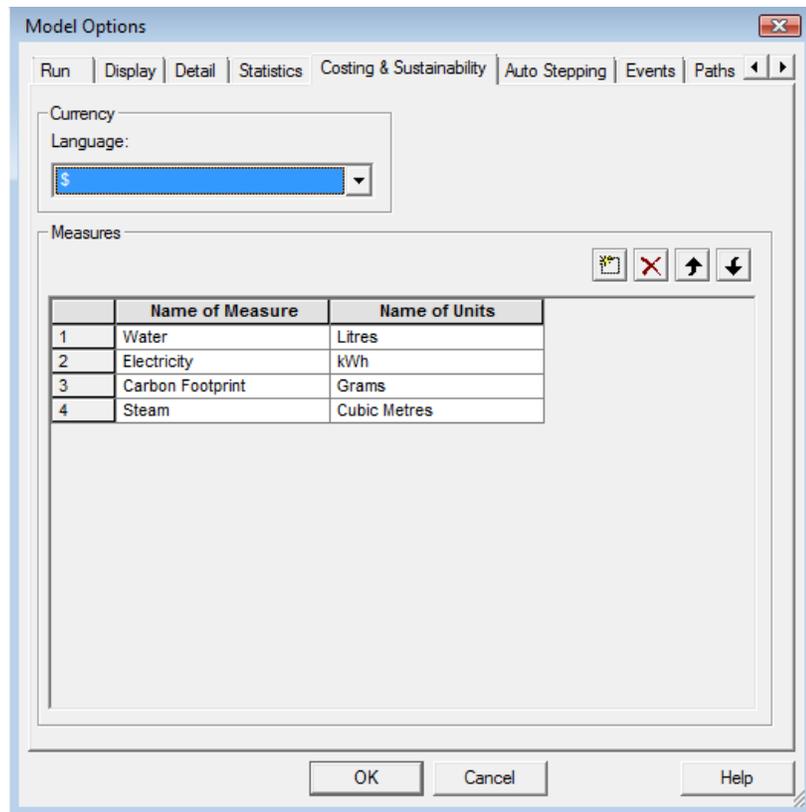


WITNESS Power with Ease Release 2 - Release Notes

Welcome to the second release of WITNESS Power with Ease. Power with Ease is a series of WITNESS releases offering new functionality on a regular basis. The first release introduced virtual reality options for all WITNESS users with the advent of Quick3D. This second release tackles a major topic of concern to all – that of sustainability. WITNESS PwE release 2 offers the ability to model, track and even optimize the use of resources and materials consumed in the processes modelled - This in addition to the normal improving of efficiency, service and levels of production.

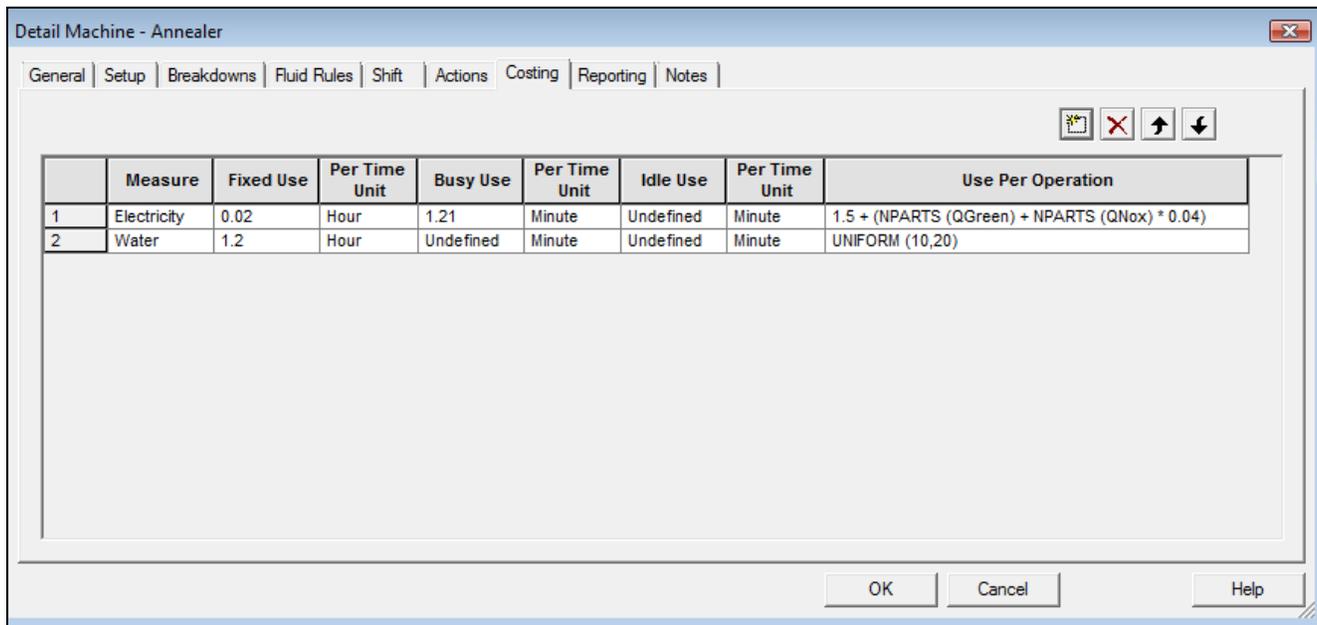
You can define which measures you wish to focus on. From Carbon to Water, from Electricity to Oil, all measures that you wish to model can be defined in the new Costing and Sustainability definition tab located in the Model/Options menu dialog.



