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

August 4, 2020

MEMORANDUM

TO: **Power Committee Members**

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

SUBJECT: **Adequacy Update (ASCC/ARM) for the 2021 Power Plan, Part 1**

BACKGROUND:

Presenter: John Fazio

Summary: To ensure that the resource strategy in the 2021 power plan will lead to an adequate supply, the Council's adequacy standard is incorporated directly into the Regional Portfolio Model via the Adequacy Reserve Margin (ARM). The ARM represents the amount of surplus generation above the expected load to cover unknown future conditions, such as extreme temperature events, low river runoff conditions, poor wind and solar generation and generating resource breakdowns. The Associated System Capacity Contribution (ASCC) is the amount of reliable capacity that an added resource contributes toward meeting the ARM requirement.

The power committee will be briefed on how these two parameters are calculated using the three climate change scenarios chosen for the 2021 power plan development.

Relevance: Through its power plan, the Council is mandated to ensure an adequate, efficient, economic and reliable power supply. Toward that end, the Council adopted a regional adequacy standard in 2011. By using the ARM and ASCC metrics in its planning models, the Council ensures that future resource acquisitions will not lead to costly overbuilt systems or to inadequate underbuilt systems.

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Workplan: A.5.2 Related to power supply adequacy assessments

Background: The Adequacy Reserve Margin is the amount of surplus generating capability above the expected load required to maintain an adequate power supply. The ARM thresholds are derived from resource and load data taken from a stochastic GENESYS study that produces a precisely adequate system (i.e. exactly meets the 5% LOLP target). The theory is that acquiring sufficient new resource capability to meet the ARM thresholds will result in a supply that, when analyzed stochastically, will yield a 5% LOLP.

The Associated System Capacity Contribution is a measure of how much reliable capacity a resource provides when added to a power supply. It indicates how much new load can be served by adding this resource, without affecting adequacy. A resource's ASCC is assessed by analyzing how much a potential peak-hour shortfall is reduced by adding an incremental amount of new resource. However, because of the dynamic interaction among all resources in a power supply, the ASCC for a specific resource can change as the resource mix changes. To accommodate for this dynamic interaction, aggregate ASCC values are assessed for many different combinations of new resources and are stored in an ASCC array (or table). When resources are needed to meet the ARM threshold, the composite ASCC value for the entire package of new resources can be interpolated from the ASCC array.

Adequacy Update for the 2021 Power Plan

Adequacy Reserve Margin

Associated System Capacity Contribution

John Fazio
Senior Systems Analyst

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Adequacy Reserve Margin

- The Adequacy Reserve Margin (ARM) is the amount of surplus capacity (or energy) needed, over the expected weather-normalized peak load (or average load), to ensure adequacy, in units of percent of expected load.
- The ARM is used in the Regional Portfolio Model as the adequacy test for resource buildouts. Building to this target should ensure that the resulting supply will meet the Council's 5% LOLP adequacy standard.

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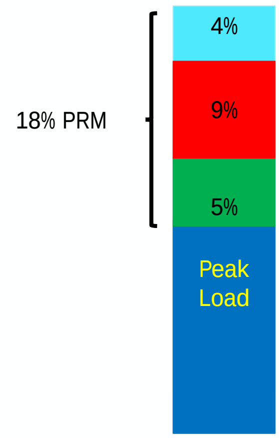
Difference between ARM and PRM

- A planning reserve margin (PRM) is commonly used by utilities for resource planning
- Like the ARM, it is the amount of surplus capacity needed over the expected peak load to cover uncertain future conditions
- A "building block" approach has often been used to set the PRM (a deterministic method)
- For example, an 18% PRM might include:
  - 5% for generator forced outages
  - 9% for contingency and balancing reserves
  - 4% for extreme weather events



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Difference between ARM and PRM

- The ARM is based on probabilistic methods, which are becoming more commonly used, and require software that simulates the hourly operation of the power supply
- The simulation is run thousands of times with different combinations of future unknowns, such as streamflow, temperature, generator outages, wind and solar generation
- The adequacy standard limits the number of simulations that have periods of insufficient generation (e.g. 5% of the time)
- To calculate the ARM
  - Design a system that exactly meets the adequacy standard
  - Use the resource capacity and expected load from that system to set the ARM

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Calculating Quarterly ARMs

- Quarterly Capacity ARMs are calculated by subtracting the quarterly weather-normalized peak load from the quarterly aggregate capacity of a system whose LOLP is precisely at the quarterly LOLP target, and then dividing by the weather-normalized peak load.

