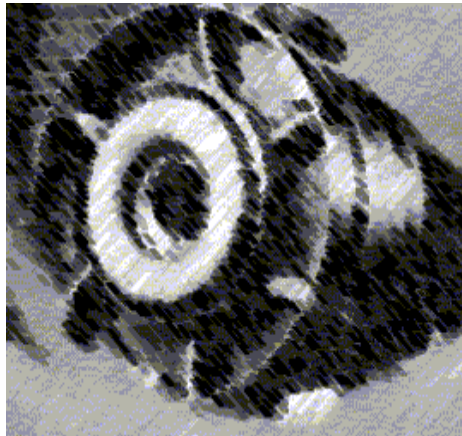


User Manual

d-gen PRO



Version 3.5

InterEnergy Software / Gas Technology Institute
1700 South Mt Prospect Rd.
Des Plaines, IL 60018
August, 2002

InterEnergy Software®

Software for the Energy Industry

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Welcome to d-gen PRO

Introduction and Disclaimer

d-gen PRO was originally developed by Architectural Energy Corporation (AEC) for the Gas Technology Institute (GTI). As of August 2002, with the release of version 3.5, the software is being maintained and upgraded by InterEnergy /GTI. It is the premier tool for determining the economic feasibility of distributed power generation. It has been developed for quickly and easily evaluating the cost-effective application of on-site and distributed power generation.

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Working With d-gen PRO

Creating a new project

Create new projects by selecting "New Project..." under the file menu. To save this project, see the topic "Saving your work".

Loading an existing project


All project information is stored in a single database. To load the data from an

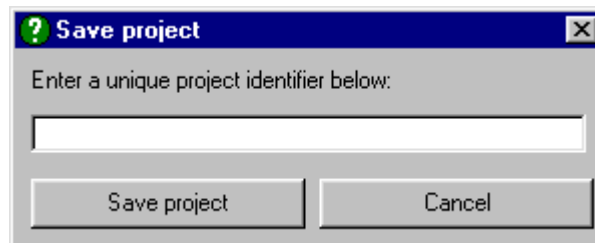
existing project choose **File| Open existing project** or press the  button. A list of all projects in the database will be displayed and you may choose the one you want.

Loading a project from the database will cause any existing data to be overwritten. You should save your project information before loading from the database.

Saving your work

Information about the projects in d-gen PRO is stored in a single database. You can save the current project (that is, the one you are currently editing) using the **File |**

Save current project menu or by pressing the  button. If this is the first time you have saved the project, you will then be asked to enter a name, which is used to uniquely identify this project:



Enter a unique name and press the button marked *Save project*. If you did not wish to save to this name press *Cancel*.

Importing and exporting project files

All information about the projects is stored in a database. Sometimes, however, you may wish to exchange the data for a single project with another user. This can be

done using the project exporting and importing features.

To export a project file, open the project in the normal fashion. Then go to the **Tools | Export Current Project** menu where you will be asked to name the exported file. d-gen PRO will then create an ASCII file with all the information about that project.

- **Note:** only the project information is stored in the ASCII file. Data for any utility rates, generators, or load shapes that you have added or modified will **not** be transferred.


To import a project, go to the **Tools | Import Project** menu where the above procedure can be performed in reverse.

- **Note:** importing a project will cause the current project to be overwritten. Be sure to save your work before importing a project.
- **Note:** You can only import project files created with d-gen PRO 3.5. If you need to import a project from an older version, use the **Import/Export Databases** command in the Tools menu.

Deleting projects

Information about the projects in d-gen PRO is stored in a single database. To remove a project from the database you must choose **File | Delete Project** from the



menu or press the  button. This will bring up a list of all the projects currently stored in the database. From this list you can select a project to be deleted from the database.

The delete function is permanent. Once a project is deleted it cannot be undeleted.


- **Note:** *you cannot delete the project you are currently working on.*

Entering project information

The project information screen allows you to keep track of information about your client for a particular project. None of the information on this screen is required for the analysis but may be useful for your own internal organization and accounting.

You enter the project information by choosing **Project Data | Enter Project**



Information from the menu or by pressing the  button.

Entering facility information

The screening tool requires information about the facility in order to run an analysis. This data is entered by choosing **Project Data | Enter Facility Information** from the



menu or by pressing the button.

You will then be prompted to enter the following information:

- The **Facility Type** is used to determine the appropriate load shape to use in the analysis. You should select a building type that is most similar to the facility in question. *You must select a building type in order to run the analysis.* Note that you can add additional building types when editing and adding load shapes, by using the Load Shape Wizard.
- The **Facility Description** box is used to keep any notes that are pertinent about the building.
- The **Facility Location** is used to get site characteristics and weather data for the facility. *You must select a location in order to run the analysis.*
- The **Service Providers** section is used for reference only and allows you to keep track of the electric service provider, natural gas service provider, and any other fuel service provider for the facility.
- You can use the **Notes** section to keep any notes specific to the facility.

Editing load shapes

d-gen PRO uses a database of building types and corresponding load shapes when it performs annual simulations. You can edit the library of load shapes through the **Tools | Run Load Shape Wizard** menu.

The load shapes are organized by building type and location. (See Load Shapes and Energy Calculations for more information on each building type. Each load shape consists of the electricity and thermal use for each month of the year, broken down by weekdays and weekends. In addition, both the electric and thermal load shapes are broken down by end uses (water heating, space heating, and other).

The load shape editor is used to add or modify existing load shapes to the load shape database. You may also add building types to the database. However, please note that there are certain load shapes in the library that are considered "template" load shapes that *cannot* be changed by the user.

When editing load shapes with the Load Shape Wizard you can copy values from other load shapes into the one you are currently editing.

Entering facility energy use information

Monthly values for the electricity and gas consumption should be entered before

running an analysis. This is done by choosing **Project Data | Enter Utility Bills |**

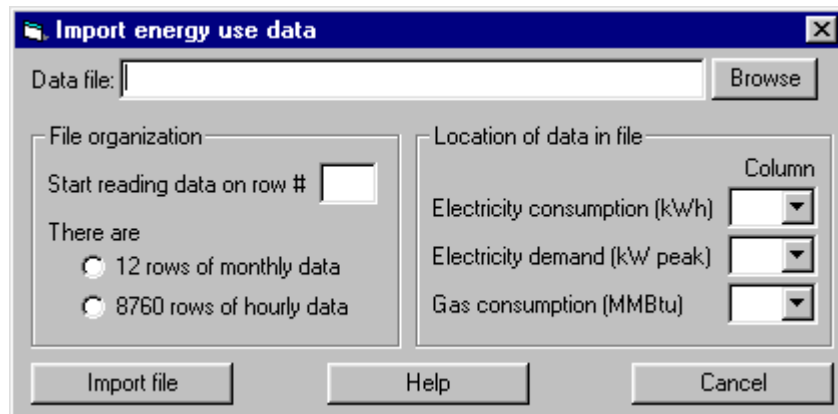


Enter Monthly Data from the menu or by pressing the **ENERGY** button. The facility energy use data consists of the electricity and gas consumption for each month of the year in units of kWh/month and MMBtu/month, respectively. The electrical demand is also entered on this screen (in units of peak kW demand for each month).

You can also import data from a 12-month or 8760-hour text file.

Importing energy use data from a text file

You may wish to enter energy use information from a data file rather than by hand. To do so, either select **Project Data | Enter Utility Bill Data | Import Data** or press **Ctrl-I** to display the menu shown below.



You can import comma, tab, or space-delimited files with any number of header rows or columns. You can specify the number of header rows in this file as well as the columns that hold the desired information.

Use the **Browse** button to select a data file. The import tool will attempt to read the selected file and count the number of rows and columns in the file.

If the file has header rows, enter the line number on which the data starts in the box labeled **Start reading data on row #**.

If the file contains monthly data, select the check box **for 12 rows of monthly data**.


Otherwise, the import tool will expect to see a file of hourly data for the year.

The data in the file may not be in proper order for direct importation. Use the **column** list boxes to match a column of data in the file with the desired input. If a column number is specified as *n/a* then any data in the screening tool will not be overwritten.

Selecting utility rates

The utility rates for electricity and natural gas must be chosen to run an analysis.

You can select the rates by choosing **Project Data | Select Utility Rates** from the

menu, by pressing **Ctrl-U**, or by pressing the  button. The resulting screen will show a list of all available electrical and gas rates. You may select different rates for the base case and the distributed generation alternative. You may also enter notes that are specific to the rates.

To edit or add rates to the list you must run the Rate Wizard.

Editing and adding utility rates

The utility rates are edited using the Rate Wizard. If you add a rate using the Rate Wizard it will immediately be placed in the list of available rates.

You must select both electric and gas utility rates in order to run the screening tool.

Selecting a generator

You must select a generator in order to run an analysis. This is done by choosing **Project Data Enter Generator Information** from the menu, by pressing **Ctrl-G**, or

by pressing the  button.

The screen will display a list of all available generators and ask you to select one. The list of generators can be sorted either by size or by manufacturer, which is useful if the list of generators is very long. Details about the selected generator are displayed on the left side of the screen.

You must also enter the total **number of generators installed** at the facility. When more than one generator is installed in the facility, the total capital cost of the generators is discounted 0.5% for each generator.

Check the box labeled **at least one generator can modulate** if the installed system can vary its power output.

Check the box labeled **heat recovery system is installed** if the generator supports cogeneration and is connected to a heat recovery system. By pressing the Configure button next to it you may access a screen to configure the heat recovery system.

Remember to increase the installation and O&M costs if heat recovery is used. The capital cost for the heat recovery system is calculated as follows:

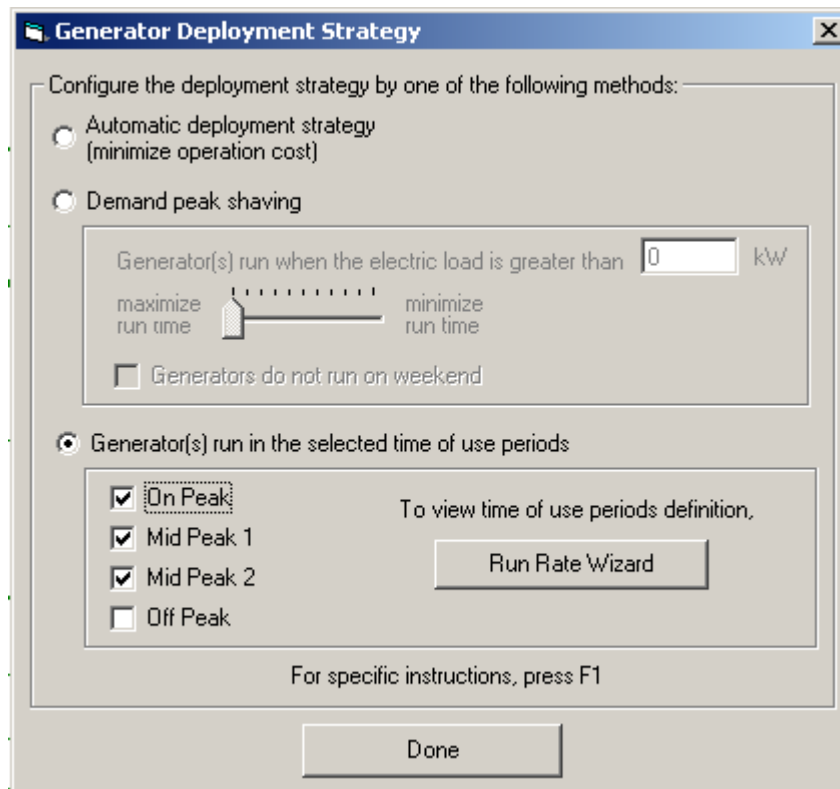
$$\text{Capital Cost}_{HR} = 0.002222 * (\text{GenCost/kW})^2 - 2.111111 * (\text{GenCost/kW}) + 666.667$$

This equation was developed by curve fitting cost data from many systems. The user can choose the **deployment strategy** among various options. To do so, press the Set/Modify deployment strategy button. This will take you to the Generator deployment strategy window.

