DPG.sim

Quick Start Guide

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Purpose of the Document

The purpose of this document is to describe the functionality of Adaptricity's simulation platform DPG.sim. DPG.sim is power system simulation software aimed at SmartGrid features in distribution grids, such as distributed storage and demand response. By modeling energy consumption and production processes down to the customer level, it is especially suitable for simulating and planning highly decentralized energy systems.

The GUI of DPG.sim is a web based frontend. Using this frontend, the user can communicate via standard Internet protocols with a locally (Intranet use) or remotely deployed (cloud-based use) backend server where all the data is stored and computations are performed.

In general, DPG.sim implements the concept that each modeled entity connected to the power grid in the system is a so-called *prosumer*, stating that each entity either produces and/or consumes energy. In doing so, a power plant, a normal household, and a household with PV and an electric car charger can all be modeled as prosumers. Prosumers consist of individual *units* which represent basic electric items such as a non-controllable load, a PV panel installation, or a heat pump. Units form together with prosumers and other relevant objects such as grids the set of *models* in DPG.sim.

This document gives an overview about the steps in DPG.sim required to set up a time-series grid simulation. For running a defined simulation scenario, DPG.sim offers non-interactive and interactive run modes. While the non-interactive run mode is suitable for running long simulations unsupervised, the interactive run mode allows for gaining deeper insights into grid behavior in specific situations.

Note: Besides this document, DPG.sim includes a help system that is continuously extended. You can find it directly in the software when clicking on the (?) icon on the top right or by clicking on one of the (i) buttons in DPG.sim.

Overview of the Simulation Platform

In order to run a time simulation of a distribution grid containing populations of prosumers, you set up a *simulation scenario* which contains all required modeling information and is passed to the simulation engine for execution.

DPG.sim is a simulation platform that allows you to define scenarios so that you can simulate and analyze the results. These scenarios can be created in the page 'New/Edit Scenario' under the menu 'Scenario'. A scenario consists essentially of one grid where you can disperse prosumers, and other parameters such as the simulation time step size and the start and end date. See 'Creating a Simulation Scenario' below for details.

There are two types of prosumers: SmartMeter prosumers which involve real metered data and Sampled Prosumers which involve data generated from statistical distributions. In general, prosumer models need to be created first in order to set up a simulation scenario but some prosumer models are already installed in DPG.sim. They are templates for specific combinations of units with a stochastic dataset (which may include a time series), meters, and tariffs that have to be designed in the first place. An example is a residential load with a PV installation and a heat pump.

The modeling information consists of building blocks that assemble a simulation scenario. Such building blocks are (see also Figure 1):

- *Unit types* are templates for physical devices connected to the grid, defining parameters as well as input, output and state variables
- A *Stochastic dataset* belongs to a certain unit type and gives numerical values to parameters and assigns constraints and time series to variables. Probability distributions can be used to model parameter diversity within a larger population of units.
- *Meter types* enable the simulation of SmartMeter systems with different degrees of information.
- *Tariff Types* enable the configuration of energy consumption and feed-in tariffs.
- *Prosumer Types* are templates for specific combinations of units, stochastic datasets, meters and tariffs (e.g. a residential customer with a PV installation and a heat pump).
- *Grids* are power flow models of the electricity networks to be simulated and are configured by importing a grid topology from a specified format, or by manually editing buses, lines, transformers and other grid elements.

