PSR OPTGEN

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. Several types of projects are available to be contemplated by the model:

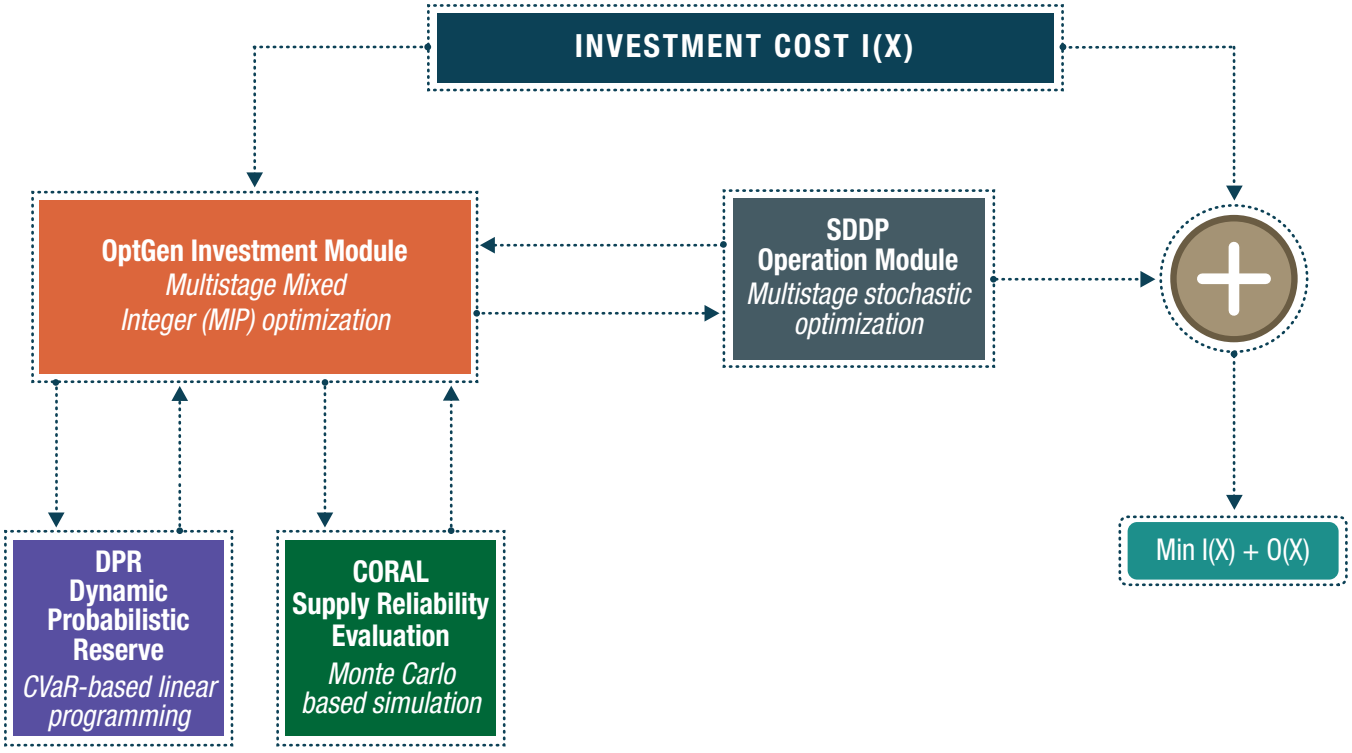
- Hydro and thermal plants
- Non-conventional Renewable Sources
- Pumped-storage plants and batteries
- Interconnections and transmission circuits
- Gas production fields and pipelines

Due to the worldwide penetration of Variable Renewable Energy sources (VREs), OptGen combines a long-term view of expansion with a short-term view of the operation and therefore it can represent the hourly chronology of variable renewables, thermal/hydro unit commitment decisions, ramping constraints, reserve requirements, and other short-term constraints.

