ETAC Meeting Agenda

April 20, 2022

Item	Lead	Start Time	End Time
Kickoff and Introductions	S. Schmitt, NorthWestern	9:30	9:40
Project Status Update	S. Schmitt NorthWestern	9:40	9:50
Deep Dive on Scenarios and Modeling Process	D. Millar, B. Mauch Ascend Analytics	9:50	11:00
Break		11:00	11:10
Mid-C Power Price Forecast	B. Nelson, Ascend Analytics	11:10	11:45
Long-term Technology Cost Forecast	D. Millar, Ascend Analytics	11:45	12:00
IRP Table of Contents Review	D. Millar, S. Schmitt	12:00	12:20
Wrap up	D. Millar, S. Schmitt	12:20	12:30

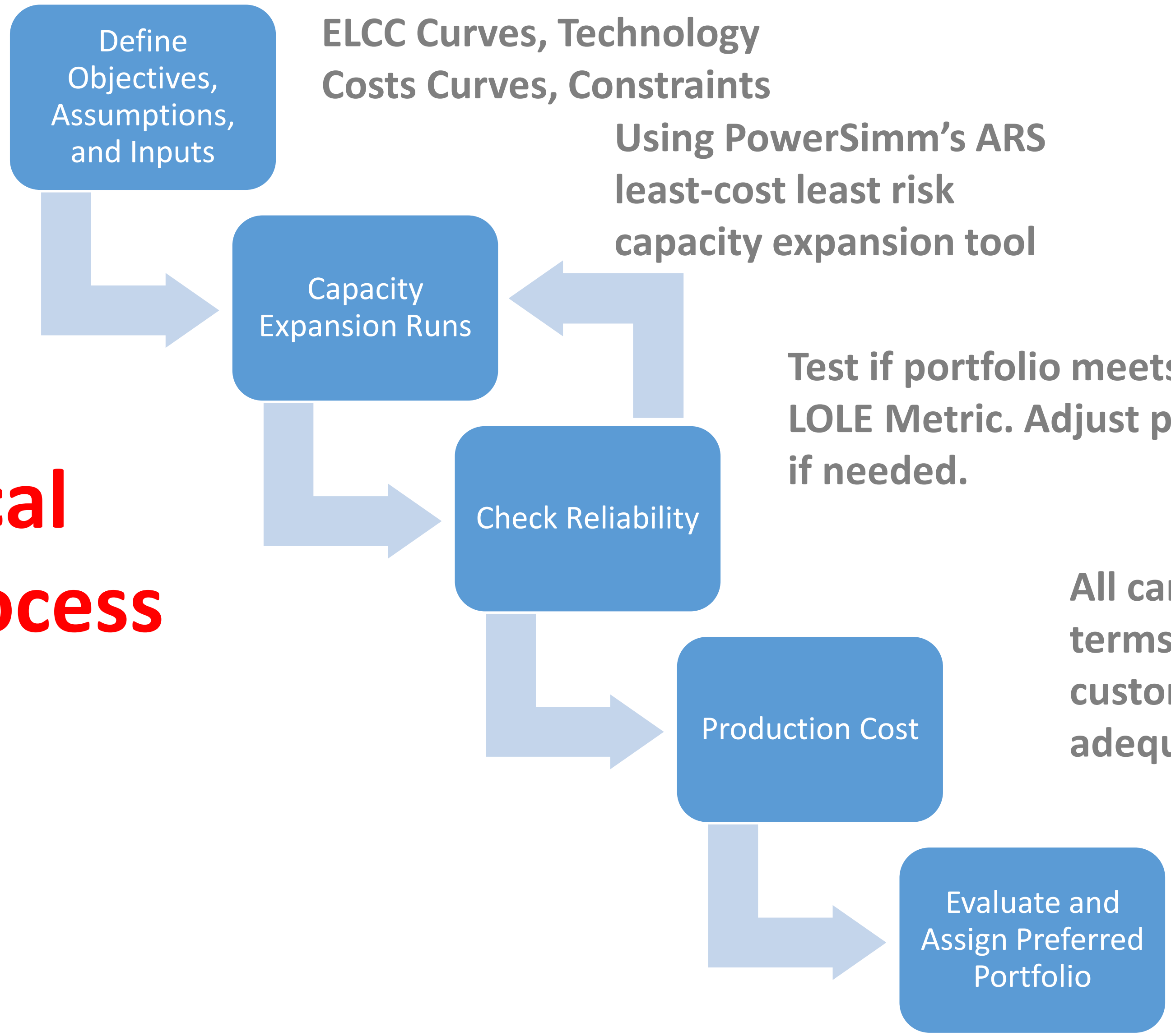
Project Schedule

Item	Status	Timing
February ETAC	Complete	Feb 22, 2022
ELCC Studies for solar, wind, and storage	Ongoing, preliminary results shown today	March – April
April ETAC	Today	April 20, 2022
Capacity Expansion and Production Cost Runs	Not Started	May – June
June ETAC *Show First Round Results*	Not Started	June 22, 2022 (tentative)
Second round (including sensitivities)	Not Started	June – August
September ETAC *Show comprehensive results*	Not Started	September 14
Write IRP	TOC Developed	May – October
Draft IRP issued to ETAC Stakeholders for Comment	Not Started	Oct 4
Receive Comments from Stakeholders	Not Started	Oct 18
Draft submitted to PSC	Not Start	October 24
Final IRP filed at the Montana PSC	Not Started	December 15

Agenda

- Project Status Update
- Scenarios and Modeling
- Mid-C Price Forecast
- Technology Cost Forecast
- TOC Review

The Analytical Planning Process



ELCC Curves, Technology Costs Curves, Constraints

Using PowerSimm’s ARS least-cost least risk capacity expansion tool

Test if portfolio meets 0.1 LOLE Metric. Adjust portfolio if needed.

All candidate portfolios evaluated in terms of net present value to NWE customers, emissions, resource adequacy, and resiliency

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Scenario Approach – Core Cases

- Four capacity expansion runs with various Colstrip retirement dates
  1. 12/31/2042 (base case)
  2. 12/31/2035
  3. 12/31/2030
  4. 12/31/2025
- Sensitivity Runs
  - Add social cost of carbon $50/ton with 5% annual growth rate)
  - Test SMR replacement of Colstrip at 2030 and 2035.
- Track carbon emissions for each run. Several scenarios will likely qualify as a decarbonization plan.

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Developing an IRP with ARS

Process

Define market assumptions and candidate resources

- Market Prices
- ELCC
- PPA costs

Define constraints

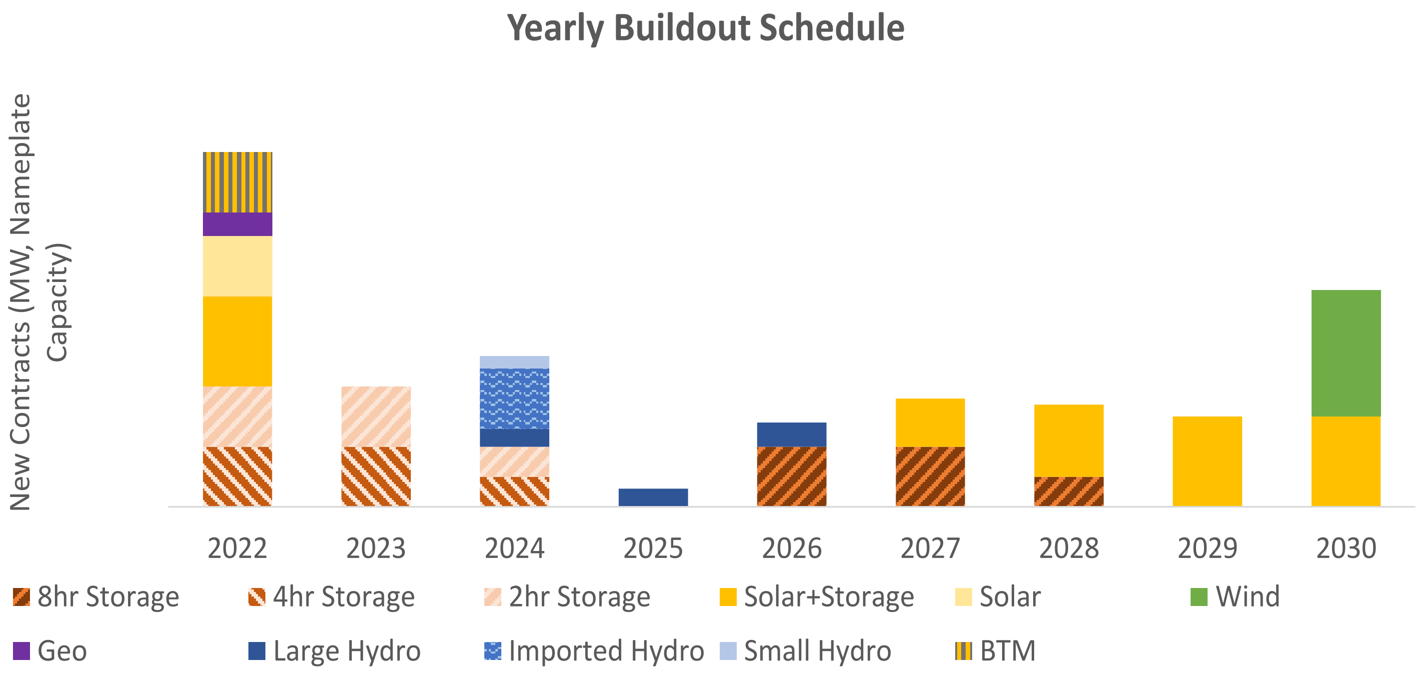
- GHG
- RPS
- Reserve Margin

Iterate

Analyze optimized expansion plan

- Resource Selection
- Cost
- Value

Choose Preferred Plan



PowerSimm can select any type of resource and optimize across multiple criteria (GHG, RPS, RA, market exposure, etc.). PowerSimm combines least-cost optimization with risk to generate portfolios that strike an optimal balance between cost and risk.

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Candidate resource list

Technology/Fuel	Resource	Size
Renewable	Wind	50 MW
	Solar	50 MW
	Solar Storage hybrid	50 MW
	Wind Storage hybrid	50 MW
Storage	Stand Alone Storage (4- hour)	25 MW
	Stand Alone Storage (8-hour)	25 MW
	Pumped Hydro (9 - hour storage)	100 MW
Natural Gas	Aeroderivative gas turbine	50 MW
	Combined Cycle (2x1)	250 MW
	RICE	18 MW
Uranium	Small Modular Reactor	80 MW or 320 MW (4 units)

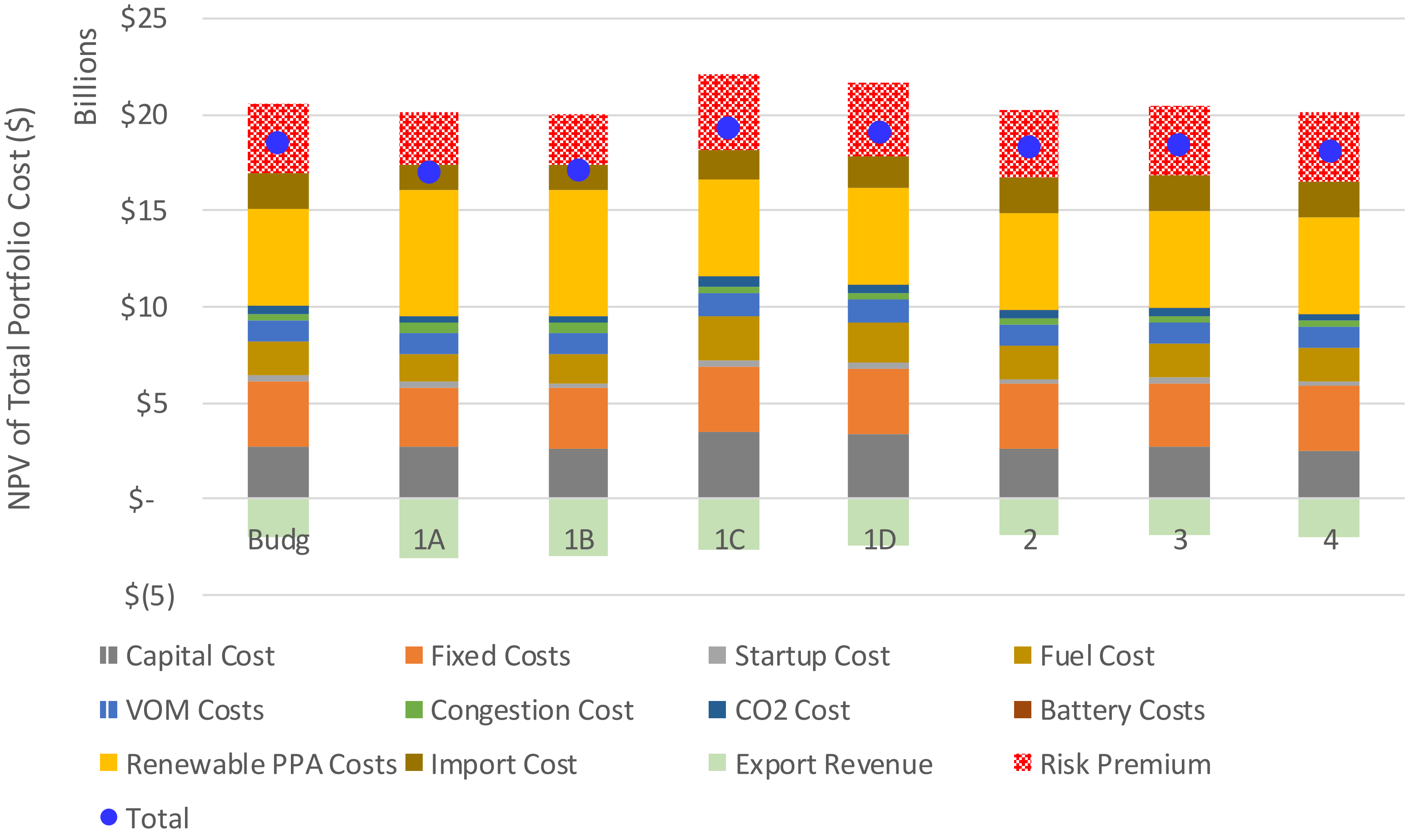
What is production cost modeling?

- Production cost modeling is used to project the physical and economic dynamics of a utility serving customer load in the future
- The core elements are customer load, utility owned and contracted resources, and market prices.
- All resource generation is valued at the hourly price of energy. Our model simulates hourly market price conditions now through 2050.
- Production cost includes the operations costs of NorthWestern units, such a fuel and operations and maintenance costs.

Q: Why do we dispatch to market prices?

A: Because NorthWestern exists within a broader wholesale energy market. NorthWestern can serve load with either owned generation or market purchases. The market provides the best indicator for the value of energy at every hour. NorthWestern is also a participant in the Western Energy Imbalance market, which today provides 15- and 5-minute prices and hourly day-ahead prices in the future.

The final analysis: a balancing act



We use production cost simulation results plus capital expenditures to calculate net present value of candidate portfolios for economic comparison.

We want to identify the portfolio with the best balance between cost, price risk, reliability risk, and environmental impacts.

