Portfolio Optimization by PLEXOS

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1. Introduction

Portfolio Optimization includes the following four activities.

1. Operation. On a daily basis, the operators in the control center (or on the trading floor) solve unit commitment and economic dispatch problems to minimum system costs while maximizing the profit from trading with neighboring utilities or markets.
2. Generating Asset Evaluation. Examples of generating assets include generators, energy contracts, demand response programs, energy storage units, etc. Performing the Generating Asset Evaluation involves quantifying the value of generating assets. Simulations both with and without the generating asset are performed for the technical life time of the generating asset. Then, the generating asset value is calculated as the production cost difference between the solutions with and without the generating asset. Generating Asset Evaluation can also be used to examine the difference between the generating asset operation and the energy and Ancillary Service markets.
3. Budgeting. Portfolio simulation can be used to predict the production cost, fuel consumption, traded energy, emission production, etc. Solutions can then be used to support decisions on rate design, fuel procurements, emission allowance allocation, etc.
4. Long-term Capacity Expansion. Long-term Capacity Expansion planning can be done using simulations that determine optimal generation or transmission facility investment (or retirement) to meet projected load growth while still complying with reliability criteria, emission limits, renewable energy portfolio standard (RPS), etc.

2. Portfolio Optimization by PLEXOS

PLEXOS solves Portfolio Optimization problem using the Security Constrained Unit Commitment (SCUC) and Economic Dispatch (ED) algorithm. This algorithm makes use of Mixed Integer Programming (MIP) to minimize a cost function subject to all operational constraints. The cost function may include the generating cost, generator startup and shutdown costs, sales contract revenue, purchase contract cost, energy or AS market sales revenue and purchase cost, transmission wheeling charges, etc. The constraints can include things such as energy balance (i.e., at any moment, the generation plus purchase are equal to the load plus sales), AS requirements, generating asset chronology (i.e., min up / down time, ramp rate, energy resources (i.e., energy limits, fuel limits, emission limits, water limits), transmission limits, etc. For example, Portfolio Optimization can be formulated as follows:

Minimize Portfolio Production Cost = generator fuel and VOM cost + generator start cost
+ contract purchase cost – contract sale saving
+ transmission wheeling
+ energy / AS / fuel / capacity market purchase cost
– energy / AS / fuel / capacity market sale revenue

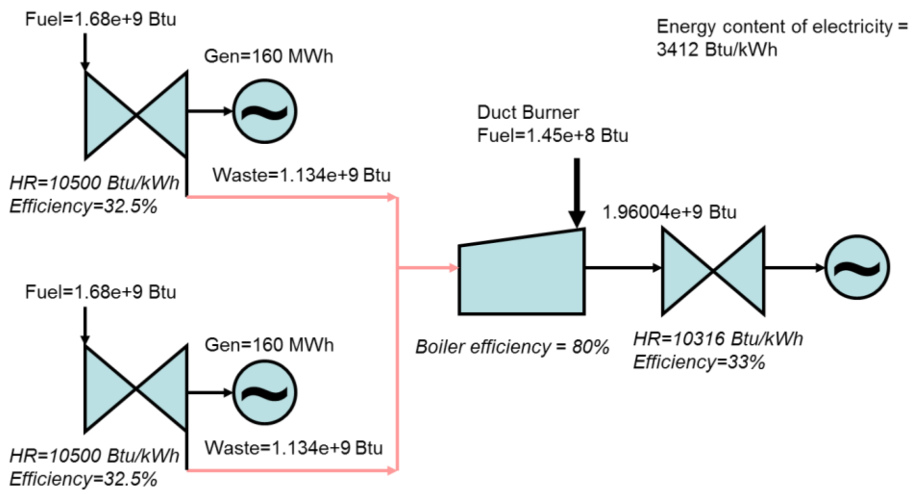
Subject to

- *Energy balance constraints*
- *Operation reserve constraints*
- *Generator and contract chronological constraints: ramp, min up/down, min capacity, etc.*
- *Generator and contract energy limits: hourly / daily / weekly / …*
- *Transmission limits*
- *Fuel limits: pipeline, daily / weekly/ …*
- *Emission limits: daily / weekly / …*
- *Others*

The PLEXOS MIP algorithm solves the Portfolio Optimization problem by simultaneously obtaining optimal solutions to unit commitment, economic dispatch, contract exercise, and market activates. This approach produces what is called "co-optimization" solutions.

