FRESA

Federal Renewable Energy Screening Assistant

User's Manual

NREL

National Renewable Energy Laboratory

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TABLE OF CONTENTS

1 GETTING STARTED

1.1 FRESA HARDWARE REQUIREMENTS

To use FRESA version (v) 2.5, you will need the following:
- IBM compatible personal computer with a 386 or higher processor
- MS Windows v 3.1 or higher

1.2 INSTALLING FRESA

From a CD-ROM:
For Windows 3.1
Insert the CD-ROM into your CD-ROM drive. In program manager, select the File Menu and choose Run. Type d:\setup.exe where d:\ is the location of your CD-ROM drive.

For Windows 95, 97, or NT
Insert the CD-ROM into your CD-ROM drive. Select the Start Menu and choose Run. Type d:\setup.exe, where d:\ is the location of your CD-ROM drive.

From the Internet:
Download the program files from
> http://www.eren.doe.gov/femp/techassist/softwaretools/softwaretools.html
> by following these instructions:
1. Download the .zip file. Save the file to your PC's desktop for easy access.
2. Create a new folder on your c:\ drive called TempFresa. *NOTE: Do not name the folder FRESA or the installation may not work properly!*
3. Using WinZip, Pkzip, or similar software, unzip the file to the location c:\TempFresa. (See http://www.winzip.com/ddchome.htm for more information and the WinZip program.)
4. Double-click on the "setup.exe" file in the unzipped files in the folder c:\TempFresa created in step 2 above.

For more help, see http://www.eren.doe.gov/femp/techassist/softwaretools/install.html Or call the FEMP Help Desk at 1-800-363-3732.

1.3 USING THIS MANUAL

The purpose of this user's manual is to provide a comprehensive description of the procedures for using the FRESA (Federal Renewable Energy Screening Assistant) personal computer software tool. To facilitate use of this manual and expedite the learning process, the following definitions are provided. These definitions apply for use in the software tool FRESA and are used throughout this manual.

Module -- A functional assembly for use with other such assemblies[††]. In this case, a subfunction of the complete FRESA code, designed to perform specific calculations or manipulate certain data within FRESA.

Data Field -- The blank "boxes" where data is entered into the different screens within FRESA.

Pull-Down Menu -- List menu that is "pulled down" by clicking on the small down-arrow located on the right edge of the rectangular box.

[††] Merriam-Webster WWWDictionary, http://www.m-w.com

2 FRESA PROGRAM STRUCTURE

2.1 INTRODUCTION

The FRESA computer program was originally developed to allow energy auditors in the DOE SAVEnergy program to quickly evaluate renewable energy conservation opportunities and renewable energy systems options for possible inclusion in a facility's energy program. FRESA provides uniform assumptions in the form of database climate and cost parameters, and generates reports consistent with the DOE/FEMP SAVEnergy Audit format. FRESA v 2.5 is a revision of the original FRESA v 1.0 program upgraded and de-bugged for user friendliness. Version 2.5 provides an easy way to collect and process building and facility data to indicate opportunities for renewable energy applications in federal facilities and buildings.

The purpose of this analytic tool is to help a facility focus feasibility study efforts on those applications most likely to prove cost-effective. The program is a supplement to energy and water conservation audits, which must be completed for all Federal buildings and will flag renewable energy opportunities by facilitating the evaluation and ranking process. FRESA results alone are generally not sufficient to establish project feasibility.

2.2 TECHNOLOGIES ANALYZED

This version of FRESA can screen facilities for the following energy systems:

- Daylighting Controls
- Solar Apertures
- Multiple Window Glazings
- Window Shading
- Solar Hot Water
- Solar Swimming Pools
- Geothermal Heat Pumps
- Active Solar Cooling
- Active Solar Heating
- Solar Ventilation Preheat
- Infiltration Control
- Wind Energy
- Solar Thermal Electric
- Water Power
- Photovoltaic (PV) Applications
- Biomass and Refuse Energy

Daylighting Controls, Solar Apertures, Multiple Window Glazings, and Window Shading are examples of passive solar applications that can be evaluated using FRESA.

Analysis for on-site power generation using Wind Energy, Hydro Power, Solar Thermal Electric, Photovoltaics, and Biomass and Refuse Energy allow the user to screen for ways to supplement, or even offset, power purchased from the grid.

Active Solar Heating and Cooling, Solar Ventilation Preheat, and Geothermal Heat Pump technologies allow the user to assess the possibility of replacing traditional HVAC equipment with renewable energy alternatives.

For more information on the technologies above, please refer to:
- The web site at: http://www.nrel.gov/ceb.html -- (NREL CLEAN ENERGY 101)
- The web site at: http://www.eren.doe.gov/femp/prodtech/fed_techalert.html -- (FEMP's New Technology Demonstration Program: Federal Technology Alerts)
- The Energy Efficiency and Renewable Energy Clearinghouse (EREC) at 1-800-DOE-EREC (363-3732), P.O. Box 3048, Merrifield, VA 22116, e-mail doe.erec@nciinc.com, or fax 1-703-893-0400.

2.3   PROGRAM MODULES

The FRESA computer program is made up of five program modules. The associated buttons to activate the modules appear on the top of all screens and are labeled as Facility/Building Info, Building/Facility Analysis, Input/Output, Weather, and Help. Module button locations are shown in Figure 1 below, and brief descriptions of the five modules follow.
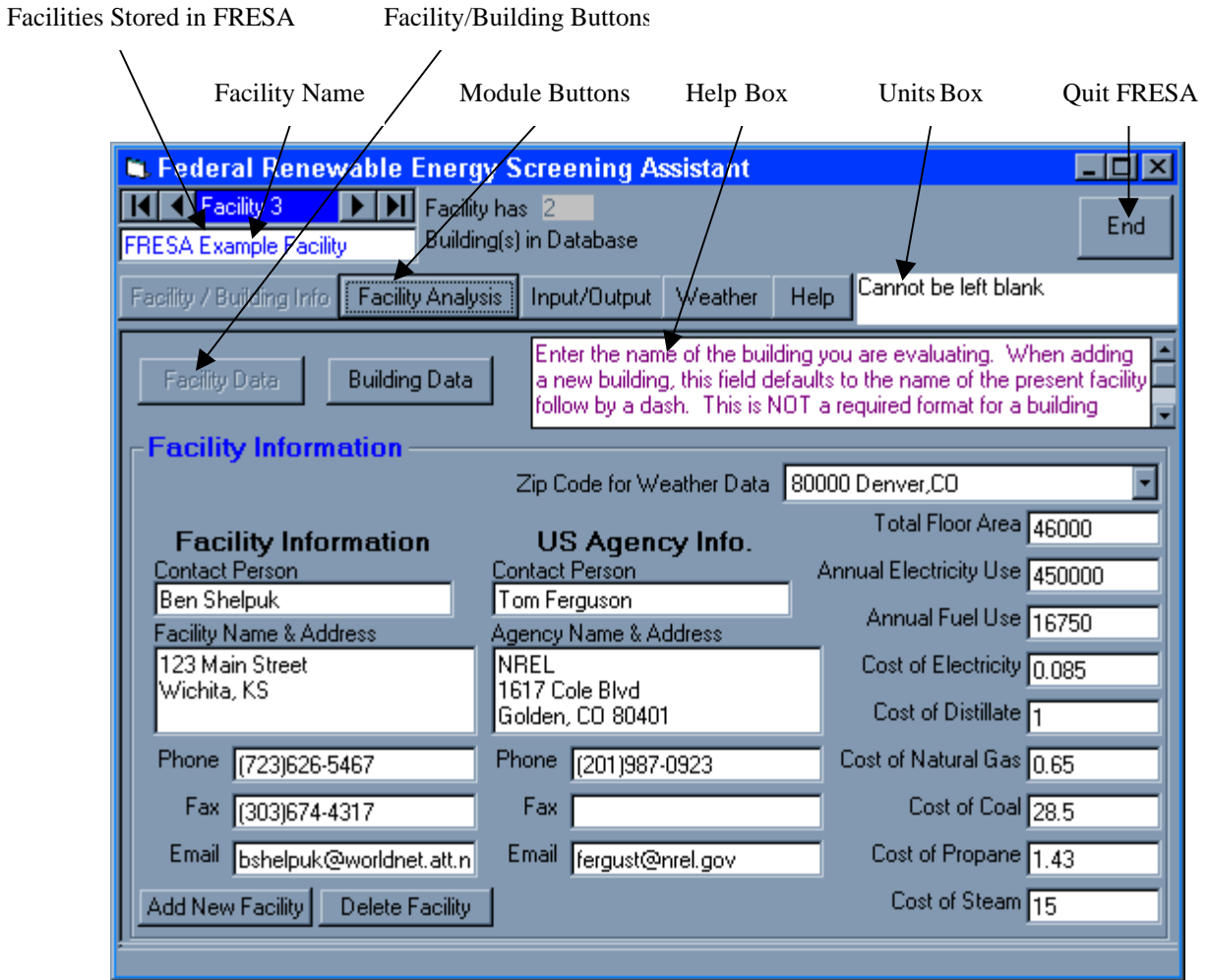
Figure 1. Module button locations on the FRESA launch screen

- Facility/Building, Module 1

This module allows the user to enter general information, which applies in all cases to either the entire facility or a specific building. A facility can (but need not) contain multiple buildings. Facilities can be analyzed independently; buildings must be associated with a facility. For an analysis that includes all the renewable energy technologies, both facility analysis and building analysis modules need to be used.

- Building/Facility Analysis, Module 2

  This module allows the user to select a renewable energy option to examine and enter the data values that are specific to that option. The pre-screening of all technology options is completed upon entry into this module (clicking on this button). Some options cannot be pre-screened, based on the information in the program database, and require additional data input. After the technology-specific data values are entered, FRESA completes the screening and calculates Savings-to-Investment Ratio (SIR) and Payback Period (PB) for that technology.

- Input/Output, Module 3

  This module allows the user to generate reports based on the user input or the FRESA-generated screening results. All reports can be viewed on-screen or directed to a file or a printer.

- Weather, Module 4

  This module contains data from 157 separate National Climatic Data Center (NCDC) weather stations. This module also allows the user to input new weather data.

- FRESA Help Menu, Module 5

  This module is the help system within FRESA. The FRESA help menu consists of a drop-down list of items and their descriptions. In addition to this help module, there is an on-screen help box (see Figure 1), which prompts the user to enter the type of information required in each data field.

3   THE SCREENING PROCESS

3.1   STAGE 1

FRESA performs an analysis in two stages. With a limited amount of information from the user, FRESA performs a pre-screen. The result of the pre-screen is an output of YES, NO, or MAYBE for each facility-scale or building-scale technology. If a YES or MAYBE is generated, it is recommended that the user continues with the screening process by entering the remaining required data.

The algorithms that FRESA uses to pre-screen are correlations between the primary variable or variables influencing cost-effectiveness, with assumptions for typical values for other parameters that appear to have a second order impact on cost-effectiveness. Understanding how FRESA rates each energy conservation measure (ECM) in the pre-screen process helps the user evaluate the validity of the pre-screening results. The algorithms are shown in detail in Appendix A.

3.2   STAGE 2

FRESA performs a life-cycle cost analysis during the second stage of the screening process. The most commonly used outputs of this analysis are the Life-Cycle Cost (LCC), SIR, and PB.   These outputs help determine which projects may be cost-effective.

Life-Cycle Cost (LCC) -- the sum of time-equivalent costs of acquiring, owning, operating, and maintaining a building, system, or equipment over a designated study period (FRESA uses 25 years). Consistent with 10CFR436, the discount rate and fuel escalation rates used in the analysis are those specified for Federal projects by the National Institute of Standards and Technology[†].

Savings-To-Investment Ratio (SIR) -- a ratio of discounted savings to costs for one building design, system, equipment, or strategy versus an alternative.

Payback Period (PB) -- the minimum time it takes to recover the costs of an investment, where the time value of money is not taken into account. PB = (Initial Investment)/(Annual Savings)

[†] Energy price Indices and Discount Factors for Life Cycle Cost Analysis 1997, Stephen R. Petersen, NISTIR 85-3273-11 (rev 7/96)

4   USING FRESA

FRESA has been designed to be a user-friendly analysis tool. Given specific information about a facility, ECMs and renewable energy (RE) options can be evaluated and ranked based on economics and potential energy savings. By following the steps below, the user will understand the basics of the FRESA screening process.

4.1   FACILITY/BUILDING INFO

The facility module describes an overall campus of buildings and/or other assets in general terms. Records for multiple facilities can be entered and stored here. They can later be modified or deleted as necessary.

Within the Facility/Building module, there are two screens on which information must be entered. The Facility Information screen contains facility contact information, U.S. agency contact information, and facility data. The Building Data screen contains building-specific information, which allows for the building-scale technology screening. Be aware that Facility Analysis screening and Building Analysis screening actually screen for different RE options. For a facility, 7 options are screened, most of which are energy *supply* technologies. For a building, 12 options are screened, most of which are energy *efficiency* technologies. The required inputs for each facility-scale and building-scale RE technologies are presented in spreadsheet form in Appendix B. These spreadsheets are particularly useful for recording data from facility and building walk-throughs that will later be entered into FRESA for analysis.

The first step to any FRESA screening is to enter a value for all the fields on the Facility Information screen. This will be the first screen that appears when the FRESA program is launched. When the Facility button is chosen, the user can view and modify data that is specific to a facility on the Facility Information screen. The data values entered here will remain the same for any ECM or RE option examined for the facility.

4.1.1   Facility Input

To begin the FRESA screening of a given facility, click on the Add New Facility button at the bottom left of the Facility Information screen. The following are descriptions of each field that appears on the Facility Information screen, in the order as prompted by the tab key. Required fields are shown in **BOLD** type.

Facility Information:

- **FACILITY NAME** -- Enter the name of the facility in this field. This is a required field and cannot be left blank.

- **ZIP CODE FOR WEATHER DATA** -- Select the zip code that is closest to your facility. You can select the weather data for your location using any zip code in the database. You may add zip codes to the weather database if the nearest zip code does not correspond well with the conditions at the desired location. This can be done by clicking on the Weather button (see Section 4.4). To add a zipcode, you must know specific weather data for that location.

Facility Data:

- **TOTAL FLOOR AREA** -- Enter the total square footage of the facility.

- **ANNUAL ELECTRICITY USE** -- Enter last year's electricity use for the facility, in kWh/year. The value should be the electricity use for the entire facility. The technology/cost algorithms credit an option with either the amount of energy produced or the amount of energy demanded (this input), whichever is smallest. Therefore, an inaccurate value here could produce misleading results.