You select the units too for each measure. These can be the full words or typical abbreviations such as kWh for kilowatt hours. The unit definitions are the measuring units that should be used throughout the model and also form the display for the standard sustainability reports.

Once the measures have been defined the usage of each measure (or generation of the measure if appropriate!) is entered in a new grid structure available within the element dialogs on the Costing tab.

These grids operate in the same way as other grids in WITNESS introduced in WITNESS 2008 for breakdowns, setups, multi-cycle machines, shifts and more, with the first button adding lines to the grid and each line representing a different usage of a defined measure. The X button deletes line(s) from the grid. Only one line per grid should be used for each measure.



An example of a machine element (activity) costing tab showing two measures defined.

In this release these new grids allowing the addition of sustainability measures are included on the following element types:

- Parts/Entities
- Machines/Activities
- Labor/Resources
- Buffers/Queues
- Paths

In subsequent Power with Ease releases further elements will be added to this list. However, even though other elements are not currently included their power or other measure usage **can** still be modelled – see later in these notes for full details on this.

It is not intended that all boxes need to have expressions added – simply use the ones that best model the usage of the measure for your model

Fixed Use represents the amount of the measure used per time unit – irrespective of whether it is being used or not, an overhead figure.

Busy Use is calculated from the machine utilization figure and the expression entered will be multiplied by that figure in percent.

Idle Use is calculated from the machine utilization figure and the expression entered will be multiplied by that figure in percent.

Use Per Operation is calculated as the model runs and added to a running subtotal.

Fuller explanations of these terms are included in the WITNESS help text.

Expressions can be added to each field. This adds great flexibility to the modelling as, for example, a machine may use 6 kWh of energy processing one part and 9 the next. The expressions can include distributions, attributes, WITNESS functions, even a call to user-defined function if the calculation is more complicated.

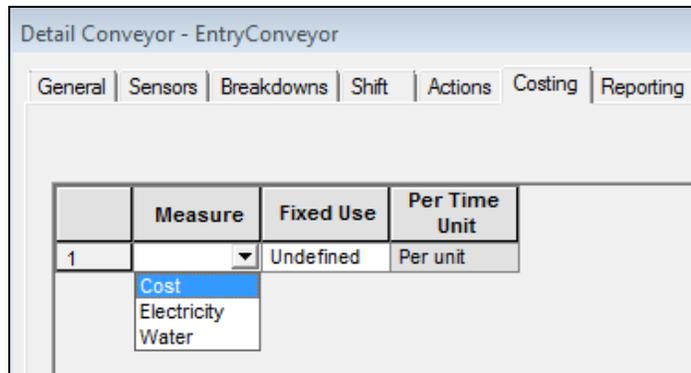
Machine - Annealer								
General Setup Breakdowns Fluid Rules Shift Actions Costing Reporting Notes								
	Measure	Fixed Use	Per Time Unit	Busy Use	Per Time Unit	Idle Use	Per Time Unit	Use Per Operation
	Electricity	0.02	Hour	1.21	Minute	Undefined	Minute	1.5 + (NPARTS (QGreen) + NPARTS (QNox) * 0.04)
	Water	1.2	Hour	Undefined	Minute	Undefined	Minute	UNIFORM (10,20)

In this machine/activity example the electricity used each time the machine operates is dependent on the number of parts in the QGreen and QNox buffers and an amount of between 10 and 20 units of Water are used in each operation.

Detail Buffer - QNox						
General Actions Costing Reporting Notes						
	Measure	Fixed Use	Per Time Unit	Per Part In	Per Time Unit Dwelling	Per Time Unit
1	Electricity	Undefined	Per unit	Undefined	2.5	Per unit

In this buffer/queue example each time unit of the model that a part or entity stays in the queue / buffer will use 2.5 units of electricity

Costing, in terms of currency, is a measure that is universally defined in all models. This does not have to be added in the measures dialog (although the currency used can be changed on that dialog). When adding a new measure using the grids Cost will always be an option.



For those elements that do not currently have the new grid structure to add measures, the costing tabs simply provide the option to enter costing measures in currency terms.

Extra Flexibility for Adding Usage

New functions extend the flexibility of recording the use of different measures. For example if a breakdown or a setup incurs extra use then this can be added at the relevant point in the WITNESS actions code using the functions below. (For full details please see the helptext)

AddUsage – This function will add a use of the specified measure against the specified element. e.g. **AddUsage ("Electricity",ActivityA(1),2.3)**
will add 2.3 units of use of Electricity into the "By Quantity" section of the report

AddGeneration – This function will add units of the specified measure as generated against the specified element

It is worth noting that this new ability also adds to the flexibility of the costing models that can be applied in WITNESS models as Costs can now also be added at any point in a model

AddCost - The **AddCost** function provides the same functionality as **AddUsage** when using the built-in currency based cost.

e.g. **AddCost (ActivityA(1),2.3)**

AddRevenue - The **AddRevenue** function provides the same functionality as **AddGeneration** when using the built-in currency based cost.

Specifying the use of energy or other measure for additional elements

The functions outlined in the section above can only be applied to those element types that offer the "By Quantity" option in their specification tab. (Machines/Activities, Buffers/Queues and Parts/Entities).

It is possible however to defined further elements of these types purely for the recording of measure use or cost.

