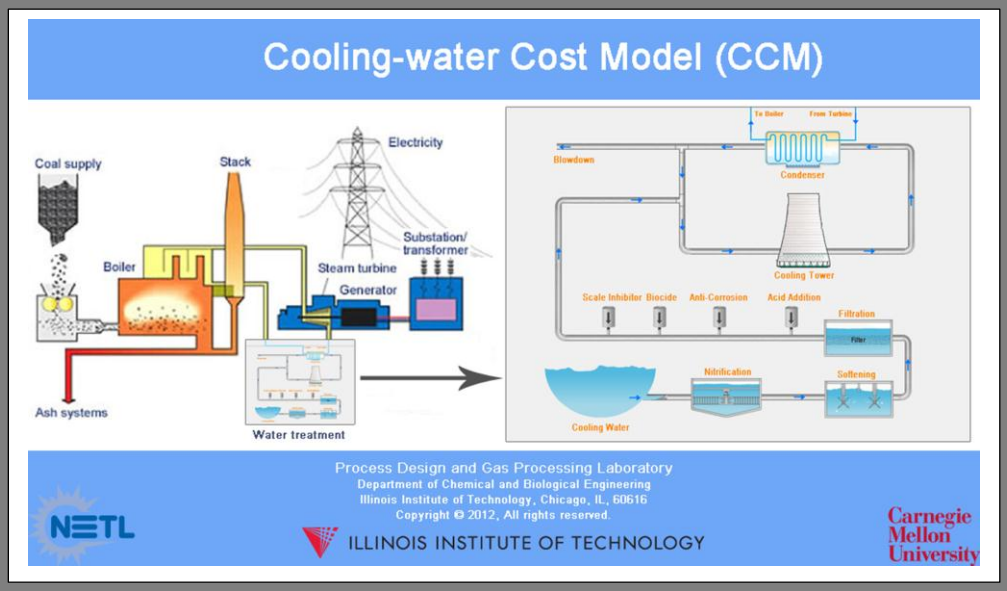
Cooling-water Cost Model (CCM)

User Manual



Illinois Institute of Technology

Cooling-water Cost Model

(CCM)

User Manual

Collaborators:

Developed By:

Process Design and Gas Processing Laboratory

Department of Chemical and Biological Engineering

Illinois Institute of Technology

Chicago, IL

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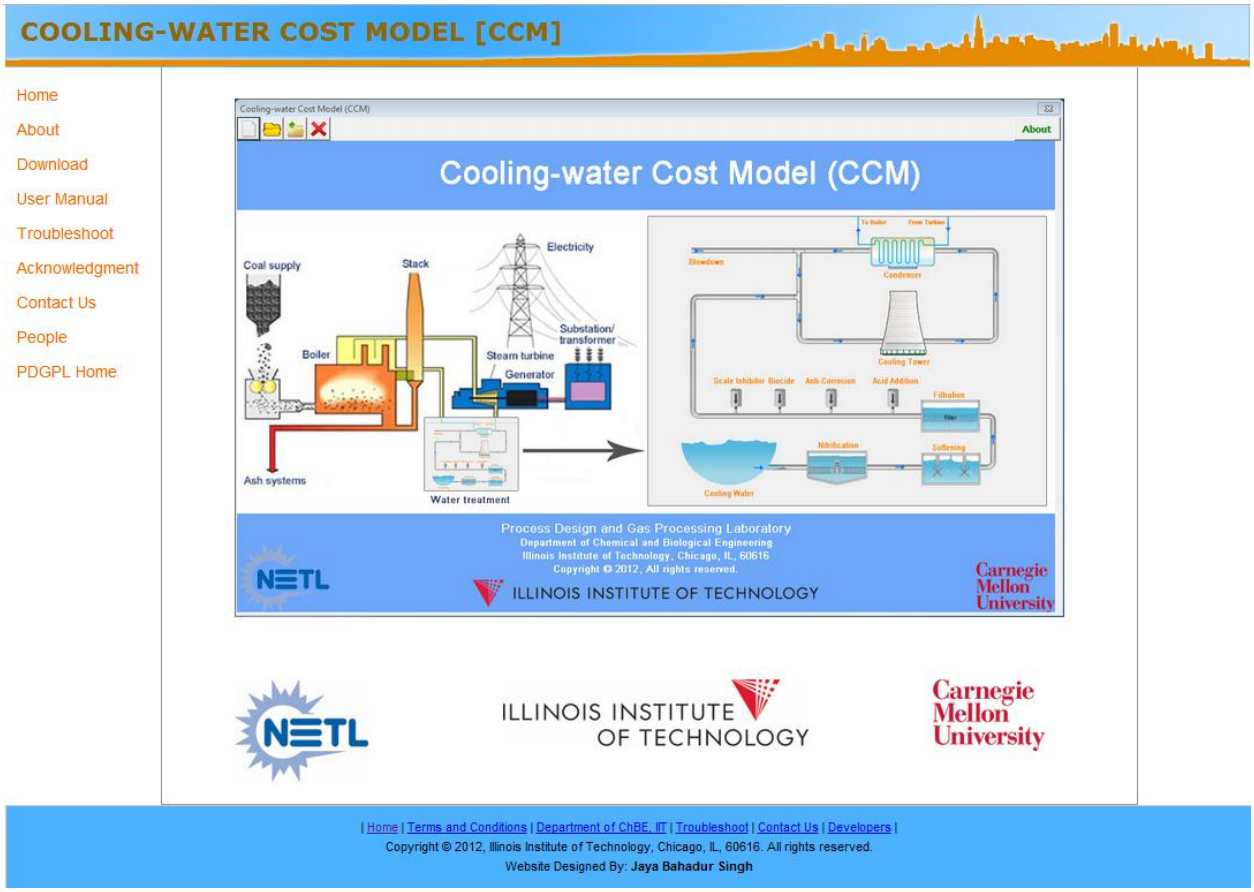
Downloading the CCM Application

CCM Application can be downloaded online for free. It has been made available by the Departmental of Chemical and Biological Engineering of the Illinois Institute of Technology, Chicago, IL.

1. Open the following website: http://mypages.iit.edu/~abbasian/CCM/index.php



2. Click on **Download**.

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3. Enter the required information marked with red asterisks (*).

   Please note that the information that you provide in the website in for record keeping purpose only and it is completely confidential.

4. Click **Submit**.

5. You will be shown the user agreement page.

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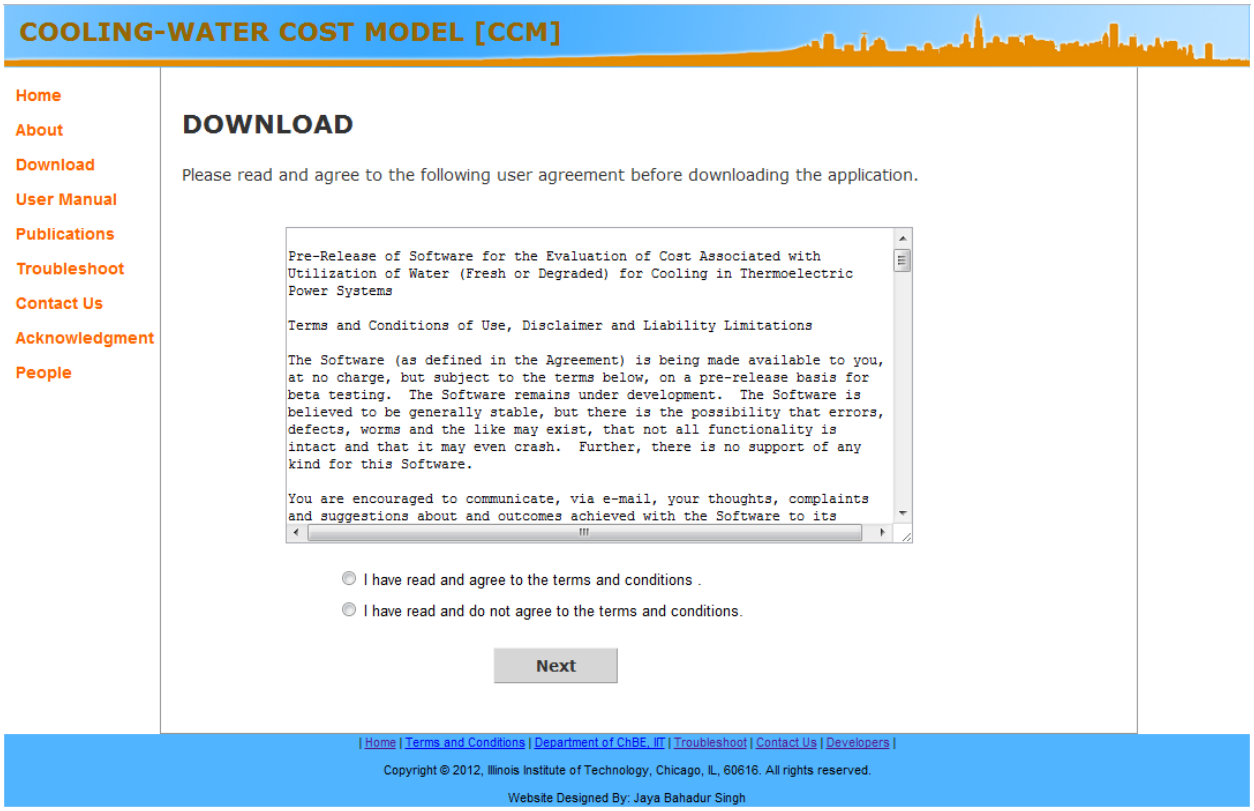

6. If you would like to agree and download the application then select the option:

   "I have read and agree to the terms of conditions."

7. Click **Next**.

8. Click the link to the program and the download should start automatically.

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VERY IMPORTANT

It is very important for you to understand the following before running the CCM application.

A. If you do not have any Excel file/s open in your computer, you can directly open the CCM application by double clicking on the CCM application Excel file.

B. If you do have Excel file/s open in your computer

   a. Do not directly open the CCM application Excel file.

   b. Open a new instance of Excel first.

      You can open a new instance of Excel from **Start → All Programs → Microsoft Office → Excel**

   c. Once you have opened a new instance of Excel, now you can open the CCM application from **File → Open.** And select the CCM application Excel file.

C. If you do have Excel file/s open in your computer and directly try to open the CCM application Excel file, you will realize that the open Excel file/s disappears.

   a. But **DO NOT** panic. They are safe. They are just hidden.

   b. They are hidden because the Excel application is set to hidden mode.

   c. The Excel application is set to hidden mode because we had to design the CCM GUI in such a way that **YOU**, the user, would be able to interact with the GUI only, for a user-friendly experience.

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d. If you want your files back, just close the CCM GUI.

D. While the CCM GUI is running, you won't be able to directly open any Excel file.

a. If you **HAVE TO** open any Excel file while the GUI is running, just open a new instance of Excel as described in **B.b**.

b. Once you have opened a new instance of Excel, click **File → Open**. Then select the file that you want to open.

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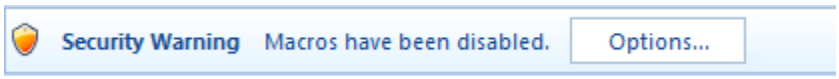
Running the CCM Application

Open the CCM application Excel file as described in the **VERY IMPORTANT** section above.

1. As a security feature in Microsoft Excel, macros (program codes) are disabled by default.
2. If you are running the application for the first time, you will see the following depending on your MS-Excel version (2007 or 2010)
    a. MS-Excel 2007



        i. Click on **Options**.
        ii. Select **Enable this content**.

    b. MS-Excel 2010

        i. Click **Enable Content**.

Once you allow the macros to run, wait for a while. The very first time the application is run, it will connect to the internet in-order to activate. When this process is complete, the CCM GUI will appear as follows:

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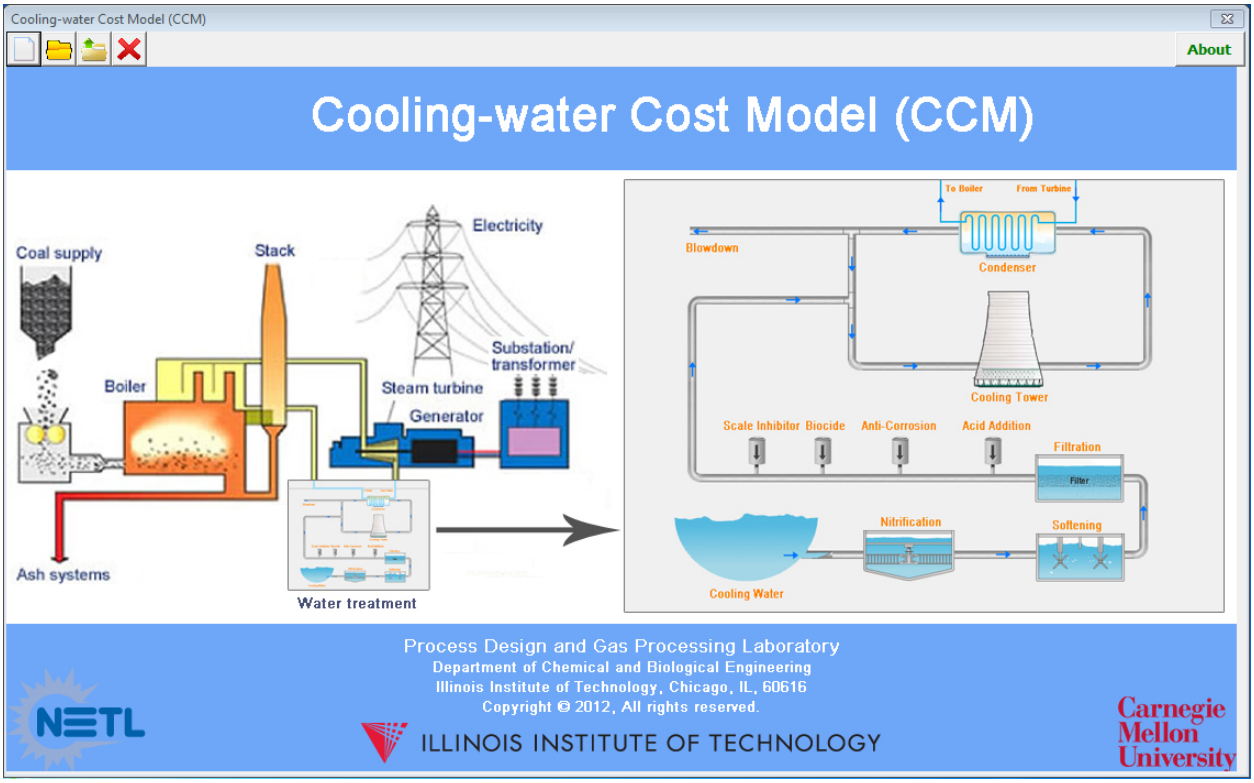

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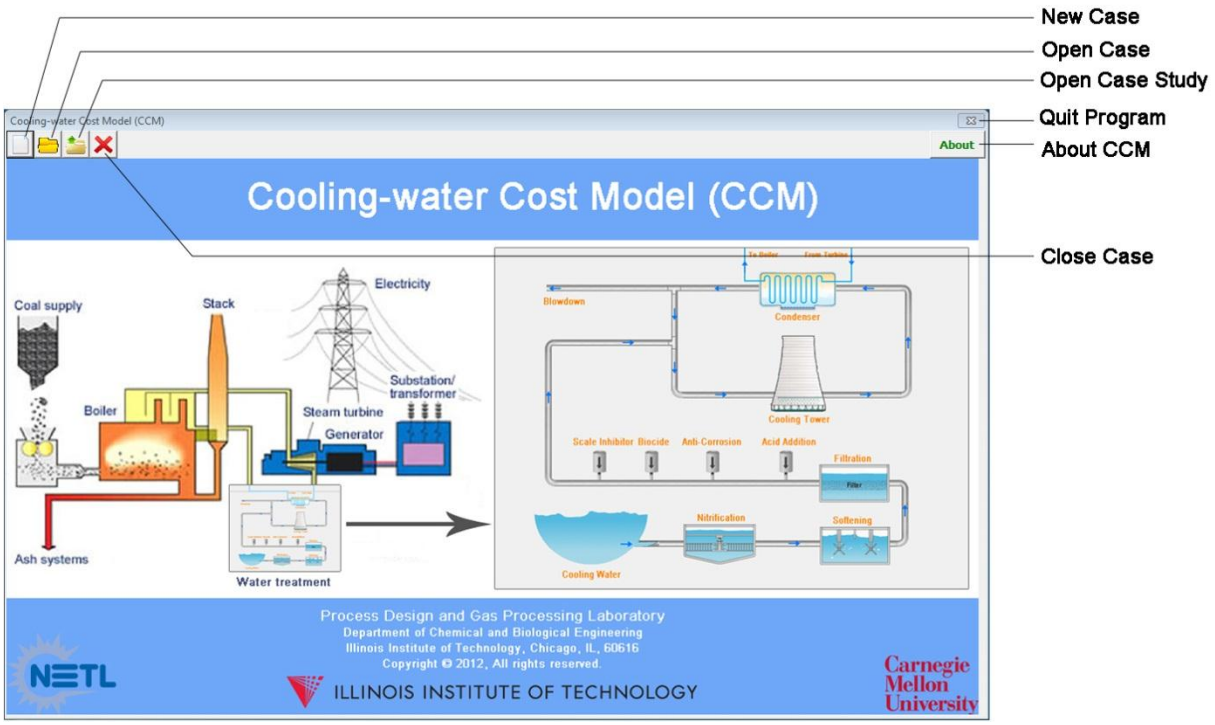
Understanding the Layout of the application window



1. **New Case**: Start a new blank case.

    a. If no case is in progress the following is displayed:

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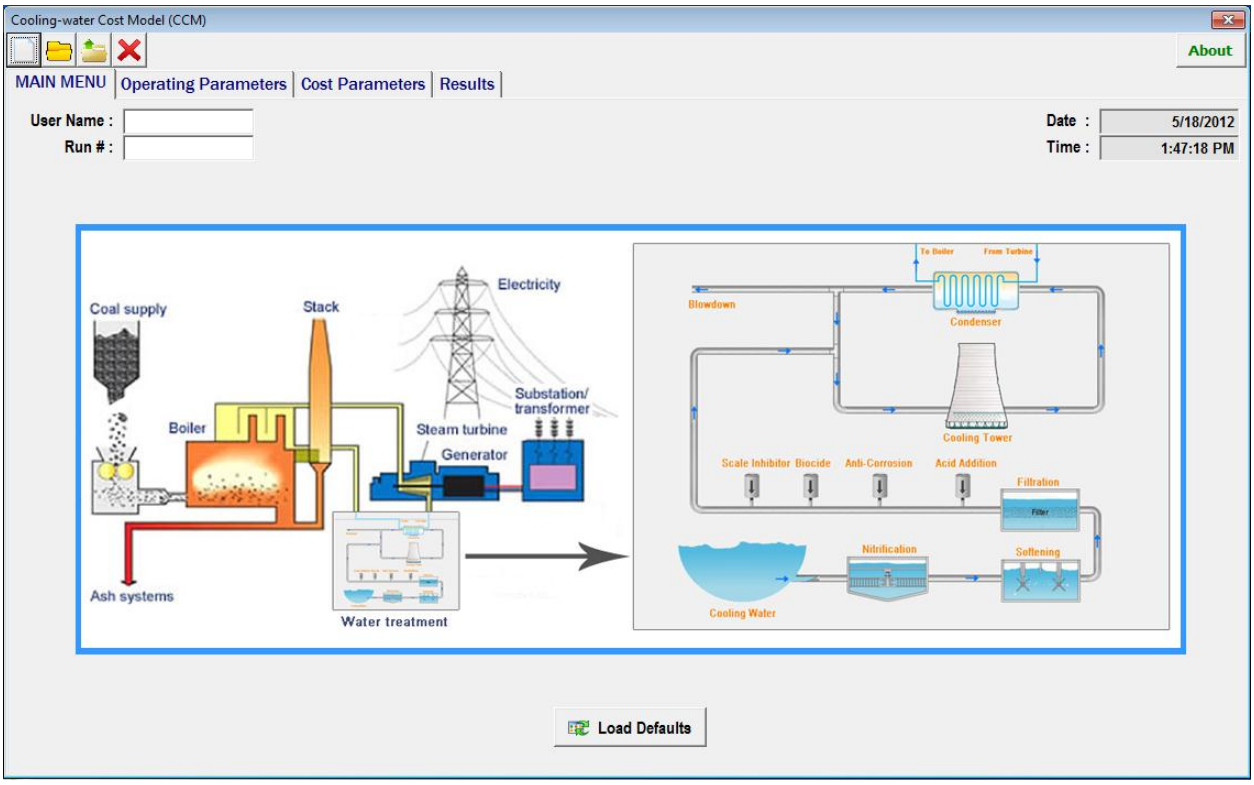
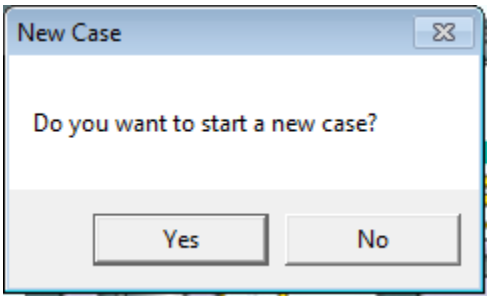


b. If a case is in progress, a dialog appears as follows:



Click **Yes** to start a new case, OR

Click **No** to stay with the current case.

2. **Open A Case**: Opens a previously saved MS-Excel file with the correct format.

More on Opening a Case.

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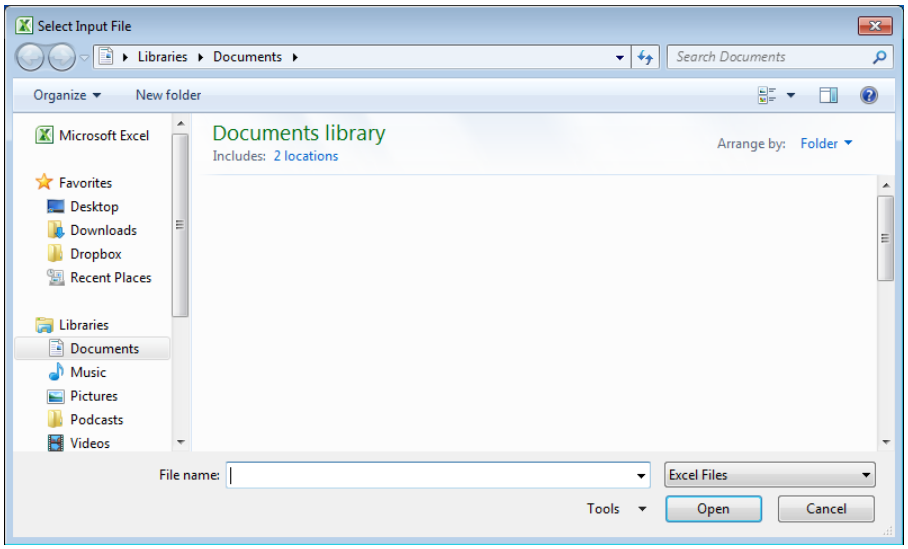
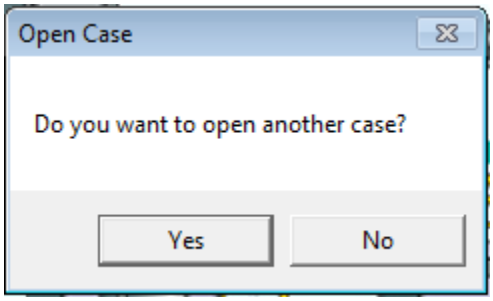
a. If no case is in progress, an Open Dialog box appears:



Select the correct file to open.

b. If a case is already in progress, the following dialog box appears:



Click **Yes** and the Open Dialog box will appear where you can select the file, OR

Click **No** to stay in the current case.

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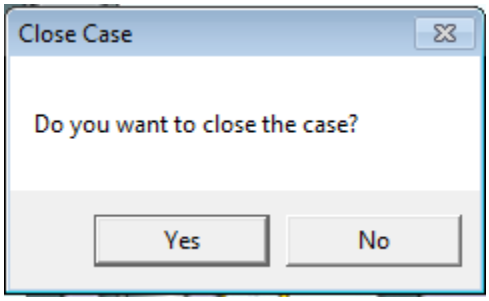
3. **Open A Case Study**: Same as **Open A Case**. But, the case study file is different than the case file. More on Opening a Case Study.

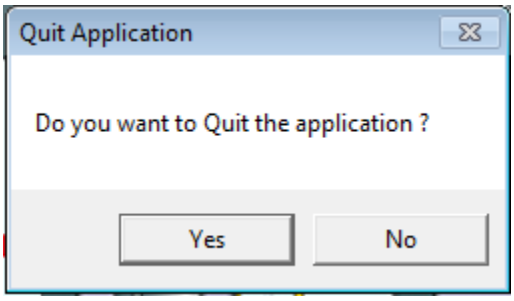
4. **Close Case**: Closes a currently running case. The following dialog box appears:



Click **Yes** to close the case, OR

Click **No** to stay with the current case.

5. **Exit**: Closes the CCM GUI application. The following dialog box appears:



Click **Yes** to exit the application, OR

Click **No** to stay with the application.

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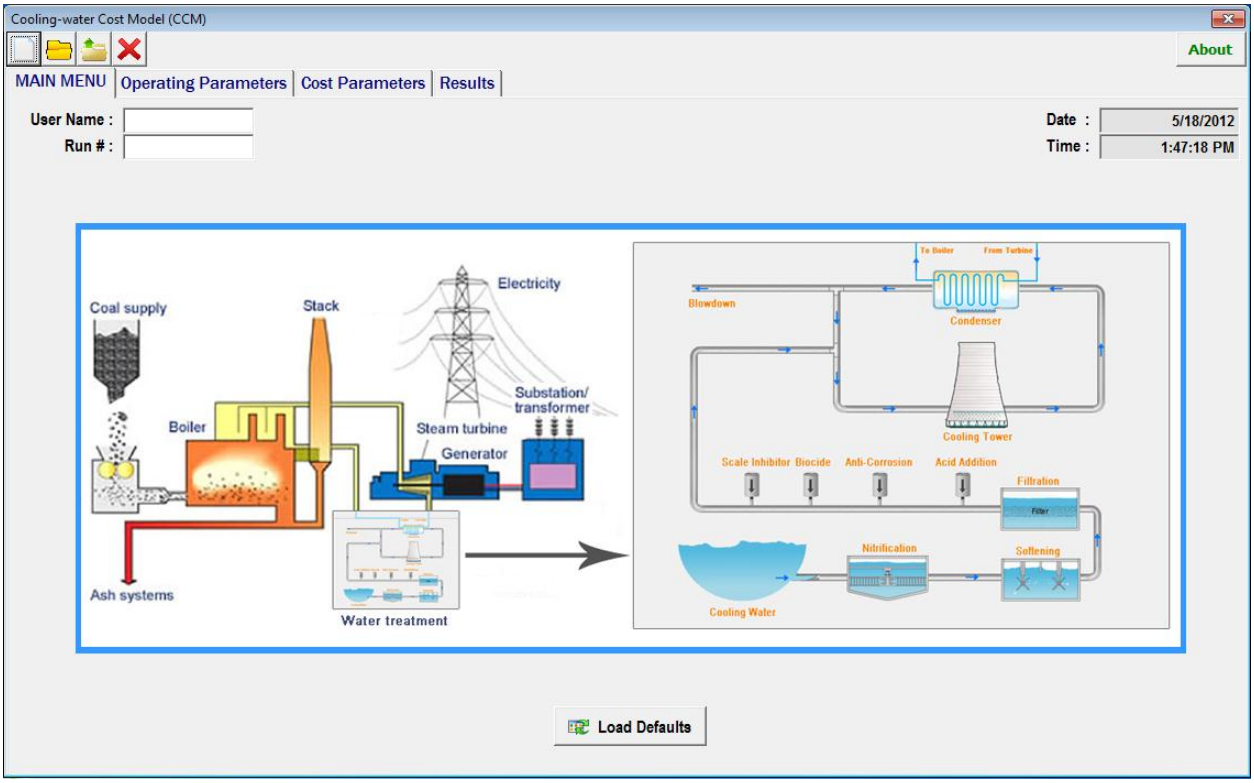
Starting a New Project

In order to start a new project:

1. Click on the **New Case** icon.

   The following appears:



   Starting a New Case loads a blank GUI. If you browse through the tabs, you can easily see that the input fields are blank.