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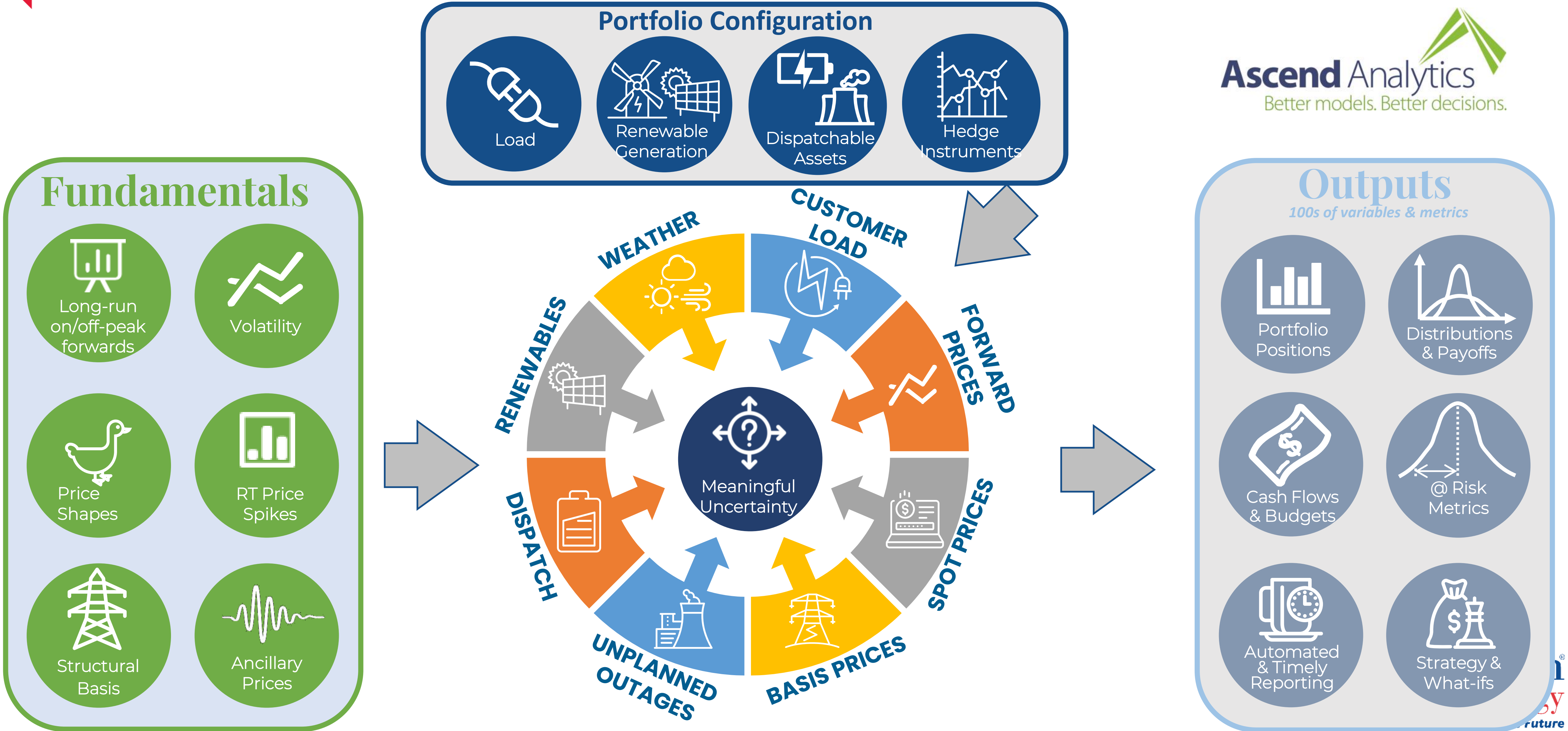
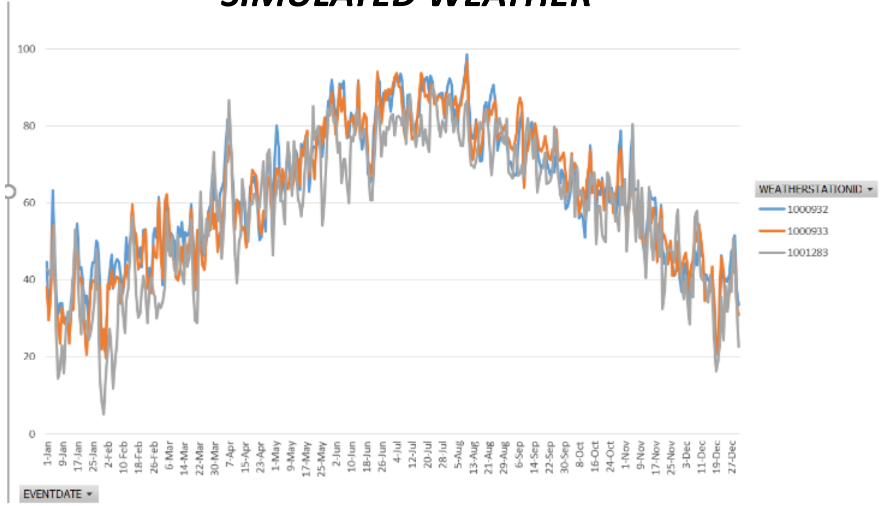
Ascend Analytics PowerSIMM for Client Portfolio Simulation



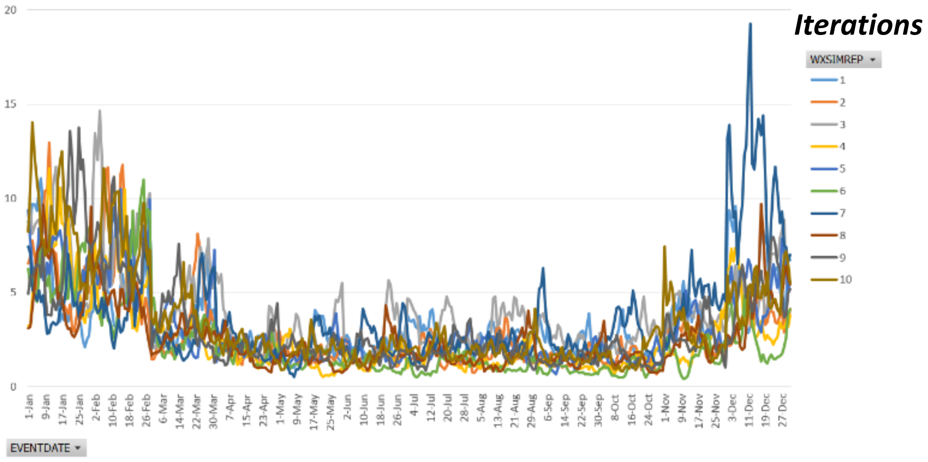
PowerSIMM's data rich & robust analytic environment

Example: Simulated Temperature, Load, Gas and Power Prices

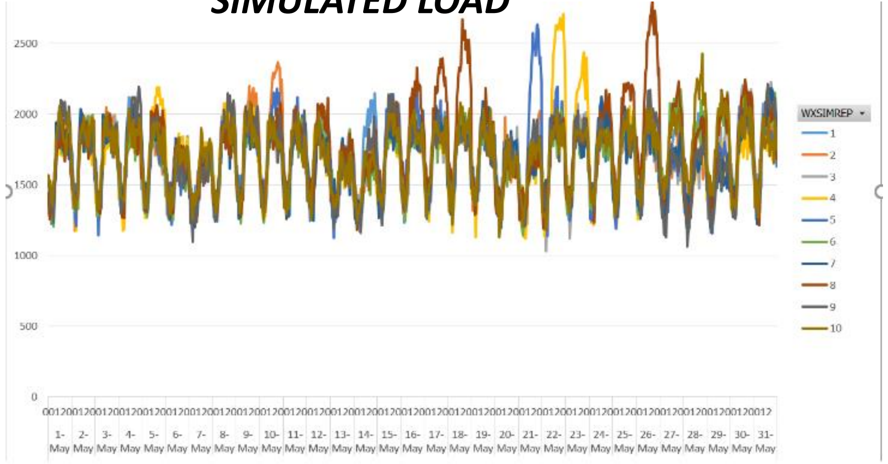
SIMULATED WEATHER



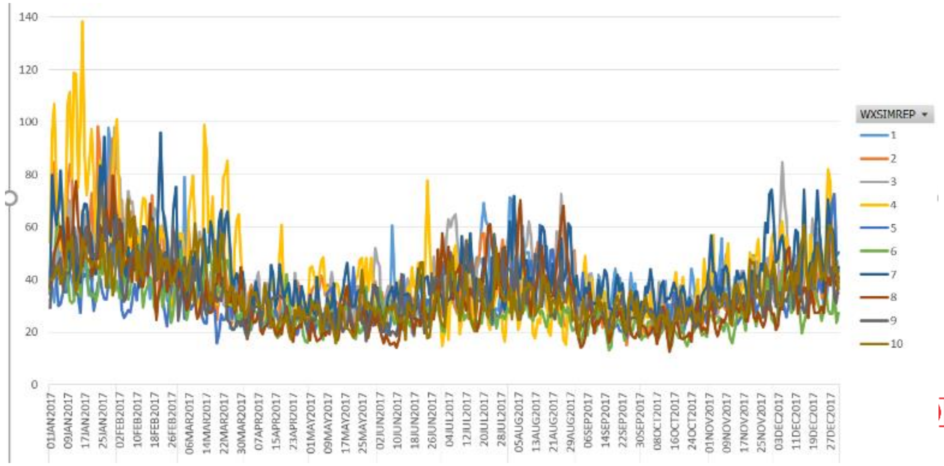
SIMULATED GAS



SIMULATED LOAD



SIMULATED POWER



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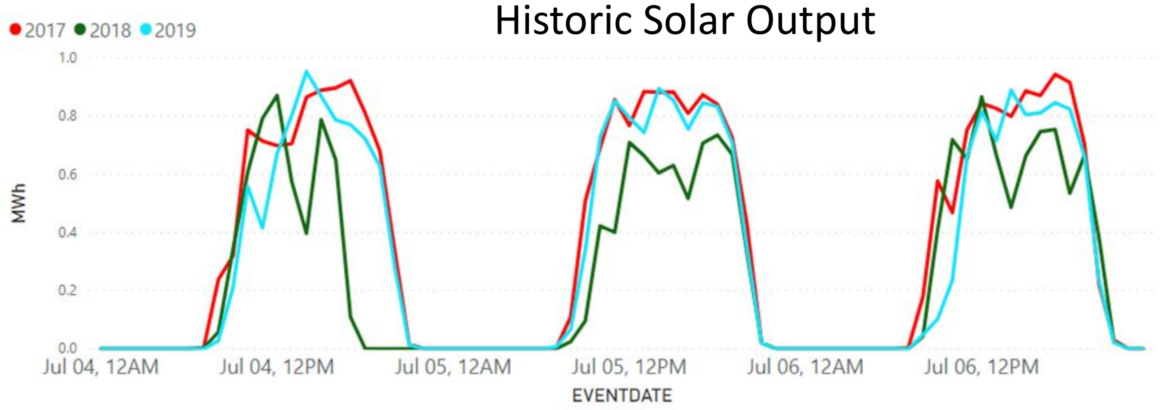
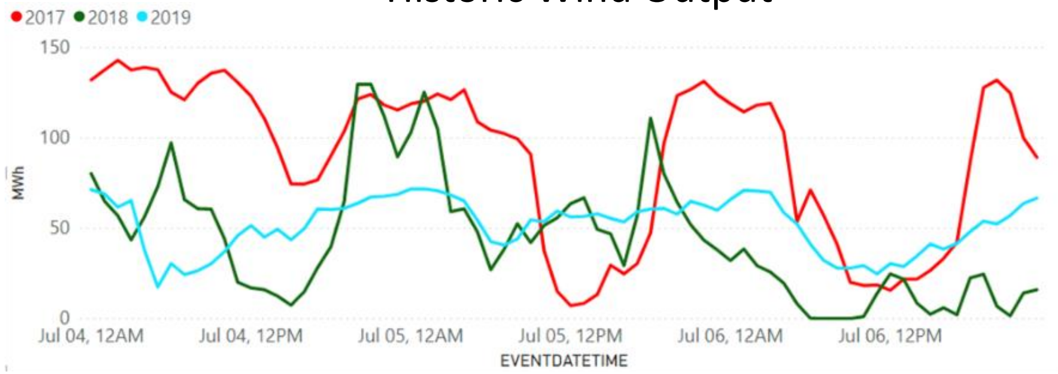
Simulating supply uncertainty in renewable generation

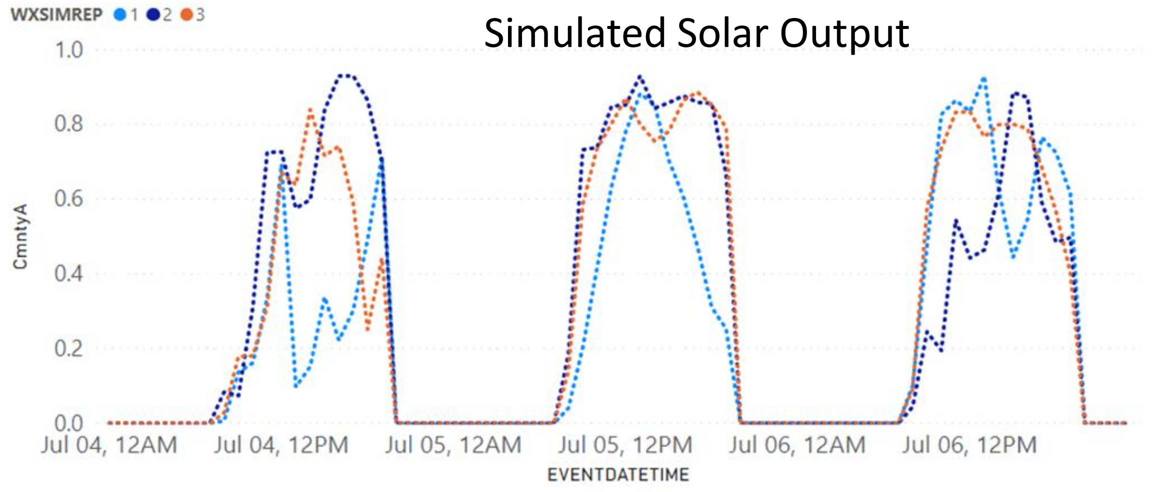
Historic Solar Output



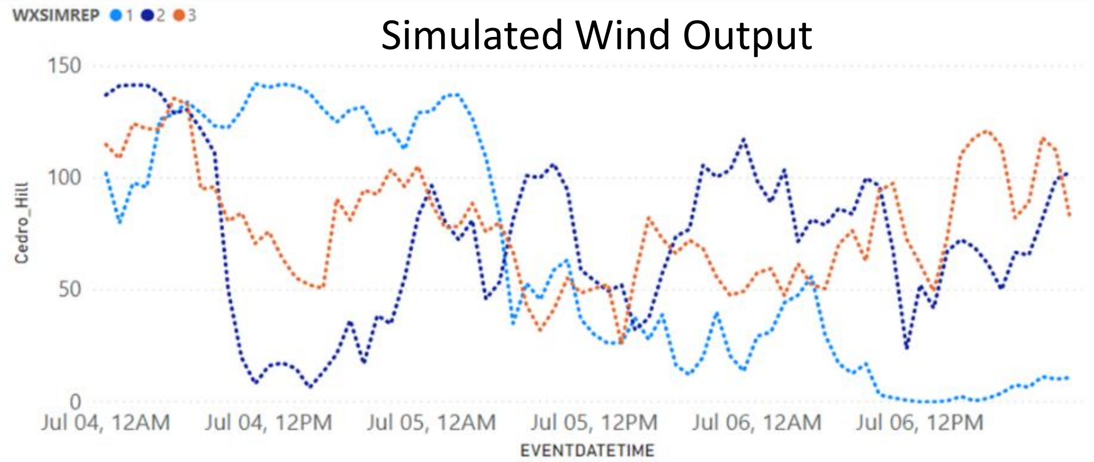
Historic Wind Output



Simulated Solar Output



Simulated Wind Output



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PowerSimm Reliability Planning

