Tutorial 6: Ramp Rates

This tutorial looks at how and why generator ramp rates are included in the model. It also explains how pre-processing works to minimise the number of constraints that are created.

The ramp rate constraint

The rate at which a generator can increase its generation in response to a *scheduled* change in quantity (as opposed to a reserve provider's *automatic* generation increase in response to a drop in frequency) is limited by the rate at which its fuel intake can be increased such that the increase is sustainable. This rate limitation is modelled by the ramp rate constraint shown in Equation 20.

$$EnergyCleared_{Gen} \leq$$

$$InitialMW_{Gen} + RampRate_{Gen} \times TimeInterval$$

Equation 20: Ramp Rate Constraint

Ramp rate example

To demonstrate the ramp-rate constraint, build the model shown in Figure 78 by tapping the buttons Bus-Bus-Gen-Gen-Load-Branch.

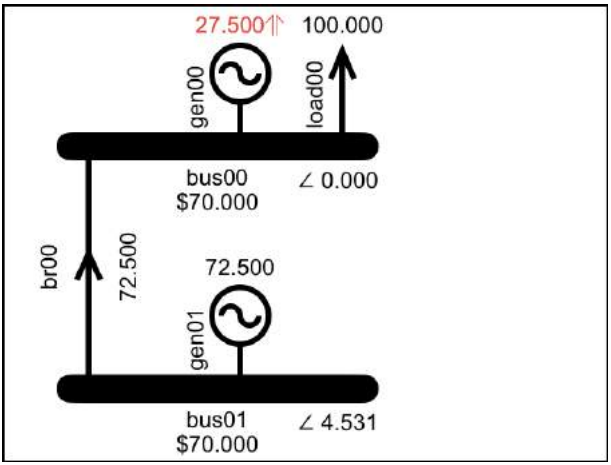

Figure 78: Model for ramp rate example

Edit gen00 to change its energy offer price to $7/MWh. Tap the Ramp button in the toolbar and enter a Ramp Rate Up value of 55, as shown in Figure 79. Leave the Initial MW as zero.

Solve the model with Losses and Reserves selected off, Ramp Rates selected on and a Time Interval of 30 minutes, as shown in Figure 80.

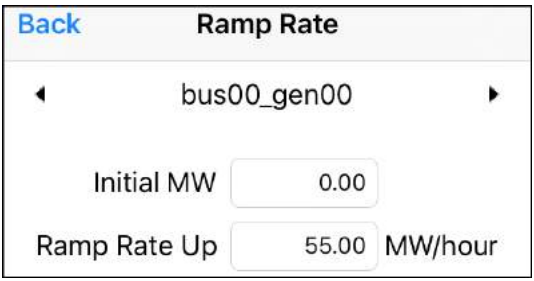

Figure 79: Ramp Rate data for gen00

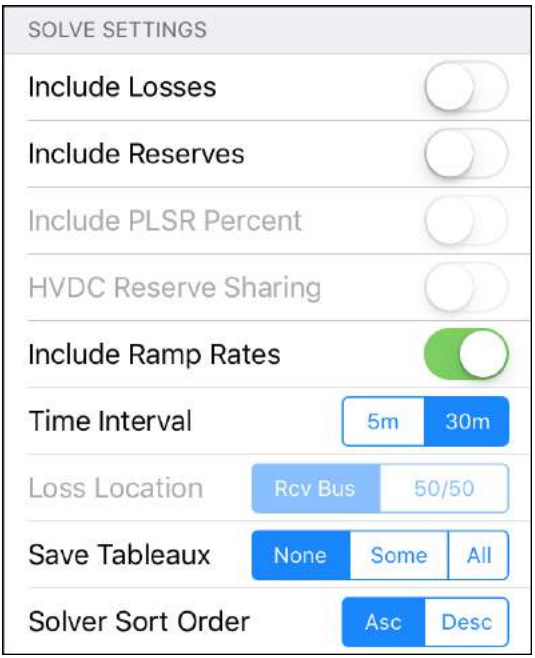

Figure 80: Solve Settings for ramp rate example

Explaining the ramp rate result

The ramp rate result is shown in Figure 78. The initial MW value entered on the Ramp Rate display is the generation at the beginning of the time interval. The time interval on the Solve Settings display is how much time the generator has to change its generation output from its initial MW value to the scheduled value… the results of the solve indicate the state of the system at the end of the time interval.

Gen00 has an initial MW value of 0MW and a ramp rate of 55MW/hour. Therefore, because we selected a time interval of 30 minutes, the maximum that gen00 can be scheduled is:

0MW + 55MW/hour x (30/60)hours = 27.5MW.

Because gen00 is cheaper than gen01 the solver schedules as much generation as it can from gen00 but is constrained by the 27.5MW limit set by the ramp rate constraint.

Indication of binding ramp rate

To indicate that generation is limited by the ramp rate, i.e., that the ramp rate is binding, the generation quantity for gen00 is coloured red and has an up-arrow suffix, as shown in Figure 78.

