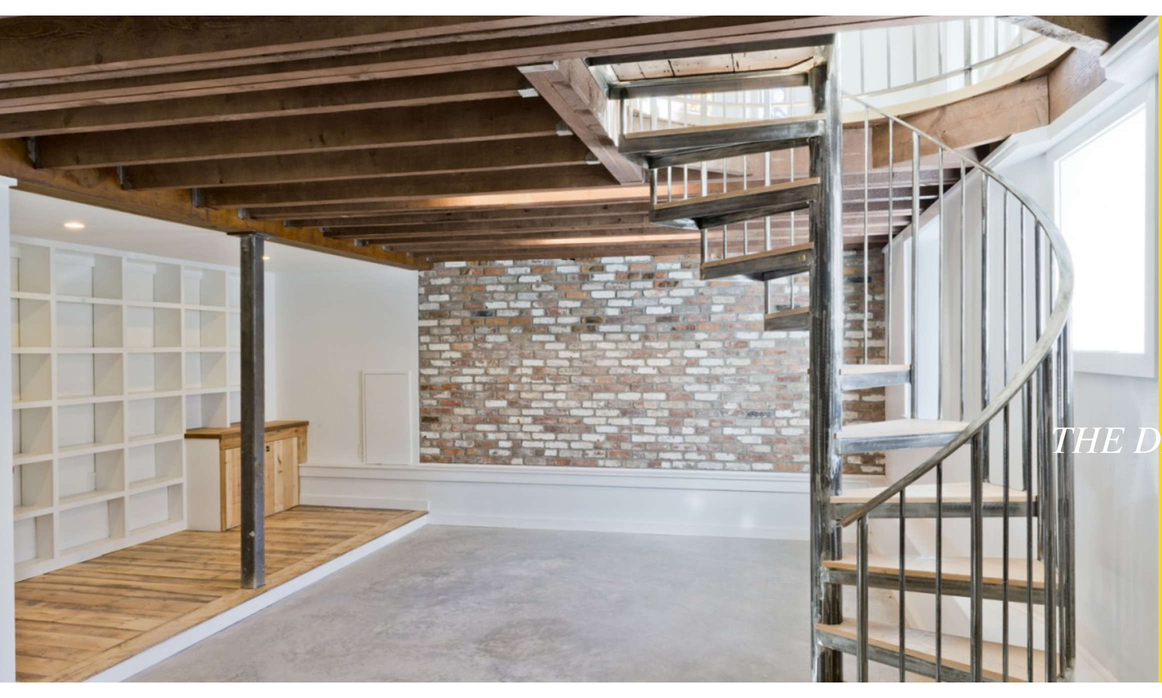


THE DESIGN PROCESS

Step 1

High-performance homes, especially those striving to achieve net zero energy performance, employ a number of materials and construction practices not found in conventional construction. Customarily designers and architects may not specify certain energy-related details or may neglect to make certain decisions relating to energy performance strategies during the design phase, resulting in added costs for builders. For a successful zero energy project, architects and designers, together with their builders, should familiarize themselves with the 12 Steps to cost-effective zero energy home construction and pay special attention to the following design strategies, detailing them on the construction plans as needed.

Site Selection

The ideal site for a zero energy home would have unobstructed sun, flat topography, and little exposure to the weather. It would also be located near access to services, shopping, and mass transit. While few sites will be perfect, being selective about the site will certainly pay off in lowered costs and better living. Solar access is especially important. A solar energy contractor can perform a site analysis to be sure that sufficient sunlight is available on the wall or roof surfaces. As is often the case, a site may have less than perfect solar access. Even with less than optimal solar access, or no solar access at all, you can still employ all the strategies discussed here to bring the home as close to net zero as possible.

Climate

Consider how the local climate affects design. One size does NOT fit all climates. Insulation levels, air tightness, moisture control strategies, daylighting opportunities, and many other design elements must reflect climate zones and local conditions. Special attention should be paid to design needs in warmer climates.

Shape

During the conceptual design phase, consider using fewer, simpler shapes, rather than many smaller shapes with lots of architectural complexity. Simpler building masses will be easier and less expensive to build, air seal, and insulate in the field. Simple shapes will also be more affordable to build.

Size

Think small and design spaces for uses of the client rather than for resale value. Even a small family can live comfortably in a well-designed 1,500-1,800 square foot home with well thought out functionality, storage, and traffic flow. Reducing the home size will save energy and pay for all the energy improvements in a zero energy home.

