GENESYS Documentation Version 1.0

Contents

[2 Introduction 2](#_Toc445824212)

[2.1 2](#_Toc445824213)

[2.2 Purpose 2](#_Toc445824214)

[2.3 History 3](#_Toc445824215)

[3 Overview 3](#_Toc445824216)

[3.1 File Types 3](#_Toc445824217)

[3.2 Structure 4](#_Toc445824218)

[3.3 Model Flow 4](#_Toc445824219)

[4 Stochastic Inputs 4](#_Toc445824220)

[4.1 Load, Wind and Solar 4](#_Toc445824221)

[4.2 Streamflows 5](#_Toc445824222)

[4.3 Forced Outages 5](#_Toc445824223)

[5 Deterministic Inputs 5](#_Toc445824224)

[5.1 Hydro Generation Parameters 5](#_Toc445824225)

[5.1.1 Constraints 6](#_Toc445824226)

[5.2 Thermal Generation Parameters 6](#_Toc445824227)

[5.2.1 Constraints 6](#_Toc445824228)

[5.3 Other Generating Resource Parameters 7](#_Toc445824229)

[5.3.1 Constraints 7](#_Toc445824230)

[5.4 Contracts/Market 7](#_Toc445824231)

[5.4.1 Constraints 7](#_Toc445824232)

[5.5 Reserves 7](#_Toc445824233)

[5.6 Topology 7](#_Toc445824234)

[5.6.1 Resource 7](#_Toc445824235)

[5.6.2 Transmission 8](#_Toc445824236)

[6 Dispatch Logic 9](#_Toc445824237)

[6.1 Summary 9](#_Toc445824238)

[6.2 Period Dispatch 11](#_Toc445824239)

[6.3 Window Dispatch 12](#_Toc445824240)

[6.4 Daily Dispatch 12](#_Toc445824241)

[6.5 Hourly Dispatch 13](#_Toc445824242)

[6.6 Emergency Resource Dispatch 14](#_Toc445824243)

[7 Appendix 14](#_Toc445824244)

[7.1 Input Files 14](#_Toc445824245)

[7.1.1 Binary files (.bin) 15](#_Toc445824246)

[7.1.2 Text files (.dat files) 15](#_Toc445824247)

[7.2 Log 21](#_Toc445824248)

[7.3 Output 21](#_Toc445824249)

[7.3.1 Text files (.out files) 22](#_Toc445824250)

[7.3.2 Text files (.vbi files) 23](#_Toc445824251)

[7.4 Modules 25](#_Toc445824252)

[7.4.1 TSR Modules 28](#_Toc445824253)

[7.5 Subroutines 32](#_Toc445824254)

[7.5.1 TSR Subroutines 39](#_Toc445824255)

[7.6 Dynamic Link Libraries 41](#_Toc445824256)

# Introduction

GENESYS, **GEN**eration **E**valuation **SYS**tem, is a constrained economic dispatch model that uses Monte Carlo sampling to simulate short-term load uncertainty, and uncertainty in streamflows, wind, and forced outages for thermal generation plants. The model performs a detailed constrained dispatch of the regulated hydro power projects in the watershed of the Columbia River and a simple dispatch of Pacific Northwest regional thermal plants against an extra-regional import market on a 14 period basis, a user defined subset of the month, and an hourly basis.[[1]](#footnote-1)

##

## Purpose

GENESYS is used by the Northwest Power and Conservation Council and Bonneville Power Administration to perform studies requiring detailed hydro dispatch for planning purposes. More specifically the Council uses GENESYS for annual adequacy assessments, periodic regulated hydro flow studies and periodic analysis of lost revenue due to hydro dispatch change. The adequacy of the regional power supply is assessed probabilistically in GENESYS by evaluating any regional shortfall against the Council’s adequacy standard[[2]](#footnote-2). This standard has been designed to assess whether the region has sufficient resources to meet growing demand for electricity in future years. Regulated hydro flow studies have been performed for the Fish and Wildlife department for fish passage survival and life-cycle studies. Additionally, GENESYS is utilized for studies of changes in hydro generation due to Fish and Wildlife Program recommendations and climate change scenarios.

## History

In 1999, deterministic load-resource balance in the region was nearly 4,000 MW deficit. GENESYS was developed as a dispatch model to evaluate adequacy in a single year by dispatching resources at each node[[3]](#footnote-3). A distinguishing characteristic of GENESYS from predecessor production cost models[[4]](#footnote-4) was the ability to utilize stochastic and deterministic input variables and perform a hydro and thermal generation dispatch. Unlike predecessor models GENESYS was not designed to test long-term load uncertainty and utilize system expansion logic. In the Council’s modeling portfolio, GENESYS is used to provide adequacy information to the Regional Portfolio Model (RPM) which considers long-term load uncertainty[[5]](#footnote-5) and performs regional power system expansion studies.

# Overview

GENESYS is made up of multiple modules of which some can be run independently[[6]](#footnote-6).

## File Types

The input, output and miscellaneous other files in GENESYS are stored as different types of files with the following suffixes:

.bin - Binary files used to store either input or output data.

.dat - Text files used to store input data.

.inp - Text file used to store input data.

.out - Text files used to store output data.

.vbi - Text file used to store output data for visual basic interface.

.dll - Dynamic link libraries needed to run GENESYS, must be in the same folder as the GENESYS executable file.exe - Executable files used to run GENESYS modules.

.f90 – FORTRAN 90 modules or sub routines

.for - FORTRAN modules or sub routines

.log - Log files used for error trapping and reporting

These files are discussed and categorized in more detail in the Appendix below.

## Structure

GENESYS is made up of modules, subroutines, compiled dynamic link libraries, input and output files that are needed to run GENESYS in multiple different modes. GENESYS also calls HYDSIM (a stand-alone program) which also uses some of the same files used in GENESYS. The structure has supported adding on functionality as needed (different hydro dispatch modes) and overwriting or switching off functionality that is legacy (long-term expansion logic).

## Model Flow

The model is initiated by running the *GENESYS VXX.exe* executable that has file structure access to folders with the compiled FORTRAN 90 modules and subroutines, and the appropriate input files as described above. The input and output files, and dynamic link libraries are often stored in the same folder as the executable, but the compiled modules and sub-routines are stored in subfolders under the current GENESYS version.

# Stochastic Inputs

The load, water conditions, wind generation, solar generation and thermal forced outages are all random variables within GENESYS. A set of hourly loads and a set of hourly wind capacity factors for each temperature year are input, as well as a set of historical 14 period streamflows by water year (currently 80).

## Load and Wind

Hourly load and wind generation are associated with 77 temperature years from 1929 to 2005. Load and wind can be aligned by temperature-year or drawn randomly.

Hourly loads are input into the model by temperature year for a particular operating year. The user has the option of inputting the hourly loads by node or in total, in which case percentages are used to apportion regional loads between nodes. The hourly load for a game is determined by the draw of a temperature year.

Wind is input as a nameplate capacity at a site (three sites are possible, each defined at a node) with hourly capacity factors by wind year for that site. The drawn wind year capacity factor multiplied by the nameplate capacity defines the wind generation for a particular game. There is an option for randomly picking from up to 20 different wind capacity factors for a particular wind year. Wind is modeled as a load reduction resource. The hourly wind at a node in a simulation is subtracted off the hourly loads and the residual load is what is used in the dispatch logic.

## Streamflows

An 80-year historical record of streamflows from 1929 to 2008 is sampled. The user can specify whether the water years are drawn from the historical record randomly, for a fixed set of years, or sequentially. Currently a random draw for water years will lead to end-of-year/beginning-of-year discontinuities because the Canadian operation is fixed based on a sequential water year selection. GENESYS can be run in random water mode without the discontinuity if it is run in refill mode, that is, if the October initial elevation is reset for each game. For Council studies the model is not commonly run in this mode. The methodology for interpreting the streamflows is described in more detail in the Period Dispatch section below.

