Energy Efficiency and Demand-Response in PLEXOS®

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Leading the field in Energy Market Modelling

Methodology for data compilation, estimation and model tuning

The methodology for data mining is based on disaggregation at regional level followed by categorization using classical clustering approach. Sources for historical and current values are prioritized by experience, state regulator publications, state-of-the-art revision. Trends will be created based on back casting and are subject to stakeholder review. Many regional system operators collect and use energy efficiency and demand response data in system studies. As well consultants, research centers and other entities regularly collect and tabulate energy efficiency and demand response data.

Information about sources and data gathering strategy:

- Fixed values of loads (or at very high prices) can be derived from regional natural resources forecasting. The final tuning can be based on current and (recent) historical values using a back cast validation.
- Unserved energy prices are publicly available at regional level in most countries.
- Residential and commercial load functions are created with at least and not limited to: shaping based on regression, time of day, and weather input models and sizing based on econometric models.
- The link between natural resource potential and price-dependent industrial load can be created based on various publications by governmental and private organizations on resource price forecasting trends.
- Large-scaled mining industrial replacement costs are available from various local resources and from organizations in most regions.
- Aggregated energy efficiency investment cost with geographical information will be determined according to energy efficiency (for short-run) functions with disaggregation level based on social distribution parameters complemented by research of various publications on modern energy efficiency models (eg. intelligent buildings, building masks)

Energy efficiency Parameters in PLEXOS®

Among others, the main parameters that define a responsive load in PLEXOS are:

- Expected Load, $/kW, Fixed Load/ Generation[1], regional factor, Unserved Energy Price.
- Purchase price/quantity, Max/Min Load, Benefit functions, Min/Max Daily/Weekly/Monthly Energy Loads, Fixed DSP Price/quantity, time of day use patterns
- Storage devices: "Load Mode" consumption (usually called "Pump Load", "Generation Mode" efficiency, max/min limits, variable and fixed costs.

There is a generic Constraint class in PLEXOS® that allows users to create linear constraints and dependencies between other system variables and co-optimize then with the capacity expansion solution. There are also Escalators and Variable stochastic sampling that are used for load parameterization.

Energy efficiency and Demand-response modelling in PLEXOS®

Demand modelling in PLEXOS ® for Energy Markets can be modelled as fixed-energy, price-dependent, and resource-planning dependent.

Fixed-energy load (L_{fixed}) are usually representative of the portion of the system load that is "curtailable" at some cost (unserved energy) usually higher than the operational costs. This is a common approach for representing the unresponsive portion of the load, mostly linked to the residential and commercial components. Dependencies with other model inputs can be defined using various deterministic Escalators or stochastic multi-variable correlated sampling using various autoregressive models (eg. Correlation between load and temperature). eg. Load = F(PIB, Cu(price), Fe(price)). Dependencies with other system variables can be modelled using deterministic linear dependencies using PLEXOS ® generic constraint classes (eg. Load(zoneX)= 0.02 Gen_Solar(zoneX) + 300). This classical approach of load modelling in PLEXOS, as a blend (or sum) of different load components, facilitates sensitivity analysis.

Price-dependent: (L_{price}) This is a generic representation. In PLEXOS, a common approach for modeling is defining either: piecewise linear price/quantity curves, stepwise curtailable quantities, fixed prices/quantities purchasers and DSP programs at regional, zonal or nodal level. These purchasers "offers" are optimally cleared by software depending on the optimal solution.

Resource-planning dependent loads (L_{rp}) are purchasers modelled as expansion "anti-generator" candidates: This means they preserve all the expansion qualities of generators

[1] Various references are available in www.energyexemplar.com section "Publications"

such as building/retirement costs, FO&M costs, debt/equity costs, economic/technical lifetime, but their net injection to the system is negative. These are optimally decided by PLEXOS since it is defined (in the objective function) as a trade-off between investing (increased investment cost) and decommitting other higher magnitude loads. This is a powerful approach for modelling lumpy investment impact at industrial level, including replacement costs, determining both an optimal timing and staging. A unique approach only possible with the integrated co-optimization of production and investment modelling in PLEXOS.

Energy Storage Systems: (L_{pump}) These are system that can return energy stored after some period. Even though these are consumer overall, they are capable of restoring. Their dispatch strategy (load/generation) is determined optimally by the software. This is a general modelling strategy used for studies of EVs, residential PV penetration, co-generation, hydro pumped-storages, flywheels, CAES and other industrial demand-response alternatives[2].

Cleared Load = (L_{fixed} - USE) + L_{price} + L_{rp} + L_{pump}

Spreading Energy Efficiency across many Nodes using Templates and Node*

Energy Storage Devices, Capacity Expansion candidates, Energy Efficiency Expansion candidate cost curves can be spread across nodes of an entire region using Templates & Node* feature in PLEXOS®.

Templates: A template is a special instance of a class that can be used as a building block for another instance. Once an object is created from a template, that relationship is preserved via a membership. Instances created from the template inherit all of the template's features, and build on those features with additional data. Templates of different energy storage devices and different technology expansion candidates with properties can be created in PLEXOS® which can linked to regional generation expansion candidates (ISONE, NYISO, PJM, MISO, SPP, SERC, FRCC etc) with a Template / Inheritor membership to the Template Candidates.

Node*: Generator Nodes* is a 'template' feature. Adding Nodes to this collection causes the simulator to create copies of the Generator at each Node. This occurs at runtime and thus allows you to maintain data on a single Generator but model several Generators in the simulation thus effectively spreading Energy Storage devices and Energy Efficiency Expansion candidates across the entire region.

[2] Research papers about the use of PLEXOS for impact studies of EV and various pumped-store systems are available at www.energyexemplar.com/publications. This includes a specialized paper about demand-response modelling in Chile using PLEXOS.