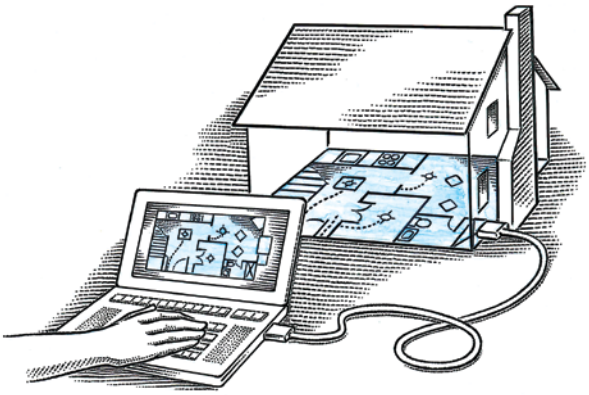
Energy Modeling Software

Is It Worth Your Time and Money?

Even the most sophisticated programs have limits

BY MARTIN HOLLADAY

As residential energy codes get more stringent, designers and builders can't avoid an increasing focus on energy efficiency. So what's a good way for designers to get a ballpark estimate of future energy bills? One way is to look at the utility bills of a comparable nearby home. In most cases, though, energy-modeling software is used for energy estimates.



Some energy-modeling programs can be downloaded for free, while others cost thousands of dollars. In general, you get what you pay for, but the free versions are actually pretty good. However, none of these programs, whether free or expensive, will deliver meaningful information unless the user understands the program's limitations.

Different tools for different tasks

One of the most common types of energy modeling is a "Manual J" calculation to determine the size of heating or cooling equipment. (It's called a Manual J calculation because it follows the Manual J method developed by the Air Conditioning Contractors of America.)

Another type of energy modeling is performed for new homes to compare the likely effects of various options—more insulation or better windows. Common programs for this purpose include REM/Design (a cousin to the REM/Rate program used by HERS raters), eQuest, HEED, HOT2000 (a Canadian program), BEopt (a tool for designing net-zero-energy homes), and the Passive House Planning Package (PHPP), a spreadsheet that helps designers meet the Passive House standard developed in Germany.

To prove compliance with energy codes, most builders use a program called REScheck. Some states have energy codes that require state-specific software programs, however; Florida builders usually use EnergyGauge software, while California builders need Title 24 compliance software (EnergyPro or MicroPas). Energy researchers and consultants who need a sophisticated program can choose from programs like DOE-2, Energy-10, EnergyPlus, and TRNSYS.

Budget plenty of time for the task

There are at least two downsides to using energy-modeling software. First, it takes a long time to enter all of the required inputs. Second, the results provided by some programs may not be accurate enough to be useful—in part because many relevant factors can't be modeled.

Most programs require you to measure the size of every room and to specify the R-value of the basement insulation, the wall insulation, and the ceiling insulation. Then you measure each window, input the direction and glazing specifications, and describe the heating and cooling equipment. In most cases, you estimate or measure the home's air-leakage rate.

In theory, programs with many inputs should be more accurate than those with fewer inputs, so software designers usually make deliberate trade-offs between accuracy and usability. At least one study, however, has called this into question. "Many existing models ask for inputs that are difficult to assess—for example, window-shading percentages, wind-exposure ratings, and soil conditions," says Michael

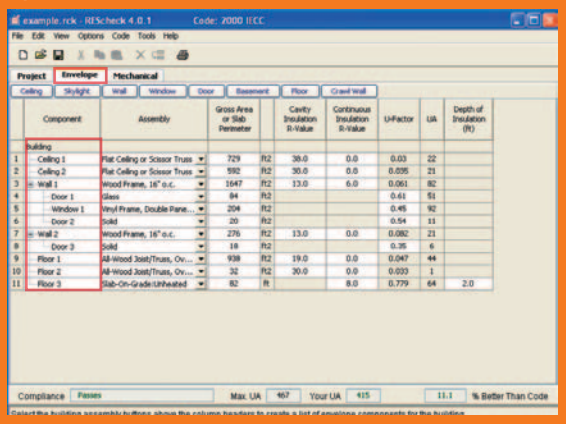
Drawings: Kevin Sprouls. Photo facing page: Daniel Morrison.

