Integrated Environmental Control Model

Model Tutorial

Prepared for the National Energy Technology Laboratory
U. S. Department of Energy

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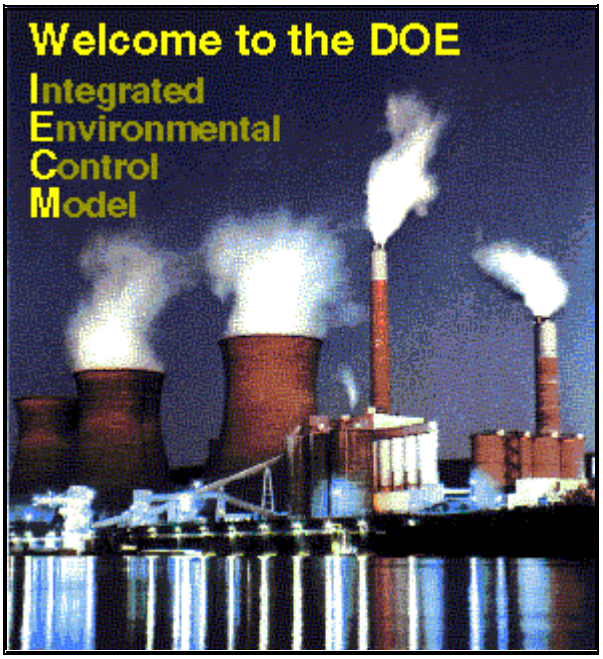

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Contents

Introduction

The Integrated Environmental Control Model

This Integrated Environmental Control Model (IECM) and Interface were developed for the U. S. Department of Energy's National Energy Technology Laboratory (NETL), formerly known as the Federal Energy Technology Center (FETC), under contracts No. DE-AC22-92PC91346 and DE-AC21-92MC29094.

Purpose

The purpose of the model is to calculate the performance, emissions and cost of employing alternative environmental control methods in a coal-fired power plant. The model consists of a base plant and various control technology modules; these modules may be implemented together in any desired combination.

A Graphical User Interface (GUI) facilitates the configuration of the technologies, entry of data, and retrieval of results.

System Requirements

The current model requires the following configuration:

- Intel-based computer running Windows 95 (or better) or Windows NT 4.0 (or better) operating system
- Pentium Processor
- any SVGA (or better) display—at a resolution of 800x600 (or more) pixels[1]
- at least 40 Megabytes of free hard disk space
- at least 32 Megabytes of total memory

[1] Smaller screen resolution results in the interface screens being scaled smaller. The taskbar, part of the Windows operating system, reduces the useable resolution of the screen if it is always visible. This may force the IECM interface to be scaled down slightly. To avoid this situation, select the "Auto Hide" option of the Taskbar properties in Windows.

Uncertainty Features

The ability to characterize uncertainties explicitly is a feature unique to this model. As many as one hundred input parameters can be assigned probability distributions. When input parameters are uncertain, an uncertainty distribution of results is returned. Such result distributions give the *likelihood* of a particular value, in contrast to conventional single-value estimates.

The model can run using single deterministic values or uncertainty distributions. The conventional deterministic form using single values for all input parameters and results may be used, or probabilistic analyses may be run—for instance, to analyze advanced technology costs.

Software Used in Development

The underlying engineering models are written in Digital Equipment Corporation's Fortran. Fortran runtime libraries are included with the IECM Interface software. This language provides the flexibility to configure many various power plant designs while also providing the power to conduct probabilistic analyses.

All databases are in Microsoft® Access format and may be viewed in Access, as long as they are not changed. This format is a software industry standard and facilitates sharing and updating of information.

To simplify the use of the model, a Graphical User Interface (GUI) has been added. The interface eliminates the need to master the underlying commands normally required for model operation. The interface is written in Microsoft® Visual C++, a standard software development tool for the Windows environment. Visual C++ runtime libraries are included with the IECM Model software and do not need to be licensed separately.

Wise InstallBuilder was used to generate full and upgrade installer programs. This product was chosen based on its flexibility and its support of Visual Basic runtime libraries and Microsoft Data Access Components (MDAC)[2]. The Visual Basic runtime libraries provide the support needed to run the database file compactor program provided with the IECM. MDAC provides the software support needed to link Microsoft® Access data files to the IECM interface program. Wise InstallBuilder provides the VB and MDAC installation as an option, rather than forcing the user to download it from Microsoft and install it prior to installing the IECM.

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[2] The current version of MDAC is 2.5. This is installed with the full installer for the IECM 3.4. Any update installers provided for upgrading the IECM from version 3.4 to a higher version does not upgrade MDAC unless the user updates MDAC separately.

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User Documentation and Help

Getting Started

Getting Started gives step-by-step instructions for installing the model software and using the interface. It describes navigating the model, using the main program areas, working with sessions, and printing or exporting results.

User Manual

The *User Manual* gives further information on both the interface and the underlying model. It provides detailed descriptions of plant configurations, parameter settings, and result screens. It also describes technical details behind the model's operation and includes an introduction to uncertainty analysis.

Model Tutorial

The *Model Tutorial* is a pictorial introduction to the IECM. It presents a graphical tour of the interface, a case study to follow using the model, and an appendix, which reproduces every screen in the model. These tools help any user to quickly become more familiar with the interface and model.

Technical Manual

The *Technical manual* is a detailed engineering description of the technologies and costing assumptions used in the IECM. This manual is not provided by default with the IECM software; however, it can be downloaded with any web browser from http://www.iecm-online.com/.

Online Help

Online help is provided via a Windows Help File containing the text of *Getting Started* and the *User Manual*.

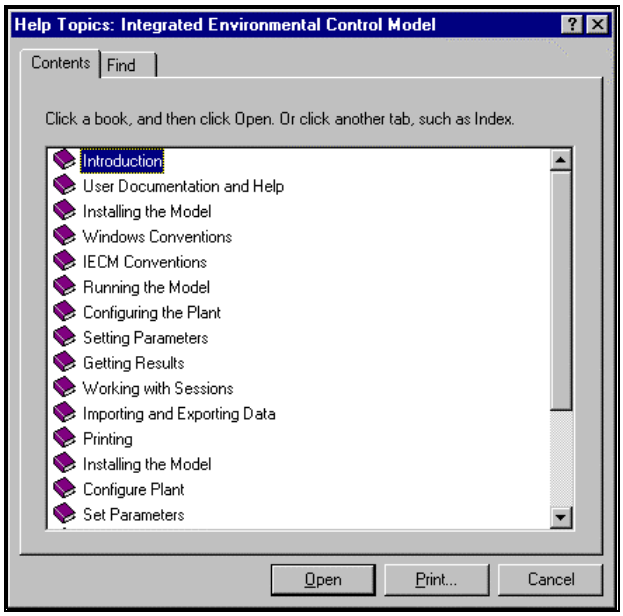
Accessing the IECM Help file:

If you are not running the IECM interface, click the **Help** icon inside the IECM folder on the **Start** menu. This opens the help file to the table of contents.

If you are running the IECM interface, do any one of the following:

- Press the **F1** key. The IECM supports context-sensitive help and will open the help file to the topic associated with the item or screen you are viewing.
- Pull down the **Help** menu at the top of the IECM window. Select **Help Topics**. This opens the help file to the table of contents.
- Click the **Context-Sensitive Help** icon on the toolbar on the left side of the IECM window. The IECM supports context-sensitive help and will open the help file to the topic associated with the item or screen you are viewing.
- Click the **Help Topics** icon on the toolbar on the left side of the IECM window. This opens the help file to the table of contents.

The IECM Help File Contents window will display.



The IECM Help File Topics Window

A Tour of the Interface

The Tour

This tour gives a graphical introduction to the interface. It reproduces and describes the commonly used screens of the interface so that you become familiar with how the model functions.

The IECM Window and Logo Box

When you first start the model, the IECM Interface Window and Logo Box will display.

The IECM Logo Box

The Logo Box will disappear in 5 seconds, after which just the IECM Window will remain and the interface will be ready for use. The IECM Window contains all the screens used by the Interface.

The IECM Window

Note the various tools used to control the software:

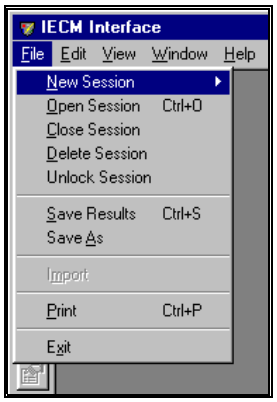
1. Pull-down menus—**File**, **View**, **Window**, **Help** in the upper left hand corner of the screen.
2. The Toolbar—the row of buttons running down the left-hand side of the screen.

Opening a Session

A session is defined as the power plant configuration and all the parameters associated with the plant technologies or components. The configuration, input values, and results are all stored in a file on your computer for each session you save.

The figure in the previous section shows the IECM with no sessions open. A session must be opened in order to use the IECM. You can open a new or existing session by using an option present under the **File** menu. Either clicking on the menu in the menubar or typing the letter "F" on the keyboard while holding down the "Alt" key can open the menu. A more detailed description of the menubar, its content and its use, can be found in the *Getting Started* manual.

Below is a figure showing the **File** menu after being clicked. Each item in the menu is described in more detail below the figure. Although the **New Session** and **Open Session** menu items are used to open a session, the other items in the menu are also described. They deal with other ways of dealing with the file holding your session data.



The File menu

You may choose the following commands from the file menu:

New Session – Creates a new session from model defaults.

Open Session – Opens a previously created session.

Close Session – Closes the currently active session.

Delete Session – Deletes a session.

Unlock Session – Unlocks a session that was not closed normally (e.g. because of a crash or loss of network connectivity.

Save Results – Saves the results from a session in an external file.

Save As – Saves a session with a different name.

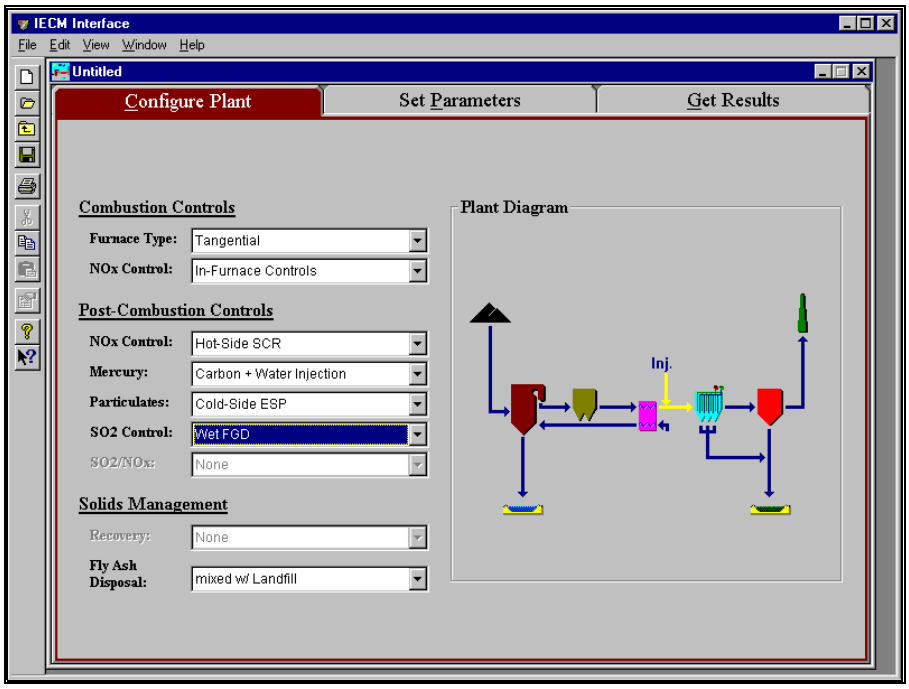
Import – Imports a session from an external database file.

Print – Prints configuration settings, inputs or results.

Exit – Closes the current session and exits the interface.

Configure Plant

The first program area—and the first screen displayed—is **Configure Plant**.



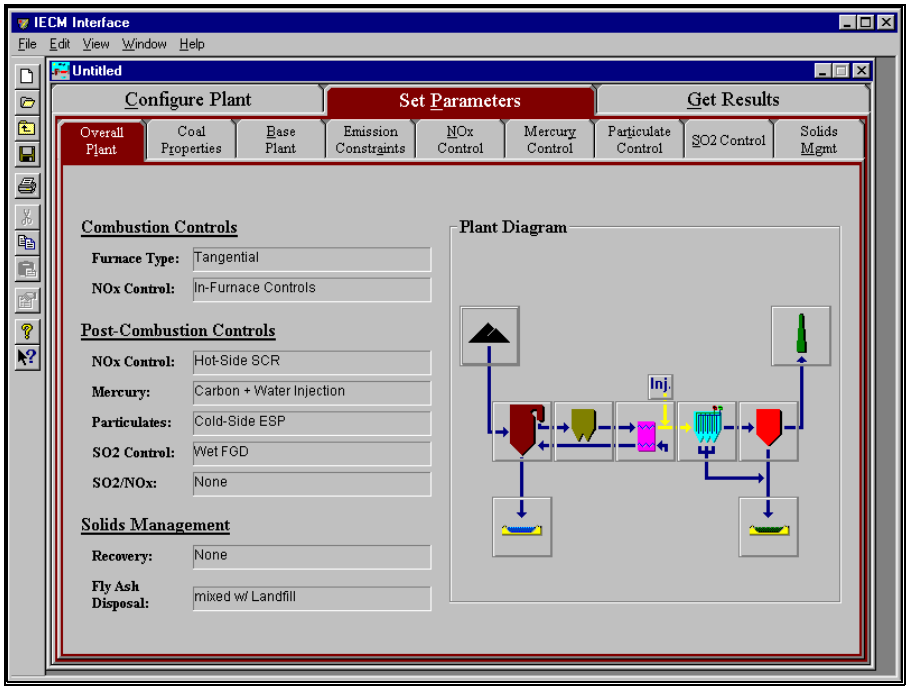
The Configure Plant Program Area

On this screen you choose the technologies implemented by the plant and how they operate. Available options are presented via pull-down menus on the left side of the screen. A "Plant Diagram" displays on the right side of the screen and reflects the various plant technologies you have chosen.

