System Analysis Advisory Committee

March 27, 2015

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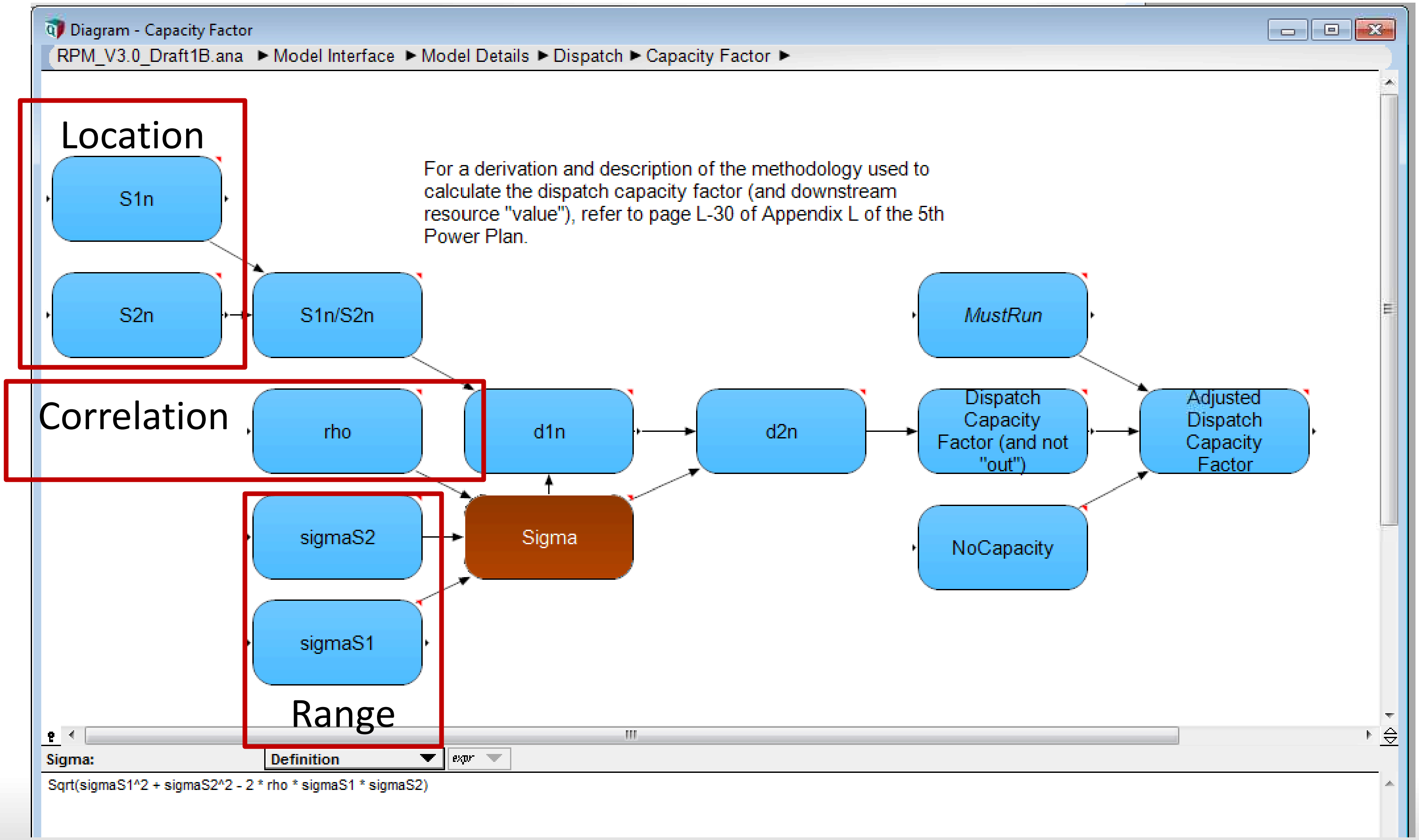
RPM Thermal Dispatch Decision

- S1n – Market Price – VOM
- S2n – Fuel Cost + CO2 Cost
- Then S1n – S2n = $ per MW earned by dispatch
- So max(S1n – S2n, 0) determines how much money a generator would make when added over each period

Within Period Variation

- Market price within a period has a distribution and gas price within a period has a distribution
- The probability of the two distributions overlapping requires the computation of the location, range and correlation

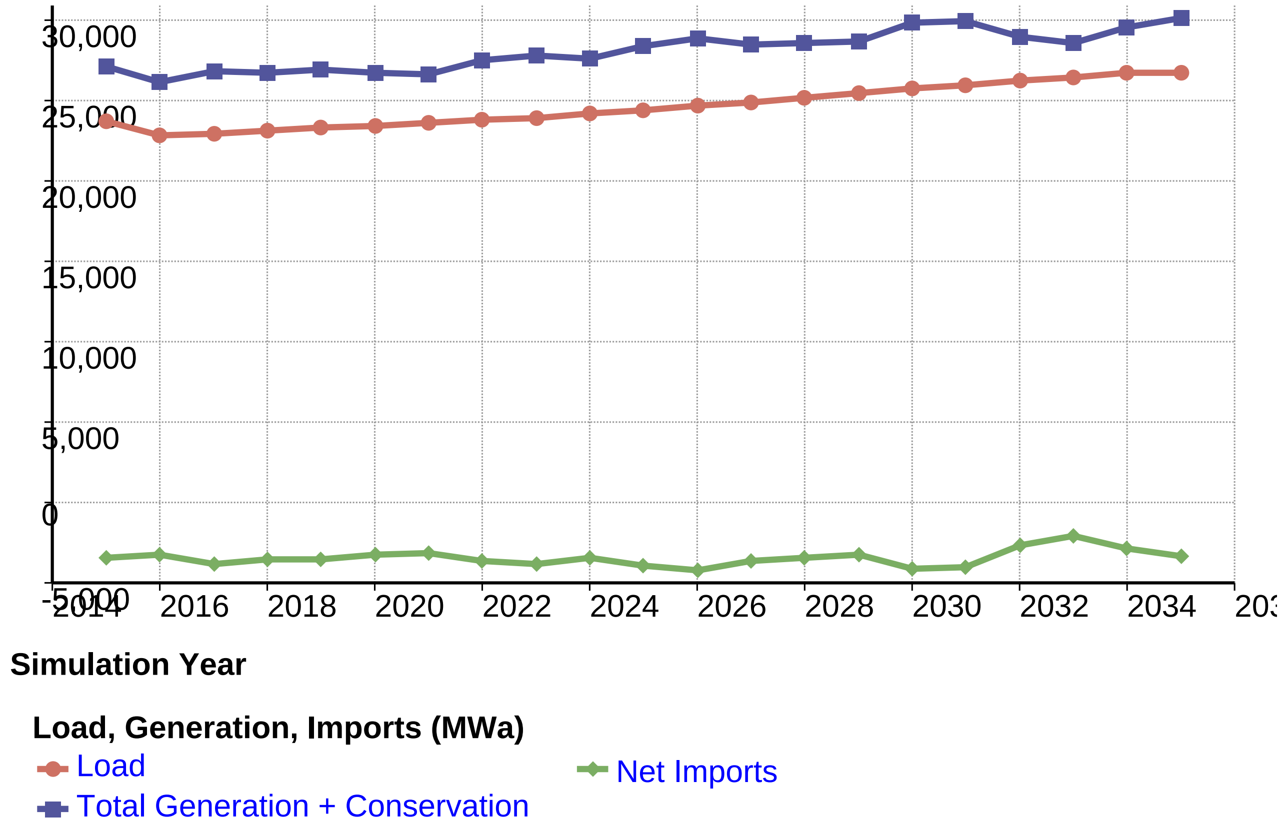
Model Thermal Dispatch Logic



RPM NPV Calculation

- Collection of costs and offsetting benefits
- Market price in RPM covers more than the region
- Exports are common, so what is the cost to the region?

On Average Generation Exceeds Loads



General Concept

- Formulation can be a bit strange, e.g. note considering the value of a MWh
  - Value of Dispatched Generation = Market Price – Variable Costs
  - Market Price – Value of Dispatched Generation = Market Price – (Market Price – Variable Costs) = Variable Costs
- So the formulation uses Market Price – Value of Dispatched Generation as a proxy

NPV Cost and Benefits

- Costs in the NPV formulation
  - Cost of serving load at market price
  - Cost of acquiring new resources
  - Cost of generation curtailment and load shedding
  - Cost of fixed O&M for existing resources
  - Resource Adequacy Penalties
- Offsetting benefits
  - Value of generation
  - Value of conservation
  - REC Values

NPV End Effects

- Calculation uses a discount rate and adjusts for perpetuity
- Tracking impacts on NPV in the RPM can help in understanding the formulation

Perpetuity Formulation

- If you miss geometric series recall:

$$\sum_{i=0}^{\infty} x^i = \frac{1}{1-x}$$

- So discounting out into infinity from the start of the perpetuity period gives:

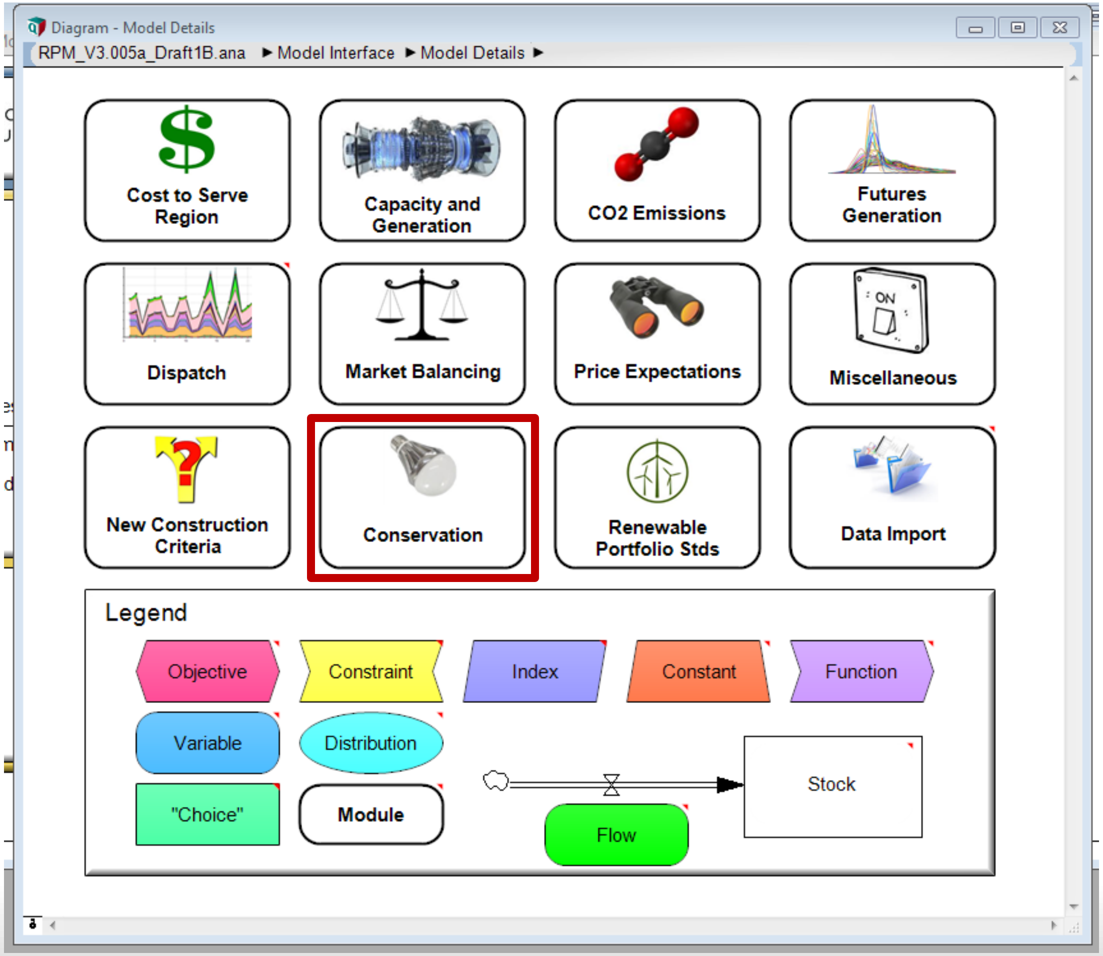
$$\frac{1}{1-(1+d)^{(E-S-1)}}$$

where E is the end of the study in periods (80) and S is the start of the perpetuity period (73)

RPM Web Interface

- See it at http://bit.ly/RPM_Navigant
- Data were updated relatively recently, Scenario 1B data will be posted after final data sets are collected
- Does not perform optimization, i.e. creating an efficient frontier

RPM Conservation Supply Curves and Logic



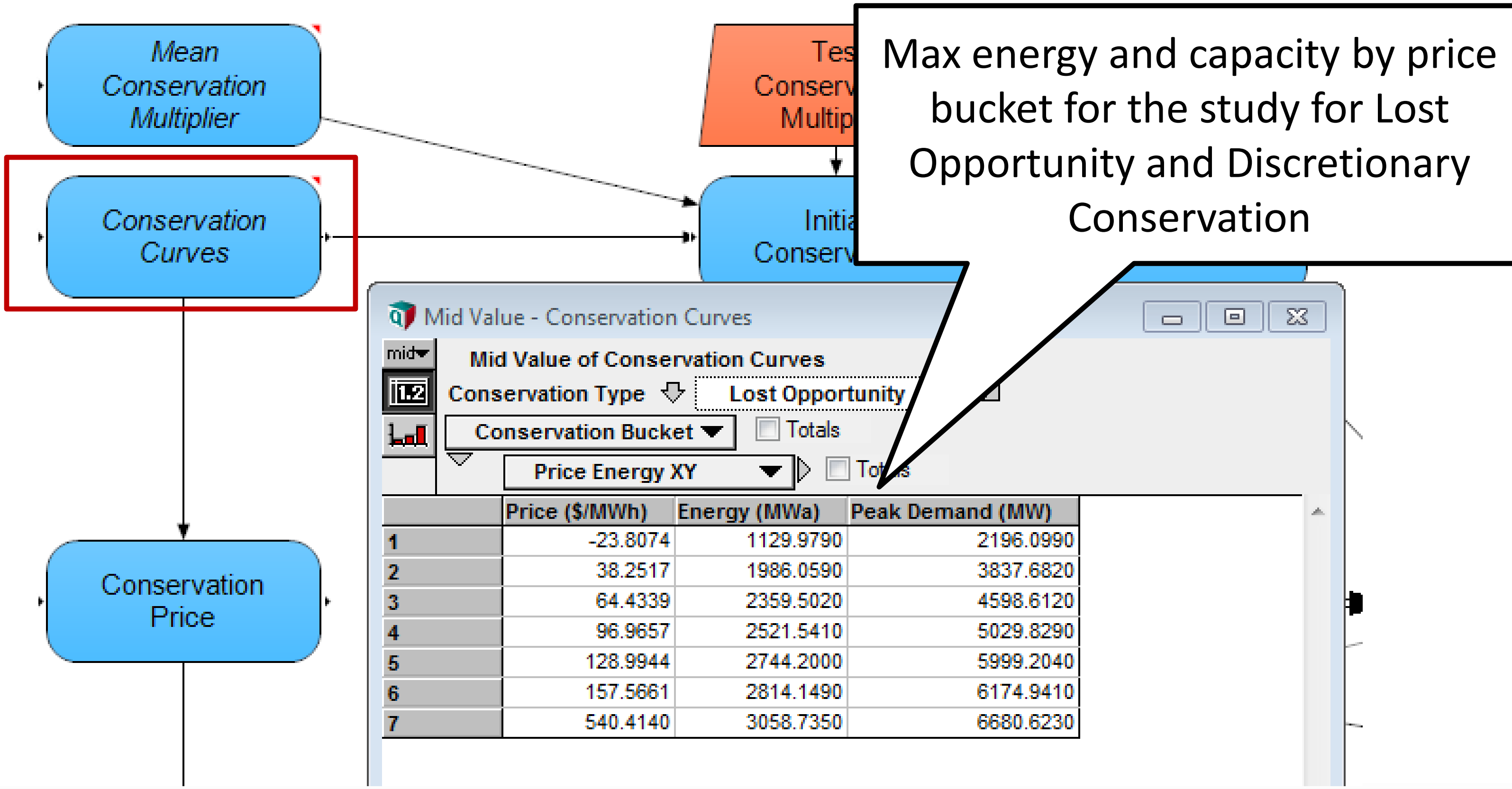
Updates Since the Sixth Plan

- Substantially updated inputs and logic for conservation
  - Added concept of program year
  - Ramp rates can change by bin and program year
  - All cost effective bins are purchased
  - Lost opportunity conservation is available based on program cycle