## Forced Outages

To reflect the uncertainty surrounding unexpected lack of availability (often unit failure) of thermal generation units, GENESYS reflects a forced outage rate and the mean amount of time it takes to repair each thermal unit. Each thermal generating resource has a user-defined forced outage rate and the mean repair time. The setting can be for zero outages, non-stochastic outages (reduction applied to every hour) or stochastic outages. When the setting is on “stochastic outages”, the forced outage rate and mean repair time are used to calculate the hours until the unit is forced out. Each resource has an initial “state” (operating or experiencing an outage) based on a random draw. The number of hours until subsequent states depends on additional random draws. The availability of thermal resources is updated every hour.

The model picks how long an outage state or an on-line state will last. For example, the state might last 257.543 hours. For 257 hours then the plant’s availability would be all the way up or down, depending on which state it’s in. The last hour the capacity available to be dispatch will transition by .543. So the thermal transitions up and down always take place over one hour, not several.

# Deterministic Inputs

All generation resources (currently 233) and contracts in the Pacific Northwest region are modeled in GENESYS. Each has a set of defined deterministic parameters that are used to determine the resource dispatch/availability under stochastic fuel uncertainty and/or forced outages.

## Hydro Generation Parameters

The hydropower generation plants in GENESYS are split into regulated and independent hydropower plants. The independent hydro generation is accumulated by water year and two nodes (PNW East and PNW West). For each hydro condition sampled generation is fixed and there is assumed to be no flexibility in the operation[[7]](#footnote-7). Dispatching the regulated hydro generation plants is one of the primary focuses of the GENESYS model.

The regulated hydro generation parameters can be split into two categories: generating capability of the hydropower plant and fueling and operating constraints (e.g. hydro availability, flow constraints, elevation targets). The hydro generation parameters are discussed in more detail in the Input Files section in the Appendix.

### Constraints

GENESYS has an option (which is not yet fully activated) to dynamically calculate the operation of Canadian reservoirs under the Treaty Storage Regulation (TSR). When this option is not active, Canadian end-of-month elevations for all periods and water records (in the PERIOD.BIN file) are fixed to the Assured Operating Plan elevations (results of a pre-run TSR regulation by BPA). These fixed elevations are dependent on how the study was done to calculate them. For example, if the study was run as a continuous sequential-hydro year study (beginning elevation of the first month of the second year is set to the ending elevation of the last month of the first year) then GENESYS must be run in sequential mode otherwise, a transition error will occur at the end of every water year for Canadian reservoirs. This logic was added so that GENESYS could be run in random water year mode. Under this option (with the TSR option active), for each year, GENESYS will first calculate the AOP elevations for Canadian reservoirs (this means running the HYDSIM module in TSR mode), set those elevations as fixed and then run the HYDSIM module again to simulate the operation of US reservoirs.

Running the HYDSIM module in the TSR mode uses a set of specific constraints that are different for a fixed-TSR run. These constraints include adjustments for flow augmentation[[8]](#footnote-8) and miscellaneous storage[[9]](#footnote-9) at Canadian projects. The resulting elevations for the Canadian hydro projects are then the targets for the HYDSIM operation-mode used in the GENESYS dispatch. Arrow target flows are also adjusted for trout spawning. When not using the TSR inside GENESYS, the user must specify the Canadian hydro projects elevations for each water condition as inputs to GENESYS. This data is part of the PERIOD.BIN file and the AER.BIN file.

## Thermal Generation Parameters

Thermal generation plants in GENESYS like hydropower plants are defined by node. Plant parameters include plant capacity, average heat rate, forced outage rate and mean time to repair (not applied deterministically), must run switch, online and offline dates, fuel type selection, maintenance schedule and fixed and variable costs. Most of the inputs are contained in the *GenRes.dat* and *GenRes cost.dat* and can be explored in more detail in theInput Files section of the Appendix. Thermal plants types include coal, nuclear, biofuel, and gas.

### Constraints

There are no explicit fueling constraints in GENESYS for thermal plants. A thermal plant generation could be constrained by transmission capability, but the only other limiting factors to thermal dispatch outside of economics are the must-run capability, limited thermal commitment, maintenance outages and forced outages.

## Other Generating Resource Parameters

Wind and solar plants are currently modeled as must-take generation accumulated by node and their hourly generation is subtracted from the load.

### Constraints

There are no explicit deterministic fueling constraints in GENESYS for wind and solar resources. The stochastic nature of the fuel availability for wind and solar generation is defined in the Load, Wind and Solar section of the Stochastic Inputs.

## Contracts/Market

Long-term contract obligations (between defined nodes) are modeled in GENESYS as well as short-term market purchases that are used to balance load in each Northwest node. Long-term contracts are defined by a particular seasonal, weekly and/or daily shape, source node and delivery nodes. Intraregional long-term contracts are executed by looping through source and delivery nodes and meeting total contract demand between nodes with the least expensive resources at the source node. Extra-regional market purchases are currently simulated as individual generic resources in the northern and southern California nodes, with sufficiently high heat rate to ensure that they will be the last resource dispatched prior to using borrowed (emergency) hydro generation. There is currently not an extra regional demand for short-term market sales.

### Constraints

There are no explicit constraints in GENESYS for contracts. However, the model does accounting on each transmission node to which a contract is associated and calculates the net contract amount between each node for each hour. The net transmission transfer capability is adjusted, in both directions, based on long-term contracts.

## Reserves

GENESYS records reserve violations by hour when the reserve requirement is greater than the reserves available. The contingency reserve requirement is based either on the generation reserve requirement or the transmission reserve requirement, whichever is greater. The generation requirement is currently set to the sum of 7% of thermal generation and 5% of hydro generation in an hour[[10]](#footnote-10). The transmission requirement is the amount of megawatts flowing on the maximum loaded line. The check for reserves for either thermal or hydro generation is the sum over what is available for dispatch (in the case of hydro this is the total hydro capacity) minus what is being generated. Operating reserve requirements are explicitly considered in TRAP for hydropower resources but operating reserve requirements are not currently explicitly assigned to thermal resources.

## Topology

### Resource

Resources in GENESYS have a couple different topological characteristics: nodal and fuel location. Per the Transmission section below, each resource in GENESYS is defined to be in a node, which defines any transmission limits on the resource. Each hydro resource is at a particular point in the Columbia watershed which determines its fuel availability. Functionally, in GENESYS, the location of any other type resource does not determine its fuel usage capability[[11]](#footnote-11).

### Transmission

The topology of GENESYS is set up into paths and nodes. The nodes are sub-regional accumulations of plants and the paths represent transmission available in a particular direction from those nodes. Represented in the “stick and bubble” format, where the paths are “sticks” and the nodes are “bubbles,” Figure 1-1 is a diagram showing the nodes and paths in GENESYS.

17000

400

1900

12000

2850

1000

3705

4300

1500

Figure 1-1: GENESYS Topology[[12]](#footnote-12)

# Dispatch Logic

## Summary

GENESYS dispatches in a chronological order over four dispatch time frames[[13]](#footnote-13). It dispatches for the month, a user defined “window” of days, daily shape, and hourly. The thermal and hydro resources are dispatched to meet loads in each dispatch time frame according to the variable costs of the thermal and hydro. The hydro variable costs are represented relative to the variable costs of particular thermal plants, as defined by the user[[14]](#footnote-14).

Figure : Multi-period dispatch diagram

## Period Dispatch

A hydro year is split up into 14 periods which are, for the most part, monthly, with April and August split into the first and last halves of the month[[15]](#footnote-15). The 14 period hydro regulator model used to determine available hydro in GENESYS is HYDSIM, developed and maintained by BPA. Reservoir and flow characteristics are modeled such as beginning and ending contents, minimum and maximum flows, minimum and maximum storage, and spills at each hydro project for each of the 14 periods. Each period, the amount of hydro energy is available to each node for the month is calculated, given the starting contents of the reservoirs of that month. The total available hydro energy is separated into what will be referred to as “blocks” of hydro energy. The hydro blocks are the amount of energy available if the system was drafted down to a given point. To determine the boundaries of the hydro blocks, the hydro regulator is run four times at the beginning of the month: to URC (Upper Rule Curve[[16]](#footnote-16)), to VECC (Variable Energy Content Curve[[17]](#footnote-17)), to draft point 6 (Proportional Draft Point), and to draft point 8 (Empty[[18]](#footnote-18)).