Setting the generator deployment strategy

You can choose among three different deployment strategies:

- **Automatic deployment strategy** to minimize operation cost.
- **Demand peak shaving.** The generator control method can be selected by setting the slider bar to set the threshold for the operation of the generator set. The generators will operate only when the building electrical load is greater than the threshold selected. To make the generators run continuously, set the threshold to 0 kW.
- **Time of use periods selection.** The generator will run during the selected time of use periods. This option must be used with care, and the user must make sure that the selection matches the time of use period definition for the electric rate in the distributed generation case. This rate definition can be accessed directly from this screen by clicking on the **Run Rate Wizard** button.



Automatic generator deployment strategy

When this option is selected in the Generator deployment strategy screen, d-gen PRO will determine on an hourly basis whether on-site generation is cheaper than

purchased electricity and deploy the generator accordingly. d-gen PRO will analyze a number of hours in advance, this number being determined by the **minimum runtime** of the generator. This value is the minimum number of hours between stops and can be entered when editing the generator library.

Configuring the heat recovery system

When a heat recovery system is installed, some additional information is needed in order to simulate its performance. A short sequence of screens allows the user to enter the necessary specifications. You can navigate through the screens by pressing the *Next* and *Previous* buttons. These screens are accessed from the **Generator Information** window.

In the first screen you select the end-use applications that will make use of the recovered heat.

| Application parameters | Minimum Temperature (°F) | Basecase Efficiency | Efficiency with heat recovery |
|---|--------------------------|---------------------|-------------------------------|
| <input type="checkbox"/> Electric DHW | | | |
| <input checked="" type="checkbox"/> Natural gas DHW | 140 | 0.85 | 0.85 |
| <input checked="" type="checkbox"/> Electric Space Heating | 122 | 1.00 | 0.80 |
| <input type="checkbox"/> Natural gas Space Heating | | | |
| <input type="checkbox"/> Generic electric process | | | |
| <input checked="" type="checkbox"/> Generic natural gas process | 150 | 0.80 | 0.75 |

<< Prev Cancel Next

Besides domestic hot water and space heating, the heat recovery model allows the selection of two generic processes whose energy source is electricity and natural gas, respectively. For those applications selected, you must enter the next values:

- **Minimum Temperature** is the minimum temperature of the available heat that the application requires.
- **Basecase Efficiency** is the energy conversion efficiency of the application before installing the heat recovery system.
- **Efficiency with heat recovery** is the energy conversion efficiency of the application using the recovered heat.

➤ **Note:** You can simulate a generic process even if its energy source is not natural gas or electricity since you will obtain the same results for any fuel provided that the process energy demand and efficiency do not change.

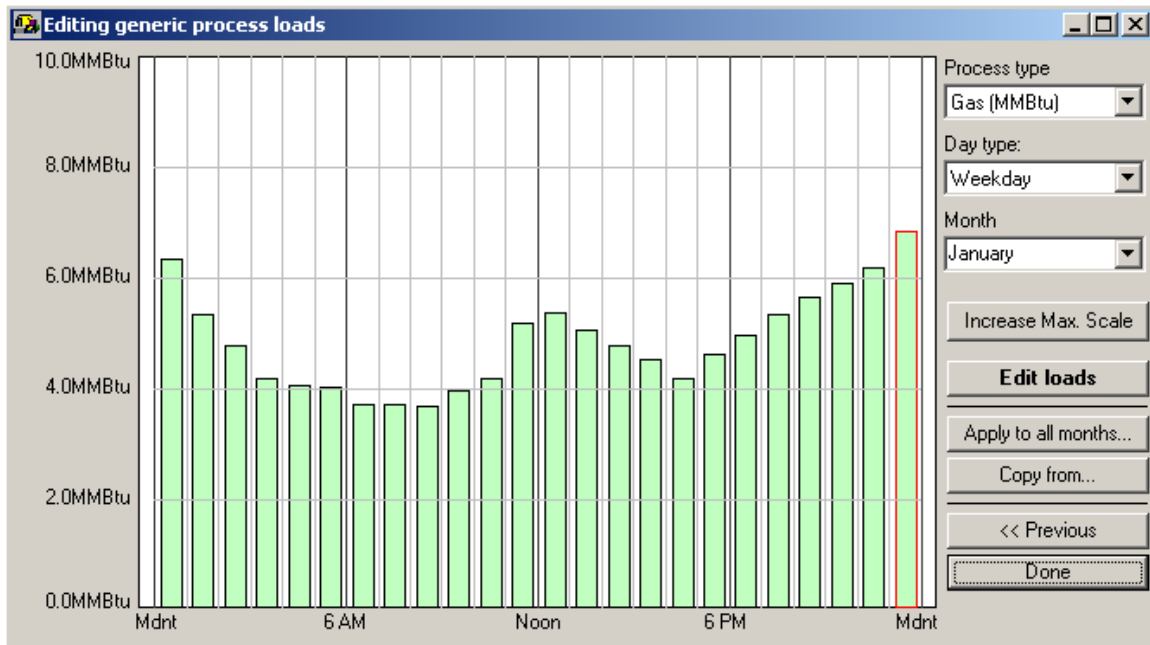
In the next screen you must specify in which order the selected processes will make use of the available heat. To do this, select an application from the list and move it up or down using the arrows on the right.



If you did not select a generic process, the heat recovery system is defined and you can return to the Generator Information window, pressing the button labeled *Done*. Otherwise, you must now define the generic process load shape(s) in the next screen.

This is accomplished by using a graphical interface scaled with energy on the vertical axis and the 24 hours of a day on the horizontal axis.

The three upper controls on the right-hand side of the screen allow the user to select the process type (if more than one is available), the day type (either a weekday or a weekend day), and the month.



The adjustments to the process loads are enabled after clicking on the button **Edit loads** on the right-hand side of the screen. Placing the cursor in the graph area allows the user to change each hourly value by clicking the left mouse button or cursor control and holding it down while dragging the cursor to the desired value. Releasing the mouse button or moving the cursor to a different hour while holding the button down set the value of the current hour and permit the user to edit the value of other hours. If the process load data is higher the current maximum of vertical scale, clicking on the button **Increase Max. Scale** allows increasing the maximum of the scale.

The **Apply to all months...** button permits copying the current load shape (for a given load type, day type, and month) to the other eleven months of the profile.

The **Copy from...** button allows copying the entire load shape, or selected portions of a load shape, from an existing d-gen PRO project into the current load shape. Selecting and completing this action will replace prior changes in the current load shape, so it should be used with care. The screen presented upon selecting the **Copy from...** button is shown below.

To accept all changes to the current load profile, click on the **Done** button.

Editing the generator library

The generator library is stored in a database and contains a list of all the generators used in the program along with the attributes of these generators. You can edit or add to this library via the **Tools | Run Generator Wizard** menu. Invoking this option will bring up the generator editor wizard. This wizard will scroll through several pages of generator information.

The generator library editor allows you to modify the following generator parameters:

- The **Generator Manufacturer** is a text string with the name of the generator manufacturer. *This is a **required** value.*
- The **Generator Model** is a text string with the model number of the generator. *This is a **required** value.*
- The **Rated Output** is the rated capacity of the generator in kW. *This is a **required** value.*
- The **Minimum Runtime** is the minimum number of hours between stops. *This is a **required** value.*
- The **Initial cost** is the manufacturer-suggested installed cost of the generator in \$/kW. This is not a required value.
- The **Annual O&M Cost** is the manufacturer-suggested annual O&M cost in \$/kW/yr. This is not a required value.
- The **Non-annual O&M Cost** is the manufacturer-suggested variable O&M cost in \$/kWh produced. This is not a required value.
- The **Heat Rate** is the rated "efficiency" of the generator in MMBtu per kWh. *This is a **required** value.*
- The **Exhaust Gas Flow** is the flue gas mass flow rate in lb/hr. The **Exhaust Gas Temperature** is the flue gas temperature in °F
- The **Jacket Water Flow** is the engine jacket water mass flow in lb/hr. The **Jacket Water Temperature** is the engine jacket water temperature in °F.
- The **Lubricant Coolant Flow** is the lubricant coolant mass flow in lb/hr. The **Lubricant Coolant Temperature** is the lubricant coolant temperature in °F.
- The **Carbon Dioxide (CO₂)**, **Carbon Monoxide (CO)**, **Nitrogen Oxides (NO_x)**, **Sulfur Oxides (SO_x)**, and **Particulate (PM₁₀)** Emissions can all be specified in grams per kWh produced. None of these are required values.
- The **temperature and altitude adjustments** are given as percent output differences as a function of the ambient temperature and the site altitude. The general equation for the corrections is

$$Actual\ Output = Rated\ Output \times \left[1 - \frac{Adjustment\ Coefficient}{100} \times (Value\ at\ Rating - Ambient\ Value) \right]$$

where the Adjustment Coefficient is given in % per °F (for temperature) or % per foot (for altitude). The Screening Tool uses the altitude for the chosen site and typical annual and daily temperature profiles for adjusting the performance of the generators. *These are **required** values.*

Entering economic parameters

d-gen PRO calculates the basic project costs and investment criteria and reports them on the Annual Summary screen. These values are based on the economic parameters used for the analysis. The economic parameters are entered by choosing **Project Data | Enter economic data** from the menu or by




pressing the  button

- The **Project lifetime** is the period over which the economic analysis will be performed. The project lifetime is assumed to be equal to the system lifetime, or the expected life of the generator used. You **MUST** enter a project lifetime in order to run the screening tool analysis.
 - The **Discount rate** is generally set equal to the rate of return of alternative investments of comparable risk. You do not have to enter a discount rate to run the analysis, but if no value is entered, a default of zero percent will be used.
 - The **Inflation rate** is the annual increase of prices. It is used to adjust both the discount rate and the cost of fuel over the project lifetime. You do not have to enter an inflation rate to run the analysis, but if no value is entered, a default of zero percent will be used.
 - The **Tax rate** is the incremental, or marginal, income tax rate. You do not have to enter a tax rate to run the analysis, but if no value is entered, a default of zero percent will be used.
 - The **Installed generator cost** is the total cost of the generating equipment and any heat recovery system including installation, wiring, plumbing, etc. This is expressed as dollars per installed kW of electrical output. You do not have to enter an installed cost to run the analysis, but if no value is entered, a default of zero will be used.
 - The **Annual O&M cost** is the sum of all operation and maintenance costs that are fixed by the installed capacity of the generating equipment expressed as dollars per installed kW per year. You do not have to enter an annual cost to run the analysis, but if no value is entered, a default of zero will be used.
 - The **Non-annual O&M cost** is the sum of all costs expressed as a function of energy produced expressed as dollars per kWh produced per year. You do not have to enter an annual cost to run the analysis, but if no value is entered, a default of zero will be used.
 - The **Depreciation period** is the period over which the generating equipment is depreciated. You do not have to enter a depreciation period to run the analysis, but if no value is entered, a default of zero will be used. Depreciation period is used to calculate the depreciation fraction and life cycle savings.
- ◆ **Note:** *You can use default values for the Installed generator cost, Annual O&M cost, and Non-annual O&M cost by pressing the button marked "Use default values for selected generator". The default values can be edited through the **Tools** | Run Generator Wizard menu.*

The financial analysis calculations performed by d-gen PRO are discussed in the [Economics Calculations](#) help section.