   In the **Main Menu** page you can see Date and Time stamps on the right hand side which are automatically generated based on your system date and time. You can't modify this information.

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There is a

button at the middle bottom of the **Main Menu** page. Clicking on this button fills **all** the input fields in the GUI with default values. You can browse through the tabs to see the default values that are loaded. This is a good way to populate the input fields in the GUI if you don't have your own set of all the inputs.

You would still have to type the username and run number in the **Main Menu** tab.

If you browse through the tabs, you will see a

button on each page. These **Load Defaults** buttons are specific to the corresponding page only. If you change some of the input values in a page and would like to change them back to the default values then you can click on the **Load Defaults** button in that page.

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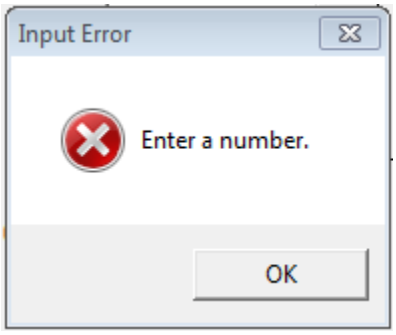
Some Common Error Flags

Error flags have been incorporated into the CCM GUI application which will pop up if the inputs are entered incorrectly. The following are some common error flags:

1. **Non-numeric Input**: All the input fields take numeric values only (except for the pop-down menus which have predefined sets of inputs that you can select from). Entering any non-numeric data like a text or a combination of text generates the following error flag:



Click **OK** to close the error flag.

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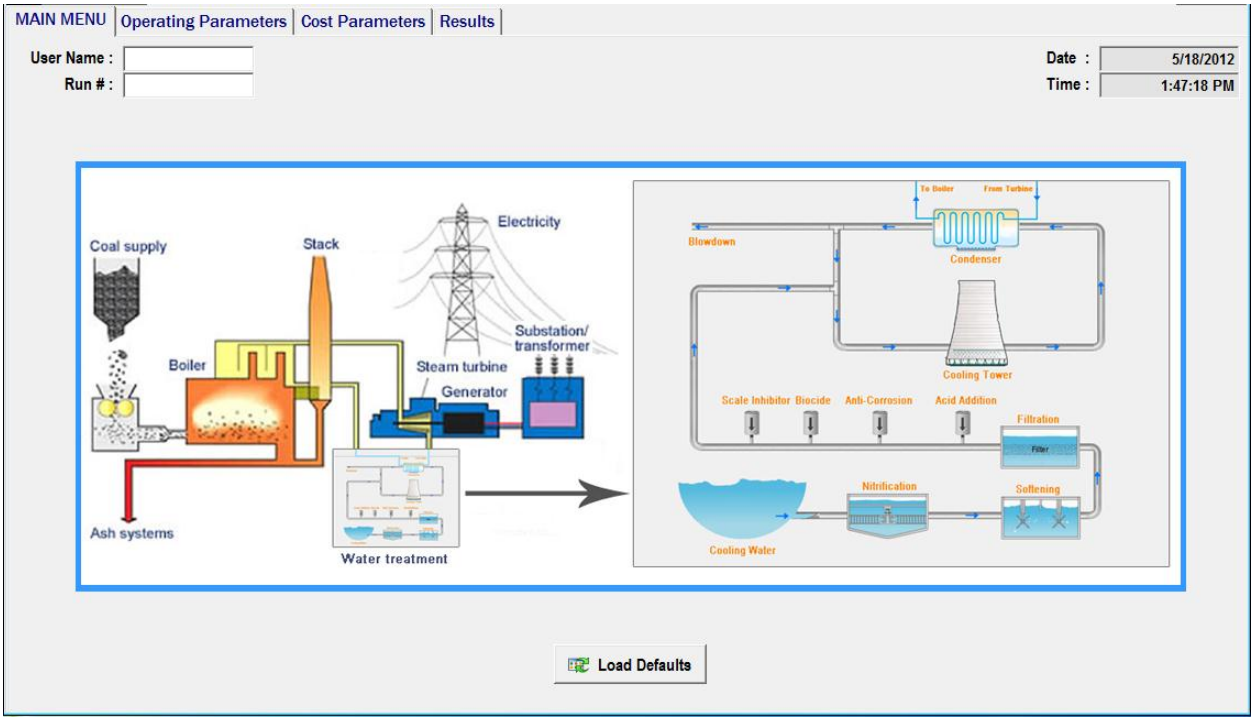
Understanding the Tabs

A. **Main Menu**: This tab contains the user name and run number fields on the top left side. On the top right side, there are date and time display fields which cannot be modified.



B. **Operating Parameters**: This tab contains three sub tabs – Plant and Cooling Tower, Condenser and Water Treatment.

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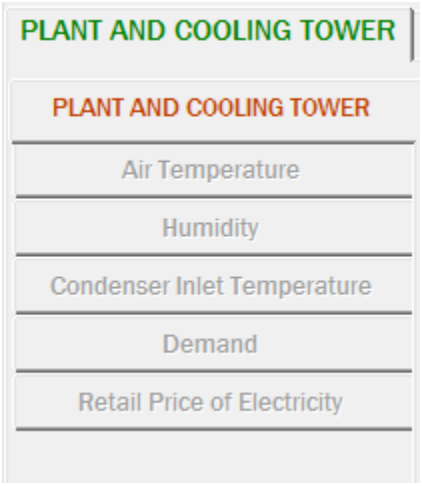
a. **Plant and Cooling Tower**: This tab contains six sub tabs – Plant and Cooling Tower, Air Temperature, Humidity, Condenser Inlet Temperature, Demand and Retail Price of Electricity.



i. **Plant and Cooling Tower**: This page contains the input fields for the plant and cooling tower parameters. The **Load Defaults** button on the bottom of the page is used to load default values to this page only. On the right side there is a section called **Include Parameter Variations?** In this section you can find the five different parameters – Air Temperature, Humidity, Condenser Inlet Temperature, Demand and Retail Price of Electricity. You can check the box beside each parameter listing in order to activate the corresponding tab on the left side. When a parameter is checked, it is an indication that, that particular parameter variation is included in the calculation of costs in the model. Two buttons - **Select All** and **Unselect All** are also available

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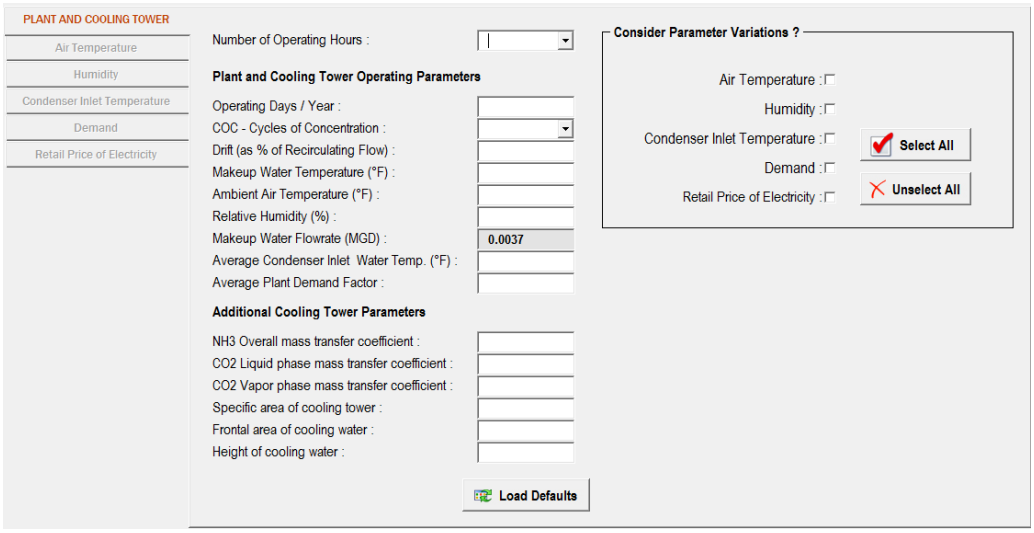
which are used to select all the variations and unselect all the variations respectively.



ii. **Air Temperature**: This tab is inactive by default, which means that the air temperature parameter variation is not included in the costs calculation by default. When the check box beside Air Temperature is checked in the Plant and Cooling Tower page, the Air Temperature tab becomes active. Clicking on the tab shows the following:

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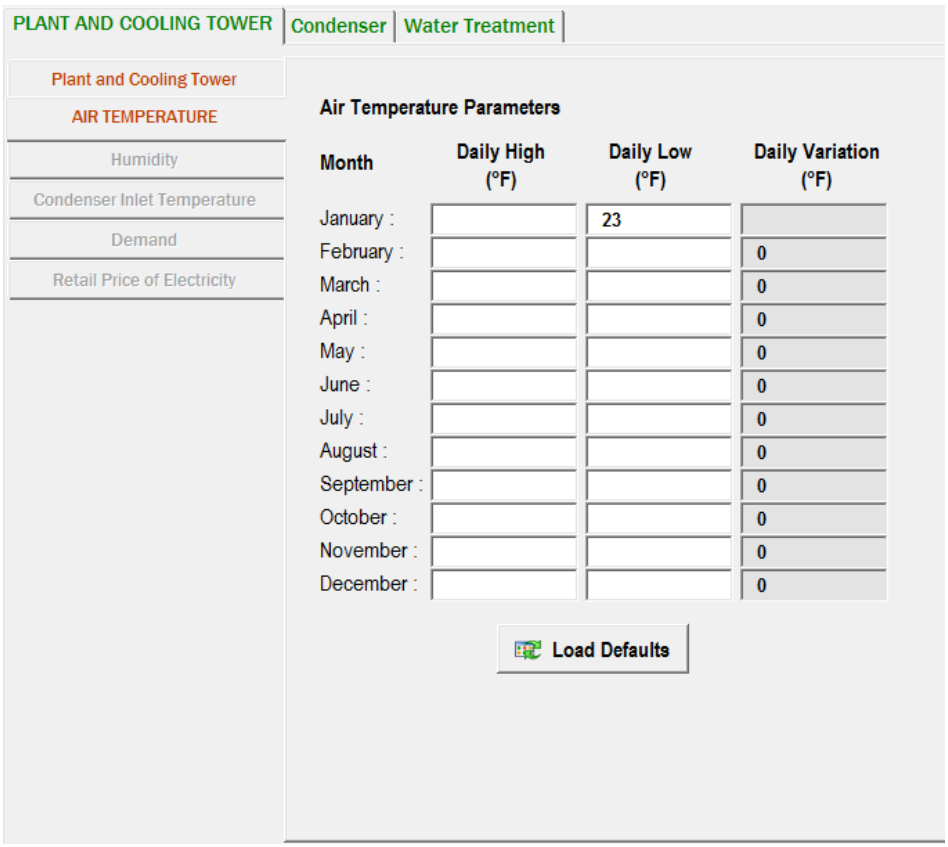

There are three columns – Daily High, Daily Low and Daily Variation. Daily High and Daily Low columns are the input columns. Daily Variation column is calculated based on the Daily High and Daily Low columns. **Daily Variation = Daily High – Daily Low**. Inputs should be entered correctly which means that the Daily High value must be a number greater than the Daily Low value, else the following error message boxes are shown:

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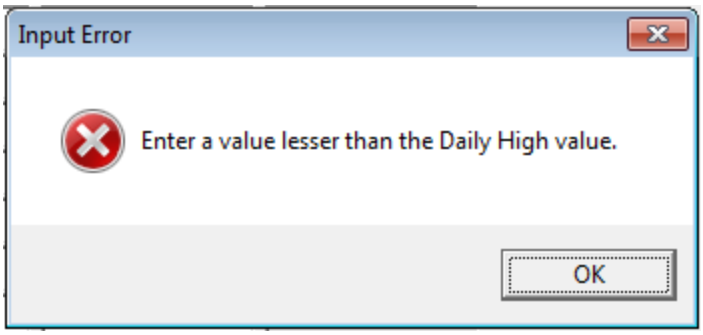
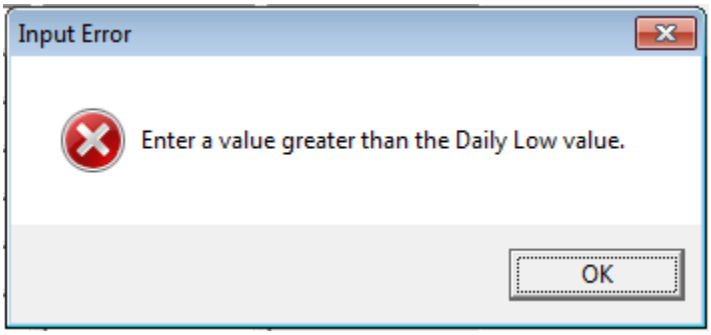


OR



iii. **Humidity**: This tab is inactive by default, which means that the humidity parameter variation is not included in the costs calculation by default. When the check box beside Humidity is checked in the Plant and Cooling Tower page, the Humidity tab becomes active. Clicking on the tab shows the following:

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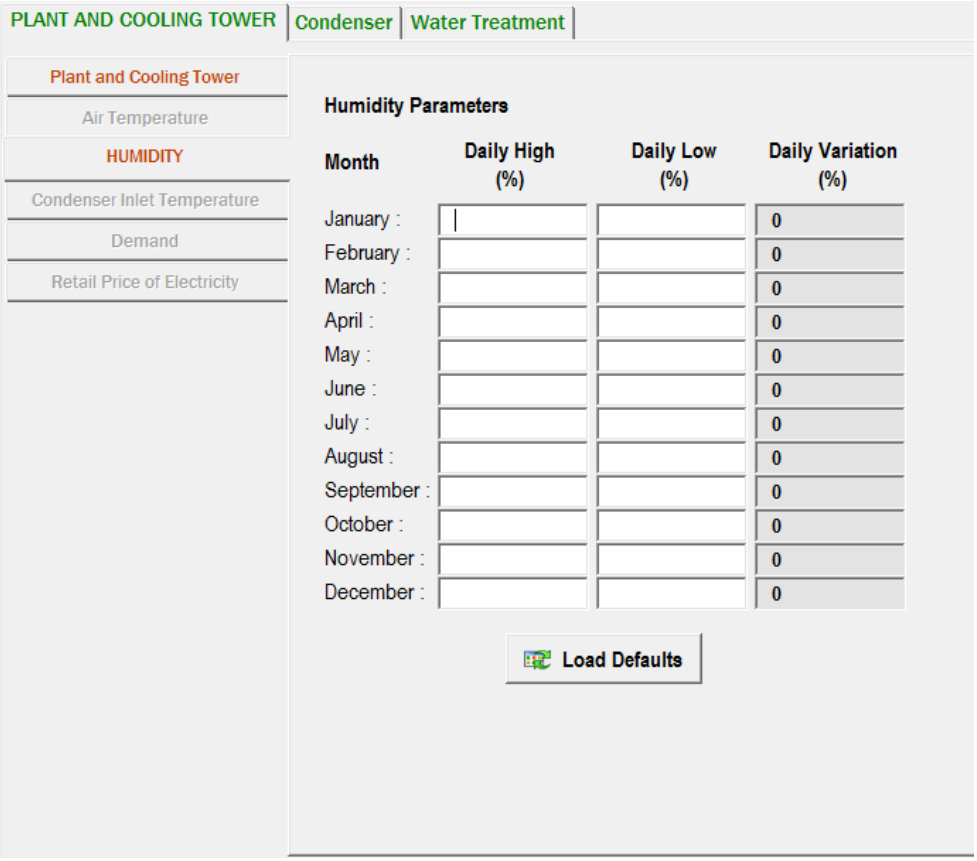

iv. **Condenser Inlet Temperature**: This tab is inactive by default, which means that the condenser inlet temperature parameter variation is not included in the costs calculation by default. When the check box beside Condenser Inlet Temperature is checked in the Plant and Cooling Tower page, the Condenser Inlet Temperature tab becomes active. Clicking on the tab shows the following:

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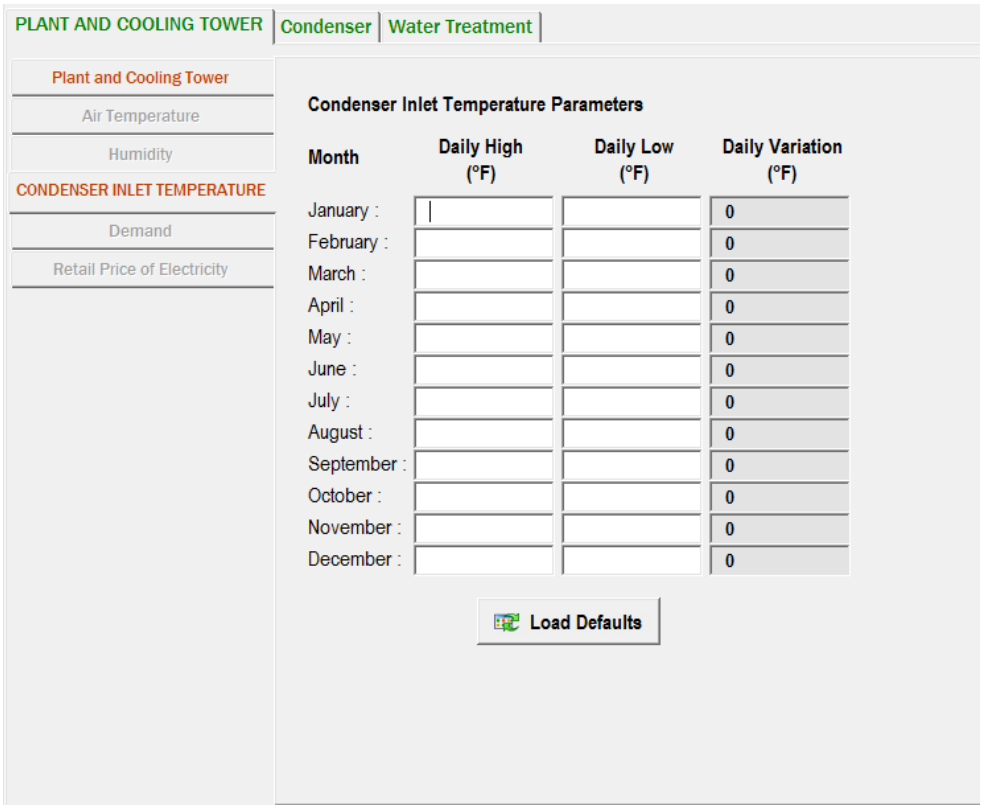

v. **Demand**: This tab is inactive by default, which means that the demand parameter variation is not included in the costs calculation by default. When the check box beside Demand is checked in the Plant and Cooling Tower page, the Demand tab becomes active. Clicking on the tab shows the following:

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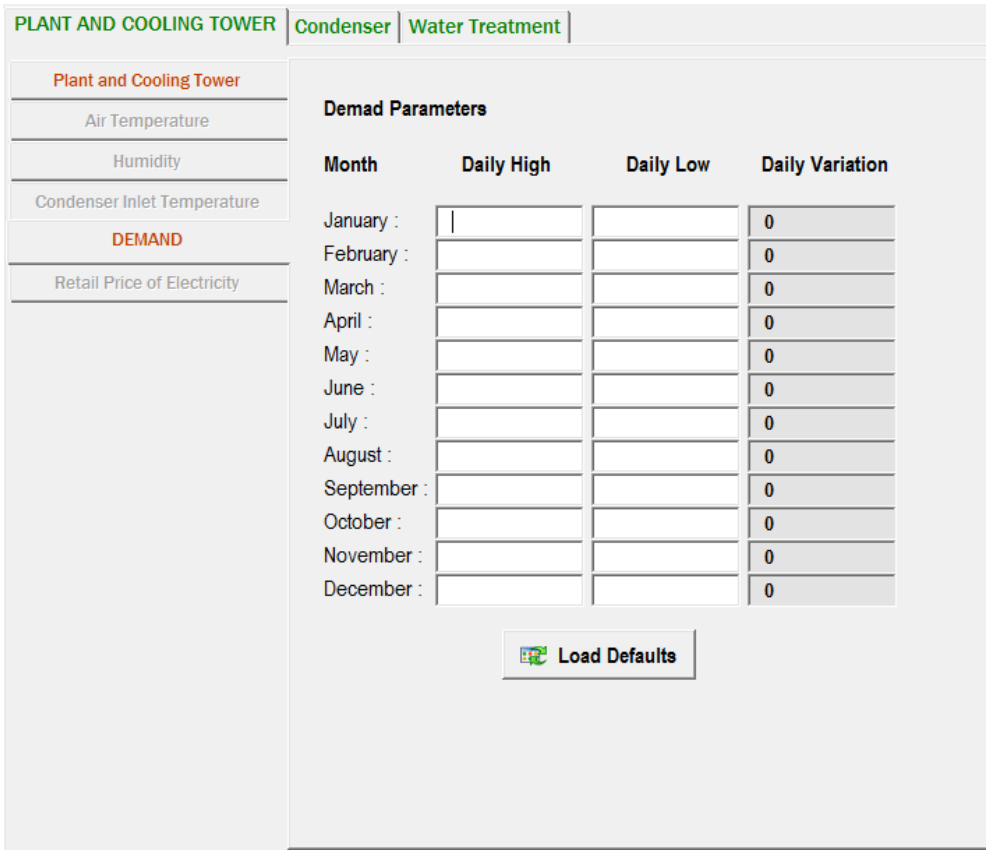

vi. **Retail Price of Electricity**: This tab is inactive by default, which means that the retail price of electricity variation is not included in the costs calculation by default. When the check box beside Retail Price of Electricity is checked in the Plant and Cooling Tower page, the Retail Price of Electricity tab becomes active. Clicking on the tab shows the following:

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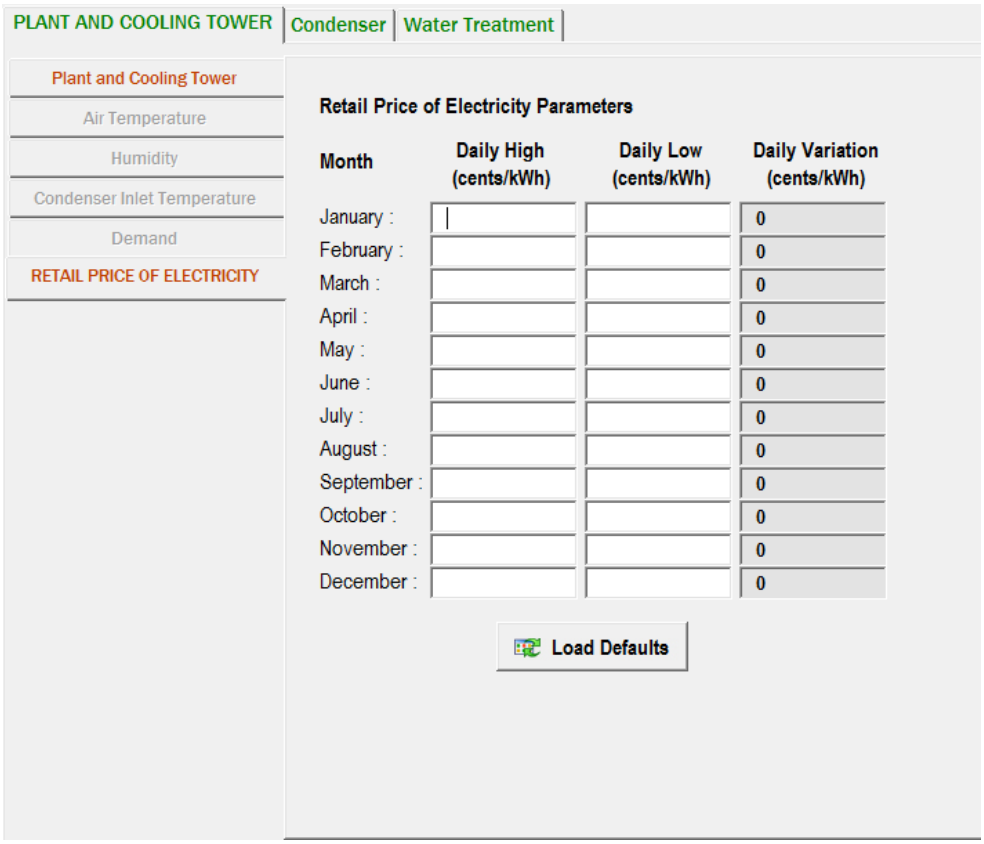
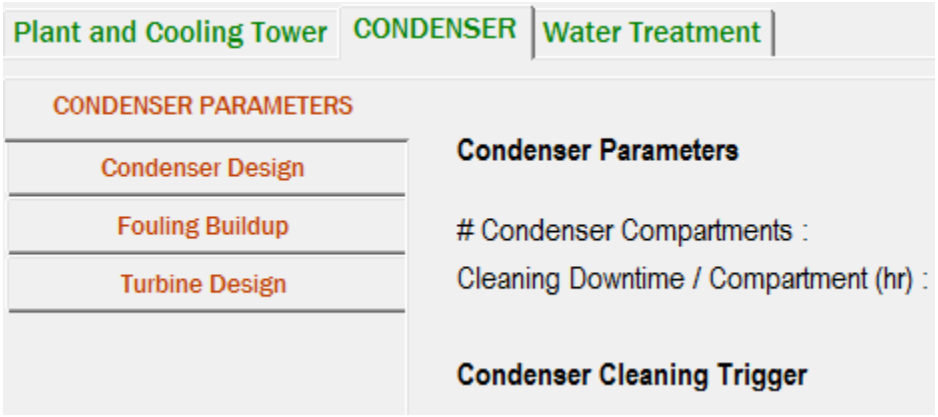


b. **Condenser**: This tab contains four sub tabs – Condenser Parameters, Condenser Design, Fouling Buildup, and Turbine Design.



i. **Condenser Parameters**: This page contains the input parameters for the condenser.

