

Instructions
for
Energy Index Calculations
in units of Btu/Ft²,DD

Program "BTUDD"

with sub-programs

W/FQ

W/F\$

November 1999 (V1.6)

INTRODUCTION

This software program, BTU/Ft², DD (British thermal units/square foot, degree day), is intended to be used as an initial diagnostic tool for dwellings in all heating-climate zones. The lower the number, the more efficient the building.

The software program will calculate BTU/Ft², DD from:

- 1) the quantity of space-heating fuel used in one year and
- 2) the total cost of space-heating fuel used in one year.

The fuels included are:

- 1) #2 Oil at 138,690 Btu input per gallon.
- 2) #1 Oil at 134,000 Btu input per gallon.
- 3) Natural Gas at 100,000 Btu input per therm.
- 4) Electricity at 3412 Btu input per kWh.
- 5) LPG at 91,500 Btu input per gallon.
- 6) Wood at 21,000,000 Btu input per cord.
- 7) K-1 kerosene at 126,000 Btu input per gallon.

The BTU/Ft², DD values are intended for space heating fuel use only. If a space-heating system also produces domestic hot water, the hot water fuel usage must be subtracted from the total fuel use or cost before BTU/Ft², DD is calculated. See the instructions below for a method for calculation of domestic hot water fuel usage.

With experience, you will develop an idea of BTU/Ft², DD number ranges for efficient, average, and inefficient buildings. Use these numbers for the initial appraisal of the work the building will require. Keep a record of the BTU/Ft², DD values so that you can develop good, average and poor ranges for your area. The numbers generally will not be influenced by fuel type.

The BTU/Ft², DD values can also serve to find unusual problems. For example, if a building is heated with an oil-fired boiler, is tighter than average, and has better than average insulation levels, we would expect a low BTU/Ft², DD value. However, if the value is high, it could indicate a number of problems such as 1) a very inefficient oil-fired boiler, 2) a buried oil tank that is leaking into the ground, or 3) clients keeping windows or doors open during the heating season, etc.

If a building has more than one space heating fuel, calculate the BTU/Ft², DD for each fuel and add the values together to get the total BTU/Ft², DD for the building.

Read at least the first few chapters in the *TI-86 Graphing Calculator Guidebook* for basic information about operating the TI-86 calculator.

DOMESTIC HOT WATER USE CALCULATION.

The calculated value for BTU/Ft², DD should include only fuel used for space heat. Fuel used for domestic water heating, lights, cooking, air-conditioning, etc. must be subtracted from any fuel-use figures before the BTU/Ft², DD calculation is done on the TI-86 calculator.

If a building has a combination space heating/domestic water heating system (tankless coil, indirect-fired hot water with storage, etc.) the space heating usage is found by subtracting the domestic hot water usage or cost from the annual fuel quantity or cost. This *base usage* (for electric heat, base load also includes electrical consumption for lighting, refrigeration, etc.) can be estimated by examining non-heating season bills, calculating the monthly base usage, and then subtracting this twelve-month base usage from the total fuel consumption or cost. The result is the fuel quality or cost for space heating.

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If you don't have a complete history of fuel usage for the calculation of base usage, the following method can be used to estimate domestic hot water usage. (This equation is programmed into the SOLVER section of your TI-86 calculator as Equation Nugget "AH20").

$$Q = \frac{\text{gal/yr} \times (T_{\text{out}} - T_{\text{in}}) \times 8.34 \text{ lbs/gal} \times 1 \text{ Btu/lb} \cdot ^\circ\text{F}}{\text{Eff} \times C}$$

where:

Q = energy per year for domestic hot water, in appropriate fuel units.

gal/yr = estimated gallons of hot water used in one year.

T_{out} = output temperature of water from the water heating appliance, °F.

T_{in} = input temperature of water to the water heating appliance, °F.

8.34 lbs/gal = the weight of water per gallon.

1 Btu/lb·°F = the specific heat of water.

Eff = seasonal efficiency of water heating appliance, as a decimal.

C = conversion factor for energy source of water heating appliance,

138,690 for #2 oil,

134,000 for #1 oil,

100,000 for natural gas,

3412 for electricity,

91,500 for liquefied petroleum gas,

21,000,000 for firewood, dry hardwood, and

126,000 for K-1 kerosene.

