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

1/7/2020

MEMORANDUM

TO: **Power Committee**

FROM: **John Ollis, Manager of Planning and Analysis**

SUBJECT: **Updates to Regional Portfolio Model Methodologies**

BACKGROUND:

Presenter: John Ollis

Summary: Since the 7th Power Plan, the capabilities of Regional Portfolio Model (RPM) have been enhanced to better prepare it to provide analytics for the 2021 Power Plan.

Relevance: In each power plan, the current and projected future state of the power system presents a different set of challenges and potential ways to address those challenges. This requires enhancing and modifying the functionality of the analytical tools used to better understand the ramifications of different regional resource strategies.

In preparation for the 2021 Power Plan, Staff has been working with System Analysis Advisory Committee and Lumidyne Consulting LLC to enhance the RPM. The enhancements implemented already improve the model as follows: better representing the interaction between the uptake of energy efficiency measures and demand response programs, improvement of the energy efficiency acquisition logic and an expanded functionality to better understand the capacity contribution of resources within the hydro-rich Northwest power system. Enhancements still under development include a methodology change for futures generation based

851 S.W. Sixth Avenue, Suite 1100
Portland, Oregon 97204-1348
www.nwcouncil.org

Steve Crow
Executive Director

503-222-5161
800-452-5161
Fax: 503-820-2370

on climate change data set structure and accounting for the costs associated with greenhouse gas emissions.

Workplan: A.5.2 Updates to models to get ready for 2021 power plan modeling

Background: During the power planning process, the Council is responsible for developing a resource strategy based on independent analysis of the region's long-term energy needs and the costs and availability of a wide variety of energy efficiency and generating resources. In addition to minimizing system costs, the analysis should address major uncertainties and strategies for mitigating risks. The RPM is an integrated resource planning model used by the Council to identify adaptive, least-cost resource strategies for the region. The RPM uses a sophisticated and unique risk analysis methodology, developed by the Council, which involves simulating numerous candidate resource plans across a broad range of possible futures to identify tradeoffs between expected cost and risk.

More Info: Summary information and updates are available at http://www.nwcouncil.org/energy/rpm/home/.

Updates to Regional Portfolio Model Methodologies

Power Committee

1/14/2020

John Ollis

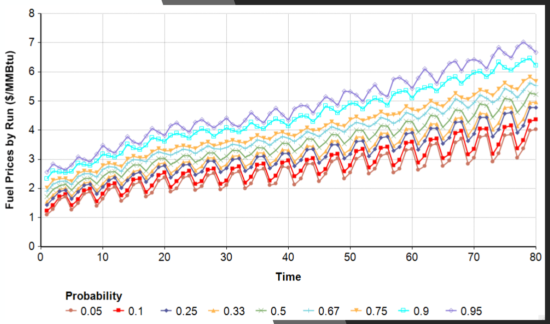
THE 2021 NORTHWEST POWER PLAN

FOR A SECURE & AFFORDABLE ENERGY FUTURE

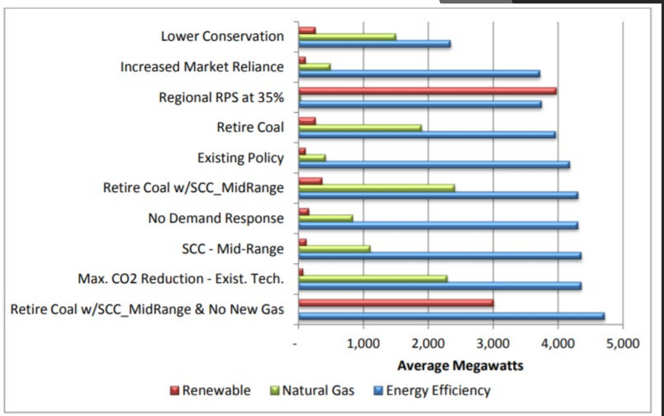
What Are We Talking About?

1. Review of the Regional Portfolio Model and its Purpose in Resource Strategy Analysis
2. Anticipated Themes of 2021 Power Plan
3. Enhancements to the Modeling

Review of Resource Strategy Development



What If????

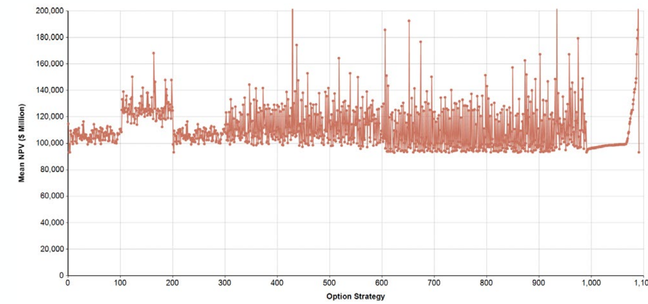


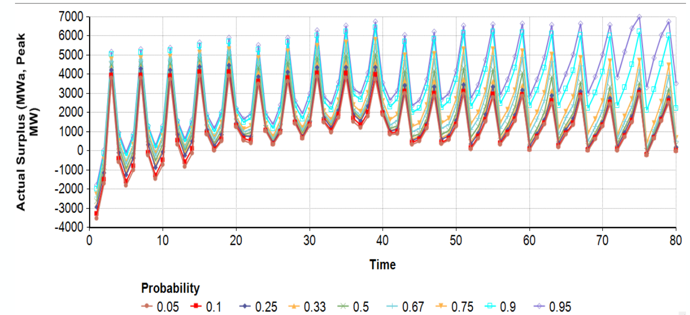
- Define a list of futures
  - Elements of risk over which we have no or little control, like fuel prices, regional demand, wholesale market electricity price, and hydro conditions.
- Define a list of scenarios
  - Policies or outcomes over which we may have some control
- Use the Regional Portfolio Model (RPM) to test regional resource strategies from 2021 to 2040.
  - A resource strategy could include investments in new generating and demand-side resources.
  - Each resource strategy is tested over all the futures for every scenario, and the RPM is used to seek the least cost/risk strategy for each scenario.