3. Combined Cycle Generator Modeling

Due to the nature of the MIP formulation, the combined cycle generator can be modeled precisely using its components, i.e., gas turbine generators and steam turbine generator. For example, the following chart illustrates the 2x1 combined cycle generator representation in PLEXOS.



Each component, the gas turbine generators and the steam turbine generator, is modeled as a regular generator. The red line in the chart represents the waste heat transfer from the gas turbines to the Heat Steam Recovery Generator (HSRG), and is modeled as a constraint in the PLEXOS MIP formulation. Then, the PLEXOS unit commitment and economic dispatch algorithm can be used to determine the best operational mode to minimize the portfolio production cost of this system.

4. PLEXOS LT-PLAN - Long-term Capacity Expansion

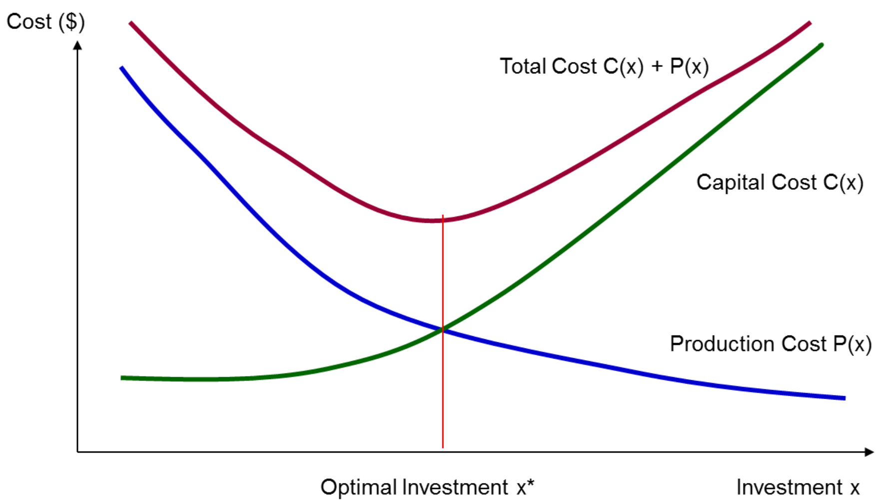
Long-term (LT) Capacity Expansion determines optimal investment decisions over long period of time, usually up to 30 years. The PLEXOS LT-PLAN module accomplishes this by minimizing the Net Present Value of forward-looking investment costs and the portfolio production cost. Therefore, the portfolio cost minimization problem is expanded to include the investment cost and the investment-related constraints as follows:

Minimize Portfolio Production Cost + Investment Cost
Subject to

- *Portfolio operation constraints*
- *Investment Constraints*

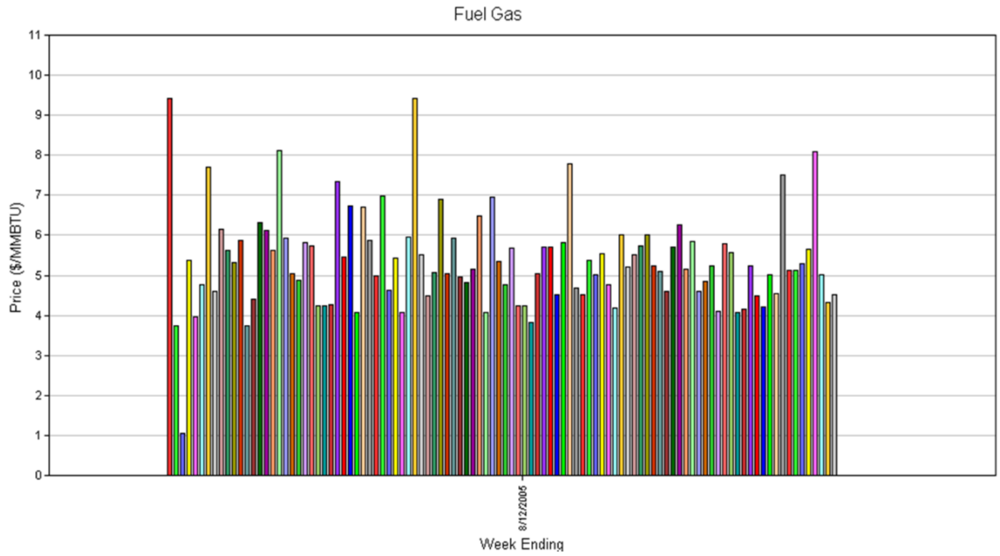
Here, Investment Cost may include cost of new generator builds, cost of transmission expansion, and/or cost of generator retirements. The Investment Constraints may include regional capacity reserve margins, resource addition and retirement candidates (i.e. maximum units built / # retired), technical and financial life spans, technology / fuel mix rules, Renewable Portfolio standard (RPS), etc. The build and retirement candidates might include thermal generators, geothermal generators, hydro or pumped storage hydro generators, wind or solar generators, transaction and demand side participation, transmission augmentations, or generator retrofits.