Note the three tabs at the top of the screen. Clicking one of these tabs chooses the program area you are in. The three program areas are **Configure Plant**, **Set Parameters**, and **Get Results**.

Set Parameters

The second program area is **Set Parameters**. From this area you can modify the input values for this session.



The Set Parameters Program Area

Note the nine tabs below the program area navigation tabs at the top of the screen. Clicking one of these tabs chooses the input area you will use. The input screens correspond to the various technologies chosen in **Configure Plant**.

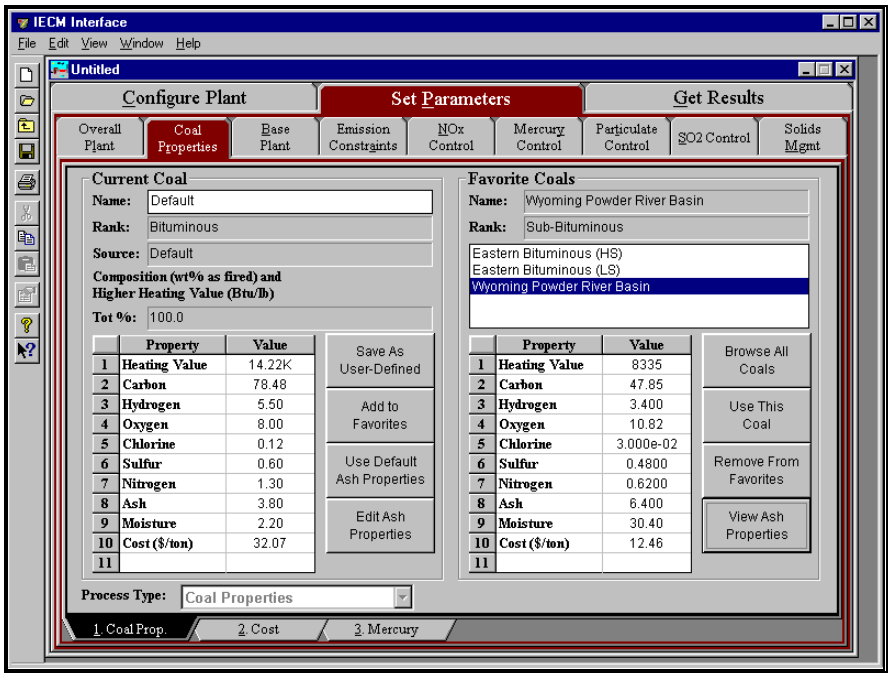
Overall Plant

The first tab of the **Set Parameters** program area is for the **Overall Plant** (see picture above). This screen displays the plant configuration settings on the left side of the page and a diagram of the plant as configured at the right of the page. No inputs are entered on this screen.

The Plant Diagram in **Set Parameters** may be used as an alternate way to move among input Technology Navigation Tabs. Clicking the button of the technology for which you would like to provide inputs chooses that input screen.

Coal Properties

The second tab of the **Set Parameters** program area is for the **Coal Properties** input area. Inputs in this area define the composition of the coal, composition of the ash, and cost of the coal used in the plant for this session.



The Coal Properties—1. Coal Prop. input screen

Note the two tabs at the bottom of the screen. Clicking one of these tabs chooses the input screen you will use. The two screens for **Coal Properties** are **1. Properties** and **2. Cost**.

1. Properties

The first screen of the **Coal Properties** input area is the **1. Properties** input screen (see picture above). The type of coal and its properties are selected on this screen.

There are two panes: one for the ash and coal properties of the **Current Coal**, the other for those of **Favorite Coals**. The current coal is the coal which the model will conduct its calculations. Favorite coals are those that you use most. From this screen, you may choose a favorite coal, choose a coal from the model defaults, enter a user-defined coal, choose a previously saved user-defined coal, or manage your coal lists.

Ash properties are provided by default with each model default coal. User-defined coals must have ash properties provided by the user. If none are provided, properties of a similar coal are defined based on the sulfur content of the coal and coal rank.

Please refer to the "User Manual" for more information on the use of the buttons and other options on this input screen. Detailed instructions for choosing, modifying, or adding a coal and its properties are described there.

2. Cost

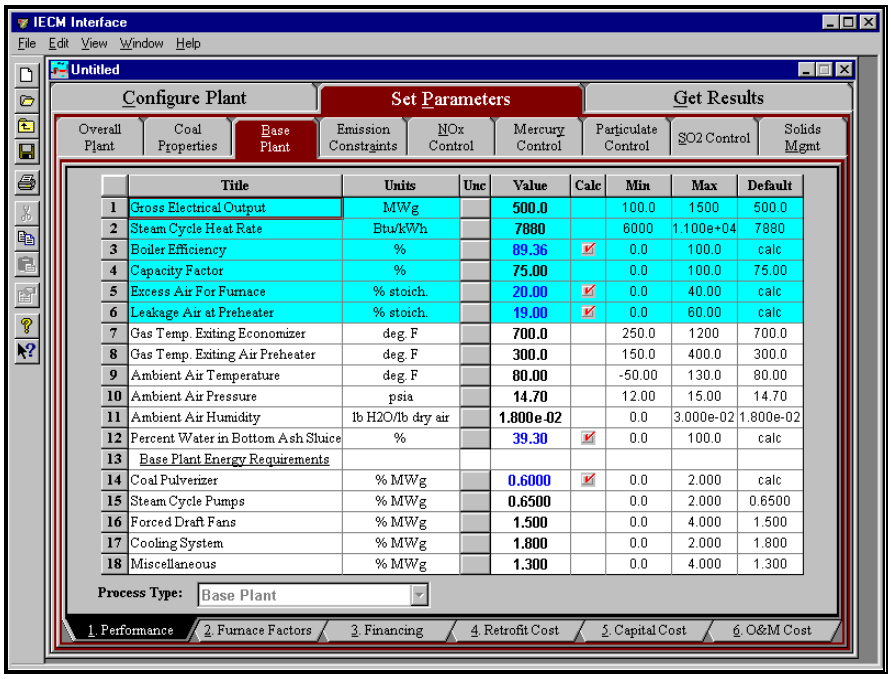
The second screen of the **Coal Properties** input area is the **2. Cost** input screen. The cost of the cleaned coal, transportation costs, and other miscellaneous coal costs are accessed on the **2. Cost** input screen.

3. Mercury

The third screen of the **Coal Properties** input area is the **3. Mercury** input screen. The concentration in the coal and speciation of Mercury in the flue gasare defined here.

Base Plant

The second tab of the **Set Parameters** program area is for the **Base Plant** input area. Inputs in this area define performance and costs directly associated with the base power plant, particularly the boiler.



	Title	Units	Unc	Value	Calc	Min	Max	Default
1	Gross Electrical Output	MWg		500.0		100.0	1500	500.0
2	Steam Cycle Heat Rate	Btu/kWh		7880		6000	1.100e+04	7880
3	Boiler Efficiency	%		89.36	☑	0.0	100.0	calc
4	Capacity Factor	%		75.00		0.0	100.0	75.00
5	Excess Air For Furnace	% stoich.		20.00	☑	0.0	40.00	calc
6	Leakage Air at Preheater	% stoich.		19.00	☑	0.0	60.00	calc
7	Gas Temp. Exiting Economizer	deg. F		700.0		250.0	1200	700.0
8	Gas Temp. Exiting Air Preheater	deg. F		300.0		150.0	400.0	300.0
9	Ambient Air Temperature	deg. F		80.00		-50.00	130.0	80.00
10	Ambient Air Pressure	psia		14.70		12.00	15.00	14.70
11	Ambient Air Humidity	lb H2O/lb dry air		1.800e-02		0.0	3.000e-02	1.800e-02
12	Percent Water in Bottom Ash Sluice	%		39.30	☑	0.0	100.0	calc
13	Base Plant Energy Requirements							
14	Coal Pulverizer	% MWg		0.6000	☑	0.0	2.000	calc
15	Steam Cycle Pumps	% MWg		0.6500		0.0	2.000	0.6500
16	Forced Draft Fans	% MWg		1.500		0.0	4.000	1.500
17	Cooling System	% MWg		1.800		0.0	2.000	1.800
18	Miscellaneous	% MWg		1.300		0.0	4.000	1.300

The Base Plant—1. Performance input screen

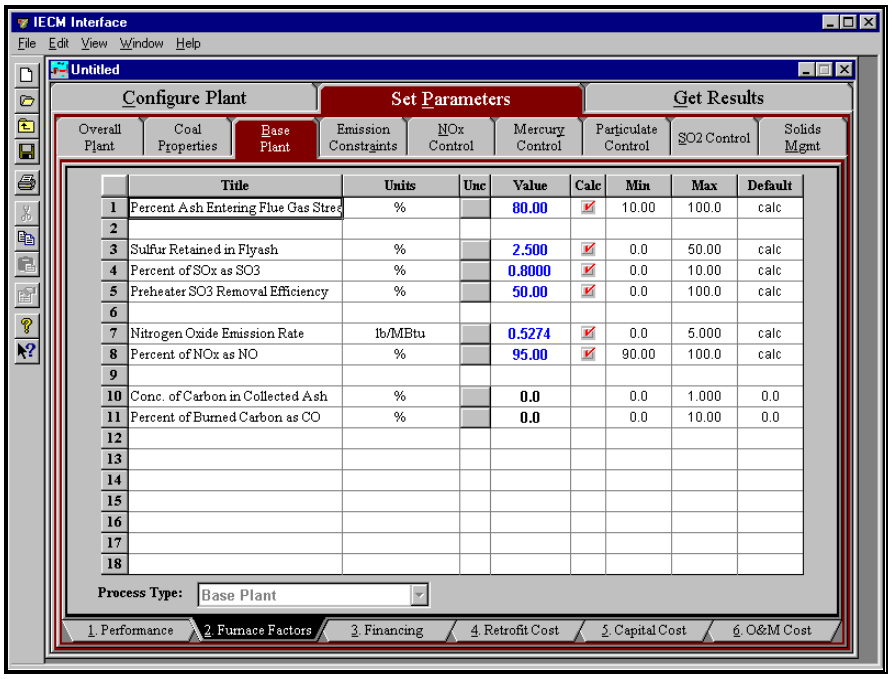
Note the six tabs at the bottom of the screen. Clicking one of these tabs chooses the input screen you will use. The **Base Plant** input area contains a Performance screen and five screens having to do with cost parameters.

1. Performance

The first screen of the **Base Plant** input area is the **1. Performance** input screen (see picture above). Inputs determining the overall plant size, temperature profiles, and major flow rates and concentrations of the gas and solids streams are entered on this screen. The first six inputs are highlighted in blue to point out their importance.

2. Furnace Factors

The second input screen in this section defines the emission rates of various gas components of the flue gas during the combustion of fuel. The emission of carbon, ash, sulfur and nitrogen are specified by the United States Government's Environmental Protection Agency's (EPA) compilation of emission factors. Also included from the compilation are the incomplete transfer percentages of solid and gaseous forms of these substances.

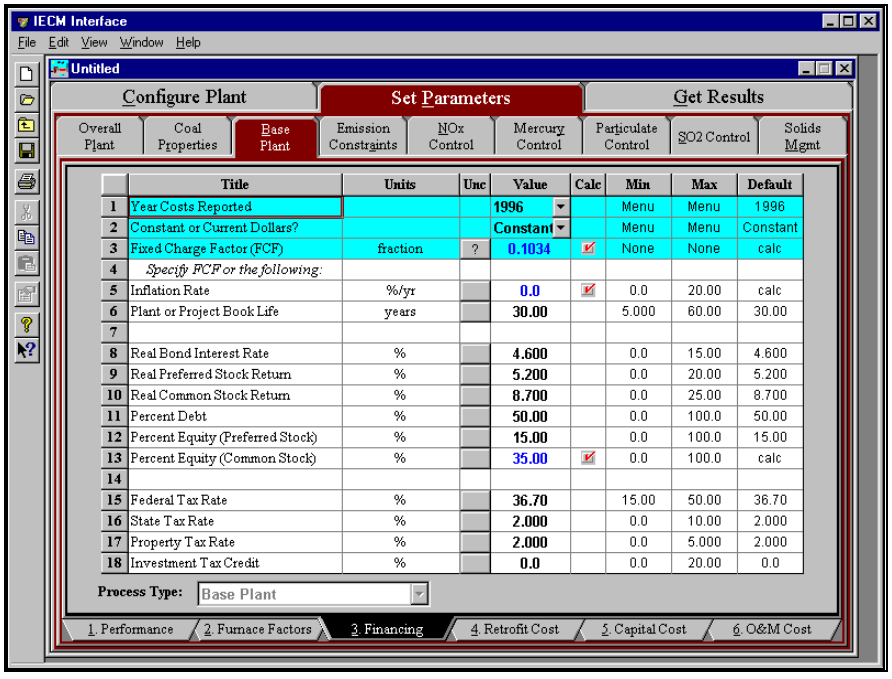


	Title	Units	Unc	Value	Calc	Min	Max	Default
1	Percent Ash Entering Flue Gas Strea	%		80.00	☑	10.00	100.0	calc
2								
3	Sulfur Retained in Flyash	%		2.500	☑	0.0	50.00	calc
4	Percent of SOx as SO3	%		0.8000	☑	0.0	10.00	calc
5	Preheater SO3 Removal Efficiency	%		50.00	☑	0.0	100.0	calc
6								
7	Nitrogen Oxide Emission Rate	lb/MBtu		0.5274	☑	0.0	5.000	calc
8	Percent of NOx as NO	%		95.00	☑	90.00	100.0	calc
9								
10	Conc. of Carbon in Collected Ash	%		0.0		0.0	1.000	0.0
11	Percent of Burned Carbon as CO	%		0.0		0.0	10.00	0.0
12								
13								
14								
15								
16								
17								
18								

The Base Plant —2. Furnace Factors input screen

3. Financing

The third base plant input screen describes the factors required to determine the carrying charge for all capital investments. The carrying charge is defined as the revenue required to pay for any capital investment. The total charge can also be expressed as a levelized cost factor or fixed charge factor.