Weather drives load and renewable generation

Simulated Weather

Simulated renewables generation & load

Renewables

Hydro

Load

+

Forced outages and energy limitations

Battery Charge level

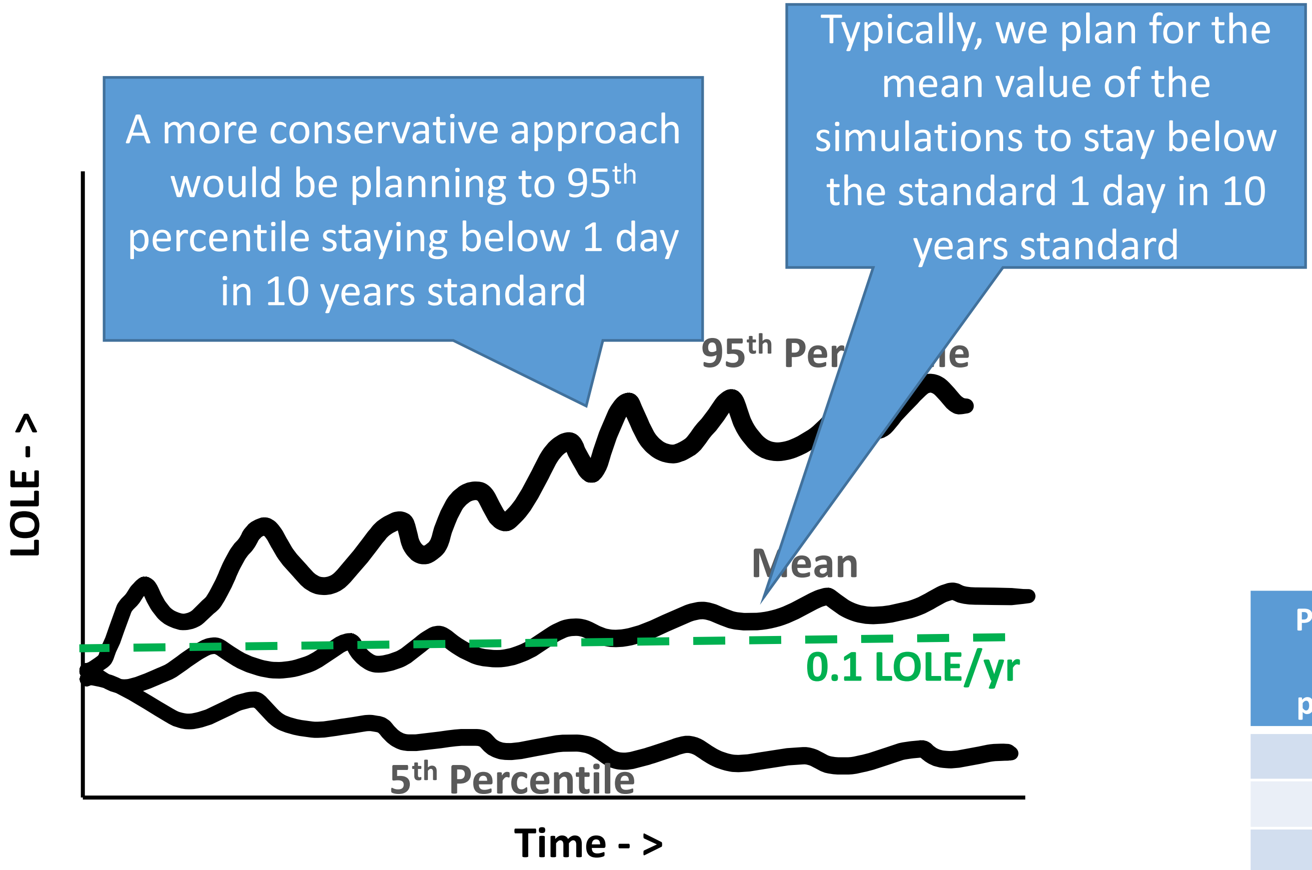
Generation outages

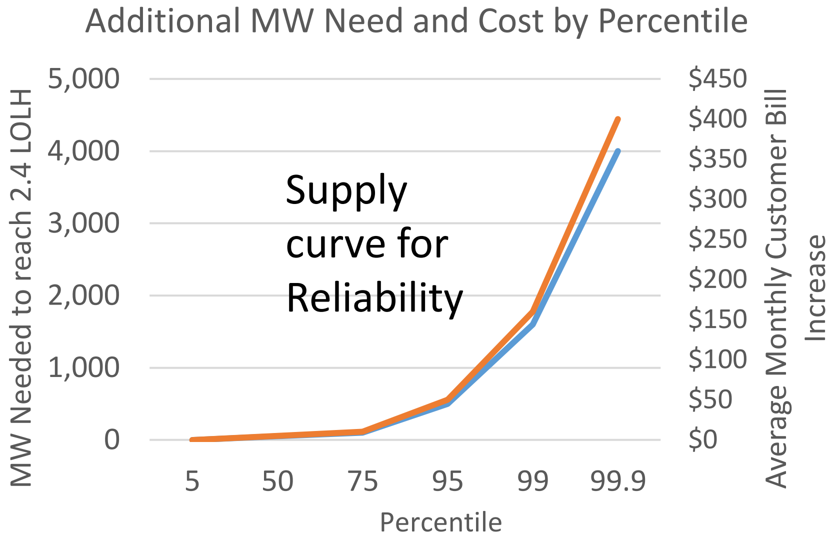
=

Loss of Load Expectation

PowerSimm™ **captures the interactions of weather→ renewables, load and storage level**

Diagram of LOLE Analysis





Plan using which percentile	Additional MW needed	Additional Capital Cost ($M)	Additional $ per Month on Cust. Bills
5	0	$0	$0
50	50	$75	$5
75	100	$150	$10
95	500	$750	$50
99	1600	$2,400	$160
99.9	4000	$6,000	$400

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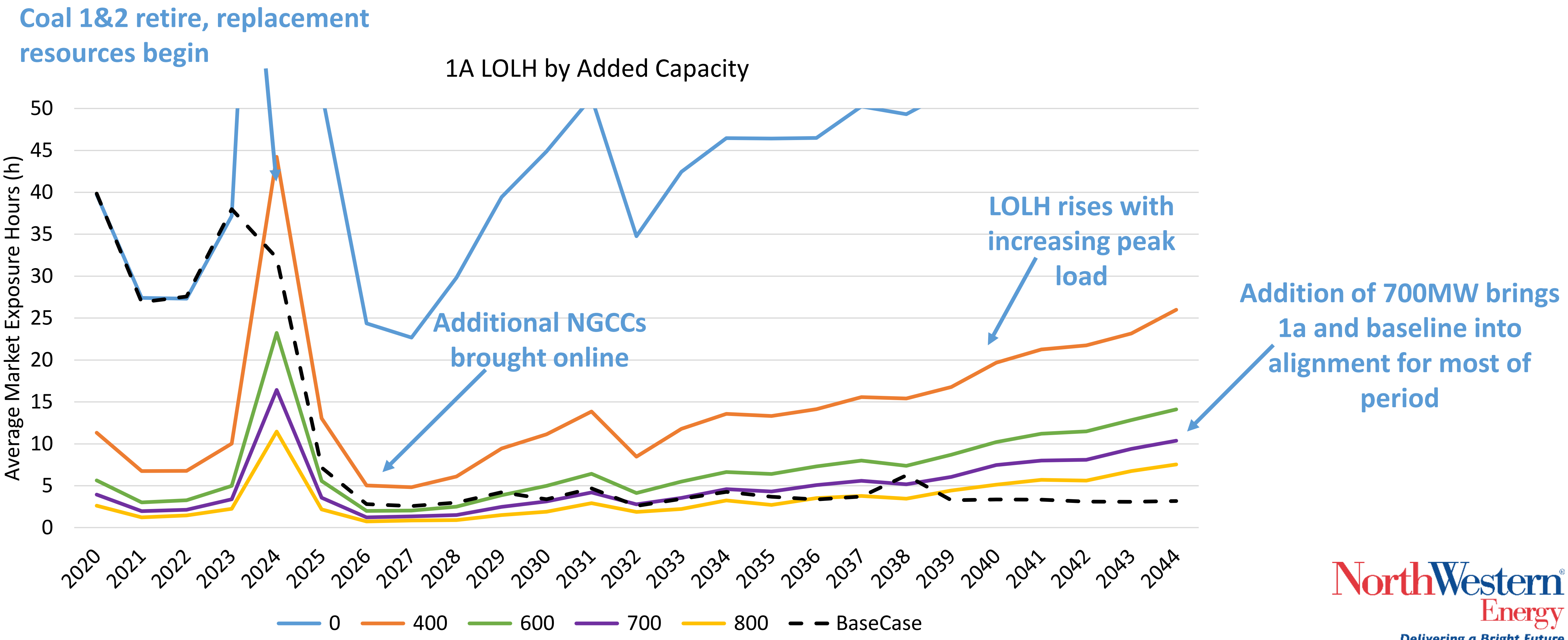
LOLE Example for Capacity Planning

Case 1a requires the addition of ~700MW to Firm Up the Portfolio



LOLH run on a 200 simrep study. Includes Forced Outages, excludes Planned Outages.

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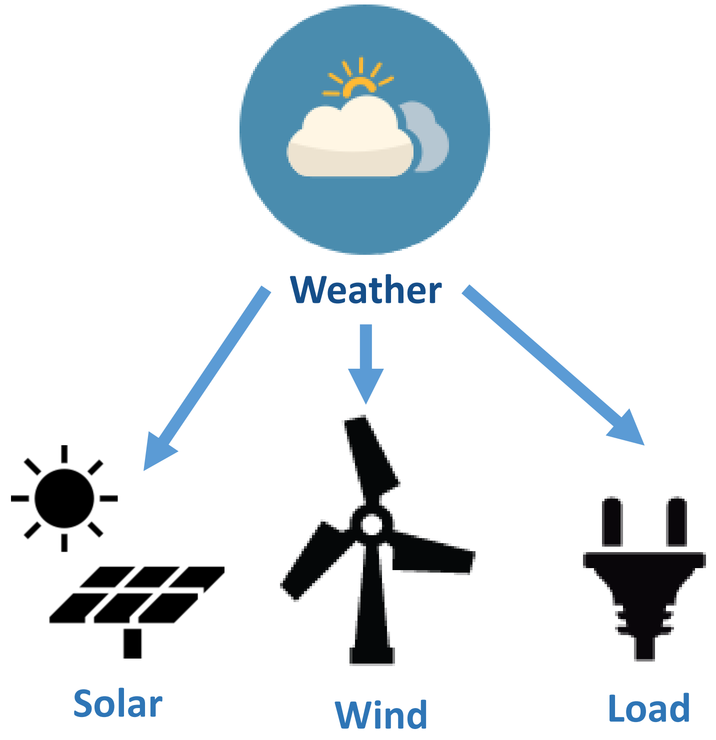
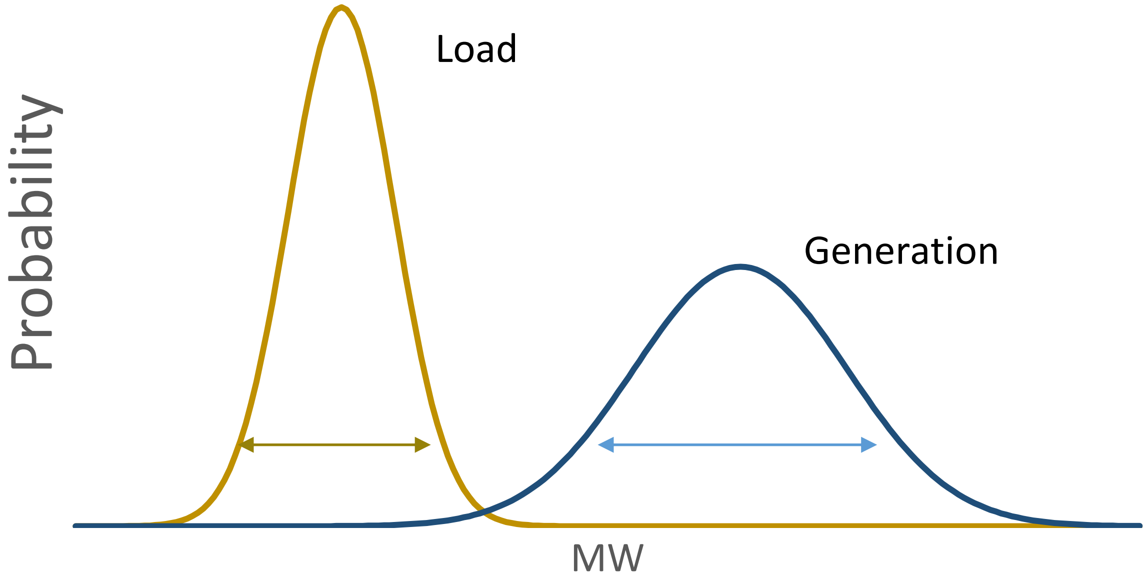
Resource Adequacy Analysis in Today's Systems

Weather is becoming the primary "fuel"

- Weather drives uncertainty in load AND generation
- In addition to unforeseen outages, there is uncertainty in generation output
- Load and generation are no longer independent variables





