Power Generation Industry Economic Dispatch Optimization (EDO)

This document provides a detailed overview of the Planning, Scheduling, and Optimization capabilities of AspenTech’s Configured Application Solution (CAPS) for the power industry, and the economic impact available to its users. It outlines a methodology that delivers an optimal economic solution for a given set of generation and market demand conditions, updated as frequently as required. The optimization is available through the use of integrated real-time models.

The business areas this paper addresses are associated with make, buy, and sell opportunities relevant to:

- real-time electricity generation
- real-time distribution of electricity
- power contract management
- real-time power trading

AspenTech’s EDO (Economic Dispatch Optimization) model provides the capability to evaluate real-time what-if scenarios within a commercial power trading environment thus providing generators, power traders and other market participants the ability to effectively manage their portfolios against the market, interactively within an intra-day and day-ahead market. This rapid, accurate market simulation has proven to deliver significant benefits to its current users.

The capability provided by these models is also available for the Independent Service Operators (ISO’s), where the optimization functionality encompasses the Bid / Offer, Economic Dispatch, Unit Commitment and Power Flow Optimization Aspects of the power industry.

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Key business processes within the generation, distribution, wholesale and retail power marketing segments of the industry focused on:

- optimal management and control of the power stations and generating sets
- least cost operation of individual stations and generation sets
- maximum profitable operations within a real-time trading environment
- effective management of generating capacity vs. contract position
- effective trading on the Power Exchange - make, buy and sell

These are the major drivers in the generation, distribution, wholesale and retail power marketing industry.

Real-Time Plant Optimization Models

AspenTech’s EDO optimization model provides a real-time optimization of assets while incorporating all of the operating variables within utility environment encompassing the areas of planning, scheduling and trading.

This optimization model is based on the leading edge Aspen MIMI™ technology, which encompasses multiple mathematical solutions, real-time simulation and display technologies including:

- linear programming - LP
- mixed integer programming - MIP
- heuristics
- expert system rules
- real-time simulation
- advanced visualization
- sophisticated what-if evaluation capabilities

The integration of these technologies within AspenTech’s EDO solution for the utility market provides a solution that covers all of the operational aspects of a real time electric market environment.

The optimization model is integrated with an external relational database, Oracle, SQLServer, etc. This database captures the static and operational data required to drive the model and to accept and distribute the output data.

To support the application, different levels of data are required within the model. The screen display below details a menu option highlighting some of the standard static data elements included the model.
Typically included within the scope of the static data requirements are:

**User / Static Data (Typical)**

- Generating Units
- generation capacity - maximum per Generating Units
- start-up and ramp rate profiles for each unit based on hot start/cold start conditions as a function of time since last run
- start-up costs
- hold points for each unit to ensure heat soaking
- minimum no load times
- minimum MwHrs to reach stable generation
- none load heat costs
- marginal costs
- transmission loss factors
- minimum uptimes, minimum downtimes, etc.

**Dynamic Data**

In addition to the static and semi-static data that is required to support the model, dynamic data is also required. This typically consists of the real-time data that reflects the current commercial environment within that which the power generator is operating.

The display below, provides details of the typical dynamic data that is utilized in the model to support the creation of optimal generating and trading scenarios. The display details the Power Exchange Buy prices for a MW by half hour periods for differential volumes and specific days. This data is subject to change based on hour of the day, day of the week, season, weather conditions, and weather forecasts.

The Power Exchange, and similar data, is typically downloaded from external database systems. Power Exchange Buy data is typically subject to market / trader intelligence as it forms one of the basic elements associated with buy, make, sell decisions.
Dynamic Data (Typical)
- initial conditions by unit, including, operational level, i.e., stable, loading, de-loading or shutdown
- current state of each unit, i.e., running, load, spinning reserve etc.
- contract position
- incremental generating costs
- etc.

The above screen display provides details of a typical data display showing dynamic data associated with the current status of the individual Genset’s and the current contract position that the generator is operating and trading against. Other data associated with the external environment is displayed in similar screens.

Optimization Alternatives
AspenTech’s EDO model can produce optimal production schedules in a real-time trading environment based on either minimizing cost or maximizing profit.

Power generators, distributors, and power marketers require the ability to evaluate the differential costs and profits associated with minimizing costs or maximizing profits. In addition, they require the ability to rapidly evaluate what-if scenarios associated with their market portfolios, i.e., determining their book against current market opportunities both positive and negative.

AspenTech’s EDO model provides the capability to rapidly evaluate minimum cost and maximum profit scenarios in response to real-time business situations.
Minimum Cost Operation
The minimum cost optimization scenario develops and optimal combination of Generating Units with capacity to meet the current contract position without exploiting the opportunities associated with power trading, Power Exchange contracts, or use of virtual generating capacity capabilities.

The output from the optimization model provides the aggregate generating capacity requirements by unit in the requisite time buckets, i.e., 1/2 hourly in MW's across the schedule horizon, taking into account all of the relevant unit operating parameters.

