

Instructions
for
**Weatherization
Cost-Effective Guidelines**
for
House Tightening
Program “WCEG”

This program was first written under contract with the Wisconsin Low-Income Weatherization Program in 1999.
Thank you to the managers of the Wisconsin Low-Income Weatherization Program for permission to adapt this software program to all areas of the United States.

September 2002 (v. 2.0)

Weatherization Cost-Effective Guidelines Program for House Tightening (WCEG)

This program was written for the Wisconsin low-income weatherization program in 1999 and later adapted for all areas of the United States. The program is useful for blower-door directed air sealing to reduce energy loss and client discomfort due to air leakage during the heating season. The calculations are based on the equation:

$$CEG = \{[26 \times 100 \times HDD \times (\text{UnitFuelCost}/\text{BtuPerUnitFuel})]/(\text{LBL}\# \times \text{FuelEff})\} \times 0.6 \times \text{PBper}$$

where:

- CEG = Cost-Effective Guideline for air sealing per 100 CFM₅₀.
- HDD = Heating Degree Days, base 65 degrees.
- UnitFuelCost = cost, in dollars, per unit of fuel. The fuel choices are natural gas, numbers 1 and 2 oil, LPG (propane), electric, kerosene (K-1), wood, and coal.
- BtuPerUnitFuel = the British thermal units per unit of fuel. These are assumed to be:
 - 1) Natural Gas at 100,000 Btu input per therm.
 - 2) #1 Oil at 134,000.
 - 3) #2 Oil at 138,690 Btu input per gallon.
 - 4) LPG at 91,500 Btu input per gallon.
 - 5) Electricity at 3412 Btu input per kWh.
 - 6) K-1 kerosene at 126,000 Btu input per gallon.
 - 7) Wood at 21,000,000 Btu input per cord (dry, mixed hardwood).
 - 8) Coal at 25,000,000 Btu input per ton.
- LBL# = the Lawrence Berkeley Laboratory correlation coefficient. This is based on the selected climate zone, number of house stories, and house exposure.
- FuelEff = Heating system *seasonal* efficiency.
- PBper = reasonable payback period for air sealing activities.

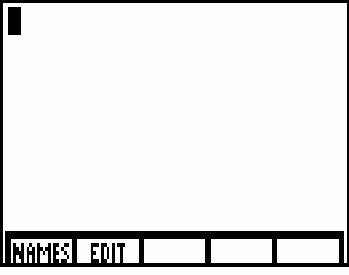

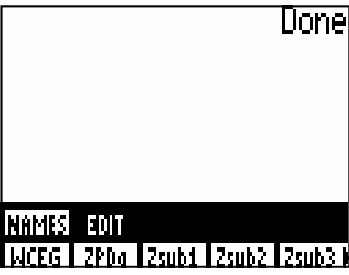
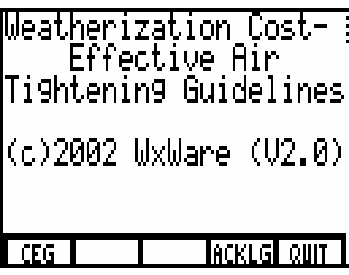
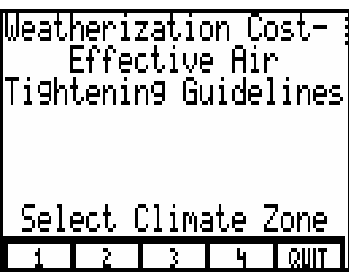
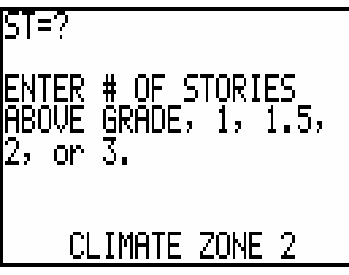
Constants are entered into the TI-86 calculator memory for this program. These constant values are used in the WCEG program, but are not actually entered in the program; they are entered in the "CONS" section of the TI-86. To view these constant values, press the **2nd** key and then **CONS** (the second function of the **4** key). Then press **F3** for "USER." This will allow you to view the constant values. The numerical values of these constants can be changed when necessary by pressing **F2** for "EDIT". It is very important that you confirm the validity of all the constant values below before using the program.

Constants for the WCEG program include (constant value when software was purchased):

- CCOAL = the cost per ton of coal (\$100.00).
- CELEC = the cost per kWh of electricity (\$0.07).
- CKERO = the cost per gallon of K-1 kerosene (\$1.60).
- CLPG = the cost per gallon of LPG or propane (\$1.00).
- CNG = the cost per therm (100,000 Btu) of natural gas (\$0.75).
- COIL = the cost per gallon of number 2 fuel oil (\$1.20).
- COILL = the cost per gallon of number 1 fuel oil (1.30).
- CWOOD = the cost of wood per full cord, cut, split, delivered and dry (\$160).
- COM = the cost of materials per worker hour (\$25.00).
- LBRT = the cost of labor per worker hour (\$15.00).
- PB = reasonable payback period for air sealing activities (10).