Weather volatility widens distributions for load and generation

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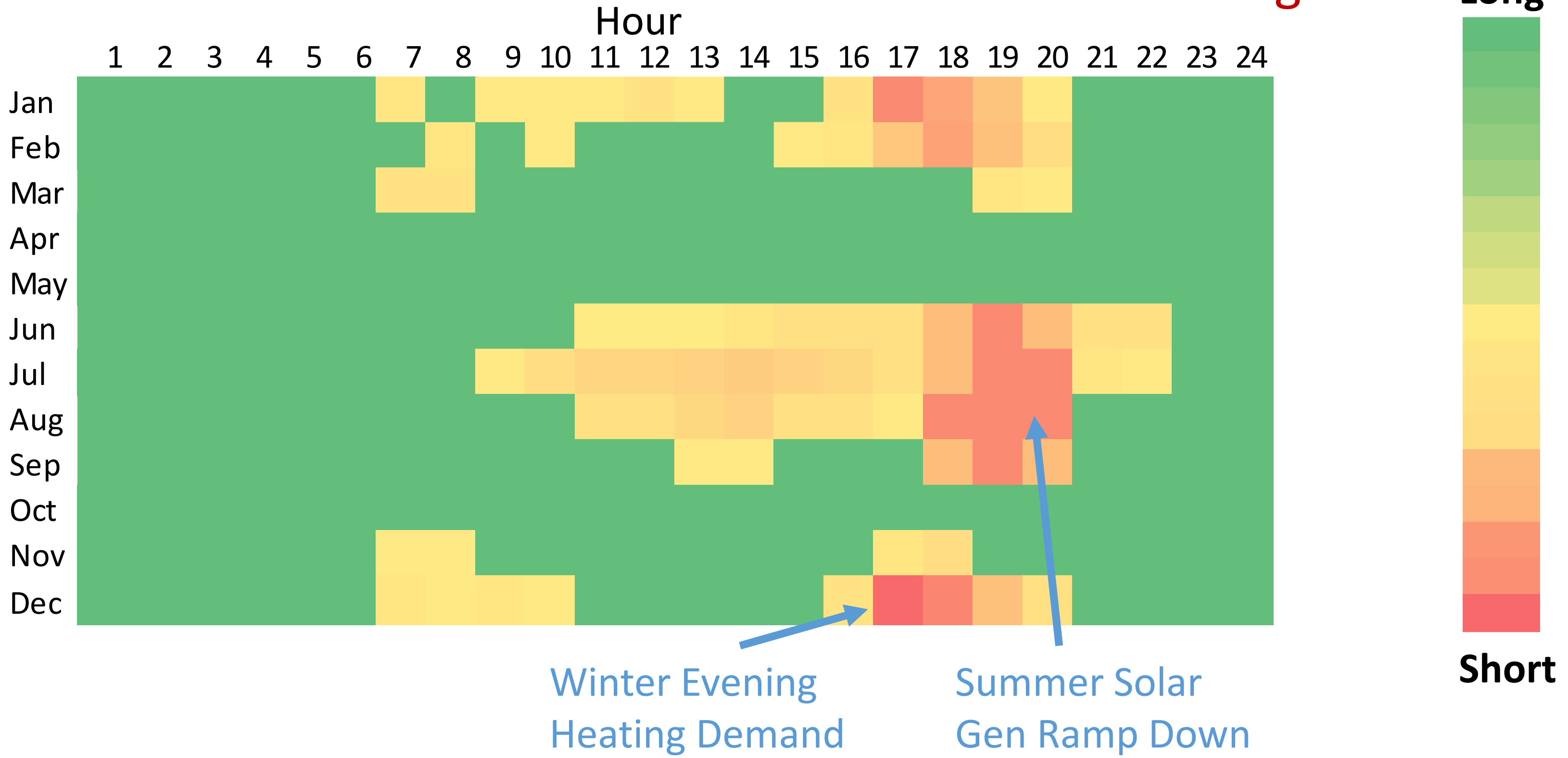
Resource Adequacy is More Than Peak Load Hours

Risk of Capacity Shortfalls Follow Seasonal and Daily Patterns of Load and Renewables

- Winter load can be high with electric heat
- Spring and fall months generally have lower load and higher wind generation
- Summer months see significant risk after solar generation comes offline and load remains high

Extreme weather will increase risk in the winter and summer evenings!



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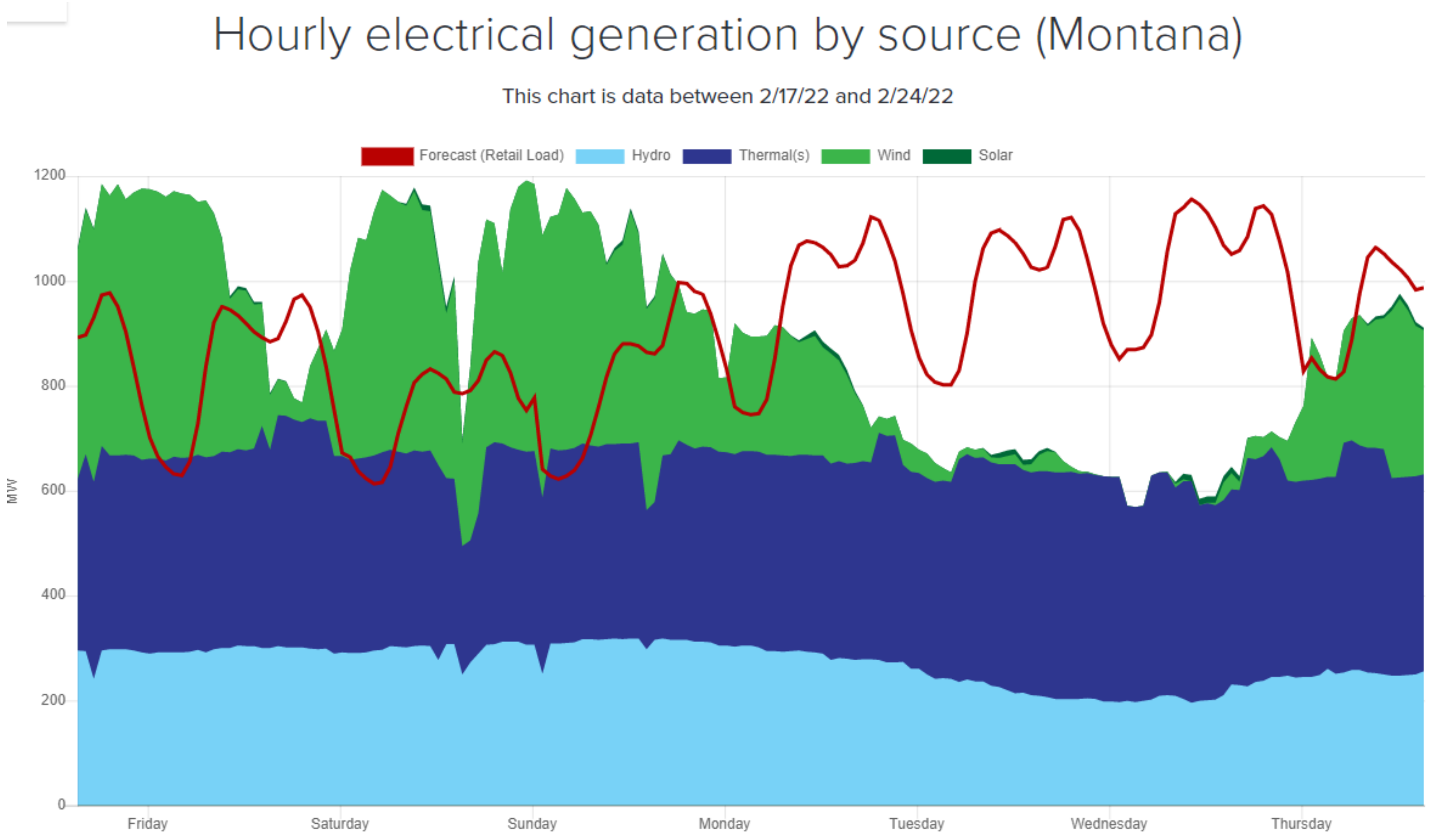
Why we worry about depth and duration of shortfalls



NWE was short resources when the wind died down in February for three days, by on average 500 MW. NWE was forced to rely on the market to fill the energy need.

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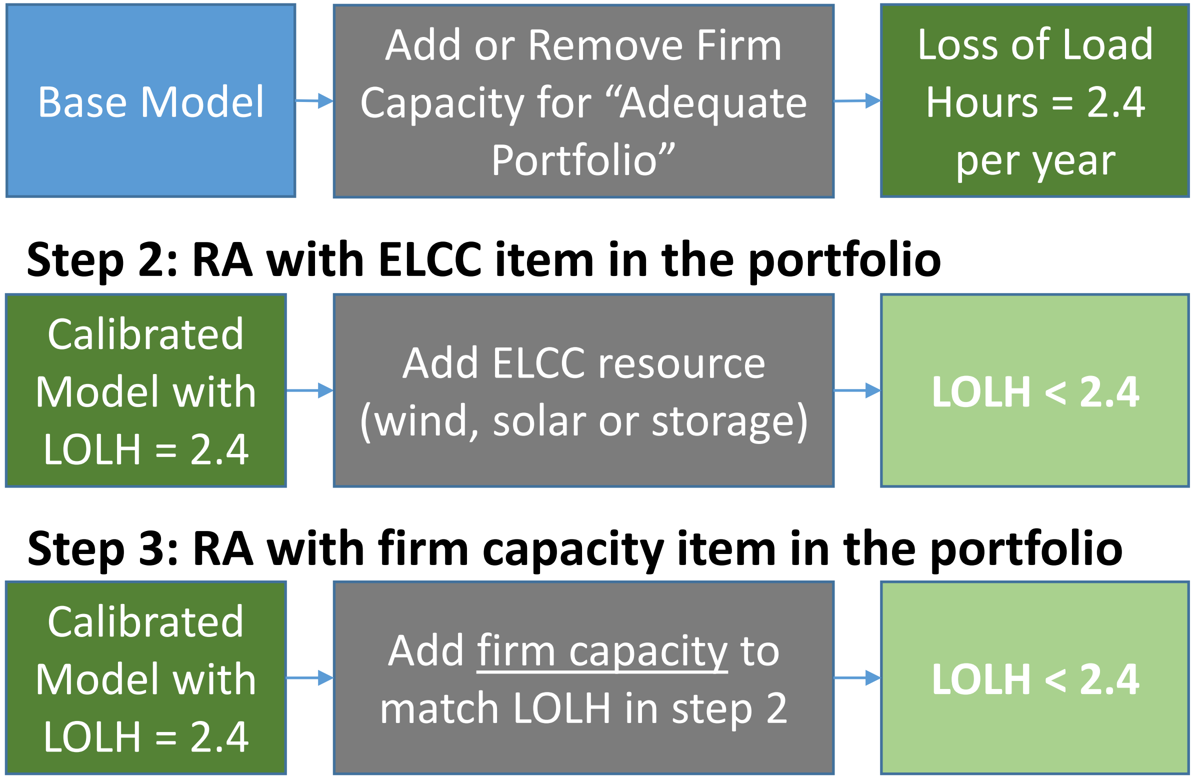
Effective Load Carrying Capability (ELCC)

- ELCC analysis determines the capacity contribution for variable resources and energy storage
  - ELCC is the industry standard approach for assigning capacity value
  - Assigns capacity value based on the contribution towards resource adequacy
- ELCC of resources are a function of the existing renewable capacity in the portfolio and the correlation of renewables with load
- As more capacity is added to a portfolio the ELCC will decline

Standard ELCC Calculation Process

Step 1: Calibrate the base portfolio to 0.1 LOLE target



$$\text{ELCC} = \frac{\text{Firm Capacity from Step 3}}{\text{Renewable Capacity from Step 2}}$$

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NWE Load Annual Peaks

Year	Peak Load (MW)	Season	Date	Day	Hour
2002	958	Summer	7/12/2002	Fri	14
2003	1,078	Summer	7/23/2003	Wed	15
2004	1,096	Winter	1/5/2004	Mon	18
2005	1,096	Winter	1/14/2005	Fri	18
2006	1122	Summer	7/28/2006	Fri	14
2007	1,177	Summer	7/6/2007	Fri	14
2008	1,225	Winter	12/15/2008	Mon	18
2009	1,219	Winter	12/8/2009	Tue	18
2010	1,166	Winter	1/6/2010	Wed	18
2011	1,139	Winter	1/31/2011	Mon	18
2012	1133	Summer	7/19/2012	Thu	11
2013	1,272	Winter	12/6/2013	Fri	18
2014	1,206	Winter	2/6/2014	Thu	18
2015	1146	Summer	8/13/2015	Thu	16
2016	1,163	Winter	12/16/2016	Fri	19
2017	1210	Summer	7/13/2017	Thu	17
2018	1196	Summer	8/10/2018	Fri	17
2019	1,171	Winter	3/4/2019	Mon	9
2020	1171	Summer	8/17/2020	Mon	16
2021	1248	Summer	7/27/2021	Tue	16

Summer months and winter months have similar peaks

NWE load peaked during summer months in five of last seven years

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Resource Adequacy Contribution of Solar

Loss of load hours by month and hour – **Base Model**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	0	0	0	0	0	0	0	0.01	0.02	0.02	0.03	0.02	0	0	0.02	0.01	0.05	0.07	0.04	0.01	0.01	0	0	0
Feb	0	0	0	0	0	0	0.03	0.02	0.02	0.01	0	0	0	0	0	0	0.03	0.06	0.06	0.01	0	0	0	0
Mar	0	0	0	0	0	0	0.01	0.01	0.01	0	0.02	0	0	0	0	0	0.01	0	0	0	0	0	0	0
Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jun	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0	0.01	0	0	0	0	0	0	0	0	0	0
Jul	0	0	0	0	0	0	0	0	0	0.04	0.09	0.12	0.11	0.22	0.17	0.18	0.08	0.03	0	0	0	0	0	0
Aug	0	0	0	0	0	0	0	0	0	0	0.02	0.03	0.06	0.11	0.06	0.09	0.04	0	0	0	0	0	0	0
Sep	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0	0	0	0	0	0	0	0
Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov	0	0	0	0	0	0	0.01	0.01	0	0	0	0	0	0	0	0	0.02	0.01	0	0.01	0	0	0	0
Dec	0	0	0	0	0	0	0.04	0	0.02	0.01	0.01	0	0	0	0	0.01	0.07	0.04	0.01	0.01	0	0	0	0

Before adding solar, NWE system is stressed July and August afternoons

Loss of load hours by month and hour – **100 MW of Solar added**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	0	0	0	0	0	0	0	0.01	0.02	0.02	0.02	0	0	0	0.02	0.01	0.05	0.07	0.04	0.01	0.01	0	0	0
Feb	0	0	0	0	0	0	0.03	0.02	0.02	0.01	0	0	0	0	0	0	0.03	0.06	0.06	0.01	0	0	0	0
Mar	0	0	0	0	0	0	0.01	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jun	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jul	0	0	0	0	0	0	0	0	0	0	0.02	0.01	0.02	0.03	0.06	0.05	0.01	0.01	0	0	0	0	0	0
Aug	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.05	0.02	0	0	0	0	0	0	0
Sep	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov	0	0	0	0	0	0	0.01	0.01	0	0	0	0	0	0	0	0	0.02	0.01	0	0.01	0	0	0	0
Dec	0	0	0	0	0	0	0.04	0	0.01	0.01	0.01	0	0	0	0	0.01	0.07	0.04	0.01	0.01	0	0	0	0

