

General Capacity Investigation Oregon PUC

Phase I Workshop: What is Capacity

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Outline

- Energy, Capacity and Flexibility
- Hydroelectric sustained-peaking capability
- Associated System Capacity Contribution (ASCC)
- Adequacy Reserve Margin (ARM)
- Validation of ARMs and ASCCs
- Optional:
Why solar ASCC is so much higher than its standalone capacity value for the PNW power supply



General Definitions

- **Energy** = Quantity
Measured in megawatt-hours or
average megawatts (1 aMW = 8,760 MW-hrs)
- **Capacity** = Rate of producing energy
Measured in megawatts
- **Flexibility** = Ramping capability
The ability of the power system to continuously match
generation to system demands



Another way to think about it

- **Energy** equates to fuel
Must have sufficient fuel to meet the highest expected annual average energy demand
- **Capacity** equates to machines
Must have sufficient machine capability to meet the highest expected hourly demand
- **Flexibility** = equates to ramping
Must have sufficient machine flexibility to increase or decrease generation moment by moment to balance within-hour scheduling mismatches



Capacity of Hydroelectric Systems

(with limited storage)

- **Single-Hour Capacity**

- Maximum power capability during peak-demand hour
- Single-hour hydro capacity = 34,222 MW
- Cannot be sustained over a cold snap or heat wave

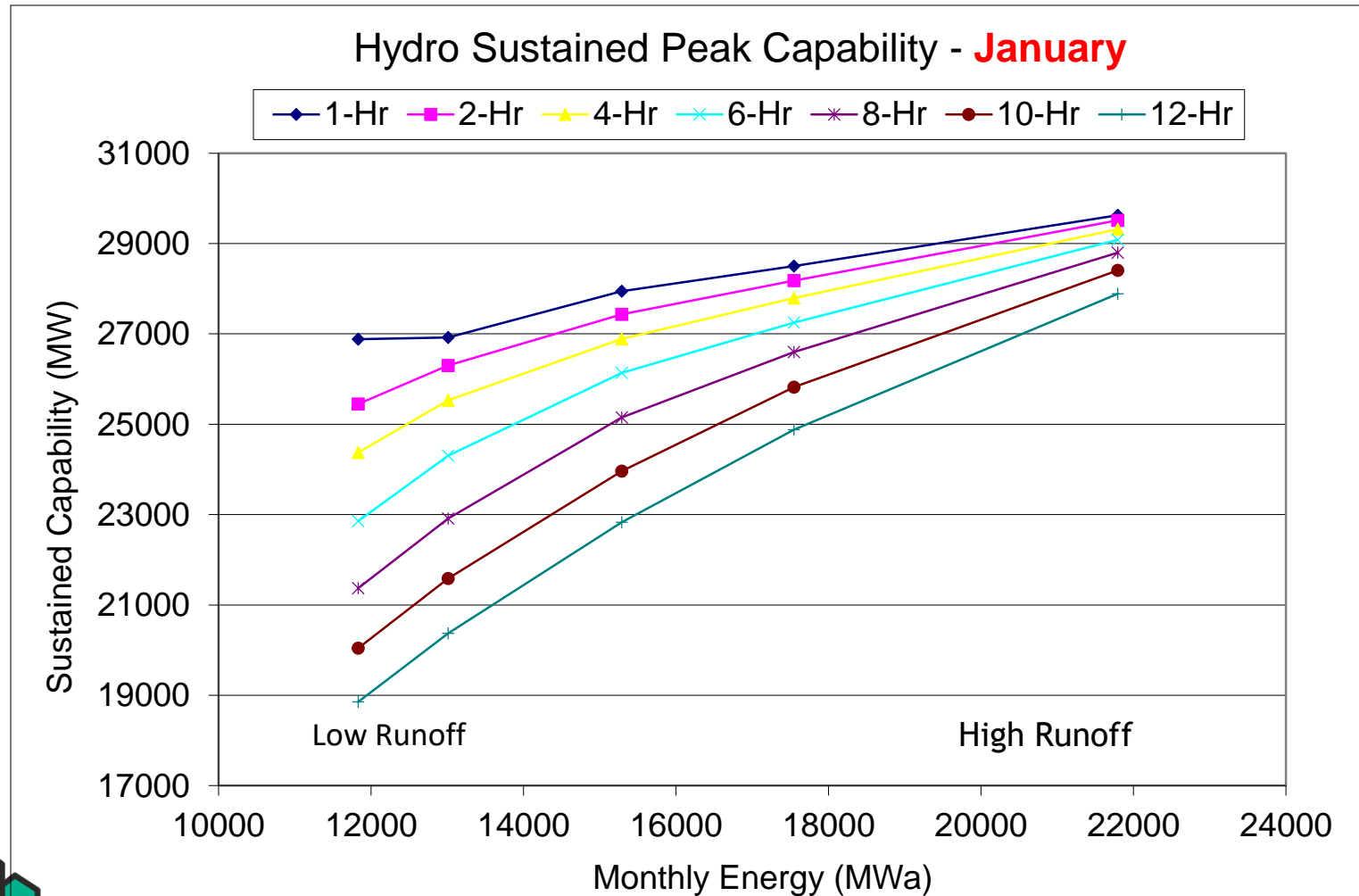
- **Sustained-Peak Capacity**

- Maximum average power capability during a limited number of peak-demand hours
- Sustained-peak hydro capability ~ 23,000 MW¹
- Can be sustained over a cold snap

