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ENERGY

SMART

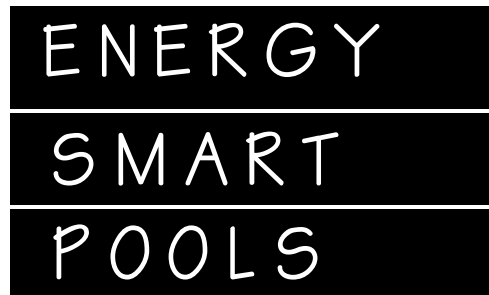
POOLS

**Version 1.0 for Windows**

## **Software Manual**

**Your guide to installing and using  
the U. S. Department of Energy's  
Energy Smart Pools software**

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Version 1.0 for Windows

U.S. Department of Energy  
Denver Regional Support Office

**Design Team**

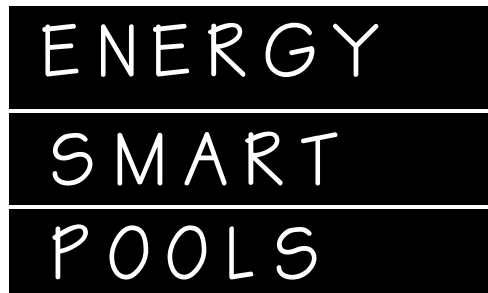
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The logo consists of three stacked black rectangular boxes. The top box contains the word "ENERGY" in white, uppercase, sans-serif font. The middle box contains the word "SMART" in white, uppercase, sans-serif font. The bottom box contains the word "POOLS" in white, uppercase, sans-serif font.

Version 1.0 for Windows

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# Getting Started

## What you need

To use the Energy Smart Pools software, you need the following equipment, software and settings:

- 100% IBM-compatible 386 or 486 computer with a minimum of 4 MB of RAM (8 MB would be better).
- A hard disk drive with a minimum of 7 MB of free hard disk space
- VGA Monitor or better
- Windows 3.1 running in enhanced mode
- Hewlett Packard LaserJet compatible printer

## Installing Energy Smart Pools Software

1. Turn on your computer and load windows.
2. Insert the Energy Smart Pools software disk labeled Disk #1 in your computer's disk drive.
3. From the Program Manager's File menu, choose Run.
4. Type a:setup in the Command Line box if you are installing from drive A, or b:setup if you are installing from drive B. Click OK to continue
5. The Energy Smart Pools Setup window appears with a suggested directory and Program Manger group. If you want to install the software in a different directory and/or group, type the name of the directory and/or select the desired group. Click on Continue to proceed.
6. When Disk #1 is complete, remove it, insert Disk #2 and click Continue.
7. When you receive the message that you have installed the Energy Smart Pools software correctly, click OK.

### If the Energy Smart Pools software didn't install correctly:

Although installation is fairly straight forward, problems may be caused by insufficient memory (less than 4 MB) or not enough space on your hard drive (less than 7 MB). Avoid memory conflicts with other programs known as TSRs (Terminate and Stay Resident), virus checkers and screen savings by closing them before installing the program. If you have a problem while installing, check your system to make sure the following settings are correct:

- Virtual memory (permanent swapfile) set at twice the computer's RAM
- Files=99 in Config.sys file
- Enable Print Manager
- No Shadow RAM in BIOS
- Disable Cache Memory in BIOS
- No Shadow RAM in Memory Manager
- Windows setup display: VGA
- Arial Font must be installed and TrueType fonts enabled

Remove the floppy disks and store them in a safe place.

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# Using the Energy Smart Pools Software

## Purpose of the Software

The Energy Smart Pools software is designed to estimate the annual cost of heating both indoor and outdoor inground swimming pools and spas. It is not designed to calculate heat losses for above ground pools and spas. The software is designed to analyze energy and water savings from using pool covers and solar pool heating systems. It can be used to determine differences between conventional heating and high efficiency heating systems and conventional and high efficiency electric motors.

The Energy Smart Pools software is designed to provide you with accurate estimates with a minimum of inputs, but will allow you to make fine adjustments as needed.

## Starting the Energy Smart Pools Software

Double click on the Energy Smart Pools icon.

A title screen, Energy Smart Pools, U.S. Department of Energy, Version 1.0 superimposed over a swimming pool and swimmers should appear. If it does not, there is a problem with available memory. Close all other applications and try again.

At the bottom of the pool you should see four buttons. The first is Residential, then Commercial, Default Data, and Exit. You'll also see a menu bar at the top of the screen with File, Residential, Commercial and Default Data. You can use either the buttons or the menu bar to select your choice:

- Residential* To enter or edit data on a residential pool (Temporarily using Commercial Input Screen)
- Commercial* To enter or edit data on a commercial pool, or
- Default Data* To set up one or more default screens to assist you in entering data.

When you first start using the program, you'll want to set up your Default Data.

## Program Basics

As you work in either the Residential Input screen, the Commercial Input screen, or the Default Input screen, you will need to understand how to do some or all of the following:

### Definition of Common Program Terms

- Field* Input box on the input screen. Each field can except a pre-designated number of characters.
  - Record* Each time you enter new information about a pool, that information is saved as a record.
-

*Button Bar*     Row of buttons at bottom of input screens.  
*Menu Bar*       Windows Menu at top of screen.

## **Entering Data**

When you select Residential, Commercial or Default Data, the input screen should come up with the first field highlighted on the last record that you were in. To enter new data in that field, just start typing. When the field is highlighted, typing replaces what was previously there. If you make a mistake, press ESC before going on to the next field.

To move between fields you can use the Tab key. You can also use the Enter key for all fields except pull-down fields. Another option is to use the mouse to click on the field that you want to edit or enter new information. You have to make sure the cursor is at the very beginning of each field. Press the Home key to insure that you are at the beginning of the field or triple click the left mouse button.

