IRP Modeling Advisory Group Webinar

Resource-to-Busbar Mapping for 2020-2021 TPP

May 22, 2020

Modeling Advisory Group (MAG) Background

- The MAG provides an **open forum** for informal technical discussion and vetting of data sources, assumptions, and modeling activities undertaken by CPUC staff to support the IRP proceeding (R.16-02-007 / R.20-05-003)
- **Participation** in the MAG is open to the public, subject to the terms of the charter, and communication of events and materials is through the IRP proceeding service list
- Feedback received during and following MAG webinars **inform** staff work products that are later introduced into the formal record of the IRP proceeding

Purpose and Scope of Webinar

- Purpose:
  - Familiarize stakeholders with the various busbar mapping-related deliverables produced for the 2020-2021 Transmission Planning Process (TPP)
    - Helps stakeholder engagement during TPP
    - Informs how load serving entities can consider transmission needs in their IRPs due September 1, 2020

- Scope:
  - Methodology and results of busbar mapping process conducted from Q3 2019 to Q1 2020, for input to 2020-2021 TPP

- Out of scope:
  - 2020-21 TPP study status
  - 2021-22 TPP portfolio selection
  - IRP Proceeding including, but not limited to:
    - Commission decisions “upstream” of busbar mapping
    - D.20-03-028, Order Instituting Rulemaking and schedule
    - Preferred System Plan
      - LSE plan development
      - LSE plan aggregation
    - IRP Procurement Track

Outline

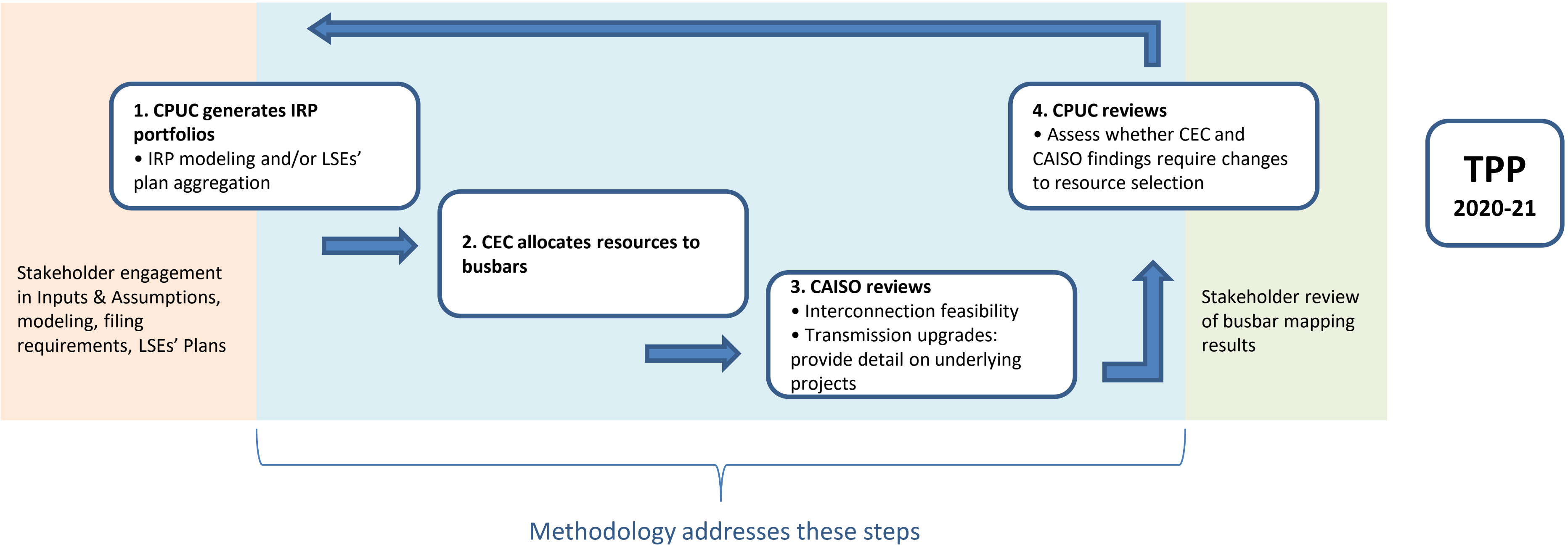
- Introduction
  - MAG background
  - Purpose and scope
  - IRP & TPP context
- Methodology
  - Portfolio preparation, including RESOLVE, by CPUC
  - Mapping by California Energy Commission (CEC) staff
  - Observation and review by California Independent System Operator (CAISO) staff
  - Battery mapping
- Results
  - Battery resources
  - Generation resources
- Next Steps & Future Challenges
- Questions