CALCULATING ENERGY USE

Although a computer program can't guess how many showers you'll take each week or how often you'll turn on the air conditioner, it can do a fairly good job of estimating the energy required for space heating in a new home.

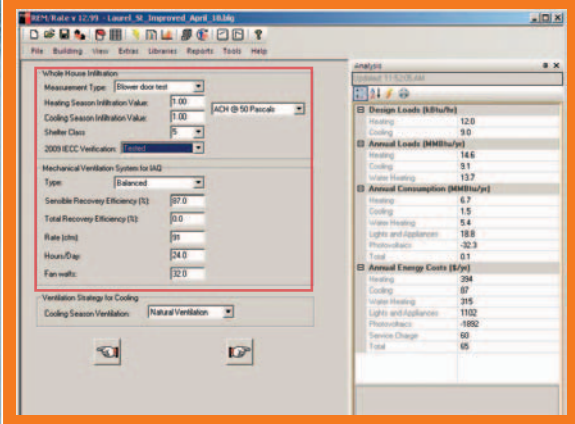
Insulation

Insulation check. Detailed inputs covering the insulation levels of the basement walls, above-grade walls, and ceilings enable REScheck to help you understand how trade-offs (such as 1 in. of wall foam vs. 6 extra in. of attic insulation) affect performance.



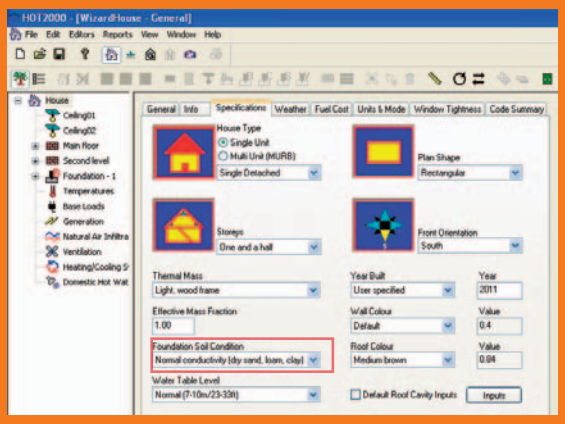
Windows

Enter your window specifications. Window orientation and glazing have a strong influence on energy use. While south-facing windows help provide free heat during the winter, west-facing windows can increase your cooling load.



House shape, soil type

Begin with the basics. House size, shape, orientation, and even soil temperature affect how much energy the house will use. HOT2000, one of the modeling-software pioneers, is still relatively easy to use and relatively accurate.



ENERGY-MODELING SOFTWARE

FREE

REScheck (energycodes.gov)
REScheck demonstrates that a house design complies with the International Energy Conservation Code (IECC). REScheck also supports the 2006 International Residential Code (IRC). Not all states allow the use of REScheck for demonstrating energy-code compliance, so it's important to check local code requirements before deciding to use REScheck.

HEED (energy-design-tools.aud.ucla.edu/heed)
HEED (Home Energy Efficient Design) is an easy-to-use program that allows designers to optimize the energy performance of a new home or to improve an existing home.

HOT2000 (canmetenergy.nrcan.gc.ca/software-tools/hot2000/84)
HOT2000 was developed in the late 1970s at the Saskatoon branch of the National Research Council Canada. For years, it was the official compliance tool for Canada's R2000 program for new energy-efficient homes.

BUILD IT SOLAR (builditsolar.com)
Build It Solar is an online tool for performing heat-loss calculations. The website warns that the results are a "rough estimate... subject to a number of potential errors" partly because infiltration losses are only estimated roughly and the tool ignores thermal-mass effects.

BEOPT (beopt.nrel.gov)
BEopt was developed by engineers at the National Renewable Energy Laboratory. It finds the least costly solution to designing a zero-energy house. The software also can be used to prioritize energy-retrofit work in existing homes.

ENERGYPLUS (apps1.eere.energy.gov/buildings/energyplus)
EnergyPlus was developed in 2001 by researchers at the University of Illinois. It models heating, cooling, lighting, ventilating, and other energy flows, as well as water use. Because it lacks a graphical interface, the program has been called "complex" and "difficult to use."