- **ANNUAL FUEL USE** -- Enter last year's total fossil fuel usage for the facility, in MBtu/year (MBtu = 1×10^6 Btu). The term "fuel" includes natural gas, coal, propane, and distillate. The value should be the fuel use for the entire facility (include all hydrocarbon fuels in use over that 1-year period). The technology/cost algorithms credit an option with either the amount of energy produced or the amount of energy demanded (this input), whichever is smallest. Therefore, an inaccurate value here could produce misleading results.

  NOTE: To convert fuel use into MBtu, see Appendix C.

- **COST OF ELECTRICITY, DISTILLATE, NATURAL GAS, COAL, PROPANE, AND STEAM** -- Enter the energy cost of electricity paid by the audited facility in $/kWh, $/gallon, $/ccf (hundred cubic feet), $/ton, $/pound, and $/MBtu, for each usage, respectively. If this is a complex schedule of rates, enter an average value that best describes an average annual rate. A zero should be entered if this fuel type is not used.

- Contact Person -- Enter the name of the point of contact for energy matters at the facility.

- Facility Name and Address -- Enter the complete mailing address of the facility.

- Facility Phone, Fax, and Email -- Enter the phone, fax, and e-mail of the point of contact for energy matters at the facility.

US Agency Information:

- <u>Contact Person</u> -- Enter the name of the point of contact for energy matters at the U.S. agency.

- <u>Agency Name and Address</u> -- Enter the complete mailing address of the agency.

- <u>Agency Phone, Fax, and Email</u> -- Enter the phone, fax, and e-mail of the point of contact for energy matters at the agency.

<u>NOTE</u>: With the exception of the Facility and US Agency contact information, ALL fields on this Facility Information screen MUST be completed before ANY analysis can be performed.

Once all the required facility information data fields have been entered, the facility-scale analysis (done just once for the entire facility) can be performed. Click on the Save Changes button to save the new facility in FRESA. Next, click on the Facility Analysis module, and a screen providing the Prescreen results, SIR, and Discounted Payback Period is shown. Further discussion of facility-scale analysis is given in Section 4.2.1 of this manual.

4.1.2   Building Input

To enter building-specific data, click on the Building Data button. This screen (see Figure 2) must be completed to perform any building-scale analysis. Even if there is only one building in the given facility, i.e. the facility and building are one and the same, this screen must still be completed. When the Building Data button is chosen, the user can view and modify data that is specific to a building. To begin entering data for a new building, click on the Add New Building button at the bottom left corner of the screen.

Building Data Screen   Add a New Building   Building Name
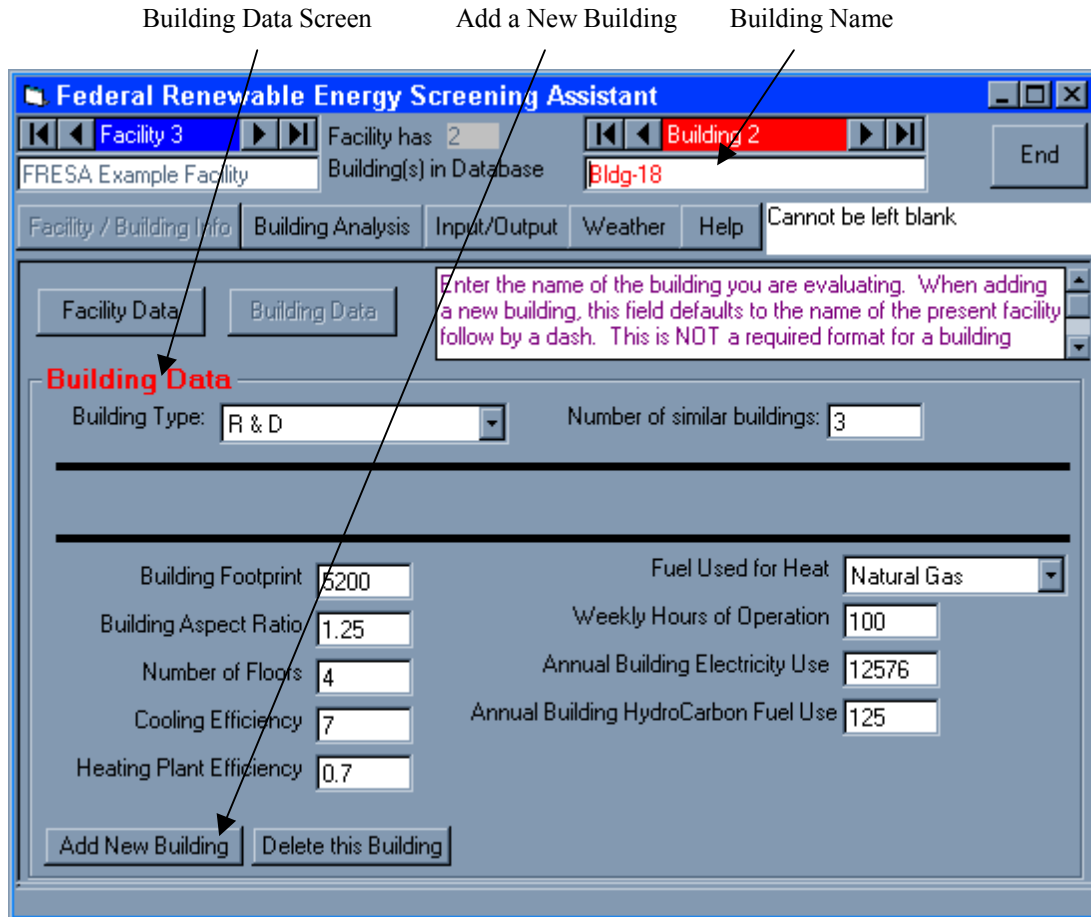
Figure 2. Building Data screen

The following are descriptions of each data field that appears on the Building Data screen, in the order as prompted by the tab key. Required fields are shown in **BOLD** type.

- Building Name -- In the upper right corner of the Building Data screen, enter the name of the building to be analyzed. This is not a required field, but will be helpful when analyzing facilities with a large number of buildings. When adding a new building, this field defaults to the name of the present facility followed by a dash.

9

- **BUILDING TYPE** -- Select the type of building that most closely identifies the building being analyzed.

  NOTE: FRESA assumes certain default values associated with the type of building selected, as shown in the table below. When unsure about what type of building to select, compare the building-specific information to the values shown below.

Building Type	Active Load (W/ft^2)	Ventilation (CFM/person)	Hot Water Use (gallons/person/day)	Infiltration* (air changes/hour)
Dining	6.13	15	20	1.34
Dormitory	2.52	25	34	1.34
Hospital	6.56	25	34	1.34
Housing	0.76	40	15	0.67
Industrial	5.04	30	4	1.34
Offices	3.38	25	3	1.34
Other	3.38	25	3	1.34
Prison	2.52	25	34	1.34
R&D	2.65	15	7	1.34
School	3.32	10	2	1.34
Services	2.65	15	2	1.34
Storage	2.11	10	2	0.67

  *Corrected for building tightness and wind velocity within the code

- **NUMBER OF SIMILAR BUILDINGS** -- Enter the number of buildings similar to this one. This number will be used to multiply the results. For instance, if the building is a housing unit and there are 5 (total) that are all similar, enter 5 in this box and the energy savings for this building will be multiplied by 5 to get a total savings. If this is the only building of its kind at this facility, enter 1.

- **BUILDING FOOTPRINT** -- Enter the area of the building footprint, in square feet. This represents the area of land the building occupies.

- **BUILDING ASPECT RATIO** -- The building aspect ratio is the ratio of the building dimension that most nearly faces south to east/west dimension. For instance, a building with a 150-foot side facing south and an 80-foot dimension on the east side would have an aspect ratio of 150/80=1.875.

- **NUMBER OF FLOORS** -- Enter the number of floors for the building.

- **COOLING EFFICIENCY** -- The Cooling Energy Efficiency Ratio, usually called CEER, describes the cooling efficiency of the air conditioning system. It is usually in the range of 8-12 Btu/Wh. For the currently installed air conditioner, its value is usually in the range of 4-7 Btu/Wh. An older system will perform at the lower end of the range. A new system may actually exceed the upper end of the range (8-10 Btu/Wh).

- **HEATING PLANT EFFICIENCY** -- Enter the heating plant efficiency of this building as a decimal equivalent. For instance, 75% efficiency should be entered as 0.75. Electric heat pumps typically have efficiencies of 101% - 500%.

- **FUEL USED FOR HEAT** -- Select from the pull-down menu the fuel used for space heating in the building.

- **WEEKLY HOURS OF OPERATION** -- Enter the weekly hours this building is occupied or is in use and requires heating, cooling, or lighting for human comfort or equipment protection.

- **ANNUAL BUILDING ELECTRICITY USE** -- Enter a value for last year's electricity use, in kWh. The value should be the electricity use for this particular building. Often, this number is not known for a single building, but only for the entire facility. One way to estimate this number is to take the annual

facility electricity usage and divide that by the total square footage of all buildings in the facility. The resulting number is in units of kWh/ft^2/year, and when multiplied by the *building* square footage, the result is a rough estimate of that building's annual electricity usage. The technology/cost algorithms credit an option with either the amount of energy produced or the amount of energy demanded (this input), whichever is smallest. Therefore, an inaccurate value here could produce misleading results. The building demand is used to evaluate energy supply technologies (like PV and Wind) for remote applications.

NOTE: This value is NOT checked against the total electricity used for the facility.

- **ANNUAL BUILDING HYDROCARBON FUEL USE** - Enter last year's HydroCarbon fuel use for the building being analyzed in MBtu {1x10^6 Btu} (all hydrocarbon fuels in use over that 1-year period for this building). The same technique can be applied here as for the Annual Building Electricity Use number. Take the annual *facility* hydrocarbon fuel usage and divide that by the total square footage of all buildings in the facility. The resulting number is in units of MBtu/ft^2/year, and when multiplied by the *building* square footage, the result is a rough estimate of that building's annual hydrocarbon fuel usage. The technology/cost algorithms credit an option with either the amount of energy produced or the amount of energy demanded (this input), whichever is smallest. Therefore, an inaccurate value here could produce misleading results. This demand may also be used to size an energy supply technology (like Wind or PV).

NOTE: This value is NOT checked against the total fuel used for the facility.

Once all the required building information data fields have been entered, the building-scale analysis (done separately for each building) can be performed. Click on the Save Changes button to save the building in FRESA. Next, click on the Building Analysis module, and a screen providing the Prescreen results, SIR, and Payback Period is shown. Further discussion of building-scale analysis is given in Section 4.2.2 of this manual.

4.2   BUILDING/FACILITY ANALYSIS

Once the required data has been entered into the Facility/Building Info module, selecting the Facility Analysis module will complete the facility-scale prescreening; selecting the Building Analysis module will complete the building-specific prescreening. This Stage 1 prescreening results in an output of YES, NO, or MAYBE. If a YES or MAYBE is generated, it is recommended that the user continue with the screening process by entering the remaining required data. This section explains how to accomplish this.

Once either the Facility Analysis or Building Analysis has been completed, a screen showing the Prescreen results and calculated Option SIR and Option PB will appear. This output is for all technologies, and the screen is labeled View All Options. Just above the table of results on this screen is a pull-down menu from which specific technologies can be selected. Selecting Wind Generation from the drop-down menu, for example, will bring up a screen to enter all the required data FRESA needs to complete the Stage 2 screening on wind generation for the given facility. After the required data values are entered for the specific technology, click on the Do Analysis button. The calculations for Stage 2 screening (still labeled as Prescreen), SIR, and PB are performed. Further results of the calculations can be viewed on-screen, by clicking on the Show Key Outputs button, or by printing them out from the Input/Output module (see Section 4.3). If there is missing or invalid input data in any of the required data fields, all results will default to a question mark (?).

To change an analysis or complete an unfinished analysis for one of the technology options, first bring up the option's input frame (use the drop-down box in the upper left corner of the window). Enter the requested information and click the Do Analysis button for temporary changes and Save Changes button for permanent changes.

4.2.1   Facility Analysis

To start the facility-scale analysis, the Facility Information screen in the Facility/Building Info module must be completed, with valid data saved in each required data field. Clicking on the Facility Analysis module button begins this analysis. Once FRESA is finished with it's facility-scale calculations, a table with Prescreen, SIR, and PB outputs appears on the View All Options screen.

If a YES or MAYBE is generated, continue with the screening process by entering the remaining required data in the technology-specific screens. To do this, select the appropriate technology from the pull-down menu in the upper right corner of the View All Options screen. Enter all of the required data into the data fields, then click on the Do Analysis button. If there is missing or invalid input data, all results will default to a question mark (?).

The data can either be temporarily stored by clicking on the Do Analysis button or changed by clicking on the Save Changes button. To "iterate" on the technology-specific analysis, the Do Analysis button recalculates the output given different inputs in the data fields. To optimize the results by varying inputs, use the Do Analysis button until the best configuration is chosen. Then save the changes with the Save Changes button.

FRESA provides system defaults for many of the technology options. To use a system default value for nearly any technology-specific input, simply press the return key when the cursor is in the data field. It is important to check the reasonableness of each default value for every application before proceeding to the next data field. The unit box at the top right corner of the screen provides the units of the data field that the cursor is currently in. In addition, an on-screen help box in the upper right hand corner describes details and prompts the user to indicate the type of information needed for a given data field.

To change an analysis or complete an unfinished analysis for one of the technology options, first select the option's input frame from the pull-down menu in the upper left corner of the window. Enter the necessary information and click the Do Analysis button.

NOTE: If the facility or weather input has changed, always recalculate results by re-typing or re-selecting an option, then saving. The program does not recognize these types of changes for building-scale technologies, and as a result, will not reevaluate the intended changes until the user reselects an option. Note that it will not suffice to simply press the Do Analysis button.

