Northwest **Power** and **Conservation** Council

October 4, 2016

MEMORANDUM

TO: **Power Committee Members**

FROM: **John Fazio, Senior Systems Analyst**

SUBJECT: **Background on GENESYS model - Outputs**

BACKGROUND:

Presenter: John Fazio

Summary: This will be the second part of a briefing that focuses on the Council's GENESYS model, used primarily for power supply adequacy assessments.

Today will include the portion not addressed in September's presentation. Primarily a summary of the output data that will focus on key results that are used for adequacy assessments and for other vital uses for the model.

Relevance: The GENESYS model is used annually to assess the adequacy of the power supply five years into the future to ensure that the region will continue to provide an adequate supply.

Besides providing an annual adequacy assessment, the GENESYS model is use to calculate the adequacy reserve margin and the associated system capacity contribution for new resources. Both of these parameters are inputs to the Council's Regional Portfolio Model (RPM) and are essential to ensuring that resource strategies produced by the RPM will provide adequate future power supplies.

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Workplan: N/A

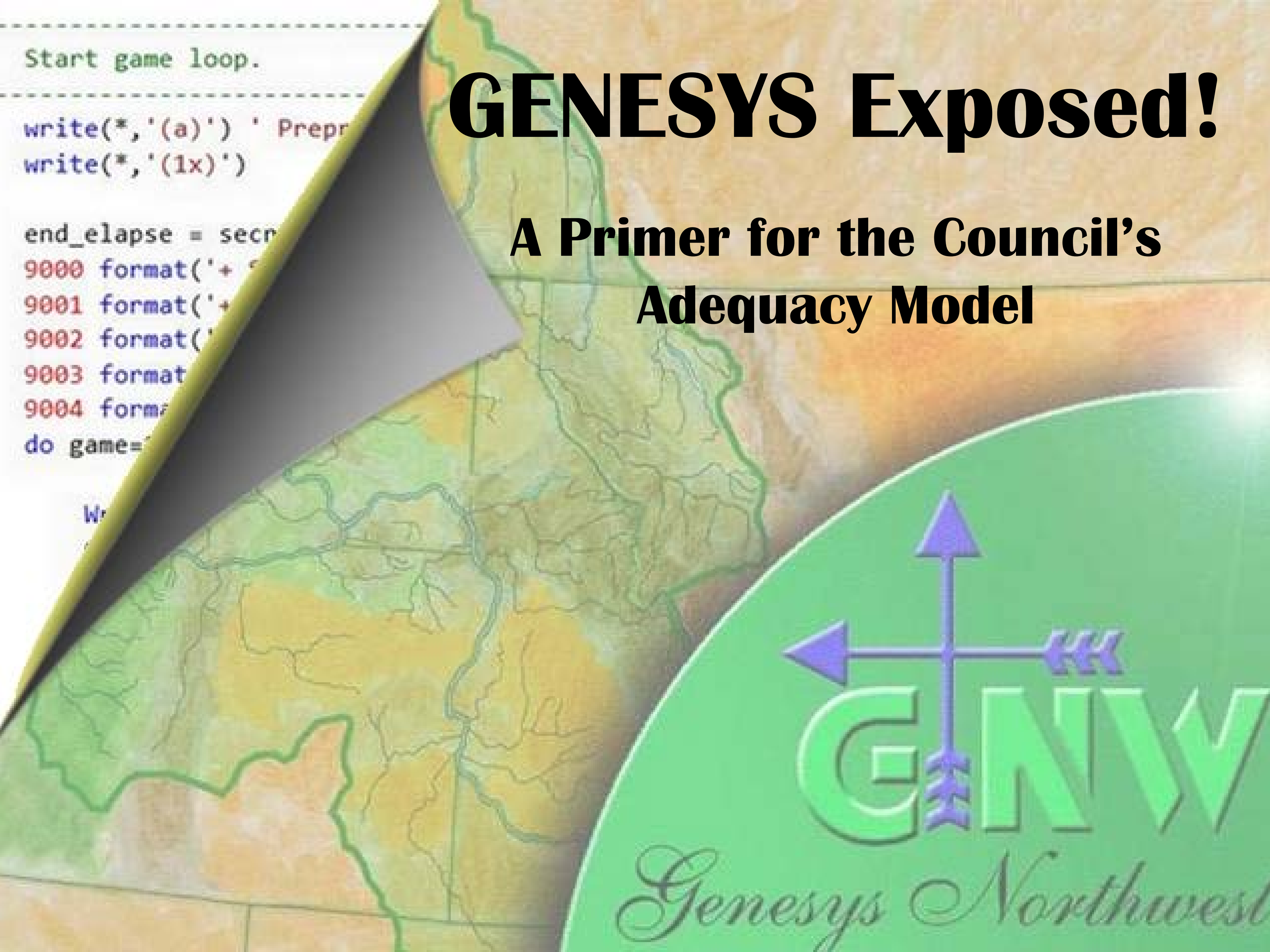
Background: Utility planners have historically used a simple comparison between available resources and expected loads to determine whether the power supply has sufficient generating capability to provide adequate service to customers. This deterministic measure, commonly referred to as the load/resource balance, is still being reported in BPA's White Book and PNUCC's NRF reports. Since about 1999, however, it was becoming more apparent to planners that a better measure was needed. It was in that year that the Council, with help from other regional entities, developed the GENESYS model to provide this better estimate of the power supply's adequacy.

GENESYS determines the likelihood that a future year's power supply will be inadequate by simulating the operation of generating resources for that year thousands of times, each time varying the conditions under which that supply operates. The likelihood of experiencing a shortfall anytime during the year is referred to as the loss of load probability (LOLP) and the Council has set the maximum allowed value for the LOLP at 5 percent. In other words, as long as the LOLP remains at or below 5 percent, the power supply is deemed adequate.

More Info: Please contact John Fazio

GENESYS Exposed!

A Primer for the Council's Adequacy Model



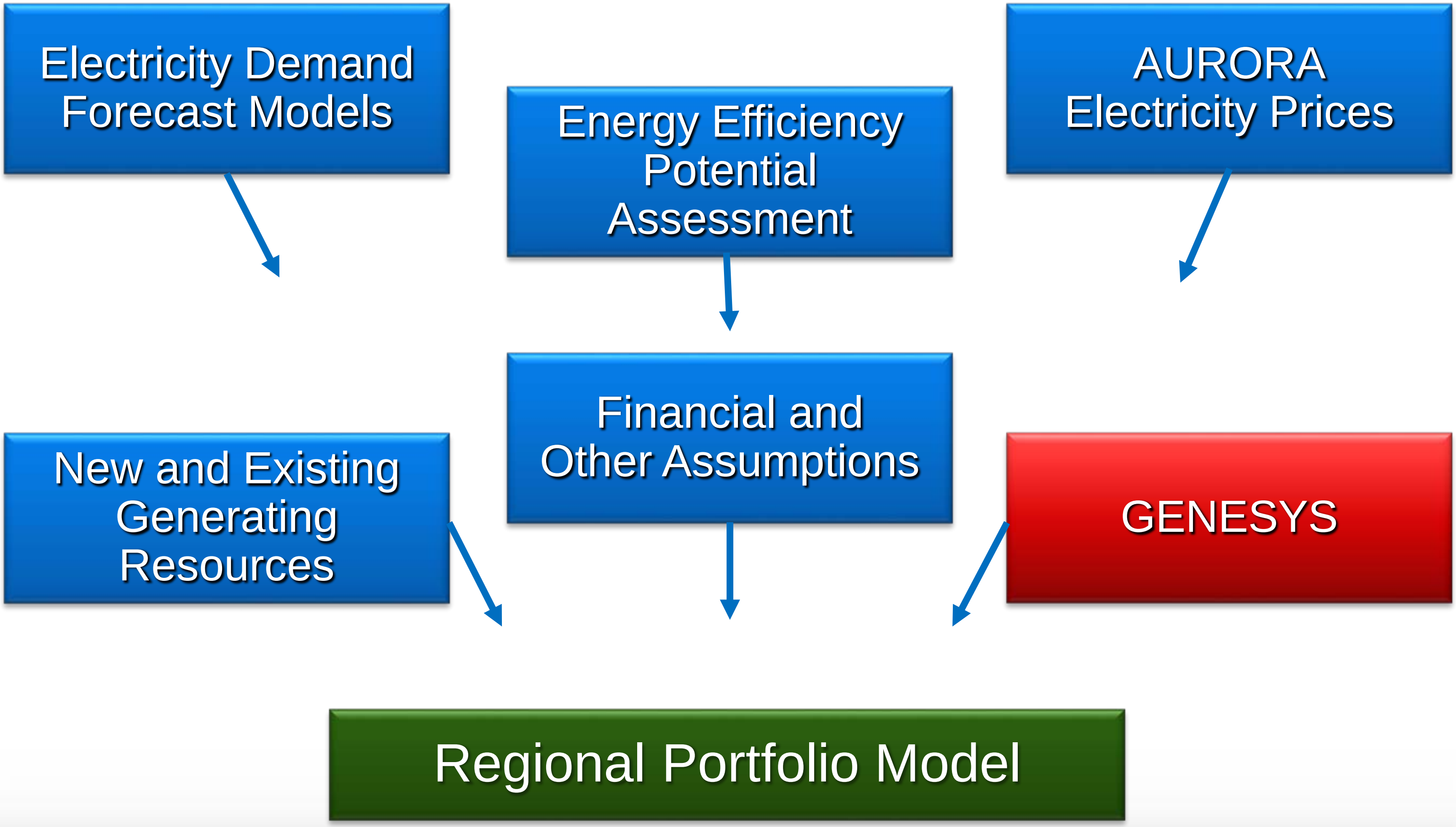
What is GENESYS

- A Computer model that simulates the operation of the regional power system
- For a single year
- Thousands of times with different combinations of future unknowns[1]
  - River flows
  - Temperatures
  - Wind generation
  - Forced outages

