean Energy Program web-site where the user could obtain additional information regarding incentives available to help offset the costs of implementing the recommendations. However, this requires the user to search the web-site to find out if incentives are available for a specific recommendation.

For example, all of the tools recommended sealing air leaks and provided information regarding potential costs and savings. The user would then need to search the New Jersey Clean Energy Program web-site only to find out there are currently no incentives available unless the user qualified for the low-income program.

A second example concerns the recommendation to purchase ENERGY STAR labeled appliances when they are being replaced. The New Jersey Clean Energy Program offers incentives for many ENERGY STAR appliances and it would have been useful if the

recommendations included information concerning the incentives instead of requiring the user to search another site. Rather than simply recommending purchasing an ENERGY STAR labeled product, more value would be added if the recommendation provided information on the cost to purchase and operate a standard efficiency model compared to a high efficiency model and the rebates available to purchase the high efficiency model. In short, rather than providing links to the web-sites that have information concerning available incentives, having the information included in the tool would provide a much more useful link to the programs.

#### *4. Provide On-line Access to Customer Bills*

Three of the tools allow customers to input specific energy usage information. However, such information is not readily available unless the customer has saved twelve months worth of utility/energy bills. The evaluator had to call his local utility and have them send this information which took approximately one week to arrive.

Allowing the user to download past electric and gas bills would greatly simplify the process and allow the user to obtain more personalized and accurate results. While this feature has not been implemented in New Jersey, NEXUS has indicated that it has been shown to add significant value in state's where it has been implemented and is available to the New Jersey Clean Energy Program if desired.

#### *5. Assess the number of customers that implement recommended measures*

The Board should perform an additional evaluation next year to determine the number of customers that install measures recommended by the audit.

## Appendix A

### ***LBNL Report: Executive Summary***

The following is the Executive Summary of the LBNL Report that sets out many of the issues faced when evaluating residential home energy audit tools:

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.