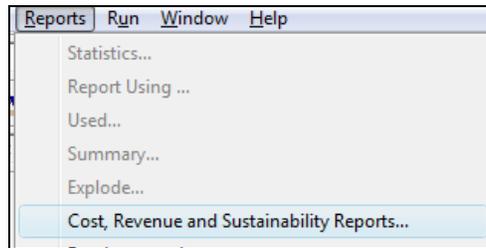
For example a machine may be defined "VehiclePower" and the new functions used to record the use of Power by vehicles in the model. Similarly if it is required to see explicitly the use of water used in a machine setup then a separate machine called "SetupMachineA" could be defined.

This method allows the use / costs to be displayed at a level of granularity chosen by the user with separate lines for important options as shown below in an example where the setup cost is isolated in the report (see below for full details of reporting).

Use	Element	Fixed	By Use	By Quantity	Total
	GreenPart	0 kWh		8338.45 kWh	8338.45 kWh
	SetupCost_Annealer	0 kWh	0 kWh	168325 kWh	168325 kWh
	Annealer	0 kWh	16754.8 kWh	14677 kWh	31431.8 kWh
	EntryConveyor	29500 kWh			29500 kWh
	QNox	0 kWh	285319 kWh	0 kWh	285319 kWh
Total Use		29500 kWh	302074 kWh	191341 kWh	522915 kWh

Reporting

Reports are neatly presented in the tabular Costing and Sustainability Report where each measure can be selected to display usage at different levels of granularity – e.g. by element, element type or model wide. This report is selected from the Reports menu.



The screenshot shows a dialog box titled 'Cost, Revenue and Sustainability Reports'. It contains three main sections: 'Generation', 'Use', and 'Balance'. The 'Measure' is set to 'Power'. The 'Show' options are 'By Individual' (selected), 'By Group', and 'By Type'. There are buttons for 'Close', 'Print', and 'Help'.

Generation	Element			By Quantity	Total
Total Generation				0 kWh	0 kWh

Use	Element	Fixed	By Use	By Quantity	Total
	ZoneA.Operation75(1)	0 kWh	0 kWh	882.74 kWh	882.74 kWh
	ZoneA.Operation75(2)	0 kWh	0 kWh	738.714 kWh	738.714 kWh
	ZoneA.Operation75(3)	0 kWh	0 kWh	743.36 kWh	743.36 kWh
	ZoneA.Operation15(1)	0 kWh	0 kWh	7490.86 kWh	7490.86 kWh
	ZoneB.Operation60(1)	522.14 kWh	14.02 kWh	862.23 kWh	1398.39 kWh
	ZoneB.Operation60(2)	522.14 kWh	5.04 kWh	309.96 kWh	837.14 kWh
	ZoneB.Operation60(3)	522.14 kWh	2.10 kWh	129.15 kWh	653.39 kWh
	ZoneB.Operation25(1)	0 kWh	0 kWh	1232.06 kWh	1232.06 kWh
	ZoneB.Operation25(2)	0 kWh	0 kWh	1319.11 kWh	1319.11 kWh
	ZoneB.Operation45(1)	0 kWh	0 kWh	912.546 kWh	912.546 kWh
	ZoneB.Operation45(2)	0 kWh	0 kWh	845.208 kWh	845.208 kWh
	ZoneB.Operation45(3)	0 kWh	0 kWh	798.768 kWh	798.768 kWh
	Storage(1)	0 kWh	298457 kWh	0 kWh	298457 kWh
Total Use		1566.42 kWh	298478 kWh	16264.7 kWh	316309 kWh

Balance					
Total Balance					(316309) kWh

The appropriate measure can be selected using the pull down list labelled 'Measure' at the side of the dialog. The figures for generation appear in the top section of the report, Usage in the middle section and a Balance figure is given in the lower section. For many sustainability models it may well only be the central section which is needed. Each section will cut and paste when selected to other applications including Excel.

Using the report figures elsewhere in WITNESS or passing out for analysis

All figures from the report can be accessed for use on displays or for exporting to Excel using a range of 11 new measure functions.

Examples:

GetTotalUse("Electricity")	will return a real value of the amount of the measure Electricity used in the model
GetFixedUseByElement("Oil",MachineA(2))	will return a real value – the oil used as specified in the fixed use box against MachineA(2)

Full List of Functions – for argument detail please see help text.

GetTotalGeneration	Returns the total generation of the selected measure calculated in the model Mode 0: All Generation Mode 1: All Generation from Shipped Product Mode 2: All Generation from Scrapped Product
GetTotalUse	Returns the total use of the selected measure calculated in the model
GetTotalBalance	Returns the total balance of the selected measure calculated in the model. i.e. generation - usage
GetGenerationByElement	Returns the generation of the selected measure calculated in the model for the element list supplied
GetFixedUsageByElement	Returns the fixed usage for the selected measure calculated in the model for the element list supplied
GetByUseUsageByElement	Returns the usage by use (based on utilizations) for the selected measure calculated in the model for the element list supplied
GetByQtyUsageByElement	Returns the usage (based on each job / task) for the selected measure calculated in the model for the element list supplied
GetGenerationByType	Returns the generation of the selected measure calculated in the model for the element types supplied Mode 0: All Generation Mode 1: All Generation from Shipped Product Mode 2: All Generation from Scrapped Product
GetFixedUsageByType	Returns the fixed usage for the selected measure calculated in the model for the element types supplied
GetByUseUsageByType	Returns the usage by use (based on utilizations) for the selected measure calculated in the model for the element types supplied
GetByQtyUsageByType	Returns the usage (based on each job / task) for the selected measure calculated in the model for the element types supplied

