EXHIBIT NO. ______ (JMR-9)
DOCKET NO. UE-04____/UG-04____
2004 PSE GENERAL RATE CASE
WITNESS: JULIA M. RYAN

BEFORE THE
WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION

WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION, **Complainant,** **v.** **PUGET SOUND ENERGY, INC.,** **Respondent.**	**Docket No. UE-04____** **Docket No. UG-04____**

EIGHTH EXHIBIT TO PREFILED DIRECT TESTIMONY OF JULIA M. RYAN (NONCONFIDENTIAL) ON BEHALF OF PUGET SOUND ENERGY, INC.

APRIL 5, 2004

SUMMARY DESCRIPTION OF THE AURORA MODEL AND MODIFICATIONS SPECIFIC TO PUGET SOUND ENERGY, INC.

AURORA relies upon key factors such as available power supply resources, regional electric demand, natural gas prices and transmission capacity to develop model results, factors that drive resource operations and prices in the electric power market. Since AURORA computes the market clearing price for power based upon the marginal generator in each hour of the dispatch simulation, and that marginal generator is often gas-fueled, the forecast of natural gas prices is an important input to the AURORA model. AURORA uses hourly demand and individual resource operating characteristics in a transmission-constrained, chronological dispatch algorithm for the entire Western Energy Coordinating Council ("WECC") area. For modeling purposes, the WECC is divided into thirteen areas and the economic dispatch for each area is determined based upon the loads and resources in each area and its transmission interconnection capacity with other areas. AURORA calculates an hourly market-clearing price for energy through balancing the economic dispatch among all of the areas. A full description of the AURORA model is included in the following pages of this Exhibit No. ___(JMR-10).

PSE and AURORA's vendor (EPIS) have made a number of extensions and database updates to the model in order to adapt AURORA to produce projected net power costs for the PSE system. These adaptations include:

- **Development of generation data**. These data were developed for Pacific Northwest hydroelectric projects for each of the 60 water years of record based on the Northwest Power Pool 2002-2003 Final Regulation. Subsequently, specific generation data were updated for each of the five Mid Columbia hydroelectric projects from which PSE purchases power based on the 2003-2004 Final Regulation. Generation data for the 60 water years of record for PSE-owned hydroelectric projects were developed based on historical daily streamflows and current plant operating capabilities and operational constraints.

- **Development of additional contract types**. These contract types simulate the cost characteristics of PSE's non-utility generation (NUG) power purchase contracts.

- **Other adaptations**. Data and databases were developed to include PSE's load and resources as a specific "Portfolio" within the Oregon/Washington/ Northern Idaho dispatch area. In order to obtain proper model results, it is necessary to define a Portfolio within AURORA that: (1) identifies the specific generating resources to be allocated to the Portfolio; (2) defines the power purchase and sales contracts included in the Portfolio; and (3) provides forecasts of the monthly loads as well as the hourly shape of the loads for the Portfolio.

PSE uses the Aurora model to estimate the cost of its resource portfolio used in serving its core customer load. The model is described below: first in general terms to explain how the model operates; followed by discussion of the inputs which are significant to the fundamentals based program.

Aurora Overview

Aurora is a fundamentals based program meaning that it relies on factors such as supply, demand and transportation which drive the electric energy market. Unlike many models which use historic data to predict the future, Aurora uses forward looking information in a dynamic process to simulate changes in the market. Aurora uses hourly demand and individual resource-operating characteristics in a transmission-constrained, chronological dispatch algorithm.

Aurora uses information to build an economic dispatch of generating resources for the market. Units are dispatched according to variable cost, subject to non-cycling and minimum run constraints until hourly demand is met in each area. Transmission constraints, losses, wheeling costs and unit start-up costs are reflected in the dispatch. The market-clearing price is then determined by observing the cost of meeting an incremental increase in demand in each area. All operating units in an area receive the hourly market-clearing price for the power they generate.

Aurora also has the capability to simulate the addition of new-generation resources and the economic retirement of existing units. New units are chosen from a set of available supply alternatives with technology and cost characteristics that can be specified through time. New resources are built only when the combination of hourly prices and frequency of operation for a resource generate enough revenue to make construction profitable; that is, when investors can recover fixed and variable costs with an acceptable return on investment. Aurora uses an iterative technique in these long-term planning studies to solve the interdependencies between prices and changes in resource schedules.

Existing units that cannot generate enough revenue to cover their variable and fixed operating costs over time are identified and become candidates for economic retirement. To reflect the timing of transition to competition across all areas, the rate at which existing units can be retired for economic reasons is constrained in these studies for a number of years.

Aurora Logic

Aurora models the competitive electric market using the following modeling logic and approaches to simulate the markets: prices are determined from the clearing price of the marginal resources. Marginal resources are determined from "dispatching" all of the resources in the system to meet loads in a least-cost manner subject to transmission constraints. This process occurs for each hour dispatched. Resulting monthly or annual

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prices are derived from that hourly dispatch. The commitment and reserve decisions are done prior to dispatch.

The unit commitment logic simulates operation of generating units that cannot cycle hourly. These units commit to operate based upon the value they create over an operating period. Once committed, units will run at either maximum available capacity or at minimum capacity depending on the value created in each hour of operation. To make the determination on unit commitment, Aurora will iterate to a solution of consistent prices and resource operation for a forecasted period. Using the pre-forecast prices AURORA examines the economics of committing the unit given the unit dispatch cost and the minimum up and down times.

To provide system reliability, a portion of resource capacity can be reserved to provide stability in the integrated electrical supply system in the event of unexpected outage conditions. Aurora determines the reserve requirement for each area and then takes a set of the higher cost units out of the dispatch stack for the hour. The portion of resources that are reserved for system reliability cannot be dispatched into the system based upon dispatch for economic profitability. Hence this leads to higher prices during periods where generation supplies are near full utilization.

Aurora optimizes the use of hydro energies over a weekly period. It uses hydro constraints such as instantaneous maximums and minimums and the number of hours of sustained peaking maximums. Given the annual and monthly energy factors for each area, Aurora shapes hydro to flatten load (net of hydro) as much as possible. It accounts for regional hydro imports and exports, too.

Long-term optimization studies are used to forecast capacity expansion resources and retirements. In Aurora you can put future resource units in the database with pre-determined start dates, or use the long-term logic that uses market economics to determine the long-term resources and the start or retirement dates. This optimization process simulates what happens in a competitive marketplace and produces a set of future resources that have the most value in the marketplace. The model assumes that new generators will be built (and existing generators retired) based on economics. The economic measure used is real levelized value (revenues less cost) on a $ per MW basis. Investment cost is included in the cost portion of the formula. Also, the methodology assumes that potentially non-economic contracts will not influence the marketplace and that someone will capture the opportunity value of non-economic contracts. Therefore contracts are not modeled into the pricing.

Aurora determines resource value from the difference between market price and resource cost. This determination is performed for every hour for every resource in the region. Thus, a very accurate value is developed which takes into account system value during on peak and off-peak and other hours, and during daily, seasonal, and annual periods of time. The modeler can specify the use of variable operation and maintenance expenses along with fixed operation and maintenance expense in the computation.

The net present value per MW of each resource is found for all periods of the study. This net present value may be used in long term future analysis for determining whether a new resource should be added to the system or whether an old resource should be dropped.

In summary, Aurora simulates the economic dispatch of resources to meet demand requirements. Aurora:

- Solves the whole system dispatch simultaneously.
- Dispatches hourly (with sampling capabilities, where appropriate).
- Determines the market-clearing prices from marginal costs.
- Values all the resources in the system.

Assumptions

Numerous assumptions are made to establish the parameters that define the optimization process. The first parameter is the geographic size of the market. In reality the continental U.S. is divided into three regions and electricity is not traded between these regions. The western most region, called the Western Systems Coordinating Council (WSCC) includes the states of Washington, Oregon, California, Nevada, Arizona, Utah, Idaho, Wyoming, Colorado, and most of New Mexico and Montana. The WSCC also includes British Columbia and Alberta, Canada, and the northern part of Baja California, Mexico. Electric energy is traded and transported to and from these foreign areas, but is not traded with Texas for example.

For modeling purposes the WSCC is divided into twelve areas primarily by state, except for California which has northern and southern regions, Oregon and Washington which are combined, and Alberta and British Columbia which are combined. These areas approximate the actual economic areas in terms of market activity. The data bases are organized by these areas and the economics of each area is determined uniquely.

Load forecasts are created for each area. The load forecast includes the base year load forecast and an annual average growth rate. Since the demand for electricity changes both over the year and during the day monthly load shape factors and hourly load shape factors are included as well. All of these inputs vary by area: for example, the monthly load shape would show southern California's summer peak demand and the northwest's winter peak.

All generating resources are accounted for. Information on each resource includes its area, capacity, fuel type, efficiency, and expected outages (both forced and unforced). Previously, the generating resource landscape saw few changes; however there are currently numerous plants under construction and many more in the planning stage. The model incorporates resources that are under construction with expected on-line dates, and is updated as resources move from the planning stages to the construction and production stages.

The price of fuel is an important factor in determining the economics of electric power production. The three most important fuels are natural gas, fuel oil and coal. The fuels need to be priced appropriately for each area. For example, a plant in Washington may receive its gas from Canada at the Sumas hub, whereas a plant in Southern California may receive gas from New Mexico or Texas at the SoCal Border hub, which are priced differently.

Water availability has great influence on the price of electric power in the Northwest. Water flow data on the Columbia river has been collected for over 100 years; however only sixty years (1928-1988) are currently accepted by the regional boards and commissions as accurately accounting for all loss factors and hence only these sixty years are used in the analysis. There is also much hydro power produced in California and the Southwest (e.g. Hoover Dam) but it does not drive the prices in those areas as it does in the Northwest. In those areas the normal expected rainfall and hence the average power production is assumed for the model.

Electric power is transported between areas on high voltage lines. When the price in one area is higher than another, electricity will flow from the low priced market to the high priced market which will move the prices closer together. The model takes into account two important factors that contribute toward the price: first, there is a cost to transport energy from one area to another which limits how much energy is moved; and there are physical constraints on how much energy can be shipped between areas. The WSCC high voltage lines were not designed like the interstate highway system to move goods easily and efficiently around the country. The limited availability of high voltage transportation between areas allows prices to differ greatly between adjacent areas.

[redacted]

The operation of resources within the electric market is modeled to determine which resources are on the margin for the Western Systems Coordinating Council (WSCC) in any given hour. Within WSCC there are
For all AURORA databases, long-term average demand and hourly demand shapes for these areas are input. These demand areas are connected by transmission links with specified transfer capabilities, losses, and wheeling costs.

Existing supply-side generating units are defined and modeled individually with specification of a number of cost components and physical characteristics and operating constraints. Hydro generation for each area, with instantaneous maximums, off-peak minimums, and sustained peaking constraints are also input. Demand-side resources and price-induced curtailment functions are defined, allowing the model to balance use of generation against alternatives to reducing customer demand.

Provides price and value forecasts for each time period being studied.

AURORA applies economic principles, dispatch simulation and bidding strategies to model the relationships of supply, transportation, and demand for electric energy.

AURORA forecasts market prices and operation based on forecasts of key fundamental drivers such as demand, fuel prices, and hydro conditions.

AURORA is able to forecast point estimates in seconds and minutes, and produce Monte Carlo stochastic analyses in minutes and a few hours.

In addition to market prices, AURORA provides information on resource value, portfolio value, net power cost, risk and uncertainty analysis, and resource planning. With appropriate inputs, AURORA can be used for near-term analysis (next day/week) to very long-term analysis (20 plus years).

Along with the software, EPIS delivers default databases. To install AURORA and its three North American databases, users run the set-up program from a CD-ROM or via the Internet. AURORA is ready to run. The underlying assumptions may be reviewed using the database tools within AURORA.

Furthermore, the user can make changes to data (using spreadsheet-like grids) in the database and run scenarios and what-if cases. Users are able to add their own proprietary data to create their own databases.

A real strength of AURORA is that it is transparent to the user. Users can view all assumptions and results. For example, using the STEP FUNCTION of AURORA, users may step through the model, following the progress of results on an hourly basis. Results are presented in straightforward graphical and spreadsheet-like grids.

Periodic model and data updates are provided via the Internet. Model upgrades for user-specified needs are part of the annual license fee as long as requested changes are of general interest and not proprietary in nature.

Moreover, along with its modeling power, AURORA is easy to use. AURORA runs on any of the following PC based operating systems: Windows XP/ME/2000/NT 4.0/98. The software uses the latest in graphical user interfaces (GUI's). It integrates well with Microsoft Office 97/2000 products; for example, MS Excel.

AURORA documentation and help are context sensitive, and available directly from the Internet.

Modeling Methodology

AURORA is specifically designed to model wholesale electricity prices in a deregulated generation market.

In a deregulated generation market, at any given time, prices should be based on the marginal cost of production. In a competitive electricity market, prices will rise to the point of the variable cost of the last generating unit needed to meet demand.

One of the principal functions of AURORA is to estimate this hourly market-clearing price at various locations in the national electric market. AURORA uses a fundamentals approach in estimating prices, reflecting the economics and physical characteristics of demand and supply.

AURORA estimates prices by using hourly demands and individual resource-operating characteristics in a transmission-constrained, chronological dispatch algorithm.

The operation of resources within the electric market is modeled to determine which resources are on the margin for each area in any given hour. The databases include all the NERC reliability areas in the North American national electric market. At this point, there are databases for the Eastern Interconnection (EAST and Central Database), for the Texas market area (ERCOT), and for the Western Systems Coordinating Council (WSCC).

For all AURORA databases, long-term average demand and hourly demand shapes for these areas are input. These demand areas are connected by transmission links with specified transfer capabilities, losses, and wheeling costs.

Existing supply-side generating units are defined and modeled individually with specification of a number of cost components and physical characteristics and operating constraints. Hydro generation for each area, with instantaneous maximums, off-peak minimums, and sustained peaking constraints are also input. Demand-side resources and price-induced curtailment functions are defined, allowing the model to balance use of generation against alternatives to reducing customer demand.

AURORA uses this information to build an economic dispatch for the markets. Units are dispatched according to variable cost, subject to non-cycling and minimum run constraints until hourly demand is met in each area. Transmission constraints, losses, wheeling costs and unit start-up costs are reflected in the dispatch. The market-clearing price is then determined by observing the cost of meeting an incremental increase in demand in each area. All operating units in an area receive the hourly market-clearing price for the power they generate.

AURORA also has the capability to simulate the addition of new-generation resources and the economic retirement of existing units. New units are chosen from a set of available supply alternatives with technology and cost characteristics that can be specified through time. New resources are built only when the combination of hourly prices and frequency of operation for a resource generate enough revenue to make construction profitable; that is, when investors can recover fixed and variable costs with an acceptable return on investment. AURORA uses an iterative technique in these long-term planning studies to solve the interdependencies between prices and changes in resource schedules.

Existing units that cannot generate enough revenue to cover their variable and fixed operating costs over time are identified and become candidates for economic retirement. To reflect the timing of transition to competition across all areas, the rate at which existing units can be retired for economic reasons is constrained in these studies for a number of years.

In summary, AURORA simulates the economic dispatch of resources to meet demand requirements. AURORA:

- Solves the whole system dispatch simultaneously.
- Dispatches hourly (with sampling capabilities, where appropriate).
- Determines the market-clearing prices from marginal costs.
- Values all the resources in the system.
- Provides price and value forecasts for each time period being studied.

Information from AURORA

AURORA forecast capabilities include forecasting for month-by-month and annual forecasts. With AURORA's daily forecasting capabilities, the model can be used for next day or next 30-120 day forecasts. The capacity expansion or long-term optimization mode may be used to develop a resource retirement and capacity expansion plan for medium- to long-range price projections.

AURORA provides the following information:

Electric price forecasts:

- Geographic areas and trading hubs
- User-specified time periods–hourly, daily, monthly and annual
- On-peak, off-peak or other defined sets of hours

Resource value forecasts:

- All existing generating units
- Future generating-unit alternatives
- Demand-side resources
- Hourly, daily, monthly and annual time periods.

Resource strategy forecasts:
- Uses NPV of resource market profitability
- Optimal resource strategies for long-term runs

Portfolio analysis:
- User-defined sets of contracts and resources
- Monthly and annual time periods
- Hourly results may be written using VB scripting capabilities within AURORA

Uncertainty analysis:
- Price, value and defined portfolios
- Input sampling of key fundamental drivers
- Transmission usage and congestion

Information from AURORA is readily and easily transferred to Excel or virtually any other MS Windows program. In addition, AURORA provides the above information in MS Access database files or MS Excel Spreadsheets. The option of writing output to Internet HTML formats is also available.

Drivers and Inputs

AURORA uses the fundamental economic drivers of the electric market to make its forecast. That information includes:

- Electricity demand by geographic area; annually and monthly including hourly shapes.
- Supply-side resources (all major generating units) in the system. Resource heat rates, fuel types, resource-commitment data and other resource information. Future resource alternatives are used in long-term optimization studies.
- Demand-side resources including an interruptible price curve.
- Fuel prices by fuel type and location.
- Hydro information for AURORA's hydro-optimization logic.
- Transmission costs and constraints.
- For uncertainty analysis, Monte Carlo sampling from statistical distributions for demand, fuel prices, hydro conditions and other drivers is used to forecast price distributions.

Users manage the cases and analyze the drivers to electricity-market forecasts by selecting the underlying assumptions of the analysis. The projections are created using assumptions for the chosen inputs, such as electricity demand growth, fuel prices, and gas-fired combined-cycle generation efficiency and cost. For example, the low electricity market scenario could include low-demand growth, low fuel prices, and optimistic assumptions about combined-cycle combustion turbines. The combination of assumptions may consist of outcomes that the user believes are plausible. A user can model the conditions, cases and options a decision-maker wants to evaluate. Without any programming, you determine the assumptions used in each forecast or study.

Modeling Logic

AURORA models the competitive electric market using the following modeling logic and approaches to simulate the markets:

AURORA market prices are determined from the clearing price of the marginal resources. Marginal resources are determined from "dispatching" all of the resources in the system to meet loads in a least-cost manner subject to transmission constraints. This process occurs for each hour dispatched. Resulting monthly or annual prices are derived from that hourly dispatch. The commitment and reserve decisions are done prior to dispatch. Commitment works as follows:

COMMITMENT LOGIC

The unit commitment logic simulates operation of generating units that cannot cycle hourly. These units commit to operate based upon the value they create over an operating period. Once committed, units will run at either maximum available capacity or at minimum capacity depending on the value created in each hour of operation. To make the determination on unit commitment, AURORA will iterate to a solution of consistent prices and resource operation for a forecasted period.

AURORA does a true economic unit commitment. Unit commitment occurs prior to dispatch. Unit commitment allows the user to define the minimum uptime and minimum downtime for each unit. AURORA performs an iterative process that runs the first hour of the study. The units that will run and the units that will not run are defined. Note: The only interdependent hour-to-hour cross-time optimization occurs in the unit commitment logic. It does this by doing a pre-forecast of prices (using an iterative approach to begin with). Using the pre-forecast prices AURORA examines the economics of committing the unit given the unit dispatch cost and the minimum up and down times.

Once committed, the unit's minimum segment is removed from the dispatch and only the upper segment is subject to dispatch.

The Step by Step logic:

1. A pre-forecast of prices for the commitment period is made. For each dispatch period and for each non-cycling resource.

AURORA will do a pre-forecast of the prices. The first hour is run without commitment logic to obtain a price for an hour. AURORA then takes that price and using the demand, net of Hydro, determines a ratio. To determine the next 167 hours AURORA uses this ratio to determine the prices.

