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## Overview

OPTGEN is a long-term expansion planning model that determines the least-cost sizing and timing decisions for construction, retirement and reinforcement of generation capacities, transmission network and natural gas pipelines.

The main characteristics of the OPTGEN model are:

- Study horizons up to several decades;
- Flexible investment time steps (year, semester, quarter and month);
- Candidate project specific data, such as, optional or obligatory decision type, integer or continuous decision variable, maximum and minimum entrance dates etc.;
- Candidate project financial data, such as, investment costs, payment schedules, lifetime, construction time etc.;
- Candidate project constraints, such as, exclusivity, association, precedence, minimum and maximum additional capacity;
- System constraints, such as, firm energy and capacity constraints, used to enforce system capacity reserve policies;
- Environmental constraints, used to represent environmental policies for development of “cleaner” expansion plans;
- Heuristics optimization procedures as the rolling horizon and the horizon-year solution strategies;
- Analysis and reinforcement of a complete or partial user provided expansion plan.

## Investment x Operation

The model OPTGEN optimizes the trade-off between investment costs to build new projects and the expected value of operative costs obtained from SDDP, the transmission-constrained stochastic hydrothermal dispatch model, which allows a detailed representation of the system’s operation under uncertainty:

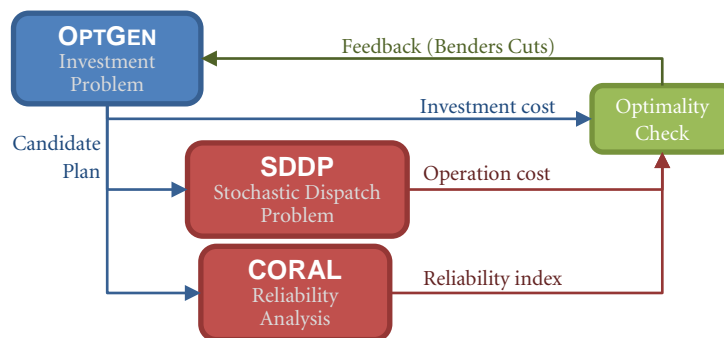
- Hydro inflows, allow handling macroclimatic events (El Niño and La Niña), snowmelt and others;
- Renewable sources (wind, solar, biomass etc.), allow capturing correlation between hydrology and climatic conditions;
- Generation and transmission outages, allows representing equipment availability;
- Sensitivity scenarios for the system’s demand, fuel costs etc.

## Investment x Reliability

Using CORAL, the reliability analysis model, both system and bus-level indexes, such as LOLP, LOLE, EPNS, can be evaluated for each proposed expansion plan. In addition, minimum security level constraints can also be incorporated into the expansion problem as a planning criteria.

## Modeling aspects

In order to solve the expansion problem, OPTGEN model uses advanced optimization techniques of mixed-integer programming and Benders decomposition, according to the following scheme:



Both input and output data managed by OPTGEN are Excel compatible CSV-format files. Data importation is available for either Super Olade's MODPIN or SDDP models. Results can be visualized by a graphical interface (GRAPH module) and a geo-referenced visualization tool.

## Uses of OptGen

The OPTGEN model has been used by either planners or electricity regulators and investors in several countries, for example:

- Long-term generation expansion planning study of Central America countries, IADB/CEAC, 2014
- Pre-Feasibility Study for the "Arco Norte" Interconnection Project, involving French Guiana, Guyana, Suriname and the Brazilian states of Roraima and Amapá, IADB, 2014.
- Maximum Insertion of Renewable Energy Resources (RER) in SEIN, taking into account the operational criteria (quality of service, reliability, etc.) and a reasonable rate impact in the electrical tariff for the implementation, Ministry of Mines and Energy of Peru (MINEM), 2014.
- Long-term generation-transmission expansion planning studies of Central America interconnected system, carried out biannually by the Electrification Council of Central America (CEAC).
- Generation expansion studies of the Ecuador system carried out annually by CENACE (the National Centre of Energy Control) and CONELEC (National Electricity Council).
- Generation expansion studies of the Colombian system carried out annually by the Planning Unit of Mines and Energy (UPME/Colombia).
- Integrated generation-transmission expansion planning studies of the Bolivian system carried out annually by the National Dispatch Center of Bolivia (CNDC).
- Evaluation studies of an interconnection link between the systems of Egypt, Sudan and Ethiopia (in Africa) to assess the benefits in terms of operational costs reduction and of exporting energy to Europe systems. The study was carried out by Electricité de France (EdF), 2007.

- Generation expansion planning studies of all continental Central America countries carried out by each state-owned companies – ETESA (Panamá), ICE (Costa Rica), ENATREL (Nicaragua), ENEE (Honduras), ICE (El Salvador) and INDE and CNEE (Guatemala), annually since 2004.
- SEETEC project to study the development and benefits of the Balkan regional energy market, with 8 interconnected countries, 30 GW demand (5 GW of forecasted increase by 2010).