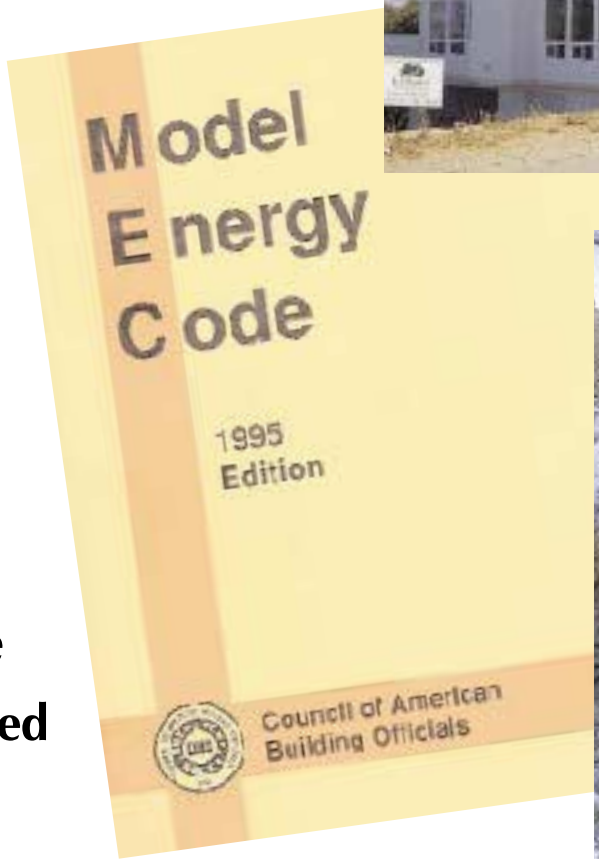
MAKING SENSE OF THE Model Energy Code

The MEC offers three ways to comply, from simple prescriptive measures to more complex but more flexible performance-based designs



Regional differences: For northern builders, foundation insulation is a must; for projects in the South and West, using roof overhangs to block solar heat gain is a priority.

by Mark Madison

When President Bush signed the National Energy Policy Act of 1992, he created the nation's first comprehensive energy policy, with far-reaching ramifications for the building industry. The act pressures states to meet or exceed the federal *Model Energy Code* (*MEC*) and requires all new single and multi-family dwellings that receive federally insured financing to comply with at least the 1992 version of the *MEC*. This means that compliance with the *MEC* is now required if builders anywhere in the country want their homes to be eligible for FHA or VA financing.

The *MEC* was first issued in 1992 and is updated every few years, much like other building codes. Its main intent is to improve the energy efficiency of new

construction. Most states have scrambled to come up with energy codes that satisfy federal *MEC* equivalence requirements (see Figure 1). Many states have adopted the *MEC* word for word or with a just few minor administrative amendments.

Three Ways to Comply

The *MEC* requires compliance with both basic details and window/insulation standards. Basic details cover specific building practices, such as using vapor barriers, sealing all penetrations, and insulating pipes and hvac ducts (Figure 2), while window and insulation requirements focus on the energy efficiency of the overall building envelope. There are three basic routes of compliance for single-family home construction: prescriptive, component tradeoff, and systems analysis. The type of design will determine what approach to take.

Prescriptive. In the simplest cases, contractors can follow regional guidelines on insulating the exterior build-