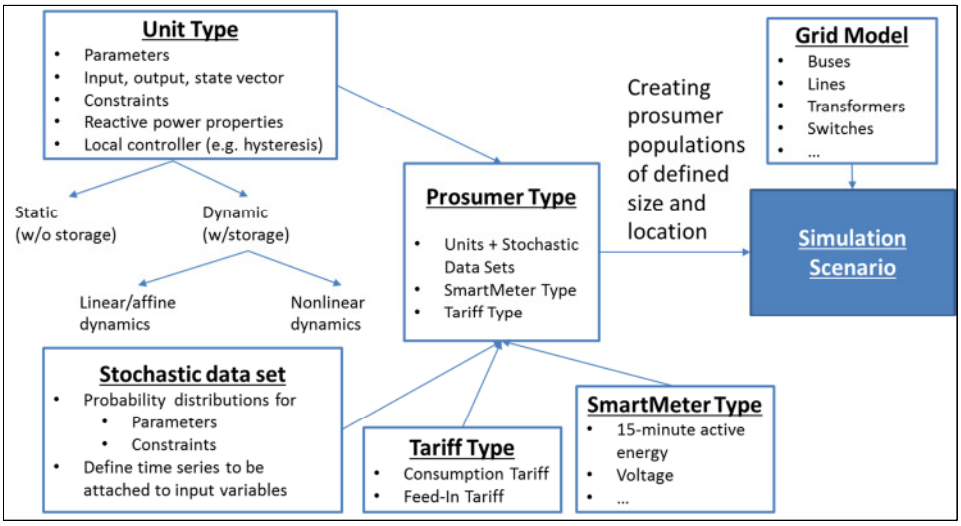

Figure 1: Building blocks of a simulation scenario

DPG.sim provides a set of unit models, datasets, and prosumers that can be used to quickly set up a simulation. These prosumers include “Household with non-controllable load and wind unit”, “Standalone generic battery unit” and “Standalone PV unit”. The stochastic datasets used by these prosumers define, e.g., the power rating of the load, PV, or wind unit.

To run a simulation, you can import the grid to be analyzed, create a scenario and disperse the provided prosumer models onto the grid. If necessary, the stochastic dataset of these prosumers can be edited first (e.g., to change the power rating). The last step before running the simulation is to select the results you want to be saved (bus voltages, line loadings etc.). This can be done under the menu item 'Scenario Variables'. The simulation can be started under the menu item ‘Interactive simulation’ or “Non-interactive simulation” and when it has finished, the results can be found under “Show and export simulation results”

Defining Unit Types

The basic physical entity in DPG.sim that exchanges energy with the grid is a so-called unit. Generally, units are based on dynamic state-space models which are known from control engineering, comprising input, output and state variables. The model dynamics represent an energy storage behavior over time. A special case is a static unit which exhibits a direct algebraic relation between input and output, i.e., no capability to store energy. The dialog to define a unit is depicted in Figure 2.