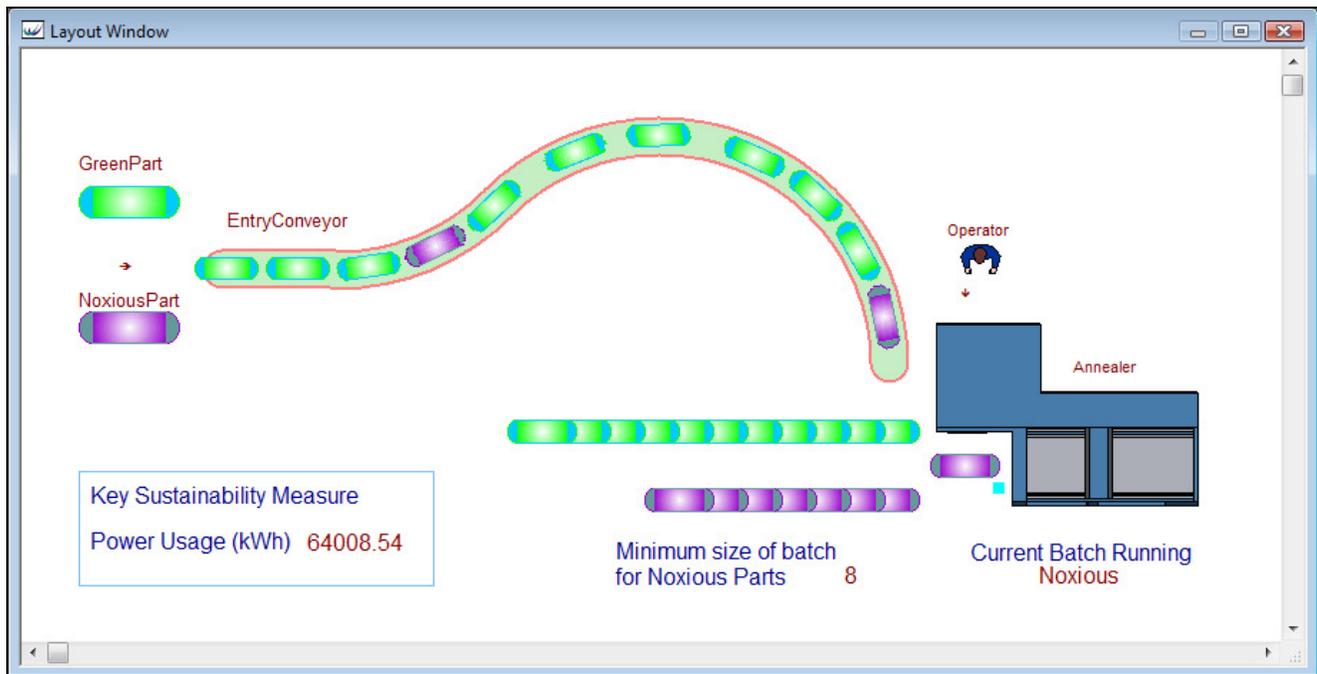
Model Example to illustrate new release - An analysis of Power Optimization

This simple model looks at a manufacturing process where the key issue is the usage of electricity(power). Parts need to be kept warm in a buffer prior to an annealing process that also takes much energy. To add to the complication machine tooling changes also consume power. The model presents an interesting balancing act where the chosen batch size materially affects the power usage.

All use of electricity is defined in the model and a series of experiments identifies the optimum batch size to minimize power usage.

Model Description and Detail

A view of the model screen display in WITNESS. The model is included in the WITNESS demonstration model directory and is called "**Energy Optimization model.mod**".



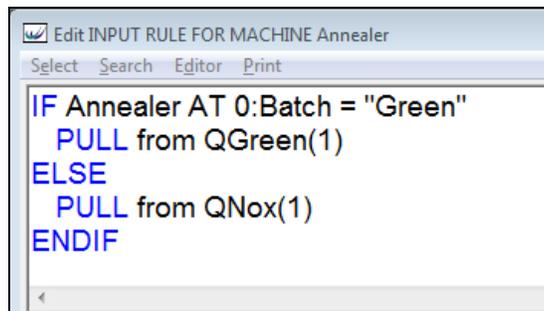
In this model there are 2 types of part

GreenPart	
NoxiousPart	

The two parts arrive into a buffer which feeds the EntryConveyor

The EntryConveyor transports the parts to two separate queues (one for each type of part) in front of a machine called Annealer.

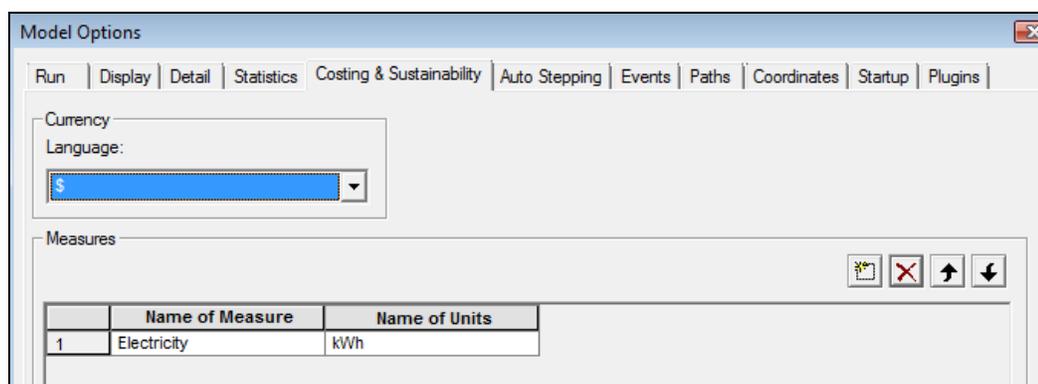
The Annealer machine pulls from the 2 buffers depending on which batch it is currently processing. An attribute on the machine called Batch is either set to "Green" or "Noxious" to indicate which part should be input. The input rule is:



```
IF Annealer AT 0:Batch = "Green"  
  PULL from QGreen(1)  
ELSE  
  PULL from QNox(1)  
ENDIF
```