## **Selecting an Existing Record**

If you already have records created, you can select the record you want by one of three ways:

You can cycle through the saved pool records by clicking on the Top, Prior, Next, and Bottom buttons on the button bar.

Select Database / Top, Bottom, Next, or Prior from the menu bar or F2 for Top, F3 for Bottom, F4 for Next, or F5 for Prior.

The third way to find the record you want is to click on the Search button on the button bar or select Database / Search from the menu bar. A search window will pop up. Select the field that you want to search. You can type in any part of what you are searching for. The most common search fields would be the Pool Name, Contact/Owner Name, Default ID and the Weather Site.

## **Adding a New Record**

- 1) To add a new record, click on the Add button on the button bar or select Database / Add Record from the menu bar or press Ctrl-N.
- 2) A blank record with the defaults brought in will appear for you to enter your information.

## **Copying a Record**

- 1) If you want some of the information from an already filled in record, click on the Copy button on the button bar or select Database / Copy Record from the menu bar.
  - 2) A duplicate record will be created.
  - 3) You can now make changes to the current record on the screen.
  - 4) On the Default Input screen you should change the Default ID to differentiate the new record from the copied record. On the Residential Input screen you'll want to change the Owner Name or add something after the owner's name to differentiate the copied record. On the Commercial Input Screen you would change or modify the Pool Name.
-

- 5) You can now make all the changes you want and the new entries will be saved as a new record.

### Deleting a Record

- 1) To delete a record, select the record you want to delete by bringing it up on the screen.
- 2) There is no delete button on the button bar. You have to select Database / Delete Record from the menu bar.
- 3) The current record will be marked for deletion. To permanently delete the marked record(s), select Utilities / Pack.

### Returning to the Main Menu

- 1) To return to the Main Menu screen, click on the Close button on the button bar or select File / Close from the menu bar.

### Exiting the Energy Smart Pools Program

- 1) Return to the Main Menu screen and click on the Exit button at the bottom of the screen or select File / Exit from the menu bar.

### Menu Bar Descriptions

#### Initial Menu Bar

<b>File:</b>	
Exit	Used to Exit the Energy Smart Pools program.
<b>Residential:</b>	A simpler input screen for residential pools (not yet hooked up). NOTE: To do a residential pool, click on this and you will be taken to the commercial input screen with residential defaults.
<b>Commercial:</b>	Input screen for commercial pools.
<b>Default Data:</b>	Input screen for creating and storing customized default data records

#### Commercial/Residential/Default Data Menu Bars

<b>File:</b>	
Close	Used to return to the Main Menu screen.
<b>Edit:</b>	
Cut	Used to move data from one field to another.
Copy	Used to copy data from one field to another.
Paste	Used to paste data into another field.
Clear	Same as pressing the Delete key
<b>Database:</b>	Standard database menu items for moving through records. The most important options are also available as buttons at the bottom of the screen.
Top	Takes you to top record in database.
Bottom	Takes you to bottom record in database.
Next	Takes you to next record in database.
Prior	Takes you to prior record in database.
Cycle	Cycles you through records. Same as Next.



Add Record	Creates blank record for entering new data
Copy Record	Copies record to create an exact second copy ready to be edited.
Delete Record	Marks record for deletion. Does not permanently delete record from database. You must select Utilities / Pack to permanently delete record.
Browse	Allows you to see database in a table format, or all of one record in change format.
Search	Allows you to search and find a particular record.
Filter	Allows you to select specific records to view in Browse mode. To reset to normal filter mode, close window and come back in.
Order	Sets the sort order of the database. To reset to normal order, close window and come back in.
<b>Analysis:</b>	(Residential & Commercial only) Select to analyze inputs and display or print reports.
Base Pool	Calculates energy and water costs of pool w/o cover or solar.
Pool Cover	Calculates energy and water savings of using a pool cover.
Solar Heating	Calculates energy and water savings of using a solar pool heating system.
Solar After Cover	Calculates energy and water savings of adding a solar pool heating system to a pool that already has a pool cover.
Cover After Solar	Calculates energy and water savings of adding a pool cover to a pool that already has a solar pool heating system.
Cover and Solar	Calculates the combined energy and water savings of adding both a pool cover and a solar pool heating system.
The Works	Simultaneously calculates energy and water savings from all the above combinations.
<b>Results:</b>	(Residential & Commercial only) For use after a particular analysis has been run. Allows you to display or print different types of reports without re-running the analysis.
<b>Utilities:</b>	
Refresh Screen	No reason to use.
Construct Index	Occasionally indexes get corrupted.
Pack	Used to permanently delete records from database.
<b>Help:</b>	Not hooked up.

## Residential or Commercial Input Screens

The Residential and Commercial Input Screens allow you to enter specific information about a pool which the program will use to perform the pool analysis.

### Opening the Residential or Commercial Input Screens

- 1) From the Main Menu screen, click on the Residential Input or Commercial Input button or select Residential or Commercial on the Menu Bar.
- 2) The Residential or Commercial Input Screen comes up. Some of the fields are requested for information purposes only. Others are essential for the program to perform calculations. The fields are coded. The following describes the color coding:

<i>Green</i>	Fields will come from Default Data which can be specified by the user. The user does not have to enter information in these fields individually. They can change the information for all future records in Default Data and for a single pool in the input screen.
<i>Yellow</i>	The program will initially insert information in these fields. The user does not have to enter information in these fields individually, but should check the inputs and change them for a single pool if desired. The user may not change the values the program initially inserts.
<i>Red</i>	The user must enter information in these fields for each record. The analysis will not be correct unless something is entered.
<i>Gray Green</i>	The user should enter the requested information if they want a complete analysis. The analysis will, however, still run if the cell is blank or has a value of zero.

Note: Most fields have ranges of acceptable values. If values outside the ranges are entered, an error or warning message box will appear.

