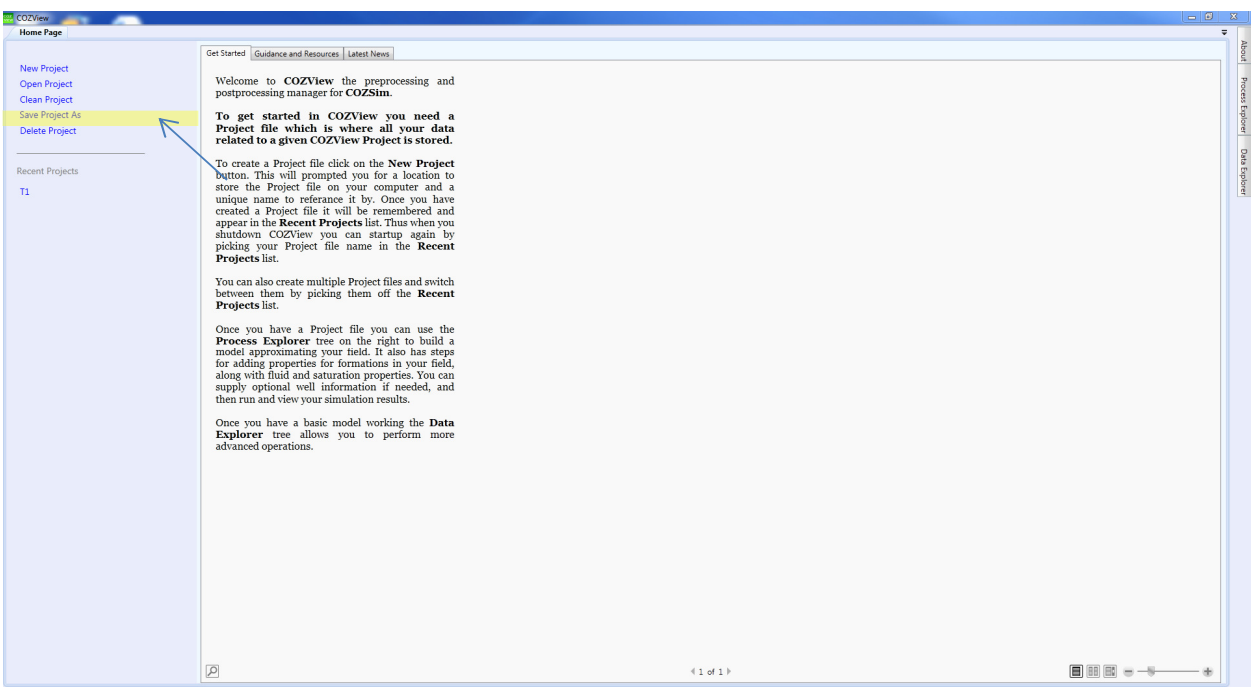
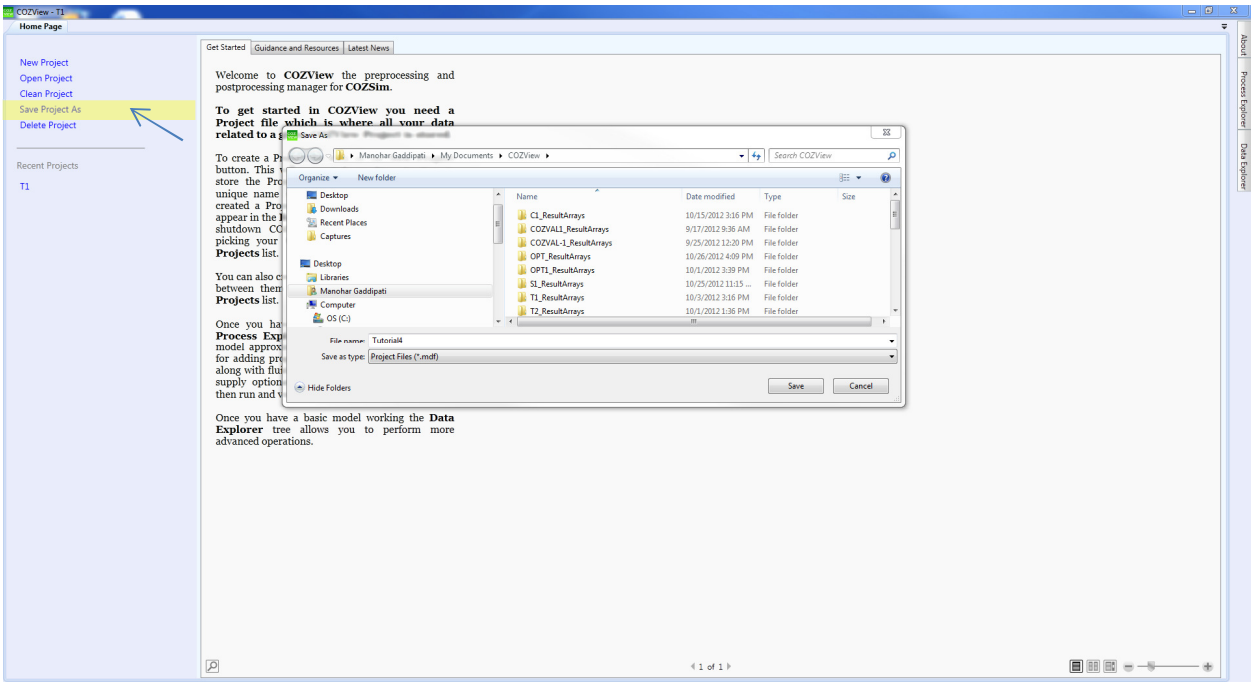
TUTORIAL #4

This tutorial demonstrates the optimization functionality that allows the user to determine maximum net present value (NPV) for a base case and a set of economic parameters. The optimization process attempts to establish the best combination of the Field (Facility) Control parameters to maximize the NPV. A minimum of 1 and a maximum of 7 Field Control parameters can be varied in the optimization process. During the optimization process artificial neural network and genetic algorithm technology are used to vary the appropriate Field Control parameters within a range of values defined by the user and to make simulation runs with those values. The optimization process designs runs with the objective of maximizing the NPV for the prediction case and its associate economic parameters. The user is allowed to run multiple optimization scenarios by using different sets of Economic scenarios and also different ranges (minimum and maximum) of each of the field controls.

