Building Efficiently

Tips for those building a new home or doing a major remodel

This document is brought to you by the Middlesex Energy Committee, an ad-hoc group of architects, designers, engineers, builders and homeowners living here in Middlesex, VT.
http://www.whatsnextmiddlesex.org/energy-committee.html

Building or remodeling a house grants you, the homeowner, an opportunity to bake in as much energy efficiency as you like. In cold climates, more tends to be better, as long as it's done right. This document goes over the concepts and considerations, relevant to Vermont's climate, to help you decide just how far you want to go.

The key components of building efficiently are:

- Insulation: A thick layer of material that keeps the heat inside, it goes below the floor, on the walls, and in the ceiling or roof, continuously enclosing the entire building. A higher "R value" means it's able to retain more heat. The best time to maximize R value is, far and away, during construction. Target levels to consider for this area: R-40 under slab & around foundation; R-60 in walls; R-80 in roof.
- Windows: Triple-glazed windows filled with gas and with insulated framing contribute to efficiency, measured by their "U factor." They are also rated for how much solar heat they let in (listed as "Solar Gain Heat Coefficient"). Look for U-values below 0.20.
- Air tightness: Every hole, crack and gap is sealed with foam, tape or other material to stop cold air from entering or warm air from escaping. A blower door test is invaluable!
- Thermal bridge elimination: As an example, a structural member (e.g. stud, rafter) that touches an inside wall and an outside wall or roof will "bridge" heat through the wall or roof. A continuous insulated envelope can eliminate this.
- Ventilation: When all of the above is done well, indoor air quality needs to be managed, typically through balanced heat recovery ventilation that preheats fresh air (by using the heat in the warm air being expelled). This ensures a healthy indoor environment.
- Orientation of the building relative to the sun and nearby trees: New construction can take advantage of solar heat through southern windows in winter and tree shade in summer. Roof overhangs also provide shade for those southern windows.
- Size of the building: Less space = less energy required to heat it! (And it costs less to build.)

Note: These considerations are just as important when trying to keep summer heat out of the house.

On the following pages, we discuss other concepts that you may find helpful to consider.

Getting Started: Hiring Contractors

The art & science of building has advanced so quickly in the past several years that many designers and builders have been left in the dust, so to speak. If you wish to obtain an affordable, comfortable, efficient, sustainable, resilient and healthy building, we suggest that you consider these tips from leading professionals in the field.

Your project team might consist of any of these: architect, designer, engineer, builder, contractor. They should be willing to present to you their certifications with dates; their awards with dates; and their insurance coverage with dates. If they have only outdated information, perhaps they've fallen behind. Just as doctors must acquire continuing education credits to maintain their privileges, so too do other professionals in evolving fields (e.g., bit.do/een-evt, bit.do/phius-cphc, bit.do/phi-cphc).

Ask them:

1. Has your team built a home to a high efficiency standard? Which standard(s)? Was it certified? Where can I view this information?
2. What professional certifications does your team possess? Are they current? Industry examples: PHIUS; PHI; EVT Efficiency Excellence Network; NAHB; Energy Star
3. Will your team use blower door tests to achieve as tight a house as possible, with a final result below 1.0 ACH50? Where have you done this before? (Achieving this result through air tightness is typically the best investment for energy savings, health, and comfort levels.)
4. Does your team believe that the building will need a boiler or furnace or wood stove or heated floor or any fossil fuels as a matter of course? Or do you also consider efficiency and modern heat pumps to be equally viable options (sometimes requiring a secondary option on the coldest days)?
5. Will you provide me with an energy model estimate of the total heating, cooling and ventilation energy needed? Can you discuss with me the energy performance characteristics of the windows, insulation levels and air sealing? (You could then use this information to estimate how much solar PV energy you'd need to offset your electricity needs.)

If you run into someone who claims these issues are unimportant, extreme, or expensive; or if s/he gives vague answers without clear examples and guarantees; then consider another team for your project. Keep in mind that many new home builds currently under construction will be candidates for weatherization upgrades as soon as they're finished!

Your Middlesex Energy Committee stands ready to hook you up with any number of professionals who will be glad to satisfy these industry standard demands and expectations,

and who have had their past work verified by a third-party independent rater. It doesn't cost more to do it right the first time by doing your due diligence.

Cost

When building a home or an addition in the northerly climate of Vermont, you'll be making decisions about how much to insulate, what kinds of windows, what to heat with, and other factors that affect the cost of the project. Although the upfront cost of buying those materials may be daunting, it is critical to also factor in how much you'll spend on heating the place in the future. The money you spend now - one time - on insulation will mean lower heating bills every year, adding up to significant savings. Modern building science and energy modeling allow us to calculate how much heat a house will need if we use so-and-so much insulation, such-and-such windows, and so on. This also informs the type and size heating appliance you'll need. Hire an energy consultant to give you that information, and then talk to your banker about how much more you can borrow to build an efficient house if you are spending less on monthly energy. Invest in your home instead of sending money out of state to fuel companies.