## Default Input Screens

The Default Input screen allows you to create and save several different combinations of common inputs that you can automatically bring into the residential and commercial input screens. These inputs can also be used when you don't know the proper number to enter. This saves you from having to enter the same numbers over again for different pools. You can create and save different default records by entering different names in the Default ID field. By selecting a Default ID from the main input screen, you can avoid having to enter over 75% of the inputs.

### Opening the Default Input Screen

- 1) From the Main Menu screen, click on the Default Data button or select Default Data on the Menu Bar.
- 2) Page 1 of 2 of the Default Input screens appears with page 2 of 2 displayed in a window title bar at the top. You can move back and forth between the two screens (pages) by clicking in their respective windows or by using page up and page down. After you have entered all the information in page 1, click on the title bar where it says Page 2 of 2.

### Residential / Commercial / Default Data Inputs Defined:

*Name & Address Info:* Information not essential to program calculation. However, the Commercial printouts use the Pool Name, Address, City, State, and Zip. Residential uses Owner Name, Address, City, State, and Zip.

*Default ID:* *Residential/Commercial Input Screens:* Allows you to select which set of defaults you want to use. *Default Input Screen:* Unique name used to call up the default data. Each record must have a unique name in order to allow you to call up the defaults on the Residential and Commercial input screens. The name can contain letters, numbers, spaces, and/or punctuation and can be up to 30 characters in length

- Type Owner:* *Commercial Input Screen Only:* Used for information purposes only.
- Type of Pool:* Must select either Indoor or Outdoor. Calculations are very different.
- Weather Site\*:* There are over 60 Weather Sites around the U.S. to choose from. You select the weather site by clicking on the down arrow and scrolling through the list or by typing the first letter of a state. The list will jump to the first state that starts with that letter. You can then use the arrow keys or the mouse to select the weather site of your choice. States are listed in alphabetical order. Find your state, and the city that most closely resembles your location's weather. If a city in an adjoining state is closest, select it instead.
- Wind Speed %\*:* Monthly weather station Wind Speeds are stored in each weather file. The Wind Speed at the weather station is usually measured several feet off the ground. Wind Speed at the pool surface is usually below the weather station speed. This input allows you to adjust the weather station wind speed to be used in the calculations for a more accurate representation of the wind speed at the pool surface. Use the following as a guideline for inputting wind speed percent:
- |                     |     |
|---------------------|-----|
| No windbreak:       | 30% |
| Moderate windbreak: | 20% |
| Good windbreak:     | 10% |
- If in doubt, a figure of 15% can be used.
- Shading %\*:* Some pools are located in shady areas or are screened in. The Shading factor allows you to input a percentage that will allow the analysis to take these factors into consideration. Typically the pool acts as a giant solar collector. Locating it in a shaded area or putting screen over it will substantially lower the solar energy collected by the pool and require more energy input to maintain the desired temperature. In hot climates like Arizona, this may keep your pool from overheating however. The Energy Smart Pools calculation assumes that the pool is completely unshaded during the peak solar hours of 8 am and 4 pm. If the pool is shaded some during this time, enter a percentage based on percent of the pool that is shaded and the percent of the time between 8 am and 4 pm that it is shaded. Pools that are screened-in should use a shading percentage between 50-75%.
- Open All Year:* Allows you to skip entering opening and closing dates if the pool is open year-round. Program defaults to yes for Indoor pools and no for Outdoor pools.
- Open Date:* Enter Month and Day pool normally opens for the season. If year-round, 1 1.
- Close Date:* Enter Month and Day pool normally closes for the season. If year-round, 12 31.
- \* These fields are pulled up from the selected default record or calculated based on default information. If the default information is correct, just tab to the next field.
- Hours/Week Use:* (*Residential only*). Enter average hours per week that the pool is used or at least would be uncovered during each time period. (Not yet available).

- Open & Closing Times:* (Commercial only). Enter the normal opening and closing times for each day of the week. Enter the time followed by AM or PM. For single digit times enter a zero first. Example: enter 0930AM for 9:30 AM. If the pool is closed all day, enter 0000 AM for both. The program will automatically convert the time entered to military time. (Do not enter in military time yourself.) Also, since many pools repeat opening and closing times, the program automatically prompts the next day's opening or closing time to be the same as the one just entered, but only the first time through. If it should be the same, just hit Enter. If not, change it.
- Pool Area:* Must enter or program can not calculate. Value entered should include the entire surface area in square feet.
- Pool Temp (F):* Enter the normal temperature of the pool in degrees Fahrenheit. Program defaults to 80°. You may enter a different temperature.
- Activity Level:* Select either high or low for normal activity level during open hours. Low indicates an average of up to 2 swimmers in a 1000 square foot pool over all hours of operation. High is any number over that.
- Fuel Costs & Eff:* (Default Input Screen). Each heating fuel should have its own cost/unit entered based on local utility prices. Each fuel can have a default heating efficiency. This efficiency is based on an annual system efficiency and not the combustion efficiency.
- Fuel:* Select type of heating fuel used to heat the pool.
- Fuel Cost\*:* Cost/unit of selected heating fuel obtained from past utility bills or from the local utility.
- Pool Heater Eff %\*:* Enter annual system efficiency and not the combustion efficiency. At this time there are no test standards for pool heaters. You will have to rely on manufacturers' data and/or an assessment of how efficiently the heat delivery system operates.
- Pump Motor HP:* Enter the horse power indicated on the pool pump.
- Pump Motor Eff %\*:* Enter the estimated efficiency for the pool pump, generally 70-90%.
- Pump Run Hrs/Day\*:* Enter the hours per day that the pump normally runs. The program defaults to 24 hours for commercial and 8 hours for residential.
- Pump Mtr Load %\*:* Enter the estimated % of load that the motor is running under. Properly sized motors generally operate at 70-100% of rated HP.
- Room Temp(F):* Enter the normal temperature of the indoor pool room in degrees Fahrenheit. Program defaults to 80°. You may enter a different temperature.
- Room Humidity %:* Enter the average relative humidity in the pool room.
- Fuel:* Select type of heating fuel used to heat the indoor pool room.