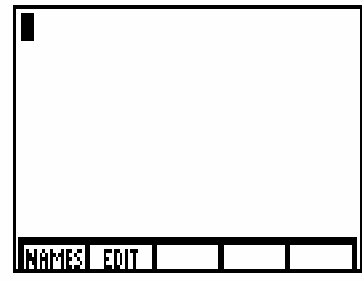

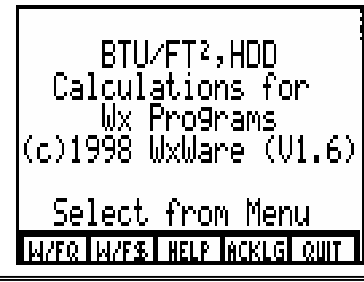
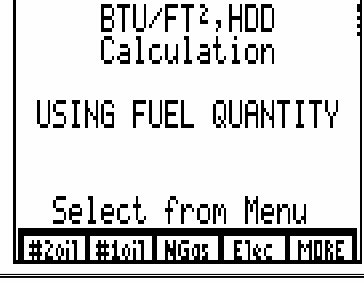
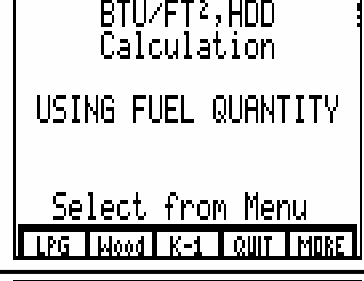
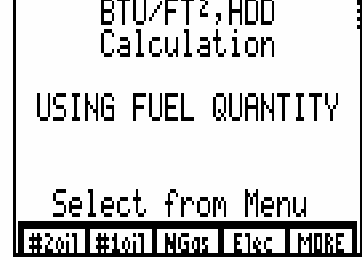
Gallons of hot water use per day in North America averages about 62 gallons per household. Two adults in a household use from 30 to 60 gallons per day. A household with two adults and two children might have an average daily use as high as 90 gallons per day. Households with very young children often use more than average, elderly people often use less than average. To get the figure for gal/yr, estimate the gallons per day and multiply it by the number of days the family is a home during the year (usually 365).

For T_{out}, the output temperature of water from the water heating appliance, °F, you can take the time to measure this temperature with a thermometer, or you can estimate it. For residential buildings it is usually between 120°F and 140°F. For T_{in}, the input temperature of water to the water heating appliance, °F, subtract the latitude from 90 for an estimate of this water temperature (usually 40°F to 50°F).

The efficiency of the water heating appliance is difficult to estimate for there are only a few field studies that have examined combination unit efficiencies. One study found that efficiencies of indirect-fired storage systems (boiler for space heating and domestic water heating with a separate storage tank for domestic hot water) were 51% to 79% during the heating season and 47% to 58% during the non-space heating months.* The greater the use of domestic hot water, the higher the efficiency. The efficiencies for tankless coil systems (no storage) are usually lower than indirect-fired storage systems.

* Subherwal, B.R., "Combination Water-Heating/Space-Heating Appliance Performance" in *ASHRAE Technical Data Bulletin: Residential Heating and Cooling*, Jan. 1987, pp. 185-202.

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BTUDD-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.
BTUDD-2		<ul style="list-style-type: none"> • You will see this menu on the screen. • Press F1, F2, F3, F4, or F5 for the program "BTUDD." The menu key for this program will depend upon the number of programs loaded into the memory of your TI-86 calculator. "BTUDD" 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.
BTUDD-3		<ul style="list-style-type: none"> • You will see this main menu on the screen. • "W/FQ" (with fuel quantity) selection is for finding BTU/Ft², DD if you have the annual fuel use figure for a fuel type. • "W/F\$" (with fuel dollars) selection is for finding BTU/Ft², DD if you have the annual dollars spent for a fuel type. • "HELP" lists instructions for this program. • "ACKLG" (Acknowledgments) selection lists the author of the program, etc. • "QUIT" selection allows you to exit the program
BTUDD-4		<ul style="list-style-type: none"> • Select "W/FQ" (with fuel quantity). • You will see this menu on the screen. • F1 is for "#2 oil," F2 for "#1 oil," F3 for "NGas" (natural gas), F4 for "Elec" (electric) heat. • Select F5, "MORE," for more choices of space-heating fuels.
BTUDD-5		<ul style="list-style-type: none"> • You will see this menu on the screen. • F1 is for "LPG," F2 for "Wood," F3 for "K-1," F4 for "QUIT," or F5 for "MORE" (this will return you to the previous main menu screen). • If you select F4, "QUIT," you will return to the main menu screen.
BTUDD-6		<ul style="list-style-type: none"> • As a demonstration, press F1 for "#2 oil."

