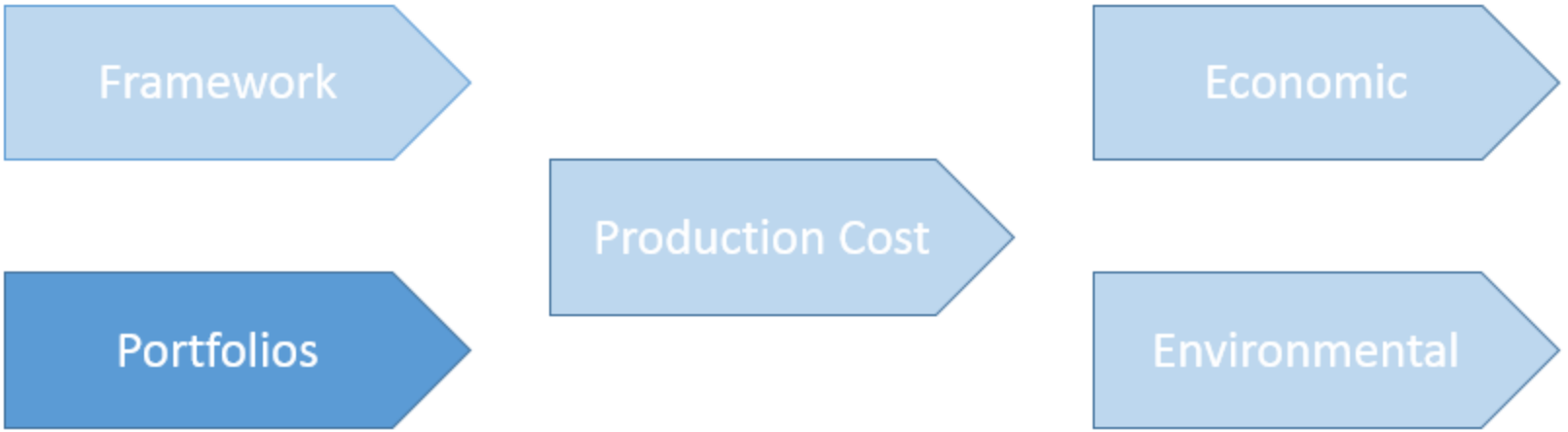
Energy+Environmental Economics

# Draft Renewable + Portfolios for CAISO SB 350 Study

CAISO Public Workshop
February 8, 2016

Arne Olson, Partner

# SB350 Study Process



# Agenda

- Overview of Portfolio Development Framework
- Key Data Inputs
- Draft Renewable Resource Portfolios
- Stakeholder Input

# Key Areas for Stakeholder Input

- **Overall renewable resource portfolios by scenario**
  - Availability of in-state and out-of-state resources
  - Availability of renewable electricity credits (RECs)
  - Quantities and types of energy storage by scenario
- **Resource cost assumptions**
- **Other key data inputs**
  - Electricity load forecast
  - Behind-the-meter solar PV
- **Other comments on overall modeling framework**

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# OVERVIEW OF PORTFOLIO DEVELOPMENT FRAMEWORK

# RESOLVE Model Overview

- **Study uses E3's Renewable Energy Solutions (RESOLVE) Model to select optimal portfolio of renewables and other resources for each scenario**
- **RESOLVE minimizes the sum of investment and operating costs over a defined time period**
  - Investment decisions are made every 5 years between 2015 and 2030
  - Performs optimal dispatch over a representative set of operating days in each year
- **Selects least-cost combination of resources, subject to power system constraints:**
  - Meets energy, capacity and balancing needs
  - Complies with RPS or CO2 target (overbuilding renewable portfolio if necessary)

# RESOLVE will be used to study the effect of regional markets on renewable portfolio

## Two major effects will be tested:

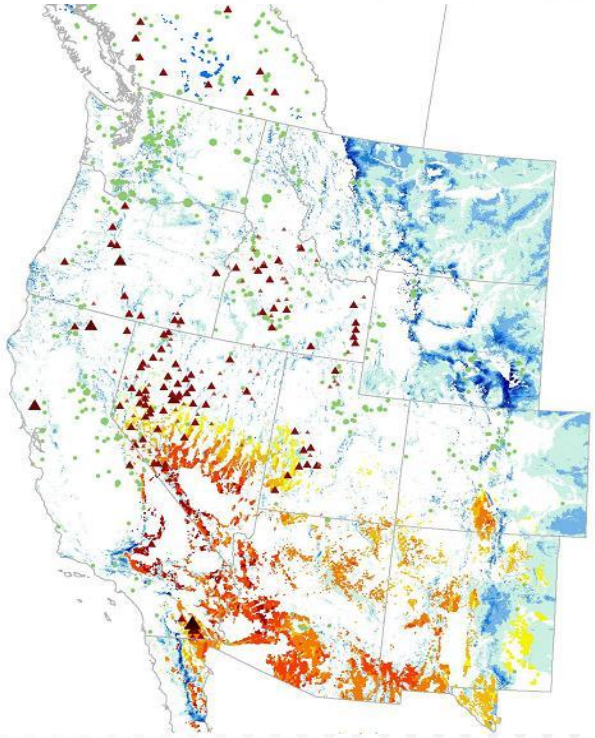
### 1. Effect of regional operations

- Increased access to latent flexible capacity across a broad, diverse region
- Increased ability to export surplus energy
- Could result in changes to least-cost portfolio

### 2. Effect of regional transmission tariff

- Reduces wheeling costs across the region
- Provides a mechanism for needed new transmission infrastructure to be studied and approved for inclusion in rates
- Provides access to high-quality wind in the Rockies and solar in the Southwest

**Renewable Resource Potential in the West**



*Source: NREL*

# Three scenarios studied

1. **Business-as-Usual (BAU) Scenario**
   - Renewable energy procurement is largely from in-state resources
   - Limited quantity of out-of-state resources available, with delivery requirements assumed
   - No regional market to help reduce curtailment
2. **Regional market operations with BAU renewable energy procurement policies**
   - Assumes no increase in availability of out-of-state resources, but transmission wheeling charges are de-pancaked
   - Curtailment of renewables is reduced through better integration
3. **Regional market and renewable energy procurement**
   - Like Scenario 2, but with additional high-quality wind resources made available (requires new transmission)

# Three alternatives for Business-as-Usual Scenario

- **Under current system of bilateral trading, ability of other Balancing Authorities to absorb energy from California during periods of high renewable output is limited**
  - Balancing authorities maintain obligation to balance their systems subject to NERC performance standards
  - Other "friction" in bilateral system may prevent some California renewable energy from finding a market
- **Due to significant uncertainty about how much California oversupply can be absorbed under bilateral markets, three scenarios are tested:**
  1. **Scenario 1a:** Net exports limited to 2000 MW
  2. **Scenario 1b:** Net exports limited to 5000 MW
  3. **Scenario 1c:** Net exports limited to 8000 MW

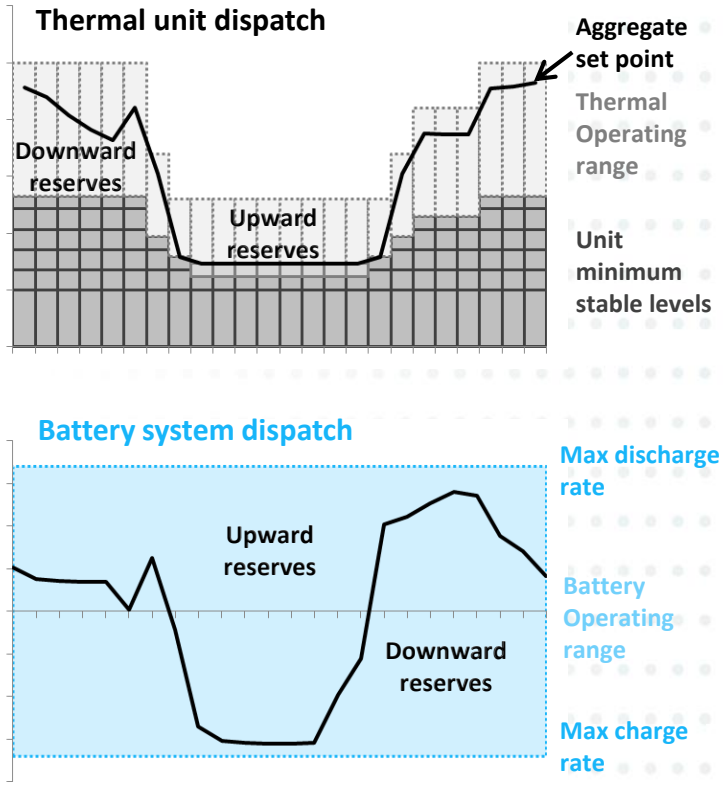
# Cost analysis in RESOLVE model

- **Minimizes cost of electric grid operation and expansion:**
  - Incremental capital costs for renewable build (excluding currently contracted renewables)
  - Incremental capital costs for conventional and storage resources
  - Operating costs (fuel, O&M, and $CO_2$) to meet load in Western footprint and, in CAISO only, to meet flexibility reserves and frequency response
- **Excluded costs:**
  - Existing and planned infrastructure costs including storage mandate (included in revenue requirement and rates, but not optimized)
  - Customer non-bill costs: EE and rooftop PV
  - Additional costs to provide regulation reserves
- **Other assumptions**
  - Renewables are compensated for curtailed energy at full PPA price
  - Generators are compensated regardless of market prices