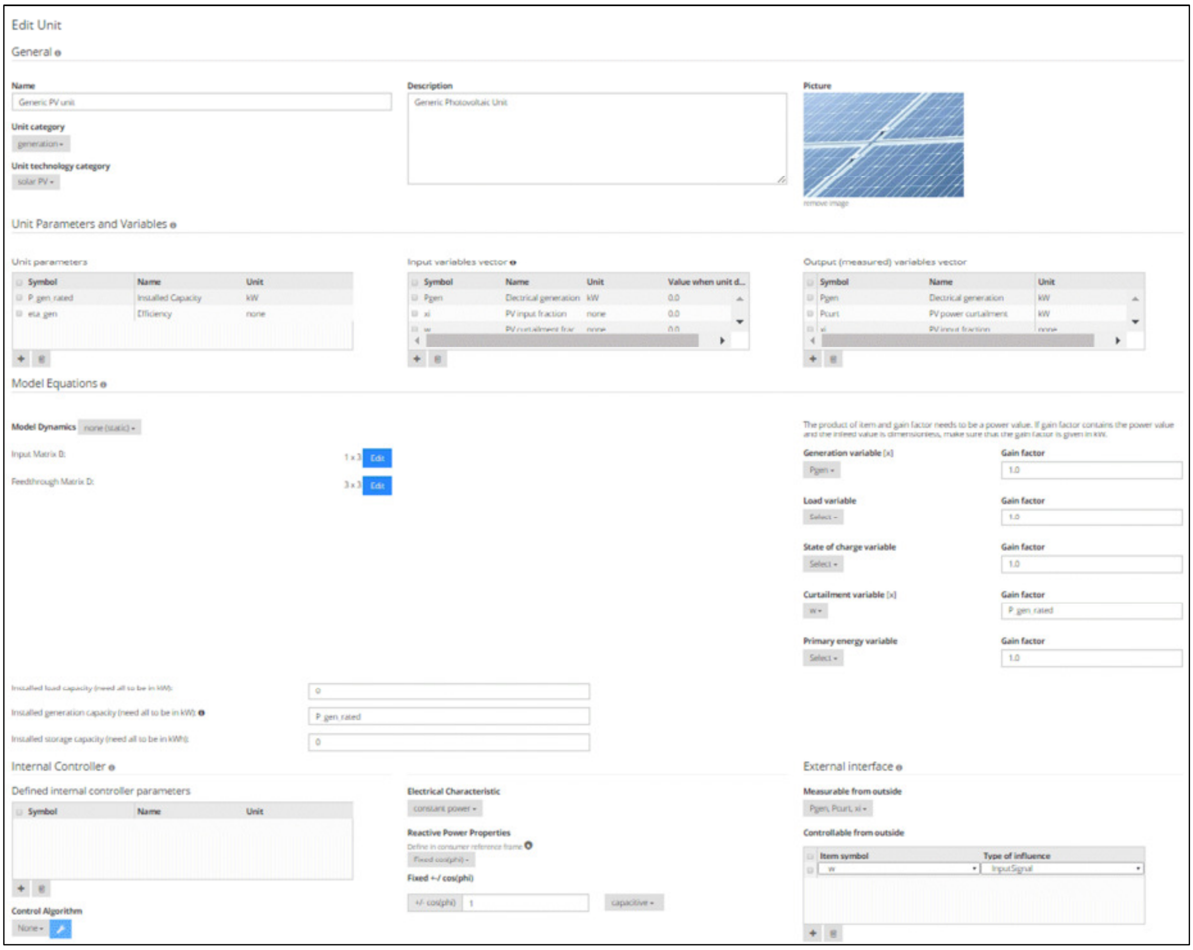

Figure 2: Dialog for editing Unit Types

Defining Stochastic Datasets

Different prosumers can be created for a single unit type. For instance, for a PV unit model, a 5kW residential PV unit and a large 200kW PV installation can be modeled. In this case, different datasets must be defined for the same unit model: a residential unit dataset would assign 5 kW to the power rating parameter and a large installation dataset would assign 200 kW. Different time series can also be used for different datasets, if desired.

Stochastic datasets can be parameterized by the dialog presented in Figure 3. Here, an example of a PV unit dataset is presented. You can define numerical values and statistical distributions for the PV unit parameters (such as power rating or efficiency) and can select a time series for input variables (like PV input power). Not all input variables need a time series since the value of other input variables can be calculated according to the unit equations.

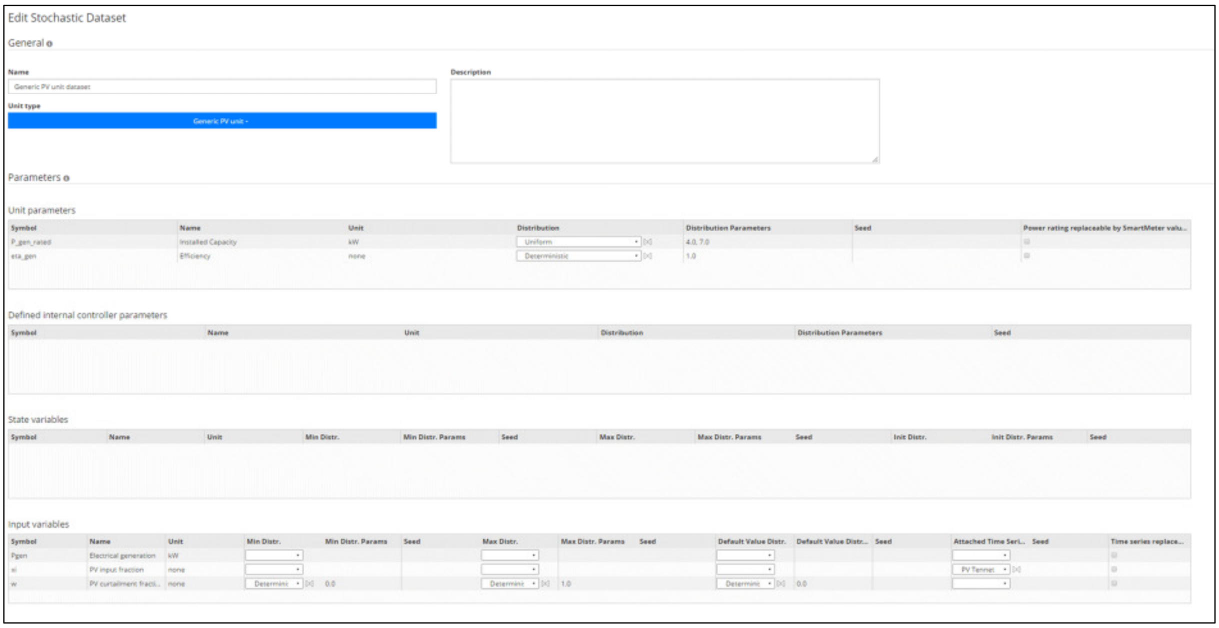

Figure 3: Dialog for editing Stochastic Datasets

Defining Tariffs

The tariff dialog allows for modeling either fixed or time-dependent cost tariffs.

Figure 4: Dialog for editing Tariffs

As can be seen in Figure 4, time-dependent tariffs can be valid for each day of the week or there can be a distinction between workdays and weekends/holidays. A tariff object consists of a selected consumption and feed-in tariff. As we will describe in the next section, in a prosumer a tariff can either be used for all units or for each unit an individual tariff can be defined.