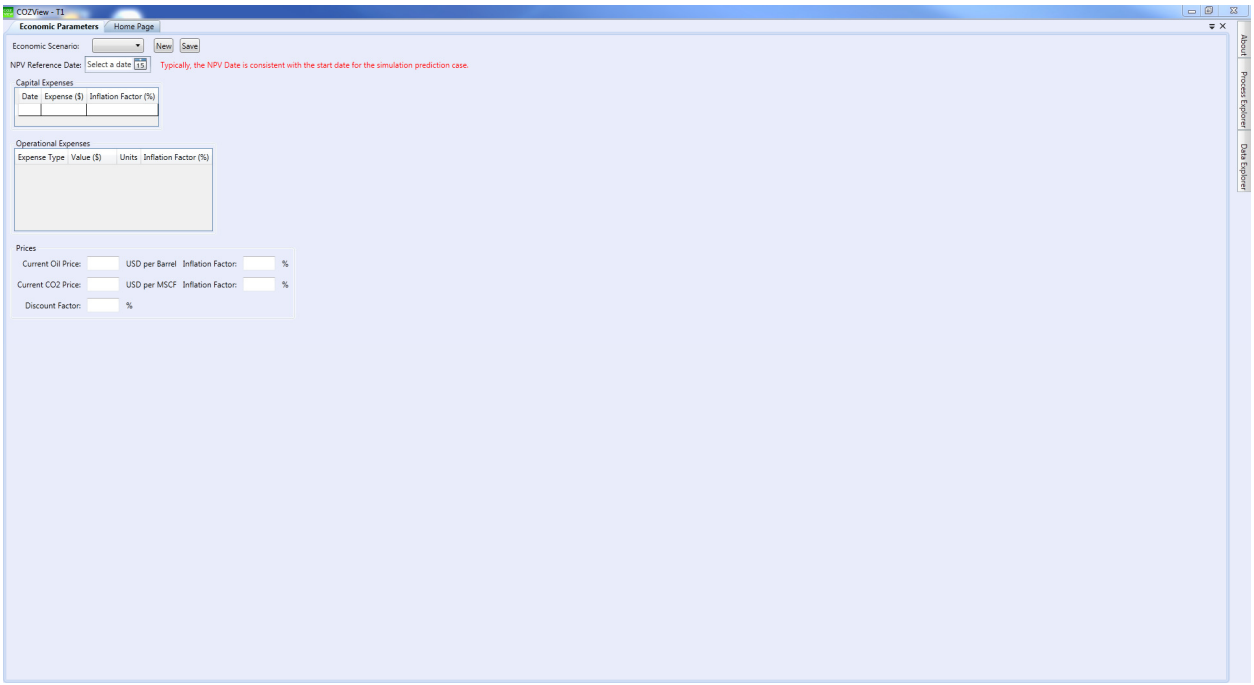
In the course of developing the tutorial examples, some COZView screens may have changed slightly from the views shown in this document. These changes should not impact the model building and simulation process.

The base case in this tutorial is Tutorial #1. From the *Recent projects* Tab in COZView Homepage, load the project file for Tutorial #1. It is recommended to save the project under a different name using **Save Project As** in the **Home Page**.

