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Automated Resource Selection for Capacity Expansion

Introduction and Overview of Automatic Resource Selection Model and Capabilities

Introduction

Automated Resource Selection ("ARS") is an advanced capability of PowerSimm Planner that uses detailed dispatch modeling to make optimal resource planning decisions by determining the least-cost and least-risk resource options to meet future load and renewable portfolio standards ("RPS") requirements. ARS uses mixed integer programming ("MIP") techniques to optimize resource selection decisions, with the objective of minimizing the net present value of capital expenditures and production costs, subject to both physical and financial constraints. PowerSimm solves for the optimal portfolio over hundreds of simulated future states, providing a robust resource plan that will be practical and cost-effective under the widest variety of possible futures.

Capabilities of Automated Resource Selection

Automated Resource Selection can optimize resource decisions in three primary categories:

- New Generation
- Retirement
- Repowering

Each candidate resource, whether new or existing, is input in full technical detail into PowerSimm to generate accurate simulations of its dispatch and market interactions across all future scenarios of the defined portfolio. Data from these simulations enables calculation of both the expected revenue generated by this resource as well as the expected marginal costs of operation over the course of its lifetime.

Because resource planning involves a trade-off between long-term capital investment decisions and variable operating costs, the optimal expansion plan seeks to minimize the net present value (NPV) of future capital expenditures and future fixed and variable costs. ARS uses the overnight capital costs and fixed/variable O&M costs to calculate a levelized annual revenue requirement for each portfolio modeled, thus accounting for any capital investment decisions not fully amortized over the simulated planning horizon.

NPV cost calculations are fine-tuned by inputting general economic assumptions such as WACC, inflation, relevant tax rates, and depreciation life of the resource, allowing for accurate discounting of future expenditures and proper depreciation of assets. The projects with maximal value (calculated as annualized revenue minus annualized costs) are selected for implementation, subject to any imposed system constraints.

One of the key features of ARS is the ability to impose system constraints on the selection of candidate resources into an optimized generation portfolio. Typically, these constraints may include:

- RPS
- Market Sales/Purchase Limits (Energy and Capacity)
- Reserve Margin Requirements

All constraints may be adjusted as a function of time, allowing for optimization over changing RPS or market conditions, for example. The Market Sales/Purchases constraint allows limits to be placed on exposure to energy and capacity markets, constraining both the market purchases and sales that a portfolio will require. The reserve margin constraint requires portfolios to meet a required reserve margin based on the dynamically calculated average and peak load of the service area.

This feature allows the user to input all the available candidate resources and let ARS add, retire, or repower the resources that will most efficiently meet these constraints and minimize capital requirements of the portfolio.

Once the optimal resource portfolio is established, ARS can also determine an optimized build schedule for all candidate resources. If a candidate project has a pre-determined implementation date, ARS can easily make the decision of whether that project is economically viable if it comes online at that time. However, if the plans are more flexible and a resource may come online in a range of time, ARS can calculate when in that time range is optimal for serving both load and economic value and automatically select an optimized start date.

Advantages of Stochastics-based Resource Selection

While deterministic models run with various sensitivities that may provide insight into resource planning decisions, the limited set of information provided by this method will bias the study results. However, stochastic simulation, in which a wide variety of studies are performed using a distribution of underlying parameters, removes this bias. Figure 1 illustrates this effect by showing how results of a single deterministic study (shown in orange) may differ substantially from the expected value across many stochastic simulations of future conditions (shown by the solid black line). Furthermore, stochastic simulation provides information on the “meaningful uncertainty” of the results, enabling accurate articulation of risk for each of the proposed portfolios.

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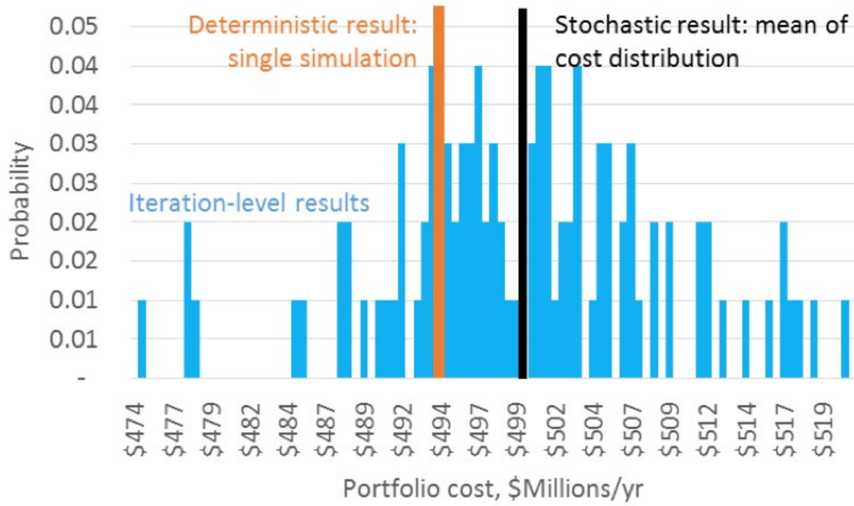