Measure Combination

- Conservation workbooks are posted with measure level data at http://www.nwcouncil.org/energy/powerplan/7/technical#Conservation
- Conservation workbook bundler at https://github.com/NWCouncil/ConservWBExtract/releases creates input supply curves

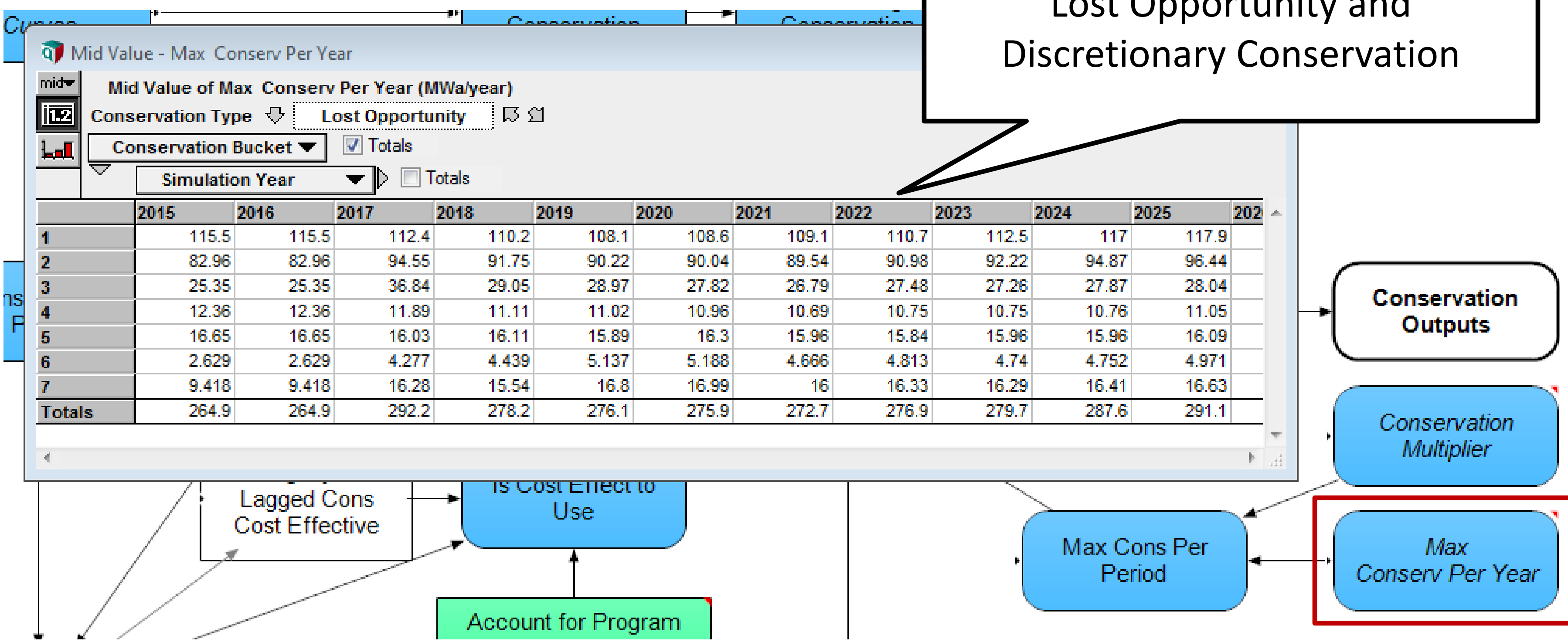
Study Supply Input



	Price ($/MWh)	Energy (MWa)	Peak Demand (MW)
1	-23.8074	1129.9790	2196.0990
2	38.2517	1986.0590	3837.6820
3	64.4339	2359.5020	4598.6120
4	96.9657	2521.5410	5029.8290
5	128.9944	2744.2000	5999.2040
6	157.5661	2814.1490	6174.9410
7	540.4140	3058.7350	6680.6230

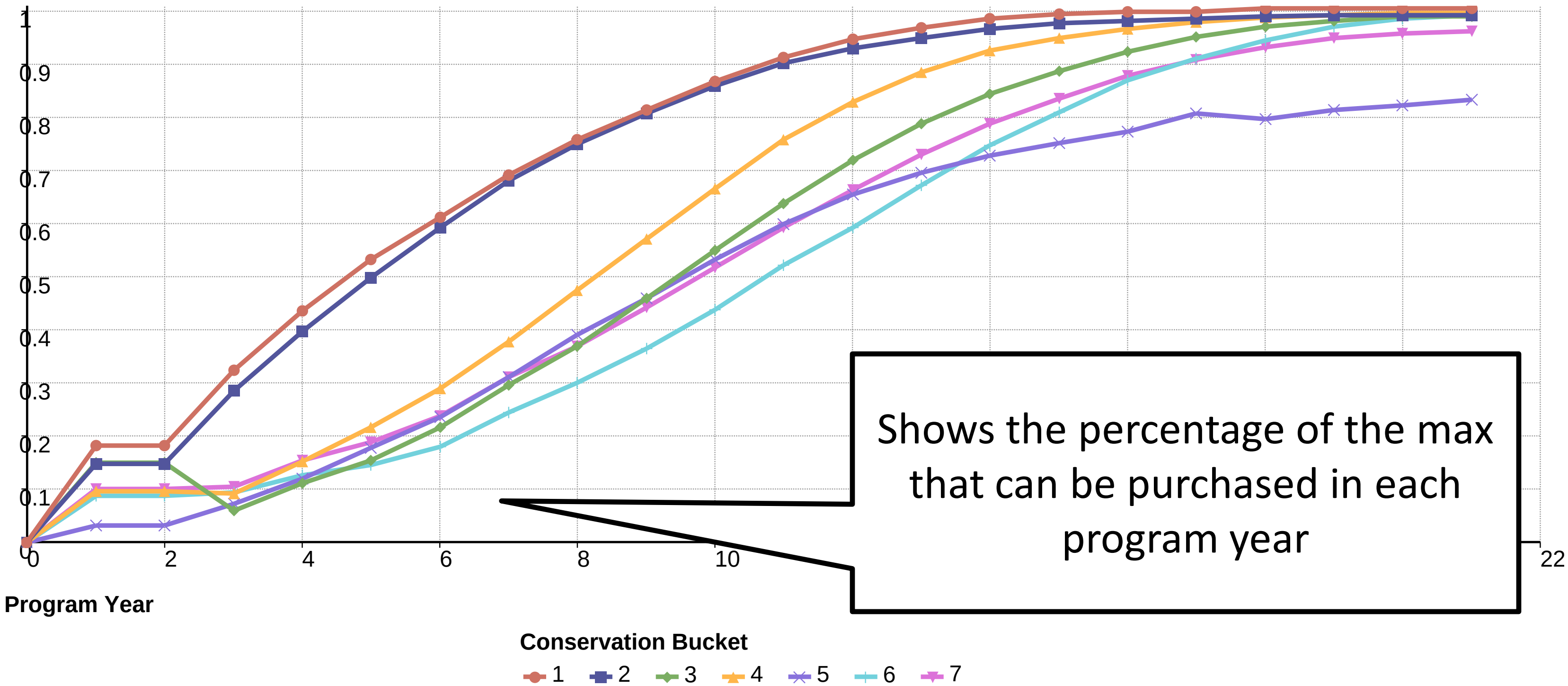
Program Year Supply

Max energy per program year for Lost Opportunity and Discretionary Conservation



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	202
1	115.5	115.5	112.4	110.2	108.1	108.6	109.1	110.7	112.5	117	117.9	
2	82.96	82.96	94.55	91.75	90.22	90.04	89.54	90.98	92.22	94.87	96.44	
3	25.35	25.35	36.84	29.05	28.97	27.82	26.79	27.48	27.26	27.87	28.04	
4	12.36	12.36	11.89	11.11	11.02	10.96	10.69	10.75	10.75	10.76	11.05	
5	16.65	16.65	16.03	16.11	15.89	16.3	15.96	15.84	15.96	15.96	16.09	
6	2.629	2.629	4.277	4.439	5.137	5.188	4.666	4.813	4.74	4.752	4.971	
7	9.418	9.418	16.28	15.54	16.8	16.99	16	16.33	16.29	16.41	16.63	
Totals	264.9	264.9	292.2	278.2	276.1	275.9	272.7	276.9	279.7	287.6	291.1	

Program Year Ramp

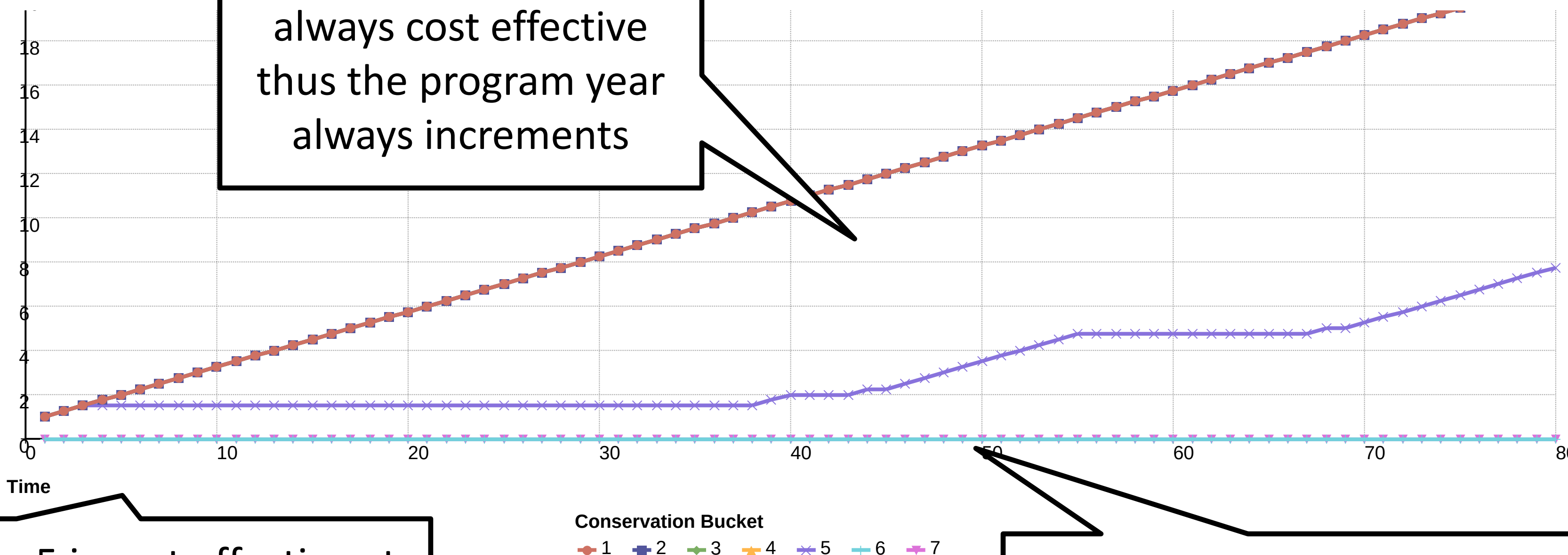


Program Year

- Moves ramps based on when programs in a bin become cost effective
  - E.g if for bin 5 the first program year allows 3% of the max conservation to be purchased and the second program year allows 7% of the max conservation to be purchased, whenever the bin becomes cost effective, the first year 3% is purchased the second year, if it remains cost effective, 7% is purchased

Effective Program Year Example

Bins 1 through 4 are always cost effective thus the program year always increments



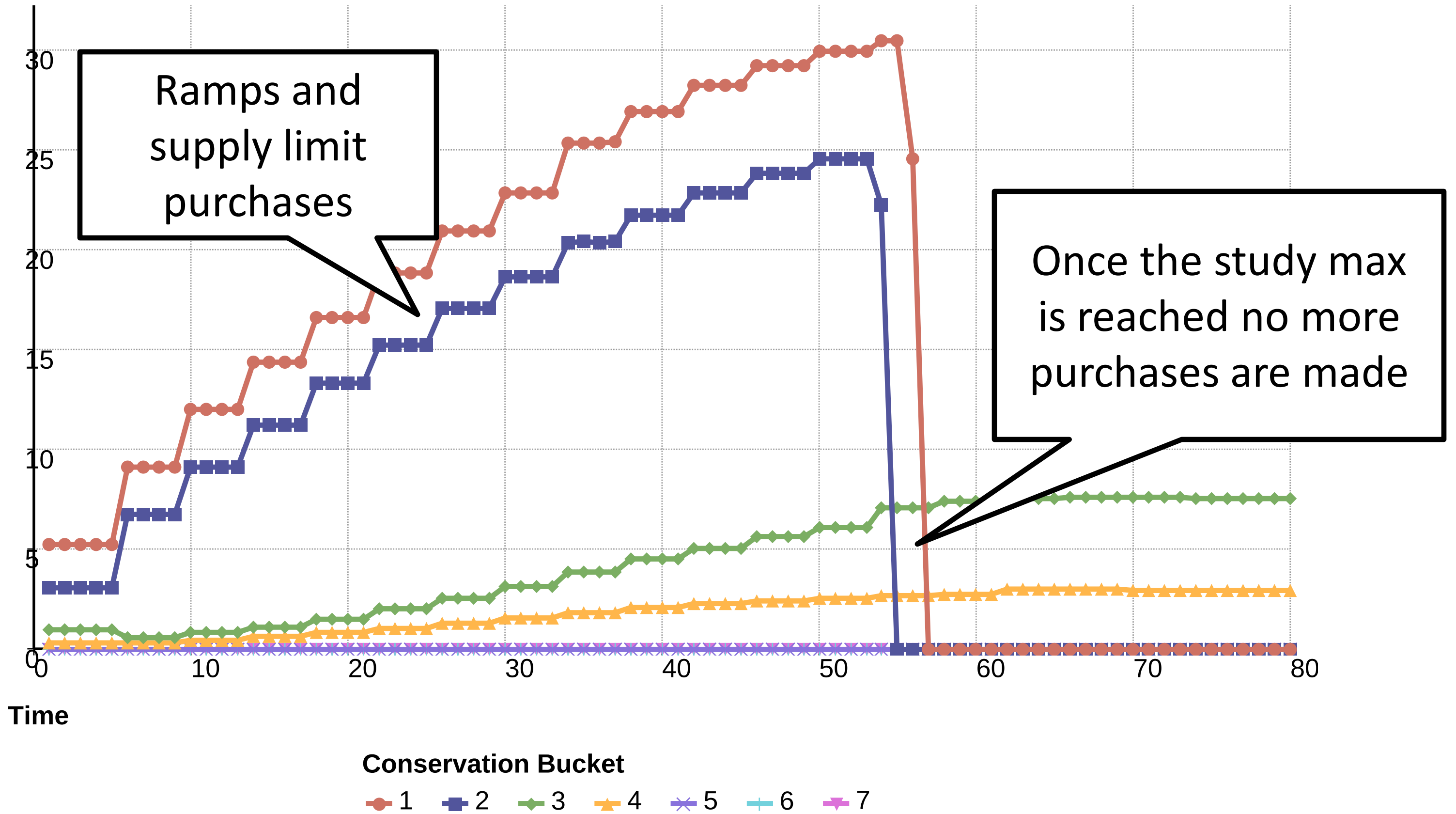
Bin 5 is cost effective at first but becomes too expensive

When bin 5 becomes cost effective again then it picks back up with the next ramp in the supply curve inputs

Combined Conservation Limits

- Each year/period the ramp is multiplied by the max energy for the program year/period which is multiplied by a factor accounting for load differences between futures to determine the supply of conservation
- When the cumulative purchases reach the study maximum, no more can be purchased