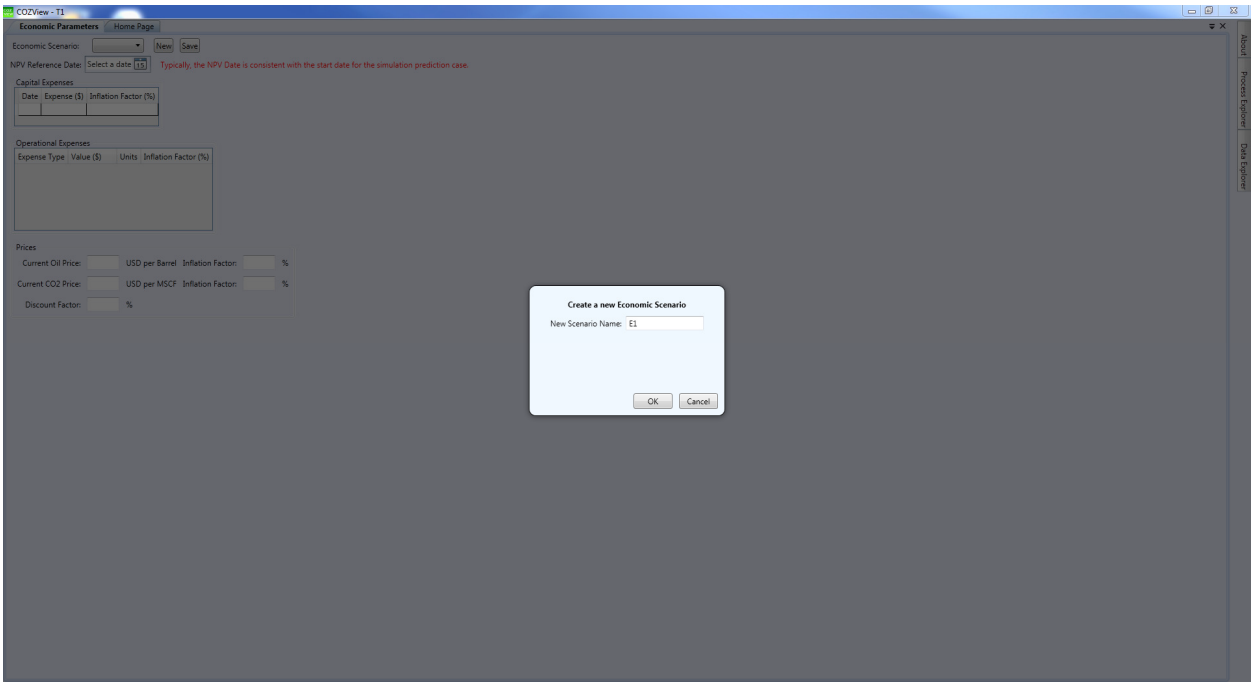


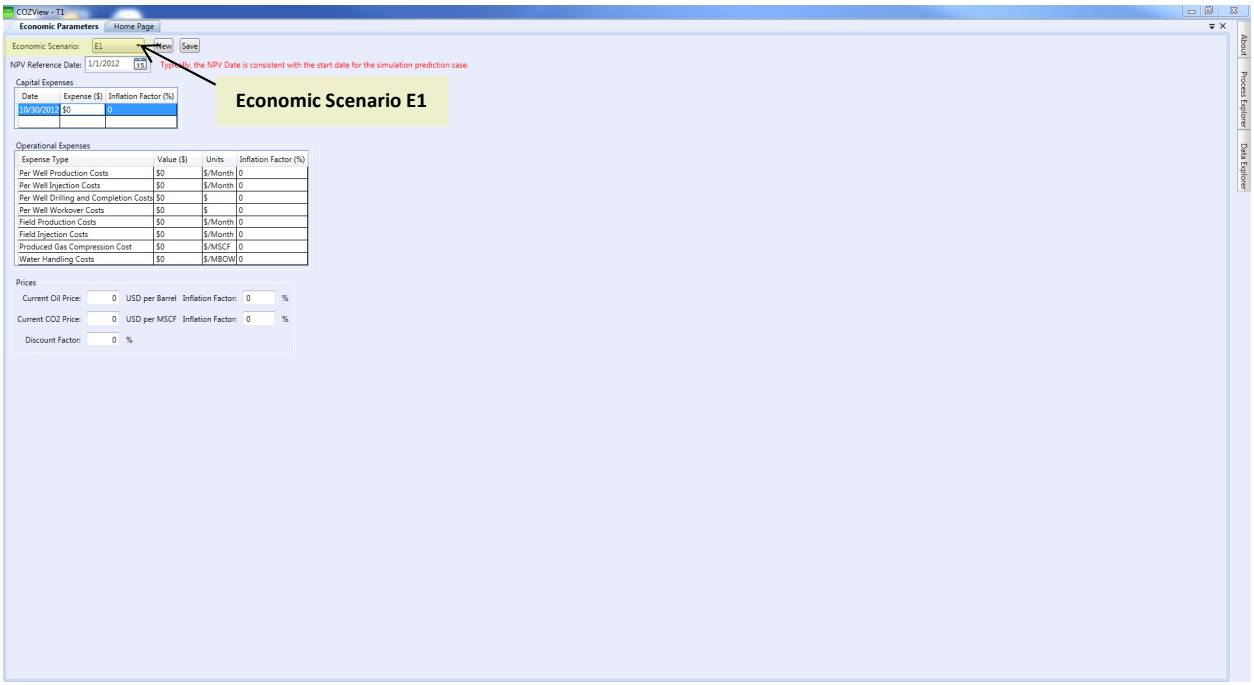


The **Economic Parameters** section allows the user to specify Capital and Operational expenses for the field. Click the **Economic Parameters** tab in the **Prediction Period** section of the **Process Explorer**. The Economic Parameter window is displayed as shown below.



Click **New** to create a new set of economic parameters. In the figure below, the new Economic Scenario is named E1. The user can define multiple economic scenarios by clicking the **New** button as many times as may be appropriate.





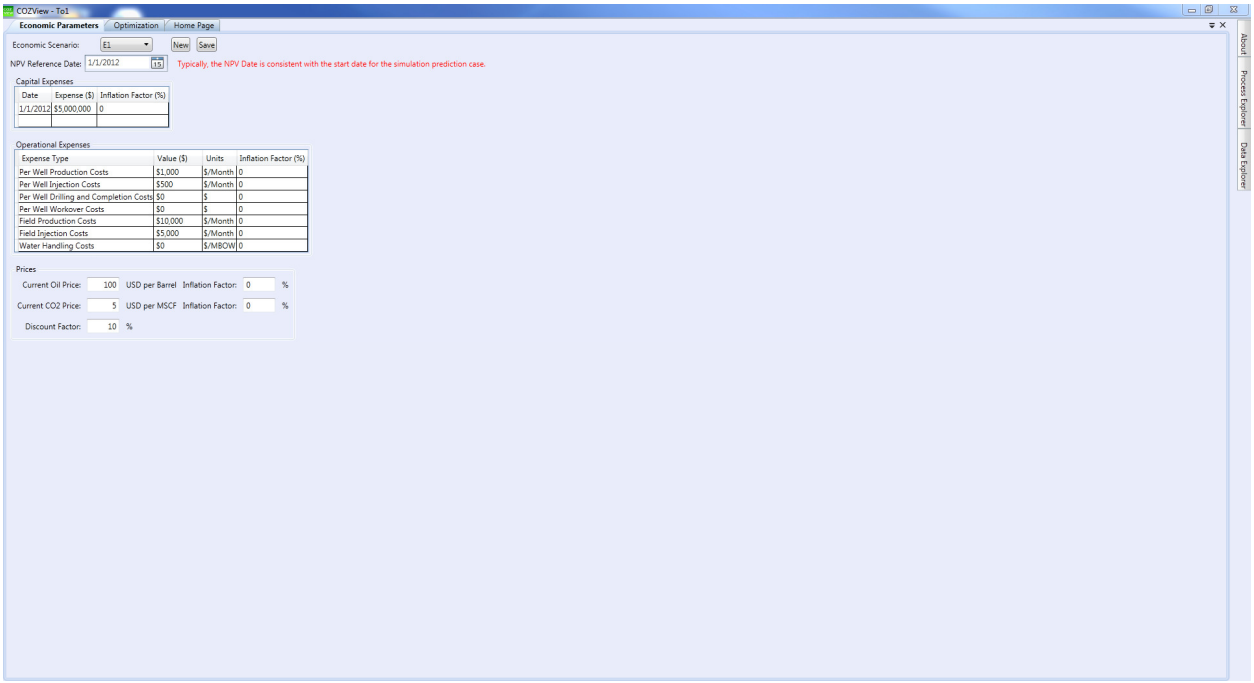
The following parameters (Capital and Operational expenses) are specified for this tutorial.