# Detailed hourly model brings operational challenges into investment decisions

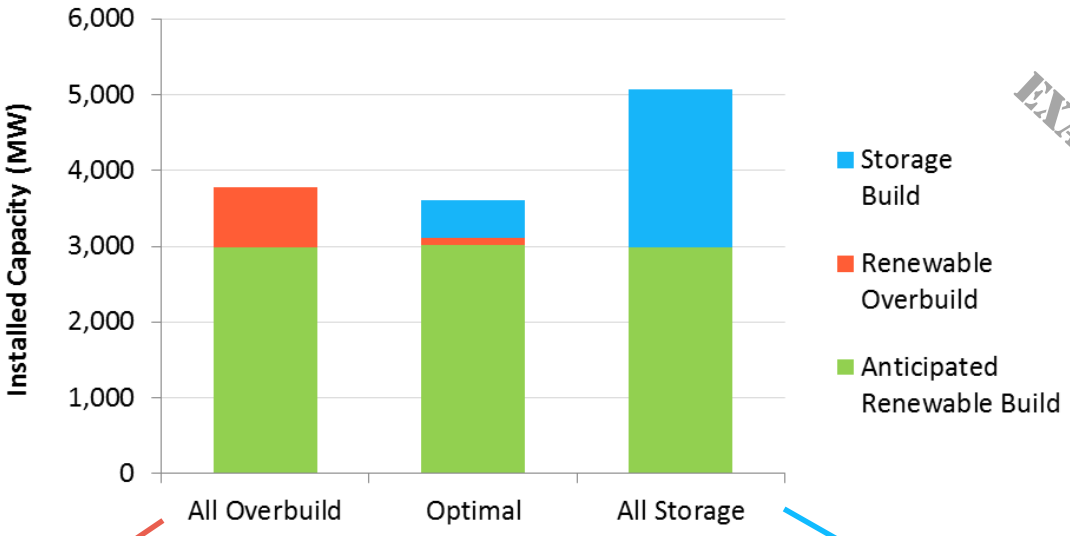
- **For each year in the simulation, a subset of days are selected and weighted to reflect long-run distributions of:**
  - Daily load, wind, and solar
  - Monthly hydro availability
- **Dispatch is modeled using linear optimization**
  - Upward and downward operating reserve constraints
  - Parameterization of sub-hourly renewable curtailment due to downward reserve shortfalls

**Simulates economic dispatch on each day subject to technical operating constraints**



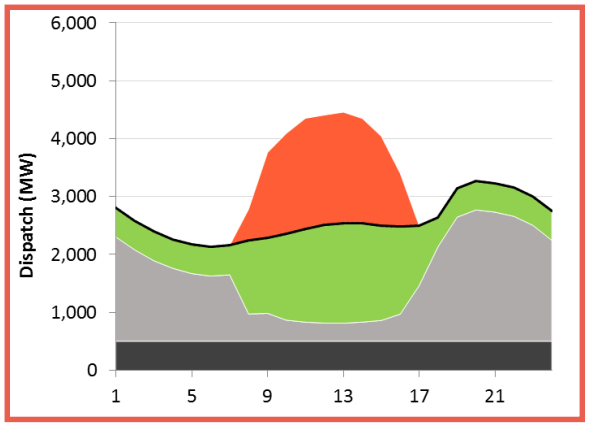
# Optimal portfolio balances solutions with overbuild

EXAMPLE PORTFOLIO

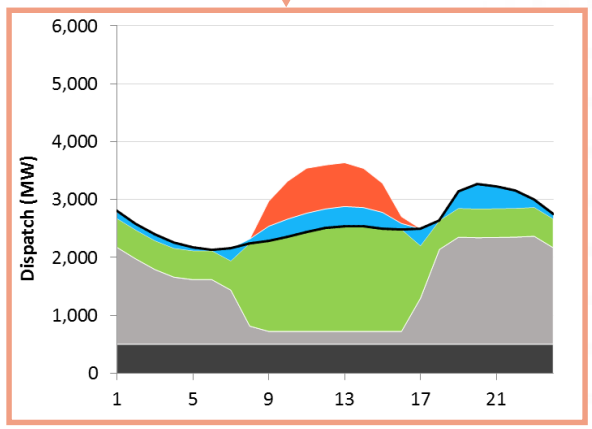



EXAMPLE PORTFOLIO

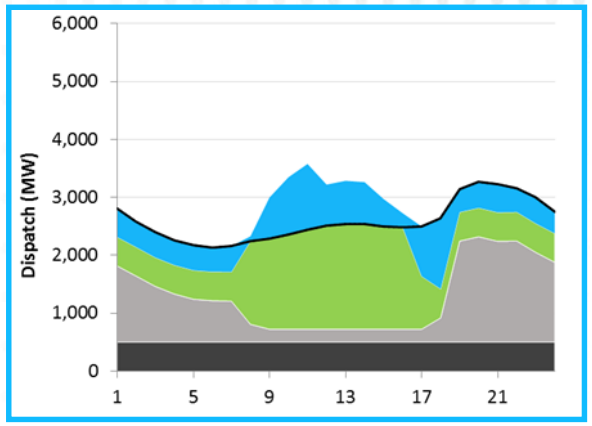
**All Overbuild**




**Mix of Overbuild and Storage**




**All Storage**



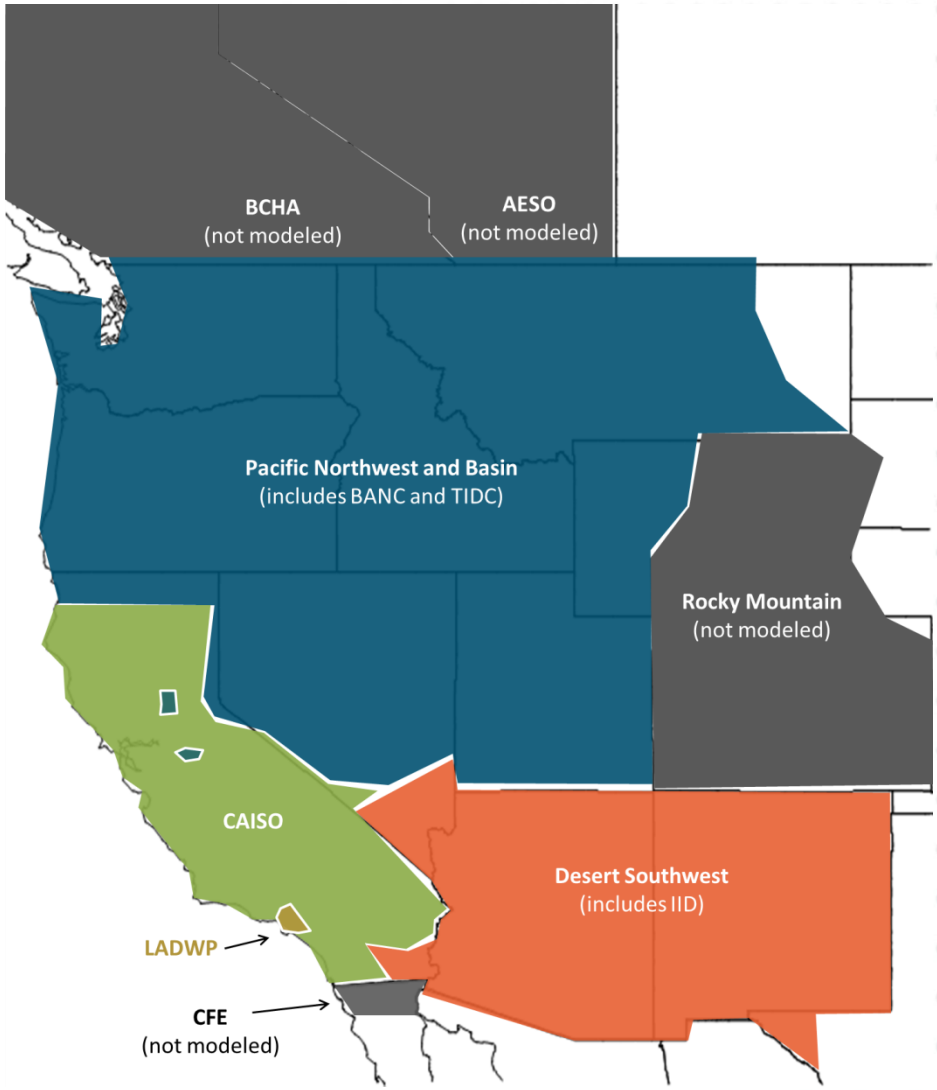
# RESOLVE considers many different solution types