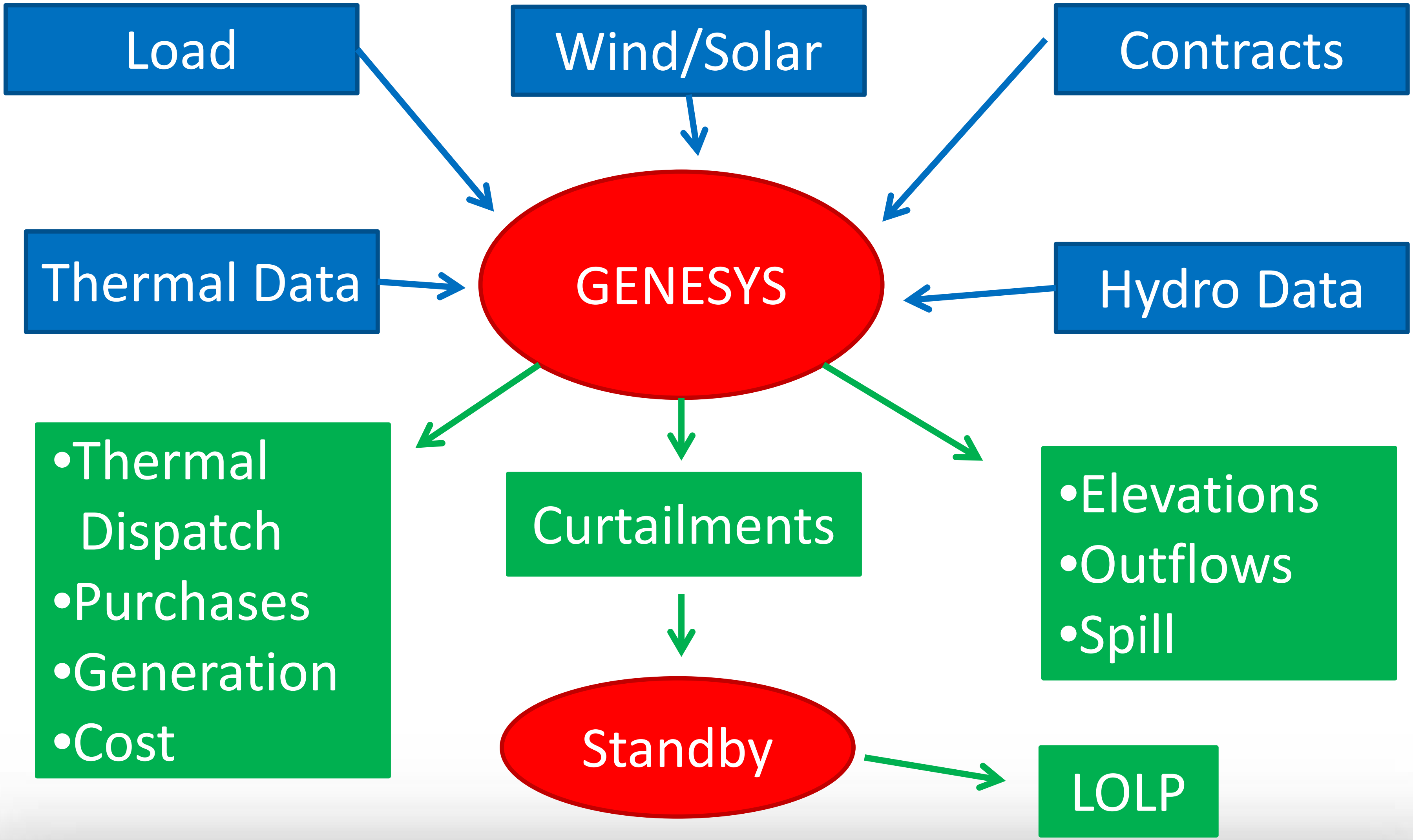
[1]This is commonly referred to as a Monte-Carlo program.

Where does GENESYS fit in?

(Not all links are shown)