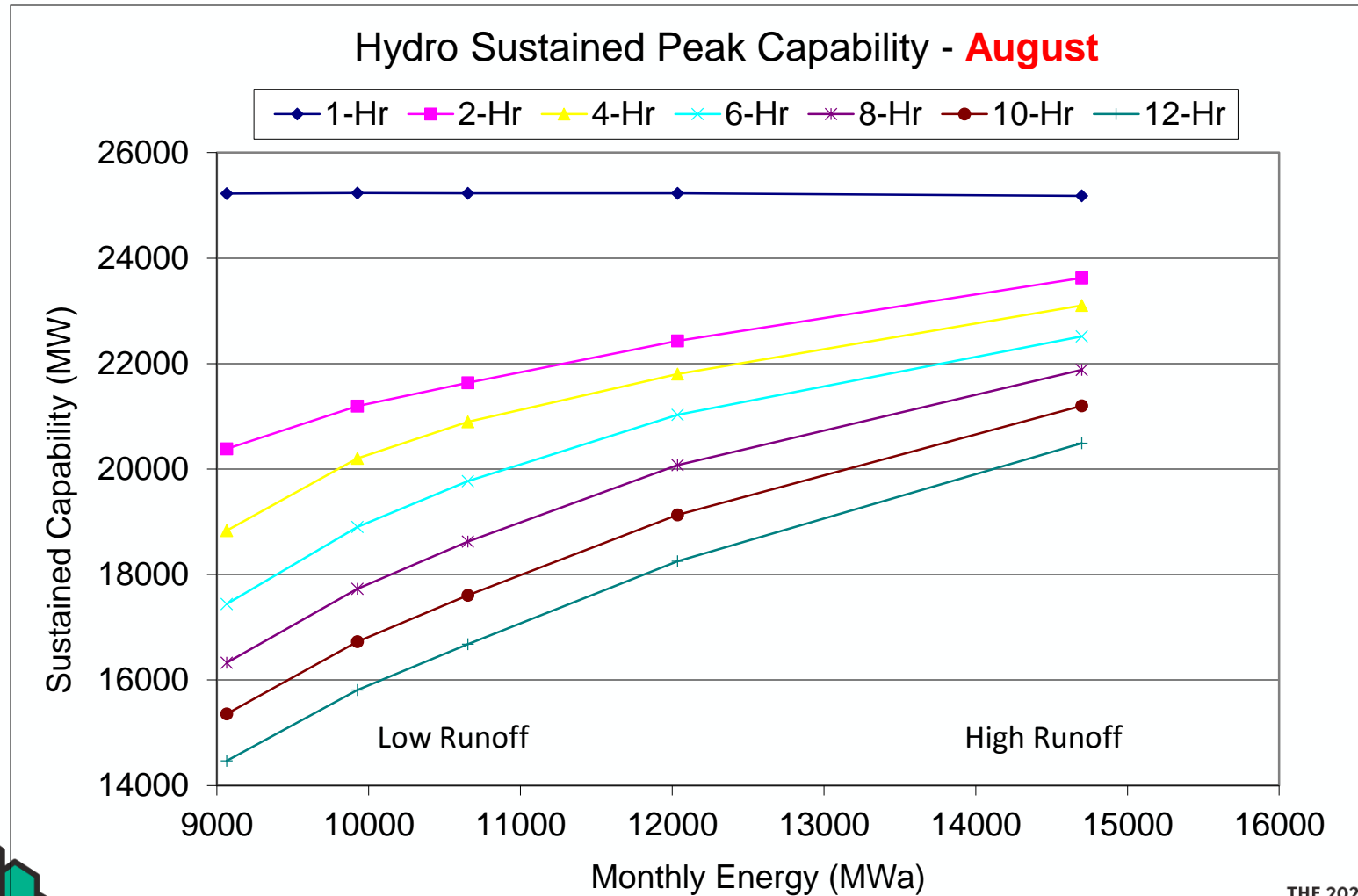
¹For 6 peak hours/day in January during the lowest runoff water year



Sustained-Peak Capacity varies by Month, Water Condition and Duration of Peak



Sustained-Peak Capacity varies by Month, Water Condition and Duration of Peak



Standalone Capacity vs. Net System Capacity

- **Standalone capacity** is the percentage of nameplate capacity that can be counted on with no interaction with available storage (i.e. hydroelectric system)
- **Net system capacity** is the percentage of nameplate capacity that can be counted on when allowed to interact with storage facilities (i.e. hydroelectric system)



Power Plan Adequacy Requirements (ARM and ASCC)

- 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.
- The **Associated System Capacity Contribution** (ASCC) is the net firm capacity gained when a resource is added to a power supply with storage, in units of percent of nameplate capacity.
- ASCC values are used to calculate ARMs and to assess if a power supply meets the ARM standard.