Pull-Down Technologies Menu   Facility-Scale Analysis Button   FRESA-Generated Facility-Scale Results
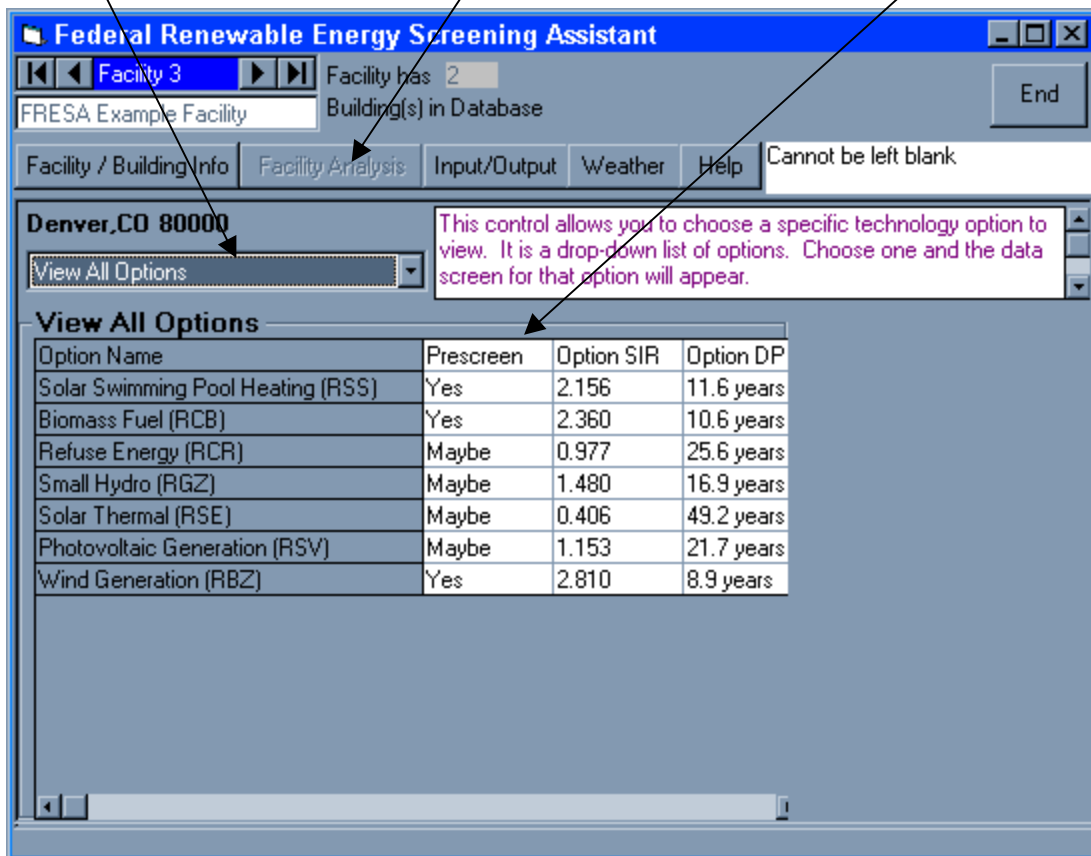
Figure 3. Facility-scale analysis results screen

A separate data input screen exists for each facility-scale renewable energy technology that FRESA analyzes. Each screen must be completed in full before FRESA can complete a Stage 2 screening. Detailed descriptions of each technology-specific data entry field follow.

4.2.1(a) Solar Swimming Pool Heating

Description
Analyzes the use of fixed flat-plate solar collectors for heating swimming pool water. Low-temperature collectors should be considered due to their comparatively low cost.

The following are descriptions of each field that appears on the Facility Analysis – Solar Swimming Pool Heating screen, in the order as prompted by the tab key.

- Pool Temperature -- Enter the desired pool temperature, in degrees Fahrenheit.

- Pool Question – Is the pool covered when not in use or is it located indoors? Answer (Y)es if either is the case. Select from the pull-down menu.

- Fuel Type – What is the fuel now used to heat the pool? Select from the pull-down menu.

- Pool Location -- Is the pool above or below ground? Select from the pull-down menu.

- Collector Area -- Enter the estimated solar collector area required, in square feet. A value of half the pool surface area is a good place to start.

- Pool Area -- Enter the surface area of the pool, in square feet.

- Pool Depth -- Enter the average depth of the pool, in feet.

- Swim Period -- Enter the number of weeks during the summer that the pool is open for use. FRESA will not analyze applications for winter usage.

- Solar Collector Cost -- Enter the cost of the solar collector, in $/ft^2. Low temperature collectors (which could be used here) are often less expensive than those used in building applications.

- Comment -- This is an optional field that will allow the user to add a technology-specific comment to the database and the input/output report.

Click on the Do Analysis button, and the calculated Pre-screen, SIR, and Payback values will be given. Click on the Show Key Outputs button for further analysis results.

FRESA Assumptions
The following assumptions are made in the interest of minimizing the analyst's input to a reasonable amount. These are hardwired into the FRESA code and cannot be changed by the user at this time.

- Solar collector performance is characterized by the fifteenth day of each winter month
- Each day of the month is assumed to have the same solar insolation
- Base Cost = $700 (In addition to unit collector costs specified by the analyst)

Approximate Base Cost Breakdown:

Pipe	$100
Controller and sensors	$140
Motorized valve	$100
Other plumbing specialties	$100
Installation	$280

- Annual O&M Cost = 1% of total first cost

4.2.1(b) Biomass Fuel

Description

Analyzes use of biomass fuels for electricity generation for the entire facility. Three electricity generation options can be analyzed: (1) direct firing of steam boilers for steam turbines, (2) a combined-cycle system, or (3) cogeneration (combined heat and power).

User-Defined Inputs

The following are descriptions of each data field that appears on the Facility Analysis – Biomass Fuel screen, in the order as prompted by the tab key.

- Distance to Fuel -- Enter the distance, in miles, to a large sustainable source of biomass. Assume that the quantity of biomass would require a plantation of 11,000 acres to sustain a 1-MW plant.

- Availability of Fuel -- Enter the number of months of the year the biomass can be supplied to the power plant. Assume that the biomass plant will require approximately 20 tons of fuel/MW/day.

- Displacing Fuel Type -- Select from the pull-down menu the kind of hydrocarbon fuel used to generate electricity at the facility.

- Rated Plant Capacity -- Enter a value for capacity of the installation, in kW. In each application except the boiler, the value will be equal to the electrical output. A capacity up to the present peak demand can be considered.

- Biomass Fuel Choice -- Select from the pull-down menu the fuel that is closest to the available supply.

- Biomass Fuel Cost -- Enter the cost for the biomass fuel you will use, in \$/Btu. FRESA has shown a default value based on your fuel choice.

- Application Question -- Select from the pull-down menu the electric conversion efficiency.

  NOTE: Efficiency for a boiler and a cogeneration system is calculated by FRESA. If you have entered your own efficiency and it is greater than 0.33, FRESA assumes you have a combined cycle.

- Power Plant Cost -- Enter a value that represents the cost of a biomass power plant, in \$/kW.

- Process Heat Temperature -- Enter a value for the temperature at which process heat is supplied, in °F. Accept the default if this is not a cogeneration system.

- Comment -- This is an optional field that will allow the user to add a technology-specific comment to the database and the input/output report.

Click on the Do Analysis button, and the calculated Pre-screen, SIR, and Payback values will be given. Click on the Show Key Outputs button for further analysis results.

FRESA Assumptions

The following assumptions are made in the interest of minimizing the analyst's input to a reasonable amount. These are hardwired into the FRESA code and cannot be changed by the user at this time.

- Plant Cost

Turboelectric	\$1350/kW
Combined Cycle	\$2000/kW
Boiler	\$500/kW (Boiler)

- Heat Exchanger Cost = \$20/ft^2

- Conversion Efficiency
    Boiler efficiency = 0.85
    Steam plant efficiency = 0.25
    Combined Cycle efficiency = 0.33
    Existing fossil efficiency = 0.25
- Fuel Cost, in $/ton
    Hardwood $57+(0.5*Distance)
    Softwood $42+(0.5*Distance)
    Peat $45+(1.0*Distance)
    Bagasse $35+(1.25*Distance)
- Annual O&M Costs = $0.01/kWh supplied

4.2.1(c) Refuse Energy

Description
Analyzes the use of solid waste produced at or near the facility as electricity generation for the entire facility. Incineration of solid wastes produces low pressure steam for a conventional steam-fired turbine generator. These systems allow a substantial reduction in the amount of solid waste that a facility must dispose of.

User-Defined Inputs
The following are descriptions of each data field that appears on the Facility Analysis – Refuse Energy screen, in the order as prompted by the tab key.

- Annual Refuse Rate -- Enter the number of tons of refuse per year to be used in electricity production. The system probably isn't practical when less than 50,000 tons per year of refuse is available.

- Start-Up Cost -- Enter the start-up cost ($/tons/day), including labor and materials, for installation of a refuse-fired electric power plant. This typically ranges from $60,000–$100,000/TPD. (TPD is tons of refuse per day.)

- Fuel Type – Select from the pull-down menu the type of hydrocarbon fuel used to generate electricity at the facility.

- Days per week of Operation -- Enter the number of days per week the refuse-fired electricity plant is to be in operation.

- Landfill Costs -- Enter the disposal tipping fees, in $/ton.

- Comment -- This is an optional field that will allow the user to add a technology-specific comment to the database and the input/output report.

Click on the Do Analysis button, and the calculated Pre-screen, SIR, and Payback values will be given. Click on the Show Key Outputs button for further analysis results.

FRESA Assumptions
The following assumptions are made in the interest of minimizing the analyst's input to a reasonable amount. These are hardwired into the FRESA code and cannot be changed by the user at this time.

- Mass reduction from incineration = 0. 7
- Waste heating value = 4500 BTU/lb
- Plant redundancy = 1.6
- Conversion efficiency = 0.23
- Refuse System installed cost = $60,000–$100,000/TPD where TPD = Tons of refuse per day

- Base Cost = $10 Million (Over the unit cost provided by the analyst. This covers permits, infrastructure, and construction, and implies that only large plants are practical.)
- Annual Cost Savings =
  [Displaced Energy Cost Savings] + [Waste Disposal Cost Savings] - [Increased O&M Costs]
- Annual O&M Cost = $0.09/kWh supplied

4.2.1(d) Small Hydro

Description
Analyzes small (2-15 MW) hydro-electric generation plants as electricity production for the entire facility.

User-Defined Inputs
The following are descriptions of each data field that appears on the Facility Analysis – Small Hydro screen, in the order as prompted by the tab key.

- Dam Height -- Enter the proposed height (or Head), in feet, of the dam for the hydroelectric plant. This can be estimated through USGS maps or a rough survey. Preferred values are in the 25-50 foot range.
- Dam Question -- Is there an existing usable dam at the proposed hydro site? Select (Y)es or (N)o from the pull-down menu.

- Fuel Type -- Select from the pull-down menu the type of hydrocarbon fuel used to generate electricity at the facility.

- Hours per year of Operation -- Enter the hours of operation for the hydroelectric power plant, in hours/year. A capacity factor of 0.7 (6132 hours) is a typical national figure.

- River Flow Rate -- Enter the river flow rate, in cubic feet per second, to be used for placement of the hydroelectric plant.

- Plant Cost -- Enter the unit capital cost to build a small hydro plant, in $/kW. FRESA will correct this cost if the site has very low head and will calculate the cost of the dam, if required.

- Comment -- This is an optional field that will allow the user to add a technology-specific comment to the database and the input/output report.

Click on the Do Analysis button, and the calculated Pre-screen, SIR, and Payback values will be given. Click on the Show Key Outputs button for further analysis results.

FRESA Assumptions
The following assumptions are made in the interest of minimizing the analyst's input to a reasonable amount. These are hardwired into the FRESA code and cannot be changed by the user at this time.

- Plant sizes analyzed are 2-15 MW
- Conversion efficiency = 95%
- Dam cost = $1500/installed kW (when a new dam must be constructed)
- Annual O&M Cost = $0.01/kWh supplied

4.2.1(e) Solar Thermal

Description
Analyzes use of a solar thermal electricity generator to supply electricity to the entire facility. Dish and trough solar collection systems can by analyzed. The dish thermal system considers 9-kW and 25-kW

dishes coupled with a Stirling engine for electricity generation. The trough system uses single axis N-S trackers and conventional steam turbines for thermal conversion to electricity.

<u>User-Defined Inputs</u>
The following are descriptions of each data field that appears on the Facility Analysis – Solar Thermal screen, in the order as prompted by the tab key.

- <u>Technology Choice</u> -- Select from the pull-down menu the type of solar thermal technology being considered.

- <u>Application Question</u> -- How will the solar thermal system be used at the facility? Select from the pull-down menu.

- <u>Fuel Type</u> -- Select from the pull-down menu the type of hydrocarbon fuel used to generate electricity at the facility.

- <u>Peak Power Rating</u> -- Enter the peak power rating, in kW, of the plant being evaluated. The following sizes are typical for the two solar electric options:
    Dish Stirling modules: 7.5 kW
    Trough steam plants: 80,000 kW

- <u>Plant Cost</u> -- Enter the unit capital cost of the solar thermal electric plant, in $/kW.

- <u>Distance to the Grid</u> -- Enter the facility's distance, in miles, from the utility electrical grid. Accept the default (zero) if you are now connected to the grid, or if the solar thermal plant will be used in a fuel-conserving mode.

- <u>Local Terrain</u> – Select from the pull-down menu the best description of the terrain over which the grid extension must be constructed. SPECIAL describes unusual requirements (e.g. swampy, etc.). Select the default NONE, if grid extension is not required.

- <u>Comment</u> -- This is an optional field that will allow the user to add a technology-specific comment to the database and the input/output report.

Click on the Do Analysis button, and the calculated Pre-screen, SIR, and Payback values will be given. Click on the Show Key Outputs button for further analysis results.

<u>FRESA Assumptions</u>
The following assumptions are made in the interest of minimizing the analyst's input to a reasonable amount. These are hardwired into the FRESA code and cannot be changed by the user at this time.

- Solar collector performance is characterized by the fifteenth day of each month:
    Trough collectors utilize data for direct beam radiation with a North-South tracker
    Dish collectors utilize data for direct beam radiation and 2-axis tracking
- Each day of the month is assumed to have the same solar insolation
- The trough option is a hybrid system with a 25% fossil energy boost
- System availability is 94%
- Trough system cost is a function of size
- Initial cost
    Dish system = $5,700/kW
    Trough system = f(system size)
- Solar Thermal Power conversion efficiency
    Dish Conversion Efficiency = 70% operating at 700 ºC
    Trough System efficiency = f(temp) where the maximum efficiency = 60%
- Array rated at 1 kW/m^2

- Annual O&M Costs:
  - Trough system $52/kW + 0.07/kWh
  - Dish system $77/kW + (0.025/kWh * PS)

4.2.1(f) Photovoltaic Generation

Description
Analyzes a grid-tied PV system's ability to supply electricity to the entire facility. This grid-tied system can be optimized based on maximum electricity output or on maximum peak demand shaving.

User-defined Inputs
The following are descriptions of each data field that appears on the Facility Analysis – Photovoltaic Generation screen, in the order as prompted by the tab key.

- Application Question -- How will the PV system be used at the facility? Select from the pull-down menu.