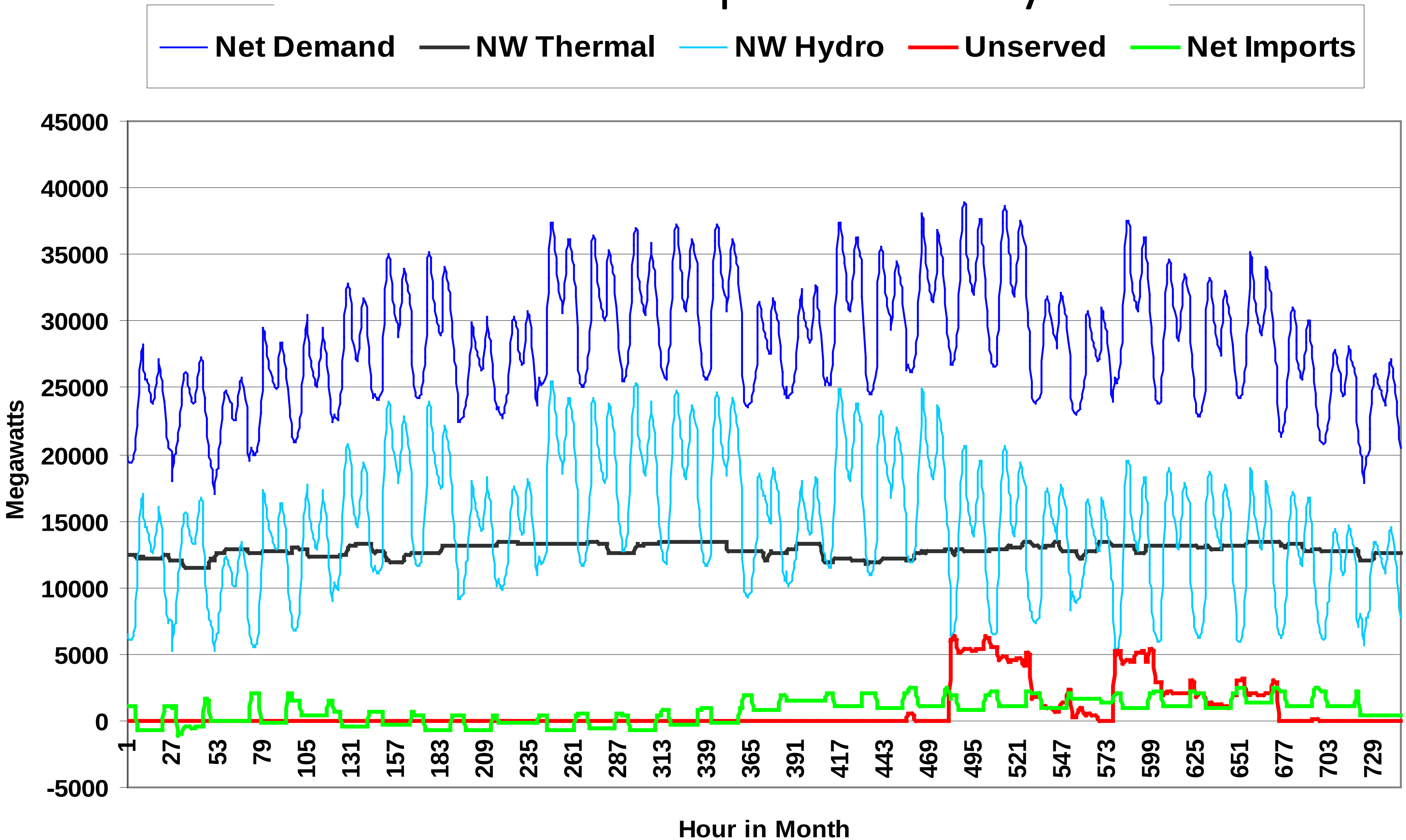
GENESYS Flow Diagram



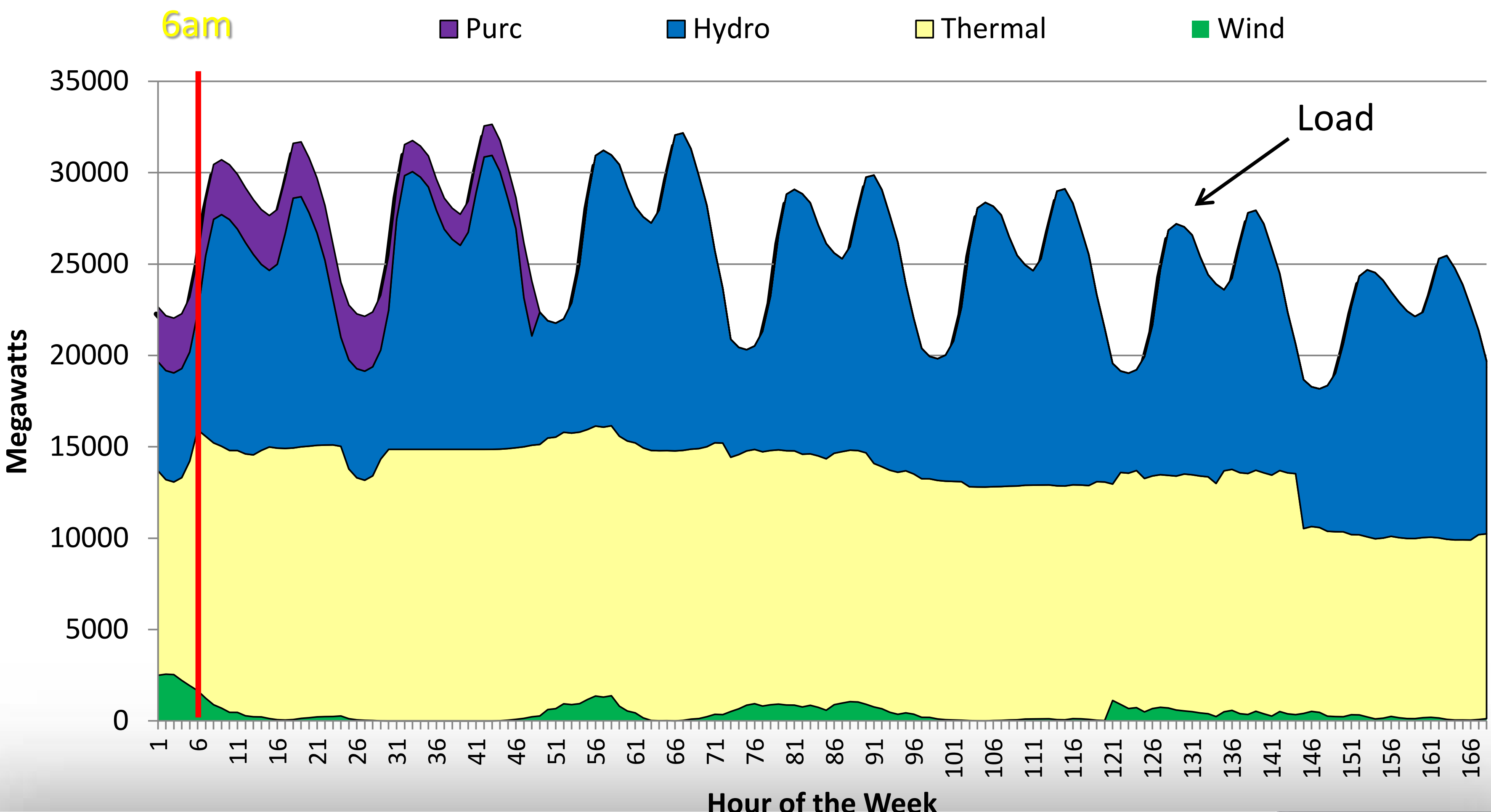
GENESYS Output

- Monthly
  - Hydro reservoir elevations
  - Outflow and spill by project
  - Hydro generation by project
- Hourly
  - Load
  - Thermal resource generation
  - Wind generation
  - Imports/Exports
  - Aggregate hydro generation
  - Curtailment

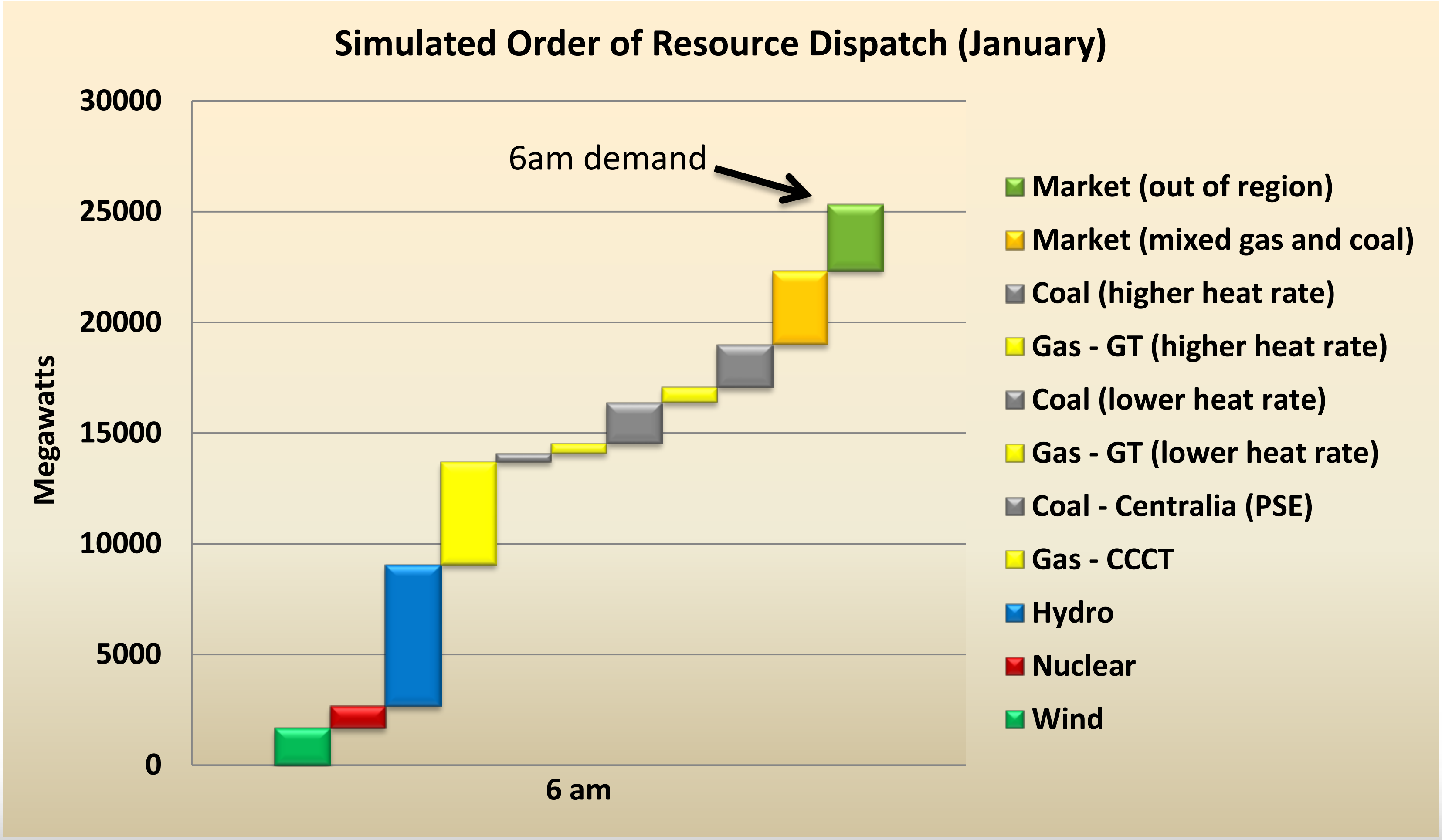
Simulated Dispatch January



Simulated Hourly Dispatch
(typical January week)



Simulated Dispatch Order
(6am January weekday)

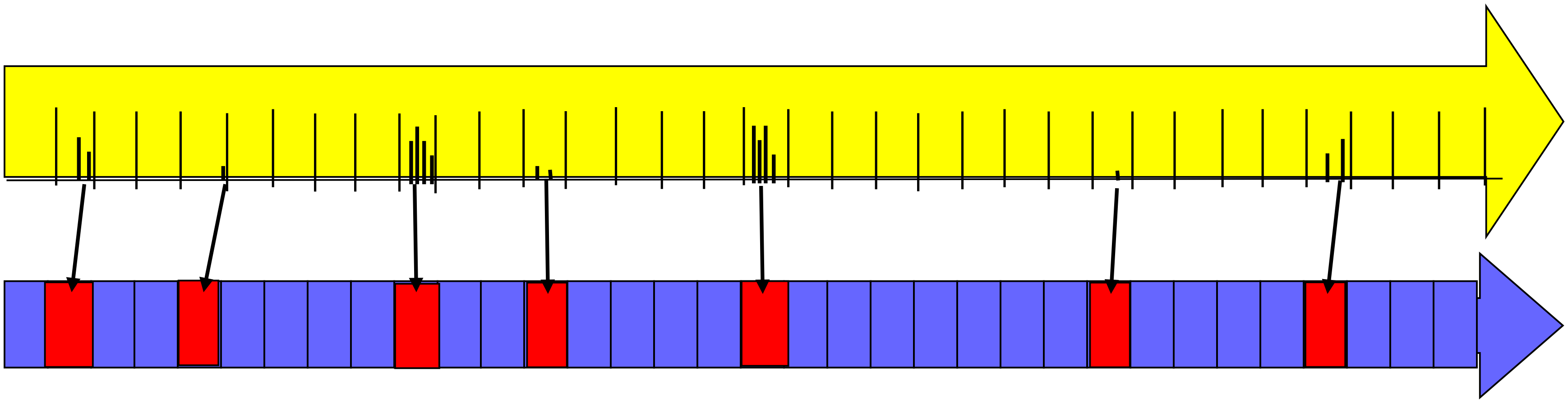


Assessing Adequacy

- Run every combination of temperature and streamflow (80 times 77 = 6,160)
- Count only existing resources or those that are sited and licensed
- EE is built into the load forecast
- Count the number of simulations (games) that have at least one curtailment