Capital Expenses

Date	01/01/2012 (same as Initialization date)
Expense ($)	5,000,000
All Inflation Factors, %	0

Operational Expenses

Per well Production costs, $/Month	1000
Per well Injection costs, $/Month	500
Per well Workover costs, $/Month	0
Field Production costs, $/Month	10,000
Field Injection Costs, $/Month	5,000
Current oil price, USD/STB	100
Current CO2 price, USD/MSCF	5
Discount Factor, %	10



Click **Save** to save the economic parameters.

The reservoir in Tutorial #1 consists of three layers, each of thickness 25 ft.

The following are the well and field limits used in Tutorial 1.

Well Constraints

Injection well (Well_5): Center well in the five spot

Maximum Bottom hole pressure (psia)	2500
Maximum CO2 Injection rate (MSCF/day)	5000

Producers (Well_1 – Well_4)

Minimum BHP (psia)	1500
Maximum Production Liquid rate (STB/day)	400

Well limits

Minimum Oil rate (STB/day)	5
Action to take	Close well

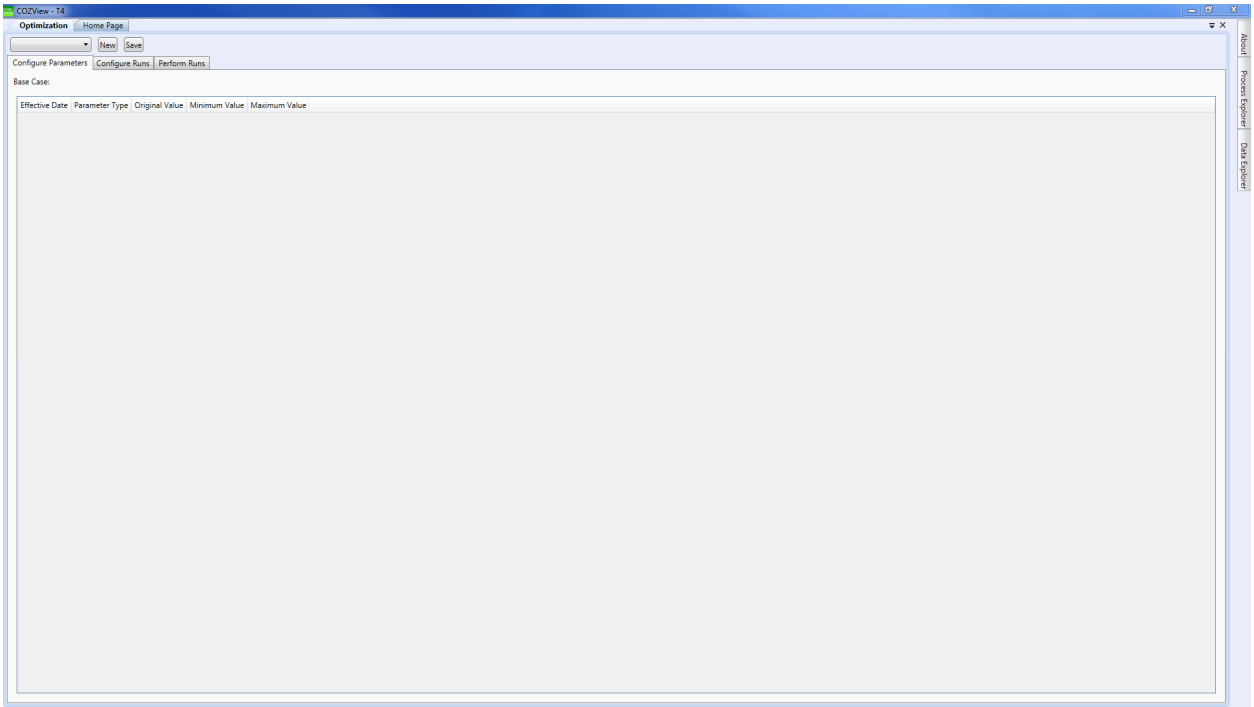
Field (Facility) Controls

Maximum Field Gas Injection Constraint (MSCF/day)	1500
Field Gas Reinjection Fraction	0.5
Available External Injection gas (MSCF/day)	1200