2. Unit value for the commitment period is computed (including startup costs).
3. If unit is running, check current prices and commitment period. If the price is economic then the unit continues to run.
4. If economic, and the unit has been down for at least the minimum down time, the unit is committed for the period.

   If not economic, then if the unit is currently committed, keep the commitment if the time since committed is less than the commitment period (Min Up Time or one week). If the unit is not currently committed then do not commit. If the unit is not committed, it may run if the market price is greater than (Variable) times the fuel cost of the unit. The variable is defined on the logic tab.
5. If the unit is committed, run full out when the dispatch cost is less than the market price.
6. When the dispatch cost is greater than the market price run the unit at the minimum level.

The input controls for the commitment and dispatch of resources are found in the Resources Table and the Fuel Table and for non-cycling units they consist of:

- Min-up Time and Min-down Time
- Non Cycling Percent
- Start-up Costs
- Must Run

Unit Cost Formula: Variable Cost + Fixed Cost + Startup Cost = Total Cost

Define a minimum uptime in hours (maximum 168) and a minimum downtime in hours.

If a commitment unit does not commit it remains in the dispatch at a penalized dispatch cost. Dispatch Penalty Formula: Dispatch Cost + Dispatch Penalty = Dispatch Penalty Cost

Other unit types are:

- Cycling Units – Cycling units can be dispatched hour by hour.
- Hydro Units
- Storage Units

The modeling of these units will be discussed in the dispatch logic, hydro logic and storage logic.

OPERATING RESERVES

[redacted]

[redacted]

DISPATCH

With commitment and reserve decisions done prior to dispatch, the dispatch works as follows:

1. AURORA builds a dispatch stack for each area.

2. Given native load the marginal unit is found in each area.

3. Pricing is determined from the marginal unit using incremental (linear) interpolation (or if selected, a decremental or second order interpolation, or exact supply pricing by area.)

   The second order dispatch switch computes the marginal pricing for load above the marginal resource by using a second order equation rather than the linear interpolation of the standard dispatch. This option will result in somewhat lower prices and will cause AURORA run time to significantly increase. Generally, we recommend that this switch not be used.

4. Given transmission capabilities and cost (losses and wheeling), economic power flows are determined.

5. Using "genetic algorithms" or "Darwinian" (combination of random and best) small sets of power flows are allowed to take place.

   AURORA will consider the potential benefits associated with shifting or moving power.

6. Given net loads in each area, marginal units are again found.

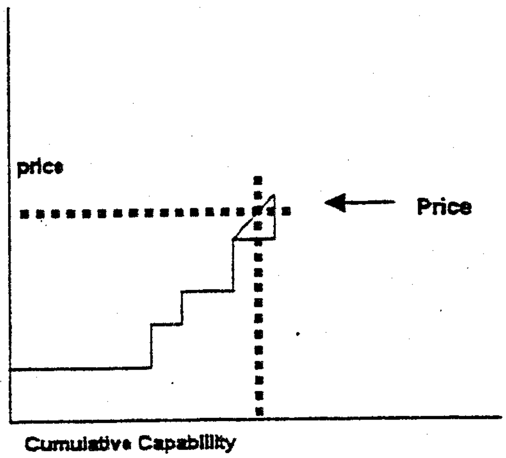
7. The process is repeated until no significant benefits can be obtained by additional power flows.

These market prices are the foundation for the value, cost, and risk analysis performed with AURORA.

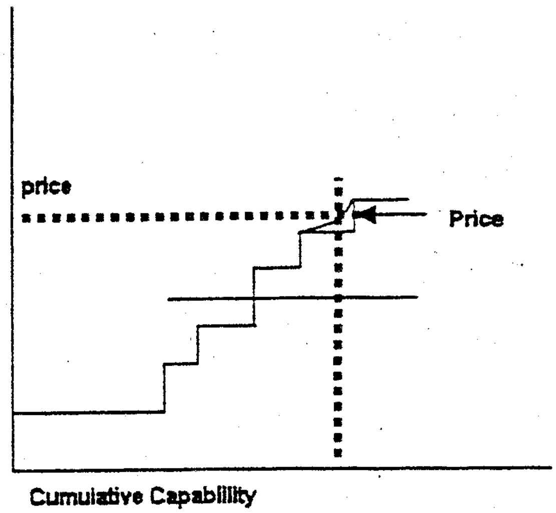
Dispatch Pricing Options

The last unit sets the market-clearing price even though it is fractionally dispatched. The price of the fractional dispatch is set by Incremental (Linear) Interpolation (the default), or if selected, Second Order Interpolation, Decremental (Linear) Interpolation, or the exact supply pricing approach.

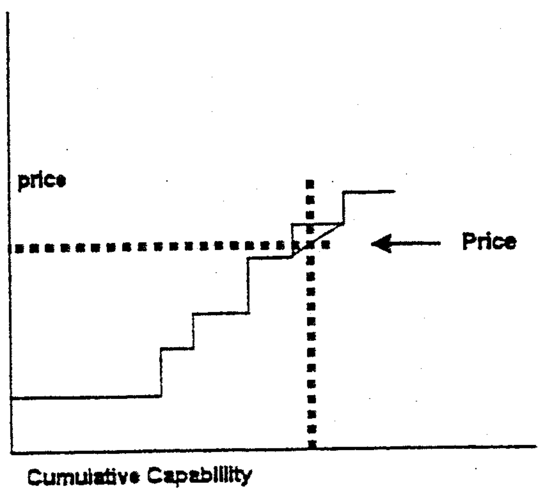
Incremental (Linear) Interpolation
(Default Dispatch)



Second Order Dispatch



Decremental (Linear) Interpolation
(Not Recommended)



Dispatch Resolution

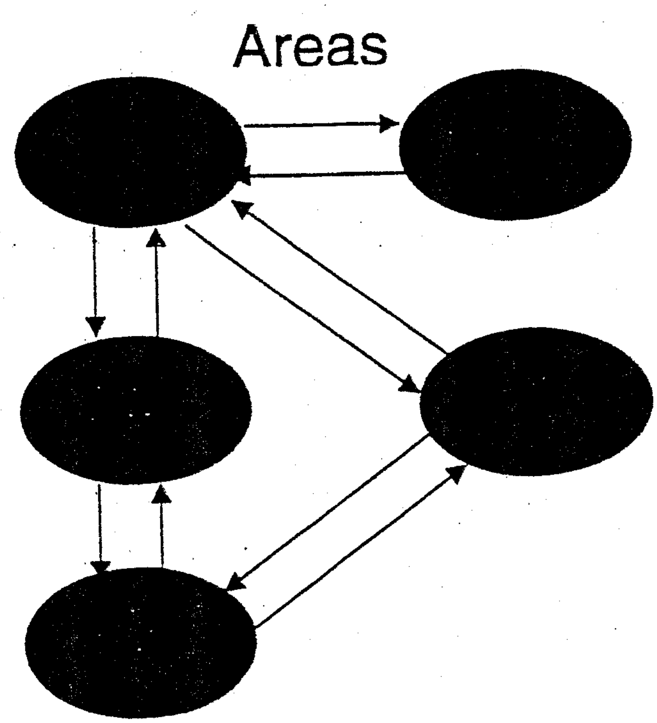
The user has the option to the control of dispatch resolution on the Logic Tab. The default resolution is "Normal." Normal represents what happens in the market because it does not reach a dispatch solution with 100% of losses or wheeling.

Resource Dispatch Margin

The resource dispatch margin (in percent) determines what margin is required for a resource to run. This margin is applied to all resources in the system. The user can specify on the Logic Tab the dispatch margin. This margin is multiplied by a monthly shape factor if one is pointed to by a value in the box for monthly shape for dispatch margin. The Monthly Shape for Dispatch Margin Pointer to a Monthly Shape Vector, located in the Monthly Shape Factors Database Table, for shaping the dispatch margin.

Summary

In summary, the dispatch provides a system dispatch that is computed using genetic algorithm techniques, AURORA determines clearing prices in all system geographic areas for each dispatch hour. Each area will have its own marginal unit (the next unit to dispatch in the area) for a particular hour. Those are displayed along with the area prices for an hour.



1. A price sorted resource stack is determined for each area.
2. A clearing price is found for each area given the native demand.
3. Economic flows are determined and sorted by value (price difference).

4. A small set of the most economic flows is used.
5. The clearing price is found for each area given native load and imports and exports.
6. Using genetic/Darwinian algorithm techniques, steps 3 through 5 are repeated until stability is reached.

HYDRO SHAPING LOGIC

AURORA optimizes the use of hydro energies over a weekly period. It uses hydro constraints such as instantaneous maximums and minimums and sustained peaking maximums. Within shaping constraints, AURORA shapes hydro to flatten load (net of hydro) as much as possible. It accounts for regional hydro imports and exports too.

Specifically, hydro resources are handled as a resource with a fixed hourly energy. The annual and monthly energy factors for each area or resource are input into AURORA. AURORA then uses shaping logic to shape the hydro for weekly (weeks begin on Mondays) periods. Inputs for shaping are a shaping factor, the instantaneous maximum, the instantaneous minimum, and the number of hours for sustained maximum.

The program works as follows:

1. The average demand for the month for the area is found.
2. The average hydro energy for the month for the area is found.
3. AURORA then shapes the hydro using the shaping factor and the following formula:

   Hourly Hydro Shape = (1 + shape factor * (hourly demand - average monthly energy)/average monthly hydro energy) * monthly energy factor * annual energy factor.

4. AURORA checks the instantaneous maximum and minimums. If there are any violations, the excess, or underage, is spread or taken evenly from the other hours.
5. AURORA checks the sustained maximum. Any violation is once again spread evenly to the other hours and AURORA loops back to the maximum and minimum checks.
6. If the constraints cannot be satisfied, AURORA will change the input shaping constraints to 1, 0, and 1 and modify the formula to use average monthly energy in the denominator. It will print a message informing the user that this has occurred.

The user has a choice to shape hour by each market area or across market areas. With **Use all Areas for Hydro Shaping** switch on, demand for all areas in the system is aggregated and the total demand is used for shaping hydro rather than the demand in the area the hydro is located. In general, for the Eastern Markets hydro is modeled for the respective market areas, and in the Western Markets all areas are used for hydro shaping.

EMISSION LOGIC

Emissions can be an important fundamental driver. AURORA allows an unlimited number of emission types to be modeled via input. Emission rates are input for each resource and emission prices and limits are input for each emission type.

Emission cost is computed using the following formula:

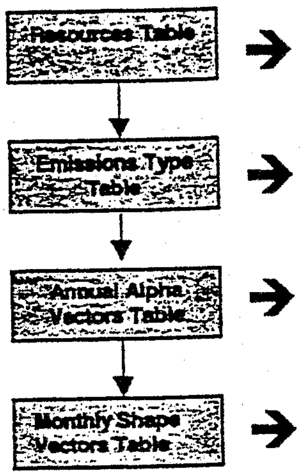
Emission cost = (emission rate - limit) x heat rate x emission allowance price / 2,000,000

Treatment of emission cost is controlled under the AURORA Assumptions Tab. Emission cost can be included in the dispatch or in the value by using the appropriate check box.

Note that emission data will always be displayed so this only determines where AURORA uses it.

EMISSION TABLE RELATIONSHIPS

After selecting emissions in the Assumptions Tab, key tables and fields for emissions modeling include:



Unit-specific emission rates are applied to the "SO2 Emission Rate", "NOX Emission Rate" and "GHG Emission Rate" fields, in lb/mmBtu

Each emission type represents a record, with data for the "Price" field ($/ton) and "Limit" field (lb/mmBtu). These may be text references linked to the "Annual Alpha Vectors" table.

The "Name" field entries are linked to the "Name" field of the "Emission Type" table. Individual year field entries are linked to "Monthly Shape Vector" table entries.

The "Use" field entries are linked to the "Name" field of the "Annual Alpha Vectors" table. Individual month entries represent emission limit values and allowance prices.

ENERGY STORAGE LOGIC

AURORA models energy storage resources, i.e. pumped storage, batteries, etc. A resource is treated as a storage project if it references a fuel type that begins with word "Storage".

To define the storage project characteristics, the model uses the standard resource input variables, as well as additional inputs for recharge capacity, storage limits, and project initial contents. The charging / generation cycle efficiency is defined through the resource heat rate.

Heat Rate - For storage resources, enter a value such that the ratio of 3412/Heat Rate gives the storage efficiency for the unit (3412 being 100% efficient).

Fuel - Energy storage resources must reference a fuel name that begins with "Storage".

Recharge Capacity - (Text) The maximum rate (MW) at which a storage resource can be recharged. This value defines maximum output on the storage side during charging. Energy input required to achieve this recharge rate will be higher by the reciprocal of unit efficiency. Recharge capacity can be changed on an annual basis by using the name of an annual alpha vector in this field.

Maximum Storage - (Text) The maximum live storage content of the storage resource in MWh. This value can be changed on an annual basis by using the name of an annual alpha vector in this field.

Initial Contents - (Single) Initial storage content of the storage resource at the beginning of the study. This value is input as a fraction and is multiplied by the Maximum Storage value to get initial contents. The value used here should reflect expected storage contents at midnight on the first Sunday of the first month of the study.

At the beginning of each week during the run, AURORA determines a charging and generation schedule for each storage project for the coming week. The inputs mentioned above are used, as well as a dynamically updated hourly area price forecast information for the week. Within each day across the week, the model identifies the combination of hours in which it is cost-effective to store and to generate without violation of the project storage constraints. It assures that revenue during the generation hours exceeds the cost of charging energy adjusted for cycle efficiency, plus any variable O&M costs incurred. Once the hourly schedule for the week has been determined, it is locked in and used to modify area load for the hours actually being dispatched as the simulation proceeds through the week.

In any individual dispatch hour, the actual hourly cost of recharge energy or the revenue from hourly generation is based on the area price determined by the full dispatch for that hour.

The default configuration for AURORA is to optimize the recharge/generation schedule, under the week-ahead price forecast, on a daily basis for each day of the week except Sunday. The schedule for Sunday will be determined using an extended price forecast into the following week. This option can be disabled on the Logic tab under Run Setup on AURORA's main form.

Use Extended Period for Storage Scheduling. When the switch is on the storage scheduling decisions for Sunday are made by extending the forecast into the following week, using a scheduling horizon through Tuesday of the following week.

With this switch turned off, scheduling decisions for Sunday will be made only on Sunday forecast hours.

There are two issues the user should be aware of when evaluating the value of energy storage projects using AURORA.

1. It's important to note that the week ahead hourly price forecast AURORA uses for determination of the hourly charging/generation schedule can and probably will differ from the prices determined by the full dispatch for the week ahead. It is possible for projects that have a marginally economic schedule based on forecast prices, to result in an uneconomic operation for a week if the full dispatch prices are substantially flatter than the forecast prices. This was an infrequent occurrence under testing with the standard AURORA databases.

2. It is important to run enough dispatch hours to capture the full economics of the charging/generation schedule. EPIS recommends using a minimum hourly setup configuration of every hour for at least one week a month.

Monthly Hydro Shaping:
The hydro shape for a month will reflect the data input in the Hydro Shaping table

Long-term Optimization Logic.

Long-term optimization studies are used to forecast capacity expansion resources and retirements. In AURORA you can put future resource units in the database with pre-determined start dates. Or, you can use the long-term logic that uses market economics to determine the long-term resources and the start or retirement dates. This optimization process simulates what happens in a competitive marketplace and produces a set of future resources that have the most value in the marketplace. AURORA assumes that new generators will be built (and existing generators retired) based on economics. The economic measure used is real levelized value (revenues less cost) on a $ per MW basis. Investment cost is included in the cost portion of the formula. Also, the methodology assumes that potentially non-economic contracts will not influence the marketplace and that someone will capture the opportunity value of non-economic contracts. Therefore contracts are not modeled in the pricing piece of AURORA.

In preparing for Long-term optimization studies, users will identify New Resources to be evaluated in the study and determine parameters for the study.

NEW RESOURCES

In the New Resources Table in the database is where the user defines a new resource and its operating characteristics. For example, the type of resource: Wind, Solar, Nuclear, Coal, Gas, Etc.

The new resources table contains columns that allow the user to define all the variables of a new unit, including when the potential unit will be placed in service. These variables provide controls for placing operating constraints on all the units in the system.

AURORA will calculate a value for each unit. This value is a Real Levelized Net Present Value (NPV) in $/MW. The capital cost is part of Real Levelized cost. AURORA uses the Real Levelized cost to make decisions about new units.

AURORA RESOURCE VALUE

AURORA determines resource value from the difference between market price and resource cost. This determination is performed for every hour for every resource in the region. Thus, a very accurate value is developed which takes into account system value during on peak and off-peak and other hours, and during daily, seasonal, and annual periods of time.

The user can specify the use of variable operation and maintenance expenses along with fixed operation and maintenance expense in the computation. We recommend however, that the value computation be performed on all forward costs. This produces the best economic view of the resource.

The net present value per MW of each resource is found for all periods of the study. This net present value is used in long term future analysis for determining whether a new resource should be added to the system or whether an old resource should be dropped.

STEPS IN LONG-TERM OPTIMIZATION

1. The first iteration begins with no changes in resources for the time period of the study. (AURORA uses resources in Resources Table)
2. Enumerates all new resources
3. Computes value for each existing resource
4. Computes value for each new enumerated resource
5. Sorts resource values
6. Selects a small set of the most negative value existing resources to retire
7. Selects a small set of the most positive value new resources to add.
8. Rerun AURORA to compute electric prices and resource value
9. AURORA repeats the Genetic/Darwinian algorithm until the system stabilizes

This is done on a gradual basis because large changes to the resources would change all of the assumptions used to compute value

This optimization approach provides an excellent approximation for how the competitive marketplace will select resources in the long-term. Resources that create value on a going-forward basis will be constructed while those that have no value on a going forward basis will be retired.

A primary result of a future analysis is a NEW RESOURCE MODIFIER table. A resource modifier table is created and becomes part of the AURORA input database. This table is the only output saved to the input database.

The output of this study may be used to input assumptions for other long-term analyses where the assumptions are applicable. The purpose of a resource modifier table is to add or retire resources in the main resource table of the applicable database.

Bidding Logic

In addition to electricity price forecasts based on the fundamental drivers, users may reflect non-fundamental price behavior by modeling bidding in the market place. This may be modeled using Bidding Logic.

The bidding logic is an optional feature in AURORA. The Use Bidding Logic box is used to control whether AURORA uses bidding logic for resource operation.

For the bidding logic to implemented, users provide input in the following tables:

In the Resources Database Tables, bidding factors and bidding shapes may be input. If they are, then they are used only if this checkbox is set.

To reflect what suppliers may bid, Bidding input put in the Resources Table and the Fuel Table, where a **Bid is equal to (1+bidding factor) x unit's marginal cost x hourly shape factor**

Bidding Factors: Specify by generating units or fuel types.

Bidding Shapes: Specify hourly shape by units by pointing to Weekly Shaping Factor Table.

The following are instructions on the Resources Table relating to bidding:

This table provides the input assumptions and parameters for all existing resources in the region being modeled. Generally, when a -1 appears in the Resource Table, the model retrieves the correct input parameter from general parameters for each fuel type.
Bidding Factor: A (Text) column that allows a value. If this value is a numeric value greater than 0 then it is a factor, which will be added to one and multiplied by the total resource variable cost to get the dispatch cost for the resource.

This simulates bidding at prices that are greater than the cost of a resource. This number will override any general resource dispatch margin, which may be used. If this value is a non-numeric alpha value then it points to an annual alpha vector where the values are input annually. If this value is a negative one then the fuel default is used. If this value is less than negative one then it is a pointer to a monthly shape vector where monthly values are input.