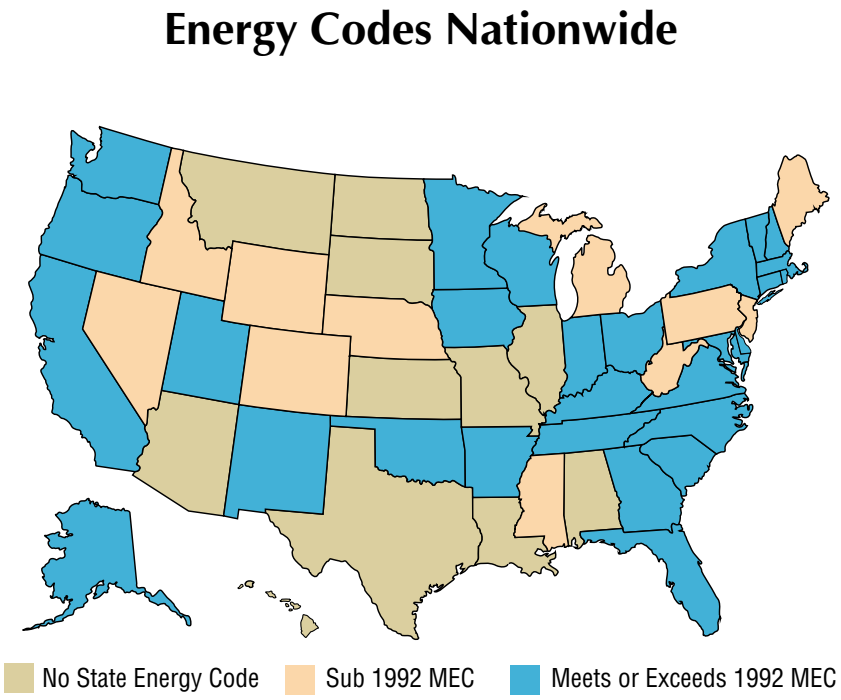


Figure 1. To date, more than 30 states have adopted residential energy codes that meet or exceed the *MEC*. In addition, where no statewide code is in place, the *MEC* has been adopted by some major cities, including Tucson, Ariz., Austin, Texas, and Kansas City, Mo.