- PV Cell Choice -- Select from the pull-down menu the PV cell type to be used in the installation. Three types can be considered:
  - CSi - Crystalline or Polycrystalline Silicon
  - ASi - Amorphous Thin-film Silicon
  - CdTe - Cadmium Telluride thin-film

  NOTE: The cost and performance for the CdTe cells used in this model reflect industry projections to the year 2000. The Si choices reflect 1995 values.

- Peak Demand Season -- Select from the pull-down menu the season of the year when peak electrical demand occurs.

- PV Nameplate Capacity -- Enter the PV system nameplate electrical capacity, in kW.

- Collector Panel Tilt -- Enter the angle from the horizontal, in degrees, at which the collector panel is mounted. The usual value is equal to the latitude of the location. If summer output is favored it can be 15 degrees less; 15 degrees more for winter preference.

- Load Shape Ratio -- Enter the load shape ratio (the ratio between the daily minimum and daily maximum loads during the peak demand period) for the facility. This will be a number less than one.

  NOTE: Use 0.6 if no better value is known.

- Demand Rate -- Enter the demand rate at the peak demand period, in $/kW. The algorithm will account for the months, so do NOT multiply the charge by 12.

- Time of Day (Peak Demand) -- Enter the time of day when peak electrical demand occurs. Enter a value based on a 24-hour clock, e.g. 2:00pm = 1400 hours.

- PV System Cost -- Enter the cost of a PV power installation, in $/W. A value of $7/ peak Watt would represent a good starting point.

- Comment -- This is an optional field that will allow the user to add a technology-specific comment to the database and the input/output report.

Click on the Do Analysis button, and the calculated Pre-screen, SIR, and Payback values will be given. Click on the Show Key Outputs button for further analysis results.

FRESA Assumptions

The following assumptions are made in the interest of minimizing the analyst input to a reasonable amount. They are hardwired into the FRESA code and cannot be changed by the user at this time.

- Solar collector performance is characterized by the fifteenth day of each winter month
- Each day of the month is assumed to have the same solar insolation
- Solar cell efficiency (Efficiency is assumed 5% larger in winter due to the temperature effect.)
    - CSi efficiency = 0.114
    - ASi efficiency = 0.06
    - CdTe efficiency = 0.11
- Load shape variation = $\cos^{0.9}$(time from peak)
- Array rated at 1 kW/m^2
- Energy withdrawn from the battery suffers a 10% round trip loss
- System cost = 1.1*array cost
  Electronics = $125/kW (rated)
  Batteries = $80 /kWh
- Annual O&M Cost = $0.002/kWh supplied

4.2.1(g) Wind Generation

Description

Analyzes a grid-connected wind power system for electricity generation for the entire facility.

User-Defined Inputs

The following are descriptions of each data field that appears on the Facility Analysis – Wind Generation screen, in the order as prompted by the tab key.

- Fuel Type -- Select from the pull-down menu the type of hydrocarbon fuel used to generate electricity at the facility.

- Plant Electrical Capacity -- Enter the rated capacity for the proposed wind farm, in kW. Begin by considering farms with nameplate capacities in the range of 50%–100% of peak load. Total displacement of existing sources with wind is beyond the scope of this analysis.

- Equipment Size Selection -- Select from the pull-down menu the nameplate rating (550, 300, or 275 kW) of the proposed wind energy conversion system (WECS) equipment for generating electricity.

  NOTE: Smaller machines (those with a lower nameplate rating) may perform better in light winds. However, use of smaller turbines may require more turbines to be installed. Thus, there is a trade-off to be aware of in selecting the nameplate rating of the turbines.

- Wind Turbine Cost -- Enter the unit wind turbine cost, in $/kW.

- Wind Class Correction -- Enter a correction factor to wind resource data used in the program. Accept the default value for the initial analysis. If the site is favorable, a value of 1 or 2 can be considered, and more if the Wind Resource Atlas[†††] data supports it. This value will be ADDED to the power class specified in the weather database.

- Comment -- This is an optional field that will allow the user to add a technology-specific comment to the database and the input/output report.

[†††] Wind Resource Atlas, Prepared by Pacific Northwest National Laboratory for the U.S. Department of Energy, Springfield, Va.: National Technical Information Service, U.S. Dept. of Commerce, 1980-1981.

Click on the Do Analysis button, and the calculated Pre-screen, SIR, and Payback values will be given. Click on the Show Key Outputs button for further analysis results.

FRESA Assumptions

The following assumptions are made in the interest of minimizing the analyst's input to a reasonable amount. These are hardwired into the FRESA code and cannot be changed by the user at this time.

- Weibull distribution of wind speeds
- A 1/7 power height correction (to account for the fact that wind data are generally provided from instruments mounted 10 meters above the ground and wind turbines are typically mounted at a different height.)
- System efficiency = 85%
- Hub Height = 120 feet
- Major equipment overhaul at years 10 and 20; i.e., replace bearings at year 10 and replace blades and bearings at year 20:
    Cost of overhaul at year 10 = 5% of initial system cost
    Cost of overhaul at year 20 = 10% of initial system cost
- Turbine costs:
    Large Turbine = $375/m rotor diameter
    Small Turbine = $525/m rotor diameter
- Annual O&M Cost = $0.01 /kWh supplied

4.2.2   Building Analysis

To start the building-scale analysis, both the Facility Information screen and the Building Data screen in the Facility/Building Info module must be completed, with valid data saved in each required data field. Clicking on the Building Analysis module button begins this analysis. Once FRESA is done with it's building-scale calculations, a table with Prescreen, SIR, and PB outputs appears on the View All Options screen.

If a YES or MAYBE is generated, continue with the screening process by entering the remaining required data in the technology-specific screens. Select the appropriate technology from the pull-down menu in the upper right corner of the View All Options screen to accomplish this. Enter all of the required data into the data fields, then click on the Do Analysis button. If there is missing or invalid input data, all results will default to a question mark (?).

The data can either be temporarily stored by clicking on the Do Analysis button or changed by clicking on the Save Changes button. To "iterate" on the technology-specific analysis, the Do Analysis button recalculates the output given different inputs in the data fields. To optimize the results by varying inputs, use the Do Analysis button until the best configuration is chosen. Then save the changes with the Save Changes button.

Pull-Down Technologies Menu   Building-Scale Analysis Button   FRESA-Generated Building-Scale Results

Federal Renewable Energy Screening Assistant

| Facility 3 | Facility has 2 | Building 2 | End |
| FRESA Example Facility | Building(s) in Database | Bldg-18 | |

| Facility / Building Info | Building Analysis | Input/Output | Weather | Help | Cannot be left blank |

Denver,CO 80000

This control allows you to choose a specific technology option to view. It is a drop-down list of options. Choose one and the data screen for that option will appear.

View All Options

View All Options

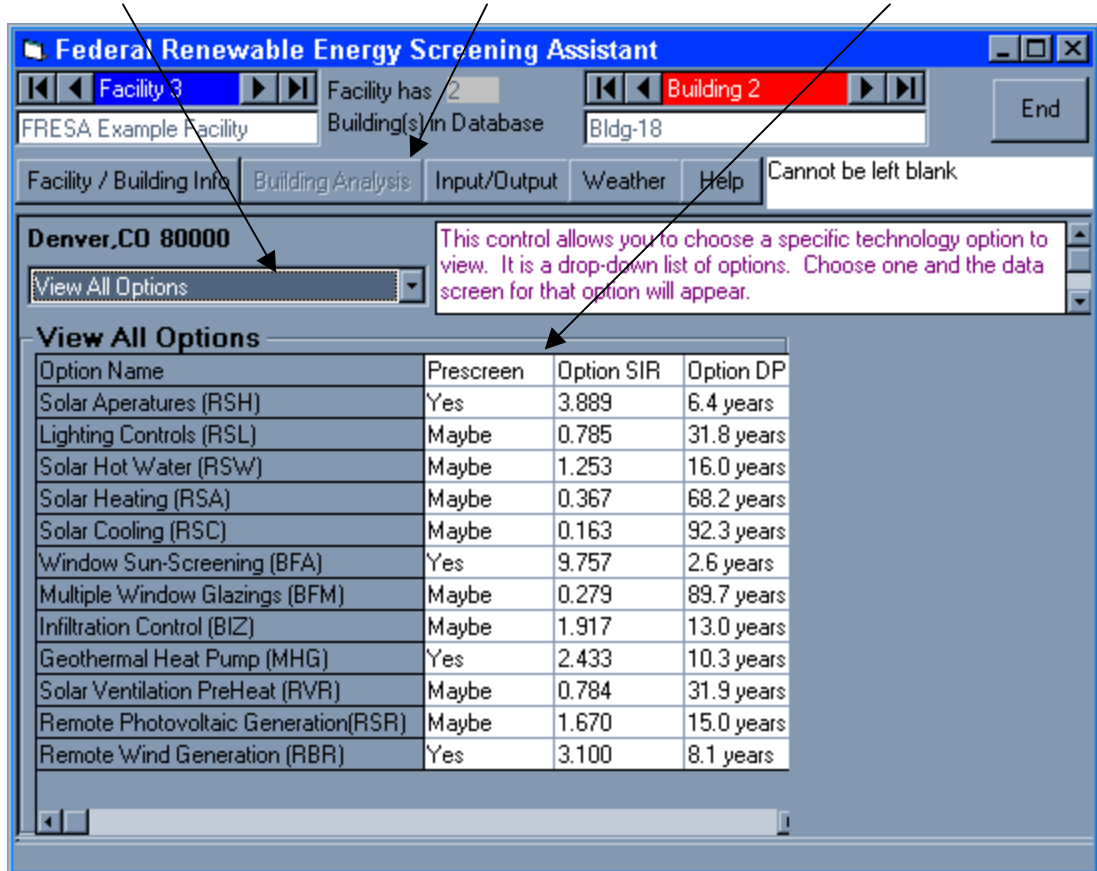| Option Name	Prescreen	Option SIR	Option DP
Solar Aperatures (RSH)	Yes	3.889	6.4 years
Lighting Controls (RSL)	Maybe	0.785	31.8 years
Solar Hot Water (RSW)	Maybe	1.253	16.0 years
Solar Heating (RSA)	Maybe	0.367	68.2 years
Solar Cooling (RSC)	Maybe	0.163	92.3 years
Window Sun-Screening (BFA)	Yes	9.757	2.6 years
Multiple Window Glazings (BFM)	Maybe	0.279	89.7 years
Infiltration Control (BIZ)	Maybe	1.917	13.0 years
Geothermal Heat Pump (MHG)	Yes	2.433	10.3 years
Solar Ventilation PreHeat (RVR)	Maybe	0.784	31.9 years
Remote Photovoltaic Generation(RSR)	Maybe	1.670	15.0 years
Remote Wind Generation (RBR)	Yes	3.100	8.1 years

Figure 4. Building-scale analysis results screen

FRESA provides system defaults for many of the technology options. To use a system default value for nearly any technology-specific input, simply press the return key on the data field. It is important to check the reasonableness of each default value for every application before proceeding to the next data field. The unit box at the top right corner of the screen provides the units of the data field the cursor is currently in. In addition, an on-screen help box in the upper right hand corner of the Building Analysis module describes details and prompts the user to indicate the type of information needed for a given data field.

To change an analysis or complete an unfinished analysis for one of the technology options, first bring up the option's input screen (use the pull-down menu in the upper left corner of the window). Enter the necessary information and click the "Do Analysis" button.

NOTE: If the facility or weather input has changed, always recalculate results by re-typing or re-selecting an option, then saving. The program does not recognize these types of changes for building-scale technologies, and as a result, will not reevaluate the intended changes until the user reselects an option. Note that it will not suffice to simply press the Do Analysis button.

A separate data input screen exists for each building-scale renewable energy technology that FRESA analyzes. Each screen must be completed in full before FRESA can complete a Stage 2 screening. Detailed descriptions of each technology-specific data entry field follow.

4.2.2(a) Solar Apertures

Description
Analyzes the use of solar apertures (skylights) for increased use of natural daylighting and reduced energy consumption due to artificial lighting. FRESA accounts for any heat gain associated with installing the skylight(s).

User-Defined Inputs
The following are descriptions of each data field that appears on the Building Analysis – Solar Apertures screen, in the order as prompted by the tab key.

- Room Floor Area -- Enter the floor area of the typical room that is to receive the skylights, in square feet.

- Number of Skylights -- Enter the number of skylights to be installed in the room being analyzed. A general convention is to assume installed skylight area will be equivalent to 2%-5% of the floor area.

- Area of Each Skylight -- Enter the area of each planned skylight opening, in square feet.

- Type of Skylight -- Select from the pull-down menu the type of skylight planned.

- Skylight Unit Cost -- Enter the skylight unit cost, in $/ft^2. Notice that FRESA has entered a default value based on the skylight type selection.

- General Light Level -- Enter the general lighting level required in the building, in footcandles (fc). Values in the range of 10-30 fc are adequate.

- Type of Artificial Lighting -- Select from the pull-down menu the type of artificial lighting currently used in the building.

- Total Floor Area -- Enter the total building floor area, in square feet, that would benefit from a skylight installation. If the skylights will be installed only in the room described, enter that area here.

- Work Days per Week -- Enter the number of days per week that the building is in use.

- Comment -- This is an optional field that will allow the user to add a technology-specific comment to the database and the input/output report.

Click on the Do Analysis button, and the calculated Pre-screen, SIR, and Payback values will be given. Click on the Show Key Outputs button for further analysis results.

FRESA Assumptions
The following assumptions are made in the interest of minimizing the analyst's input to a reasonable amount. These are hardwired into the FRESA code and cannot be changed by the user at this time.

- Heat gain through the skylight is characterized by the fifteenth day of each winter month
- Each day of the month is assumed to have the same solar insolation
- Skylight illumination is defined by the IES Handbook description of cloudy day illumination on a horizontal surface
- Eligible floor space is limited to one floor (directly below the roof)
- FRESA assumes artificial lighting is required for all hours of occupancy if no solar apertures are present.
- Artificial Lighting energy consumption:
    Incandescent = 50 Watts/FC
    T8 Fluorescent = 15 Watts/FC
    T12 Fluorescent = 12 Watts/FC

- Cost assumptions:

Skylight Type	Cost ($/ft^2)
Vented Skylight	71.25
Double Translucent	$(41.36 - (2.18 * Area) + (0.06 * Area^2) - (0.0005 * Area^3)$
Double Transparent	$(41.36 - (2.18 * Area) + (0.06 * Area^2) - (0.0005 * Area^3)$

- Annual O&M Cost = $0

4.2.2(b) Lighting Controls

Description
Analyzes use of light-switching and light-dimming controls for harvesting natural daylight and reducing energy consumption required for artificial lighting. Switching controls call for switching banks of lights on or off as daylight provides the specified light level at each of three room locations. Dimming controls call for continuous dimming of artificial lights as daylight provides the specified light level at each of three room locations.