Ramp rate constraints

The ramp rate constraint that the app creates for gen00 is shown in Figure 81 (accessed via the ∑ button on the Data Display for the Gen component).

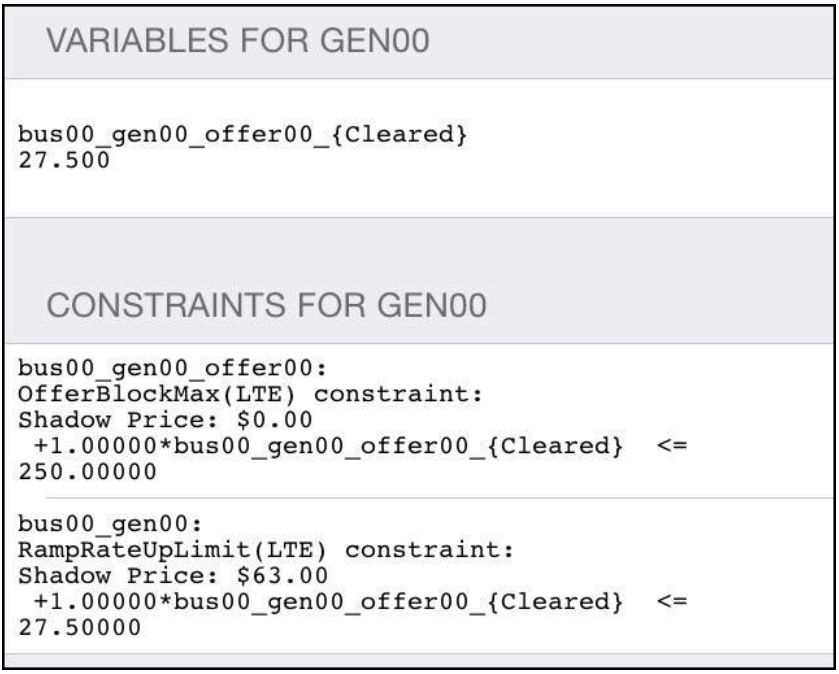

Figure 81: Constraints for gen00, including ramp-rate

Pre-processor exclusion of constraints

As you may have already noticed, there are no constraints created for bids and offers that have a quantity of zero. The creation of these constraints is excluded by pre-processing code that is run prior to the schedule being solved.

Similarly, when ramp-rates are enabled, the pre-processing code excludes the ramp-rate constraints for those generators where the sum of the generation offers is less than the maximum

generation limit that would be set by the ramp-rate constraint.

For example, if we look at the constraints for gen01 with the default up-ramp-rate of 99999, as shown in Figure 82 there is no ramp-rate constraint.

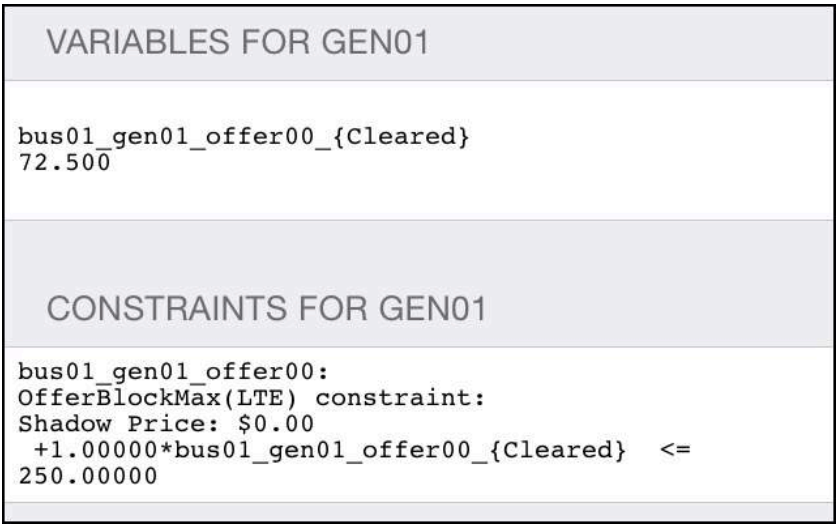

Figure 82: No ramp-rate constraint for gen01 because limit would be higher than sum of generation offers

Because of this pre-processing, and the high value that is used for the default up-ramp-rate, any generator that has the default up-ramp-rate is unlikely to have ramp-rate constraints created.

This makes it easy to investigate the impact of ramp-rates because only those generator's that have their ramp-rates edited will be affected by the

ramp-rate constraint… other generators can be left with the default ramp-rate in place and they are unlikely to have ramp-rate constraints applied.

Summary

In this tutorial we introduced the ramp-rate constraint that models the physical reality of the time it takes for a generator to increase its generation in a sustainable manner. Then we created an example to demonstrate the ramp-rate constraint in action.

We also saw how pre-processing excludes constraints that do not need to be applied, for example when bid or offer quantities are zero, or when the limit that would be imposed by the ramp-rate constraint is higher than the sum of the generation offer quantities.