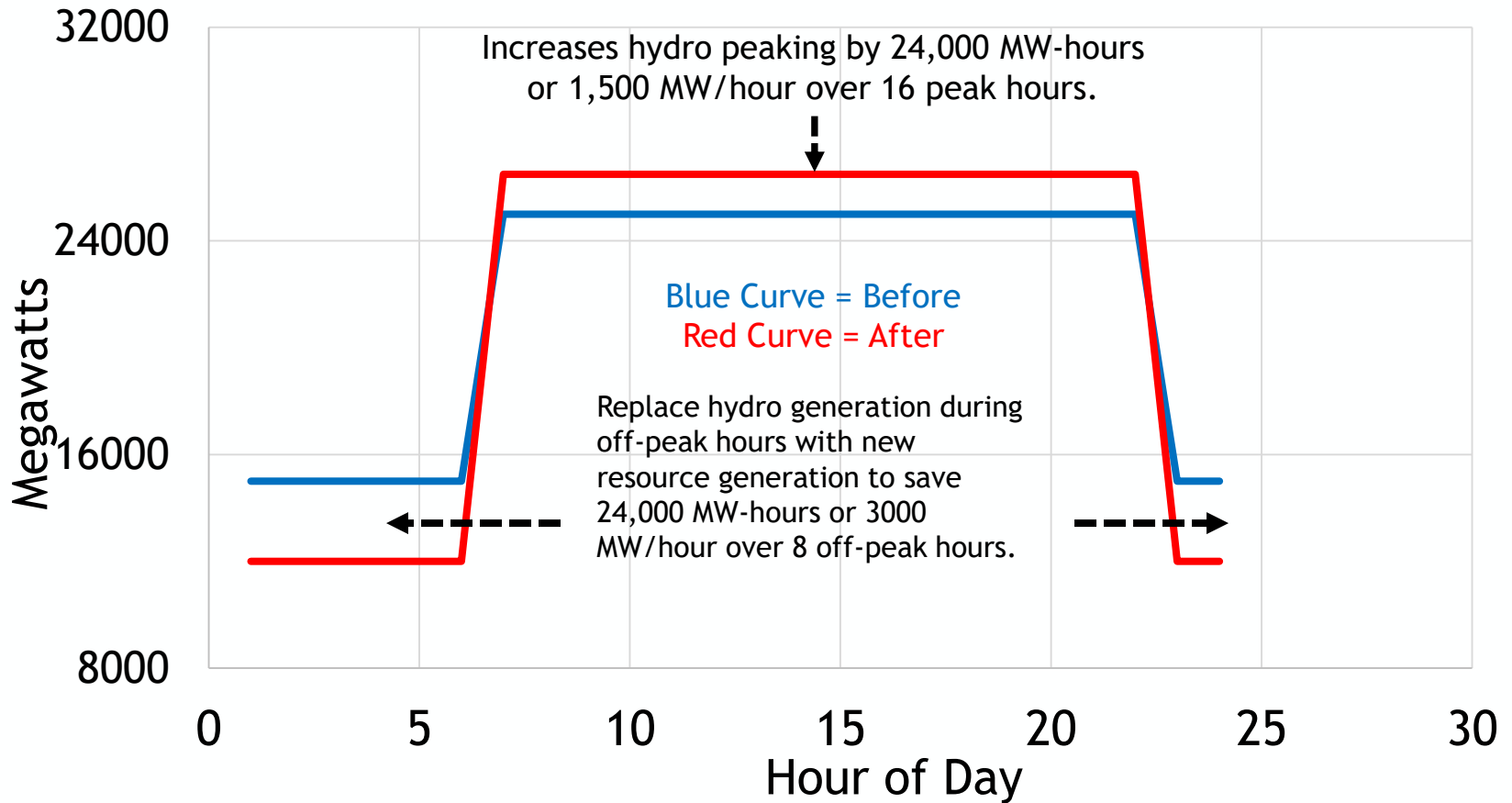
Associated System Capacity Contribution

- ASCC is the net firm capacity gained when a resource is added to a power supply with storage (e.g. hydroelectric system).
- During off-peak hours (conditions allowing), the added resource can be operated to replace hydro generation, which saves water
- Saved water translates into added hydro capacity
- $ASCC = \text{Resource's stand-alone capacity} + \text{Added hydro capacity}$