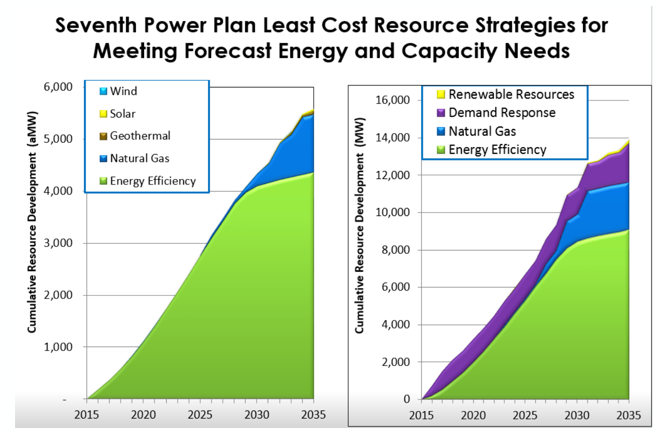
Regional Strategy Analysis – What We Do?

Assess the cost and risk associated with different regional investment strategies in RPM, and check strategies of interest in AURORA and GENESYS.

- Test optioning and building generic new resources at different times during the 20 year time horizon to determine the least cost investment strategy.
- Consider market reliance and adequacy but do not model hourly and topological detail in the RPM.
  - Focus on capital investment decision making to meet adequacy and policy constraints in the most economic way
  - Economic signals external to the region are reflected to some extent in external market electricity price and emissions forecast
  - Regional adequacy standard is reflected via the adequacy reserve margin, associated system capacity contribution and hydro available under critical conditions.







Regional Portfolio Model Review

- Regional Portfolio Model (RPM)
  - Optimizes for least cost regional resource strategy
    - Capital expansion model for the region
  - Quarterly fidelity (distributional dispatch)
  - A regional strategy must be in load resource balance while meeting the reserve margin, existing state/local policies/goals and other predefined constraints

Reserve Margin Review

- Adequacy Reserve Margin
  - Like a planning reserve margin for energy and peak capacity but associated with Council's adequacy criteria
- Associated System Capacity Contributions
  - Like Effective Load Carrying Capability, but changes quarterly capacity contribution of a resource from nameplate to account interaction with the rest of the regional portfolio

Resources in the RPM

- Existing Resources
  1. Existing coal binned by efficiency or pending retirements
  2. Existing gas binned by efficiency
  3. Solar
  4. Wind
  5. Nuclear
  6. Other Must Run (biomass, geothe
  7. Hydro
- New Resources: (7th Plan)
  1. Gas Plants: CCCT and Peaker
  2. Wind: Gorge and Montana
  3. Solar: Idaho
  4. Demand Response (binned by price)
  5. Energy Efficiency (binned by price)
  6. Geothermal

New in 2021 Plan

1. 4-hour battery
2. Pumped Storage (8 hour, closed loop)
3. Solar Plus battery
4. New locations for renewables

RPM System Obligations

- Statewide RPS Policies
  - Current accounting uses existing REC balance, state RPS policy and future resource REC contributions
- Clean Policies
  - Could account for similarly
  - Needs an enhancement in the RPM
- System Adequacy
  - Adequacy Reserve Margin (ARM) is the reserve margin required over or under load resource balance to meet the Council's adequacy standard. Includes consideration of reserve requirements, fuel limitations, transmission limitations and in general, operation constraints on the system.
  - Associated System Capacity Contribution (ASCC) evaluates new resources capacity contribution considering reserve requirements, fuel limitations, transmission limitations and in general, operation constraints on the system.
    - The more renewable resources the more important the ASCC and ARM are to ensuring the RPM is getting us close, in the right "ballpark" operationally, to reasonable, operationally feasible solution
    - After the 7th Plan knew we needed to be able to input more than one ASCC per resource to represent changing capability of new resources with the same shape to meet peak in the system.

THE 2021 NORTHWEST POWER PLAN

Themes of 2021 Power Plan

GHG EMISSIONS

RESOURCE ADEQUACY

MARKET EXPANSION

BONNEVILLE CONTRACTS AND COMPETITIVENESS

RPM Enhancements for 2021 Plan (by theme and/or justification)

- Enhancements already implemented (in validation process):
  - **EE/DR interaction** (Resource Adequacy and consistency)
  - Lost Opportunity and Retrofit distinction (cleanup)
  - Conservation logic: EE bin selection by number (cleanup)
  - Streamline optimization process (run model faster)
  - **ASCC array** (Resource Adequacy)
  - Avoided Market Emissions Rate as a time series (GHG Emissions)
- Enhancements in development:
  - Methodology change for futures generation based on climate change data set structure and implications (best data available)
  - **GHG accounting** (GHG Emissions)
  - **Clean policy implementation** (GHG Emissions, Resource Adequacy, Market Expansion, and existing policy modeling)
- Data driven enhancements
  - Different definition of on and off-peak for dispatch (Market Expansion, better valuation of different resource types)
  - Bonneville only system data (Bonneville contracts and competitiveness)

Walk Through Enhancement Progress…

- **Low Hanging Fruit, Highly Valuable**:
  EE/DR Interaction
- **More Complex, Highly Valuable**:
  ASCC Array
- **Low Hanging Fruit, Being Implemented**:
  GHG Accounting
- **More Complex, Being Developed**:
  Clean Policy Implementation

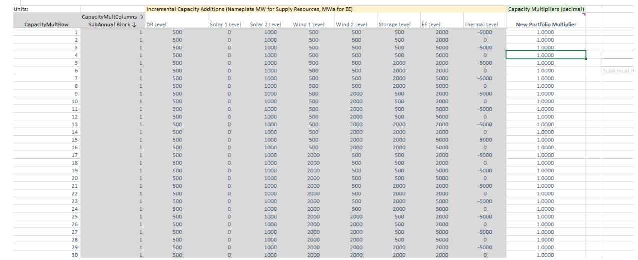
EE/DR Interaction

- Initially, it appeared we would not be able to model EE and DR interaction dynamically, but it appears to some extent we may.
- A multiplier is applied to derate the amount of available new and acquired DR per the EE acquisition via a multipler.