Note the use of a machine attribute here and the syntax which holds for machine, vehicle and labor attributes. Note also that the attributes must be defined as machine attributes of Group 0.

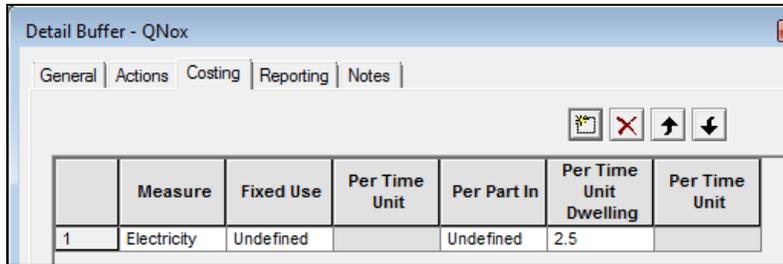
The measure to be monitored and optimized in this model is electricity. This is defined in the Model/Options/Costing & Sustainability dialog along with the units to be used – here we choose kWh.



In this model the Noxious parts need to be kept warm for the annealing process all the time that they are in their waiting buffer. The longer they wait the more electricity they use. The definition of this can be seen in the WITNESS dialog below.

Detail Buffer - QNox

General | Actions | Costing | Reporting | Notes

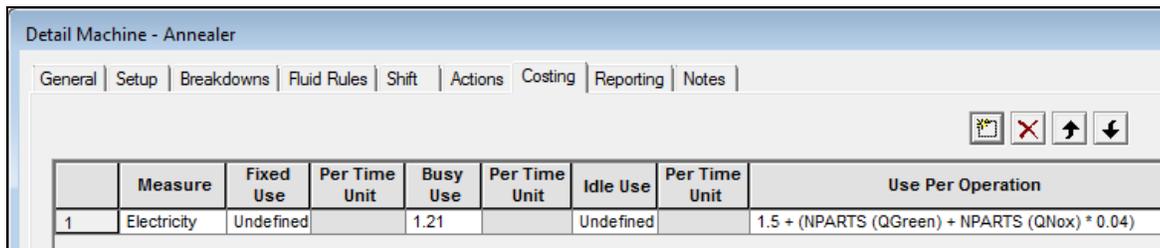


	Measure	Fixed Use	Per Time Unit	Per Part In	Per Time Unit Dwelling	Per Time Unit
1	Electricity	Undefined		Undefined	2.5	

The Annealer uses electricity whilst it is busy at a certain rate (1.21 kWh per time unit) and also uses a set amount of electricity for each operation. This calculation is more complicated as it is based on a constant figure (1.5) plus a factor of the number of waiting parts in the 2 queues which place a power drain on the machine whilst in operation.

Detail Machine - Annealer

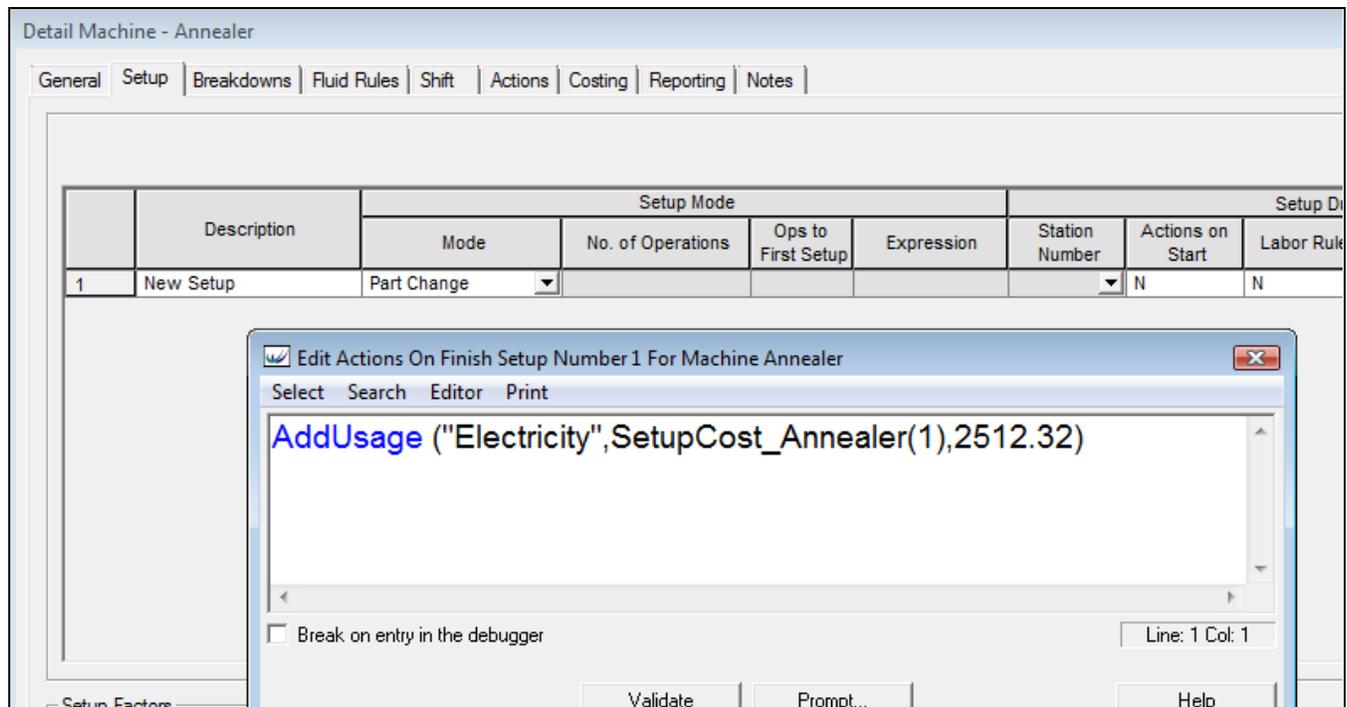
General | Setup | Breakdowns | Fluid Rules | Shift | Actions | Costing | Reporting | Notes