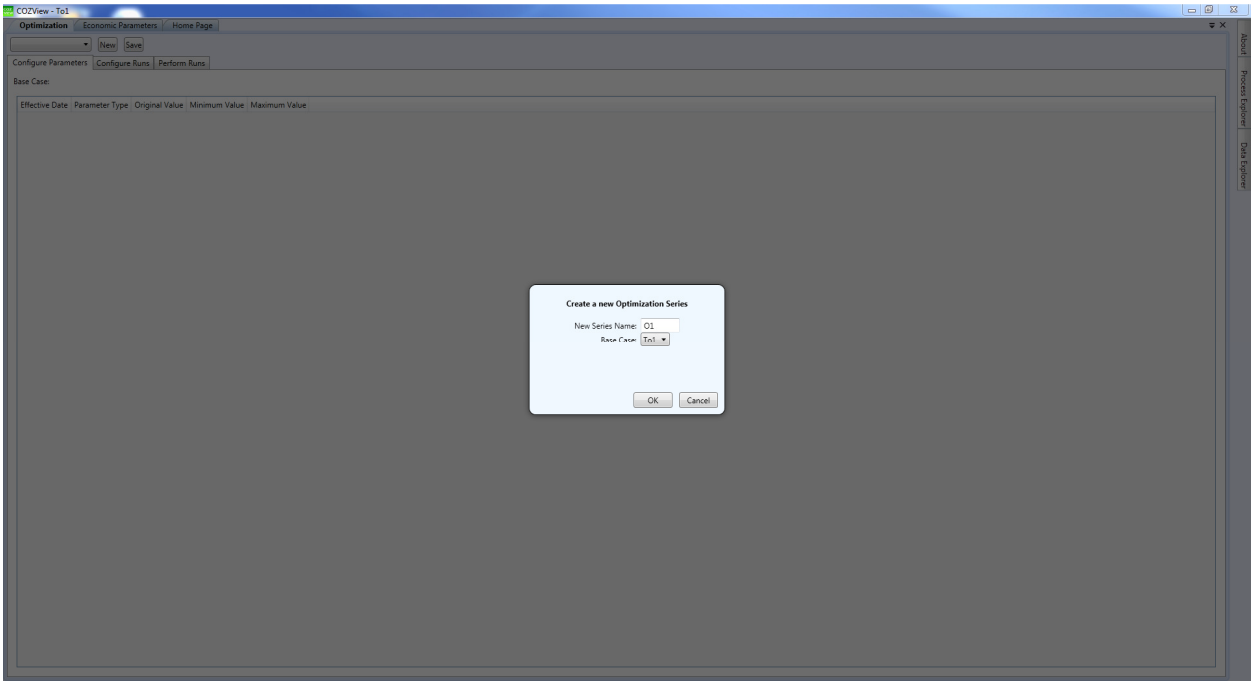
Field limits

Minimum Oil rate, STB/d	10

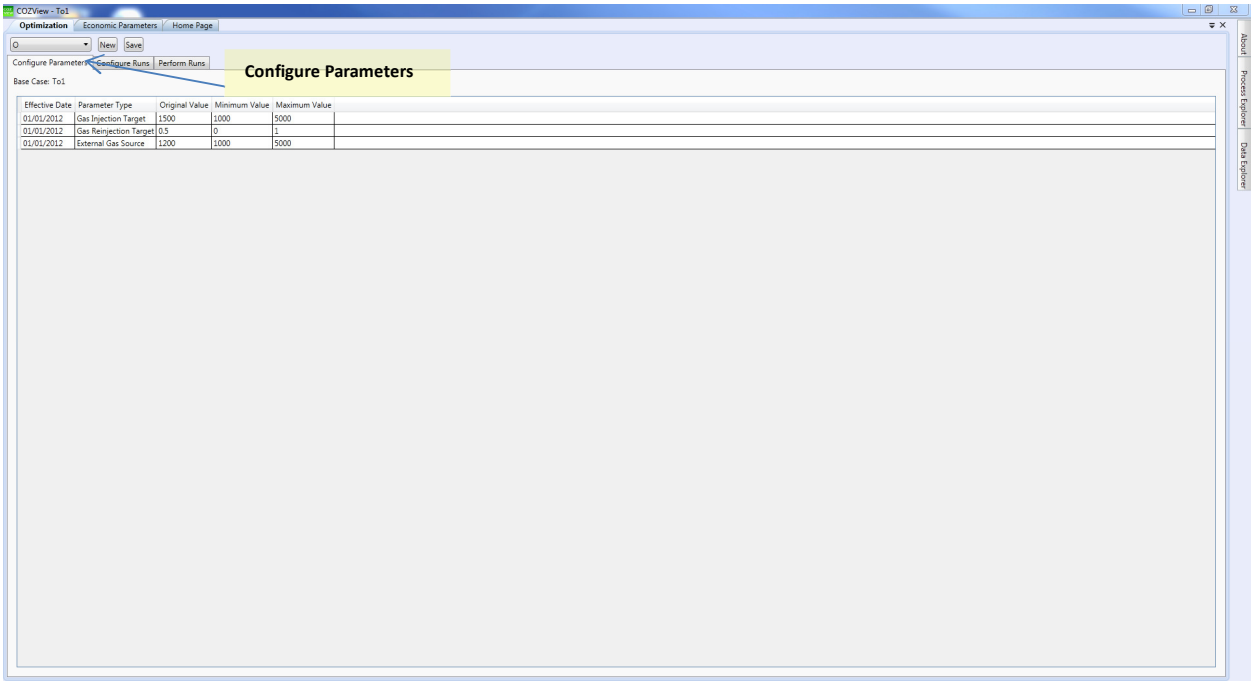
Select the **Optimization** tab under Process Explorer.



Click **New** to create a new Optimization Series name. Name the Optimization Series and select the base case (Tutorial1 for this example). An Optimization Series will be a particular set of Field (Facility) parameters and ranges and a given Economic Scenario.



A table of the previously specified Field parameters and their original values will be displayed in the Configure Parameters section. These are the parameters available for investigation in the optimization process. The user can specify a range (minimum and maximum) over which each parameter's value can be varied during the optimization process. The user can choose to not vary a particular parameter by not providing minimum and maximum values.