ARM_C (capacity) = (peaking capacity – peak load)/peak load

- Quarterly Energy ARMs are calculated by subtracting the quarterly weather-normalized average load from the quarterly aggregate average generating capability of a system whose LOLP is precisely at the quarterly LOLP target, and then dividing by the weather-normalized average load.

ARM_E (energy) = (average capability – average load)/average load

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Assigning Quarterly LOLP Targets

- Council's adequacy standard = 5% annual LOLP
- Quarterly LOLP targets are assigned based on a future year's assessed seasonal resource needs
- For example, 80% of projected shortfalls in 2023 occur in quarter 1 and 20% of shortfalls occur in summer, thus the Q1 target is 4% and the Q3 target is 1%

Target LOLP (%)	Q1	Q2	Q3	Q4
2023	4		1	
2027	2		2	1
2031			5	

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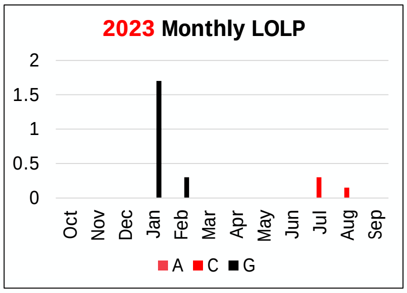
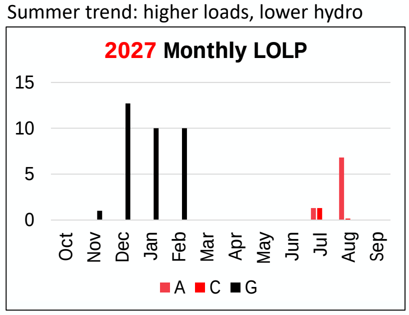
Transitioning from Winter to Summer Needs
(Preliminary Resource Needs Assessment)

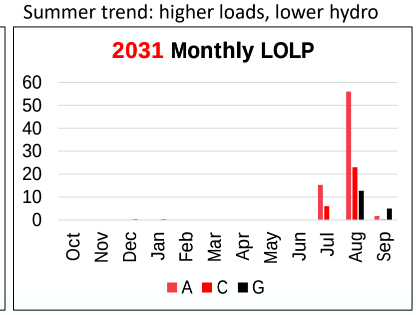
Small shortfalls mostly in winter
Winter trend: lower loads, higher hydro
Summer trend: higher loads, lower hydro
IPP + spot market help in summer



Larger shortfalls still mostly in winter
3,000 MW total coal retirement
Winter trend: lower loads, higher hydro
Summer trend: higher loads, lower hydro



Much larger shortfalls all in summer
1,800 MW of additional coal retirement
Winter trend: lower loads, higher hydro
Summer trend: higher loads, lower hydro



Assumptions: No new EE, full year IPP availability, full year 2,500 MW out-of-region spot market, summer spot market not available from hours 17-22.

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Assumptions for Calculating the ARM

- DR and standby resources are not included
- Market supplies are not included (IPP and out-of-region)
- ASCCs[1] not used because only existing resources are counted (no new EE)
- Wind and solar
  - Capacity is the expected generation over the 2-hour peak load
  - Energy is the expected average period generation
- Hydro
  - Capacity is the 3.3 percentile 2-hour sustained peak
  - Energy is the 3.3 percentile average period generation
  - Note: Historical critical hydro is a 1-in-80-year event, whereas for the climate change data, lowest hydro is a 1-in-30-year event
- Peak and energy loads are weather-normalized frozen efficiency loads

[1]The ASCC is defined in the second half of this presentation.