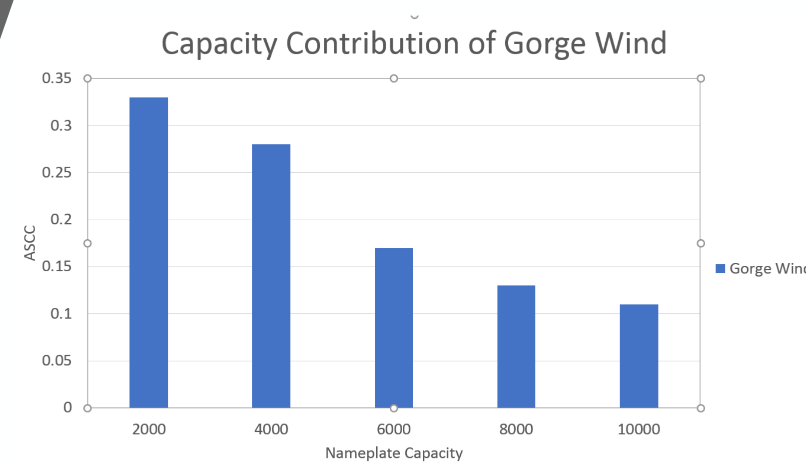
		Units:	fraction		
Conservation Type↓	DR Type → EE Price Bin↓	DR1	DR2	DR3	DR4
Conservation	1	1.0000	0.9000	0.5000	1.0000
Conservation	2	1.0000	0.0000	0.0000	0.0000
Conservation	3	1.0000	0.0000	0.0000	0.0000
Conservation	4	1.0000	0.8000	1.0000	1.0000
Conservation	5	1.0000	1.0000	1.0000	1.0000
Conservation	6	1.0000	1.0000	1.0000	1.0000
Conservation	7	1.0000	1.0000	0.0000	1.0000
Conservation	8	1.0000	0.9000	0.5000	1.0000
Conservation	9	1.0000	0.0000	0.0000	0.0000
Conservation	10	1.0000	0.0000	0.0000	0.0000
Conservation	11	1.0000	0.8000	1.0000	1.0000
Conservation	12	1.0000	1.0000	1.0000	1.0000
Conservation	13	1.0000	1.0000	1.0000	1.0000
Conservation	14	1.0000	1.0000	0.0000	1.0000

ASCC as an array

- This expands the ASCC logic from last time to include an ASCC for each new sub-portfolio of resources.
- Why: If we test large variable energy resource buildouts with one ASCC we…
  - Overrepresent capacity contribution of resources, and
  - Underrepresent the increased flexibility requirements.



Units:		Incremental Capacity Additions (Nameplate MW for Supply Resources, MWa for EE)								Capacity Multipliers (decimal)
CapacityMultRow	CapacityMultColumns → SubAnnual Block ↓	DR Level	Solar 1 Level	Solar 2 Level	Wind 1 Level	Wind 2 Level	Storage Level	EE Level	Thermal Level	New Portfolio Multiplier
1	1	500	0	1000	500	500	500	2000	-5000	1.0000
2	1	500	0	1000	500	500	500	2000	0	1.0000
3	1	500	0	1000	500	500	500	5000	-5000	1.0000
4	1	500	0	1000	500	500	500	5000	0	1.0000
5	1	500	0	1000	500	500	2000	2000	-5000	1.0000
6	1	500	0	1000	500	500	2000	2000	0	1.0000
7	1	500	0	1000	500	500	2000	5000	-5000	1.0000
8	1	500	0	1000	500	500	2000	5000	0	1.0000
9	1	500	0	1000	500	2000	500	2000	-5000	1.0000
10	1	500	0	1000	500	2000	500	2000	0	1.0000
11	1	500	0	1000	500	2000	500	5000	-5000	1.0000
12	1	500	0	1000	500	2000	500	5000	0	1.0000
13	1	500	0	1000	500	2000	2000	2000	-5000	1.0000
14	1	500	0	1000	500	2000	2000	2000	0	1.0000
15	1	500	0	1000	500	2000	2000	5000	-5000	1.0000
16	1	500	0	1000	500	2000	2000	5000	0	1.0000
17	1	500	0	1000	2000	500	500	2000	-5000	1.0000
18	1	500	0	1000	2000	500	500	2000	0	1.0000
19	1	500	0	1000	2000	500	500	5000	-5000	1.0000
20	1	500	0	1000	2000	500	500	5000	0	1.0000
21	1	500	0	1000	2000	500	2000	2000	-5000	1.0000
22	1	500	0	1000	2000	500	2000	2000	0	1.0000
23	1	500	0	1000	2000	500	2000	5000	-5000	1.0000
24	1	500	0	1000	2000	500	2000	5000	0	1.0000
25	1	500	0	1000	2000	2000	500	2000	-5000	1.0000
26	1	500	0	1000	2000	2000	500	2000	0	1.0000
27	1	500	0	1000	2000	2000	500	5000	-5000	1.0000
28	1	500	0	1000	2000	2000	500	5000	0	1.0000
29	1	500	0	1000	2000	2000	2000	2000	-5000	1.0000
30	1	500	0	1000	2000	2000	2000	2000	0	1.0000