IRP and TPP – busbar mapping context

- Resource-to-busbar mapping ("busbar mapping"): process for translating geographically-coarse portfolios to plausible network locations for Transmission Planning Process (TPP) modeling
- Busbar mapping scope: utility-scale generation and storage resources that are not already in the baseline
- Learnings and questions from 2017 and 2018 efforts included:
  - Engaging the CAISO, as well as the CEC, in the busbar mapping process can address issues iteratively during the IRP portfolio formation process, rather than later, during TPP
  - How to validate that the theoretical resource potential estimates in RESOLVE are sufficiently representative of commercial interest?
  - How to ensure that gen-ties are feasible, economically and from a land-use perspective?
  - What other success criteria should be used to determine whether allocations are appropriate?

METHODOLOGY

Methodology for 2019-20 busbar mapping

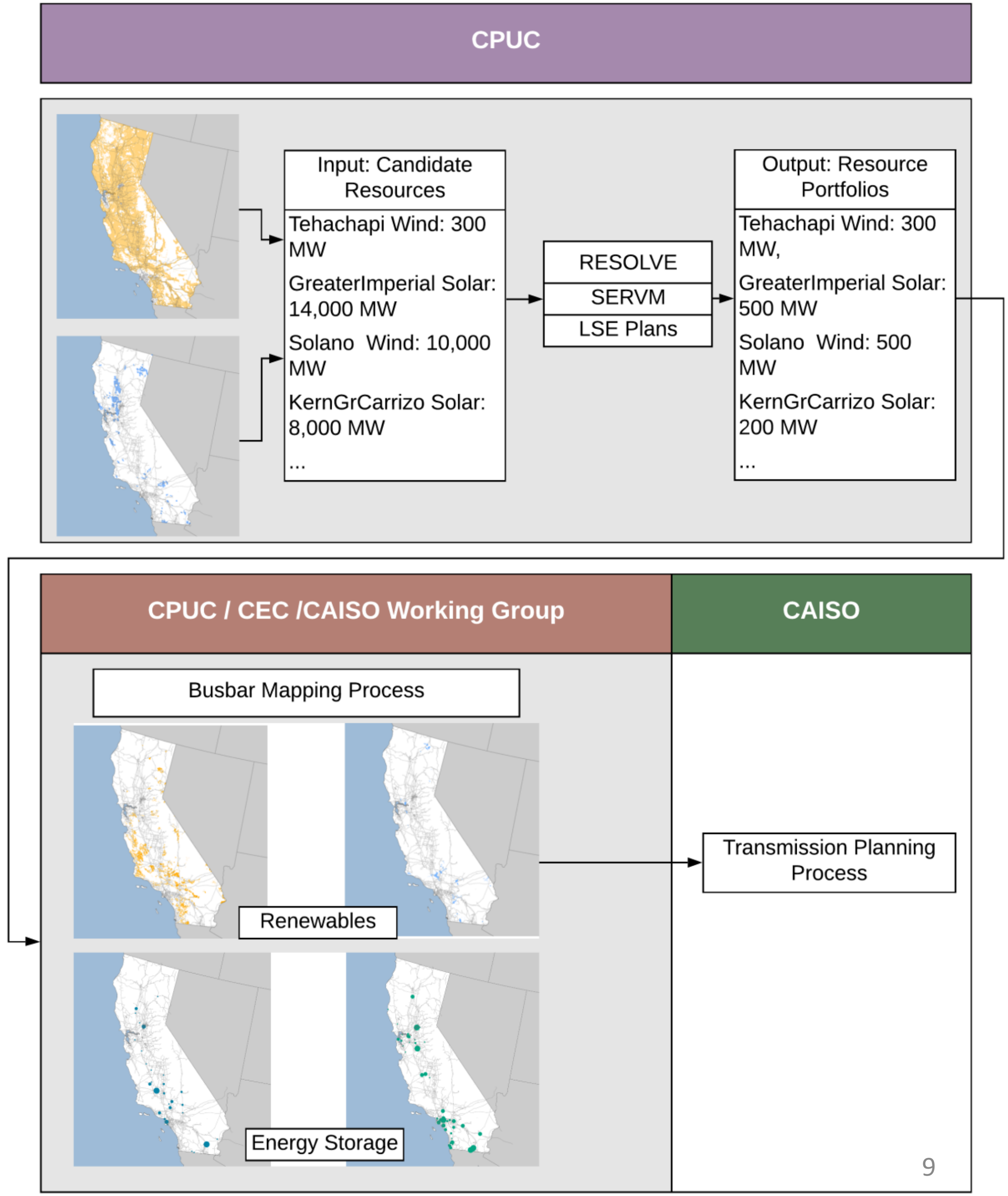


- Improvements for 2019-20 busbar mapping
  - Publishing Methodology for stakeholder vetting upfront
  - Identifying specific steps performed by each agency's staff, enabling iterative refinement of IRP portfolios
  - Introducing validation of resource potential with commercial interest
  - Articulation of guiding principles and criteria for effective mapping
  - Mapping battery storage for the first time

Criteria for success

- Developed via the Methodology staff proposed in September 2019, informal comments received, and staff experience during the mapping process:
  - Distance to transmission
  - Transmission capability
  - Available land area
  - Use of high environmental value land
  - Commercial interest
  - Consistency with prior year’s mapping
- Detail of how these were implemented will be described in Results section of this webinar

Methodology



Deliverables completed in Q1 2020

- Methodology
- Report
  - Release 1
    - Focused on 2017-2018 Preferred System Portfolio, with updated baseline
  - Release 2
    - Focused on 2019-2020 Reference System Portfolio, and 2019 30 MMT by 2030 with Expanded Energy Only Transmission Capacity Sensitivity Portfolio