*Hydro block 1* is the amount of energy that must be generated to get to URC plus the energy generated by the hydro independents.

* Basically must run hydro, priced just more than Columbia Generating Station.

*Hydro block 2* is the amount of energy between URC and VECC.

* Priced just less than Beaver 1-7.

*Hydro block 3* is the amount of energy in non-treaty storage (currently not modeled).

*Hydro block 4* is the amount of energy between VECC and draft point 6[[19]](#footnote-19).

* Priced just more than Fredonia 1.

*Hydro block 5* is the amount of energy between draft point 6 and CRC, Critical Rule Curve [[20]](#footnote-20). XTRA1 on BPAREGU.OUT is the critical rule curve.

*Hydro block 6* is the amount of “provisional draft” energy. Not currently used.

*Hydro block 7* is the amount of energy between hydro block 5 and draft point 8, limited by the user input for “borrowed hydro” of a 1000 MW-periods. Draft point 8 in BPAREGU.OUT is the total energy (XTRA2) when drafting from starting content to as close to empty as constraints allow.

Note that the minimum amount of hydro in each of the hydro blocks is set to one megawatt. The hydro blocks are divided between the nodes in the PNW region according to the total amount of hydro energy output from the hydro projects specified for each node.

Besides using the 14 period hydro regulator to estimate how much hydro energy is available in a “month”, GENESYS estimates how much hydro energy will be needed from the hydro system to meet load in the current month by doing an economic dispatch of hydro and thermal resources by node. This total amount of monthly hydro energy defines the trapezoid approximation function (described later) used to determine the sustained peaking limits in each hydro window. The marginal monthly hydro value is calculated as the shadow price of the last hydro block dispatched.

After the hourly dispatch is done for each hour of the month, the amount of hydro dispatched in the month in total is added up and the hydro regulator is run again to determine the ending contents of the reservoirs for that month, which become the starting contents for the next month.

## Window Dispatch

The hydro “window” is a number of days, defined by the user either as a set number of days (currently using two days) or by the days of the week in which case a window is either a) Monday thru Sunday or b) the number of days at the beginning and end of the month left over from dividing the month into weeks.

An economic dispatch is done for a window using the average loads for the window[[21]](#footnote-21), the expected thermal for the window (using information on whether the thermal was forced out in the last window), and the hydro available per the period dispatch step. A key piece of information coming out of the window dispatch is the marginal hydro price for that window. It is used as the shadow hydro price for hydro in all the hourly dispatches for that window. In the hourly dispatch the marginal hydro price is the price of all the hydro above hydro minimums, but below “borrowed” hydro. The estimated hydro energy from the window dispatch is used to estimate the sustained peaking capacity based on inputs from the trapezoidal approximation (explained in more detail in Daily Dispatch). The hydro block availabilities and estimated current draft levels are updated, and the borrowed hydro accounting is performed for every window.

## Daily Dispatch

The dispatch for the first day of the window immediately follows the window dispatch in the GENESYS logic. The most important piece of information from the day dispatch is the amount of hydro energy needed from the system for that day. The amount of hydro energy dispatched for the day is then shaped hourly (explained in detail in an appendix) based on the load shape, sustained peaking limits, and hydro minimums. The amount specified in each hour from this shaping sets the hydro available to the hourly dispatch, except for hourly borrowed hydro. The code tries to preserve the load shape in shaping the hydro as much as possible. The thermal is assumed to be dispatched flat through the day, except for off peak thermal purchases or resources, as defined by the user. After the average daily dispatch, the amount of unserved energy over the day is calculated and is used later to uniform the deficit over the day. The deficit is uniformed to reflect how a system operator would probably purchase to meet the deficit.

The trapezoidal approximation is a preprocessor to GENESYS that estimates the hydro system's peaking capability based on a linear approximation model. It approximates the twin peak load shape to be that of a trapezoid, which is run against a set of detailed hydro regulator model outputs for a given fish flow regime across the 80-year water record. The results are synthesized into GENESYS inputs representing the sustained peaking capability and hydro minimum of the system as a function of monthly energy generated. The sustained peaking capability is defined for a 1, 2, 4, and 10 hour duration. As explained above, in GENESYS, after the hydro energy for the day has been shaped into the day’s hours, the hourly amounts are checked against the sustained peaking constraints and the hydro minimums, and then adjusted if necessary before the hourly operation.

## Hourly Dispatch

After the day dispatch, each hour of the day is modeled. The loads and resources and their shadow prices have been defined via the window dispatch, day dispatch, and hourly hydro shaping before the hourly dispatch. The key thing that can change in the hourly dispatch is thermal generation based on forced outages. The dispatch logic that the model goes through is similar to the month, window, and day dispatches.

After all hours of the day are modeled, the next day in the window is dispatched, first as a day average and then on an hourly basis, until all days in the window have been dispatched at which time the next window in the month is dispatched.

Slice Logic

The slice logic is only used for BPA runs. All hydro, thermal, wind, and contracts are assumed to be sliced resources unless otherwise specified by the user. When the user specifies “BPA” as a node, the slice logic is turned on in GENESYS. Each sliced resource is reduced by the slice percent before being placed in the dispatch resource stack. After the dispatch, each resource’s generation is increased by the slice percent. The generation above what was dispatched to loads is the amount that is deemed to go to the slice customers.

Borrowed Hydro

Hydro can be “borrowed” in periods of system stress to serve load in the window, day, or hourly dispatches. The amount of hydro energy available in the window and day dispatches can be determined by the user defined borrowed hydro limit, or the maximum of the user defined borrowed hydro limit and the amount of hydro block 7 available from the period hydro regulator. The price of the borrowed hydro is user defined. Borrowed hydro dispatched in the window dispatch affects the marginal hydro price, and, therefore, the hydro price in each of the hours of the window. Borrowed hydro dispatched in the day dispatch is added to the other hydro, shaped to load, and included in the check on sustained peaking limits. In the hydro shaping routine, no differentiation is made between borrowed hydro and other hydro, and, therefore, in the hourly dispatch the borrowed hydro is not broken out separately from the other hydro.

The difference between the maximum amount of borrowed hydro available to the day dispatch and what was dispatched in the day dispatch is converted to megawatt-hours and that amount is made available at the borrowed hydro price to the hourly dispatches within that day. In addition, if there is any hydro in an hour that was shaped into that hour, but not dispatched in that hour’s dispatch, it is also added to this megawatt-hour amount and dispatched at the borrowed hydro price. As the hourly borrowed hydro is dispatched through the day, the amount of megawatt-hours available in each hour is decremented. After each hourly dispatch, the sustained peaking limits are checked. If the sustained peaking limits are reached, the borrowed hydro is made unavailable for the rest of the day. Making hourly borrowed hydro available ameliorates thermal outages and any error in the hydro shaping logic.

Before the window dispatch, the amount the system has “flexed” in borrowing hydro in the last window is calculated and is equal to the average hydro dispatched over the window hours minus what the firm rights to hydro for the period was from the hydro regulator. From this, the maximum megawatt-hour flex amount for the period and the end-of- period flex megawatt amount is calculated. The end-of-period amount megawatt target is indicative of how much the hydro regulator will have to make up at the start of the next period.

Borrowed hydro is priced so that it will be dispatched last. If later in the period, not all the hydro available is used in a window, the system begins to “pay back” the borrowed hydro. If at the end of the period, the borrowed hydro has not all been recouped, the beginning contents of the next period reflects that deficit therefore, and, therefore, the amount of hydro energy available in the next period is less.