Ventilation

Never before has there been such a focus on air quality and its impact on health. As buildings across North America look to re-open, concerns about COVID-19 are high for good reason.

Balanced ventilation with heat recovery is a key to a healthy, comfortable and energy efficient building, whether residential, commercial or institutional.

A key factor of an energy efficient building is air tightness. 30 to 50% of our heating and cooling energy is lost due to air leakage in the building envelope. The walls are not supposed to breath. But people must breath fresh air to stay healthy and productive. Therefore, as we tighten our buildings, we provide a mechanical balanced ventilation system. Balanced means that it supplies the same volume of fresh air to bedrooms and living rooms as it extracts stale air from kitchens and bathrooms, without losing energy in the process.

High CO2 levels are a good indicator of re-circulated, trapped indoor air, and clearly "re-breathed" air is to be minimized this COVID year more than ever.

Proper ventilation contributes to increased occupant performance:

A recent peer-reviewed study found a 400 ppm increase in CO2 was associated with a 21% decrease in cognitive scores.

A 70-school study in the southwestern USA demonstrated that students' average mathematics scores increased by 0.5% for each 2 cubic feet per minute (cfm) per person increase in Ventilation Rate (VR), ranging up to 15 cfm/person.

A 54-school study demonstrated that math and reading scores were 14% higher when VR was greater than 10 cfm/student compared to scores when VR was less than 5 cfm/student.

Poor ventilation degrades the health of occupants:

A large comparison study of 168 California classrooms demonstrated that increasing classroom VR from the California average (8.5 cfm/person) to the state standard of 15 cfm would decrease illness absences by 3.4%.

A Washington and Idaho study of 434 classrooms showed that a 1000 PPM increase in CO2 was associated with a 10% - 20% increase in student absence.

Build Small

The definition of "small" has changed over the years. Today's small house was "normal" 50 years ago. Architects are returning to those smaller dimensions with an eye toward comfort and efficient use of space. Smaller bedrooms paired with generous living/dining rooms give you the space where you spend more of your waking time. Building smaller is the first step toward construction cost savings initially and energy cost savings for the life of the building.

Comfort

People are more susceptible to germs & viruses when they're stressed by temperatures that are too low or changing too rapidly, as well as when the humidity is too low to support their airway's attempts to clear out those little invaders. In winter, we try to avoid chilly spots in our homes & often have to run humidifiers. None of these are problems in a high performance (HP) home. In a Passive House building the excess heat from TVs & computers, from cooking, the fridge, even occupant body heat goes a long way toward heating the home in the winter. *(Remember, you only have to add heat to replace that which you let get away.)*

High temps & humidity are often problems in the summer. Smoke, pollen & other pollutants in the outside air can make bringing in "fresh air" problematic, especially for folks with allergies or breathing difficulties. Inside the home, pet dander, smells, VOCs (volatile organic compounds like off-gassing furniture, rugs, cooking fumes, paint), CO2, (& for those who burn fossil fuels inside their homes to cook or heat, CO & exhaust gas poisons - bit.do/gas-cook) are of concern. HP homes filter the "fresh air" being brought in from outside, just as they also filter the inside air as it is redistributed around the home. Some ERVs (energy recovery ventilators - exchanging inside air for outside air while saving the temperature difference) will measure the parts per million of CO2 & VOCs separately & will exchange your inside air for fresh filtered outside air when necessary.

Any building built to the Passive House standard will maintain even temperatures from the basement to the top floor. Proper air sealing & insulation levels isolate your home from the

outside environment to an extent that allows you total & affordable control over your interior health & comfort levels year-round. *And yes, you can open the windows & doors anytime you wish. In fact, sitting on a deep window sill in the dead of winter is comfortable.*

Air Sealing & Blower Door Tests

Only in recent years has it become clear that in typical construction air leakage through the envelope can make up one third to half of the total heat loss of a house. Efforts to tighten up a building during construction has a very quick payback - in fact the best payback of any investment in energy efficiency. Of course this applies to renovations of existing buildings as well, but it is easier to make a house tight during construction.

Using a blower door makes the process obvious and easy to accomplish. Efficiency Vermont and energy contractors can provide assistance using a blower door early in the construction process to identify leaks before they are covered up. The benefits of this exercise will result in heat savings for the life of the building. Homeowners building a new home should explore this wonderful and easy opportunity to save fuel costs, regardless of the heat source used. Once you begin to address air sealing, ventilation is an important consideration for health and comfort.

Resources

Efficiency Vermont: Technical assistance, financial assistance, educational resources, certified contractors. bit.do/evt or (888) 921-5990

Capstone Community Action's Weatherization Assistance Program bit.do/cap-weather

Passive House Vermont: Education and contractors for high-performance building VTPH.org

EPA: Weatherization and Indoor Air Quality bit.do/epa-iaq-weather

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