Solar reduces summer risks

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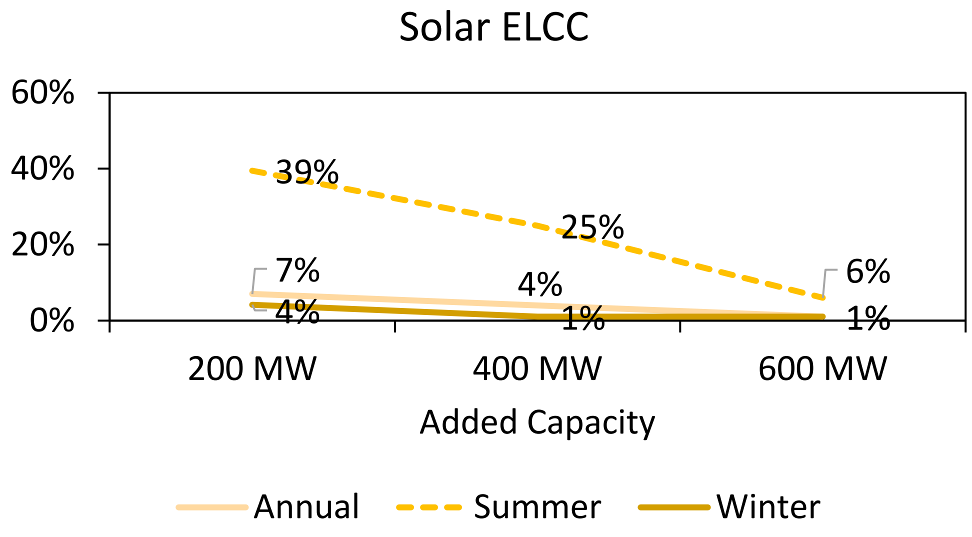
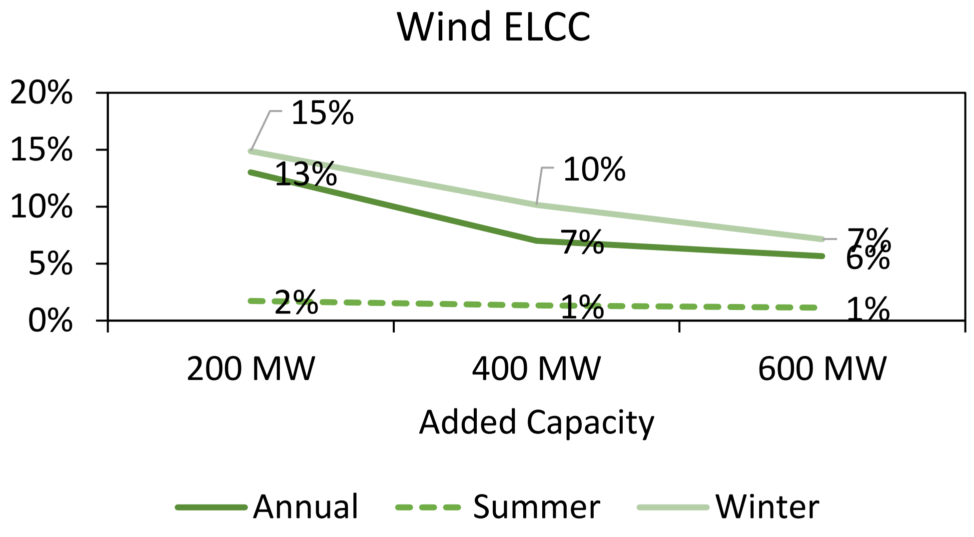
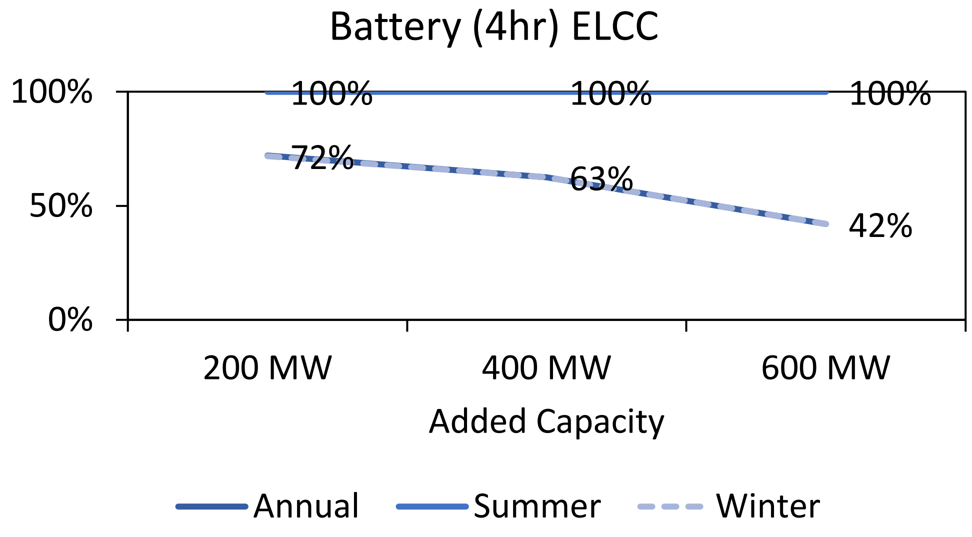
Declining value of ELCC







Values shown in the graphs assume a base portfolio ***without QFs*** in the development queue

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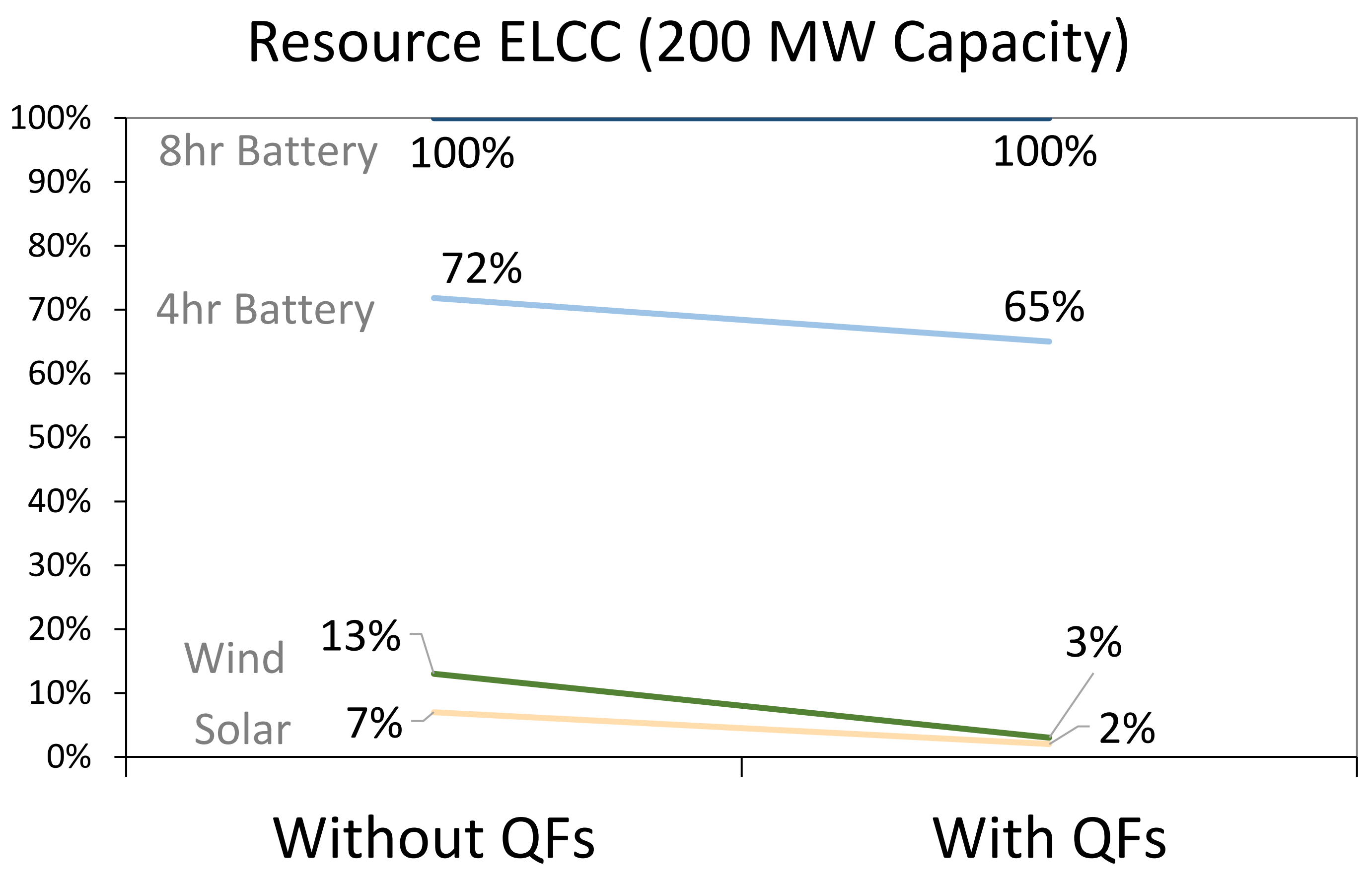
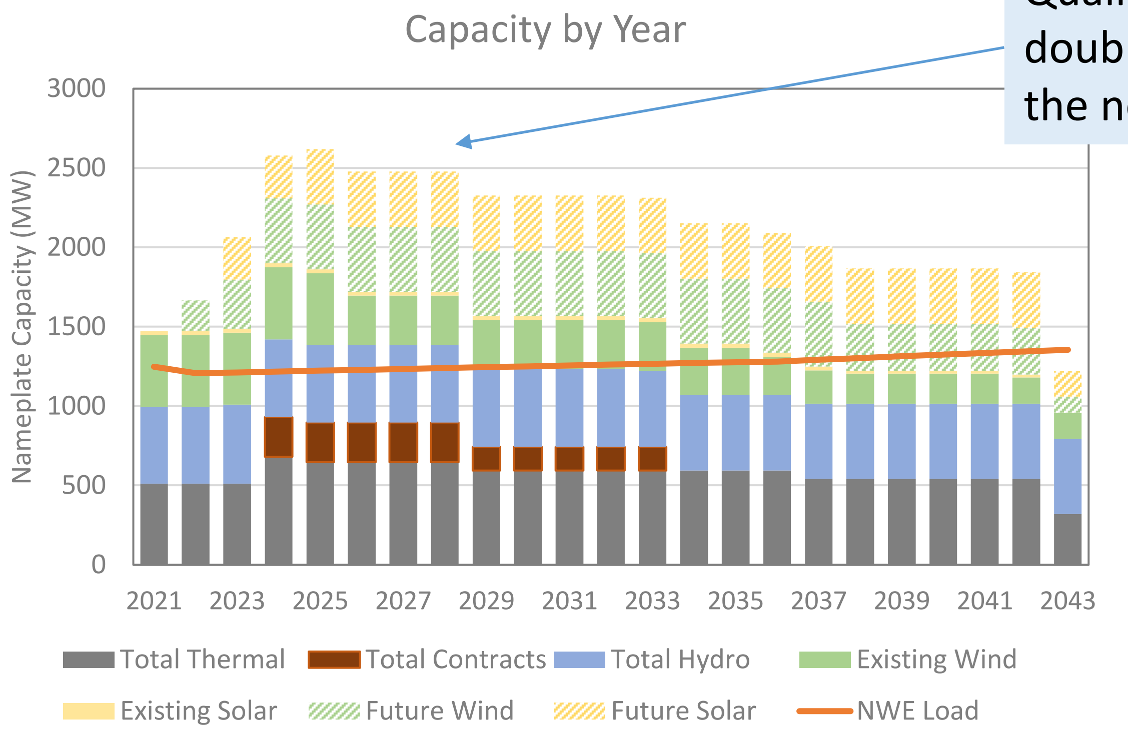
Potential QF impact on ELCC



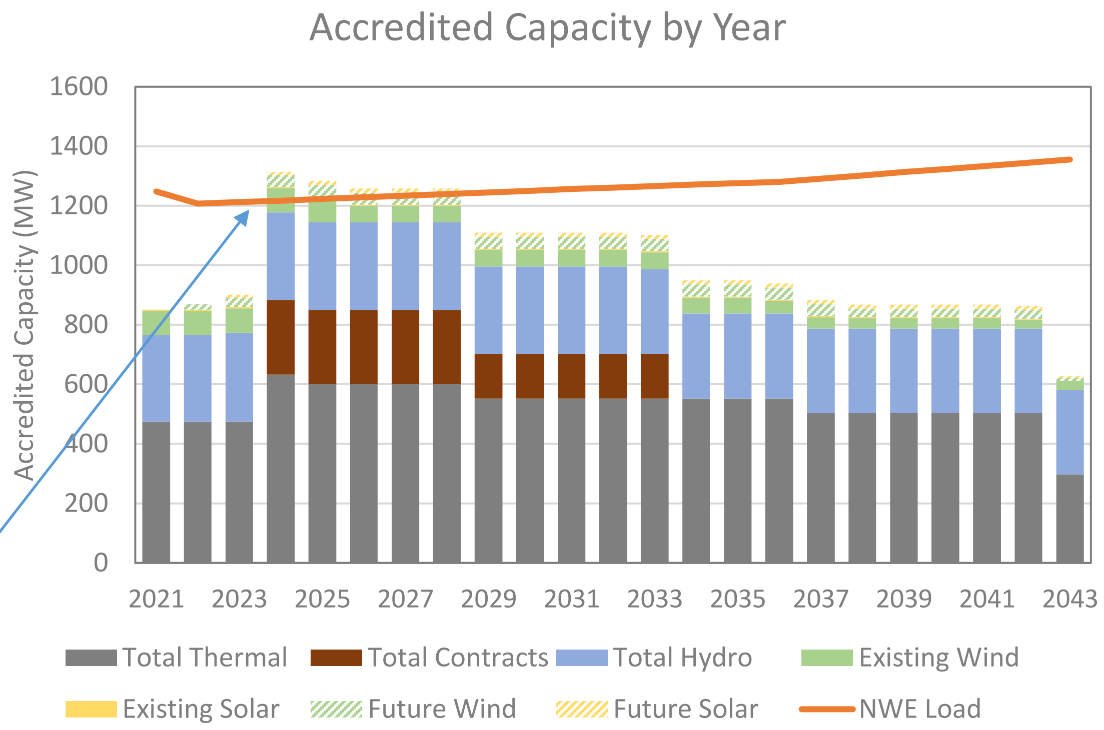
The current queue for QF projects in development includes

- 350 MW of solar
- 415 MW of wind
- 250 MW of battery (charged from wind or solar)

NWE Base Portfolio with all QFs



Qualifying facilities double wind and solar in the next 4 years.



When adjusted for ELCC, wind and solar capacity is limited

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Agenda

Project Status Update

Scenarios and Modeling

Mid-C Price Forecast

Technology Cost Forecast

TOC Review

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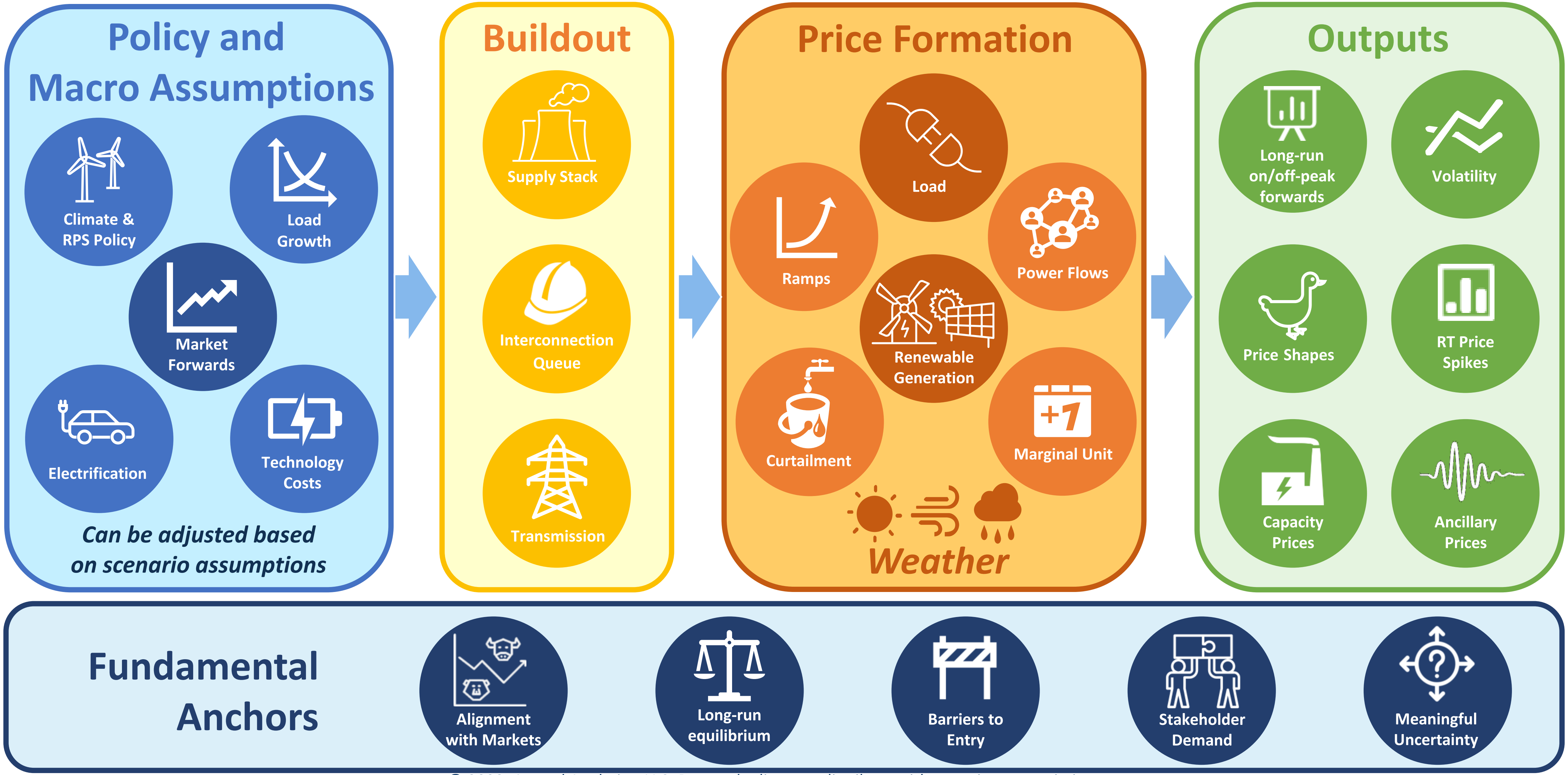
Ascend Analytics Fundamental Forecasting Framework

Ascend Analytics
Better models. Better decisions.