- Mapping dashboard
  - 2018 Updated PSP
  - 2019 RSP
  - 2019 30 MMT EO Portfolio
- Busbar mapping results workbooks
  - Generation
  - Battery energy storage

RESOLVE's role in busbar mapping

- RESOLVE **inputs** utilize Fully Deliverable (FD) and Energy-Only (EO) transmission limits consistent with CAISO guidance
- RESOLVE then **outputs** least-cost capacity expansion portfolio results, which serve as key inputs in the busbar mapping analysis
  - The portfolio of selected resources by 2030 and their assigned FD or EO transmission zones is the foundation of the busbar mapping process
- Adjustments made during the busbar mapping process are compared back to RESOLVE's FD and EO limits, to **avoid** transmission limit violations
- The **results** of three scenarios representing the TPP Base Case and the TPP Policy-driven Sensitivity Cases were used for this analysis
  - 2018 Preferred System Portfolio (TPP Base Case)
  - 2019 Reference System Plan (TPP Sensitivity)
  - 2019 30 MMT EO Portfolio (TPP Sensitivity)

RESOLVE supply curve

- The RESOLVE supply curve contains resource attribute data at a generator level
- This generator level data is aggregated to form the resources that are used in the RESOLVE optimization

Supply Curve

Active Screen	5
Count	946

Resource Specification							Resource Characteristics			Environmental Screens	
Index	RE ID	Name	Electrical Zone: Super CREZ or WREZ	Latitude	Longitude	Type	Raw Resource Potential with Limits Applied to Baja Wind and NorCal Wind based on Interconnection Queue [MW]	Raw Resource Potential [MW]	Capacity Factor [%]	Base [%]	Env Baseline [%]
801	BV_CA_67	CA Wind 86	Norcal_Z3_SacramentoRiver	38.39	-121.57	Wind	84	84	32.76%	100.0%	0.00%
802	BV_CA_99	CA Wind 133	GK_Z3_NorthOfVictor	34.91	-116.69	Wind	29	29	37.04%	100.0%	75.86%
803	BV_CA_156	CA Wind 219	SCADSNV_Z3_GreaterImperial	32.89	-114.72	Wind	115	115	34.28%	100.0%	0.00%
804	BV_CA_131	CA Wind 182	SCADSNV_Z3_GreaterImperial	33.39	-115.22	Wind	55	55	40.28%	100.0%	0.00%
805	BV_CA_153	CA Wind 215	SCADSNV_Z3_GreaterImperial	32.65	-116.13	Wind	75	75	35.79%	100.0%	0.00%
806	BV_CA_94	CA Wind 126	Tehachapi	35.45	-118.10	Wind	67	67	38.72%	100.0%	0.00%