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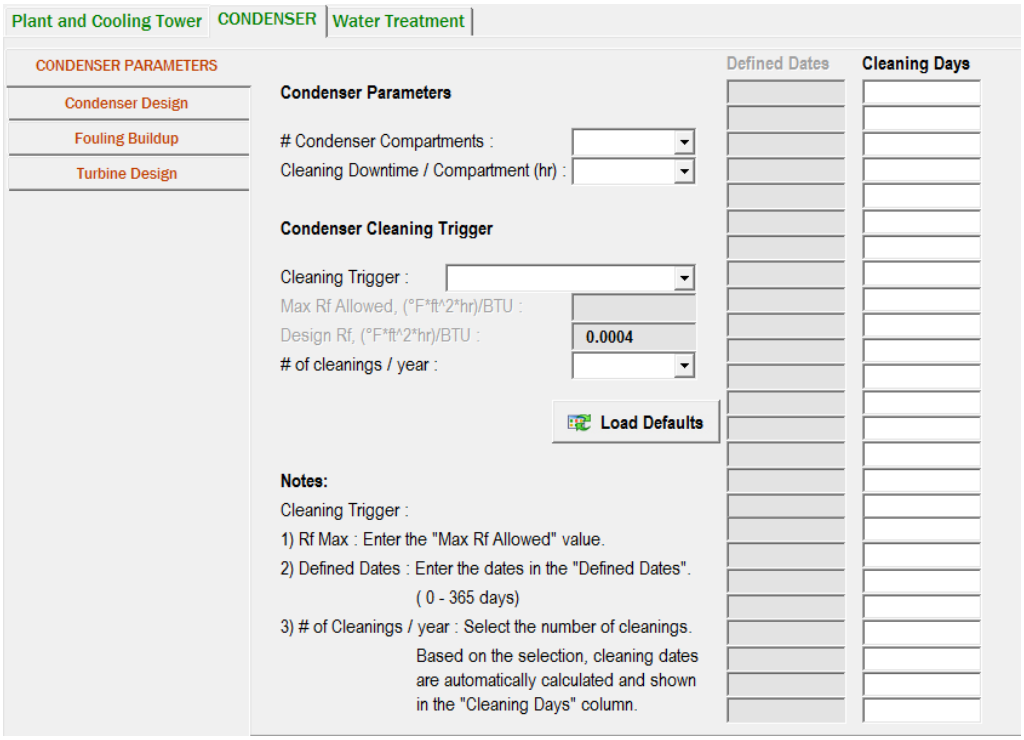
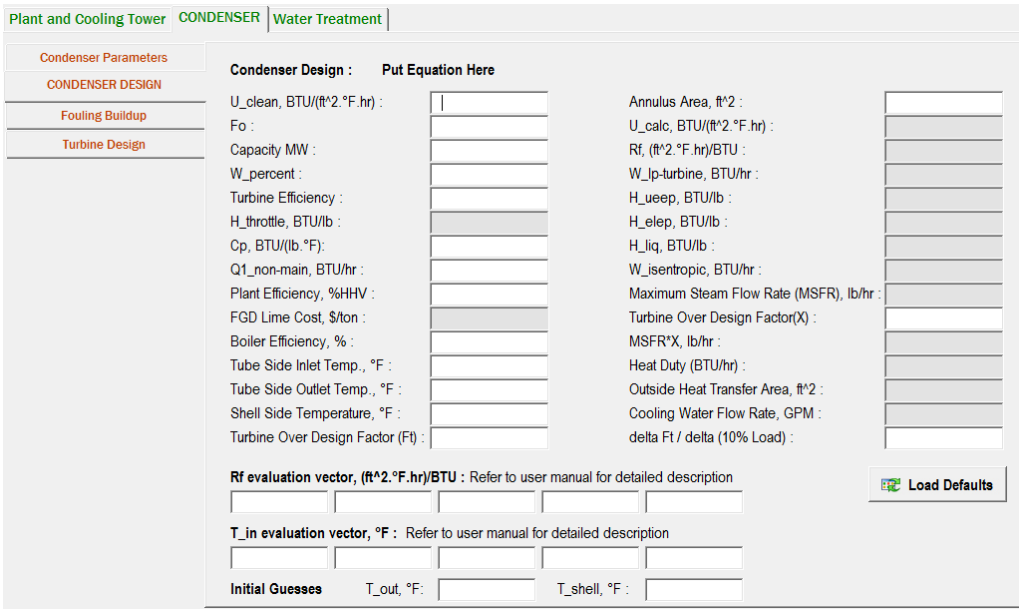


ii. **Condenser Design**: This page contains the condenser design input parameters.



All the fields in gray are not input fields, they are the display fields.

Calculated values are displayed in these fields.

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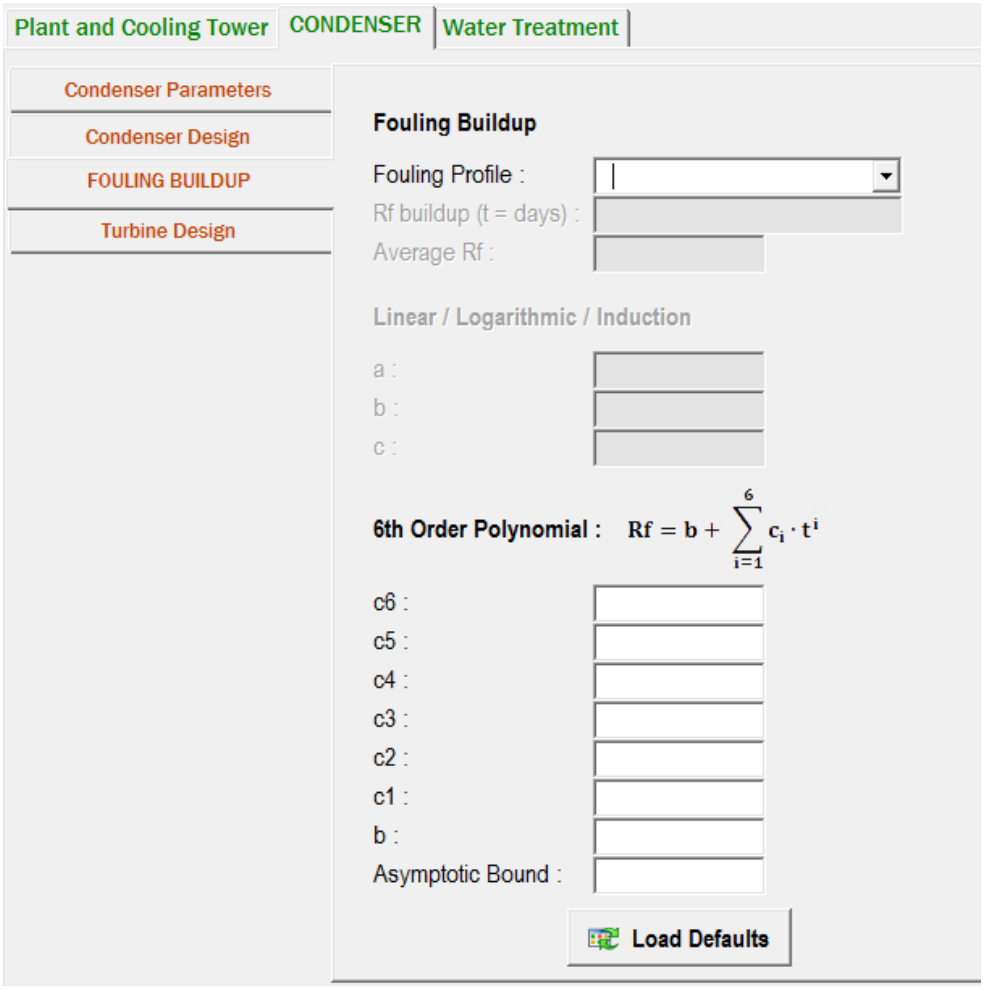
iii. **Fouling Buildup**: This page contains the fouling buildup parameters input fields.



Based on the selection of the Fouling Profile, required input fields are highlighted and the rest of the fields are disabled.

iv. **Turbine Design**: This page contains the entire turbine design input parameters field.

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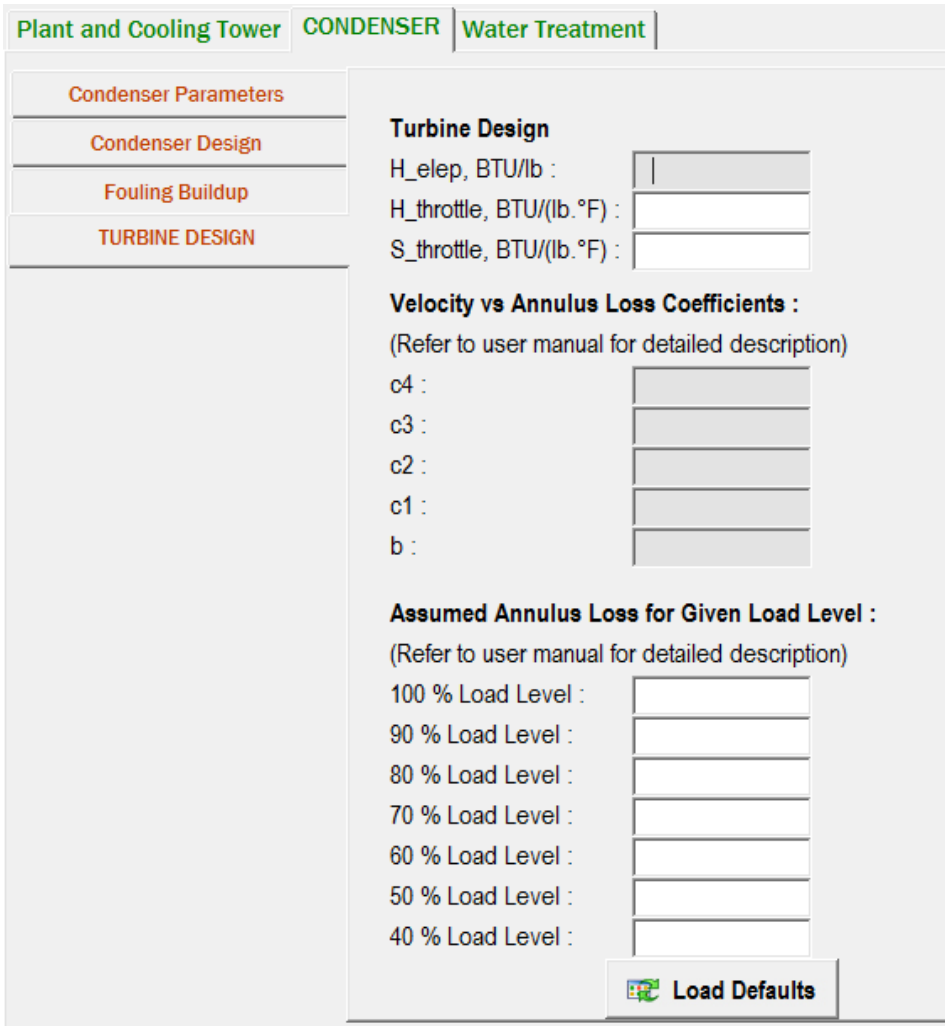

c. **Water Treatment**: This tab contains eight sub tabs – Treatment Options, Water Delivery, Water Quality Specifications, Nitrification, Softening, Filtration, Acid Addition and Chemical Addition.

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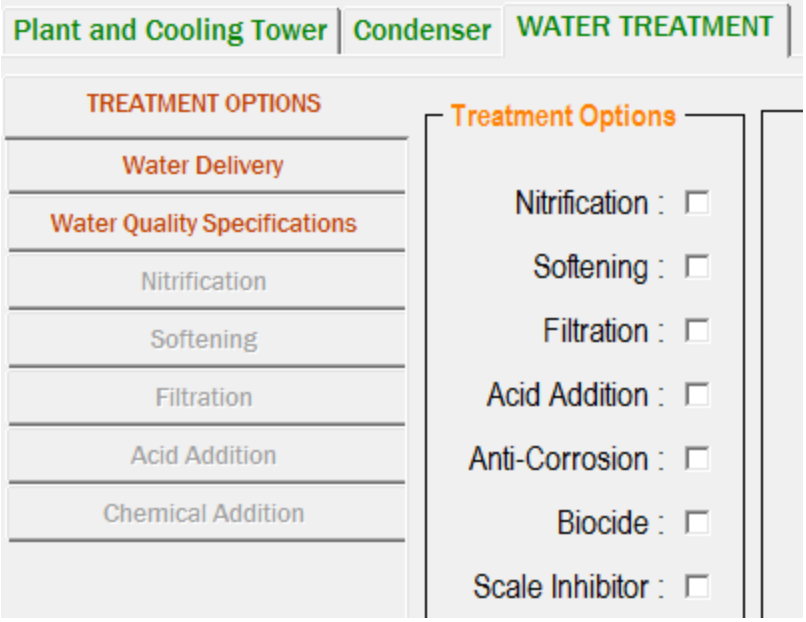
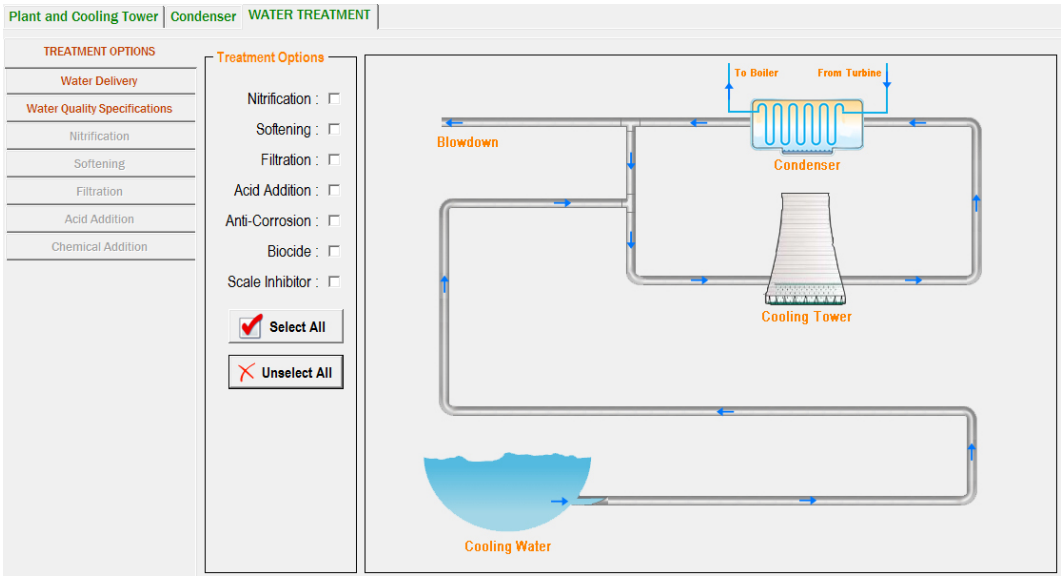


i. **Treatment Options**: This page contains the list of all the treatment options available to be included in the costs calculation. This page looks as follows:



Selecting a treatment option by checking the box beside the treatment option means that, that particular treatment is included in the costs calculation. It also enables the

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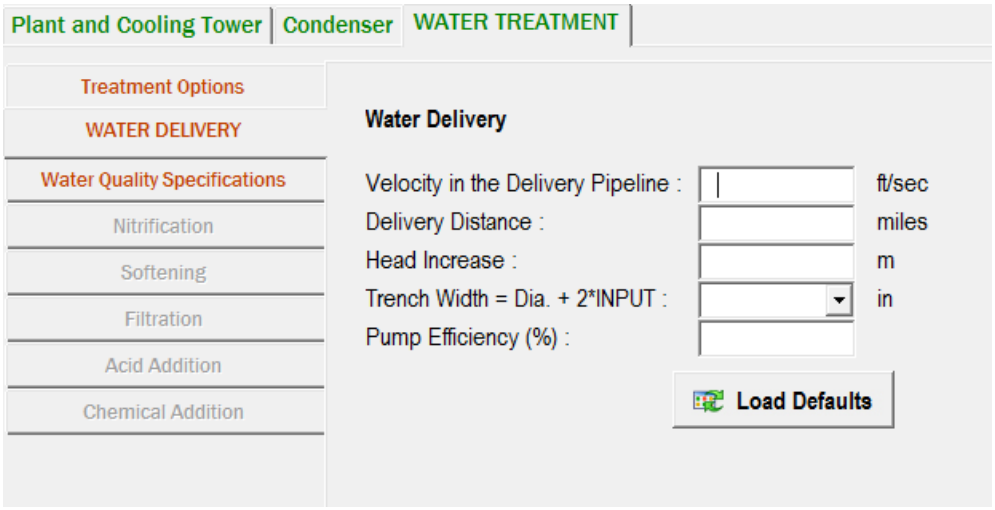
corresponding tab on the left side which contains the necessary input fields for that particular treatment option.

ii. **Water Delivery**: This page contains all the water delivery input fields required for costs calculation.



iii. **Water Quality Specifications**: This page contains all the water quality specifications input fields required for costs calculation.

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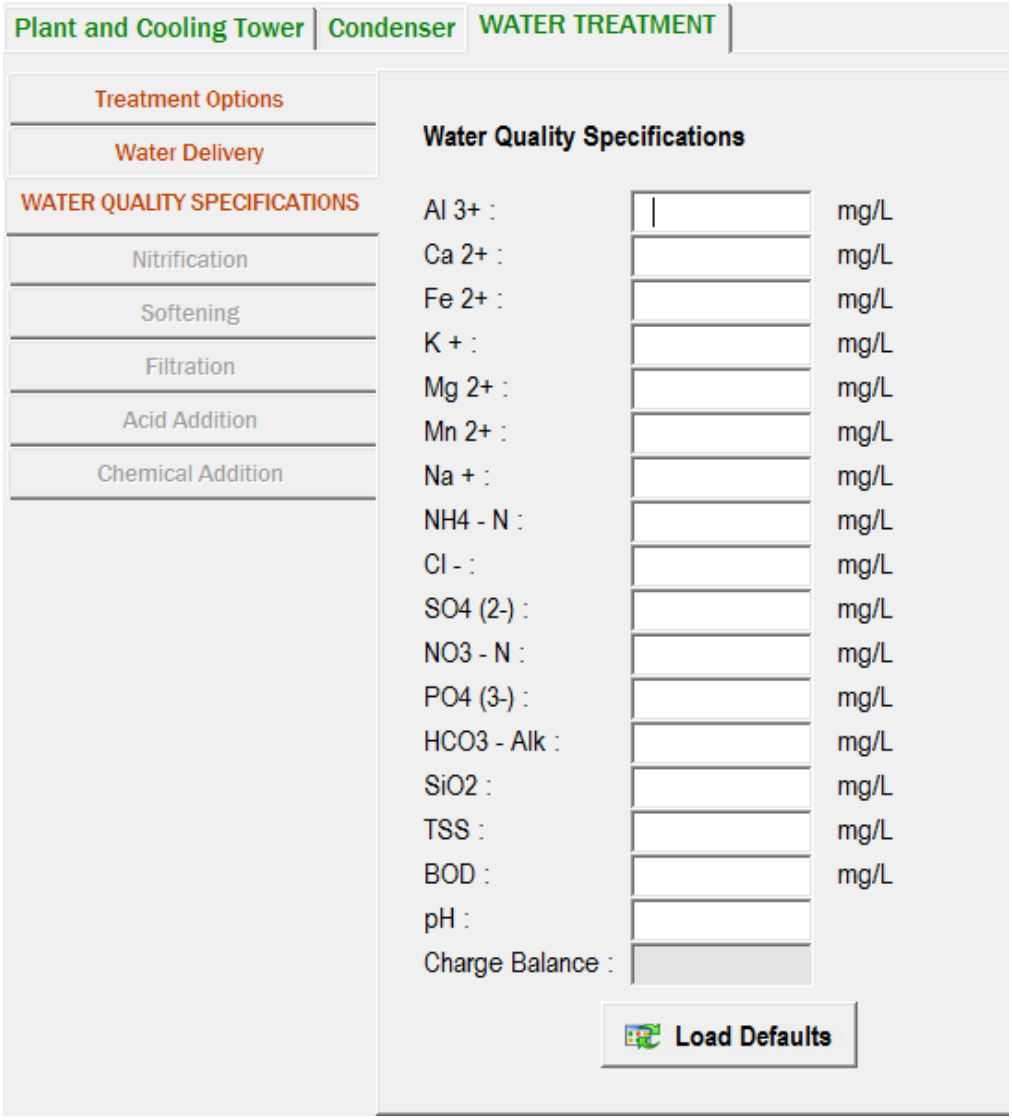

iv. **Nitrification**: This page contains all the input fields required for computing the costs if nitrification is selected as a water treatment option from the Treatment Options page.

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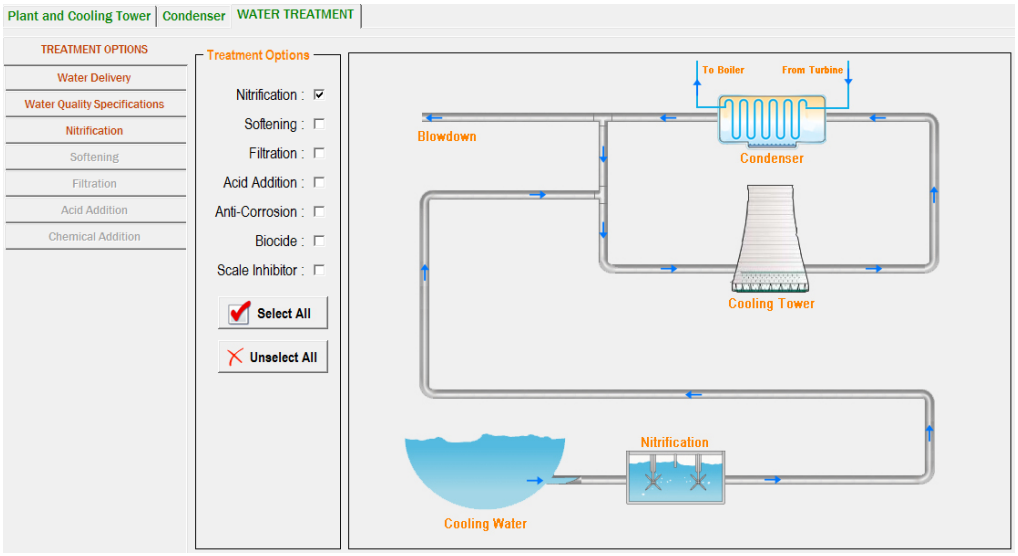

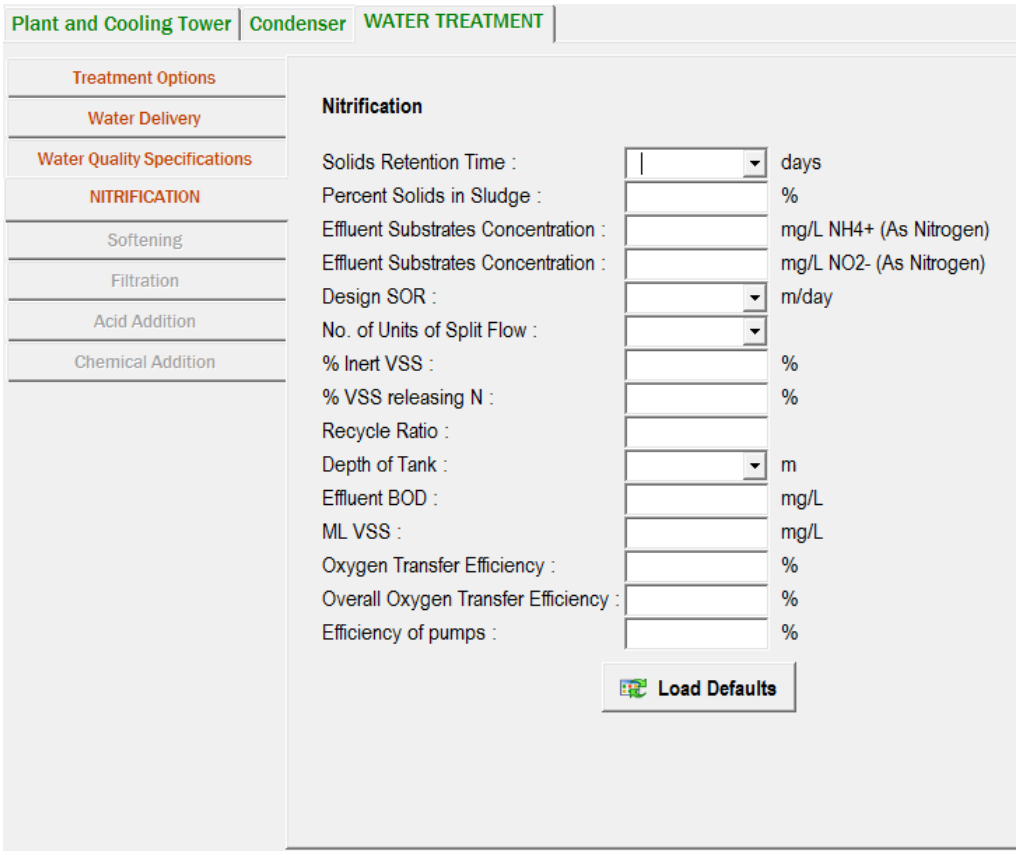

v. **Softening**: This page contains all the input fields required for computing the costs if softening is selected as a water treatment option from the Treatment Options page.