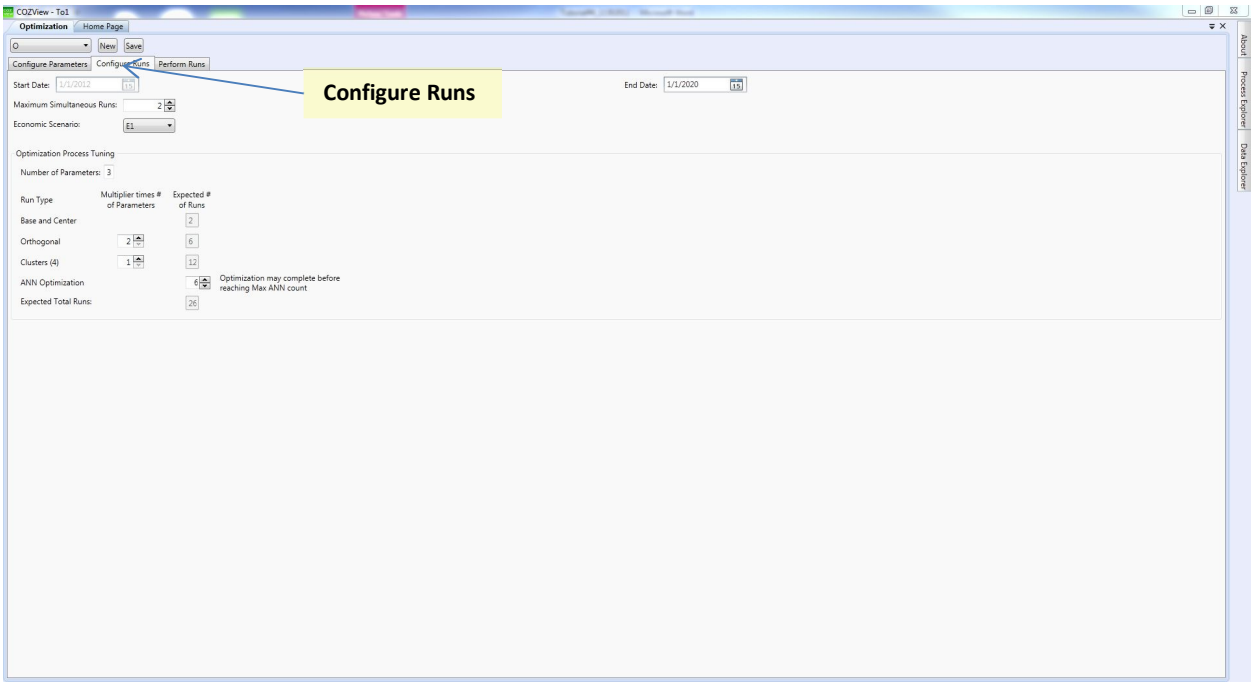
The following are the parameters used in this tutorial.

	Minimum Value	Maximum Value
Gas Injection Target, MSCF/D	1000	5000
Gas Reinjection Target, fraction	0.0	1.0
External Gas Source, MSCF/D	1000	5000

Select the **Configure Runs** tab. This section allows the user to specify the End Date of the optimization process. The user can specify the maximum number of runs that can be run simultaneously. For users with multi-core CPUs, the Maximum simultaneous runs can typically be set to the number of cores available. Because many of the simulation runs made during the optimization process are independent of other runs, multiple runs can be processed simultaneously if multiple CPUs are available. This can significantly speed the elapse time required for the runs made during the optimization process.

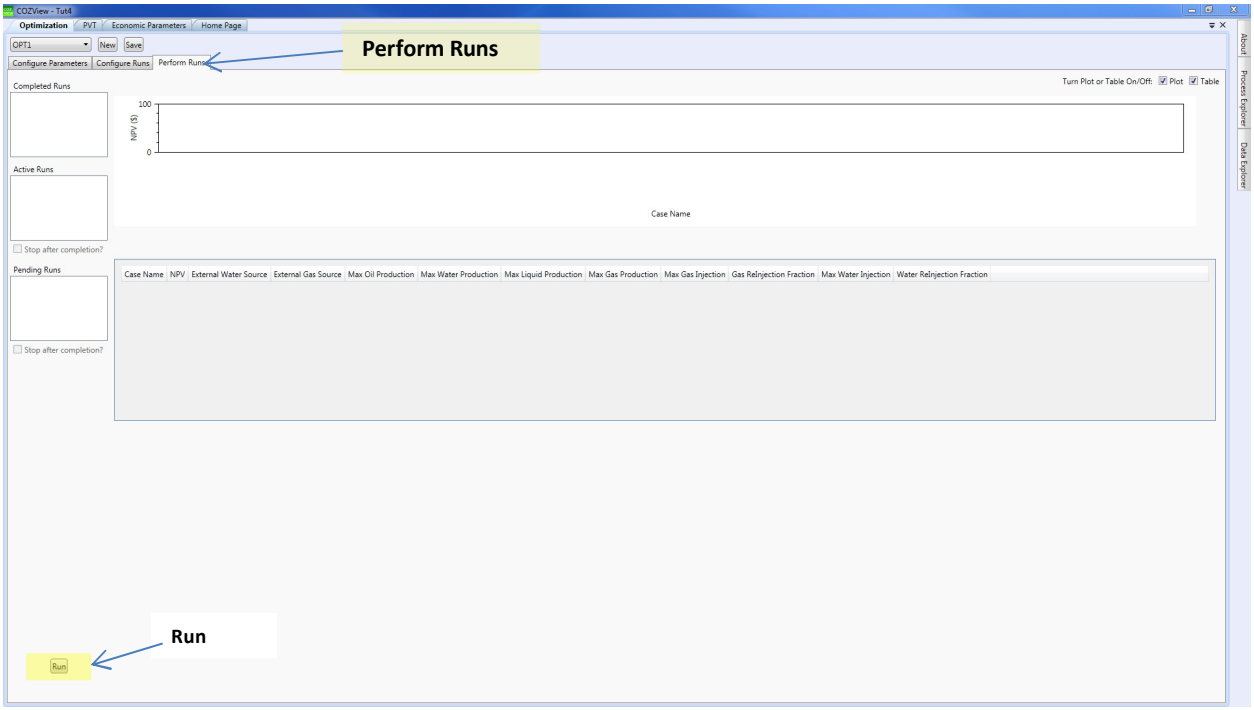
Economic scenario to be used for optimization process must be selected from the drop down menu as shown below. The following are the parameters used in this tutorial

Start Date	1/1/2012
End Date	1/1/2020
Maximum Simultaneous Runs	2
Economic Scenario	E1 (Economic Scenario defined previously)
Expected number of runs	26 (Default for 3 parameters)



Click **Save** before leaving this section.

Select Perform **Runs**. This section is used to launch the optimization process simulation runs. Click **Run** to start the process.