Hydro Capacity Gained with New Resource

Using Hydro Storage to Increase Capacity



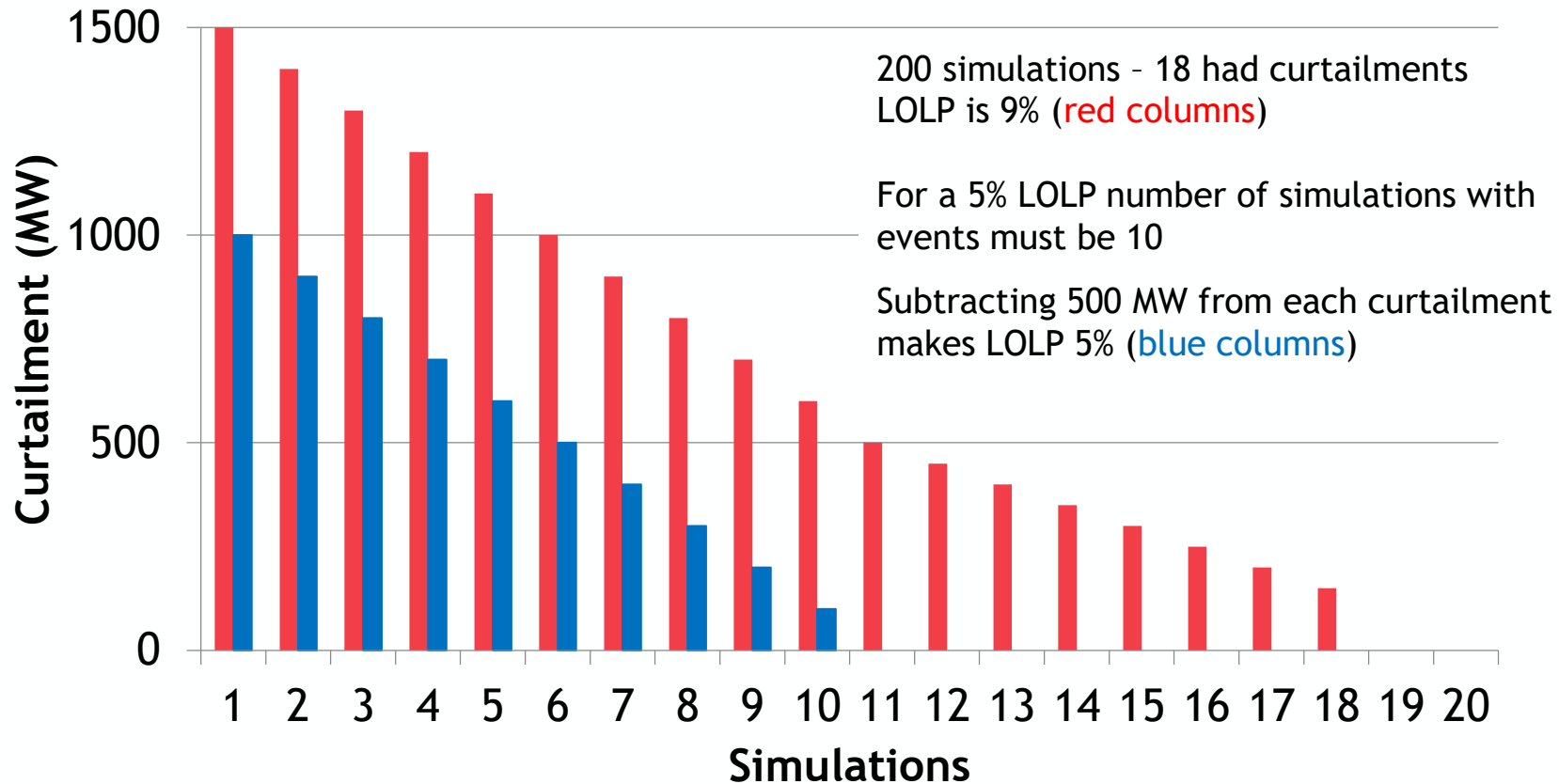
Calculating ASCC

1. Base case:
Begin with an inadequate supply (i.e. LOLP \gg 5%)
2. Determine how much “perfect” capacity is needed to reduce LOLP to 5% (cap-need-base)
3. Study case:
Add a new resource (with nameplate-capacity)
4. Determine how much “perfect” capacity is needed to reduce LOLP to 5% (cap-need-study)
5. $ASCC = \frac{\text{cap-need-base} - \text{cap-need-study}}{\text{nameplate-capacity}}$