A typical output in 1/2 hourly aggregated time buckets is displayed graphically in the above screen display. This provides a view of the contract position, total height of each column, with the generating demand for each of the units comprising the elements of the column.

This output forms the basis for the dispatch instructions that are sent to the individual power stations and units as minute by minute loading instructions.

Maximum Profit Optimization
The maximum profit optimization scenario provides the optimal operating cost model utilizing generating capacity and the availability of energy available on the power exchange, to meet the current contract position.

The below output screen is for the same demand / contract position as displayed in the minimum cost option above. The major difference is that within this maximum profit scenario, the model is allowed to buy and sell energy on the Power Exchange. The major difference is the dispatch points of the individual units are based on the start-up costs associated with bringing them on line as opposed to the relatively low cost of purchasing the energy from the Power Exchange market.
economic distribution

The economic distribution of optimal generating requirements to the individual Power Stations and Gensets is provided by AspenTech's EDO integrated power industry solution, at a granularity with a 1 minute resolution, or less where required.

The economic distribution information is passed from the AspenTech optimization model to the corporate relationship database from which the information can be distributed to the individual Genset operators in multiple ways including Web based.

The below display provides a view of a minute-by-minute dispatch points by Generating Unit. The dispatch point is identified as MW requirements in each time period across the schedule horizon.

Power Trading / Power Exchange

The Power Exchange operates as the overall market demand and availability, and provides the controlling mechanism for the supply of power within the overall consumer environment.

The generators power marketers use overall demands within this market to develop their portfolios against which they can trade energy.

In order to effectively operate within this real time environment, the generators and the power marketers need the capability to evaluate multiple business scenarios within very short time intervals. This enables them to determine the optimal combination of generation, buy and sell options, to maintain a maximum profit position within the trading environment.

The AspenTech EDO model provides the capability to evaluate the different optimal scenarios in multiple business environments. A typical output detailing the requirement to operate individual Gensets to meet the same contract position are displayed below. One is a minimum cost option and the other details the same contract position, however within a maximum profit position.
Optimized Scheduling Capabilities

Within the AspenTech EDO solution, the model provides displays information that allow the whole of the schedule to be viewed within the Aspen MIMI optimization tool.

The Aspen MIMI planning board supports a real-time dynamic simulation environment that supports full drag and drop capabilities, and allows the planners and power marketers to dynamically add additional generating requirements in response to power market opportunities, without the necessity to rerun the optimization routines.

The display capabilities of the Aspen MIMI planning board also provide the ability to view the overall schedule for each of the units across the schedule horizon.

Typical Planning Board Display

The planning board provides views with two windows. The upper window details the individual generating requirements for each Genset as activities within each of the time periods. Each of the individual activities has an associated information display (example shown in the opposite display).

The details within the upper window display the different activities, i.e., start-up, shut-down, stable running, etc. These can be color coded to meet the client’s specific requirements, as can the information windows.

The lower window, provides a view of the selected unit and its operating condition as a trend plot through time, detailing the actual generating load / capacity that is required. Within the display is the yellow trend line showing the Genset starting up, ramping to plateaus associated with the individual unit. On initial start-up, the ramp curve details the unit as users of energy.

The planning board display provides a view of a unit operating between stable generating level and its maximum generating level, within the Sync / De-sync constraints. The dispatch point of the unit are associated with achieving the optimal generating requirement against the current and forward contract position.

The trend display provides the capability to view multiple trends across the schedule horizon and the detail of how each unit achieved capacity vs. contract position within each time period, together with the volumes of energy being purchased / sold on the Power Exchange.
Typical Response Times
To be an effective tool in a real-time environment the model must provide the capability to rapidly evaluate what-if scenarios.

An example of a typical generation company, an operational model encompassing greater than 250 Generation Units comprising of a mixed portfolio of:

- Nuclear
- Hydro
- Pumped Storage
- Fossil (coal)
- CCGTs
- Gasoline Turbines
- Oil

AspenTech’s model using real-time data and time segments of 60 minutes over a 7-day horizon provide optimal fleet dispatch and minute-by-minute unit commitment solutions in approximately 3 minutes on a desktop personal computer.

This rapid response time provides the capability to run multiple what-if scenarios against current market position to assess the level of risk and strategies to gain advantage under current market trading conditions.

about AspenTech
Aspen Technology, Inc. is a leading supplier of enterprise software to the process industries, enabling its customers to increase their margins and optimize their business performance. AspenTech’s engineering solutions, incorporating Hyprotech’s technologies, help companies design and improve their plants and processes, maximizing returns throughout their operational life. AspenTech’s supply chain manufacturing solutions allow companies to run their plants and supply chain more profitably, from customer demand through to the delivery of the finished product. Over 1,200 leading companies rely on AspenTech’s software every day to drive improvements across their most important engineering and operational processes. AspenTech’s customers include: Air Liquide, AstraZeneca, Bayer, BASF, BP, ChevronTexaco, Dow Chemical, DuPont, ExxonMobil, GlaxoSmithKline, Lyondell Equistar, Merck, Mitsubishi Chemical, Shell and Unilever. For more information, visit www.aspentech.com.