Buildings
Zero Energy Housing

by Emil ter Horst - Novem

Reprinted with permission from the Sustainable Energy Industry Journal, Issue 7 1998. Emil ter Horst spoke at NESEA's Building Energy '96 Conference. He is a member of the IEA's Terrestrial PV Systems Committee along with NESEA member Steven Strong.

Dutch thinking about sustainability ascribes considerable importance to zero energy housing. And it's more than just thinking. A number of pilot projects have already demonstrated the practical feasibility of the concept.

The zero energy concept is that the annual energy consumption of a house or building should be equal to the amount of energy produced by it. It assumes that all energy will be generated by sustainable methods and that energy consumption will be kept as low as possible. Energy production may be achieved, for example, by using passive solar energy for space heating, solar collectors for water heating and photovoltaic (pv) modules for electricity. Energy demand is reduced by extensive thermal insulation and energy-efficient systems and appliances. Since no concessions are made as regards comfort, zero energy housing is not a Spartan option reserved for idealists but a realistic basis for 21st century architecture.

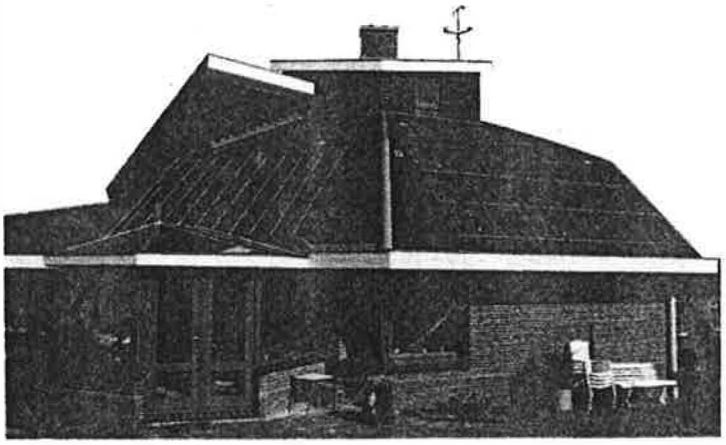
Modern zero energy concepts usually involve a connection to public energy supplies. In that case, the term 'zero energy' refers to a zero (equal) balance: excess solar power generated during the day is delivered to the network 'in exchange' for electricity drawn from the same network during the evening and night. Or, alternatively, excess power generated during the summer - when the pv-modules will regularly produce more than is needed - can be exchanged for extra energy to meet the wintertime demand.

The zero energy concept creates a new role for the roof. It no longer simply provides necessary protection from the elements, but becomes a fifth facade with a whole range of functions: to supply electricity and thermal energy, to help with cooling and daylighting and even, for example, to collect rainwater to flush lavatories.

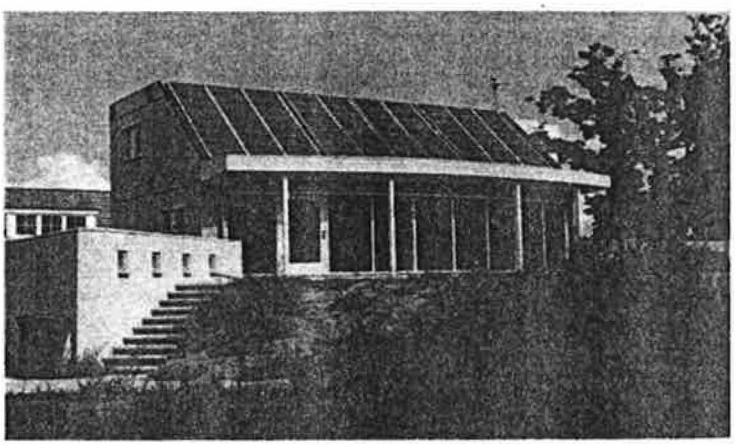
Clearly, this kind of concept is likely to attract interest. Not only is it a visible manifestation of sustainability, but it will very soon be a cost-effective approach to building. The additional investment required can be partially offset by savings on traditional roofing materials and the systems produce year-on-year savings - something which cannot be said for traditional tiles.

All things considered, the zero energy concept is a logical basis for development projects, and one that is already feasible using current technology. Even so, we cannot expect an instant switch to universal zero energy building: the concept is too different from traditional approaches for that to happen. The 'fifth facade' idea demands a cultural revolution in the construction industry and amongst the other parties involved. Utilities, government authorities, planners, architects, contractors, roofing specialists and building service companies will all have to learn to think in sustainable terms in order to be capable of constructing sustainable buildings. And, equally importantly, the new building materials (like solar collectors and pv-modules) must be carefully designed to avoid any possible problems of sizing, diversity, connectivity etc. on the drawing-board, not to mention the actual building site. To guarantee this, great efforts are currently being made in the Netherlands and elsewhere to achieve coordination between the various parties involved in the sustainable building field.