## Emergency Resource Dispatch

The emergency resource dispatch is a post processing step used to include the capability of high cost resources used for system reliability such as demand response, pumped hydro, and dispatchable standby generation. All these resources have constraints on total hours of generation and total available capacity per period. The emergency resources are the last resources dispatched before system curtailment is examined for resource adequacy purposes.

# Appendix

This appendix contains a list of input, output and log files in addition to modules and subroutines needed to run current and latent functionality in GENESYS.

## Input Files[[22]](#footnote-22)

Some of these input files are currently required to run GENESYS and some support what is as of now legacy capability.

### Binary files (.bin)

HourlyLoads.bin

* Input file- User specified hourly loads for the run. 80 years of hourly loads represented in an 8760 by 80 matrix, no leap year.

AER.bin

* Input file - Actual Energy Regulation, initial guesses at the end of period target elevation for all the reservoirs

constraints00.bin

* Output file – constraints violated in general

contraintswy.bin

* Output file – constraints violated for specific water years

PERIOD.bin

* Input file – contains all the temporal data, changes period-by-period for each water year.
* Examples: modified natural flows adjusted for irrigation and evaporation, rule curves.

PLANT.bin

* Input file- Non-Temporal data for reservoirs and run-of-river projects
* Examples: H/K versus head, tailwater versus outflow, storage versus elevation, head versus tailwater

VIOL.bin

* Output file – violations.

wind\_XX.bin

* Input files – hourly capacity values in an 8760 by 77 matrix.
* One file for each of the 20 different temperature correlations to the capacity factor.
* Only Columbia Gorge wind

solar\_XX.bin

* Input files – hourly capacity values in an 8760 by 12 matrix.
* Only for Southern Idaho wind from NREL WWSIS[[23]](#footnote-23)

### Text files (.dat files)

Alloc.dat

* Input file – allocates demand and user input conservation (not currently used) into the nodes via specified percentage amounts.

AllocMainHydro.dat

* Input file – assigns hydro generation resource to a particular node
* Currently just two nodes, PNW East and West

AOP.dat

* Input file – Assured Operating Plan for Canadian firm and secondary loads
* Firm and secondary loads (aMW) by period
* Only used when running TSR (Treaty Storage Regulation) mode. This input file allows GENESYS to dynamically calculate the AOP elevations for random water year runs.
* When not running TSR studies, Canadian operation is fixed based on an AOP study from outside the model which prevents doing random draws on water years.

BYP.dat

* Input file – Bypass spill parameters.
* Currently overwritten by information from operexcep.dat or the SPILL.dat file
* Potentially redundant.

Cashflow.dat

* Input file –percentage split of costs, for financing calculations. Carryover from production costing algorithms.
* Since GENESYS used currently for reliability studies, this is not currently crucial to results.

Conserv.dat

* Input file – conservation parameters for when we want to explicitly add effect of conservation, instead of just netting it out in the *HourlyLoads.bin* file.
* Not currently used to input conservation.

Contracts.dat

* Input file – Firm contract price, shape (by period and by hour), volume by source and delivery nodes.

DayShape.dat

* Input data – 24 hour shape to be applied to resources

DayTempCA.dat

* Input file – Northern CA daily average temperatures used to modify import capability based on temperatures.
* Not currently used.

DAYTEMP.dat

* Input file – Regional daily average temperatures weighted by loads in Portland, Seattle, Spokane and Boise.
* These temperatures are used in the Council’s short-term load forecasting model to generate the 8760 (hour) by 80 (temp year) load file used in GENESYS.

Demand.dat

* Input file –Defines nodes and associated data.

ECC\_ARC\_14RC20.dat

* Input file – Assured Refill Curves for September to December by reservoir plant
* Currently used ????

ENCROACH\_U9205.dat

* Input file – Used by HYDSIM to determine encroachment by upstream plant. Shows relationship between upstream tailwater and downstream forebay elevation.
* Currently used by HYDSIM.

Escl.dat

* Input file – Cost escalation rates from when GENESYS was used as a production cost model (SAM).
* Not currently used.

FELCC.dat

* Input file – Can be used to feed in periodly hydro FELCC from Northwest Power Pool PNCA study.
* Not currently used.

Finance.dat

* Input file – Financial life and discount rate from when GENESYS was used as a production cost model (SAM).
* Not currently used.

FixLoadYearsCycle.dat

* Input file – This file is for when switch activated in StudyDef.dat to feed the order of the load years for every game that is run.

FLOW\_LIM.dat

* Input file – Flow constraints by dam.
* Examples: QL (Min flow), QH (Max flow), WB (Water budget) BiOp flow constraints, DR (draft from upstream dam), QP (flow requirement at downstream dam), CM (comments).

FlowAug.dat

* Input file – Flow augmentation adjustments to be used with TSR GENESYS runs.

Fuels.dat

* Input file – Fuel prices and pointers toward escalation and shaping by fuel type.

Gen Vs Temp.dat

* Input file – Temperature and capacity ratio ordered pairs for????
* Not currently used.

GenRes.dat

* Input file – Generation resources available for dispatch (does not include regulated hydro, but includes IPP, spot market and purchase-ahead resources) parameters.

GenRes Cost.dat

* Input data – Generation resource fixed and variable cost, and pointers to multi-year shape information.

HI\_2020\_2node.dat

* Input file – Hydro independents generation (aMW) for each of the 80 hydro conditions
* Nodes must be in the same order as Demand.dat

HKcpav\_14RC20.dat

* Input file – Initial guess at the power factor (H over K) for each of the regulated hydro projects

HYAVAIL.dat

* Input file – Hydro generation resource availability
* Percent available by resource by period

HYDDEF.dat

* Input file – Study definition file for running HYDSIM
* User switches, some data (e.g. drawdown limit for Coulee).

MDDef.dat

* Input file – Multi-dam definition file, way to run GENESYS as stand-alone HYDSIM
* Not currently used.

MDFileNames.dat

* Input file – Defines data files necessary to run GENESYS in oper regulation or non-TSR mode.
* Shows the name and the path to run GENESYS

MICA.dat

* Input file – Flow and reservoir information on Mica and Arrow.
* Canadian operations are fixed with the exception of this water balancing data for Mica and Arrow.
* Tells GENESYS what ending elevations need to be for Mica and
Arrow depending on flow.

Period Distr.dat

* Input file – Periodic shape file used for contracts and gen resource (or anything that has a period shape) capacity factors

NTS 10\_01 STD05.dat

* Input file – Non-treaty storage
* Fixed operation (reservoir ending elevations) for the non-treaty storage (4.5 maf) additional to treaty operation.
* Not sure if this is being used.

NWSFCST.dat

* Input file – Volume forecast of modified natural flows going into The Dalles, by hydro condition year and period.
* Decisions are based on this forecast, but the model is then run on the modified streamflows per the *PERIOD.dat* file.

OPER\_EXCEP.dat

* Input file – the operating constraints for all hydro projects, for which the binding constraint is the last listed.
* Examples: Min and Max elevation, min and max flow, and bypass spill.
* These override *FLOW\_LIM.dat*, *STOR\_LIM.dat* and *SPILL.dat*.

ResAmt.dat

* Input file – Additional reserve requirements beyond the WECC contingency reserves.

RHL\_14RC20.dat

* Input data – Residual hydro load by hydro condition and period
* When running GENESYS as stand-alone HYDSIM this was as the residual load that has to be met by the hydro resource.
* Not currently used.

Runoff Volumes.dat

* Input file – Observed historic runoff volumes at the Dalles by hydro condition year.
* May be redundant to *NWSFCST.dat.*
* Currently used???

RUNOFF.dat

* Input file – Residual volume runoff January through July at the Dalles
* Like observed runoff in NWSFCST.dat, but it is the residual amount between the period you are in and July.
* Currently used???