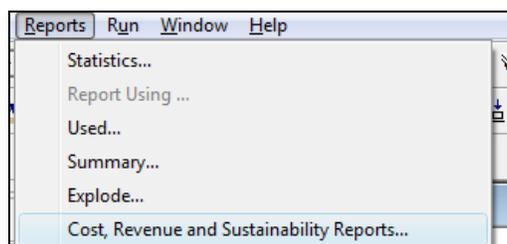
	Measure	Fixed Use	Per Time Unit	Busy Use	Per Time Unit	Idle Use	Per Time Unit	Use Per Operation
1	Electricity	Undefined		1.21		Undefined		1.5 + (NPARTS (QGreen) + NPARTS (QNox) * 0.04)

The power of WITNESS to accept expressions in these fields is vital to its ability to model real life facilities where the calculations of measure use needs to be extremely flexible.

In this model the Annealer machine also needs power to perform a tool change setup between part types. For the Annealing machine the Actions on Finish for its setup add electricity usage to the running totals. In this case the electricity usage is added to a new dummy machine called SetupCost_Annealer, purely so that the separate costs for this can be clearly seen in the standard reports.



After the model has been run the Costing and Sustainability Report can be chosen from the report menu.



This is also available using the toolbar button 

Here the results after a run of 20,000 time units shows that a total of 328,284 kWh have been used in production and also provides details of where in the model the power has been used.

The screenshot shows a software window titled "Cost, Revenue and Sustainability Reports". It contains two main tables and a control panel on the right.

Generation	Element			By Quantity	Total
Total Generation				0 kWh	0 kWh

Use	Element	Fixed	By Use	By Quantity	Total
	SetupCost_Annealer	0 kWh	0 kWh	115567 kWh	115567 kWh
	Annealer	0 kWh	11233.8 kWh	9238.84 kWh	20472.6 kWh
	QNox	0 kWh	192245 kWh	0 kWh	192245 kWh
Total Use		0 kWh	203479 kWh	124806 kWh	328284 kWh

Balance					
Total Balance					(328284) kWh

Control Panel (Right):
 Close
 Measure: Electricity
 Show: By Type, By Group, By Individual
 Show All
 Print
 Help

Scenario Manager Analysis and Optimization

The WITNESS Scenario Manager offers an easy way to analyze the options for different batch sizes in the model and to determine the optimal solution.

BatchSize is an integer variable in the WITNESS model that is set in the Model Initialize Actions

The screenshot shows a software window titled "Initialize Actions" with a menu bar (Select, Search, Editor, Print). The main text area contains the code "BatchSize = 8". At the bottom, there is a checkbox for "Break on entry in the debugger" and a status indicator "Line: 4 Col: 1".

It is this variable that determines when a batch of NoxiousParts is to be processed through a setting on the Actions on Entry into the buffer of NoxiousParts before the Annealer.

The actions that set the Batch Attribute for the Annealer machine

```
Edit Actions On Input For Buffer QNox
Select Search Editor Print
|IF NPARTS (QNox) = BatchSize
  Annealer AT 0:Batch = "Noxious"
ENDIF
```

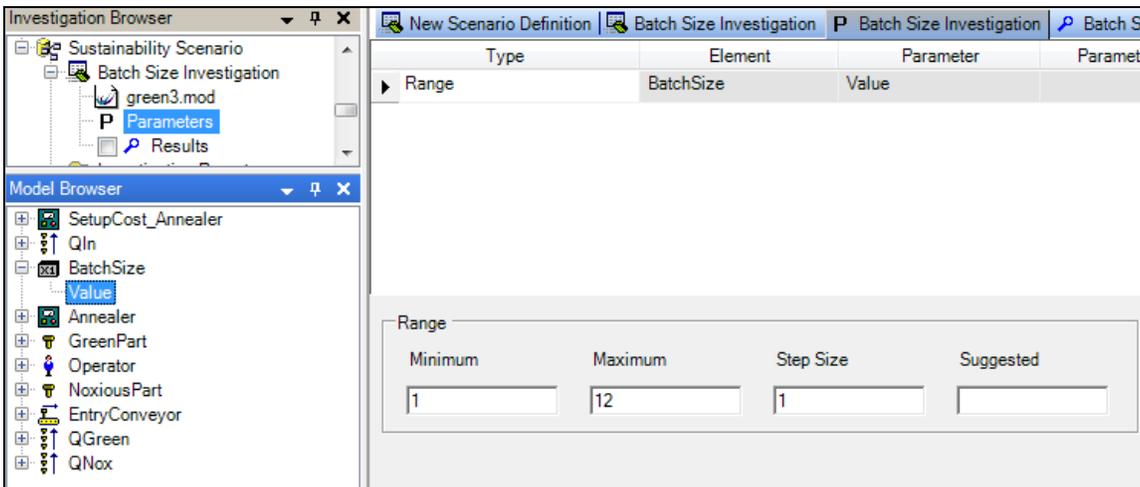
```
Edit Actions On Output For Buffer QNox
Select Search Editor Print
|IF NPARTS (QNox) = 1
  Annealer AT 0:Batch = "Green"
ENDIF
```