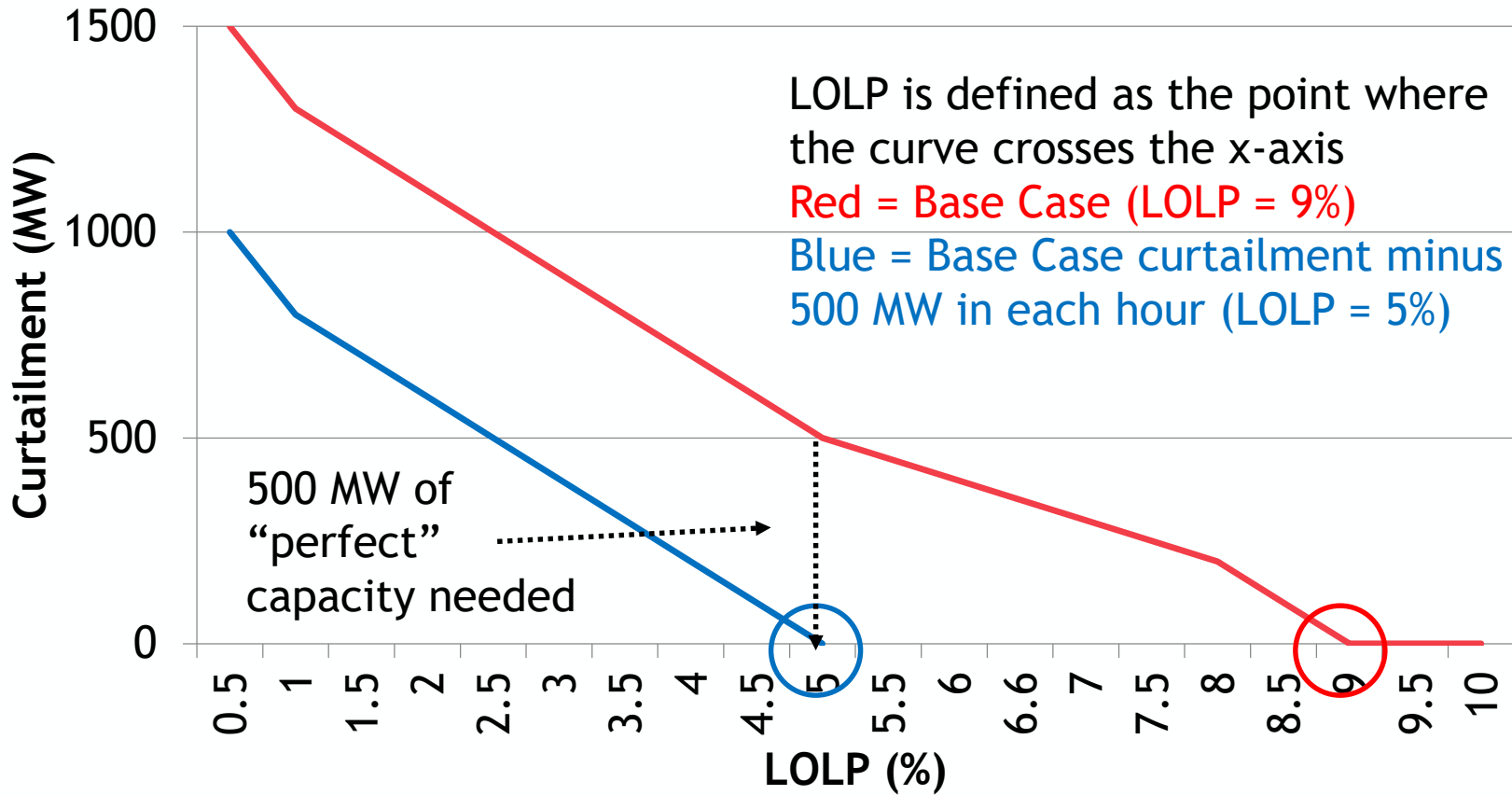
Peak-Hour Curtailment Duration Curve

(Largest hour curtailment per game, sorted highest to lowest)