Loss of Load Probability

6160 Simulations



Out of 6160 simulations, 308 had curtailment events **(red bins)**

Loss of Load Probability (LOLP) = 308/6160 = 5 percent

2021 Adequacy Results
(LOLP > 5% means inadequate)

Case ➡ / Loads ⬇	No Boardman No Centralia 1	No Boardman No Centralia 1 No Colstrip 1 & 2
High Load	24 %	31 %
Med Load	10 %	13.2 %
Low Load	4 %	5.1 %

Curtailment Record

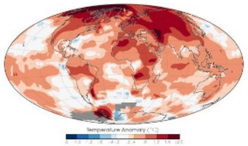
- Link to Event Spreadsheet (spinner graph)

Additional Slides

Uses for GENESYS

LOLP Power supply adequacy

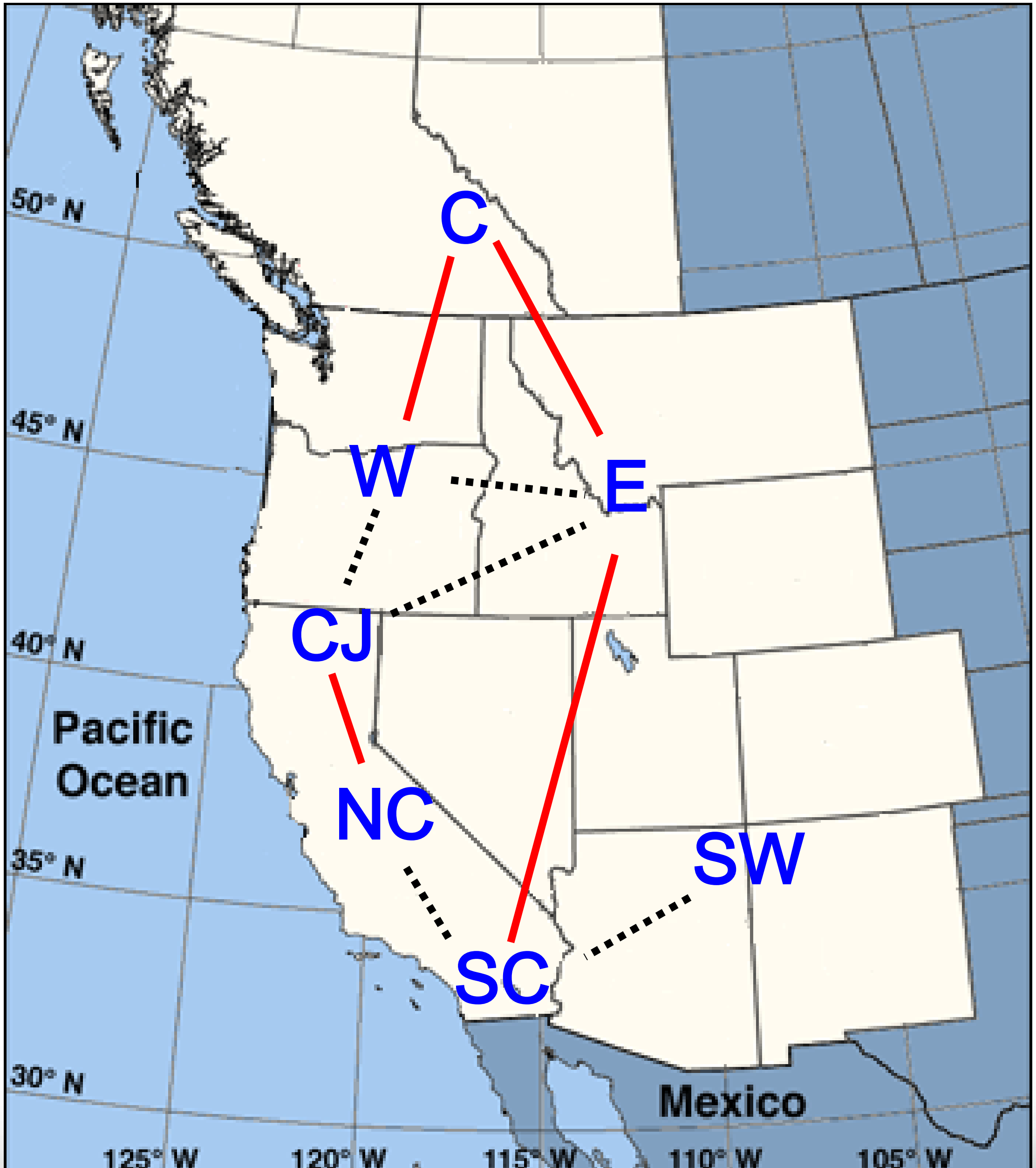
Alternative hydro operations



Climate change analysis

Short-term extreme weather analysis

Resource cost effectiveness



Transmission in GENESYS

- NW region includes:
  - East (E)
  - West (W)
- Solid lines indicate transmission into and out of the region
- Not a power-flow analysis
- East/west transmission capability varies based on BPA data
- Southern interties have fixed transfer capability
- SW modeled as import market only

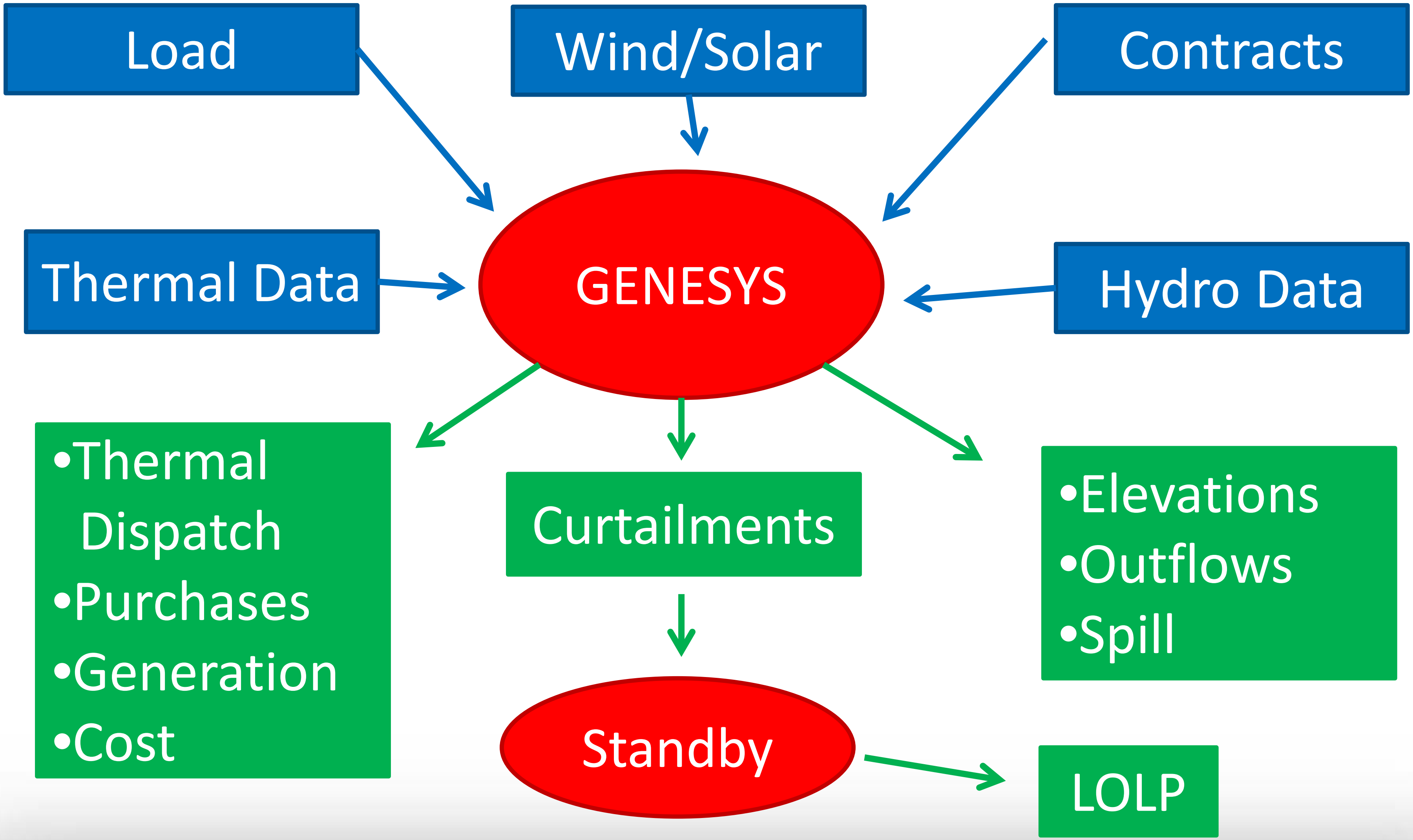
Treatment of Reserves

- Contingency reserves
  - To protect system integrity during a loss of a major resource or transmission line
  - After the simulation, if unused resources are not sufficient to cover this reserve, then counted as an outage

- Balancing reserves
  - Generation with fast ramp times to cover variability in demand and in wind and solar generation
  - Preprocessor to GENESYS reduces hydro peaking and increases hydro minimum generation[1]

[1]The redeveloped GENESYS will model balancing reserves dynamically.