Bidding Shape: A (Text) column that allows the number of the weekly shape vector (of hours) to use for shaping the bidding factor hourly (they are multiplicative). An alpha string may be used in this field. If it is, then it points to an annual alpha vector, which must point to a monthly shape factor. The monthly shape factor then contains the weekly shape vector for each month. By this means, you can vary the shape by month and year. If this is zero, -1 or not given, then no shape is used.

The following are instructions on the Fuel Table relating to bidding:

Bidding Factor - (Text) If this value is a numeric value greater than 0 then it is a factor, which will be added to one and multiplied by the total resource variable cost to get the dispatch cost for the resource.

This simulates bidding at prices that are greater than the cost of a resource. This number will override any general resource dispatch margin, which may be used. If this value is a non-numeric alpha value then it points to an annual alpha vector where the values are input annually. If this value is less than negative one then it is a pointer to a monthly shape vector where monthly values are input.

SELECTING OPTIONAL LOGIC SETTINGS:

In AURORA, the user is able to control many of the parameters that relate to the above logic by using the switches and settings on the Logic Tab.

Use Operating Reserves box is used to control whether AURORA reserves generation for operating reserve purposes.

If this box is checked, then AURORA will reserve a percentage of resources at the top of the stack for operating reserves (the capability of these resources will be set to 0 for the hour). The percentage of resources reserved is set to 6.5 percent by default. The Areas table in the input database can be used to change those defaults. The exact formula used in the reserve requirement calculation is as follows:

ReserveRequirement = (ResourceCapabilityForArea + HydroResourceReservesForArea) * PercentReserveRequirementForArea/100 - HydroResourceReservesForArea

Use all Areas for Hydro Shaping When the switch is on demand for all areas in the system is aggregated and the total demand is used for shaping hydro rather than the demand in the area the hydro is located. See the explanation of the hydro shaping logic for more information.

Use Price Caps allows the use of price cap inputs in the area table.

Use Extended Period for Storage Scheduling When the switch is on the storage scheduling decisions for Sunday are made by extending the forecast into the following week, using a scheduling horizon through Tuesday of the following week.

With this switch turned off, scheduling decisions for Sunday will be made only on Sunday forecast hours.

Use Second Order Dispatch The second order dispatch switch computes the marginal pricing for load above the marginal resource by using a second order equation rather than the linear interpolation of the standard dispatch.

This option will result in somewhat lower prices and will cause AURORA run time to significantly increase. Generally, we recommend that this switch not be used. Consult with EPIS.

Use Decremental Dispatch The decremental dispatch switch should not be set unless you have consulted with EPIS.

Normalize Demand and Hydro box is used to control the normalization of hourly demand and hydro factors.

When the box is checked, then hourly demands and hydro factors, for a month, for the hours that are dispatched are modified so that the monthly average is exactly one.

For demand, there is also a flag (default is true) for each demand number, which can be set in the Escalation of Demand table. Both the global box on this tab and each individual demand numbers flag must be set for the demand for that number to be normalized. However, if you are doing daily mode runs, then the normalization of demand will be for all hours in the month and hydro factors will not be normalized.

When the box is not checked, no modifications are made to the input hourly demands or the hourly hydro factors computed by the hydro optimization routine.

Use Bidding Logic box is used to control whether AURORA uses bidding logic for resource operation.

In the Resources Database Tables, bidding factors and bidding shapes may be input. If they are, then they are used if this checkbox is set and are not used if this checkbox is not set.

Use Ramp Rate box is used to control whether AURORA uses resource ramp rates in determining resource capabilities. Ramp rates affect the resource capacity that is available to dispatch in any given hour, making it a function of the resource output in the previous dispatch hour.

Ramp rate logic will only be effective if AURORA is set to dispatch for all hours (8760 per year). Ramp rates are input as a percent for individual resource units or by fuel type. Generally, the ramp rate logic will affect market prices during shoulder hours when load is increasing.

Dispatch Resolution drop-down allows the user to control the dispatch resolution. For most purposes, this should be left at normal. The dispatch provides a system dispatch that is computed in a radically new way. Using genetic algorithm techniques, AURORA determines clearing prices in all system geographic areas for each dispatch hour. System resources are not used like they were in the old dispatch (the master resource table will be empty); each area will have its own marginal unit (the next unit to dispatch in the area) for a particular hour. Those are displayed along with the area prices for an hour (see hour area in the view button screen). Contact EPIS before changing the dispatch resolution.

Dispatch resolution affects what % of difference exists between existing areas. Selecting a higher than normal resolution will result in a smaller difference between areas. The default is NORMAL, which represents reality more accurately.

Use Congestion Pricing box is used to control whether AURORA will use congestion pricing on the effective link wheeling rates. You may add the column "Link Congestion Year" to the Link table and set the first year you want each link to use congestion pricing (default, pricing will be used for the link). When congestion pricing is used, link-wheeling rates are determined by the following formula:

70 - Exponent for congestion pricing (by default).

The user can change this with the Congestion Exponent box.

Congestion Wheeling Rate = Input Wheeling Rate times Fraction Link Loaded ^ Exponent times 1000

The effect is to multiply the Input Wheeling Rates by the values from the chart below with the x-axis representing the congestion or the fraction the link is loaded.

Note - a value of one occurs at about .905 with an exponent of 70.

Resource Dispatch Margin The resource dispatch margin (in percent) determines what margin is required for a resource to run. This margin is applied to all resources in the system. The dispatch margin is multiplied by a monthly shape factor if one is pointed to by a value in the box for monthly shape for dispatch margin.

Monthly Shape for Dispatch Margin Pointer to a Monthly Shape Vector, located in the Monthly Shape Factors Database Table, for shaping the dispatch margin.

Non-Commitment Penalty The Non Commitment Penalty allows the user to specify the "penalty" or increment (in percent) in the dispatch cost to be used to dispatch a commitment type unit when it has not committed for operation.

By default, this is set to 2900 percent or a 30 times penalty so commitment-type units will not run if not committed.

Risk Analysis

Prices and values of resources and portfolios may be forecast and understood under conditions of uncertainty. AURORA's speed makes it possible to get results in a matter of hours, not days. To see the effects of uncertainty, AURORA samples from statistical distributions of key drivers. AURORA can be run in Monte-Carlo or Latin Hypercube mode, results are tabulated, and a full set of statistical results can be analyzed. For instance, the effects of summer-peaking situations may be understood or the effects of hydro uncertainties can be examined. Because the basic economics of the system are not linear, this kind of analysis can lead to insights that would not otherwise be available. On the Risk Tab, the user can select risk analysis to be able to perform Uncertainty Analysis.

In the Risk Analysis demand, fuel, hydro and resources can be sampled from distributions including normal, log-normal, uniform and binomial distributions. Also, the user can sample from a user-defined distribution. The sample draws may be done as Monte-Carlo or Latin-Hyper-cube sampling. For each iteration sampled, AURORA provides detailed sample/iteration results, statistical results (mean and standard deviation), and histogram results

Also, AURORA may be used as a "pricing" application or engine within another Monte Carlo application or system of models.

Data Elements of AURORA Software

Run Set-Up Controls

Set the Time frame--next hour to very long term (20+years)

Set the Price Forecasts Output

For Areas and Trading Hubs may output prices for following time frames:

Hourly prices
Daily prices
Monthly prices
Annual prices

Resource Forecasting

Hourly, daily, monthly and annual operation, cost, and value
Marginal resources and fuels
Dual fuel modeling
Cycling and commitment resources
Minimum down and up times
Must-run resources (set monthly or annually)
Multiple Segments and Heat Rates
Ramp rates
Bidding factors by resource
All existing resources (thousands)
Emissions dispatch and reporting
Planned resources
New resource additions
Automatic capacity expansion
Resource Stacks displayed graphically
Resource dispatch order information available

Portfolio Value

Hourly, monthly and annual cost, revenue and value
Hundreds of contracts and resources in each portfolio
Many portfolios examined simultaneously
Many contract types, including a variety of option and must-takes

Basic Variables

Resource cost and availability
Hourly demand by area
Transmission costs and constraints
Demand-side cost and availability

- Thermal Resources including ramp rates
- True economic commitment logic
- Peaking and Non-cycling unit commitments
- Hydro Resources
    - Annual, monthly and hourly factors
    - Optimization of hydro on weekly basis
    - Hydro constraints include maximum and minimum stream flows
- Flexible new resource definitions
- Unlimited new resource types
- Unlimited emission types
- Market-value-driven resource decisions
- Flexible constraints on new resources and retirements

DATA INPUTS

AURORA is very flexible and can be used for a variety of purposes through changing its input data. Below is a discussion of the major input variables, their purposes, constructs, and with some sources for updates.

Also it should be noted that the economic assumptions in AURORA can be overridden by user input. For instance, modeling the new FERC price caps in the west requires non-economic assumptions, but can be modeled in AURORA.

In the Appendix is a complete set of AURORA input tables with definition of variables.

Annual Alpha Vectors

Purpose: resource parameters that vary by year

Principle Variables:

- heat rates, allows technology improvements for future resources
- variable O&M, differing rates in future for new or existing resources
- fixed and variable O&M of future resources, including capital costs
- rebuild costs, tests recovery of cyclical costs to rebuild generator (e.g., 20 year life cycle of certain equipment)

Annual alpha vectors are used as a reference for variables that may be changed yearly. This table is replacing the Annual Vectors table. This table has the word alpha in it to indicate that the table requires the use of alpha characters in the references to it. The alpha characters are used to indicate that a reference is implied rather than a value. Variables that may be input via the Annual Alpha Vectors table are documented with the variable definition.

Annual Vectors

Purpose: inputs varying by year

- resource build and retirement limits

- inflation rate
- fuel pointers to monthly shapes
- hydro pointers to monthly shapes
- annual load escalation

Principle Variables:

- load escalation with differential annual escalation
- inflation rates
- can specify annual fuel costs with differential annual escalation

Data Sources/Tools: inflation rates from government agencies: e.g., BLS, OMB, EIA

- inflation rates from subscription companies: e.g., DRI, WEFA
- annual load escalation from NERC regions from Loads and Resources Assessment order forms annual load escalation from FERC 714 filings http://www.ferc.fed.us/electric/f714/F714data.htm

Annual vectors are used as a reference for variables that may be changed yearly such as inflation rates and annual growth in demand. Variables which reference annual vectors include: transmission wheeling (reference monthly shape of transmission costs for each year), new resources (annual maximum number of units), escalation of demand (annual growth rate in demand specified for each area), and general information (inflation rate). This table is being phased out and replaced by the annual alpha vectors table. Other vector tables include "monthly shape factors" and "hourly shape factors".

Areas

Purpose: specifying the areas for which prices are determined
Principle Variable: creating new/different areas

- define existing resources, future resources, loads, and transmission
- existing resources: fuel costs, hydro parameters, and load curtailment 'resource'
- future resources: fixed O&M, variable O&M, fuel costs
- loads: base year annual average load, monthly and hourly shapes, annual growth rates
- transmission: paths with transfer limits, transmission charges and loss rates with each other area

Listing of geographic load and resource areas identified in the model. The selection is generally based on significant areas where transmission interconnections with other areas are well defined.

Columns include:

- Area Number - Area identification number.
- Area Name - A name for the area.

- Area Demand Number - A pointer to the column in demand tables to use for the area (the demand tables are the "demand" (hourly) and "demand case" (monthly and annual tables).
- Average Marginal Cost (Optional column type single) - If input, this provides the rolling average marginal cost (over 12 months) to use at the beginning of a run.
- Area Reserve Requirement (Optional column type single) - If this column exists, then the values in the column (including 0 or blank) override the default value of 6.5 % for area operating reserve requirements when the use operating reserves check box is set. The values are input as a percentage.
- Short Area Name (Optional column type text) - If this column exists, then the values will be used for a shortened form of the area name (used with some outputs). If this column does not exist, then the short area name will be the left 5 characters of the area name.
- Price Cap (Optional column type single) - If this column exists, then the non-zero values will set a price cap for the area. The price cap will be artificial and will not effect resource dispatch. It may affect connected hub prices. The Use Price Caps checkbox must also be set.
- Exact Supply Pricing (Optional column type boolean) - If this column exists, then those areas with this column checked will have prices computed based on the exact dispatch cost of the marginal supply side resource. Because of this logic, imports will not be used for the pricing.

Hourly Demand

Purpose: hourly load shapes for each month. A set of hourly loads or percentages, which define each month's hourly load shape for each area.

Principle Variable: historical multi-year averages can be used to specify a 'normal' year

- an actual year can be specified to model either a high or low year data sources hourly loads available through FERC714 control area hourly loads http://www.ferc.fed.us/electric/f714/F714data.htm

This is a data table of hourly load factors for an annual period (8760 + 8 days). Each column is numbered and is referenced by an area or portfolio/power cost entity. In general, EPIS has set up the table columns to match the areas. The load data begins on a Monday and continues for an additional 192 hours (8 days) at the end of the year. This allows for indexing in on the table to the correct beginning day of the week for any year specified (including leap years). AURORA can automatically normalize the hourly demand factors so that the average of the demand factors for the hours being dispatched in a month always equals 1.0. This is controlled from the logic tab. Please note that the columns in the Demand table must be in the following order. Additional columns are not allowed in this table.

Columns include:

Hour - The hour in the year beginning on a Monday at 12:00 - 1:00 a.m.
Number - The identification number as used by the area or portfolio/power cost entity using this table. These numbers must be sequential. This column is repeated for each demand number in the database.

Demand Moderate

Purpose: annual average load and monthly shapes
Principle Variables: area load forecasts

- monthly load shapes for each area

Data Sources:

- historical EIA utility loads from Annual Energy Report, useful for allocating a larger area forecast to smaller AURORA areas
  http://www.eia.doe.gov/cneaf/electricity/esr/esr_tabs.html [Table 17]
- NERC load forecasts (compilation of utility forecasts)
- EIA Annual Energy Outlook forecast (utilizing NEMS)
  http://www.eia.doe.gov/oiaf/aeo/electricity.html

Fuel Moderate

Purpose: specify fuel cost and generic operating parameters by resource type
Principle Variables: fuel prices

- resource operating parameters: O&M, availability, commitment and must run designation

Data Sources:

- EIA Annual Energy Outlook forecast
  http://www.eia.doe.gov/oiaf/aeo/supplement/index.html
- EIA historical data, FERC 423, cost of fuel by plant
  http://www.eia.doe.gov/cneaf/electricity/epm/epm_sum.html
  http://www.ferc.fed.us/electric/f423/form423.htm
- And, various proprietary gas-forecasting services.
  See EPIS Energy links on www.epis.com

Hydro Moderate

Purpose: specify hydro energy generation
Principle Variables: annual and monthly hydro energy specified in percentage of installed hydro capacity
Data Sources:

- EIA 759 monthly generation, hydro reported by resource
  http://www.eia.doe.gov/cneaf/electricity/page/eia759.html
- NERC regions resource data

- Power pool and planning information

Link

Purpose: specify transfer capability across transmission paths
Principle Variables: inter-area transmission path transfer capability
Data Sources:
The primary source of data for this table is a wholesale transmission map. The WSCC transmission map showing transmission limits is available from the Western System Coordinating Council (www.wscc.com) or WSCC Path Rating Catalog in FERC 715 filing (http://www.ferc.fed.us/electric/F715/F715data.htm). The National transmission map showing transmission limits is available from the North American Electric Reliability Council (www.nerc.com).

For transmission, the primary source of data is wholesale electric transmission tariffs. However, transmission data will be used as incremental wheeling cost and losses components of the marginal-clearing price of unit(s) on the margin. Therefore, the values used here should reflect the cost of transmission and wheeling for the resource on the margin. Counter-flow scheduling and resale of unused firm transmission rights (i.e. non-firm) should be considered in judging the values input to transmission.

Review Data: By activating the "Sys" button on the AURORA toolbar prior to a run you are able to view the transmission system geometry as defined by the Link table.

Monthly Shape Factors

Purpose: specify various inputs that change by month
Principle Variables: seasonal generation capacity changes

- splitting generation between areas by season
- fuel shapes
- hydro operating parameters

Data Sources: Existing Resources

New Resources

Purpose: specify various inputs that change by month
Principle Variables: seasonal generation capacity changes

- splitting generation between areas by season
- fuel shapes
- hydro operating parameters

Data Sources:

- State siting agencies and Western Interstate Energy Board
- News reports (Internet searches)

- McGraw-Hill Power Generation Markets Quarterly info: http://www.mhenergy.com/products/electric/pgmq.html
- Multiple sources: See EPIS Energy links on www.epis.com

This table provides the input assumptions and parameters for new resources types to be evaluated when the model runs a long-term study. It optimizes the expansion and retirement of resources. This table is similar to the resource table. Values in this table, which are set to -1.0, indicate that the value from the fuel table should be used for the area (in the case of hydro).

Heat rate, fixed O&M and variable O&M fields may be input as text strings. If the fields are not numeric, then they are assumed to point to a record in the Annual Alpha Vectors table. Thus values for heat rate, fixed O&M, and variable O&M can now vary by year. For the new resources table, the values will be the values used for all years for the vintage of new resource being created for the capacity expansion. If you need to use changing annual "real" values for a vintage of new resources then the Annual Alpha Vectors table may contain a text string which should point to another record in the Annual Alpha Vectors table which contains the appropriate annual "real" values for that vintage new resource. For the resources table, the values in the Annual Alpha Vectors table will be the annual "real" values used in the run.

The column order in the resources table is not important. Column names must match those below exactly. When adding columns to an EPIS supplied database, you should check your results carefully to ensure that the column names were correct and the data is actually being read.

Columns include:

- Number - Identification number for the new resource type. New resources created for evaluation from these types are numbered sequentially starting at one and if they are actually used in the dispatch, then they are numbered sequential, starting with the next number after the last existing resource.
- Name - The reference name of the resource, used for reporting purposes. The letters "demand" anywhere in a resource name indicate that the resource is a demand side rather than a supply side resource.
  The names are subject to the following constraints:
  - Can be up to 30 characters long.
  - Can include any combination of letters, numbers, spaces, and special characters except a period (.), an exclamation point (!), an accent grave (`), and brackets ([ ]).
  - Can't begin with leading spaces.
  - Can't include control characters (ASCII values 0 through 31).
- Utility - Generally not used for new resources, but you can identify resources by utility.