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2027 Capacity ARM

Capacity ARM (units in MW)	Quarterly LOLP Target (%)	2	0	2	1
Resource Type	**Capacity ARM Calculation**	**Q1**	**Q2**	**Q3**	**Q4**
Existing Thermal	Nameplate * (1 - FOR)	10290	10429	10389	10287
Existing Wind	Expected generation over the 2-hour peak load	1897	2553	2407	1970
Existing Solar	Expected generation over the 2-hour peak load	0	351	373	0
Existing Battery	Nameplate * (1 - FOR)	5	5	5	5
Existing Firm Contracts	Net peak hour (import - export)	-483	-793	233	-384
Existing Hydro	2-Hour Sustained Peak (3.33 percentile)	25537	23325	21918	23638
Capacity for Adequacy	Capacity needed to meet LOLP target	4591	0	897	1528
Total Resource		41837	35870	36222	37044
Load	Weather-normalized peak hour	30253	27321	29577	28295
ARM_C	(Total Dedicated Regional Resource - Load)/Load	**38.3%**	**31.3%**	**22.5%**	**30.9%**

Greyed out ARM means system is surplus (LOLP is below target), no resources needed, not to be used as build target

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Adequacy Reserve Margins
(based on CC data used for the 2021 Plan)

Capacity ARM	Q1	Q2	Q3	Q4
2022-2026	0%	0%	0%	0%
2027-2030	**38.3%**	0%	**22.5%**	**30.9%**
2031-2041	0%	0%	**27.7%**	0%

Energy ARM	Q1	Q2	Q3	Q4
2022-2026	0%	0%	0%	0%
2027-2030	**3.5%**	0%	**11.5%**	**21.4%**
2031-2041	0%	**-8.5%**	**-4.7%**	0%

Black = System is deficit – use calculated ARM
Grey = System is surplus, ARM is positive – set ARM to zero (otherwise could overbuild)
Red = System is surplus, ARM is negative – use negative ARM (otherwise could overbuild)

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Example of How the ARM_C Works

For a Future Operating Year	
Expected peak load	39,000 MW
System capacity	42,900 MW
Surplus (% relative to load)	10%
ARM Capacity Requirement	15%
Assessment:	System is inadequate

Action:	More resource needed
Total resource need = Load * (1 + ARM)	39,000 * (1.15) = 44,850 MW
Incremental resource need = Total resource need – system capacity	44,850 – 42,900 = 1,950 MW

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Associated System Capacity Contribution

- The Associated System Capacity Contribution (ASCC) is the net firm capacity gained when a resource is added to a power supply, in units of percent of nameplate capacity.
- ASCC values are used to determine the amounts of new resources needed for adequacy (i.e. to meet the ARM threshold).

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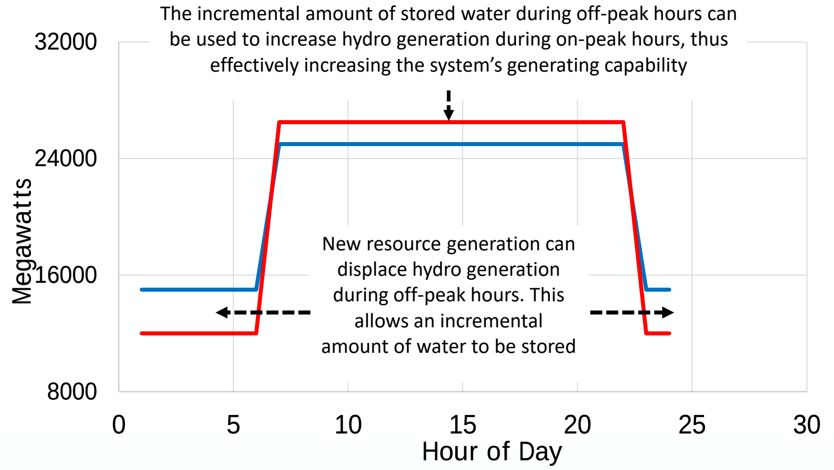
How Hydro Storage Can Increase System Capacity



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Calculating the ASCC

- ASCC is calculated by measuring the reduction in the peak-hour curtailment after an increment of new resource is added
- The reduction in peak-hour curtailment is derived from the peak-hour curtailment duration curves (see next two slides for examples)

$$ASCC = \frac{\text{Reduction in Peak Curtailment}}{\text{Incremental Capacity Added}}$$