Thermal Boundary

Clearly define the thermal boundary on design plans. That means deciding what is inside and what is outside the conditioned space. For example: vented attics and crawl spaces are outside the conditioned space. Basements and garages are generally outside, too.

Ceilings

Use only one type of ceiling throughout the house: either flat or cathedral. Whenever ceiling heights change, there will be a wall separating the room with the high ceiling from an unheated space, usually an attic. This “vault wall” or “high wall” can be very tricky to air seal and insulate. The insulation level of that wall should equal other exterior walls, and it will need to be covered on both sides with a rigid material to enclose the insulation. If more than one ceiling height is present, develop clear details for air sealing, insulation, and rigid backing.

Building Orientation

Orient the building to take the greatest advantage of seasonal sun angles for both passive heating and cooling and for maximum solar energy production. Depending on climate, this could involve maximizing passive solar heat gain in cold climates or natural shading in warm climates. For solar panels, a direct southern roof orientation is preferable. However, when southern orientation is not possible, consult with your solar installer to determine the optimal orientation for optimizing solar gain for your local climate conditions and utility interconnection guidelines.

Roof Overhangs

Design a solar shading strategy that allows sun to heat the building when needed and avoid overheating when not needed. One strategy is to design and build fixed roof overhangs, especially on the south sides and on west sides when they are exposed to direct afternoon sun. Calculate and specify the southern roof overhang to maximize winter sun exposure and minimize heat from the summer sun. These fixed overhangs must be a compromise between similar sun angles in spring and fall when the heating or cooling requirements are much different. An alternative would be to consider a shorter fixed overhang of 12 to 18 inches along with moveable shading, such as awnings, sun screens or vegetation. This will allow greater heat gain during spring and less heat gain during fall.

R-Values

Specify R-values on the plans for wall, ceiling and floors and U-values for windows and doors. In cold climates, typical R-values are R-40 for walls, R-60 for ceilings and R-38 for floors. In warm climates typical R-values are R-19 for walls, R-30 for ceilings, and R-19 for floors. Optimal R-values and U-values for your specific climate zone should be determined using energy modeling.

Thermal Bridging

Clearly specify measures for avoiding thermal bridging on the plans. This includes using advanced framing techniques for the wall, floor, and ceiling systems as well as exterior foam sheathing, staggered-stud, and double-stud framing.

Envelope Insulation

Specify that wall insulation is fully enclosed with rigid sheets of OSB, Thermoply, or similar materials and never design walls where it is difficult to properly cover insulation. Pay particular attention to soffits, attics, bathtub surrounds, under stairs on exterior walls, and fireplace enclosures. If you’re drawing double-stud walls, be sure to include details for enclosing the framing cavity, including a plywood cap, across the parallel top plates and plywood bucks inside window and door openings.

Air Sealing Goal

Specify the air tightness standard to be achieved on plans. This is generally expressed in air changes per hour at 50 Pascals (ACH50). The threshold needed to reach net zero energy should be 2.0 ACH50 or less.

Air Barrier Systems

Identify the type of air barrier system to be used. Will it be air-tight drywall approach, ZIP System, SIGA membrane and tape, Aerobarrier, or something else? List air sealing materials and techniques on design plans.

Blower Door Directed Air Sealing

Specify that blower door directed air sealing be conducted, after ceiling drywall has been installed and before insulation is installed, in order to locate unexpected air leaks and to effectively seal them.

Heating and Cooling Equipment

Locate all heating and cooling equipment, along with their pipes, ducts and refrigerant lines. Locate the hot water system and specify its efficiency rating. Draw these on the plans and specify the need for sealing any penetrations. Make every effort to locate this equipment within the conditioned space.

Ventilation

Draw mechanical ventilation equipment and ductwork on the design plans and locate equipment and ducts within the conditioned envelope of the building where feasible. Remember that heat recovery ventilators need a condensate drain. Specify all equipment efficiency ratings on the plans.

Water Heater

Decide on the type of water heater to be used and the best location. Electric resistance water heaters should be centrally located inside the conditioned space in heating-dominated climates and outside the conditioned space in cooling-dominated climates. In heating-dominated climates, heat pump water heaters should be located outside the conditioned space in areas with about 1,000 cubic feet of volume and a supply of waste heat. If gas-fired water heaters are used in an air-tight home, they must be sealed combustion models.