Viewing annual results

Once you have entered all the required information, you may run the analysis and view the annual results by choosing **Results | View Annual Results** from the menu,

by pressing **Ctrl-V**, or by pressing the  button.

Two matrices (one for electricity and one for natural gas) are displayed, similar to the one shown here:

| Annual grid electricity use and costs | | | | |
|--|---------------------|----------------|-----------------------|------------------------|
| | Total Use kWh/yr | Peak Use kW | Total Cost \$/year | Average Cost \$/kWh |
| Baseline: | 10,415,330 | 2,346.0 | \$1,325,192 | \$0.127 |
| With Generators: | 46,206 | 546.0 | \$8,971 | \$0.046 |
| Savings: | 10,369,130 | 1,800.0 | \$1,316,220 | \$0.082 |

| Annual gas use and costs | | | | |
|---------------------------------|-----------------------|-----------------------|-----------------------|--------------------------|
| | Total Use MMBtu/yr | Peak Use MMBtu/day | Total Cost \$/year | Average Cost \$/MMBtu |
| Baseline: | 56,407 | 338 | \$236,691 | \$4.196 |
| With Generators: | 154,475 | 533 | \$648,039 | \$4.195 |
| Savings: | -98,068 | -195 | -\$411,348 | \$0.001 |

The top line of each matrix reflects the energy use of the facility before the installation of any on-site power production. The middle line reflects the same values but with the generators in place, and the bottom line reflects the savings.

In addition, the annual results page will show an economics summary similar to this one:

| Economics | |
|--------------------------------------|-------------|
| Total generator installation cost: | \$567,000 |
| Payback (based on 1st year savings): | 0.6 years |
| Life cycle savings: | \$9,140,320 |
| Internal rate of return: | 108.6% |

The total generator installation cost is the total present value of the installation. The payback is calculated as the ratio of the installation cost and first year savings.

$$\text{Payback} = \frac{\text{Installation Cost}}{\text{First Year Savings}}$$

The life cycle savings are calculated by the difference between the total savings of the generators and the total installation and operating costs (corrected for taxes and inflation) over the lifetime of the project.

The internal rate of return is simply the discount rate at which the life cycle savings are zero.

Economic Calculations

The economic calculations used in d-gen PRO are based on widely accepted financial equations. This section explains the theory of how the calculations are performed.

d-gen PRO uses three financial measures to allow you to evaluate each scenario:

1. Life Cycle Savings
2. Simple Payback
3. Internal Rate of Return

Life Cycle Savings

Life Cycle Savings is calculated on an annual basis using the following equations:

Equation 1:

$$\begin{aligned} \text{FirstYearSavings} = & \text{AnnualElectric}\$_{WOG} + \text{AnnualGas}\$_{WOG} - \text{AnnualElectric}\$_{WG} - \text{AnnualGas}\$_{WG} \\ & - \text{FixedOM}\$_{WG} - \text{VariableOM}\$Rate \times \text{AnnualkWhGenerated} \end{aligned}$$

where $WOG = \text{WithOut_Generators}$

$WG = \text{With_Generators}$

The Annual Electric Cost and Annual Gas Cost for the Without Generators (baseline case) and the With Generators case are calculated by summing the computed monthly totals for electric and gas costs using the utility rate structures selected in the Selecting Utility Rates screen. The Fixed Operations and Maintenance Cost (Fixed OM\$) is the maintenance cost that is associated with the selected generators regardless of whether they are used or not. The Variable Operations and Maintenance Cost is calculated by multiplying the annual kWh produced by the generators by the Variable Operations and Maintenance Cost Rate (entered as \$/kWh produced by the generators). The Variable Operations and Maintenance Cost is the maintenance cost associated with running the generators and it is assumed to have a direct relationship with the amount of kWh produced. The Fixed and Variable O&M Costs are entered in the Economics Screen.

The results from Equation 1 are used in Equation 2:

Equation 2:

$$\begin{aligned} \text{LifeCycleSavings} = & \frac{\text{FirstYearSavings} \times (1 - \text{IncrementalTaxRate})}{\text{CapitalRecoveryFactor}(\text{DiscountRate}, \text{SystemLifeTime})} \\ & - \text{CapitalCost} \times (1 - \text{IncrementalTaxRate} \times \text{DepreciationFraction}) \end{aligned}$$

The Capital Recovery Factor is calculated using Equation 3.

Equation 3:

$$Capital\ RecoveryFactor = \frac{R}{1 - (1 + R)^{-N}}$$

R = Nominal Discount Rate entered by the user, and
 N = Time as Number of Years for the Project (System) Life Time entered by the user.

The Nominal Discount Rate is assumed to be the investment rate that the user would use to evaluate the relative value of different investment opportunities and it includes a factor for general inflation.

Capital Cost is calculated using cost information in the form of \$/kW from the d-gen PRO Generator Database or user input multiplied by the total installed generator capacity. Capital Cost is multiplied by the factor shown in Equation 4 when more than one generator is installed.

Equation 4:

$$InstallationCost\ ReductionFactor = 1.005 - 0.005 * NumberOfGeneratorsInstalled$$

If heat recovery equipment is installed, Capital Cost is increased by adding the amount calculated from Equation 5, which was formulated based on available industry data.

Equation 5:

$$CapitalCostHeat\ RecoveryAdjustmentFactor = 0.002222 \times (InstalledCostPerKW)^2 - 2.111111 \times (InstalledCostPerKW) + 666.667$$

Depreciation Fraction is calculated using Equation 6.

Equation 6:

$$DepreciationFraction = \frac{1}{Capital\ RecoveryFactor(DiscountRate, DepreciationPeriod)}$$

Simple Payback

The equation for Simple Payback is:

Equation 7:

$$SimplePayback = \frac{CapitalCost}{FirstYearSavings}$$

Simple Payback is the number of years that it will take to recover the capital cost of the generators, assuming that the estimated first year savings is achieved every year. It does not take into account inflation or the time-value of money.

Internal Rate of Return

Internal Rate of Return is defined as the annual yield from a project over the Project Life Time. It is a compound rate of interest which, when used to discount cash flows of a generator case alternative, will result in zero Life Cycle Savings. Since this number is difficult to calculate directly, it is iteratively calculated by adjusting the Discount Rate until the Life Cycle Savings is less than \$1.00.

Generator and Heat Recovery Capital Costs

The capital cost for the generators is discounted 0.5% when more than one generator is included in a project. The equation for generator capital cost modification is as follows:

$$CapitalCost = CapitalCost * (1.005 - 0.005 * Number\ Of\ Generators\ Installed)$$

The cost of heat recovery equipment installed on a generator is calculated as follows:

$$CapitalCost_{HR} = 0.002222 \times (GenCost / KW)^2 - 2.111111 * (GenCost / KW) + 666.667$$

This equation was developed by curve fitting cost data from many systems.

Simulation Assumptions

d-gen PRO performs an hour-by-hour annual simulation of the building based on the weather conditions at the selected location, the actual energy use at the building and the selected energy use loadshapes, and the selected generators and control scenario.

Some of the assumptions used in this simulation are:

- Three sources of heat recovery are considered in the **heat recovery model**.

They are:

1. Exhaust gas.
2. Water jacket.
3. Lubricant system.

The heat available from the heat recovery equipment is calculated according to the following equation:

$$q = \dot{m}_e \times (C_p)_e \times (t_e - t_{fe}) + \dot{m}_w \times (C_p)_w \times (t_w - t_{fw}) + \dot{m}_c \times (C_p)_w \times (t_c - t_{fc})$$

where

$\dot{m}_e, \dot{m}_w, \dot{m}_c$ = mass flow rate of exhaust, jacket water, lubricant coolant (lbs/hr)

t_e, t_w, t_c = exhaust, jacket water, lubricant coolant temperature (°F)

t_{fe}, t_{fw}, t_{fc} = exhaust, jacket water, lubricant coolant final temperature (°F)

$(C_p)_e$ = Specific heat of exhaust = 0.251 btu/(lb°F)

$(C_p)_w$ = Specific heat of water = 1 btu/(lb°F)

➔ **Notes:**

To avoid condensation and acid formation in the exhaust piping a minimum final exhaust temperature of 302 degree F is considered.

To avoid thermal stress, a maximum drop of 46.4 degree F in the engine jacket is considered.

Minimum temperatures allowed by the applications to take advantage of the recovered heat set another limit to the final temperatures in the heat fluids.

Recovery in the water jacket and lubricant system only applies to internal combustion engines.

- When simulating the heat recovery in the batch processing mode, the available heat from the heat recovery equipment is assumed to be 50% of the heating value of the fuel consumed.

The performance **degradation for altitude and ambient temperature** are calculated differently for each generator type, as follows:

Microturbine and gas turbine performance is degraded based on the generator adjustment factors, which are entered in the generator wizard and are expressed in terms of % per degree F, and % per foot.

Naturally aspirated Internal combustion engine performance is degraded based on the change in air density as the conditions vary from the rating conditions

Turbocharged Internal combustion and fuel cells engine performance is not significantly affected by changes in air density, and so the performance is assumed to be the same as at the rating conditions.