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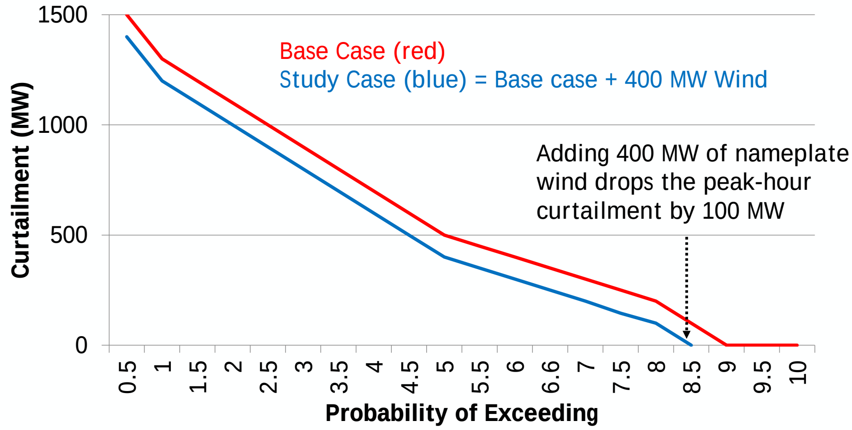
Peak-Hour Curtailment Duration Curve



ASCC = 100/400 = 25%

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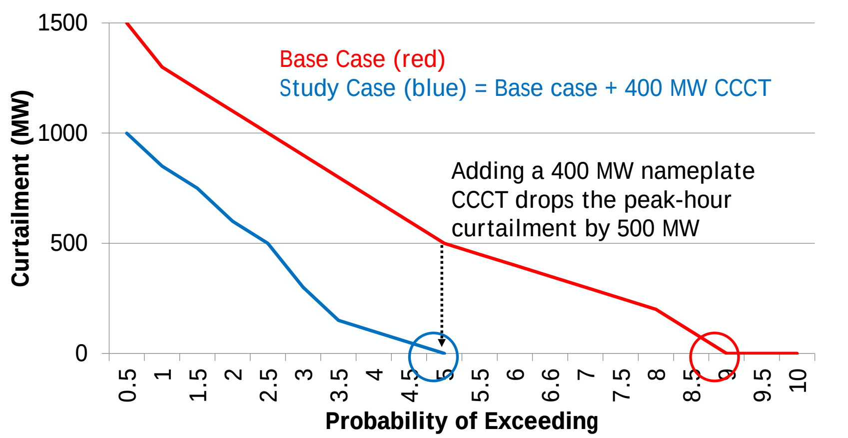
Peak-Hour Curtailment Duration Curve



ASCC = 500/400 = 125%

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Single-Resource ASCC Values (%)[1]

Resource	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
4-Hour Battery	26%	N/A	45%	34%
Combined Cycle CT	148%	N/A	111%	153%
Combo Winter-Summer DR	63%	N/A	32%	38%
Energy Efficiency	182%	N/A	108%	199%
Gorge Wind	14%	N/A	21%	13%
Montana Wind	61%	N/A	36%	44%
Pumped Storage	41%	N/A	61%	44%
S Idaho Solar	41%	N/A	54%	39%

[1]ASCC values when adding 2,100 MW of new resource and assuming historic water and temperature conditions. ASCC values diminish as more resource is added.
[2]ASCC values for energy efficiency are based on average annual EE savings and not peak-hour savings.

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ASCC Array
(Composite ASCC values for New Resource Mixes)

- The ASCC is a function of a resource's hourly generating profile, the hourly load shape, available storage and the overall resource mix
- Studies show that the ASCC declines as more resource is added
- The ASCC also declines as other competing resources are added

- Thus, using single-resource ASCC values could lead to underbuilding
- And, the composite ASCC value for 2 or more added resources is NOT just the average of the single-resource ASCC values

- Solution is to calculate the ASCC for multiple combinations of potential resource additions

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ASCC Declines with Added Resource