Conservation Acquisition



Cost Effective Logic

- Exponentially smoothed price (one game):

$$P_t = P_{t-1} + .25\left(e_{t-1} - P_{t-1}\right)$$

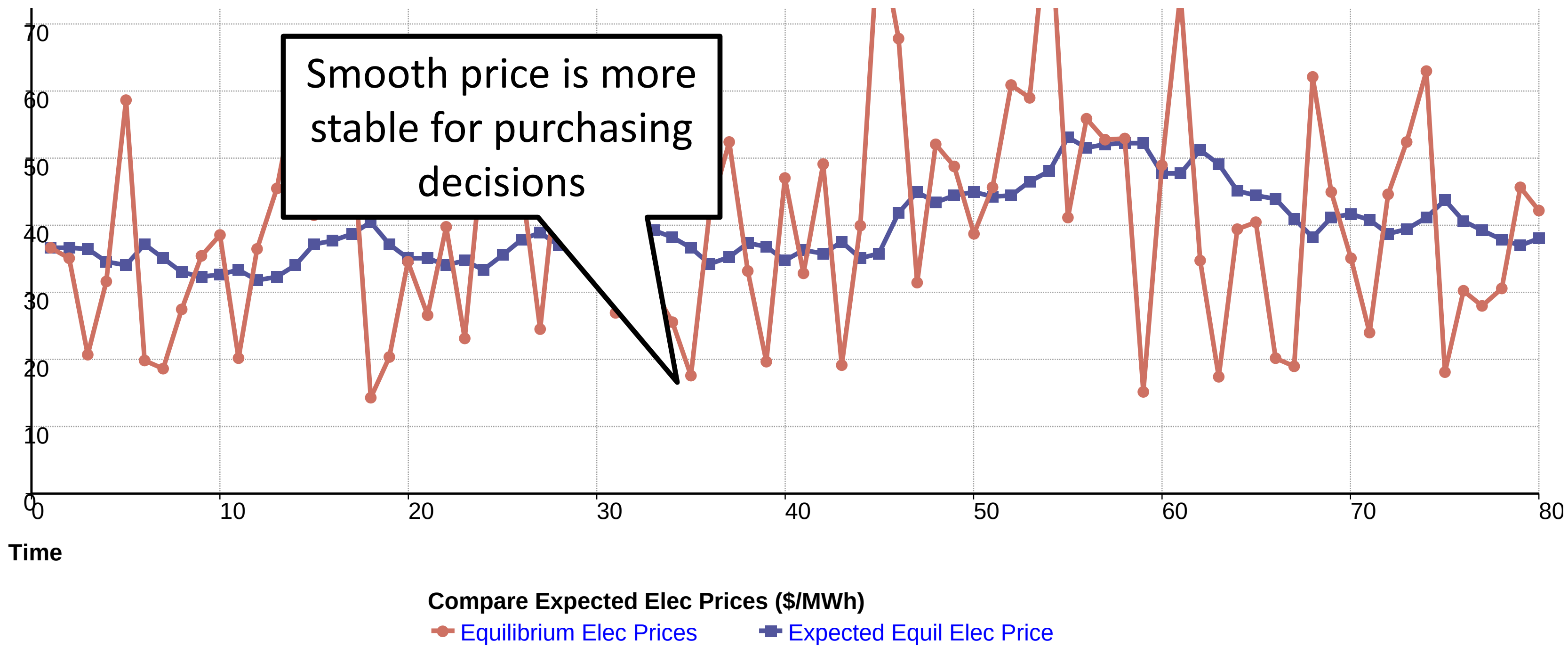
where

P_t is expected price at time t

e_t is the equilibrium electric price at time t

- Market Adjustment (Conservation Adder)
- Avoided Cost Credit

Example Game Price Smoothing



Compared to Conservation Cost

- Conservation is cost effective if

  $$1.1P_t + a \geq c$$

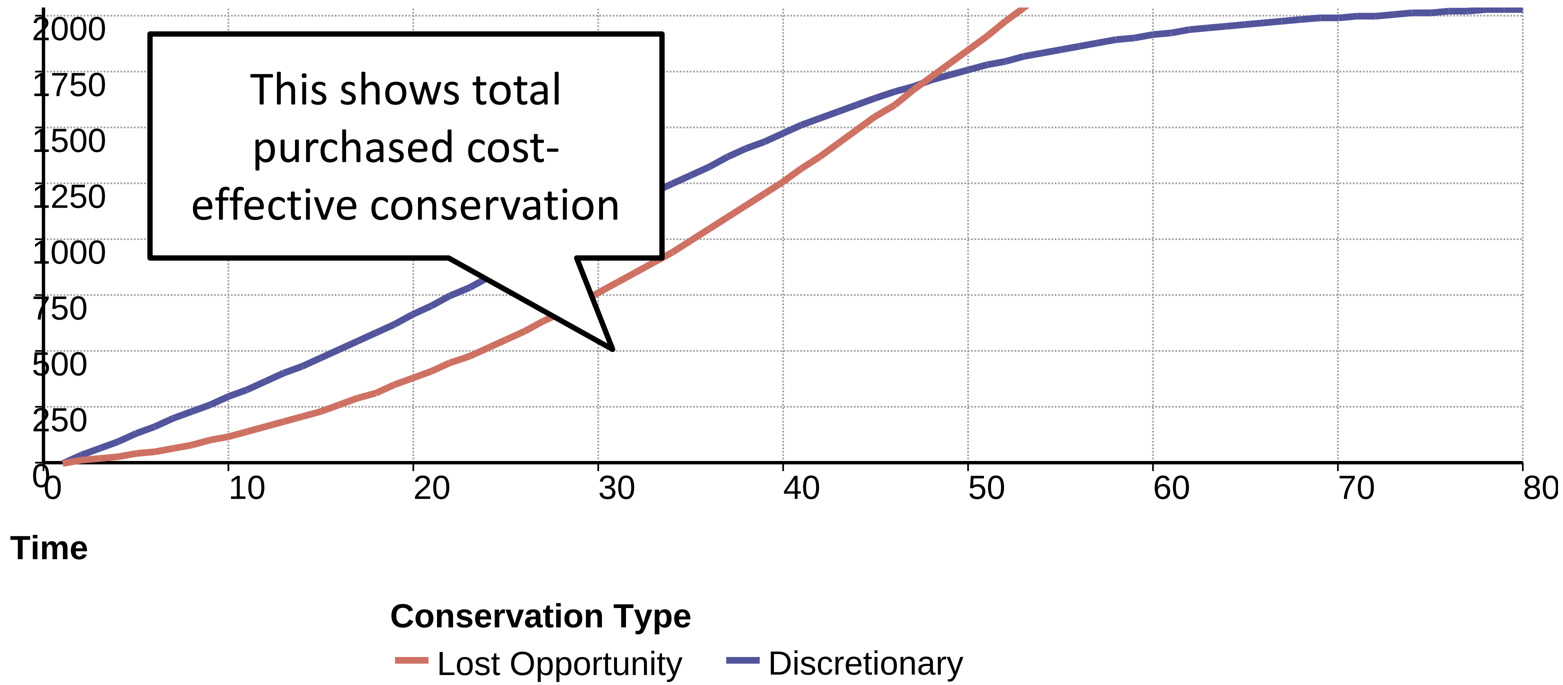
  where

  P_t is expected price at time t

  a is the conservation adder

  c is the cost of conservation bin
- Note, the 1.1 represents the Power Act credit for conservation

Average Cumulative Conservation



Into the RPM…

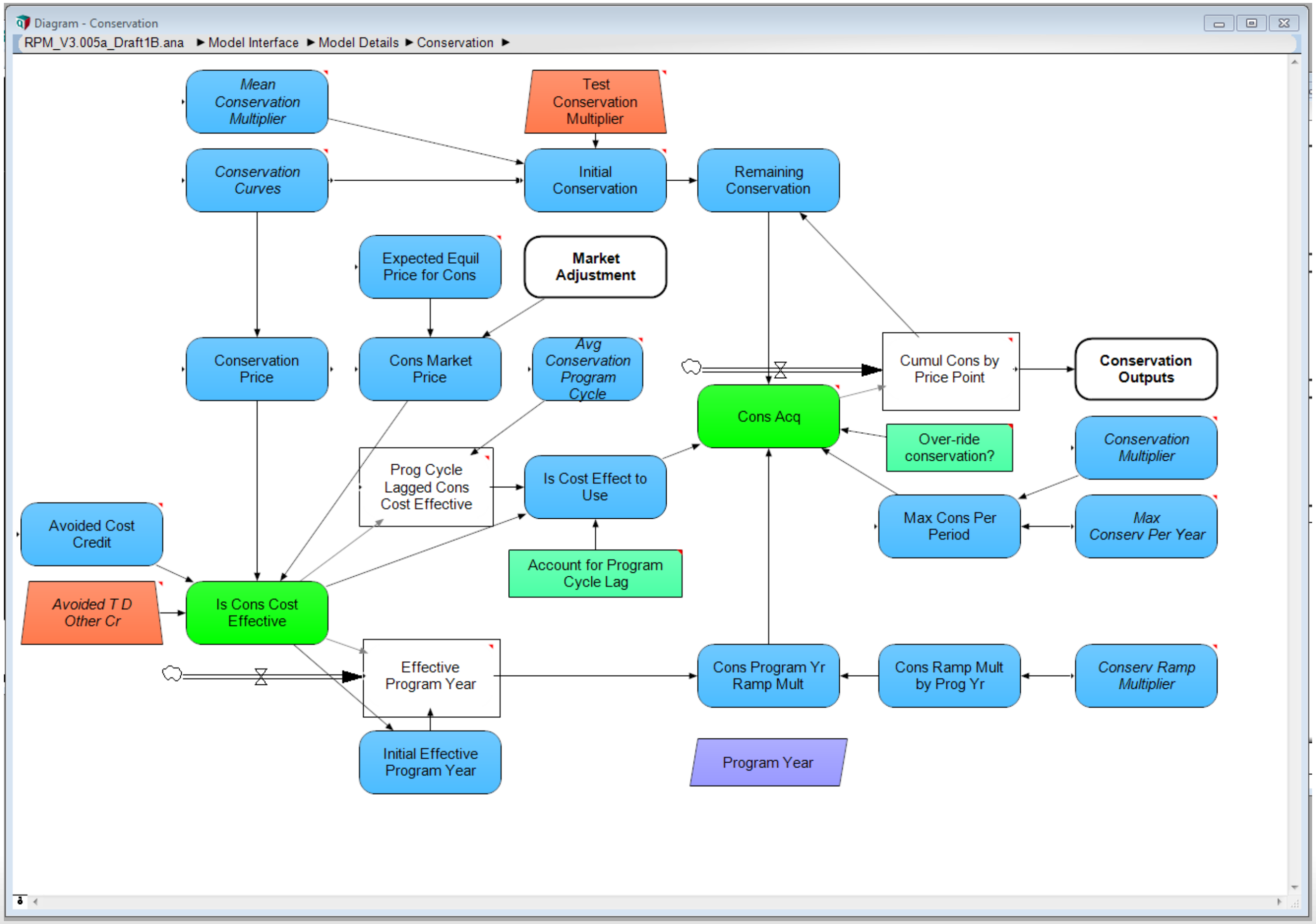


Diagram - Conservation
RPM_V3.005a_Draft1B.ana ► Model Interface ► Model Details ► Conservation ►
Mean Conservation Multiplier
Test Conservation Multiplier
Conservation Curves
Initial Conservation
Remaining Conservation
Expected Equil Price for Cons
Market Adjustment
Conservation Price
Cons Market Price
Avg Conservation Program Cycle
Cumul Cons by Price Point
Conservation Outputs
Cons Acq
Over-ride conservation?
Conservation Multiplier
Prog Cycle Lagged Cons Cost Effective
Is Cost Effect to Use
Max Cons Per Period
Max Conserv Per Year
Avoided Cost Credit
Account for Program Cycle Lag
Avoided T D Other Cr
Is Cons Cost Effective
Effective Program Year
Cons Program Yr Ramp Mult
Cons Ramp Mult by Prog Yr
Conserv Ramp Multiplier
Initial Effective Program Year
Program Year

RPS Logic

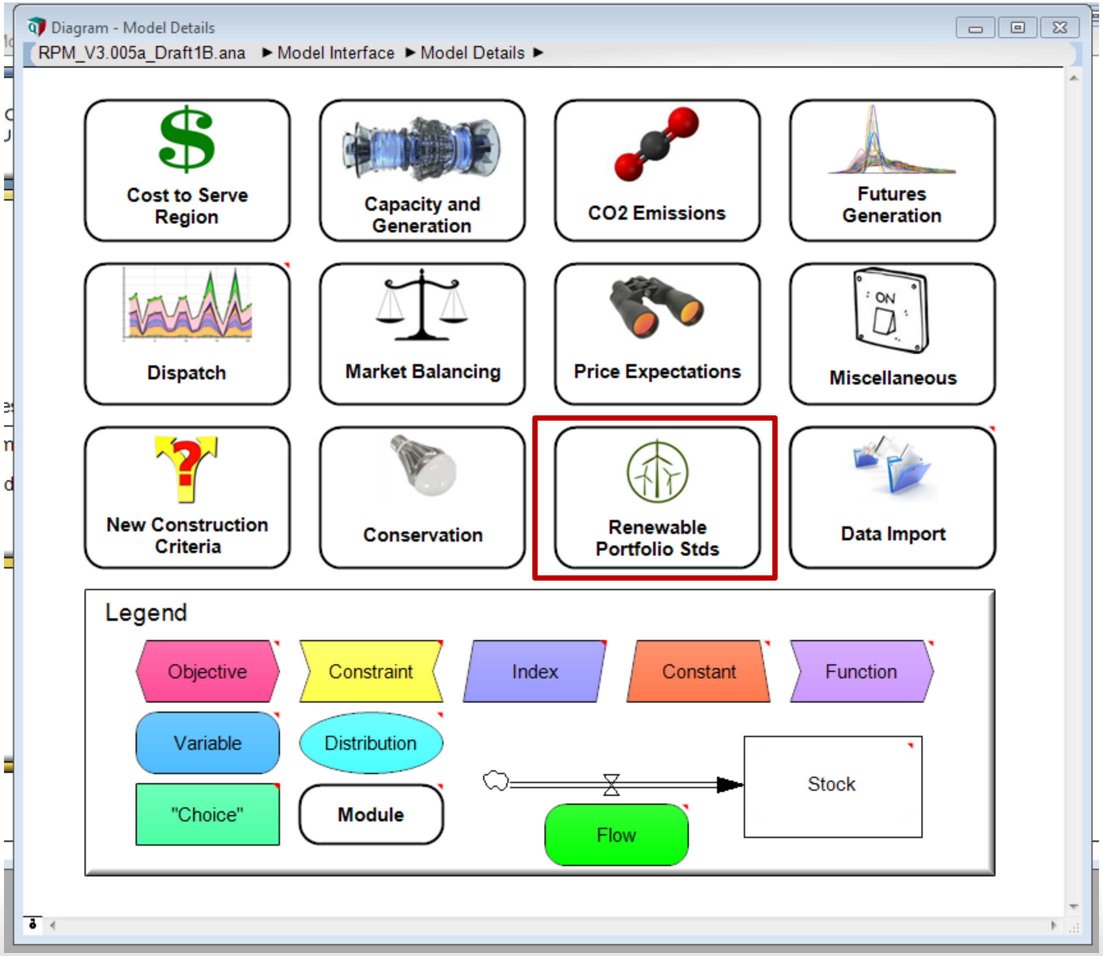
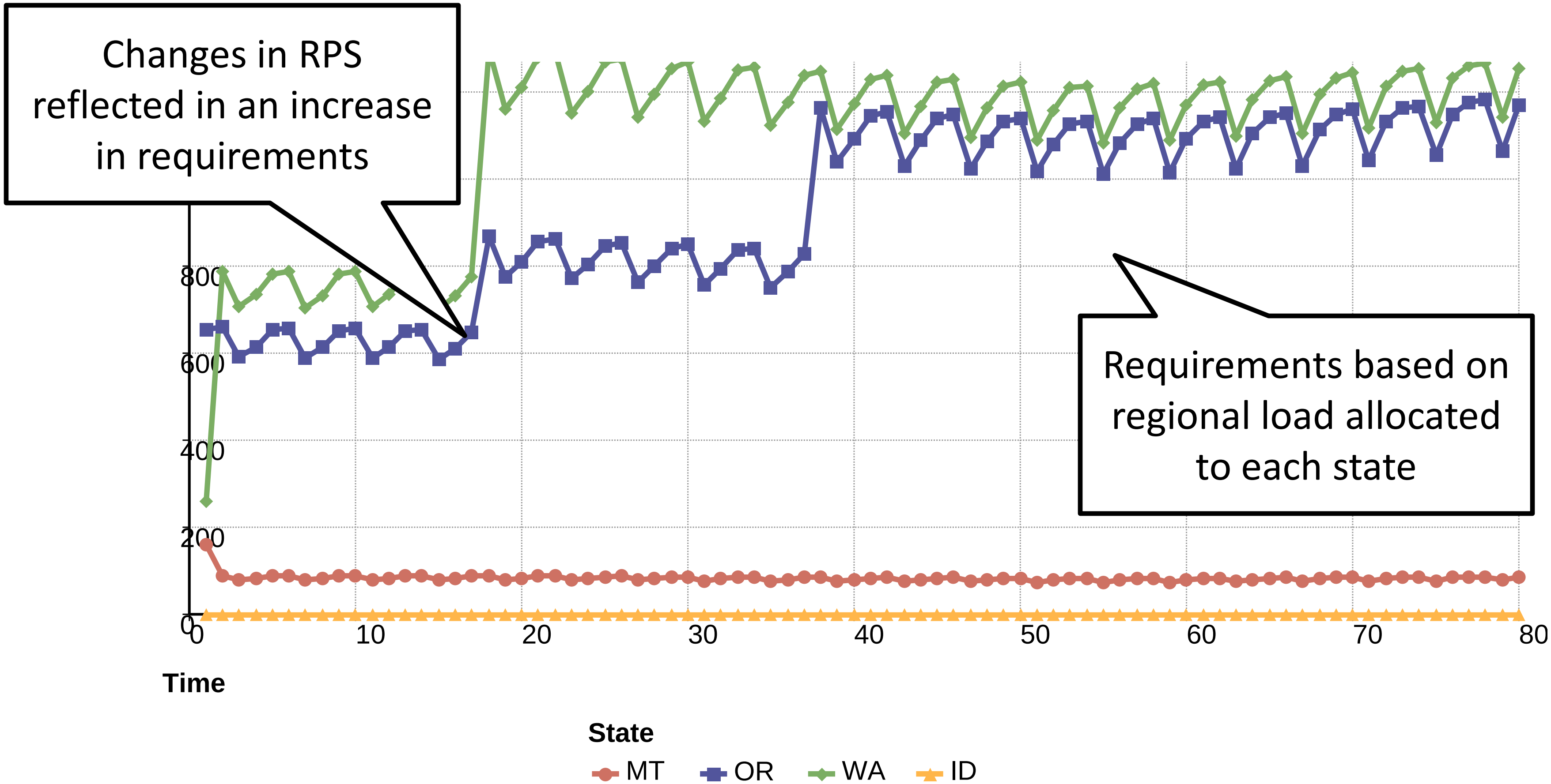