Follow the instructions on the following pages in order to learn how to use the program. Contact WxWare Diagnostics if you have difficulty with the instructions or with the software program.

ZipTest Pro² Building Diagnostics Software for the Texas Instruments TI-86 Graphing Calculator

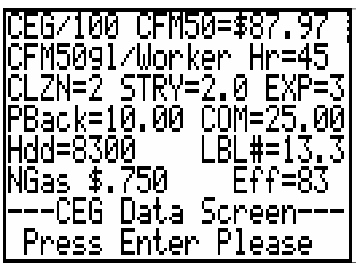
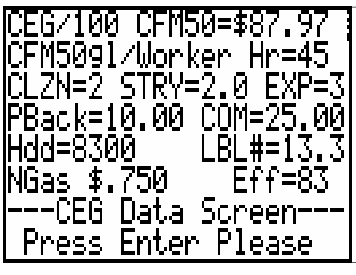
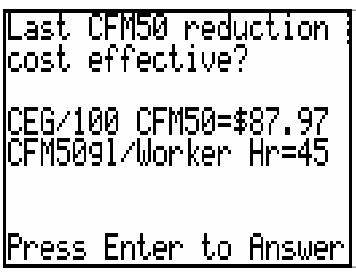
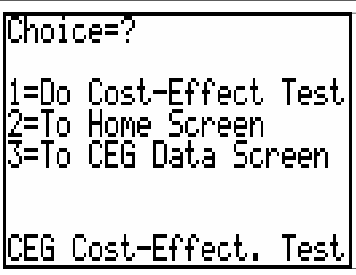
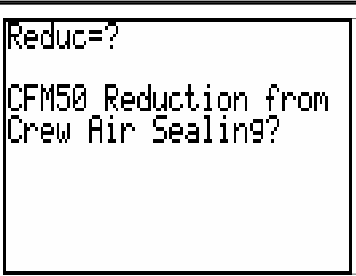
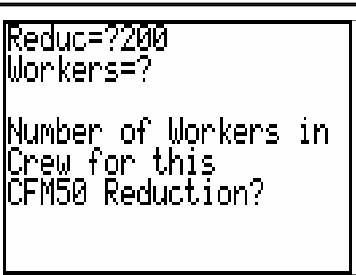
WCEG-1		<ul style="list-style-type: none"> • Turn the TI-86 calculator on. • Press PRGM (Programs). • You will see this menu on the screen. • Press F1 for "NAMES." • NOTE: It is best never to press "EDIT," F2.
WCEG-2		<ul style="list-style-type: none"> • You will see this menu and sub-menu on the screen. • Press the MORE key to move to the next menu set.
WCEG-3		<ul style="list-style-type: none"> • "WCEG" will appear above the F1 key. • Press F1 to load the "WCEG" program. • "WCEG" will appear at the cursor location. • Press ENTER. Note: The exact name of the program must appear at the cursor position, if not, you will receive an error message.
WCEG-4		<ul style="list-style-type: none"> • You will see this main menu screen. • F1, "CEG" starts the Weatherization Cost-Effective Guideline program for cost-effective air sealing. • F4, "ACKLG" (Acknowledgments) selection lists the author of the program, etc. • F5, "Quit" selection allows you to exit the program. Always exit the program by selecting F5 from this menu; the decimal place is thereby set to "floating," which you will prefer when you do mathematical calculations. • Press the F1 key to start the program.
WCEG-5		<ul style="list-style-type: none"> • Select the climate zone from the menu at the bottom of the screen. Check the map on page 20 to find your climate zone. The four climate zones have to do with average wind speed. • To move back to the main menu screen, press F1 for "QUIT." • Select F2 for climate zone two. • This will move you on to the next screen.
WCEG-6		<ul style="list-style-type: none"> • You are prompted to enter the number of exposed stories of the house. Basements below grade generally should not be included in the number of stories. The value you enter will be displayed after the "?" • Do not enter any numbers other than 1, 1.5, 2, or 3. Notice the instruction on the screen. Also, notice that your selected climate zone is listed at the bottom of the screen. • Enter "2" stories, for example, and press ENTER. This will move you to the next screen.