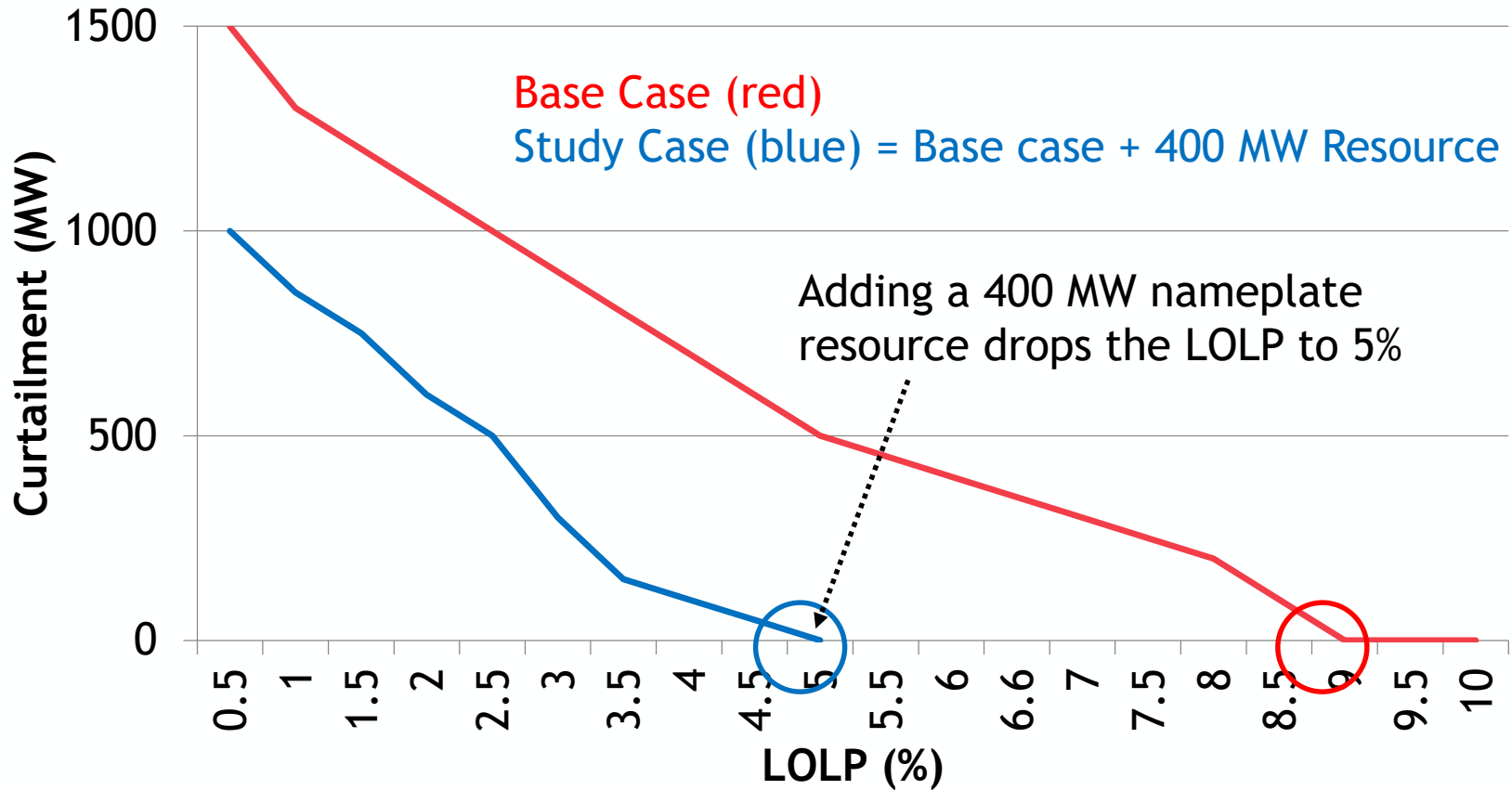
Peak-Hour Curtailment Duration Curve

(Same as before but LOLP on x-axis)



Peak-Hour Curtailment Duration Curve

(Same as before but LOLP on x-axis)



Adding a 400 MW resource is equivalent to adding 500 MW of “perfect” capacity to the curtailment curve, thus
 $ASCC = 500/400 = 125\%$



ASCC Values (%) from the 7th PPlan^{1,2}

Resource	Fall	Winer	Spring	Summer
Solar PV	26	81	81	42
Energy Efficiency	124	101	114	116
Wind	3	11	11	8
Gas-Fired Turbine	128	100	102	120
Geothermal	128	100	102	120

¹The net gain in peaking capability should be attributed to the hydro system.

²Incremental capacity gains diminish as more resource is added.



ASCC vs. ELCC

- The **ASCC** is essentially the same as the Effective Load Carrying Capability (ELCC)
- The Council chose to use a different name because of the way in which it calculates ASCC
- **ELCC** is more typically calculated using Expected Unserved Energy (EUE) instead of using the curtailment duration curve
- ELCC is more precise because it accounts for all shortfall hours but it takes longer to assess (more iterations)
- ASCC is faster and is sufficient for the analytical tools used to develop the power plan



Calculating ELCC using EUE

- Begin with an adequate power supply (however it is defined)
 - Record the EUE
 - Add an increment of load and record the increase in peak hour load
 - The resulting EUE is larger because the new system (with higher load) becomes less adequate
 - Add increments of new resource until the EUE matches the original EUE (for an adequate supply)
 - The ELCC (in units of percent) tells us how much peak load each unit of new resource can serve without affecting adequacy
 - Example: If ELCC is 10% then 100 MW of resource can serve 10 MW of peak load adequately
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- $ELCC = 100 \times \frac{\text{increase in peak load}}{\text{added nameplate capacity}}$



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.
- The Council's 5% Loss-of-Load-Probability (LOLP) standard is translated into an Adequacy Reserve Margin (ARM).
- Seasonal (quarterly) ARM's are used in the Council's Regional Portfolio Model to ensure that resulting resource strategies yield adequate future power supplies.



