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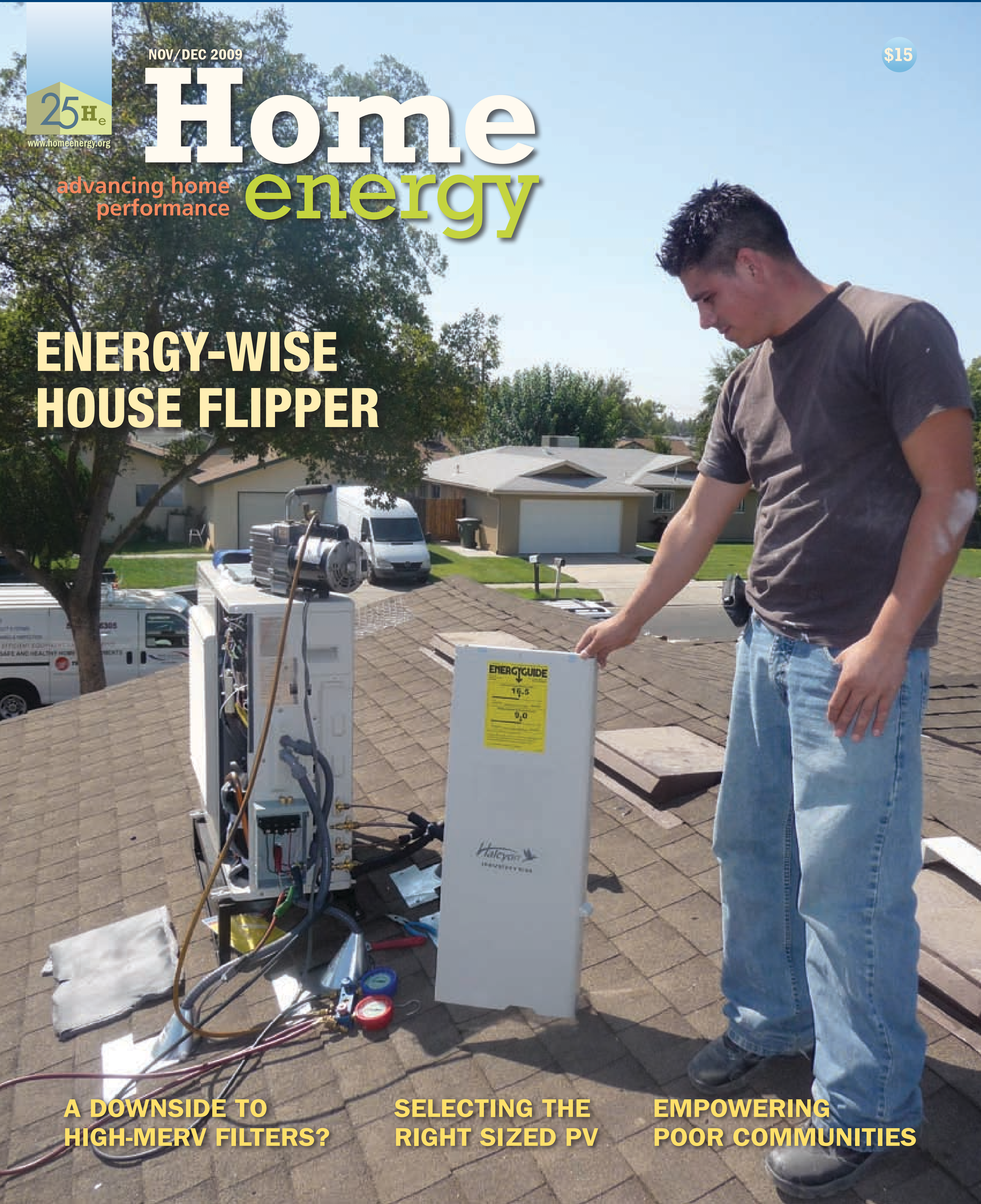

## ENERGY-WISE HOUSE FLIPPER

**A DOWNSIDE TO HIGH-MERV FILTERS?**

**SELECTING THE RIGHT SIZED PV**

**EMPOWERING POOR COMMUNITIES**

# RIGHTSIZING Solar PV Systems

Save 10% to 20% by selecting the right size PV system.

BY BRUCE BARKER

Energy conservation improvements are often the most cost-effective energy-related improvements that we can make to a building. Energy that is not used is energy that does not need to be generated.

Energy conservation improvements include sealing leaks in HVAC ducts; sealing holes in the thermal envelope; upgrading insulation (both its quantity and the quality of the installation); and changing lamps to CFLs or LEDs. Such improvements can produce significant returns for much less than it would cost to install a solar PV system.