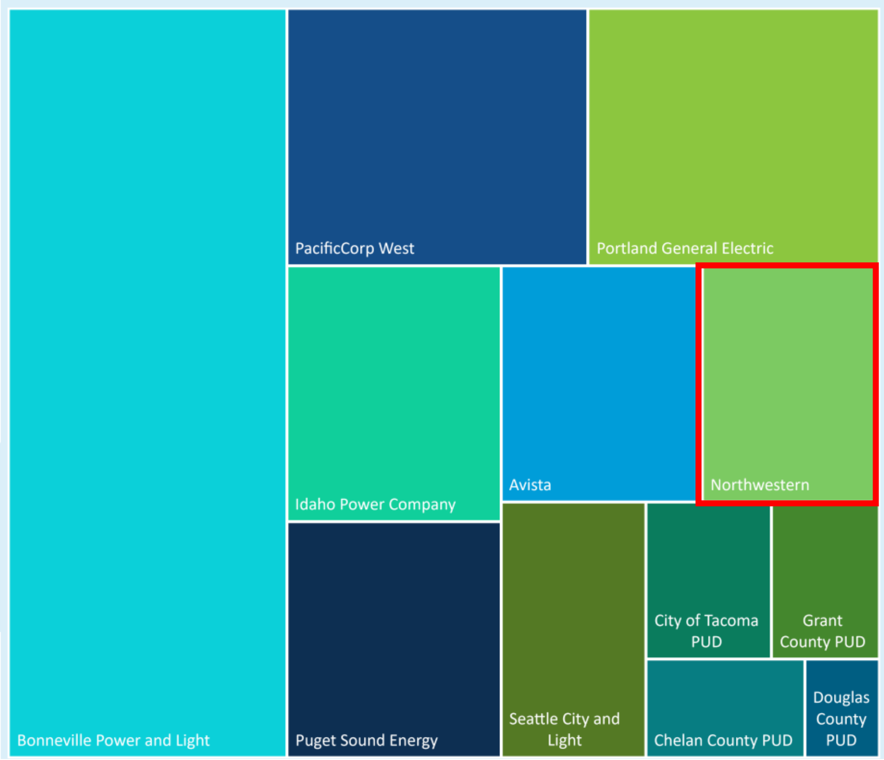


Forecasting in a bilateral market

Mid-C Supply Stack

Additions	Retirements	Capacity Accreditation	Generation	Demand
EIA – announced additions	EIA – announced retirements	Regional studies	Technology-specific profiles	Hourly demand from 12 local utilities
RPS-targets	Additional retirements based on cost, age	Local experience	Hourly tech. generation from 12 utilities	Wtd. Avg. demand growth projections
Policy-driven capacity targets				Integrated Resource Plans (IRPs)
Reliability additions				
IRPs				

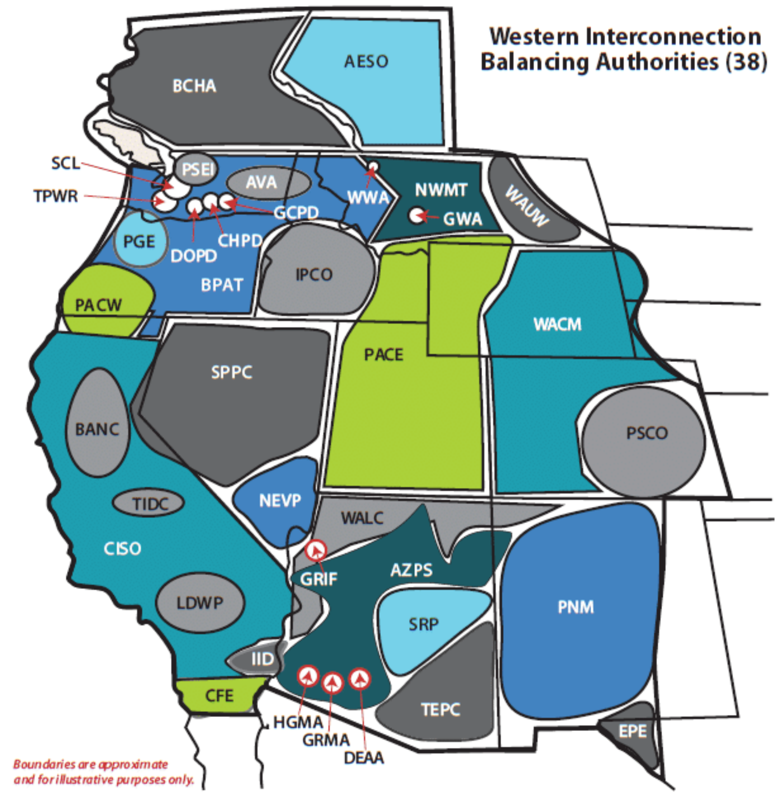
Average share of demand in Mid-C



- Resource buildouts driven by announced projects as well as capacity, reliability and RPS targets in the region
- Local experience, IRPs, and regional RA studies informed capacity credits and needs in the future
- Demand and generation forecasts derived from historical hourly data for 12 regional utilities from EIA and RFPs

Clean Energy Growing Across the West

- **California** — 60% RPS by 2030, 100% GHG free retail sales by 2045
- **Oregon** — 100% GHG free by 2040
- **Washington** — 100% clean energy by 2045, Legislation to achieve 25% below 1990 levels by 2035, phase out coal by 2025
- **Idaho** — Idaho Power goal of 100% clean by 2045
- **Colorado** — Governor wants 100% renewable energy by 2040; Xcel committed to GHG free by 2050
- **Arizona** — APS committed to 45% renewable by 2030; APS 100% GHG-free by 2050; ACC considering targets
- **New Mexico** — 100% GHG-free by 2045
- **Nevada** — 50% RPS by 2030 and 100% (non-binding) GHG-free by 2050



AESO - Alberta Electric System Operator
AZPS - Arizona Public Service Company
AVA - Avista Corporation
BANC - Balancing Authority of Northern California
BPAT - Bonneville Power Administration - Transmission
BCHA - British Columbia Hydro Authority
CISO - California Independent System Operator
CFE - Comision Federal de Electricidad
DEAA - Arlington Valley, LLC
EPE - El Paso Electric Company
GRMA - Gila River Power, LP
GRIF - Griffith Energy, LLC
IPCO - Idaho Power Company
IID - Imperial Irrigation District
LDWP - Los Angeles Department of Water and Power
GWA - NaturEner Power Watch, LLC
NEVP - Nevada Power Company
HGMA - New Harquahala Generating Company, LLC
NWMT - NorthWestern Energy
PACE - PacifiCorp East
PACW - PacifiCorp West
PGE - Portland General Electric Company
PSCO - Public Service Company of Colorado
PNM - Public Service Company of New Mexico
CHPD - PUD No. 1 of Chelan County
DOPD - PUD No. 1 of Douglas County
GCPD - PUD No. 2 of Grant County
PSEI - Puget Sound Energy
SRP - Salt River Project
SCL - Seattle City Light
SPPC - Sierra Pacific Power Company
TPWR - City of Tacoma, Department of Public Utilities
TEPC - Tucson Electric Power Company
TIDC - Turlock Irrigation District
WACM - Western Area Power Administration, Colorado-Missouri Region
WALC - Western Area Power Administration, Lower Colorado Region
WAUW - Western Area Power Administration, Upper Great Plains West
WWA - NaturEnur Wind Watch, LLC

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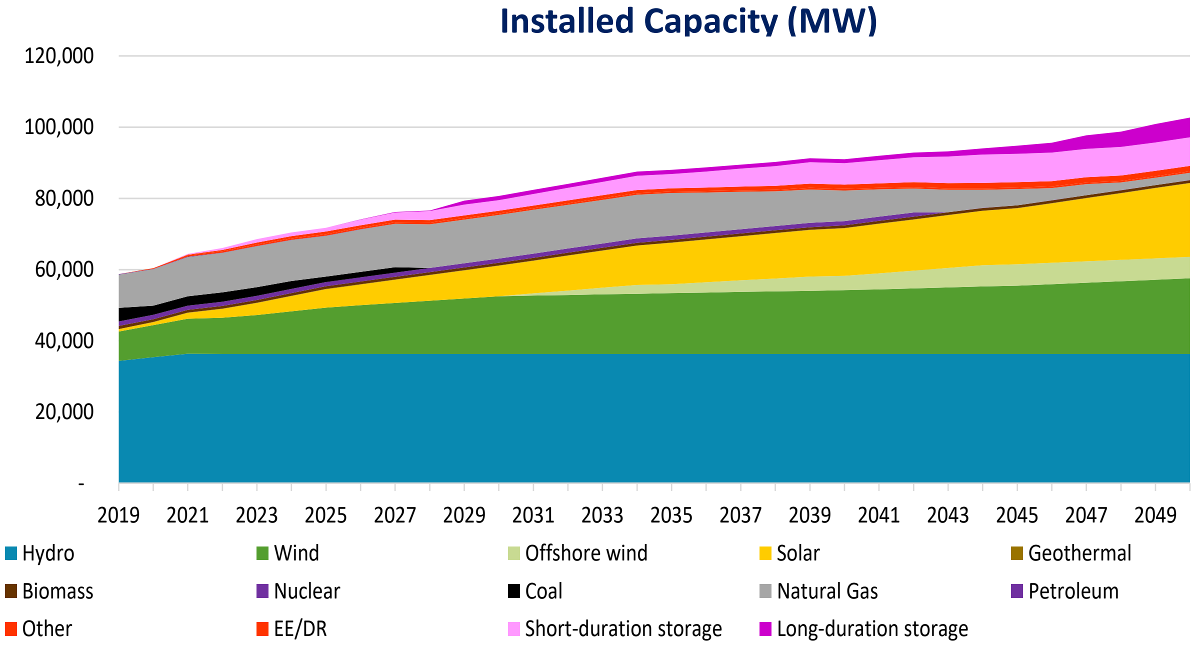
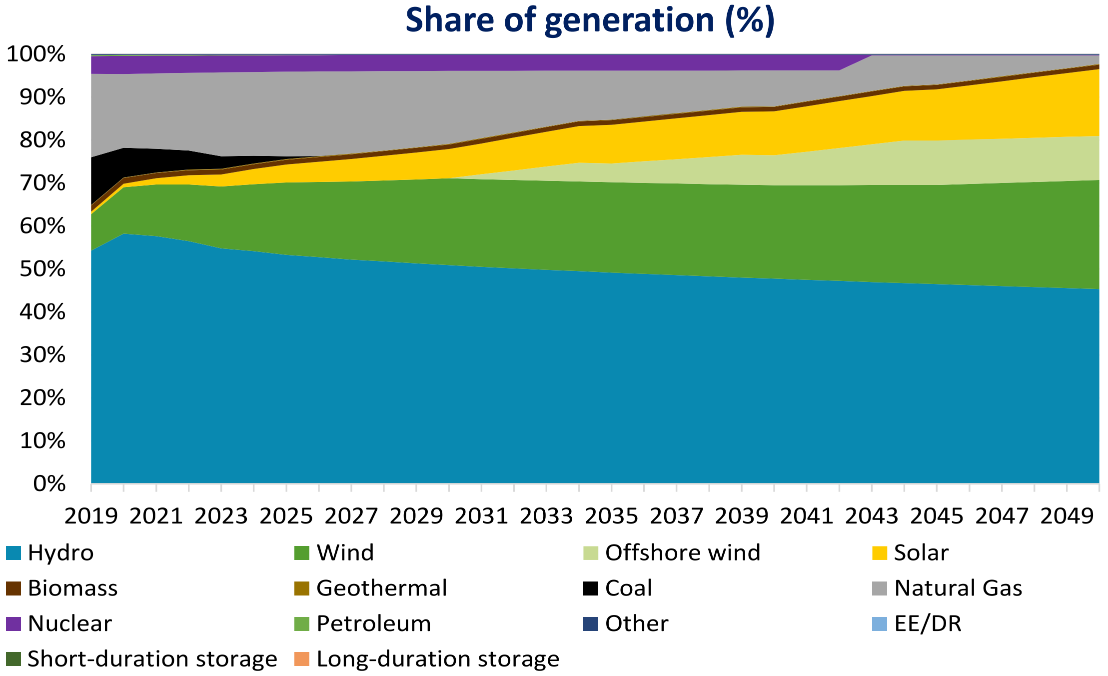
PNW Supply Evolution: Capacity almost doubles over the forecast period