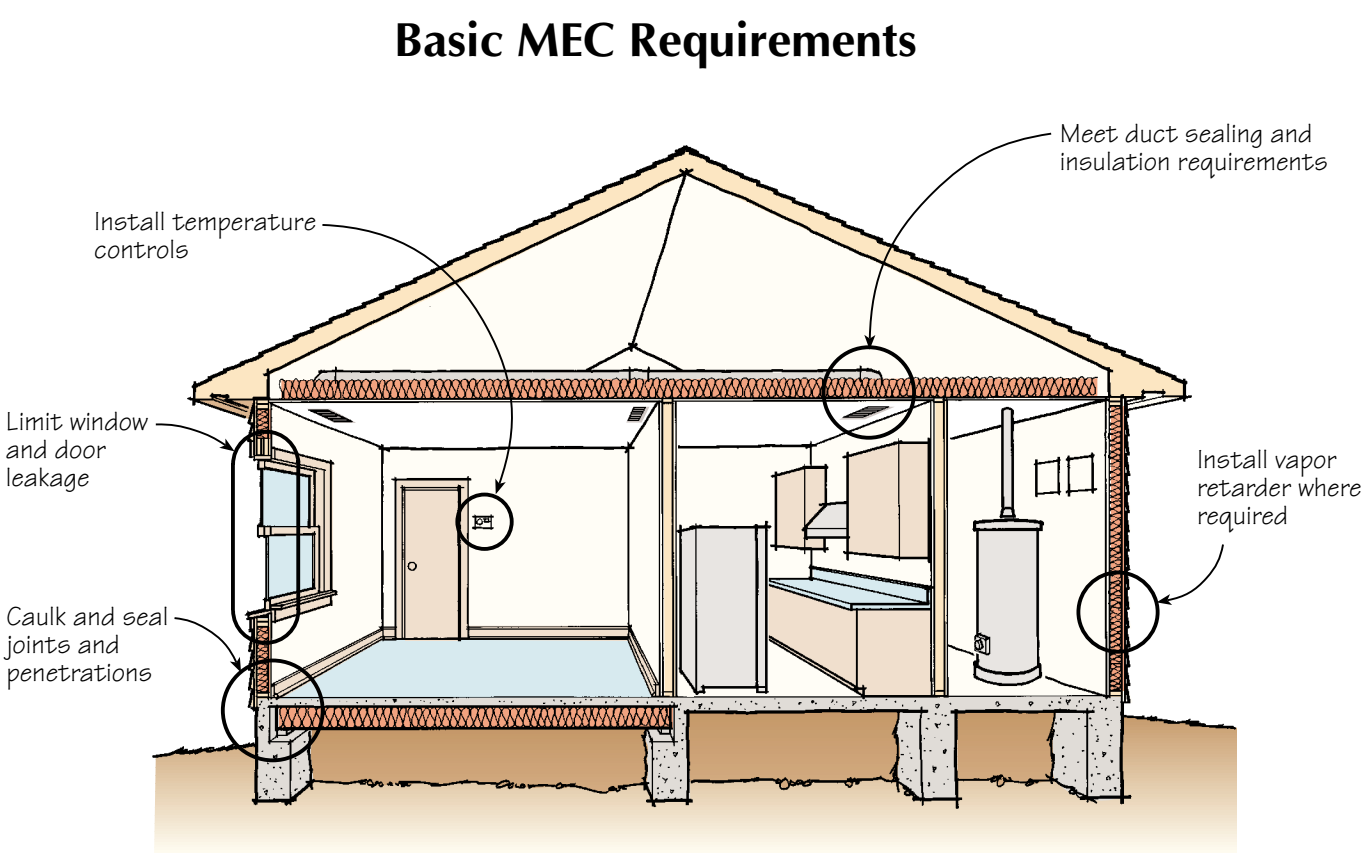


Figure 2. For all residential construction, the *MEC* requires basic energy-saving building features, such as insulated ducts, sealed envelope penetrations, and vapor barriers. Actual requirements vary by climate zone and state.

ing envelope. These guidelines, known as *MEC* Prescriptive Packages (Figure 3) are different for each climate zone and can be found on the Department of Energy's Web site for building standards (www.energycodes.org/meccheck/mecdownload.html) or by calling DOE's residential building standards hotline (800/270-CODE).

Component Tradeoffs

If it seems like a project won't work by following a set prescriptive package, builders can turn to a second approach. The component tradeoff method of compliance is detailed in chapters 5 and 6 of the *MEC*. It consists of a checklist of building standards that define acceptable designs, depending on the climate zone of individual building sites. For example, the component tradeoff method limits glass area, but allows glass area to be increased up to 25% of wall area if a builder installs more efficient windows or higher insulation levels.

Energy calculation aids. Builders can often make at least some of their own energy calculations, using longhand worksheets or specialized computer software (Figure 4). CABO (Council of American Building Officials) has developed a simplified tradeoff approach that provides a measure of flexibility while maintaining overall simplicity. The computerized tradeoff worksheet known as *MECcheck* enables builders to experiment with varying insulation levels in the ceiling, walls, floors, basement walls, slab edges, and crawlspaces, and to modify glazing and door u-values. The software also gives some credit for high-efficiency heating and cooling equipment. Some states have customized versions of *MECcheck* that conform to their particular energy codes.

To use *MECcheck*, the builder enters simple information based on the proposed plans and specifications. The software then compares the thermal performance of the plan's envelope to the standard required for that climate zone and determines if the project complies with *MEC* requirements. If the

