

OPTGEN VERSION 8.0



PSR

► SYSTEM EXPANSION PLANNING WITH RESILIENCE

The main objective of OptGen is to support countries globally to conduct integrated energy planning systematically, especially for a cleaner, affordable, flexible, and resilient energy future. In this context, the word resilience is drawing a lot of attention, as it consists of the system's ability to attenuate the impact of very severe events and to accelerate the recovery of normal operating conditions.

One example is the recent energy crisis in Texas¹, in 2021, where an extreme weather event followed by shocks in supply (due to unavailability of some generators) and in demand (caused by the need to heat the houses) put a solid electricity market under severe stress due to lack of resilience planning. When the effects caused by extreme events are incorporated into decision making, resilience measures, which are typically adopted, include source diversification, storage distribution and greater self-sufficiency in each region.

Over the years, energy planning models have incorporated uncertainties in inputs, equipment availability and production variability. All these parameters are represented by probabilistic models. However, these models have low adherence when considering extreme events, essentially due to the following reasons: (i) it is very difficult to know which

is the most adequate distribution for extreme events; (ii) due to the rarity of occurrence, the estimation of the parameters is extremely uncertain; and (iii) a small error in this estimate can lead to dramatically different results. In this context, the best option is to treat these events as extreme scenarios, without assigning a specific probability.

OptGen 8.0 introduces this new functionality for expansion planning, the “Resilience (Critical scenarios)” option. This option uses extreme scenarios informed by the user and aims to ensure continuity of supply assuming the occurrence of each scenario: droughts and very severe temperatures due to climate change; prolonged reduction in renewable generation; interruptions in fuel imports; prolonged output of large generation trunks etc.

¹ “The Timeline and Events of February 2021 Texas Electric Grid Blackouts”, The University of Texas at Austin, July 2021.



The optimization methodology used by OptGen, the Benders decomposition, allows each phenomenon to be modeled by specialized algorithms, guaranteeing a lot of flexibility. In this way, it is possible to co-optimize the sum of investment costs and the expected value of the operating cost, representing both probabilistic and extreme aspects in an integrated manner.

This option is only available when the selected solution strategy is “OptGen 1”.

For more info, please refer to OptGen’s user manual. Check this new and interesting feature out!

▶ **CANDIDATE PROJECTS FOR HYDROGEN AND ELECTRIFICATION PROCESSES**

Starting with version 17.0, SDDP can explicitly model the hydrogen supply chain and its integration into the power system: hydrogen production factories consuming electricity from the power grid, hydrogen distribution nodes, transportation, storage, and price-responsive hydrogen demand can be combined to design and simulate in detail a hydrogen system.

Starting with this OptGen version, both producers and hydrogen/electrification storage and transport devices can be candidate projects for OptGen! Try it!



▶ **CONCENTRATED SOLAR POWER (CSP) CANDIDATE PROJECTS**

SDDP presents a specific agent for the users to model CSPs. Starting with version 17.1, SDDP began to present a specific agent so that the user can model CSPs.

Now, in OptGen 8.0, CSPs can be candidate projects for OptGen. Check it out!



▶ NOT IDENTIFIED (N/I) CANDIDATE PROJECTS

Many clients want to add projects that do not present operative data to be part of the summary of the capital buildout values and the disbursement schedules calculated by OptGen. For this reason, a new type of candidate project is now available: “Not Identified”, N/I.

At the end of the run, the “N/I” projects that were added by OptGen will appear individually in all output files, such as: optgen.out, outpdec.csv, outdisbu.csv. The only difference is that their type will be N/I = Not identified. As can be seen, they are added if they are obligatory or are associated, or with precedence, with

other “standard” mandatory or attractive projects, i.e., if they have an investment cost greater than zero and are not mandatory or associated with any other “real” project, they will not be part of the optimal expansion plan.

▶ OPTION TO NOT PERFORM THE EXPANSION PLAN SIMULATION

An OptGen execution involves two phases:

- 1-** the expansion planning task, i.e., the optimal expansion plan determination;
- 2-** the expansion plan simulation, which in turn is a production costing simulation of the whole study horizon contemplating the optimal expansion plan found in phase (1)

In previous versions, the user was not able to select different options for phases (1) and (2), i.e., phase (2) was automatically and mandatorily performed after phase (1). Now, the user will be able to choose whether to automatically carry out phase (2) after phase (1) or not through the option highlighted in the figure below:

The screenshot shows the 'Expansion planning' and 'Expansion plan simulation' sections of the OptGen software interface. The 'Expansion plan simulation' checkbox is highlighted with a red box.