In the Netherlands, photovoltaic solar energy in the built environment is seen as the most promising sustainable energy option for the 21st century. In order to be in a position to exploit that option, great attention is already being paid to optimizing the layout of future development projects in terms of solar orientation - this being an essential precondition for sustainable building. The zero energy concept has a major role to play, for example, as the driving force behind the large-scale use of solar energy in the coming decades.



The zero energy house in the Dutch town of Woubrugge is a demonstration project set up under IEA task 16. The photo shows the roof-mounted solar collectors (left) and pv-modules which produce excess summertime energy matching the amount of energy purchased in the winter.



All-electric zero energy house in Zandvoort, The Netherlands. Every conceivable measure has been taken to minimize energy consumption in this house while retaining all the usual comfort of a modern home. In the first year, 1995, the pv-modules alone supplied 2876 kWh, compared with total energy consumption of only 2582 kWh: so this is actually a sub-zero energy house.

Keeping Cool Naturally - Inexpensively

It's starting to get warm in the Northeast. When we think of energy efficiency in buildings, we often think first of keeping heat in. Rather than thinking only about staying warm through the winter, it's time to figure out how we can stay cool in the summer as well.

Many of the practical, relatively inexpensive efforts to stay warm (insulation, innovative landscaping, use of appropriate building materials), also help to keep us cool.

Former NESEA Executive Director, Alex Wilson, publisher of ***Environmental Building News****, and John Morrill present some advice on how to stay cool, while saving money, energy, and the environment, excerpted from the* ***Consumer Guide to Home Energy Savings****, published by American Council for an Energy-Efficient Economy (reprinted with permission).*

There are two basic ways to cool a home:

1. Reduce the cooling load

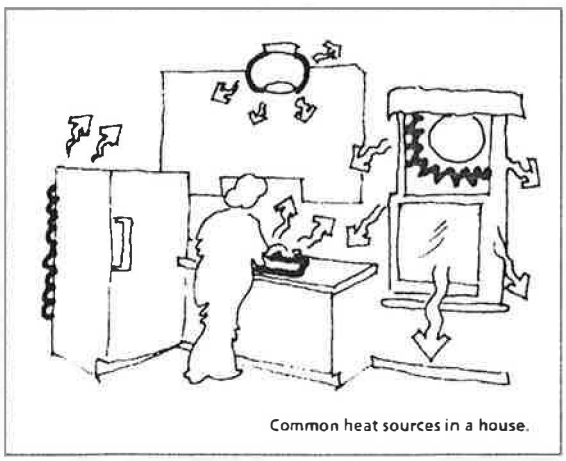
2. Install an appropriate air conditioning unit

In most cases with private homes in the Northeast, it is possible to reduce the cooling load to the extent that only a very small air conditioner is needed, if at all.

The optimal range of comfort in a home is between 72 and 78 degrees F (up to 82 degrees with a slight breeze), and between 35 and 60% relative humidity.

The first place to start is to consider what you can do to reduce the "cooling load", the amount of energy required to make a hot or humid home comfortable.

There are three major sources of unwanted heat in your house during the summer: heat that conducts through your walls and ceiling from the outside air, waste heat that is given off inside your house by lights and appliances, and sunlight that shines through your windows.



Common heat sources in a house.

1. **Heat gain through walls and ceiling.** Whenever the outdoor temperature is higher than the indoor temperature, heat will conduct through the walls and ceiling of the house to the interior. Warm air will blow into the house through cracks.

To reduce these gains, you can insulate and tighten your house. One of the most cost-effective energy conservation measures, for both heating and cooling, is to add extra ceiling insulation. Increase its depth to a full 12 inches. If you don't have wall insulation, have cellulose blown into the walls by a qualified insulation contractor.

Proper attic ventilation can eliminate most of the heat in your attic, before it gets into your living area. Attics should be equipped with soffit vents and either continuous ridge vents or gable end vents. Proper attic ventilation also helps prevent moisture damage to insulation and building materials.

2. **Waste heat from appliances and lights.** Most of the energy used for lights, refrigerators, stoves, washers and dryers, dishwashers, and other household appliances eventually ends up as waste heat that will raise the interior temperature of your house.

The best solution is to use energy-efficient appliances. Energy-efficient appliances and lights produce far less waste heat. Standard incandescent light bulbs for example, emit 90% of their energy as heat, only 10% as light. In some cases you can delay heat-producing tasks until the cooler evening hours. You might also consider relocating a freezer to the basement or garage, where it won't contribute its waste heat to your living space.

3. **Solar gain through windows.** Sunlight shining in windows, particularly those on the east and west sides of a building, usually adds the largest amount of unwanted summertime heat. In addition, the sun heats up the roof and walls of the house, increasing heat conduction to the interior. With no shading of east and west windows, the interior temperature of a typical house could rise as much as 20 degrees F on a hot day, either making your air conditioner work a lot harder, or making you uncomfortable.