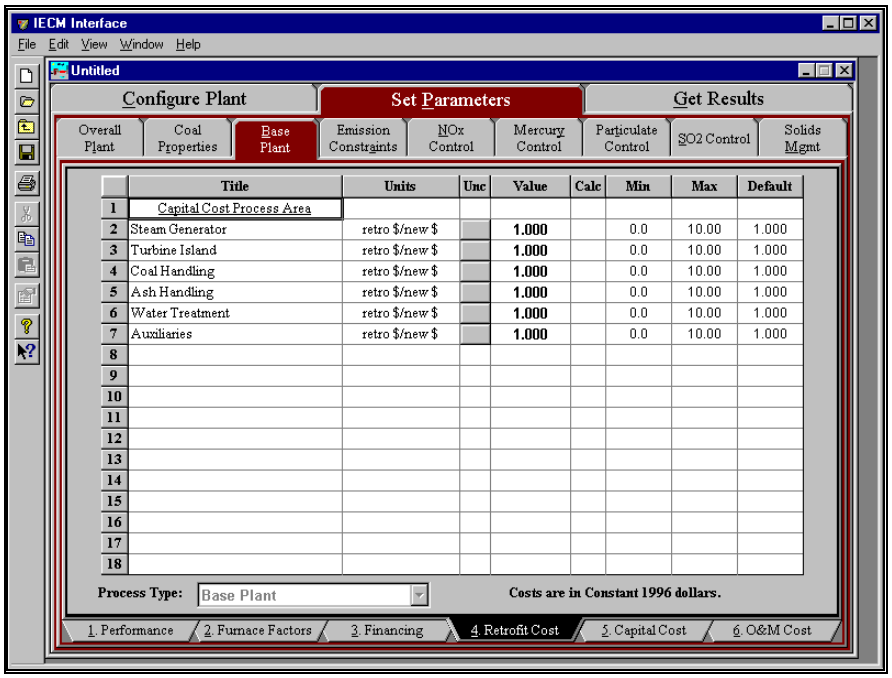


	Title	Units	Unc	Value	Calc	Min	Max	Default
1	Year Costs Reported			1996		Menu	Menu	1996
2	Constant or Current Dollars?			Constant		Menu	Menu	Constant
3	Fixed Charge Factor (FCF)	fraction	?	0.1034	☑	None	None	calc
4	*Specify FCF or the following:*							
5	Inflation Rate	%/yr		0.0	☑	0.0	20.00	calc
6	Plant or Project Book Life	years		30.00		5.000	60.00	30.00
7								
8	Real Bond Interest Rate	%		4.600		0.0	15.00	4.600
9	Real Preferred Stock Return	%		5.200		0.0	20.00	5.200
10	Real Common Stock Return	%		8.700		0.0	25.00	8.700
11	Percent Debt	%		50.00		0.0	100.0	50.00
12	Percent Equity (Preferred Stock)	%		15.00		0.0	100.0	15.00
13	Percent Equity (Common Stock)	%		35.00	☑	0.0	100.0	calc
14								
15	Federal Tax Rate	%		36.70		15.00	50.00	36.70
16	State Tax Rate	%		2.000		0.0	10.00	2.000
17	Property Tax Rate	%		2.000		0.0	5.000	2.000
18	Investment Tax Credit	%		0.0		0.0	20.00	0.0

The Base Plant—3. Financing input screen

4. Retrofit Cost

The fourth screen of the **Base Plant** input area is the **4. Retrofit Cost** input screen, shown below. The retrofit cost factor of each process is a multiplicative cost adjustment, which considers the cost of retrofitted capital equipment relative to similar equipment installed in a new plant. These factors affect the capital costs directly and the operating and maintenance costs indirectly. Every technology tab of the **Set Parameters** program area contains a retrofit cost input screen.

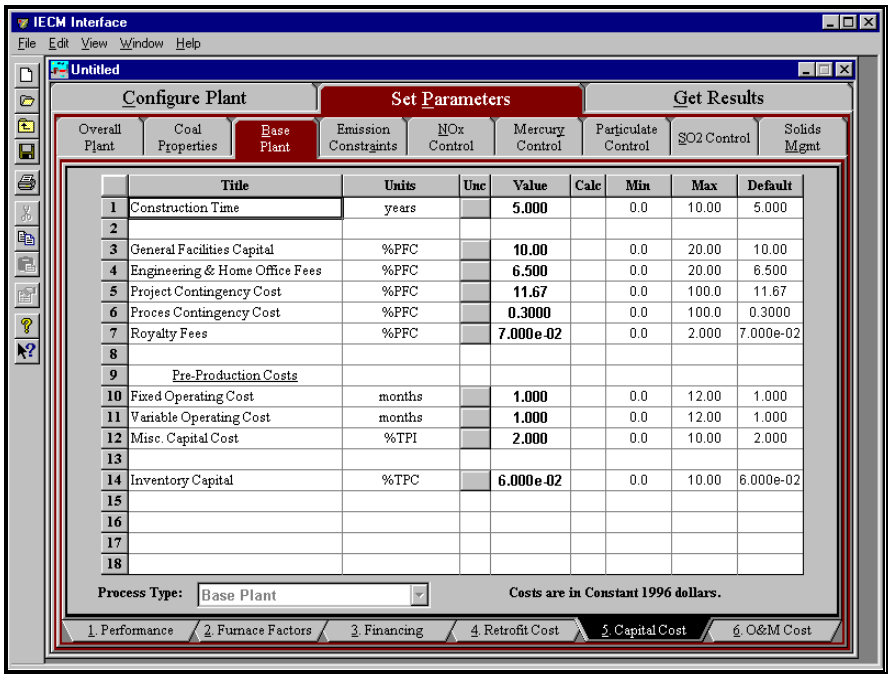


The Base Plant—4. Retrofit Cost input screen

5. Capital Cost

The fifth screen of the **Base Plant** input area is the **5. Capital Cost** input screen, shown below. The necessary capital cost input parameters associated with the base plant are on this input screen. Every technology tab of the **Set Parameters** program area contains a capital cost input screen.

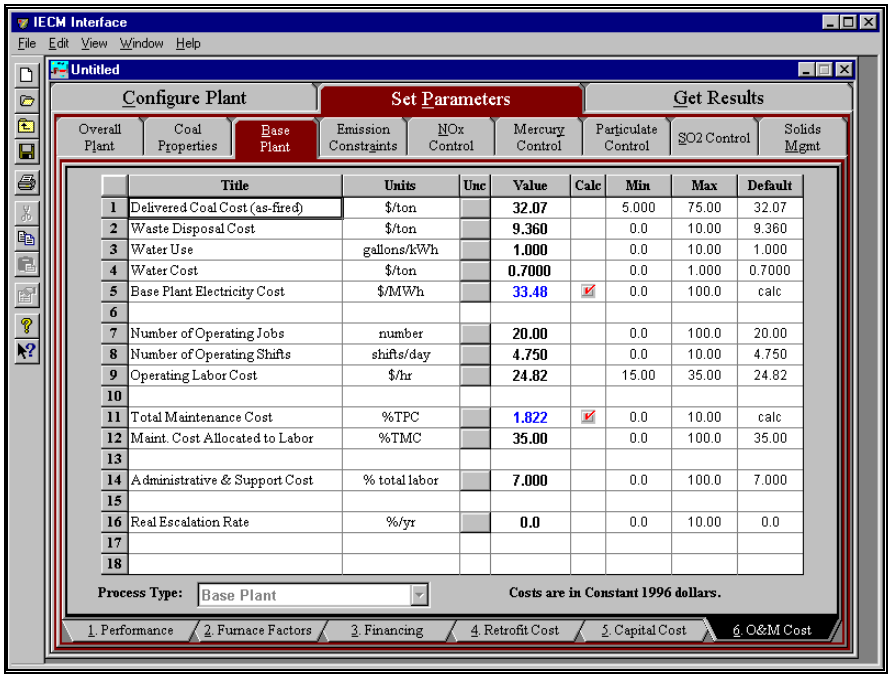
The capital cost parameters and terminology used in the IECM are based on the methodologies developed by the Electric Power Research Institute (EPRI). They have prepared a Technical Assessment Guide (TAG) to provide a consistent basis for reporting cost and revenues associated with the electric power industry. The IECM has been developed around this TAG system so that costs associated with various technologies can be compared directly on a consistent basis and communicated in the language used by energy engineers, researchers, planners, and managers.



The Base Plant—5. Capital Cost input screen

6. O&M Cost

Inputs for the operation and maintenance costs of the base plant itself are entered on the **6. O&M Cost** input screen, shown below. O&M is a short form for "operating and maintenance." Every technology tab of the **Set Parameters** program area contains an O&M cost input screen.



The Base Plant—6. O&M Cost input screen

The EPRI TAG method of categorization has been also used for operating and maintenance cost screens. It provides a consistent basis of reporting for a wider audience of users.

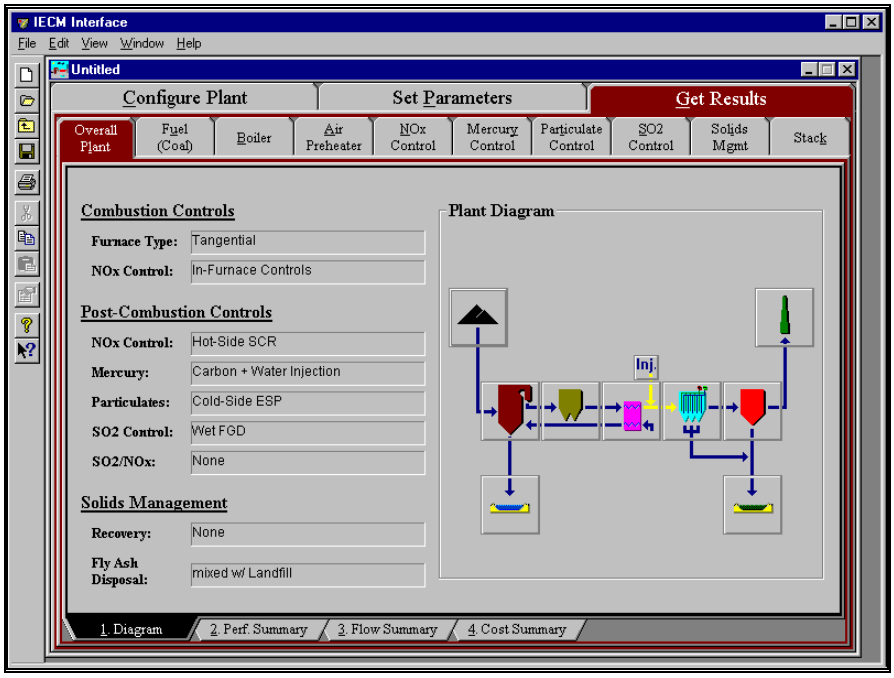
Other Input Areas

As has been noted, there are up to nine input areas, depending on the technologies selected in **Configure Plant**. Each contains performance and/or cost screens as is appropriate to the technology. Each will have at least one performance input screen, one retrofit cost screen, one capital cost screen, and one O&M cost screen.

The detail of each parameter on each screen is described in detail in the "User Manual." The general use of the options shown on the input screens is described in more detail in the *Getting Started* manual.

Get Results

The third program area is **Get Results**. From this area you can view the results for the session.



The Overall Plant—1. Diagram screen

Note the nine tabs below the program area navigation tabs at the top of the screen. Clicking one of these tabs chooses the result area that displays. The result screens correspond to the various technologies chosen in **Configure Plant**.

Note also the four tabs at the bottom of the screen. Clicking one of these tabs chooses the result screen in the particular area that displays.