Diagram - Model Details
RPM_V3.005a_Draft1B.ana ► Model Interface ► Model Details ►
Cost to Serve Region
Capacity and Generation
CO2 Emissions
Futures Generation
Dispatch
Market Balancing
Price Expectations
ON
Miscellaneous
New Construction Criteria
Conservation
Renewable Portfolio Stds
Data Import
Legend
Objective
Constraint
Index
Constant
Function
Variable
Distribution
Stock
"Choice"
Module
Flow

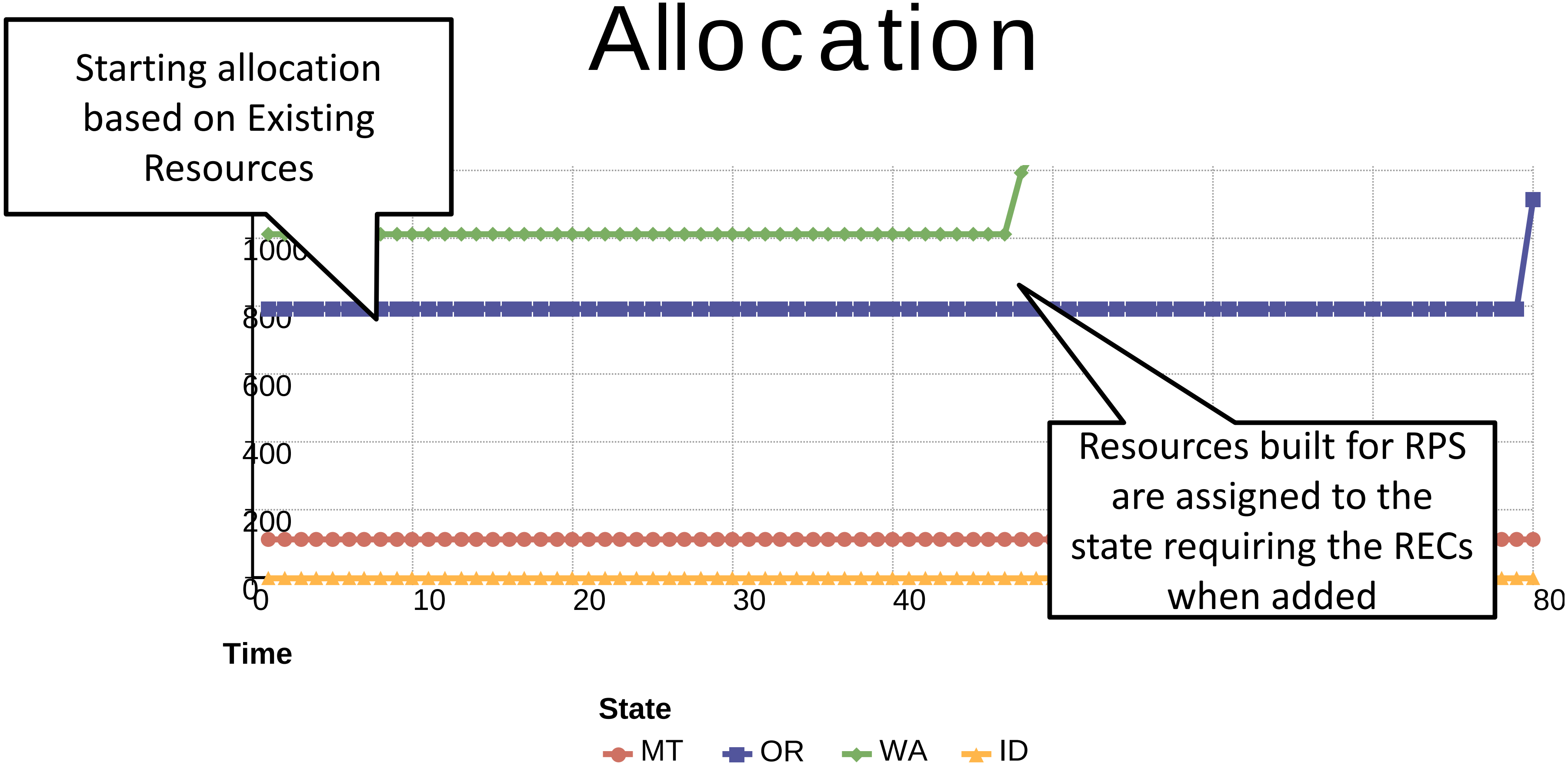
REC Calculations

- Starting REC bank balances
- Existing resource annual contribution to REC banks
- New resources optioned for adequacy or economics are allocated to REC banks based on proportion of RPS requirement
- Resources built for RPS are allocated based on REC bank balance approaching zero
- Expiring RECs based on First In First Out approximation