DOE-2 (doe2.com)
DOE-2 was developed in the 1970s by consultants at James J. Hirsh & Associates and Lawrence Berkeley National Laboratory. Although DOE-2 is not particularly user-friendly, it is the "engine" used by several other easier-to-use energy-modeling programs, including eQuest and BEopt.

EQUEST (doe2.com/equest)
eQuest is a sophisticated multifunction energy-modeling program that has a user-friendly graphical interface and can be used by new-home designers to weigh the effects of a variety of energy-efficiency measures.

SPECPRO (hvacspecpro.com)
Contractors for Pacific Northwest can use SpecPro for HVAC design. The program is provided free of charge to Energy Star builders in the Northwest.

FOR SALE

$474-$495 **MANUAL J SOFTWARE**
Manual J is a heat-load and cooling-load calculation method developed by the Air Conditioning Contractors of America (ACCA). Manual J calculations are performed with the help of modeling software; the best-known Manual J software programs are Elite RHVAC ($495; www.elitesoft.com), Wrightsoft Right-J8 ($474; www.wrightsoft.com), Adtek AccuLoads ($495; www.adteksoft.com), and EnergyGauge ResSize Pro ($299 per year; www.energygauge.com).

$347 **REM/DESIGN** (archenergy.com)
REM/Design is a program for new-home designers, but it also can be used to assess existing homes and to evaluate proposed retrofit measures. It was developed in the early 1980s by Michael Holtz and Russ Derekson of the Architectural Energy Corporation. REM/Design software does not provide users with a home's HERS rating.

$235 **PHPP** (smallplanetworkshopstore.com)
The Passive House Planning Package (PHPP) is an Excel spreadsheet used by designers of new homes that aim to meet the Passive House standard. PHPP can only be used to model a superinsulated building with a low level of air leakage; it is not intended to provide accurate results for other types of homes.

ENERGY-10 ($375; WWW.nibs.org/sbic/energy10-soft)
Energy-10 was developed in 1992 at the National Renewable Energy Laboratory. Designers can use Energy-10 to evaluate trade-offs when refining a building's specifications. Energy-10 produces results as graphical outputs.

TRNSYS ($4740; WWW.TRNSYS.COM)
TRNSYS is a complex energy-modeling software program developed at the University of Wisconsin in 1975. Because of its high cost, TRNSYS is unlikely to be used by builders.

Blasnik, an energy consultant with decades of data-crunching experience. "One model asks you how many doorbells are in the house. Questions like that seem like a colossal waste of time. The moral is to get the big stuff right and don't waste time with the other stuff."

In 2009, Blasnik cooperated with an Oregon study illustrating that simple modeling programs sometimes get the best results. "You can sometimes get worse answers if you collect more data than if you just make reasonable default assumptions," Blasnik concludes.

How accurate are the models?

When applied to new homes, most energy models are fairly accurate. Designers should remember, though, that energy use is driven not only by envelope design, but also by occupant behavior. One family may run the air conditioner every day and take 21 showers a week, while the family next door may rarely turn on the air conditioner and only take five showers a week.

Some variables are difficult to model, including heat loss through foundations, walls, and attics; air leaks; framing factors; edge effects; window heat gain and loss; interior and exterior shading; the effect of insect screens; air films; HVAC-equipment performance; duct efficiency; and AC-refrigerant charge. There are also variables, such as soil conductivity and wind speed, that are extremely difficult for software users to estimate.

Model new houses with software

If you are designing a new energy-efficient home, it makes sense to refine your specifications with a program such as REM/Design (or at the very least to hire a consultant to run the model for you).

Modeling results need to be interpreted with common sense. While software can be used to compare different energy-saving options—for example, adding 8 in. of attic insulation versus upgrading windows—designers need to determine whether a program's suggested specifications are buildable. According to Blasnik, "There will probably be something else that affects your decision more than what the model says—maybe the logistics of getting the insulation up in the attic, or how big a raised-heel truss you can get. These trade-off decisions require judgment—that is, a knowledge of what is buildable, a ballpark idea of how much energy you can save, and a feel for prices." Expressing the same point, Virginia architect Adam Cohen recently quipped, "Energy modeling is 25% science, 25% experience, 25% art, and 25% voodoo."