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BTUDD-7	<pre> FT2=? ENTER FT² OF BUILDING #2 OIL </pre>	<ul style="list-style-type: none"> • You will see the screen at the left displayed . • You are asked to “ENTER FT² OF BUILDING.” Enter the square feet of the <i>occupied</i> area of the building. When you enter the square footage, the value will be displayed after the “?” • Notice that “#2 OIL” is displayed at the bottom of the screen as a reminder of your fuel selection. • Press ENTER.
BTUDD-8	<pre> FT2=?2400 DD=? ENTER DEGREE DAYS #2 OIL </pre>	<ul style="list-style-type: none"> • You are asked to “ENTER DEGREE DAYS.” Enter the heating degree days, base 65°F, for the location of the building. When you enter the heating degree days, the value will be displayed after the “?” • Press ENTER.
BTUDD-9	<pre> FT2=?2400 DD=?8000 GAL=? ENTER GAL OIL/YR #2 OIL </pre>	<ul style="list-style-type: none"> • You are asked to “ENTER GAL OIL/YR.” Enter the gallons of #2 oil used in one year for space heating only. If your fuel use figure includes fuel for domestic hot water, subtract this amount from the total to get space heating fuel quantity (see page 26 for instructions). When you enter the gallons of oil used, the value will be displayed after the “?” • Press ENTER
BTUDD-10	<pre> FT2=?2400 DD=?8000 GAL=?1245 EFF=? ENTER EFFICIENCY #2 OIL </pre>	<ul style="list-style-type: none"> • You are asked to “ENTER EFFICIENCY.” Enter the estimated <u>seasonal efficiency</u> for the oil heating system. When you enter the <u>seasonal efficiency</u>, the value will be displayed after the “?” Enter the efficiency as a decimal. • Note: If you enter “1.00,” your answer will be a BTU/Ft², DD <i>input</i> value. If you enter a decimal efficiency number, i.e., “0.72,” your answer will be a BTU/Ft², DD <i>output</i> value. • Press ENTER.
BTUDD-11	<pre> FT2=?2400 DD=?8000 GAL=?1245 EFF=? .72 BTU/FT², DD=6.48 #2 OIL </pre>	<ul style="list-style-type: none"> • Notice the answer is displayed on the screen after “BTU/Ft², DD=“. • All of the values you entered are displayed on the screen. • Enter the BTU/Ft², DD on your audit form, if required. • Each of the other fuels—#1oil, NGas, Elec, LPG, Wood, and K-1—work in the same manner when you select F1, “W/FQ” from the main menu. • Press ENTER to return to main menu.
BTUDD-12	<pre> BTU/FT², HDD Calculations for Wx Programs (c)1998 WxWare (V1.6) Select from Menu W/FQ W/F\$ HELP WCKLG QUIT </pre>	<ul style="list-style-type: none"> • Your will see the screen at the left displayed , the main menu screen. • As another demonstration, select F2, “W/F\$” (with fuel dollars), the selection for finding BTU/Ft², DD if you know the annual dollars spent for a fuel type. • Do not use this routine unless you must. Using “W/FQ” is more accurate because one less variable—fuel cost per unit—is required.

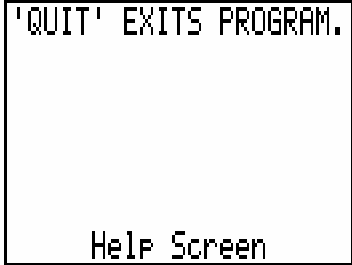
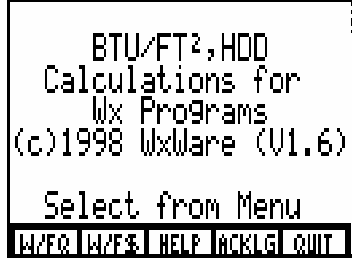
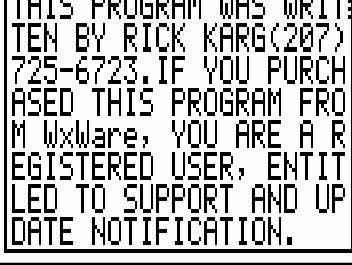