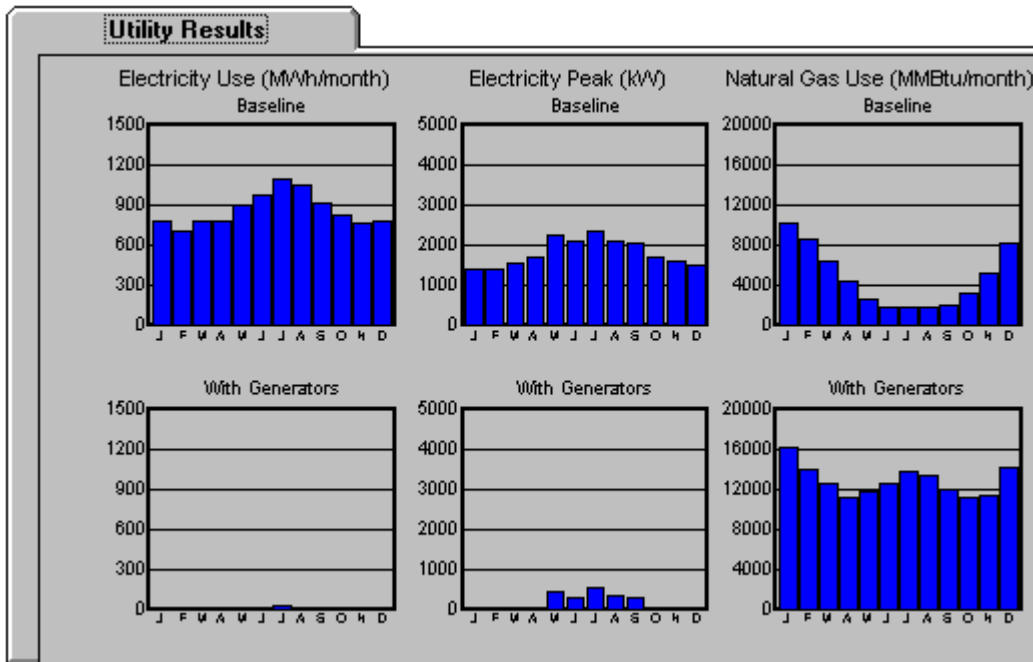
Viewing monthly energy use graphs

Once the required data has been entered you can view graphs of the monthly energy consumption with and without the generators in place. This is done by choosing **Results | View monthly energy use** from the menu or by pressing the



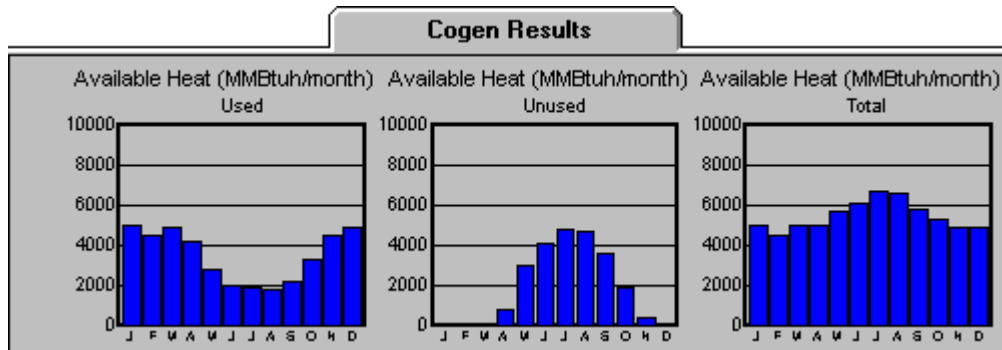
button.

A screen with tabs for Utility Results and Cogen Results is displayed. The Utility Results tab displays graphs similar to those shown below. The top line of graphs are the baseline (i.e., without generators) electricity consumption and peak values along with the natural gas MMBtu consumption. The bottom graphs show the same quantities modified by the on-site power production.



These graphs also appear on the [printed report](#).

The Cogen Results tab displays graphs similar to those shown below. The graph on the left shows the available heat actually used by the building, the middle graph shows the heat that was available but was unused because all heating loads were satisfied, and the graph on the right shows the total heat that was available from the heat recovery system.



Batch Processor

The batch processor is an add-in feature, which extends d-gen PRO capabilities. It is only available in an extended version of d-gen PRO.

The batch processor is capable of running consecutively up to 4 scenarios of a selected batch of projects. They represent possible combinations of turbine/reciprocating engines with/without heat recovery.

This feature requires a more skillful user who must be able to manually enter some information in the "Project" database. This database accompanies d-gen PRO and stores all project information.

The batch processor counts with its own method for **entering the hourly consumption of electricity and natural gas** and the breakdowns of these into end-uses (domestic hot water and space heating). It admits 4 types of input, whose selection will affect the input in the "Project" database.:

I 8760 total consumption values per year.

II 576 total consumption values (24 hours * 2 days * 12 months) per year.

III 8760 total and by-end-use values per year.

IV 576 total and by-end-use values per year.

◆ **Notes:**

For input types II and IV the 2 days per month represent weekdays and weekends, in this order. The annual load shape will be created by repeating these days.

For input types I and II the application will use its own templates to produce the by-end-use breakdown, based on the facility type and location.

The batch processor has its own visual interface, which allows the user to enter other necessary information. It can be accessed through the **Tools | Run Batch Processor** menu.

The results for each run are displayed in the projects database and may be accessed directly by the user.

Batch Processor: Entering information in the "Project" database

Before using the batch-processing feature of d-gen PRO, some information must be entered into the "Project" database. Its full name is Project_3.5.mdb and it can be found in the same folder as d-gen PRO. Batch process specific information must be entered manually into the database. All other information can be entered using the visual user interface.

There are three tables that store the required batch processing information:

1. Project
2. BatchInput
3. BatchEnergyInformation

Project

The general information for a single project is stored in one row of this table. All information in this table can be also entered using the regular d-gen PRO visual interface.

If the information is entered directly into the database the minimum fields required for each project are:

- **ProjectSaveName.**
- **FacilityType.** This field is only required if by-end-use load shapes are not provided (input types I and II). d-gen PRO will then produce an automatic breakdown by end-use based on the facility type and location.

BatchInput

This table is for the exclusive use of the batch processor. It stores additional information about the project and must be populated manually. There must be an entry for each project in order for the batch processor to run. The following fields are required:

- **ProjectID.** Identifier that relates the record to a project in the Project table.
- **EnergyInformationType.** It represents the type of Energy Information Input and can have the following values:
 1. 8760 cumulative values per year provided (TotalkWh, TotalMMBtu)
 2. 576 cumulative values per year provided
 3. 8760 cumulative and by-end-use values per year provided (TotalkWh, TotalMMBtu, DHWkWh, DHWMMBtu, HeatingkWh, HeatingMMBtu)
 4. 576 cumulative and by-end-use per year provided.
- **FacilityCity.** It must match exactly one of the location character strings listed in the Facility reference location drop-down box (located in the Facility Information screen)

BatchEnergyInformation

This table stores the energy consumption information. Depending on the **EnergyInformationType** (in **BatchInput** table) this table will store 8760 or 576

hourly values per project. The required fields vary depending on the EnergyInformationType. As a general rule, cumulative values are always required and by-end-use values are only needed when the EnergyInformationType equals 2 or 3. Following is complete description of the fields in this table:

- **ProjectID.** It relates the record to a project in the Project and BatchInput tables.
- **HourIndex.** Integer that identifies the hour of the year. It will be a sequence from 0 to 8759 when the EnergyInformationType equals 1 or 3. When it equals 2 or 4 the values will be in blocks of 48 hours sorted by month with the first 24 values associated with the weekday load and the next 24 values associated with the weekend load.
- **TotalkWh.** Electricity consumed in that hour (kWh). Always required.
- **Total MMBtu.** Natural gas consumed in that hour (MMBtu). Always required.
- **DHWkWh.** Electricity used for domestic hot water preparation in that hour (kWh). Required when EnergyInformationType equals 3 or 4.
- **DHWMMBtu.** Natural gas used for domestic hot water preparation in that hour (MMBtu). Required when EnergyInformationType equals 3 or 4.
- **HeatingkWh.** Electricity used for space heating in that hour (kWh). Required when EnergyInformationType equals 3 or 4.
- **HeatingMMBtu.** Natural gas used for space heating in that hour (MMBtu). Required when EnergyInformationType equals 3 or 4.

Batch Processor: Energy Information Input

The batch processor counts with its own method for **entering the hourly consumption of electricity and natural gas** and their breakdowns into end-uses (domestic hot water and space heating). It admits 4 types of input, whose selection will affect the input in the “Project” database.:

I 8760 total consumption values per year.

II 576 total consumption values (24 hours * 2 days * 12 months) per year.

III 8760 total and by-end-use values per year.

IV 576 total and by-end-use values per year.

Note: For input types II and IV the 2 days per month represent weekdays and weekends, in this order. The annual load shape will be created by repeating these days. For input types I and III the application will use its own templates to produce the by-end-use breakdown, based on the facility type and location.

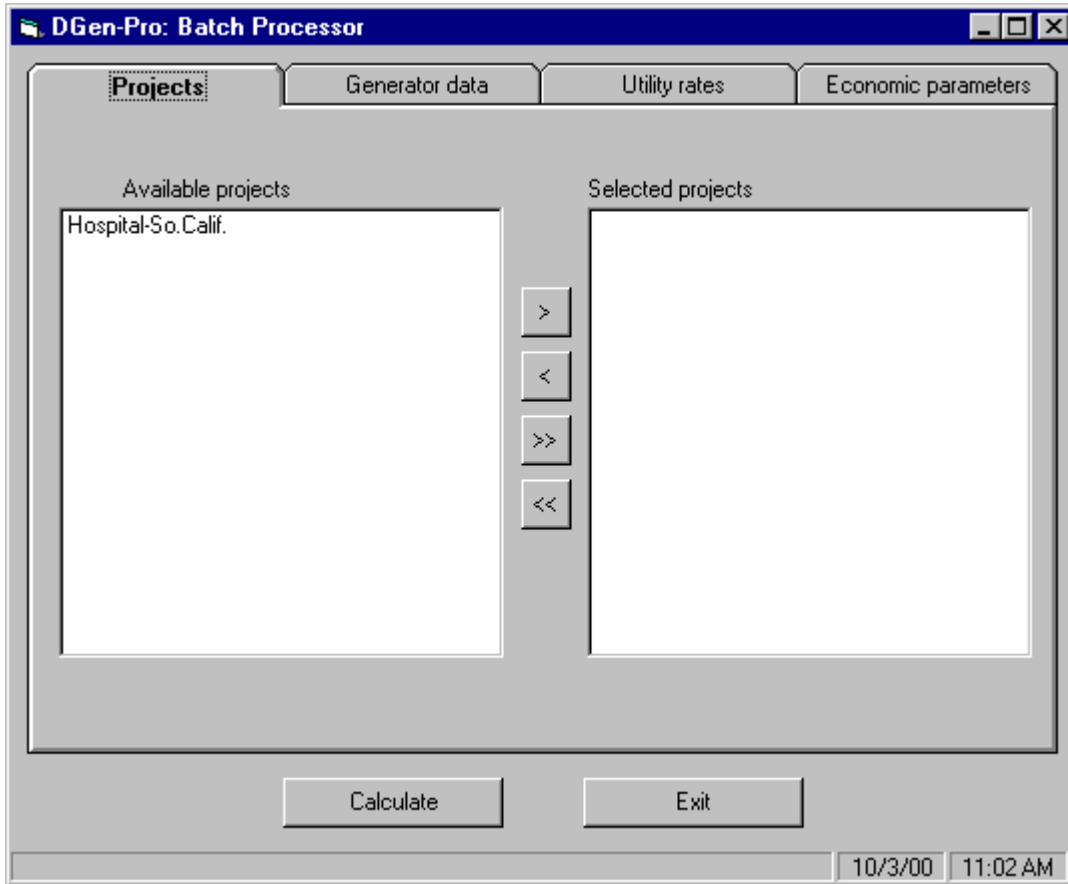
Batch Processor: Visual Interface

The batch processor visual interface can be accessed through the **Tools | Run Batch Processor** menu. This action displays a window with four tabs: Projects,

Generator Data, Utility Rate and Economic Parameters.