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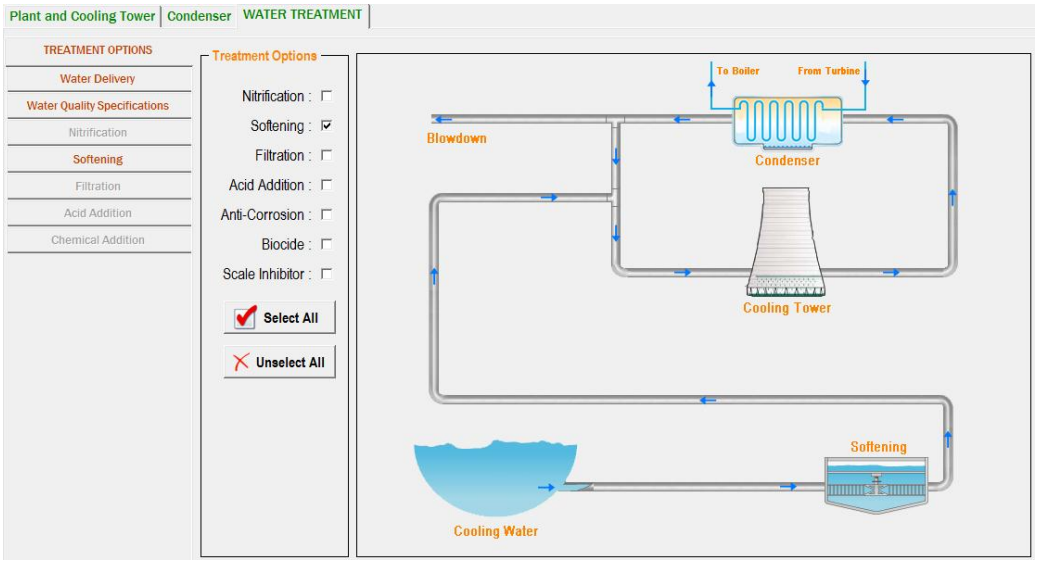

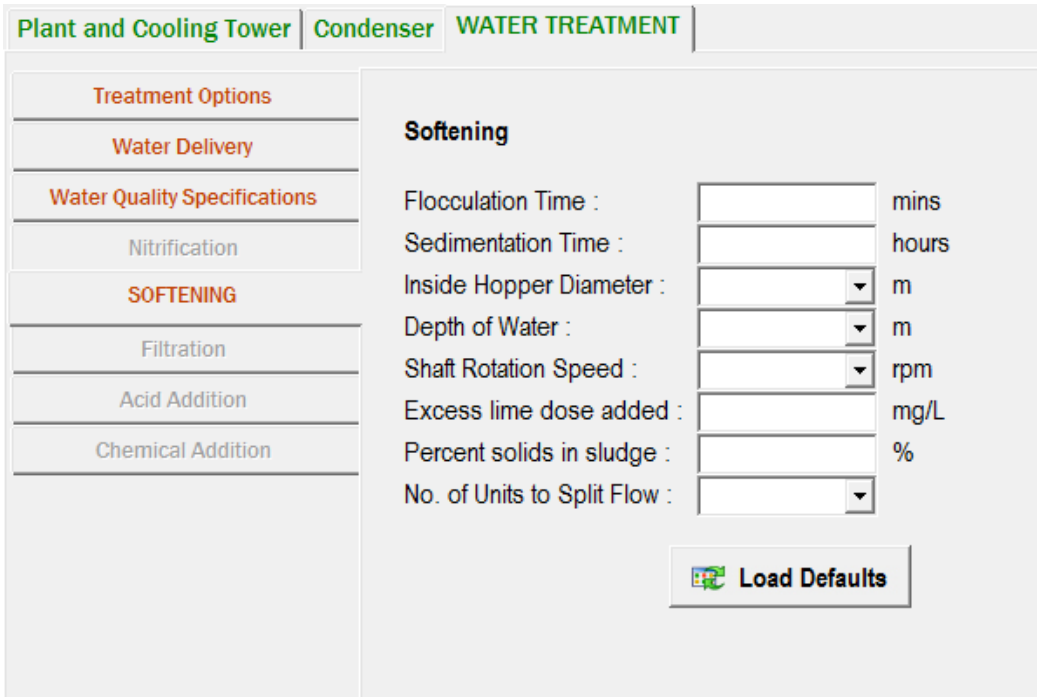

vi. **Filtration**: This page contains all the input fields required for computing the costs if filtration is selected as a water treatment option from the Treatment Options page.

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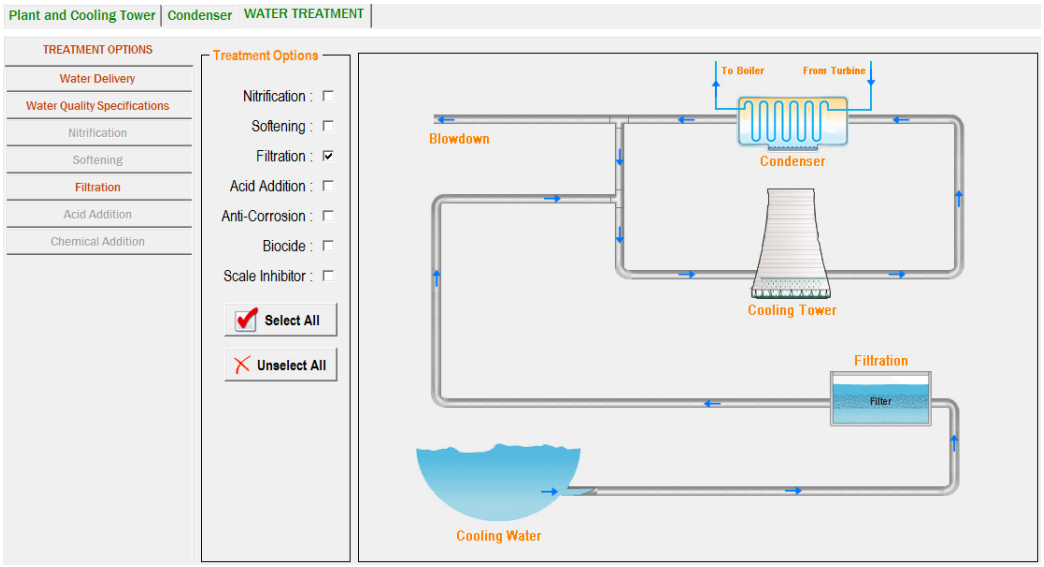

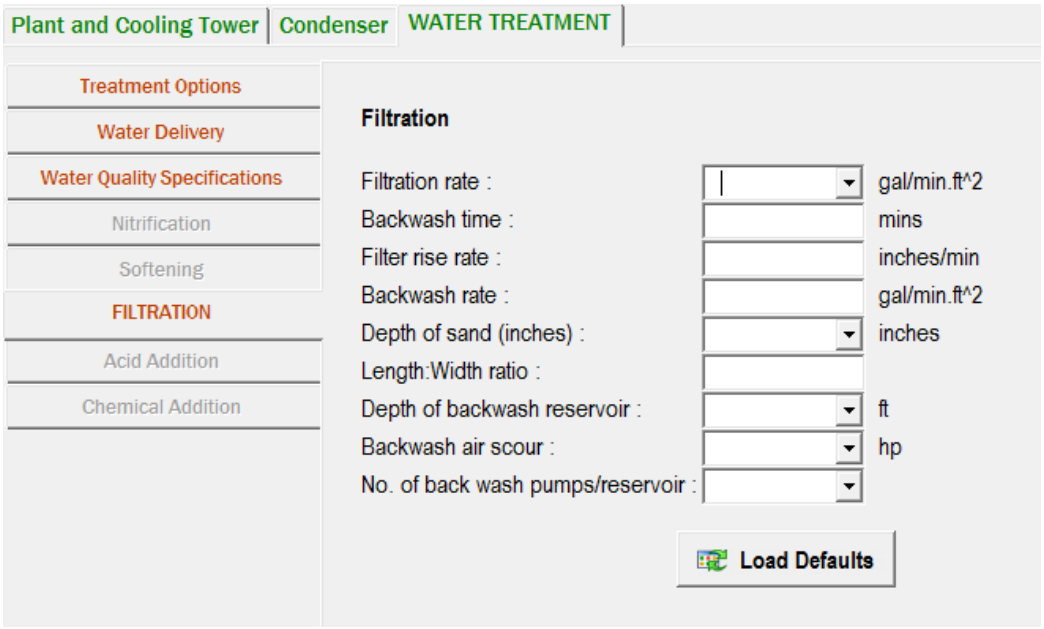

vii. **Acid Addition**: This page contains all the input fields required for computing the costs if acid addition is selected as a water treatment option from the Treatment Options page.

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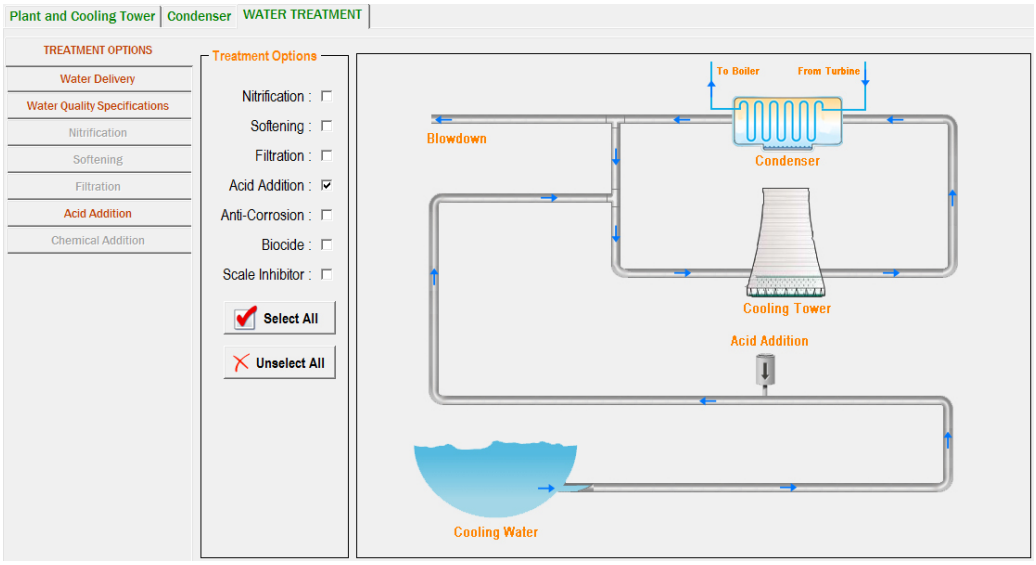

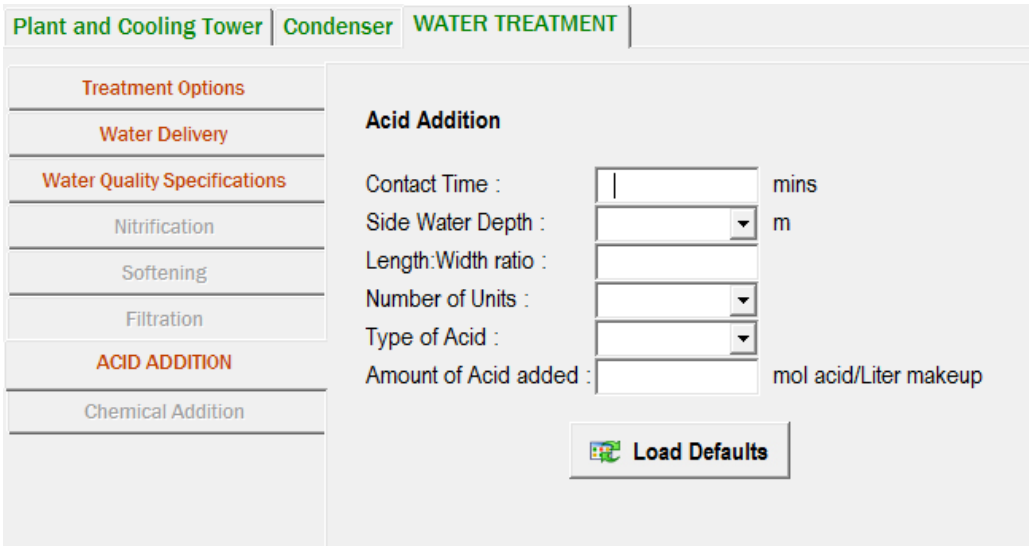

viii. **Chemical Addition**: This page contains all the input fields required for computing the costs if any of the anti-corrosion, biocide and scale inhibitor options are selected as water treatment options from the Treatment Options page.

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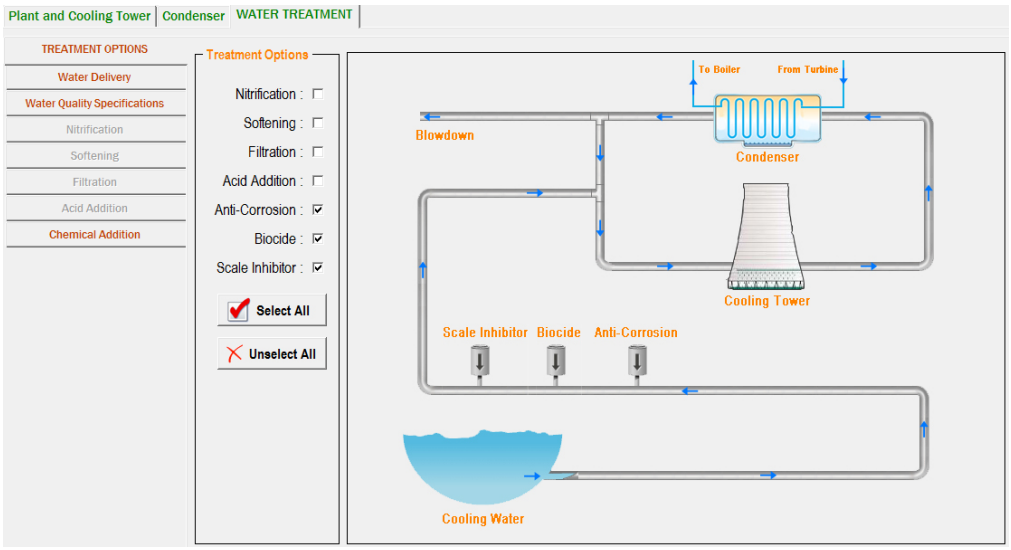

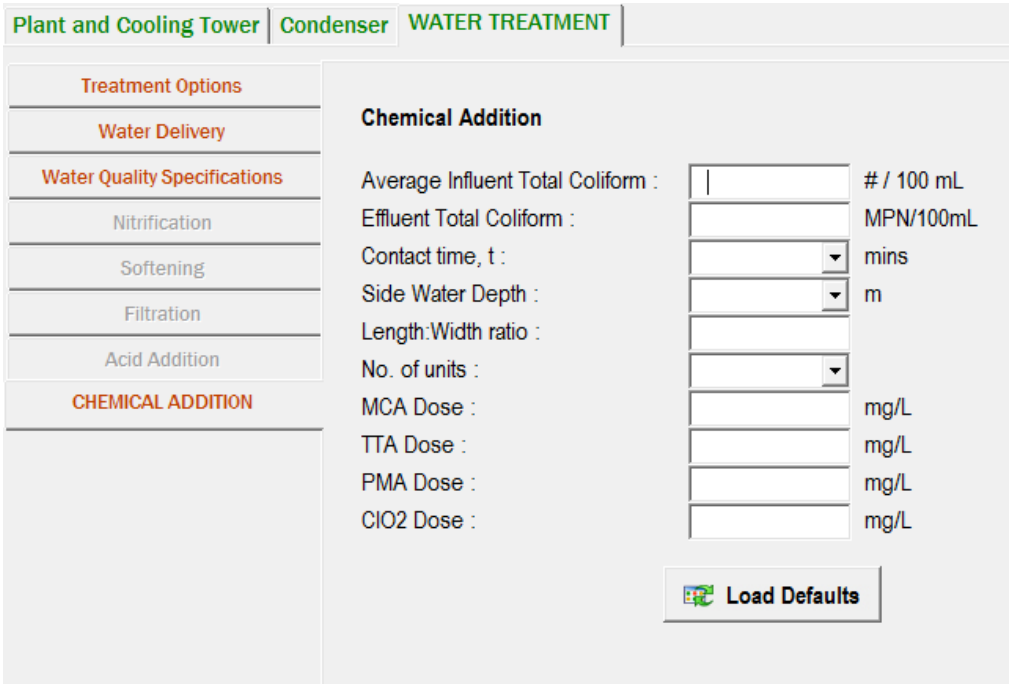

C. **Cost Parameters**: This tab contains three sub tabs – Commodities, Utilities, Services; Cost Factors; and Construction and Processing.

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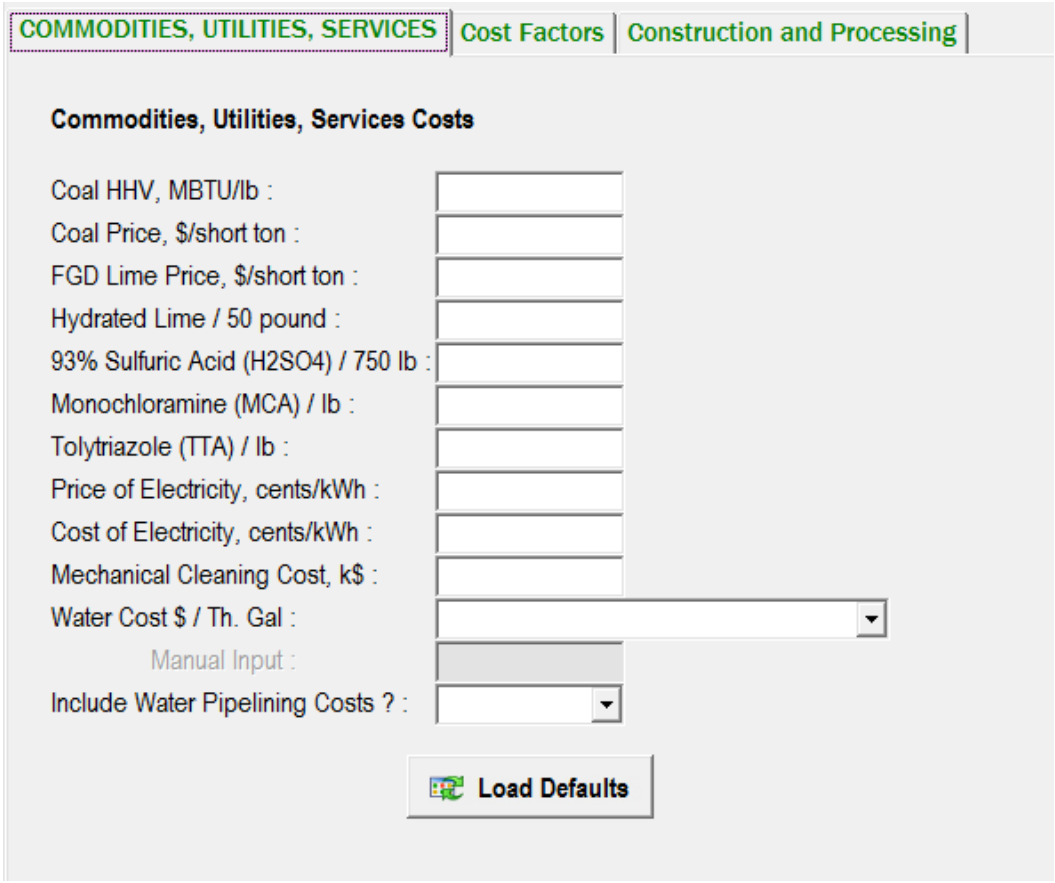
a. **Commodities, Utilities and Services**: This page contains all the input fields related to commodities, utilities and services which are required to do the costs calculations.



b. **Cost Factors**: This page contains all the cost factors input fields required for the calculations.

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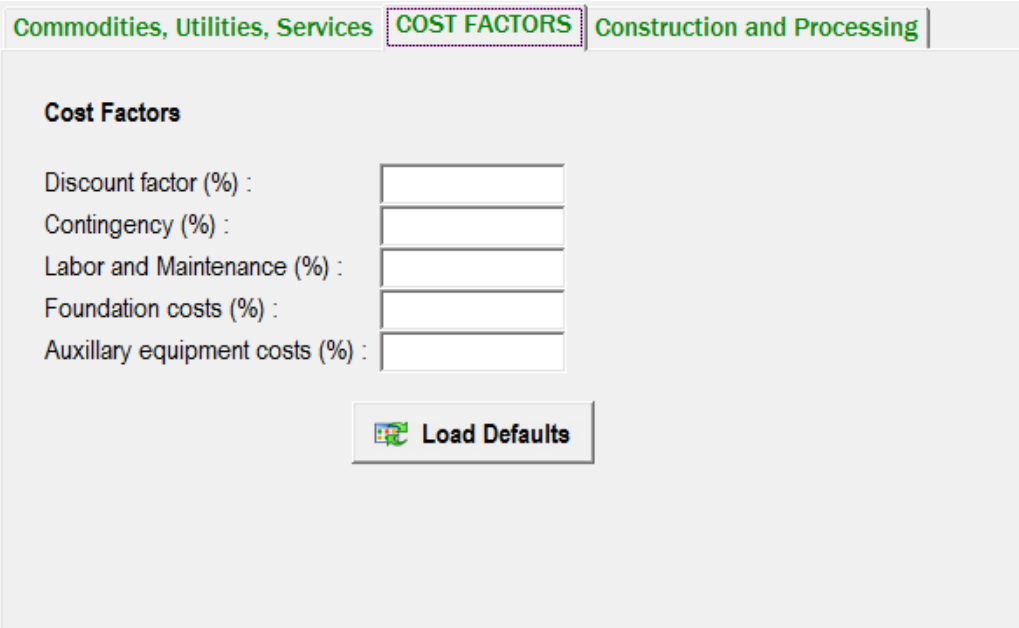

c. **Construction and Processing**: This page contains all the construction and processing input fields required for the costs computation.

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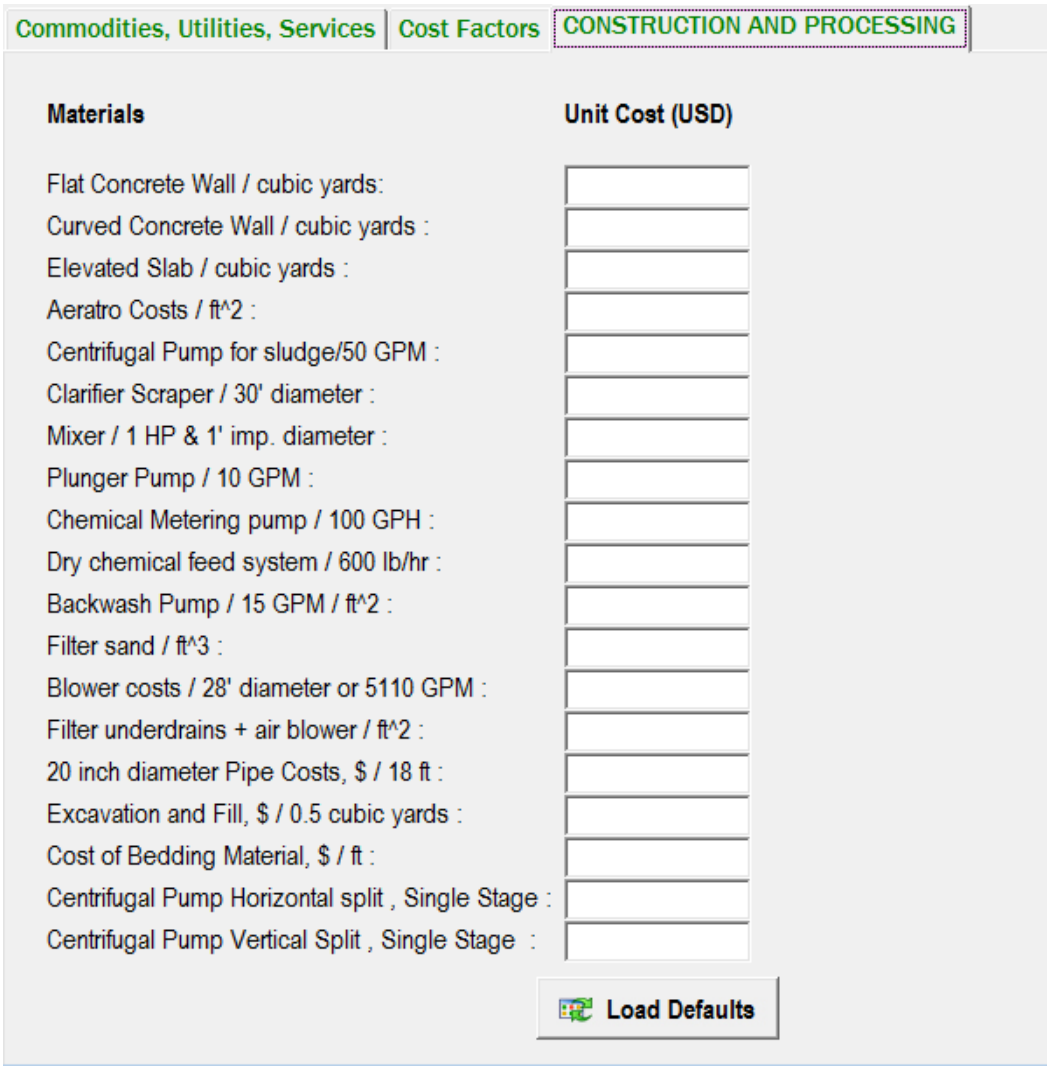

D. **Results**: This tab is used to display the results. Clicking on this tab does an input validation first – which means that if any of the required inputs are missing then it will let you know which specific input is missing by directing you to that input field. If multiple input fields are missing then the guiding will be done in a particular order. This message is displayed every time a required input is missing:

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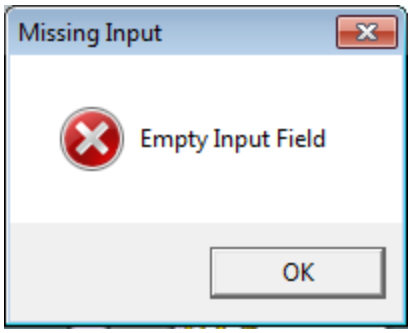
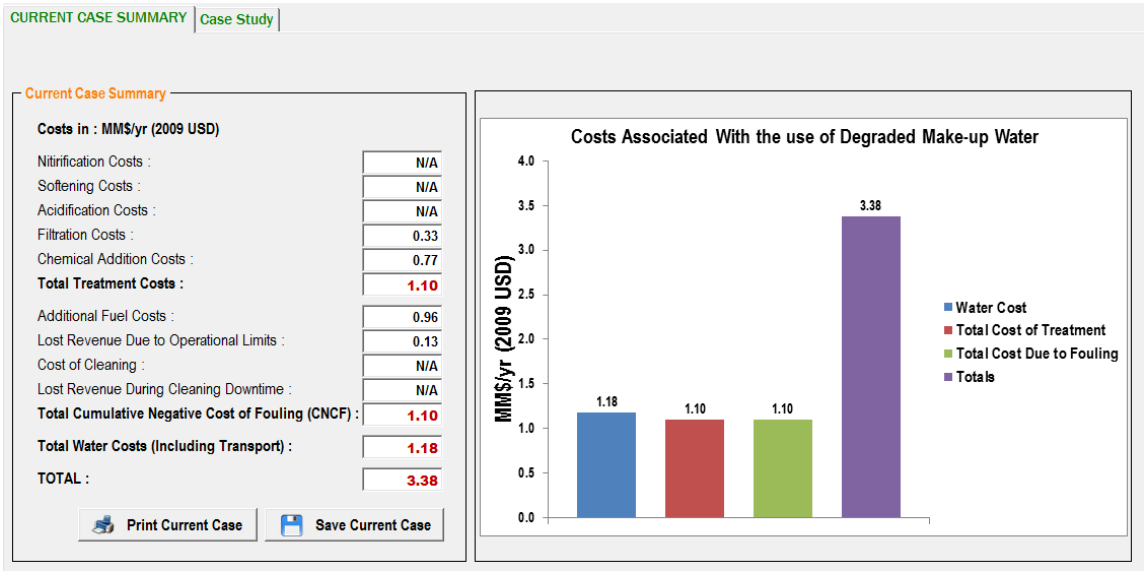


If all the inputs are entered correctly then clicking on the Results tab displays two sub tabs – Current Case Summary and Case Study

a. **Current Case Summary**: This page displays the results of the currently running case. It displays some important results of the costs calculation as well as a graph to visualize the important costs.



All the costs are represented in MM$/yr (2009 USD). A **N/A** symbol in the costs field means that there is no cost associated with that particular

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description. For example in the above figure, there is no cost due to nitrification, softening and acid addition because those treatment options were not selected in the costs calculation.

