ENERGY MODELS

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Computer energy models calculate heat flow through a building. Of course, they only approximate reality, but if you understand the assumptions, the models can be very useful design tools when considering alternative designs. The models answer the question, "How much energy is used?" and guide us to the most energy effective choices. The image [below] is typical of a building graphic from eQUEST. The boxes represent conditioned zones, but could also represent rooms, as appropriate.

During the 1970s energy crisis, before there were personal computers, architect Ed Mazria published *The Passive Solar Energy Book – Professional Edition*, which presented simple equations that could be done by hand. In that same year, DOE-2, the grandfather of many modern energy modelling programs was written by J.J. Hirsch, to run on a mainframe computer.[1]

By the 1980s, the energy crisis was "resolved." Very few clients cared about the energy use of their buildings. In this environment, construction budgets were spent on other goals, and a mechanical engineer could be confident of a happy client if he or she oversized the heating system to handle anything. Most of the systems were modelled in software provided free by the equipment manufacturers, which, while accurate, focused on specifying equipment, not integrated design.

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Fast-forward to today and a new crisis: global warming. Society is mandating more energy efficient buildings, and owners are interested in exemplary performance in order to impress their customers. Ed Mazria is once again leading the way by providing a framework for energy use: the 2030 Challenge.

USING MODELLING SOFTWARE TO ASSESS THERMAL PERFORMANCE

Knowing how much energy a building will use is one thing; knowing if that amount represents high or low performance is another.

The method used to show compliance with our building codes, and performance under the LEED rating system is to model a "reference building" that has the same size and shape, window pattern, HVAC systems and lighting distribution, but uses code minimums for insulation, window performance, fan efficiency and lighting power density, while the proposed model uses values from proposed construction and equipment. The two numbers are compared, and compliance or savings are established.

This process does not penalize projects that adapt to challenging circumstances, however, it tends to reward more efficient mechanical and building envelope components. The factors that are held the same, particularly the window-to-wall ratio, are important when reducing energy use. If you have a great view to the north and want to wallpaper it with windows, you will not be penalized.

This approach masks the absolute energy use, or energy intensity, expressed as annual energy use/area. A common unit of measure for this is equivalent kwh/m^2. Designers who regularly work with energy intensity are more likely to understand the different energy use patterns of occupancy types – building envelope efficiency is more important in small buildings than large, for example. Building this intuition is important for the energy design performance of architects and engineers!

The LEED rating system uses a similar method except that the cost of energy, rather than the quantity, is used. The cost of energy appears to serve as an approximation of the amount of GHG emissions, which is not always the case, so the focus is not on the highest GHG reductions.

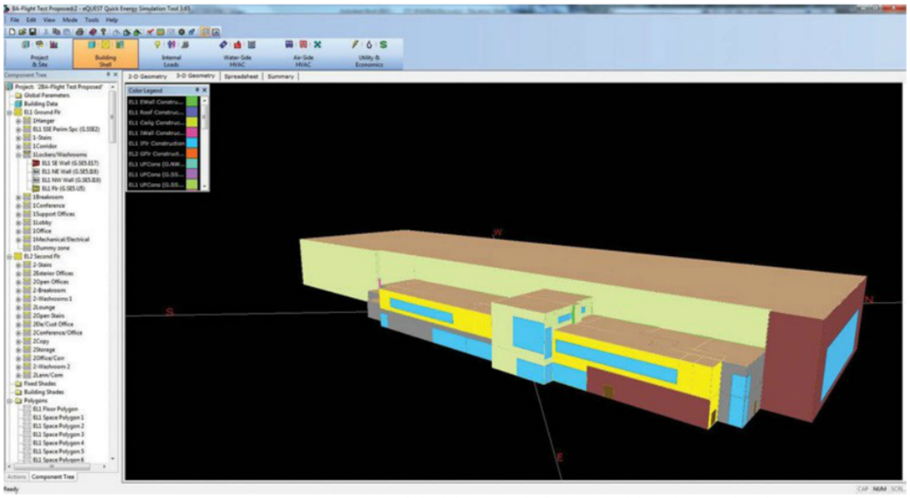
The 2030 Challenge takes a different approach. It sets energy intensity targets for new buildings and major renovations by occupancy type. The benchmark is the average energy use of buildings by type, in 2006, with the target energy use being reduced every five years. In 2014, the target is 60 per cent below the benchmark. So, for example, the average performance of an office building in Ontario in 2006 was 395 equivalent kwh/m^2. In 2014, the 2030 target energy intensity is 60 per cent of this figure, or 158 equivalent kwh/m^2. Benchmark data is available from architecture2030.org. This method ties energy use to that required to stabilize the climate: zero greenhouse gas emissions. It does not mask high energy use decisions.