RESOLVE results – FD and EO buildout

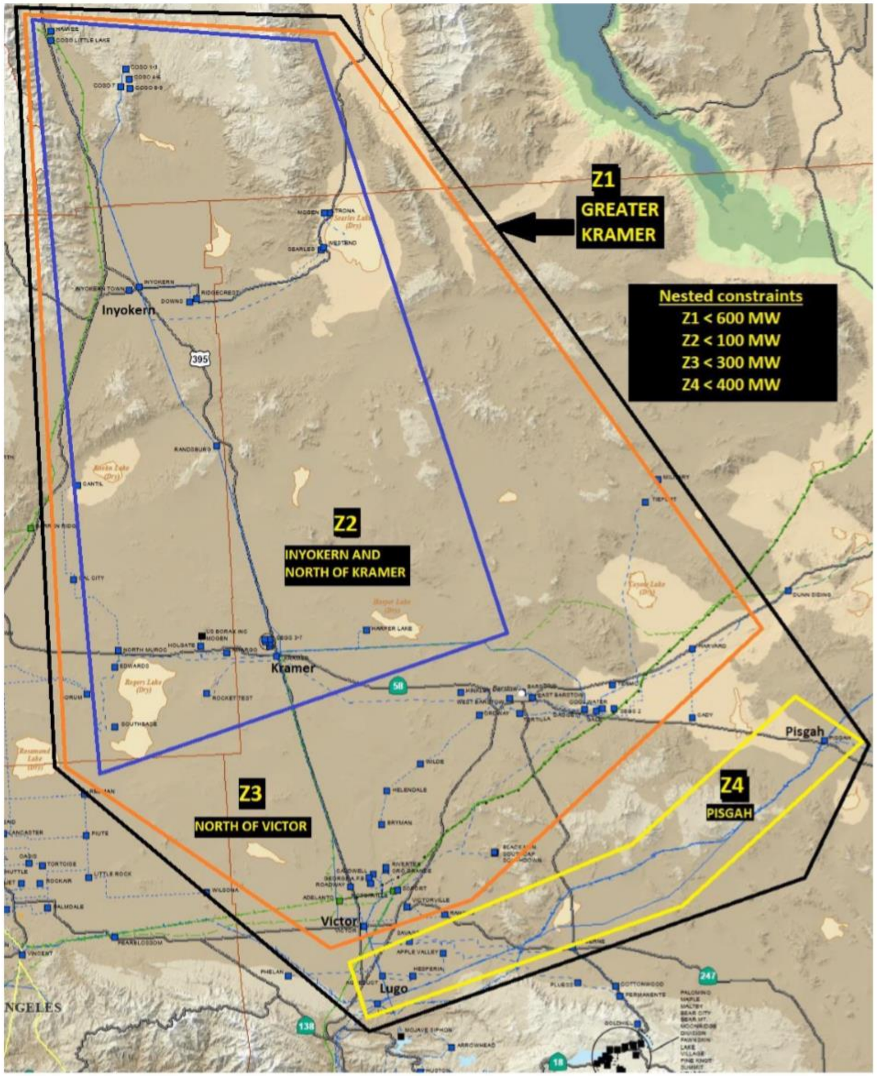
- The selected resources are reported by FD and EO status in the Portfolio Analytics tab of the Results Viewer workbook of the RESOLVE package.

393	**Selected Renewables by Location**		
465			
466	**Selected Renewables by Location (Fully Deliverable)**		
538			
539	**Selected Renewables by Location (Energy Only)**		
540			
541	**EO Renewable Resource Summary by Location (MW)**		
542	**RESOLVE Resource**	**Tx Zone**	**2020**
543	InState_Biomass	None	-
544	Greater_Imperial_Geothermal	SCADSNV-Greater_Imperial	-
545	Inyokern_North_Kramer_Geothermal	Inyokern_North_Kramer-Greater_Kramer	-
546	Northern_California_Ex_Geothermal	Northern_California_Ex	-
547	Pacific_Northwest_Geothermal	N/A	-
548	Riverside_Palm_Springs_Geothermal	SCADSNV-Riverside_Palm_Springs	-
549	Solano_Geothermal	Sacramento_River-Solano	-
550	Southern_Nevada_Geothermal	Mountain_Pass_El_Dorado-SCADSNV	-
551	Carrizo_Solar	Carrizo-Kern_Greater_Carrizo-SPGE	-
552	Carrizo_Wind	Carrizo-Kern_Greater_Carrizo-SPGE	-

Dashboard | Portfolio Analytics | Scenario Comparison | Lists | raw_annual_curtailment | raw_annual_energy | raw_annual_load | raw_fuel_burn | raw_ghg | raw_ghg_imports | raw_inputs_passthrough | raw_loca ...