- Heat Rate - The heat rate assumption for the resource in BTU of fuel energy per kWh delivered. This is a standard measure of energy efficiency for thermal resources and should be the higher heat rate value, not the manufacturers lower heat rate. This field may be left blank for units with zero fuel cost.
- Capacity - The rated plant capacity in kilowatts (not MW)
- Fuel - The fuel identification reference number as identified in the "fuel case" table. Each resource must include a fuel reference number of a valid fuel in the fuel table.
- Area - The area where the resource is located. The resource must be in one of the areas identified in the "area" table.
- Variable O&M - Variable operation and maintenance expense is expressed $/MWh.
- Fixed O&M - Fixed operation and maintenance expense (plus any investment carrying costs) for new resources of this type, expressed in $ per MW-week. A typical input with 3 $/MWh fixed O&M for a unit in full operation would be 3x168 hours per week or $504. Since fixed O&M are not dependent on plant operation, the fixed cost is applied regardless of plant operation. See the appendix article on Investment costs for information on how they should be included in this input.
- Maintenance Begin - day/month/year that maintenance begins. The maintenance will repeat annually from this date forward. See editing summary for information on using the calendar.
- Maintenance End - day/month/year that maintenance ends. This date specifies the period at which annual maintenance will end. When multiple years are run in the model, the maintenance period will be repeated each year beginning and ending on the same day. At this time, varying annual maintenance periods cannot be input to Aurora. When maintenance periods change yearly, the model can be run separately for each year. See editing summary for information on using the calendar. Generally, if you do not want maintenance by date, you should put a 1/1/80 in the maintenance end date and a 1/2/80 in the maintenance begin date in the fuel table only. Put the dates of 1/1/80 in both columns in the resources, resource modifier and new resources tables - a date of 1/1/80 defaults to whatever is in the fuel table. If you want to put non-defaulting dates in other tables, use something like 1/1/81 and 1/2/81 and not 1/1/80 and 1/2/80 because 1/1/80 will default to the fuel table and 1/2/80 will not.
- Forced Outage - The percentage of time the resource will be unavailable due to unscheduled outages. This field reduces the plant capability for each dispatch multiplying the plant capacity from this Table by the quantity 1- forced outage percent/100. This value may be an alpha, which would point to an annual alpha vector. There is the capability to use a number greater than 1000. If this is done, then the logic will use the monthly vector pointed to by the value in the forced outage field less 1000. If the resulting forced outage rate field is negative, then AURORA will assume the absolute value of the field is a pointer to a weekly vector where the hourly forced outage rates are input.
- Maintenance Rate- The percentage of time the resource will be unavailable due to scheduled outages. This field reduces the plant capability for each dispatch multiplying the plant capacity from this Table by the quantity 1- Maintenance Rate/100. This value may be an alpha, which would point to an annual alpha vector.

There is the capability to use a number greater than 1000. If this is done, then the logic will use the monthly vector pointed to by the value in the maintenance field less 1000. If the resulting maintenance rate field is negative, then AURORA will assume the absolute value of the field is a pointer to a weekly vector where the hourly maintenance rates are input.

- Non Cycling - Non-zero number indicates percent premium of market price over dispatch cost required to dispatch the resource during the commitment period (one week). Once on, the unit remains on at least at minimum capacity until the next commitment period.
- Must Run - Flag (on is 1, off is zero) which sets the units to a "must run" condition. Units that have this flag set assume a zero cost of dispatch and will be the first units to operate.
- Hydro Number - For hydro resources, any of the hydro shapes in the "hourly hydro factors" and "hydro monthly" tables may be reference for any hydro resource unit. The user may also choose a new hydro shaping factor for any hydro resource by including a new shape in both the "hourly hydro factors" and "hydro monthly" tables and referring to that shape in the "resource" table.
- Minimum Capacity - For non-cycling resources, specifies the minimum capacity at which the unit can run when the non-cycling logic is active. The unit for the input is percentage of resource capacity.
- Begin Date - The beginning date when this resource is available to be included in a capacity expansion. See editing summary for information on using the calendar.
- End Date - The ending date when this resource is available to be included in a capacity expansion. See editing summary for information on using the calendar.
- Annual Max - A reference to the "annual vector" table indicating the maximum number of these units that are available in the year of capacity expansion.
- Overall Max - Maximum number of the new resource type resources that will be created.
- The following fields or columns are optional.
- Resource Group - (Long) The resource group that new resources created from this type will belong to.
- Capacity Monthly Shape - (Long) If this value is greater than zero, then it must be a reference number to a valid row in the monthly shape table where monthly factors for shaping capacity are input.
- Min Up Time - (Long) The minimum number of hours the unit must stay up if committed to run with new commitment logic. Defaults to fuel table if this column is not in the database.
- Min Down Time - (Long) The minimum number of hours the unit must stay down if it is a commitment type (non-cycling non-zero) and not committed with new commitment logic. Defaults to fuel table if this column is not in the database.
- (Emission Type Name) Emission Rate - (Single) This field or fields contains the resource emission rate in lb/mmbtu for the emission type given by the name. The field or column name is the concatenation of the emission type name and " Emission Rate". Monthly rates should not be used for new resources.

Resources

Purpose: specify existing resources, costs, and operating parameters
Principle Variables: each available resource with its operating parameters:

- configuring hydro to save time and memory by combining like hydro resources in each area
- balancing resources with loads (consistent with statement of self-generation)
- cold-start generators, lower availability by using start up cost
- must-take energy, must run with high minimum capacity
- differentiate between CCCT and SCCT, FOR and minimum capacity

Data Sources:

- ES&D Energy Supply and Demand Report, an annual report by the federal government on existing resources
- EIA 860 (A & B) reports
- http://www.eia.doe.gov/cneaf/electricity/page/data.html

Transmission

Purpose: specify transmission prices and losses between each pair of areas
Principle Variables:

- wheeling charges can be specified within each area to get delivered prices specifying within an area will distort generator value computations
- percentage rates for transmission line losses

Data Sources: FERC tariffs for OAT charges and losses

Weekly Vectors

Purpose: specify variables by hour within a week
Principle Variables:

- defines hours in "Conditions", e.g., on-peak and off-peak hours
- allows shaping of resources or contracts
- provides weekly shaping factors by hour that can be referenced by the condition table, the portfolio contract table, the electric price table and/or the resources table. Weeks begin on a Monday.

Columns include:

- Number - A reference number that is referred to in the condition table or the power cost/contract table.
- Name - The name of the vector. Not used by AURORA.
- 1-168 - The hourly value of the vector for each hour of the sample week - the first hour is hour 0 to 1 of Monday.

Information on the complete set of AURORA input tables with definition of variables are in the Appendix. This is from the AURORA on-line documentation. It is recommended that users use the on-line information to ensure the use of the latest information.

Sample Output of AURORA

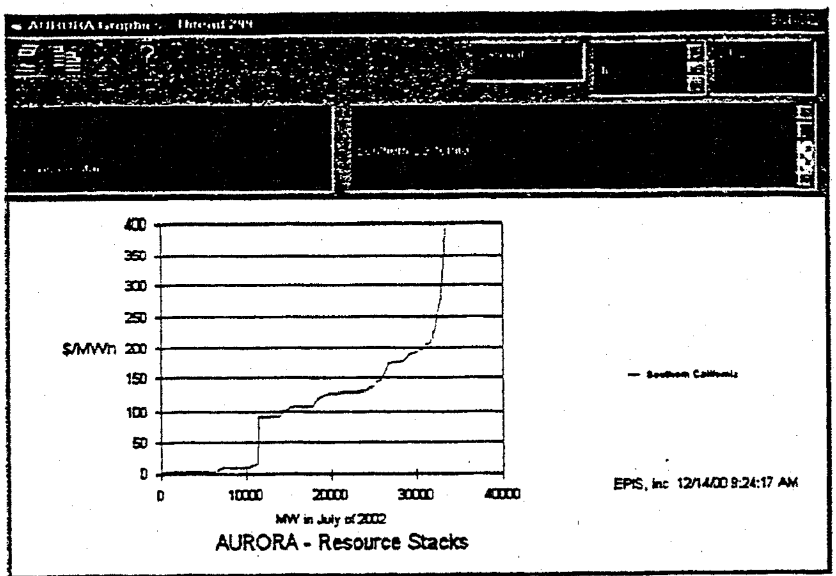
AURORA enables the user to view the results while the results are still in the virtue memory of the computer, or to create an output in AURORA, MS Access or MS Excel. This enables users to view all assumptions and results. Results are presented in straightforward graphical and spreadsheet-like grids.

By way of example, outputs for Resource Stacks and Marginal Fuel information are shown below. In the appendix a complete list of the outputs is available.

See Figure 1 below for an example of a Resource Stack for Southern California for July 2002 based on Capacity (MW).

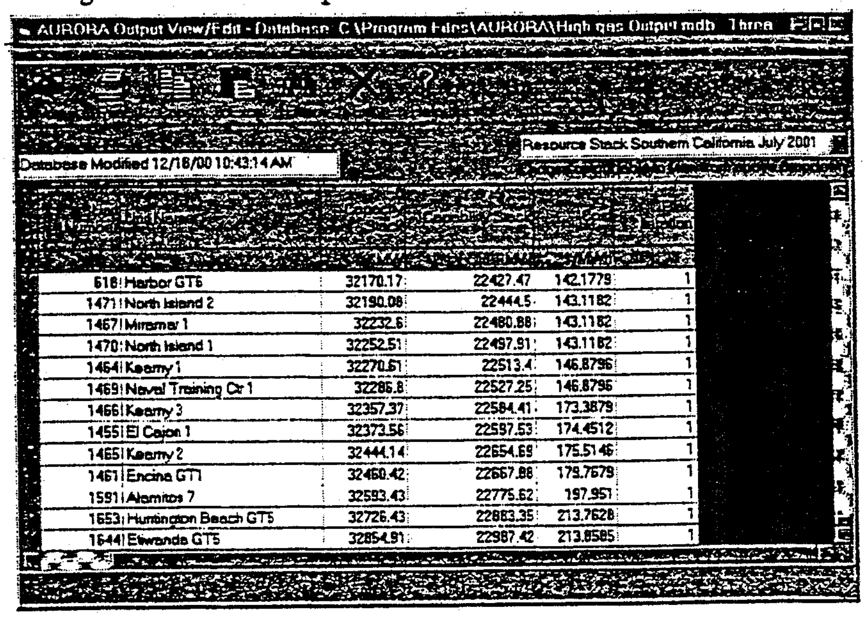
- Resource Stacks are available in terms of Capacity (MW) or Capability (De-rated Capacity in MW).
- You may choose one or multiple areas to display (by holding the "Ctrl" key down while clicking).
- By right clicking on the graphical output, you can choose the copy command and copy the graph and its data to the clipboard for pasting into other applications.
- The toolbar gives buttons for printing or copying the data in the graph or for exiting the graphics display.

Figure 1: Graphical Display of Resource Stacks



- *Resource Stack Information Standard Output.* In addition to the graphical display, you can get the lists of resources in the area resource stacks with dispatch costs and dispatch order.
- By left clicking in the upright corner of an output table, you can choose the copy command and copy the data to the clipboard for pasting into other applications, or you can just push the "ToExcel" button and the data will be exported to an MS Excel Workbook.
- The toolbar has buttons for printing or filtering of data in the table display.

Figure 2: Standard Output of Resource Stack Information.


AURORA Output View/Edit - Database C:\Program Files\AURORA\High gas Output.mdb Three

Resource Stack Southern California July 2001

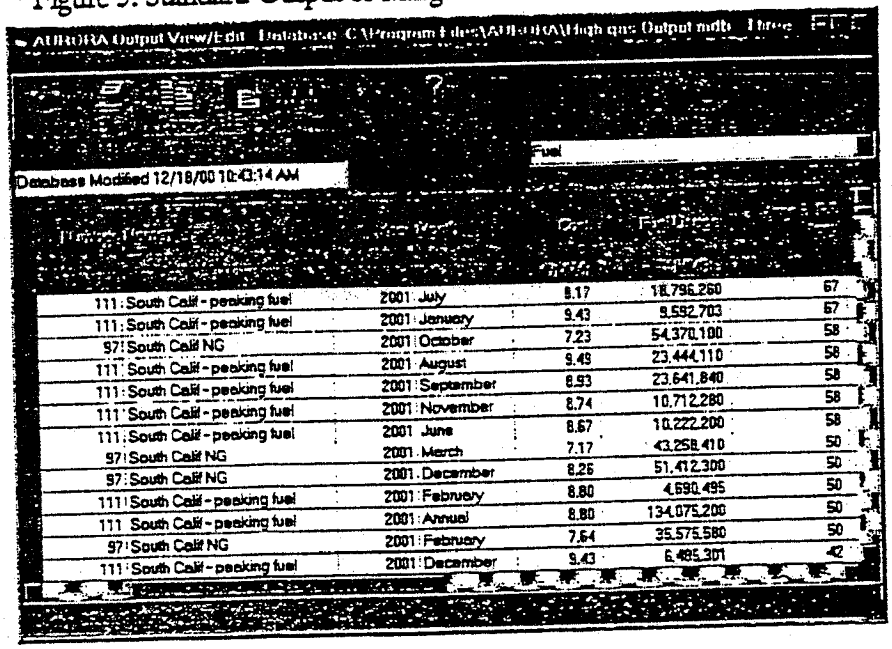
Database Modified 12/18/00 10:43:14 AM

618	Harbor GT6	32170.17	22427.47	142.1779	1
1471	North Island 2	32190.08	22444.5	143.1182	1
1467	Miramar 1	32232.6	22480.88	143.1182	1
1470	North Island 1	32252.51	22497.91	143.1182	1
1464	Kearny 1	32270.61	22513.4	146.8796	1
1469	Naval Training Ctr 1	32286.8	22527.25	146.8796	1
1466	Kearny 3	32357.37	22584.41	173.3879	1
1455	El Cajon 1	32373.56	22597.53	174.4512	1
1465	Kearny 2	32444.14	22654.69	175.5146	1
1461	Encina GT1	32460.42	22667.88	179.7679	1
1591	Alamitos 7	32593.43	22775.62	197.951	1
1653	Huntington Beach GT5	32726.43	22883.35	213.7628	1
1644	Etiwanda GT5	32854.91	22987.42	213.8585	1

Marginal reporting for Fuels, Resources and Groups

Fuel Output. A fuel output table is now available as a standard output at the end of each AURORA run. It has monthly and annual fuel cost, fuel usage and percent marginal for each area. Specifically, for each month of the year and annual, the FUEL report displays fuel cost in $/mmBTU, fuel usage in mmBTU and the percent of time in the period the fuel was being used by marginal generation for each area. See Figure 3 for an example.

Figure 3: Standard Output of Marginal Fuel Information


Fuel

Database Modified 12/18/00 10:43:14 AM

111 : South Calif - peaking fuel	2001 : July	8.17	18,796,260	67
111 : South Calif - peaking fuel	2001 : January	9.43	9,592,703	67
97 : South Calif NG	2001 : October	7.23	54,370,100	58
111 : South Calif - peaking fuel	2001 : August	9.49	23,444,110	58
111 : South Calif - peaking fuel	2001 : September	8.93	23,641,840	58
111 : South Calif - peaking fuel	2001 : November	8.74	10,712,280	58
111 : South Calif - peaking fuel	2001 : June	8.67	10,222,200	58
97 : South Calif NG	2001 : March	7.17	43,258,410	50
97 : South Calif NG	2001 : December	8.26	51,412,300	50
111 : South Calif - peaking fuel	2001 : February	8.80	4,690,495	50
111 : South Calif - peaking fuel	2001 : Annual	8.80	134,075,200	50
97 : South Calif NG	2001 : February	7.64	35,575,580	50
111 : South Calif - peaking fuel	2001 : December	9.43	6,485,301	42

Operating Platform

Software. AURORA uses the latest software technologies from Microsoft and other leading software vendors. The model is written in MS Visual Basic 6.0 (SP4) and MS C++ 6.0.

Ease of use and analysis of multiple scenarios are facilitated by Visual Basic Scripting (VB Scripting) capability in the AURORA software. VB Scripting is used to place results directly in MS Excel.

AURORA can use MS Worksheets for input by linking the worksheets to database tables.

Requires MS DAO and VB Scripting engines (installations are included with AURORA installation)

AURORA input and output are stored in standard Jet databases--MS Jet (Access 97) databases (Excel worksheets are also supported). Input databases are about 3-8 MB each.

We are using the latest MS software and all DLL's etc. included with the installation are the latest MS available.

AURORA is year 2K compliant and as far as we can tell, the MS software included is also year 2K compliant.

Hardware and Operating System AURORA is optimized to run on Pentium III or IV processors.

Minimum Requirements

The computer must meet the following minimum requirements. The processing will be slow for long-term capacity expansion runs. And, the minimum configuration is not recommended for performing risk analysis.

Hardware:

- Fast Pentium PC (at least 400 MHz)
- 128 MB and should have at least 256 MB of memory for long-term capacity expansion and for risk studies.
- 150 MB of free hard disk space for the install and enough free hard disk space for the virtual memory settings. Uses up to 20-80 MB of disk space for data and results depending on what (database capabilities) is currently installed on your computer.

Operating System:

- Windows XP, ME, 2000, NT4.0 (SP5), or 98
- Internet Explorer 5.5 or later is needed to use the HTML Help system

Recommended Requirements

This configuration will handle long term and risk analysis runs.

Hardware:

- Pentium III (at least 500 MHz)
- 256 MB of RAM (384 MB for 20 year studies with at least 400 MB of virtual memory)
- 150 MB of free hard disk space for the install and enough free hard disk space for the virtual memory settings
- Uses up to 40-120 MB of disk space for data and results (long term results databases are 3-6 MB unless you are writing resource operations or hourly information)

Operating System:

- Windows XP, ME, 2000, NT4.0 (SP5), or 98
  (Note: Windows 98 may not be stable for long term runs.)
- Internet Explorer 5.5 or later is needed to use the HTML Help system

APPENDIX

AURORA Inputs from AURORA On-line Documentation

Annual Alpha Vectors

Annual vectors are used as a reference for variables that may be changed yearly. This table is replacing the Annual Vectors table. This table has the word alpha in it to indicate that the table requires the use of alpha characters in the references to it. The alpha characters are used to indicate that a reference is implied rather than a value.

Variables that may be input via the Annual Alpha Vectors table are documented with the variable definition.

Annual Vectors

Annual vectors are used as a reference for variables that may be changed yearly such as inflation rates and annual growth in demand. Variables which reference annual vectors include: transmission wheeling (reference monthly shape of transmission costs for each year), new resources (annual maximum number of units), escalation of demand (annual growth rate in demand specified for each area), and general information (inflation rate).

This table is being phased out and replaced by the annual alpha vectors table.

Other vector tables include "monthly shape factors" and "hourly shape factors".

Data Documentation is here.

Area To Area Path

Note: This table is no longer used.

Areas

Listing of geographic load and resource areas identified in the model. The selection is generally based on significant areas where transmission interconnections with other areas are well defined.

Columns include:

Area Number - Area identification number.

Area Name - A name for the area.

Area Demand Number - A pointer to the column in demand tables to use for the area (the demand tables are the "demand" (hourly) and "demand case" (monthly and annual tables).

Average Marginal Cost (Optional column type single) - If input, this provides the rolling average marginal cost (over 12 months) to use at the beginning of a run.

Area Reserve Requirement (Optional column type single) - If this column exists, then the values in the column (including 0 or blank) override the default value of 6.5 % for area operating reserve requirements when the use operating reserves check box is set. The values are input as a percentage.

Short Area Name (Optional column type text) - If this column exists, then the values will be used for a shortened form of the area name (used with some outputs). If this column does not exist, then the short area name will be the left 5 characters of the area name.

Price Cap (Optional column type single) - If this column exists, then the non-zero values will set a price cap for the area. The price cap will be artificial and will not effect resource dispatch. It may affect connected hub prices. The Use Price Caps checkbox must also be set.

Exact Supply Pricing (Optional column type boolean) - If this column exists, then those areas with this column checked will have prices computed based on the exact dispatch cost of the marginal supply side resource. Because of this logic, imports will not be used for the pricing.

Adding or changing Areas is a significant process. Refer to the appendix on changing areas for more information.

Conditions

A pointer to the weekly vector table where identification of specific hours is made. This is used to define periods of time such as on- and off- peak periods.

This table gives the identification number used in the "weekly vectors" table where specific hours of a sample week are set.

Columns include:

Number - Identification number for the condition. This may be displayed in some output reports.

Name - Name of the condition such as on-peak, off-peak or heavy load, etc.

Weekly Vector - Identifies the vector to use from the "weekly vectors" table which specifies the condition for each hour (a one meaning set and a zero meaning not set).

Daily Case

Daily input for the model. The user creates a table with the "Case" name and chooses the table on the Run Setup / Study Period tab.