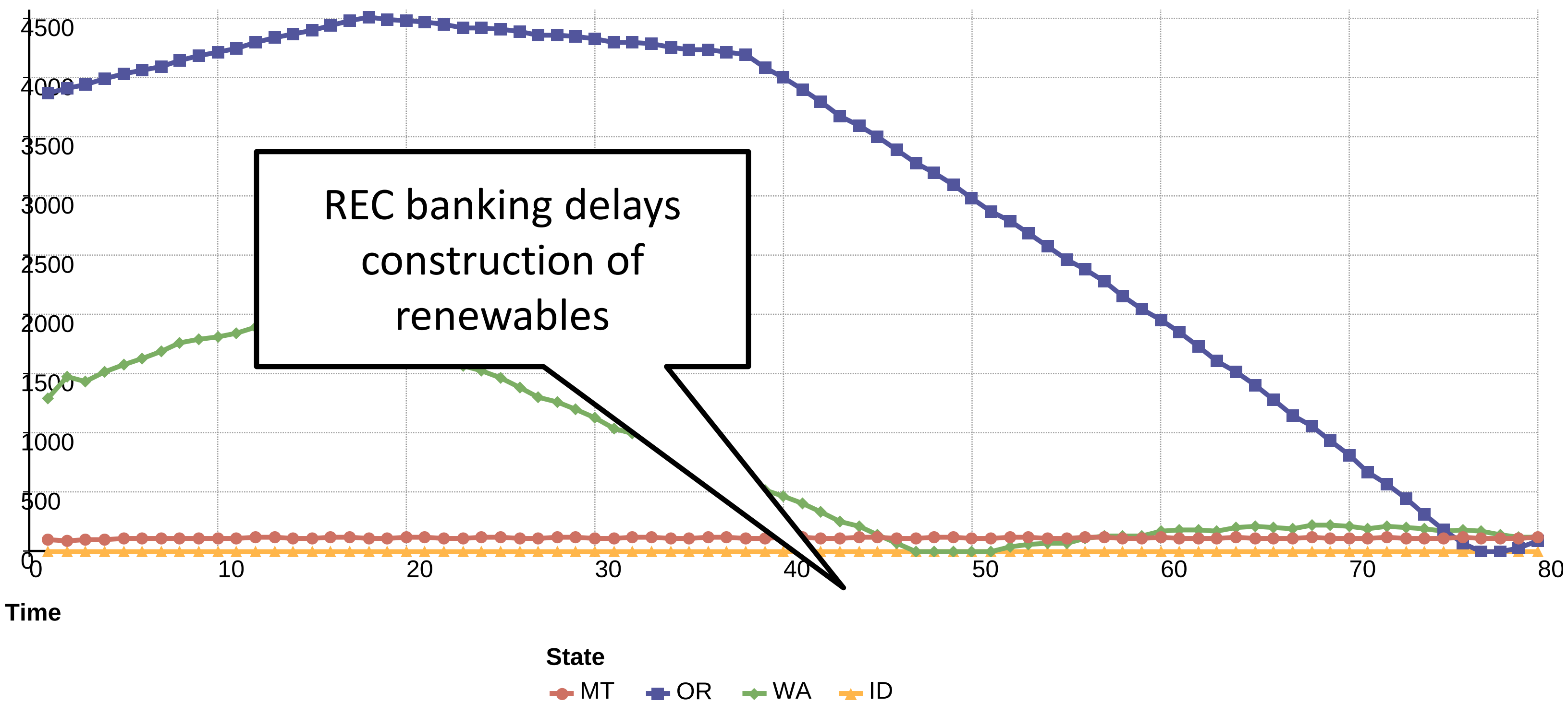
RPS Requirement



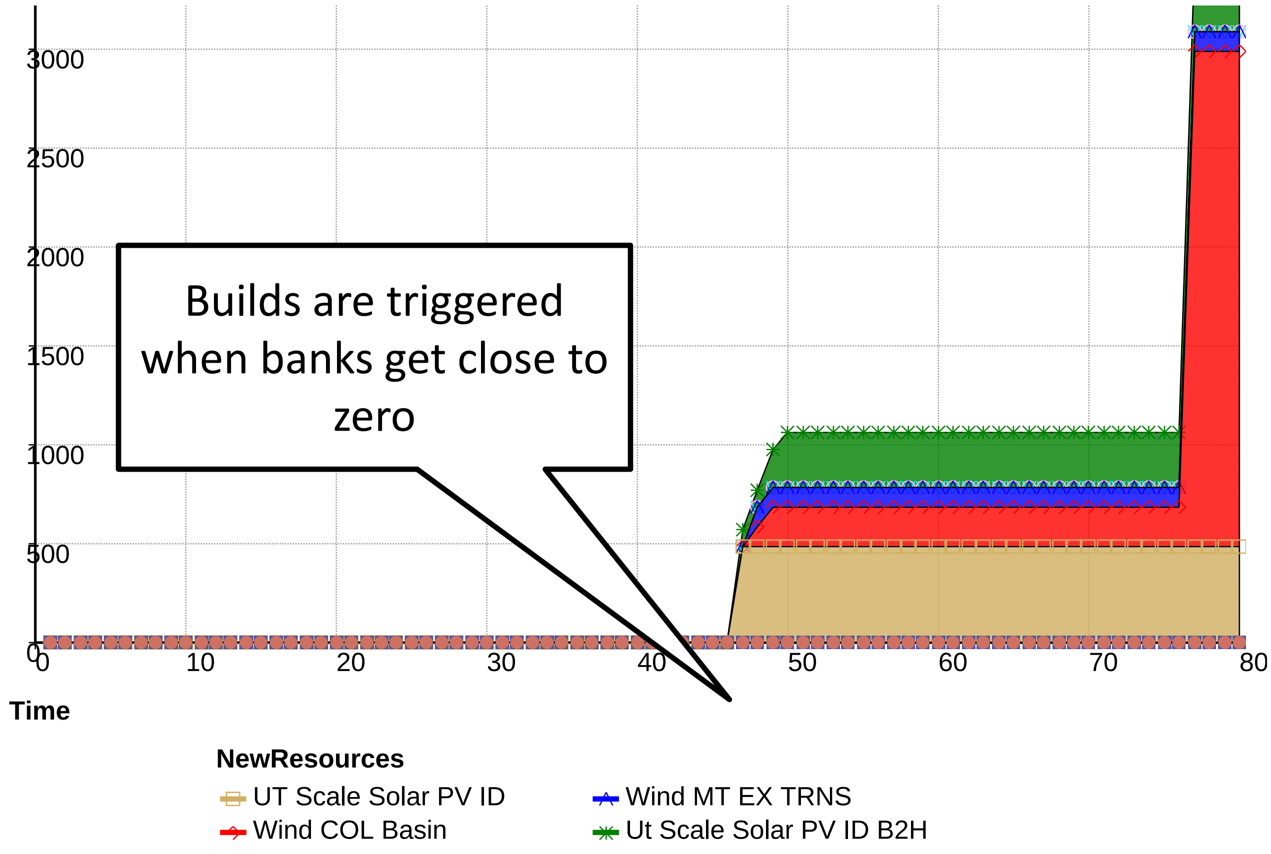
Renewable Resources Allocation



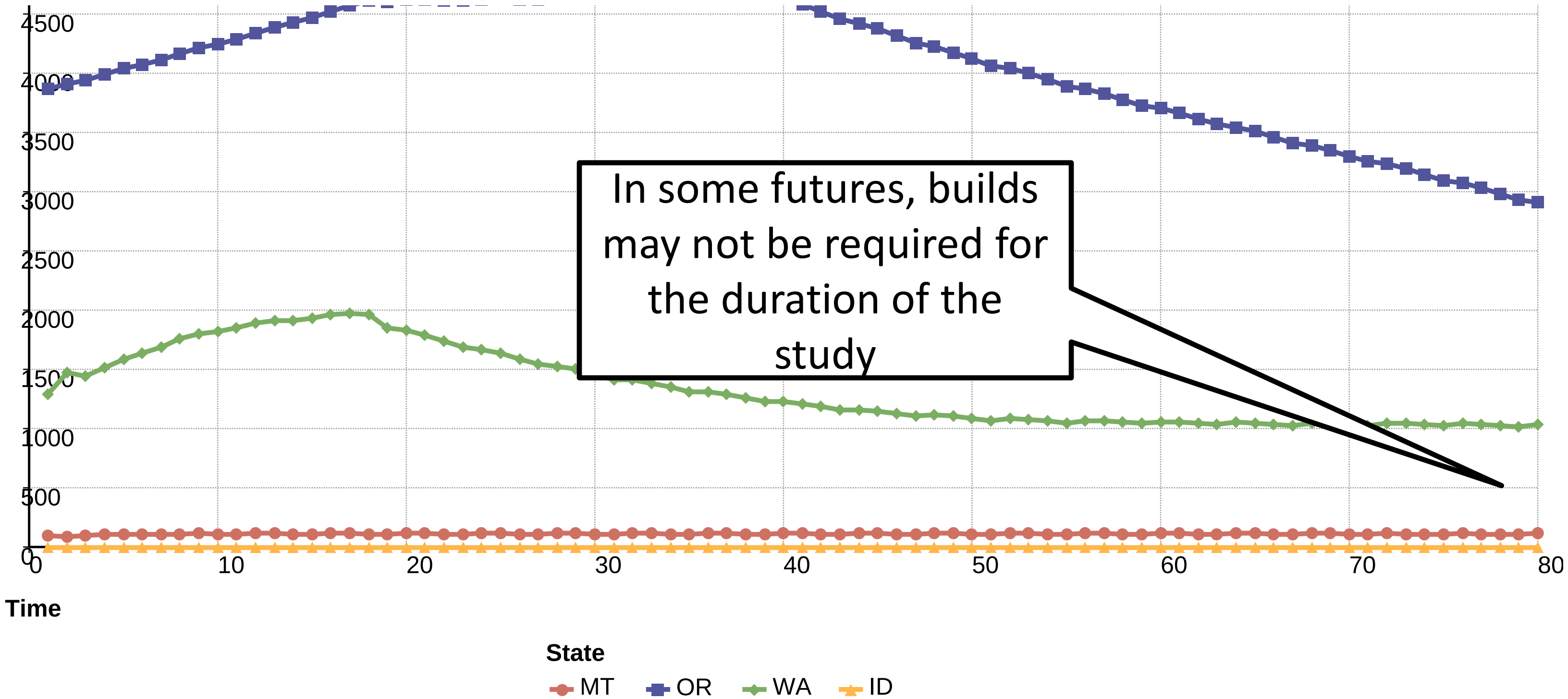
REC Bank Balance Example



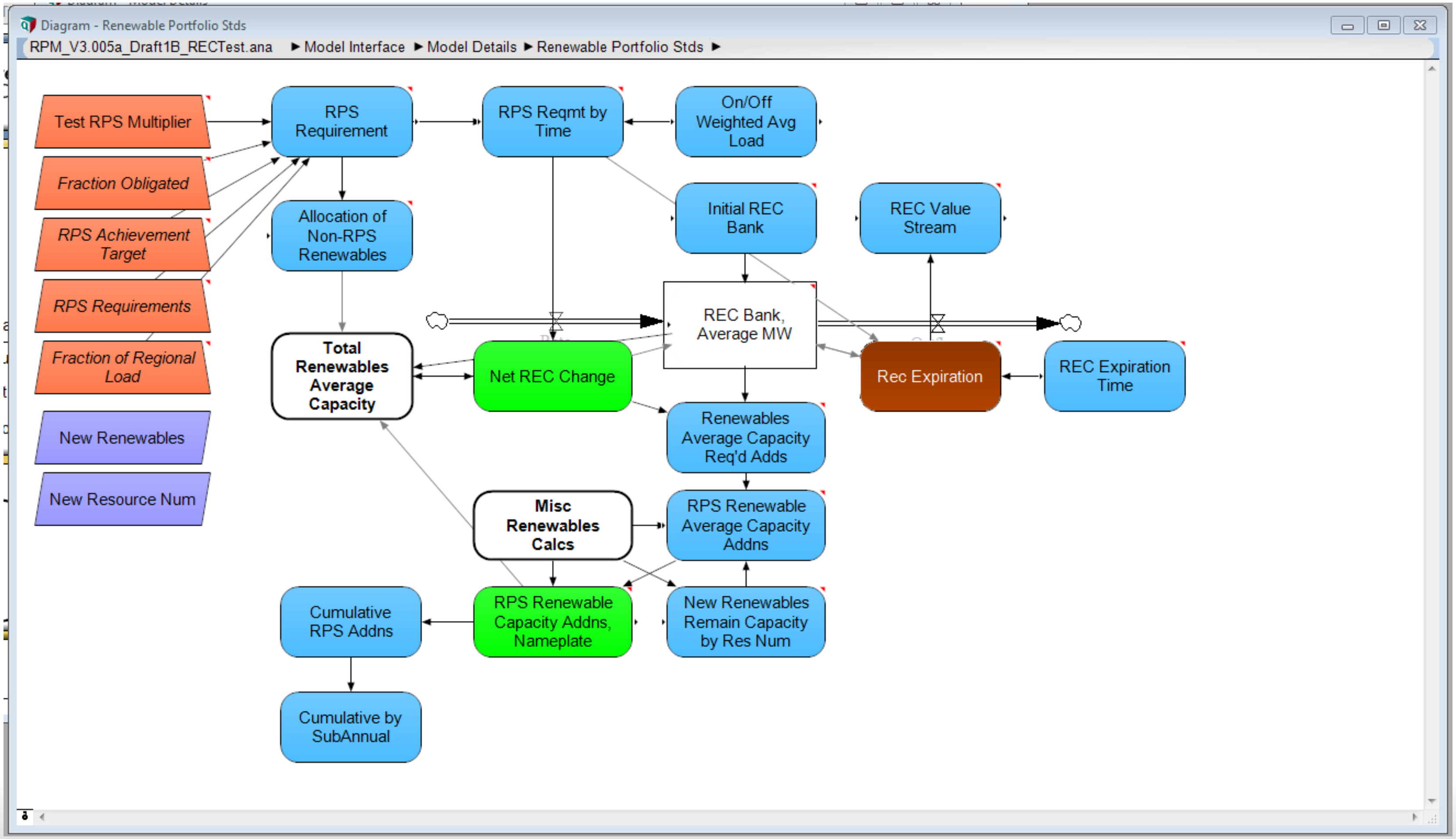
RPS Build Example



No Renewable Build Example



Into the RPM again…



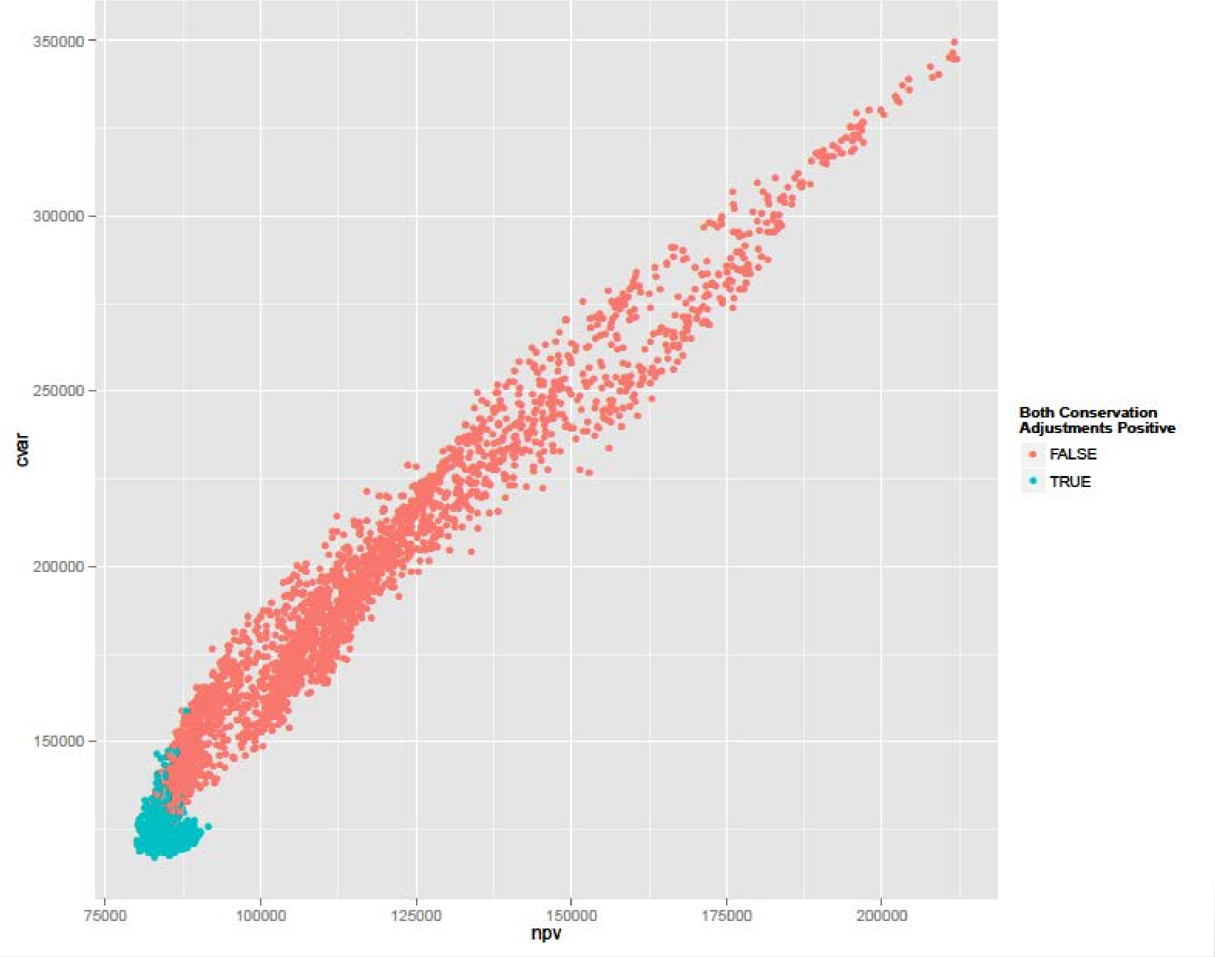
Scenario 1B - Disclaimer

- Data inputs for the Draft Plan are still being finalized
- Some of the model logic is still being vetted
- Resource strategies are shown for illustrative purposes and are likely not optimal model solutions
- All results shown with 80 games rather than 800 for time consideration

Scenario 1B

- No carbon regulation
- No RPS changes
- Only known retirements
- Includes 800 futures

Why not Negative Conservation Adders



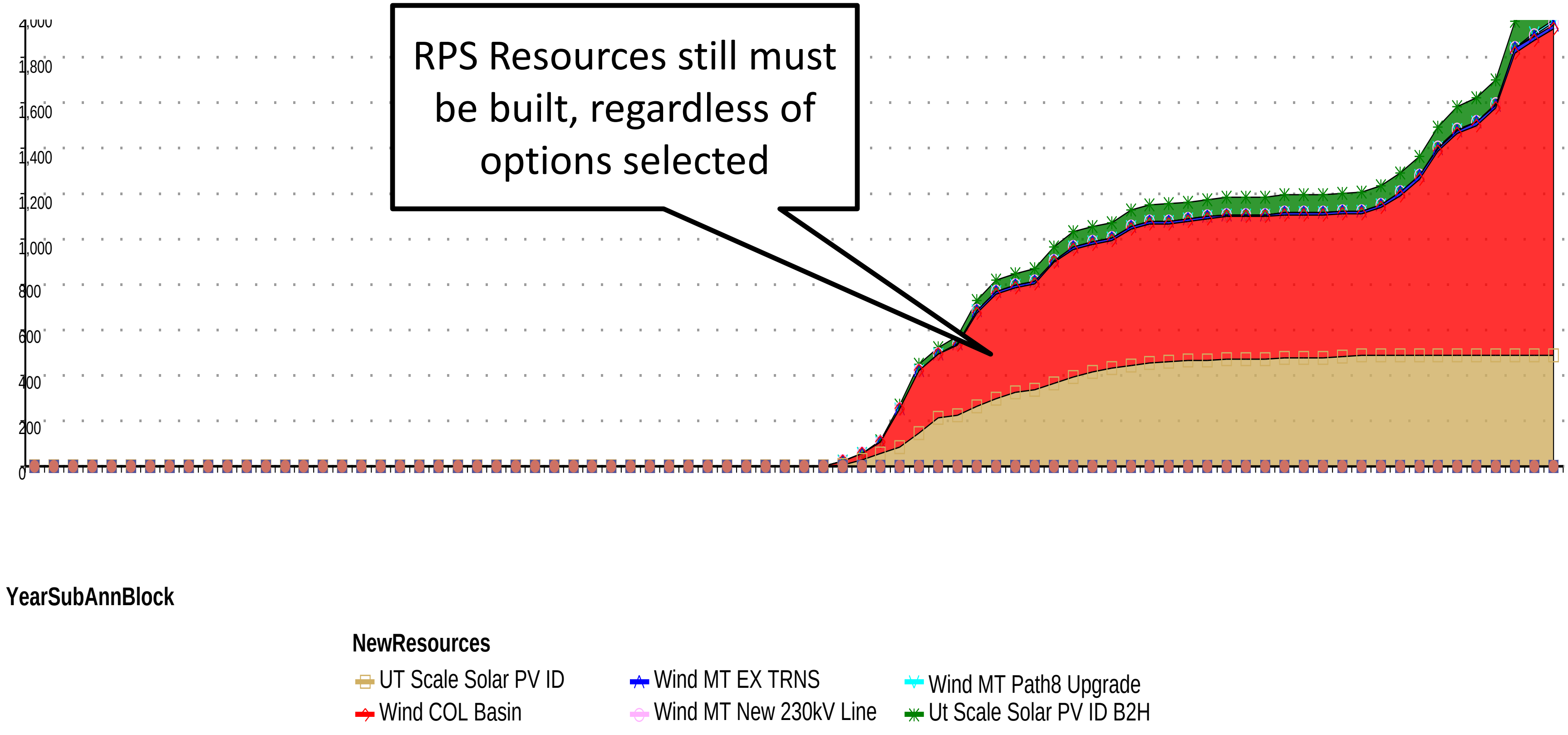
Why not Negative Conservation Adders

- Model spent over 70% of the time exploring extremely expensive and risky resource strategies
- NPV arithmetic in effect guarentees negative adders will not result in optimal results
- RPM allows for real-time scenario examination that will make it easy to compare to strategies with negative adders when questions arise

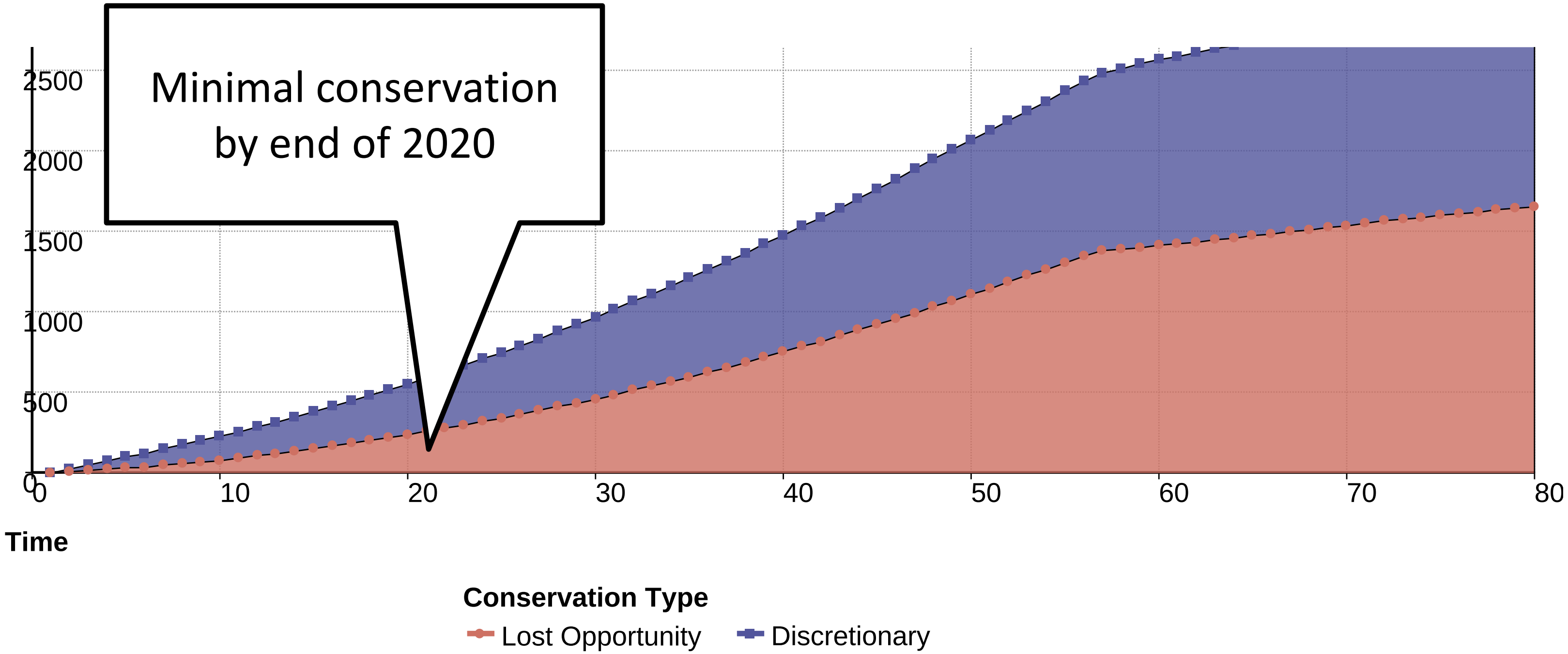
Resource Strategies

- Option nothing – zero conservation adder
- Option nothing – mid-range conservation adder
- Option nothing – extreme conservation adder
- Option DR Bin 1 and Recips – mid-range conservation adder
- Option everything – zero conservation adder
- Option everything – mid-range conservation adder