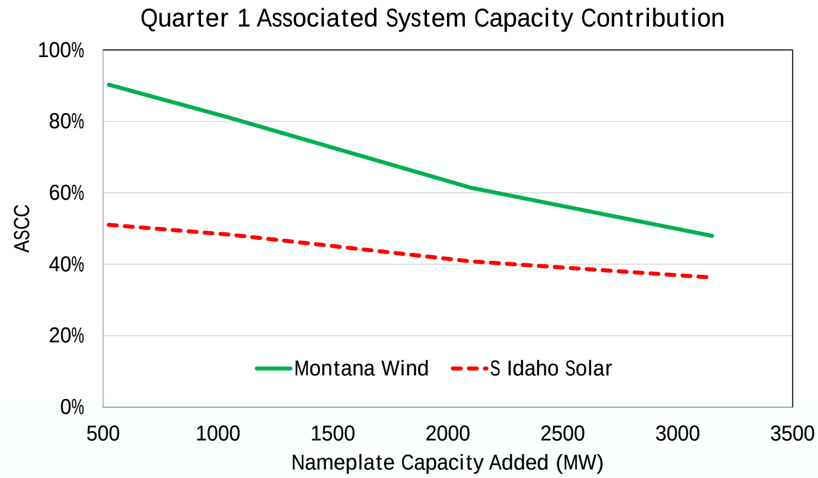

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Illustration of an ASCC Array Table[1]

Wind Capacity (MW)	Solar Capacity (MW)	Composite ASCC[2]
500	500	55
1000	1000	42
1500	1500	30
2000	2000	22
2500	2500	20
500	1000	47
1000	500	45
1000	2000	28
⋮	⋮	⋮

[1]Can also be thought of as an ASCC surface that is a function of the installed wind and solar capacity plotted in 3-dimensions (see next slide).
[2] These composite ASCC values were made up for this illustration.

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ASCC Array Surface[1] for Wind + Solar

Illustrative Example:

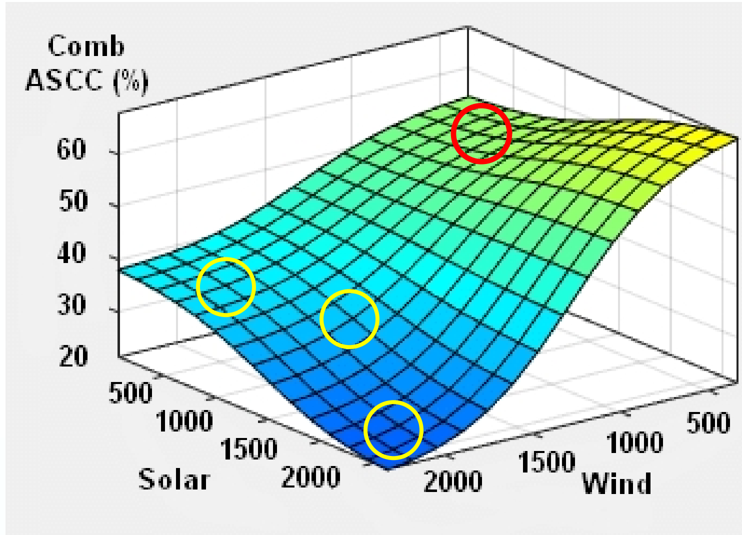
2000 wind + 2000 solar > 22%

2000 wind + 500 solar > 38%

1500 wind + 1000 solar > 32%

500 wind + 500 solar > 55%

[1]Generic surface shape – not completely representative of ASCC relationships. For N new resources, can be thought of as an N-dimensional surface (or function). However, in practice an ASCC table is used (see next slide).



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Using the ASCC Array Table in the RPM

- For the 2021 plan, an ASCC array table will be used, which has ASCC values for all combinations of new resource types
- To assess the ASCC for all combinations of 7 resource types and 2 levels of installed capacity requires 128 GENESYS studies
- And because the plan incorporates 3 CC scenarios, 384 studies are needed to create the ASCC array

- The RPM estimates the composite ASCC for a specific set of new resources by linearly interpolating between the two nearest points in the ASCC array table