Transmission zone assumptions

Figure 2-1: Transmission capability estimates for Greater Kramer transmission zone



https://www.caiso.com/Documents/WhitePaper-TransmissionCapabilityEstimates-InputtoCPUCIntegratedResourcePlanPortfolioDevelopment.pdf

In-state transmission zones within RESOLVE

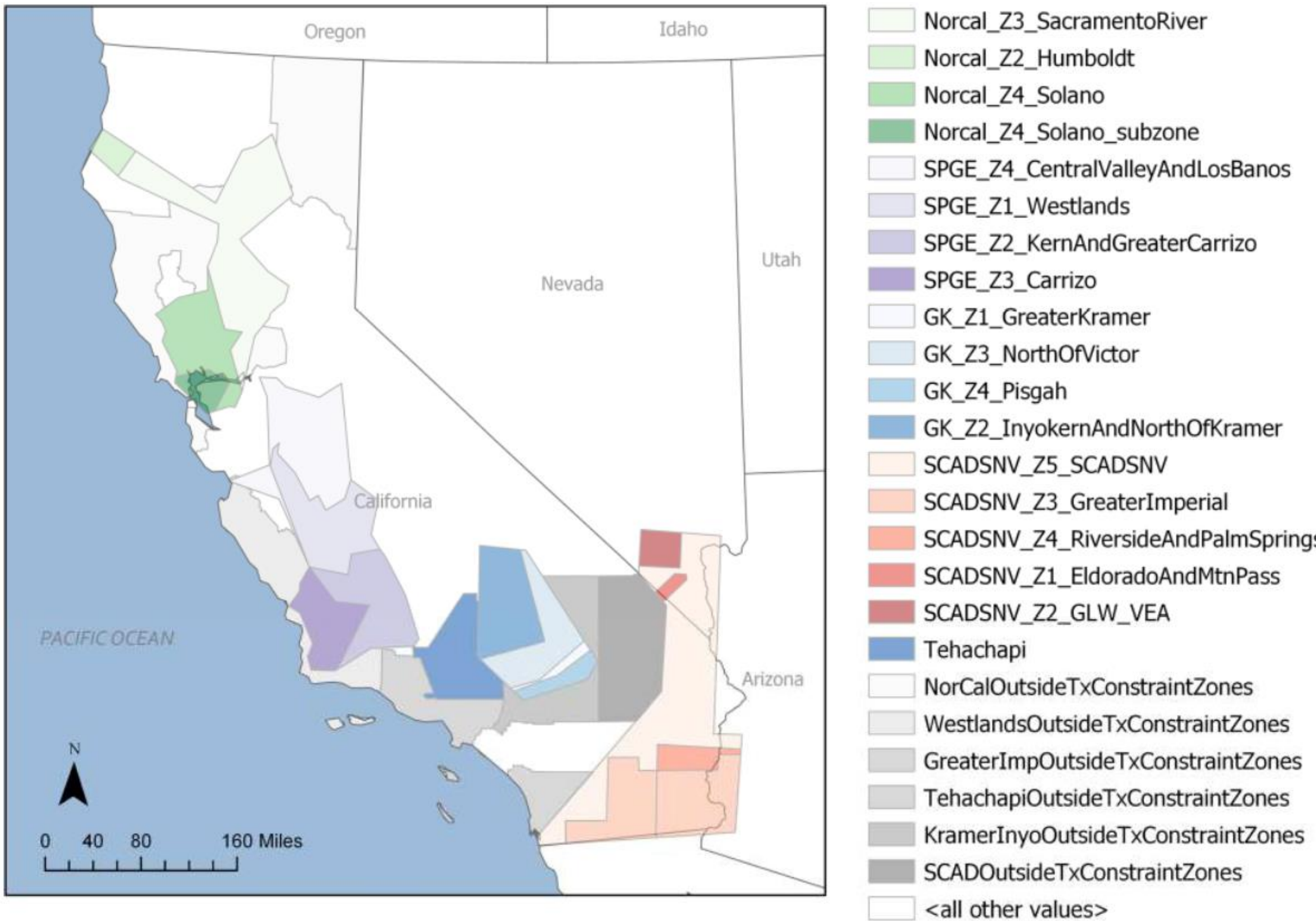


Figure 4.1, Inputs & Assumptions ftp://ftp.cpuc.ca.gov/energy/modeling/Inputs%20%20Assumptions%202019-2020%20CPUC%20IRP%202020-02-27.pdf