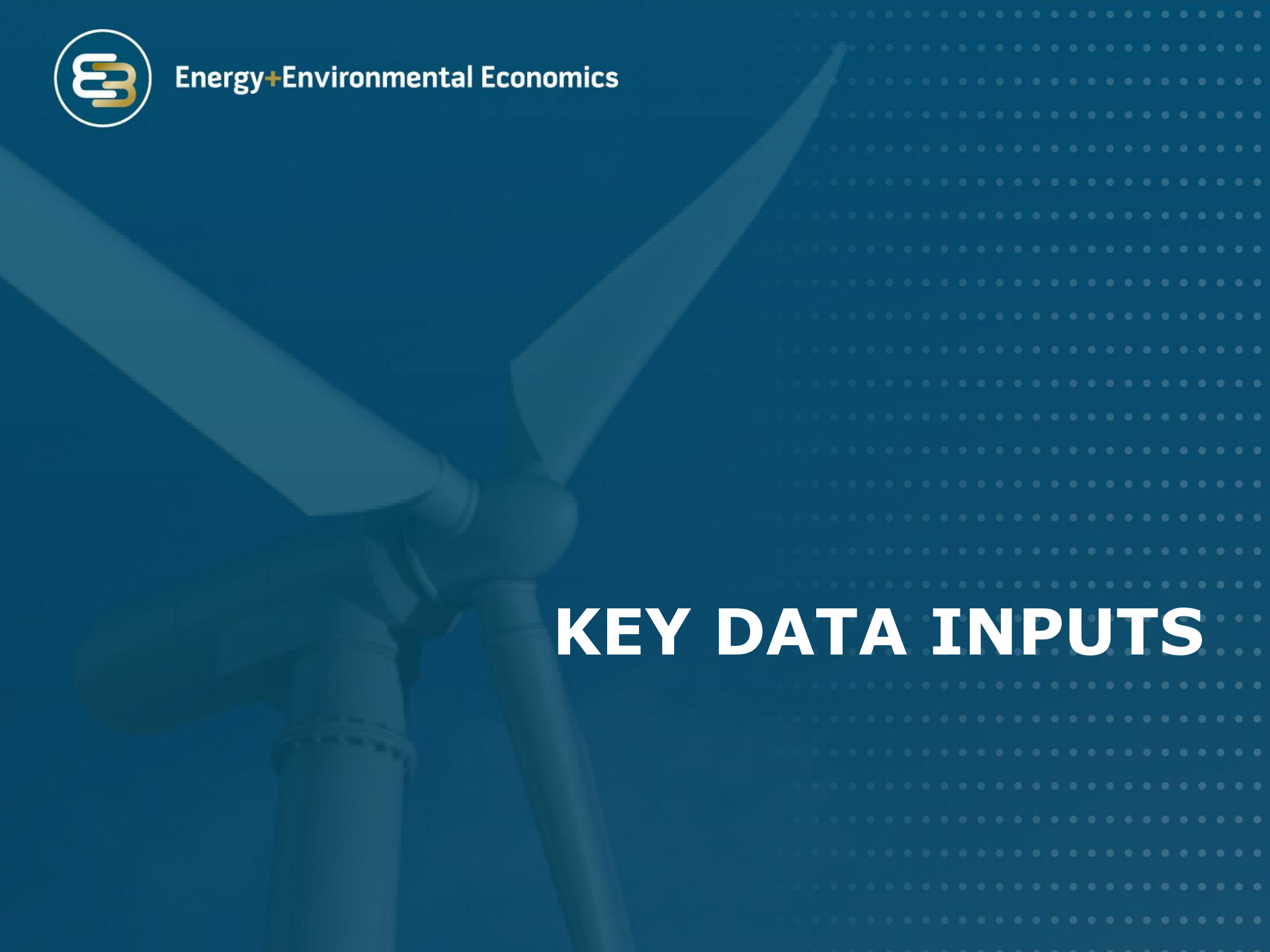
## + RESOLVE selects optimal mix of technologies based on installed costs and operational value

| Integration Solution | Examples of Available Options | Assumptions & Data Sources |
|---|---|---|
| Energy Storage | • Batteries: 1-, 2-, 4-, or 8-hour<br>• Pumped Storage: 12-hr, 24-hr | • Literature review |
| Demand Response | • Existing & new demand response programs | • Based on LTPP assumptions |
| New Flexible Gas Plants | • Simple cycle gas turbines<br>• Reciprocating engines<br>• Flexible combined cycle gas turbines | • WECC/E3 capital cost study |
| Renewable Dispatch | • Scheduled & real-time renewable curtailment | • Dynamic downward dispatch of renewable resources to help meet within-hour flexibility needs<br>• Curtailed renewables must be replaced to ensure RPS compliance |

# Zonal Topology for Operations

- **Operations modeled for four zones in Western Interconnection:**
  - CAISO
  - NW (includes BANC & TID)
  - SW (includes IID)
  - LADWP
- **Investment decisions evaluated for CAISO only**
  - But can include out of state resources
- **Greater geographic resolution for renewable resource supply**



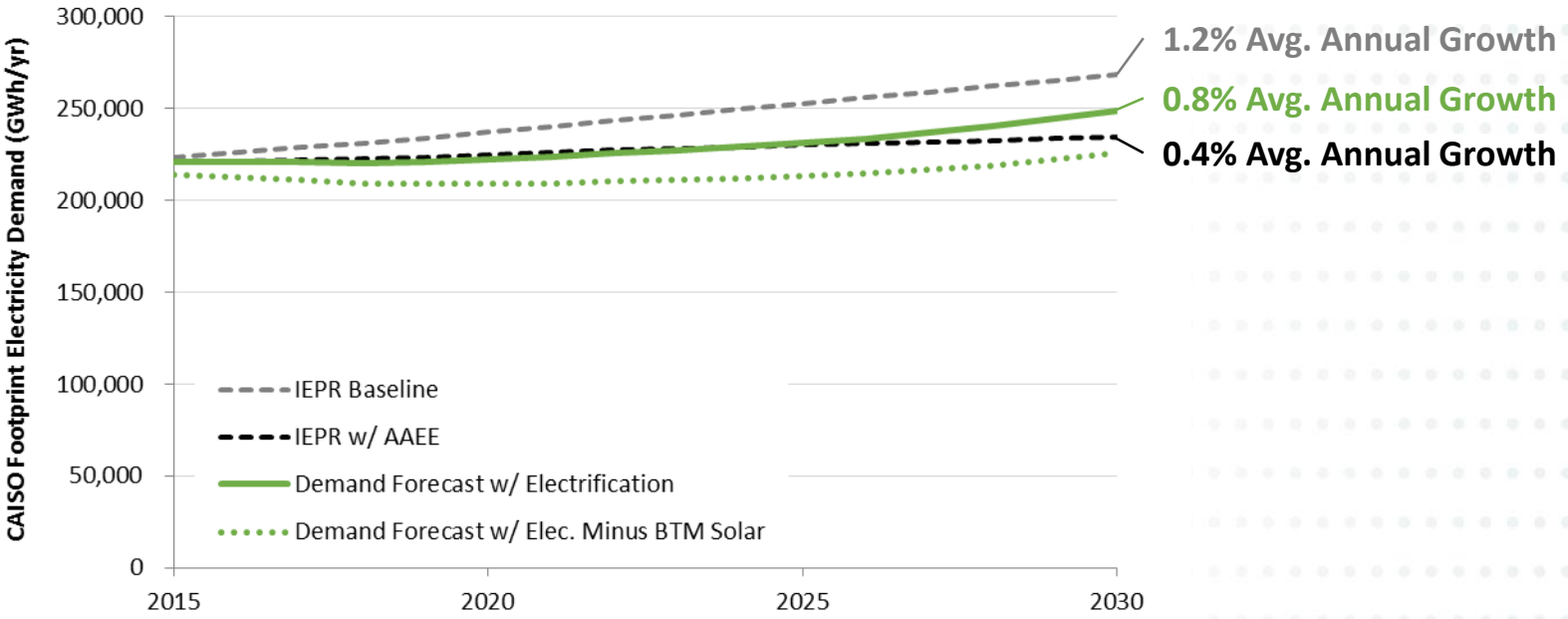



# KEY DATA INPUTS

# Load Assumptions (CAISO zone)

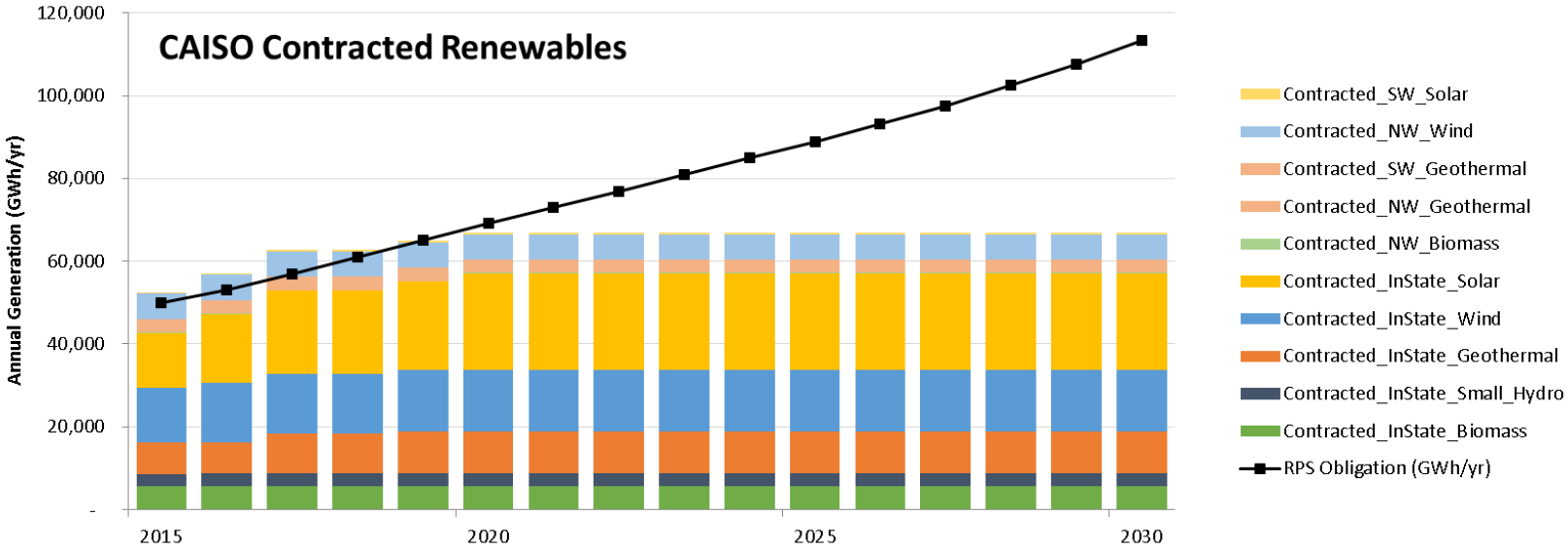
## + Load

- CEC's 2013 IEPR California Electricity Demand Mid Baseline + Mid AAEE for non-thermal and non-transportation end uses
- Additional electric vehicles and residential & commercial heating loads are included based on PATHWAYS High BEV Case (high electrification)