Defining Prosumers

As mentioned above, a prosumer consists of different units. Figure 5 and Figure 6 show the creation of a prosumer using two units. In the example, a non-controllable load and a PV unit together form a household with a PV installation.

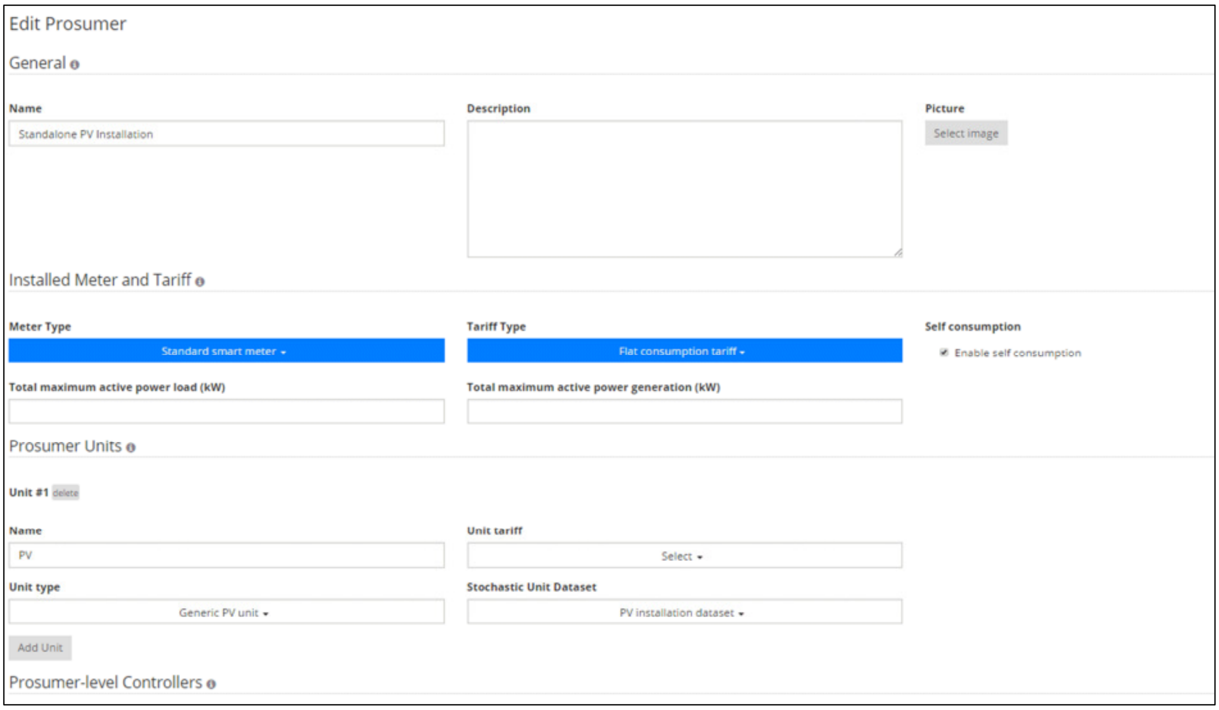

Figure 5: Prosumer creation dialog showing a prosumer with two units

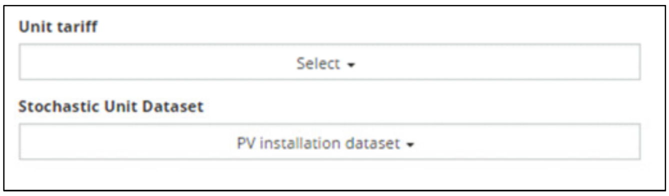

Figure 6: Detailed view of Tariff and Stochastic Unit Dataset

For each prosumer, the maximum total active power load and total active power generation can be defined. A tariff can be defined for a prosumer. This tariff will be used for all units for which no individual tariff is defined.

The created prosumer acts as a generation template for dispersing groups of prosumers, so-called *prosumer populations*, onto the grid in the scenario definition dialog. In order to consider stochasticity during the generation of prosumer populations for each prosumer, for each unit a stochastic dataset is selected which defines distribution and value ranges for unit characteristics, such as maximum power generation for a PV unit or the maximum load for a non-controllable load.

If you want to use your own unit models to create a new prosumer, you need to create them in the first place. Then, you need to import a time series and define the unit parameter values in the stochastic dataset menu. The new prosumer types can be created with these unit models and stochastic dataset and later dispersed onto the grid in the menu 'Scenario'.