Solar Sensitivity Modeling: Background

- Throughout the course of IRP capacity expansion modeling, CPUC staff, consultants, and stakeholders have observed that the location of solar resources selected in IRP modeling can be **sensitive to small cost and performance differences** between solar resources
  - California has many areas of high solar resource quality
  - Other resource types, including wind and geothermal, have more distinct location-specific characteristics
- Transmission constraints provided by CAISO help to **guide the location** of solar resources in IRP modeling, but many iterations of IRP modeling have suggested that solar resources typically "fill in" around other renewable resources (wind and geothermal)
  - Even though the RESOLVE model deploys all resources simultaneously, results have suggested that, at least conceptually, RESOLVE usually uses system-wide economic factors to determine the capacity of wind and geothermal resources, and then deploys the least cost solar resources "next" using any available transmission
- The location-specific cost information available to IRP analysis is not as granular as that available to project developers and **therefore may not accurately** capture local cost differences

Full Solar Cost Sensitivity Modeling slides are available at:
https://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/UtilitiesIndustries/Energy/EnergyPrograms/ElectPowerProcurementGeneration/irp/2019/2020-02-Solar_Cost_Sensitivity_Modeling-slides-V1.0.pdf

Solar Sensitivity Modeling: Conclusion

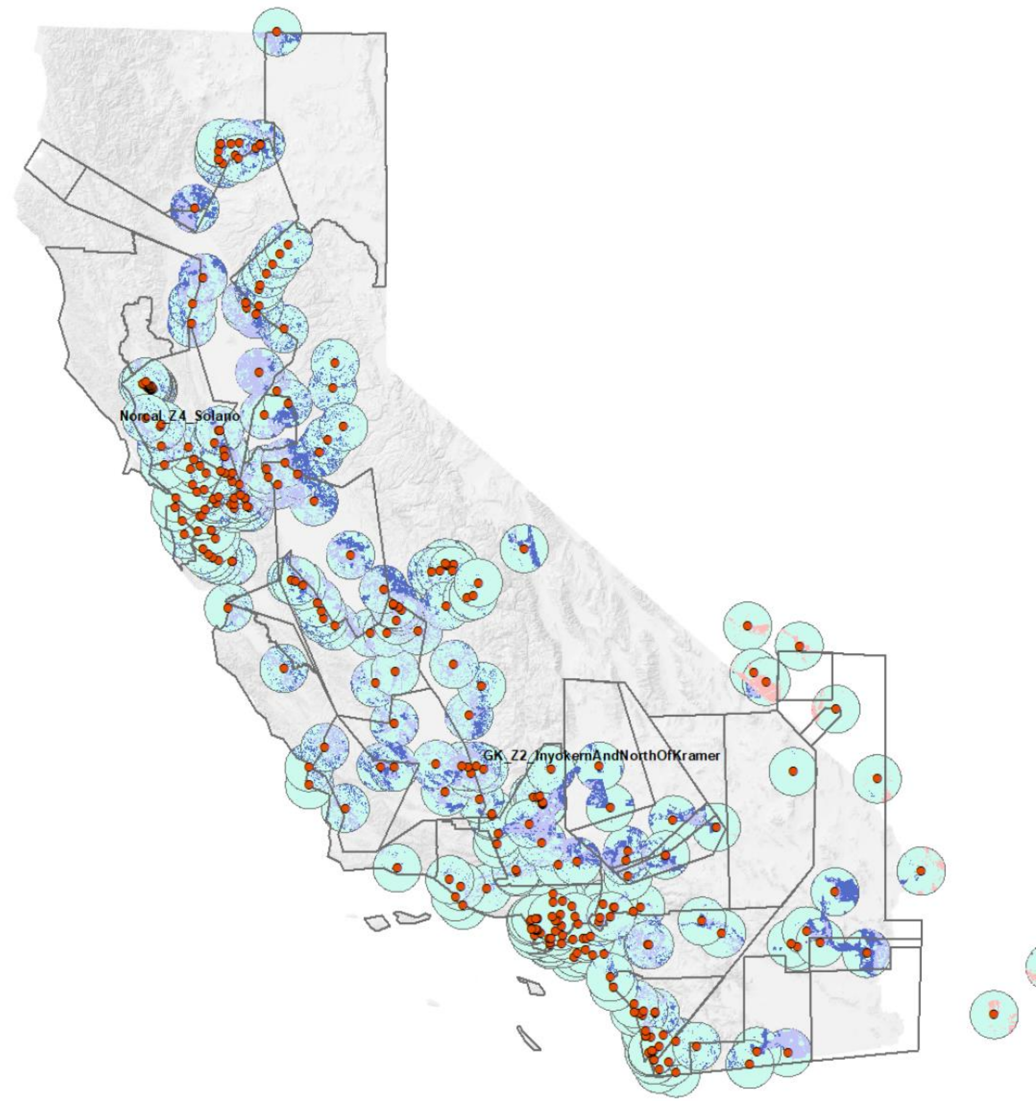
- This analysis **tests the hypothesis** that small cost differences can cause large shifts in the location of solar resources, but will result in minimal changes in the overall resource portfolio (solar vs. wind. vs. battery, etc.) and accordingly, minimal differences in the expected cost, reliability, and emissions performance of the portfolio
- In general, the analysis **confirms the hypothesis,** suggesting that, for the purpose of providing inputs to the TPP, it may be appropriate to post-process RESOLVE solar location results to consider non-modeling factors (for example, alignment with commercial interest)
- From experience analyzing numerous IRP scenarios, Staff expect this conclusion to have **broad relevance t**o a wide range of portfolios with a similar GHG target
  - **Note** that as the GHG target is reduced, the scale of new resources selected generally increases
    - Given the relatively homogenous nature of California's solar potential, RESOLVE selects solar with a priority on not triggering new transmission
    - As the GHG target is reduced, there will be a point where solar is selected up to its limit in each transmission zone and accordingly the relevance of this analysis recedes