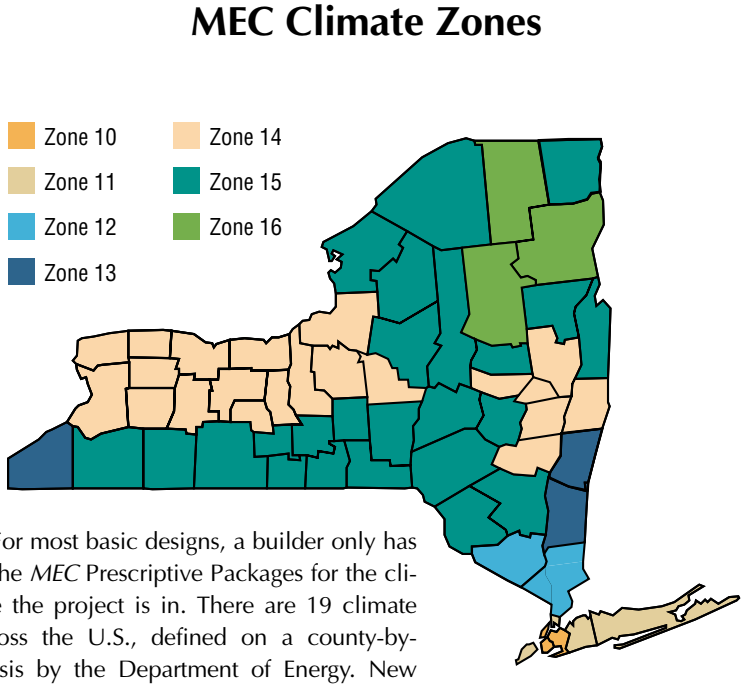
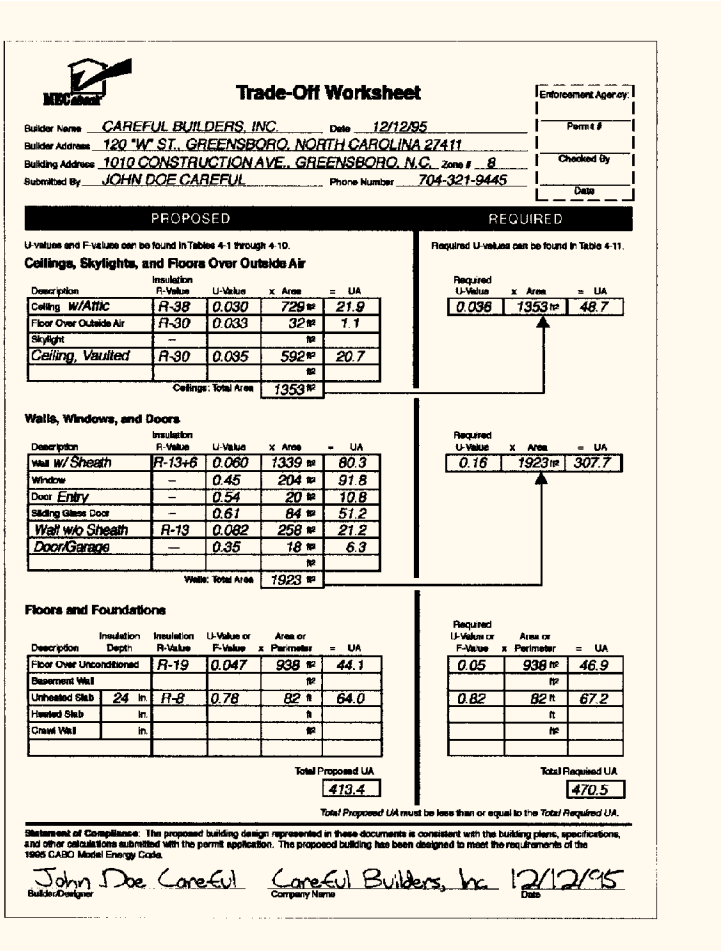


Figure 3. For most basic designs, a builder only has to follow the *MEC* Prescriptive Packages for the climate zone the project is in. There are 19 climate zones across the U.S., defined on a county-by-county basis by the Department of Energy. New York, for example, has seven different climate zones.



Trade-Off Worksheet

Builder Name: CAREFUL BUILDERS, INC. Date: 12/12/95
Builder Address: 120 "W" ST., GREENSBORO, NORTH CAROLINA 27411
Building Address: 1010 CONSTRUCTION AVE., GREENSBORO, N.C. Zone #: 8
Submitted By: JOHN DOE CAREFUL Phone Number: 704-321-9445

Enforcement Agency: Permit #: Checked By: Date:

PROPOSED | REQUIRED

U-values and F-values can be found in Tables 4-1 through 4-10. Required U-values can be found in Table 4-11.