Solar Energy System

Based on an accurate energy model, determine the optimal size of the photovoltaic system. Check that there is adequate roof area with the proper tilt and orientation to supply sufficient energy to reach the zero energy threshold. Make sure that chimneys, plumbing vents, and other roof penetrations are located outside of the roof area planned for solar panels.

Appliances

Specify energy-efficient appliances and their ratings that were selected during energy modeling. The Energy Star Products page is a good resource for choosing efficient appliances.

Engage the Team

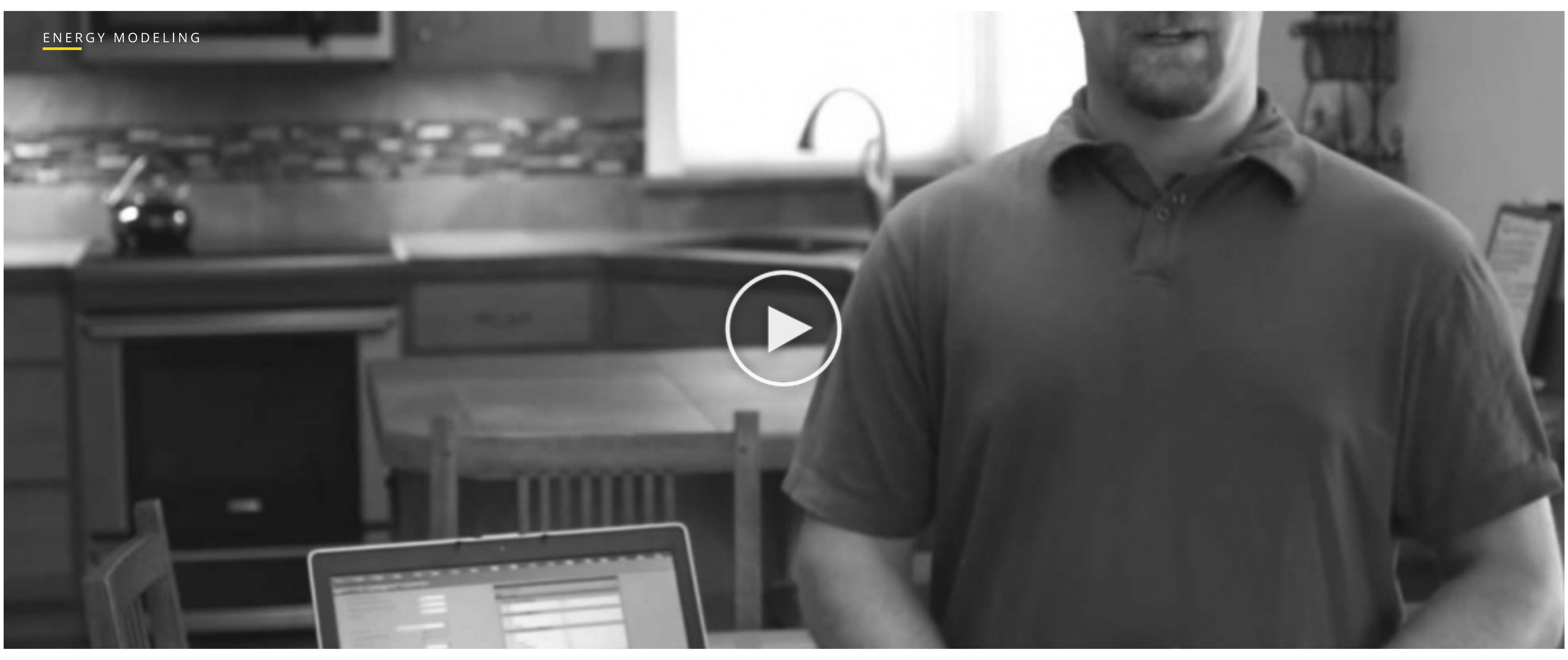
Early in the design process, create a project team including all the relevant building trades, such as framers, insulators, plumbers, electricians, and solar contractors. The team should identify the most cost-effective energy efficiency measures in the design and the most cost-effective sequence for implementing these measures. Ask the team to review the design and incorporate their feedback in construction documents.