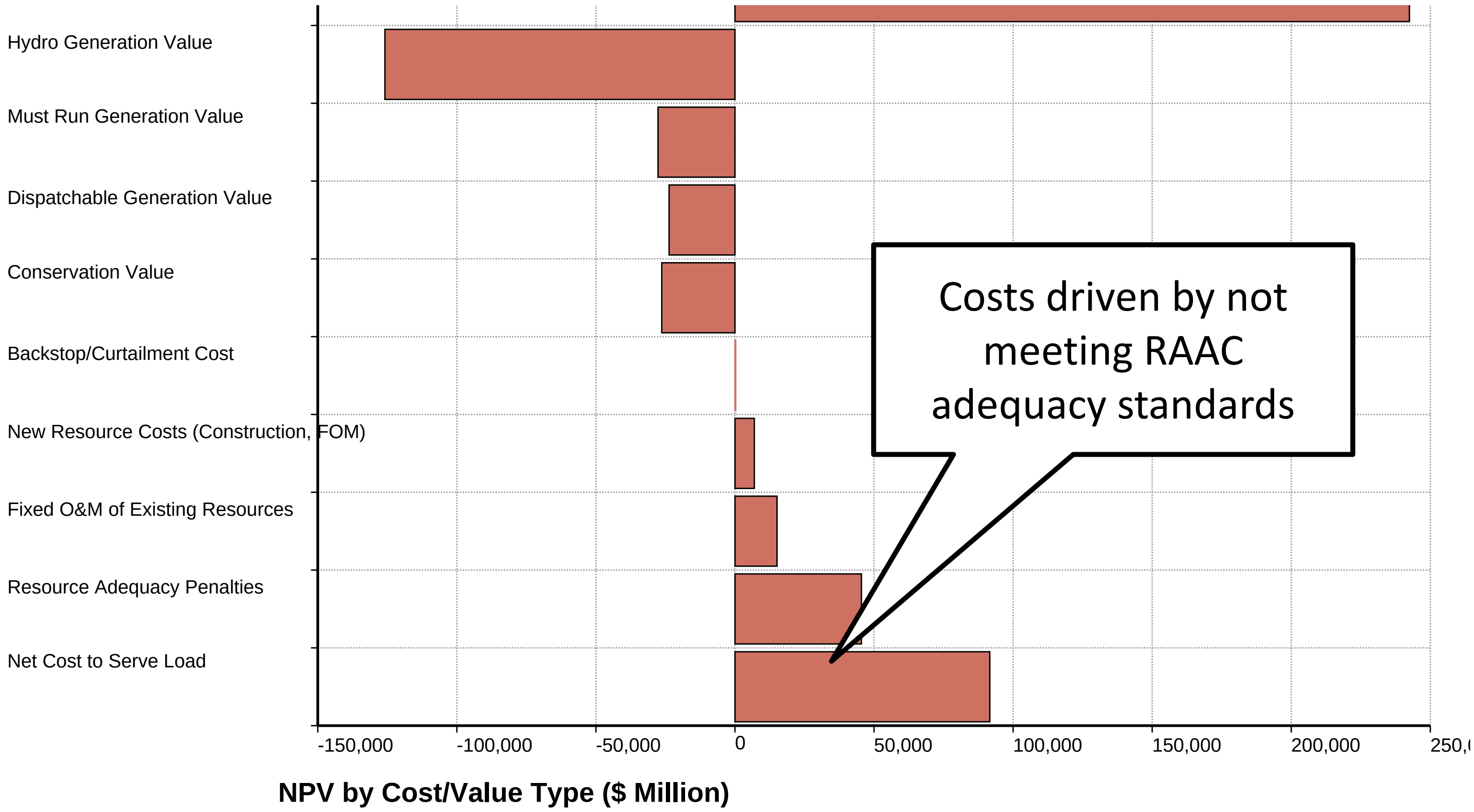
No Options Average Resource Build



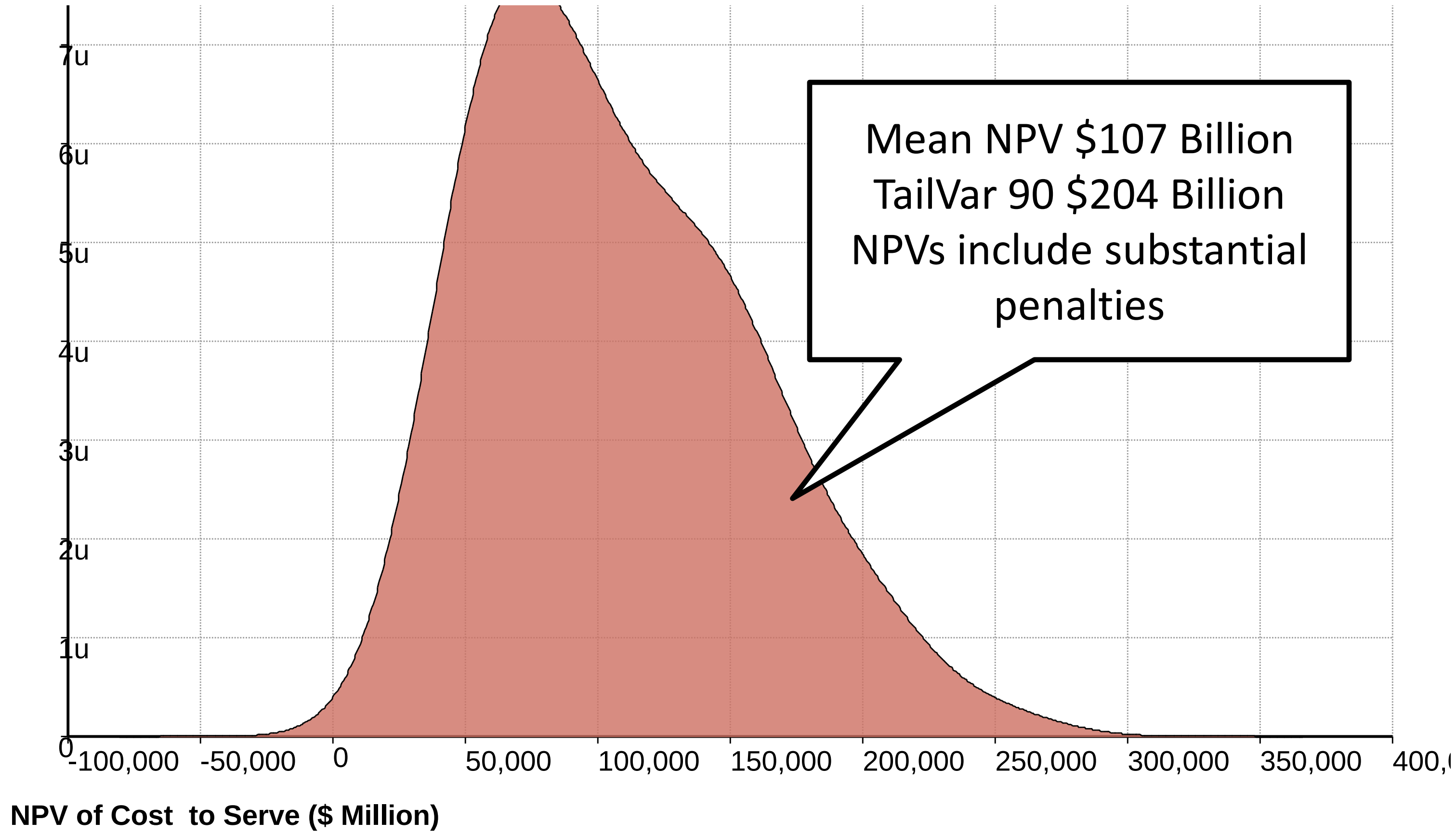
Zero Conservation Adder Average Conservation



No Options Zero Adder Costs



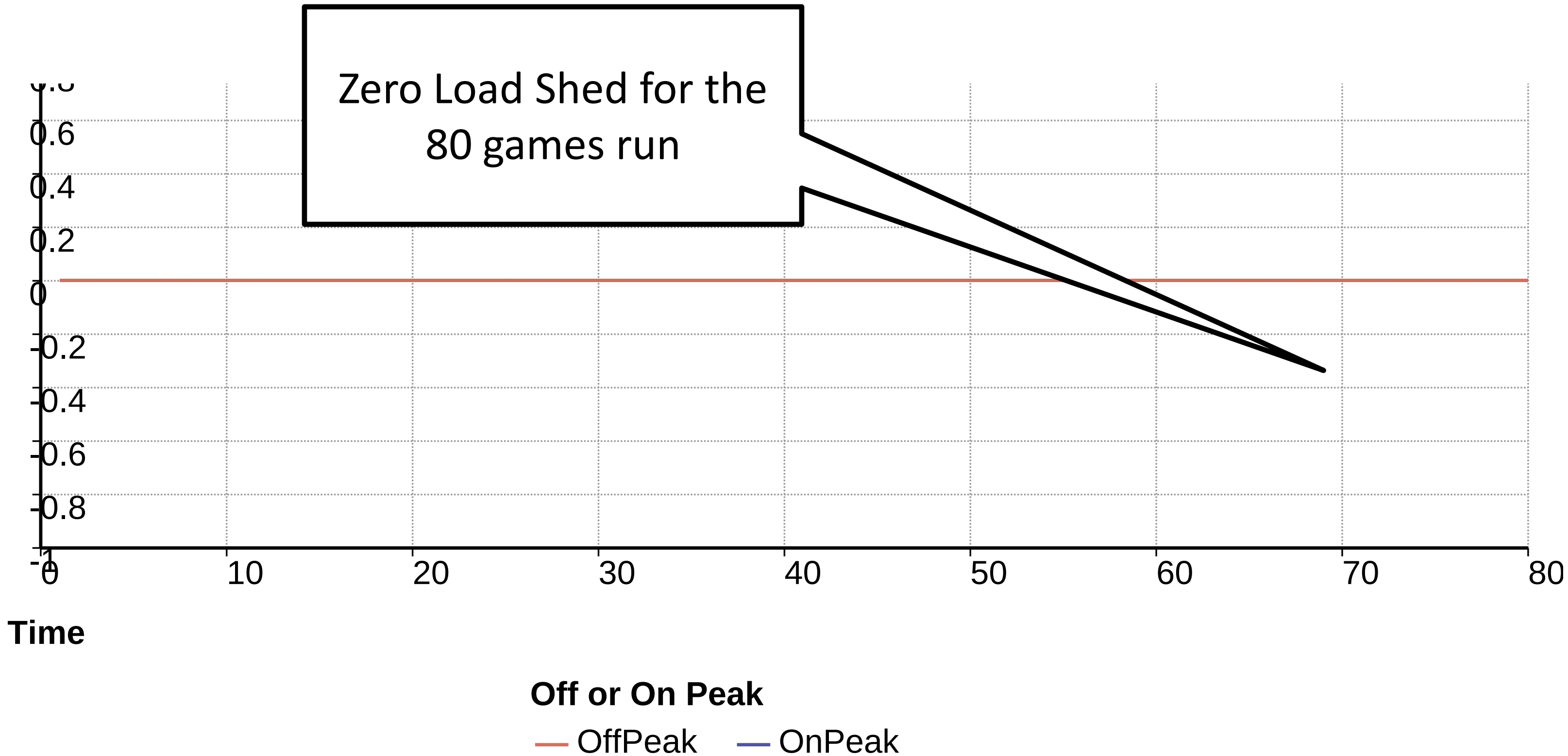
NPV Zero Conservation Adder



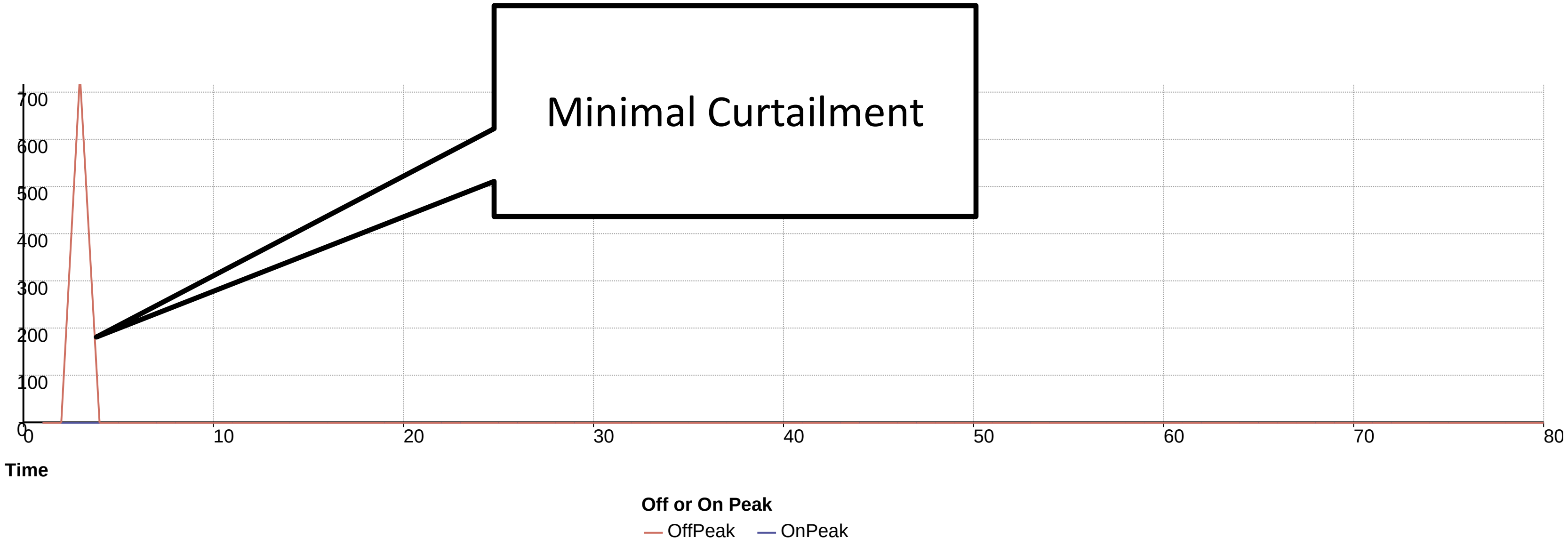
Zero Supply Conservation No Options

- Sets all supply curves to zero so no conservation can be bought
- No load shed in the 80 games run
- Minimal generation curtailment
- Market depth same as Sixth Plan, i.e. 6000 MW
- Demonstrates that Resource Adequacy Penalties have a much higher impact than curtailment/load shed penalties