Figure 1. Deterministic versus Stochastic Simulation Based Results

The use of stochastic simulations can be combined with the ARS module of PowerSimm Planner to systematize the resource selection process. This methodology provides the best supply portfolio overall based on all simulated future conditions. Given a distribution of possible dispatch scenarios based on hundreds of simulations of weather, load, prices, and renewable generation, each planning portfolio can be accurately judged on its associated risk and cost. A deterministic model may select the lowest average expected cost, but this may be the most volatile portfolio which introduces significant risk that the utility needs to consider in its analysis. The ability to select the optimal portfolio over a broad spectrum of future conditions without loss of generation modeling details provides substantial advantages over picking the best portfolio from a single deterministic run.

Key Takeaways

- ARS optimizes decisions about changing a utility's portfolio of generation resources by evaluating additions of new generation resources as well as repowering or retirement of existing generation. The selection of any changes, and their timing, are based on market conditions, capital costs, and operations and maintenance (both fixed and variable) costs with the objective of achieving the lowest net present value cost of the overall portfolio. Decisions can be further constrained based on a variety of other variables or scenarios, including Renewable Portfolio Standards, market sales/purchases constraints, and reserve margin requirements.
- ARS allows utilities to make long-term resource planning decisions based on a least-cost and lowest-risk comparison of any number of resources that are defined for the analysis.
- ARS uses a stochastic simulation, which allows for the utility to make decisions over hundreds of future scenarios, rather than restricting the decision to a single simulated outcome. This distribution of scenarios provides an understanding of the risk associated with planning decisions.

Optimization formulation of Automatic Resource Selection

The mathematical formulation of automatic resource expansion optimization is summarized as follows:

The Objective Function is to minimize the expected value of total portfolio cost, mathematically described as:

$$Total\ Cost\ NPV = min \sum_{t} \sum_{i} \left[y_{ti}^{BUILT} \frac{1}{N_s} \sum_{s} \left(C_{tis}^{Op} - R_{tis} \right) + C_{ti}^{Fixed} + C_{ti}^{RET} x_{ti}^{RET} + C_{ti}^{BUILD} x_{ti}^{BUILD} \right]$$

where the first term describes the net operating/power costs and revenue averaged across all simulations, the second term describes the fixed costs, the third term describes retirement costs, and the fourth term describes build costs. The objective function minimizes the total cost over all time periods *t* and scenarios *i* to determine the optimal resource mix. The function is subject to the following constraints:

Reserve Margin Constraints

$$\sum_{i=1}^{N} Capacity_{it} \geq \gamma PeakLoad_t \quad for\ t = 1\ to\ T$$

where γ is the required reserve margin

Energy Constraint

$$\sum_{i=1}^{N} Energy_{it} \geq Load_t \quad for\ t = 1\ to\ T$$

Renewable Constraint

$$\sum_{i=1}^{N} Renewables_{it} \geq RPS_t \quad for\ t = 1\ to\ T$$

Maximum Export/Import Constraint

$$\sum_{i=1}^{N} Energy_{it} \leq Load_{it} + Export\ Limit\ for\ t = 1\ to\ T$$

$$\sum_{i=1}^{N} Energy_{it} \geq Load_{it} + Import\ Limit\ for\ t = 1\ to\ T$$

Ancillary Service Requirements

$$\sum_{i=1}^{N} Regulation_{it} \geq `Reg\ Limit \quad for\ t = 1\ to\ T$$

$$\sum_{i=1}^{N} Spin\ Res_{it} \geq Spin\ Limit_t$$

$$\sum_{i=1}^{N} NonSpin\ Res_{it} \geq NonSpin\ Req$$

$$\sum_{i=1}^{N} Flex\ Ramp_{it} \geq Flex\ Ramp\ Req$$