On this form:

· The record type column (column type is text) has dropdowns with the choices for types of data records (fuel, demand, resources or hydro). Once the record type is chosen, the Name column (column type is text) will display valid fuel, area (only hydro numbers that are a valid area number may be used for daily input) or resource names for the database currently being used. Use the dropdown to choose the appropriate value.

· The date column (column type is date) will display a calendar if you click on button in the cell.

· The change type (optional) column (column type is text) allows you to choose whether the input will be absolute value, percent change or absolute change. See the types below for more information. Resources can only have have a value of absolute value for this column. The default is absolute value if this column is not in the table.

· The value for the data is entered into the remaining columns (column type is text). The data in the column named 1 is for the date in the date column, the data in column 2 is for the day after the date in the date column and so forth.

· For fuel, for absolute value, the data is the fuel price (or basis) in $/mmBTU for the day. For percent change, the value is the percent change to the fuel value from the active fuel table. For absolute change, the value is the change in $/mmBTU for the fuel price or basis for the day. Any fuel costs not defined in the daily data table will default to the standard fuel cost from the active fuel table. Thus, transportation basis and other items that do not change on a daily basis can be input in the standard fuel table and only fuels with daily changing prices need to be input in this table.

· For demand, for absolute value, the data is the average demand for the day. Hourly demand factors from the demand hourly table for each day are applied to the average demand to obtain hourly demand. Those factors are normalized for the day to equal an average of one for the hours dispatched. For absolute change, the value is the change in average MW to the average demand for the day. For percent change, the value is the percent change in average MW to the average demand for the day.

· For hydro, for percent change, the data is the percent change to make to the hourly factor (as computed by AURORA hydro shaping logic and including the monthly and annual hydro factors).

· For link, for absolute value the data is the link capability in MW for the day. For percent change, the value is the percent change to the link capability for the link for the year and with any monthly shaping. For absolute change, the value is the change in link capability in MW for the day.

No escalations are applied to the demand or fuel prices as input in these tables.

For resources, only absolute value is allowed and the data is the maximum capability (as a fraction of input (monthly) capacity) for the resource for the day.

Demand Hourly

This is a data table of hourly load factors for an annual period (8760 + 8 days). Each column is numbered and is referenced by an area or portfolio/power cost entity. In general, EPIS has set up the table columns to match the areas.

The load data begins on a Monday and continues for an additional 192 hours (8 days) at the end of the year. This allows for indexing in on the table to the correct beginning day of the week for any year specified (including leap years).

AURORA can automatically normalize the hourly demand factors so that the average of the demand factors for the hours being dispatched in a month always equals 1.0. This is controlled from the logic tab.

Please note that the columns in the Demand table must be in the following order. Additional columns are not allowed in this table.

Columns include:

Hour - The hour in the year beginning on a Monday at 12:00 - 1:00a.m.

Number - The identification number as used by the area or portfolio/power cost entity using this table. These numbers must be sequential. This column is repeated for each demand number in the database.

Demand Monthly

This table specifies the monthly demand shape and annual average energy for each vector referenced by area or power cost entity specified in the model. The 13th row is the annual average energy (for areas only, although you should have a value in the table for this line, the value used as input is in the power cost information table for power cost). The monthly demand shapes should average to 1.0 and when multiplied by the annual average energy and the hourly demand (demand hourly table) they determine the hourly energy demand for each area.

"Case" in "demand case" allows the user to have a variety of demand cases in a particular database and to choose the case to use on the Assumptions setup tab of Aurora. The user may want to save several cases that can be selected from on the Input Assumptions tab such as "demand moderate", "demand high" and "demand low".

Columns include:

Year - The beginning year that the load shape specified in this table will be used. Changes in shapes may be made in subsequent years by adding additional sets of 13 rows with the first year to be used for the set put in this field.

Month - The month number for shape to be used. Note that month 13 represents the yearly annual average energy

Number (Columns) - monthly factors and average annual energy for the area or power cost entity referencing this column. Average annual energy is input in average MW.

Electric Prices

This table provides for input of forecast electric prices by area. This is useful if you wish to run the portfolio analysis with forward electric prices rather than AURORA forecast electric prices. The prices are input monthly and have hourly shapes. To use these prices, the use input price box must be checked on the Run Setup / Logic tab.

The columns are:

Number - The area number for the price input.

Shape - The number of the weekly shape vector (of hours) to use for this price input. A alpha string may be used in this field. If it is, then it points to an annual alpha vector which must point to a monthly shape factor which should have the number of the weekly shape vector in it. By this means, you can vary the shape by month and year.

Month - A date field which has any date in the first month for which the electric price input should be used.

1 - Last Month - The remaining fields contain the monthly price inputs (nominal $/MWh) starting with the month from the month field.

Emission Types

The columns are:

Type Number - (Long) The reference number for the emission type. Must be equal to or less than the number of rows in this table.

Name - (Text) The name of the emission type.

Price - (Text) The price for the emission in $/ton. This value may be an alpha in which case it refers to a row in the annual alpha vectors table where the annual value will refer to a monthly shape factor.

Limit - (Text) The limit before costs are charged for the emission in lb/mmbtu. This value may be an alpha in which case it refers to a row in the annual alpha vectors table where the annual value will refer to a monthly shape factor.

Environmental Types

No Longer Used

Escalation of Demand

This provides for the input of an annual vector number to use for the annual escalation of demand and for input of a flag for normalizing demand.

Each column or field corresponds to the reference number for the demand.

Rows are used as follows:

1) The annual vector number which points to a row in the Annual Vectors table where the annual escalation of demand (in percent) for each of the Demand vectors if found. One plus the escalation (for a year) is multiplied times the average demand (for the same year as the escalation) to get the average demand for the following year.

2) (Optional) A flag which determines if normalization of demand will be used. Any value other than one in these cells indicates that the flag will be set to true and normalization will be used. If this row is not found then the flags for each demand numbers will be set to true.

Note: For normalization to be used, the Demand and Hydro Normalization flag must be set on the Logic tab.

Fuel Case

Case" in "fuel case" allows the user to have a variety of fuel cases in a particular database and to choose the case to use on the Assumptions setup tab of Aurora. The user may want to save several cases that can be selected from on the Input Assumptions tab such as "fuel moderate", "fuel high" and "fuel low".

The fuel table provides the information for fuel types and resource defaults for resources which use the fuel type. This table is built to provide a high degree of flexibility in specifying fuel prices and other variable and fixed resource cost. The table also provides for input of real fuel escalation and monthly shaping factors. Other resource parameters such as variable O&M, are used only when the "resource" table has a -1.0 in its corresponding field, indicating to Aurora that it should be default to information in the fuel table.

Heat rate, fixed O&M and variable O&M fields may be input as text strings. If the fields are not numeric, then they are assumed to point to a record in the Annual Alpha Vectors table. Thus values for heat rate, fixed O&M and variable O&M can now vary by year. For the resources table, the values in the Annual Alpha Vectors table will be the annual "real" values used in the run. For the new resources table, the values will be the values used for all years for the vintage of new resource being created for the capacity expansion. If you need to use changing annual "real" values for a vintage of new resources then the Annual Alpha Vectors table may contain a text string which should point to another record in the Annual Alpha Vectors table which contains the appropriate annual "real" values for that vintage new resource.

Columns include:

Fuel Number - Fuel number identification. This identification number is referenced in the "resource" table for each resource. This number is also used within the fuel table by other fuel types that may be based on the price of the referenced fuel adjusted by a basis price difference between the fuel and the referenced fuel.

Fuel Name - Description of Fuel type. Resource that refer to the fuel name "Water" are treated as hydro resources in AURORA.

Fuel Type - Fuel type identification (not currently used in Aurora)

Units - Description of units used for pricing; currently all fuel prices are in $/mmBtu. Fuels denominated with other units should be converted to $/mmBtu.

Price -Corresponding price of fuel or basis difference in price to reference fuel. Fuel prices are input in base year prices (the base year is defined on the project tab of Aurora). If the fuel does not reference another fuel, the price represents the total price of the fuel. If a reference fuel is input, the price is the basis difference between the fuel and the reference fuel input. If the price input is greater than 1000 then, this field is a pointer to an annual vector which contains the annual price for fuel.

Escalation - Annual real escalation rate (percent) for the fuel. If a number greater than 1000 is input in this field, the model will look to the "annual vector" table for a row with a number value equal to the value in this escalation field.

Reference Fuel - When set, links this fuel to another fuel type. Each individual fuel line in the reference chain is computed using its own monthly shape factors and real escalations. The fuels in the chain are then added to obtain a total fuel cost for the current fuel type. Referencing is used only for fuel price. All other resource defaults are taken from the fuel line directly referenced in the resource table.

Monthly Shape Vector - A reference to a monthly shape vector for shaping the annual price by month. If no monthly shape vector is input, then the annual price is assumed flat for the whole year. If the value is greater than 1000 then this points to an annual vector which contains the monthly shape vectors by year.

Fixed O&M - Fixed operation and maintenance expense (plus any investment carrying costs) for resources of this fuel type, expressed in $ per MW-week. This value is used for resources where the corresponding field in the "resource" table is set to -1.0. A typical input with 3 $/MWh fixed O&M for a unit in full operation would be 3x168 hours per week or $504. Since fixed O&M is not dependent on plant operation, the fixed cost is applied regardless of plant operation. See the appendix article on Investment costs for information on how they should be included in this input.

Variable O&M - Variable operation and maintenance expense is expressed $/MWh. This value is used for resources where the corresponding field in the "resource" table is set to -1.0.

Maint Begin - day/month/year that maintenance begins. This value is used for resources where the corresponding field in the "resource" table is set to -1.0. The maintenance will repeat annually from this date forward. Note that when no maintenance is desired, this date must be set to a day in the year later than then Maint End date. See editing summary for information on using the calendar.

Maint End - day/month/year that maintenance ends. This value is used for resources where the corresponding field in the "resource" table is set to -1.0. This date specifies the period at which annual maintenance will end. When multiple years are run in the model, the maintenance period will be repeated each year beginning and ending on the same day. At this time, varying annual maintenance periods cannot be input to Aurora. When maintenance periods change yearly, the model can be run separately for each year or you can use the maintenance rate as described below to vary the maintenance by month and year. See editing summary for information on using the calendar.

Generally, if you do not want maintenance by date, you should put a 1/1/80 in the maintenance end date and a 1/2/80 in the maintenance begin date in the fuel table only. Put the dates of 1/1/80 in both columns in the resources, resource modifier and new resources tables - a date of 1/1/80 defaults to whatever is in the fuel table.

If you want to put non defaulting dates in other tables you should use something like 1/1/81 and 1/2/81 and not 1/1/80 and 1/2/80 because 1/1/80 will default to the fuel table and 1/2/80 will not.

Forced Outage - The percentage of time the resource will be unavailable due to unscheduled outages. This field reduces the plant capability for each dispatch multiplying the plant capacity from the Resource Table by the quantity 1- forced outage percent/100. This value may be an alpha which would point to an annual alpha vector. There is the capability to put a number greater than 1000 in the fuel or resource forced outage rate field in the database. If this is done, then the logic will use the monthly vector pointed to by the value in the forced outage field less 1000. If the resulting forced outage rate field is negative, then AURORA will assume the absolute value of the field is a pointer to a weekly vector where the hourly forced outage rates are input.

Maintenance Rate- The average percentage of time the resource will be unavailable due to scheduled outages. This field reduces the plant capability for each dispatch multiplying the plant capacity from the Resource Table by the quantity 1- Maintenance Rate/100. This value may be an alpha which would point to an annual alpha vector. There is the capability to put a number greater than 1000 in the fuel or resource maintenance rate field in the database. If this is done, then the logic will use the monthly vector pointed to by the value in the maintenance field less 1000. If the resulting maintenance rate field is negative, then AURORA will assume the absolute value of the field is a pointer to a weekly vector where the hourly maintenance rates are input.

Non Cycling - Non-zero number indicates percent premium of market price over dispatch cost required to commit the resource for operation. With the old commitment logic, the commitment period is one week. With the new commitment logic, the commitment period is specified by the Min Up Time. Once on, the unit remains on at least at minimum capacity until the next commitment period or for the Min Up Time. If you desire to change the value on an annual basis, then put the name of an annual alpha vector (should have some non-numeric characters in the name) in the this field. The annual vector can then contain the values by year or a number greater than 1000 where the logic for monthly vectors described above will be used.

Must Run- Flag which sets the units to a "must run" condition. Resources that have this flag set assume a zero cost of dispatch for the minimum capacity and will be the first units to operate. This value is used for resources where the corresponding field in the "resource" table is set to -1.0. If you desire to change the value on an annual basis, then put the name of an annual alpha vector (should have some non-numeric characters in the name) in the this field. The annual vector can then contain the values by year or a number greater than 1000 where the logic for monthly vectors described above will be used.

Minimum Capacity - For non-cycling and must run resources this specifies the minimum capacity the unit can run at when the non-cycling logic is active. The unit for the input is a percentage of resource capacity. This value is used for resources where the corresponding field in the "resource" table is set to -1.0. If you desire to change the value on an annual basis, then put the name of an annual alpha vector (should have some non-numeric characters in the name) in the this field. The annual vector can then contain the values by year or a number greater than 1000 where the logic for monthly vectors described above will be used. Note, if an UBB Segment Size (see below) is specified, then this is a percent of the capacity after the UBB Segment Size is subtracted.

Can Drop Resource - Allows resource to be dropped during a capacity expansion run. This value is used for resources where the corresponding field in the "resource" table is set to -1.0.

Start up - If this cost ($ per MW per startup) is included for non-cycling units and commitment logic is turned on, then these units will run commitment for a period of 5 to 18 hours (depending on the economy of running for that period). Caution - do not use startup costs for units in general. Aurora requires unit marginal costs for marginal units to price the system. With all marginal units on commitment, there can be no good computation of prices. Use these startup costs for particular units where you want to see their precise operation. For general use, add startup costs to the fuel cost. This value is used for resources where the corresponding field in the "resource" table is set to -1.0.

Resource Group - Specifies the resource group that the resource should be reported in.

Capacity Monthly Shape - (Long) If this value is greater than zero, then it must be a reference number to a valid row in the monthly shape table where monthly factors for resource shaping capacity are input.

Bidding Factor - (Text) If this value is a numeric value greater than 0 then it is a factor which will be added to one and multiplied by the total resource variable cost to get the dispatch cost for the resource. This simulates bidding at prices that are greater than the cost of a resource. This number will override any general resource dispatch margin which may be used. If this value is a non-numeric alpha value then it points to an annual alpha vector where the values are input annually. If this value is less than negative one then it is a pointer to a monthly shape factor where monthly values are input.

Ramp Rate - (Text) If this value is a numeric value greater than 0 then it is a percent which will be divided by 100 and multiplied by the resource capacity to get the increase in capability available in the next hour for the resource. Ramp rates are effective only if the ramp rate logic is set to on and you are making a run with 8760 hours being dispatched. If this value is a non-numeric alpha value then it points to an annual alpha vector where the values are input annually. If this value is less than negative one then it is a pointer to a monthly shape factor where monthly values are input. If not given or zero then AURORA defaults to 100 percent. Ramp rates do not apply to decreases in unit output.

Min Up Time - (Long) The minimum number of hours the unit must stay up if committed to run with new commitment logic. Defaults to 24 if this column is not in the database.

Min Down Time - (Long) The minimum number of hours the unit must stay down if it is a commitment type (non-cycling non-zero) and not committed with new commitment logic. Defaults to 12 if this column is not in the database.

UBB Heat Rate - (Text) The heat rate of an upper (third) block of a resource. The segment size must also be specified (see below). If this value is a non-numeric alpha value then it points to an annual alpha vector where the values are input annually. If this value is less than negative one then it is a pointer to a monthly shape factor where monthly values are input.

UBB Bidding Factor - (Text) The bidding factor (see above) to use for the upper (third) block of a resource. The segment size must also be specified (see below). If this value is a non-numeric alpha value then it points to an annual alpha vector where the values are input annually. If this value is less than negative one then it is a pointer to a monthly shape factor where monthly values are input.

UBB Segment Size - (Text) The segment size in percent of the upper (third) block of a resource. If this value is a non-numeric alpha value then it points to an annual alpha vector where the values are input annually. If this value is less than negative one then it is a pointer to a monthly shape factor where monthly values are input.

Second Fuel - (Long) Optional column. Specifies a secondary resource fuel type to use for resources (New Resources do not use this second fuel during capacity expansion runs) that refer to the current fuel type. If this has a value greater than zero, then resources that use the current fuel type will check and use the lower fuel price of the two fuels. If the secondary fuel type is being used then a flag will be displayed in the period resource tables under the view button or the detailed resource report under the output button.

General Information

General information supplied to Aurora.

Columns include:

Company Name - Put the name of your company here. This name is used on a variety of reports.

Discount Rate - The nominal discount rate (in percent) to be used in valuation calculations. (By default this assumes a 2.5 percent annual inflation rate). If you are varying inflation by year, you should use the optional input Real Discount Rate.

Inflation Vector - The yearly change in general inflation to be applied to fixed and variable costs. Costs with inflation include variable O&M, fixed O&M, fuel costs and the investment cost of future resources. This points to an Annual Vector. The inflation vector is applied as follows: First, a cumulative inflation variable by year is created. This cumulative inflation variable is set to one for the first year (base year) and then multiplied by (1+inflation vector(first year)) to get the second year cumulative inflation. Each subsequent year is done in a similar fashion. The yearly cumulative inflation variable is then multiplied by all costs to be inflated to get the cost for the year.

Real Discount Rate - (Optional of type single) If input, then this takes precedence over the discount rate as input above. The annual nominal discount rate is then computed based on the real discount rate and the annual inflation.

Trans Length Factor - No longer used.

Hubs

This table provides trading hub identification and location. Hub locations are described by the areas on either side of the hub. The hub is, for transmission pricing purposes, assumed to be positioned midway between the adjacent areas. For hubs that lie within an area, the same area can be included for both fields. When a hub lies between two areas, the price for each hour is the lower of either of the adjacent areas plus any transmission to get delivery to the hub location. If the transmission line is full in that hour, the price is the higher cost of the adjacent areas if the last field is checked else, it is the lower cost.

Columns Include:

Number - Hub identification number.

Name - Hub name.

Area Reference Number 1 and 2 - Areas on each side of the hub. For hubs within an area, use the same area number for both.

Use High Cost - If checked then when transmission is totally congested, the higher cost is used, otherwise the lower area cost is used.

Use Avg Cost (Optional column type boolean) - If checked then the hub will always use the average of the the two areas prices.

Average Hub Price (Optional column type single) - If input, this provides the rolling average hub price (over 12 months) to use at the beginning of a run.

Hydro Monthly

This table specifies the monthly hydro shape and annual average capacity factor as referenced by areas or individual resources. At the end of the monthly shapes in the table is the annual average capacity factor. The monthly hydro shapes generally average to 1.0 and when multiplied by the plant capacity (resource table), the annual average capacity factor, the hourly hydro factor determined by Aurora and the forced outage rate determine the hourly hydro capability for each area. Note that the shapes are applied to get the hourly capability (MW) for the unit. Thus we are actually inputting capacity shapes and not energy shapes. To end up with exactly the right energy for the year or month (if energy is your starting point), the monthly shapes should be adjusted for the number of days in a month and will not average exactly 1.0 for the year. The adjustment would be "Avg Days In Month divided by Days In Month".

Columns include:

Year - The beginning year that the hydro shape specified in this table will be used. Changes in shapes may be made in subsequent years by adding additional sets of 13 rows with the first year to be used for the set put in this field.

Month - The month number for shape to be used. Note that month 13 represents the yearly annual average energy factor

Number (Columns) - monthly factors and average annual hydro energy factor for the area or resource referencing this column.