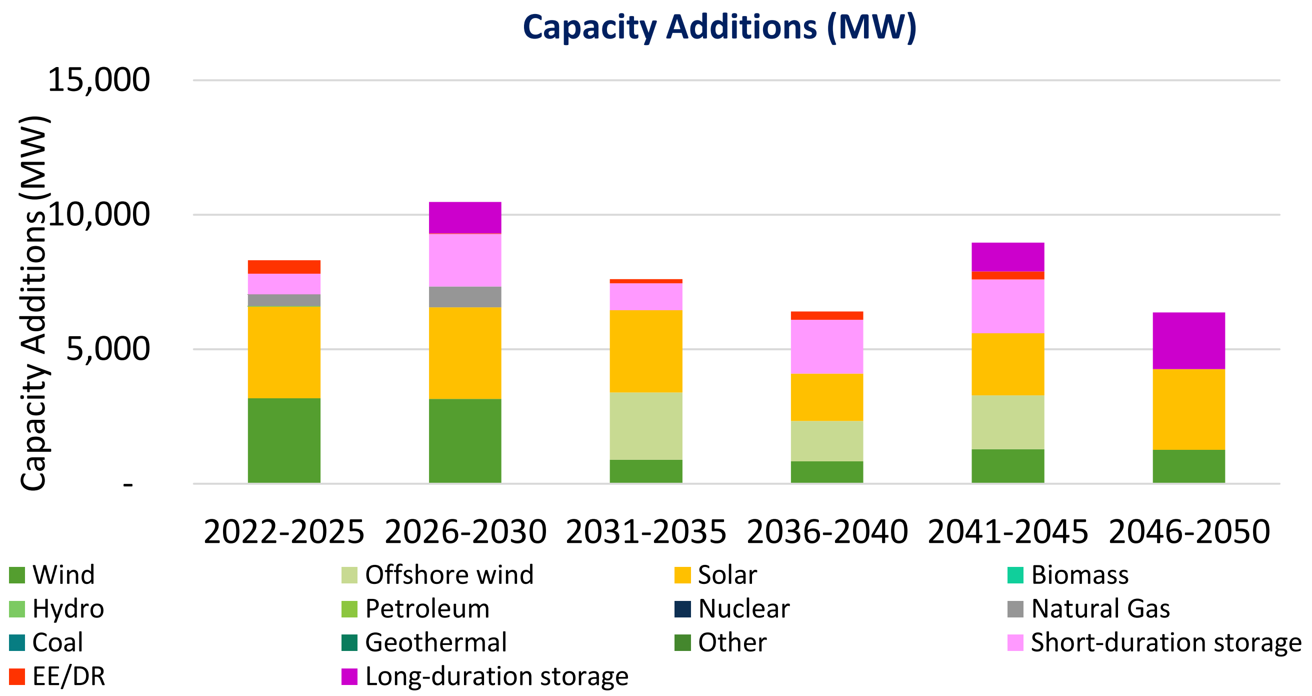


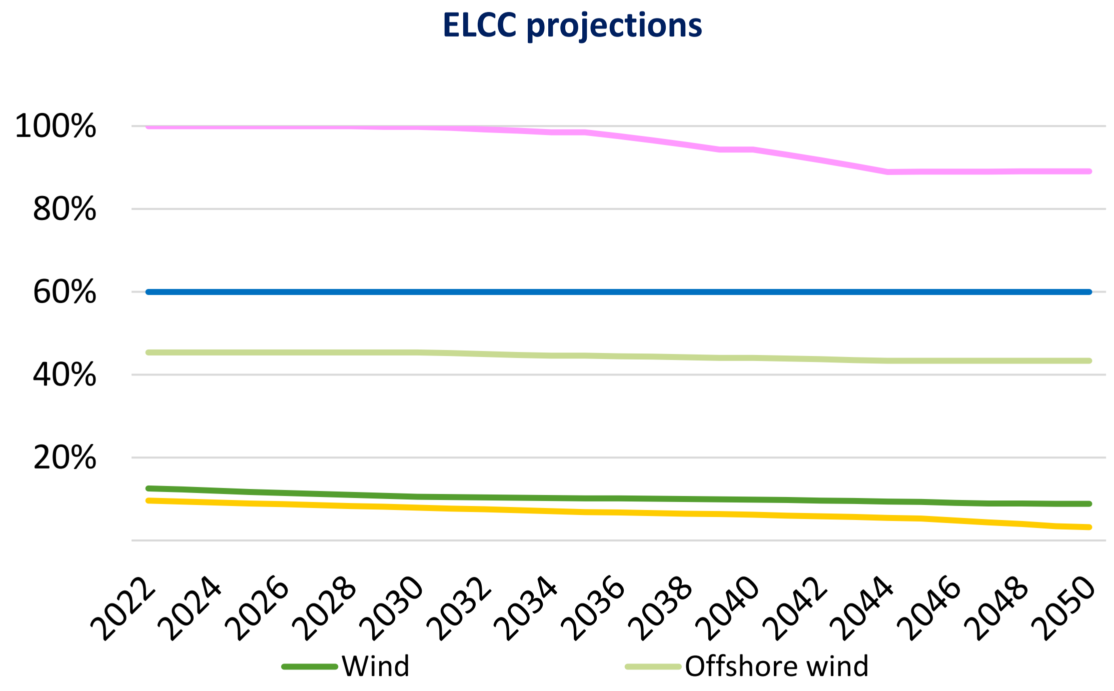


- Coal in the Pacific Northwest is expected to phase out
- Hydro will continue to be the primary contributor to generation, with solar and wind & batteries replacing much of the remaining thermal generation
- Hydro capacity remains constant, but re-licensing + climate conditions are source of uncertainty for future viability
- Offshore wind will grow in the 2030s as an additional renewable resource to meet state targets
- Storage will be the primary capacity replacement for retiring thermal generation, with gas beginning to retire starting in the 2030s

Source: Internal Ascend forecasts, Mid-C Projections

Battery buildout compensates for declining effective VRE capacity in late 2020s

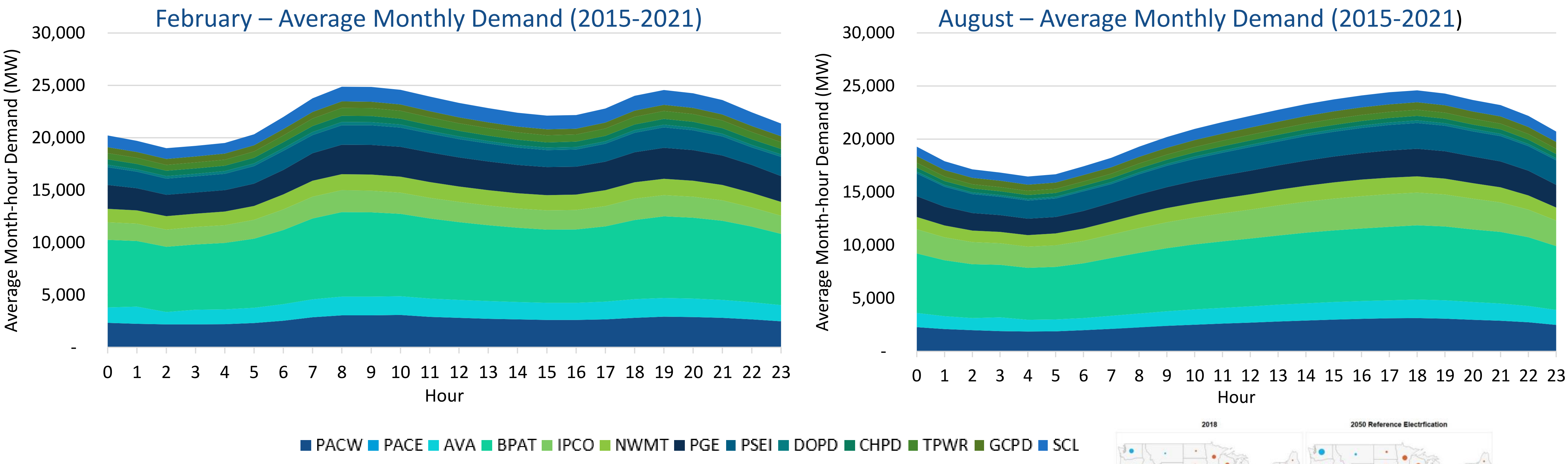




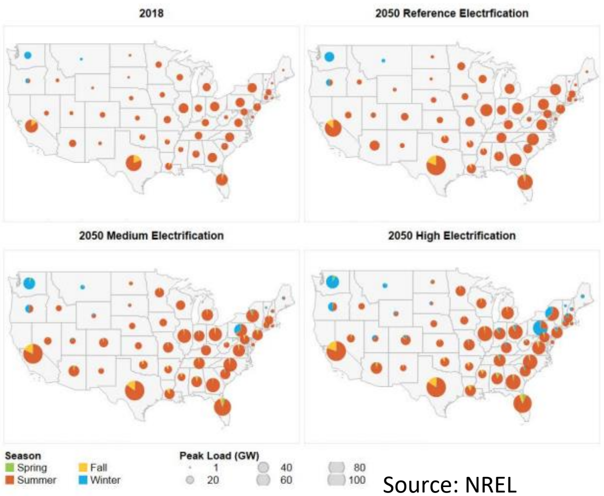
- Near-term additions driven by state-level resource buildouts from the EIA
- Onshore wind and solar resources drive the bulk of resource additions through the 2040s to meet rising RPS targets
- Offshore wind additions commence in the early 2030s with development of floating technology, primarily off the Oregon coast
- Incremental contribution of VRE to peak demand declines through the forecast, increasing value of dispatchable resources
- Longer-duration storage systems come online in the late-2020s to meet reliability needs

Source: Internal Ascend forecasts, Mid-C Projections

PNW Demand Evolution: Feeling the heat



- Most utilities in PNW plan for a winter peak, but summer peak very close as well
- Aggregated demand from 12 utilities grows at a 0.7% CAGR through the forecast
- Heat-waves and AC demand mean that PNW can expect to see higher summer peaks compared to the past, with more frequent summer peaking
- Dual-peaking market creates reliability planning considerations in both seasons



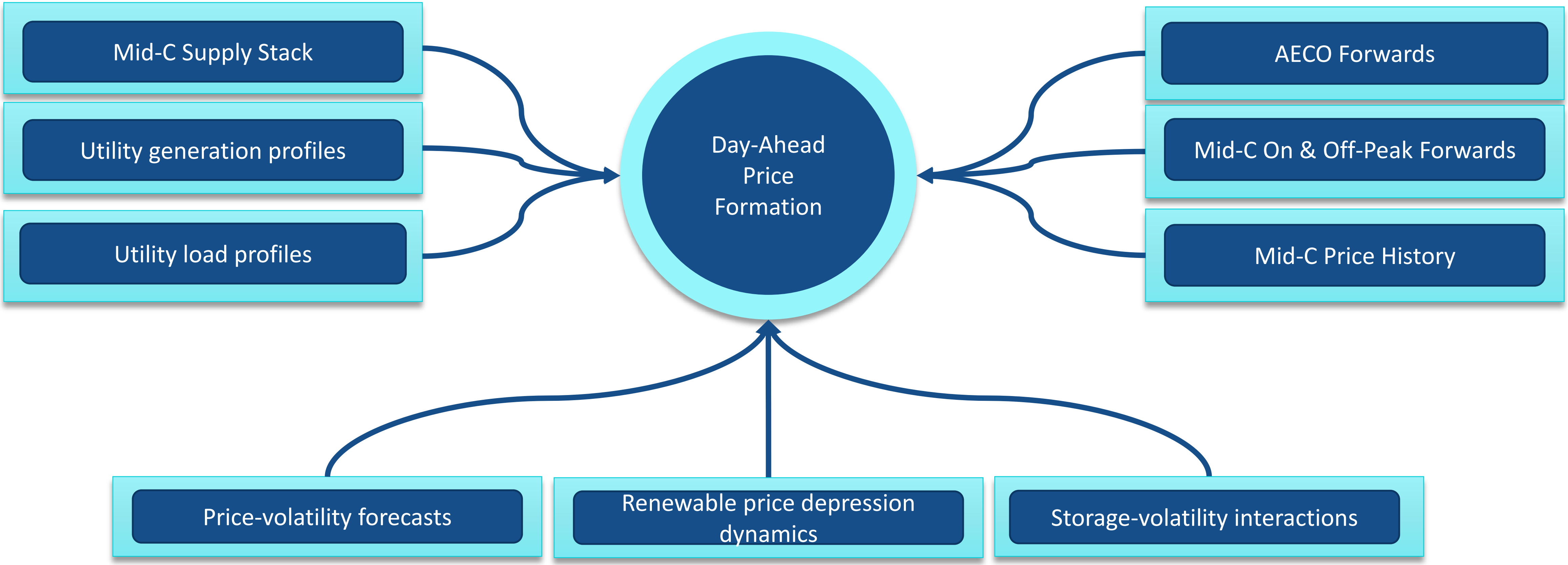
Source: NREL

Figure 3. Peak load magnitude and seasonal timing by state for 2018 and 2050 for three electrification scenarios