User-Defined Inputs
The following are descriptions of each data field that appears on the Building Analysis – Lighting Controls screen, in the order as prompted by the tab key.

- Window Area Fraction -- Enter the percentage of the outside wall that is window in a typical room of this building. Use a decimal equivalent, e.g. 15% = 0.15.

- Electrical Modifications Questions -- Is the existing lighting wired such that banks of lights can be switched on and off from a photocell controller? Select (Y)es or (N)o from the pull-down menu. A YES answer would require at least two banks of fixtures running parallel to the window wall.

- Required Light Level -- Enter the required lighting level required in the building, in fc. Values in the range of 10-30 fc are adequate.

- Type of Artificial Lighting – Select from the pull-down menu the type of the artificial lighting currently used in the building.

- Room Floor Area -- Enter the floor area, in square feet, of the typical room that is to receive the lighting controls.

  NOTE: The energy results assume that all perimeter rooms for a single floor of the building are fitted with lighting controls. If all floors are upgraded, multiply the room floor area by the number of floors.

- Perimeter Area Fraction -- Enter the percentage of the building area that is exposed to window sidelighting. That is, the fraction of the floor area on the perimeter of the building where windows can contribute natural daylighting. Use a decimal equivalent, e.g. 75% = 0.75.

- Work Days per Week -- Enter the number of days per week that the building is in use.

- Room Width -- Enter the average width of perimeter rooms, from window to far wall, in feet. If they are all different, select the average value that best characterizes the building.

- Wiring Cost -- Enter the cost of rewiring the lighting, in $/ft, which would allow for sequential switching of three banks of lights. A value of $1.80/ft is typical.

- Controller Cost -- Enter the cost of purchase and installation of a lighting controller.

- Comment -- This is an optional field that will allow the user to add a technology-specific comment to the database and the input/output report.

Click on the Do Analysis button, and the calculated Pre-screen, SIR, and Payback values will be given. Click on the Show Key Outputs button for further analysis results.

FRESA Assumptions
The following assumptions are made in the interest of minimizing the analyst's input to a reasonable amount. These are hardwired into the FRESA code and cannot be changed by the user at this time.

- Window illumination is defined by the IES Handbook description of cloudy day illumination on a vertical surface
- Eligible floor space is limited to building perimeter space
- Installed artificial lighting delivers at least 110% of the desired footcandle output to account for lamp lumen depreciation
- Installation cost (switching) = 0.50 x (Area of the Room) + (Wiring Cost)
      where   Wiring Cost = 5.40 x (Area of the Room)/(Width of the Room)
- Building description:
      N/S and E/W building orientation assumed
      Uniform windows on all sides
      9-foot ceilings
- Occupancy is symmetrical about noon; any hours above 10 are assumed to occur in the evening rather than the morning.
- Dimming is assumed to save 10% more energy than switching because dimming controls to automatic compensation for lumen depreciation.
- Dimming or switching circuitry is activated when the lighting level at the sensor location is 30% of the design footcandles.
- Dimming control ramps linearly between 30% and 100% power and vice-versa.
- Annual O&M Cost = $0

4.2.2(c) Solar Hot Water

Description
Analyzes a stand-alone solar hot water heating system with flat plate collectors. The system is sized to meet the specified load in winter.

User-Defined Inputs
The following are descriptions of each data field that appears on the Building Analysis – Solar Hot Water screen, in the order as prompted by the tab key.

- Water Heater Fuel Type -- Select from the pull-down menu the type of fuel used in the water heater.

- Daily Hot Water Demand -- FRESA has provided the value shown, from national averages, for the specified type of building. If you can provide a better value, enter the daily hot water demand in gallons per day for each occupant. Some typical values (in gallons/occupant/ day):
    Men's Dormitory - 22
    Women's Dormitory - 26.5
    Hospital - 30
    Office - 1
    School - 1.8
    Restaurant - 4.8

- Hot Water Supply Temp -- Enter the hot water temperature in the water heater tank, in degrees Fahrenheit.

- Available Area for Panels -- Enter the footprint area, in feet, on or near the building, where solar panels could be mounted.

- Average Building Occupancy -- FRESA has provided the value shown, from national averages, for the specified type of building. If you can provide a better value, enter the average number of people that occupy the building on a working day.

- Collector Panel Tilt -- Enter the angle from the horizontal, in degrees, at which the collector panel is mounted. The usual value is equal to the latitude of the location. If summer output is favored, it can be 15 degrees less; 15 degrees more for winter preference.

- Solar Collector Cost -- Enter the cost of the solar collector modules, in $/ft^2. Press Enter to accept the default collector cost, $25/ft^2. FRESA will calculate the cost of a trough collector.

- Comment -- This is an optional field that will allow the user to add a technology-specific comment to the database and the input/output report.

Click on the Do Analysis button, and the calculated Pre-screen, SIR, and Payback values will be given. Click on the Show Key Outputs button for further analysis results.

FRESA Assumptions
The following assumptions are made in the interest of minimizing the analyst's input to a reasonable amount. These are hardwired into the FRESA code and cannot be changed by the user at this time.

- Solar collector performance is characterized by the fifteenth day of each winter month
- Each day of the month is assumed to have the same solar insolation

- Base Cost = $2000 (In addition to the unit collector costs specified by the analyst)

  Approximate Base Cost Breakdown:

Pipe	$100
Insulation	$50
80-gallon tank with integral heat exchanger	$900
Glycol	$50
Controller and sensors	$140
Expansion tank	$50
Pump	$100
Other plumbing specialties	$50
Installation (at $35/hour)	$560

- Annual O&M Cost = 2% of total first cost

4.2.2(d) Solar Heating

Description
Analyzes the use of flat plate or trough solar collectors to heat water and subsequently provide heat to the building as needed. To analyze trough collectors, use the default value (hit Enter) on the Solar Collector Cost data field.

User-Defined Inputs
The following are descriptions of each data field that appears on the Building Analysis – Solar Heating screen, in the order as prompted by the tab key.

- Collector Panel Tilt -- Enter the angle from the horizontal, in degrees, at which the collector panel is mounted. The usual value is equal to the latitude of the location. If summer output is favored it can be 15 degrees less; 15 degrees more for winter preference.

- Building Construction -- Is the construction of the building tight or loose? Select (T)ight or (L)oose from the pull-down menu.

- Window Ratio -- Enter the percentage of outside wall that is made up of windows, on this building. Use a decimal equivalent, e.g. 15% = 0.15.

- Glazing Type -- Select from the pull-down menu the type of glazing of the window to be draped. Select (S)ingle, (D)ouble, or (T)riple glazed windows.

- U Value of Wall Insulation -- Enter the overall heat transfer coefficient, U, for the existing walls of the building. Select from the pull-down menu options or enter your own value, if known. Any building design handbook should also have values. Some typical values, in $Btu/ft^2\text{-}°F\text{-}hr$, are:
  - .090 -- Surface finish, 3-inch insulation, surface finish
  - .100 -- 4-inch brick, 2-inch insulation, 8-inch concrete block
  - .198 -- 1-inch stucco, 8-inch concrete, 1-inch insulation
  - .203 -- metal siding, 1-inch insulation, air, metal
  - .237 -- 4-inch brick, air, 8-inch concrete block
  - .240 -- 4-inch lightweight concrete
  - .335 -- 4-inch brick, air, 4-inch brick
  - .512 -- 1-inch stucco, air space

- Solar Collector Cost -- Enter the cost of plate solar collectors for a heating system, in $/ft^2. For flat plate collectors, values in the range of $25/ft^2 can be considered. FRESA will calculate the cost of the trough collector. Trough collector cost is calculated internally, so choose the default value to continue with that analysis.

- Comment -- This is an optional field that will allow the user to add a technology-specific comment to the database and the input/output report.

Click on the Do Analysis button, and the calculated Pre-screen, SIR, and Payback values will be given. Click on the Show Key Outputs button for further analysis results.

FRESA Assumptions
The following assumptions are made in the interest of minimizing the analyst's input to a reasonable amount. These are hardwired into the FRESA code and cannot be changed by the user at this time.

- Solar collector performance is characterized by the fifteenth day of each winter month
- Each day of the month is assumed to have the same solar insolation
- Base Cost = $2700 (In addition to the unit collector costs specified by the analyst. A drainback system with a non-pressurized storage tank is assumed.)

Approximate Base Cost Breakdown:

Pipe	$200
Insulation	$100
Controller and sensors (one controller with two delta T channels, or two separate controllers)	$300
Collector pump (bronze high-head pump)	$235
Load pump (bronze)	$195
Load heat exchanger	$300
Domestic hot water (DHW) heat exchanger	$150
Other plumbing specialties	$100
Installation (at $35/hour)	$1,120

- Annual O&M Cost = 1% of total first cost

4.2.2(e) Solar Cooling

Description
Analyzes the use of flat plate or trough solar collectors coupled with an absorption cooler to provide building cooling and dehumidification.

User-Defined Inputs
The following are descriptions of each data field that appears on the Building Analysis – Solar Cooling screen, in the order as prompted by the tab key.

- Shading Device -- Select from the pull-down menu the type of shading device that will be used to shade the windows of the building. (The numbers represent the shading coefficient.)

- Technology choice -- Select from the pull-down menu the type of solar collector technology being considered. Trough collectors are appropriate only for large systems.
     Trough: Single Axis, tilted at latitude
     Plate: Double glazed, tilted at -15 latitude

- Building Construction -- Is the construction of the building tight or loose? Select (T)ight or (L)oose from the pull-down menu.

- Glazing Type -- Select from the pull-down menu the type of glazing of the window to be draped. Select (S)ingle, (D)ouble, or (T)riple glazed windows.

- U Value of Wall Insulation -- Enter the overall heat transfer coefficient, U, for the existing walls of the building. Select from the pull-down menu options or enter your own value, if known. Any building design handbook should also have values. Some typical values, in Btu/ft^2-°F-hr, are:
    - .090 -- Surface finish, 3-inch insulation, surface finish
    - .100 -- 4-inch brick, 2-inch insulation, 8-inch concrete block
    - .198 -- 1-inch stucco, 8-inch concrete, 1-inch insulation
    - .203 -- metal siding, 1-inch insulation, air, metal
    - .237 -- 4-inch brick, air, 8-inch concrete block
    - .240 -- 4-inch lightweight concrete
    - .335 -- 4-inch brick, air, 4-inch brick
    - .512 -- 1-inch stucco, air space

- Solar Collector Cost -- Enter the cost of plate solar collectors for a cooling system, in $/ft^2$. For flat plate collectors, values in the range of $25/ft^2$ can be considered. FRESA will calculate the cost of the trough collector and an appropriate absorption unit suitable for the application. Trough collector cost is calcuated internally, so choose the default value to continue with that analysis.

- Window Ratio -- Enter the percentage of outside wall area that is made up of windows. Express as a decimal, e.g. 15% = 0.15.

- Comment -- This is an optional field that will allow the user to add a technology-specific comment to the database and the input/output report.

Click on the Do Analysis button, and the calculated Pre-screen, SIR, and Payback values will be given. Click on the Show Key Outputs button for further analysis results.

FRESA Assumptions
The following assumptions are made in the interest of minimizing the analyst's input to a reasonable amount. These are hardwired into the FRESA code and cannot be changed by the user at this time.

- Solar collector performance is characterized by the fifteenth day of each winter month
- Each day of the month is assumed to have the same solar insolation
- Base Cost = $8000 (In addition to the unit collector costs specified by the analyst. Does not include storage.)

Approximate Base Cost Breakdown:

Pipe	$500
Insulation	$250
Glycol	$200
Expansion Tank	$200
Controller and sensors (one controller with two delta-T channels, or two separate controllers)	$300
Collector pump	$500
Storage pump	$500
Collector/storage heat exchanger	$1,100
Load pump	$500
Domestic hot water (DHW) heat exchanger	$300
DHW pump	$200
Other plumbing specialties	$650
Installation (at $35/hour)	$2,800

- Air conditioner is an absorption unit:

  COP = 0.72

  Cost = $1000/ton
- Solar cooling storage cost = $7/square foot of collector
- Annual O&M Cost = 1.5% of total first cost

4.2.2(f) Window Sun-Screening

Description

Analyzes the ability of interior or exterior window sun-screening methods to reduce heat gains through building windows.

User-Defined Inputs

The following are descriptions of each data field that appears on the Building Analysis – Window Sun-Screening screen, in the order prompted by the tab key.

- Shading Device -- Select from the pull-down menu the type of shading device that will be used to shade the windows of the building. (The numbers represent the shading coefficient.)

- Glazing Type -- Select from the pull-down menu the type of glazing of the window to be draped. Select (S)ingle, (D)ouble, or (T)riple glazed windows.

- Window Area -- Enter the total area, in square feet, of the windows to be shaded in the building.

- Direction of Exposure -- Select from the pull-down menu the building's direction of exposure to the sun.

- Expected Lifetime -- Enter the expected lifetime, in years, of the planned window shadings.

- Shading Cost -- Enter the cost for the selected window shading, in $/square feet.

- Comment -- This is an optional field that will allow the user to add a technology-specific comment to the database and the input/output report.

Click on the Do Analysis button, and the calculated Pre-screen, SIR, and Payback values will be given. Click on the Show Key Outputs button for further analysis results.

FRESA Assumptions

The following assumptions are made in the interest of minimizing the analyst's input to a reasonable amount. These are hardwired into the FRESA code and cannot be changed by the user at this time.

- Building is oriented in N/S and E/W direction
- Shading coefficients and costs

Shading Device	Shading Coefficient	Cost ($/ft^2)
No Shading	0.85	0
Venetian Blinds, fully closed	0.55	5.00
Drapes, avg. transmittance, fully closed	0.55	4.39
Roller Shade, fully drawn	0.39	5.25
Louvered External Screens	0.25	13.00
Reflective Polyester Film	0.24	4.00

- Annual O&M Cost = $0.10/ft^2

4.2.2(g) Multiple Window Glazings

Description
Analyzes the installation of multiple pane glazings for reducing building heating and cooling loads.

User-Defined Inputs
The following are descriptions of each data field that appears on the Building Analysis – Multiple Window Glazings screen in the order as prompted by the tab key.

- Window Area Being Replaced -- Enter the total area, in square feet, of the single-glazed windows in the building that will be replaced by double-glazed windows.

- Glazing Cost -- Enter the cost to install double-glazed windows, in $/ft^2. Use $6-$9/ft^2 for combination storm and screen windows, or $9–$15/ft^2 for double-glazing.