USE ENERGY MODELING
Step 2

Energy modeling helps determine which energy saving features are most cost effective. Energy modeling software is an important design tool that helps builders identify the least expensive measures required to create a zero energy home. Modeling should be conducted in multiple iterations of the design, analyzing the energy impact of different design choices, such as a ground source heat pump versus an air source heat pump, or comparing the impact of R-30 wall insulation with that of R-60 wall insulation.

Energy modeling can be done as soon as the designer creates preliminary plans with dimensions, elevations, basic floor plan, and windows and doors. The plans can then be adjusted based on the modeling results so that the project will reach the net zero energy goal at the lowest cost possible. Decisions made during energy modeling will be reflected in the final plan and construction documents. The payback on the costs of energy modeling itself – a matter of a couple of months – is surprisingly short.

Any energy-saving upgrade that costs less per kWh saved than the cost per kWh of installed PV would be considered cost effective and should be integrated into the plan. By using energy modeling to help ensure the cost effectiveness of energy saving measures, the added costs of constructing a zero energy home can be as little as 5% of the sales price, after rebates and tax incentives, depending on the state.



Energy Savings Comparison Chart

The secret to affordable zero energy homes is making small improvements to many specific building elements, such as air sealing, insulation, heating and cooling systems, and solar. Skillful use of modeling tool allows you to optimize the package of elements that makes sense for your budget.

Bruce Sullivan of BaseZero, LLC created the following chart based on a house in Bend, Oregon. It provides a rough sample of the relative energy savings from boosting the efficiency of specific components. Because results will vary depending on building details, climate and other factors, it is recommended that designers and builders conduct a similar exercise for each net zero energy project.

Improvement	Energy Savings in BTUs
Wall from R30 to R40	200,000
Floor from R38 to R44	500,000
Windows from U-0.28 to U-0.22	700,000
Heat Pump HSPF from 9.5 to 10.5	300,000
ACH from 2.5 to 1.5	700,000
Adding 1 kWh of PV panels	4,800,00
Adding one 180 Watt PV panel	796,000
Ceilings from R50 – R60	300,000

It is important to factor in the cost of each improvement when comparing their relative energy savings. Further upgrades will give smaller returns, so that upgrading an energy saving feature beyond a certain point may not be cost-effective any longer. Similarly, upgrading one component will affect the impact of upgrading other components. Energy modeling will help determine the point at which returns in efficiency are no longer cost effective as well as what combination of energy saving measures amounts to the highest savings.
It's nearly impossible to pinpoint the exact net cost of different energy measures because they vary over time and across home building markets. But while energy modeling only provides an estimate, it gives useful guidance as to the relative cost/benefit of each energy-saving measure considered.

Energy Modeling Software Directory

The following links provide information about some of the different energy modeling software that is available:

Energy Gauge, Florida Solar Energy Center

Energy 10, Sustainable Buildings Industry Council (SBIC)

REM Design While not the most accurate or comprehensive energy modeling program available, it is relatively easy to use and quickly provides some of the most helpful energy modeling comparisons. A functionally identical program called REM/Rate is used by certified home energy raters.

EnergyPlus Published by the U.S. Department of Energy, this is a highly sophisticated modeling engine.

BeOpt, National Renewable Energy Laboratory. BeOpt is unique because it allows many options to be compared directly. By entering the cost of each option, the program suggests an optimum package for cost-effectively designing a zero energy home. This provides a graphical user interface for EnergyPlus. Learn more about BeOpt from the Green Building Advisor.

HEED shows how much energy and money and carbon you can save by making various design or remodeling changes to a home with this free new easy-to-use program. You can draw in the floor plan of a house, then click and drag windows to their correct location.

Passive House Planning (Design) Package, (PHPP), Passive House Institute. PHPP may well be the ultimate in energy modeling, however it requires very detailed information and can be time-consuming and expensive. To use this program effectively, you must attend Passive House Consultant training.

Building Energy Software Tools Directory, U.S. Department of Energy. This is a comprehensive and alphabetical directory of energy modeling programs, gathered by the U.S. Department of Energy.

Carbon Foot Printing and Life Cycle Assessment Software

One Click LCA allows designers to import building data from X-cel, Revit, and BIM packages to run standards-based life cycle assessments, carbon footprinting, and job costing.

BuildingScope is a web-based tool used to model and analyze environmental life cycle impact, greenhouse gas emissions and energy use.