Defining Grid Models

An electricity grid model can be imported and edited via the dialog shown in Figure 7.

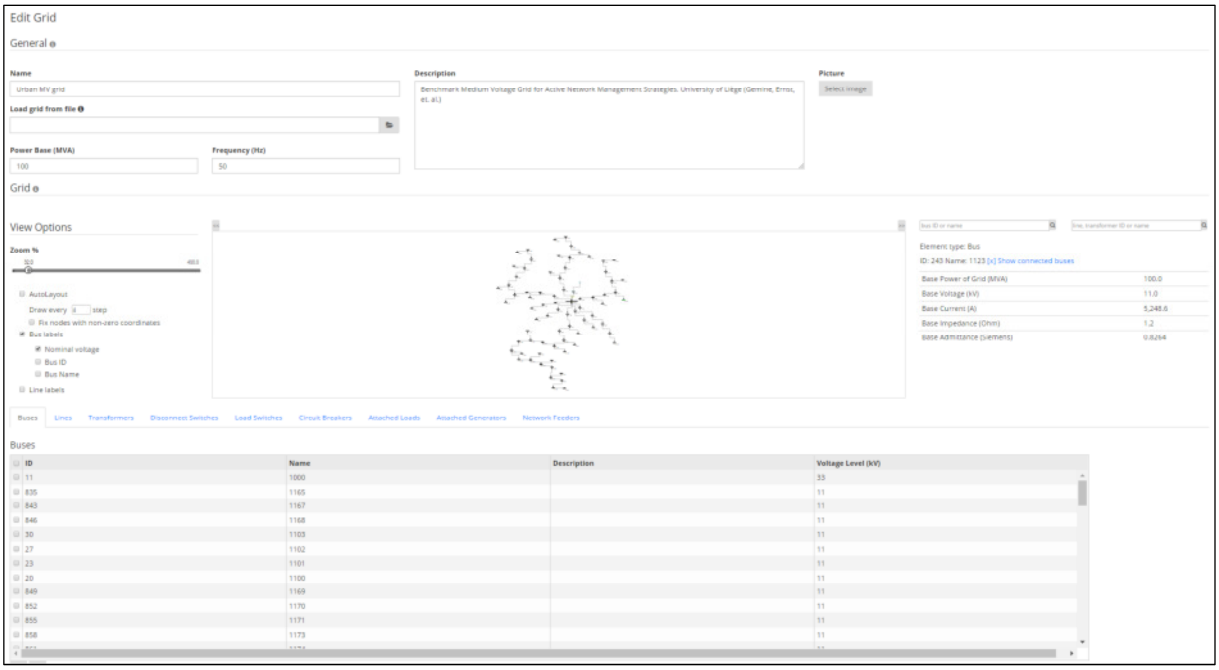

Figure 7: Defining grid models

Creating a Simulation Scenario

The creation of a simulation scenario works as follows. For a given scenario, general parameters such as start and end date, time step length of the simulation, and the considered distribution grid can be selected. Using the defined prosumers described above, prosumer populations can be dispersed onto the grid. For this purpose, the size of the prosumer population and where the population shall be dispersed in the grid (i.e., at which voltage levels and at which buses of the grid) can be defined.