The key measure of performance here is the usage of electricity. The longer parts stay in the Noxious buffer the more power they take to keep hot but less time in the buffer means more machine setups which take time and also take use power. To track this easily in the Scenario Manager a function called Objective is added to the model.

The function detail for Objective utilizes one of the new sustainability functions and is simply:

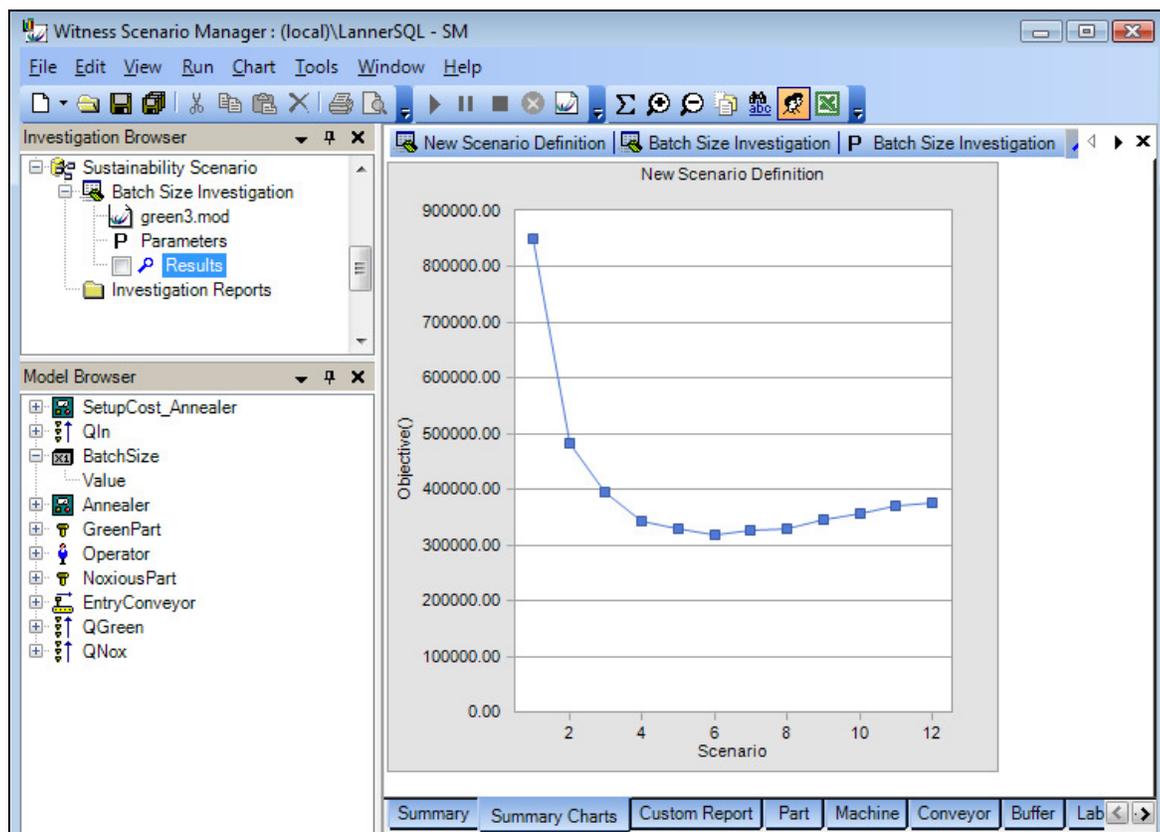
```
Edit Function Body For Objective
Select Search Editor Print
RETURN GetTotalUsage ("Electricity")
```

In Scenario Manager the model is selected and a run length of 20,000 time units defined. The Objective function is ticked to be tracked. The parameter list is accessed and the value of the BatchSize variable is set to vary in a range of 1 to 12