Ceilings, Skylights, and Floors Over Outside Air

Description	Insulation R-Value	U-Value	x Area	= UA
Ceiling w/Attic	R-38	0.030	729 ft²	21.9
Floor Over Outside Air	R-30	0.033	32 ft²	1.1
Skylight	–		ft²	
Ceiling, Vaulted	R-30	0.035	592 ft²	20.7
			ft²	
		Ceilings: Total Area	1353 ft²	

Required U-Value	x Area	= UA
0.036	1353 ft²	48.7

Walls, Windows, and Doors

Description	Insulation R-Value	U-Value	x Area	= UA
Wall w/ Sheath	R-13+6	0.060	1339 ft²	80.3
Window	–	0.45	204 ft²	91.8
Door Entry	–	0.54	20 ft²	10.8
Sliding Glass Door	–	0.61	84 ft²	51.2
Wall w/o Sheath	R-13	0.082	258 ft²	21.2
Door/Garage	—	0.35	18 ft²	6.3
			ft²	
		Walls: Total Area	1923 ft²	

Required U-Value	x Area	= UA
0.16	1923 ft²	307.7

Floors and Foundations

Description	Insulation Depth	Insulation R-Value	U-Value or F-Value	x Area or Perimeter	= UA
Floor Over Unconditioned		R-19	0.047	938 ft²	44.1
Basement Wall				ft²	
Unheated Slab	24 in.	R-8	0.78	82 ft	64.0
Heated Slab	in.			ft	
Crawl Wall	in.			ft²	
				Total Proposed UA	413.4

Required U-Value or F-Value	x Area or Perimeter	= UA
0.05	938 ft²	46.9
	ft²	
0.82	82 ft	67.2
	ft	
	ft²	
		Total Required UA: 470.5

Total Proposed UA must be less than or equal to the Total Required UA.

Statement of Compliance: The proposed building design represented in these documents is consistent with the building plans, specifications, and other calculations submitted with the permit application. The proposed building has been designed to meet the requirements of the 1995 CABO Model Energy Code.

John Doe CarefUl — Builder/Designer
CarefUl Builders, Inc. — Company Name
12/12/95 — Date

Figure 4. For homes with up to 25% glass area and designs that don't fit a prescriptive package, tradeoffs can be calculated on worksheets or with the user-friendly *MECcheck* software (800/270-CODE; www.energycodes.org/meccheck/mecdownload.html).

MEC Climate Zones

How the *MEC* is applied depends on your climate zone. All counties in the United States are rated from 1 to 19, with Zone 1 being the warmest (southern Florida) and Zone 19 being the coldest (Alaska).

U-Value is a measure of how well a material or series of materials conducts heat. U-values for windows and door assemblies are the reciprocal of the assembly R-value: U-value = 1/R-value. For other building assemblies (such as a wall), the R-value used covers the entire assembly, not just the insulation.

Insulation Requirements by Climate Zone

Climate Zone	Ceiling U-Value	Single-Family Wall U-Value	Floor U-Value	Basement Wall U-Value	Crawlspace Wall U-Value
1	0.047	0.25	0.08	0.360	0.477
2	0.044	0.23	0.08	0.360	0.137
3	0.042	0.21	0.07	0.360	0.137
4	0.039	0.20	0.07	0.121	0.137
5	0.036	0.18	0.07	0.113	0.124
6	0.036	0.17	0.05	0.106	0.111
7	0.036	0.16	0.05	0.098	0.098
8	0.036	0.16	0.05	0.090	0.085
9	0.033	0.15	0.05	0.082	0.071
10	0.031	0.14	0.05	0.081	0.058
11	0.028	0.13	0.05	0.080	0.058
12	0.026	0.13	0.05	0.079	0.058
13	0.026	0.12	0.05	0.078	0.058
14	0.026	0.11	0.05	0.077	0.058
15	0.026	0.11	0.05	0.075	0.058
16	0.026	0.11	0.05	0.052	0.058
17	0.026	0.11	0.05	0.052	0.058
18	0.026	0.10	0.05	0.052	0.058
19	0.025	0.10	0.04	0.052	0.058

project does not pass, the builder can run new calculations with different insulation levels and window or door products to search for a scenario that brings the project into compliance. The program generates a report for plancheck submittal.