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New Resource Types

Resource Type	Resources Included	Min Level	Max Level
Thermal	CCCT, New SCCT, Geothermal	0	2100 MW
Solar	Westside Solar, Eastside Solar, Solar Plus Storage	0	6000 MW
Wind 1	Montana Wind, SE WA Wind	0	6000 MW
Wind 2	Gorge Wind	0	1900 MW
Energy Efficiency	Energy Efficiency Bins 1-14	700 aMW	3500 aMW
Short Term Energy Limited	DR Bins 1-4, 4-hour battery	0	3000 MW
Long Term Energy Limited	Pumped Storage	0	3000 MW

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Sample ASCC Array Table

(Using draft MW range & based on historic hydro and temperature data)

New Resources							Total Added	Composite ASCC			
EE	CT	DR	PS	Wind 1	Wind 2	SOL	Capacity	Q1	Q2	Q3	Q4
700	0	0	0	100	100	100	1000	2.01	1.07	1.03	1.89
700	0	0	0	100	100	5000	5900	0.50	0.41	0.47	0.49
700	0	0	0	100	5000	100	5900	0.52	0.41	0.31	0.56
700	0	0	0	100	5000	5000	10800	0.37	0.23	0.33	0.38
700	0	0	0	5000	100	100	5900	0.37	0.21	0.24	0.40
700	0	0	0	5000	100	5000	10800	0.28	0.23	0.29	0.29
700	0	0	0	5000	5000	100	10800	0.29	0.23	0.20	0.32
700	0	0	0	5000	5000	5000	15700	0.26	0.16	0.24	0.27
700	0	0	1000	100	100	100	2000	1.08	0.81	0.67	1.03
700	0	0	1000	100	100	5000	6900	0.44	0.36	0.45	0.43
700	0	0	1000	100	5000	100	6900	0.46	0.36	0.31	0.50
700	0	0	1000	100	5000	5000	11800	0.34	0.21	0.31	0.36
700	0	0	1000	5000	100	100	6900	0.34	0.25	0.24	0.38
700	0	0	1000	5000	100	5000	11800	0.27	0.21	0.29	0.28
700	0	0	1000	5000	5000	100	11800	0.28	0.21	0.21	0.32
700	0	0	1000	5000	5000	5000	16700	0.26	0.15	0.24	0.27
700	0	1000	0	100	100	100	2000	1.08	0.58	0.55	1.25
700	0	1000	0	100	100	5000	6900	0.43	0.36	0.43	0.47
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

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Validating ASCC and ARMs

- The Council's goal is to develop a resource expansion strategy that will provide an adequate, efficient, economic and reliable power supply.
- The ARMs and ASCCs are metrics designed to ensure that viable resource strategies will produce adequate power supplies
- The Council's 5% LOLP standard is translated into an adequacy reserve margin, which is met in future years by adding resources based on their ASCC values
- To test the efficacy of the ARMs and ASCCs, various future resource buildouts are extracted from the RPM studies and analyzed with the Council's adequacy model to ensure that the resulting LOLP is under 5% (adequate) but not zero (overbuilt)

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Additional Slides

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2023 Capacity ARM

Capacity ARM (units in MW)	Quarterly LOLP Target (%)	4	0	1	0
Resource Type	**Capacity ARM Calculation**	**Q1**	**Q2**	**Q3**	**Q4**
Existing Thermal	Nameplate * (1 - FOR)	11198	11337	11297	11195
Existing Wind	Expected generation over the 2-hour peak load	1897	2553	2407	1970
Existing Solar	Expected generation over the 2-hour peak load	0	351	373	0
Existing Battery	Nameplate * (1 - FOR)	5	5	5	5
Existing Firm Contracts	Net peak hour (import - export)	-483	-793	233	-384
Existing Hydro	2-Hour Sustained Peak (3.33 percentile)	25537	23325	21918	23638
Capacity for Adequacy	Capacity needed to meet LOLP target	0	0	0	0
Total Resource		38154	36778	36233	36424
Load	Weather-normalized peak hour	29314	26917	28923	29786
ARM_C	(Total Dedicated Regional Resource - Load)/Load	30.2%	36.6%	25.3%	22.3%