Blasnik explains, "If you are building a superefficient home, the heating usage will be dominated by hard-to-model factors, like lightbulbs and plug loads. One large-screen plasma TV may matter more than the thickness of the foam insulation under the slab".

Older buildings are harder to model

Several studies have confirmed that most software programs are less accurate at modeling older homes than new homes. "Pre-retrofit energy use in older homes is dramatically overestimated because of poor assumptions, biased inputs, and bad algorithms," says Blasnik. Models and energy auditors often underestimate the efficiency of existing heating equipment; they also tend to underestimate the R-value of existing walls and existing windows.

Although agencies perform that energy-retrofit work often require weatherization contractors to perform energy modeling, the exercise is probably a waste of time. "We don't need to model individual homes, especially on retrofit jobs," says Bruce Manclark, a residential energy expert at Fluid Marketing Strategies in Portland, Ore. "We've been retrofitting homes for a long time. We know that adding insulation to an R-11 attic is a good idea."

Of course, homeowners planning energy-retrofit work need guidance on which measures to invest in first. Although energy modeling may help with these decisions, a software program is likely to recommend similar measures for most older homes, and the conclusions end up having the familiar whiff of good-old rules of thumb.

Using software to size HVAC equipment

Most builders know that they are supposed to use energy software to size a furnace or air conditioner. Surprisingly, however, after energy experts have spent several decades reminding HVAC contractors that Manual J calculations are vitally important, the pendulum has recently begun to swing the other way.

Researchers have discovered that oversize air conditioners aren't as bad at reducing high indoor humidity as previously thought. Moreover, today's modulating or two-stage furnaces can operate efficiently under part-load conditions. "For most energy-efficient homes, there are really only two sizes of furnace to choose from—40,000 Btu or 60,000 Btu—so why should you be so exact, when at the end of the sizing exercise you are just going to take a meat ax to it?" Manclark asks.

The most likely cause of comfort problems in new homes isn't equipment oversizing; it's bad duct design and installation. That's why it's still important to perform calculations to size the ducts or radiators serving each conditioned room of a house. When it comes to room-by-room load calculations, software programs are likely to do a better job than rules of thumb.

Honesty is the best policy

New users of energy-modeling software should be aware of the "garbage in, garbage out" problem. Some software users find it hard to resist tweaking their inputs to provide a margin of safety—for example, by lowering the winter design temperature, raising the summer design temperature, or telling the program that the house is leakier than it really is. Once you've tweaked your inputs, however, the results won't be useful.

"If you are building a superefficient home, the heating usage will be dominated by hard-to-model factors, including internal gains like lightbulbs"

Anyone performing a heat-load or cooling-load calculation should heed the advice from Manual J: "Manual J calculations should be aggressive, which means that the designer should take full advantage of legitimate opportunities to minimize the size of estimated loads. In this regard, the practice of manipulating the outdoor design temperature, not taking full credit for efficient construction features, ignoring internal and external window shading devices and then applying an arbitrary 'safety factor' is indefensible."

Do I really need energy-modeling software?

If you're ready to investigate energy-modeling software but aren't yet ready to spend hundreds of dollars, start with one of the free programs such as eQuest, HEED, or HOT2000. After fooling around with free software, you may decide that you want to integrate energy modeling into your regular work routine; at that point, you will probably appreciate the advantages—especially, the improved technical support—that comes when you purchase REM/Design or a similar program.

Most residential builders would rather pay a consultant to perform energy modeling than learn to use the software themselves. "Mike Duclos does most of our modeling when we need it, using REM/Rate or PHPP," says Paul Eldrenkamp, a Boston-area builder and published author. If you do enough modeling on enough projects, you eventually develop a good intuition about what you need to do on any given project to reach a general level of performance. Once you have that intuition in place, the modeling becomes less useful. In fact, the modeling sometimes proves to be less accurate than the intuition. But the modeling is an indispensable step in gaining the intuition." □

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