Overall Plant

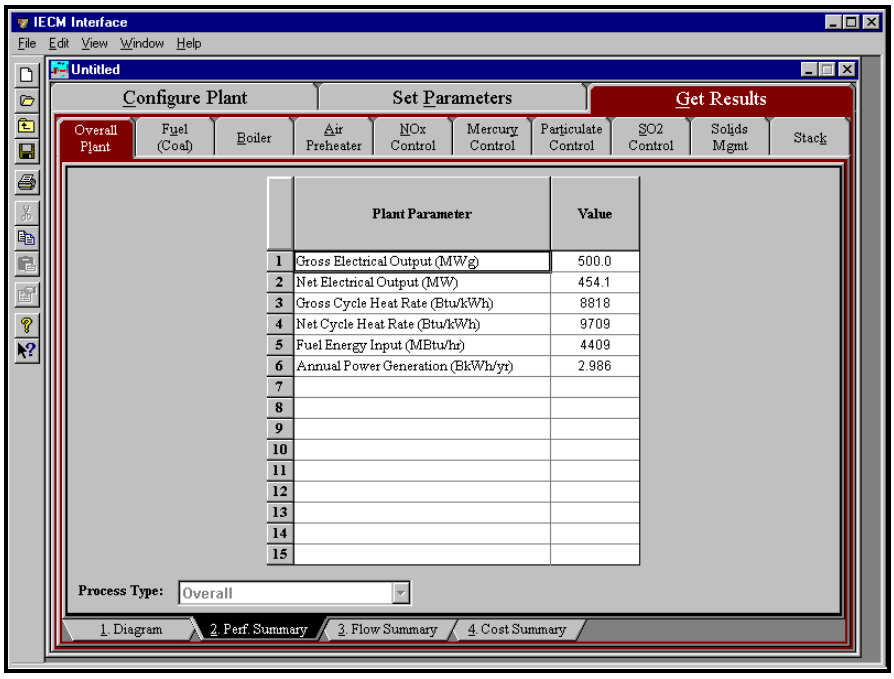
The first tab of the **Get Results** program area is for the **Overall Plant**. This area contains result screens for the plant as a whole.

1. Diagram

The first screen of the **Overall Plant** result area is the **1. Diagram** result screen (see picture above). It displays the plant configuration settings on the left side of the page and a diagram of the plant as configured at the right of the page. No results are displayed on this screen.

2. Performance Summary

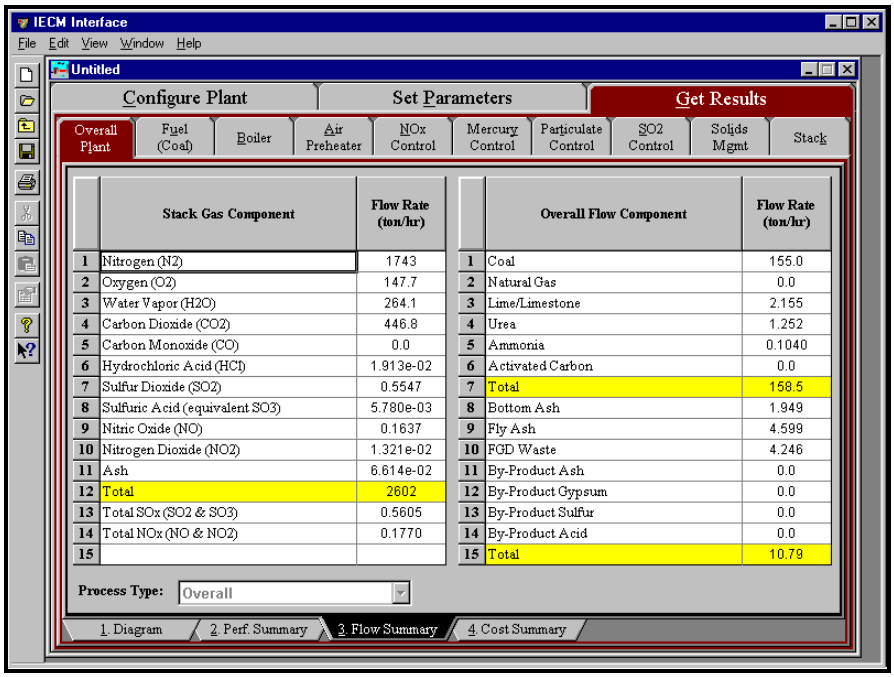
The second screen of the **Overall Plant** result area is the 2. **Perf. Summary** result screen. It displays performance results for the plant as a whole. Values for the major input and outputs of the power plant are given.



The Overall Plant—2. Perf. Summary result screen

3. Flow Summary

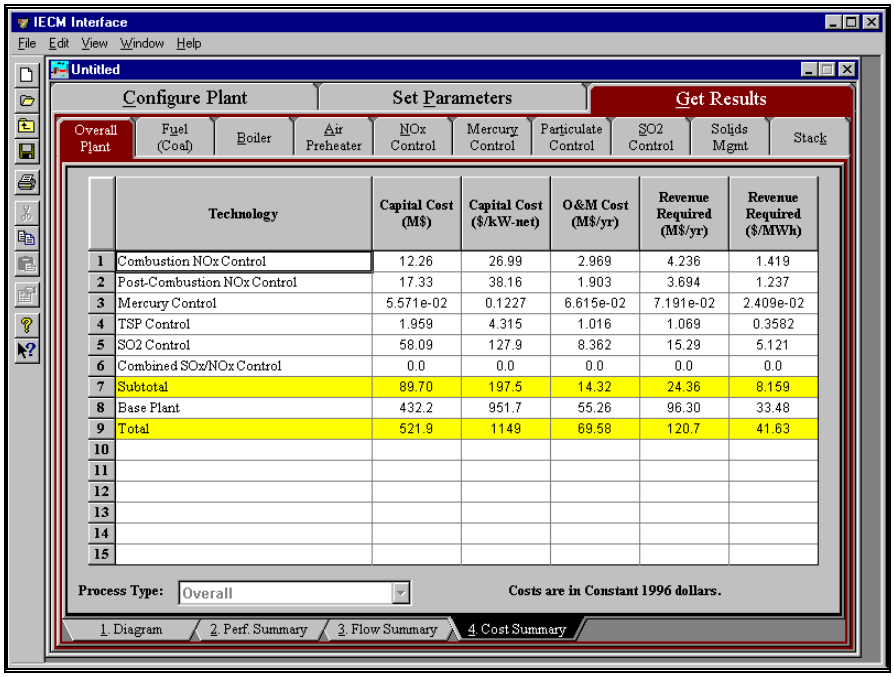
The third screen of the **Overall Plant** result area is the **3. Flow Summary** result screen. It displays values for the major flows in, through and out of the power plant. Subtotals and totals are highlighted with yellow on this and all result screens.



The Overall Plant—3. Flow Summary result screen

4. Cost Summary

The fourth screen of the **Overall Plant** result area is the **4. Cost Summary** result screen. It displays costs associated with the power plant as a whole. Details of each of the values shown on this screen can be accessed in the cost tables for each separate technology. This is described in more detail in the following sections.



The Overall Plant—4. Cost Summary result screen

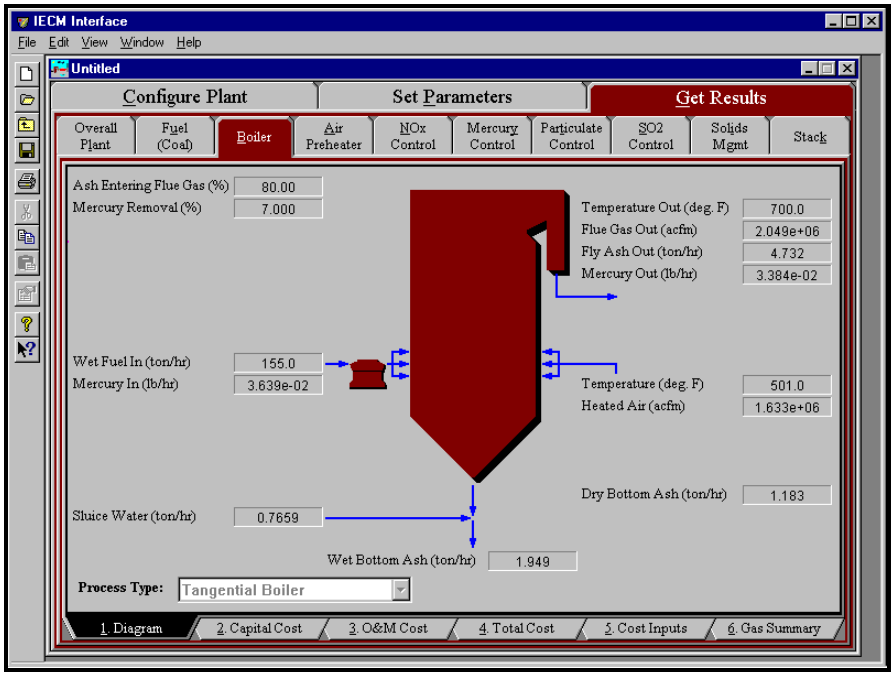
Boiler

The third tab in the **Get Results** program area is for the **Boiler** result area. It contains result screens for flows and costs related to the Boiler itself. The individual result screens for this result area will be described in the following sections. They are representative of all the result screens for the remainder of the result areas in the **Get Results** program area.

Each result area contains the same result screens. The first is a pictorial diagram with the major flow rates, temperatures, and performance values. The second screen is a table summarizing the capital costs. The third result screen shows a detailed breakdown of the O&M costs. The fourth screen summarizes the total costs shown on the second and third screens but on an annualized basis. The fifth screen summarizes the input parameters used to derive the results on the second, third and fourth screens. The sixth and last screen summarizes the flue gas component flow rates in and out of the device.

1. Diagram

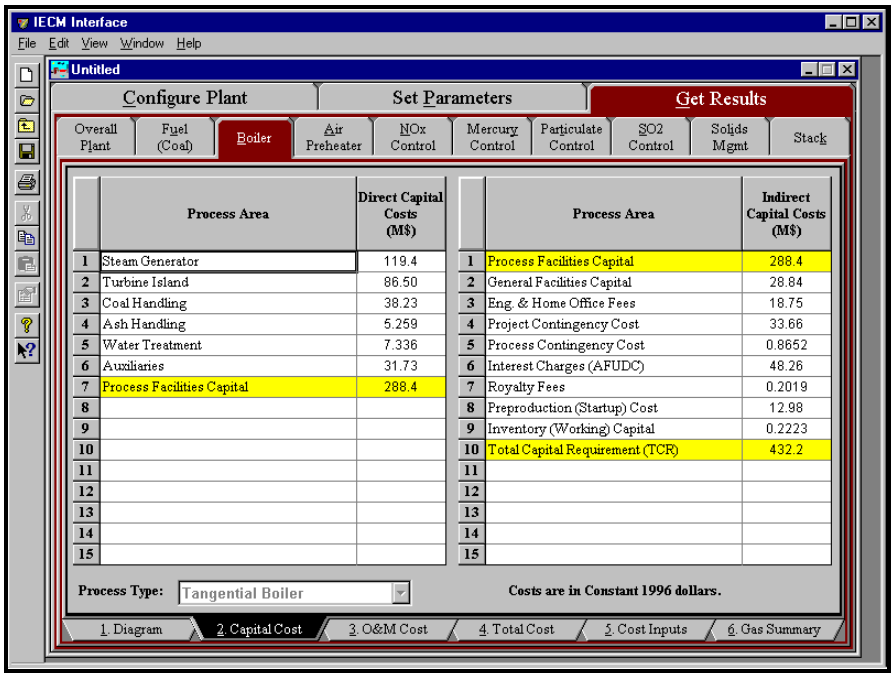
The first screen in the **Boiler** result area is the **1. Diagram** result screen. It displays an icon for the Boiler and values for major flows in and out of it.



The Boiler—1. Diagram result screen

2. Capital Cost

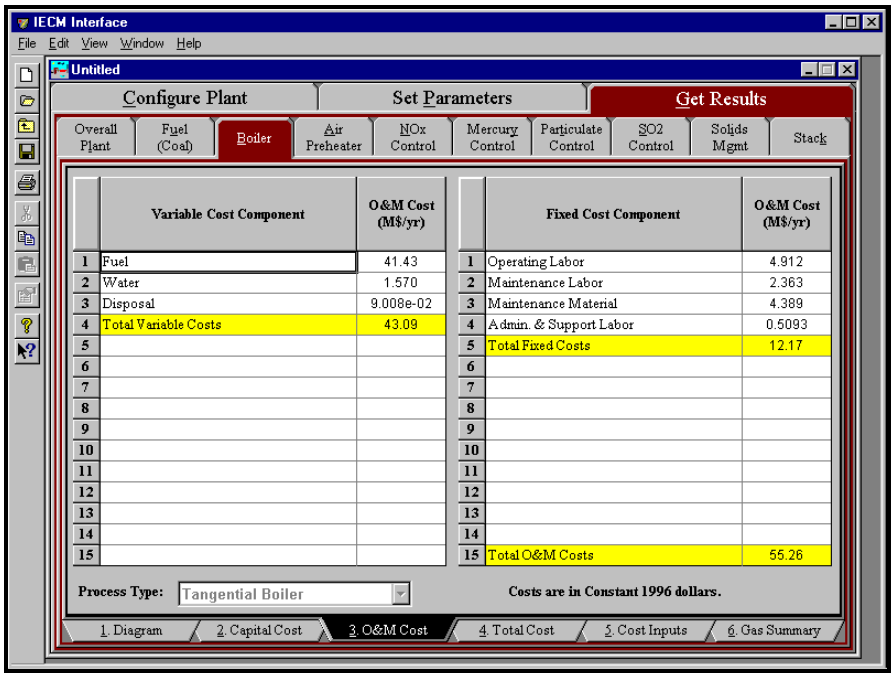
The second screen in the **Boiler** result area is the **2. Capital Cost** result screen. It displays tables for the direct and indirect capital costs related to the Boiler.