Although *MECcheck* automates calculations, options are limited to tradeoffs among glass area, glass u-values, and wall, roof, and floor insulation levels. This is because the component tradeoff approach is designed to be a quick and simple way to show compliance. Some builders, however, will want significantly more glass area in a home design, or won't want to be forced to insulate a particular house to the levels prescribed by *MECcheck* or the Chapter 5 worksheet for their climate zone. For these situations, the tradeoff approach is too restrictive and inflexible. To receive full credit for other energy-saving features such as shading treatments, thermal mass, building orientation, and high-efficiency water heating systems, builders have to turn to the more complicated Chapter 4 systems analysis approach.

Systems Analysis

Trained energy consultants can find better solutions for complicated cases by looking at the entire house, rather than just a limited number of components. One way of thinking about this performance-based method is that you don't have to par every hole, just par the course.

Instead of a simple checklist of features the home must include, Chapter 4 provides the builder/architect with a per-square-foot energy budget for the building. How builders achieve this goal is up to them. For example, the simplified tradeoff approach may have required a builder to install double-pane windows with thermal breaks, an expensive option. To eliminate this requirement but still offset the energy loss of cheaper windows, the systems analysis approach allows other energy-saving features, such as winter passive solar heating. As long as the overall energy use per square foot is the same

or better than that called for by the simplified tradeoff approach, a building complies with the *MEC*.

The real advantage of the Chapter 4 systems analysis approach is that it gives credit for energy-saving features that may already be included in a design, such as building orientation, thermal mass, high-efficiency air conditioners and water heaters, hydronic heating systems, shading devices, overhangs, and solar water heating. Often, such energy-saving features will permit a 30% increase in glass area, less expensive glazing products, or less insulation in walls, ceilings, or floors.

Modeling energy budgets. The performance-based approach involves three steps. The first step is to create a base case model that meets all the insulation and glass u-value requirements demanded by the more simplified approaches. This would include specs such as minimum hvac equipment efficiencies as well as minimum duct insulation levels for a particular climate.

The next step is to take this base case house and run heat gain and heat loss calculations to determine its annual energy budget, expressed either as a total btu-per-hour figure or as total energy use per square foot per year. This figure becomes the target energy budget that the actual building will need to meet or beat. Computing complex energy budgets requires more sophisticated and less user-friendly energy modeling software, such as the *Manual J* package offered by the Air Conditioning Contractors of America (202/483-9370).

The third and final step involves comparing the energy budgets of various options to that of the base case house. This makes it possible to decide which design changes to incorporate — such as adding more windows or skylights, using less expensive glass, or eliminating basement wall insulation. During this third step, it's possible to include any extra energy-saving fea-

Performance-Based Compliance: Case Studies

The performance-based systems analysis approach is one of the best-kept secrets contained in the often maligned *Model Energy Code*. Although a builder has to spend a few hundred dollars for the services of an energy consultant, the systems analysis approach offers plenty of design flexibility for custom homes. Two examples, one from the Northeast and another from the Southwest, clearly make the point.

Case 1: A One-Story Ranch House in Connecticut

Using the simplified component tradeoff approach would limit the house's glass area to no more than 22% of its gross wall area. The glass would need a u-value of 0.65 or better and the exterior walls would need insulation equal to R-19, with R-7 insulation incorporated into the concrete basement walls below grade. The base model energy calculation would total 135,000 Btu per sq. ft. per year.

The homeowners, however, would like to eliminate the basement insulation requirement but they are comfortable with the window area and u-values. They are willing to introduce passive solar heating strategies (the southern orientations of the walkout basement plan would work well for this) and to upgrade to a tankless water heating system. After running the revised plan with these changes, the new energy use is 128,000 Btu/sq. ft. The energy savings from eliminating the energy-wasting water heating tank, in addition to the tremendous savings provided by the thermal mass effect of the basement walls and floors more than offset the loss of insulation in the concrete wall assemblies. And so the revised building still complies with the *MEC* with room to spare.

Case 2: A Two-Story Custom Home in Arizona

Given the severity of the region's climate, the simplified approach limits the glass area to 25% of the wall area and requires u-values of at least 0.75. Minimums for wall insulation would be R-19; for roof insulation, R-38. But the building site affords a breathtaking view that's just too good to pass up, even though the required glass area would exceed the amount commonly allowed by a simpler application of *MEC* rules.