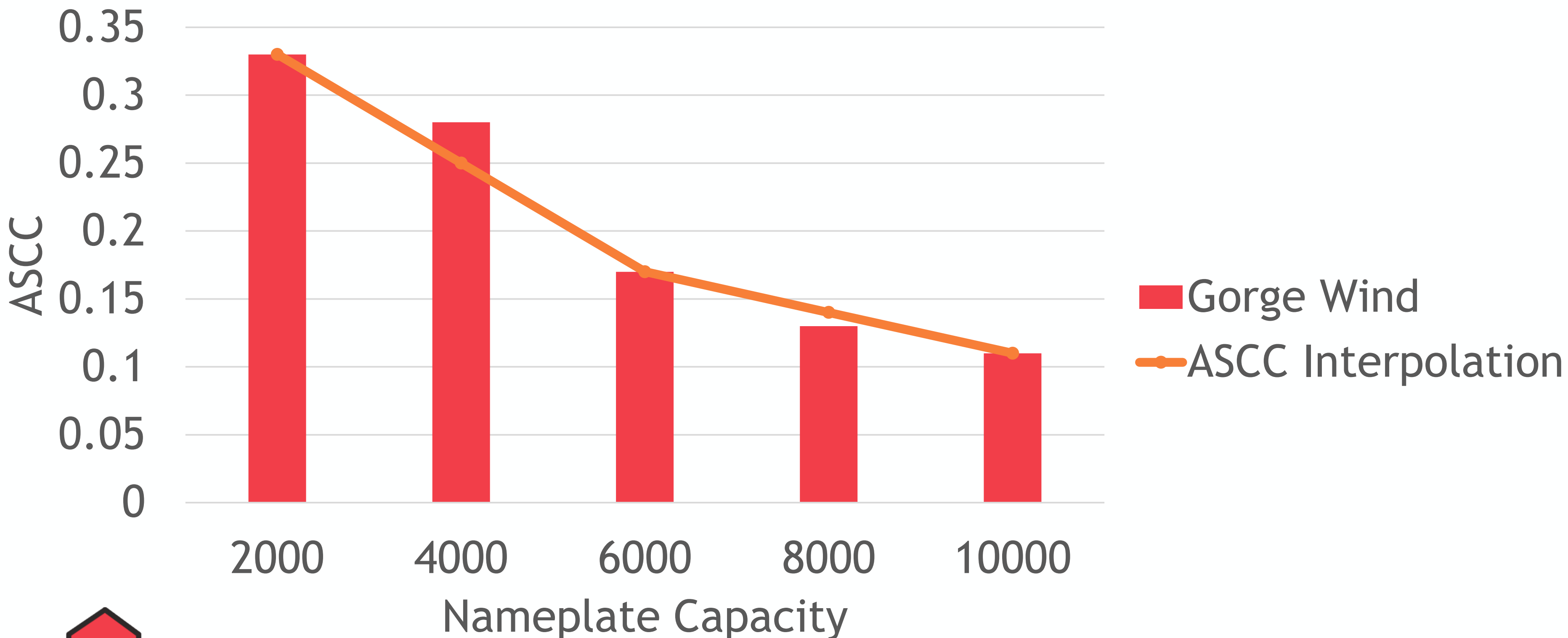


Combinations of ASCCs: 35 for Just Wind!

- Only Gorge wind (5 combinations of ASCC multipliers)
- Only Montana wind (5 combinations of ASCC multipliers)
- All combinations of both (5*5 = 25 combinations of ASCC mults.)

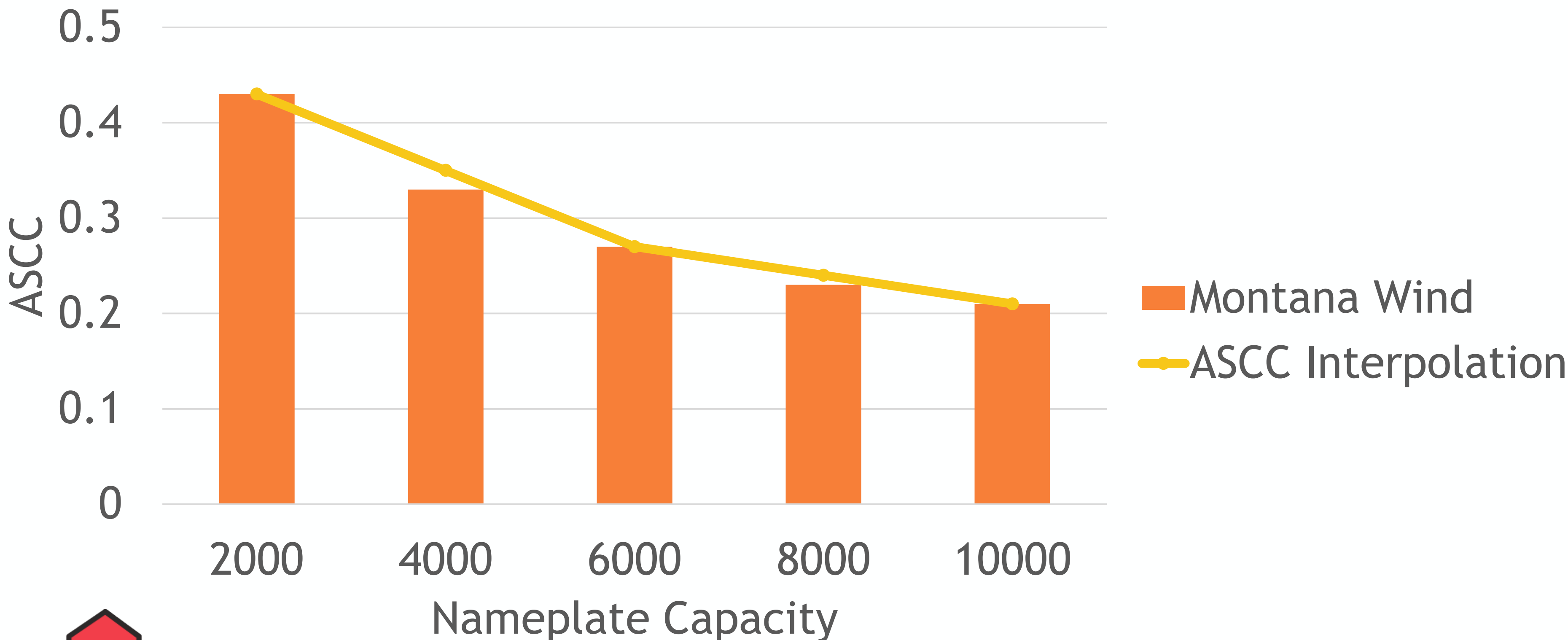
	Montana Wind (MW)					
Gorge Wind (MW)	0	2000	4000	6000	8000	10000
0	*No addition*	*6*	*12*	*18*	*24*	*30*
2000	*1*	*7*	*13*	*19*	*25*	*31*
4000	*2*	*8*	*14*	*20*	*26*	*32*
6000	*3*	*9*	*15*	*21*	*27*	*33*
8000	*4*	*10*	*16*	*22*	*28*	*34*
10000	*5*	*11*	*17*	*23*	*29*	*35*