SCLFishData.dat

* Input file – Flow constraints for fish passage by fish type
* ???

settoaer.dat

* Input file – Sets certain projects to run at the Actual Energy Regulation curve
* This can override the target elevations set in the AER.bin file

SI\_OPER\_Period.dat

* Input file – Initial contents or elevation by project.
* Implementation period for these starting contents or elevations is determined in the *STUDY.def* file.

simhydro.dat

* Input file – Definition file for the stand-alone run GENESYS like HYDSIM.
* Not currently used.

SLIDE\_Spill.dat

* Input file – Used in the past for sliding scale bypass spill as a function of flow.
* Not currently populated.

SPILL.dat

* Input file – Defines bypass spill, spill cap limits and other spill parameters by hydro project

SPILLPRI.dat

* Input file – If there is more generation than load, this tells you which projects you can spill the extra generation.
* Defines priority of spill in overgeneration instances.

Standby.dat

* Input file – Provides energy and peak capacity limits for emergency resources.
* Includes demand response, pumped storage, etc.
* Post-processing, not dynamic within GENESYS.

STOR\_LIM.dat

* Input file – Defines storage parameters by hydro project.
* Examples: max and min elevations (soft and physical)

Storage.dat

* Input file – Parameters for modeling pump storage.

StudyDef.dat

* Input file – User inputs, study parameters (like study start and stop, number of games), , switches used and specifies input files used in the run.
* Like a run setup sheet.

Sust Peak 4k Regional New.dat

* Input file – Sustained peak versus energy curves for 2, 4 and 10 hours by node.
* Input from TRAP (trapezoidal approximation program).
* Can include in the effects of INC and DEC.

ThermCommittmentData.dat

* Input file – This is placeholder data for untested unit commitment logic.
* Future capability

ThermMaint.dat

* Input file – Parameters for thermal maintenance for projects that have maintenance that does not start at beginning of the period and end at the end of the period.
* Currently used???

Trans.dat

* Input file – Transmission parameters between nodes, including the SW intertie.

WaterYearOverride80.dat

* Input file – In random hydro mode, this is used to weight the water year draws

WindCapacity.dat

* Input file – Defines the nameplate capacity for three different potential wind sites.
* Multiple sites can be at one node.

WindSampling.dat

* Input file – Definition of filenames for the 20 temperature correlated wind profiles.

Watysel.inp

* Input file – List of water years for each contract year and game.
* Not currently used.

## Log

OvergenSpill.log

* Logs when certain constraints were relaxed to allocate the overgeneration spill in hydsim.

## Output

Listed below is a catalog of a common output file types that can be selected for GENESYS

### Text files (.out files)

BPAREGU.out

* End of period results by plant.
* Outflow, bypass spill, force spill (spill because flow above turbine limits), overgeneration, other spill (sluiceway, leakage, locks), incremental H over K (H over K for that plant and everything downstream), average MW, draft (in ksfd), end storage (in ksfd), ending elevation (in feet above sea level), rule curves (flood control, ECC, AER in ksfd), constraint violations in order of violation (farthest right violation is first constraint violated, farthest left is the last constraint encountered, which controlled plant operation).
* Asterisk by plant name means generation not counted in the total to meet load.
* Period energy that one can get to draft to each hydro block.
* System generation summary including hydro independents, pumping (currently always zero, built into loads), One Dam model stats like content of the entire system in energy (MW-periods).

DEBUG.out

* Error trapping for HYDSIM.

FILEREC.out

* Report of file paths of the files used to run GENESYS.
* All not hydro related except the WaterYearOverride80.dat

Gameseed.out

* Random seeds used for every game, IF switch is activated in *StudyDef.dat*.
* Could be random seed same for all games, different for any game, or random seed taken from clock.

MDFileREC.out

* Report of file paths of the files used to run HYDSIM.
* WaterYearOverride80.dat file path is overwritten by FILEREC.OUT

Message.out

* GENESYS error and warning log.
* Potential place for study setting and data validation.

NodePath.out

* All possible permutations of transaction paths between nodes. Note that a transaction can move between several nodes before getting to final destination.
* Includes wheeling cost (in $ per MWh), losses, shadow price, node names.
* Includes resources by home node and destination nodes.

Plant by Plant Generation.out

* Output of a post-processing program, READBPAREGU program.
* Builds summary matrices of output or input by plant.

RelibRec.out

* Hourly output by game (identified by game number which is associated with a water year, temperature year, wind characteristic triplet) that returns megawatts curtailed, reserve violation flag, load, reserve requirement (from TRAP), additional reserves, thermal generation, contract purchases, hydro generation, wind generation, megawatts forced out, percentage of thermal resources forced out, WCF, and slicacc.

ResOut.out

* Hourly dispatch for specified resources, by an individual game.

SOS1.out

* State of the System output
* Average dispatch over all games and all hours, by period of resource types.
* Raw LOLP (prior to emergency resource dispatch), probability of using borrowed hydro, maximum borrowed hydro used in a game (GWh).

SOS2.out

* State of the System output
* Dispatch level percentiles over all games by resource type, unserved load and market.

SOS3.out

* State of the System output
* Hourly duration curves by period by selected resource type and for unserved load.

System.out

* Specified single game summary (default is game 1).
* Supply demand summary, supply availability and dispatch, node-to-node, contracts, transmission loading across all nodes by period.

WeatherYr.out

* Selection for the water, temperature and the wind year plus the wind set (out of the 20 different correlated wind capacity factors for that temperature year)

### Text files (.vbi files)

These text files often summarize the above text output files in a format created for the graphics package in an old user interface.

DayUSDDurat.vbi

* Duration curve data for daily unserved demand by node.

Exceed.vbi

* Unserved demand by percentile

GamePV.vbi

* Present values for each game.

MeanDemand.vbi

* Mean period nodal demand

MeanMonthlySourceAvail.vbi

* Mean period resource availability across all games

MeanMonthlySourceCapacity.vbi

* Mean period resource capacity across all games

MeanMonthlySourceFixOp.vbi

* Mean period fixed operating costs by resource across all games (in millions $)

MeanMonthlySourceFuelUse.vbi

* Mean period source fuel use by resource across all games (in trillions of Btu)

MeanMonthlySourceOutput.vbi

* Mean period output by resource for all games (in aMW)

MeanMonthlySourceVarOp.vbi

* Mean period variable operating costs by resource (in millions of dollars)

Multidam.vbi

* Subset of the BPAREGU.OUT results.
* There is an error: “Dalles” listed, but The Dalles data is not currently provided in GENESYS. Needs to be fixed.
* 6160 by 14 periods of Minflow, Forced spill, Bypass spill. Average MW, ending content (in ksfd), ending elevation (in feet above sea level), rule curves (flood control, PDP in ksfd).

NetDemandDurat.vbi

* Duration curve for period demand

PNW Balance.vbi

* Average load resource balance by period by game

Pods.vbi

* Probability of designated shortage values

SegTrak.vbi

* For a specified game, gives hourly load, curtailment, long-term purchases, hydro generation, wind generation, contract imports/exports, reserve requirements, hydro reserves, thermal reserves, reserve violation.

SegTrans.vbi

* Hourly transmission flows by node for a specified game.

SegUnservedDurat.vbi

* Hourly unserved demand data (MW) by year for a specified game.

SourceAvailDurat.vbi

* Sorting hourly source availability observations ???

SourceOutput.vbi

* Sorting hourly source output observations ???

Srcecost.vbi

* Mean variable and fixed operating costs, and capital costs by resource.

TranFlow.vbi

* Mean transmission flow by period for each transmission source/destination pair.

TransDuratMo.vbi

* Sorting hourly transmission observations ???

## Modules

* All modules[[24]](#footnote-24) called by GENESYS have the suffix .f90.

AllocateLoads – Declares the variables used to allocate load.

arroflow – Declares flow constraints for fish spawning at Arrow.

CFlow - Declares flow???

Conserv1 – Contains the conservation data

ContractData – Contains the long-term contract data

Costdata1 – Contains cost data

Cststat1 – Cost statistics variables and arrays

Demand1 – Declares demand and nodal settings.