An investment in energy conservation improvements should usually precede a PV investment. A more-efficient home will use less electricity and will require a smaller, less costly PV system.

In the real world, mastic and caulk are not as sexy as a shiny new solar array. So if the solar bug has bitten your client, how do you help them to select a rightsized system for their needs? The answer to this question seems simple. Take last year's electricity use from the client's utility bills and invest in a PV system that generates close to that amount. The simple answer may be good if your client pays the same rate all year around, and if you don't expect this situation to change. If the situation is more complex, and you want to help your client to make a wise financial decision, the answer may be more complex as well.

Now is a good time to invest in a PV system. The cost of PV modules is down from last year. Utility and tax incentives reduce the net cost to an amount that many people can afford. If you know how to rightsize a PV system, you can save your clients an additional 10%–20% on their PV system investment.

The rightsizing method described in this article is based on financial considerations. Other valid methods exist for rightsizing a PV system. If, for example, your clients wish to provide power to the electricity grid for environmental reasons, or because they believe that utilities will eventually pay market price for all power purchased from consumers, a different rightsizing protocol would be appropriate.

## Important Terms

It helps to understand a few important terms when rightsizing a PV system.

***Standard test conditions*** are the artificial conditions under which PV module wattage output is measured. Actual PV system wattage output will be at least 10%–30% less than the stated wattage output, depending on the conditions at your client's home.

***Net metering*** is when the utility buys electricity from customers for the same price at which it sells them electricity. Many utilities offer net metering. If a PV system produces more electricity than the customer uses, net metering will build a kWh credit balance in the account. Some utilities reduce any kWh credit balance in a customer's account to zero at year's end. This means the utility gets free electricity. Some utilities give a credit (often at a low wholesale rate) for any kWh credit balance in the account at year's end. Either way, credit balances pay little or nothing to your client. By rightsizing the PV system, you can avoid winding up with a credit balance.

***Time-of-use rate schedules*** charge different rates for electricity depending on the time of day and the time of year when electricity is used. These schedules may produce the lowest electricity bill, and we assume this type of schedule in this article. If your client is not on a time-of-use schedule, then a simple comparison of actual (or estimated) electricity use to the PV system output will usually suffice to rightsize the PV system.

An important feature of time-of-use schedules is that they divide electricity use into two or more buckets. There are usually one or more peak period buckets and an off-peak period bucket. Electricity produced by a PV system during a peak period is credited to one of the peak buckets. Electricity produced during the off-peak period is credited to the off-peak bucket. A PV system produces electricity during daylight (usually the peak period), so most of its production goes into the peak buckets.

Some utilities mix and some do not mix the two buckets. If not, a kWh credit in one bucket is not offset against any kWh charges in the other bucket. Any credit balance in either bucket should be as close to zero as possible when your client's system is rightsized, because utilities may pay little or nothing for credit balances in either bucket. Matching PV system production to your client's actual electricity use pattern (peak and off peak) is an important part of rightsizing the PV system.

## Rightsizing Your Client's PV System

As explained above, this article assumes that your client is on a time-of-use rate schedule. To rightsize your client's PV system, begin by taking these steps:

1. Obtain the client's electricity bills for each of the prior 12 months. Your client may be able to do this easily through the utility's Web site. Identify actual kWh use and dollar cost for peak and off-peak periods for each month.
2. Adjust the client's future kWh use and dollar cost for any anticipated changes in electricity use. If the client may be using less electricity because of energy conservation improvements, reduce the actual use by an appropriate amount to estimate future kWh use and future cost. Be sure to allocate increases or decreases to the appropriate months. For example, a higher-efficiency air conditioner will reduce electricity use in the summer, but not in winter.
3. Add up the actual or adjusted peak and off-peak kWh use for the prior 12 months.
4. If you know the specifications of the PV modules and inverter that you plan to install, you can estimate PV system kWh production using the National Renewable Energy Laboratory calculator at www.pvwatts.org. If you don't know the specifications, obtain an estimate from a PV contractor. Warning: The NREL calculator has a steep learning curve, and it does not provide PV system cost information.
5. Estimate the total annual peak and off-peak PV system kWh production, using the NREL calculator, as described in step 4. Assume that about 70% of total PV system kWh production will be peak production, and that the rest will be off-peak production. This allocation accounts for PV system production during off-peak periods, such as weekends. This allocation is approximate and will vary for each PV system and for each utility. Check with your client's utility to determine peak and off-peak periods, including any partial-peak periods.
6. Compare the estimated peak and off-peak PV system kWh production (from step 5) with your client's actual (or adjusted) peak and off-peak electricity use (from steps 1 and 2) for the prior 12 months. The difference is the amount of electricity that your client may use or may provide to the utility.