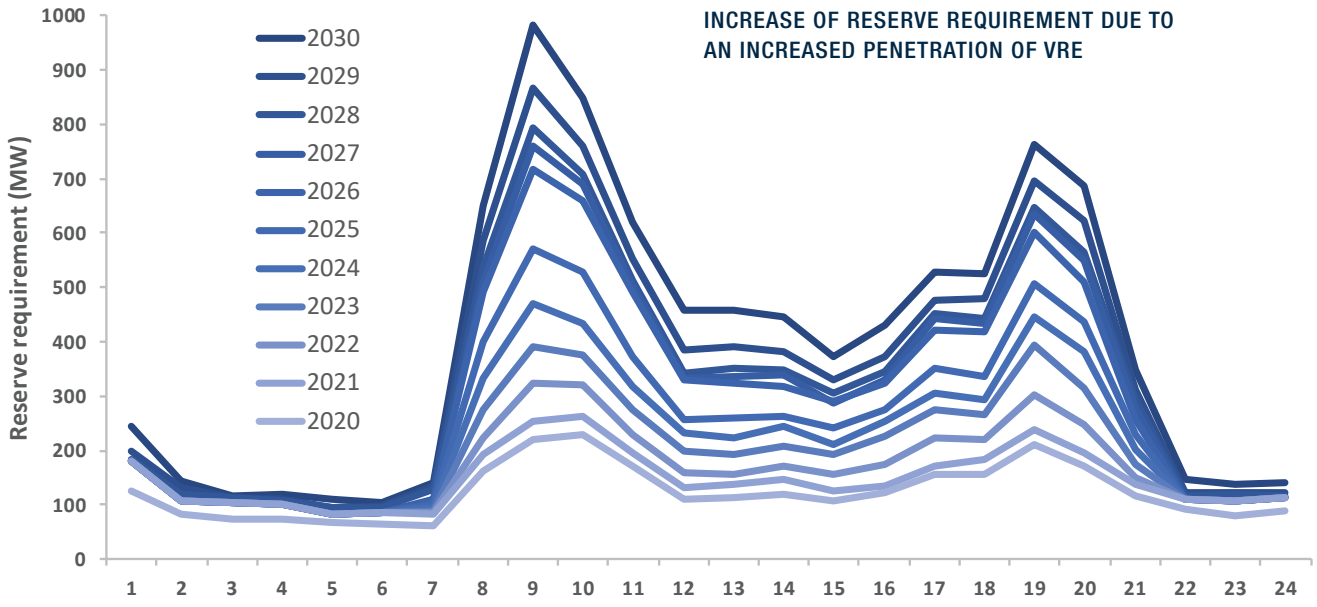
- Hourly time steps
- Unit commitment decisions
- Start-up and shutdown costs
- Minimum up/down-times
- Ramping constraints
- Hydraulic constraints in river basin
- VRE scenarios are temporally and spatially correlated with hydro inflows
- Energy demand and fuel price uncertainties
- Energy, capacity and reserve requirements

OBJECTIVE

Main components of OptGen model:



OptGen's objective function is to minimize investment plus expected operation costs, subject to supply reliability constraints. OptGen is the only tool in the market capable of co-optimizing Generation, Transmission and Dynamic Probabilistic Reserves. The idea of the Dynamic Probabilistic Reserve is to guarantee the supply of electricity through secondary reserves, not only in the event of demand variability or largest unit failure, but also the variability caused by VREs. Therefore, while using OptGen, it is possible to co-optimize flexibility-related investments such as batteries or pumped-hydro-storage (related to probabilistic dynamic probabilistic reserve requirements) and energy-related investments.



Source: study conducted for AG (Chile), 2017.