Demand2 – Declares more demand settings.

DiscFac – Declares discount factors for present value calaculation.

DISTRIB1 – Declares distribution array settings.

DuraStor – Declares variables for creating duration curves.

Equate – Declares variables for fixed load year mode???

Errflag1 – Declares and establishes initial settings for error flagging capability.

Escl1 – Declares and establishes initial parameters for escalation and deflation.

Esp – Declares variables for setting up the one game only run.

FILELUN1 – Defines variables and settings to delineate output reports.

FINANCE1 – Declares variables used for holding financial data.

FlexInfo - Declares and establishes initial parameters for hydro flexibility and emergency use???

Flowaug – Declares variables for flow augmentation.

Fueldata1 – Declares fuel data structure and type.

GenTempVar – Declares variables for transmission capacity limit as a function of demand.

HydBlockInfo – Declares the variables used for defining hydro blocks.

HYDIND – Declares the variables used for storing hydro independent data.

Ifilname1 – Declares variables used to store file input names.

INITS – Declares variables for use in HYDSIM runs.

LoopFlow1 – Declares and defines variables for use in transmission loop flow for transactions.

MargInfo1 – Declares variables for use in demand segments.

Misc1 – Declares miscellaneous variables.

Misc2 - Declares miscellaneous variable.

Mparam - Declares and defines hardwired run parameters used in all modes.

Mwmon – Declares variables for input from TRAP and sets parameters for some hydro inputs.

NLDVars1 – Defines variables used for demand and node information.

NodeGroupInfo – Declares variables for grouping nodes.

Nrgsplit – Declares nodal split for hydro energy.

Oper1 – Declares variables for system operation and transactions.

OverrideInfo – Declares variables for override data.

OWNER1 – Declares variables containing ownership information.

OYHrlyLd – Declares parameters, variables and switches associated with hourly load data.

OYWinddata - Declares parameters, variables and switches associated with hourly load data.

PathData – Declares variables associated with the paths connecting nodes.

PERINFO – Declares sub-period data variables.

RELIB1 – Declares variables associated with reliability.

ReserveAmt – Declares variables associated with calculating reserve requirements

Runoff – Declares variables associated with hydro runoff.

SEASDAT1 – Declares variables associated with seasonal distribution data.

Secondary – Declares variables associated with secondary ???

SegDef – Declares and initializes variables associated with demand segments.

SegOpVar – Declares segment operational variables.

SegVars – Declares variables used to delineate segment size and demand

Simhydro – Declares variables used to store HYDSIM output for use in GENESYS.

Slice\_customers – Declares variables used to delineate slice resources when slice logic on.

SOSReport – Set up variables for SOS reporting.

Source1 – Declares supply source variables.

Source2 - Declares supply source variables.

Source3 - Declares supply source variables (used by HYDSIM and GENESYS)

STACK – Declares variables used in stacking hydro blocks.

Stparms – Declares variables used to store general study parameters.

SurrogateFlows – Declares variables used to store information about surrogate flows.

TDFunctionVar – Defines and initializes variables for transmission capacity limit as a function of demand.

ThermCommitment – Defines variables containing thermal commitment parameters.

thermMaintdata – Defines variables containing thermal maintenance data.

Transm1 – Declares variables used for transmission topology

Transmission\_losses – Declares transmission losses variables.

Weather1 – Declares variables associated with weather and temperature.

Workdata – Declares variables used to transfer operating year to calendar year data.

WRITESW1 – Declares switches used to determine output files written.

Wrkstrng – Declares variables used for internal to the program.

### TSR Modules

* The following modules are used specifically for treaty storage regulation mode of the model.

Aerpdp

Albeni\_mod

Alder\_mod

BPAmica

Bpaperdat

Bparegdef

Bpascom

Bpasdat

Bpaspl

Bypdates

Calendar

Constraint\_mod

Environment

Errors

Expect1

Flovol

Gorgemin\_mod

HYavlc

Hydfish

Hydhk

Hydsize

Hytime

Lfalls

Mcnary\_tw

Merwin\_mod

PeriodPeriodMod

Opr\_AERPDP

Opr\_Albeni\_Mod

Opr\_Alder\_mod

Opr\_bpaarc

Opr\_bpamica

Opr\_bpaperdat

Opr\_bparegdef

Opr\_bpascom

Opr\_bpasdat

Opr\_bpaspl

Opr\_bypdates

Opr\_constraint\_mod

Opr\_Errors

Opr\_Expect1

Opr\_flovol

Opr\_hyavlc

Opr\_hydfish

Opr\_hydhk

Opr\_hydind

Opr\_hydsize

Opr\_hytime

Opr\_Inits

Opr\_lfalls

Opr\_mcnary\_tw

Opr\_merwin\_mod

Opr\_periodperiodmod

Opr\_pltlkup

Opr\_projname

Opr\_recdrft\_mod

Opr\_settoaer

Opr\_simhydro

Opr\_slide\_spill

Opr\_Source3

Opr\_spill

Opr\_splcutoff

Opr\_stparms

Opr\_Waterb

Opr\_wbslide

Opr\_xfmr\_losses

Param - Declares parameter constants used by HYDSIM.

Pltlkup

Projname

Recdrft\_mod

Reglun

Settoaer

Slide\_spill

Spill

Splcutoff

Stparms

Tsr\_aerPDP

Tsr\_Albeni\_mod

Tsr\_Alder\_mod

Tsr\_BPAmica

Tsr\_Bpaperdat

Tsr\_Bparegdef

Tsr\_Bpascom

Tsr\_Bpasdat

Tsr\_Bpaspl

Tsr\_Bypdates

Tsr\_Calendar

Tsr\_Constraint\_mod

Tsr\_Environment

Tsr\_Errors

Tsr\_Expect1

Tsr\_Flovol

Tsr\_Gorgemin\_mod

Tsr\_HYavlc

Tsr\_Hydfish

Tsr\_Hydhk

Tsr\_Hydsize

Tsr\_Hytime

Tsr\_Lfalls

Tsr\_Mcnary\_tw

Tsr\_Merwin\_mod

Tsr\_PeriodPeriodMod

Tsr\_Param

Tsr\_Pltlkup

Tsr\_Projname

Tsr\_Recdrft\_mod

Tsr\_Reglun

Tsr\_Settoaer

Tsr\_Slide\_spill

Tsr\_Spill

Tsr\_Splcutoff

Tsr\_parms

Tsr\_pltlkup

Tsr\_projname

Tsr\_recdrft\_mod

Tsr\_settoaer

Tsr\_simhydro

Tsr\_slide\_spill

Tsr\_Source3

Tsr\_spill

Tsr\_splcutoff

Tsr\_stparms

Tsr\_Waterb

Tsr\_wbslide

Tsr\_xfmr\_losses

## Subroutines[[25]](#footnote-25)

* All subroutines[[26]](#footnote-26) currently run by GENESYS have the suffix .f90.
* Subroutines that look at financial accounting for plants and explicit conservation build-out are mostly legacy, as the GENESYS resource expansion logic is no longer used.
* Only GenSimMain and MDInterface are described in detail as they are major routines in the hierarchy of GENESYS.

AddStack – Adds supply block to the dispatch stack.

Annrept – Writes out annual reports from GENESYS output.

BorHydWrite – Writes out borrowed hydro report.

Btrim – Trims leading and trailing blanks from character variables.

CalcProbDurCurve – Calculates probability distributions for different variables.

CapCost - Determines cash flow and capital revenue requirements for new source and transmission projects, and conservation programs.

CapItem - Determines cash flow and capital revenue requirements for a specific capitalized item.

CFlowIn – Reads cash flow data.

CheckSustpkAgain - Checks the sustained peaking limits after any additions of borrowed hydro in the hourly dispatch.

ChooseWindow – Defines window size and can develop allocation procedure for hydro energy within the window.

Config - Determines transmission system configuration for current year.

Consched - Calculates annual schedule for conservation program units.