- Glazing Type -- Select from the pull-down menu the type of glazing of the window to be draped. Select (S)ingle, (D)ouble, or (T)riple glazed windows.

- Direction of Exposure -- Select from the pull-down menu the direction of exposure to the sun of the windows to be replaced.

- Comment -- This is an optional field that will allow the user to add a technology-specific comment to the database and the input/output report.

Click on the Do Analysis button, and the calculated Pre-screen, SIR, and Payback values will be given. Click on the Show Key Outputs button for further analysis results.

FRESA Assumptions
The following assumptions are made in the interest of minimizing the analyst's input to a reasonable amount. These are hardwired into the FRESA code and cannot be changed by the user at this time.

- Window exposures are limited to the four main compass directions
- Heat loss (winter) and heat gain (summer) are calculated from a curve fit of hour-by-hour analysis results
- Annual O&M Cost = $0

4.2.2(h) Infiltration Control

Description
Analyzes ability of caulking and weather stripping upgrades to reduce building heating and cooling loads.

User-Defined Inputs
The following are descriptions of each data field that appears on the Building Analysis – Infiltration Control screen, in the order as prompted by the tab key.

- Building Type -- Select the building type from the pull-down menu options:
    1: Data Processing or Special Application Buildings
    2: Buildings with Forced Air HVAC System
    3: Buildings without Forced Air Systems

- Door Perimeter -- Enter the number of feet in the perimeter of the doors to be caulked or weather-stripped.

- Window Test -- Has the window been weather-stripped? Select (Y)es or (N)o from the pull-down menu.

- Caulking Status -- Have the door(s) and window(s) of the building been caulked? Select (Y)es or (N)o from the pull-down menu.

- Cost of Caulk -- The cost, in $/ft, of material and labor for caulking in the given facility. Use $1.00-$1.50/ft for a starting value.

- Window Perimeter -- Enter the number of feet in the perimeter of the windows to be caulked or weather-stripped.

- Window Type -- Select the type of windows in the building from the pull-down menu options:
  - 1: Hinged Window
  - 2: Double Hung Window
  - 3: Steel Casement Windows

- Building Floor Area -- Enter the floor area, in square feet, of the room where windows or doors are to be caulked or weather-stripped.

- Building Construction -- Is the construction of the building tight or loose? Select (T)ight or (L)oose from the pull-down menu.

- Weather Stripping Status -- Has the door been weather-stripped? Select (Y)es or (N)o from the pull-down menu.

- Cost of Weather-stripping -- The cost, in $/ft, of materials and labor for weather-stripping in the given building. Use $2.00-$3.00/ft for a starting value.

- Expected Lifetime (caulk) -- Enter the expected lifetime, in years, of the caulking for the building.

- Expected Lifetime (stripping) -- Enter the expected lifetime, in years, of the weather-stripping for the building.

- Comment -- This is an optional field that will allow the user to add a technology-specific comment to the database and the input/output report.

Click on the Do Analysis button, and the calculated Pre-screen, SIR, and Payback values will be given. Click on the Show Key Outputs button for further analysis results.

FRESA Assumptions
The following assumptions are made in the interest of minimizing the analyst's input to a reasonable amount. These are hardwired into the FRESA code and cannot be changed by the user at this time.

- Basic building infiltration rate is 0.67 building volume changes/hour (for residential buildings)
- Non-residential buildings have twice the infiltration rate of residential buildings
- Infiltration rate for the unoccupied building is half of the daytime, occupied rate
- Loose construction leads to a doubling of the infiltration rate
- Infiltration rates are calculated from curve fits relating wind velocity, outdoor temperature, window type, occupancy, and caulking/weather-stripping condition.
- Annual O&M Cost = $0

4.2.2(i) Geothermal Heat Pump

Description
Analyzes use of geothermal heat pumps as an alternative to traditional building mechanical systems for heating and cooling. This analysis uses a bin method to match the building loads and heat pump performance.

User-Defined Inputs
The following are descriptions of each data field that appears on the Building Analysis – Geothermal Heat Pump screen, in the order as prompted by the tab key.

- Application Question -- Can the ground-coupled heat exchanger have a horizontal configuration (the most cost-effective)? This will require available ground space of 80-120 ft^2/ton of cooling load. Select (Y)es or (N)o from the pull-down menu. An answer of NO designates that a vertical configuration must be used (also required for a rocky location).

- Building Construction -- Is the construction of the building tight or loose? Select (T)ight or (L)oose from the pull-down menu.

- Glazing Type -- Select from the pull-down menu the type of glazing of the window to be draped. Select (S)ingle, (D)ouble, or (T)riple glazed windows.

- Soil Condition -- Select from the pull-down menu the type of soil into which the heat exchanger will be installed. The default conditions for each soil type are:

Soil Type	Diffusivity (α) (ft^2/hr)	Conductivity (k) (Btu/hr-ft-°F)
1	0.05	2.0
2	0.025	0.75
3	0.02	0.5
4	0.011	0.2

- Shading Coefficient -- Select from the pull-down menu the type of shading device that will be used to shade the windows of the building being analyzed. (The numbers represent the shading coefficient.)

- U Value -- Enter the overall heat transfer coefficient, U, for the existing walls of the building. Select from the pull-down menu options or enter your own value, if known. Any building design handbook should also have values. Some typical values, in Btu/ft²-°F-hr, are:
   .090 -- Surface finish, 3-inch insulation, surface finish
   .100 -- 4-inch brick, 2-inch insulation, 8-inch concrete block
   .198 -- 1-inch stucco, 8-inch concrete, 1-inch insulation
   .203 -- metal siding, 1-inch insulation, air, metal
   .237 -- 4-inch brick, air, 8-inch concrete block
   .240 -- 4-inch lightweight concrete
   .335 -- 4-inch brick, air, 4-inch brick
   .512 -- 1-inch stucco, air space

- Window Ratio -- Enter the percentage of outside wall area that is made up of windows. Express as a decimal, e.g. 15% = 0.15.

- Pipe Burial Cost -- Enter a value that represents the local drilling or trenching costs (as appropriate), pipe burial, and grouting. Values of $7.00/ft depth/ft diameter (drilling) and $1.50/ft (trenching) represent a good starting point.

- Comment -- This is an optional field that will allow the user to add a technology-specific comment to the database and the input/output report.

Click on the Do Analysis button, and the calculated Pre-screen, SIR, and Discounted Payback values will be given. Click on the Show Key Outputs button for further analysis results.

FRESA Assumptions
The following assumptions are made in the interest of minimizing the analyst input to a reasonable amount. They are hardwired into the FRESA code and cannot be changed by the user.

- The heat pump performance modeled is characterized as 'Advanced ground-source heat pump' by the industry
- The installed cost for a system assumes the following component costs:

System Component	Cost
Heat Pump cost Premium	$685/ton
Circulating Pump	$200/system
Installed Pipe:	
Diameter < 0.75 in.	$0.50/ft
Diameter > 0.75 in.	$0.70/ft
Fittings	$250/system
Miscellaneous	$800/system

- Annual O&M Cost = $100/year

4.2.2(j) Solar Ventilation Preheat

Description
Analyzes the energy savings associated with the use of a transpired solar collector to preheat building ventilation air.

User-Defined Inputs
The following are descriptions of each data field that appears on the Building Analysis – Solar Ventilation PreHeat screen, in the order as prompted by the tab key.

- Building Construction -- Is the construction of the building heavy or light? Select (H)eavy or (L)ight from the pull-down menu.

- Glazing Type -- Select from the pull-down menu the type of glazing of the window to be draped. Select (S)ingle, (D)ouble, or (T)riple glazed windows.

- U Value -- Enter the overall heat transfer coefficient, U, for the existing walls of the building. Select from the pull-down menu options or enter your own value, if known. Any building design handbook should also have values. Some typical values, in Btu/ft^2-°F-hr, are:
    - .090 -- Surface finish, 3-inch insulation, surface finish
    - .100 -- 4-inch brick, 2-inch insulation, 8-inch concrete block
    - .198 -- 1-inch stucco, 8-inch concrete, 1-inch insulation
    - .203 -- metal siding, 1-inch insulation, air, metal
    - .237 -- 4-inch brick, air, 8-inch concrete block
    - .240 -- 4-inch lightweight concrete
    - .335 -- 4-inch brick, air, 4-inch brick
    - .512 -- 1-inch stucco, air space

- Window Ratio -- Enter the percentage of outside wall area that is made up of windows. Express as a decimal, e.g. 15% = 0.15.

- Ventilation Requirements -- Enter a value for the total ventilation required by the building, in cubic feet per minute (CFM). Recommended values are:

	Per Person (CFM)	Per Sq ft of floor (CFM)
Office	15	0.25
Factory	10	0.10
Garage	--	1.00
Hospital	30	0.33
Kitchen	--	3.00
Laboratory	20	0.33
Meeting Room	50	1.25
Apartments	20	--

- Solar Collector Cost -- Enter the cost for the solar installation, in $/ft^2. Usual range is about $10/ft^2 for a retrofit or $7/ft^2 for a new installation.

- Comment -- This is an optional field that will allow the user to add a technology-specific comment to the database and the input/output report.

Click on the Do Analysis button, and the calculated Pre-screen, SIR, and Payback values will be given. Click on the Show Key Outputs button for further analysis results.

FRESA Assumptions
The following assumptions are made in the interest of minimizing the analyst's input to a reasonable amount. These are hardwired into the FRESA code and cannot be changed by the user at this time.

- Solar collector performance is characterized by the fifteenth day of each winter month
- Each day of the month is assumed to have the same solar insolation
- Collector Efficiency = 70%
- Base Cost = $1000 (In addition to the unit collector costs specified by the analyst)
- Annual O&M Cost = 1% of total first cost

4.2.2(k) Remote Photovoltaic Generation

Description
Analyzes the use of a stand-alone (vs. grid-connected) PV system to supply electricity to a remote building or facility. The system can be utilized either (1) to avoid building a potentially expensive grid extension, or (2) to provide fuel savings where a fossil fuel-fired electric generator is currently being used.

User-Defined Inputs
The following are descriptions of each data field that appears on the Building Analysis – Remote Photovoltaic Generation screen, in the order as prompted by the tab key.

- Application Question -- How will the PV system be used at the building? Select from the pull-down menu.

- PV Cell Choice -- Select from the pull-down menu the PV cell type to be used in the installation. Three types can be considered:
    c-Si - Crystalline or Polycrystaline Silicon
    a-Si - Amorphous Silicon thin film
    CdTe - Cadmium Telluride thin-film

    NOTE: The cost and performance for the CdTe cells used in this model reflect industry projections to the year 2000. The a-Si and c-Si cell choices reflect 1995 values.

- Fuel Type -- Select from the pull-down menu the kind of fuel that electricity from the PV panels will displace. If the application is Remote2, then this input is not applicable; FRESA will displace electricity at the cost given on the Facility Information input screen.

- Local Terrain -- Select from the pull-down menu the best description of the terrain over which the grid extension must be constructed. Select the default NONE, if grid extension is not required.

- Max Cloudy Days -- Enter the maximum number of consecutive cloudy days expected at this location, for which battery storage will be required.

- PV Nameplate Capacity -- Enter a value for the PV system nameplate electrical capacity, in kW.

- Collector Panel Tilt -- Enter the angle from the horizontal, in degrees, at which the collector panel is mounted. The usual value is equal to the latitude of the location. If summer output is favored it can be 15 degrees less; 15 degrees more for winter preference.

- Load Shape Ratio -- Enter the load shape ratio (the ratio between the daily minimum and daily maximum loads during the peak demand period) for the building. This will be a number less than one.

  NOTE: Use 0.6 if no better value is known.

- Distance to the Grid -- Enter the building's distance, in miles, from the utility electrical grid. Accept the default (zero) if you are now connected to the grid or if the PV will be used in a fuel-conserving mode.

- System Cost -- Enter the cost of a PV power installation, in $/W. A value of $7/peak Watt would represent a good starting point.

- Comment -- This is an optional field that will allow the user to add a technology-specific comment to the database and the input/output report.

Click on the Do Analysis button, and the calculated Pre-screen, SIR, and Payback values will be given. Click on the Show Key Outputs button for further analysis results.

FRESA Assumptions
The following assumptions are made in the interest of minimizing the analyst's input to a reasonable amount. These are hardwired into the FRESA code and cannot be changed by the user at this time.

- Solar cell performance is characterized by the fifteen day of each winter month
- Each day of the month is assumed to have the same solar insolation
- Solar cell efficiency: (Efficiency is assumed to be 5% greater in winter due to the temperature effect.)
      c-Si efficiency = 0.114
      a-Si efficiency = 0.06
      CdTe efficiency = 0.11
- Array is rated at 0.85 kW/m^2
- System cost = 1.1*array cost
- Electronics = $125/kW (rated)
- Batteries = $80/kWhr
- Estimated grid extension cost savings:

Terrain Description	Grid Extension Savings ($)
None	$0
Normal	$20,000 * Distance to grid
Hilly	$35,000 * Distance to grid
Special	$50,000 * Distance to grid
Under Ground	$75,000 * Distance to grid

- Annual O&M cost = $0.002/kWhr supplied

4.2.2(l) Remote Wind Generation

Description
Analyzes the use of a stand-alone (vs. grid-connected) wind power system to supply electricity to a remote building or facility. The system can be utilized either (1) to avoid building a potentially expensive grid extension, or (2) to provide fuel savings where a fossil fuel-fired electric generator is currently being used.

User-Defined Inputs
The following are descriptions of each data field that appears on the Building Analysis – Remote Wind Generation screen, in the order as prompted by the tab key.

- Rated Capacity -- Select from the pull-down menu the nameplate capacity rating, in W, of the wind turbine proposed for generating electricity. Other values will be filled in based on this value, but they can be changed.

  NOTE: Smaller machines (those with a lower nameplate rating) may perform better in light winds. However, use of smaller turbines may require more turbines to be installed. Thus, there is a trade-off to be aware of in selecting the nameplate rating of the turbines.

  NOTE: This value will be entered automatically if you have selected 'Let FRESA choose the size' for this building in the Facility/Building Info window.

- Capacity Cost -- Enter the cost of installing the turbine on the tower at the selected sight, including materials and labor, in $/W.

- Other Costs -- Enter any other costs not directly associated with installing the wind turbine on the tower, including things like batteries, controllers, inverters, and wiring.

- Rated Speed -- Enter the *rated* speed, in m/s, for the wind turbine. This is the wind speed corresponding to the turbine's power rating (1 mph = 0.44704 m/s).

- Cut-In Speed -- Enter the wind speed, in m/s, at which this wind turbine will *start* to generate power (1 mph = 0.44704 m/s).