GENESYS Flow Diagram

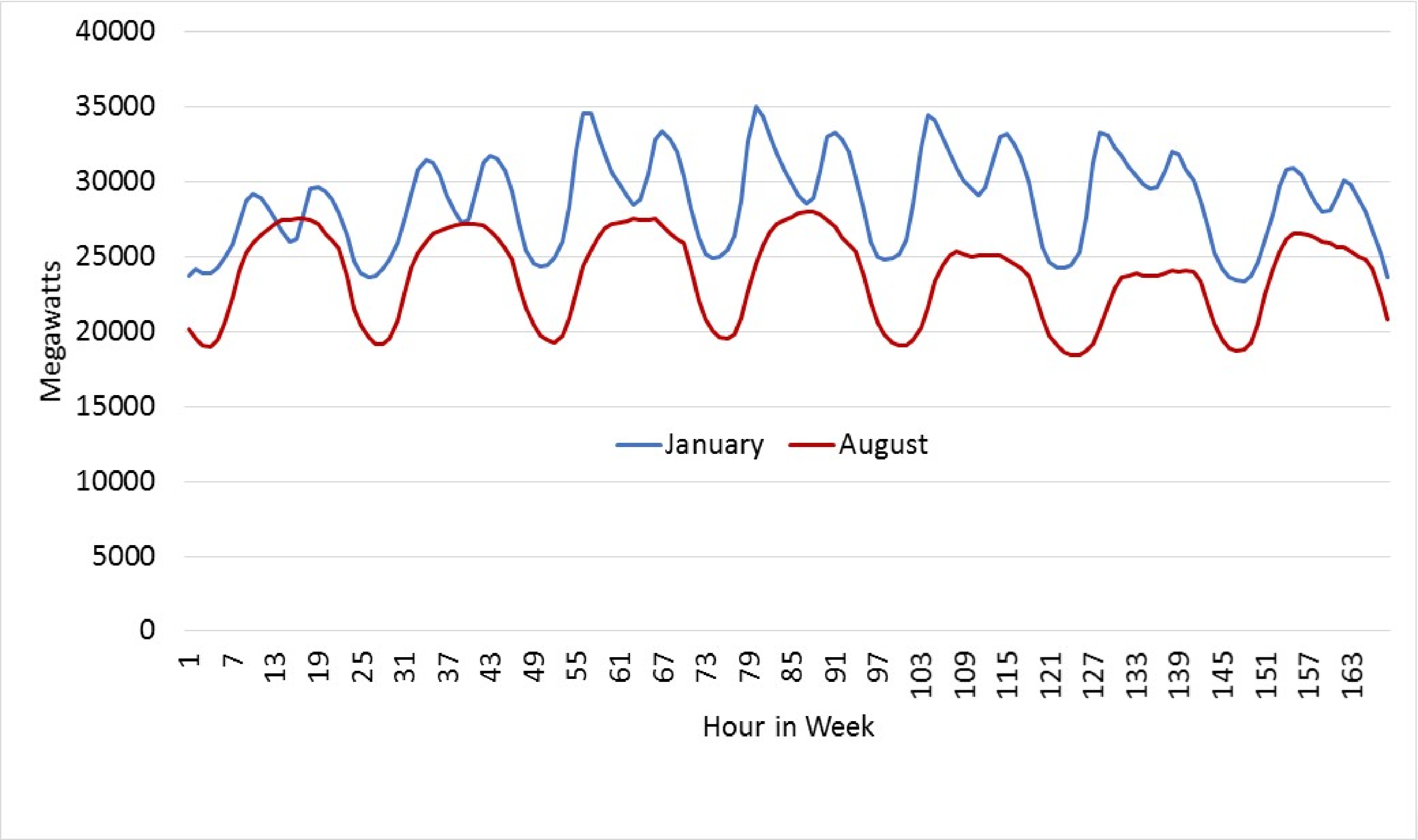


Sample Hourly Load Forecast

- Operating year is Oct 1st through Sep 30th
- 77 Temperature profiles (1929-2005, to match wind data)

Year	Month	Day	Hour	1929	1930	• • •	2005
2014	10	1	1	15059	15108	• • •	14961
2014	10	1	2	14750	14797	• • •	14654
2014	10	1	3	14595	14642	• • •	14500
•							
•							
•							
2015	9	30	22	19014	19075	• • •	18889
2015	9	30	23	17337	17393	• • •	17224
2015	9	30	24	15943	15995	• • •	15840

Sample Hourly Loads

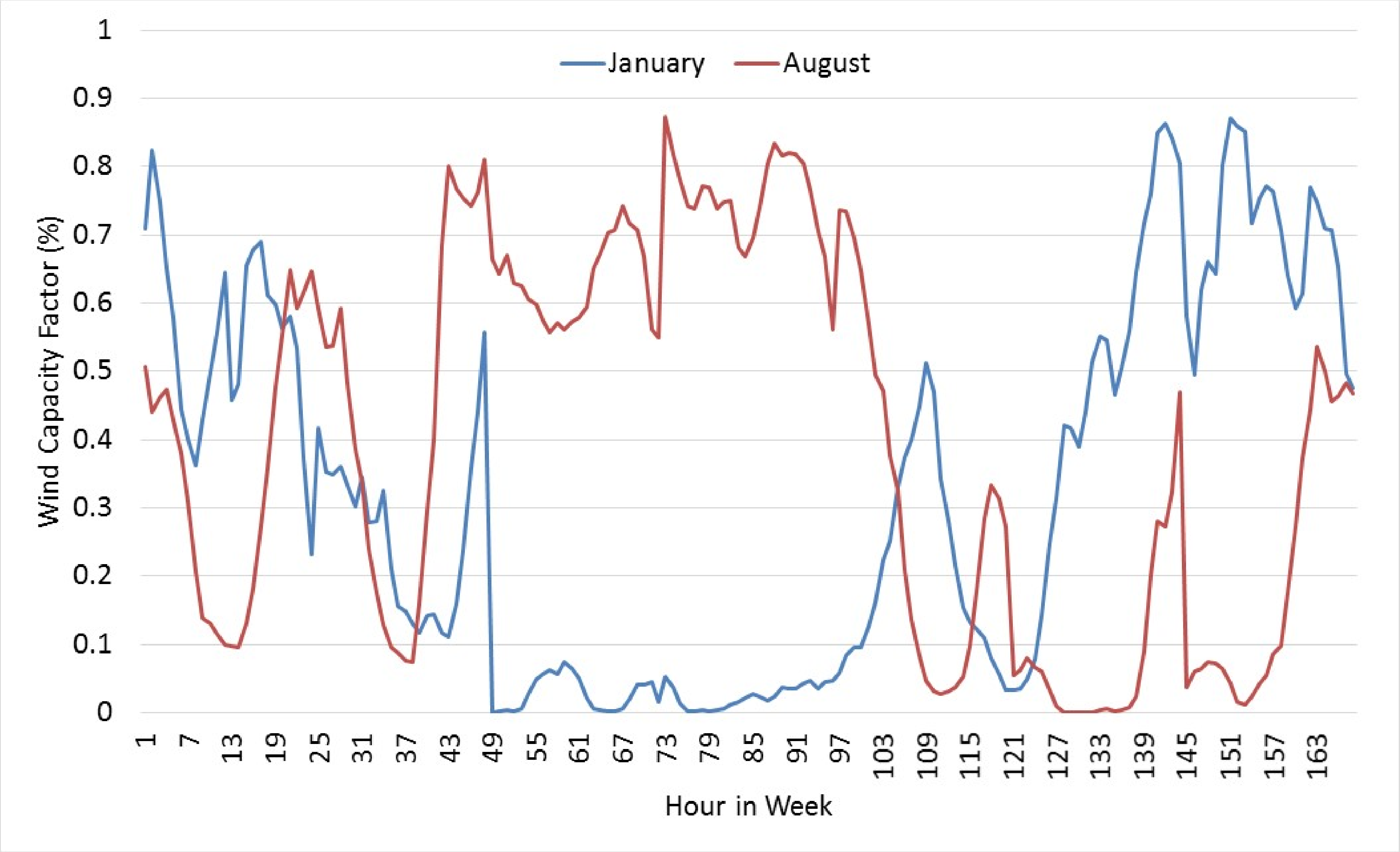


Sample Wind Generation Data

- Hourly factor times total site wind nameplate = generation
- 77 Temperature profiles (1929-2005, to match load data)

Year	Month	Day	Hour	1929	1930	• • •	2005
2014	10	1	1	.25	.23	• • •	.31
2014	10	1	2	.28	.24	• • •	.33
2014	10	1	3	.28	.24	• • •	.38
•							
•							
•							
2015	9	30	22	.15	.15	• • •	.95
2015	9	30	23	.05	.10	• • •	.92
2015	9	30	24	.04	.12	• • •	.81