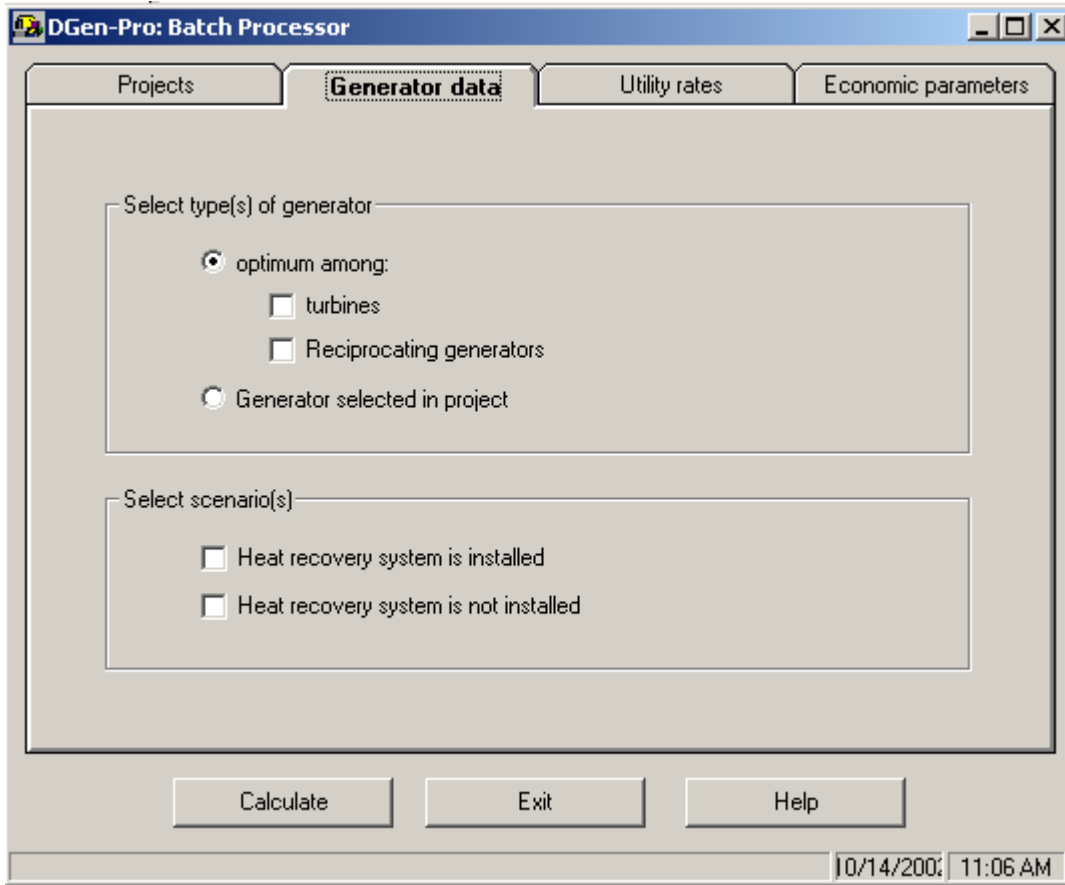
Projects

In this tab the projects to be simulated must be selected from the list of available projects. Only projects with properly populated records in the **Project** and **BatchInput** tables are listed here.



Generator Data

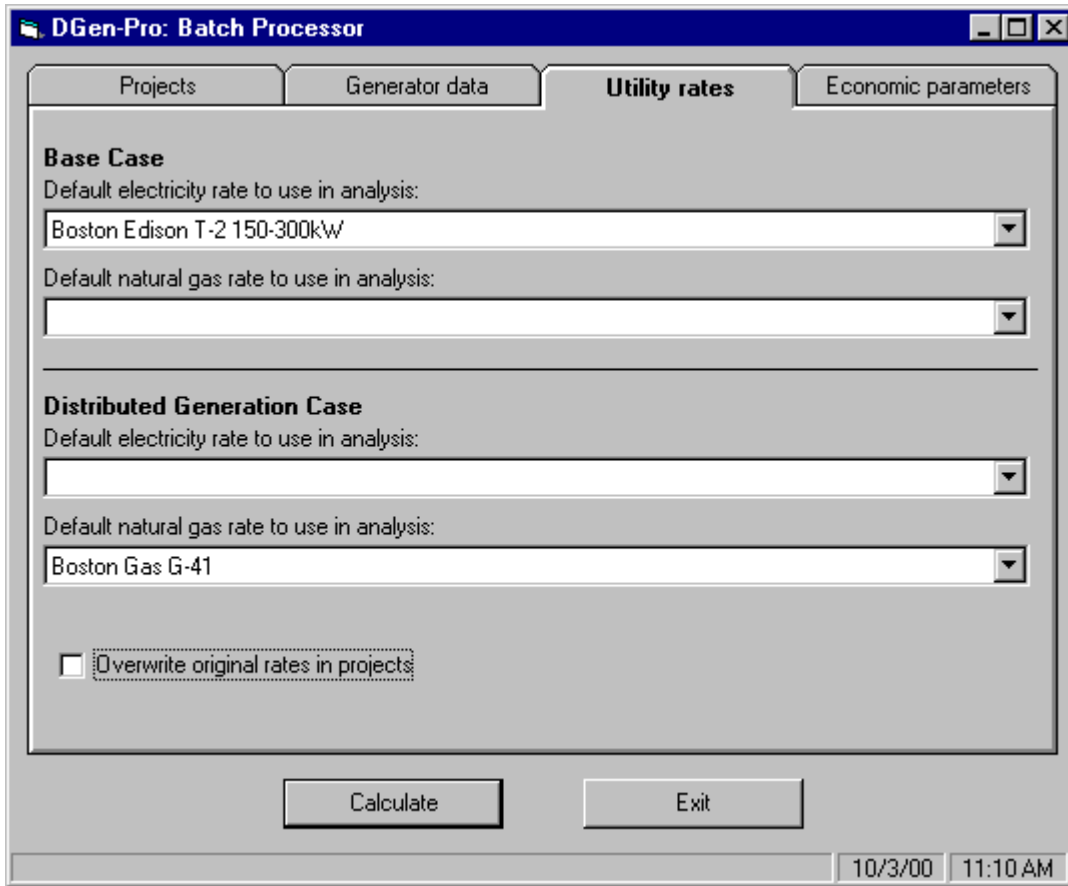
Here the user can select which type or types of generator will be tested and whether heat recovery shall also be evaluated. At least one of the options for each group must be selected. d-gen PRO will determine the most adequate generator or group of generators for the current load among those in the selected type, or alternatively will use the existing selection for each project. For the second option, make sure that there is indeed a generator selected for all projects.



Utility Rate

In this tab the user must select the default utility rates, which will be used in case projects in the batch have empty utility rate records (partially incomplete Project table). Additionally the user can choose to overwrite the existing rate information in the Project table.

Values in this tab must be selected even if all projects are complete.



Economic Parameters

This tab allows the input of default **economic parameters**, which will be used in the simulation in case the Project table is not complete. Values must be entered even if they will not be used.

Batch Processor: Results

The results for each run are displayed in the **BatchResults** table in the **Project_3.5.mdb** database. It includes the following fields:

- **ProjectID.** It identifies the projects. There may be up to 4 records for a single project, representing the number of cases selected in the **Generator Data** tab in the Visual Interface.
- **GeneratorID.** Identifies the generator selected by d-gen PRO as the optimum. Its match can be found in the **Generators_3.5.mdb** database also launched with d-gen PRO.
- **NumberOfGeneratorsInstalled.**
- **HeatRecovery.** Yes/No value that reports whether heat recovery was considered in that run.
- **TotalInstallationCost (\$)**
- **Payback (years)**
- **LifeCycleSavings (\$)**
- **InternalRateOfReturn**

An explanation of the financial measures can be found in [Economic Calculations](#).

Printing report

Once you have entered all of the project information you can print out an annual performance report containing all the project, facility, and generator information as well as modified energy use numbers and the economic evaluation. The **Report Wizard** will assist you in this process.

- You can access the Report Wizard from the menu using **Results | Print Report**

- The shortcut for the Report Wizard is the  button

The Report Wizard allows you to create a custom report by selecting sub-reports from a list. The available sub-reports are the following:

- **Project summary.** Always included in reports.
- **Energy Consumption Summary**
- **Demand Summary**
- **Energy Cost Summary**
- **Waste Heat Summary**
- **Distributed Generation Energy Breakdown**
- **Distributed Generation Operation Cost Breakdown**
- **Generator Information**
- **Selected Rates Information**

➤ **Note:** In order to print out your report d-gen PRO must first perform an annual calculation and save your project. If you did not do so previously, or later made any change, you will be prompted to do so.

Units Selection

Users can select whether they want to enter and receive all inputs in SI units rather than American units. To do so, select your preference in **Tools | Select Units**. If you have an opened project at that moment this will automatically convert all values in your project to the new norm.

d-gen PRO will remember your preference the next times you run the application.

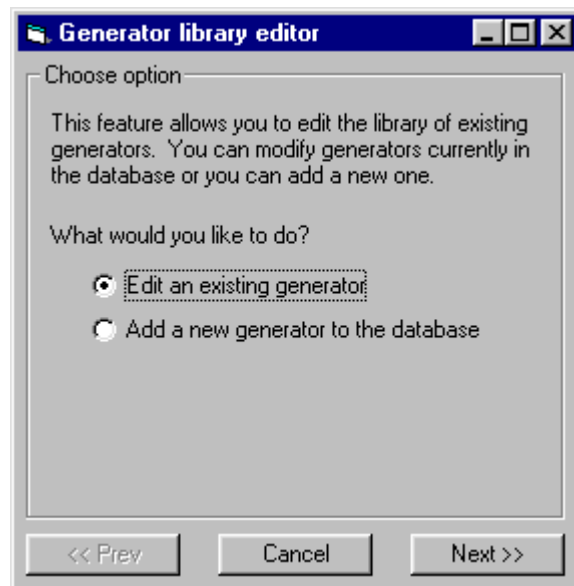
Generator Wizard

d-gen PRO uses a database of building types and corresponding load shapes when it performs annual simulations. You can edit the library of load shapes through the **Tools | Run Load Shape Wizard** menu.