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WCEG-7		<ul style="list-style-type: none"> You are prompted to enter the appropriate exposure number for the house. The value you enter will be displayed after the “?”. The “EXP” or exposure value should be entered with care. “SHIELDED” is for buildings with significant blockage to the wind (trees or other buildings), “NORMAL” signifies buildings in a typical suburban setting (obstructions to the wind around building, but not dense), “EXPOSED” is for buildings with very little wind blockage (meadow settings, lake-side, etc.). Enter “3,” for example, and press ENTER.
WCEG-8		<ul style="list-style-type: none"> You are prompted to enter the appropriate heating degree day value, base 65 degrees, for the locality. The value you enter will be displayed after the “?” Enter 8300 and press ENTER to move to the next screen.
WCEG-9		<ul style="list-style-type: none"> You are now asked to select the fuel type. Notice that F5 is for “MORE.” “NGas” is natural gas, “#2oil” is number 2 oil, “LPG” is liquefied petroleum gas or propane, “Elec” is electric heat. Press F5 for “MORE”.
WCEG-10		<ul style="list-style-type: none"> This moves you to the additional fuel selections of kerosene, wood, coal, and #1 oil. Other selections on the second menu set are “QUIT” and “MORE,” which take you back to the first menu set. “KERO” is kerosene or K1, “Wood” is wood heat, “COAL” is coal heat and “#1oil” is number 1 oil. Press F5 (“More”) to move back to the previous fuel menu. Select F1 for natural gas to move to the next screen.
WCEG-11		<ul style="list-style-type: none"> You are prompted to enter the <i>seasonal</i> efficiency of the heating system. For natural gas you have four choices, “1” for 72%, “2” for 78%, “3” for 83%, and “4” for 90%. As you use this program, you will notice that there are various fuel efficiency choices for each fuel. If you are installing a new heating system, use the fuel type and efficiency—seasonal or AFUE—of the new system. Press “3” for 83 percent and ENTER to move to the next screen.
WCEG-12		<ul style="list-style-type: none"> This is the CEG Data Screen, as listed at the bottom of the screen. “CEG/100 CFM50=\$87.97” is the cost-effective tightening guideline, a program output, for this example house. This means that if your crew is able to reduce the CFM₅₀ by 100 for less than \$87.97, it is cost-effective. A CFM₅₀ reduction of 100 costing more than \$87.97 is not cost-effective. The next line, “CFM50g/Worker Hour=45” is the CFM₅₀ tightening guideline (g) per worker for this job. This means that each worker must reduce CFM₅₀ by at least 45 per hour to be cost-effective. [continued on next panel]

This is very important!

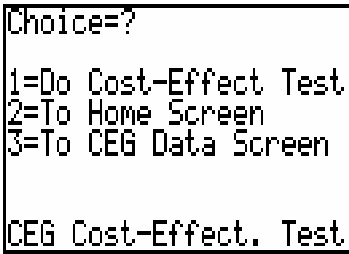
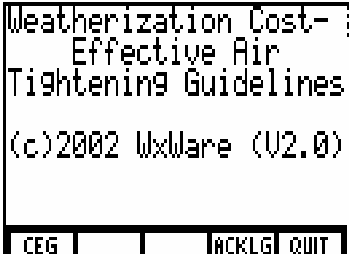
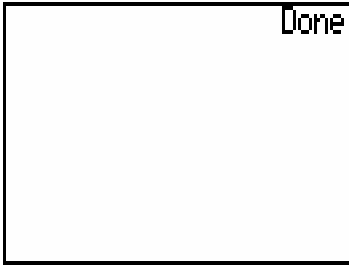
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WCEG-13		<ul style="list-style-type: none"> • “CLZN” is the selected climate zone. • “STRY” is the selected number of house stories. • “EXP” is the selected exposure of the house. • “Pback” is the selected payback for the analysis (a program constant). This might be set to a different number for your program. • “COM” is the selected cost of materials per hour (a program constant). This might be set to a different number for your program. • “Hdd” is the entered heating degree days, base 65 degrees Fahrenheit. <p style="text-align: right;">[continued next panel]</p>
WCEG-14		<ul style="list-style-type: none"> • “LBL#” is the calculated Lawrence Berkeley Laboratory number. This is the number the CFM₅₀ value is divided to yield the CFM_{natural} value. • “NGas” is the cost per unit of fuel, in this case, the cost per therm of natural gas (a program constant). • “Eff” is the selected <i>seasonal</i> efficiency of the heating system. • If you want to print this screen, you have all the inputs and outputs here. You must have the Texas Instruments Graph Link to print a screen. • Press ENTER to move to the next screen.
WCEG-15		<ul style="list-style-type: none"> • You are asked if you would like to check to determine if the last CFM₅₀ tightening session was cost-effective or not. • For your convenience, the first two output lines of the previous screen are listed on lines four and five (the blank line is counted here). • Press ENTER to proceed.
WCEG-16		<ul style="list-style-type: none"> • You are now prompted to make one of three choices: 1 = do a cost-effective calculation to determine if your last air tightening session was cost-effective or not; 2 = quit the program and go back to the program home screen; or 3 = go back to the “CEG Data Screen” (for this example this is the screen pictured in panels WCEG-12 through WCEG-14). • Choice number 2 requires no explanation. • Try choice number 3 by pressing “3” and then ENTER. • Now enter “1” for your “Choice=” and press ENTER.
WCEG-17		<ul style="list-style-type: none"> • As the instruction on line three states, enter the last CFM₅₀ reduction accomplished by the crew (not each worker, but the entire crew). The number of workers making up the crew will be entered next). • This reduction is determined by a single-point blower door test. • For this example, enter “200” and press ENTER.
WCEG-18		<ul style="list-style-type: none"> • You are prompted to enter the number of workers on your air-sealing crew. • For this program, we have used the term “worker” for one air-sealing person. The term “crew” signifies the group of workers performing air-sealing. • Enter “2” and press ENTER to move to the next screen.