\* These fields are pulled up from the selected default record or calculated based on default information. If the default information is correct, just tab to the next field.

*Vent Heater Eff %\*:* Enter annual system efficiency and not the combustion efficiency. At this time there are no test standards for pool heaters. You will have to rely on manufacturers data and/or an assessment of how efficiently the heat delivery system operates..

*Vent Motor HP:* Enter the horse power indicated on the ventilation motor.  
*Vent Motor Eff %\*:* Enter the estimated efficiency for the ventilation motor, generally 70-90%.  
*Vent Run Hrs/Day:* Enter the hours per day that the ventilation motor normally runs.  
*Vent Mtr Load %\*:* Enter the estimated % of load that the ventilation motor is running under. Properly sized motors generally operate at 70-100% of rated HP.

*Pool Cover Defaults:* *Default Input Screen.* The program asks for default values for R-values and costs per square foot for manual and automatic, bubble/solar covers, vinyl covers and insulated covers. Bubble/solar covers are similar to bubble packing material. Vinyl covers are heavier duty sheet covers. Insulated covers have some type of insulation material sandwiched between two layers of vinyl or plastic. The following lists typical R-values and costs:

Cover Type	R-value	\$/sqft manual	\$/sqft auto
Bubble/Solar	1.5	\$1.00	NA
Vinyl	.1	\$1.50	\$6.00
Insulated	2.0	\$2.00	\$7.00

*Cover Type:* Select either Bubble/Solar (like packaging material), Vinyl (any sheet type cover), or Insulated (insulation material is sandwiched between two layers of plastic or vinyl).  
*System:* Select whether the planned system will be automatic or manual.  
*Cover R-Value\*:* Enter the estimated R-value of the pool cover. (See chart above).  
*Coverage %\*:* If the pool can not be completely covered, enter the percentage that is covered.  
*Installed Cost\*:* The installed cost will be automatically calculated from the pool area and the default cover cost/square foot. This value can be overridden by entering a projected complete pool cover system cost.  
*Water \$/1000 Gal\*:* Enter the cost per 1000 gallons that the local water department charges for water.  
*Pump Mtr Hrs/day\*:* For residential pools, the hours of pump operation can often be reduced when you add a pool cover. A value of 50% is a good place to start. Commercial pools pumps are often required to run 24 hours per day.  
*Vent Mtr Hrs/day\*:* The hours of ventilation motor operation can often be reduced when you add a pool cover. A value of 50% is a good place to start.

\* These fields are pulled up from the selected default record or calculated based on default information. If the default information is correct, just tab to the next field.

*Solar System Defaults:* *Default Input Screen.* The program asks for default values for solar collector costs per square foot and efficiencies. The Y-intercept and slope identify the collector's efficiency curve. The higher the Y-intercept and the flatter the slope the more efficient the collector is.

These values can be obtained from the manufacturer. All legitimate solar collectors have been tested and rated by the Solar Rating and Certification Corporation (SRCC). If in doubt, use \$8/sqft for unglazed collectors and \$30/sqft for glazed collectors.

*Sqft Collector/Pool Area: Default Input Screen.* By entering a percentage of the pool area to be used for solar collector square footage, the program will calculate the square footage of solar collectors on the main input screens. If in doubt, use a value between 50-100%.

*Collector Sqft\*:* This number will be calculated automatically based on the pool area and the default Sqft Collector/Pool Area percent. This value can be overridden by entering the total square feet of collector surface area proposed.

*Collector Type:* Select either unglazed or glazed collectors systems.

*Eff Y-Intercept\*:* The Y-intercept identifies the collector's efficiency at a given outside temperature. The higher the Y-intercept the more efficient the collector is. These values can be obtained from the manufacturer. All legitimate solar collectors have been tested and rated by the Solar Rating and Certification Corporation (SRCC).

*Efficiency Slope\*:* The slope of the collector curve indicates the collector efficiency as it relates to outside temperature. The greater the downward slope the less efficient the collector at cooler outdoor temperatures. Unglazed systems usually have steep slopes, but are usually operated in warm temperatures. Glazed collectors have flatter slopes and can maintain a fair operating efficiency even at cold outdoor temperatures.

*Installed Cost\*:* The installed cost will be automatically calculated from the pool area and the default collector cost/square foot. This value can be overridden by entering a projected complete solar pool heating system cost.

\* These fields are pulled up from the selected default record or calculated based on default information. If the default information is correct, just tab to the next field.

## Data Analysis

Once you have the data entered on a pool, you can let the computer do the rest of the work. Click Analysis on the menu bar and select one of the following:

<i>Base Pool</i>	Calculates energy and water costs of pool w/o cover or solar.
<i>Pool Cover</i>	Calculates energy and water savings of using a pool cover.
<i>Solar Heating</i>	Calculates energy and water savings of using a solar pool heating system.
<i>Solar After Cover</i>	Calculates energy and water savings of adding a solar pool heating system to a pool that already has a pool cover.
<i>Cover After Solar</i>	Calculates energy and water savings of adding a pool cover to a pool that already has a solar pool heating system.

<i>Cover and Solar</i>	Calculates the combined energy and water savings of adding both a pool cover and a solar pool heating system.
<i>The Works</i>	Simultaneously calculates energy and water savings from all the above combinations.

An option window will appear with the following options:

<i>Executive Summary</i>	Provides all the basic information you need.
<i>Engineer's Report</i>	You know engineers, always wanting to know what makes things tick. This report gives you a comprehensive listing of all calculated values.
<i>Both Reports</i>	Both reports.
<i>(You must select one of the above before going on.)</i>	
<i>Printer</i>	Prints results on your printer.
<i>Screen</i>	Shows results on the screen.
<i>Cancel</i>	Gives you the option to change your mind and start over.