Gorge Wind Capacity Factors



Thermal Resource Data

From Council's Generating Resource Database

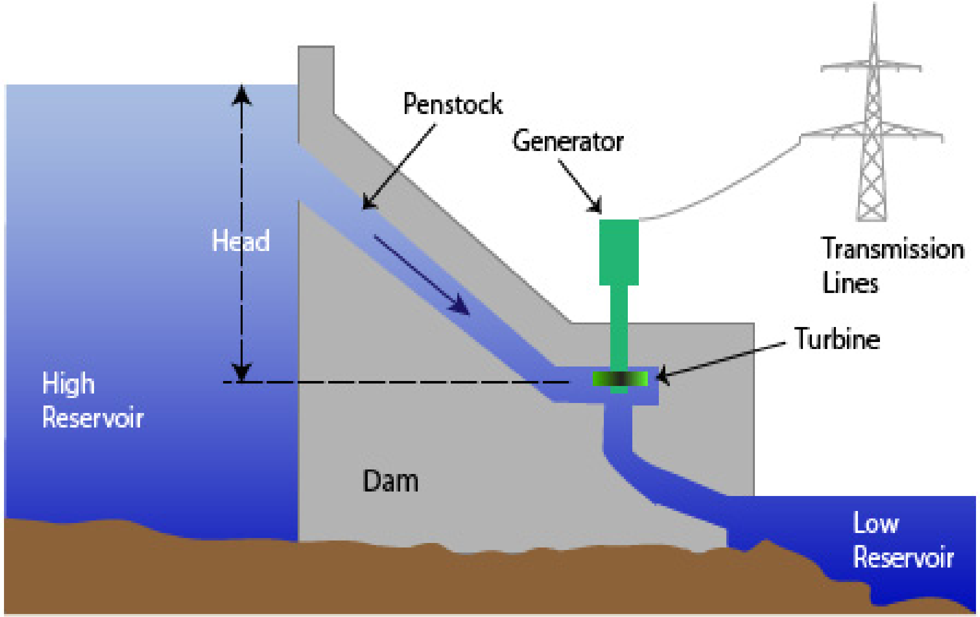
Sample Data:

Name: Langley Gulch
Node: PNW East
Source D Type: Thermal
Source P Type: CCCT
Capacity: 300 MW
Online Date: 2012-06-01
Retire Date: 2051-01-01
Avg Heat Rate: 6900
Fuel Type: PNW E. gas

FOR: 0.059
Maintenance: 21 days winter
Mean Repair Time: 32 days
Stochastic Outage: TRUE
Cost Set: CCCT - PNW E.
Operating Life: 30
Gen vs. Temp: NULL
Emissions: NULL
Must Run Level: NO

Non-Time Dependent Hydro Data

- Physical top and bottom
- Min and Max turbine flow
- Plant data tables
  - Max flow vs. storage
  - Max generation vs. head
  - Elevation vs. storage
  - Tail water elevation vs. outflow
  - Power factor vs. head



Time Dependent Hydro Data

By Water Year, by Month, by Plant

- Natural stream flows
- Rule Curves
- Min and max outflow
- Min and max elevation
- Bypass spill

Rule Curves

- Upper Rule Curve (URC)
  Max elevation to avoid flooding, varies by water year

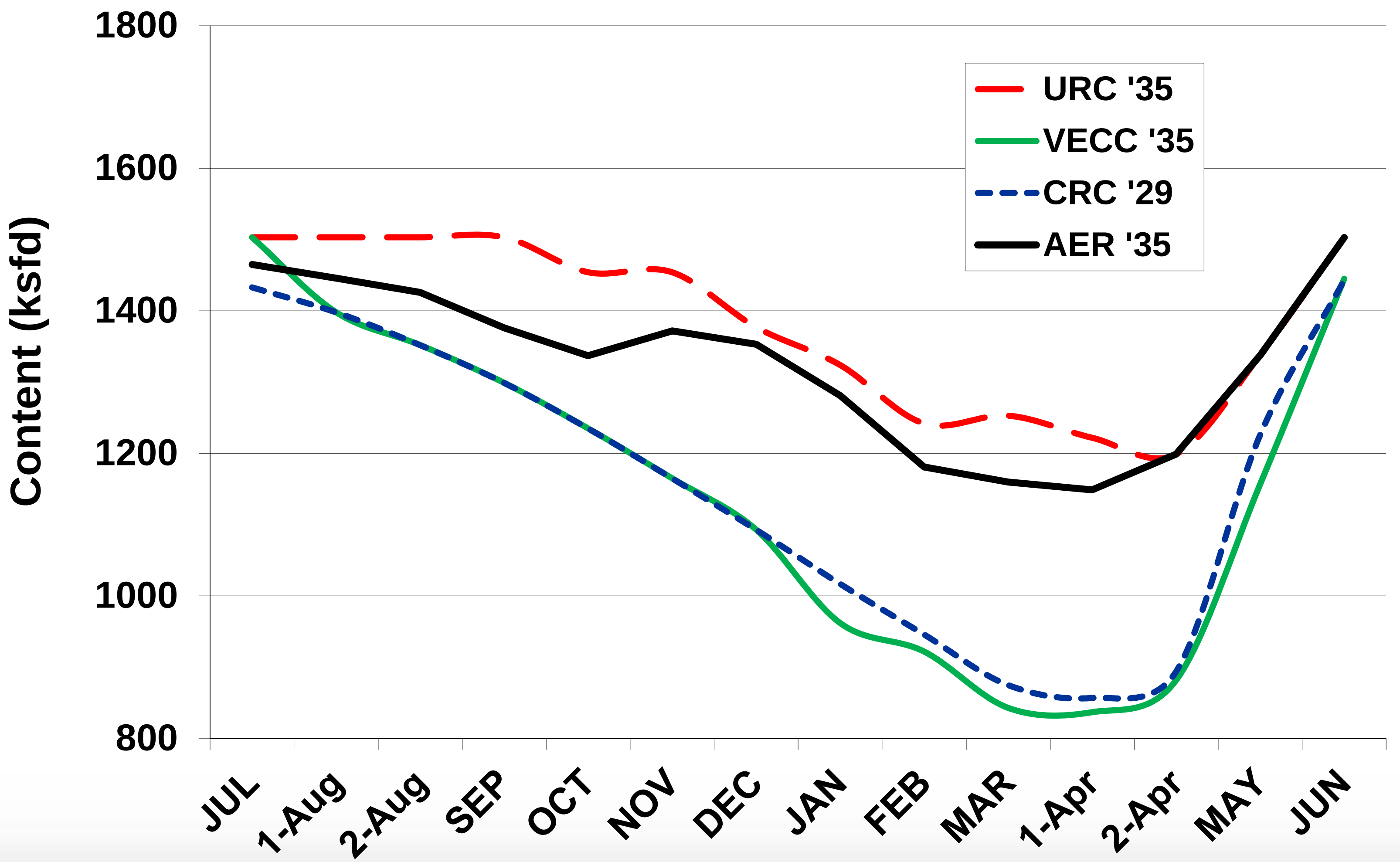
- Critical Rule Curve (CRC)
  Min elevation during critical water year for firm energy

- Variable Energy Content Curve (VECC)
  Min elevation to ensure refill, varies by water year

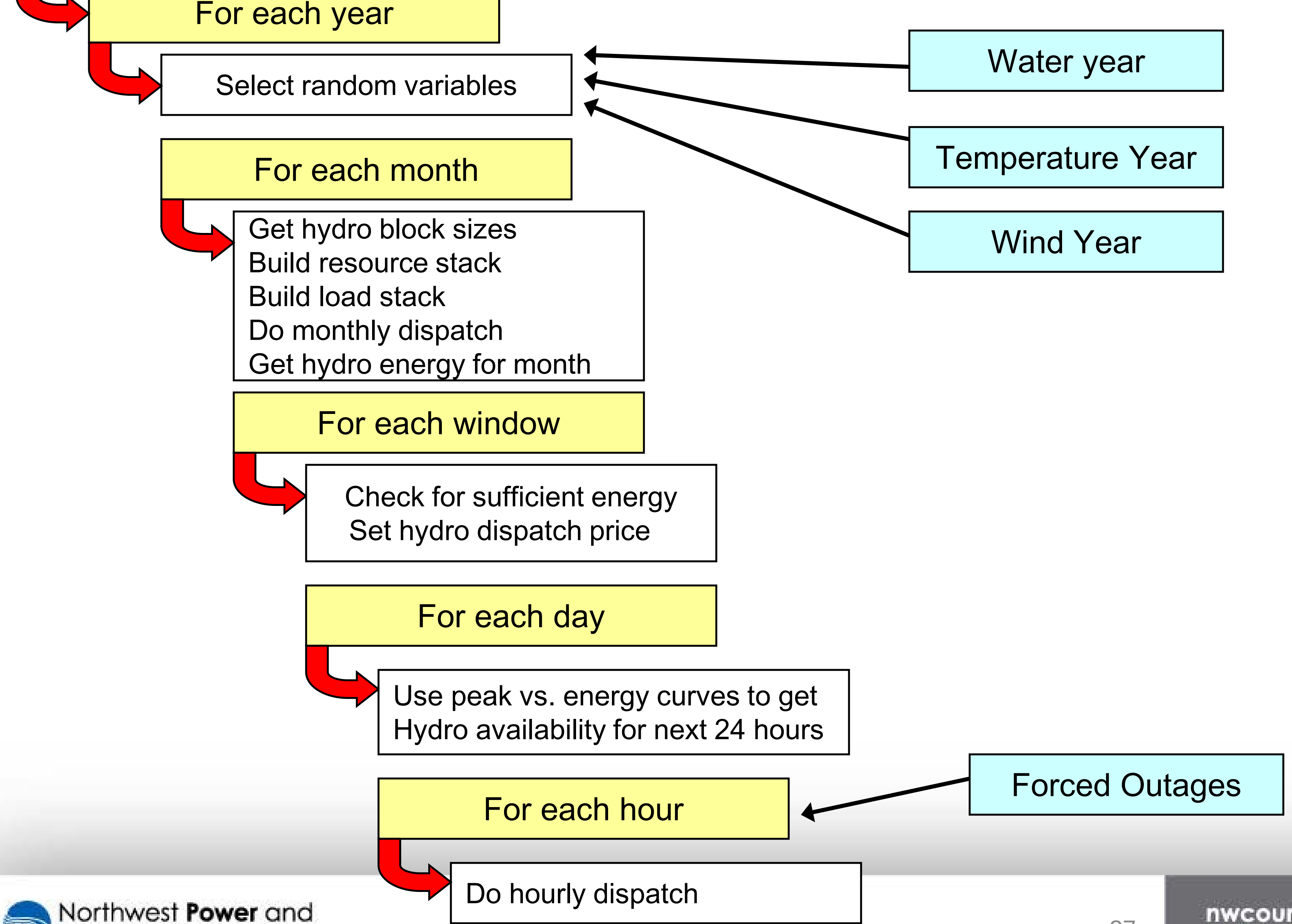
- Assured Energy Regulation (AER)
  Sets target elevation (proportional draft point) and includes fish recovery operations, varies by water year