# Existing & Contracted Renewable Resources

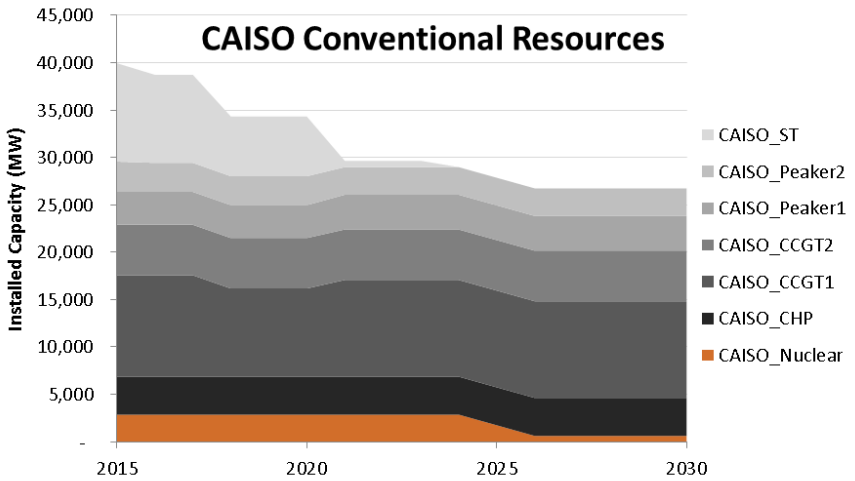
- Existing and contracted renewables are from the RPS Calculator
- 14.6 GW of rooftop PV by 2030



# Conventional Generator Additions and Retirements

## + Retirements

- Nuclear: Assumes retirement of Diablo Canyon in 2025
- California Once-through cooling (OTC) units are retired per 2014 LTPP thermal stack assumptions




- Out of state coal retirements are based on announced retirements (including retirements assumed in PacifiCorp IRP)

## + Additions

- RESOLVE adds new capacity if resource adequacy needs are not met with preferred resources
  - No new capacity additions are triggered in these scenarios

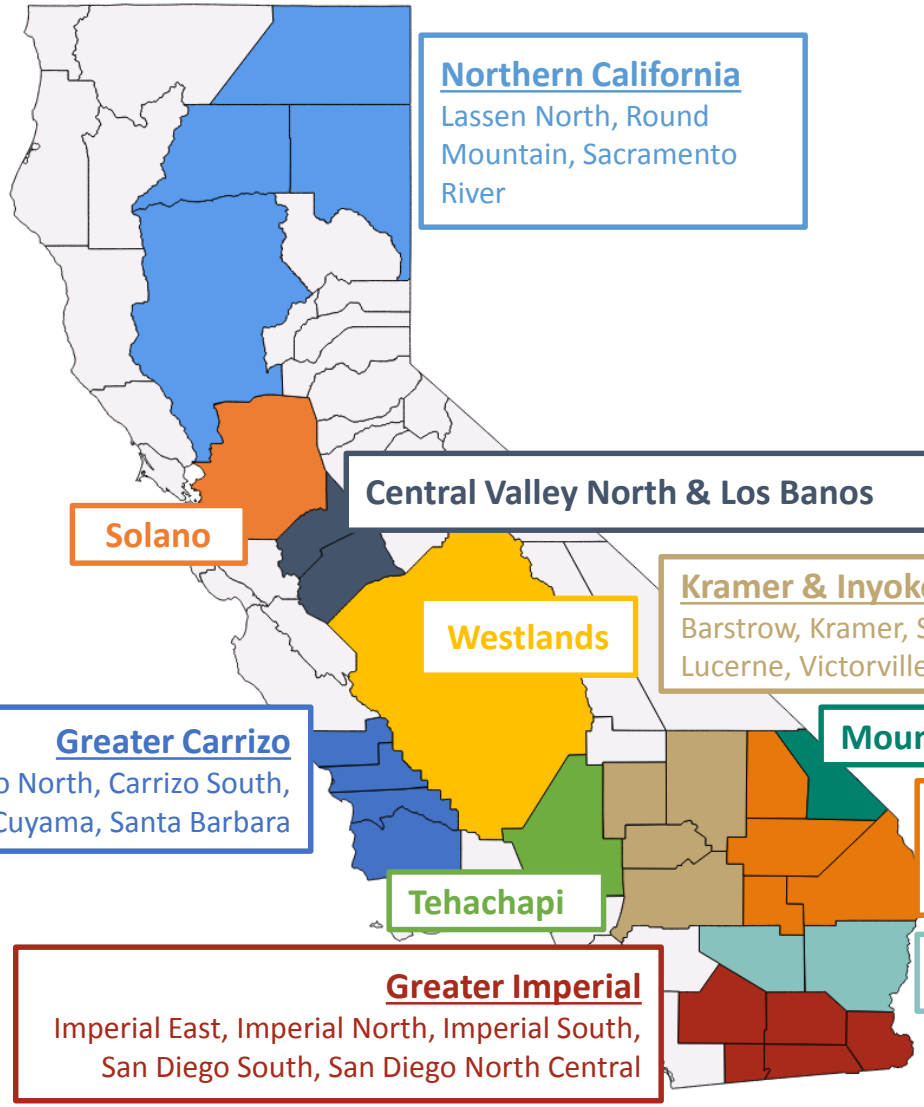
# Overview of In-State Renewable Resource Potential

- **Initial renewable resource supply curve developed based on RPS Calculator**
  - Model includes extensive data on renewable resource potential and performance in California, as well as transmission cost and availability provided by CAISO
  - Renewable cost and performance assumptions developed by **Black & Veatch**
- **Resource potential available:**
  - Solar potential is nearly unlimited
  - 1,800 MW of geothermal potential
  - Wind is limited to 3,000 MW due to concerns about ability to develop marginal wind resources

**SuperCREZ Geography in RPS Calculator**

**Map source**: CPUC

# California CREZs aggregated based on CAISO "Special Study"



**Northern California**
Lassen North, Round Mountain, Sacramento River

**Resource & Transmission Zone**
Constituent CREZ(s)

Solano

Central Valley North & Los Banos

Westlands

**Kramer & Inyokern**
Barstrow, Kramer, San Bernandino – Lucerne, Victorville, Inyokern

**Greater Carrizo**
Carrizo North, Carrizo South, Cuyama, Santa Barbara

Mountain Pass & El Dorado

**Southern California Desert**
Iron Mountain, Pisgah, Twentynine Palms, San Bernandino - Baker

Tehachapi

Riverside East & Palm Springs

**Greater Imperial**
Imperial East, Imperial North, Imperial South, San Diego South, San Diego North Central

# Out-of-State Resources

**Out-of-state resources are divided into three classes:**

1. **Resources that are used for local needs but qualify for RECs in California**
   - 2000 MW of medium-quality wind and solar resources
2. **Resources that can be delivered to California on the existing transmission system**
   - Transmission wheeling and losses charges apply
   - Resources selected for proximity to existing delivery points rather than resource quality
   - 3000 MW of medium-quality wind and solar resources available
3. **Resources that require new transmission for delivery to California or local loads**
   - 6000 MW of high-quality wind from WY and NM added under S2, S3

# Out-of-state Resource Availability by Scenario

- **5000 MW of out-of-state resources available for selection in Scenarios 1 and 2**
- **6000 MW of additional wind made available in Scenario 3**

| | Scenarios 1 and 2 | Scenario 3 |
|---|---|---|
| NW Wind RECs | 1,000 | 1,000 |
| NW Wind, Existing Transmission | 500 | 500 |
| WY Wind, Existing Transmission | 1,000 | 1,000 |
| WY Wind, New Transmission | - | 3,000 |
| SW Solar RECs | 1,000 | 1,000 |
| SW Solar, Existing Transmission | 500 | 500 |
| NM Wind, Existing Transmission | 1,000 | 1,000 |
| NM Wind, New Transmission | - | 3,000 |
| *Total Out of State Resources* | *5,000* | *11,000* |

# Renewable Resource Costs

- **Renewable resource cost assumptions are based on the CPUC's RPS Calculator v.6.1**
  - Assumptions developed by Black & Veatch
- **Pro forma cash flow model translates costs into estimated PPA prices**
- **Costs are location-specific and incorporate difference in local costs of materials and labor**

| Category | Geothermal | Solar PV* | Wind |
|---|---|---|---|
| Capital Cost ($/kW) | $6,633 | $2,470 | $2,045 |
| Interconnection Cost ($/kW) | $260 | $200 | $136 |
| Fixed O&M ($/kW-yr) | $263 | $30 | $33 |