To add columns see the appendix adding hydro numbers.

Hydro Vectors Case

This table provides for the input of hydro data for the hydro shaping logic of Aurora.

"Case" in "HydroVectors Case" allows the user to have a variety of hydrovectors cases in a particular database and choose the case to use on the Hydro Tables setup under the Assumptions tab of Aurora. The user may want to save several cases that he may select from on the Input Assumptions tab such as "hydrovectors base", "hydrovectors high" and "hydrovectors low".

Each hydro number (column) has an pointer to a vector in the Annual Vectors table which references a row in the monthly shape vectors table. To add hydro numbers see the appendix Adding Hydro Numbers.

Area Number (called Hydro Number in older databases) - The area number where resource which refer to this hydro number (column) are located.

Shape - A number which represents the annual vector number used for pointing to the monthly shaping factors used in the hydro shaping logic. The shape factors control the degree of shaping Aurora attempts to do on the hydro energy. At a factor of 1, the logic will attempt to flatten the net load after hydro by shaping the hydro energies to that extent. Of course the shaping is subject to the other constraints defined in this table. Shape factors can be greater than one and less than 1000 and that may be appropriate if hydro should be shaped to meet loads outside the hydro area. If a shape factor is specified as greater than 1000 then 1000 is subtracted from the shape factor and the results is used to point to a weekly vector. In this case, the weekly vector should contain an input shape for the hydro. The input shape is used subject to the constraints below and subject to total energy for the month as input in the hydro monthly table. An example of the use of input shapes is the case where you may want to specific certain hours at maximum operation. Place a one in the weekly vector for those hours and a zero in other hours. AURORA will keep the maximum at 1 (if the Maximum and Sustained Maximum input below are one and provided there is enough energy to allow output at maximum for those hours) and increase the other hours to give the correct energy for the month.

Maximum - A number which represents the annual vector number used for pointing to the monthly maximum factors used in the hydro shaping logic. The maximum factors control the maximum output allowed from the hydro system and range from 0 (no output) to 1 (name plate capacity times the availability for hydro output).

Minimum - A number which represents the annual vector number used for pointing to the monthly minimum factors used in the hydro shaping logic. The minimum factors control the minimum output allowed from the hydro system and range from 0 (no output) to 1 (name plate capacity times the availability for hydro output).

Sus Number - A number which represents the annual vector number used for pointing to the monthly sustained number used in the hydro shaping logic. The monthly sustained number indicates the number of hours during the week over which the sustained maximum factor is applied. It can range from 1 to 168 and typically is set for 20 to 50 hours.

Sus Maximum - A number which represents the annual vector number used for pointing to the monthly sustained maximum used in the hydro shaping logic. The monthly sustained maximum indicates the maximum amount (as a fraction of hydro name plate capacity times the availability) of energy that may be generated over the sustained number of hours of the week.

Link

This table provides the input of transmission links and corresponding capacity values. Transmission "links" are defined as the transmission between areas adjacent to one another. Links are used to establish transmission "paths" which are made up of one or more transmission links. The direction of flow is accounted for in the model. All flows, however, are now accounted for with positive numbers. Additionally, transmission line capacity is typically not equal in both directions. This is due to network characteristics of the transmission system. It is important to include the correct directional capacities.

Columns include:

Area From - Number of the area from which energy is flowing.

Area To - Number of the area to where energy is flowing

Capacity - Transmission capacity (MW) of the link. These should be put in for each direction of the link - i.e. link 1 to 2 100MW and link 2 to 1 50 MW. This value can be an alpha whereas the value then points to an Annual Alpha Vector which contains annual transmission capacities.

Link Monthly Shape (Optional column type long) - If this value is greater than zero, then it must be a valid reference to a line in the Monthly Shape Factors table, where the monthly shaping (factors) of transmission capacity is input.

Link Congestion Year (Optional column type long) - The first year to use congestion pricing for this link. If this column is not included or no value or zero is specified, then the first year of the study is used.

Wheeling (Optional column type single - if included then overrides Transmission table) - The wheeling rate charge from the area being dispatched to the area being served. This field may include a $/MWh cost or a reference to a vector in the "annual vector" table (done by using a value > 1000) which further references the "monthly shaping table" which would contain monthly cost values.

Losses (Type single - must be included if wheeling column is in this table) - The fraction of losses in energy for transmission from the area being dispatched to the area being served.

Shape (Optional column type text) - If input, the number of the weekly shape vector (of hours) to use for this area2 to area1 transmission wheeling. This value is multiplicative on the wheeling rate. A alpha string may be used in this field. If it is, then it points to an annual alpha vector which must point to a monthly shape factor. The monthly shape factor then contains the weekly shape vector for each month. By this means, you can vary the shape by month and year. If not input, then no hourly shaping of transmission is used.

Area From Descrip - Name description of the area from which energy is flowing. Note - this field is not used in the model but is included for the convenience of the user.

Area To Descrip - Name description of the area to where energy is flowing. . Note - this field is not referenced in the model but is included for the convenience of the user.

Monthly Shape Factors

Table of monthly shaping factors that can be referenced from other tables requiring monthly shaping. This table can include values that shape transmission prices and fuel costs.

Columns include:

Number - Reference number of the shaping factor. This reference number can appear on several other tables. These include transmission where references to an annual vector can be made which refers to a monthly shaping vector. In the fuel table, fuel types have a field that references a monthly shaping value. And, the portfolio/power cost contract table can have a column which references this table. See the tables discussed for additional information.

Factors by month - 12 monthly shaping factors. Depending on their use in the model, these can represent either factors that are used for shaping or values such as monthly transmission prices.

New Resources

This table provides the input assumptions and parameters for new resources types to be evaluated when the model runs a long-term study. It optimizes the expansion and retirement of resources. This table is similar to the resource table. Values in this table which are set to -1.0 indicate that the value from the fuel table should be used for the area (in the case of hydro)

Heat rate, fixed O&M and variable O&M fields may be input as text strings. If the fields are not numeric, then they are assumed to point to a record in the Annual Alpha Vectors table. Thus values for heat rate, fixed O&M and variable O&M can now vary by year. For the this new resources table, the values will be the values used for all years for the vintage of new resource being created for the capacity expansion. If you need to use changing annual "real" values for a vintage of new resources then the Annual Alpha Vectors table may contain a text string which should point to another record in the Annual Alpha Vectors table which contains the appropriate annual "real" values for that vintage new resource. For the resources table, the values in the Annual Alpha Vectors table will be the annual "real" values used in the run.

Starting with version 4.7.32, column order in the resources table is no longer important. Column names must match those below exactly. When adding columns to an EPIS supplied database, you should check your results carefully to ensure that the column names were correct and the data is actually being read.

Columns include:

Number - Identification number for the new resource type. New resources created for evaluation from these types are numbered sequentially starting at one and if they are actually used in the dispatch, then they are numbered sequential, starting with the next number after the last existing resource.

Name - The reference name of the resource, used for reporting purposes. The letters "demand" anywhere in a resource name indicate that the resource is a demand side rather than a supply side resource.

The names are subject to the following constraints:

Can be up to 30 characters long.

Can include any combination of letters, numbers, spaces, and special characters except a period (.), an exclamation point (!), an accent grave (`), and brackets ([ ]).

Can't begin with leading spaces.

Can't include control characters (ASCII values 0 through 31).

Utility - Generally not used for new resources, but you can identify resources by utility.

Heat Rate - The heat rate assumption for the resource in BTU of fuel energy per kWh delivered. This is a standard measure of energy efficiency for thermal resources. and should be the higher heat rate value not the manufacturers lower heat rate. This field may be left blank for units with zero fuel cost.

Capacity - The rated plant capacity in kilowatts (not MW)

Fuel - The fuel identification reference number as identified in the "fuel case" table. Each resource must include a fuel reference number of a valid fuel in the fuel table.

Area - The area where the resource is located. The resource must be in one of the areas identified in the "area" table.

Variable O&M - Variable operation and maintenance expense is expressed $/MWh.

Fixed O&M - Fixed operation and maintenance expense (plus any investment carrying costs) for new resources of this type, expressed in $ per MW-week. A typical input with 3 $/MWh fixed O&M for a unit in full operation would be 3x168 hours per week or $504. Since fixed O&M is not dependent on plant operation, the fixed cost is applied regardless of plant operation. See the appendix article on Investment costs for information on how they should be included in this input.

Maint Begin - day/month/year that maintenance begins. The maintenance will repeat annually from this date forward. See editing summary for information on using the calendar.

Maint End - day/month/year that maintenance ends. This date specifies the period at which annual maintenance will end. When multiple years are run in the model, the maintenance period will be repeated each year beginning and ending on the same day. At this time, varying annual maintenance periods cannot be input to Aurora. When maintenance periods change yearly, the model can be run separately for each year. See editing summary for information on using the calendar.

Generally, if you do not want maintenance by date, you should put a 1/1/80 in the maintenance end date and a 1/2/80 in the maintenance begin date in the fuel table only. Put the dates of 1/1/80 in both columns in the resources, resource modifier and new resources tables - a date of 1/1/80 defaults to whatever is in the fuel table.

If you want to put non defaulting dates in other tables you should use something like 1/1/81 and 1/2/81 and not 1/1/80 and 1/2/80 because 1/1/80 will default to the fuel table and 1/2/80 will not.

Forced Outage - The percentage of time the resource will be unavailable due to unscheduled outages. This field reduces the plant capability for each dispatch multiplying the plant capacity from this Table by the quantity 1- forced outage percent/100. This value may be an alpha which would point to an annual alpha vector. There is the capability to use a number greater than 1000. If this is done, then the logic will use the monthly vector pointed to by the value in the forced outage field less 1000. If the resulting forced outage rate field is negative, then AURORA will assume the absolute value of the field is a pointer to a weekly vector where the hourly forced outage rates are input.

Maintenance Rate- The percentage of time the resource will be unavailable due to scheduled outages. This field reduces the plant capability for each dispatch multiplying the plant capacity from this Table by the quantity 1- Maintenance Rate/100. This value may be an alpha which would point to an annual alpha vector. There is the capability to use a number greater than 1000. If this is done, then the logic will use the monthly vector pointed to by the value in the maintenance field less 1000. If the resulting maintenance rate field is negative, then AURORA will assume the absolute value of the field is a pointer to a weekly vector where the hourly maintenance rates are input.

Non Cycling - Non-zero number indicates percent premium of market price over dispatch cost required to dispatch the resource during the commitment period (one week). Once on, the unit remains on at least at minimum capacity until the next commitment period.

Must Run - Flag (on is 1, off is zero) which sets the units to a "must run" condition. Units that have this flag set assume a zero cost of dispatch and will be the first units to operate.

Hydro Number - For hydro resources, any of the hydro shapes in the "hourly hydro factors" and "hydro monthly" tables may be reference for any hydro resource unit. The user may also choose a new hydro shaping factor for any hydro resource by including a new shape in both the "hourly hydro factors" and "hydro monthly" tables and referring to that shape in the "resource" table.

Minimum Capacity - For non-cycling resources, specifies the minimum capacity at which the unit can run when the non-cycling logic is active. The unit for the input is percentage of resource capacity.

Begin Date - The beginning date when this resource is available to be included in a capacity expansion. See editing summary for information on using the calendar.

End Date - The ending date when this resource is available to be included in a capacity expansion. See editing summary for information on using the calendar.

Annual Max - A reference to the "annual vector" table indicating the maximum number of these units that are available in the year of capacity expansion.

Overall Max - Maximum number of the new resource type resources that will be created.

The following fields or columns are optional.

Resource Group - (Long) The resource group that new resources created from this type will belong to.

Capacity Monthly Shape - (Long) If this value is greater than zero, then it must be a reference number to a valid row in the monthly shape table where monthly factors for shaping capacity are input.

Min Up Time - (Long) The minimum number of hours the unit must stay up if committed to run with new commitment logic. Defaults to fuel table if this column is not in the database.

Min Down Time - (Long) The minimum number of hours the unit must stay down if it is a commitment type (non-cycling non-zero) and not committed with new commitment logic. Defaults to fuel table if this column is not in the database.

(Emission Type Name) Emission Rate - (Single) This field or fields contains the resource emission rate in lb/mmbtu for the emission type given by the name. The field or column name is the concatenation of the emission type name and " Emission Rate". Monthly rates should not be used for new resources.

Not Standard Table

The table you are editing cannot be recognized by AURORA. It is not a standard table name and is not currently set to replace a standard table in the change table dialog on the Assumptions tab. No help is available.

Portfolio/Power Cost Contracts

This table provides for input of contracts used in the power cost logic of Aurora. This information can provide power cost analysis for any entity that the user may want to define or for portfolios of contract groups (or positions taken in the market). It evaluates costs and value as well as risk.

A number of different types of contracts (for both purchases and sales) may be entered in this table. This allows the user to provide a combination of contracts that exactly replicate nearly any circumstance. The result is a very versatile and powerful tool in which positive (energy inflow) and negative (energy outflow) energy values can be included in the table to represent individual contracts or combinations can be used to simulate contracts that are more complex.

The first type of contract is a "Must Take Fixed Price" contract. This type of contract specifies the timing and amount of energy at a fixed price. The user can specify the exact flow of energy for this kind of contract using the shaping vectors provided.

The second type of contract that can be entered is a "Option Fixed Price" contract. This type of contract represents an option to take (or deliver) energy that is priced at a fixed price.

The third type of contract that can be entered is a "Must Take Market Price" contract. This type of contract represents an amount of energy to be delivered at the market price plus any input energy cost. The amount of must take energy can be shaped with the Shaping Vector reference in this table. For the market price, they may be based on the price in the area where the portfolio is located, an input area, an input hub, two input hubs or an input fuel type. The following is the precedent for input. If input, fuel pricing takes precedence over the two hub pricing, which takes precedence over the single hub pricing which takes precedence over the pricing area which takes precedence over pricing in the area where the portfolio entity is located. See below for information on how to input the various market pricing information.

The fourth type of contract that can be entered is a "Option Market Price" contract. This type of contract represents an option to take (or deliver) energy that is delivered at the market price plus any input energy cost. This option is only exercised when the pricing is based on an area, hub, hubs other than the one the portfolio entity is located in or it is based on a fuel. Note: To model a heat rate hedge contract, simply use this contract type and choose the fuel type being used for the heat rate conversion (the number of a fuel type in the fuel table) in the Pricing Fuel column, and use the heat rate divided by 1000 in the fuel factor column. See below for information on how to input the various market pricing information.

The fifth type of contract is a "Must Take Average Market Price Capped". This type of contract represents an amount of energy to be delivered at the rolling average (12 month) market price plus. The amount of must take energy can be shaped with the shaping vector reference in this table. You should run Aurora for a least 12 months before the first month examined under this contract to have a valid rolling average market price or you may input the beginning rolling average marginal cost in the area table or the rolling average hub price in the hub table.

The sixth type of contract is a "Requirements Contract". This type of contract will buy or sell power at the indicated price for all demand remaining after the resources and prior contracts (important - prior contracts are all contracts listed and numbered prior to this contract in the contract file). The amount of energy can be shaped with the shaping vector referenced so different contracts can be used for on-peak and off-peak periods.

The seventh type of contract is a "Requirements Market Purchase". This type of contract will buy at the market price for all demand remaining after the resources and prior contracts (important - prior contracts are all contracts listed and numbered prior to this contract in the contract file). The amount of energy can be shaped with the shaping vector referenced so different contracts can be used for on-peak and off-peak periods.

The eight type of contract is a "Requirements Market Sale". This type of contract will sell at the market price for all demand (negative) remaining after the resources and prior contracts (important - prior contracts are all contracts listed and numbered prior to this contract in the contract file). The amount of energy can be shaped with the shaping vector referenced so different contracts can be used for on-peak and off-peak periods.

The ninth type is "Requirements Contract Load" similar to Requirements Contract but which computes the cost based on the total load no matter what other contracts exist. No energy is taken from this contract. It should be used in conjunction with Requirements Contract.

The tenth type is "Demand Charge" which does not account for energy, only capacity charges.

Contact EPIS if you need a contract type other than the listed above.

Columns include:

Number - Number used by Aurora to reference this contract.

Portfolio - The portfolio number (setup in Portfolio Information) for the portfolio of contracts that the contract is to be included with.

Name - The name of the contract.

Begin - The start date of the contract (MM/DD/YYYY). See editing summary for information on using the calendar.

End - The end date of the contract (MM/DD/YYYY). See editing summary for information on using the calendar.

Type - The type of contract. This must be one of the following strings with the types as defined above:

If you are editing the database in AURORA, a dropdown will be provided with these choices when you edit the cell.

Must Take Fixed Price

Must Take Market Price

Option Fixed Price

Option Market Price

Must Take Average Market Price Capped

Requirements Contract

Requirements Contract Load

Demand Charge

There are some additional specialized daily pricing contract types listed in the database dropdowns. Contact EPIS for more information on these daily pricing contracts.

Shape - The number of the weekly shape vector (of hours) to use for shaping the energy for this contract. (The shape value will be multiplicative with the energy). An alpha string may be used in this field. If an alpha is used, then it points to an annual alpha vector which must point to a monthly shape factor. The monthly shape factor then contains the weekly shape vector reference for each month. By this means, you can vary the shape by month and year.

NOTE: Energy Max, Energy Min, Energy Cost and Capacity Cost columns may be input as text strings. If the fields are not numeric, then they are assumed to point to a record in the Annual Alpha Vectors table.

Energy Max - The maximum amount of energy (in MW) that can be delivered for any contract. For must take contracts, the maximum energy represents the amount of energy delivered. If a shape vector is specified then each hour of the shape vector is multiplied by this maximum amount.

Energy Min - The minimum amount of energy (in MW) delivered for option deliveries. The minimum amount is an amount of energy that is firm (and must be delivered) under the contract regardless of the market price.

Energy Cost - This is the price of the contract for fixed price contacts. For market price contracts, this is the margin above the market price used for this contract. Input in $/MWh. If this is greater than 1000 then it points to an annual vector containing these costs.

Capacity Cost - A fixed monthly capacity charge in thousands of dollars per MW. If this is greater than 1000 then it points to an annual vector containing these costs.

Monthly Shape - (Optional column type long) A pointer to a monthly shape vector which will shape the Energy Max by month.

Energy Amount Max - (Optional column type text) The annual maximum energy in MWh that can be used under the contract.

Pricing Area - (Optional column type long) The area used for pricing contracts of type Market Price. If this pricing area is non-zero then this areas price is used rather than the area the entity is located in for pricing of the marginal cost of the contract. It the contract is also of type Non-Firm then the strike price is the input price plus the price in this area vs the price in the area the entity is located in.

Pricing Hub - (Optional column type long) If input and non-zero, operates the same as pricing area only uses hub prices. In general, the formula for hub pricing is as follows: (pricing hub * hub factor + pricing hub 2 * hub factor 2) / 2 + energy cost.

Hub Factor - (Optional column type single) If this factor is input and non-zero, then it acts as a multiplier against the price from the pricing hub.

Pricing Hub 2 - (Optional column type long) If this hub is input and non-zero, then its price (multiplied by hub factor 2) is averaged with the pricing hub (multiplied by hub factor).

Hub Factor 2 - (Optional column type single) If this factor is input and non-zero, then it acts as a multiplier against the price from pricing hub 2.

Pricing Fuel - (Optional column type long) If this fuel number is input and non-zero, then it will be used for pricing contracts of type Market Price (except the rolling average type). The electricity price used is the escalated fuel price for the month times the fuel factor (see below). Thus the fuel factor should contain the appropriate adjustment from $/mmBtu to $/MWh along with any other adjustment being made for pricing purposes. See the explanation in contract type "Option Market Price" for information on modeling a heat rate hedge.

