

STEP

Simplified Total Energy Program

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US Army Corps of Engineers
BUILDING STRONG®



STEP

Simplified Total Energy Program

Introduction:

STEP is a software application originally developed as a self use tool for a Energy Manager.

The application is designed to provide a “quick” ranking of alternative energy sources to determine which show merit and may want to be studied further.

The application is currently under going many modifications to allow flexibility for multiple users and information sources.



STEP Requires a minimum of inputs!

SIMPLIFIED TOTAL ENERGY PROGRAM

Ver. β1.01a
BY: Robert B. McMillan, PE, CEM

SCROLL FOR SOLUTIONS:



Select Code or ASHRAE Zone (C/Z):
Enter Garrison/City Code (See Below):

c
295

Building Type: BTOSUT **Future use, Please enter building data**
Project Year: 2015

Discount Rate:
Include Environmental credits in LCCA?

0.03
No

SCROLL FOR GARRISON/CITY CODES:



BASIC DATA FOR: FT. HOOD, TEXAS

English

Metric

If the building type is in the data base, usually a single garrison or city code will produce a “first cut” report! The program has the ability to input non-standard building data! Options allow the user to alter many program parameters so “what if” scenarios can be run!

Typically only the code is required for the initial run. Other options include selecting the project start date (for the LCCA net present values); the current discount rate (again for the LCCA); and the option of including environmental credits (CO₂ & Water) in the savings. Although the building type button is displayed, the data base for standard building types is still under construction.



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PROGRAM INPUT

Scrolling down on the MAIN sheet tab, a list of garrison and city codes are presented. This code is entered on the button at the top of the sheet, to activate the analysis process.

Garrisons are listed in alphabetical order, while cities are listed by state. If a standard building type is desired, only "what if" values need be changed. Non-standard buildings are also analyzed by inputting base data as shown on the following slide.

Garrison Codes

ABERDEEN PROVING GROUNDS, MD	278
ANNISTON ARMY DEPOT	255
FT. BELVOIR	298
FT. BENNING	265
FT. BLISS	294
FT. BRAGG	289
FT. CAMPBELL	275
FT. CARSON	264
CARLISLE BARRACKS	291
FT. DETRICK	279
FT. DIX	282
FT. DRUM	285
FT. EUSTIS	299
FT. GORDON	266
FT. GREELY	258
FT. HAMILTON	286
FT. HOOD	295
FT. HUACHUCA	261
HUNTER ARMY AIR FIELD	269
FT. IRWIN	263
FT. JACKSON	293
FT. KNOX	276
FT. LEAVENWORTH	273
FT. LEE	300
FT. LEONARD WOOD	281
FT. LEWIS	304



OUTPUTS: SITE SPECIFIC DATA IS

	English	Metric
County:	Bell	Bell
ASHREA Zone:	2a	2a
Time Zone:	Central	Central
Latitude:	31°08'30" North	0.54 Radians
Longitude:	97°47'45" West	1.71 Radians
Latitude:	31.14 Degrees	0.54 Radians
Longitude:	97.80 Degrees	1.71 Radians
Elevation:	801 ft.	244.15 m
Barometric Pressure:	14.27 psia	98.36 kPa
Average Annual Temperature:	65.7 °F	18.71 °C
Ground Water Temperature:	68.2 °F	20.09 °C
Heating Degree Days (HDD):	1,959 Base 65°F	1,959 Base 18.3°C
Cooling Degree Days (CDD):	2,792 Base 65°F	2,792 Base 18.3°C
Heating Days:	168 Days.	168 Days.
Cooling Days:	197 Days.	197 Days.
Annual Rain Fall:	31.70 in.	80.52 cm
Humidity: (Average)	71.70 %	71.70 %
Humidity A.M.	83.10 %	83.10 %
Humidity P.M.	60.30 %	60.30 %
Average Wind Speed:	10.98 MPH	1.50 m/sec.
Days of Sun Shine:	146 Days.	146 Days.
Days Partly Cloudy:	106 Days.	106 Days.
Cloudy Days:	113 Days.	113 Days.
Shortest hours of Sunlight:	9.97 Hours.	9.97 Hours.
Longest hours of Sunlight:	14.03 Hours.	14.03 Hours.
Annual Sunlight:	4,360 Hours.	4,360 Hours.
Annual Clear Sky Solar Insolation:	6.53 Suns/day	2,070.41 BTU/ft. ² -day
Weather Adjusted Insolation:	5.05 Suns/day	1,599.61 BTU/ft. ² -day

Once a code is entered, site specific data is displayed. Much of this data is utilized in calculating the various energy alternatives included in the program.