The important difference is usually the peak used number. Because your client will receive little or nothing for kWh credit balances remaining at year's end, this difference should be close to zero. If the peak difference is large and positive, the system may be too small. If the peak difference is large and negative, the system may be too large. Table 1 shows how you might perform this comparison.

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Eight PV modules are connected in an array on this roof.

## Estimating Electricity Cost Savings

A precise estimate of electricity cost savings using a PV system requires a very complex spreadsheet or a good solar calculator.

**Table 1. Comparing Peak and Off Peak Energy Use**

| MONTH | PRIOR ACTUAL PEAK | PV PRODUCED PEAK | PEAK USED (TO GRID) | PRIOR ACTUAL OFF PEAK | PV PRODUCED OFF PEAK | OFF PEAK USED (TO GRID) |
|---|---|---|---|---|---|---|
| JAN | 166 | 254 | (88) | 486 | 101 | 385 |
| FEB | 303 | 285 | 18 | 690 | 113 | 577 |
| MAR | 232 | 366 | (134) | 409 | 146 | 263 |
| APR | 201 | 437 | (236) | 389 | 174 | 215 |
| MAY | 293 | 471 | (178) | 517 | 188 | 329 |
| JUN | 554 | 445 | 109 | 876 | 177 | 699 |
| JUL | 503 | 433 | 70 | 875 | 173 | 702 |
| AUG | 620 | 416 | 204 | 1,139 | 166 | 973 |
| SEP | 461 | 377 | 84 | 627 | 150 | 477 |
| OCT | 363 | 341 | 22 | 521 | 136 | 385 |
| NOV | 230 | 263 | (33) | 353 | 105 | 248 |
| DEC | 262 | 244 | 18 | 650 | 93 | 557 |
| TOTAL | 4,188 | 4,332 | (144) | 7,532 | 1,722 | 5,810 |

Table 2. Approximate Annual Cost Savings

| | SUMMER PEAK | SUMMER OFF PEAK | WINTER PEAK | WINTER OFF PEAK | TOTAL | TOTAL COST |
|---|---|---|---|---|---|---|
| Actual kWh used in prior year | 2,794 | 4,555 | 1,394 | 2,977 | 11,720 | |
| Estimated PV system kWh output | 2,579 | 1,028 | 1,753 | 694 | 6,045 | |
| Estimated electricity used (kWh to grid) | 215 | 3,527 | (359) | 2,283 | 5,666 | |
| Approximate cost/kWh | $0.14 | $0.02 | $0.11 | $0.02 | $0.05 | |
| Approximate electricity cost | $30 | $71 | $0 | $46 | $283 | $430 |
| Monthly charges | | | | | | $200 |
| Approximate electric bill with solar | | | | | | $630 |
| Electric bill without solar | | | | | | $1,467 |

You can find solar calculators on the Internet. The solar module manufacturer Kyocera has a solar calculator at www.kyocerasolar.com/products/pvcalculator.html.

One problem I find with most solar calculators is that they provide financial information based on an assumed PV system size instead of helping you to rightsize the system for your client. Another problem is that they do not account for the peak and off-peak kWh data that you often need to rightsize a system.

You can develop a better savings estimate using the following steps and a simple spreadsheet. Some work is required to figure out the total actual cost of electricity for a particular rate schedule.

This example assumes both a time-of-use and a seasonal difference in electricity rates. Check with your utility to determine electricity rates at your client's location. Be sure to account for all costs included in your client's electricity bill. Some rate schedules are very complex and include costs that vary with kWh use, costs that are based on the number of days in a billing cycle, and costs that are based on taxes and fees imposed by governments.

1. Start with your client's electricity bills for the prior 12 months. Use the actual amounts in the bills if you anticipate no changes in future electricity use. Use the adjusted amounts if you anticipate changes in future electricity use. Separate the bills into the seasonal periods used by your client's utility. In this example, you have a winter period and a summer period.
2. Add peak and off-peak kWh use for the summer period and for the winter period. In this example, you also add the total kWh use for all 12 months, because some of this utility's per kWh charges apply equally to all electricity, regardless of when it is used.
3. Calculate the peak and off-peak PV system kWh production for the summer and winter periods, and calculate the total annual PV system kWh production. Use the 70% estimated ratio between peak and off-peak production, as described above.
4. Subtract the PV system production estimates from the actual or adjusted kWh use for each period and type (summer peak and summer off-peak, winter peak and winter off-peak, and total annual).
5. Multiply each of the five results by your utility's electricity use billing rates. In this example, multiply summer peak by $0.14, summer and winter off-peak by $0.02, winter peak by $0.11, and total kWh by $0.05.
6. Add the utility's monthly charges. Monthly charges are usually the minimum charge to provide electricity service. Monthly charges are often based on the number of days in a billing cycle, not on the kWh use. In this example, the total monthly charges for a year are $200.
7. Add the results from steps 5 and 6. The total is your client's estimated electricity bill using your proposed PV system.
8. Subtract the estimated PV system electricity cost from the total actual or adjusted prior electricity cost. This is your client's approximate annual electricity cost savings. Table 2 shows how to arrange this information in a spreadsheet. Note that if there is a negative number in the electricity used (to grid) row, you should enter zero in the approximate cost row if your utility does not reimburse you for credit balances in your account at year's end.