If you selected screen, when you are finished looking at the results screen you can press Continue to go on to the next screen or Cancel will return you to the input screen. If you selected printer, your results will magically appear at your printer.

## Reports

There are two types of reports that print out; Summary and Engineer's. The summary report page one gives a quick overview of costs, savings, and paybacks. Page two goes into a little more detail, showing all costs and savings numbers. Between the two, they should give you all the information that you need to make a well-informed decision.

The Engineer's reports go into great detail allowing the technical person to see all the numbers behind the summary figures. They include monthly Btu consumption and savings with breakouts for evaporation, outside ventilation air, radiation, convection, solar gains, solar heating system outputs and system summaries.

The Engineer's Report has either one or two parts depending on the analysis selected. Part I analyzes all pool loads without a pool cover. Part II analyzes all pool loads with a pool cover applied during the hours the pool is closed. Part II is necessary for the Pool Cover, Cover after Solar, and Solar after Cover analyses. Each of the two parts is two printed pages.

The labeling at the top of the Engineer's Report shows the type of analysis selected followed by the Part shown. For example, the label "Pool Cover Part II w/ Pool Cover" means the Pool Cover Analysis. Part II shows all the loads with the pool cover on. An Engineer's Report is not available for the Solar and Cover or The Works analyses because these summaries really draw from more than one of the other analyses.

# Program Assumptions and Calculations

The Energy Smart Pools program was developed to provide a reasonable, unbiased estimate of the energy savings and investment potential of pool efficiency/renewable energy options.

With a minimum of input data, the program can provide:

- A Base Case Energy Simulation of Annual Energy Costs
- Annual Costs, Savings and Payback of Adding a Pool Cover System
- Annual Costs, Savings and Payback of Adding a Solar Heating System

Although the program incorporates few site specific measurements, it should, in most cases, provide reasonable pool load analyses with and without a pool cover. Calculations are based on recent pool evaporation rate research, standard engineering principles, statistically compiled weather data, and user input parameters reflecting operating conditions and schedules. Because actual weather and operating conditions can be highly variable, utility bill records should be compared to the base case simulation if possible.

The solar heating system choices and analysis are limited, and we recommend the results be used with a more detailed analysis based on actual site conditions, available options, and potential savings by a product vendor.

Initial default product cost estimates in the program are generic, so detailed product cost estimates should be obtained from vendors before capital expenditure decisions are made.

## Indoor Pool Assumptions

### Base Pool Energy Consumption

Energy use is due to pool evaporation losses and the requirement for outside air to control humidity. Convection, conduction and radiation losses are negligible.

The program calculates evaporation rates and outside air requirements for three, eight - hour time periods each month.

Average air speed at the pool surface is very low, about 10 feet per minute.

It is assumed swimmers are in the pool at all hours the pool is open. An activity factor is applied to the calculated quiet pool evaporation rate for these operating hours. The factor for a "low" activity level is 1.3, and the factor for a "high" activity level is 1.7. These factors are based on recent experimental findings at Colorado State University.

An average of the active (activity factor applied) and quiet pool evaporation rates is determined for each time period on the basis of the weighted number of hours the pool is open (operating)

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and closed (non-operating). Evaporation losses are converted to energy consumption at the rate of 1050 BTU/lb. This is around the latent heat of vaporization for water at 75 to 80 degrees F. Evaporation rates for the quiet pool are based on recent studies. Rates are about 73% of those predicted by the Carrier equation used in the 1991 ASHRAE Applications Handbook. Results of the studies have been reported and are expected to be included in the next ASHRAE Applications Handbook.

The energy required to condition ventilation air is based on the theoretical volume of outside air required to remove evaporated water from the pool for each time period. (From the ASHRAE 1991 Applications Handbook) This approximates a humidistat controlled, modulated outside air system without heat recovery.

In warmer, more humid climates, this calculation, if not constrained, would yield unrealistically high outside air ventilation rates. Therefore, the maximum ventilation rate is limited to 4 cfm/sq. ft. of pool area. This "rule of thumb" constraint was chosen because it is simple to calculate and it should in most cases exceed required design rates. Note that ANSI/ASHRAE Standard 62-1989, "Ventilation for Acceptable Indoor Air Quality" specifies a minimum of .5 cfm per square foot of pool and deck area, and ASHRAE 1991 Applications Handbook recommends 4 to 8 air changes per hour for humidity control.

The program does not currently have capability to simulate other ventilation systems. While this capability may be desirable in the future, it would require detailed data collection and review of mechanical drawings and specs beyond the level of many of the intended typical simulation program users, (pool managers, pool owners, some vendors, etc.) It is also likely that many pools have ventilation systems which are unique or can not be easily, generically modeled. For instance, a pool where the staff is instructed to open windows to control humidity would be difficult to model.

Only energy to heat ventilation air from Sept. 15 to May 15 is considered. Cooling energy required in the summer season is not considered. A pool air conditioned in the summer will require more energy and realize more pool cover savings than that shown in the program.

If a pool facility has sensible and/or latent heat reclaim equipment, the actual ventilation energy requirements would be lower than the simulation results. This should not typically affect pool cover savings more than 10%. This should have little effect on solar heating system savings.

The fuel supplying heat to the ventilation system may be different than that for the pool water heating. Overall ventilation and pool water heating system efficiencies are specified by the user.

Ventilation fan and pump motor energy use and savings are based on user supplied values of motor hp, load, efficiency and run times. The best way to assess motor loads and efficiencies is with good, instrumented measurements, but these are usually not practical to obtain. In the absence of good measurements, it is probably best to assume the load is 70% - 120% of motor rating, and the efficiency is in the 70%-90% range. Efficiency will generally be good unless the motor is greatly oversized for the load. (Load is less than 50% or so.)

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Pump and fan performance efficiencies are not considered.