PLANNING

By providing a powerful set of flexible modeling features, OptGen becomes suitable for different types of power system expansion studies. The model allows the definition of study horizons up to several decades, considering the project's payment schedule, lifetime, and construction time. The model offers the possibility to incorporate several expansion policies and assumptions, according to the planner's criteria:

Investment cost reduction curves
To capture the evolution due to technology advances and other factors

Environmental criteria
Clean energy certificates, emission costs and caps

Governmental energy policies
Related to decarbonization policies and penetration target of renewables

Firm energy and firm capacity constraints
To enforce system policies for the security of supply

OptGen's aims to deliver consistent results that help both, (i) planners in the expansion decision making process and also (ii) market players, so that they have the best possible view of the system expansion. Based on the state-of-the-art methodologies, the model offers potentially efficient options for solving this problem:

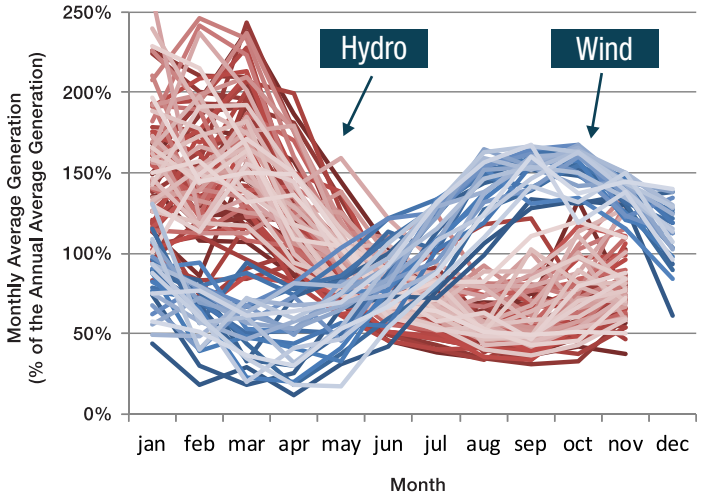
Optimization procedures, such as the rolling horizon and the horizon year solution strategies

Analysis and reinforcement of user provided expansion plans

Graphical dashboard tools to analyze macro operative results

INVESTMENT X OPERATION

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 dispatch model. This integration enables OptGen to take advantage of all SDDP's features to represent an electrical system while solving the operative dispatch. This includes, among others, detailed modeling with hourly or intra-hourly resolution, demand response to price signals, uncertainty sources representation such as:



Hydro inflows
macroclimatic events (El Niño/La Niña) and snowmelt

Renewable sources
VRE generation scenarios, time and space correlated with hydro inflows

Outages
generation and transmission equipment availability

Sensitivities
demand and fuel cost scenarios

INVESTMENT X RELIABILITY

Integration with CORAL, the reliability analysis model, enables both system and bus-level indexes, such as LOLP, LOLE, EPNS, to be evaluated for each proposed expansion plan. Moreover, minimum security level constraints can also be incorporated into the optimal expansion process, allowing OptGen to make expansion decisions respecting reliability requirements.

USES OF OPTGEN

The OptGen model has been successfully used by planners, electricity regulators and investors in several countries in all five continents. Also, the model has been used in several international studies for valuation of projects, due-diligences, evaluation of renewable potential, and others.

OPTGEN'S NEW CLIENTS:

- MANITOBA HYDRO
- EGYPTIAN ELECTRICITY HOLDING COMPANY (EEHC)
- MEM OF MOROCCO
- MINISTRY OF ECONOMY AND FINANCE (MEF)
- CHILEAN ENERGY MINISTRY
- EMPRESA DE PESQUISA ENERGÉTICA (EPE)

RECENT PROJECTS DEVELOPED:

THE WORLD BANK

Technical assistance for the analysis of the impact of the increase in penetration levels of non-conventional renewable generation in the Peruvian interconnected electricity system, 2018.

CREG

COMISIÓN DE REGULACIÓN DE ENERGÍA Y GÁS

Analysis of complementary services for the Colombian national interconnected system, 2019.

GIZ

DEUTSCHE GESELLSCHAFT ÜR INTERNATIONALE ZUSAMMENARBEIT

Energy systems of the future: integrating variable renewable energy sources in the energy matrix of Brazil, 2018.

AG

ASOCIACIÓN DE GENERADORAS DE CHILE

Long term analysis of the national electric system of Chile considering variable and intermittent renewable sources, 2017.