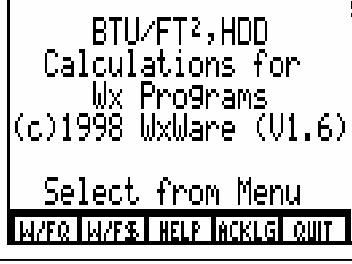

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BTUDD-13		<ul style="list-style-type: none"> You will see this menu on the screen. F1 is for "#2 oil," F2 for "#1 oil," F3 for "NGas" (natural gas), F4 for "Elec" (electric) heat. Select F5, "MORE," for more choices of space-heating fuels.
BTUDD-14		<ul style="list-style-type: none"> F1 is for "LPG," F2 for "Wood," F3 for "K-1," F4 for "QUIT," or F5 for "MORE" (this will return you to the previous menu screen). If you select F4, "QUIT," you will return to the main menu screen. Select F5, "MORE," and then select F1, "#2oil," for #2 Oil.
BTUDD-15		<ul style="list-style-type: none"> You are asked to "ENTER FT² OF BUILDING." Enter the square feet of the <i>occupied</i> area of the building. When you enter the square footage, the value will be displayed after the "?" Notice that "#2 OIL" is displayed at the bottom of the screen as a reminder of your fuel selection. Press ENTER.
BTUDD-16		<ul style="list-style-type: none"> You are asked to "ENTER DEGREE DAYS." Enter the heating degree days, base 65°F, for the location of the building. When you enter the heating degree days, the value will be displayed after the "?" Press ENTER.
BTUDD-17		<ul style="list-style-type: none"> Enter the cost in one heating season for #2 oil used for space heating. If your fuel cost figure includes fuel for domestic hot water, subtract this amount from the total to get space heating fuel dollars. When you enter the seasonal cost for oil, the value will be displayed at the "?" Press ENTER.
BTUDD-18		<ul style="list-style-type: none"> You are asked to "ENTER EFFICIENCY." Enter the estimated <i>seasonal</i> efficiency for the oil heating system. When you enter the seasonal efficiency, the value will be displayed after the "?" Enter the efficiency as a decimal. Note: If you enter "1.00," your answer will be a BTU/Ft², DD <i>input</i> value. If you enter a decimal efficiency number, i.e., "0.72," your answer will be a BTU/Ft², DD <i>output</i> value. Press ENTER.

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BTUDD-19	<pre>FT2=?2400 DD=?8000 YR=?1400 EFF=? .72 UNIT=? ENTER \$/GALLON #2 OIL</pre>	<ul style="list-style-type: none"> You will see this menu on the screen. You are asked to "ENTER \$/GALLON." Enter the average cost per gallon for the last heating season. Obtain the cost per gallon from the client or the fuel oil dealer. Press ENTER.
BTUDD-20	<pre>FT2=?2400 DD=?8000 YR=?1400 EFF=? .72 UNIT=? .82 BTU/FT², DD=8.88 #2 OIL</pre>	<ul style="list-style-type: none"> Notice the answer is displayed on the screen after "BTU/Ft², DD=" All of the values you entered are displayed on the screen. Enter the BTU/Ft², DD on your form, if required. Each of the other fuels—#1oil, NGas, Elec, LPG, Wood, and K-1—work in the same manner when you select F2, "W/F\$," from the main menu. Press ENTER to return to main menu.
BTUDD-21	<pre>BTU/FT², HDD Calculations for Wx Programs (c)1998 WxWare (V1.6) Select from Menu W/F\$ W/F# HELP ACKLG QUIT</pre>	<ul style="list-style-type: none"> From the main menu, select F3, "HELP." You will see the screen at the left displayed. Press ENTER.
BTUDD-22	<pre>PRESS F1, W/FQ (WITH FUEL QUANTITY), TO CALCULATE BTU/FT², DD FOR SELECTED FUELS IF YOU KNOW THE QUANTITY OF FUEL USED IN ONE YEAR. Help Screen</pre>	<ul style="list-style-type: none"> You will see the screen at the left displayed. Press ENTER.
BTUDD-23	<pre>PRESS F2, W/F\$ (WITH FUEL DOLLARS), TO CALCULATE BTU/FT², DD FOR SELECTED FUELS IF YOU KNOW THE COST OF FUEL USED IN ONE YEAR Help Screen</pre>	<ul style="list-style-type: none"> You will see the screen at the left displayed. Press ENTER.
BTUDD-24	<pre>'ACKLG' (ACKNOWLEDG- MENTS), LISTS CREDITS, SUPPORT AND REGISTRA- TION INFORMATION. Help Screen</pre>	<ul style="list-style-type: none"> You will see the screen at the left displayed. Press ENTER.

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BTUDD-25		<ul style="list-style-type: none"> You will see the screen at the left displayed. Press ENTER. Note: If you make a mistake while entering data before you press ENTER, use the arrow buttons to move the cursor over the erroneous entry and type the correct entry. If you notice you have made a mistake after you have pressed ENTER, press the 2nd button, the QUIT button (next to the 2nd button), and then ENTER. This will return you to the main menu.
BTUDD-26		<ul style="list-style-type: none"> Select F4, "ACKLG," Acknowledgments.
BTUDD-27		<ul style="list-style-type: none"> Press ENTER.
BTUDD-28		<ul style="list-style-type: none"> Press ENTER.
BTUDD-29		<ul style="list-style-type: none"> You will see the screen at the left displayed. To exit the program, select F5, "QUIT." Note: Always exit the program by pressing "QUIT;" this automatically resets the decimal place for calculator use.
BTUDD-30		<ul style="list-style-type: none"> You will see the screen at the left displayed. Press ENTER if you want to re-enter the program. If you want to reenter the program, simply press ENTER. Note: The TI-86 automatically shuts off after two minutes of non-use. When you turn it back on, you will be able to pick up right where it shut off.

This is very important!