Calculating ARMs

- The **capacity ARM** is calculated by subtracting the expected peak load from the aggregate capacity of a system whose LOLP is exactly 5%, divided by the load.
- The **energy ARM** is calculated by subtracting the expected average load from the aggregate average generating capability of a system whose LOLP is 5%, divided by the load.
- Aggregate capacity takes ASCC values into account, which include forced outage rates and maintenance.
- Expected peak and average loads are weather-normalized
- ARM_E (energy) = (average capability – average load)/average load
- ARM_C (capacity) = (peaking capacity – peak load)/peak load



ARM_C (Capacity)

(Based on a power supply just at a 5% LOLP)

Resource Type	Adequacy Reserve Calc	Value (MW)
Thermal	Nameplate	15,000
Wind	ASCC value of 5%	250
Hydro	Lowest 10-hr sustained peak	20,625
Solar	ASCC value of 25%	125
Imports	Max per hour	2,500
Total Resource		38,500
Load	Peak-hour Load	35,000
ARM Capacity	(Resource - Load)/Load	10%



Example of How the ARM_C Works

For a Future Operating Year	
Peaking capability	41,000 MW
Peak load	39,000 MW
Implied adequacy reserve	$(41,000 - 39,000) / 39,000 = 5\%$
ARM Capacity Requirement	10%
Assessment:	System is inadequate
Action:	More resource needed
Resource need = (ARM * Load) + Load	$(0.1 * 39,000) + 39,000 = 42,900$ MW
Incremental resource need = Resource need - peaking capability	$42,900 - 41,000 = 1,900$ MW

For this example, to meet the 10% ARM requirement, an additional 1900 MW of capacity must be added to the system.



Validating ASCC and ARMs

- From the 7th power plan, several future year resource buildouts were selected to test for adequacy
- **Goal: LOLP should be between about 2% and 5%** (i.e. to ensure an adequate but not overbuilt supply)
- For all tested years from the 7th plan output, the LOLP fell within the desired range.
- Without using the ASCC values, future resource mixes were always overbuilt (i.e. LOLP = 0%)