Because heat gain is the chief energy concern, accommodating this request requires reducing the heat gain enough to offset the increase in glass area. One solution is to use overhangs and window shading treatments on the southern and western sides. Another option is to take advantage of the thermal mass of the tile floor and concrete slab, which will absorb the heat gain and reduce the air conditioning load during peak periods. A third alternative is to install a radiant barrier in the attic above the batt insulation that will reflect radiant heat energy away from conditioned space. Calculations on the revised design, with its increased glass area and additional energy-saving strategies, reveal an annual energy use that is equal to the base model house and therefore is in compliance with the *MEC*.

1995 MEC Residential Compliance Schedule

Project: Smith residence
Brent Lane @ Mustang St.
Tucson, Arizona

Compliance Results:

FRONT FACING EAST
Source Energy Use

(KBtu/sf-yr)	Base Case Design	Proposed Design	Compliance Margin
Space Heating	22.48	21.43	1.05
Space Cooling	44.22	42.43	1.79
Domestic Hot Water	32.25	30.65	1.60
Totals	**98.95**	**94.51**	**4.44**

******Building Complies******

Building Shell

Component	Type	R-value	Location
Roof/Ceiling	Batt Insul/radiant	R-38	Roof assembly
Framed wall	Batt Insul.	R-19	Typical 3-coat stucco
Slab floor perimeter	N/A	N/A	Slab perimeter

Fenestration

Component	Type	Frame	Area	U-value
Window #1	Operable	Aluminum	459	0.75 Dual Pane/t.b.
Window #2	Fixed	Aluminum	259	0.68 Dual Pane/t.b.
Door #1	French	Wood	320	0.55 Dual Pane
Door #2	Entry	Wood	40	3.03 R-value

HVAC

Minimum heating efficiency: 77% AFUE (Combined Hydronic Radiant Heating System)
Minimum cooling efficiency: 10.00 SEER
Minimum duct insulation: 6.00 R-value

Water Heater

75-gallon or smaller gas water heaters with minimum recovery efficiency of 77%. Hot water pipe from garage to conditioned space must be insulated to a minimum of R-5.0.

Figure 5. Whenever prescriptive packages or component tradeoff worksheets don't provide needed results, builders can have energy consultants run complex energy calculations that take into account many more energy-saving factors, such as thermal mass and building orientation. This example of a systems analysis report shows the specs for a Tucson, Ariz., project that calls for more than 700 square feet of glass.

tures that would have been ignored in the component tradeoff approach and were not included in the base case run. These might include thermal mass, overhangs, interior or exterior shading devices, hydronic heating systems, hot water recovery devices, or solar water heating systems.

In the end, the rule is simple: If the energy-saving features of a planned house result in energy use that is the same or less than that of the base case, the house is in compliance with Chapter 4 of the *MEC* (Figure 5).

It's important to understand that the Chapter 4 systems analysis approach cannot perform miracles and allow you to build glass houses with no insulation in Minnesota. However, for a builder who is willing to be flexible with design and can incorporate various energy-saving features, houses can be built with more glass area and less expense than when using the simpler but more restrictive component tradeoff approach.

If the performance-based approach is so useful, you might wonder, why are so few people within the building industry talking about it? For one thing, most building departments prefer the simplified tradeoff approach because it is easier to explain, understand, and plancheck. Most building industry groups promote the tradeoff approach to their membership for the same reasons. Another reason is that the Chapter 4 systems analysis approach is poorly documented in all three versions of the *Model Energy Code*. It's hard to find and understand the complex rules governing the calculations. This makes it difficult for anyone but energy specialists to use. Hopefully, this will improve as the *MEC* is updated and rolled into the new nationwide *International Energy Conservation Code* that will start to be adopted around the country beginning in the year 2000.

Mark Madison *is a principal of San Clemente, California, based Energy Code Works (800/700-0131 or www.energycode.com), a national energy consulting firm specializing in energy code compliance in all 50 states.*