The Boiler—2. Capital Cost result screen

3. O&M Cost

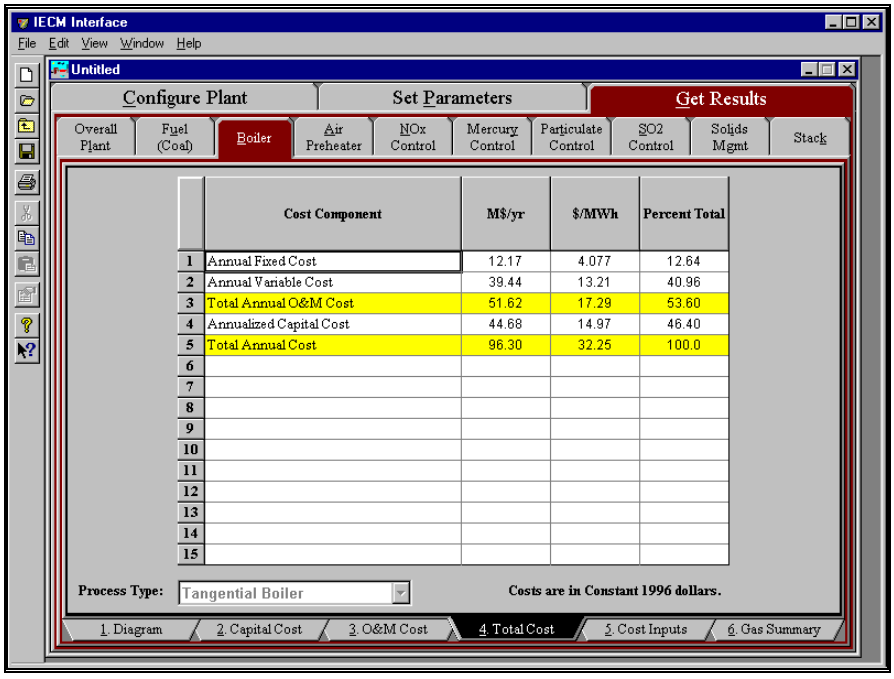
The third screen in the **Boiler** result area is the **3. O&M Cost** result screen. It displays tables for the variable and fixed operation and maintenance costs involved with the Boiler.



The Boiler—3. O&M Cost result screen

4. Total Cost

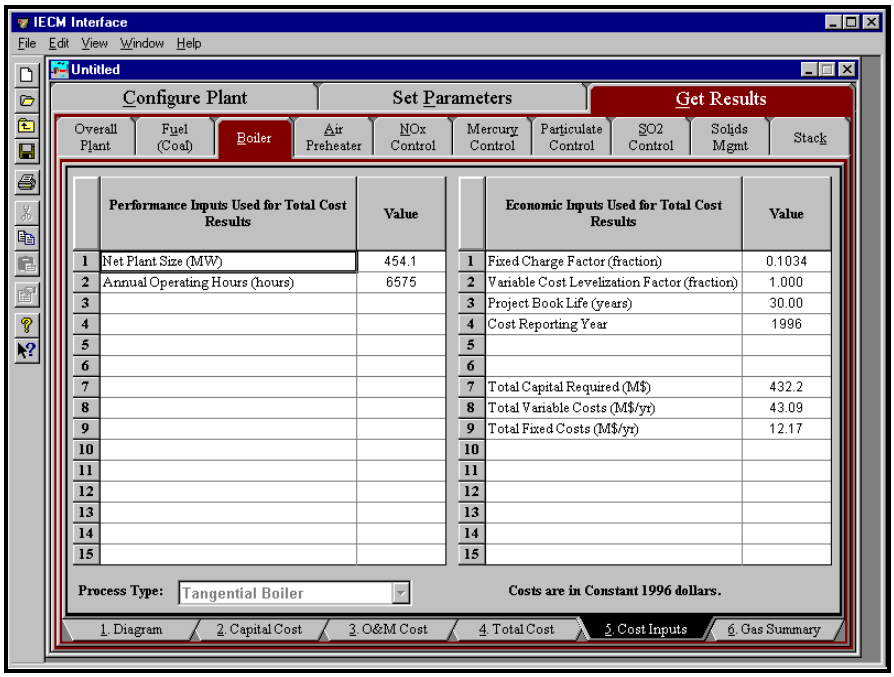
The fourth screen in the **Boiler** result area is the **4. Total Cost** result screen. It displays a table which totals the annual fixed, variable, operations and maintenance, and capital costs associated with the boiler.



The Boiler—4. Total Cost result screen

5. Cost Inputs

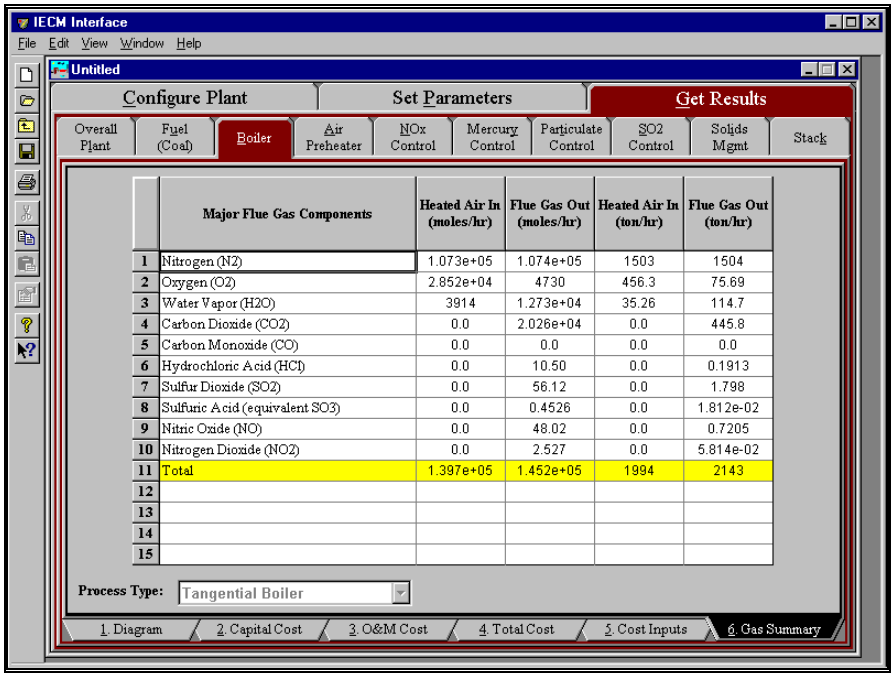
The fifth screen in the **Boiler** result area is the **5. Cost Inputs** result screen. It displays tables for the performance and economic inputs used in deriving total costs for the boiler.



The Boiler—5. Cost Inputs result screen

6. Gas Summary

The sixth screen in the **Boiler** result area is the **6. Gas Summary** result screen. It displays a table of quantities of flue gas components entering the boiler in heated air and exiting the boiler in the flue gas. For each component, quantities are given in both moles and mass per hour.



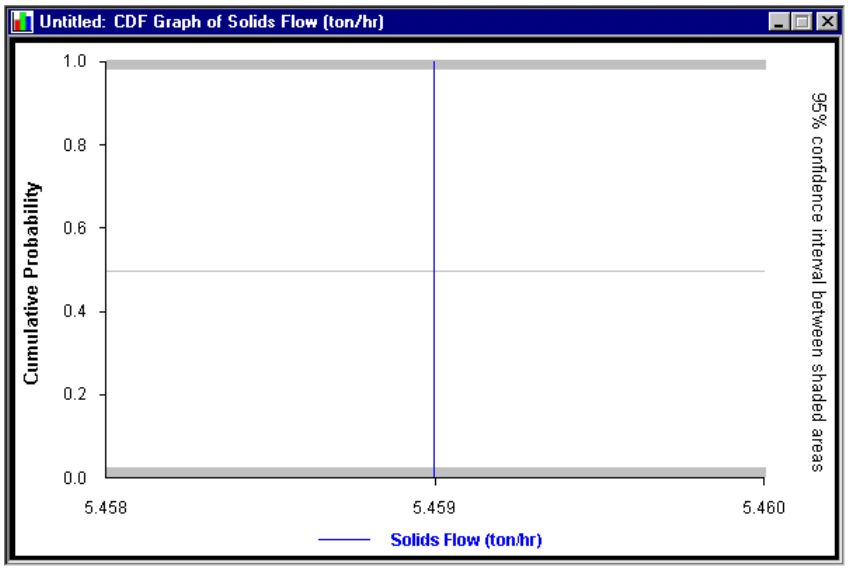
The Boiler—6. Gas Summary result screen

Other Result Areas

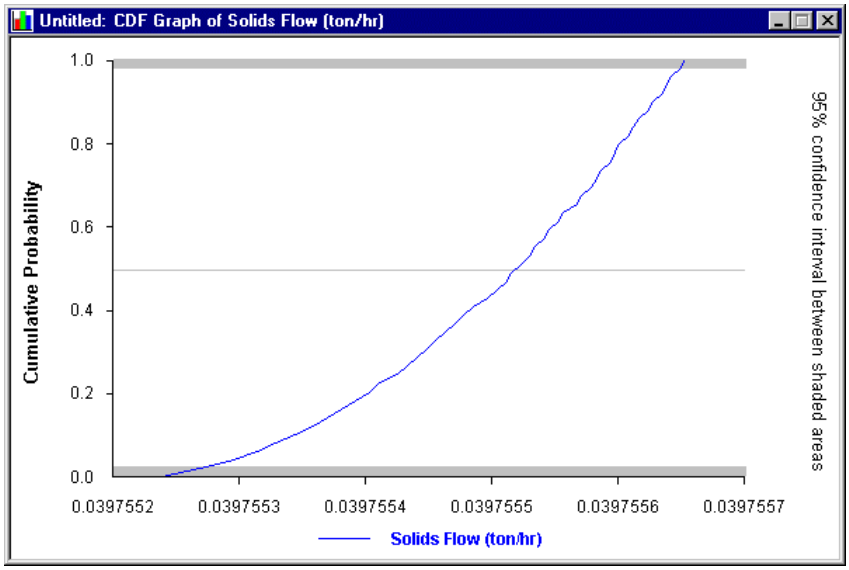
As has been noted, there are up to nine result areas, depending on the technologies selected in **Configure Plant**. Each contains diagram and/or cost screens as is appropriate to the technology.

Graphs

Double-clicking any of the result values given on any of the result screens displays a graph of the value. While all of the values displayed in diagrams and tables are deterministic, some have uncertainty in their calculation. If there is no uncertainty in the value's calculation, the graph displays a vertical line. If uncertainty is present, the graph displays a curve of all possible values.



Boiler Flue Gas Solids Flow Graph (Deterministic Result)



ESP Flue Gas Out Solids Flow Graph (Uncertain Result)

Case Study

The Case Study

This chapter is meant to be used with the IECM Interface installed and running. The case study takes you to the commonly used screens described in the previous chapter. It is recommended that you:

1. Follow the directions to set up a plant, enter input parameters, and look at results for the sample plant and
2. compare the screen shots to the screens you see.

Installing the IECM Software

To install the IECM software, see the instructions in *Getting Started* and the *User Manual*.

The IECM Window and Logo Box

Once you have installed the IECM software, a program group called “IECM Interface” will appear in the **Programs** group in the Start Menu. To start the Model, click the **IECM Interface** icon in the Start Menu.

The IECM Logo Box

The model will launch, and the IECM Interface Window and Logo Box will display.

The Logo Box will disappear in 5 seconds, after which the interface will be ready for use. You may also click the **Close** button in the upper right hand corner of the logo box to begin.

Once launched, the IECM Window displays. The IECM Window contains all the screens used by the Interface and all the tools that control the software.

The IECM Window

The New Session Dialog Box

The first time you use the software, you will have to create a new session. At subsequent startups, you can create a new session or use a previously saved session.

To create a new session:

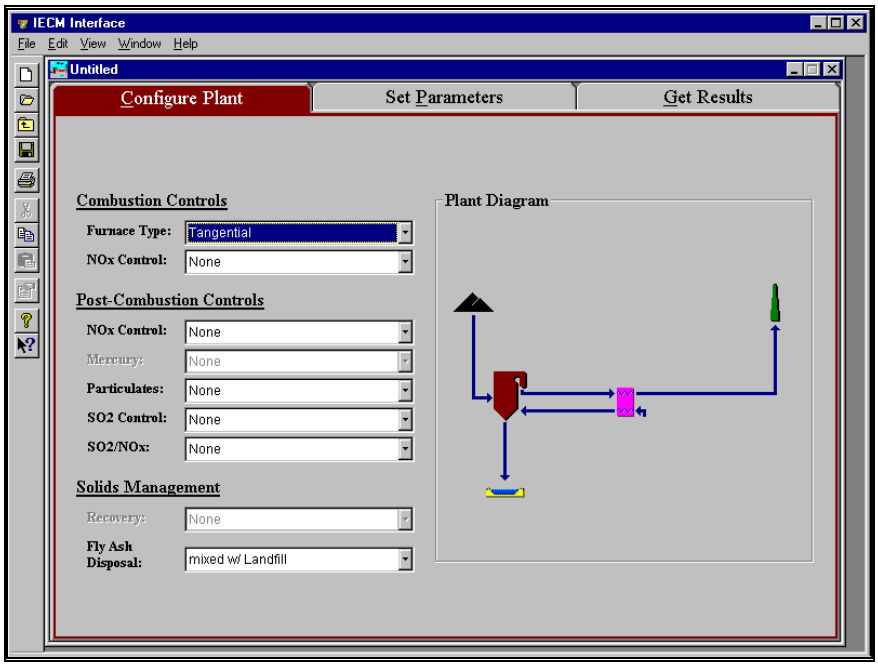
1. Pull down the **File** menu and select **New Session** The **New Session** dialog box will display.
2. Type **Case Study**. The screen should look like the following:

The New Session dialog box

3. Click the **Ok** button.

A more detailed description of managing session data is described in the *Getting Started* manual.