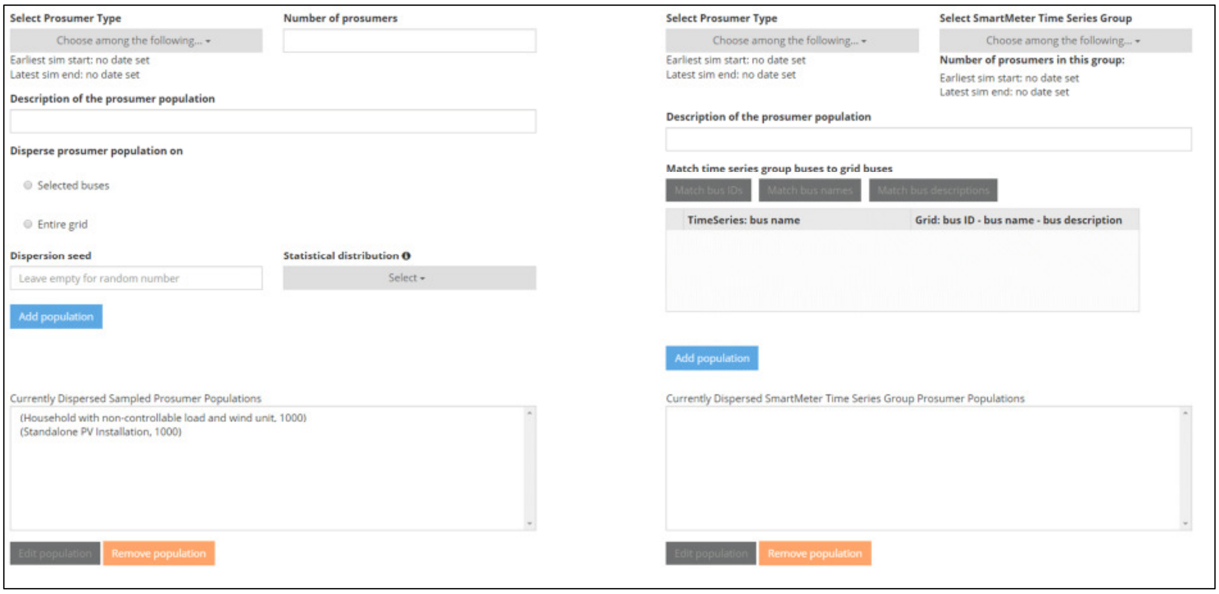

Figure 8: Dispersing prosumer populations in the simulation scenario edit dialog

As shown in Figure 8, DPG.sim supports generated prosumer population as well as prosumer populations derived from measured SmartMeter data. The latter option allows for a detailed mapping and reproduction of real distribution grid operation scenarios.

If you have SmartMeter data of the prosumers in a specific grid, all SmartMeter measurements can be imported from one file in the 'Measurements' menu. The file must already include the ID, name, or description of the bus to which the measurement will be attached.

A prosumer can only use SmartMeter data if one of the selected units uses a SmartMeter-compatible dataset. For instance, a "Household with PV unit" prosumer includes two units: one non-controllable load and one PV generation unit. The load unit has to use a stochastic dataset that allows SmartMeter data.

This type of stochastic dataset must include one checked checkbox for the input variable that will use the SmartMeter data and one checked checkbox for the unit parameter that represents the power rating of the unit.

There is a unit model and a stochastic dataset for a 'Generic non-controllable load' included in DPG.sim which is already compatible with SmartMeter measurements. Prosumers with this unit can be selected in the 'Scenario' menu along with a set of SmartMeter measurements to be dispersed onto the grid.

Defining Scenario Variables

During the simulation, many values are generated that might be interesting for evaluation after the simulation. In order to select which scenario variables you would like to have recorded during the simulation, use the edit scenario variables dialog. As can be seen in Figure 9, this dialog allows you to select which grid variables, unit variables in each prosumer population, SmartMeter variables, energy bill variables, and control strategy statuses shall be recorded. These variables will be available for showing and exporting simulation results.

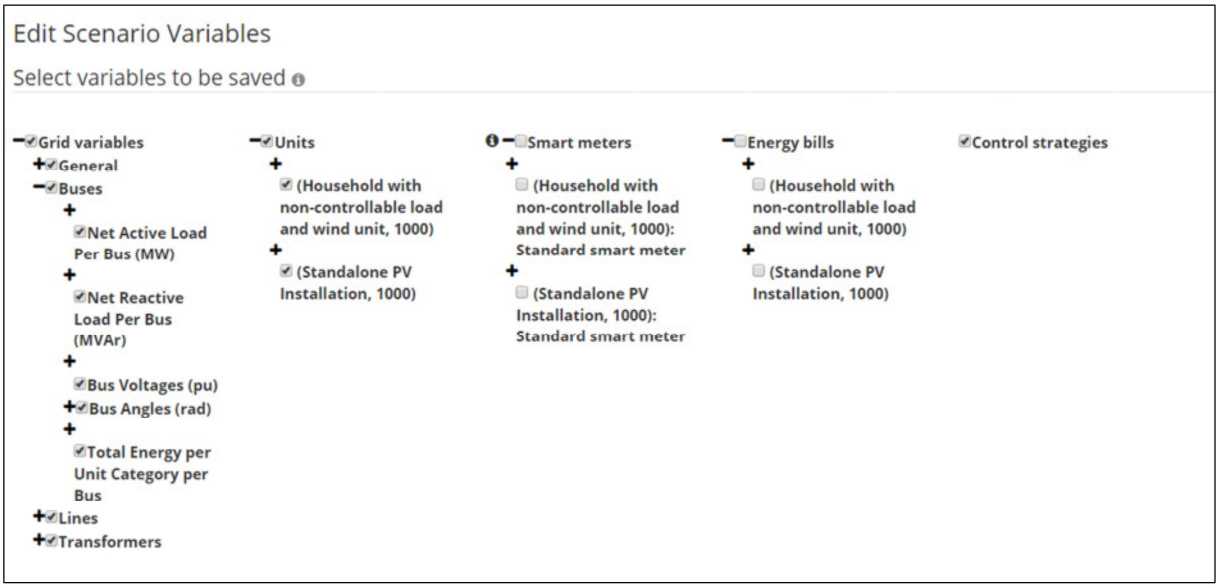

Figure 9: Edit scenario variables dialog

Creating Control Strategies

Controllers allow influencing specific unit input variables depending on the time of day or the state of the grid.