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2023 Energy ARM

Energy ARM (units in MW)	Quarterly LOLP Target (%)	4	0	1	0
Resource Type	**Energy ARM Calculation**	**Q1**	**Q2**	**Q3**	**Q4**
Existing Thermal	Nameplate * (1 - FOR) * (1 - MOR)	11160	8263	11220	11152
Existing Wind	Expected average energy	2860	2663	1598	1598
Existing Solar	Expected average energy	148	262	275	148
Existing Battery	Average net energy (loss)	-1	-1	-1	-1
Existing Firm Contracts	Net average energy (import - export)	-348	-448	1303	-291
Existing Hydro	"Critical" energy (3.33 percentile)	10841	11785	11061	14387
Energy for Adequacy	Energy needed to meet LOLP target	0	0	0	0
Total Resource		24660	22524	25456	26992
Load	Weather-normalized quarterly average	22160	20363	21929	21336
ARM_E	(Total Dedicated Regional Resource - Load)/Load	11.3%	10.6%	16.1%	26.5%

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2027 Energy ARM

Energy ARM (units in MW)	Quarterly LOLP Target (%)	2	0	2	1
Resource Type	**Energy ARM Calculation**	**Q1**	**Q2**	**Q3**	**Q4**
Existing Thermal	Nameplate * (1 - FOR) * (1 - MOR)	10252	7704	10312	10244
Existing Wind	Expected average energy	2860	2663	1598	1598
Existing Solar	Expected average energy	148	262	275	148
Existing Battery	Average net energy (loss)	-1	-1	-1	-1
Existing Firm Contracts	Net average energy (import - export)	-348	-448	1303	-291
Existing Hydro	"Critical" energy (3.33 percentile)	10841	11785	11061	14387
Energy for Adequacy	Energy needed to meet LOLP target	145	0	1	5
Total Resource		23897	21965	24549	26089
Load	Weather-normalized quarterly average	23088	20465	22009	21487
ARM_E	(Total Dedicated Regional Resource - Load)/Load	**3.5%**	**7.3%**	**11.5%**	**21.4%**

Greyed out ARM means system is surplus (LOLP is below target), no resources needed, not to be used as build target

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2031 Capacity ARM

Capacity ARM (units in MW)	Quarterly LOLP Target (%)	0	0	5	0
Resource Type	**Capacity ARM Calculation**	**Q1**	**Q2**	**Q3**	**Q4**
Existing Thermal	Nameplate * (1 - FOR)	8881	9019	8979	8877
Existing Wind	Expected generation over the 2-hour peak load	1897	2553	2407	1970
Existing Solar	Expected generation over the 2-hour peak load	0	351	373	0
Existing Battery	Nameplate * (1 - FOR)	5	5	5	5
Existing Firm Contracts	Net peak hour (import - export)	-483	-793	233	-384
Existing Hydro	2-Hour Sustained Peak (3.33 percentile)	25480	23318	21886	23481
Capacity for Adequacy	Capacity needed to meet LOLP target	0	0	3891	0
Total Resource		35780	34453	37774	33949
Load	Weather-normalized peak hour	31190	27045	29571	30715
ARM_C	(Total Dedicated Regional Resource - Load)/Load	**14.7%**	**27.4%**	**27.7%**	**10.5%**

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2031 Energy ARM

Energy ARM (units in MW)	Quarterly LOLP Target (%)	0	0	5	0
Resource Type	**Energy ARM Calculation**	**Q1**	**Q2**	**Q3**	**Q4**
Existing Thermal	Nameplate * (1 - FOR) * (1 - MOR)	8842	6837	8902	8834
Existing Wind	Expected average energy	2860	2663	1598	1598
Existing Solar	Expected average energy	148	262	275	148
Existing Battery	Average net energy (loss)	-1	-1	-1	-1
Existing Firm Contracts	Net average energy (import - export)	-348	-448	1303	-291
Existing Hydro	"Critical" energy (3.33 percentile)	11334	9598	9032	12847
Energy for Adequacy	Energy needed to meet LOLP target	0	0	78	0
Total Resource		22835	18911	21187	23134
Load	Weather-normalized quarterly average	22954	20671	22225	21753
ARM_E	(Total Dedicated Regional Resource - Load)/Load	-0.5%	-8.5%	**-4.7%**	6.3%

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