ADDITIONAL DISPLAYED DATA

Solar Efficiency:	21.03 %	21.03 %
Solar Offset:	7.80 Degrees	31.20 Minutes
Diffusion Factor:	0.48288 Ω	0.48288 Ω
Beam Radiation Factor:	0.77260 β	0.77260 β
Electric Generation (CO ₂):	1.547 lbm/kWh	701.71 gm/kWh
Water Usage (Generation):	0.430 Gal./kWh	1.63 lt./kWh
Fuel Region:	3	3
Electric Consumption:	2,344,491 kWh/yr.	2,344,491 kWh/yr.
Natural Gas Consumption:	1,105,226 kWh/yr.	1,105,226 kWh/yr.
Natural Gas Consumption:	3,771.03 MCF/yr.	106.78 km ³ /yr.
Total Energy:	3,449,717 kWh/yr.	68.51 kWh/sq.ft.-yr.
Fossil Fuel Ratio:	84.34%	84.34%
Electric Fossil Fuel:	167.43 As Tons CH ₄	151.89 As Tonnes CH ₄
Natural Gas Fossil Fuel:	78.93 As Tons CH ₄	71.60 As Tonnes CH ₄
Input Energy:	246.36 As Tons CH ₄	223.50 As Tonnes CH ₄
Input CO ₂ :	141,301.62 Tons/yr.	128,186.67 Tonnes/yr.
Cost of Water:	\$1.37 CCF	\$0.00 lt.
Sewer Cost:	\$1.26 CCF	\$0.00 lt.
Electricity Unit Cost:	\$0.0947 kWh/yr.	\$0.09 kWh/yr.
Natural Gas Unit Cost:	\$8.31 MCF/yr.	\$0.29 m ³

Although many of these values are fixed i.e. altitude, latitude etc., some are variable and will be updated i.e. cost of utilities.



THE PROGRAM HAS THE ABILITY TO OVER RIDE CERTAIN DATA. AS AN EXAMPLE FOR A NON-STANDARD BUILDING:

BASIC BUILDING DATA				
Item	Default Base	New Base	Select	Value
Total Sq. Ft.	50,350	10000.00	n	10,000 sq. ft.
Total Energy:	3,449,717		D	3,449,717 kWh
Lighting Energy:	116,019		D	116,019 kWh
Heating Energy:	729,547		D	729,547 kWh
Cooling Energy:	479,650		D	479,650 kWh
Total Electrical	2,344,491		D	2,344,491 kWh
Total Gas	1,105,226		D	1,105,226 kWh
Water Heating:	375,679			
ASHRAE Zone:		2a		
	Base Annual kWh/ft. ²			68.51 kWh/ft. ²
Daily Hot Water Use (110°F):				Gallons
Electric/Gas Ratio:		2.1213		
	kBTU	kWh		
	856.00	250879.25		

Use the calculator to the left to obtain kWhs from kBTUs!

By entering a new value in the white box and entering an “N” for new in the button, the default number is automatically updated throughout the program. This along with other overrides, are provided on a separate “program sheet.” The Total energy is the sum of all input energy to the building.



OUTPUTS

ONCE THE LOCATION CODE IS ENTERED, SCROLLING TO THE RIGHT WILL DISPLAY THE CURRENT PROGRAM ALTERNATIVES.

- 1. WIND GENERATION**
- 2. SOLAR HOT WATER**
- 3. PHOTOVOLTAICS**
- 4. SKYLIGHTS**
- 5. WINDOWS**
- 6. COMBINED HEAT AND POWER**
- 7. GROUND SOURCE HEAT PUMPS**
- 8. INSULATION (UNDER DEVELOPMENT)**
- 9. L.E.D. LIGHTING (UNDER DEVELOPMENT)**
- 10. WATER RECOVERY FROM HVAC (PROPOSED)**

The following few slides illustrate the output for WIND GENERATION. The others are displayed in similar formats. In addition, a summary report is also available, and is shown later.