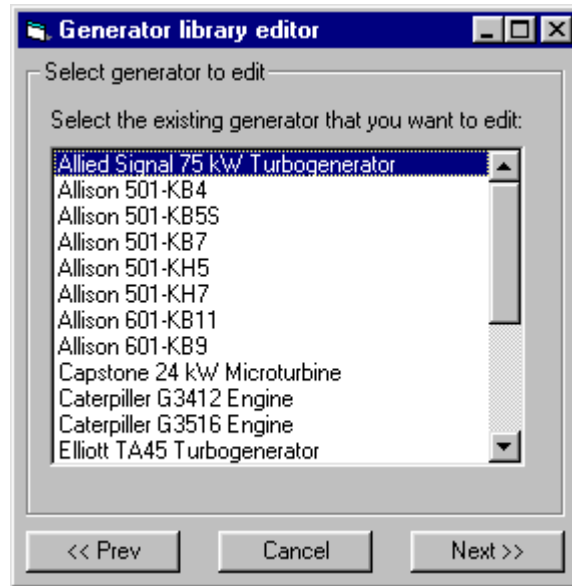
The Generator Wizard allows you to edit or add new entries to the Generator Database. The features and screens for the two primary paths through the Generator Wizard, (1) Editing an Existing Generator, and (2) Adding a New Generator, are the same. The screens for editing an existing generator are discussed below.

The entry screen allows you to either edit data for a generator already in the database or add data for a new generator.

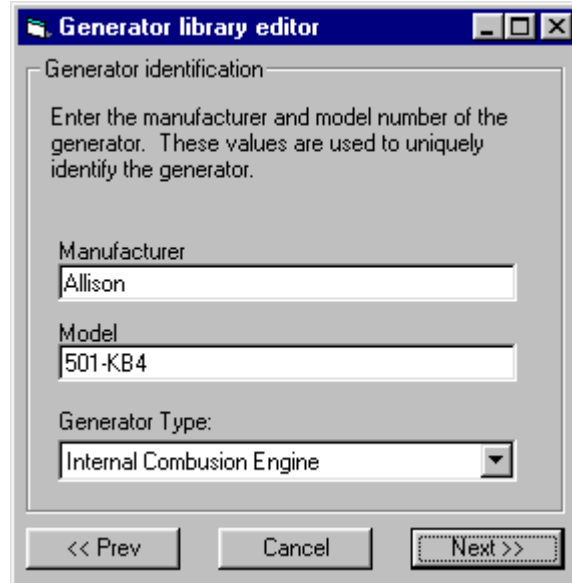
Control buttons used in each screen of the Generator Wizard allow you to advance by clicking on the **Next>>** button, return to the previous screen by clicking on the **<<Prev** button, or return the main d-gen PRO screen by clicking on the **Cancel** button.



The list of generators in the database is displayed in scrollable list. Use the arrows or slide bar to see other entries. Select an entry by clicking on the name.



After selecting a generator and clicking on the Next>> button, you user can edit the manufacturer's name, model description, and select the type of generator. The combination of the manufacturer's name and model description is used as a identifier in the database. If you edit or enter a new description, it should be unique. The generator type is used to calculate performance when ambient conditions are different than rated conditions.



Generator operating characteristics are entered in the next screen, including Rated Output, Heat Rate and Minimum Runtime. This information is available from the manufacturer.

Generator library editor

Generator operating characteristics

Enter the rated output, efficiency, and heat recovery values for the generator

Rated output kW

Heat rate Btu/kWh

Minimum runtime (hours between stops)

<< Prev Cancel Next >>

Heat recovery data are entered in the next screens. Values for the mass flow and temperature of the exhaust gas at various percentages of full load are requested. When the generator is an internal combustion engine, another two screens will request the same values for the jacket water and the lubricant coolant.

Generator library editor

Exhaust Gas Heat Recovery Data

Enter the data for the exhaust gas when the generator is operating at the specified percent of full load.

| Percent Full Load | Temperature °F | Flow lbs/hr |
|-------------------|------------------------------------|-------------------------------------|
| 25% | <input type="text" value="0"/> | <input type="text" value="0"/> |
| 50 % | <input type="text" value="986"/> | <input type="text" value="248004"/> |
| 75% | <input type="text" value="986"/> | <input type="text" value="278604"/> |
| 100% | <input type="text" value="910.3"/> | <input type="text" value="375336"/> |

<< Prev Cancel Next >>

Generator purchase costs and maintenance costs are entered as normalized values. Annual Operations and Maintenance (O&M) costs are fixed costs that will be incurred whether the generator is used to produce electricity or not. Non-annual O&M costs are associated with the run-time hours of the generator and are expressed as dollars per kWh produced.

Generator library editor

Generator default costs

Enter the default costs for this generator

Initial cost \$ 368 per kW installed

Annual O&M cost \$ 0 per yr / kW

Non-annual O&M cost \$ 0.003 per kWh

<< Prev Cancel Next >>

The electric power output of a gas-fired generator changes with ambient temperature and altitude. The rated conditions and correction factors for performance are available from each manufacturer.

Generator library editor

Generator adjustments

Enter the temperature and altitude adjustments used for this generator.

Temperature

at rating conditions 59.5 °F

correction factor -0.5848 % per °F

Altitude

at rating conditions 0 feet

correction factor -0.0031 % per foot

<< Prev Cancel Next >>

If the generator emissions are known, they may be entered into the database. None are required entries. If they are available, d-gen PRO uses them to calculate estimated annual production of pollutants.

Generator library editor

Generator emissions

Enter the pollutant emissions for this generator at rating conditions.

| | | |
|------|--------------------------------|-------------|
| CO2 | <input type="text" value="0"/> | grams / kWh |
| CO | <input type="text" value="0"/> | grams / kWh |
| NOx | <input type="text" value="0"/> | grams / kWh |
| SOx | <input type="text" value="0"/> | grams / kWh |
| PM10 | <input type="text" value="0"/> | grams / kWh |

<< Prev Cancel Next >>

The next screen requests the efficiency of the generator when it is operating at various percents of full load. They are needed to simulate modulation.

Generator library editor

Part Load Ratio

Enter the efficiency for the generator when it is operating at the specified percent of full load.

| Percent Full Load | Efficiency (0.0-1.0) |
|-------------------|--|
| 25% | <input type="text" value="0.5770119"/> |
| 50 % | <input type="text" value="0.8469001"/> |
| 75% | <input type="text" value="0.9507772"/> |
| 100% | <input type="text" value="1.011294"/> |

<< Prev Cancel Done

The generator part load ratio screen is the last in the Generator Wizard series. Clicking on the **Done** button enters the changes into the database and returns to the main d-gen PRO screen. You may return to any other screen in the Wizard by clicking the **<<Prev** button. If you decide not to keep the current changes, click on the **Cancel** button.

Load Shape Wizard


d-gen PRO uses a database of building types and corresponding load shapes when

it performs annual simulations. You can edit the library of load shapes through the **Tools | Run Load Shape Wizard** menu. For a list of existing building types, refer to the Load Shapes help section.

The entry screen for the Load Shape Wizard allows you to select one of three options: (1) editing an existing load shape for an existing location, (2) add a load shape for an existing building type at a new location, or (3) add a load shape for a new building type. Each option is discussed in this section.

Control buttons used in each screen of the Load Shape Wizard allow you to advance by clicking on the **Next>>** button, return to the previous screen by clicking on the **<<Prev** button, or return the main d-gen PRO screen by clicking on the **Cancel** button.



The next screen presents a pull-down list of building types that is activated by clicking on the 



After selecting the building type, the Wizard presents a screen to permit you to select a location from those already in the database.

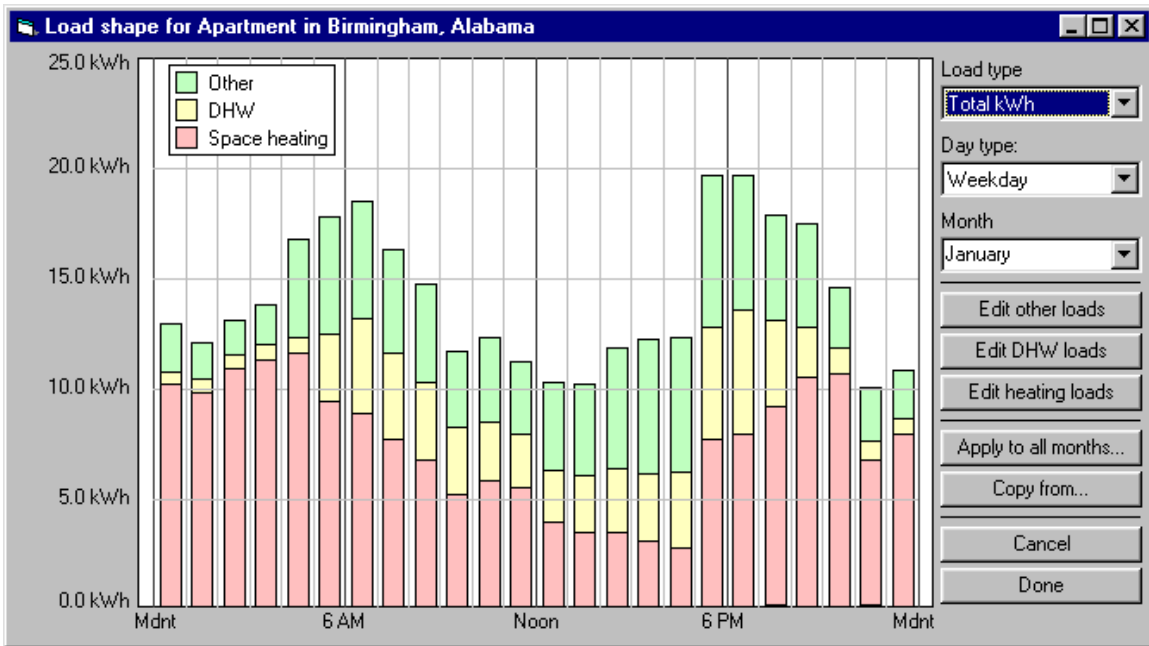


The next screen requests you to verify the building type and location selected. Click on the **Finish** button if the selections are correct; if they are not, click on the **<<Prev** button to return to the previous screen to adjust your selections.