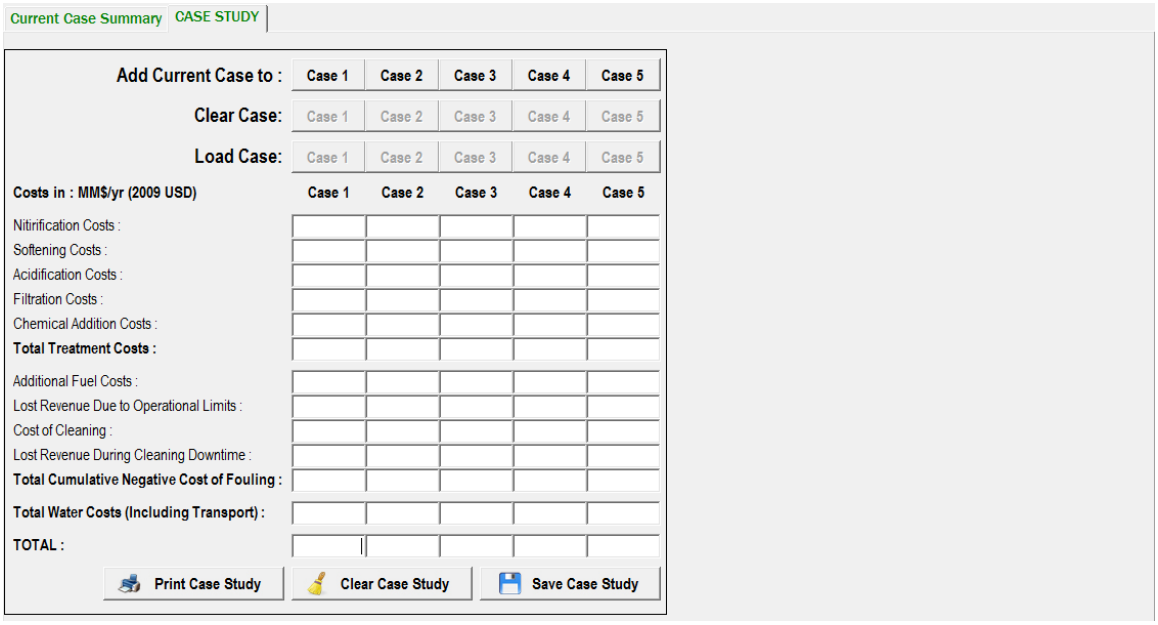
This page also contains two important buttons:

and

More on Print Current Case

More on Save Current Case

b. **Case Study**: This page is for doing a case study where one or more (up to 5) cases can be analyzed side-by-side. The page looks as follows:



To begin with, the Case Study page is empty.

More on Performing a Case Study

More on Print Case Study

More on Save Case Study

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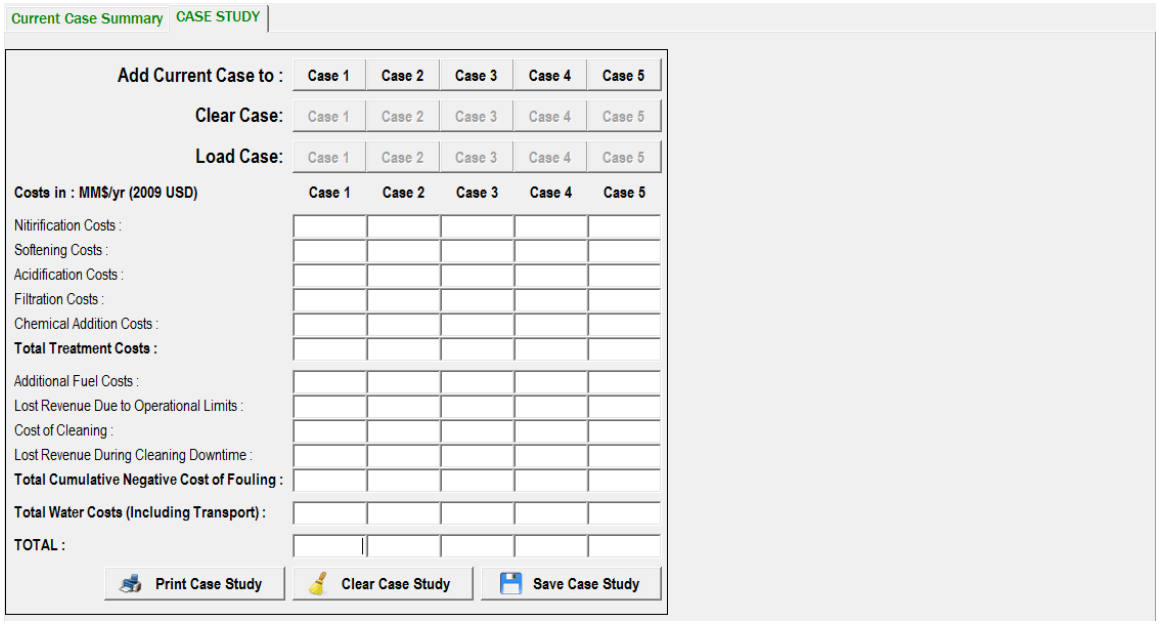
Performing a Case Study

The Case Study page is empty to begin with and it looks like this:



- In order to enter the **Results** tab we need to have a case (a complete set of inputs). Otherwise, we will encounter a missing input error message box.

  In this case we will load all the input fields with default values by clicking on **Load Defaults** button in the **Main Menu** page. We will also enter the user name and run number. For e.g.: user name = IIT, run number = R1
- Once we have a case, its results are computed immediately. Clicking on the **Results** tab displays the Current Case Summary.
- In the Case Study page, we can add the current case into any of the 5 cases – Case 1, Case 2, Case 3, Case 4 and Case 5.
- In order to do that, we click any of the buttons beside Add Current Case to:

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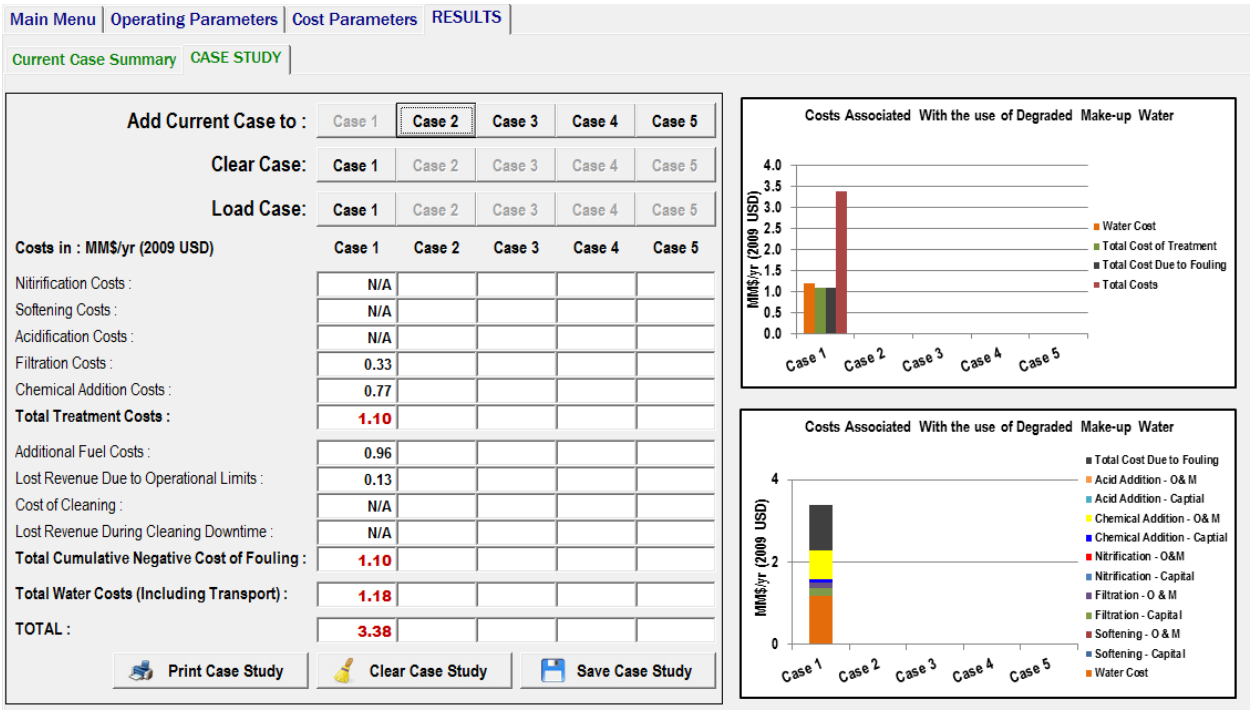
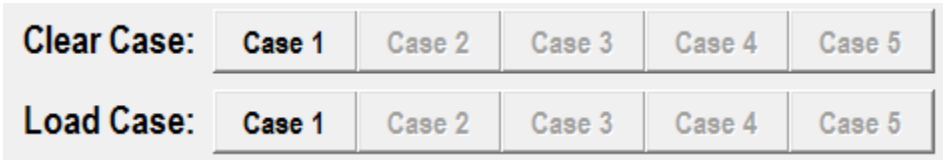
- Suppose we want to add the current case to Case 1. We click on the **Case 1** button beside Add Current Case to and this is what we get:



- We can see that the important costs information is populated in the Case 1 column and two graphs are also displayed on the right side.
- We can also see that the Clear Case and Load Case options for Case 1 are now available.



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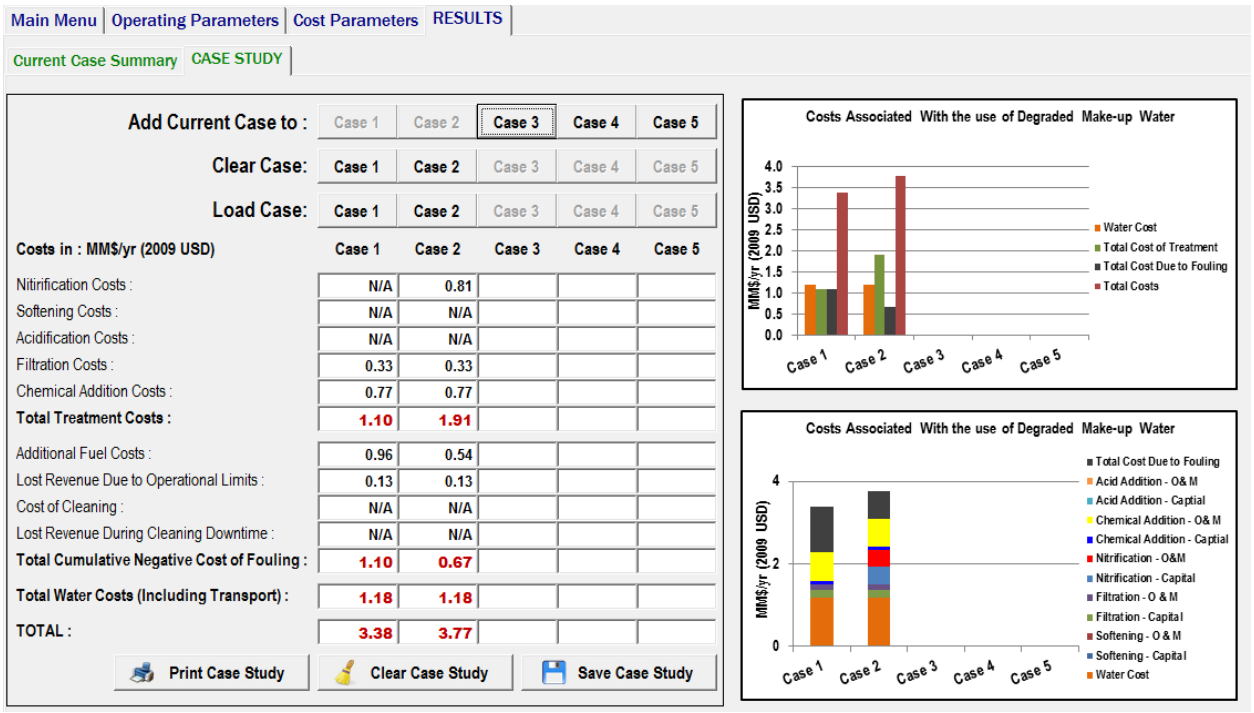
- Clicking on **Case 1** button beside Clear Case will clear the Case 1 column and the Case 1 part of the graph. We will be able to see this later when we will add some more cases to this case study.
- When a case is added to a particular case study, all the input information of that case is saved temporarily in the program. Load Case feature is used to access that information. We will explore this option later.

Now, let's suppose we want to manipulate some of the input parameters. In this example, we will add **Nitrification** to the current case. And add the results to **Case 2**. This is what we get:



Now, we will add **ALL** the treatment options from the Treatment Options page and add that case to Case 3.

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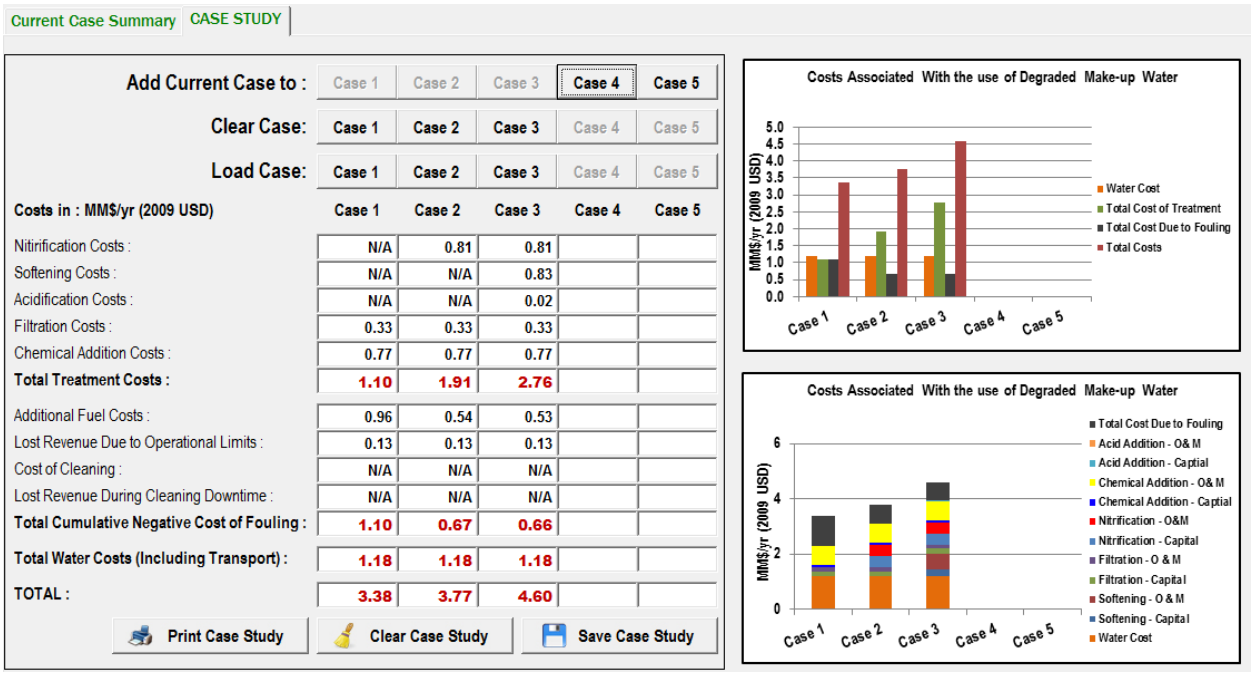

These are the three cases that we have added so far:

- Case 1: All default values (Filtration, Acid Addition and Scale Inhibitor are default treatments).
- Case 2: All default values + Nitrification.
- Case 3: All default values + All treatment options.

Next, we will explore the Load Case feature.

- Click on **Case 2** beside **Load Case**. We will see a **LOADING …** sign and it takes a while for the case to load.

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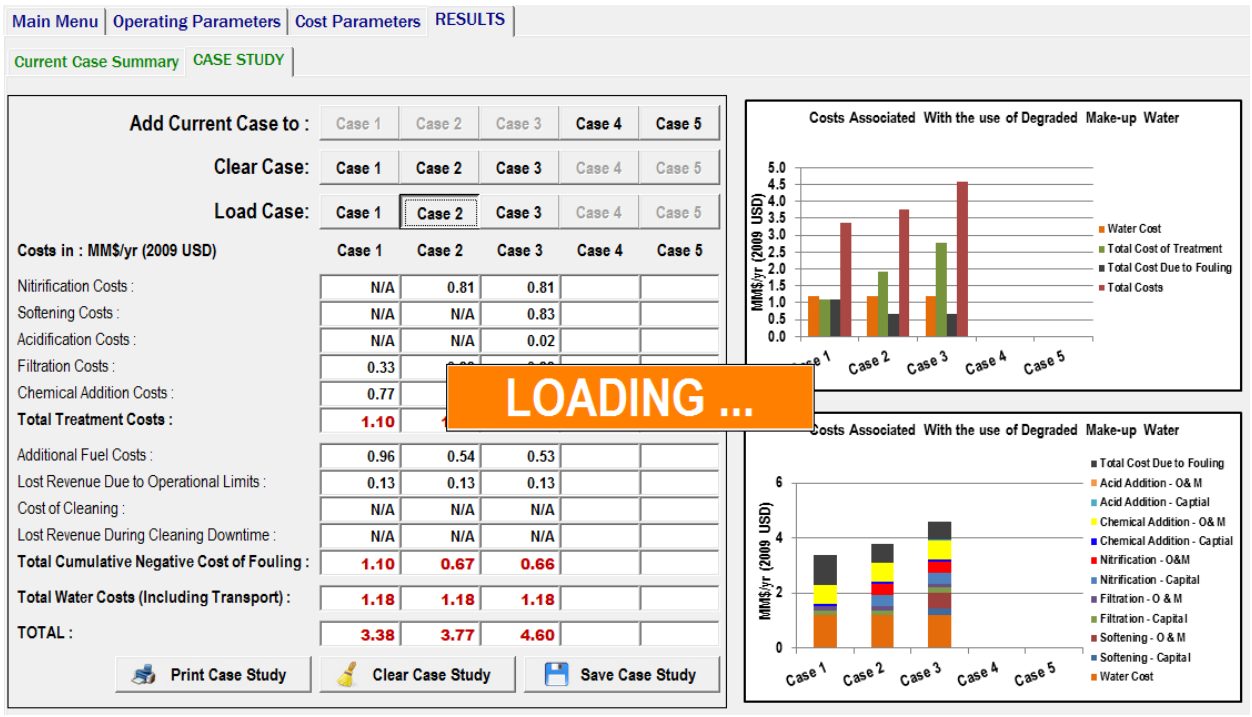
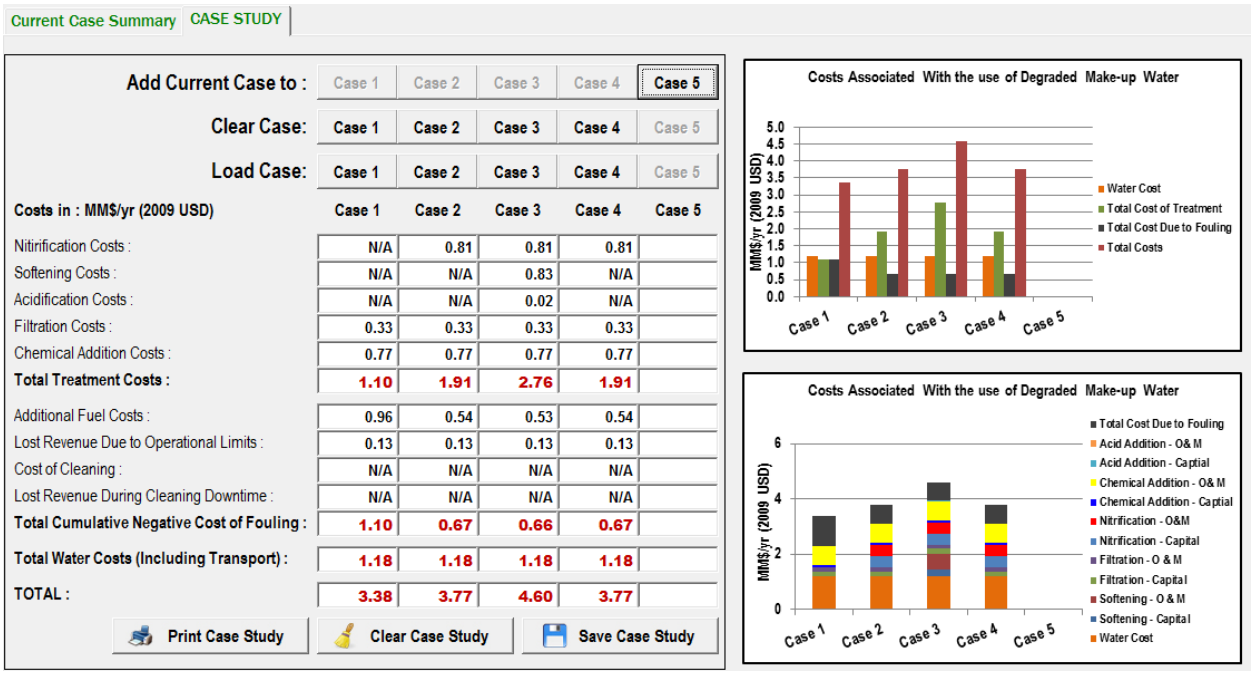


- Now click on **Case 4** beside **Add Current Case to**.



- We can see that Case 4 and Case 2 are identical.

Next, we will clear Case 1.

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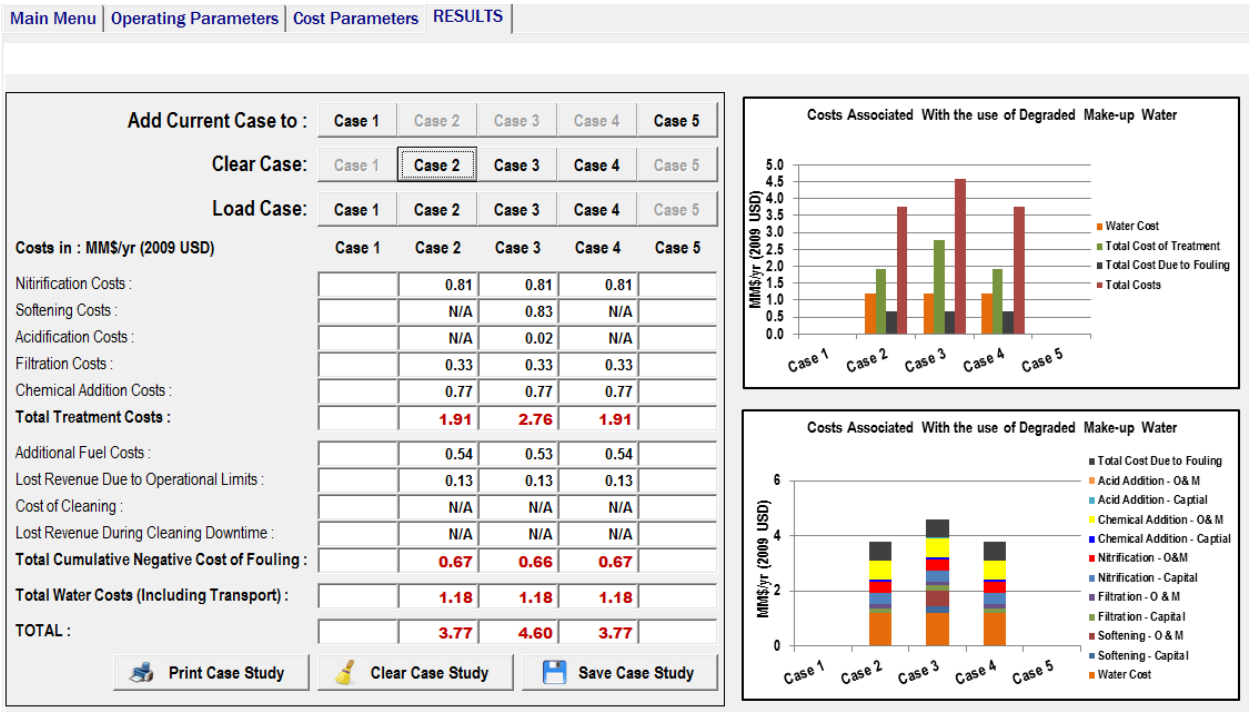
- Click **Case 1** beside the Clear Case.



- Case 1 column becomes empty and the Case 1 graph disappears as well.
- Click **Case 1** beside Load Case.
- Once the Loading is complete, click **Case 5** beside Add Current Case to. This is what you will see:

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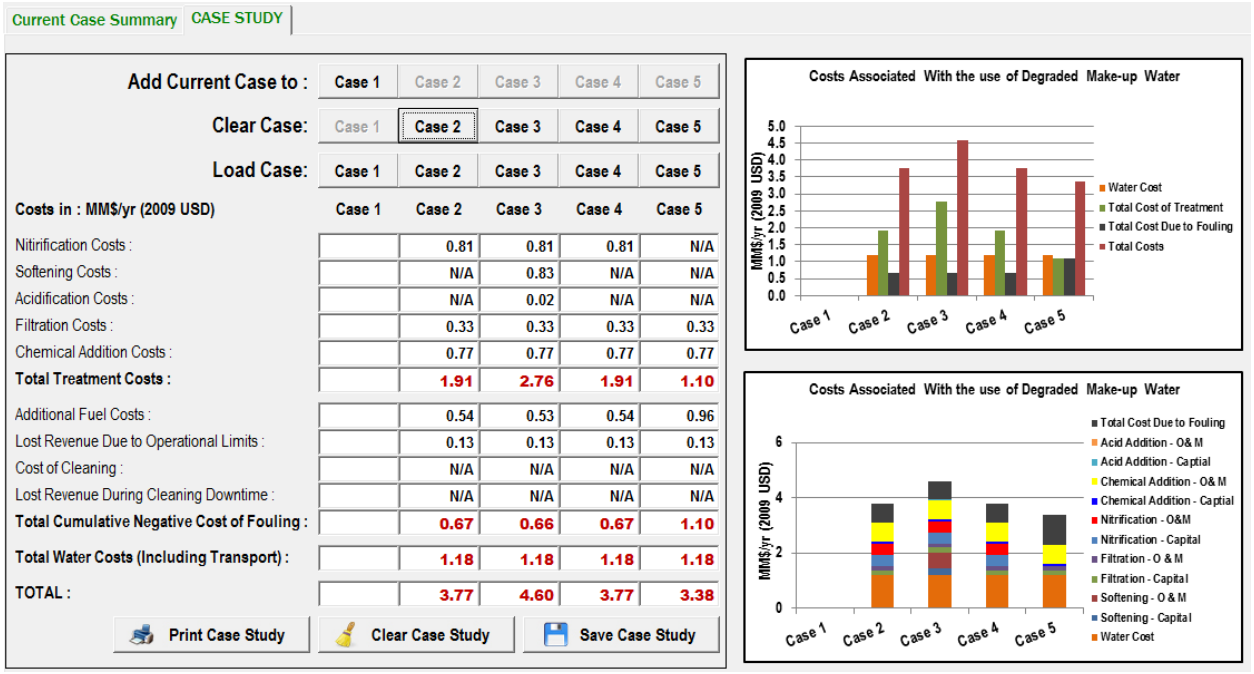

- As you can see, Case 5 is exactly the same as Case 1. This means that clearing the case doesn't clear the temporary data related to that case stored in the program. Clearing a case only erases the information that is being displayed in the case study page.
- The only way to overwrite the temporary data related to a particular case (e.g. Case 1) is to add a different case to it. Let's add Case 3 to Case 1.
- In order to do that, we will load Case 3 first then we will add it to Case 1.