The PLEXOS LT-PLAN solution is be illustrated by the following chart. The x-axis corresponds to the investment and the y-axis corresponds to the cost. As the investment increases, the production cost, P(x), decreases (blue line) and the capital cost, C(x) increases (green line). The total cost (red line) is the sum of the capital and production costs, C(x) + P(x). The PLEXOS LT–PLAN simulation returns the optimal investment decision (x*) while observing the investment and operational constraints.



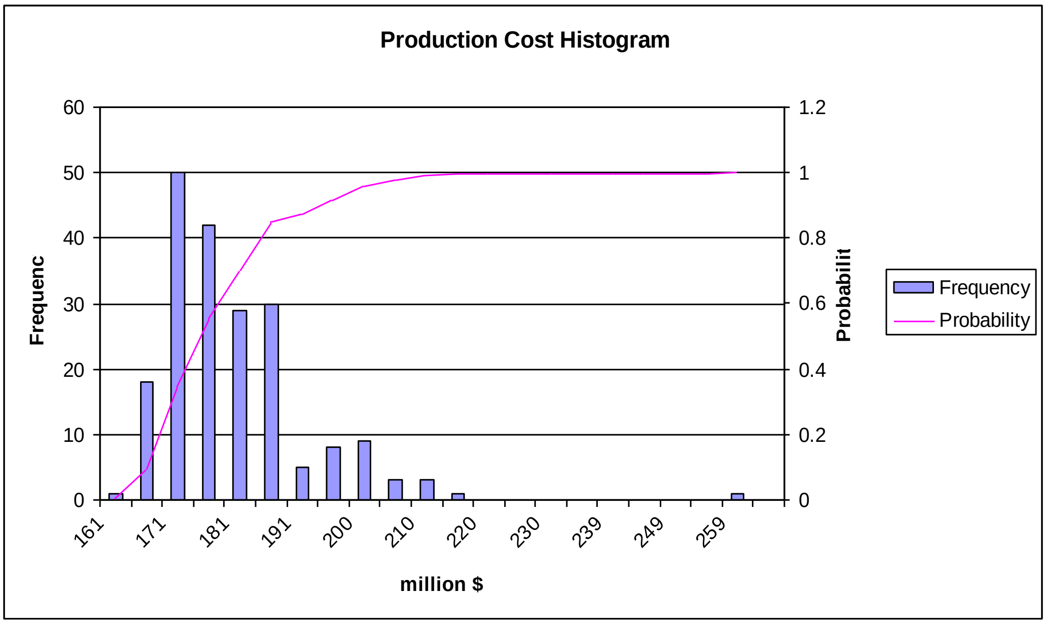
5. Stochastic Simulations to Incorporate Risk

In the portfolio optimization, risk is an important consideration in the corporate decision-making environment. To incorporate risk, PLEXOS uses stochastic simulation to produce solutions with a statistic distribution for a given set of the stochastic drivers, such as fuel prices, load forecast, renewable generation profiles, market prices, etc. These stochastic drivers can be specified in PLEXOS exogenously, i.e., the user provides the stochastic time series, or endogenously, i.e., PLEXOS produces the stochastic time series for the stochastic drivers based on parameters provided by the user. For example, the following chart shows a weekly gas price distribution over one hundred samples.



Here, the first four bars represent the maximum value, minimum value, standard deviation, and mean value over the one hundred gas price samples. The remaining bars represent the one hundred samples.

For the given stochastic driver time series, PLEXOS performs multiple iterations of simulations and produces multiple iterations of solutions. The following histogram shows the distribution of portfolio production costs for a week over the stochastic drivers of gas price, load forecast and market price forecast.



The chart shows that the mean production cost in this week is about $180 million with a worst case scenario of $260 million and a best case scenario of $161 million. The distribution of the weekly production cost provides value insight to the corporate decision makers.