In order to create a controller, it has to be defined for which variables this controller will be active. For this purpose, an aggregation can be created using Control Center/Aggregations. Afterwards, Control Center/Control Strategies allow defining the controller to be used. DPG.sim allows creating two types of controllers:

- Rule-based controllers: These controllers are activated when rules are true and
- Time-table based controllers: These controllers are activated depending on the time of day.

For Rule-based controllers, a condition and a rule executed if the condition is true can be defined. Several conditions and rules can be defined while rules are executed from top to bottom. Hence, later defined rules may override rules defined above them. In order to have a default value defined, for each controlled item first a default rule containing the condition “true” should be defined in order to have a default value for the corresponding controlled item if no other rules are applied afterwards.

Using Control Center/Strategy Assignment, Controllers can be assigned to aggregations. These defined assignments can then be selected when starting a simulation in order to use them in a simulation run.

Figure 10: Edit Control Strategies dialog

Simulating Scenarios

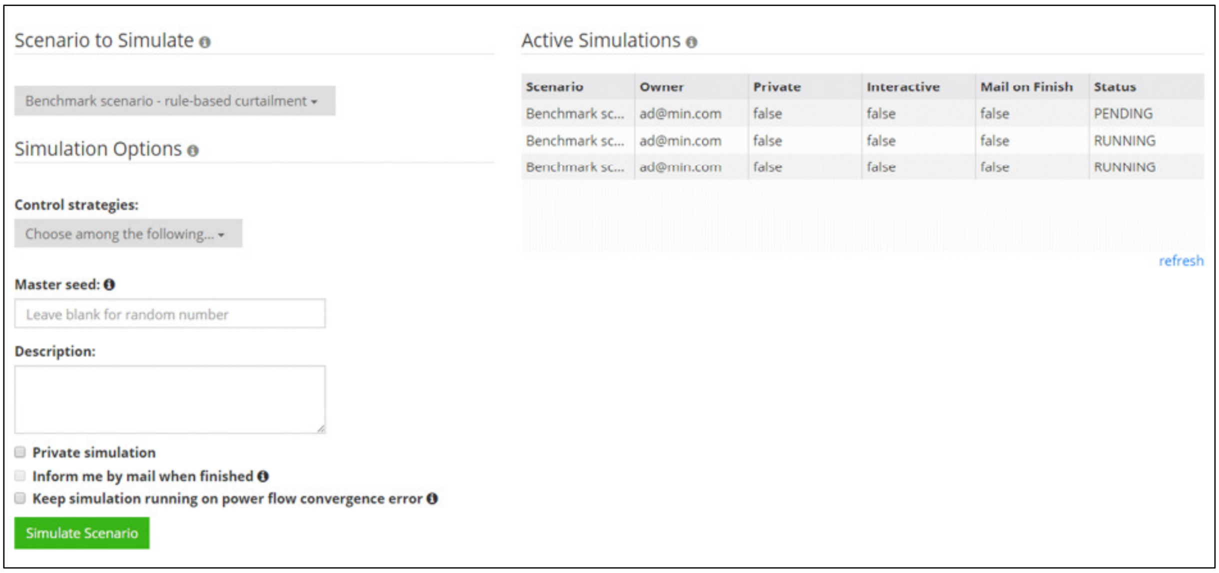

Figure 11: Non-interactive Simulation run mode

As mentioned above, a scenario can either be run in non-interactive mode or interactive mode. The non-interactive run mode shown in Figure 11 allows for an overview of currently running simulations and fast execution of large simulation scenarios since no diagrams are displayed during the simulation run. In order to obtain in-depth insights into specific system situations, DPG.sim offers the interactive run mode which is shown in Figure 12. The interactive simulation run mode consists of various diagrams that show among others during the simulation run:

- Total Load,
- Total Generation,
- Residual and Slack Load,
- Voltage Levels at all buses,
- Controller Status as well as
- Line and Transformer Loadings.