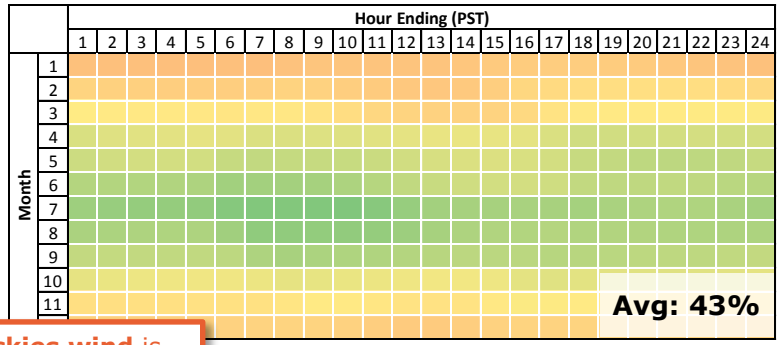
Notes: Costs represent an average plant installed in California in 2015; costs are expressed in 2015 $; solar PV costs are expressed with respect to AC capacity

* Solar PV is modeled as single-axis tracking with an inverter loading ratio of 1.30

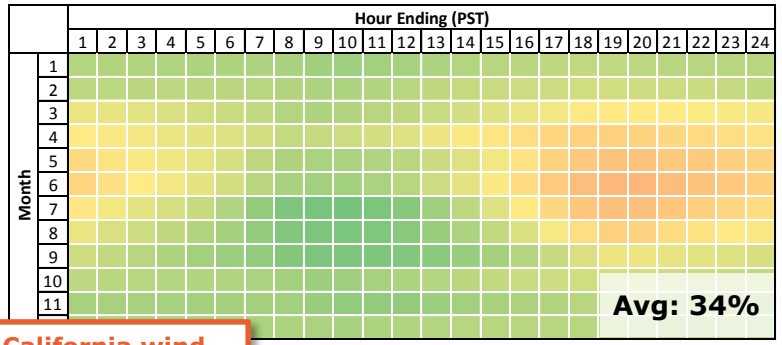
# Wind Resource Performance

## + NREL's WIND Toolkit database used to derive location-specific hourly profiles for analysis

### Wyoming



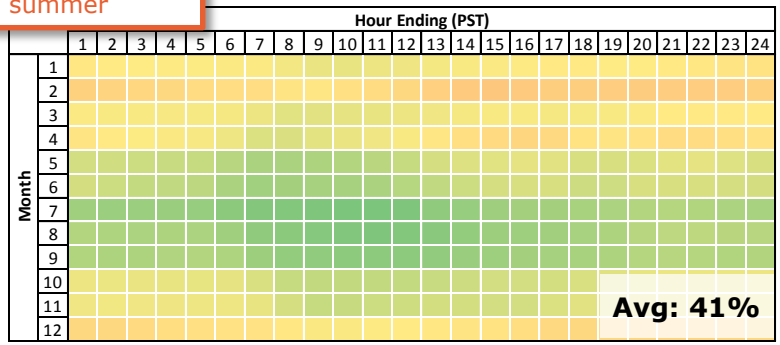

### Tehachapi



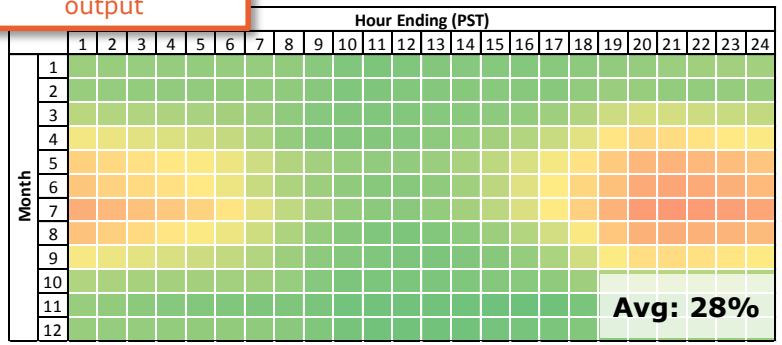

**Rockies wind** is strongest in winter and weakest in summer

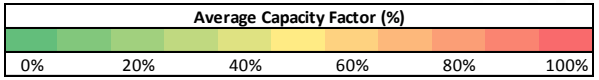
**California wind** exhibits strong diurnal patterns of output

### New Mexico



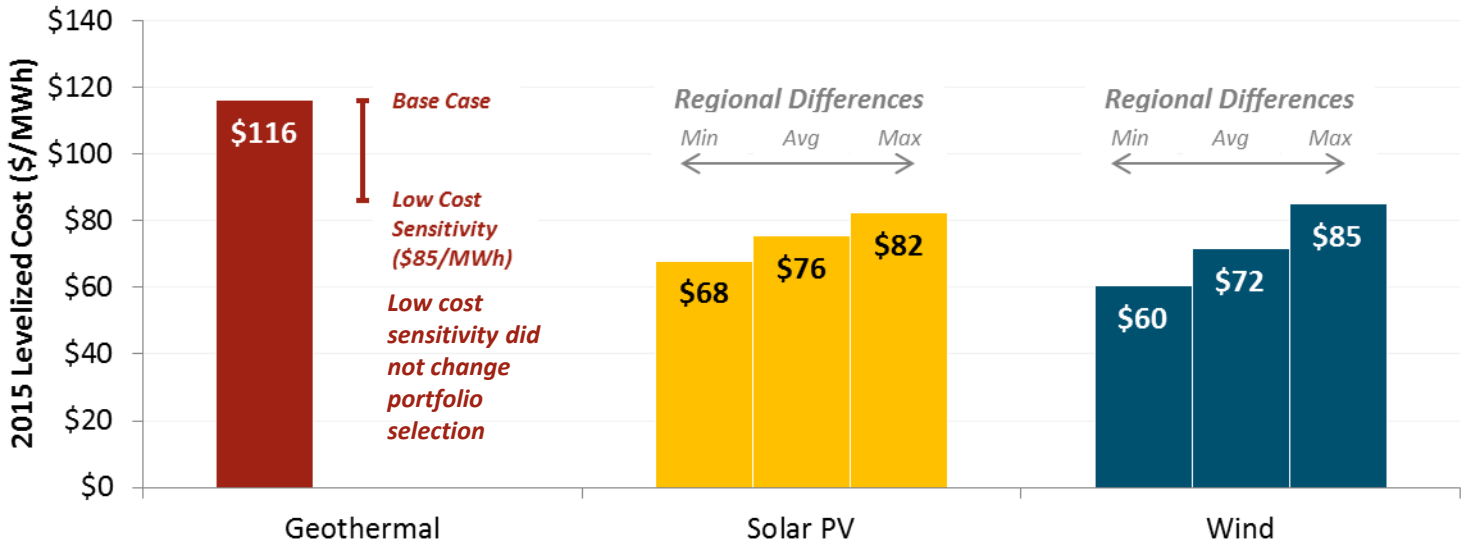

### Solano



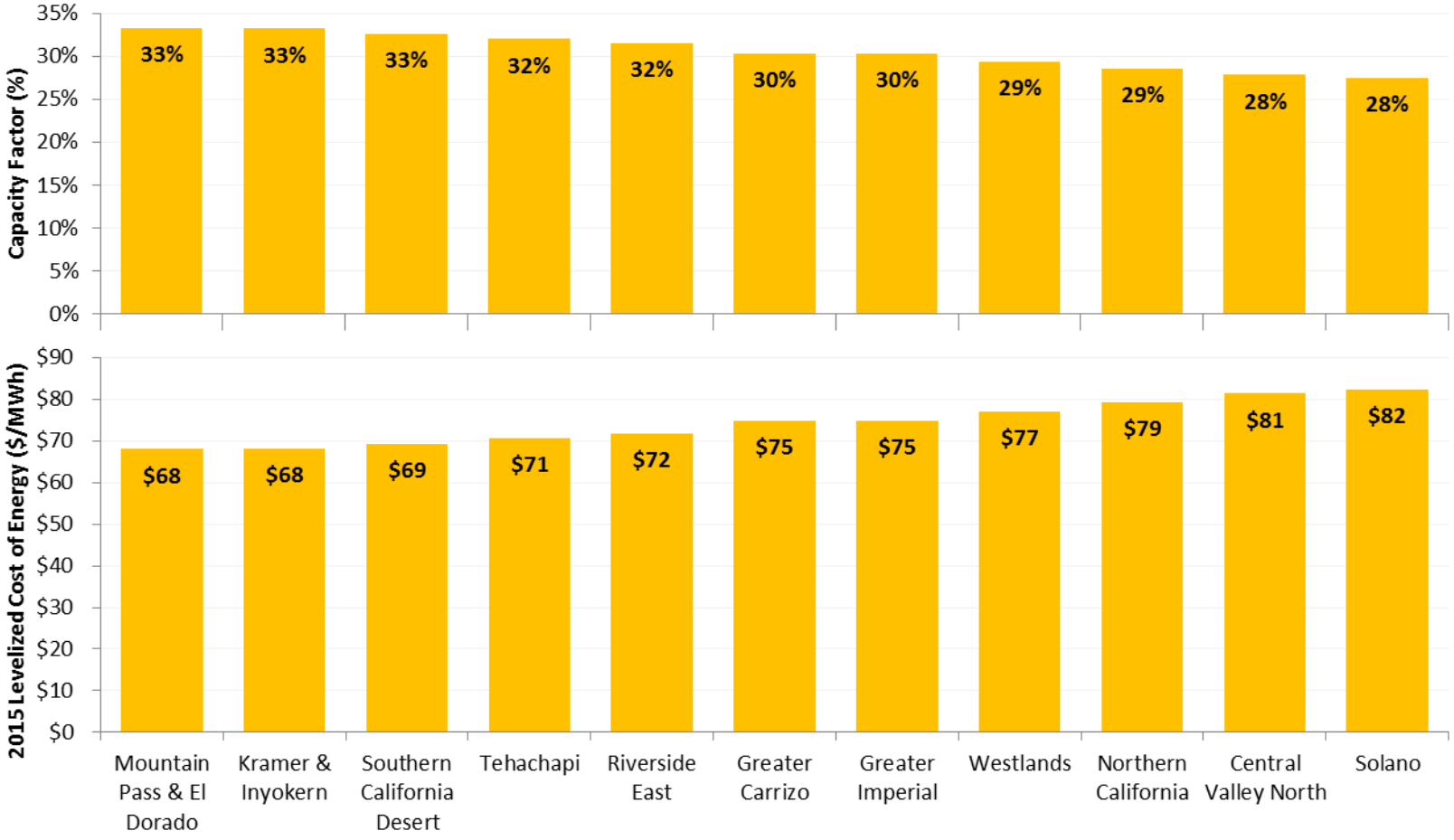
# Modeled California PPA Prices for 2015 Delivery