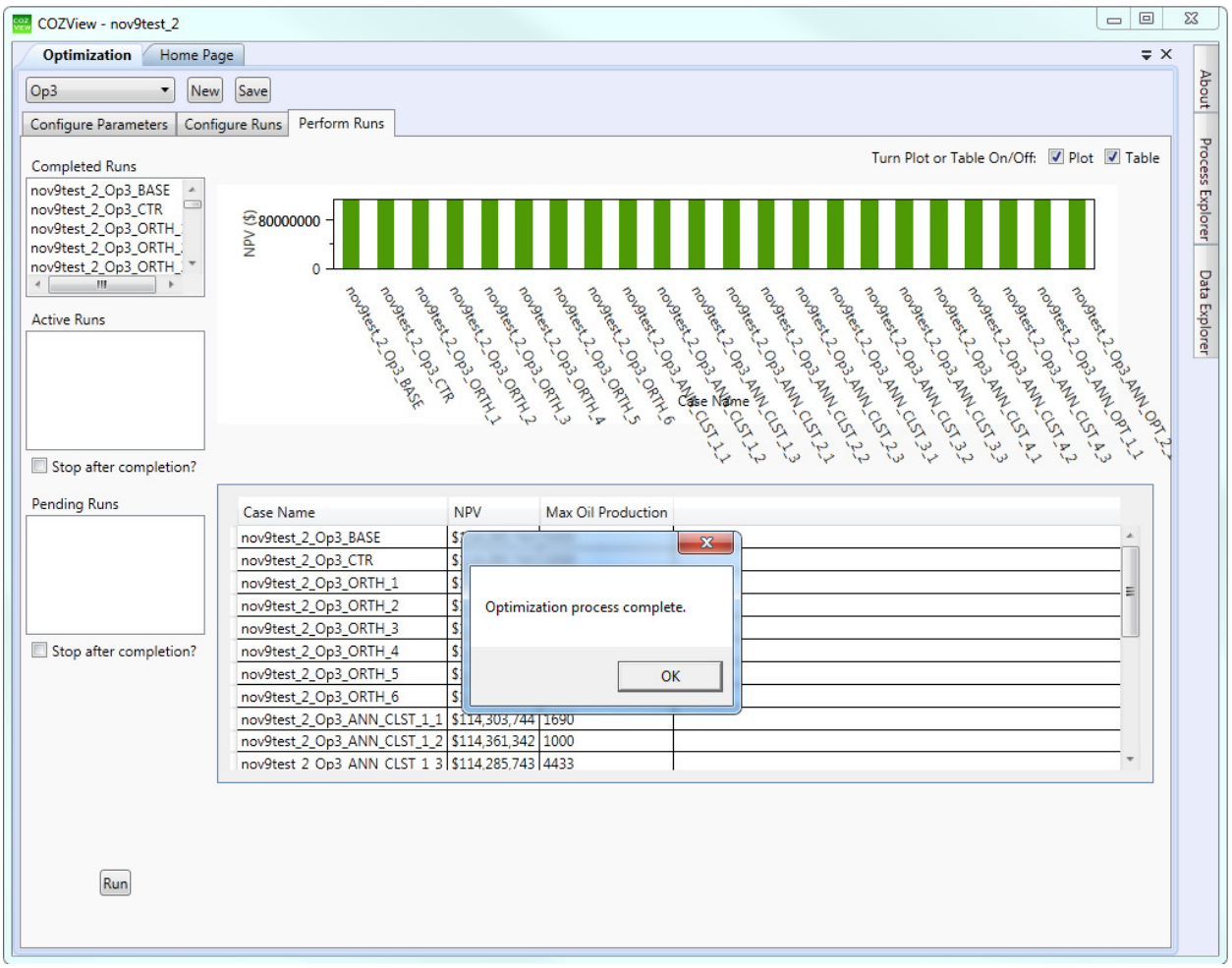


The user can monitor all the optimization process simulation runs in this section. The screen will provide information about the simulation runs that have been *Completed*, are *Active* (in progress) and *Pending* (waiting to run) on the left side of the screen. Pending Runs are only those that have been designed at that point in time. New runs may be designed as the process progresses. The Simrunner window will appear for each active simulation run. As a simulation run completes, a small window will appear notifying the user that the results of the completed simulation run are being loaded. Once the results are loaded a bar chart will display the calculated NPV for the case.

DO NOT close COZView or the Optimization tab during the simulation run as this will stop the optimization process. COZView can be minimized while the process is in progress.