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WCEG-19	<pre> Reduc=?200 Workers=?2 Time=? CREW Minutes for this CFM50 Reduction? </pre>	<ul style="list-style-type: none"> • Now you are asked to enter the time it took to accomplish the reduction in CFM₅₀. Enter the time in minutes, not hours. If the crew of two worked for 45 minutes, enter "45". • For this example, enter "45" minutes for the time it took to reduce the CFM₅₀ by 200. • Press ENTER to move on the next screen and see the results of the cost-effective test.
WCEG-20	<pre> Reduc=?200 Workers=?2 Time=?45 Cost/100 CFM50=30.00 CEG/100 CFM50=87.97 CFM50g1/Worker Hr=45 Continue Air Sealing! PRESS ENTER </pre>	<ul style="list-style-type: none"> • The second to the last line on the screen states "Continue Air Sealing!" This is because the cost of the last CFM₅₀ reduction was \$30.00 per 100 CFM₅₀ (see line four on the screen at the left). The cost-effective guideline per 100 CFM₅₀ reduction for this job is \$87.97 (see line five on the screen at the left). Since the actual cost per 100 CFM₅₀ reduction is less than the guideline of \$87.97, continue air sealing. • Press ENTER and we will continue with our air-sealing example.
WCEG-21	<pre> Choice=? 1=Do Cost-Effect Test 2=To Home Screen 3=To CEG Data Screen CEG Cost-Effect. Test </pre>	<ul style="list-style-type: none"> • At the "Choice=?" prompt, enter "1" for another cost-effective test. • Press ENTER.
WCEG-22	<pre> Reduc=?100 Workers=?2 Time=?70 CREW Minutes for this CFM50 Reduction? </pre>	<ul style="list-style-type: none"> • At the "Reduc=?" prompt, enter 100 and press ENTER. • At the "Workers=?" prompt, enter 2 and press ENTER. • At the "Time=?" prompt, enter 70 minutes and press ENTER.
WCEG-23	<pre> Reduc=?100 Workers=?2 Time=?70 Cost/100 CFM50=93.33 CEG/100 CFM50=87.97 CFM50g1/Worker Hr=45 --Stop Air Sealing!-- PRESS ENTER </pre>	<ul style="list-style-type: none"> • This air sealing session was not cost-effective (the "Cost/100 CFM50=93.33" is greater than the "CEG/100 CFM50=87.97"), so "Stop Air Sealing!" In other words, the cost was greater than the savings. • Actually, you might want to continue air sealing if you think your next session can be cost-effective. This is likely to be the case if you just discovered a large hole that will be easy to seal. However, generally air sealing is—and should be—a progressive process, that is, you seal the large, <p style="text-align: right;">[continued on next panel]</p>
WCEG-24	<p>[intentionally left blank]</p>	<p>productive holes first, then move on to the medium holes, and then to the small holes. In reality, the air sealing process is not always progressive. If you think you crew has air sealed in a progressive manner, stop your air sealing activities at this time. However, if you think you can be cost-effective during your next session, for whatever the reason, proceed with another air sealing session.</p> <ul style="list-style-type: none"> • Press ENTER.

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WCEG-25		<ul style="list-style-type: none"> • This takes us back to the “CEG Cost-Effect. Test” screen. • Now, let’s quit the program by selecting “2” and then pressing ENTER.
WCEG-26		<ul style="list-style-type: none"> • This returns us to the main menu screen for this program. • “QUIT” the program by pressing F5.
WCEG-27		<ul style="list-style-type: none"> • We have exited the program correctly. • If you want to get back to the program right away, just press ENTER. This will take you back to the main menu screen of the CEG program (the last program you worked with on the TI-86 calculator)>
WCEG-28	<p>[intentionally left blank]</p>	
WCEG-29	<p>[intentionally left blank]</p>	
WCEG-30	<p>[intentionally left blank]</p>	

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