Bin temperatures, mean coincident wet bulb temperatures, monthly wind speeds, percent sunshine, and barometric pressures are mostly from ASHRAE format weather files used in the building energy analysis program, ASEAM. ASEAM was developed for the Department of Energy's Federal Energy Management Program and Office of State and Local Assistance Programs. ASHRAE format is derived from "WYEC" (Weather Year for Energy Calculations) where hourly data is a composite of typical monthly weather data taken from different years. Some additional weather sites, not available in ASHRAE format, are taken from Battelle format data which is based on WYEC and a Test Reference Year or from Department of Defense format data which are based on long term averages.

Solar insolation data is from the ASHRAE 1982 Applications Handbook, Table of Total Irradiation on Horizontal and South Facing Surfaces Tilted at Various Angles on the 21st Day of Each Month.

### **Pool Cover**

The pool cover is assumed to eliminate evaporation for the percent of pool area covered. This is specified by the user. The pool cover is assumed to be on the pool during all non-operating hours.

In some cases, a pool cover may allow the pool owner to reduce the amount of time the pool water is filtered. To account for this possibility, the user can enter a pump run time (hrs./day) with a pool cover different than the run time entered for the base case.

A pool cover may also allow the pool owner to reduce the run time of the ventilation system because less humidity control may be required. To account for this possibility, the user can enter a ventilation motor run time (hrs./day) with a pool cover different than the run time entered for the base case.

### **Solar Heating System**

The program calculates savings for either a single glazed collector system or an unglazed system. The unglazed terminology is meant to include unglazed collectors made of black plastic or EPDM which can be a flexible mat or fixed panel design. The systems should be viewed as representative examples of the technology, but there are many other possibilities. Different collectors, storage systems, levels of freeze protection, features, and sizes are available.

The simplified analysis is based on collector efficiency (slope & intercept), monthly clear day total irradiation (not including reflected radiation), weather file percent sunshine, and a clearness factor. The analysis may give an initial estimate of potential savings, but it can not specify the optimum system. It is intended to be the initial step in a more detailed analysis by the vendor which can consider site space availability, placement, orientation, shading, and other pertinent factors.

All collected thermal energy is used directly, without intermediate storage.

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Collector efficiencies may be varied.

For summer only pools, (opening and closing bounded by April - September) the system is assumed to face direct south at an angle to horizontal of latitude minus 10 degrees. For pools open longer than this or all year, the system is assumed to face direct south at an angle to horizontal equal to latitude.

The program calculates pool loads and solar heating system output on a monthly basis. If the system output exceeds the pool load in a given month, the program uses the pool load as the solar heating system savings. A comparison of monthly loads to the solar heating system output is shown on the user selected "Engineer's Report".

Generally it is desirable to size a system so that it will meet only part of the thermal load, so that all collected energy is used. The user specifies the size of the system.

## **Outdoor Pool Assumptions**

### **Base Pool Energy Consumption**

Energy use is due to pool evaporation, convection, and radiation losses. Conduction losses are negligible. Solar gains offset heating energy use requirements.

The program calculates evaporation, convection, and radiation rates for three, eight - hour time periods each month.

Evaporation rates for the quiet pool are based on recent experimental studies. Rates are about 75% to 85% of those predicted by the Carrier equation used in the ASHRAE Applications Handbook. Results of the studies have been reported and are expected to be included in the next ASHRAE Applications Handbook.

Average wind speeds at the pool surface are generally much less than the wind speeds in the weather files. This is because weather station wind measurements are at heights of 10 to 30 feet. The user enters the pool surface wind speed as a percentage of the weather station value. Values of 10% to 40% are typically representative.

It is assumed that swimmers are in the pool at all hours the pool is open. An activity factor is applied to the calculated quiet pool evaporation rate for these operating hours. The factor for a "low" activity level is 1.1, and the factor for a "high" activity level is 1.5. These factors are based on recent experimental findings at Colorado State University.

An average of the active (activity factor applied) and quiet pool evaporation rates is determined for each time period on the basis of the weighted number of hours the pool is open (operating) and closed (non-operating). Evaporation losses are converted to energy consumption at the rate of 1050 BTU/lb. This is around the latent heat of vaporization for water at 75 to 80 degrees F.

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Convection losses are calculated as a function of a convection coefficient and pool water temperature - air temperature difference. The convection coefficient is a function of pool surface wind speed.

Radiation losses are calculated by the Stefan-Boltzman equation. Radiation is a function of fourth order temperature difference between the pool water and the sky. The sky temperature is estimated as the air temperature minus 20 degrees F. Emissivity of the pool is estimated at .9.

The pool is assumed to absorb 80% of direct available solar radiation. This solar gain helps to heat the pool.

The amount of pool shading is specified by the user as a percentage value. The percentage should represent an estimate of the sun which could fall on the pool but is blocked by trees, structures, canopies, etc. More weight should be given to shading which occurs at the height of solar intensity, around mid day.

The overall heating system efficiency is specified by the user.

If the monthly solar gain exceeds the combined evaporation, radiation, and convection losses, the program calculates that month's load to be zero.

Pump motor energy use and savings are based on user supplied values of motor hp, load, efficiency and run times. The best way to assess motor loads and efficiencies is with good, instrumented measurements, but these are usually not practical to obtain. In the absence of good measurements, it is probably best to assume the load is 70% - 120% of motor rating, and the efficiency is in the 70%-90% range. Efficiency will generally be good unless the motor is greatly oversized for the load. (Load is less than 50% or so.)

Pump performance efficiency is not considered.

Bin temperatures, mean coincident wet bulb temperatures, monthly wind speeds, percent sunshine, and barometric pressures are mostly from ASHRAE format weather files used in the building energy analysis program, ASEAM. ASEAM was developed for the Department of Energy's Federal Energy Management Program and Office of State and Local Assistance Programs. ASHRAE format is derived from "WYEC" (Weather Year for Energy Calculations) where hourly data is a composite of typical monthly weather data taken from different years. Some additional weather sites, not available in ASHRAE format, are taken from Battelle format data which is based on WYEC and a Test Reference Year or from Department of Defense format data which are based on long term averages.