- **Levelized Cost of Electricity for wind, solar, and geothermal based on Black & Veatch assessment of cost and performance for RPS Calculator. Includes effect of federal tax credits.**



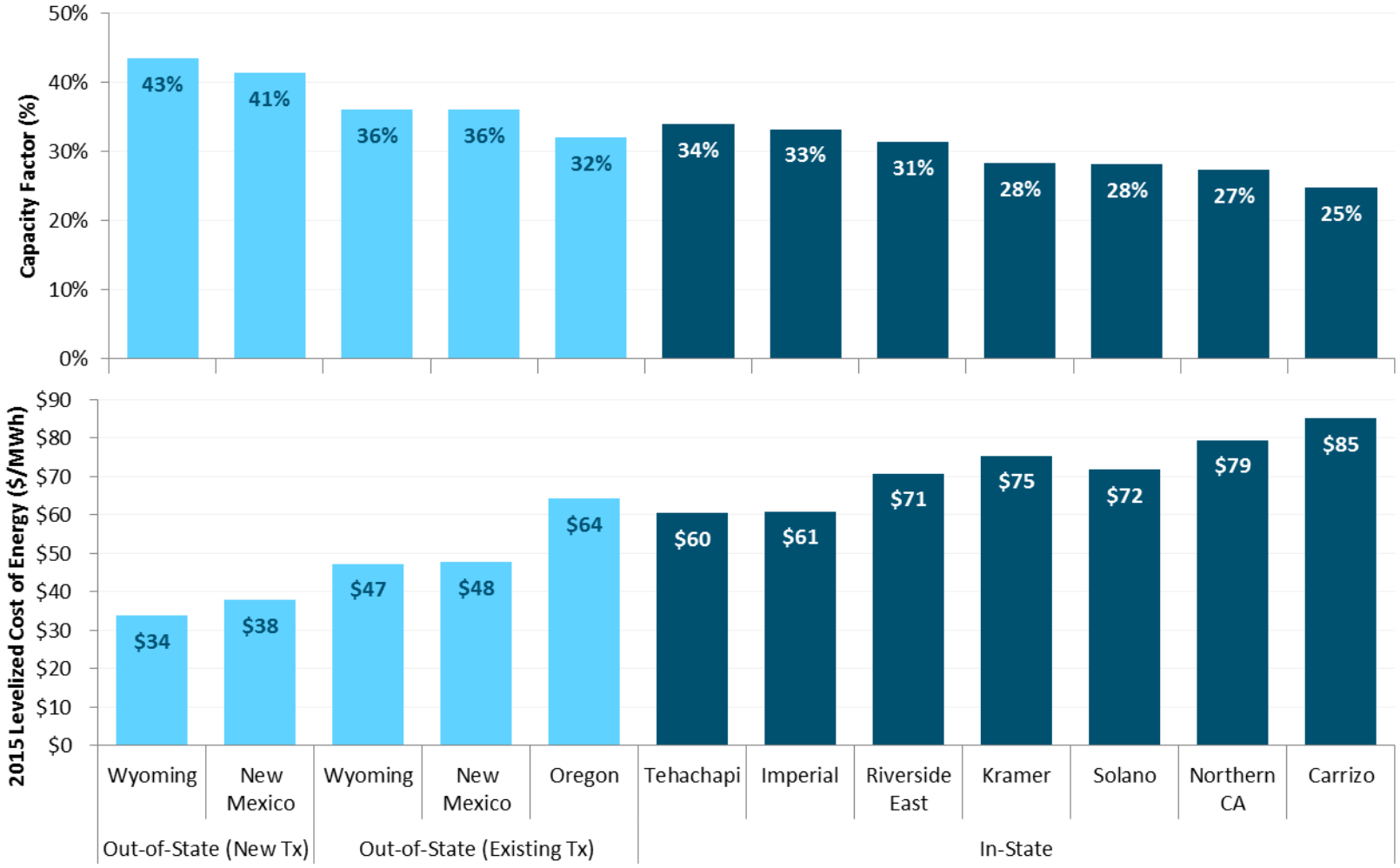

- **Wind and solar PPA prices vary by location due to differences in cost and capacity factors**
- **Geothermal costs are highly site-specific & uncertain, so a range of costs was tested**

# Regional Variations in Solar Quality & Cost




Assumptions: single axis tracking solar PV with an inverter loading ratio of 1.3, impacts of federal tax credits are included

# Regional Variations in Wind Quality & Cost




Impacts of federal tax credits are included

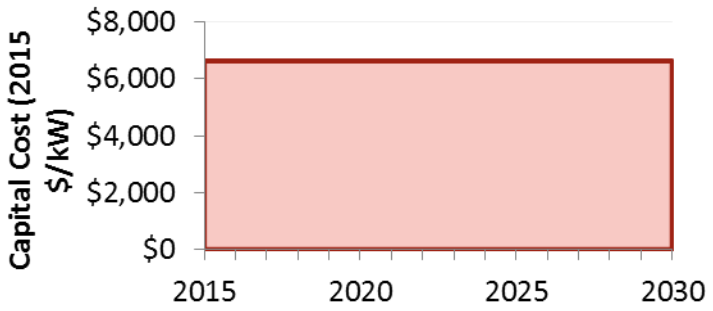
# PPA prices change over time

- **Power purchase agreement prices are projected through 2030 based on long-term industry trends:**
  - **Capital cost reductions:** technological improvement expected to reduce renewable resource costs
    - Projections provided by Black & Veatch for RPS Calculator
  - **Long run financing:** financing costs expected to increase over time due to rising interest rates
  - **Property tax exemption:** the exemption of solar facilities from California property tax is not available to facilities installed after 2024
  - **Federal tax credit sunsets:** Federal ITC and PTC roll off in 2017
    - Solar PV & geothermal eligible for 10% ITC after 2017

# Future Capital Cost Reductions

## Geothermal

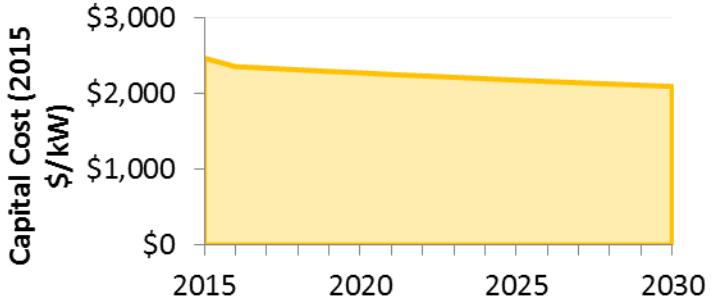
- No projected future cost declines




## Solar PV

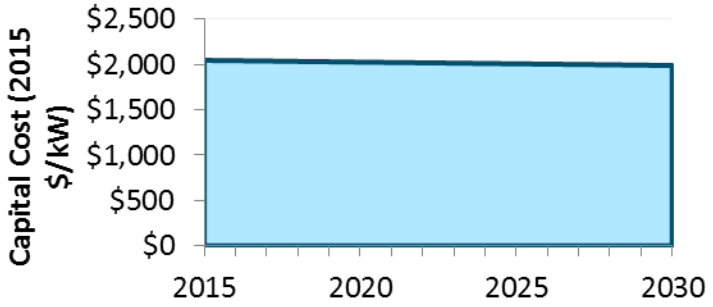
- 8% cost reduction by 2020
- 15% cost reduction by 2030