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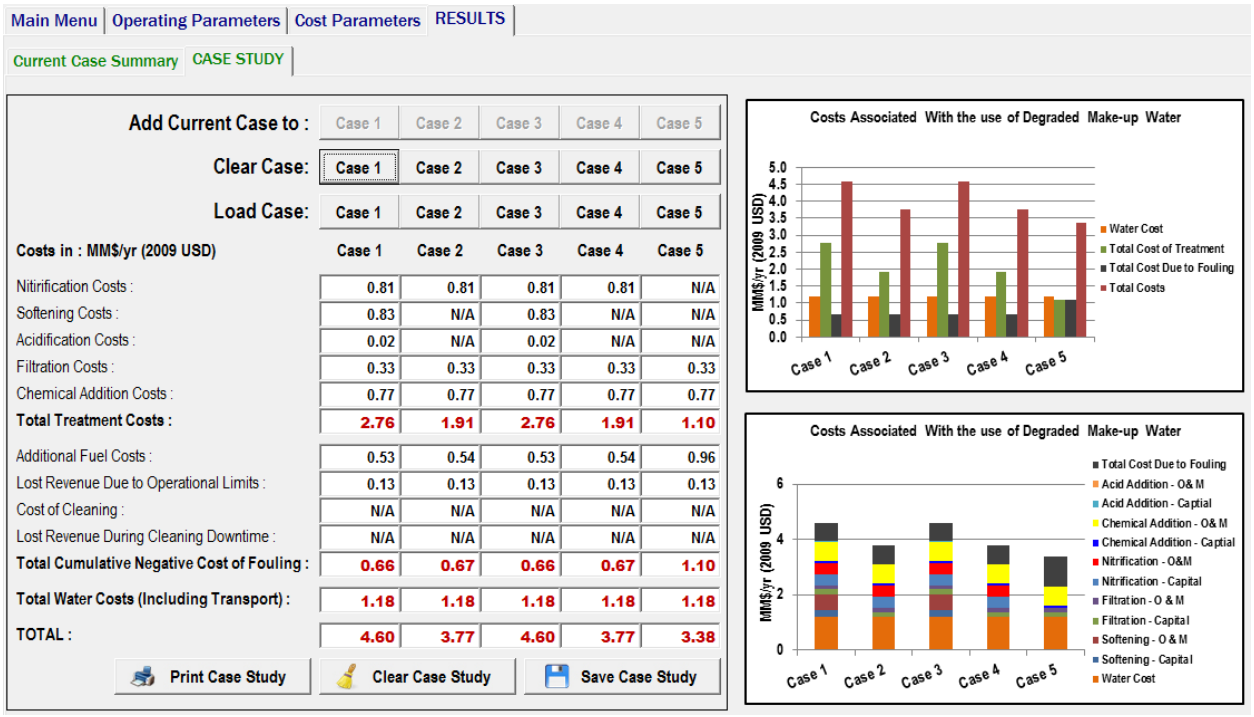
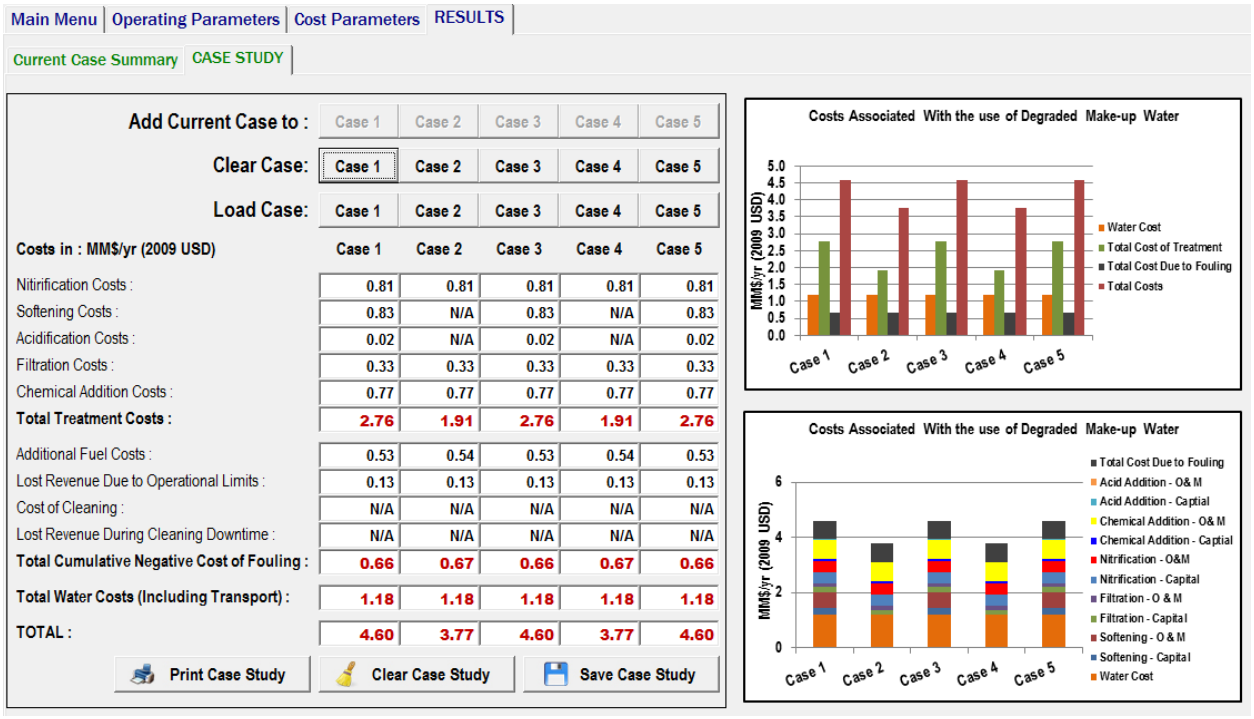


- Next, we will clear Case 5, Load Case 1, and add Case 1 to Case 5.



- As we can see, Case 5 is identical to Case 1. But, the values are different from what we had loaded from Case 1 before.

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Saving a Case

A case can be saved as an MS-Excel file. Saving a case is useful because:

- It is a record of complete input and output information which can be accessed anytime.
- It can be opened (loaded) into the program in order to change some of the parameters and/or in order to do a case study.

In order to save a case, go to **Results → Current Case Summary** and click on **Save Current Case**.

A Save As dialog box appears with a suggested file name (which is username_runnumber):

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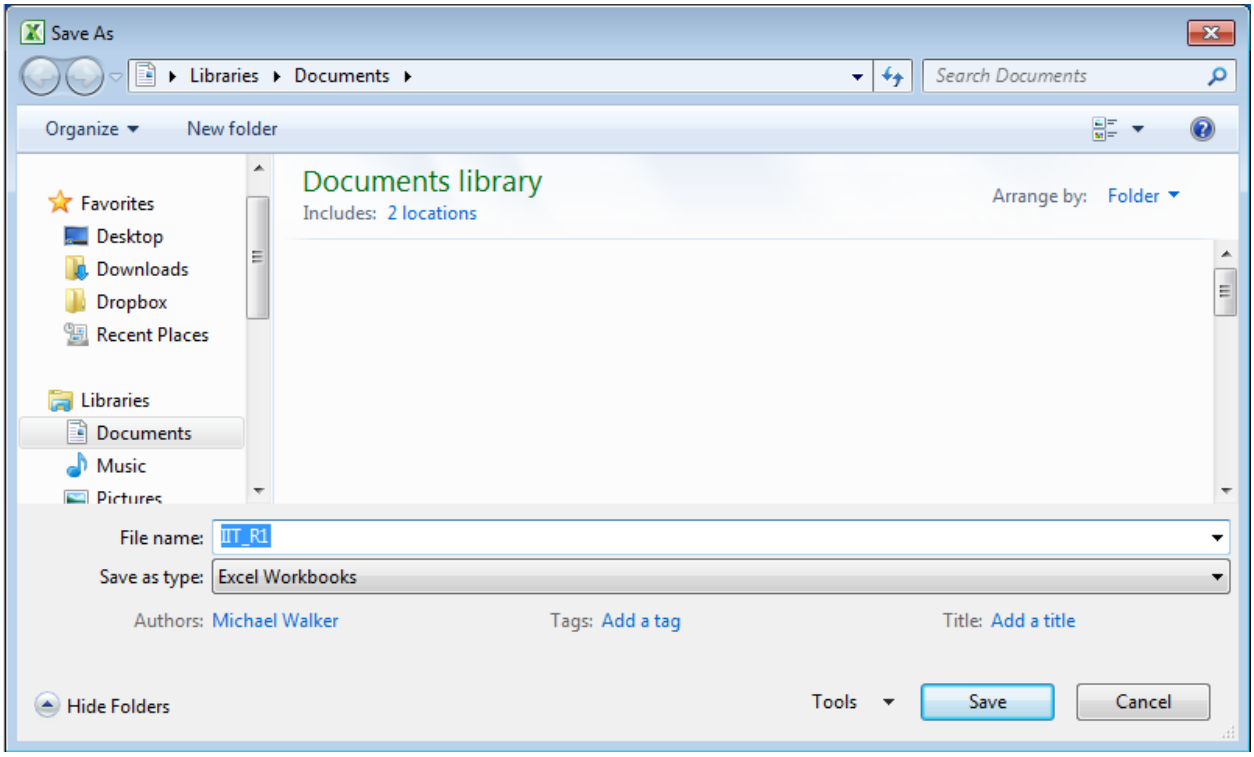

You can change the location to wherever you want to save the file.

Click on **Save**.

A **SAVING…** sign is displayed. Once the save is complete the sign disappears.

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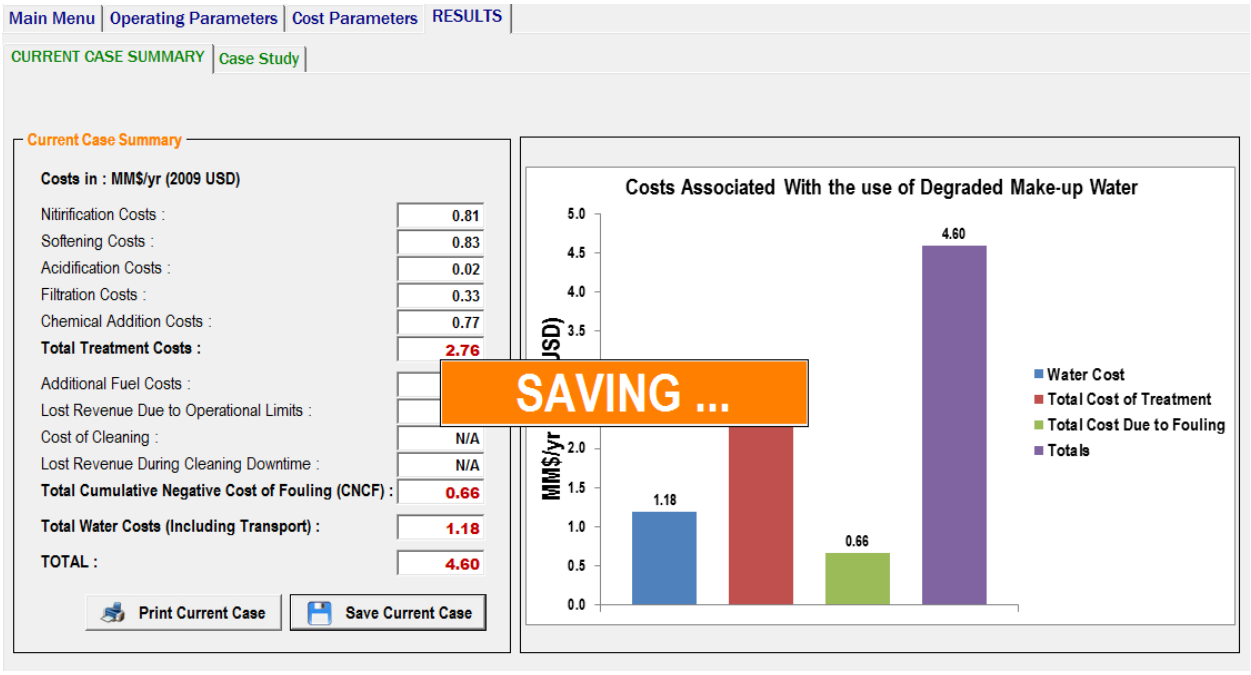

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Saving a Case Study

Saving a case study is similar to saving a case. The difference is that if you save a case study, a complete input – output information for each case in the case study is saved. Along with that, a case study report sheet is also saved which shows the information in the Case Study page of the GUI.

In order to save a case study, go to **Results → Case Study** and click on **Save Case Study**.

Note: You must have at least one case added to the case study in order to save or print a case study.

A Save As dialog box appears with a suggested file name. Choose the location where you would like to save the case study file and click on **Save**.

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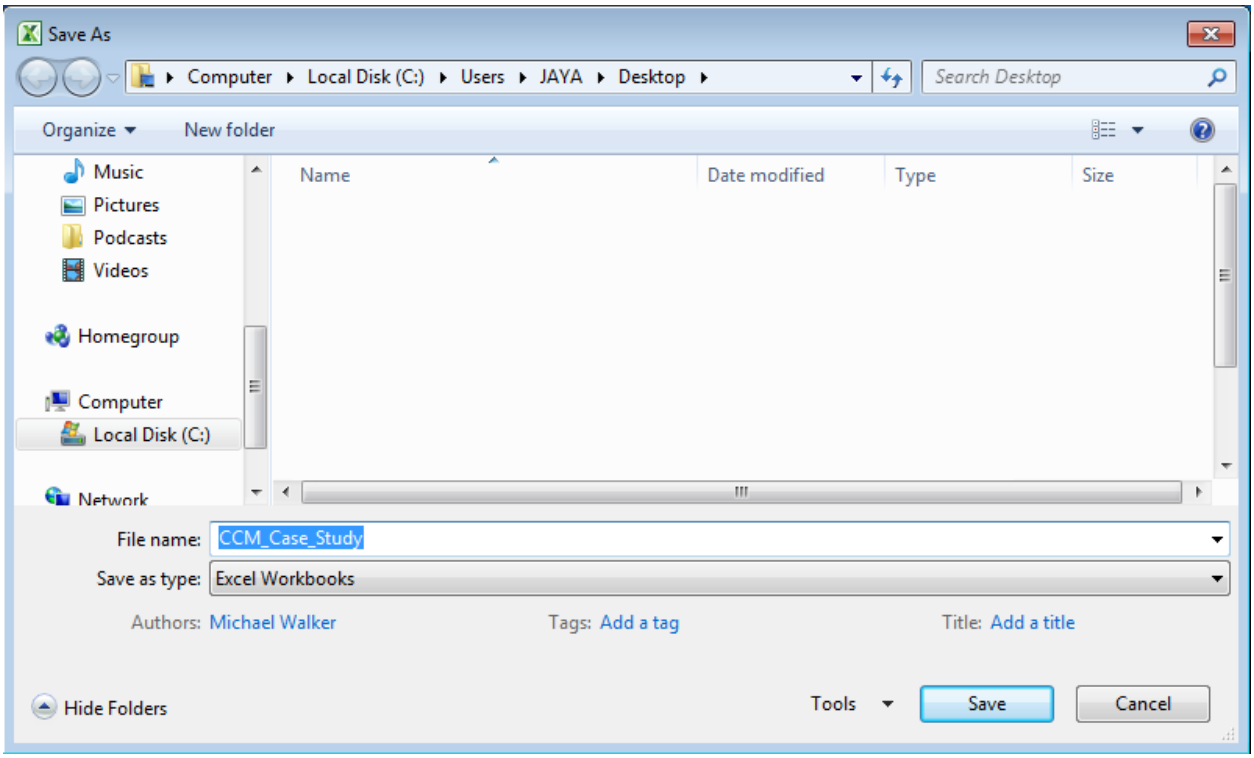
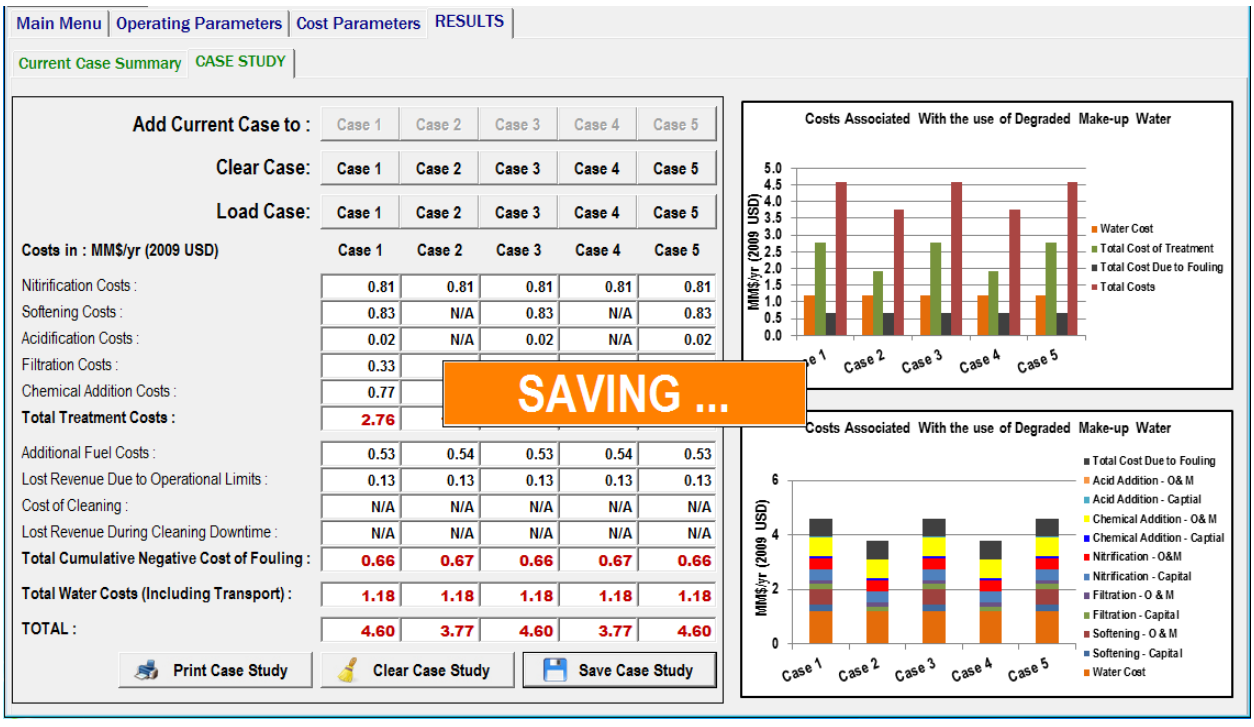


A **SAVING…** sign is displayed. Once the save is complete the sign disappears.



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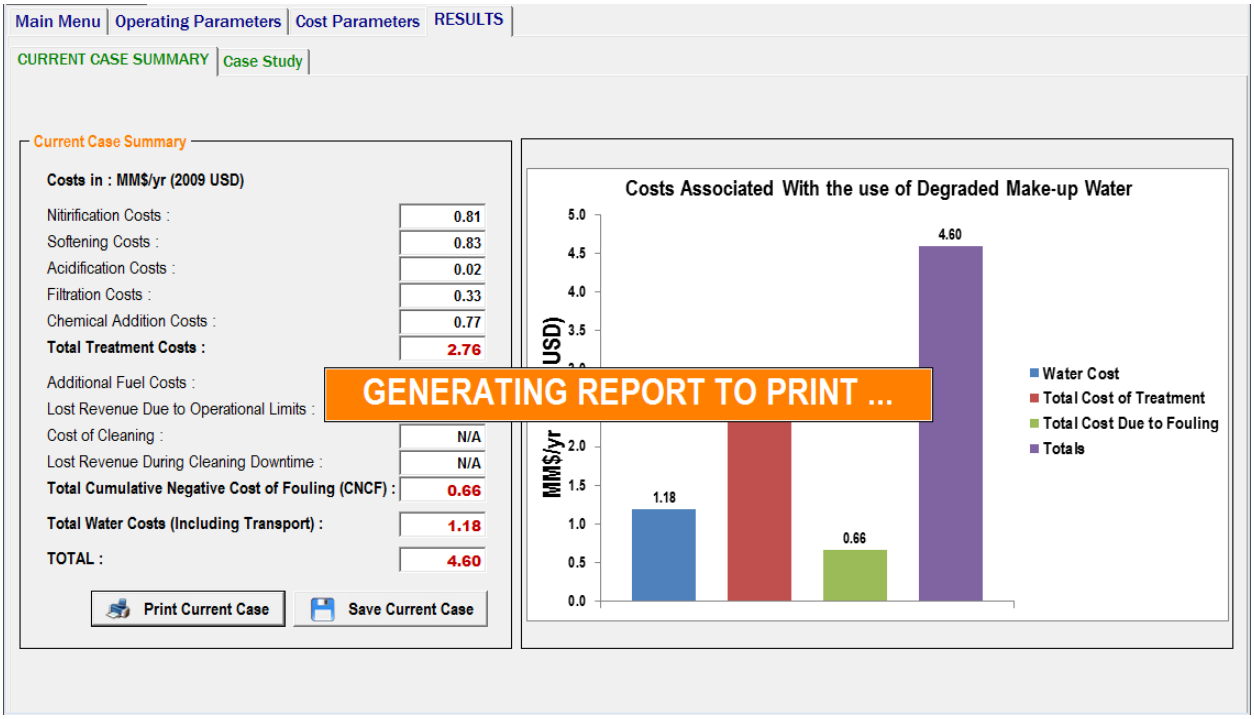
Printing a Case

You can save a case and print it whenever you want. You can also print a case directly from the GUI.

Note: Even if you print a case directly from the GUI, we recommend you to save the case immediately. Saving a case is beneficial due to the reasons presented in the Saving a Case section above.

In order to print a case, go to **Results → Current Case Summary** and click on **Print Current Case**.

A **Generating Report To Print …** sign appears.



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After successful generation of the report, an Excel file named "**temp [Read Only].xlsx"** opens into the Print Preview mode.

If you want to print just click Print icon on the top left side.

Once you are done printing or if you don't want to print anything, close the Print Preview mode and close the "**temp [Read Only].xlsx"** file.

Note: If you don't close the file and try to return to the GUI, you will find that the GUI is unresponsive to clicks. Just close the "**temp [Read Only].xlsx"** file and go back to the GUI.

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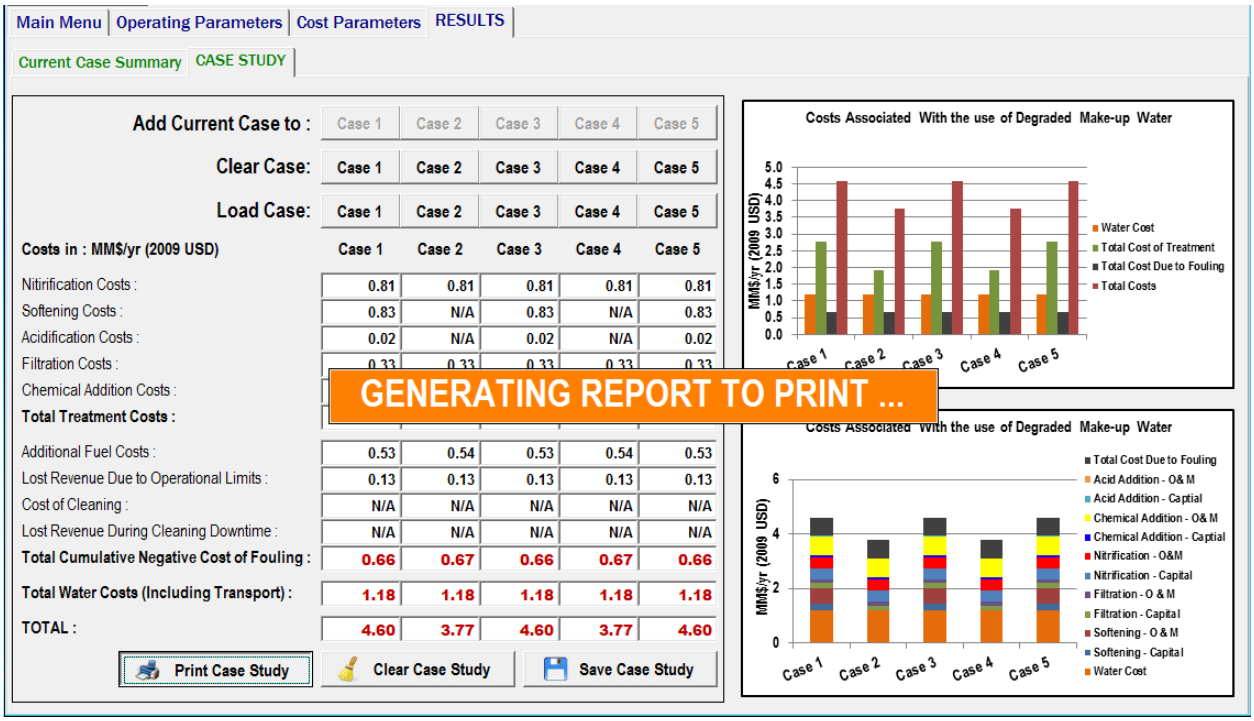
Printing a Case Study

Since there can be one or more cases in a case study, in which case there will be too many pages to print, printing a case study only prints the one page **Case Study Report** sheet.

In order to print a case, go to **Results → Case Study** and click on **Print Case Study**.

A **Generating Report To Print …** sign appears.



After successful generation of the report, an Excel file named "**temp [Read Only].xlsx**" opens into the Print Preview mode.

If you want to print just click Print icon on the top left side.

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Once you are done printing or if you don't want to print anything, close the Print Preview mode and close the "**temp [Read Only].xls"** file.

Note: If you don't close the file and try to return to the GUI, you will find that the GUI is unresponsive to clicks. Just close the "**temp [Read Only].xls"** file and go back to the GUI.