## Analyzing the Investment

For many people, the decision to invest in a PV system involves more than money. People may make this investment for environmental reasons, for patriotic reasons (to reduce our dependence on fossil fuels), or for other reasons. Whatever the reasons, most of us do not have the resources to ignore the financial impact of such an investment. Some simple financial analysis can help your clients decide if a PV system investment makes sense for them financially, as well as for other reasons.

The easiest financial analysis tool to use for this purpose is the payback period. The *payback period* is the time (usually in years) that it takes for your client's electricity savings to equal the cost of the PV system. A rightsized PV system will usually have the shortest payback period compared to larger or smaller systems. Here is one formula for calculating the payback period:

(PV system net cash cost + interest on borrowed money)/annual electricity bill savings = payback period

The PV system net cash cost is the total PV system cost less all utility and tax incentives. You can calculate the interest on borrowed money using many financial calculators or using the CUMIPMT function in Microsoft Excel.

**For example, assume the following:**

| | |
|---|---|
| PV system net cash cost = | $5,100 |
| Amount borrowed = | $10,000 |
| Interest rate = | 10% |
| Loan period = | 18 months |
| Total interest paid = | $810 |
| Annual electricity cost savings = | $837 |

The payback period is
($5,100+$810)/$837 per year = 7.1 years

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These are typical solar PV system components.

The good news about the payback period is that it is easy to understand and to calculate. The bad news is that it is difficult to interpret. There are no rules about what constitutes a good payback period, except that a short payback period is better than a long payback period. In the ideal situation, the payback period is less than the time your client intends to occupy the home. The ideal situation is unusual, so we need to explore a more complex financial analysis tool.

Present value is the value today of your client's future electricity cost savings. Think of present value as the difference between the advertised lottery jackpot and the substantially lower amount people receive if they take a lump sum payment. The lump sum payment is the value today of (usually 20) annual lottery payments. In general, if the present value of your client's electricity cost savings is greater than the cost of the PV system, the PV system is a good financial investment.

## >> For more information:

*Everybody's Building Code* is available for purchase online at http://EverybodysBuildingCode.com.

The American Solar Energy Society (ASES) offers tours of solar PV installations and seminars. Click on Find a Tour at the ASES Web site (www.ases.org) to learn if and when a seminar is happening in your area.

The bad news about present value is that it is difficult to calculate by hand. The best methods are to use a financial calculator or to use the PV (present value, not photovoltaic) function in Microsoft Excel. The good news about present value is that it provides results that are easier to interpret objectively. Here are a couple of ways to use present value to analyze a PV system investment.

A PV system will add value to your client's home, but how much value will it add? One way to estimate value added to a home is to assume that buyers will recognize and pay for the future electricity cost savings. While they may not perform a present value calculation, they may instinctively arrive at a similar result. Your client could also include the present value calculation in the advertising material for a home to justify the asking price.

**For example, assume the following:**

| | |
|---|---|
| Annual electricity cost savings = | $837 |
| Interest rate = | 3% |
| Period buyers will occupy home = | 5 years |

Adding a PV system
will increase the home's value by about $3,800.

You can use the same present value calculation to estimate the value of your client's PV system investment while the client continues to occupy the home. If, for example, your client intends to occupy the home for four more years after the PV system is installed, substitute four years for five in the previous example. Adding a PV system will increase the present value of your client's electricity cost savings by about $3,100.

The sum of the increase in a home's value and the present value of the homeowner's electricity cost savings is $7,200. If this is more than the PV system cost, then not only is the PV system investment wise from an environmental perspective, it is also wise from a financial perspective.

One of the great features of spreadsheets is that they allow you to compare different PV system sizes and costs, to help your clients to select a rightsized PV system for their needs. Given the size of the investment, it is worth taking some time to understand the financial, as well as the environmental and technical aspects, of PV systems. A rightsized PV system can be good for your business, good for your client, good for the environment, and good for the country.


**Bruce Barker** *is a Certified Building Performance Analyst, thermographer, building contractor, and building inspector. He is the author of the book Everybody's Building Code.*



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