Full Solar Cost Sensitivity Modeling slides are available at:
https://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/UtilitiesIndustries/Energy/EnergyPrograms/ElectPowerProcurementGeneration/irp/2019/2020-02-Solar_Cost_Sensitivity_Modeling-slides-V1.0.pdf

Step 2: Mapping performed by CEC

Overview of Statewide Environmental and Land Use Data Methodology for Solar Resources

- Geographic Map for each Renewable Energy Resource (Solar, Wind, Geothermal)
- Environmental and Land Use Information Assembled
- Select Existing and Proposed Substations
- Overlay to Identify Potential Implications



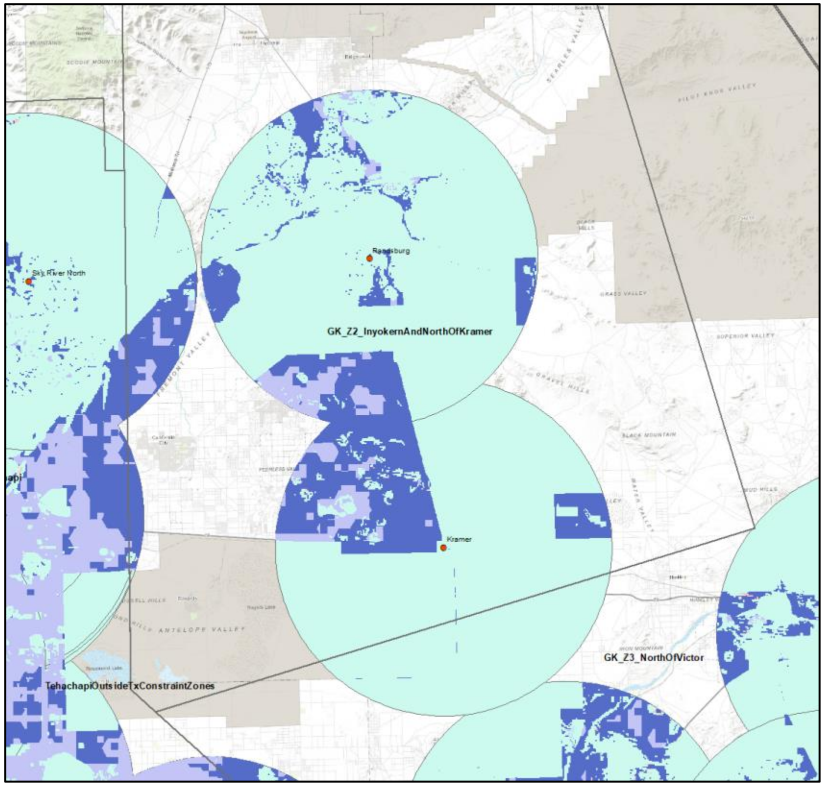
Environmental and Land Use Data - Examples