Solar insolation data is from the ASHRAE 1982 Applications Handbook, Table of Total Irradiation on Horizontal and South Facing Surfaces Tilted at Various Angles on the 21st Day of Each Month.

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## **Pool Cover**

The pool cover is assumed to eliminate evaporation for the percent of pool area covered. This is specified by the user. The pool cover is assumed to be on the pool during all non-operating hours.

Convection rate is reduced with a pool cover. A convection/conduction coefficient based on water to cover convection film, cover R value, and cover to air convection film is calculated. Convection losses are calculated as a function of the convection/conduction coefficient and pool water temperature - air temperature difference.

Radiation rate is assumed to be reduced by 20% for the percent of pool area covered.

Solar gain is reduced when the pool is covered for part or all of the 8:00AM to 4:00PM time period. (This time period corresponds to the time when 80-95% of the solar gain occurs in most months in most locations.) Solar gain is reduced for the percent of pool area covered. Solar gain is assumed to be reduced by 15% for a bubble cover, and 25% for an opaque vinyl or insulated cover.

In some cases, a pool cover may allow the pool owner to reduce the amount of time the pool water is filtered. To account for this possibility, the user can enter a pump run time (hrs./day) with a pool cover different than the run time entered for the base case.

## **Solar Heating System**

(See assumptions for Indoor Pools)

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# Basic Calculation Methods

## Indoor and Outdoor Pools

### Evaporation Rates - Quiet Pool

$$W_Q = \frac{(A_P)(C_1 + C_2 v)}{Y} (P_W - P_{DP})$$

Where:

$W_Q$	=	evaporation rate of water, lb/hr.
$A_P$	=	area of pool surface, ft <sup>2</sup> .
$C_1$	=	69.4 BTU/(hr-ft <sup>2</sup> )-in.Hg.
$C_2$	=	30.8 BTU/(hr-ft <sup>2</sup> )-in.Hg.
$v$	=	air velocity over water surface, MPH.
$Y$	=	latent heat required to change water vapor at surface water temperature, BTU/lb.
$P_{DP}$	=	saturation pressure at room air dewpoint, in.Hg.
$P_W$	=	saturation vapor pressure taken at the surface water temperature, in.Hg.

### Evaporation Rates - Active Pool

$$W_A = W_Q \times AF$$

Where:

$W_A$	=	evaporation rate of water for an active pool, lb/hr.
$W_Q$	=	evaporation rate of water, lb/hr.
$AF$	=	Activity Factor: Indoor Pool, Low Activity = 1.3 Indoor Pool, High Activity = 1.7 Outdoor Pool, Low Activity = 1.1 Outdoor Pool, High Activity = 1.5

### Evaporation Rates with a Pool Cover On

$$W_{QC} = W_Q (1 - \text{Cover}\%)$$

Where:

$W_{QC}$	=	evaporation rate of water with cover, lb/hr.
$W_Q$	=	evaporation rate of water, lb/hr.
Cover%	=	percentage of pool that is covered.

## Annual Total System Energy Usage

$$Q_{TS} = \frac{Q_{TA}}{\eta_{system}}$$

Where:

- $Q_{TS}$  = annual total pool heating system energy use BTU/yr.  
 $Q_{TA}$  = annual total energy load, BTU/yr.  
 $\eta_{system}$  = annual system fuel use efficiency, BTU/lb.

## Active Solar Heating System Contribution to Pool Heating

Daily Insolation Values -  $I_{CD}$  come from:

ASHRAE Tables - daily insolation (21st day of each month).

Surface Tilt = angle equal to location latitude for pools operated year round or before/after April - September.

Surface Tilt = angle equal to location latitude minus 10 degrees for pools operated only within the April - September time period.

Calculation of Average Hourly Insolation Falling on Collector Each Month -  $I_{CH}$  :

$$I_{CH} = \frac{I_{CD}}{Hr_{sun}}$$

Where:

- $I_{CH}$  = BTU/ft<sup>2</sup>-hr.  
 $I_{CD}$  = BTU/ft<sup>2</sup>-day.  
 $Hr_{sun}$  = average number of hours the sun is up each day of that month.

## Monthly Solar Energy Available from the System:

$$QSOL_M = (Y_S - M_S \frac{(T_P - T_{DBS})}{I_{CH}}) (I_{CD}) (\frac{DAYS}{MONTH}) (CL) (S_P) (A_C)$$

Where:

- $QSOL_M$  = monthly solar load energy available from system, BTU/month.  
 $Y_S$  = Y-intercept of solar collector SRCC efficiency curve.  
 $M_S$  = slope of solar collector SRCC efficiency curve.  
 $T_P$  = pool water temperature, °F.  
 $T_{DBS}$  = air dry bulb temperature for the 8:00am to 4:00pm time bin, °F.  
 $I_{CH}$  = average hourly insolation falling on collector, BTU/ft<sup>2</sup>-hr.  
 $I_{CD}$  = average daily insolation falling on collector, BTU/ft<sup>2</sup>-hr.  
 $CL$  = clearness factor.  
 $S_P$  = mean percentage of possible sun which occurs in a given month.

$A_C$  = surface area of solar collector, ft<sup>2</sup>.

### Motor Electrical Fuel Use

$$F_M = \frac{HP_M \times L_M \times HRS_M \times 0.746 \times DAYS}{\eta_M}$$

Where:

$F_M$  = motor electrical fuel use, kWh.  
 $HP_M$  = motor horsepower, hp.  
 $L_M$  = motor load factor.  
 $HRS_M$  = hours of operation, hrs/day.  
 $\eta_M$  = efficiency of motor.