*(costs shown in $/kW-AC)*



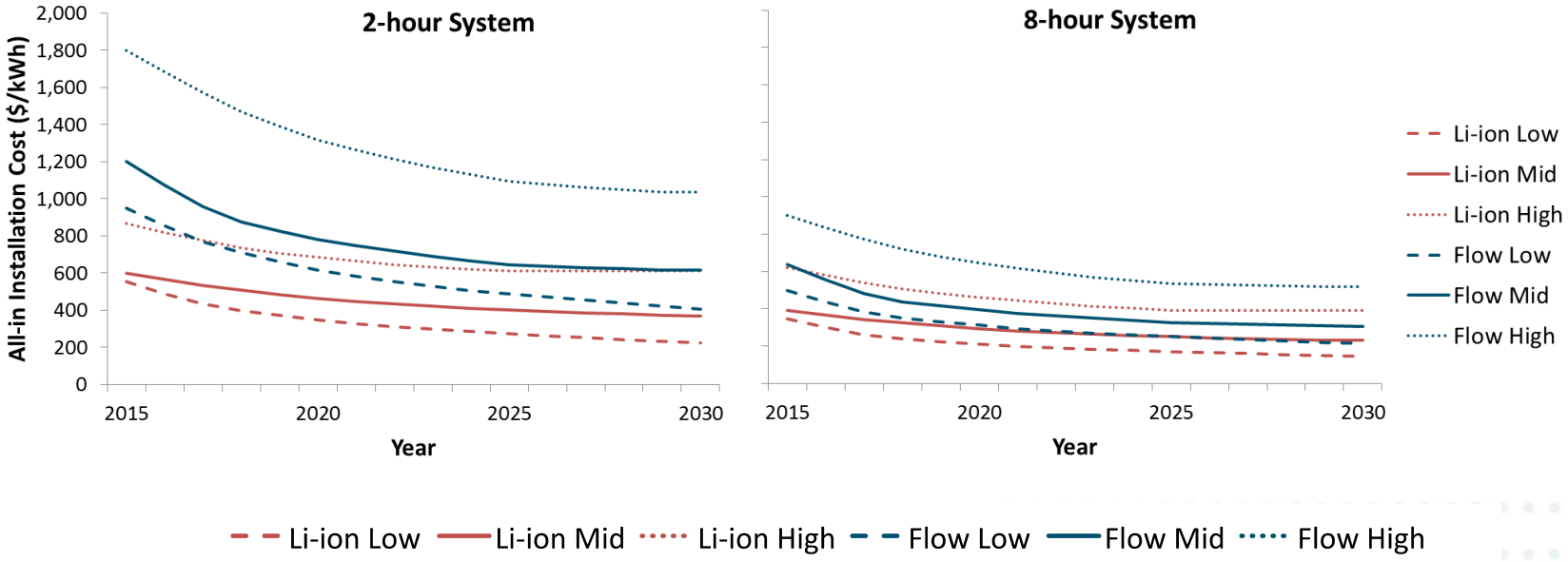

## Wind

- 1% cost reduction by 2020
- 3% cost reduction by 2030



# Battery Installed Costs

- **Battery cost estimates are based on literature review and quotes from manufacturers**
  - Mid-range costs used for base case
- **Installed cost of Li-ion is lower even at long durations, but flow battery has lower O&M costs and does not require replacement.**
- **RESOLVE selects least-cost storage type, capacity and duration.**



# Pumped storage costs

- **Pumped storage costs are site-specific with wide ranges**
  - Literature review and developer quotes found range between $1500/kW and $/5,485 kW
- **No changes to pumped storage costs assumed over time**
- **Installed cost of $2,400/kW assumed for a 12-hour system**
  - Based on E3 WECC Capital Cost Study
  - RESOLVE tested low and high ranges: $1,600 - $3,400/kW. Mid costs are used for base scenarios.

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# DRAFT RENEWABLE PORTFOLIOS

# Renewable Portfolios & Scenarios

- **Resources are incremental to existing and contracted resources from RPS Calculator**
- **Least-cost combination of resources selected to meet RPS targets in each period**
- **500 MW of geothermal and 500 MW of pumped storage manually added for portfolio diversity**

| Scenario | Description | CAISO Simultaneous Export Limit |
|---|---|---|
| **1** | BAU procurement<br>CAISO grid operations | 1a) 2,000 MW |
| | | 1b) 5,000 MW |
| | | 1c) 8,000 MW |
| **2** | BAU procurement<br>WECC operations | 8,000 MW |
| **3** | WECC procurement<br>WECC operations | 8,000 MW |

# Common Renewable Resources to Meet 33% RPS (All Scenarios)

- **All scenarios start with renewable resources under contract to meet a 33% RPS**
  - Base portfolio is drawn from CPUC RPS Calculator v6.1
- **Base portfolio assumes CPUC storage mandate plus existing pumped storage**
- **Base portfolio assumes 14,600 MW of behind-the-meter PV in CAISO area**
  - Reduces sales but does qualify for RPS

| Base Portfolio to meet 33% RPS in 2030 (MW) | |
|---|---|
| | **Scenarios 1 - 3** |
| CAISO Solar | 9,890 |
| CAISO Wind | 5,259 |
| CAISO Geothermal | 1,117 |
| CAISO Small Hydro | 429 |
| CAISO Biomass | 794 |
| Northwest Wind | 2,186 |
| Northwest Biomass | 1 |
| Northwest Geothermal | 32 |
| Southwest Solar | 197 |
| Southwest Geothermal | 449 |
| Total CAISO Resources | 17,489 |
| Total Out-of-State Resources | 2,865 |
| Total Renewable Resources | 20,354 |
| Energy Storage | 3,820 |
| Behind-the-meter Rooftop PV | 14,600 |

# Incremental resources selected (in MW)

- Model selects a diverse portfolio of in-state solar and out-of-state wind across all cases

| | BAU Procurement CAISO Operations | | | BAU Procurement WECC Operations | WECC Procurement WECC Operations |
|---|---|---|---|---|---|
| | Scenario 1a | Scenario 1b | Scenario 1c | Scenario 2 | Scenario 3 |
| CAISO simultaneous export limit | 2000 | 5000 | 8000 | 8000 | 8000 |
| Procurement | BAU | BAU | BAU | BAU | WECC-wide |
| Operations | CAISO | CAISO | CAISO | WECC-wide | WECC-wide |
| **Portfolio Composition (MW)** | | | | | |
| CAISO Solar | 7,774 | 8,268 | 7,798 | 8,058 | 4,362 |
| CAISO Wind | 3,000 | 3,000 | 3,000 | 1,900 | 1,500 |
| CAISO Geothermal | 500 | 500 | 500 | 500 | 500 |
| Northwest Wind, Existing Transmission | 389 | - | - | - | - |
| Northwest Wind RECs | 1,000 | - | - | - | - |
| Wyoming Wind, Existing Transmission | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 |
| Wyoming Wind, New Transmission | - | - | - | - | 1,500 |
| Southwest Solar, Existing Transmission | - | - | - | 500 | 500 |
| Southwest Solar RECs | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 |
| New Mexico Wind, Existing Transmission | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 |
| New Mexico Wind, New Transmission | - | - | - | - | 1,500 |
| Total CAISO Resources | 11,274 | 11,768 | 11,298 | 10,458 | 6,362 |
| Total Out-of-State Resources | 4,389 | 3,000 | 3,000 | 3,500 | 6,500 |
| Total Renewable Resources | 15,663 | 14,768 | 14,298 | 13,958 | 12,862 |
| | | | | | |
| Energy Storage (MW) | 500 | 500 | 500 | 500 | 500 |

# Incremental resources selected (in GWh)

- **Model selects a diverse portfolio of in-state solar and out-of-state wind across all cases**

| | BAU Procurement CAISO Operations | | | BAU Procurement WECC Operations | WECC Procurement WECC Operations |
|---|---|---|---|---|---|
| | **Scenario 1a** | **Scenario 1b** | **Scenario 1c** | **Scenario 2** | **Scenario 3** |
| CAISO simultaneous export limit | 2000 | 5000 | 8000 | 8000 | 8000 |
| Procurement | BAU | BAU | BAU | BAU | WECC-wide |
| Operations | CAISO | CAISO | CAISO | WECC-wide | WECC-wide |
| **Portfolio Composition (GWh)** | | | | | |
| CAISO Solar | 22,221 | 23,745 | 22,491 | 23,223 | 12,752 |
| CAISO Wind | 8,193 | 8,193 | 8,193 | 5,560 | 4,442 |
| CAISO Geothermal | 4,380 | 4,380 | 4,380 | 4,380 | 4,380 |
| Northwest Wind, Existing Transmission | 914 | - | - | - | - |
| Northwest Wind RECs | 2,350 | - | - | - | - |
| Wyoming Wind, Existing Transmission | 3,151 | 3,151 | 3,151 | 3,151 | 3,151 |
| Wyoming Wind, New Transmission | - | - | - | - | 5,659 |
| Southwest Solar, Existing Transmission | - | - | - | 1,417 | 1,417 |
| Southwest Solar RECs | 2,833 | 2,833 | 2,833 | 2,833 | 2,833 |
| New Mexico Wind, Existing Transmission | 3,153 | 3,153 | 3,153 | 3,153 | 3,153 |
| New Mexico Wind, New Transmission | - | - | - | - | 5,426 |
| Total CAISO Resources | 34,794 | 36,318 | 35,064 | 33,163 | 21,574 |
| Total Out-of-State Resources | 12,401 | 9,137 | 9,137 | 10,554 | 21,639 |
| Total Renewable Resources | 47,195 | 45,455 | 44,201 | 43,717 | 43,213 |

* Note: table lists *available* GWh; delivered GWh is the same in all scenarios; differences in total GWh due to changes in renewable curtailment