Fuel Factor - (Optional column type single but required if a pricing fuel is non-zero) A factor which will be multiplied by the price of the pricing fuel and added to the energy cost to get the contract option price in $/MWh.

Price Cap - (Optional column type single) Provides a price cap to use for price capped contracts.

Cost Shape - (Optional column type text) The number of the weekly shape vector (of hours) to use for shaping the Energy Cost hourly (they are multiplicative). A alpha string may be used in this field. If it is, then it points to an annual alpha vector which must point to a monthly shape factor. The monthly shape factor then contains the weekly shape vector for each month. By this means, you can vary the shape by month and year. If this is zero or not given, then no shape is used.

Capacity Cost Shape - (Optional column type text) The number of the weekly shape vector (of hours) to use for shaping the Capacity Cost hourly (they are multiplicative). A alpha string may be used in this field. If it is, then it points to an annual alpha vector which must point to a monthly shape factor. The monthly shape factor then contains the weekly shape vector for each month. By this means, you can vary the shape by month and year. If this is zero or not given, then no shape is used.

Portfolio 2 through Portfolio 10 (Optional columns type long) - These columns allow contracts to be defined for multiple portfolios. Enter the reference number of the portfolio (see the portfolio column above).

Portfolio/Power Cost Information

This defines the portfolio/power cost entities that will be evaluated. The entities may be utilities, customers, portfolios of contracts and positions or any user defined list of contracts and resources.

Columns include:

Number - The identification number. This is used to reference the portfolio in the portfolio/power cost contracts and the portfolio/power cost resources tables.

Name - The name of the entity.

Area - The location where the entity exists. This must be one of the dispatch areas as defined in the areas table.

Demand - The average energy in MW for the entity being evaluated. This should be entered as zero for portfolios that have no end user demand.

Demand Number - The reference number of the loads as used in the demand hourly and demand monthly tables. The average energy in the demand monthly table is not used for portfolio/power cost analysis.

Market Value Area - (Optional column type long) The area number of the pricing area to be used in computing the market sales or purchases revenues or costs.

Market Value Hub - (Optional column type long) The hub number of the pricing hub to be used in computing the market sales or purchases revenues or costs.

Shape - (Optional column type long) The weekly vectors number to use for shaping an entire portfolio. If the shape value is one for the hour, then the portfolio is active for the hour, otherwise, it is not active for the hour.

Net Market Transactions - (Optional column type boolean) If checked, then market purchases and sales are used. If not checked, then the checkbox on the run setup portfolio tab determines whether market purchase and sales are used.

Portfolio/Power Cost Resources

The resources available or owned by an entity are defined in this table. The portfolio/power cost analysis uses these resources as part of the power cost computation. The effect of including resources here is to provide an "option" value of the resource when power costs are determined. The option value is the reduction in power costs that occurs as a result of having the ability to dispatch this resource below the market price in any hour.

Columns include:

Number - The reference number of this resource for portfolio/power cost modeling.

Portfolio - The reference number of the portfolio that has this resource. This must be one of the portfolios defined in the Portfolio/Power Cost Information Table.

Resource Number - The reference number of the resource as input in the Resource Table.

Percent Owned - The percentage of the resource that is owned or used by the portfolio entity.

Begin (Optional column type date) - The start date for the resource in the portfolio.

End (Optional column type date) - The end date for the resource in the portfolio.

Losses (Optional column type single) - The losses in percent for the resource to the portfolio grid.

Energy Only (Optional column type boolean) - This resource will supply energy to the portfolio but not any associated cost.

Portfolio 2 through Portfolio 10 (Optional columns type long) - These columns allow resources to be defined for multiple portfolios. Enter the reference number of the portfolio (see the portfolio column above).

Percent Owned 2 through Percent Owned 10 (Optional columns type single) - These columns allow resource percents to be defined for multiple portfolios. Enter the percentage of the resource that is owned or used by the portfolio entity. Note, you should include Percent Owned columns for each Portfolio column defined or you will get a percent for the portfolio referenced by the column of zero.

Resource Groups

This table contains information on resource groups. Resource groups may be used to group output of resources for a variety of purposes. For instance, you may want a group of resource to be defined for all gas fired units.

In this table, each group is defined with a name. A sample of the table is shown below:

Number	Name
1	Peaking Gas
2	Regular Gas
3	Coal

Resources are defined to be in a specific group by designation of the group number in the Resources table or the Fuel table in a column called Resource Group.

Resource Modifier

The resource modifier table is generally created by a long-term analysis run of Aurora. This table may be specified as null (no name) in which case it will not be used. The information contained in the table is the same as the Resource Table with the addition of columns which are used in determining whether a resource has been dropped, at what date it was dropped, and whether this is a new resource that has been added and information about the new resource. Refer to the Resource Table for columns in this table that mirror the resource table. Only the additional columns are defined here.

Starting with version 4.7.32, column order in the resource modifier table is no longer important. Column names must match those below exactly. When adding columns to an EPIS supplied database, you should check your results carefully to ensure that the column names were correct and the data is actually being read.

Additional columns include:

Begin Date - The first day for which the resource is operational. This is the date the new resource is placed in service.

End Date - The last day of service for a resource being dropped. This is the date the existing resource is retired.

Dropped Resource - The number from the resource table of the resource being dropped (if this line is for a dropped resource).

Input New Resource - The number from the New Resource table of the new resource type used for this additional resource.

NPV Value - The net present value in $000/MW for the resource calculated on the last iteration of the long-term run used to generate this table. Output only, column must be present, but is not read by AURORA.

From New Resource - The number of the AURORA generated new resource that is the basis for this line in the Resource Modifier Table.

Resource Fixed - (Boolean) True (1) or False (0) specifying whether the resource should be considered fixed and not subject to retirement for long term optimization runs.

Resources

This table provides the input assumptions and parameters for all existing resources in the region being modeled.

Generally, when a -1 appears in the table, the model retrieves the correct input parameter from the Fuel Case Table which provides general parameters for each fuel type. For dates, a 1/1/80 indicates to use the parameters from the fuel table. For hydro, a -1 indicates to use the hydro factors for the area of the resource.

Capacity, Heat rate, Fixed O&M, Variable O&M and Bidding Factor fields may be input as text strings. If the fields are not numeric, then they are assumed to point to a record in the Annual Alpha Vectors table. Thus values for capacity, heat rate, fixed O&M and variable O&M can vary by year. The values in the Annual Alpha Vectors table will be the annual "real" values used in the run.

Starting with version 4.7.32, column order in the resources table is no longer important. Column names must match those below exactly. When adding columns to an EPIS supplied database, you should check your results carefully to ensure that the column names were correct and the data is actually being read.

Columns include:

Number - A unique number for each resource. These should be sequential numbers for the resources in the table (use the renumber 1st column menu item in the pop up menu when in editing data in the database.

Name - The name of the resource.

The letters "demand" anywhere in a resource name indicate that the resource is a demand side rather than a supply side resource. Demand side resources generally use the same logic as supply side, but are reported differently on some reports.

The names are subject to the following constraints:

Can be up to 50 characters long.

Can include any combination of letters, numbers, spaces, and special characters except a period (.), an exclamation point (!), an accent grave (`), and brackets ([ ]).

Can't begin with leading spaces.

Can't include control characters (ASCII values 0 through 31).

Utility - The utility which owns and operates the resource. This value is not used in Aurora except for reporting.

Heat Rate - The heat rate for the resource in BTU per kWh. This is a measure of the energy efficiency for thermal resources. This field may be 0 for resources with zero fuel cost. For storage resources, enter a value such that the ratio of 3412/Heat Rate gives the storage efficency for the unit (3412 being 100% efficent).

Capacity - The rated plant capacity in kilowatts. This value will be multiplied by the forced outage rate, and for hydro units, the hydro factors, to give the capability of the unit.

Fuel - The fuel reference number as found in the "fuel case" table. Each resource must have a valid fuel reference number. Hydro resources should reference a fuel with the name of Water. Energy storage resources must reference a fuel name that begins with "Storage".

Area - The area in which the resource in located. This is one of the area reference numbers as defined in the area table.

Variable O&M - Variable operation and maintenance expense is expressed $/MWh.

Fixed O&M - Fixed operation and maintenance expense (plus any investment carrying costs) for this resource, expressed in $ per MW-week. A typical input with 3 $/MWh fixed O&M for a unit in full operation would be 3x168 hours per week or $504. Since fixed O&M is not dependent on plant operation, the fixed cost is applied regardless of plant operation. See the appendix article on Investment costs for information on how they should be included in this input.

Maint Begin - day/month/year that maintenance begins. The maintenance will repeat annually from this date forward. See editing summary for information on using the calendar.

Maint End - day/month/year that maintenance ends. This date specifies the period at which annual maintenance will end. When multiple years are run in the model, the maintenance period will be repeated each year beginning and ending on the same day. At this time, varying annual maintenance periods cannot be input to Aurora. When maintenance periods change yearly, the model can be run separately for each year or you can use the maintenance rates as described below to vary maintenance monthly and by year. See editing summary for information on using the calendar.

Generally, if you do not want maintenance by date, you should put a 1/1/80 in the maintenance end date and a 1/2/80 in the maintenance begin date in the fuel table only. Put the dates of 1/1/80 in both columns in the resources, resource modifier and new resources tables - a date of 1/1/80 defaults to whatever is in the fuel table.

If you want to put non defaulting dates in other tables you should use something like 1/1/81 and 1/2/81 and not 1/1/80 and 1/2/80 because 1/1/80 will default to the fuel table and 1/2/80 will not.

Forced Outage - The percentage of time the resource will be unavailable due to unscheduled outages. This field reduces the plant capability for each dispatch multiplying the plant capacity from the Resource Table by the quantity 1- forced outage percent/100. This value may be an alpha which would point to an annual alpha vector. There is the capability to put a number greater than 1000 in the fuel or resource forced outage rate field in the database. If this is done, then the logic will use the monthly vector pointed to by the value in the forced outage field less 1000. If the resulting forced outage rate field is negative, then AURORA will assume the absolute value of the field is a pointer to a weekly vector where the hourly forced outage rates are input.

Maintenance Rate- The average percentage of time the resource will be unavailable due to scheduled outages. This field reduces the plant capability for each dispatch multiplying the plant capacity from the Resource Table by the quantity 1- Maintenance Rate/100. This value may be an alpha which would point to an annual alpha vector. There is the capability to put a number greater than 1000 in the fuel or resource maintenance rate field in the database. If this is done, then the logic will use the monthly vector pointed to by the value in the maintenance rate field less 1000. If the resulting maintenance rate field is negative, then AURORA will assume the absolute value of the field is a pointer to a weekly vector where the hourly maintenance rates are input.

If you desire to change the value on an annual basis, then put the name of an annual alpha vector (should have some non-numeric characters in the name) in the forced outage rate field. The annual vector can then contain the forced outage rates by year or a number greater than 1000 where the logic for monthly vectors described above will be used.

Non Cycling - Non-zero number indicates percent premium of market price over dispatch cost required to commit the resource for operation. With the old commitment logic, the commitment period is one week. With the new commitment logic, the commitment period is specified by the Min Up Time. Once on, the unit remains on at least at minimum capacity until the next commitment period or for the Min Up Time. If you desire to change the value on an annual basis, then put the name of an annual alpha vector (should have some non-numeric characters in the name) in the this field. The annual vector can then contain the values by year or a number greater than 1000 where the logic for monthly vectors described above will be used.

Must Run- Flag (on is 1, off is zero) which sets the units to a "must run" condition. Resources that have this flag set assume a zero cost of dispatch for the minimum capacity and will be the first units to operate. If you desire to change the value on an annual basis, then put the name of an annual alpha vector (should have some non-numeric characters in the name) in the this field. The annual vector can then contain the values by year or a number greater than 1000 where the logic for monthly vectors described above will be used.

Hydro Number - For hydro resources, any of the hydro shapes in the "hydro monthly" table may be referenced for any hydro resource unit. The user may also choose a new hydro shaping factor for any hydro resource by including a new shape in both the "hydrovectors case" and "hydro monthly" tables and referring to that shape in the "resource" table. Entering minus one indicates that the value of the area should be used for this resource. If the unit is not an hydro unit (does not have a fuel with the name "Water"), then this value is not used.

Minimum Capacity - For non-cycling and must run resources this specifies the minimum capacity the unit can run at when the non-cycling logic is active. The unit for the input is a percentage of resource capacity. If you desire to change the value on an annual basis, then put the name of an annual alpha vector (should have some non-numeric characters in the name) in the this field. The annual vector can then contain the values by year or a number greater than 1000 where the logic for monthly vectors described above will be used. Note, if an UBB Segment Size (see below) is specified, then this is a percent of the capacity after the UBB Segment Size is subtracted.

The following fields or columns are optional.

Second Fuel - (Long) Specifies a secondary resource fuel type to use for the current resource. If this has a value greater than zero, then AURORA will check (on a monthly basis) and use the lower fuel price of the two fuels. If the secondary fuel type is being used then a flag will be displayed in the period resource tables under the view button or the detailed resource report under the output button.

Start Up Costs - (Single) If this cost ($ per MW per startup) is included for cycling units and commitment logic is turned on, then these units will run commitment for a period of 5 to 18 hours (depending on the economy of running for that period). Caution - do not use startup costs for units in general. Aurora requires unit marginal costs for marginal units to price the system. With all marginal units on commitment, there can be no good computation of prices. Use these startup costs for particular units where you want to see their precise operation. For general use, add startup costs to the fuel cost. If this cost is included for non-cycling units and the commitment logic is turned on, then the startup costs will be included in the commitment decision.

Can Drop - (Long) This flag is set to zero or greater depending on how you want to restrict the retirement of a unit. If the value is positive, the unit will not retire until the year represented by this flag. If the flag is zero, then the unit can not be retired. If the flag is set to one then the resource can be retired at any time. If the flag is set to 2010 then the resource can not be retired until the year 2010.

Resource Group - (Long) Specifies the resource group that the resource should be reported in.

Resource Begin Date - (Date) Specifies the beginning date of a resource. Before this date, the resource will not be used in calculations in AURORA for dispatch and value.

Resource End Date - (Date) Specifies the ending date of a resource, i.e. its retirement date. After this date, the resource will not be used in calculations in AURORA for dispatch and value.

Resource Fixed - (Boolean) True (1 or -1) or False (0) specifying whether the resource should be considered fixed and not subject to retirement for long term optimization runs.

Capacity Monthly Shape - (Long) If this value is greater than zero, then it must be a reference number to a valid row in the monthly shape table where monthly factors for shaping capacity are input. A (-1) will default to the fuel table.

Bidding Factor - (Text) If this value is a numeric value greater than 0 then it is a factor which will be added to one and multiplied by the total resource variable cost to get the dispatch cost for the resource. This simulates bidding at prices that are greater than the cost of a resource. This number will override any general resource dispatch margin which may be used. If this value is a non-numeric alpha value then it points to an annual alpha vector where the values are input annually. If this value is a negative one then the fuel default is used. If this value is less than negative one then it is a pointer to a monthly shape factor where monthly values are input.

Bidding Shape - (Text) The number of the weekly shape vector (of hours) to use for shaping the bidding factor hourly (they are multiplicative). A alpha string may be used in this field. If it is, then it points to an annual alpha vector which must point to a monthly shape factor. The monthly shape factor then contains the weekly shape vector for each month. By this means, you can vary the shape by month and year. If this is zero, -1 or not given, then no shape is used.

Committed Heat Rate - (Single) The heat rate to use for dispatch decisions during periods when the resource is committed. If this is zero or not given, then the heat rate (input above) is used.

Ramp Rate - (Text) If this value is a numeric value greater than 0 then it is a percent which will be divided by 100 and multiplied by the resource capacity to get the increase in capability available in the next hour for the resource. Ramp rates are effective only if the ramp rate logic is set to on and you are making a run with 8760 hours being dispatched. If this value is a non-numeric alpha value then it points to an annual alpha vector where the values are input annually. If this value is less than negative one then it is a pointer to a monthly shape factor where monthly values are input.

Min Up Time - (Long) The minimum number of hours the unit must stay up if committed to run with new commitment logic. Defaults to fuel table if this column is not in the database.

Min Down Time - (Long) The minimum number of hours the unit must stay down if it is a commitment type (non-cycling non-zero) and not committed with new commitment logic. Defaults to fuel table if this column is not in the database.

UBB Heat Rate - (Text) The heat rate of an upper (third) block of a resource. The segment size must also be specified (see below). If this value is a non-numeric alpha value then it points to an annual alpha vector where the values are input annually. If this value is a negative one then the fuel default is used. If this value is less than negative one then it is a pointer to a monthly shape factor where monthly values are input.

UBB Bidding Factor - (Text) The bidding factor (see above) to use for the upper (third) block of a resource. The segment size must also be specified (see below). If this value is a non-numeric alpha value then it points to an annual alpha vector where the values are input annually. If this value is a negative one then the fuel default is used. If this value is less than negative one then it is a pointer to a monthly shape factor where monthly values are input.

UBB Segment Size - (Text) The segment size in percent of the upper (third) block of a resource. If this value is a non-numeric alpha value then it points to an annual alpha vector where the values are input annually. If this value is a negative one then the fuel default is used. If this value is less than negative one then it is a pointer to a monthly shape factor where monthly values are input.

UBB Bidding Shape - (Text) The number of the weekly shape vector (of hours) to use for shaping the UBB Bidding factor hourly (they are multiplicative). A alpha string may be used in this field. If it is, then it points to an annual alpha vector which must point to a monthly shape factor. The monthly shape factor then contains the weekly shape vector for each month. By this means, you can vary the shape by month and year. If this is zero, -1 or not given, then no shape is used.

(Emission Type Name) Emission Rate - (Single) This field or fields contains the resource emission rate in lb/mmbtu for the emission type given by the name. The field or column name is the concatenation of the emission type name and " Emission Rate". There is the capability to put a number greater than 1000 in the resource emission rate field in the database. If this is done, then the logic will use the monthly vector pointed to by the value in the emission rate field less 1000. If the emission rate is greater than 1000 then it must be input in the monthly vector.

Reporting - (Boolean) This field specifies if the resource will be reported in the Detailed Resource Report and in the Resource Operations Report.

Additional variables for energy storage resources:

Beginning with version 5.5.0, any resource that references a fuel name beginning with "Storage" is defined to be an energy storage resource. The Heat Rate is used to input the unit efficency as described in Heat Rate above. There are currently three additional variables which define the characteristics of storage resources:

Recharge Capacity - (Text) The maximum rate (MW) at which a storage resource can be recharged. This value defines maximum output on the storage side during charging. Energy input required to achieve this recharge rate will be higher by the reciprocal of unit efficiency.

Recharge capacity can be changed on an annual basis by using the name of an annual alpha vector in this field.

Maximum Storage - (Text) The maximum live storage contents of the storage resource in MWh. This value can be changed on an annual basis by using the name of an annual alpha vector in this field.

Initial Contents - (Single) Initial storage content of the storage resource at the beginning of the study. This value is input as a fraction and is multiplied by the Maximum Storage value to get initial contents. The value used here should reflect expected storage contents at midnight on the first Sunday of the first month of the study.

Risk Input

This table sets up the selection of input variables to use when performing risk analysis. The input variables to be used and the definition of when they should be varied and by how much are in this table. Note that the table is built with the most general (in terms of location and time period) distribution of input variables first. As subsequent variables added to the table, the previous variables are superseded for the given locations and time periods.

Columns include:

Input Variable - One of five primary variables: Demand, Fuel, Hydro, Resources or Portfolio Demand. A drop down box will allow you to choose one of these.