- Cut-Out Speed -- Enter the wind speed, in m/s, at which this wind turbine will *stop* producing power in order to protect itself from damage (1 mph = 0.44704 m/s).

- Tower Height -- Height of the wind turbine tower, in m. This number will be used to adjust the average wind speed, assuming that measurements were taken at 10 m.

- Fuel Type -- Select from the pull-down menu the type of fuel that electricity from the wind turbine will displace. If the application is Remote2, then this input is not applicable; FRESA will displace electricity at the cost given on the Facility Information input screen.

- Application -- How will the wind turbine system be used at the building? Select from the pull-down menu.

- Local Terrain -- Select from the pull-down menu the best description of the terrain over which the grid extension must be constructed.

- Wind Power Class Correction -- Enter a correction factor to wind resource data used in the program. Accept the default value for the initial analysis. If the site is favorable, a value of 1 or 2 can be

considered, and more if the Wind Resource Atlas data supports it. This value will be ADDED to the power class in the weather database.

- Distance to Grid -- Enter the distance of the facility from the utility electrical grid, in miles.

- Comment -- This is an optional field that will allow the user to add a technology-specific comment to the database and the input/output report.

Click on the Do Analysis button, and the calculated Pre-screen, SIR, and Payback values will be given. Click on the Show Key Outputs button for further analysis results.

FRESA Assumptions

The following assumptions are made in the interest of minimizing the analyst's input to a reasonable amount. These are hardwired into the FRESA code and cannot be changed by the user at this time.

- Weibull distribution of wind speeds
- A 1/7 power height correction (to account for the fact that wind data are generally provided from instruments mounted 10 meters above ground and wind turbines typically are mounted at a different height).
- Standard turbine parameters assumed:

Rating	Cost	Speed (m/sec)		
(Watts)	($/Watt)	Rated	Cut-in	Cut-out
600	1.65	12.0	2.7	15.6
1000	1.50	11.1	3.1	15.0
1500	2.30	12.5	3.6	14.7
2400	1.75	9.0	2.7	18.0
3000	1.07	11.1	2.1	15.6
10000	1.50	11.6	3.1	15.6

- Grid extension cost savings. Distance to Grid has units of miles.

Local Terrain Condition	Grid Extension Cost Savings ($)
None	$0
Normal	$20,000 * Distance to Grid
Hilly	$35,000 * Distance to Grid
Special	$50,000 * Distance to Grid
Under Ground	$75,000 * Distance to Grid

- Annual O&M Cost = $0.01/kWh supplied

4.3   INPUT/OUTPUT

The third module, Input/Output, allows the user to create reports, import data from other databases, and change the NIST economic data. The Choose An Option pull-down menu includes: Create a Report, Import Data, and Change NIST Data.

- Create a Report -- This module creates one of two types of reports, a Summary Report and an Input/Output Report. Either can generate a report on building-scale, facility-scale, or individual technology analysis. The FRESA Building Summary Report contains the final results from all the calculations completed for a specified building. It shows all technologies for which SIR calculations have been completed. The Input/Output Report displays user inputs and the FRESA-generated results, which include SIR and Payback Period. All reports can be viewed on-screen or directed to a file or a printer.

  To generate these reports, choose between the Facility or Building buttons in the Building/Facility Info module. After all of the facility and/or building entries have been completed, click on the Facility Analysis or Building Analysis module buttons, as appropriate. Once results have been calculated, proceed to the Input/Output module.

  To look at the data provided by any of the reports prior to printing them, simply view them on-screen. To navigate within the report, use the scroll bars and forward/backward arrows at the bottom of the screen.

- Import Data -- This module imports data utilizing an automatic browse function of the hard drive. It displays Available Files, Facilities/Buildings to import under View What?, and Available Data. Click on the Import button to begin this function.

  To import an archived file (see Section 5.2) from FRESA v 2.5, go to the Input/Output module and choose the Import Data option from the pull-down menu. Choose the directory that you would like files to be transferred from, highlight the specific facility to be imported, and click on the Import button.

  NOTE: Because of changes made to the core of FRESA, it is not possible to import FRESA files from previous versions into version 2.5. The user must re-enter the information required in each data field as if starting a new facility or building.

- Change NIST Data -- This module changes NIST data for Census Regions 1 through 4. Electricity, Coal, Natural Gas, and Distillate have available entries to save or cancel data changes. Consistent with 10CFR436, the discount rate and fuel escalation rates used in the analysis are those specified for federal projects by the National Institute of Standards and Technology[†].

[†] Energy price Indices and Discount Factors for Life Cycle Cost Analysis 1997, Stephen R. Petersen, NISTIR 85-3273-11 (rev 7/96), http://www.bfrl.nist.gov/oae/publications/nistirs/3273.html.

4.4   WEATHER DATA, OR ADDING A ZIP CODE

The fourth module, is the Weather module. Data from 157 separate National Climatic Data Center (NCDC) weather stations are included in the FRESA database. They can be viewed and edited through this module. The data is called up according to the zip code of the particular location.

Selecting the Weather module displays information on the weather statistics for a given zip code. If the zip code is one of the originals in the database, the data cannot be changed, only viewed. The numbers can only be changed if it is a user-defined zip code or if the zip code is entered as 00000. If needed, a new zip code can be defined for the site. It may be wise to create a new zip code using the data from the nearest city as default values when better information is unavailable. To add a zip code to the weather database, click the Add New Zip code button on this screen. The zip code will be added to the list once all data has been entered and verified. It will then be available in the drop-down menu on the Facility/Building Info screen.

NOTE: The user may want to keep in mind that temperature and wind data for a site could be significantly different from the nearest city. One resource that could be helpful is:
http://met-www.cit.cornell.edu/other_rcc.html

Descriptions of the data fields required in the Weather module are as follows:

- **LATITUDE** -- Area geographic latitude, in degrees.

- **WINTER DESIGN TEMPERATURE** -- The temperature, in degrees Fahrenheit, that is exceeded for 97.5% of the hours in January, February, and March.

- **AVERAGE WINTER TEMPERATURE** -- The average of all temperatures that are less than 55 ^{o}F.

- **SUMMER DESIGN TEMPERATURE** -- The temperature, in degrees Fahrenheit, that is exceeded 2.5% of the time between June and September.

- **AVERAGE SUMMER TEMPERATURE** -- The average of all temperatures exceeding 75 ^{o}F.

- **DESIGN DEW POINT TEMPERATURE** -- The wet bulb temperature, in degrees Fahrenheit, that is exceeded 2.5% of the time between June and September.

- **AVERAGE DEW POINT TEMPERATURE** -- The average of all wet bulb temperatures when the dry bulb temperature exceeds 75 ^{o}F.

- **MINIMUM AVERAGE DAILY SOLAR** -- The minimum total daily solar radiation on a horizontal surface, in kWh/m^2/day. Usually occurs in the month of December.

- **MAXIMUM AVERAGE DAILY SOLAR** -- The maximum total daily solar radiation on a horizontal surface (in kWh/m^2/day. Usually occurs in the month of June.

- **MINIMUM AVERAGE DIRECT SOLAR** -- The minimum total daily direct solar radiation on a one-axis tracking surface tilted at an angle equal to the latitude, in kWh/m^2/day. Usually occurs in the month of December.

- **MAXIMUM AVERAGE DIRECT SOLAR** -- The maximum total daily direct solar radiation on a one-axis tracking surface tilted at an angle equal to the latitude, in kWh/m^2/day. Usually occurs in the month of June.

- **CENSUS REGION** -- Geographic region for the facility, as defined in NIST handbook 135.

- **WINTER LENGTH** -- The number of hours per year, expressed in weeks, that the outdoor temperature is less than 55°F.

- **SUMMER LENGTH** -- The number of hours per year, expressed in weeks, that the outdoor temperature is greater than 75°F.

- **ENERGY HEATING INDEX** -- The annual energy required to heat 1000 CFM of outside air to 68 ^{o}F, assuming 50 hours per week of requirement.

- **ENERGY COOLING INDEX** -- The annual energy required to cool and dehumidify 1000 CFM of outside air to 55°F, assuming 50 hours per week of requirement.

- **PEAK CORRECTION** -- A factor to correct for maximum direct solar radiation not occurring during June. The value is 0.4 for each month of variation. The value is negative if the peak occurs before June, positive, if it occurs after June.

- **MAXIMUM 2X SOLAR** -- The maximum total daily direct solar radiation on a two-axis tracking surface, in kWh/m^2/day. Usually occurs in the month of June.

- **MINIMUM 2X SOLAR** -- The minimum total daily direct solar radiation on a two-axis tracking surface, in kWh/m^2/day. Usually occurs in the month of December.

- **AVERAGE WIND SPEED** -- The average of the nine quarter-degree quadrants surrounding and including the longitude/latitude of the representative city of the zip code, expressed in wind class units.

  NOTE: If the wind data is the only value of concern, it can be altered through the Wind Power Generation technology choice within the Facility/Building Analysis module. The user can add or subtract from the average wind speed depending on locations such as a hill, flat plane, densely covered forest etc. by indicating a -6 to a +6 correction factor. The assumed average wind speed will be indicated on the Show Key Outputs screen.

Wind Power Class	Average Wind Speed (m/s)
1	5
2 or 3	6
4 or 5	7
6	8
7	10

- **HEATING DEGREE-DAYS** -- Annual degree-days above 68 ^{o}F.

- **HOURS ABOVE 78 DEGREES** -- The annual number of degree-hours that the dry bulb temperature equals or exceeds 78 ^{o}F.

5 OTHER FRESA HOW-TO'S

5.1 TROUBLESHOOTING

Q: I've updated the Weather data in my FRESA screening, but the analysis results haven't changed.

A*:* If the facility or weather input has changed, always recalculate all screening results by re-typing or re-selecting a specific technology, then saving the changes. The program does not recognize these types of changes for building-scale technologies and as a result will not re-evaluate the intended changes until the user reselects an option. Note that it will not suffice to simply press the Do Analysis button.

Q: I know the electricity and fuel usage for the facility, but not for individual buildings. How can I find this?

A: One way to estimate the building annual electricity usage is to take the annual *facility* electricity usage and divide that by the total square footage of all buildings in the facility. The resulting number is in units of kWh/ft^2/year, and when multiplied by the specific *building* square footage, the result is a rough estimate of that building's annual electricity usage, in kWh/year.

The same technique can be used for estimating the annual building hydrocarbon fuel usage. Take the annual *facility* hydrocarbon fuel usage and divide that by the total square footage of all buildings in the facility. The resulting number is in units of MBtu/ft^2/year, and when multiplied by the *building* square footage, the result is a rough estimate of that building's annual hydrocarbon fuel usage, in MBtu/year.

Q: How do I know what the units should be for a given data input field?

A: The units box for all user-supplied FRESA inputs is located at the top left corner of each screen, just to the right of the Help button. Units for each input field are also included in this user's manual in sections 4.2.1 and 4.2.2. In addition, an on-screen help window is located just below the units box, and a complete Help module is available by clicking on the Help button.

Q: What if I don't know the exact answer to a required FRESA input?

A: If unsure about which choice to select in a pull-down menu, or what exact answer to provide in a data input field, DO NOT select the "?" character. This character implies no answer has been provided for that input field, and FRESA will not perform an analysis when any required data field contains this character. When unsure of the exact input, select a best estimate or the choice which most closely reflects the actual situation. The value can always be changed and the analysis re-run at a later time.

Q: What if I don't know the cost of a certain ECM or RE option?

A: Because materials and labor costs differ significantly in different parts of the country and world, and because technology changes on a daily basis, the default technology costs provided in FRESA may not be accurate in some applications. One resource for cost information on federal projects is the GSA supply schedule, which can be found on the internet at http://www.fss.gsa.gov/cgi-bin/advwel . Type in the area code used in the FRESA analysis, and select Browse. The supply schedule can then be searched for a specific ECM or RE technology.

5.2 ARCHIVING DATA

To archive previous screenings in FRESA, go to the FRESA icon on your computer. Copy and paste this to another location (such as a new folder in the current directory). Then rename the icon from FRESA to Archive. Import older projects to the archived version, then delete those in the active version.

APPENDIX A

ALGORITHMS USED IN FRESA PRESCREENING

The following are the algorithms that FRESA uses to pre-screen, listed in alphabetical order. They are correlations between the primary variable or variables influencing cost effectiveness with assumptions for typical values for other parameters that appear to have a second order impact on cost effectiveness.

Biomass Fuel

CRITERIA	FEASIBILITY
Distance to Biomass Source $\leq$ 10 and Number of Months Biomass Available > 5	YES
For All Cases Not Listed	MAYBE
Distance to Biomass Source > 5 or Number of Months Biomass Available < 3	NO

Geothermal Heat Pump

CRITERIA	FEASIBILITY
Electricity Used to Heat/Cool and (electricity cost * 292/ fuel cost) > 3 and 2.5 > (ha78/HDD) > 0.5 or Electricity is not used to Heat/Cool and (cost of fuel) > 3.5 and (electricity cost * 292/ fuel cost) > 3	YES
For All Cases Not Listed	MAYBE
Electricity used to Heat/Cool and (electricity cost * 292/ fuel cost) > 2 or Electricity is not used to Heat/Cool and (electricity cost * 292/ fuel cost) < 2	NO

Where   HDD is the heating degree days
        ha78 is the number hours above 78^0F

Infiltration Control

CRITERIA	FEASIBILITY
HDD * (cost of fuel) > 26,395	YES
For All Cases Not Listed	MAYBE
HDD * (cost of fuel) < 8,200	NO

Where   HDD is the heating degree days

Lighting Controls

CRITERIA	FEASIBILITY
window area/wall area $\geq$ 0.1 Question = YES	YES
window area/wall area $\geq$ 0.3 Question = NO	MAYBE
For All Cases Not Listed	NO

Where   Question is: Is the lighting wired for separate banks of fixtures (window to far wall)?