# Scenario 1: Incremental Renewable Resource Portfolio Composition

| | BAU Procurement CAISO Operations | | | BAU Procurement WECC Operations | WECC Procurement WECC Operations |
|---|---|---|---|---|---|
| | **Scenario 1a** | **Scenario 1b** | **Scenario 1c** | **Scenario 2** | **Scenario 3** |
| CAISO simultaneous export limit | 2000 | 5000 | 8000 | 8000 | 8000 |
| Procurement | BAU | BAU | BAU | BAU | WECC-wide |
| Operations | CAISO | CAISO | CAISO | WECC-wide | WECC-wide |
| **Portfolio Composition (MW)** | | | | | |
| CAISO Solar | **7,774** | **8,268** | **7,798** | 8,058 | 4,362 |
| CAISO Wind | **3,000** | **3,000** | **3,000** | | |
| CAISO Geothermal | **500** | **500** | **500** | | |
| Northwest Wind, Existing Transmission | **389** | - | - | | |
| Northwest Wind RECs | **1,000** | - | - | | |
| Wyoming Wind, Existing Transmission | **1,000** | **1,000** | **1,000** | | |
| Wyoming Wind, New Transmission | - | - | - | | |
| Southwest Solar, Existing Transmission | - | - | - | | |
| Southwest Solar RECs | **1,000** | **1,000** | **1,000** | | |
| New Mexico Wind, Existing Transmission | **1,000** | **1,000** | **1,000** | | |
| New Mexico Wind, New Transmission | - | - | - | | |
| Total CAISO Resources | 11,274 | 11,768 | 11,298 | 10,458 | 6,362 |
| Total Out-of-State Resources | 4,389 | 3,000 | 3,000 | 3,500 | 6,500 |
| Total Renewable Resources | 15,663 | 14,768 | 14,298 | 13,958 | 12,862 |
| | | | | | |
| Energy Storage (MW) | 500 | 500 | 500 | 500 | 500 |

- Increased export capability improves the economics of in-state solar due to lower curtailment
- Lower curtailment causes in-state solar to displace out-of-state wind

# Scenario 2: Incremental Renewable Resource Portfolio Composition

| | BAU Procurement CAISO Operations | | | BAU Procurement WECC Operations | WECC Procurement WECC Operations |
|---|---|---|---|---|---|
| | Scenario 1a | Scenario 1b | Scenario 1c | Scenario 2 | Scenario 3 |
| CAISO simultaneous export limit | 2000 | 5000 | 8000 | 8000 | 8000 |
| Procurement | BAU | BAU | BAU | BAU | WECC-wide |
| Operations | CAISO | CAISO | CAISO | WECC-wide | WECC-wide |
| **Portfolio Composition (MW)** | | | | | |
| CAISO Solar | **7,774** | | | **8,058** | 4,362 |
| CAISO Wind | **3,000** | | | **1,900** | 1,500 |
| CAISO Geothermal | **500** | | | **500** | 500 |
| Northwest Wind, Existing Transmission | **389** | | | **-** | - |
| Northwest Wind RECs | **1,000** | | | **-** | - |
| Wyoming Wind, Existing Transmission | **1,000** | | | **1,000** | 1,000 |
| Wyoming Wind, New Transmission | **-** | | | **-** | 1,500 |
| Southwest Solar, Existing Transmission | **-** | | | **500** | 500 |
| Southwest Solar RECs | **1,000** | | | **1,000** | 1,000 |
| New Mexico Wind, Existing Transmission | **1,000** | | | **1,000** | 1,000 |
| New Mexico Wind, New Transmission | **-** | | | **-** | 1,500 |
| Total CAISO Resources | 11,274 | 11,768 | 11,208 | 10,458 | 6,362 |
| Total Out-of-State Resources | 4,389 | | | | 6,500 |
| Total Renewable Resources | 15,663 | | | | 2,862 |
| | | | | | |
| Energy Storage (MW) | 500 | | | | 500 |

- Ability to export makes possible lower curtailment and higher solar procurement
- Lower curtailment reduces in-state and out-of-state wind

- Southwest "existing transmission" solar procured in Scenario 2 as it can be delivered locally and does not exacerbate California curtailment

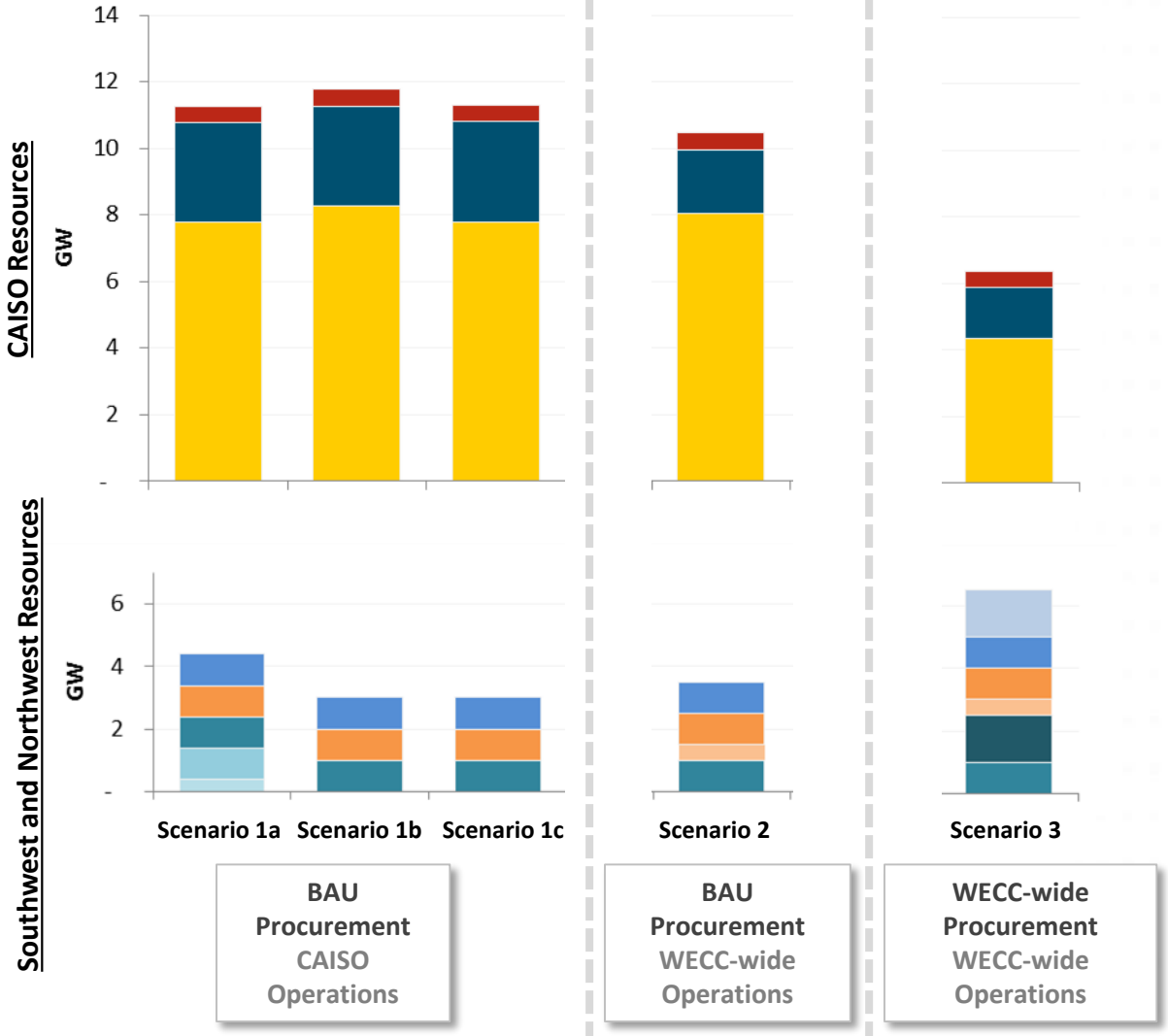
# Scenario 3: Incremental Renewable Resource Portfolio Composition

| | BAU Procurement CAISO Operations | | | BAU Procurement WECC Operations | WECC Procurement WECC Operations |
|---|---|---|---|---|---|
| | **Scenario 1a** | **Scenario 1b** | **Scenario 1c** | **Scenario 2** | **Scenario 3** |
| CAISO simultaneous export limit | 2000 | 5000 | 8000 | 8000 | 8000 |
| Procurement | BAU | BAU | BAU | BAU | WECC-wide |
| Operations | CAISO | CAISO | CAISO | WECC-wide | WECC-wide |
| **Portfolio Composition (MW)** | | | | | |
| CAISO Solar | **7,774** | | | | **4,362** |
| CAISO Wind | **3,000** | | | | **1,500** |
| CAISO Geothermal | **500** | | | | **500** |
| Northwest Wind, Existing Transmission | **389** | | | | **-** |
| Northwest Wind RECs | **1,000** | | | | **-** |
| Wyoming Wind, Existing Transmission | **1,000** | | | | **1,000** |
| Wyoming Wind, New Transmission | **-** | | | | **1,500** |
| Southwest Solar, Existing Transmission | **-** | | | | **500** |
| Southwest Solar RECs | **1,000** | | | | **1,000** |
| New Mexico Wind, Existing Transmission | **1,000** | | | | **1,000** |
| New Mexico Wind, New Transmission | **-** | | | | **1,500** |
| Total CAISO Resources | 11,274 | | | | 6,362 |
| Total Out-of-State Resources | | | | | |
| Total Renewable Resources | 15,663 | | | | 12,862 |
| | | | | | |
| Energy Storage (MW) | | | | | |

Fewer California resources procured with WECC-wide resource availability

Diverse WECC-wide portfolio procured, including 3000 MW of Wyoming and New Mexico wind as well as Southwest solar

# Summary: Incremental Renewable Resource Portfolio Composition



# Key Areas for Stakeholder Input

- **Overall renewable resource portfolios by scenario**
  - Availability of in-state and out-of-state resources
  - Availability of renewable electricity credits (RECs)
  - Quantities and types of energy storage by scenario
- **Resource cost assumptions**
- **Other key data inputs**
  - Electricity load forecast
  - Behind-the-meter solar PV
- **Other comments on overall modeling framework**

Energy+Environmental Economics

# Thank You!

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