Fun With Numbers

International comparisons of house energy performance are difficult because of inconsistent definition of terms. Energy use for space heating in new energy efficient homes in cold climates is a small portion of total household energy used. Waste heat from appliances now provides a major portion of space heating.

The main difference between new houses in cold and warm climates are the technologies used to achieve thermal comfort. Total energy use is now the most appropriate indicator of performance.

We give kids "fun with numbers" arithmetic books so when they grow up they will not be afraid of math. The real keeners grow up to become statisticians!

This comes to mind when looking at the findings of a recent International Energy Agency report that tried to compare the energy performance of houses in seven countries. International comparisons are complicated by inconsistent definitions of key terms. The study looked at available data on houses in seven countries and twenty different indicators of energy efficiency. It found that the results depend on what is being compared and how.

Uniform measurement becomes important as we try to credit reductions in greenhouse gas emissions. Emissions credit trading may take place because sometimes it may be more cost effective in the short term to pay for energy efficiency improvements somewhere else rather than undertake immediate and extensive upgrades. For example, a coal burning electrical plant in Alberta or Nova Scotia may find it cheaper in the short term to subsidize residential and commercial building energy efficiency improvements inside or even outside their immediate trading area, rather than change the thermal plant.

The homes in the study represented a wide range of locations, designs, and efficiencies. Their size ranged from 107 to 223 m^2.

A major problem was that there was no complete data for many homes. For example, many houses had carefully instrumented single systems, such as a solar heater system or ground source heat pump but did not have whole-house energy metering. Others monitored energy use for only a few months, while still others were unclear how energy sources were measured. Full building thermal characteristics, numbers and types of appliances in the house, indoor temperatures, or the number of occupants were not recorded. The exception was the R-2000 homes database which has all this data (and more).

Calculating Energy Efficiency

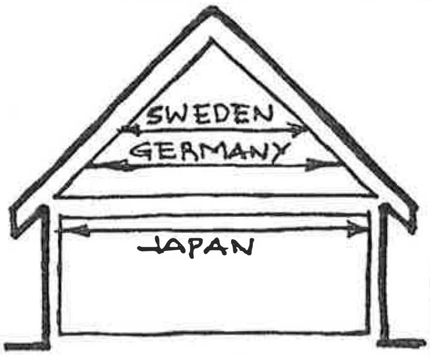
Measurement of energy efficiency may seem a simple matter of reading a meter or fuel bill or the energy used by the furnace or boiler. However, that is only one very simple indicator. Some people calculate only the energy used at the house, others consider entire energy system use, so that generation and distribution losses in the entire energy grid are also taken into account. Even how energy content of fuel is measured varies, as Europe and the United States measure the energy content of fuels differently. Houses that appear energy efficient based on how much energy is used when measured at the house are not so efficient when offsite energy use is also considered.

Until recently, the focus on residential energy consumption has been on space heating. However, in newer more energy efficient homes in cold climates the use of energy for space heating is becoming a small portion of total household energy used. Appliance waste heat may now be providing a major portion of heating requirements, so the energy consumed by traditional heating systems is often less than one third of total energy use, and can no longer be examined in isolation. That is why we have to consider the total energy use of buildings rather than just focus on space heating. For example, the sauna in the Finnish house consumed nearly 6 kWh/day, most of this eventually becoming useful internal gains.

The greatest distinction between new, cold-climate houses and warmer-climate houses is not how much space heat is consumed—it is about the same for both—but the technologies used to achieve the same level of thermal comfort. Simple indicators of energy performance cannot capture these effects. For these reasons, total energy use is increasingly the most appropriate indicator of performance.

Calculating the Liveable Floor Area

The floor area is an important, commonly used factor for comparison. Unfortunately, every coun-



Level at which attic space floor area calculation is taken in each country.

try seems to calculate the liveable portion differently. In many European houses, the living area under the roofs (or attics) represents a significant fraction of the total floor area. Because of the different methods of calculation, the same house in Japan, Germany or Sweden would have substantially different floor areas. If this inconsistency is overlooked, Swedish houses appear 25% less efficient (per unit of floor area) than their Japanese counterparts. Adjusting for this discrepancy alone makes Swedish houses much more efficient.

Other variations include calculating gross versus net floor area, treatment of basements, garages, and distinctions between heated floor area and total floor area. These definitions are typically inconsistent between countries and sometimes even inside countries because they vary with construction type.

Even within Canada, local zoning regulations use different methods of calculation. In some places any space more than four feet high is counted as floor area, while elsewhere it may be higher, or spaces such as basements may be completely excluded.

Calculating Degree-Days

The number of degree-days is a useful indicator of the severity of the winter. However, there is no single definition of a degree-day, so there is no simple way to convert degree-day information. Each country has special variants to suit its needs as shown in the Table.

Degree Day Definitions				
Country	**Heating begins**	**Inside temperature**	**Calculation**	**Time of year**
Germany, Poland	T_{out} <15°C	20°C	T_{in} - T_{out}	Sept - May
Sweden, Finland, Norway				depends on location
fall	T_{out} <12°C	20°C	17°C - T_{out}	
spring	T_{out} <10°C	20°C	17°C - T_{out}	
Canada, United States	T_{out} <18°C	21°C	18°C - T_{out}	
Japan	T_{out} <18°C	n/a	18°C - T_{out}	depends on location

Use and Occupancy

Use and occupancy assumptions can also have a big impact on a home's energy performance. High occupancy combined with low appliance energy and low indoor temperatures will affect energy use.

The Polish house studied was small, occupied by a family of six, and consumed very little electricity for appliances. It looked like a moderately energy efficient house. In fact, the low energy use was due to the home's high occupancy. It also had fewer appliances and relied on a district heating system (the heat was generated in a neighborhood heating plant and shared by many units).

The Japanese house appeared to be very efficient. However, the four occupants maintained the house at 13 - 20°C during the winter, but most of the time above 17°C. A small portable electric heater provided personal heating for the occupants when sitting in the living room and allowed them to maintain comfort at lower room air temperatures. The heat recovery ventilator was used only during the daytime. Cold water was normally used in the washing machine.

The quality of the indoor environment, such as temperature, air quality, and other amenities, is not adequately reflected in any of the indicators. This rises in importance because some amenities are energy-intensive.

As the study showed, any modern house can be considered as the most efficient – it all depends on which criteria are being used for the comparison. As all builders who've had to compete on a bid know, you just hope that all bidders are basing their costs on the same specifications. The same goes for energy efficiency. To be an honest comparison, you have to use the same base criteria on which to make the judgement.

***Indicators of Energy Efficiency in Cold-climate Buildings**. Results from an Expert Working Group for the International Energy Agency.*

Copies of the full report can be downloaded from http://eetd.lbl.gov/Buildings/ALAN/Indicators99/