Illustration of Rule Curves

(Hungry Horse Dam)



Genesys Overview



For Each Month

1. Get size of hydro blocks in energy
   - Draft/fill from starting elevation to URC
   - Draft/fill from starting elevation to VECC
   - Draft/fill from starting elevation to AER
   - Draft/fill from starting elevation to empty

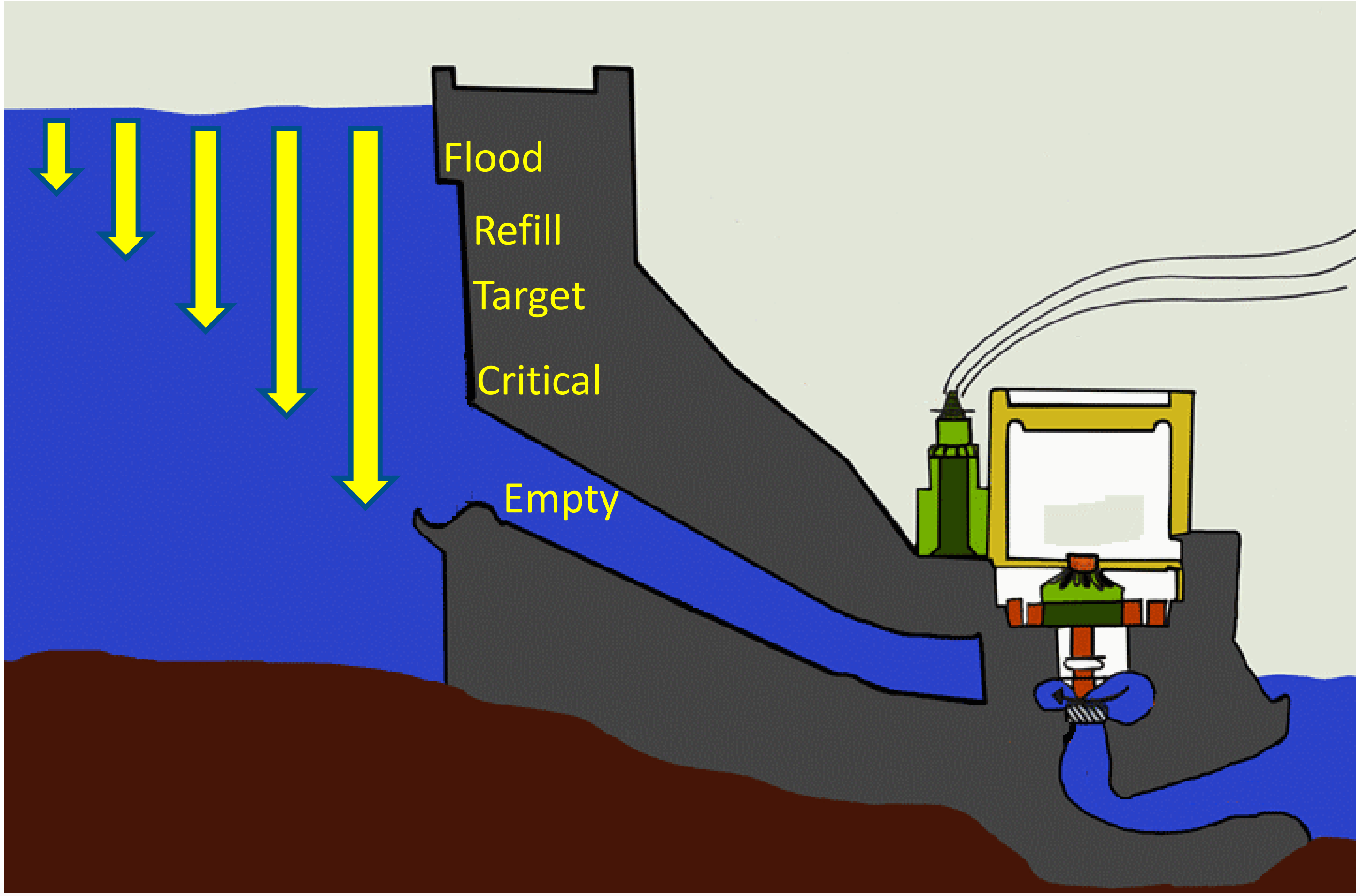
2. Price hydro blocks relative to specific thermal units

3. Add hydro blocks to resource stack
   Adds resources from cheapest to most expensive

4. Compare resource stack to load

5. Determine monthly hydro energy

Get Hydro Block Size



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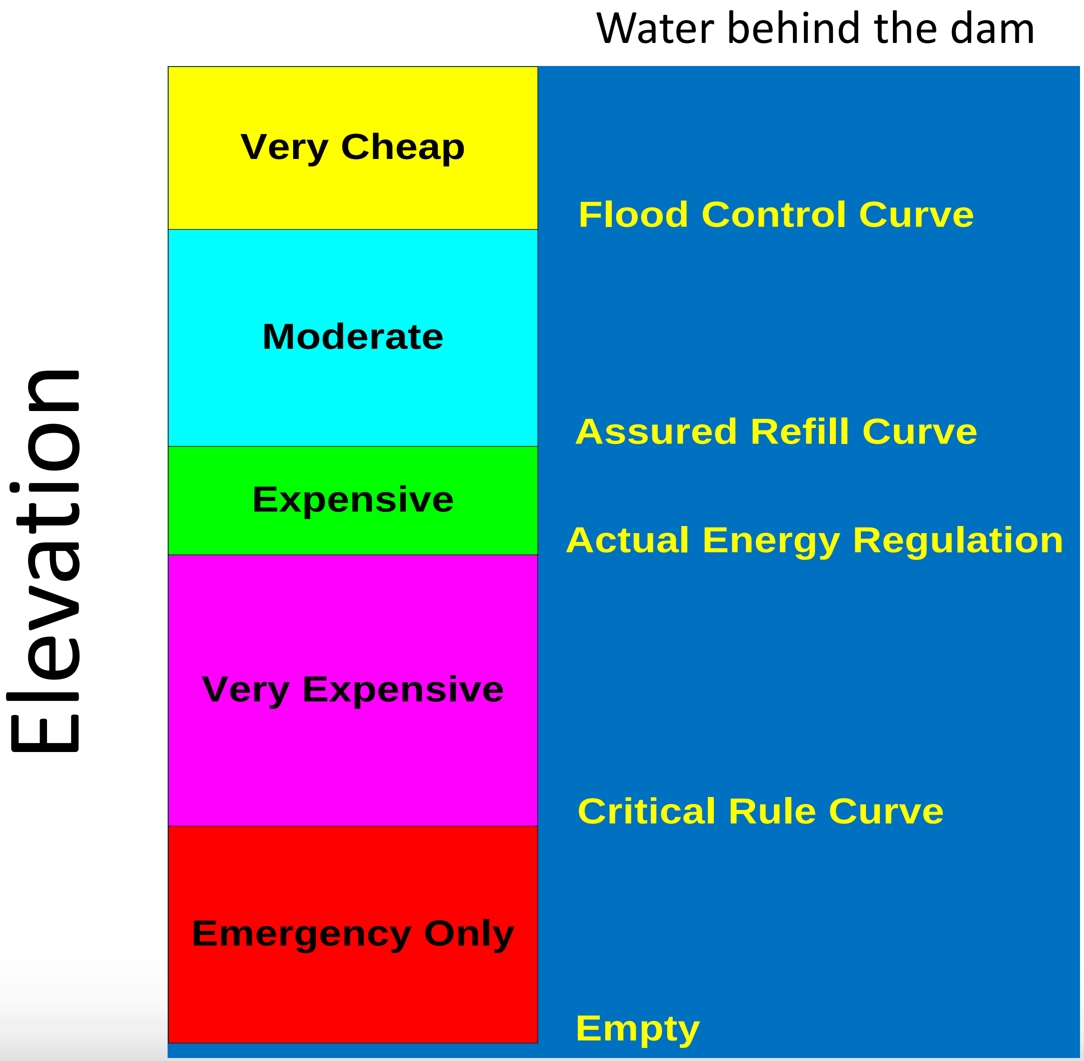
Hydro Blocks – Based on Value of Water