Once you have created a session, a session window will display. It contains all the screens used by the session. The screen should look like the following:



The Session Window

Configure Plant

The **Configure Plant** Program area will be the first screen displayed in the session window. On this screen, use the menus to choose the following technologies:

Combustion Controls:

NOx Control: **In-Furnace Controls**

Post-Combustion Controls:

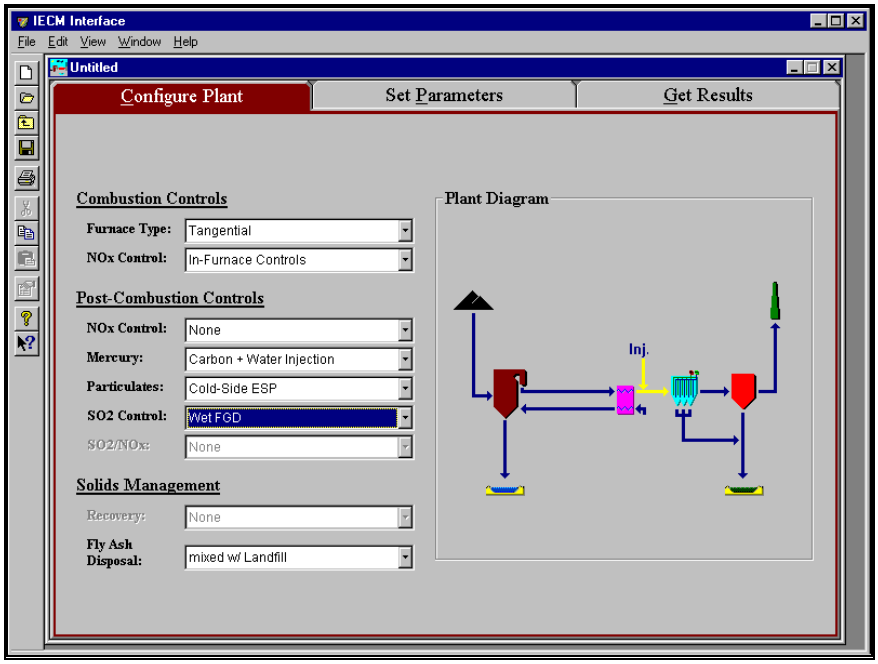
Particulates: **Cold Side ESP**

Mercury: **Carbon + Water Injection**

SO2 Control: **Wet FGD**

A description of drop-down or pop-up menus is given in the *Getting Started* manual. Detailed descriptions of all individual settings are given in the *User Manual*.

The screen should look like the following:

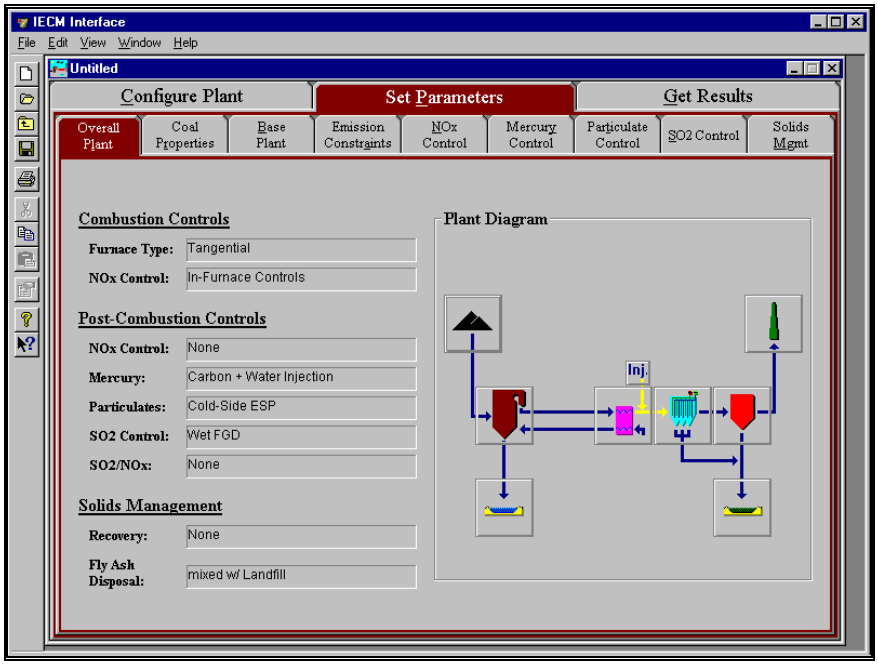


The Configure Plant Program Area

Once you have chosen the options, move on to the **Set Parameters** program area. (You may return to **Configure Plant** to change the settings at any time: click its tab at the top of the screen.)

Set Parameters

Click the tab for the **Set Parameters** program area. The screen should look like the following:



The Set Parameters Program Area

You may return to **Set Parameters** and change the inputs at any time: click its tab at the top of the screen. Detailed descriptions of all inputs are given in the *User Manual*.

Overall Plant

When you first enter the **Set Parameters** program area, the active Technology Navigation Tab is for the **Overall Plant**. This screen displays the plant configuration settings on the left side of the page and a diagram of the plant as configured at the right of the page. No inputs are entered on this screen.

You can navigate to the other Technology Tabs by either clicking on them or using a keyboard equivalent (described in more detail in the *Getting Started* manual). You may use the Plant Diagram as an alternate way to move among input Technology Navigation Tabs. Click the button for the technology for which you would like to provide inputs and it will activate the corresponding tab for that technology. You may also move through the Plant Diagram by pressing the **Tab** key (a highlighting box will surround the technology selected) and press the **Space bar** to activate the corresponding tab for that technology.

Coal Properties

Click the Technology Navigation Tab for the **Coal Properties** input area. Inputs in this area define the composition and cost of the coal used in the plant.

1. Properties

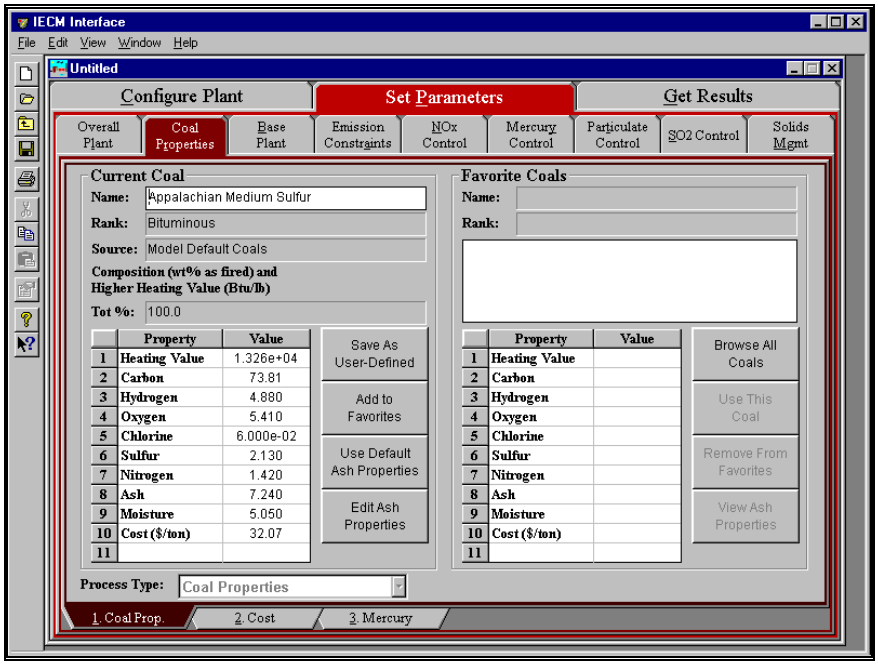
When you first enter the **Coal Properties** input area, the **1. Properties** input screen is displayed. On this screen you select the particular coal and its properties.

There are two panes: one for the ash and coal properties of the **Current Coal**, the other for those of **Favorite Coals**. The current coal is the coal which the model will conduct its calculations. Favorite coals are those that you use most. From this screen, you may choose a favorite coal, choose a coal from the model defaults, enter a user-defined coal, choose a previously saved user-defined coal, or manage your coal lists.

Choose the **Appalachian Medium Sulfur** coal for this model run:

1. Click the **Browse All Coals** button in the **Favorite Coals** pane.
2. Click **Appalachian Medium Sulfur** in the drop-down menu of the **Select Coal** pane.
3. Click the **Use This Coal** button.

When you are finished, the screen should look like the following:



The Coal Properties—1. Properties input screen

Base Plant

Click the Technology Navigation Tab for the **Base Plant** input area. Inputs in this area define performance and costs directly associated with the power plant, particularly the boiler.

1. Performance

When you first enter the **Base Plant** input area, the **1. Performance** input screen is displayed. Inputs for the major flow rates and concentrations of the gas and solids streams are entered on this screen.

The first six inputs are highlighted in blue to point out their importance. Detailed descriptions of all inputs are given in the *User Manual*. Descriptions of how to enter inputs and replacing calculated values are given in the *Getting Started* manual.

Enter the following values for the first five inputs:

Gross Electrical Output: 600 MW

Steam Cycle Heat Rate: 8100 Btu/kWh

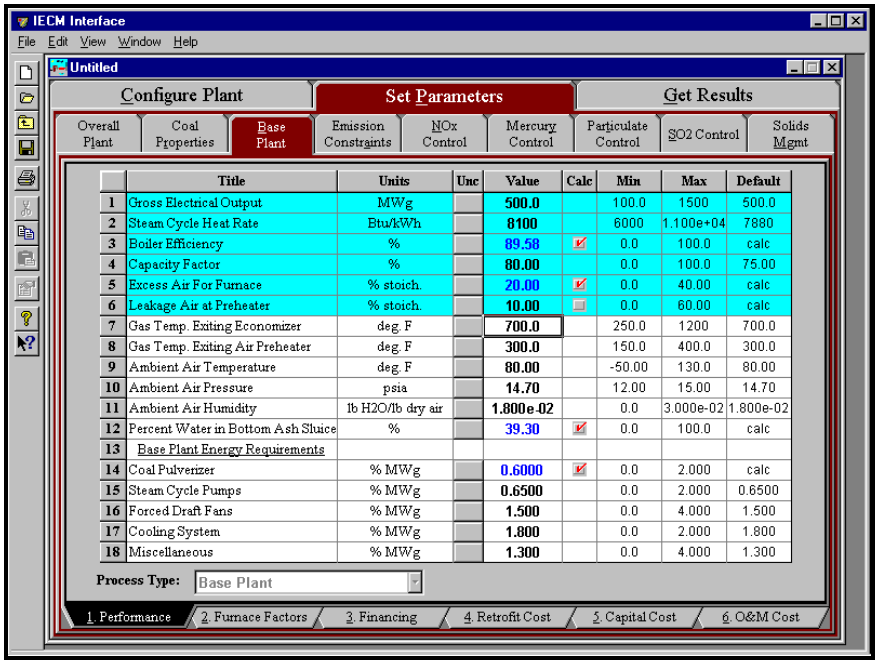
Boiler Efficiency: this is calculated by the model – do not change it

Capacity Factor: 80 %

Excess Air For Furnace: this is calculated by the model – do not change it

Leakage Air at Preheater: 10 % (override calculated value)

When you are finished, the screen should look like the following:



	Title	Units	Unc	Value	Calc	Min	Max	Default
1	Gross Electrical Output	MWg		500.0		100.0	1500	500.0
2	Steam Cycle Heat Rate	Btu/kWh		8100		6000	1.100e+04	7880
3	Boiler Efficiency	%		89.58	☑	0.0	100.0	calc
4	Capacity Factor	%		80.00		0.0	100.0	75.00
5	Excess Air For Furnace	% stoich.		20.00	☑	0.0	40.00	calc
6	Leakage Air at Preheater	% stoich.		10.00	☐	0.0	60.00	calc
7	Gas Temp. Exiting Economizer	deg. F		700.0		250.0	1200	700.0
8	Gas Temp. Exiting Air Preheater	deg. F		300.0		150.0	400.0	300.0
9	Ambient Air Temperature	deg. F		80.00		-50.00	130.0	80.00
10	Ambient Air Pressure	psia		14.70		12.00	15.00	14.70
11	Ambient Air Humidity	lb H2O/lb dry air		1.800e-02		0.0	3.000e-02	1.800e-02
12	Percent Water in Bottom Ash Sluice	%		39.30	☑	0.0	100.0	calc
13	Base Plant Energy Requirements							
14	Coal Pulverizer	% MWg		0.6000	☑	0.0	2.000	calc
15	Steam Cycle Pumps	% MWg		0.6500		0.0	2.000	0.6500
16	Forced Draft Fans	% MWg		1.500		0.0	4.000	1.500
17	Cooling System	% MWg		1.800		0.0	2.000	1.800
18	Miscellaneous	% MWg		1.300		0.0	4.000	1.300

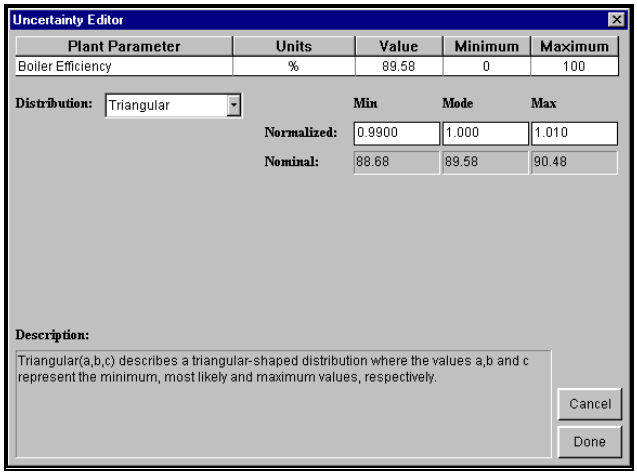
The Base Plant—1. Performance input screen

Uncertainty distributions are provided by default with several of the cost input parameters of the technologies accessible from the various navigation tabs. These are described in more detail in the *User Manual*. For this case study, only one performance parameter will be used to demonstrate the use of uncertainty.