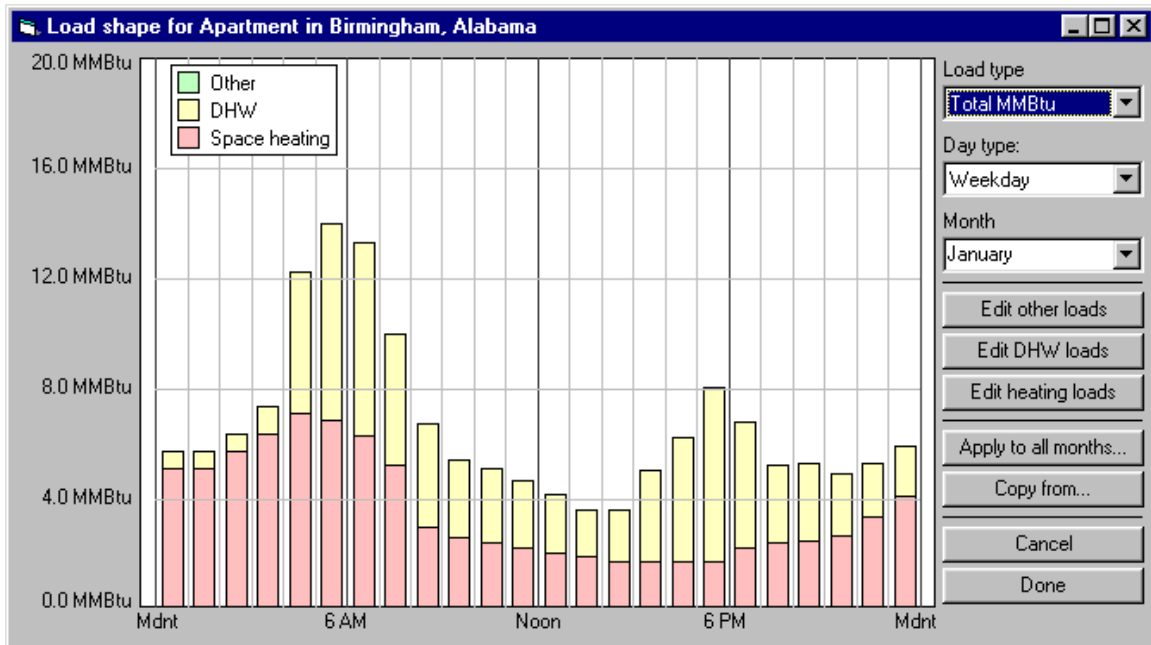


The load shape adjustments are made using a graphical interface that is scaled with energy on the vertical axis and the 24 hours of a day on the horizontal axis. The initial load profile shown on the graph consists of composite bars showing the energy end uses of space heating, service hot water (DHW), and other process or internal loads.

The three upper controls on the right-hand side of the screen allow the user to select the load type (either electricity or gas), the day type (either a weekday or a weekend day), and the month.



The following screen shows an example of a gas load profile that appears when the Load Type is changed to "Total MMBtu".



The adjustments to each energy end use by month are made by clicking on one of three buttons on the right-hand side of the screen: (1) **Edit other loads**, (2) **Edit DHW loads**, (3) **Edit heating loads**. Each of these screens shows a single energy end use. Placing the cursor in the graph area allows you to change each hourly value by clicking the left mouse button or cursor control and holding it down while dragging the cursor to desired value. Releasing the mouse button or moving the cursor to a different hour while holding the button down sets the value of the current hour and permit you to edit the value of other hours.

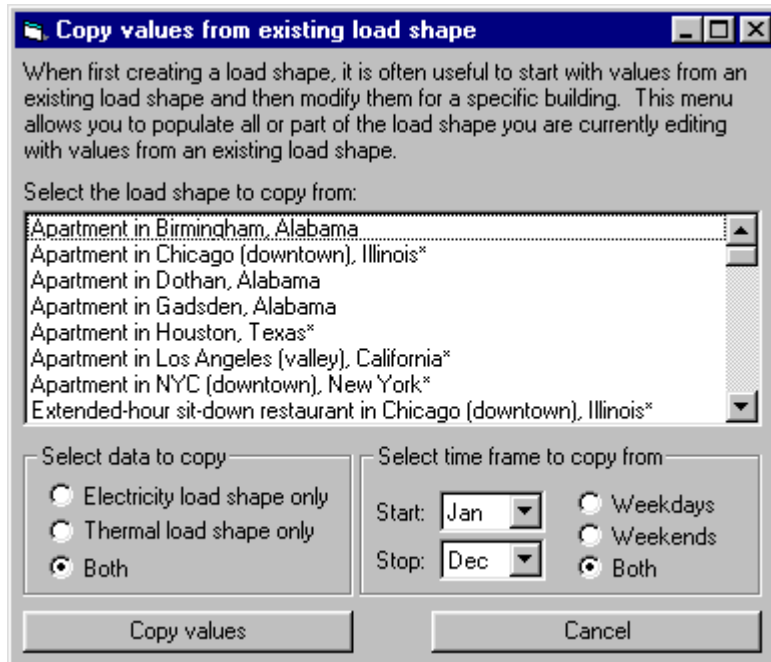
The **Apply to all months...** button permits copying the current load shape (for a given load type, day type, and month) to the other eleven months of the profile.

The **Copy from...** button allows copying the entire load shape, or selected portions of a load shape, from an existing building/location combination into the current load shape. Selecting and completing this action will replace prior changes in the current load shape, so it should be used with care. The screen presented upon selecting the **Copy from...** button is shown below.

To abandon all changes to the current load profile, click on the **Cancel** button.

To accept all changes to the current load profile, click on the **Done** button.

The following screen shows the selections available to copy values from an existing load shape into the current load shape.



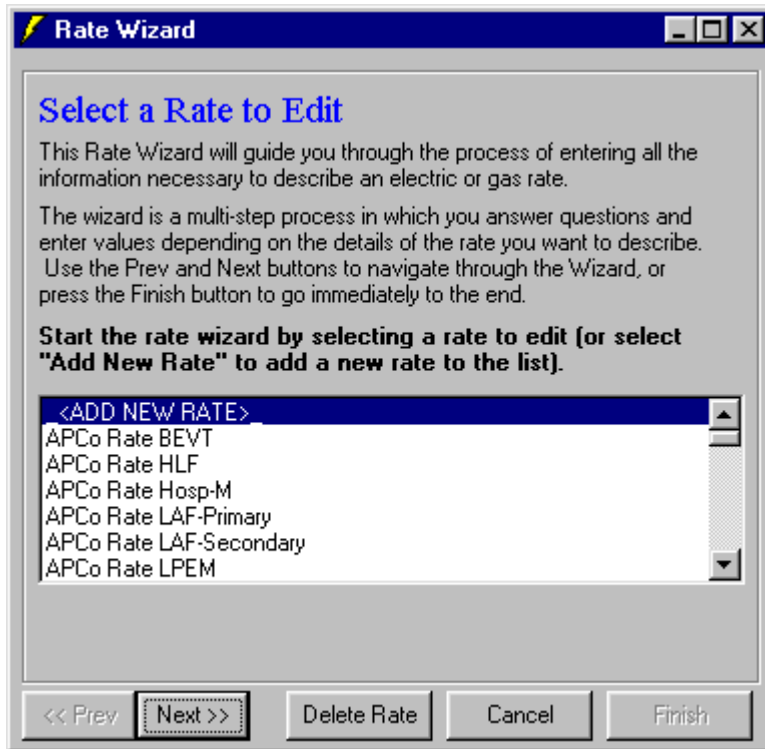
Rate Wizard

The utility rates are edited using the Rate Wizard. If you add a rate using the Rate Wizard it will immediately be placed in the list of available rates.

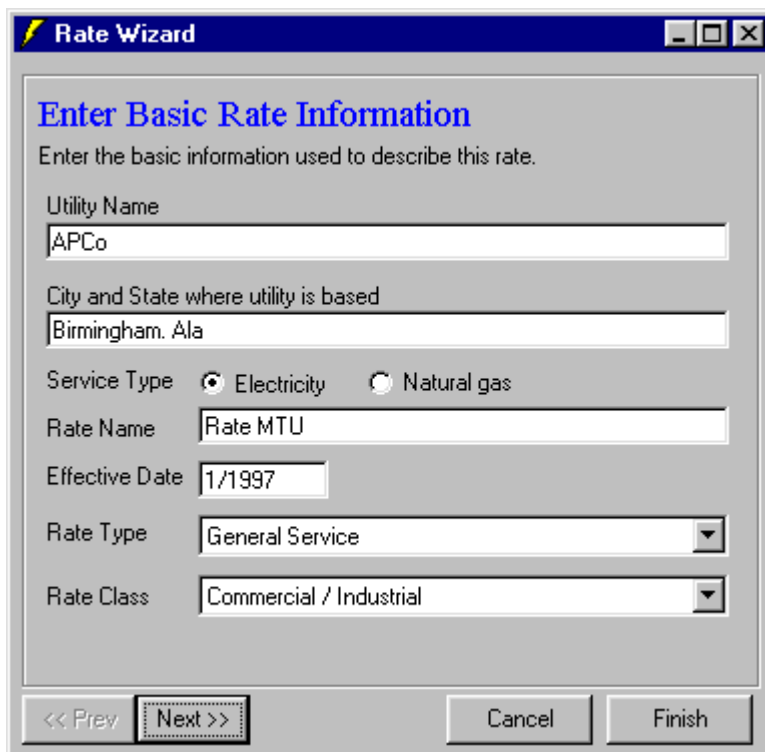
Control buttons used in each screen of the Rate Wizard allow you to advance by clicking on the **Next>>** button, return to the previous screen by clicking on the **<<Prev** button, or return the main d-gen PRO screen by clicking on the **Cancel** button.

When selecting the Utility Rate Wizard, the first screen allows you to either select a rate to edit, or to add a new rate to the rate database. After selecting an existing or new rate Click **Next>>** to proceed.

To delete a rate, first select the rate and then click "Delete Rate"

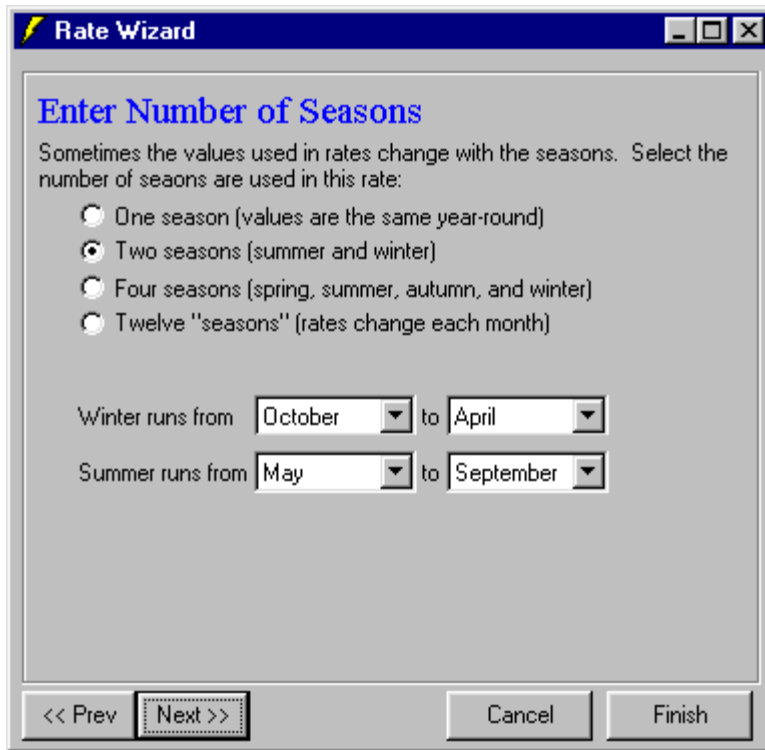


Enter basic rate information for the rate being edited in this screen.