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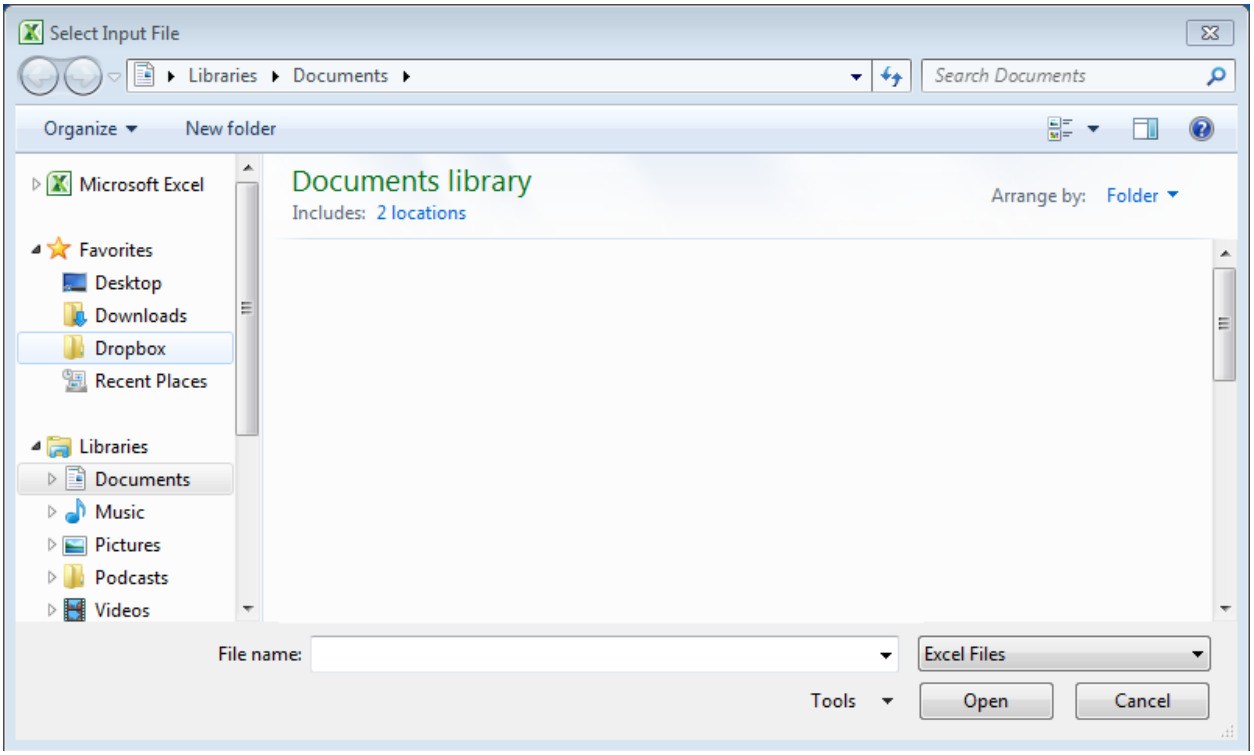
Opening a Case

A saved case can be opened in the CCM GUI. Opening a case will load all the input information into the GUI. This is useful if we want to do a case study by changing some of the parameters of the case.

In order to open a case, click on the **Open Case** icon.

A dialog box appears asking for the file to be opened as follows:



If an Excel file is selected that is not a correct input file then the following error message appears:

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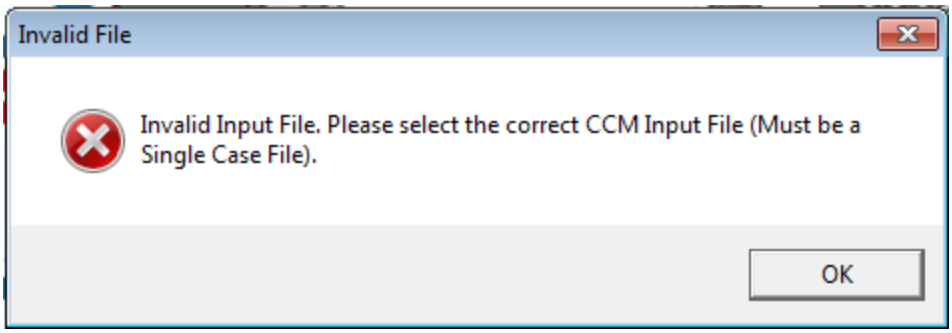
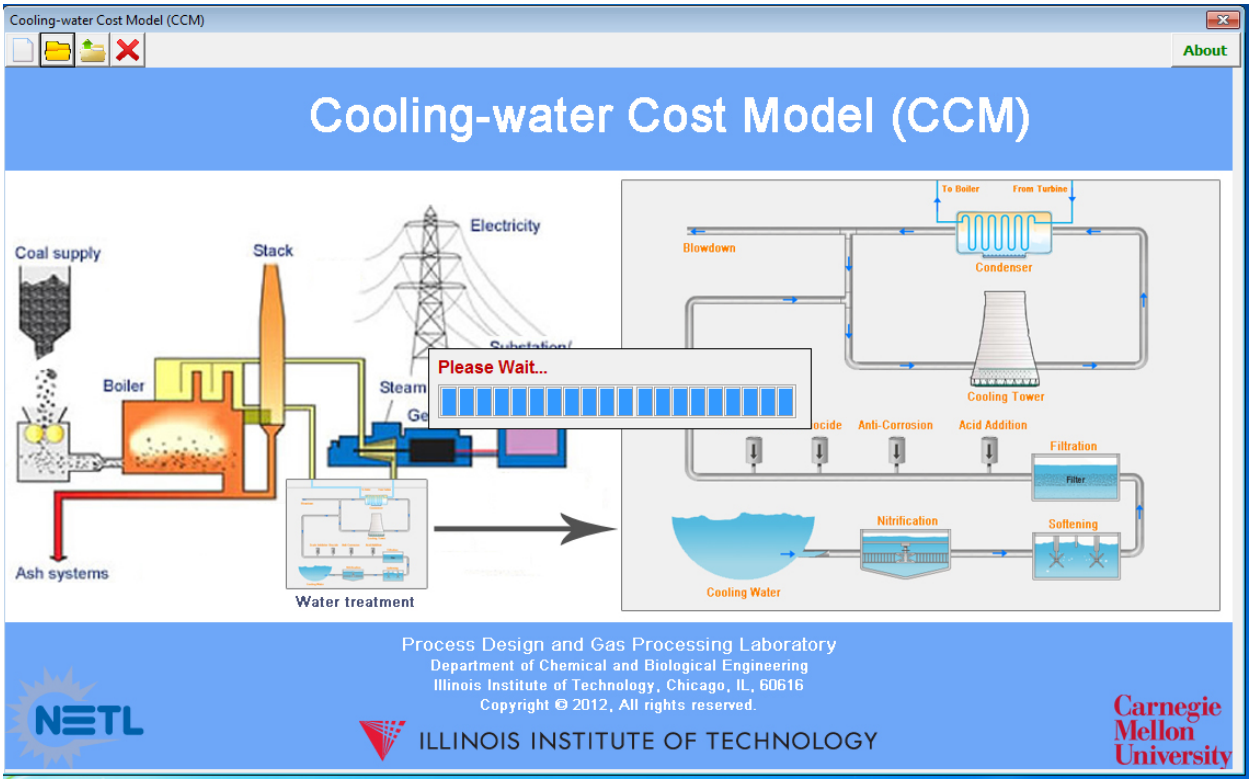


If the correct file is selected then, the following screen appears:



The progress bar shows the progress of importing the data to the GUI. Once it is complete all the input fields are loaded with the values from the file and the Main Menu page of the GUI will be visible as follows:

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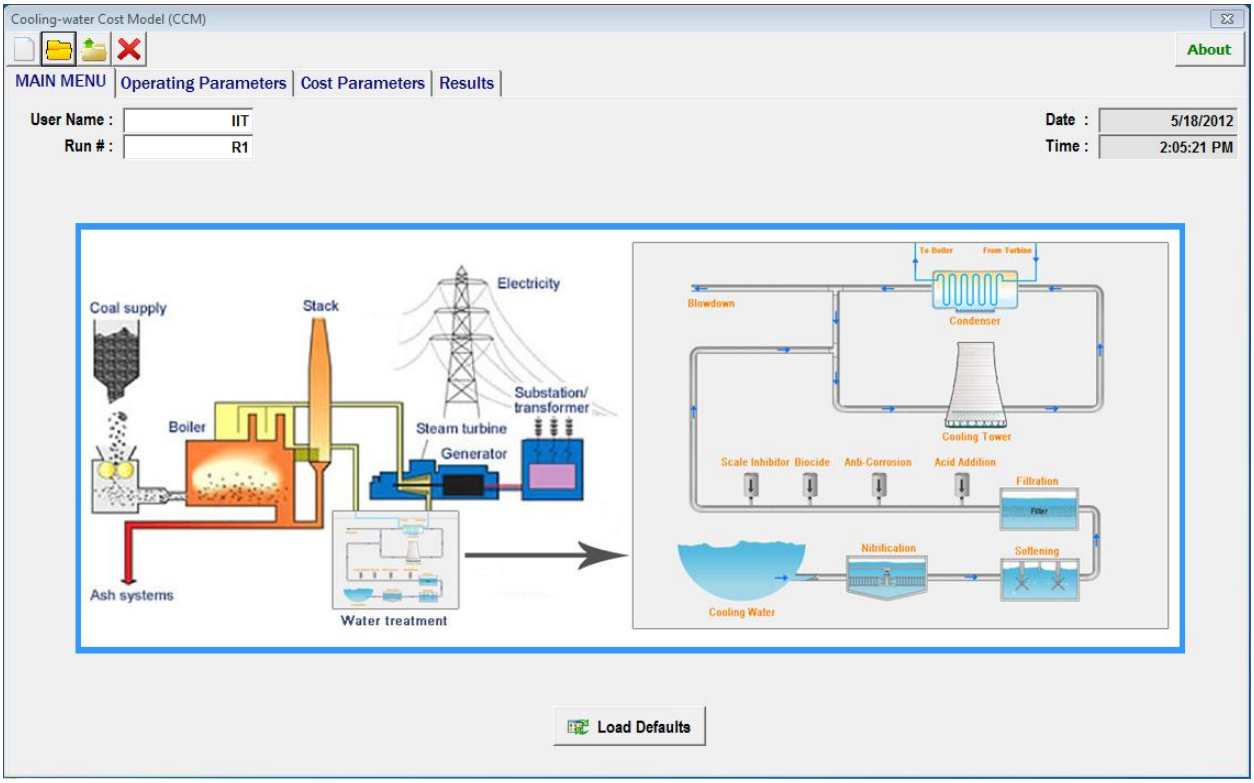

Now you can view the results by clicking on the **Results** tab.

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Opening a Case Study

A saved case study file can be opened in the CCM GUI. Based on the number of cases added to the case study, a saved case study file can contain anywhere between 1 to 5 complete sets of input-output information. For e.g., if three cases were added to a case study as Case 1, Case 2 and Case 3, and the file was saved, then the saved file contains four sheets – Case 1, Case 2, Case 3 and Case Study Report. Case 1, Case 2 and Case 3 sheets contain complete sets of input-output information about those particular cases whereas Case Study Report is a one page summary which contains the same information that is available in the **Case Study** page of the GUI.

So, when we open this case study file, each sheet (only the ones that contain the complete input information which means Case Study Report sheet is excluded) are imported in order and the respective columns in the **Case Study** page of the GUI are populated accordingly. Since all the input fields in the GUI display the input information one case at a time, they keep on changing for each case until the very last case. So, when a case study file is opened, the input fields display the information from the very last case that is imported. For e.g., if a case study file contains three cases – Case 1, Case 2 and Case 3, then the input fields in the GUI display the inputs from Case 3 because it is the last case to be imported.

In order to open a case, click on the **Open Case Study** icon.

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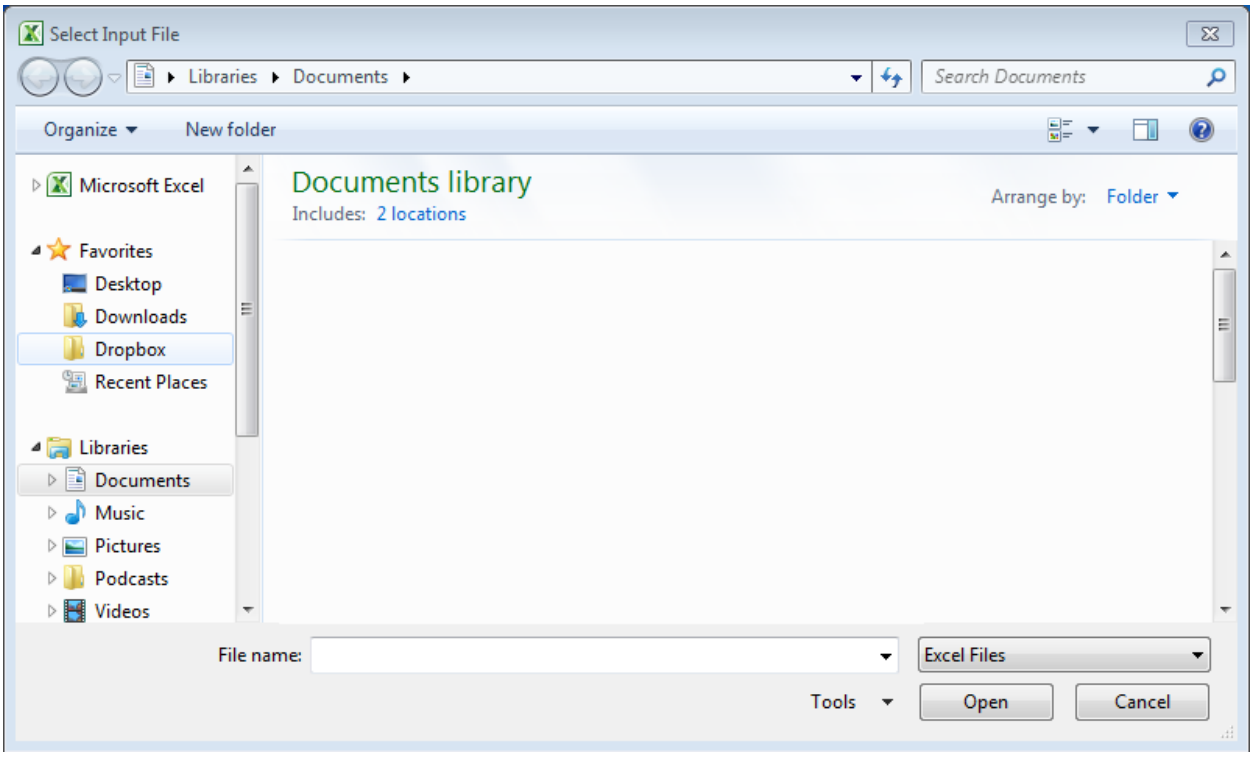
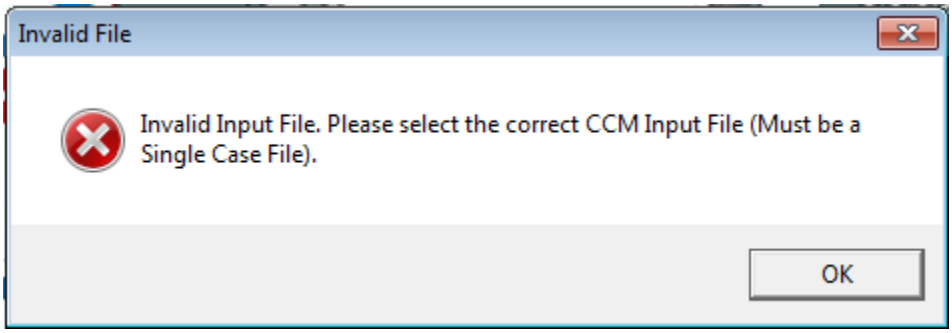
A dialog box appears asking for the file to be opened as follows:



If an Excel file is selected that is not a correct input file then the following error message appears:



If the correct file is selected then, the following screen appears:

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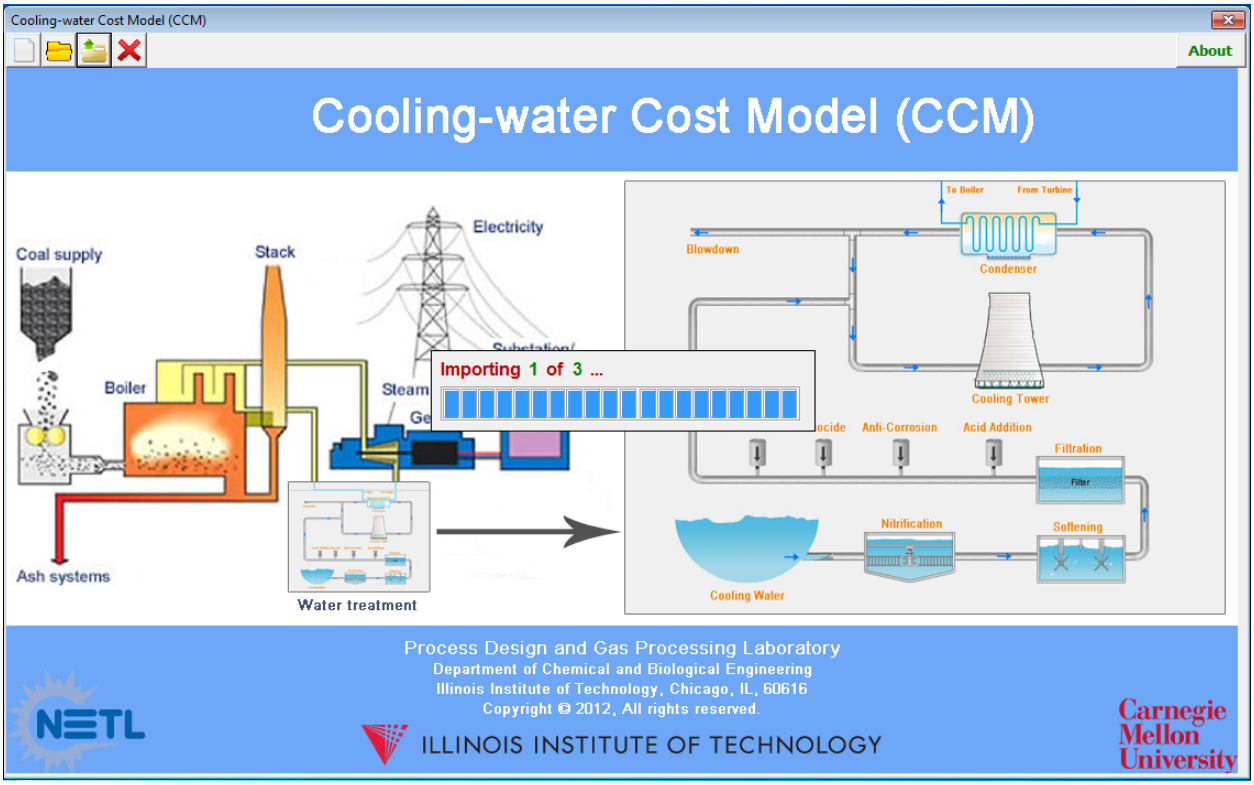

The progress bar will show the progress of importing data from the case study file. Depending on the number of cases present in the file, the progress bar notifies which case is being imported.

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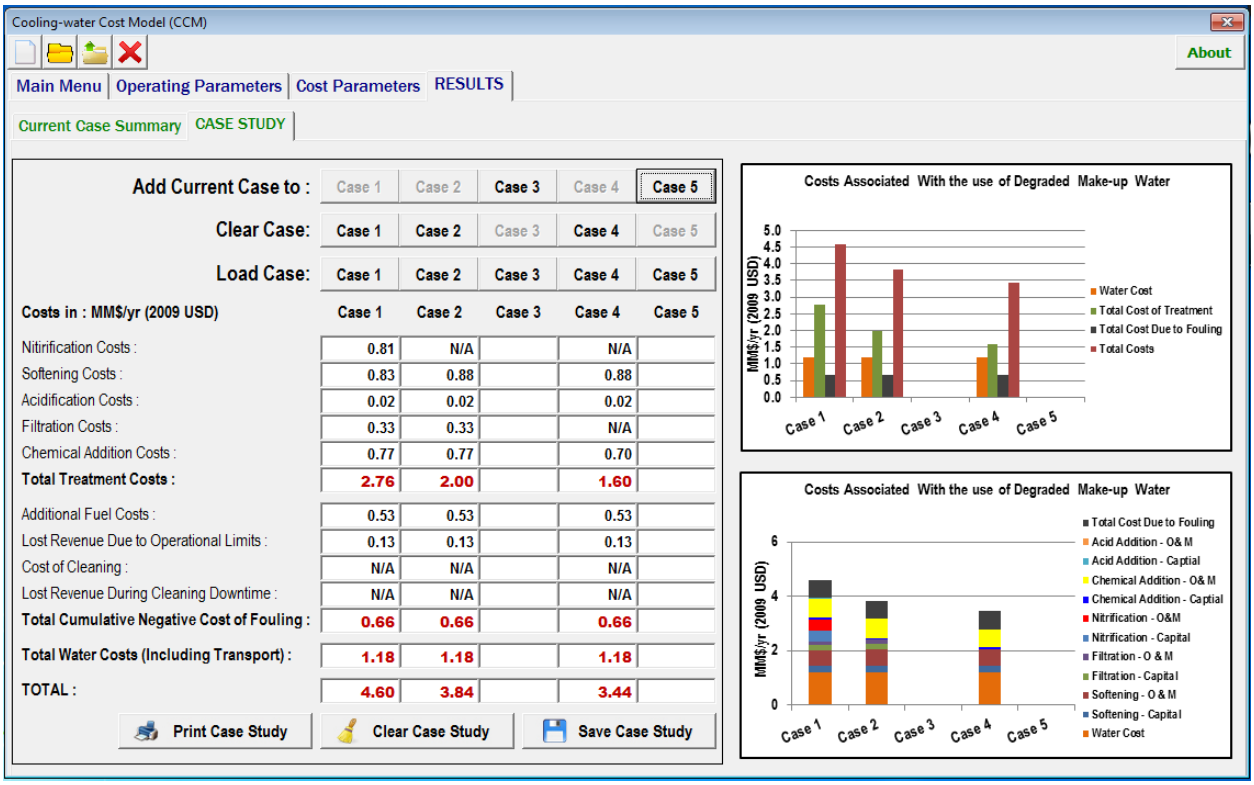

Once all the cases are imported, the **Case Study** page is displayed.

Even though the input fields in the GUI will contain the input information from Case 5 (in this example as shown in the picture above because Case 5 is the last case to be imported), we can easily load the input fields with the input information from other cases by clicking on the appropriate button beside Load Case.

More on Performing a Case Study.

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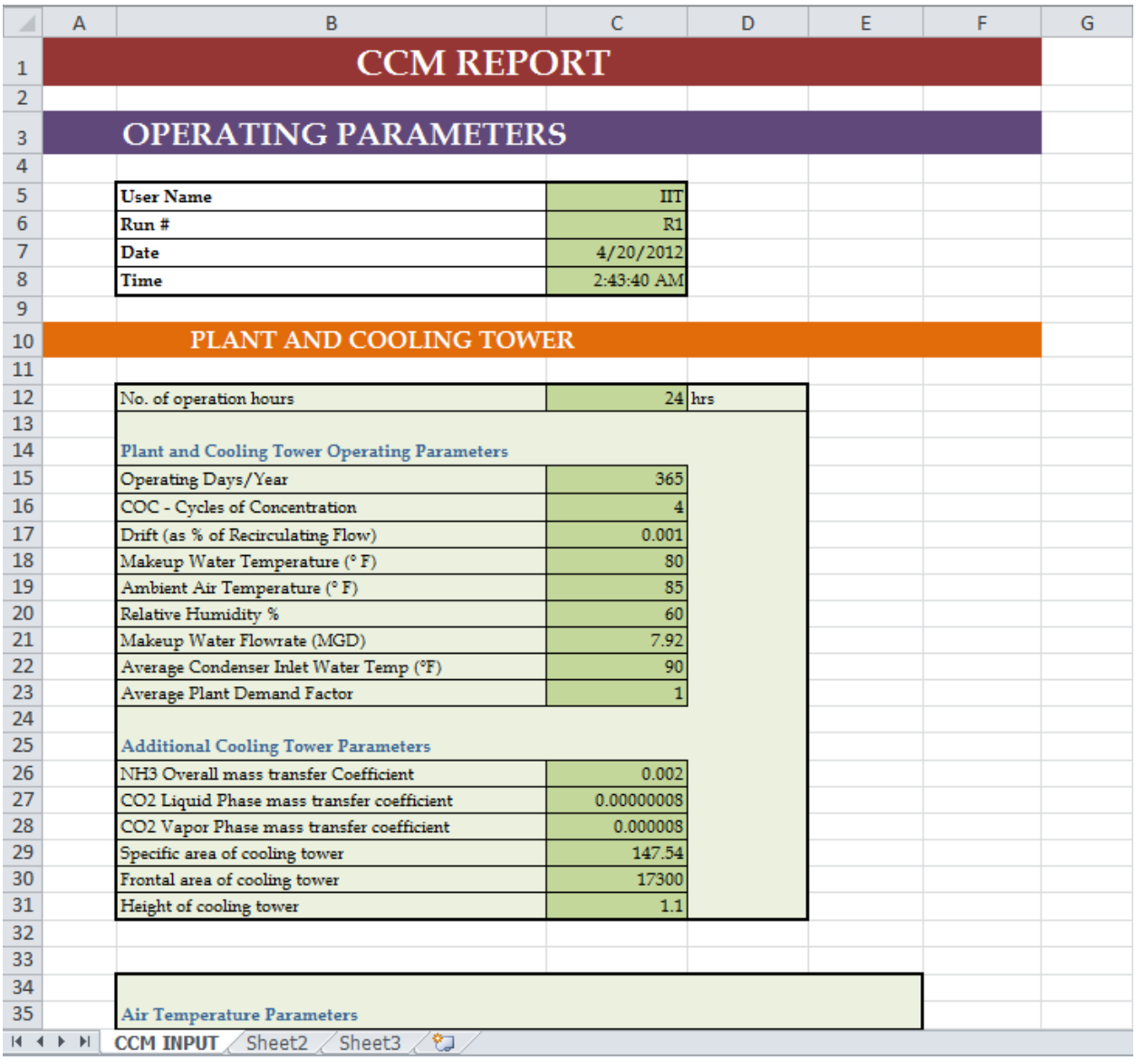
Formal Report Sheet for a Case

A saved case contains only one sheet named "**CCM INPUT**" which contains the complete input-output information. The top part of the sheet contains the input information and the bottom part contains the output information.