Define a triangular distribution for boiler efficiency:

1. Click the **Boiler Efficiency (%)** uncertainty button in the **Unc** column. This will bring up the **Uncertainty Editor** window.
2. Select **Triangular** from the **Distribution:** drop-down menu.
3. Assume the boiler efficiency can be 1% higher or lower than the nominal value calculated by the IECM. This would be represented by entering 0.99, 1.00, and 1.01 in the **Mid**, **Mode**, and **Max** input fields respectively. Notice that these are multiplicative factors. The nominal or actual values are displayed immediately below the normalized values you entered.

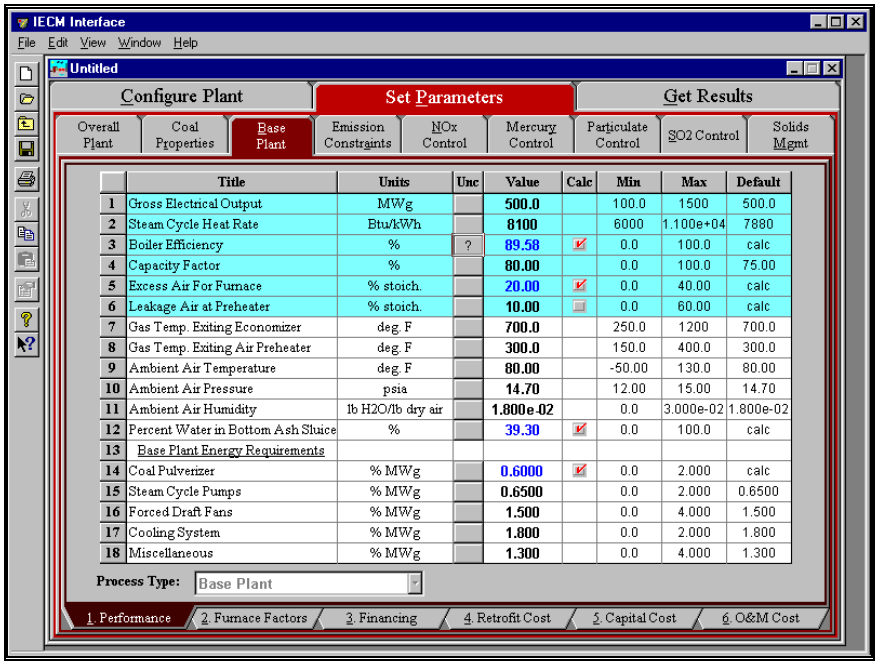
After you are finished entering the triangular distribution parameters, the screen should look like the following:



Uncertainty Editor

4. Click the **Done** button to close the **Uncertainty Editor**.

Notice that a "?" appears inside the uncertainty button. This is a reminder that uncertainty has been applied to this input parameter. This is shown in the following:



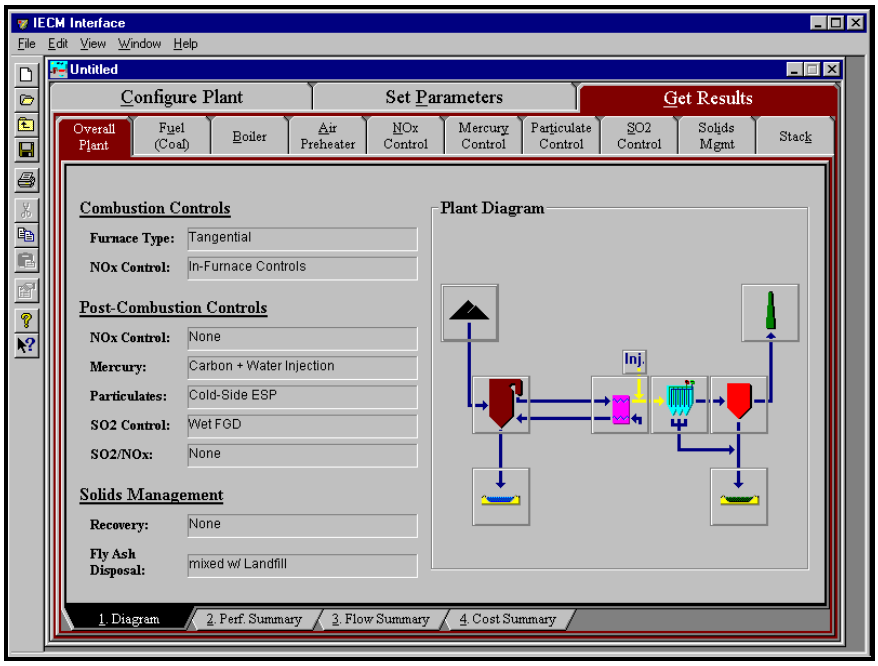
The Base Plant – 1. Performance input screen

Other Input Areas and Technologies

Default parameters will be used for all the other input areas for the base plant and other technology tabs. You may browse these input screens to view the defaults.

Get Results

Click the tab for the **Get Results** program area. From this area you can view the results for this session.



The Get Results Program Area

You may return to **Get Results** to look at results at any time: click its tab at the top of the screen. Detailed descriptions of all results are given in the *User Manual*.

Overall Plant

When you first enter the **Get Results** program area, the Technology Navigation Tab which is active is for the **Overall Plant**. This area contains result screens for the plant as a whole.

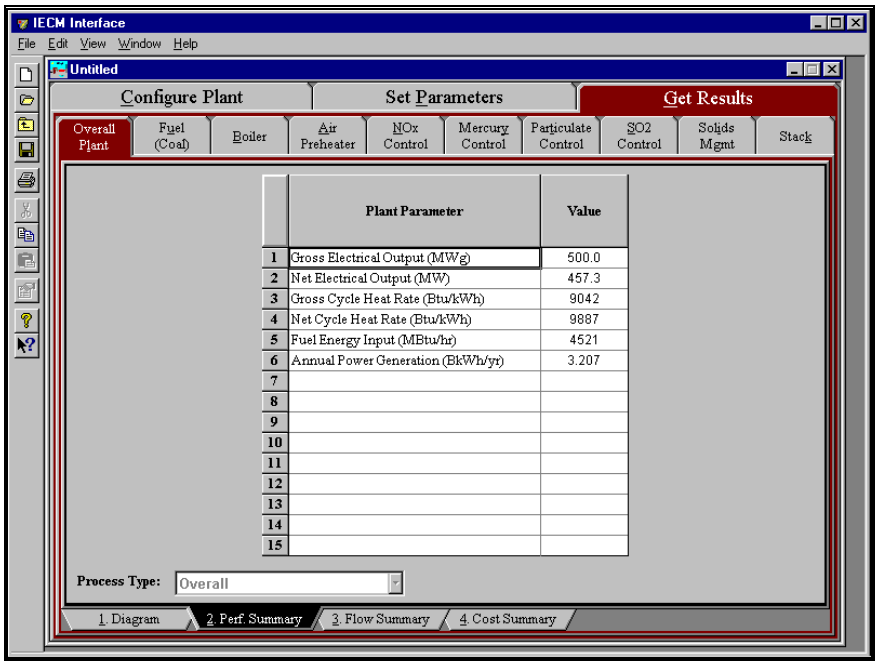
1. Diagram

When you first enter the **Overall Plant** result area, the **1. Diagram** result screen is displayed. This screen displays the plant configuration settings on the left side of the page and a diagram of the plant as configured at the right of the page. No results are displayed on this screen.

You may use the Plant Diagram as an alternate way to move among input Technology Navigation Tabs, similarly to the alternatives available on the **Set Parameters** program area. See “Overall Plant” on page 29 to see the alternatives.

2. Performance Summary

Click the Result Navigation Tab for the **2. Perf. Summary** result screen. It displays performance results for the plant as a whole. Values for the major input and outputs of the power plant are given. The screen should look like the following:



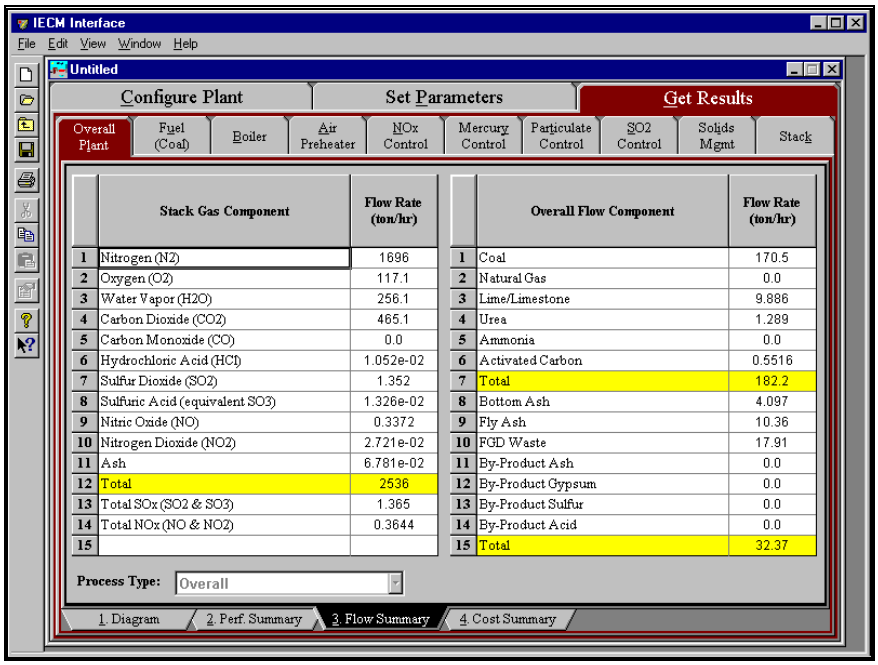
The Overall Plant—2. Perf. Summary result screen

When you first enter a screen with results, there may be a short delay as results are calculated. Once results are calculated, there should be little more than a split second delay when you move to other screens. (However, if you change the plant configuration or input values and then return to **Get Results**, the results will have to be recalculated, causing another delay.)

You should notice that the **Gross Plant Size** is the same as you entered earlier. The other parameters are calculated by the model as a function of the other input parameters and technologies loaded. Each result is described in detail in the *User Manual*.

3. Flow Summary

Click the Result Navigation Tab for the **3. Flow Summary** result screen. It displays values for the major flows in, through and out of the power plant. The screen should look like the following:

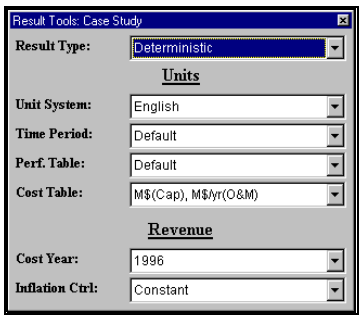


The Overall Plant—3. Flow Summary result screen (maximum hourly values)

As mentioned before, the totals are highlighted for you in yellow. Each result is described in detail in the *User Manual*.

The results above are based on a maximum hourly flow rate which assumes 100% capacity. To see the annual average values, which takes into consideration the capacity factor you entered earlier, do the following:

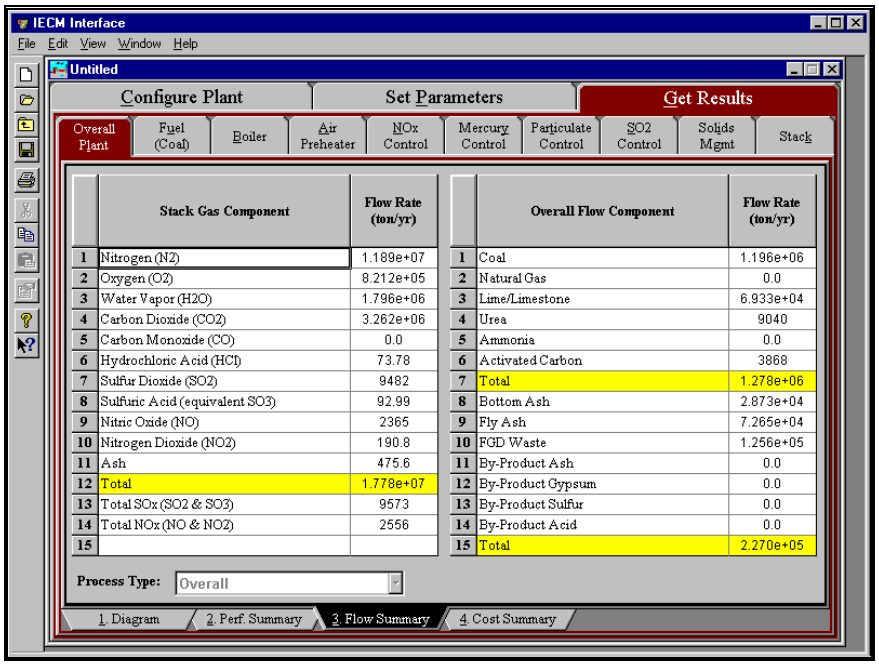
1. Select **Result Tools** from the **View** menu. This displays a window with result menu options.



Result Tools

2. Select **Avg Annual Avg.** from the **Time Period:** menu. The flow rates on the result screen are automatically updated.
3. Select **Result Tools** from the **View** menu again. This closes the window. (An alternative way to close the window is to click the "X" box in the upper right corner of the window.)

The numbers on the result screen will automatically be updated. The year costs are reported can be changed on this tool window.