Diminishing Capacity Contribution of Gorge Wind



THE 2021 NORTHWEST POWER PLAN

Diminishing Capacity Contribution of Montana Wind



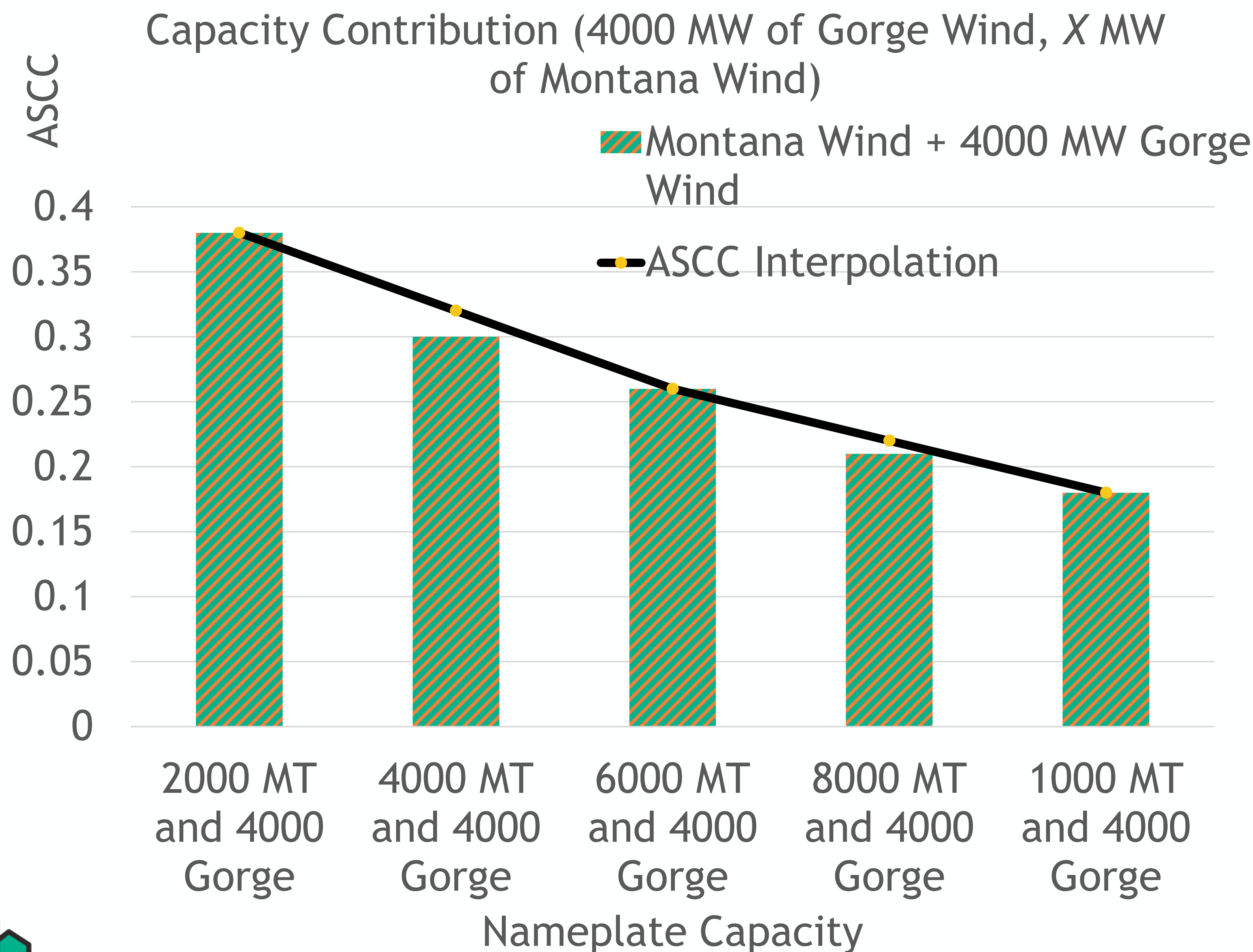
Are All Combinations Necessary?

- **I hope not…**
- When extrapolating the combinations of *seasonal* ASCC by resource type and penetration level of each resource type:

Number of combinations for n resource types is

$$4\left(\prod_{i}^{n} x_i - 1\right)$$

Where x_i is the number of penetration levels tested at a particular resource type


Capacity Contribution (4000 MW of Gorge Wind, X MW of Montana Wind)
ASCC
Montana Wind + 4000 MW Gorge Wind
ASCC Interpolation
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2000 MT and 4000 Gorge
4000 MT and 4000 Gorge
6000 MT and 4000 Gorge
8000 MT and 4000 Gorge
1000 MT and 4000 Gorge
Nameplate Capacity

Why Do We Need a Limit on Combinations?

1. **Computation Time**: Multiple ASCC's make problem harder for RPM to solve.

   - Linear optimization model uses to solve adequacy problem is fast, but will slow down with too many ASCCs to look up.

2. **Staff Time**: Calculation of 100's of ASCCs will take significant staff time

   - Calculating each ASCC will require set up of GENESYS and validation.

Initial Simplifications Without Much Fidelity Loss

1. Linear interpolation between different ASCC values
   - Went from 5 to 3 ASCCs in examples without losing much accuracy.
2. By resource **group** rather than **type**
   - Clump Thermal, EE, DR, Solar, Wind (maybe), etc.)