Consin2 - Reads conservation data.

Consper - Calculates hourly conservation by node and by site for current period. Used in SliceSegOp.out

ContractIn – Reads contract data file.

CostIn – Reads financial and cost data.

CostStat – Keeps track of cost statistics like mean present value, mean operating costs, etc.

Dataidx - Does data indexing and error checking on input pointers.

DayShapeIn - Reads day shape and demand segment definition data.

Defin - Reads Study Definition File

Deflset - Sets up deflation information.

Demandin - Reads demand data file.

Discset - Sets up discount rate factors.

Echo - Prints study parameters back to screen.

Esclin - Reads escalation data.

Exchsort - Exchange sort. Original array is reordered. Value of "direction" determines sort order.

Exchsort2 - Exchange sort for integers. Original array is reordered in ascending order. Secondary array is in same order as original.

ExSortdx - Exchange sort returning pointers. Expects real array.

Fileclose - Closes any open files.

FileOpen - Opens files which are held open for entire study. E.g, binary flow and weather data files, VB interface, output files, daily results binary files.

Finanin – Reads in financial data.

Finish - Sorts for recorded game results, etc. Writes a number of vbi files. Called once at completion of game loop.

FlowAugIn – Read in flow augmentation data.

FuelIn – Reads in fuel cost data.

**GenSimMain**

* Main subroutine for GENESYS completes the following tasks:
1. Creates Study ID
2. Initializes values not read in input files
3. Calls definition input and echo subroutines.
4. Calls the following input routines:
	1. FuelIn
	2. CostIn
	3. TransIn
	4. SourceIn
	5. DemandIn
	6. SustPkIn
	7. EsclIn
	8. SeasIn
	9. FinanIn
	10. CflowIn
	11. DayshapeIn
	12. OwnerIn
	13. ConsIn
	14. ContractIn
	15. GTFunctionIn
	16. ReserveAmtIn
	17. ReadHourlyLoads
	18. WxIn
	19. Dataidx
5. If switches selected, calls the following subroutines:
	1. RunoffIn
	2. ReadThermCommit
	3. CallSurrogateDailyFlows
	4. Readwinddata
6. If TSR run enabled, calls the following subroutines:
	1. GetTSRFileNames
	2. TSRHydata
	3. ReadTSRLoads
7. If Operation Regulation input is selected, then the following sub routines are called:
	1. GetOPRFileNames, oprHYDATA, and FlowAugIn

OR

* 1. GetMDFilenames and HYDATA
1. Opens files which persist throughout study and preprocesses study by calling
	1. FileOpen
	2. Preproc
2. Set up the conservation savings schedule, if calculated explicitly within study by calling the below subroutine. Currently conservation is entered by modifying the load.
	1. ConSched
3. Calculate capital costs for resource and transmission projects, by calling the subroutine below. GENESYS not currently used for resource expansion.
	1. Capcost
4. Start simulation loop. Does year loop, period/period loop, and day loop

Subroutines always used are as follows:

* 1. Resetgam
	2. HydroInd
	3. GetHDay
	4. HydWinDisp2
	5. HydroDayCheck2
	6. PerDemand
	7. HydroDayShape2
	8. HydroPost
	9. PeriodPost
	10. Sysstat
	11. Annrept
	12. PresVal
	13. CostStat

Subroutines used depending on configuration are as follows:

* 1. WeatherSet
	2. PickHourlyHydroShape
	3. Config
	4. MoCons
	5. ResetAnn
	6. Windcap
	7. OPRSetUp
	8. SourceCapac
	9. SourcePrice
	10. OYHourDemand
	11. MoTrans
	12. PathOrder
	13. HydroPre
	14. ChooseWindow
	15. Slice\_PerDemand
1. Develops output, writes state of the system reports and closes routine by calling the following subroutines.
	1. writeSOSReport
	2. writeEndContent
	3. Finish
	4. VbiStdy
	5. Fileclose

GenTempAdj - Estimates thermal availability for the next "period\_days" days, for appropriate resources whose availability is function of temperature.

GetHDay - Determines day and how many days are left in the current hydro window.

GetOPRFileNames – Reads multi-dam file names in operate regulation mode.

GetOverride – Reads thermal and transmission override data.

GetTSRDef – Reads stand-alone multi-dam study parameters.

GetTSRFileNames - Reads multi-dam file names in treaty storage regulation mode.

GetUFlow – Reads user defined flow year data.

GTFunctionIn – Reads generation versus temperature function data.

HrloadSubs - Calculates observed hourly demands for single large loads. Calculates observed hourly conservation program savings for the current period. Calculates observed hourly contract flows between nodes.

HydEDisp – Estimates hydro energy use in window dispatch.

HydroCapState - Determines observed state levels for hydro capacity functions. Builds the hydro capacity vs energy functions used for the current time period.

HydroDayCheck2 - Checks adequacy of hydro energy to meet current day residual load.

HydroDayShape2 - Determines PNW east/west hydro shaping factors for the current day.

HydroInd – Reads in hydro independent data.

HydroPost – Performs end-of-period hydro accounting.

HydroPre – Performs beginning-of-period hydro accounting.

HydroVal – Calculates value associated with the different hydro blocks.

HydWinDisp2 – Calculates average hydro window dispatch and sets capacity limits.

Indxchar – Creates array positions linking pointer values to data IDs (Indexing program).

Indxchar2 - Creates array positions linking pointer values to data IDs (Another indexing program).

Initialize\_seed – Initializes variables where input is not read in.

Inumval - Finds position of last non-zero entry in an integer vector.

Linterp – Performs linear interpolation on input data.

Locate – A find and replace routine that returns the found data and replaces with a pointer.

LocateW - A secondary find and replace routine that returns the found data and replaces with a pointer.

MallocNLD - Allocates memory for new large demand variables.

MargCalc – Calculates a node’s marginal value.

**MDINTERFACE**

* Interface to the multi-dam model.
* Calls HYDSIM modules from GENESYS multiple times to draft to rule curves to get the hydro block sizes.
* Then, after GENESYS “dispatch” calls one more time to draft to the amount of hydro generation specified by the GENESYS “dispatch.”

Mocons – Calculates nodal monthly savings for conservation programs.

PeriodPost – Period post processing

MoTrans - Adjusts transmission capacities for seasonality in current month.

Numval - Finds position of last non-zero entry in a real vector

OneDamCap - Estimates hydro capacity using pre-determined trapezoidal functions when one dam model is used for hydro generation.

OpenPC – Opens and reads in file.

Operate2 - Operations for current demand segment.

Overparm - Writes error message to logfile on for exceeding parameters.

Override - Overrides thermal availability states, with user defined occurrences

Ownerin – Reads in ownership and allocation data, and trues up shares to 100%.

OYHourDemand - Called by period. Uses one operating year of hourly loads input by user in HourlyLoad\_file. Results for month stored in annual array Hrload in current period dimension. Also calls single large demand and hourly conservation shaping routines.

Page - Does form feed (unless page=1), writes passed page number and study ID to the passed logical unit.

PARPurchase – Governs purchase ahead resource (market purchases) acquisition.

PathDef – Finds transmission paths.

PathOrder – Determines node to node path order for current period.

Peraggr - Accumulate current sub period values into larger time periods.

PerDemand - Calculates observed nodal segment demands for current dispatch day. Could be either individual day or period average.

PHB\_Subs – Contains sorting routines.

PickHourlyHydroShape – Picks hourly hydro shape from surrogate hydro data.

Preproc2 - Perform any general preprocessing that can be done outside of game loop.

Presval - Calculates present values.

Ran2 – Random number generator.

ReadHourlyLoads - Reads binary hourly load file.

READPeriodCheck – Reads hydro period data.

ReadSurgDailyFlows – Reads surrogate daily flows.

ReadThermCommit – Thermal commitment logic.

ReadThermMaint – Model thermal maintenance

ReadTSRLoads – Read period TSR loads.