Optional

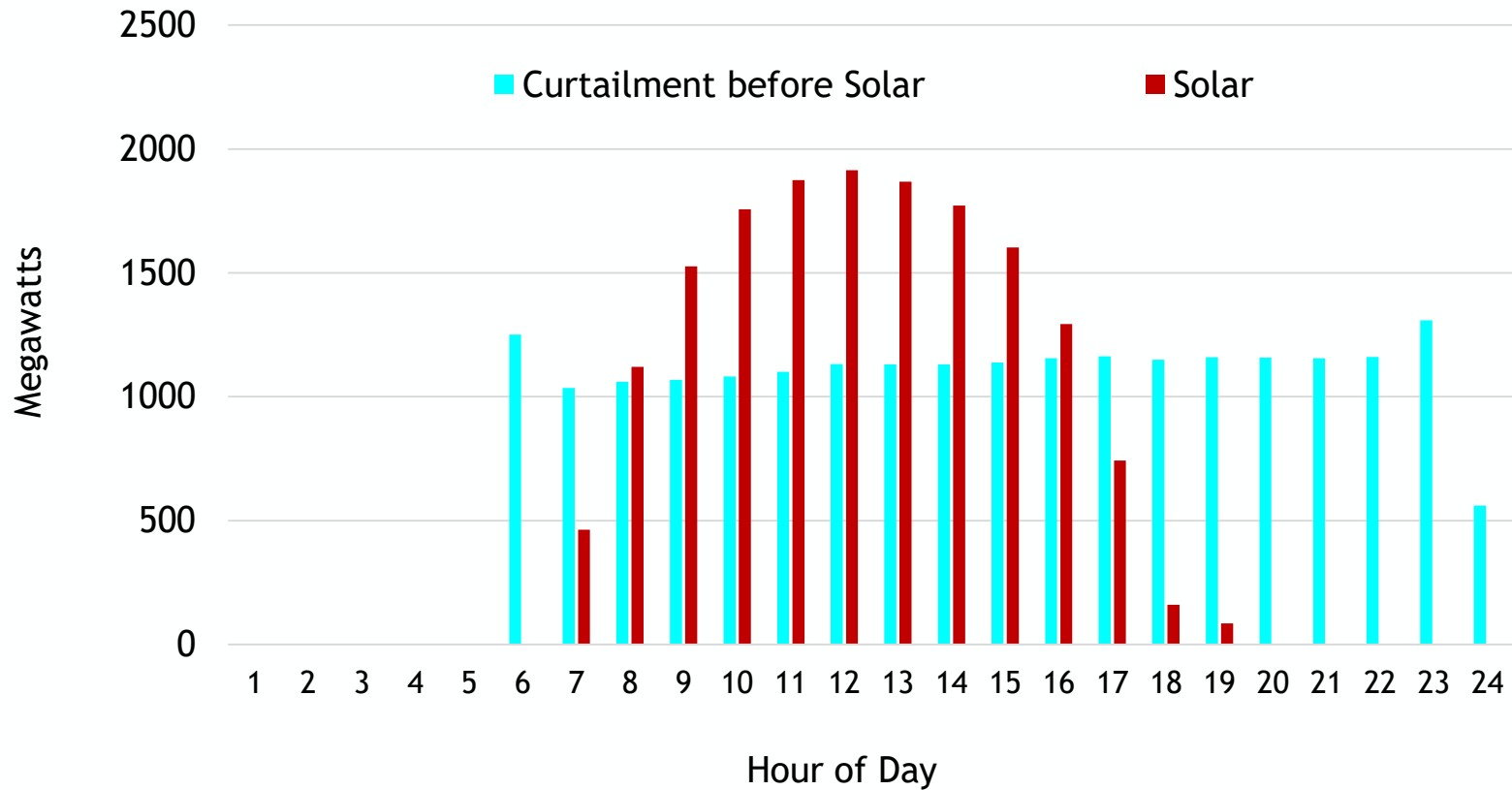


Why Solar Integrated Capacity is so much higher than its Standalone Capacity

- Simulated curtailment events range from one hour to over 24 hours
- About 1/3 of all curtailment events are 18 hours in duration (because the hydro system is used to flatten out anticipated peak hours shortfalls)
- Since solar only provides generation roughly between 7am and 7pm, not all of the 18-hour shortfall events will be satisfied
- However, when coupled with hydro storage, the combined effect can satisfy many more longer-duration curtailment events
- Example is provided in the following slides...



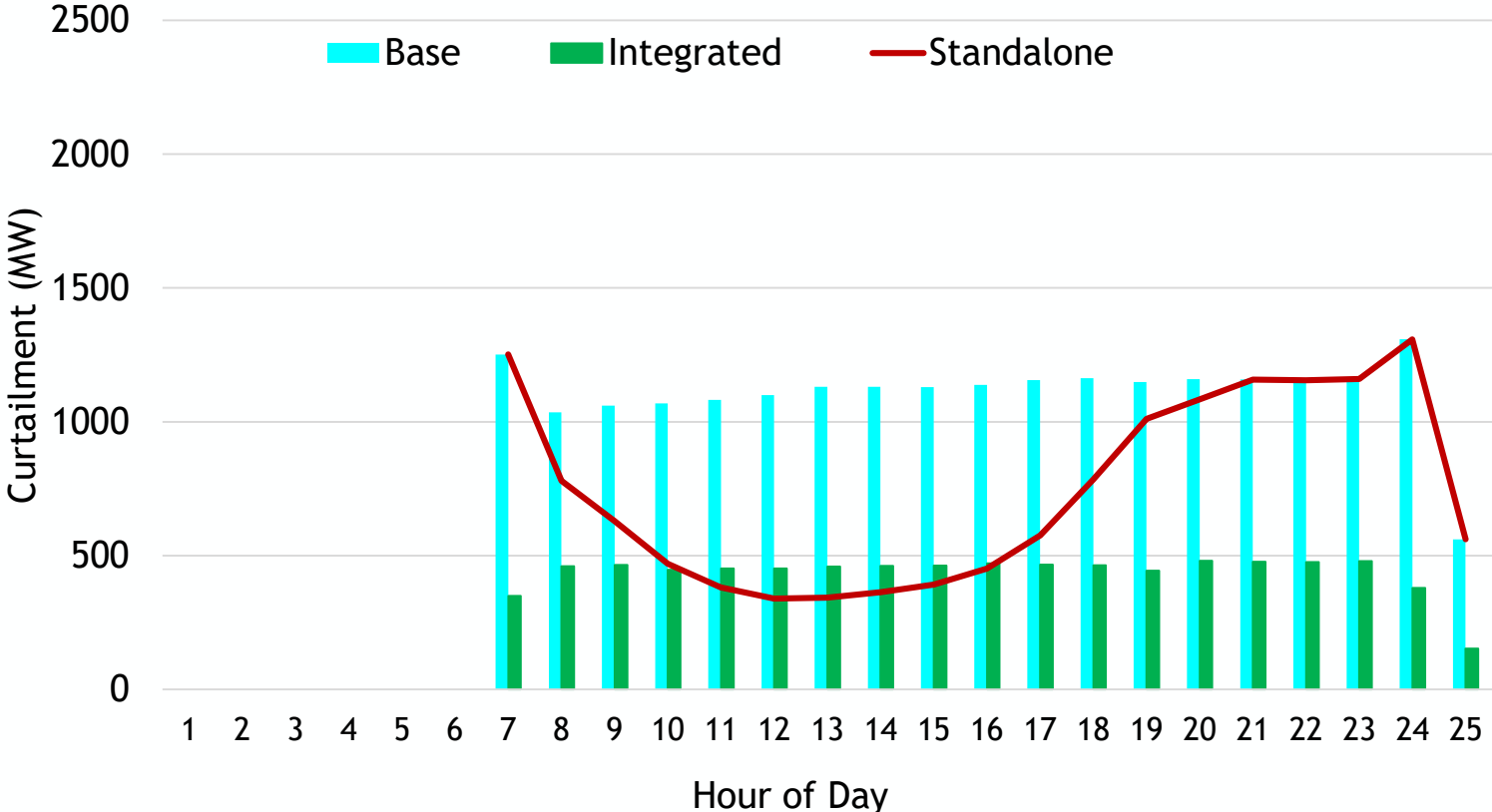
Typical Shortfall Event and Solar Generation



- Some curtailments occur when solar is not generating
- As a standalone resource, surplus solar generation cannot be shifted into other hours



Curtailment with Standalone and Integrated Solar



Integrating Solar affects Hydro & Thermal Resources