The federal government's Energuide program, and the German Passive House standard also use energy intensity to assess compliance.

HOW DO YOU KNOW THAT THE RESULTS ARE ACCURATE?

Great model results and actual high performing buildings are different things. The most common software has been validated through the measurement of many actual building performances against predicted performances.

Additionally, if the input is inappropriate, the results will be too. Energy modelling programs were not originally intended to verify regulatory compliance. Using unrealistic settings can result in false "passes" and false performance claims.



An energy model of the New Flight Test Building for Bombardier at Downsview. Screen Capture by Sheena Sharp

Licensed architects and engineers must stand behind their work so they need to approve the inputs.

Air-tightness provides a good example, since it can have a significant effect on performance. Constructed air-tightness will depend on detailing, materials selected for the air barrier, and adherence to the details during construction. Good judgment is required to ensure that a realistic value is modeled.

Another potential problem is the inaccurate modelling of user behaviour. You may have a great model, but if your client does not mention that they sleep with the windows open in January, the future will not be as predicted!

Finally, is it built as modelled? "Unintended" ventilation can be responsible for 40 per cent of building heat loss. A successful strategy for ensuring that actual air-tightness matches modelled air-tightness is to require blower door tests during construction for all building types.

While commercial blower door tests can be expensive, the fact that a test will be done will ensure a higher standard of workmanship, as leaks must be found and repaired before the work is accepted. Consider that we would never forgo concrete testing. We should view air tightness with similar seriousness.

CHOOSING MODELLING SOFTWARE

Modelling software can be divided into two types: whole building programs and feeder programs. The whole building program selected should be appropriate to your building type and energy reduction strategy. However, it may not have data for the equipment you are using. Other programs may ask for U-values, but will not calculate them. This is where small, one-task programs may be used to calculate input values. Examples are THERM (thermal Bridges), FRAME (window frames), and RETscreen (renewables). For those thinking of adding modelling to their skill set, below is an overview of common whole building programs.

If your project uses typical Canadian residential details and equipment, HOT2000 is a good choice because assumptions appropriate to wood-frame housing are built in, and therefore models can be built faster. It has the added benefit that it can be used for building code compliance through the Energuide path. This software is developed by the Canadian government through NRCAN, and is free of charge.

The Passive House standard, despite its name, is appropriate for all housing and buildings up to six storeys. Certification requires a high standard of performance and is determined through the use of custom spreadsheet modelling software, which can be used even if you are not seeking certification. Most programs remain silent on the issue of thermal bridges (e.g., wall studs and window placement). PH software requires users to explicitly calculate thermal bridges, resulting in high predictive accuracy. The Passive House spreadsheet is sold by the Canadian Passive House Institute.

Based on the DOE2 engine, eQUEST is the software most commonly used for larger commercial buildings. It is also appropriate for small buildings and houses, if they have complex thermal reduction strategies. It includes a project set-up wizard, that speeds the process of model building. It is endorsed for code compliance and LEED performance calculations and is available free of charge from www.DOE2.com.

If your energy strategy includes using the thermal mass of the building to store heat, you will need EnergyPlus or IES-VE, which model thermal mass effects. EnergyPlus is a calculation engine employed by several user interfaces, Open Studio being the most common. It is available free of charge. IES-VE is a robust suite of programs sold by IES.

Sefaira, a new entrant to the field, has strengths in its graphic output, and in interfaces with REVIT, and has some nifty "goal seek" functions. However, it is not approved for compliance, and while it is easy to use, it is not idiot-proof: it is hard to find and approve its inputs. It is sold by Sefaira.

There are many programs purporting to "Model energy use, simplified for design." But these programs are not up to professional standards. All the programs above can be used in the early design stages by entering target performance in lieu of details.

CONCLUSION

Increasingly, regulation and client goals include high thermal performance. Energy modelling is a necessary tool to meet these goals. Given this, we can expect to hear a lot more about it in boardrooms and on kitchen tables across Ontario.

NOTES

1. http://www.bembook.ibpsa.us/index.php?title=History_of_Building_Energy_Modeling

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