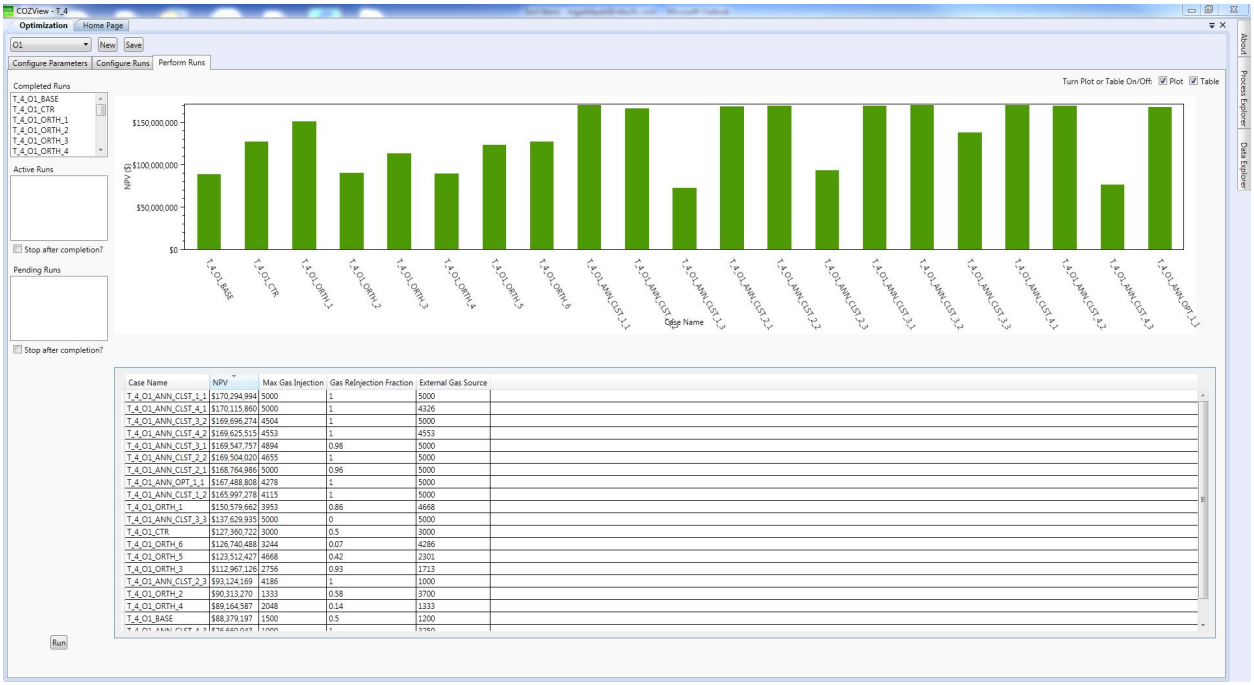
DO NOT cancel any simulation run during the optimization process. This will result in an incomplete optimization process. As soon as the simulations are completed, a window will appear saying "Optimization process Complete" as shown below. If the user wishes to cancel the optimization process before it completes all simulation runs, select check box **Stop after completion** under the Active and Pending run areas. This will result in a proper shut down of the process.

The simulation cases made during the optimization process will have unique case names. These names will start with the Base Case name provided by the user (T2 in this case) followed by SER_#, followed by an optimization process identification name. The SER_# is associated with the number of Economic Scenario and Field parameter combinations run through the optimization process for the Base Case.



In some cases the optimization process will not utilize the maximum number of simulation runs expected for the number of Field parameters being varied. If the optimization process determines that additional simulation runs are not warranted, the process will complete with the message “Optimization process has completed before maximum run count was reached”.

The *Perform Runs* screen will display a table and a bar chart showing all the simulation results.



Click the **NPV** column heading on the table to sort NPV in increasing or decreasing order. Clearly in this tutorial the best case is the CLST case (Case Name: To1_O_ANN_CLST_2_3) with NPV of $170 Million USD.

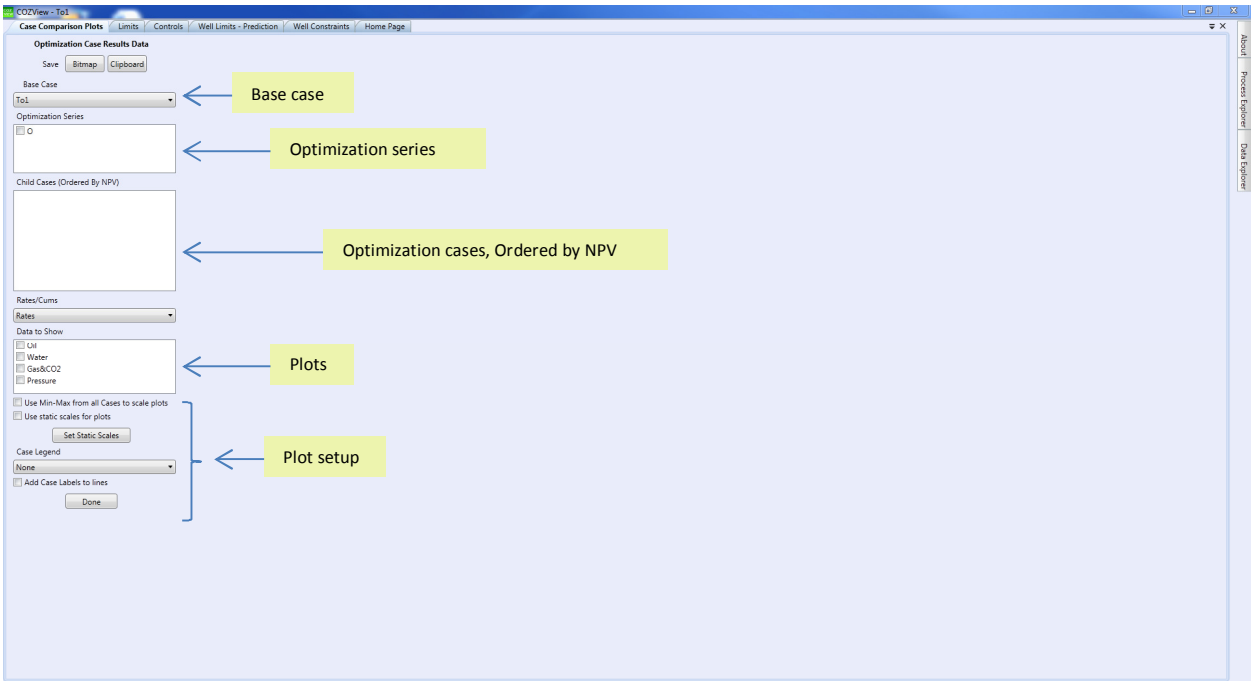
The Field controls that will maximize NPV are

Maximum Gas Injection	5000 MSCF/D
Gas Reinjection fraction	0
External gas source	5000 MSCF/D

As each simulation run completes in the optimization process the Field production/injection results are loaded into the **Simulation Results** Plots and Tables. Only the field results are loaded for the optimization simulation runs. The Plots and Tables can be viewed while the optimization process is in progress. However, **DO NOT** close the Optimization tab until the total optimization process is completed.

The results of different optimization cases can be compared using **Case Comparison Plots** under **Optimization** tab. For more details about Optimization and Case Comparison Plots please refer to User Manual (Section 3.7)

Click on the **Case Comparison Plots**.



Select the base case and click on the Optimization series. The figure below shows the base run and the run that has high NPV.