Expansion planning	
Solution strategy i	OptGen 2
<input checked="" type="checkbox"/> Operation	Model: Scenarios
<input type="checkbox"/> Reliability	Model: CORAL
<input type="checkbox"/> Resilience (Critical scenarios)	
<input checked="" type="checkbox"/> Expansion plan simulation	
<input checked="" type="checkbox"/> Operation	Model: SDDP
<input type="checkbox"/> Reliability	Model: CORAL

Deactivating this function becomes interesting during the initial calibration stage of the expansion plan. In the case of the “OptGen 1” solution strategy, the user has only the expansion plan available, and therefore, in addition to the initial view of the optimal expansion plan, this option only makes sense if the user wants to change SDDP’s execution parameters in relation to those used to obtain the plan during phase (1).

In the case of the “OptGen 2” solution strategy, the user has both the investment and operative outputs of “OptGen 2” available to analyze, which greatly speeds up the process of calibrating the expansion plan using this second approach.



THE DASHBOARD HAS BEEN COMPLETELY REDESIGNED

OptGen's dashboard is now very informative, having results from both phases (expansion planning task & expansion plan simulation), thus providing a complete view of the macro results of the case. Check it out!



OPERATIVE LIFETIME (YEARS)

New data available for definition: “operative lifetime (years)” on the “Project data > Entrance schedule” screen. As an example, imagine that the user activated this option and defined that the operative lifetime of a given project is 20 years, if OptGen decided to place the project in the year 2025 and the study horizon goes until 2050, in 2045 this project will be taken out of operation.

If this option is deactivated, the default behavior of OptGen applies: it is assumed that the plant never ceases to operate, that is, it is available to the system throughout the entire study horizon since the date it started operating.

DIFFERENT TYPES OF (FIXED) O&M COST DEFINITION

In addition to the investment cost, on the “Project data > Financial data” screen, the user is also able to introduce the fixed O&M cost² in [\$/kW.year]. Due to the Levelized Cost of Energy (LCOE) reduction curves, especially for renewables, the user is also able to introduce both data (investment cost and O&M cost) changing over time on the “Project data > Chronological costs > Investment and O&M costs” screen. This means that if OptGen decides to build the project in year X, the investment and fixed O&M costs over the entire lifetime of the project will be the ones defined for this year X. If OptGen decides to build the project in year Y, these costs over the lifetime of the project will be those defined for year Y and so on. In summary, these costs are associated with the project’s decision year.

Now, a new screen has been introduced: “Project data > Chronological costs > Variable O&M costs”. If the user activates the “Consider variable O&M costs” option, the (fixed) O&M costs that should be defined on this screen change over time after the in-service

date, i.e., the value defined for year 1 will be used for the first year of operation; the value defined for year 2 will be used for the second year of operation, and so on, and so forth.

² We call it fixed O&M cost, because the variable O&M cost is the one that varies according to the dispatch level of the plant, and as it depends on the generated amount at each moment, it is defined in the SDDP on the “Basic data > Thermal plant configuration > Fuel” screen.

NETPLAN: DETAILED STUDIES OF TRANSMISSION NETWORKS

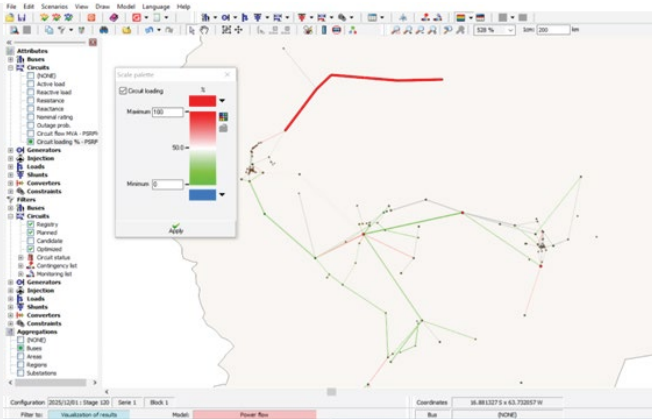
OPTGEN 8.0 and SDDP 17.0 are fully integrated with NetPlan 4.0, a tool that allows carrying out studies of:

- 1- detailed planning of the expansion and operation of transmission networks with the representation of contingencies
- 2- expansion of voltage support
- 3- power flow
- 4- allocation of costs for the use of the transmission system to end users (demands and generators).