Multiple Window Glazing

CRITERIA	FEASIBILITY
(0.39 * ha78 + HDD) > 9,800 - 35,000* (cost of electricity)	YES
(0.39 * ha78 + HDD) < 12,500 - 26,000* (cost of electricity)	MAYBE
For All Cases Not Listed	NO

Where   ha78 is the number hours above 78^0F
          HDD is the heating degree days

Photovoltaic (Grid Connected)

CRITERIA	FEASIBILITY
N/A	YES
IrMax > 6 and Question = UTILITY2	MAYBE
For All Cases Not Listed	NO

Where   IrMax is the maximum daily total solar radiation of a horizontal surface (kWh/day)
          Question: How will the PV used by the utility? (Utility1 - Capacity
          displacement or Utility2 - Peak shaving)

Refuse Energy

CRITERIA	FEASIBILITY
(Refuse Rate)/365 > (Startup Cost/106 * 35.94 + 1,250)	YES
For All Cases Not Listed	MAYBE
(Refuse Rate)/365 < (Startup Cost/106 * 20.55 + 500)	NO

Remote Photovoltaic Generation

CRITERIA	FEASIBILITY
IrMax > 6 and Question = Remote2 and Annual Electricity Use < 20,000	YES
IrMax > 6 and Question = Remote2	MAYBE
For All Cases Not Listed	NO

Where   IrMax is the maximum daily total solar radiation of a horizontal surface (kWh/day)
Question is the 'Application Question' Input
Remote2 is a stand-alone location with no grid connection

Remote Wind Generation

CRITERIA	FEASIBILITY
Wind Power Class > 4	YES
For All Cases Not Listed	MAYBE
Wind Power Class < 3	NO

Small Hydro

CRITERIA	FEASIBILITY
Question = YES and DamCost < 2,725 or Question = NO and DamCost < 725	YES
Question = YES and DamCost > 7,780 or Question = NO and DamCost > 5,780	MAYBE
For All Cases Not Listed	NO

Where   Question: Is there an existing dam?
DamCost = Cost to build a dam = $49,000*(1.085^{(dam\ head)})*((dam\ head)^{-1.96})$

Solar Apertures

CRITERIA	FEASIBILITY
skylight area/floor area > 0.2	YES
$0.05 \leq$ skylight area/floor area ≤ 0.2	MAYBE
skylight area/floor area < 0.05	NO

Solar Cooling

CRITERIA	FEASIBILITY
IrMax > 6 and HDD > 400 and ha78 > 5000	YES
IrMax > 6 and HDD > 200 and ha78 > 400	MAYBE
For All Cases Not Listed	NO

Where   IrMax is the maximum daily total solar radiation of a horizontal surface (kWh/day)
        ha78 is the number hours above 78^0F
        HDD is the heating degree days

Solar Heating

CRITERIA	FEASIBILITY
IrMax > 7 and HDD > 1000	YES
IrMax > 6 and HDD > 600	MAYBE
For All Cases Not Listed	NO

Where   IrMax is the maximum daily total solar radiation of a horizontal surface (kWh/day)
        ha78 is the number hours above 78^0F

Solar Hot Water

CRITERIA	FEASIBILITY
IrMax > 6 and Heating Fuel is Natural Gas or IrMax > 5 and Heating Fuel is Electricity	YES
IrMax > 5 and Heating Fuel is Natural Gas or IrMax > 4.5 and Heating Fuel is Electricity	MAYBE
For All Cases Not Listed	NO

Where IrMax is the maximum daily total solar radiation of a horizontal surface (kWh/day)

Solar Thermal

CRITERIA	FEASIBILITY
Daily Direct Solar II > 6.5 and (Technology Choice) = DISH and Question = Remote2 and (Annual Electricity Use) < 16,000	YES
Daily Direct Solar II > 5.5 and (Technology Choice) = DISH and (Annual Electricity Use) < 40,000 or Daily Direct Solar I > 5.5 and (Technology Choice) = TROUGH and (Annual Electricity Use) > 70,000,000	MAYBE
For All Cases Not Listed	NO

Where   I means a fixed horizontal-axis tracking system (kWh/day)
           II means a 2-axis tracking system (kWh/day)
           Question: How will the solar thermal system be used at the facility?
           Remote1 indicates a fuel saving system in a remote location
           Remote2 indicates a stand alone system with no grid connection

Solar Ventilation Pre-heat

CRITERIA	FEASIBILITY
IrMax > 5.5 or HDD > 5000	YES
For All Cases Not Listed	MAYBE
IrMax < 4 or HDD < 2000	NO

Where   IrMax is the maximum daily total solar radiation of a horizontal surface (kWh/day)
           HDD is the heating degree days

Solar Swimming Pool Heating

CRITERIA	FEASIBILITY
IrMax > 6.5 and DeltaTemp > 10 and Summer Length > 6 or Summer Length > 30	YES
For All Cases Not Listed	MAYBE
IrMax < 4.5 or Question = YES or DeltaTemp < 3 or Summer Length < 6	NO

Where   IrMax is the maximum daily total solar radiation of a horizontal surface (kWh/day)
          DeltaTemp = (Pool Temperature - Average Dew Point Temperature)
          Question: Is the pool covered at night or is it an indoor pool?

Wind Generation (Grid Connected)

CRITERIA	FEASIBILITY
Wind Power Class > 4	YES
For All Cases Not Listed	MAYBE
Wind Power Class < 3	NO

Window Sun-Screening

CRITERIA	FEASIBILITY
ha78 > -115,385 * (cost of electricity) + 21,950	YES
ha78 > -39,063* (cost of electricity) + 9,111	MAYBE
For All Cases Not Listed	NO

Where   ha78 is the number hours above 78^0F

APPENDIX B

EXCEL SPREADSHEETS FOR FRESA INPUTS

NOTE: Italicized boxes are required input for a Stage 1 prescreen. Remaining (non-italicized) inputs are required to complete the Stage 2 screening.

I. FACILITY INFORMATION

Contact Person		Total Floor Area (sq ft)	
Phone		Annual Electricity Use (kWh)	
Fax		Annual Hydrocarbon Use (MBtu)	
Email		Cost of Electricity ($/kWh)	
		Cost of Distillate ($/gal)	
Facility Name		Cost of Natural Gas ($/ccf)	
Facility Address		Cost of Propane ($/lb)	
		Cost of Steam ($/MBtu)	

II. FACILITY-SCALE TECHNOLOGY-SPECIFIC INFORMATION

Swimming Pool		**Biomass Fuel Use**	
Pool Temperature (F)		*Distance to Fuel (miles)*	
Pool covered when not in use (Y/N)		*Months of the year fuel is available*	
Fuel Used for heating		Displacing which fuel	
Above or Below ground		Biomass Fuel Type	
Pool Area (sq ft)		Fuel Cost	
Average pool depth (ft)			
Weeks pool is in use		**Refuse Energy**	
		Number of tons per year of refuse available	
Small Hydro		Cost of disposal tipping fees ($/ton)	
Possible dam height (ft)			
Is there an old dam at the site (Y/N)		**Photovoltaic**	
River Flow Rate		Peak demand season	
		Load Shape Ratio (ratio between the daily	
Solar Thermal		minimum and daily maximum load during	
If grid extension needed- describe ground terrain		the peak demand period)	
		Time of Day during Peak Demand (hr)	

III. BUILDING INFORMATION		Building Name:	
Building Type (ex. Office, R&D, Prison)		Heating Plant Efficiency (%)	
Building Footprint (sq ft)		Fuel Used for Heat	
Number of Levels		Weekly Hours of Operation	
Building Aspect Ratio (South/East Face)		Annual Electricity Use (kWh)	
Cooling Efficiency (Btu/Wh)		Annual Hydrocarbon Use (MBtu)	

IV. BUILDING-SCALE TECHNOLOGY-SPECIFIC INFORMATION			
Solar Apertures		**Lighting Controls**	
Floor Area of Room (sq ft)		*Fraction of the outside wall that is window(%)*	
Light level required (foot-candles)		*Can banks of lights be switched on and off from*	
Type of lights used		*a photocell controller? (Y/N)*	
Number of days per week occupied		Light level required (foot-candles)	
		Type of lights used	
Solar Hot Water		Floor area on perimeter of building (%)	
Method of Heating Water		Number of days per week occupied	
Daily hot water demand (gal)		Average distance from window to far wall (ft)	
Hot water supply temperature (F)			
Available Area for Solar Panels (sq ft)		**Solar Heating/Cooling**	
Number of People Occupying Building		Building Construction (Loose/Tight)	
		Fraction of wall area filled with windows (%)	
Window Sun-Screening		Glazing Type (Single/Double/Triple)	
Glazing Type (Single/Double/Triple)		Average U-Value of Walls (Btu/sq ft-degree-hr)	
Area of windows in Representation Room (sq ft)			
Direction of Window Exposure (N/S/E/W)		**Multiple Window Glazing**	
		Direction of Window Exposure (N/S/E/W)	
		Window Area being Replaced in Building (sq ft)	

IV. BUILDING SCALE TECHNOLOGY-SPECIFIC INFORMATION (cont.)			
Infiltration Control		**Geothermal Heat Pump**	
Building Type:		Is there an open area of land?	
1: Data Processing or Special Application Building		(ex. large parking area or field) Y/N	
2: Buildings with Forced Air HVAC System		Building Construction (Loose/Tight)	
3: Buildings without Forced Air Systems		Glazing Type (Single/Double/Triple)	
Windows weather-stripped (Y/N)		Soil Description:	
Doors weather-stripped (Y/N)		1: Hard Rock	
Doors and windows caulked (Y/N)		2: Heavy Damp Soil	
Perimeter of the windows to be caulked		3: Heavy Dry Soil	
or weather-stripped (ft)		4: Light Dry Soil	
Perimeter of the doors to be caulked		Average U-Value of Walls (Btu/sq ft-degree-hr)	
or weather-stripped (ft)		Fraction of wall area filled with windows (%)	
Floor area of rooms being examined (sq. ft)			
Building Construction (Loose/Tight)		**Solar Ventilation Preheat**	
		Glazing Type (Single/Double/Triple)	
Remote Photovoltaic		Average U-Value of Walls (Btu/sq ft-degree-hr)	
Fuel being used to generate electricity		Fraction of wall area filled with windows (%)	
Local Terrain for grid connection:		Ventilation Requirement (CFM)	
1: Flat Prairie			
2: Hilly		**Remote Wind Generation**	
3: Underground		Fuel being used to generate electricity	
4: Other		Local Terrain for grid connection:	
Distance to the grid (ft)		1: Flat Prairie	
Load Shape Ratio (ratio between the daily		2: Hilly	
minimum and daily maximum load during the		3: Underground	
the peak demand period)		4: Other	
		Distance to the grid (ft)	

APPENDIX C

OTHER USEFUL INFORMATION

CONVERSION FACTORS FOR SELECTED FUELS

Type Of Substance	Conversion Factors
Fuel	
Oil	1 bbl = 159 liters (42 gal)
Natural gas	1 therm = 100,000 Btu (approx.25,000 kcal)

THERMAL VALUES OF SELECTED FUELS

Type Of Fuel	kcal	Btu (gross)
Solid fuels		
Bituminous coal	$(5.8 \text{ to } 7.8) \times 10^6/\text{Mg}$	$(21.0 \text{ to } 28.0) \times 10^6/\text{ton}$
Anthracite coal	$7.03 \times 10^6/\text{Mg}$	$25.3 \times 10^6/\text{ton}$
Lignite	$4.45 \times 10^6/\text{Mg}$	$16.0 \times 10^6/\text{ton}$
Wood	$1.47 \times 10^6/\text{m}^3$	$21.0 \times 10^6/\text{cord}$
Liquid fuels		
Residual fuel oil	$10 \times 10^3/\text{liter}$	$6.3 \times 10^6/\text{bbl}$
Distillate fuel oil	$9.35 \times 10^3/\text{liter}$	$5.9 \times 10^6/\text{bbl}$
Gaseous fuels		
Natural gas	$9,350/\text{m}^3$	$1,050/\text{ft}^3$
Liquefied petroleum gas		
Butane	6,480/liter	97,400/gal
Propane	6,030/liter	90,500/gal

To estimate the power, in Btu, produced by a fuel:
1) Multiply Fuel Use/Day (in tons, liters, gallons, ccf, etc.) by Btu/Unit (tons, liters, gallons, ccf, etc., as used in the Fuel Use/Day number). The result of this calculation has units of Btu/Day.
2) Multiply the answer from 1) by 365 to get annual fuel use, in Btu/Year. Divide that number by 1×10^6 to get the answer in units of MBtu/Year.

WEIGHTS OF SELECTED SUBSTANCES

Type Of Substance	g/liter	lb/gal
Butane, liquid at 60 °F	579	4.84
Crude oil	850	7.08
Distillate oil	845	7.05
Gasoline	739	6.17
Propane, liquid at 60 °F	507	4.24
Residual oil	944	7.88
Water	1000	8.4

DENSITIES OF SELECTED SUBSTANCES

Substance	Density	
Fuels		
Crude Oil	874 kg/m^3	7.3 lb/gal
Residual Oil	944 kg/m^3	7.88 lb/gal
Distillate Oil	845 kg/m^3	7.05 lb/gal
Gasoline	739 kg/m^3	6.17 lb/gal
Natural Gas	673 kg/m^3	1 lb/23.8 ft^3
Butane	579 kg/m^3	4.84 lb/gal (liquid)
Propane	507 kg/m^3	4.24 lb/gal (liquid)
Agricultural Products		
Corn	25.4 kg/bu	56 lb/bu
Milo	25.4 kg/bu	56 lb/bu
Oats	14.5 kg/bu	32 lb/bu
Barley	21.8 kg/bu	48 lb/bu
Wheat	27.2 kg/bu	60 lb/bu
Cotton	226 kg/bale	500 lb/bale

APPENDIX D

A<small>CRONYMS AND</small> A<small>BBREVIATIONS</small>

Acronyms and Abbreviations

a-Si	amorphous thin-film silicon
Btu	British thermal units
ccf	hundred cubic feet
CdTe	cadmium telluride thin-film
c-Si	crystalline or polycrystalline silicon
ECM	energy conservation measure
fc	foot candles
ft^2	square feet
in.	inch
kW	kilowatt-hour
LCC	life-cycle cost
m	meter
MBtu	million British thermal units
PB	payback period
PV	photovoltaics
RE	renewable energy
SIR	savings to investment ratio
v	version
WECS	wind energy conversion system
Wh	watt-hour

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13. ABSTRACT *(Maximum 200 words)*

The FRESA computer program, Version 2.5, provides an easy way to collect and process building and facility data to indicate opportunities for renewable energy applications in federal facilities and buildings. The purpose of this analytic tool is to focus feasibility study efforts on those applications most likely to prove cost-effective. The program is a supplement to energy and water conservation audits, which must be completed for all federal buildings and will flag renewable energy opportunities by facilitating the evaluation and ranking process. FRESA results alone are generally not sufficient to establish project feasibility.

The FRESA User's Manual provides instruction on getting started; an overview of the FRESA program structure; an explanation of the screening process; detailed information on using the functions of Facility/Building Info, Building/Facility Analysis, Input/Output, and Weather Data or Adding a Zip Code; troubleshooting; and archiving data. Appendices include Algorithms Used in FRESA Prescreening, Excel Spreadsheets for FRESA Inputs, Other Useful Information, and Acronyms and Abbreviations.

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