Number or Area - Corresponds to a number such as the fuel number (or generally the area in the case of demand and hydro) which the user desires to vary. A -1 indicates that all numbers or areas are varied by the distribution.

Distribution Type - Currently, there are five distribution types: Normal - normal distribution defined by both mean and standard deviation. Uniform - flat distribution having equal probability over the range. Binomial - an on/off distribution where Parameter 1 defines the probability (in percent) of the distribution being on. This distribution is included for modeling resource forced outages. Lognormal - A lognormal distribution where Parameter 1 is defined to be the log of the mean and Parameter 2 is the log of the standard distribution. Finally, User Defined - A user defined distribution.

User defined distribution type - Parameter 1 contains the percent change to the mean if the user distribution type is a normal distribution. Parameter 2 contains the percent standard deviation if the user distribution type is normal. These factors affect other distributions in ways that depend on the distribution. The User Defined Vector contains a reference to the weekly vectors table row where the distribution is defined. The User Defined Number is the number of Y values in the distribution up to 168 which is the number of data columns in the weekly vector table. To use this user defined distribution, the user builds the distribution as a series of equally spaced Y values which are put into the weekly vectors table row. See below for additional notes on user defined distributions. When using a user defined distribution type, AURORA cannot use the Latin Hypercube methodology. Therefore the Latin Hypercube is automatically turned off if you have chosen a user defined distribution type. Because of this, you may need to run many more samples or iterations to have a smooth output distribution (depending on the number of variables, a 1000 or more). Therefore do not use the user defined distributions for any distribution which is can be input based on the other specific distribution types.

The result of sampling from these distributions is then divided by 100 and added to one. They are then multiplied by the input variable value (or 1 in the case of Resources) to give the sample value for the input variable for the particular risk iteration AURORA is currently performing.

Parameter 1 (Mean) - This parameter inputs the change in mean value for the distribution. (Normal, see above for other distribution types)

Parameter 2 (St Dev) - This parameter inputs the value for the standard deviation. (Normal, see above for other distribution types)

Dependent Number - This input correlates input variables. When a dependent number is entered, the value used in the random selection establishing the distribution of inputs is the same for this line as for the line referenced by the dependent number. References may be any number of levels deep (that is a variable may be dependent on a second variable which is in turn dependent on a third variable), however, they cannot be circular (a variable may not be dependent on a second variable which is in directly or indirectly dependent on the first variable). A negative one (-1) denotes that the variable should be elected independently of the other variables.

Risk Percent Correlated - (Optional column type single) If this column is included, then it provides a percentage correlation for variables with a dependent number. Defaults to 100% if this column is not included.

Day - (Optional column type long) The day (number from the start of the daily study) in which the input variable distribution is used. A - 1 indicates that it applies to all days. Use a particular day only when you are running a daily run with risk analysis.

Month - The month in which the input variable distribution is used. A -1 indicates that it applies to all months.

Year - The year in which the input variable distribution is used. A -1 indicates that it applies to all years.

User Defined Vector - (Optional column type long) The weekly vector for a user defined distribution. See above.

User Defined Number - (Optional column type long) The number of values in the user defined distribution (maximum of 168). See above.

System Diagram Info

This table is created by AURORA when the user save the system diagram information while viewing the system diagram. Users should not edit this table directly.

Transmission

Starting with Version 5.2, this table is no longer used. This data is now input in the Link table.

Weekly Vectors

This table provides weekly shaping factors by hour, that can be referenced by the condition table, the portfolio contract table, the electric price table and/or the resources table. Weeks begin on a Monday.

Columns include:

Number - A reference number that is referred to in the condition table or the power cost contract table.

Name - The name of the vector. Not used by Aurora.

1-168 - The hourly value of the vector for each hour of the sample week - the first hour is hour 0 to 1 of Monday.

AURORA Results

AURORA results can be displayed in a variety of ways. The user can quickly view intermediate results in the middle of a model run by pressing the Pause button and then pressing the View button on the toolbar. Final results can also be viewed with the View button. When a run is complete, data may be written to the output database. Pressing the Output button on the toolbar will write the database (or Excel workbook - please note that the Excel workbook should not be open or AURORA may fail to write the data and no error message may appear) and open a grid for viewing the tables in the output database.

For formal reports, use the options under the Results tab to create specific reports that may be viewed on the screen and printed as desired. Because of the extensive nature of the data produced, results are written to an output database that may be reported from with any standard database reporting tools including Excel.

Information that can be viewed during the models operation is accessed using the View button on the toolbar. This information is generated from data stored within the model during its operation. This information can easily be extracted to other Windows programs with simple copy and paste commands (right click on the mouse or use the standard clipboard "ctl c" and "ctl v" keystrokes). Information accessible here includes hourly information for the current hour of dispatch and period information for months and years of time (already run by AURORA).

The results can be reported in several ways. Since the information is stored in a standard Access compatible database, the user can use any database-reporting tool including Access or Excel to report or graph information from AURORA. Or you can simply use the grid printing function to produce quick reports.

Each line of output to the database has a "DateTime" column or field. This column will display the datetime the run started by default or the Run ID if the user has entered it on the Assumptions tab. If the multiple runs checkbox is checked on the Results tab, multiple runs will be output to the same tables in the database.

This form allows all of the tables in the output database to be viewed and reported from.

Each row of each table in the database has a field which displays the date and time of the start of the AURORA run. This is useful when putting multiple runs to the database and examining the results with an Excel Pivot Table.

Each row also has a field (in the last or furthest right position) which displays the Risk Iteration number. This can be used when running AURORA risk analysis to display complete information for each of the risk samples. Set the flag for Auto database write on the results tab or only the last sample will be available when the output button is pressed. Once again, an Excel Pivot table is excellent for viewing and manipulating multiple sets of output.

Output data must be specified by using the standard or the standard and detailed reporting check boxes. If standard is not checked then no output will be sent to the database.

Annual Resource Output

This output table displays annual summary result information on resources that are being used by the Aurora.

Name - Name of the resource from the Resource input table

Capacity (MW) - The resource capacity from the Resources data input table

Heat Rate (BTU/kWh) - The heat rate of resource from the Resource input table

Area - Area where the resource is located from the Resource input table

Fuel Name - The fuel name from the Resource input table or the "Fuel Case" table.

Must Run - The must run setting (as input) for the resource. It is a 1 if the unit is must run.

Year - The year of the results

Cost ($/MWh) - Average variable cost of the resource over the year. This includes both fuel and variable O&M cost.

Value (thousands of $) - The value of the resource for the year. The value is defined to be the difference between the market price of electricity in the area where the resource is located and the cost of the resource (including variable and fixed operation and maintenance expense as indicated by the assumptions flags)

Revenue (thousands of $) - The revenues the unit will generate at the market price of electricity in the area where the resource is located and given the resources output.

Capability (MW) - The average capability of the resource for the year. Net of hydro flow rates, forced outage rates and operating reserves.

Output (MW) - The average output of the resource for the year. (For energy storage resources, this value will be the net of generation and charging energy.)

Total Output (MWh) - The energy generated over the period. (See above note for storage resources.)

Percent Marginal - The percent of time in the period the unit is at the margin.

NPV Values ($000/MW) - The NPV of value for the resource divided by the resource capacity.

Startups - If the unit is commitment type, the number of startups for the period.

Resource Group - The resource group number of the resource.

Begin Date - The beginning date for the resource operation.

End Date - The ending date for resource operation (retirement date).

Utility - The utility owning or operating the resource.

Emissions - Emission amounts and costs are shown for the period for each emission type.

Group Number - The group number the resource is in.

Area Price

This report provides the average prices and loads for monthly and yearly periods for each area in the model. The year to be displayed is chosen when the report is entered.

Fields include:

Area - The area number

Name - The area name

Year - The year of operation being displayed

Month -The numeric month with 13 indicating the annual average. All months and annual amounts are displayed for each area.

Price ($/MWh) - The average "market price" for the period

Demand (MW)- The average native demand for the period

Net Load (MW) - The average net (of imports and exports) load for the period

Supply Capability (MW) -- The average capability (capacity de-rated for forced outage rates, maintenance and hydro energy factors) for all supply resources in the area (those resources not beginning with the letters "demand side") for the period.

Resource Output (MW) -- The average amount all supply side resources were run in the area for the period.

Demand Side(MW) - The average amount all demand side resources (also known as curtailment or interrupted load) was used for the period.

Peak Demand (MW) -- The peak demand for the period for the area.

Supply Capacity (MW) --The total capacity of all supply resources in the area.

Peak Reserves (MW) -- The difference between Peak Demand and Supply Capacity in the area

Area Price Condition

This report displays the some of the same results as the Area Price report. It includes one additional field, Condition. The results are therefore displayed by condition (i.e. On-Peak and Off-Peak)

Condition - The condition number as defined in the condition data input table.

Daily Area Price

This table provides the following fields:

Area - The number of the area being reported.

Name - The name of the area being reported.

Date - The date of the information being reported.

Weekday - The day of the week of the information being reported.

Condition - The time condition of the information being reported.

Price - The average price ($/MWh) for the indicated condition, date and named area.

Daily Hub

This table provides the following fields:

Hub - The number of the hub being reported.

Name - The name of the hub being reported.

Date - The date of the data being reported.

Week Day - The day of the week of the information being reported.

Condition - The time condition of the information being reported.

Hub Price - The average price ($/MWh) for the indicated condition, day and hub.

Daily Transmission Usage

This table provides the following transmission information:

Link From To - Transmission link from area number to area number.

Area From - The name of the area the transmission is from.

Area To - The name of the area the transmission goes to.

Date - The date of the information.

Weekday - The day of the week of the information.

Condition - The time condition of the information.

Link Load - The average load on the transmission link in MW for the condition and date.

Link Capacity - The capacity on the transmission link in MW for the condition and date.

Percent Loaded - The link load divided by the link capacity, reported in percent.

Detailed Resource Output

This report is available only if the diagnostic output switch is turned on and only for resources tagged with a true in the reporting column of the resources table. The report is similar to the annual resource output report except that annual and monthly information is in the report and the area name is displayed rather than the area number.

Additional or modified fields:

Month - The month summarized on the row. Number 13 is used for an annual summary

Area - The name of the area where the resource is located

Second Fuel - Displays a true is the secondary fuel for the resource is used for the month.

Fuel

For each month (1 to 12) of the year and annual (13) and for each year run, this report displays nominal fuel cost in $/mmBTU, fuel usage in mmBTU and the percent of time in the period the fuel was being used by marginal generation for each area.

Fuel Condition

For condition (on-peak, etc) and for each month (1 to 12) of the year and annual (13), this report displays nominal fuel cost in $/mmBTU, fuel usage in mmBTU and the percent of time in the period the fuel was being used by marginal generation for each area.

Group Output

This table contains information about resources summarized by group. The groups are defined in the group table with references to the group table from the resources table or the fuel table.

Results displayed for the group include the following:

Name - The name of the group.

Year - The year of operation being displayed

Month -The numeric month with 13 indicating the annual average. All months and annual amounts are displayed for each area.

Capacity - The total capacity for all of the resources in the group in MW.

Output - The total output for all of the resources in the group in MW.

Percent Marginal - The percent of the period the group is at the margin. Note, since the percent margin is an area computation, if their are resources in a group in more than one area, the total percent can be larger than 100.

Value - The total value for all of the resources in the group for the hour in $000.

Fuel Usage - The total fuel usage for all of the resources in the group in MmBtu.

(Type) Emission Amount - The total amount of emissions for all of the resources in the group for the emission type.

(Type) Emission Cost - The total cost of emissions for all of the resources in the group for the emission type.

Hourly Data

This report is available only if the Hourly to Database box is checked before you make a run. The report displays hourly prices by hub and area and displays hourly demand by area. Many lines are written for each dispatch hour, so use care when writting this report with lots of dispatch hours.

Run DateTime - The date and time the AURORA run was made.

Date - The date of the forecast output data.

Hour - The hour in the day.

Condition columns - One column for each condition (such as On-Peak) with a flag indicating whether the hour is in the condition.

Area Number - Number of the area being reported on the output row.

Area Name - Name of the area being reported on the output row.

Demand - For area rows, the hourly demand for the area.

Hub Number - Number of the hub being reported on the output row.

Hub Name - Name of the area hub reported on the output row.

Prices ($/MWh) - The area or hub price.

ORM (Percent) - For area rows, the operating reserve margin for the hour. Defined to be the Demand less 50% of imports plus 50 % of exports divided by the supply.

Marginal Resource - The resource at the margin for the area or hub.

Res Number - The number of the marginal resource.

Second Fuel - Has a value of true if a second fuel type is being used for the month.

Risk Iteration - The number of the risk iteration if a risk run is being performed.

Day Commit Price - Used internally only.

ORM Premium - Not currently used.

Hourly Hydro Results

Displays diagnostic information on the hydro shaping logic. Contact EPIS for more information.

Hourly Resource Results

Displays hourly information for resources chosen in the dialog after the hourly resource box is checked on the results tab.

The information on the current hour is the same as the hourly data report. Then there is a column for each chosen resource which displays the value, as chosen in the resource dialog form.

Hourly Transmission Results

Displays hourly information for all transmission links with non-zero capability when the hourly resource box is checked on the results tab.

The information on the current hour is the same as the hourly data report. Then there are columns which displays the loading and the capability.

Hub Price

This report displays the average of hourly hub prices over both monthly and annual periods. The year displayed is chosen when the report is entered.

Hub - The hub number.

Name - The identification name of the hub

Year - The year of operation being displayed

Month -The numeric month with 13 indicating the annual average. All months and annual amounts are displayed for each hub.

Hub Price ($/MWh) - The average price for the period

Hub Price Condition

This report displays the same results as the Hub Price report. It includes one additional field, condition. The results are therefore displayed by condition (i.e. On-Peak and Off-Peak)

Condition - The condition number as defined in the condition data input table.

LT Annual Resource Change

This table is created with long term optimization runs (see future tab). It contains system summary information on resource changes by year.

Year - Year of the study.

Area Number - Area number of the additions or retirements.

Area Name - Area name of the additions or retirements.

Resource Additions - MW of new resource additions for the year.

Resource Retirements - MW of existing resource retirements for the year.

ORM Premium Output

Reporting for this feature is provided hourly. Hourly data is available only if the Hourly to Database box is checked before AUROA is run.

This report displays hourly prices and ORM percent by area and displays hourly demand by area. The reporting of ORM percent is a function of the ORM premium logic, which requires the "ORM Input Premium" table to be accepted in the AURORA Project File.

Portfolio / Power Cost

This report provides a quick summary of resource operation and cost, contract purchases and sales and market purchases and sales to determine the overall portfolio value or power cost for a portfolio. There is no limitation on the definition of a portfolio that can represent anything from a large utility to a portfolio of contracts.

Portfolio - Name of the entity or portfolio. The user is allowed to analyze many portfolios simultaneously.

Type - The type of information contained in the row. It may be either cost or energy

Name - The name of the contract, resource or summary line item.

Month (January through December) - Monthly energy (MWh) or cost (thousands of $) for each line item.

Annual - Annual energy or cost for each line item.

Note : Value of a portfolio will be displayed as a negative (cost).

Resource Iteration Value

Written to the output database for each iteration of the long term study. Lists the NPV value of each existing and new resource in $000/MW.

Resource Operation Report

A report, displayed for each chosen resource (chosen when the check box is changed from off to on or tagged with a true in the Reporting column of the resources table) and for each year of monthly and annual information. See the Annual Resource Output report for more information about resources.

The report contains the following information:

Capability - Displayed in average MW. Essentially the plant availability in MW.

Output - The forecasted plant generation in average MW.

Capacity Factor - The capacity factor (capacity / output).

Fuel Unit Cost - Cost of fuel for the plant in $/mmBTU.

Fuel Usage - Fuel usage in mmBTU.

Revenue - Revenue ($000) from selling the plant output at market prices in the area where the plant is located.

Fuel Cost - The cost ($000) of fuel used by the plant.

Variable O&M - The cost ($000) of variable O&M for the plant.

Fixed O&M - The cost ($000) of fixed O&M for the plant.

Startup Cost - The cost ($000) of unit startups for the plant.

Emission Cost - The cost ($000) of emissions for all types for the plant.

Value - Then Revenues minus fuel cost minus variable O&M minus fixed O&M minus startup cost.

Note, the use of certain costs in the Value computation is determined by check boxes on the Assumptions tab. Reference that tab to determine how the Value is actually computed.

Resource Stack Report

A resource stack report output table is created with data in it for each area, for each month and annual for each year.

This table contains the unit number, unit name, area, month, year, the stack capacity (MW), the stack capability (MW) and the stack price for each unit in the stack. It displays by area.

Use the filter button to filter the table for the month, year and area you wish to display. Or copy to Excel (use the button) and use the autofilter capability in Excel. You can display this information graphically at the end of a run with the graph button.

Risk Demand Input

This report displays the input distributions of demand for each iteration along with a statistical summary. Monthly inputs are shown. The demand number or area is chosen when the report is entered.

Iteration - The iteration number. The last two rows labeled 10,001 and 10,002 contain the "mean" and "standard deviation" results.

Demand percent change - The remaining columns display the values for each period. These are percent changes from the base input value.

Risk Fuel Input

This report displays the input distributions for fuel for each iteration along with a statistical summary. Monthly inputs are shown. The fuel number is chosen when the report is entered.

Iteration - The iteration number. The last two rows labeled 10,001 and 10,002 contain the "mean" and "standard deviation" results.

Fuel Percent Change - The remaining columns display the values for each period. These are percent changes from the base input value.

Risk Hydro Input

This report displays the input distributions for hydro for each iteration along with a statistical summary. Monthly inputs are shown. The hydro number or area is chosen when the report is entered.

Iteration - The iteration number. The last two rows labeled 10,001 and 10,002 contain the "mean" and "standard deviation" results.

Hydro Percent Change - The remaining columns display the values for each period. These are percent changes from the base input value.

Risk Results

This report displays the results of risk analysis showing the output results of each iteration and along with a statistical summary. The report is in matrix format with the results across the columns and the iteration (Monte Carlo sample) in rows. The last two rows give the mean and standard deviation information for the results.

Iteration - The iteration or sample number. The last two rows labeled 10,001 and 10,002 contain the "mean" and "standard deviation" results.

Risk Output - The remaining columns display risk results for each iteration and the mean and standard deviation. Each column is labeled with the variable and the time period which the results represent.

Study Log

A log of changes made for each iteration to the resources. Used for diagnostic purposes only.

Temporary Resource Modifier

This is the interim table of resource modifications made for the last iteration completed in a long term study. The format is exactly the same as the Resource Modifier table. This table is deleted when a long term run completes successfully. It may be used in a restart of an aborted long term run.

Transmission Usage

This report displays the average loading for the transmission links for monthly and yearly periods. The year displayed is chosen when the report is entered. See hourly link for an explanation of positive and negative numbers.

Link From To - Link area from and area to numbers

Area From - Name of the area that energy is coming from

Area To - Name of the area where energy is going to

Year - The year of operation being displayed

Month -The numeric month with 13 indicating the annual average. All months and annual amounts are displayed for each link.

Avg Load (MW) - The average load over the period. The average is mathematical sum of flows from "area from" to "area to" divided by the number of hours dispatch in the time period.

Link Capacity (MW) -The link capacity for the period.

Percent Loading - The average percent loading of the link for the period. Negative numbers indicate that flows take place predominately in the reverse direction. Negative numbers should be ignored.

Transmission Usage Condition

This report displays the same results as the Transmission Usage report. It includes one additional field, condition. The results are therefore displayed by condition (i.e. On-Peak and Off-Peak)

Condition - The condition number as entered in the Condition table.