## Indoor Pool Calculations

### Volume Flow Rate of Outside Air Required to Remove Evaporated Water for the Time Bin

$$V_O = \frac{W}{C_4 \rho (\omega_I - \omega_O)}$$

Where:

$V_O$  = quantity of air, cfm.  
 $W$  = evaporation rate of water, lb/hr.  
 $C_4$  = time conversion to minutes, 60 min/hr.  
 $\rho$  = calculated air density, lb/ft<sup>3</sup>.  
 $\omega_I$  = humidity ratio of outdoor air at design criteria lb/lb.  
 $\omega_O$  = humidity ratio of pool air at design criteria, lb/lb.

### Hourly Energy Load for Outside Air for the Time Period

$$Q_{AH} = V_O (T_I - T_O) (1.08) \left( \frac{P_B}{29.92} \right)$$

Where:

$Q_{AH}$  = hourly air heating energy load, BTU/hr.  
 $V_O$  = quantity of air, cfm.  
 $T_I$  = indoor air temperature, °F.  
 $T_O$  = outdoor air temperature, °F.  
 $P_B$  = barometric pressure, in.Hg.



## Outdoor Pool Calculations

### Convection Heat Transfer Coefficient between Pool Water and Air

$$H = (1 + .3V_G)$$

$$V_G = V_W \times GF$$

Where:

- H = convection heat transfer coefficient between water and air, BTU/hr-ft<sup>2</sup>-°F.  
 V<sub>G</sub> = mean velocity of wind at ground level, MPH.  
 V<sub>W</sub> = mean velocity of wind measured at the weather station, MPH.  
 GF = ground factor for wind, default = 0.15.

### Convection/Conduction Coefficient Between Pool Water and Air With a Pool Cover:

$$H_{PC} = \frac{1}{.15 + R_C + \frac{1}{H}}$$

Where:

- H<sub>PC</sub> = convection/conduction heat transfer between water and air with a pool cover on, BTU/hr-ft<sup>2</sup>-°F.  
 R<sub>C</sub> = R-value of pool cover, hr-ft<sup>2</sup>-°F/BTU.  
 H = convection heat transfer coefficient between water and air, BTU/hr-ft<sup>2</sup>-°F.

### Hourly Convection Rate With Pool Cover Off

$$Q_{CH} = A_P(H)(T_P - T_{DB})$$

Where:

- Q<sub>CH</sub> = hourly convection energy load, BTU/hr.  
 A<sub>P</sub> = surface area of pool, ft<sup>2</sup>.  
 H = convection heat transfer coefficient between water and air, BTU/hr-ft<sup>2</sup>-°F.  
 T<sub>P</sub> = temperature of pool water, °F.  
 T<sub>DB</sub> = dry bulb temperature of the air, °F.

### Hourly Convection Rate With Pool Cover On

$$Q_{CHPC} = A_P(Cover\% \times H_{PC} + (1 - Cover\%) \times H)(T_P - T_{DB})$$

Where:

- Q<sub>CH.PC</sub> = hourly convection energy load with pool cover, BTU/hr.  
 A<sub>P</sub> = surface area of pool, ft<sup>2</sup>.  
 H<sub>PC</sub> = convection/conduction coefficient between pool water and air with a pool cover on, BTU/hr-ft<sup>2</sup>-°F.

- H = convection heat transfer coefficient between water and air, BTU/hr-ft<sup>2</sup>-°F.  
 T<sub>P</sub> = temperature of pool water, °F.  
 T<sub>DB</sub> = dry bulb temperature of the air, °F.

### Hourly Radiation Rate With Pool Cover Off

$$Q_{RH} = A_P(0.1713)(0.9)\left(\left(\frac{460 + T_P}{100}\right)^4 - \left(\frac{440 + T_{DB}}{100}\right)^4\right)$$

Where:

- Q<sub>RH</sub> = hourly radiation energy load, BTU/hr.  
 A<sub>P</sub> = surface area of pool, ft<sup>2</sup>.  
 T<sub>P</sub> = temperature of pool water, °F.  
 T<sub>DB</sub> = dry bulb temperature of the air, °F.

### Hourly Radiation Rate With Pool Cover On

$$Q_{RH}(PC) = Q_{RH}((U_{CR} \times \text{Cover}\%) + (1 - \text{Cover}\%))$$

Where:

- Q<sub>RH</sub>(PC) = hourly radiation energy load with cover on, BTU/hr.  
 Q<sub>RH</sub> = hourly radiation energy load with cover off, BTU/hr.  
 U<sub>CR</sub> = reduction in radiation losses of the pool with a pool cover on, default = 0.8.

### Monthly Direct Solar Gain to Pool

Calculation of Solar Gain Heat Reduction Factor Due to Pool Cover:

$$SGRF = 1 - \left(\frac{(HRS_N)(1 - \tau_c)}{(HRS_O + HRS_N)}\right)$$

Where:

- SGRF = solar gain reduction factor due to a pool cover  
 HRS<sub>N</sub> = hours between 8:00am to 4:00pm that the pool is not in operation, hrs.  
 HRS<sub>O</sub> = hours between 8:00am to 4:00pm that the pool is in operation, hrs.  
 τ<sub>C</sub> = transmission value of pool cover.  
 Bubble/solar τ = 0.85  
 vinyl τ = 0.75  
 insulated τ = 0.75

### Monthly Solar Gain to Pool

$$Q_{SG} = I_{DH} \left(\frac{DAYS}{MONTH}\right)(CL)(S_P)(A_P)(Sh\%)(SGRF)$$

Where:

$Q_{SG}$	=	monthly solar gain to pool, BTU/month.
$I_{DH}$	=	daily insolation on a horizontal surface, BTU/ft <sup>2</sup> -day.
$CL$	=	clearness factor.
$S_P$	=	mean percentage of possible sun which occurs in a given month.
$A_P$	=	surface area of the pool, ft <sup>2</sup> .
$Sh_{\%}$	=	percentage of pool that is shaded.
$SGRF$	=	solar gain reduction due to a pool cover.



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