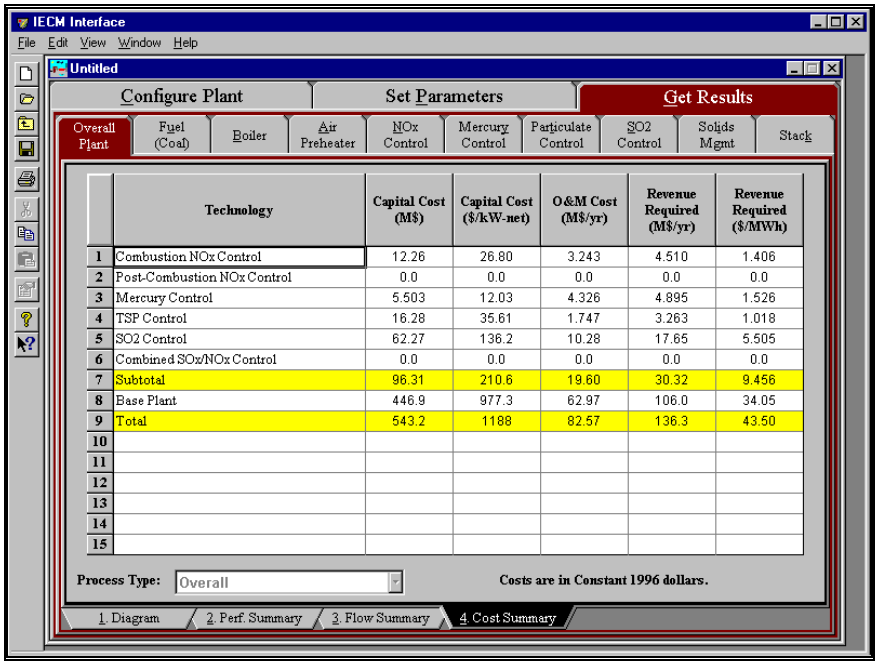
	Stack Gas Component	Flow Rate (ton/yr)
1	Nitrogen (N2)	1.189e+07
2	Oxygen (O2)	8.212e+05
3	Water Vapor (H2O)	1.796e+06
4	Carbon Dioxide (CO2)	3.262e+06
5	Carbon Monoxide (CO)	0.0
6	Hydrochloric Acid (HCl)	73.78
7	Sulfur Dioxide (SO2)	9482
8	Sulfuric Acid (equivalent SO3)	92.99
9	Nitric Oxide (NO)	2365
10	Nitrogen Dioxide (NO2)	190.8
11	Ash	475.6
12	Total	1.778e+07
13	Total SOx (SO2 & SO3)	9573
14	Total NOx (NO & NO2)	2556
15		

	Overall Flow Component	Flow Rate (ton/yr)
1	Coal	1.196e+06
2	Natural Gas	0.0
3	Lime/Limestone	6.933e+04
4	Urea	9040
5	Ammonia	0.0
6	Activated Carbon	3868
7	Total	1.278e+06
8	Bottom Ash	2.873e+04
9	Fly Ash	7.265e+04
10	FGD Waste	1.256e+05
11	By-Product Ash	0.0
12	By-Product Gypsum	0.0
13	By-Product Sulfur	0.0
14	By-Product Acid	0.0
15	Total	2.270e+05

The Overall Plant—3. Flow Summary result screen (annual average values)

4. Cost Summary

Click the Result Navigation Tab for the **4. Cost Summary** result screen. It displays costs associated with the power plant as a whole. Costs are in constant 1996 dollars. The screen should look like the following:



	Technology	Capital Cost (M$)	Capital Cost ($/kW-net)	O&M Cost (M$/yr)	Revenue Required (M$/yr)	Revenue Required ($/MWh)
1	Combustion NOx Control	12.26	26.80	3.243	4.510	1.406
2	Post-Combustion NOx Control	0.0	0.0	0.0	0.0	0.0
3	Mercury Control	5.503	12.03	4.326	4.895	1.526
4	TSP Control	16.28	35.61	1.747	3.263	1.018
5	SO2 Control	62.27	136.2	10.28	17.65	5.505
6	Combined SOx/NOx Control	0.0	0.0	0.0	0.0	0.0
7	Subtotal	96.31	210.6	19.60	30.32	9.456
8	Base Plant	446.9	977.3	62.97	106.0	34.05
9	Total	543.2	1188	82.57	136.3	43.50
10						
11						
12						
13						
14						
15						

The Overall Plant—4. Cost Summary result screen

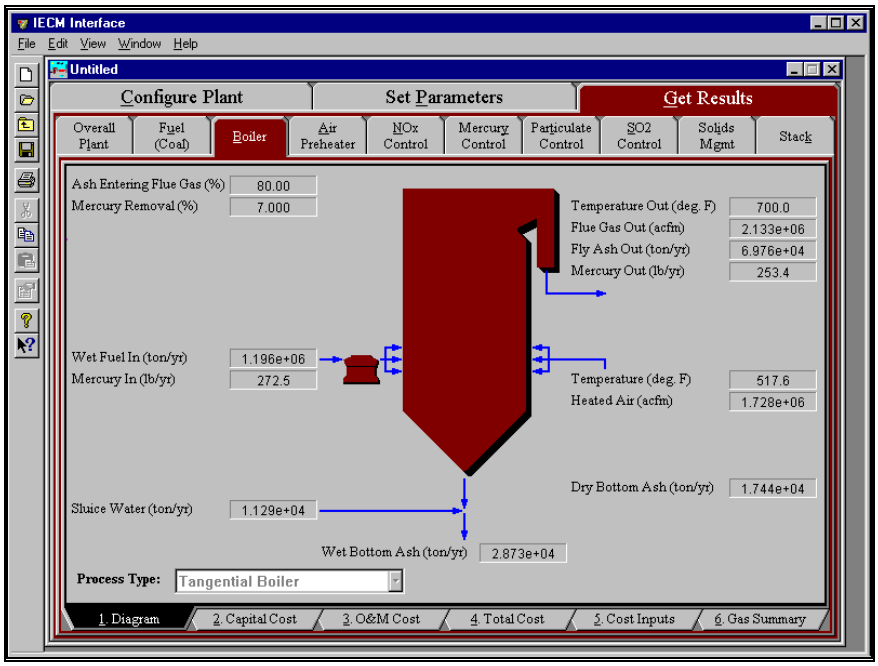
Each result is described in detail in the *User Manual*.

Boiler

Click the Technology Navigation Tab for the **Boiler** result area. This area contains result screens for flows and costs related to the Boiler itself.

1. Diagram

When you first enter the **Boiler** result area, the **1. Diagram** result screen is displayed. This screen displays an icon for the Boiler and values for major flows in and out of it. The flow rates are shown in annual average units (tons/yr) due to the unit change made earlier. Due to the trace flow rates of mercury, it's flow rate is reported in lb/yr. The screen should look like the following:

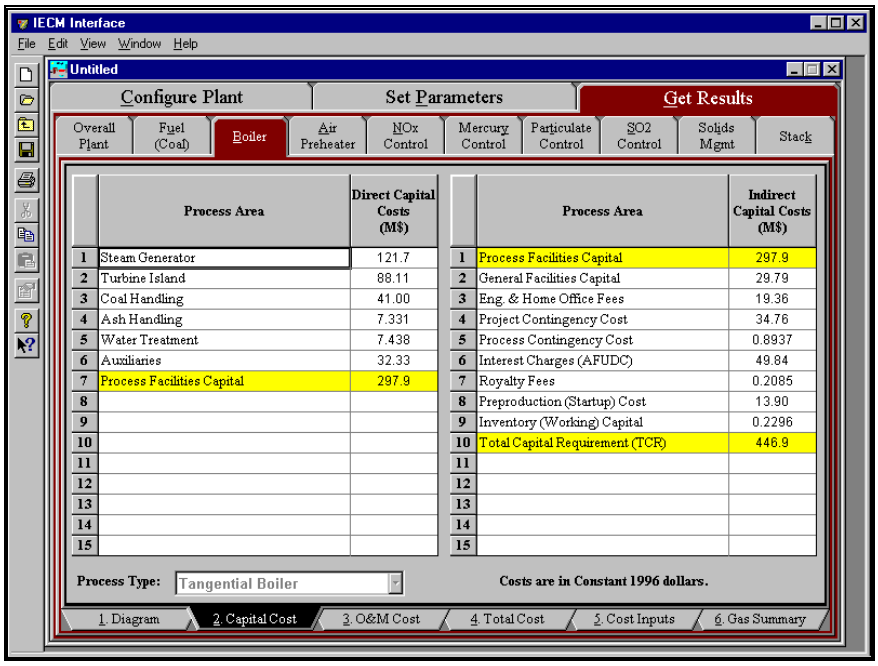


The Boiler—1. Diagram result screen

Each result is described in detail in the *User Manual*.

2. Capital Cost

Click the Result Navigation Tab for the **2. Capital Cost** result screen. It displays tables for the direct and indirect capital costs related to the Boiler. Costs are in constant 1996 dollars. The screen should look like the following:

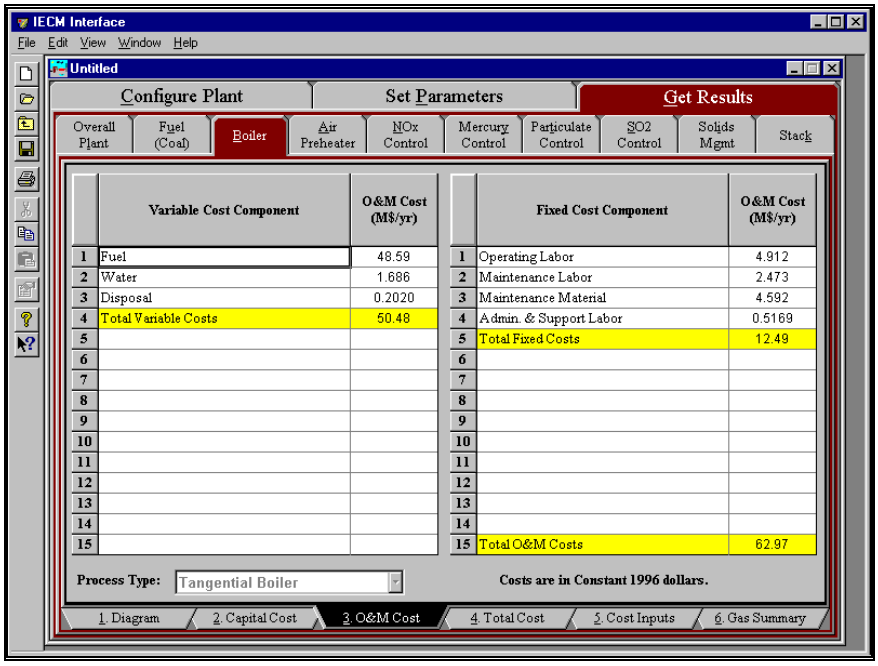


The Boiler—2. Capital Cost result screen

Each result is described in detail in the *User Manual*.

3. O&M Cost

Click the Result Navigation Tab for the **3. O&M Cost** result screen. It displays tables for the variable and fixed O&M costs involved with the Boiler. Costs are in constant 1996 dollars. The screen should look like the following:

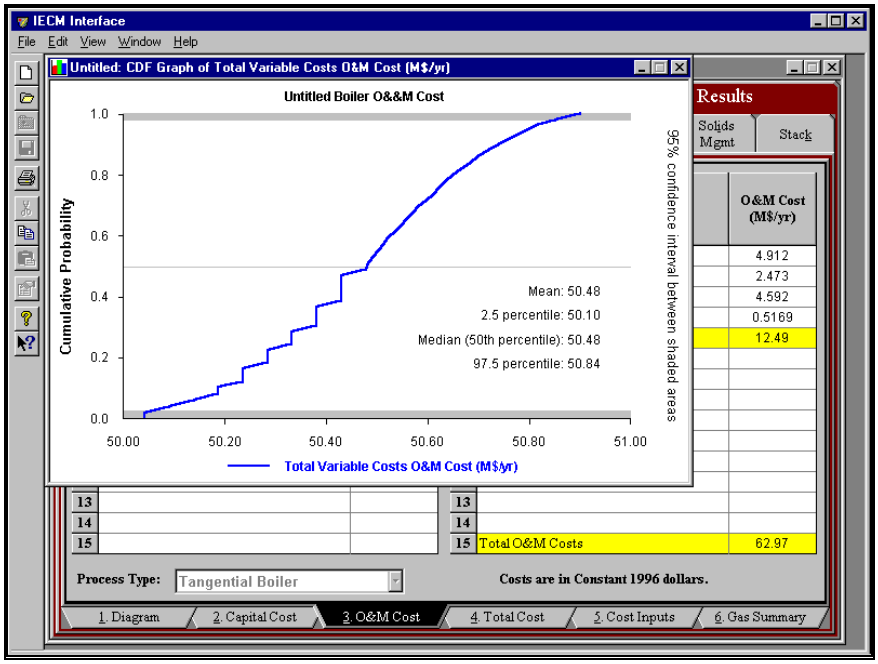


The Boiler—3. O&M Cost result screen

Each result is described in detail in the *User Manual*.

Graphs

Double-click the result value on the Boiler—3. O&M Cost result screen for the Total Variable costs. A graph of the value will display. The screen should look like the following:



Graph of Total Variable Costs (Uncertain)

When you first bring up a graph, there will be a short delay as all result graphs are drawn. Once all the graphs are drawn, there should be little more than a split second delay when you choose another graph. (However, if you change the plant configuration or input values and then return to **Get Results**, the graphs will have to be redrawn, causing another delay.)

While all of the values displayed in diagrams and tables are deterministic, some have uncertainty in their calculation. If there is no uncertainty in the value's calculation, the graph displays a vertical line. If uncertainty is present, the graph displays a curve of all possible values.

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