Figure 12: Interactive Simulation run mode

Displaying and Analyzing Simulation Scenario Results

After different configurations (e.g., different controllers applied during operation) of a simulation scenario have been simulated, the results can be directly viewed and evaluated in DPG.sim.

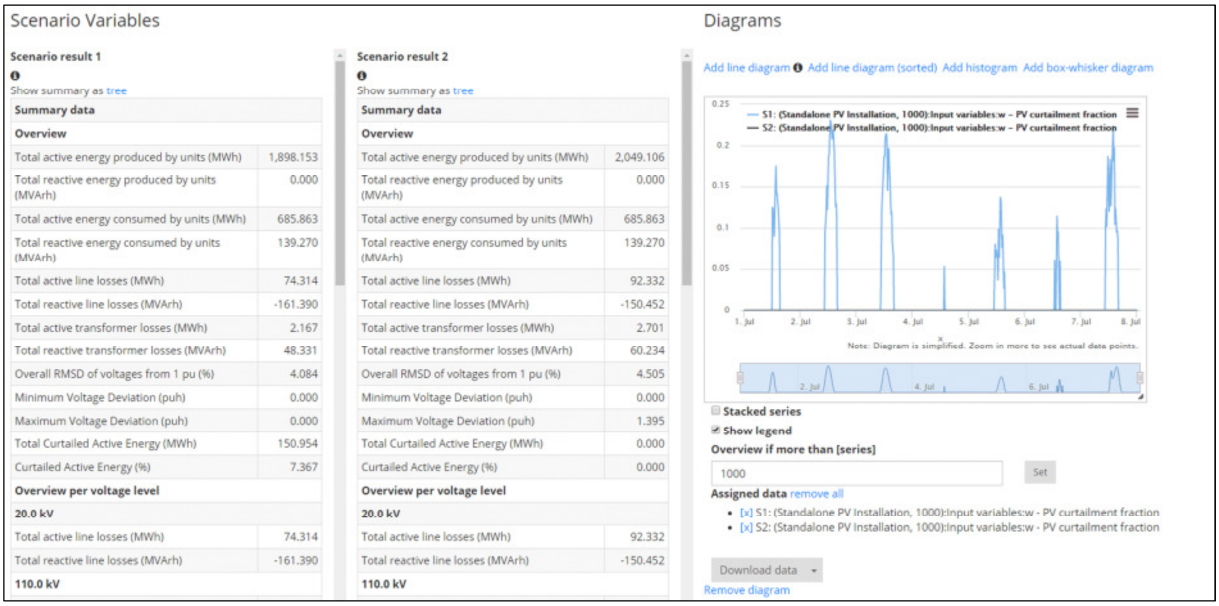

Figure 13: Comparing results of the same Simulation Scenario

DPG.sim also offers the possibility to compare the results of two simulation scenario runs directly side-by-side. This allows, for example, the direct evaluation of the same simulation scenario using two different configurations.

DPG.sim Admin Panel

Clicking on the admin symbol in the upper right part of the Menu Panel allows the access to the admin panel.

The menu point *Database Tools* (see Figure 14) allows, both, to backup new scenario setups that have been created by the user as well as to rebuild the initially available models and simulation scenarios. This will regenerate the database for all teams that are currently defined. **Note that this will delete all user-defined models, scenarios, and scenario results.**

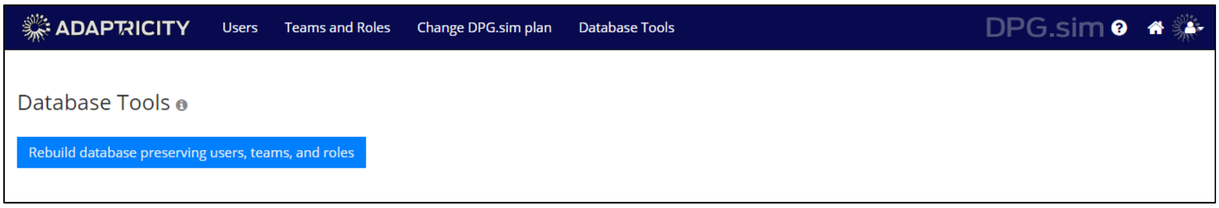

Figure 14: Database Tools menu point: Allows to backup new simulation scenarios as well as to rebuild / restore built-in simulation scenarios

In the admin panel, also new teams and users can be created. When creating a new team, the built-in models and simulation scenarios will be created for that team. **When a team is deleted, all models, simulation scenarios, and simulation results of that team will be deleted.**