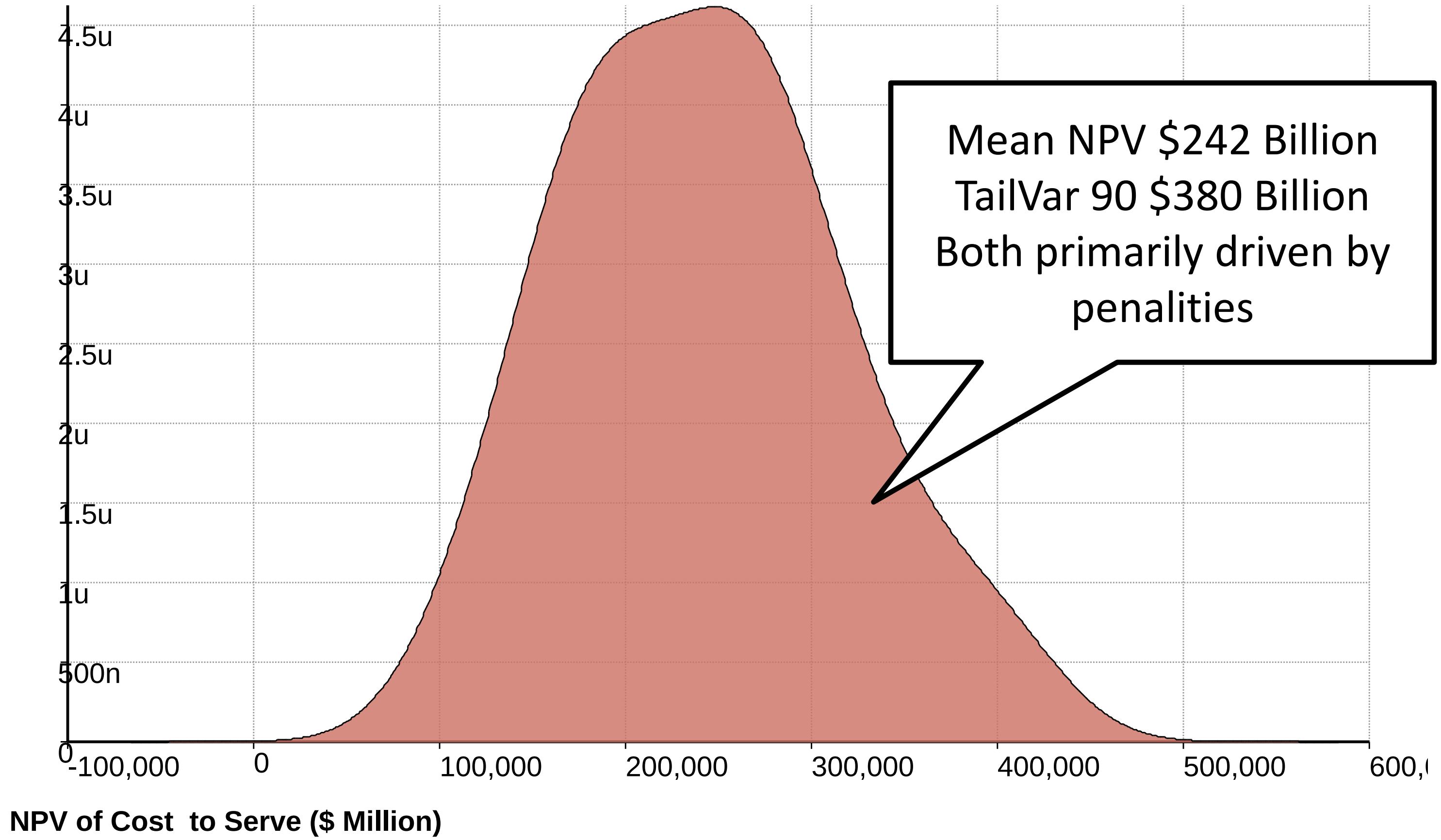
Maximum Load Shed



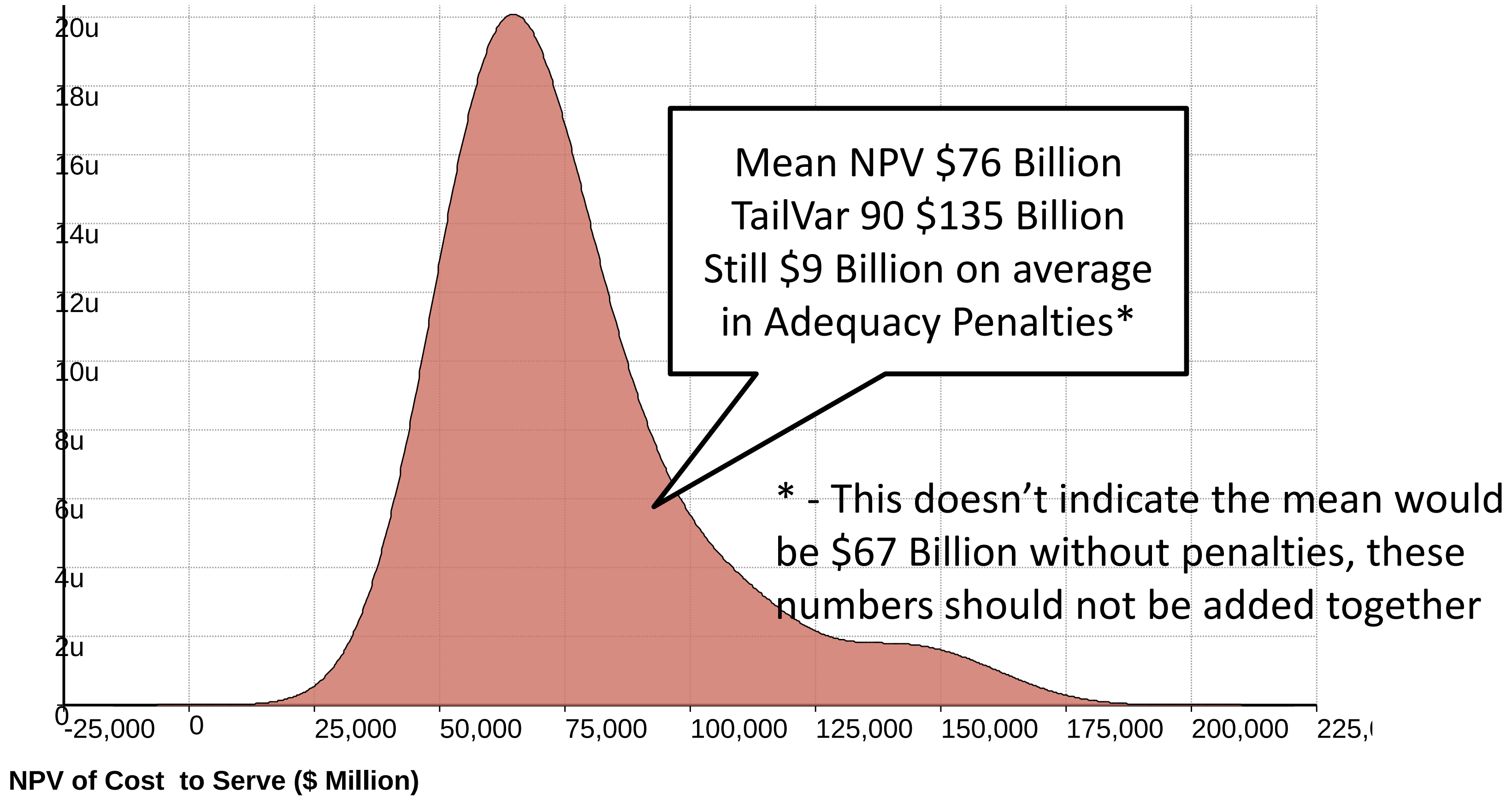
Maximum Generation Curtailment



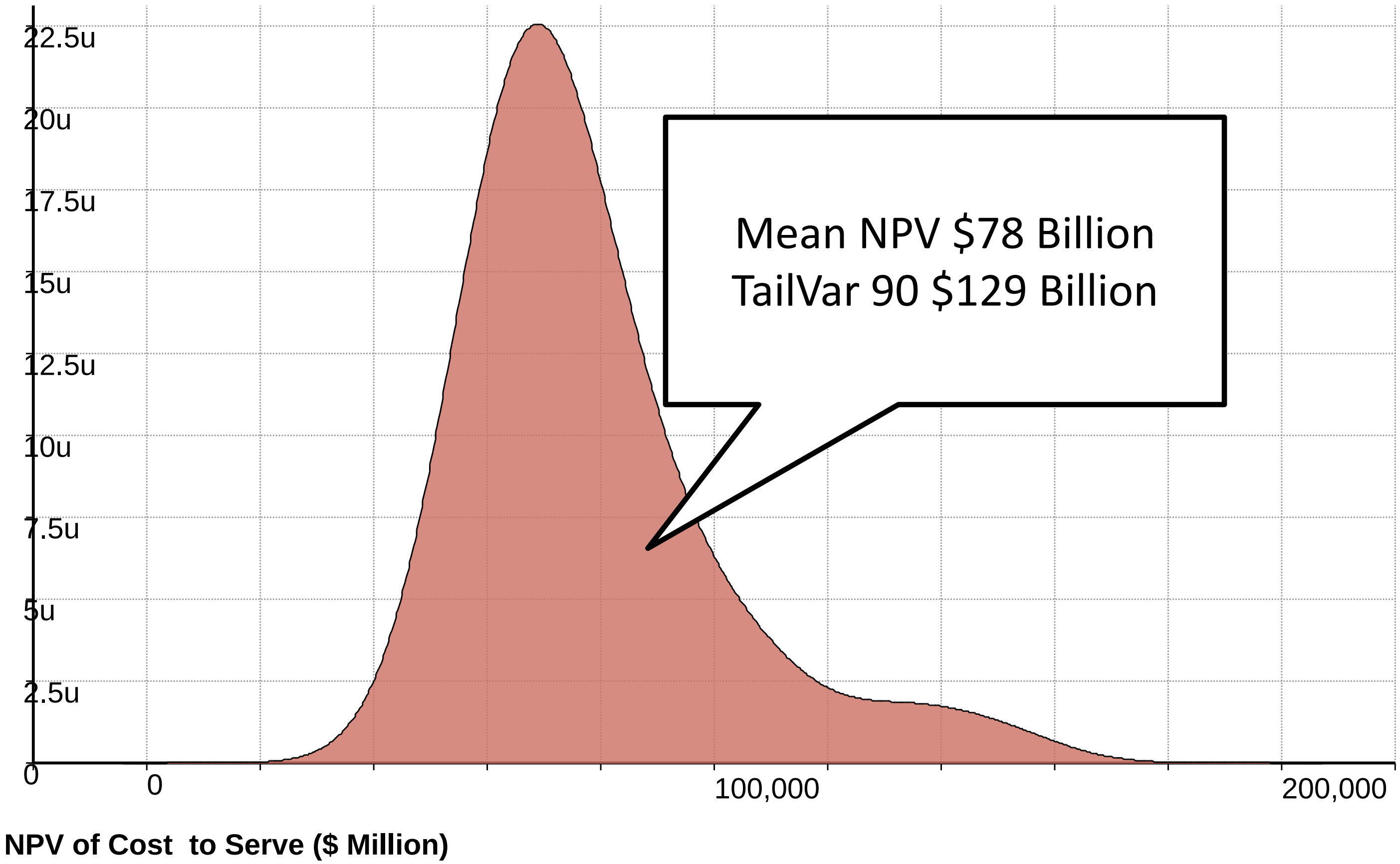
No Options Zero Conservation Adder NPV Distribution



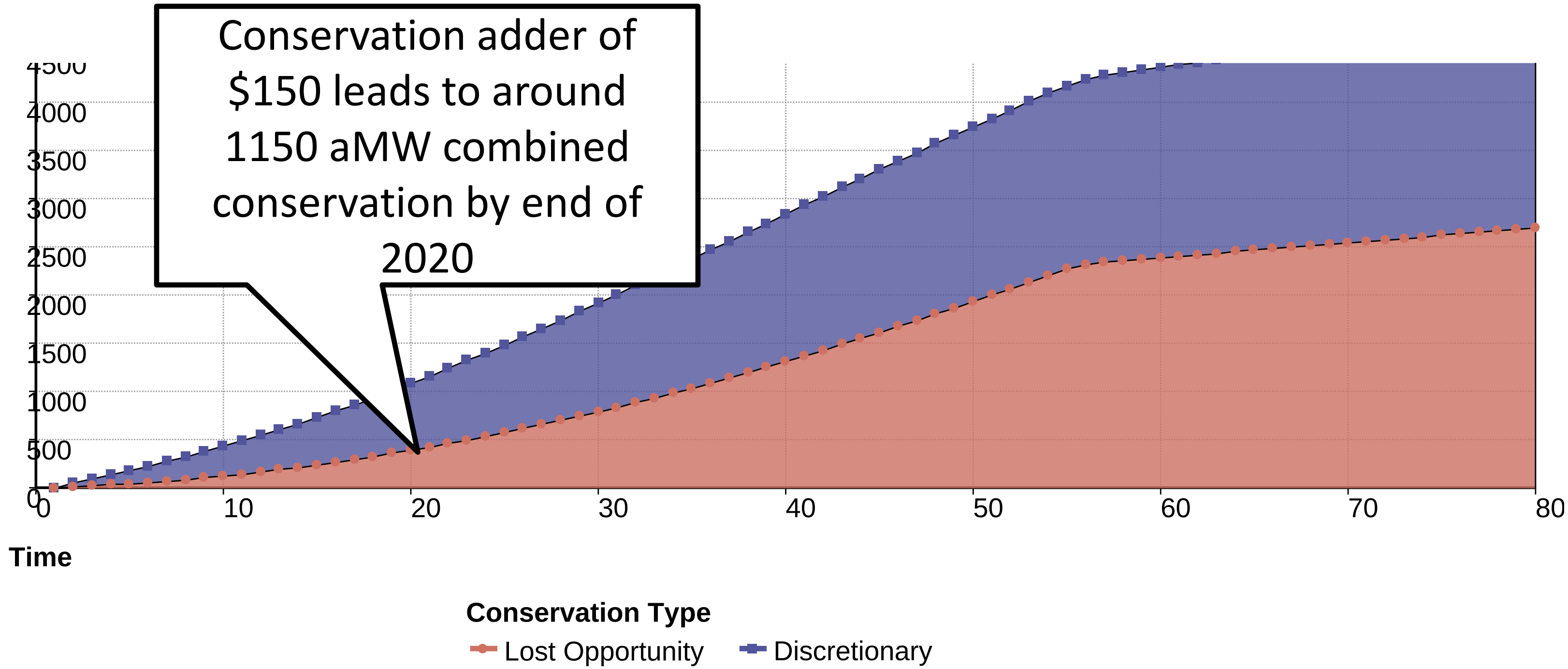
No Options $75 Conservation Adder NPV Distribution



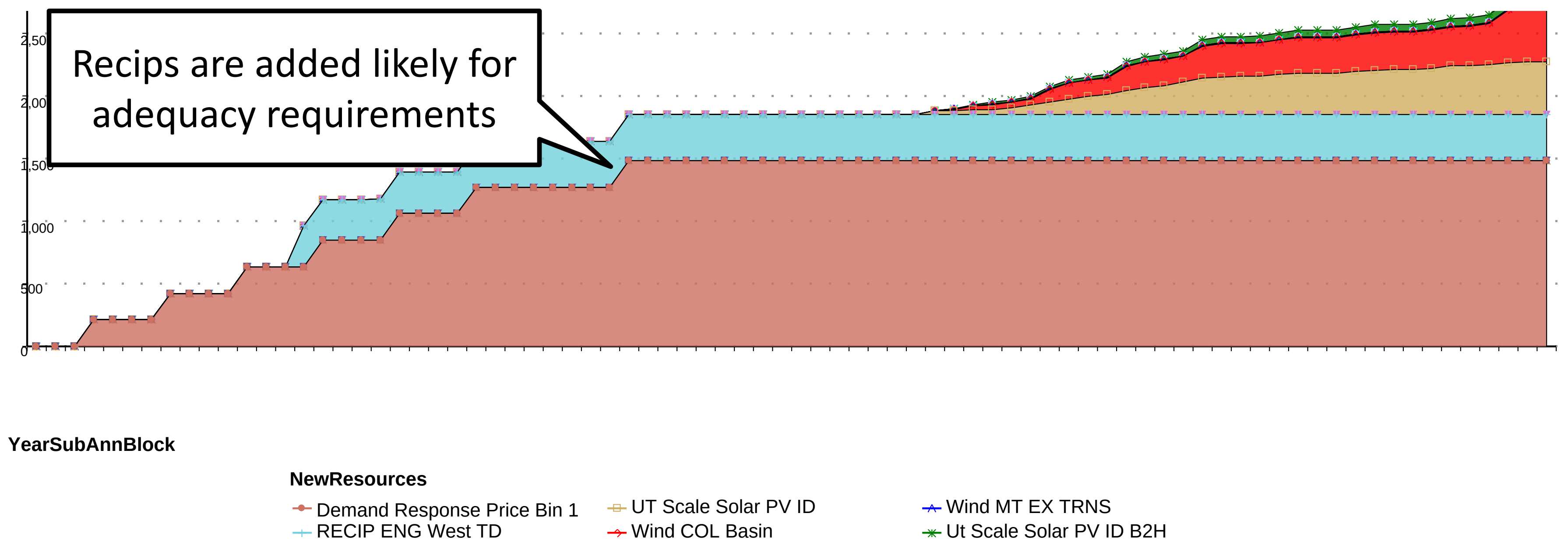
No Options $150 Conservation Adder NPV Distribution