Supply stacks, prices and empirical relationships drive DA price formation

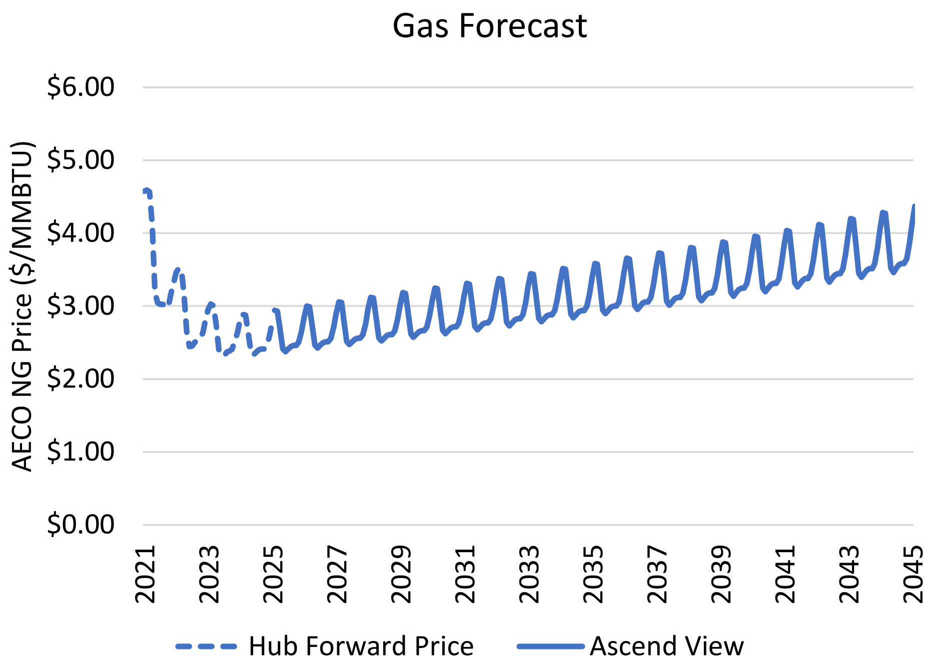
Supply stack & regional fundamentals

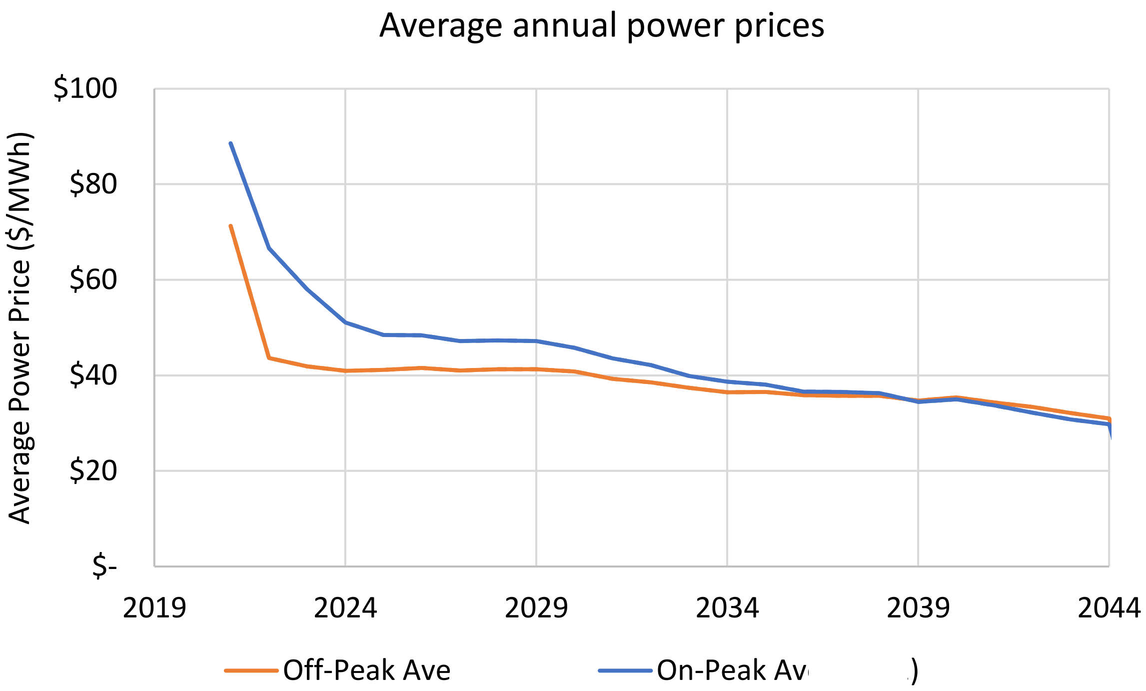
Forwards & Price History



Empirical relationships between prices and renewable penetration

The Narrowing On/Off-Peak Gap

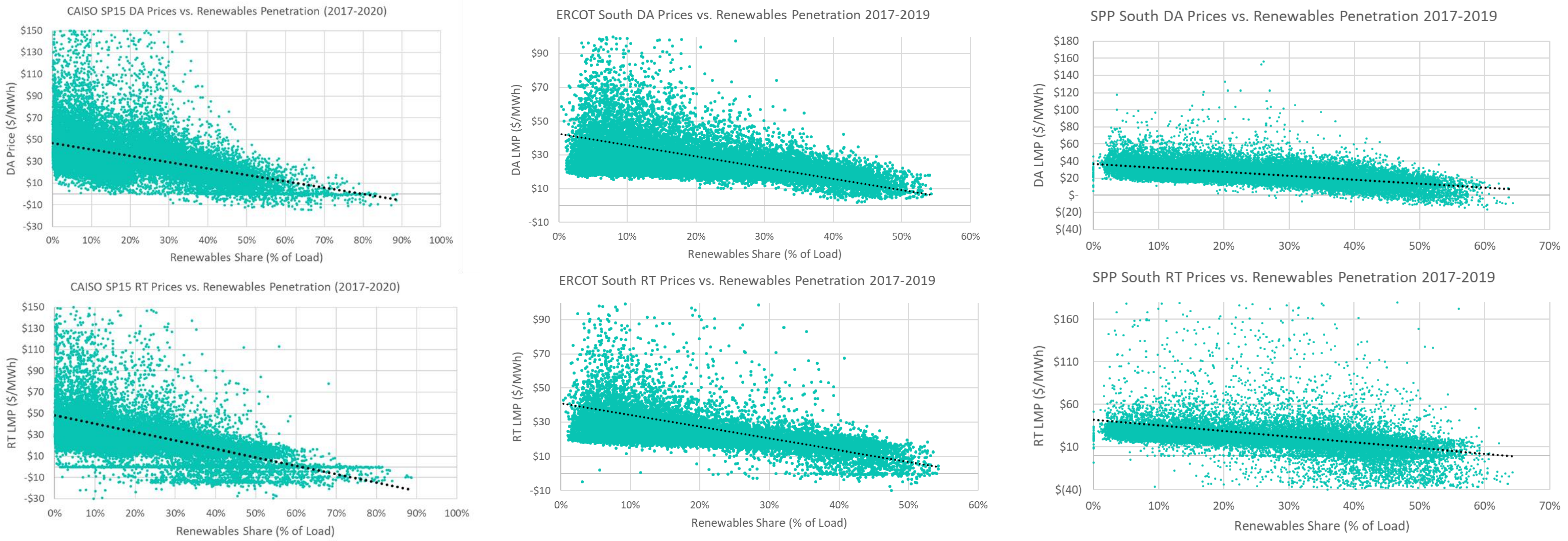




- **Renewable deployment will depress wholesale prices**
  - Solar and wind additions to meet clean energy goals will shift the supply stack to the right, driving declining implied heat rates and prices
  - On-peak and off-peak power prices will converge over time with increasing solar deployment
    - As solar buildout grows relative to wind, on-peak prices will experience greater downward price pressure
    - On-peak forwards have already dropped below off-peak in CAISO
  - Near-term rise in power prices driven by high near-term gas prices and reliability concerns during the summer months

Ascend Analytics

Price Depression with Increasing Renewables Occurs Across Markets

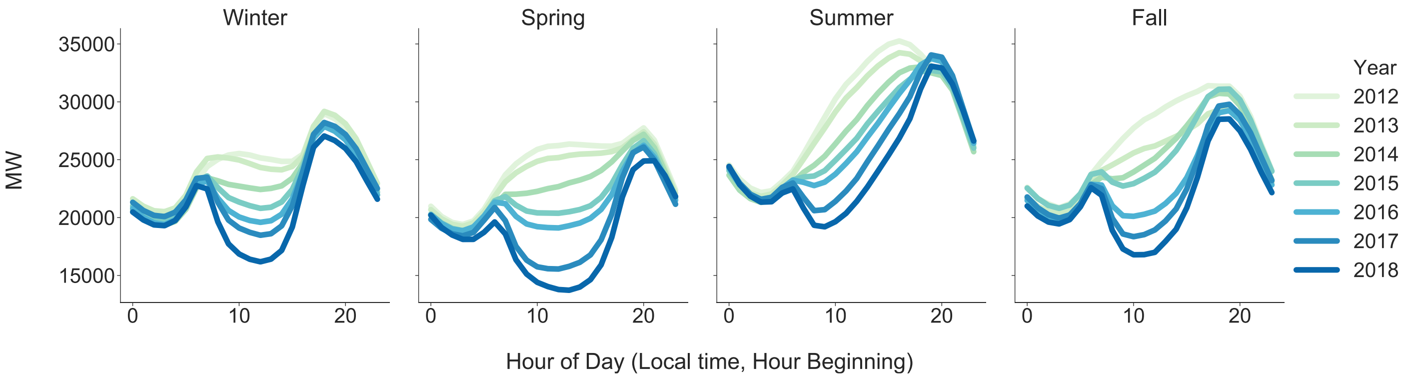


CAISO **ERCOT** **SPP**

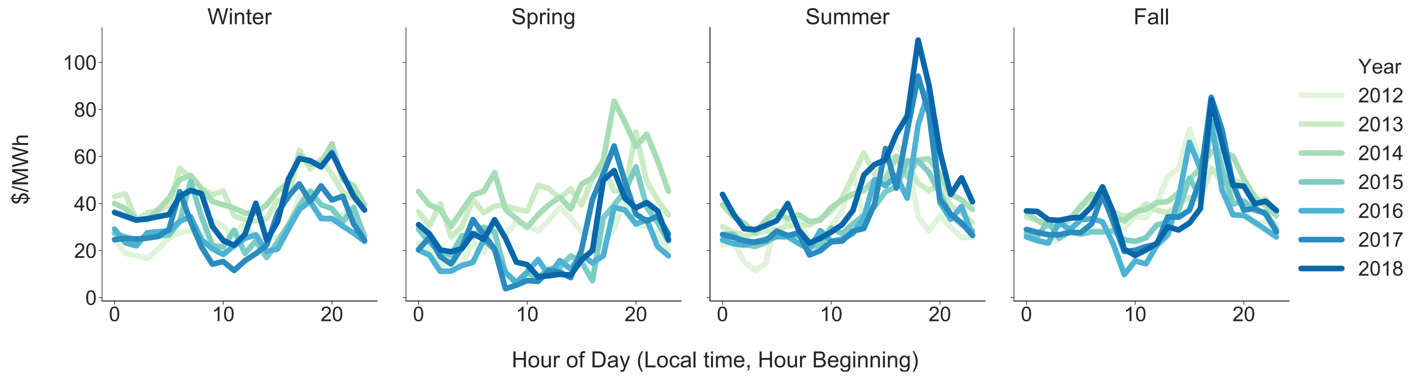
- Across all markets with substantial renewable penetrations, prices are negatively correlated with renewable generation in both the DA and RT markets
- With large amounts of incoming renewables, these price dynamics are expected to manifest in PNW

Solar Penetration vs. Price: CAISO Duck Curve Coming to PNW

Solar will have pronounced impacts on net load and prices, as CAISO has already shown:



Average net load



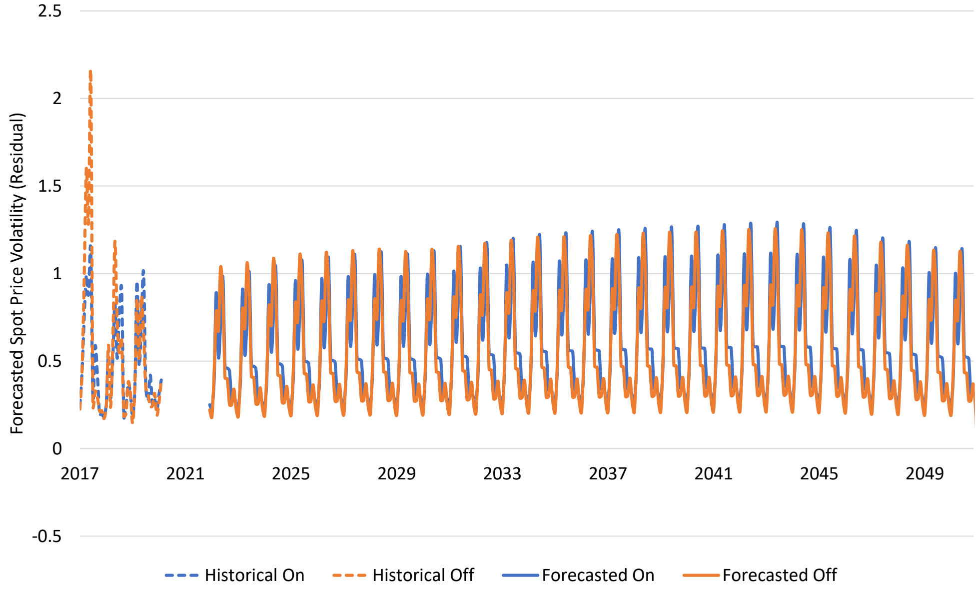
Average diurnal prices

- Implied heat rates decline over time due to renewable entry. As solar penetration increases, mid-day heat rates decline when solar is at its peak production, while afternoon heat rates increase due to inflexible generation during peak load hours.
- As PNW solar penetration increases rapidly, the duck curve effects that CAISO already experiences will begin to impact the hourly price shapes in PNW

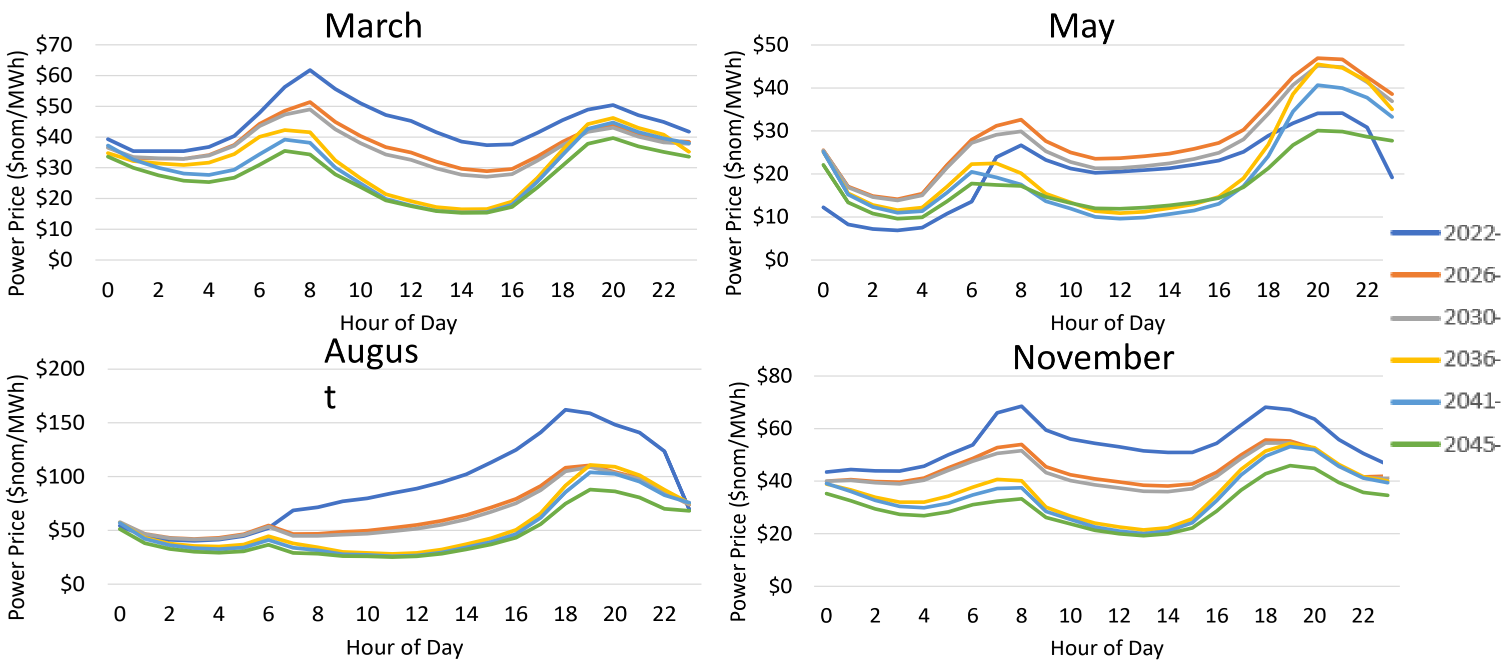
Source: Lawrence Berkeley National Lab

Volatility and “ducky” shapes are coming

DA Price Volatility



Month-hour average price shapes



- Price volatility grows through the 2030s with rising renewable deployment and thermal retirements, and then steadily falls with the addition of long-duration storage in the 2040s
- The “belly” of the duck will continue to deepen before stabilizing in the mid-2030s
- Volatility and duck shapes will not disappear because these price deltas are needed to drive incentives for storage dispatch

Agenda

- Project Status Update
- Scenarios and Modeling
- Mid-C Price Forecast
- Technology Cost Forecast
- TOC Review

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Technology Cost Forecasts

- The modeling team is currently working on long-term cost forecasts for technology costs
  - Renewables
  - Thermal gen
  - Storage
- We leverage projections from several data sources
  - NREL's Annual Technology Baseline (ATB) -> Waiting for 2022 update in April
  - Lazard
  - BNEF
  - RFPs
- Major changes occurring due to world events
  - Supply chain bottlenecks
  - Commerce Department investigation into the solar panel tariff evasion
- The modeling team plans to release our long-term technology cost assumptions in May. Can organize a short call to review them with ETAC if desired.

NorthWestern Energy
Delivering a Bright Future

Agenda

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NorthWestern Energy
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New Website

- Supply Planning Website:
  - https://www.northwesternenergy.com/about-us/gas-electric/electric-supply-resource-procurement-plan
- Please sign up for the email distribution list:
  - https://lp.constantcontactpages.com/su/XE0SdNG
- Submit portfolio requests and other feedback via the new feedback form:
  - Electric Supply Planning Feedback Form (northwesternenergy.com)

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Thank you.