THERE ARE FOUR COMMON DISPLAY AREAS

1. DESCRIPTION & PERFORMANCE.1

Blade Diameter (ft.):	25	↑ May Increase!	
Swept Area:	490.87 ft. ²		45.604 m ²
Average Wind Speed:	10.98 MPH		4.91 m/s
Average Wind Speed:	16.11 ft./s		4.91 m/s
Wind Class:	2	Insufficient Speed for grid connection!	2
W/m ² (w/Humidity):	318.72 W/m ²		318.72 W/m ²
Base Density:	0.076327 lbm./ft. ²	✓	1.2226 kg/m ³
Average Humidity:	71.70 %		71.70 %
Humidity Correction:	1.0109		1.0109
Average Temperature:	65.7 °F	✓	18.7 °C
Temperature correction:	0.9892		0.9892
Altitude:	801 ft.	✓	244.15 m
Altitude Correction:	0.9710		0.9710
Corrected Density:	0.0741 lbm./ft. ²		1.19 kg/m ³
Betz Limit:	59.30 %		59.30 %
Coefficient of Performance:	0.36	η _p	0.36
Generator Efficiency:	0.92	η _g	0.92
Gearbox Efficiency:	0.82	η _b	0.82
Equivalent Power Output:	53.345 Hp.	✓	39.795 Kilowatts
kWh per year:	14,535 kWh/yr.		14,535 kWh/yr.
Electrical Offset:	\$1,376.32 per yr.		\$1,376.32 per yr.

In this case, the input data for a 25 foot wind turbine is displayed. Note that “green and gray (metric equivalent) are calculated values, white are input variables that can be altered and the Gold messages are only informational. Warnings are displayed in Red. Also note inputs are always within provided “buttons.”



2. ENERGY REDUCTION. & 3. ENVIRONMENTAL IMPACT

ENERGY REDUCTION [CH₄ Equivalent]

Fossil Fuel Reduction:	0.88 Tons/yr.	0.79 Tonnes/yr.
Generation Percent Fossil Fuel:	84.34%	84.34%
Percent Fossil Fuel Reduction:	0.36%	0.36%

EMISSION DATA

CO₂ Reduction:	11.24 Tons/yr.	10.20 Tonnes/yr.
H₂O Reduction:	6,250 Gal./yr.	0.24 m³
H₂O Reduction:	8.36 CCF	0.24 m³
CO₂ Credit:	\$267.58 per yr.	\$267.58 per yr.
H₂O Credit:	\$11.45 per yr.	\$11.45 per yr.
CO	1.98 lb./yr.	0.90 kg/yr.
NO_x	4.56 lb./yr.	2.07 kg/yr.
SO₂	0.05 lb./yr.	0.02 kg/yr.
Particulates:	0.35 lb./yr.	0.16 kg/yr.

All energy is converted to a CH₄ (Methane) equivalent to assure an apple to apple comparison. The generated % fossil fuel is the actual percentage of the supplied power that is generated using fossil fuels. Like wise, the reduction in emissions is based on the actual generation type distribution for the supplier of power.



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4. ECONOMICS

ECONOMICS

Utility Unit Cost:	\$0.09 per kWh.	\$0.09 per kWh.
Total Annual Savings:	\$1,376.32	\$1,376.32
Annual Savings w/Credits:	\$1,655.34	\$1,655.34
Project Cost:	\$17,123.60	\$17,123.60
LCCA:	\$7,381.11 40 yrs.	\$7,381.11 30 yr.
IRR:	6.14%	6.14%
Carbon Credit:	\$267.58	\$267.58
Water Credit:	\$11.45	\$11.45
Energy Savings:	\$1,376.32	\$1,376.32
Simple Pay Back:	12.4 yrs.	12.4 yrs.
Cost per kWh:	\$0.02 **	\$0.02 **
Percent Energy Reduction:	0.42%	0.42%
Cost per Square Foot of Bldg:	\$0.34 ft ²	\$3.66 m ²
Cost per Percent:	\$40,641.39	\$40,641.39
Installed kW:	14.80 kW	14.80 kW
Dollars per kW installed:	\$1,157.00	\$1,157.00
Dollars per swept square foot:	\$34.88	\$375.49