We are testing resource group combinations and will report back to SAAC

Do we need to change as portfolio changes over time?

- ASCC by resource group rather than by resource type at a particular time.
  - For example, if each new resource, R, $ASCC_R(i)$ has an associated system capacity contribution at time i.
  - These values would need to be calculated for a combination of new resources for every time i.
  - Even if energy efficiency and combined cycle gas units were the only resources we are capable of adding, we would need an i ASCC multipliers for every reasonable combination of natural gas and EE.
- We don't need to ASCC for all time i, if we calculate associated system capacity effect of changing the **existing resources** amounts.

Describe how this will work within adequacy logic in RPM:

Also known as the slide for those who like math.

- The amount a portfolio of r resource groups can contribute to a capacity adequacy requirement =

$$ASCC_i(p_1, \dots, p_n) * \left(\sum_{r=1}^{n} Cap_{r,i}\right)$$

where $Cap_{r,i}$ is the total *nameplate** capacity $Cap_{,i}$ of resource group r

and $ASCC_i(p_1, \dots, p_n)$ is the associated system capacity contribution for nameplate capacity p totals of resource groups *1* through n in season i

* Note that EE and DR do not have *nameplate* capacity in a traditional sense, so $Cap_{EE,i}$ and $Cap_{DR,i}$ will likely be represented by peak capacity capability instead of nameplate. In GENESYS, during the ASCC calculation, the actual characteristics of a certain penetration of EE and DR type resources will be represented.

Another reason why this is worth the trouble…

- **Flexibility characteristics and forecast error** associated with certain resource types **are key** aspects of the problem that are difficult to capture without modeling decision time frames and scheduling uncertainty in normal power system operations, especially **in futures with high renewable resource buildouts** .
- Since **these complexities can be handled** endogenously within GENESYS, we can reduce the complexity of capturing these additional requirements within RPM itself **by**…

Doing a bunch of GENESYS runs ahead of time…

Downstream Effects of This Improvement

Improves Staff Analytical Capability to Address *Today's* Power System

- Can better capture diversity effects of different resources added to a portfolio
- Can better capture flexibility attributes or requirements associated with different portfolios of resources.
  - Some resources like batteries and DR would virtually indistinguishable using old technique

Big Effort Up Front, Opens Up More Modeling Flexibility in RPM

- Staff and model time to run a large number of GENESYS runs is considerable, but should only have to go through exercise a few times a plan.
- Also gets a good idea of capacity contributions of resources without making the RPM simulate on an operational level.

Potential Enhancement in Development:
Preparing for GHG Emissions as a Damage Cost

Table 2: Social Cost of CO_2, 2010 – 2050 (in 2007 dollars per metric ton of CO_2)

Year	5% Average	**3% Average**	2.5% Average	High Impact (95th Pct at 3%)
2010	10	**31**	50	86
2015	11	**36**	56	105
2020	12	**42**	62	123
2025	14	**46**	68	138
2030	16	**50**	73	152
2035	18	**55**	78	168
2040	21	**60**	84	183
2045	23	**64**	89	197
2050	26	**69**	95	212

- Council has estimated emissions rates for regional plant emissions of carbon dioxide, methane, and nitrous oxide.
- Council can calculate emissions rates for the market: i.e. use extra-regional WECC plant emissions of carbon dioxide, methane, and nitrous oxide.
- CO2e calculations include
    - Carbon dioxide, Methane, Nitrous oxide, Water vapour, Tropospheric ozone, Chlorofluorocarbons (CFCs), Hydrochlorofluorocarbons (HCFCs), Perfluorocarbons, Sulphur hexafluoride
- Use a Societal Cost of CO2e as a proxy damage cost

GHG Emissions Damage Cost Enhancement Development

Accounting for cost of GHG emissions damages in the objective function

- The total emissions implied by the dispatch market and regional portfolio resources will be multiplied by the selected social cost of GHG emissions and considered by the RPM when determining a least cost plan in ALL scenarios.

Accounting for cost of GHG emissions in dispatch decisions

- In some scenarios, the GHG emissions cost may be included in the dispatch decision to test the effect of policies.

Accounting for cost of GHG emissions in rates/reported costs.

- In some scenarios, the GHG emissions cost may be included in rates depending on policy tested (say a tax), but, in general, any carbon damages will be backed out.

Objective Function Accounting

- An objective function in a least cost planning exercise requires an attempt to minimize total system cost while maintaining constraints on the system (reliability, state federal policies, fish and wildlife constraints, etc.)

$$Total\ System\ Cost = Fixed\ Cost + Variable\ Cost$$

Minimize this number

Account for emissions by multiplying damage cost by number of emissions in a candidate resource strategy

Include Change in Dispatch

$$Total\ System\ Cost = Fixed\ Cost + Variable\ Cost$$

Minimize this number

Account for emissions by multiplying damage cost by number of emissions in a candidate resource strategy

AND…

Account for change in dispatch by inputting damage cost in plant dispatch decision.

- This will likely make coal plants and inefficient gas plants dispatch less

Clean Policy Enhancement:

Day in the Life of Developing an Enhancement

- **Needs**
  1. to be able to reflect WA existing policy
  2. to be able to test expansion of something like the WA policy region-wide as a potential policy lever or risk.
- **Status**
  - Working with Lumidyne Consulting to implement per best understanding of current policy
  - Trying to allow for something like RPS logic but with a better understanding of adequacy
  - Will need to present final methodology to SAAC.