Readwinddata - Reads wourly wind binary files for up to three sites that contain hourly capacity factors at the site. Also reads the wind capacity file that gives the capacity at each site.

ReserveAmtIn – Read in fixed reserve amounts for each period.

ReserveCalc - Calculate reserve levels for demand segment just dispatched. Calculate reserves and reserve requirements for NW thermal and hydro. Find the biggest import for single largest contingency calc.

Resetann - Reset annual variables.

Resetgam - Resets specific variables used in game loop.

RunoffIn – Reads in runoff and finds quintiles of runoff.

RunTSR - Run Treaty storage regulation for the year to determine ending contents of Mica and Arrow in each month.

Seasin - Reads seasonal distribution data and sets up period shaping factors.

SegWrite - Write Segment operations report and *SegOp.vbi*.

Slice\_PerDemand - Calculates single large load and sliced contract amounts for current dispatch day.

SliceIn – Reads in slice resources from *slice\_res* file.

SliceSegWrite - Write Segment operations report *SliceSegOp.out*.

Slicesubs - Availability of dispatchable resource is reduced by slice\_percent.

Slint - Simple linear interpolation routine.

SourceCapac - Sets source capacity for current period.

Sourcein2 – Reads supply source data.

SourcePrice - Source current month variable costs

Supply - Determines source supply and calls operation routine. Called each day (or once for a period dispatch).

SustPkIn - Reads sustained peak data.

Sysstat – Calculates source use, reliability, transmission use and other statistics.

ThermalSetFD - Use frequency/duration method for determination of thermal states.

Transin - Reads transmission data.

TSRINTERFACE - Interface to multi-dam model.

Ucase.f90

VBbool – Returns true or false depending on VB Boolean operator read in.

VbiStudy - Writes several end of study VB Interface Files.

WeatherSet - Determine historical year to use for flow and weather.

Weekday - Calculates day of week corresponding to a specific date.

Windbymonth - Calculates hourly wind capacity by node and by site for current month.

WinCap - Calculates hourly wind capacity for the year by site.

writeEndContent – Writes end content.

writeSOSreport – Writes the state of system output.

Wxin – Reads weather data.

### TSR Subroutines

* The following subroutines are used specifically for treaty storage regulation mode of the model.

OprBLDCONSTR

OprCHKPLT

OprCHKROR2

OprFINDMO

OprGETBYD

OprGETHKS

OprHYAVAIL

OprHYDATA

OprHYPLA

OprHYSPRD

OprINITHKAV

OprINTERP

OprMICARD

oprMonthperiodInit

oprPROCESSDR

oprQMINIT

oprRDSINIT

oprREADCONSTR

oprREADFISHGORGE

oprREADPr

oprREGDEF\_HYDSIM

oprSCANSEQ

oprSET\_PERIOD\_TIMING

oprSETUP

oprSLIDE\_SPL

oprSTODATE

oprUPDATECONSTR

oprWBPREP

oprWRITECONSTR

TBLSET\_old

tsrBLDCONSTR

tsrCHKPLT

tsrCHKROR2

tsrFINDMO

tsrGETBYD

tsrGETHKS

tsrHYAVAIL

TSRHydata

TSRHypla

tsrHYSPRD

tsrINITHKAV

tsrINTERP

tsrMICARD

tsrMonthPeriodInit

tsrPROCESSDR

tsrQMINIT

tsrRDSINIT

tsrREADCONSTR

tsrReadFishGorge

tsrREADPR

TSRREGDEF\_HYDSIM

tsrSCANSEQ

tsrSET\_PERIOD\_TIMING

tsrSLIDE\_SPL

tsrSTODATE

tsrUPDATECONSTR

tsrWBPREP

tsrWRITECONSTR

## Dynamic Link Libraries

* All compiled libraries called by GENESYS have the suffix .dll.

libifcoremd

libifcoremdd

libifportmd

libmmd

msvcr100d

svml\_dispmd

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q:\jf\genesys redevelop\genesys\_techdocumentation\_02162015vers1 jf.docx

1. This document will rely heavily on the work of previous documentation efforts by John Fazio and Gwen Shearer. Much of the language and information is compiled from “documentation.docx”, “GENESYS geneology.doc” and other documents in the Source Documentation folder in the GENESYS redevelopment folder. [↑](#footnote-ref-1)
2. See Chapter 11 in the 7th Power Plan for a more detailed description of the adequacy standard. [↑](#footnote-ref-2)
3. Note that the definition of node as it has been used in GENESYS is not necessarily consistently with nodal analysis as is used in a Security Constrained Economic Dispatch model. [↑](#footnote-ref-3)
4. System Analysis Model (SAM) and ISAAC [↑](#footnote-ref-4)
5. The RPM assesses more long-term uncertainties other than load including fuel and power price uncertainty, [↑](#footnote-ref-5)
6. Not currently used, but can run HYDSIM as a standalone module. [↑](#footnote-ref-6)
7. However, from the TRAP, independents do provide some capacity and it is incorporated into the sustained peak file. [↑](#footnote-ref-7)
8. Note that the current setting is to place all the flow augmentation on Mica. [↑](#footnote-ref-8)
9. Note that the current setting is to place all miscellaneous storage on Arrow. [↑](#footnote-ref-9)
10. This will be updated to reflect the 3% generation and 3% load WECC contingency reserve requirements. [↑](#footnote-ref-10)
11. Operationally, thermal resources could also experience fuel limitations due to location, but that is not currently modeled in GENESYS. Thermal resources are not topologically limited. Wind resources are similarly dependent on fuel limitations by location, but the variability and constraints of that is very complex and modeled externally. [↑](#footnote-ref-11)
12. From a presentation made to the RAAC Modeling Subgroup on 10/22/2013, GENESYS Topography.pptx. [↑](#footnote-ref-12)
13. Source documentation from *documentation.docx* [↑](#footnote-ref-13)
14. Note that this is a proxy for the opportunity cost of different hydro blocks. [↑](#footnote-ref-14)
15. This is due to distinctive runoff and operation characteristics between the first and second halves of April and August. [↑](#footnote-ref-15)
16. *Upper Rule Curve* is also known as the flood control rule curve. Calculated by the Army Corp of Engineers, it “defines the drawdown required to assure adequate space is available in a reservoir to regulate predicted runoff for the year without causing flooding downstream.”, per “Modeling the System” pamphlet. [↑](#footnote-ref-16)
17. *Variable Energy Content Curve* guides non-firm generation energy generation, and is usually the lowest of the four rule curves in winter and early spring and is based on the predicted runoff during the year. Functionally this is a reservoir energy content curve. Drafting a reservoir no further than this point ensures a high probability of refilling by the end of spring runoff season. VECC is made up of Made up of the Assured Refill (ARC), Variable Refill (VRC), and Limiting Rule (LRC) Curves from BPA [↑](#footnote-ref-17)
18. Because of constraints other than the rule curves, GENESYS never gets to empty. [↑](#footnote-ref-18)
19. Note that draft point 6 is effectively the Critical Rule Curve since Hydro Block 5 is not currently used. [↑](#footnote-ref-19)
20. *Critical Rule Curve* “defines the reservoir elevations that meet firm energy hydro requirements under the most adverse streamflows on record”, per “Modeling the System” pamphlet. [↑](#footnote-ref-20)
21. From a specific temperature-year. [↑](#footnote-ref-21)
22. Details about input files was derived heavily from conversations with John Fazio and *documentation.doc* by Gwendolyn Shearer. [↑](#footnote-ref-22)
23. WWSIS, Western Wind and Solar Integration Study [↑](#footnote-ref-23)
24. Modules in Fortran 90 contain variable declarations and subprograms. [↑](#footnote-ref-24)
25. A list of the GENESYS subroutines with more detailed explanations is catalogued in *GENESYS\_Subroutines\_20011212.doc* [↑](#footnote-ref-25)
26. Subroutines in Fortran 90 are similar to functions in Fortran 90 but they can have any number of inputs and outputs. [↑](#footnote-ref-26)