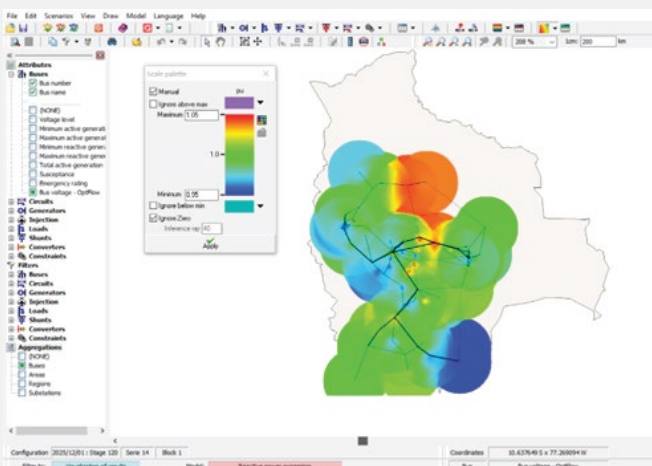
The decisions to expand the generation and interconnections of the OptGen and the operative decisions related to the dispatch of the generation units calculated by SDDP are incorporated, automatically, in the detailed analyzes of the transmission network with the optimization and simulation modules. This makes it possible to define the necessary reinforcements to the transmission network, taking into account the uncertainties in the production of renewable plants (hydroelectric, wind, solar, etc.) through sets of generation and demand scenarios obtained by SDDP. At the end, the transmission network expansion decisions obtained by the NetPlan are automatically incorporated into the database for the analysis of the operation in SDDP or planning of the integrated generation-transmission expansion that can be performed through OptGen.

In previous versions of OptGen, there were already the following types of transmission candidate projects: interconnections, AC transmission lines, DC links, and transformers. Now, with this full integration with NetPlan 4.0, the following new types of transmission candidate projects are also available: three-winding transformers, switchable series capacitors, LCC converters, P2P converters, VSC converters, shunt equipment, AC buses and DC buses.

NetPlan has a friendly graphical interface that allows you to view the network diagram, verify/modify element data, and view the results produced by the models directly on the diagram.



For example, it is possible to visualize the circuits that operate in overload according to the SDDP dispatch schedule, which allows to identify the circuits of the network where it would be indicated to add candidate projects for the OptNet expansion module. In turn, the transmission expansion plan decisions obtained by OptNet are also illustrated in the diagram.



In addition, nodal results such as generation and demand per bus, marginal costs, angle and voltage magnitude can be viewed. The figure to the side illustrates the “countouring” graph for the magnitude of voltage across the buses, calculated by the OptFlow optimum power flow module. This type of result makes it possible to identify regions that present reactive power deficiencies (blue and red colored regions in the diagram to the side); and whose buses would be candidates for expansion of capacitors and/or reactors in planning studies of the expansion of voltage support.

Other improvements

- ▶ Batteries defined in the database can now have both firm capacity and firm energy associated with them. Additionally, they were also included in the “Minimum and maximum additional constraints” screen so that they can be included in user-defined constraints.
- ▶ In the “Selections” tab, a screen called “Constraints” has been added, where the user can select which constraints defined in the “Minimum and maximum additional constraints” screen will be considered in the execution.
- ▶ Previously, the “Substitutes an agent” option available on the “Project Data” screen only allowed the selection of an existing agent. This option has now been extended to allow a candidate project to be a potential candidate to replace a future plant or even another candidate.
- ▶ When applying the “Use consecutive iterations” heuristic, the user can now select whether he wants the OR (\vee) or AND (\wedge) logic to be applied for the two available criteria: number of iterations and convergence gap.
- ▶ New column available in the outpdec.csv file that refers to the “optimal expansion plan” (available in the "Reports" button of the OptGen interface) containing the accumulated decision of each project in p.u., which is especially important for projects with continuous or integer decision variables.

▶ PSR CLOUD

PSR Cloud is our web-based computational environment that enables running SDDP without the need of investing in high-performance computers. It is a pay-per-run and per processor scheme in which the users may select the desired number of processors for each execution. The machines available for execution are constantly upgraded.

More details about PSR Cloud at <http://psr.cloud/>

PSR offers to all OptGen/SDDP users the free use of up to 64 processor-hours in PSR Cloud; please contact PSR at optgen@psr-inc.com for more details.