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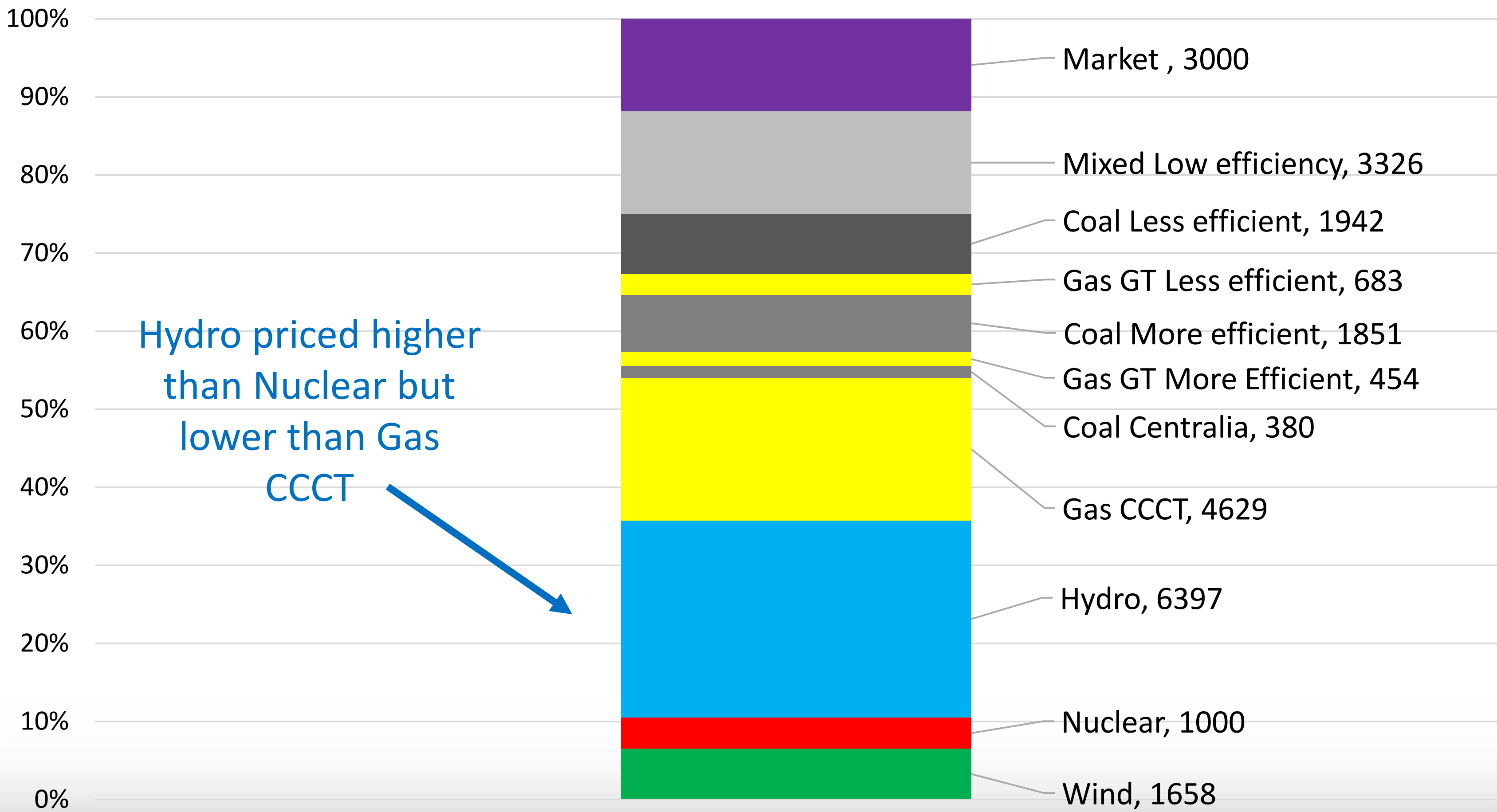
Sample Resource Stack



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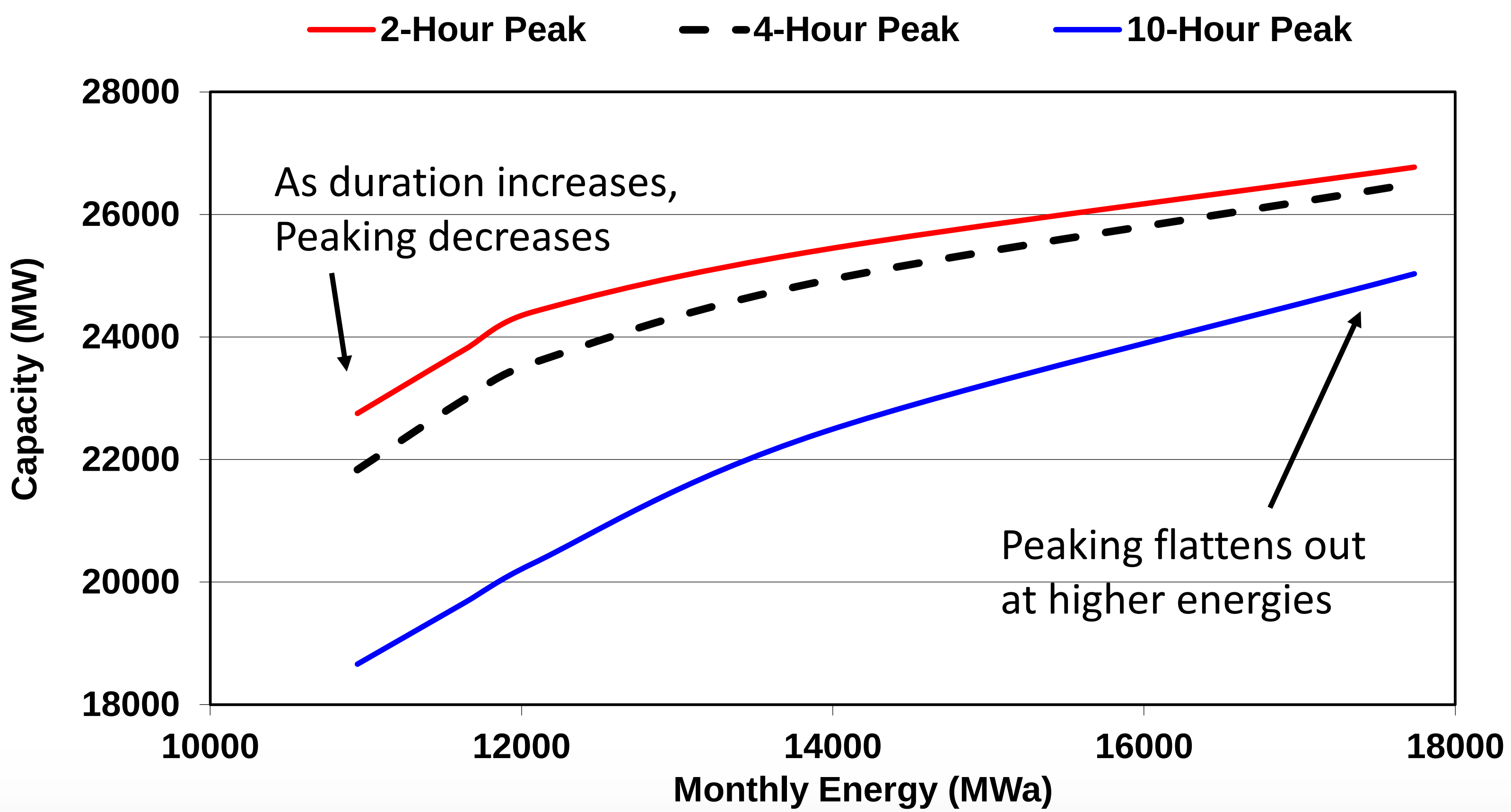
For Each Day

1. Allocate daily hydro energy to match the shape of hourly loads (24 hours)

2. Hydro shaping is constrained by sustained peaking limits (see next slide)
   - As peak duration increases,
     sustained peaking capability decreases
   - Peaking capability flattens out at high energies

3. If hydro does not meet load, attempt to make the deficit uniform over all hours

Hydro Sustained Peaking vs. Monthly Energy



Allocating Hourly Hydro

- Calculate hourly load factors for 24 hours:
  Hour(1) LF = Hour(1) load /day average load
- Calculate hourly hydro availability:
  Hour(1) hydro = Daily hydro energy/Hour(1) LF
- Make sure hydro doesn't exceed peaking capability
  - 2 consecutive hour gen can't exceed 2-hour peaking max
  - 4 consecutive hour gen can't exceed 4-hour peaking max
  - 10 consecutive hour gen can't exceed 10-hour peaking max

Example of Hydro Shaping