The best way to eliminate solar gain is to provide effective shading. Plant tall trees (prune lower branches so as not to impede summer breezes), or use awnings wider than the windows to provide shade. If you have a choice, place porches, sheds, and garages on east and west walls to provide further shading. Unless you have extensive areas of south glass, the south wall should not require summer shading because the summer sun is at too high an angle to cause much of a problem.

If you're replacing windows, put in high-performance windows with low E glazings that look perfectly clear yet block out a large percentage of unwanted heat gain. Another way to reduce solar gain through windows is to install drapes with light-colored linings or operable blinds that will reflect sunlight back outside. Also, choose lighter colors for roofs and walls to reflect sunlight and reduce conductive heat gain.

Getting Rid of Unwanted Heat Through Ventilation

Natural or mechanical ventilation can help reduce air conditioning costs in every area of the country. In the northern US, ventilation can often totally eliminate the need for air conditioning.

In order for air conditioning to be effective, the temperature of the incoming air should be 77 degrees F or lower, making this strategy most effective at night and on cooler days. Keep the house closed up tight on hot days and try to limit unwanted heat gains during the day, then ventilate the house at night. In breezy locations, natural ventilation can be provided simply by opening screened windows. Plantings and fences can be used to help funnel breezes towards your house. If there isn't much wind, you'll need to provide mechanical ventilation with either window fans or a whole-house fan.

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Window fans for ventilation are a reasonable option if they are used properly. They should be located on the leeward side of the house facing out. A window should be open in each room. Interior doors must remain open to allow air flow. Window fans will not work as well in houses with long, narrow hallways, or those with small rooms and many interior partitions. Window fans can be noisy, especially on high setting, but they are very inexpensive.

A **whole-house fan** is a more convenient option than window fans and may cost no more than three or four window fans. Mounted in a hallway ceiling on the top-floor, the fan sucks air from the house and blows it into the attic. The fan is usually covered on the bottom by a louvered vent. (To reduce heat loss through the fan during the winter-time, the entire assembly should be installed within an insulated, weather-stripped box with a removable or hinged lid.)

The fan should have at least two speeds, with the highest one capable of changing the entire volume of air in the house very quickly. Because the fan blows air into the attic, the attic must have sufficient outlet vents.

Before turning on the fan, be sure to open several windows in various areas of the house. If just one or two windows are open, the air flow through them will be intolerably high. For safety reasons, the fan should have manual controls. A fusible link, which automatically shuts the fan down in case of fire, should be included for safety.

The whole-house fan should be turned on as soon as the outdoor temperature drops about three degrees below the indoor temperature. The fan speed should be adjusted according to how quickly you want to cool the house down. Mechanical ventilation uses far less electricity than mechanical air conditioning.

1. Reduce the cooling load by employing cost-effective conservation measures. Provide effective shade for east and west windows. When possible, delay heat-generating activities such as dish washing until evening on hot days.

2. Over most of the cooling season, keep the house closed tight during the day. Don't let in unwanted heat and humidity. Ventilate at night either naturally, or with fans.

3. Use ceiling fans to increase comfort levels at higher thermostat settings.

4. Plant shade trees around the house. Don't plant trees on the south if you want to benefit from passive solar heating in the winter.

5. If you have an older, central air conditioner, consider replacing the outdoor compressor with a modern, high-efficiency unit. Make sure that it is properly matched to the indoor unit.

6. If buying a new air conditioner, be sure that it is properly sized. Get assistance from an energy auditor or air conditioning contractor.

7. Buy a high-efficiency air conditioner: for room air conditioners the EER should be above 9; for central air conditioners look for a SEER above 12.

8. In hot, humid climates, make sure that the air conditioner you buy will adequately get rid of high humidity. Models with variable or multispeed blowers are generally best. Try to keep moisture sources out of the house.

9. Make sure that compressors are well shaded, both for central and room air conditioners. This may be difficult with room air conditioners, but do your best.

10. Try not to use a dehumidifier at the same time your air conditioner is operating. The dehumidifier will increase the cooling load and force the air conditioner to work harder.

11. Seal all air conditioner ducts with duct tape and insulate ducts that run through unheated basements, crawl spaces, and attics.

12. Keep the thermostat set at 78 degrees F - or higher if using ceiling fans. Don't air condition unused rooms.

13. Maintain your air conditioner properly to maximize efficiency.

ACEEE Publications are available at 2140 Shattuck Ave., Berkeley, CA 94704. Also, see Homemade Money, by Richard Heede, published by Rocky Mountain Institute, 1739 Snowmass Creek Road, Snowmass, CO 81654-9199; two issues of the Environmental Building News - Volume 3, #3, and Volume 6, #2, also by Alex Wilson, and Energy-Efficient and Environmental Landscaping, by Anne Simon Moffat and Marc Shiler, published by Appropriate Solutions Press, Dover Road, Box 39, South Newfane, VT 05351.