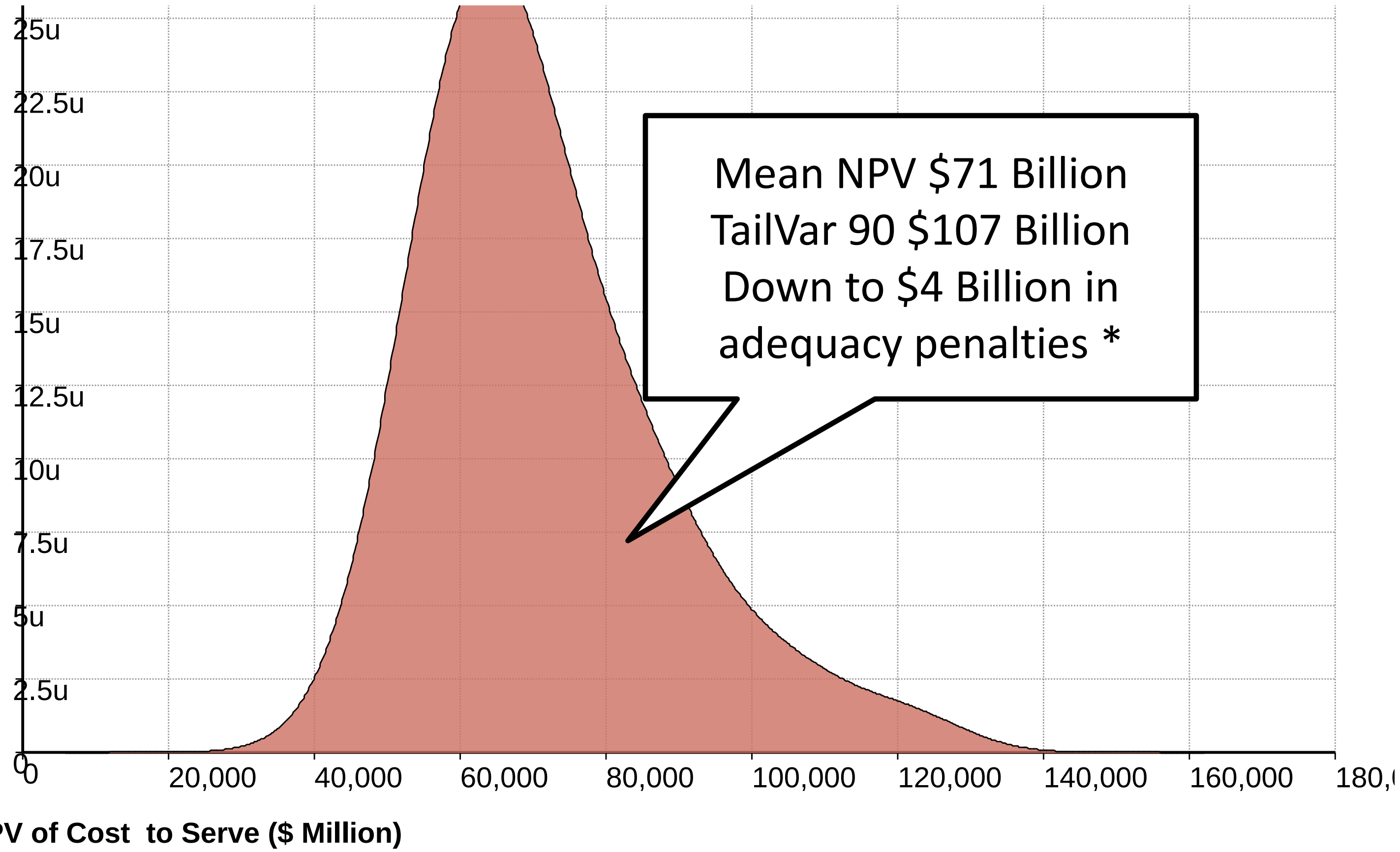
No Options $150 Conservation Adder Average Conservation



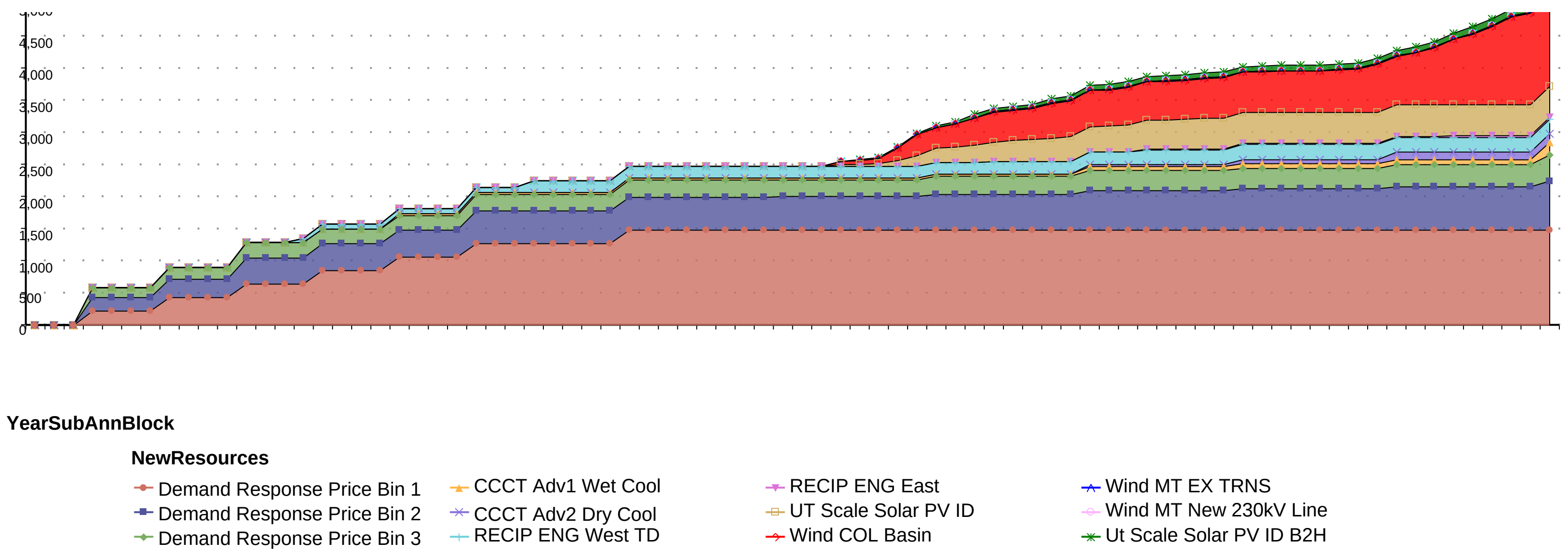
DR Bin 1 and Recip Option Average Resource Build



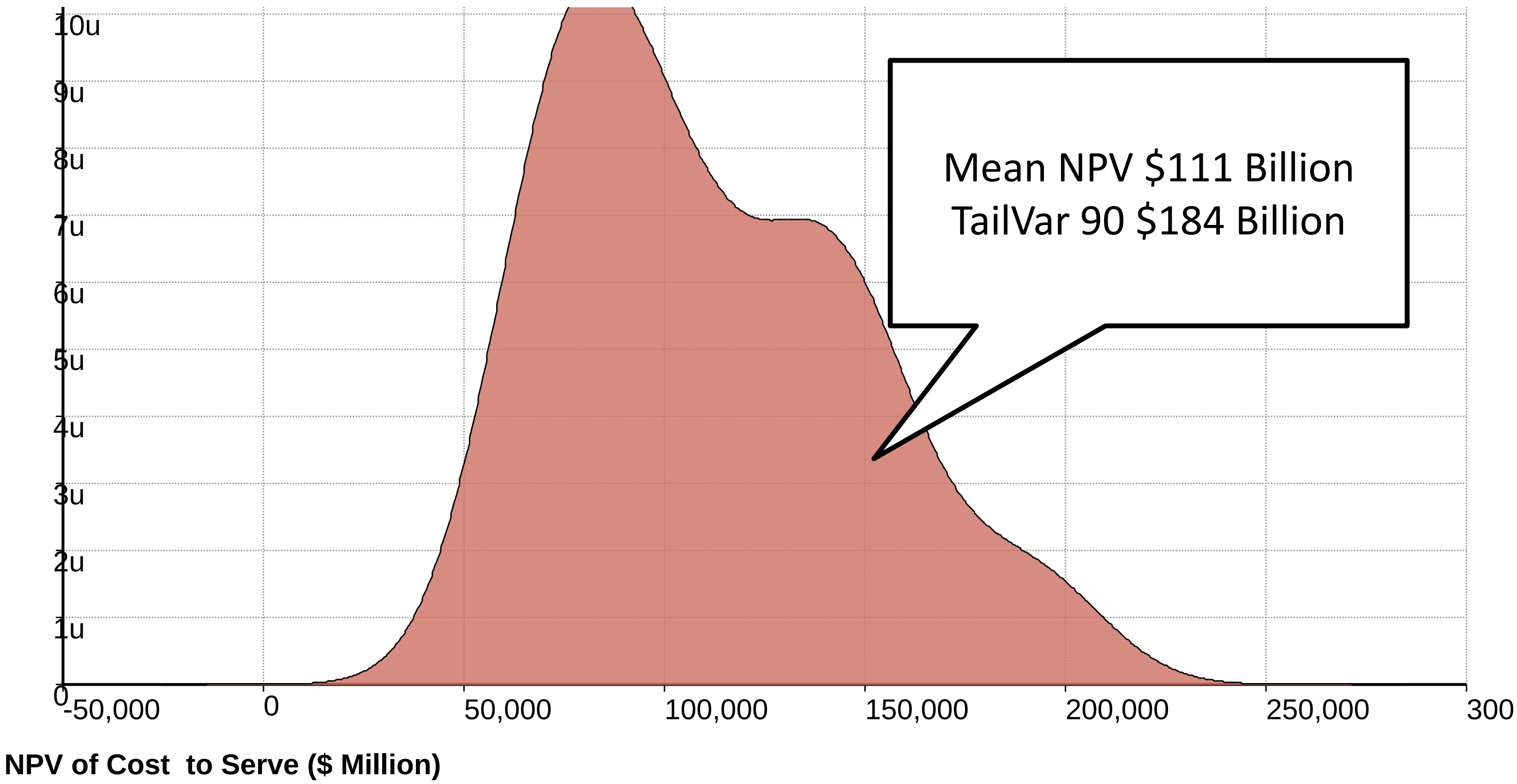
DR Bin 1 and Recip Option NPV Distribution



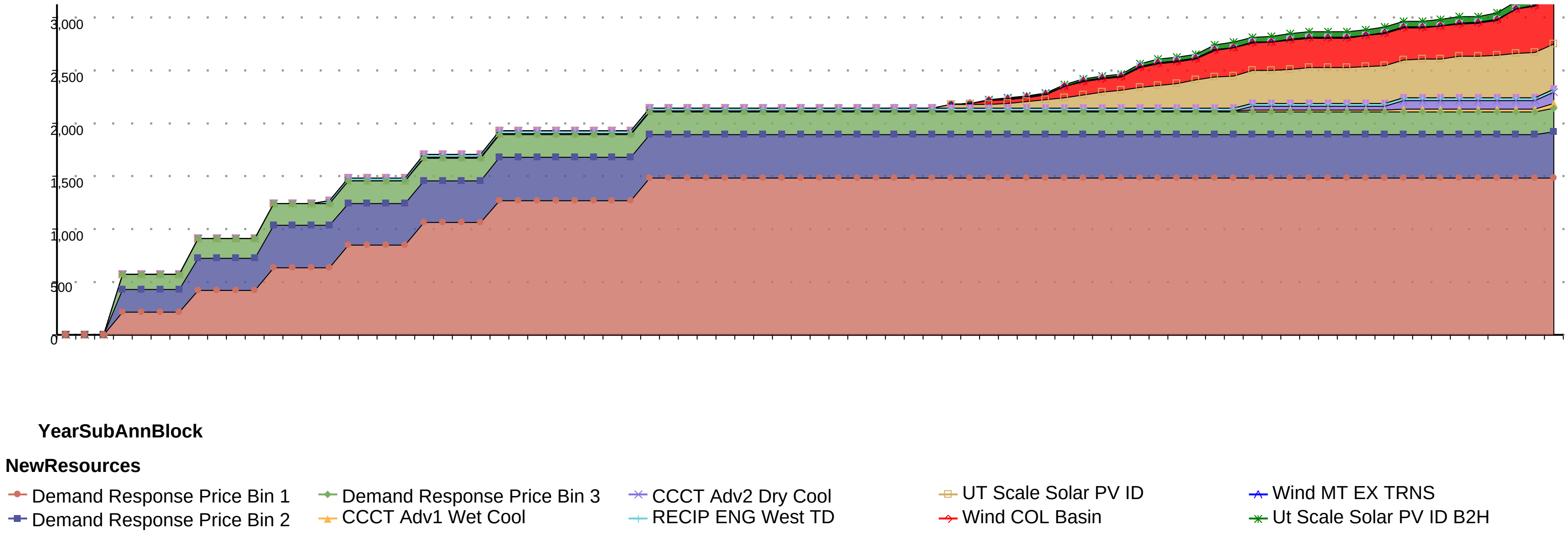
Option Everything $0 Adder Resource Build



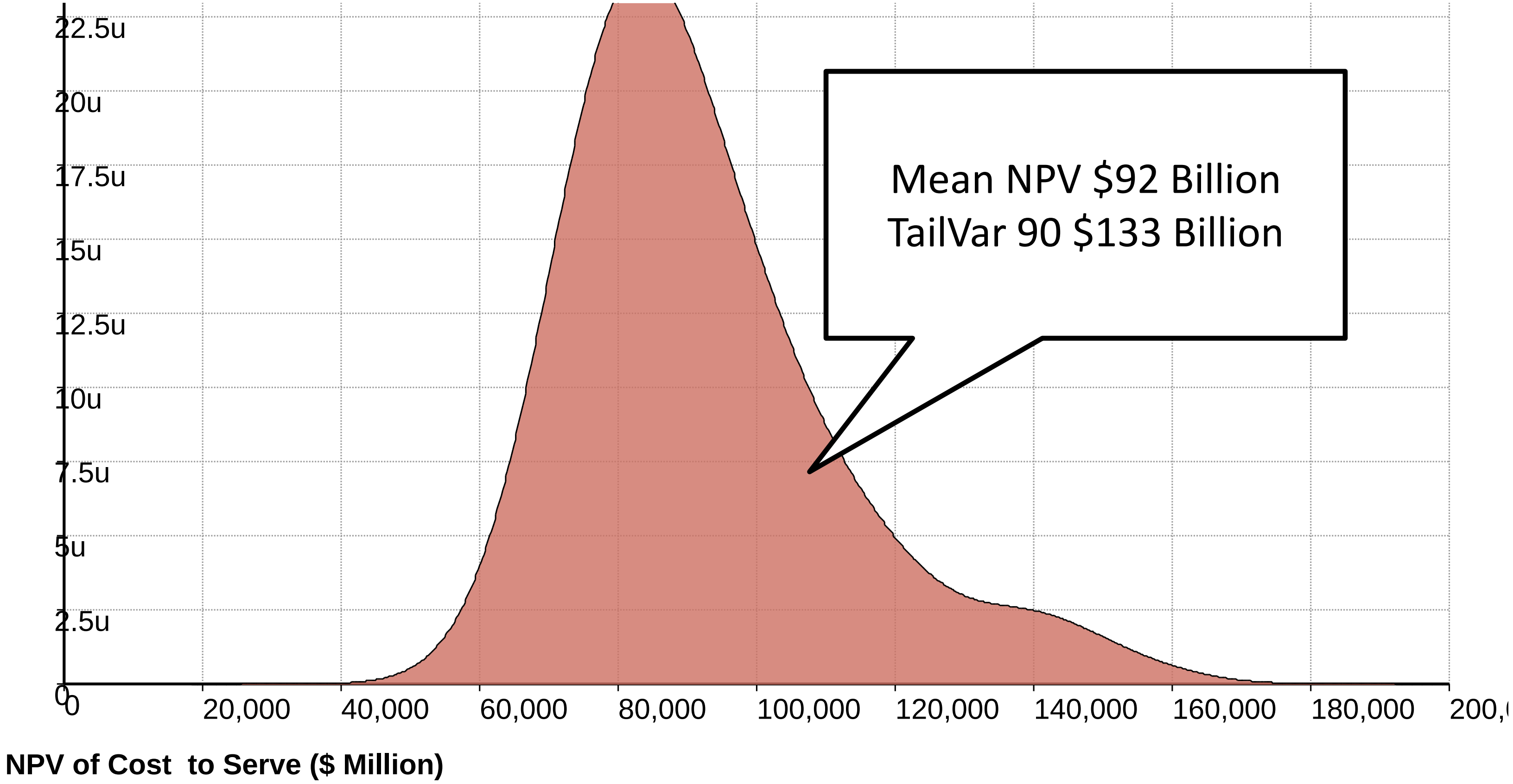
Option Everything $0 Adder NPV Distribution



Option Everything $75 Adder Resource Build



Option Everything $75 Adder NPV Distribution



What do you want to see?

- Explore outputs from points in 1B?
- Try other inputs?
- Any results you would expect given different inputs?
- Note: most real-time analysis will be done with 80 games to allow for results in a timely manner

Communicating Results

- What would you advise for communicating results from the model effectively?
- Are the graphs from the model you feel are helpful or misleading?
- What policy questions would you recommend we take forward based on the outputs you have seen today?