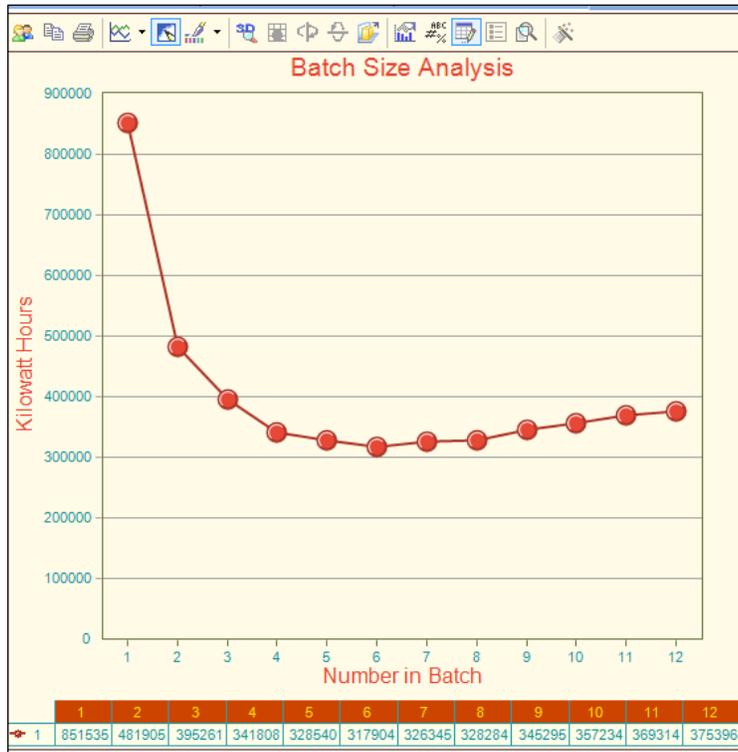
The model is then run from the Scenario manager.

Because the Power usage was treated as a key performance indicator (KPI) and defined in the WITNESS function (Objective) a chart is automatically created to show this result for each of the 12 different scenarios:



The chart immediately shows that the optimal batch size in this situation is 6.

Accurate figures may be accessed from the chart using the chart toolbar (or from the automatically generated tables) which may also be used to format the chart before easy cut/paste to Powerpoint, Word, etc.

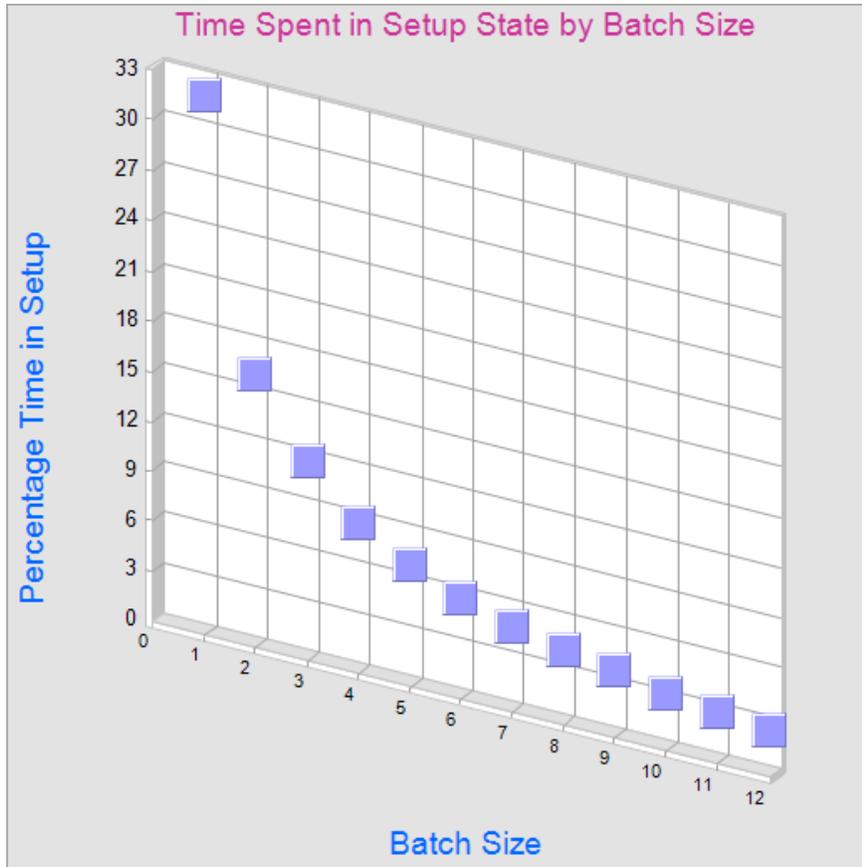


BatchSize.Value	Objective()
1	851534.94
2	481904.51
3	395260.94
4	341808.22
5	328540.09
6	317903.80
7	326345.36
8	328284.46
9	345295.48
10	357233.74
11	369314.34
12	375395.91

A selected table of automatic results reported in the Scenario Manager

Scenario	Name	BatchSize. Value	% Idle	% Busy	% Setup	% Broken Down	No. Of Operations
1	Annealer	1	0.90	39.84	32.28	26.98	1139.00
2	Annealer	2	5.06	46.44	16.40	32.10	1326.00
3	Annealer	3	9.58	46.42	11.90	32.10	1325.00
4	Annealer	4	12.48	46.42	9.00	32.10	1326.00
5	Annealer	5	14.00	46.50	7.40	32.10	1327.00
6	Annealer	6	15.48	46.42	6.00	32.10	1326.00
7	Annealer	7	16.28	46.42	5.20	32.10	1326.00
8	Annealer	8	16.88	46.42	4.60	32.10	1326.00
9	Annealer	9	17.43	46.47	4.00	32.10	1327.00
10	Annealer	10	18.04	46.46	3.40	32.10	1326.00
11	Annealer	11	18.36	46.34	3.20	32.10	1324.00
12	Annealer	12	18.89	46.21	2.80	32.10	1320.00

An example custom chart created from 2 selected columns of the tabular report:



For more complex optimization, where there is no time to run all the possible options, the WITNESS Optimizer should be used to search intelligently for a good solution.

Key Conclusion

In this example the 12 experiments showed the optimal batch size to be six, a saving of over 2.5% of the energy required for the next best solution of size seven.