**** Based on LCCA**

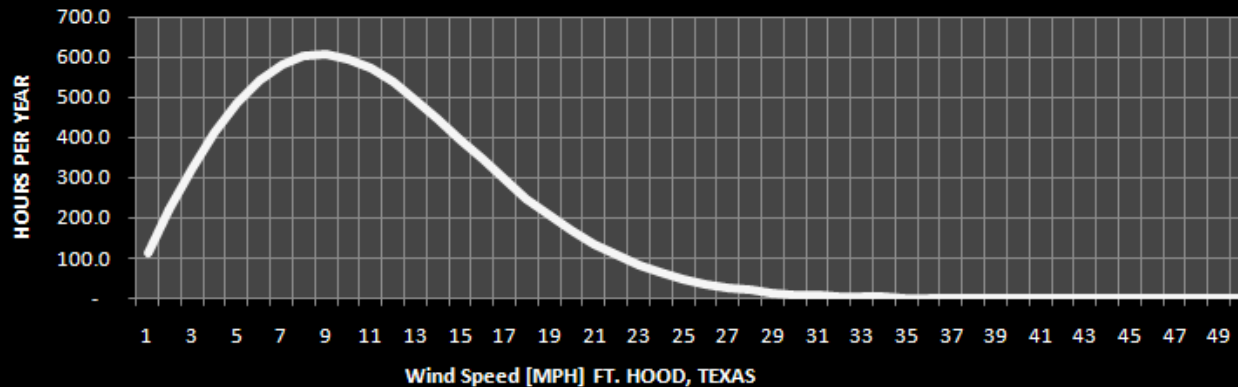
Life cycle cost analysis and internal rate of return along with the simple payback are strong indicators as to the viability of the proposed alternative. Cost per square foot, percent energy reduction and cost per percent energy reduction are available to assist in determining which alternatives will be required to meet the proposed requirements for energy reduction.



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MOST ALTERNATIVES INCLUDE GRAPHICS

RAYLEIGH WIND DISTRIBUTION



NOTE: Power output is a function of the wind speed cubed. Thus the speeds above the mean will have proportionally larger outputs than the reduction for the same sigma below the mean.

The program utilizes advanced techniques to evaluate alternatives. Illustrated here is the Rayleigh distribution of the probability of a given wind speed. This provides far more accuracy than utilizing the simple mean or average wind speed. As shown, the probability of the wind blowing 22 MPH is 100 hours per year @ Ft. Hood, TX.



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A SIMPLIFIED SUMMARY REPORT CAPTURES THE HIGHLIGHTS OF EACH ALTERNATIVE FOR COMPARISON.

<u>ENERGY ANALYSIS REPORT</u>				
For: FT. HOOD, TEXAS				5/12/2011 Page 1
Building Type:	BTOSUT	Electrical Consumption:	2,344,491	kWh
Square Footage:	50,350	Natural Gas Consumption:	3,771.03	MCF
Number of Persons:	1,200	HDD:	1,959	
Longitude:	97°47'45" West	CDD:	2,792	
Latitude:	31°08'30" North	Average Temperature:	65.7	°F
		Elevation:	801	ft.
Total Energy Consumed:	246.36	Tons of CH4 Equivalent		
CO ₂ Emissions:	141,301.62	Tons per year		
1. WIND GENERATION:		Recommended! Good Return!		
Blade Diameter:	25 ft.	Average Wind Speed:	10.98	MPH
Average Power Output:	39.80 kW	Wind Class:	2	
System Cost:	\$17,123.60	CO ₂ Savings:	9.74	Tons/year
Net Annual Savings:	\$1,376.32	Value (First Year):	\$267.58	
LCCA:	\$7,381.11 @ 30 years	Residual Electric:	2,329,956	kWh/yr.
Internal Rate of Return (IRR):	6.1%	Residual Gas:	3771.03	MCF
Simple Payback:	12.4			
Energy Savings:	14,535 kW/yr.			
Percent Savings:	0.42%			
Cost per percent:	\$40,641.39			
Cost per ft ² of Bldg.	\$0.34			
2. SOLAR WATER HEATING:		Poor Investment!		
Percent Offset:	30%	Gross Insolation:	6.53	Suns
Volume:	630 Gal./day @ 140 °F	Sunny Days:	146	
Required Area (Net):	502 ft. ²	Partly Cloudy Days:	106	
System Cost:	\$29,688.28	Cloudy Days:	113	
Net Annual Savings:	\$1,275.70	Net Insolation:	5.05	Suns
LCCA:	-\$11,319.10 @ 20 years.			

Although only the first portion of the report is shown, each alternative is displayed with the same basic data as shown for "WIND GENERATION." Future developments include the ability to rank these alternatives based on selected criteria, such as energy reduction percent, cost, LCCA, emission reduction, cost per square foot etc.



CONCLUSION

STEP - Has a very high degree of accuracy. As an example, solar data is viewed by the half hour vs. the standard of 1:00 PM on the 21st of each month.

STEP - Is user friendly and expandable. Proven analysis can be added in the future.



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