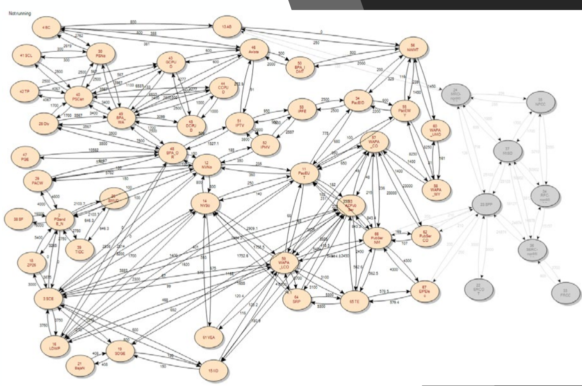
Keeping the SAAC Updated on Modeling Enhancements

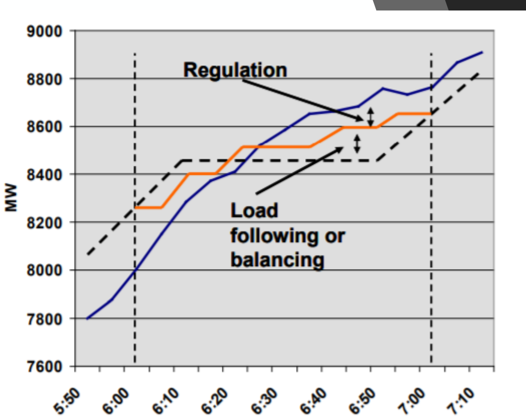
- December SAAC Meeting discussed enhancements already implemented (in validation process) and those that are being developed:
  - EE/DR interaction
  - Lost Opportunity and Retrofit distinction
  - Conservation logic: EE bin selection by number
  - Streamline optimization process
  - ASCC array
- Future SAAC Meetings (January –March)
  - Discuss enhancements in development as they are implemented.

Keeping You Updated on Important Modeling Changes

- Staff is preparing to model an adequate, more connected regional power system that may look substantially different than today's regional power system with more constraints on resource attributes.
  - GHG Emissions
  - Resource Adequacy
  - Market Expansion
- Staff is also attempting to explicitly model a subset of the regional power system within the context of the entire regional system.
  - Bonneville contracts and competitiveness

Questions?





Review of Resource Strategy Analysis and Adequacy Check

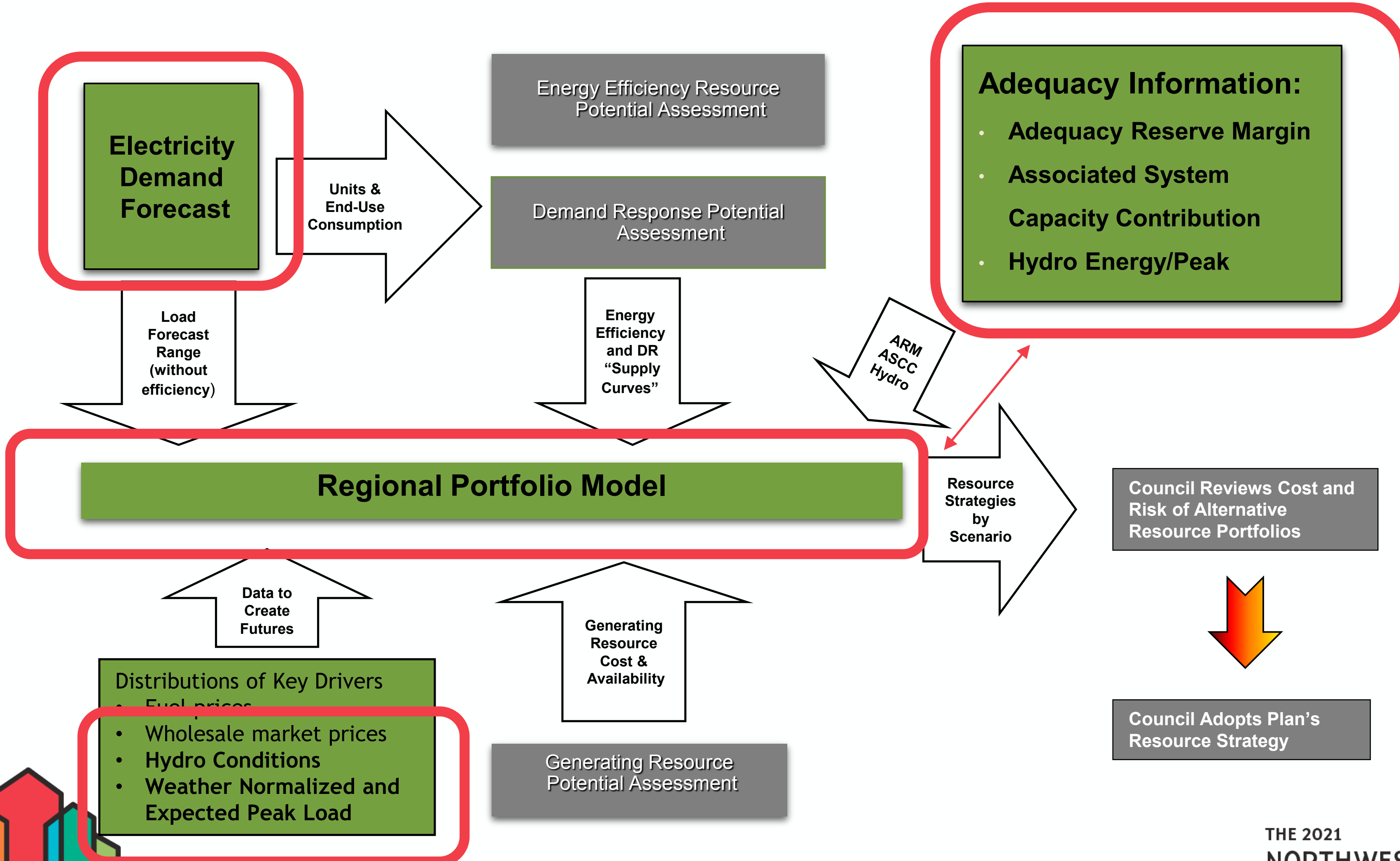
- To perform a regional resource expansion from 2021 to 2040 considered implicitly in RPM but not in detail.
    - Plant retirements and additions (out of the region)
    - Reliance on planning reserve margins for outside the region WECC planning areas for excess market availability
    - Existing state and regional policies (i.e. RPS, clean policies, carbon cap and trade policies, etc.)
    - Operational feasibility of a resource strategy
- Use AURORA to examine the repercussions of resource strategies on a WECC-wide basis
- Use GENESYS to check whether a regional resource strategy of interest meets the Council's adequacy standard.
    - This will include a consideration of whether balancing reserves and operational constraints of the system are maintained.