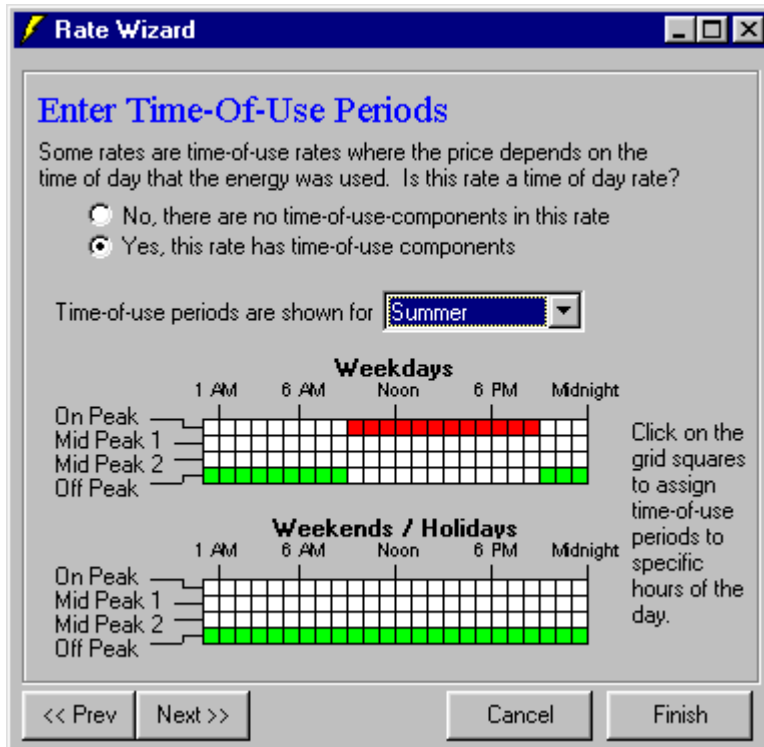
Select the number of seasons with different rates. In the example shown here, there are two seasons.

Select the period for each season. Note that the specified periods must cover an entire year.
Click Next>> to proceed.

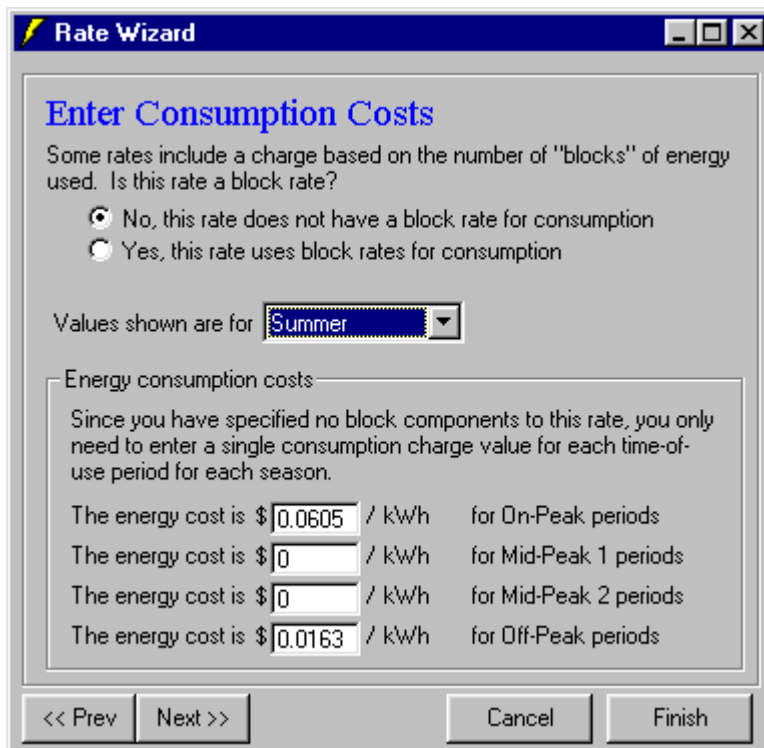


The screenshot shows a dialog box titled "Rate Wizard" with a blue header bar. The main content area has a title "Enter Number of Seasons" in blue text. Below the title is a paragraph: "Sometimes the values used in rates change with the seasons. Select the number of seasons are used in this rate:". There are four radio button options: "One season (values are the same year-round)", "Two seasons (summer and winter)", "Four seasons (spring, summer, autumn, and winter)", and "Twelve 'seasons' (rates change each month)". The "Two seasons" option is selected. Below the options are two rows of date pickers. The first row is labeled "Winter runs from" and has two dropdown menus with "October" and "April" selected, separated by the word "to". The second row is labeled "Summer runs from" and has two dropdown menus with "May" and "September" selected, separated by the word "to". At the bottom of the dialog box are four buttons: "<< Prev", "Next >>", "Cancel", and "Finish". The "Next >>" button is highlighted with a dotted border.

In the next screen, specify if there are time-of-use periods for this rate. Each season may have different time-of-use periods. Select each season using the drop-down list box. In this example screen, the summer season has been selected. Click on the grid squares to assign time-of-use periods to specific hours of the day for both weekdays and weekends.
If there are no time-of-use components in the rate, select "No".
Click Next>> to proceed.



Next, enter consumption costs for each period, and for each season. The sample shown below is for the summer season. If the rate has a block rate, see Block Rates for information on entering information on block rates.



Next, enter the demand costs for each period, and for each season. The sample shown below is for the summer season. If the rate has a block rate, see Block Rates for information on entering information on block rates.

The screenshot shows a window titled "Rate Wizard" with a blue header bar. The main content area is titled "Enter Demand Costs" in blue text. Below the title, there is a question: "Some rates include a demand charge based on the number of 'blocks' of demand. Does this rate have a demand block component?". There are two radio button options: "No, this rate does not use demand blocks" (which is selected) and "Yes, this rate uses demand blocks". Below these options, there is a text label "Values shown are for" followed by a dropdown menu showing "Summer". To the right of the dropdown is a checkbox with the text "Check this box if the demand charge is ratcheted over the year." Below this is a section titled "Demand charge with time-of-use component" with a sub-instruction: "You only need to enter a single demand charge for each time-of-use period for each season." This section contains four rows of input fields, each labeled "The demand cost is \$" followed by a text box containing "0", a slash, and "kW". The labels for these rows are "for On-Peak periods", "for Mid-Peak 1 periods", "for Mid-Peak 2 periods", and "for Off-Peak periods". At the bottom of the dialog are four buttons: "<< Prev", "Next >>" (which is highlighted with a dashed border), "Cancel", and "Finish".

Any additional seasonal charges may be added in this screen.

Rate Wizard

Enter Additional Seasonal Charges

Many rates include various seasonal charges that are added to the consumption and demand charges. Enter any values that apply:

Charges shown are for: Winter

Customer Charge: \$2000

Minimum Charge: \$0

Energy Cost Adjustment: \$0.014 /kWh

Click here to apply values to all seasons in rate

<< Prev Next >> Cancel Finish

Utility rate surcharges and tax rates are added in the following screen for all seasons. If desired, you may add a second set of surcharges and tax rates by checking the "Second Surcharge and Tax" checkbox, which will display an additional screen similar to this one when the Next>> button is clicked.

Rate Wizard

Enter Surcharge and Tax Rates

Practically all utility rates are subject to surcharges and taxes. Enter the appropriate values below:

The values shown are for: Winter

Second Surcharge and Tax Copy values to all seasons

First Surcharge

Select the surcharge as:

Percentage \$/kWh

% of the following:

- customer charge
- energy charge
- energy cost adjustment
- demand charge

First Tax

The tax rate is %

Taxes are applied to:

- customer charge
- energy charge
- energy cost adjustment
- demand charge
- first surcharge

<< Prev Next >> Cancel Finish

After all of the screens have been viewed and edited, the final screen, announcing the completion of the rate edit, is displayed. Clicking Done will save the rate.



User Guidance Wizard

The User Guidance Wizard provides additional guidance to new d-gen PRO users. The first time the application is run the user will be guided step by step through a distributed generation project analysis.

Note: When you do not need this additional guidance anymore, just check "do not show this screen anymore".

Load Shapes

This help section discusses the generic load shapes used by d-gen PRO, modifications made to the generic load shapes to match the energy use of a specific project, and the energy calculation process used for the base case and the generator case. The generic load shapes are modified by d-gen PRO using utility bill data entered by the user. The user may also modify any generic 24-hour load shape to match measured hourly load data or to create a hypothetical load shape.

Generic Load Shapes

d-gen PRO has weekday and weekend load profiles for the following 12 generic building types.

Apartment
Hospital
Hotel, Large
Hotel/Motel, Small
Industrial Building, Large
Office, Large (10 hour)
Office, Large (24 hour)
Prison
Restaurant, Fast-Food
Restaurant, Full-Service (Extended Hours)
Retail, Large
School, Secondary
Supermarket (18 hour)
Supermarket (24 hour)

The user selects one of the above building types during the process of defining the project.

Modifications to Generic Load Shapes

The user enters the energy billing data into d-gen PRO by choosing **Project Data |**



Enter Utility Bills | Enter Monthly Data from the menu or by pressing the button. The facility energy use data consists of the electricity and gas consumption for each month of the year in units of kWh/month and MMBtu/month, respectively. The electrical demand is also entered on this screen (in units of peak kW demand for each month).

d-gen PRO processes the monthly electric consumption and electric demand into 24-hour weekday and weekend profiles for each month by the following process:

1. Selecting the energy profile for building type designated by the user and creating a full year profile based on the weekday and weekend days for calendar year 1998.
2. Setting the profile peak demand to the actual peak demand for each month entered by the user, and
3. Adjusting the electric consumption for the month by increasing or decreasing the demand for each hour of the profile for each month to match the total entered by the user.

Copying load shapes

When creating a new load shape, it is often useful to start with values from existing load shapes that can then be edited. The Copy from... button allows you to copy values from an existing load shape into the one you are currently editing. You can

copy values from any contiguous ranges of months, broken down by electric and/or thermal load shapes and by weekends and/or weekdays.