A report sheet looks like this in MS-Excel:



CCM REPORT

OPERATING PARAMETERS

User Name	IIT
Run #	R1
Date	4/20/2012
Time	2:43:40 AM

PLANT AND COOLING TOWER

No. of operation hours	24	hrs
Plant and Cooling Tower Operating Parameters		
Operating Days/Year	365	
COC - Cycles of Concentration	4	
Drift (as % of Recirculating Flow)	0.001	
Makeup Water Temperature (° F)	80	
Ambient Air Temperature (° F)	85	
Relative Humidity %	60	
Makeup Water Flowrate (MGD)	7.92	
Average Condenser Inlet Water Temp (°F)	90	
Average Plant Demand Factor	1	
Additional Cooling Tower Parameters		
NH3 Overall mass transfer Coefficient	0.002	
CO2 Liquid Phase mass transfer coefficient	0.00000008	
CO2 Vapor Phase mass transfer coefficient	0.000008	
Specific area of cooling tower	147.54	
Frontal area of cooling tower	17300	
Height of cooling tower	1.1	

Air Temperature Parameters

CCM INPUT | Sheet2 | Sheet3

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Detailed CCM Report Sheet looks like this:

CCM REPORT

OPERATING PARAMETERS

User Name	IIT
Run #	R1
Date	4/20/2012
Time	2:43:40 AM

PLANT AND COOLING TOWER

No. of operation hours	24	hrs
Plant and Cooling Tower Operating Parameters		
Operating Days/Year	365	
COC - Cycles of Concentration	4	
Drift (as % of Recirculating Flow)	0.001	
Makeup Water Temperature (° F)	80	
Ambient Air Temperature (° F)	85	
Relative Humidity %	60	
Makeup Water Flowrate (MGD)	7.92	
Average Condenser Inlet Water Temp (°F)	90	
Average Plant Demand Factor	1	
Additional Cooling Tower Parameters		
NH3 Overall mass transfer Coefficient	0.002	
CO2 Liquid Phase mass transfer coefficient	0.00000008	
CO2 Vapor Phase mass transfer coefficient	0.000008	
Specific area of cooling tower	147.54	
Frontal area of cooling tower	17300	
Height of cooling tower	1.1	

Air Temperature Parameters			
Consider Variation?	No		
Month	**Daily High**	**Daily Low**	
January	85	85	F
February	85	85	F
March	85	85	F
April	85	85	F
May	85	85	F
June	85	85	F

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July	85	85	F
August	85	85	F
September	85	85	F
October	85	85	F
November	85	85	F
December	85	85	F

Humidity Parameters

Consider Variation?	No		
Month	**Daily High**	**Daily Low**	
January	60	60	%
February	60	60	%
March	60	60	%
April	60	60	%
May	60	60	%
June	60	60	%
July	60	60	%
August	60	60	%
September	60	60	%
October	60	60	%
November	60	60	%
December	60	60	%

Condenser Inlet Temperature Paremeters

Consider Variation?	No		
Month	**Daily High**	**Daily Low**	
January	90	90	F
February	90	90	F
March	90	90	F
April	90	90	F
May	90	90	F
June	90	90	F
July	90	90	F
August	90	90	F
September	90	90	F
October	90	90	F

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November	90	90	F
December	90	90	F

Demand Parameters

Consider Variation?	No	
Month	**Daily High**	**Daily Low**
January	0.85	0.85
February	0.85	0.85
March	0.85	0.85
April	0.85	0.85
May	0.85	0.85
June	0.85	0.85
July	0.85	0.85
August	0.85	0.85
September	0.85	0.85
October	0.85	0.85
November	0.85	0.85
December	0.85	0.85

Retail Price of Electricity Parameters

Consider Variation?	No		
Month	**Daily High**	**Daily Low**	
January	9.87	9.87	(¢/kwh)
February	9.87	9.87	(¢/kwh)
March	9.87	9.87	(¢/kwh)
April	9.87	9.87	(¢/kwh)
May	9.87	9.87	(¢/kwh)
June	9.87	9.87	(¢/kwh)
July	9.87	9.87	(¢/kwh)
August	9.87	9.87	(¢/kwh)
September	9.87	9.87	(¢/kwh)
October	9.87	9.87	(¢/kwh)
November	9.87	9.87	(¢/kwh)
December	9.87	9.87	(¢/kwh)

CONDENSER

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Condenser Parameters	
# Condenser Compartments	2
Cleaning Downtime/Compart. (hr)	12
Condenser Cleaning Trigger Method	# of Cleanings
Max Rf Allowed, (°F*ft^2*hr)/BTU	0.00E+00
Design Rf, (°F*ft^2*hr)/BTU	3.53E-04
# of Cleanings / Year	0

Defined Dates	Cleaning Days

Condenser Design	
U_clean, BTU/(ft^2*^{0}F*hr)	500
Fo	0.85
Capacity MW	550
W_percent	38.137
Turbine Efficiency	0.9
H_throttle, BTU/lb	1397.9
Cp, BTU/(lb.^{0}F)	0.999
Q1_non-main, BTU/hr	1.66E+08
Plant Efficiency, %HHV	36.8
FGD Lime Cost, $/ton	20.6

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Boiler Efficiency, %	89
Tube Side Inlet Temp., °F	90
Tube Side Outlet Temp., °F	110
Sheel Side Temperature, °F	130
Turbine Over Design Factor, Ft	1
Annulus area, ft^2	225
U_calc, BTU/(ft^2*°F*hr)	425
Rf, (ft^2*°F*hr)/BTU	0.000352941
Wt_lp-turbine, BTU/hr	716345748.4
H_ueep, BTU/lb	1076.86649
H_elep, BTU/lb	1070.520261
H_liq, BTU/lb	97.964
W_isentropic, BTU/hr	795939720.4
Maximum Steam Flow Rate (MSFR), lb/hr	2479304.172
Turbine Over Design Factor (x)	1.1
MSFR*x, lb/hr	2727234.589
Heat Duty, BTU/hr	2577321672
Outside Heat Transfer Area, ft^2	210172
Cooling Water Flow Rate, GPM	257783.9302
ΔFt/Δ(10% Load)	0.02
Rf evaluation Vector, (Ft^2.°F.hr)/BTU	
	0
	0.00025
	0.0005
	0.00075
	0.001
T_in evaluation Vector, °F	
	40
	55
	70
	85
	100
Initial Guesses	
T_out, °F	110
T_shell, °F	160

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Fouling Buildup	
Fouling Profile	Sixth Order Poly
Rf buildup (t = days)	Polynomial
Avg. Rf	0
Linear / Logarithmic / Induction	
a	1.50E-04
b	0.00E+00
c	0.00E+00
6th Order Polynomial	
c6	3.64E-19
c5	-4.30E-16
c4	1.99E-13
c3	-4.30E-11
c2	3.82E-09
c1	3.94E-08
b	4.06E-07
Bound	2.00E-05

Turbine Design	
H_elep, BTU/lb	1029
H_throttle, BTU/(lb.°F)	1397.9
S_throttle, BTU/(lb.°F)	1.762
Velocity vs Ann Loss Coeffs.	
c4	2.89E-11
c3	-1.67E-07
c2	3.11E-04
c1	-1.75E-01
b	3.39E+01
Assumed Annulus Loss for Given Load level	
100 % Load Level	6
90 % Load Level	8.3
80 % Load Level	7.1
70 % Load Level	5.9
60 % Load Level	5.1
50 % Load Level	5.2
40 % Load Level	5.1

WATER TREATMENT

Treatment Options

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Nitrification	Yes
Softening	Yes
Filtration	Yes
Acid Addition	Yes
Anti-Corrosion	Yes
Biocide	Yes
Scale Inhibitor	Yes

Nitrification		
Solids Retention Time	15	days
Percent Solids in Sludge	1.5	%
Effluent Substrates conc.	0.6	mg/L NH4+(As Nitrogen)
Effluent Substrates conc.	0.36	mg/L NO2-(As Nitrogen)
Design SOR	12	m3/m2/d
No. of Units to Split Flow	2	
% inert VSS	20	%
% VSS releasing N	80	%
Recycle Ratio	0.45	
Depth of Tank	5	m
Effluent BOD	5.8	mg/L
MLVSS	2000	mg/L
Oxygen transfer efficiency	10	%
Overall Oxygen transfer efficiency	12	%
Efficiency of pumps	75	%

Softening		
Flocculation time	30	min
Sedimentation time	2	hours
Inside hopper dia	4	m
Depth of water	5	m
Shaft rotation speed	3	rpm
Excess lime dose added	30	mg/L
Percent solids in sludge	5	%
No. of Units to Split Flow	2	

Filtration		
Filtration rate	5	gal/min.ft2
Backwash time	5	min
Filter rise rate	24	in/min

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Backwash rate	62.6	gal/min.ft2
Depth of sand (inches)	48	in
Length:Width ratio	1	
Depth of backwash reservoir	4	ft
Backwash air scour	5	hp
No. of back wash pumps/reservoir	2	

Acid Addition		
Contact time	5	mins
Side Water Depth	3	m
Length:Width ratio	4	
Number of units	2	
Type of acid	H2SO4	
Amount of acid added	0	mol acid / Liter makeup

Chemical Addition		
Average Influent Total Coliform	10000	#/100 mL
Effluent Total Coliform	23	MPN/100 mL
Contact time, t	15	mins
Side Water Depth	3	m
Length:Width	1.25	
No. of units	2	mg/L/hr
MCA Dose	52	mg/L
TTA Dose	1	
PMA Dose	0	mg/L
ClO2 Dose	0	mg/L/hr

Water Delivery		
Velocity in the Delivery Pipeline	6	ft/sec
Delivery Distance	10	miles
Head Increase	0	meters
Trench Width = Dia.+2*INPUT	12	inch
Pump Efficiency (%)	90	

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Water Quality Specifications		
Al3+	0.2	mg/L
Ca2+	41.5	mg/L
Fe2+	0.504	mg/L
K+	16.3	mg/L
Mg2+	10.7	mg/L
Mn2+	0.317	mg/L
Na+	94.2	mg/L
NH4-N	21	mg/L
Cl-	106	mg/L
SO4(2-)	86	mg/L
NO3-N	3.6	mg/L
PO4(3-)	4.5	mg/L
HCO3- Alk (as CaCO3)	177	mg/L
SiO2	8.54	mg/L
TSS	25	mg/L
BOD	31.9	mg/L
pH	7	
Charge Balance	0.003035607	

COST PARAMETERS

COMMODITIES, UTILITIES, SERVICES

Coal HHV, MBTU/lb	11.67
Coal Price, $/short ton	54.25
FGD Lime Price, $/short ton	20.60
Hydrated Lime/50 pound	3.4
93% Sulfuric Acid (H2SO4)/750 lb	185
Monochloramine (MCA)/lb	0.46
Tolytriazole (TTA)/lb	2.75
Price of Electricity, ¢/kwh	9.87
Cost of Electricity, ¢/kwh	6.835
Mechanical Cleaning Cost, k$	13.5
Water Cost $/Th. Gal	Secondary Wastewater - Low

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Manual Input	0.5
Include Water Pipelining Costs?	Yes

COSTING FACTORS

Discount factor (%)	12
Contingency (%)	35
Labor and Maintenance (%)	8
Foundation Costs (%)	25
Auxiliary Equipment Costs (%)	15

CONSTRUCTION AND PROCESSING

Materials	Unit Cost (USD)
Flat Concrete Wall/cubic yards	387
Curved Concrete Wall/cubic yards	793.68
Elevated Slab/cubic yards	617.47
Aerator Costs/ft^2	15
Centrifugal Pump for sludge/50 GPM	4000
Clarifier Scraper/30' dia	50000
Mixer /1 HP & 1' imp. Dia	7000
Plunger Pump/10GPM	12000
Chemical Metering pump/100 GPH	3000
Dry chemical feed system/600 lb/hr	500000
Backwash Pump/15 GPM/ft^2	20000
Filter sand/ft^3	4.5
Blower costs/28' dia or 5110 GPM	28800
Filter underdrains+air blower/ ft^2	175
20 inch dia Pipe Costs, $/18 ft	127
Excavation and Fill, $/0.5 cubic yards	12.04
Cost of Bedding Material, $/ft	7.8
Centrifugal Pump Horizontal split, Single Stage	34600
Centrifugal Pump Vertical Split, Single Stage	21000

RESULTS

CASE SUMMARY

Costs in MM$/yr (2009 USD)

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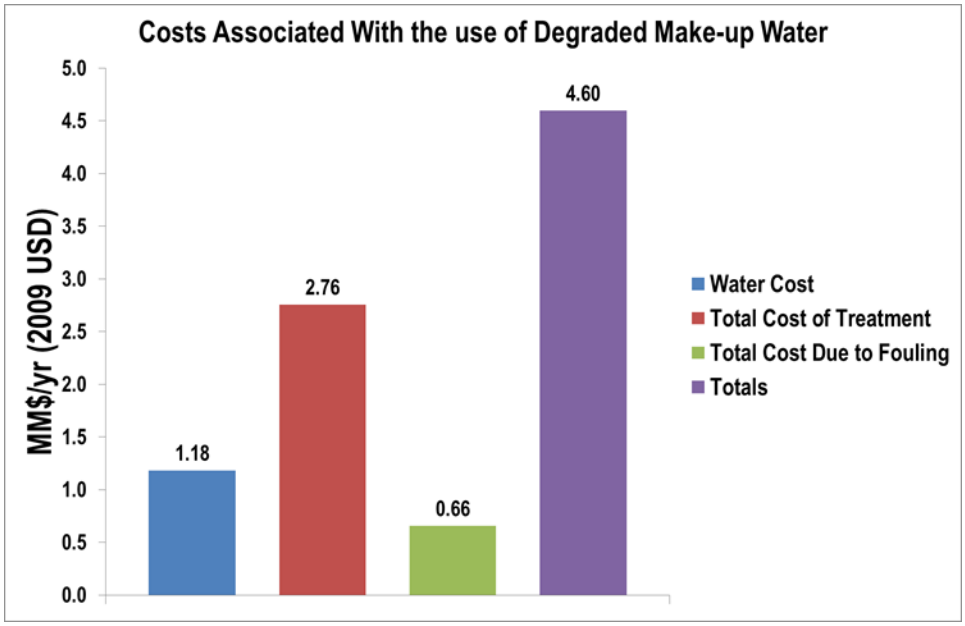
Nitrification Costs	0.81
Softening Costs	0.83
Acidification Costs	0.02
Filtration Costs	0.33
Chemical Addition Costs	0.77
Total Treatment Costs	**2.76**
Additional Fuel Costs	0.53
Lost Revenue Due to Operational Limits	0.13
Cost of Cleaning	N/A
Lost Revenue During Cleaning Downtime	N/A
Total Cumulative Negative Cost of Fouling	**0.66**
Total from Water Costs	**1.18**
TOTAL	**4.60**



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DETAILED OUTPUT

Tertiary Treatment	Yearly Total (1000 $US)	Yearly Avg (1000 $US)	Yearly Max (1000 $US)	Yearly Min (1000 $US)
Nitrification - Capital	404.87			
Nitrification - O&M Fix	269.91			
Nitrification - O&M Var.	139.80			
Variable O&M (Electricity, N)	139.80	0.19	0.19	0.19
Nitrification Totals	814.58			
Softening - Capital	240.17			
Soft - O & M Fix	248.28			
Soft - O & M Var.	339.35			
Variable O&M (Lime, S)	126.86	0.17	0.17	0.17
Variable O&M (Electricity, S)	21.06	0.03	0.03	0.03
Variable O&M (Soda Ash, S)	191.43	0.26	0.26	0.26
Softening Totals	827.80			
Acid Addn. - Capital	11.10			
Acid Addn. - O&M Fix	7.40			
Acid Addn. - O&M Var	0.00			
Variable O&M (Acid, A)	0.00	0.00	0.00	0.00
Acid Addition Totals	18.50			
Filtration - Capital	192.94			
Filter - O & M Fix	128.63			
Filter - O & M Var	6.45			
Variable O&M (Electricity, F)	6.45	0.01	0.01	0.01
Filtration Totals	328.02			
Chemical Addition - Captial	75.05			
Chemical Addition - O& M Fix	50.03			
Chemical Addition - O& M Var	643.51			
Variable O&M (MCA, C)	577.16	0.79	0.79	0.79
Variable O&M (TTA, C)	66.35	0.09	0.09	0.09
Chemial Addition Totals	768.59			
Water Source Costs	520.53			
Water Transport - Capital	366.63			
Water Transport - O & M Fix	29.33			

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Water Transport - O & M Var	267.02			
Variable O&M (Electricity, Water Supply)	267.02	0.37	0.37	0.37
Water Trans. & Supply Totals	1183.51			

Cost Impact of Fouling	**Yearly Total**	**Yearly Avg: 12-hr period**	**Yearly Max: 12-hr period**	**Yearly Min: 12-hr period**
Fouling Buildup (Rf), (F*ft^2*hr)/BTU		0.00	0.00	0.00
Condenser Inlet Temperature, F		90.00	90.00	90.00
Condenser Perceived Demand		1.00	1.00	1.00
Mass Flow of Steam: LP Stage, lb/hr		2644031.01	2714637.99	2624361.37
Shell Temperature, F		128.35	138.93	125.43
Makeup Water Flow, 1000 gal	2891834.56	3961.42	3961.42	3961.42
Heat Rate Loss, BTU/hr		25885.81	118740.58	52.37
Base Cost of Electricity, 1000 $US	329310.30	451.11	451.11	451.11
Sales, 1000 $US	475536.60	651.42	651.42	651.42
Max Possible Revenue By Demand (MPRD), 1000 $US	146226.30	200.31	200.31	200.31
Power Production (Turbine Follow Mode), MWh	4818000.00	6600.00	6600.00	6600.00
Lost Production (Wloss), MWh	1698.03	2.33	11.32	0.00
Lost Production (Downtime), MWh	0.00	0.00	0.00	0.00
Base Coal Flow, lb	3831436147.59	5248542.67	5248542.67	5248542.67
Base Coal Cost, 1000 $US	103927.71	142.37	142.37	142.37
Unused Fuel "Savings" During Downtime, 1000 $US	0.00	0.00	0.00	0.00
Excess Coal Feed Required, lb	19430992.08	26617.80	122098.29	53.86
FGD Lime Flow, lb	381790000.00	523000.00	523000.00	523000.00
FGD Lime Price, 1000 $US	3932.44	5.39	5.39	5.39
Unused Lime "Savings" During Downtime, 1000 $US	0.00	0.00	0.00	0.00

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Formal Report Sheet for a Case Study

A saved case study contains variable number of sheets based on the number of cases added to the case study. In this example, there were 5 cases added to the case study. Therefore there are sheets named – Case 1, Case 2, Case 3, Case 4 and Case 5 which contain the complete input-output information for each of those cases. Besides the standard input-output sheets there is one additional sheet named "CCM CASE REPORT" that contains a summary of all the cases along with two graphs.

A case study report sheet looks like this in MS-Excel:

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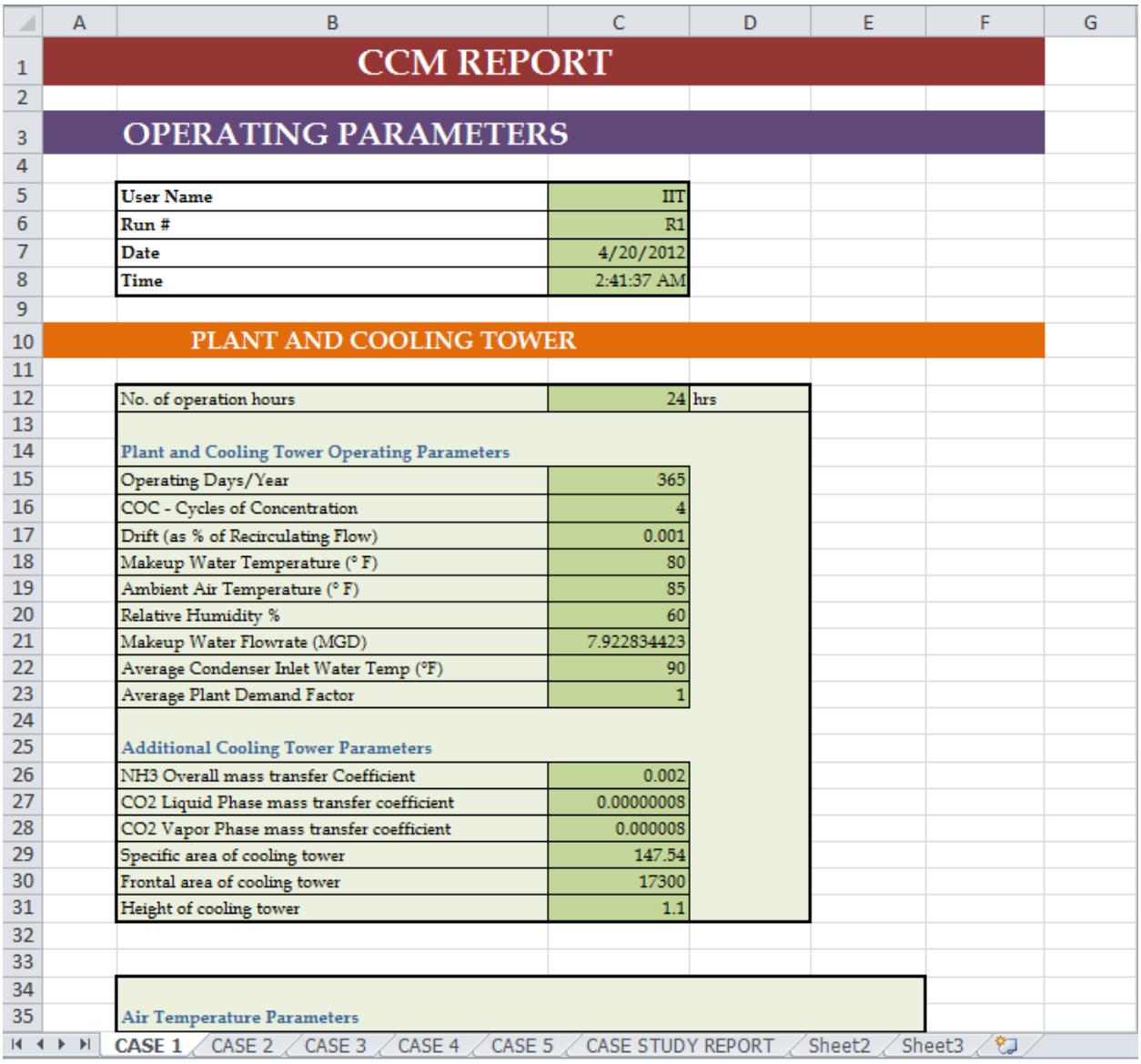

CCM REPORT

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Time	2:41:37 AM

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Makeup Water Temperature (° F)	80
Ambient Air Temperature (° F)	85
Relative Humidity %	60
Makeup Water Flowrate (MGD)	7.922834423
Average Condenser Inlet Water Temp (°F)	90
Average Plant Demand Factor	1

Additional Cooling Tower Parameters

NH3 Overall mass transfer Coefficient	0.002
CO2 Liquid Phase mass transfer coefficient	0.00000008
CO2 Vapor Phase mass transfer coefficient	0.000008
Specific area of cooling tower	147.54
Frontal area of cooling tower	17300
Height of cooling tower	1.1

Air Temperature Parameters

CASE 1 | CASE 2 | CASE 3 | CASE 4 | CASE 5 | CASE STUDY REPORT | Sheet2 | Sheet3

The detailed Report sheet for Case 1, Case 2, Case 3, Case 4 and Case 5 is the same as the detailed Report sheet for a single case as shown here.

The Case Study Report sheet looks like this:

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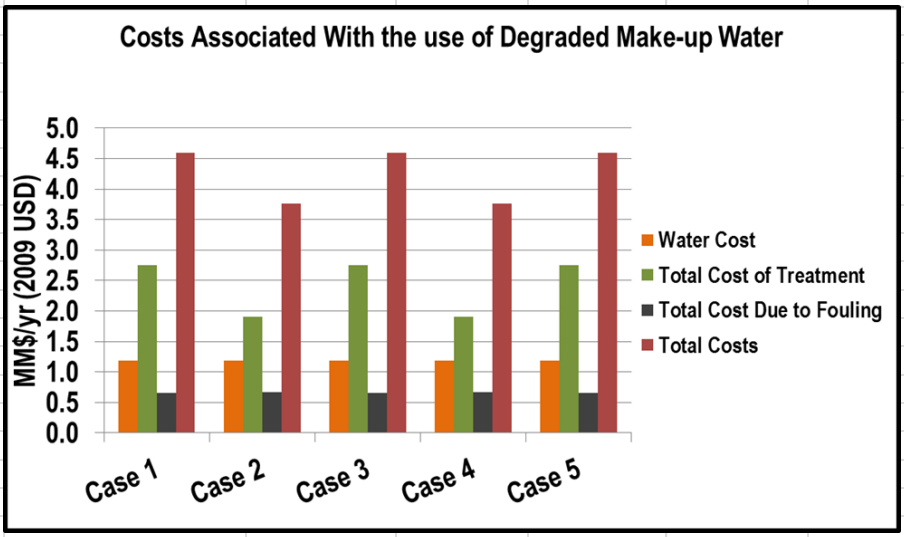
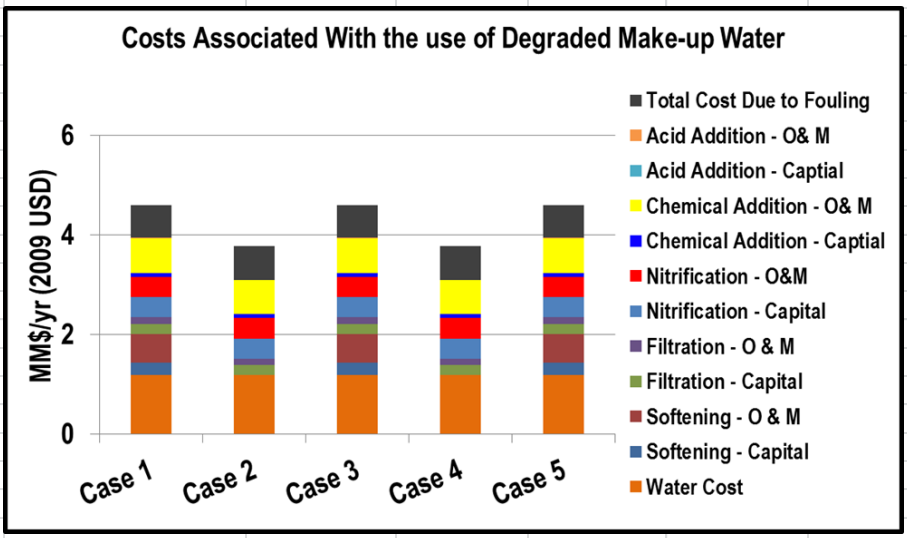
CASE STUDY SUMMARY

Costs in MM$/yr (2009 USD)	Case 1	Case 2	Case 3	Case 4	Case 5
Water Cost	1.18	1.18	1.18	1.18	1.18
Softening - Capital	0.24	-	0.24	-	0.24
Softening - O & M	0.59	-	0.59	-	0.59
Filtration - Capital	0.19	0.19	0.19	0.19	0.19
Filtration - O & M	0.14	0.14	0.14	0.14	0.14
Nitrification - Capital	0.40	0.40	0.40	0.40	0.40
Nitrification - O&M	0.41	0.41	0.41	0.41	0.41
Acid Addition - Captial	0.01	-	0.01	-	0.01
Acid Addition - O& M	0.01	-	0.01	-	0.01
Chemical Addition - Captial	0.08	0.08	0.08	0.08	0.08
Chemical Addition - O& M	0.69	0.69	0.69	0.69	0.69
Total Cost Due to Fouling	0.66	0.67	0.66	0.67	0.66
Total Cost of Treatment	2.76	1.91	2.76	1.91	2.76
TOTALS	4.60	3.77	4.60	3.77	4.60





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