Remove Lost Opportunity and Retrofit distinction

- Lost Opportunity and Retrofit Energy Efficiency used to have different logic that was implicit in the RPM.
- Over time that logic has become less necessary and impactful per how the EE supply curves are created.

Conservation Bucket ↓	Price/Energy → Conservation Type ↓	Price ($/MWh)	Energy (MWa)
1	Conservation	-61.6788	675.5635
2	Conservation	4.0695	1226.4302
3	Conservation	16.9806	1673.3917
4	Conservation	23.6028	2177.4519
5	Conservation	35.2382	2591.6307
6	Conservation	44.3626	3004.8995
7	Conservation	54.9362	3360.6077
8	Conservation	64.1063	3526.3074
9	Conservation	72.7223	3695.4710
10	Conservation	83.5145	3851.4769
11	Conservation	94.2800	3986.3288
12	Conservation	113.2450	4219.0520
13	Conservation	148.6436	4409.2445
14	Conservation	505.7276	4966.0604

Plan Analytical Process Flow and Climate Change Data



Regional Portfolio Model Overview

RPM is a quarterly time step capital expansion model that tests resource strategies over many futures

- Resources: Achievable potential, parameters, seasonal shape and costs
  - Demand Response
  - Energy Efficiency
  - Generating Resources
- Futures: Many combinations (800 simulated in 7th Power Plan for each scenario)
  - Weather Normalized Loads and Expected Peak Loads
  - Hydro Conditions
  - Fuel Prices
  - Electricity Prices
- Adequacy Inputs: Using [illegible] model
  - Adequacy Reserve Margin
  - Associated System Capacity Contribution

Like a planning reserve margin using Council's adequacy standard

Like a ELCC calculation but set up to understand resource interaction with the hydro system

Resource Strategy Analysis in RPM

- The main drivers for building new resources:
  - Economic (from a market perspective)
    - A resource can cover all its variable and fixed costs with its expected return from the market.

Big driver in 7th Plan!

  - Adequacy (from a regional perspective)
    - A resource, or combination of resources, is the expected least cost way to address a future adequacy need.
  - State Policy Constraints (like RPS)
    - The expected least cost way to meet a policy goal.
- *Expected* refers to expected least cost over all the simulated futures

Adequacy Review

- In GENESYS, the previous paradigm was to simulate system operation for 80 hydro conditions (1929-2008) and 88 load/temperature years (1929-2016). All combinations were tested.
- With the climate change data, the proposed method will be to associate one temperature/load year (8760 hours) with one hydro condition (per the associated temperature and precipitation data).
  - Use 2020-2050 precipitation and temperature forecast and associated hydro and load conditions and sample assuming decadal similarity.
  - For example, 2025 adequacy analysis could sample from the GCM 2020 through 2029 forecasts. Say the GCM year selected is 2028. Then both 2028 hydro conditions and load would be used for that simulation
- The Associated System Capacity Contributions (ASCC), Adequacy Reserve Margin (ARM) and associated hydro energy/capacity are calculated using GENESYS and passed to the RPM.
  - Key way to inform the RPM of the higher fidelity system and operational information in GENESYS.

7th Power Plan Method of Sampling Futures

- Simulate the costs of a future resource strategy testing 80 hydro conditions (1929-2008) over a range of weather normalized and peak loads.
  - The annual variation in load was derived from multiple weather normalized load forecasts informed by different assumptions about economic growth.
  - The seasonal variation was derived from the temperature varying loads (1928-2013).
- The hydro and load futures were simulated **without assuming any correlation** between the hydro conditions and load.

Proposed Method of Sampling Futures (part 1)

- Proposed method of creating hydro and load futures for the RPM will be similar to the adequacy approach.
  - Associate one temperature/load year (8760 hours) with one hydro condition (per the associated temperature and precipitation data), but still incorporate annual and seasonal variation associated with the load.

1. Use 2020-2050 precipitation forecast and associated hydro conditions and sample hydro conditions assuming decadal similarity.
   - For example, 2025 plan year could sample any year from the GCM 2020 through 2029 forecasts.
   - Use chronological hydro conditions.

Proposed Method of Sampling Futures (part 2)

2. Use climate adjusted loads from 2020 to 2050 to incorporate temperatures from the forecast window associated with the precipitation years that will be sampled.
    a. For the annual variation still create distribution from high, medium and low forecasts that will be informed by the annual HDD/CDD from the climate change dataset.
    b. For the seasonal variation, create the distribution from a series temperature varying load years that are in lock step with the hydro futures that were sampled in step (1).

Example: Sampling CC futures

Plan Year	2022	2023	2024	2025	2026	…	2031	2032	2033
F1	2025	2026	2027	2028	2029		2035	2036	2037
F2	2026	2027	2028	2029	2020		2036	2037	2038
F3	2027	2028	2029	2020	2021		2037	2038	2039
F4	2028	2029	2020	2021	2022		2038	2039	2030
F5	2029	2020	2021	2022	2023		2039	2030	2031
F6	2020	2021	2022	2023	2024		2030	2031	2032
F7	2021	2022	2023	2024	2025		2031	2032	2033

- F#: future associated with a particular sequence of years from the GCM. Temperature and precipitation for a plan year will be from the listed GCM year.
- Each F# associated hydro condition sequence would be used in the RPM.
- Each F# associated temperature sequence would be used to represent the likelihood of a temperature future when creating the distribution from which seasonal variation in the load will be sampled in the RPM.

Next Steps and Other Considerations

- Enhance RPM to take multiple different load and hydro distributions

1. Climate change model
2. Hydro start year
   - Load and hydro condition must be linked per temperature and precipitation data coming from outputs of particular climate model, sequence and decadal relationship.