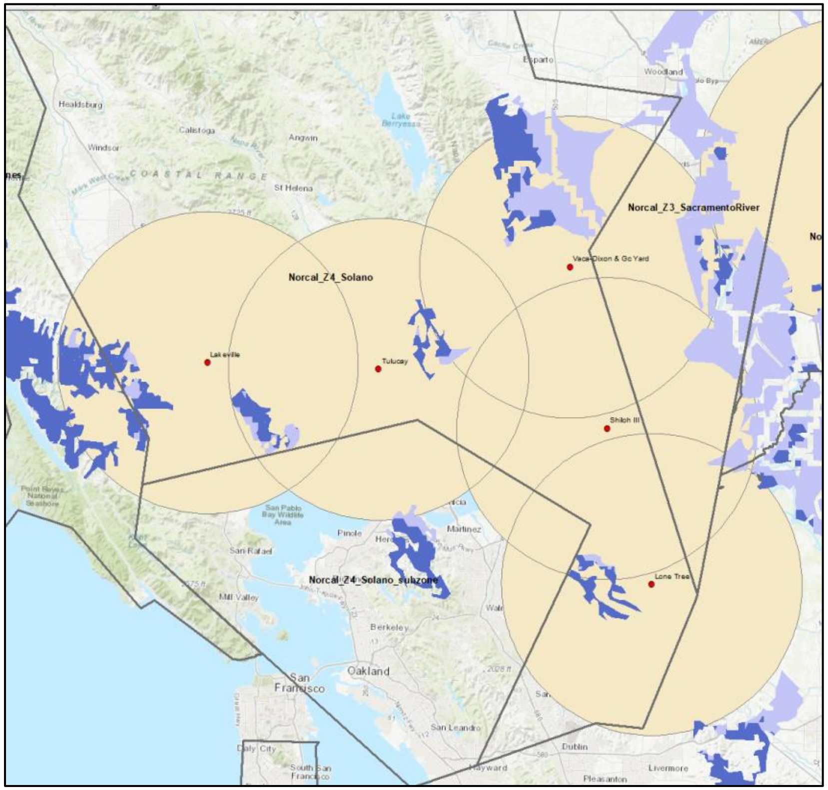
Solar Resource

- Select resources within 15-mile radius of substations
- Calculate acreage values with GIS
- Assign MW proportionally between available substations

Wind Resource

- Select resources as identified by RESOLVE
- Identify Substations where resource can connect within a 15-mile radius
- Use MW and Resource Acres from Resource Database





Bus Bar Allocation Output - Example

RESOLVE Resource	Tx Zone	2030 FD	2030 EO	TOTAL	SUBSTATION	MW ASSIGNED	CEC NOTES
Inyokern_North_Kramer_Solar	Inyokern_North_Kramer Greater_Kramer	97		97			
					Kramer	43	
					Randsburg	54	

Solar Resource Acre Calculations - Example

SELECTED												
Tx Zone/Substation	ACRES_15_LOW	ACRES_15_HIGH	TOTAL ACRES_15	Proportion of Total Acres	Potential MW	Potential MW Low	Potential MW High	MW Allocation	Percent Total ACRES	Percent ACRES Low		RESOLVE MW
GK_Z2_InyokernAndNorthOfKramer												97
Kramer	22,292	108,531	130,823	0.44	18,689	3,185	15,504	43	0.10%	1.35%		
Randsburg	32,006	132,828	164,834	0.56	23,548	4,572	18,975	54	0.13%	1.18%		
Total	54,298	241,359	295,657		42,237	7,757	34,480					

Step 3: Observations and recommendations by CAISO

- If CAISO staff identify any conceptual transmission upgrade likely to be required for a portfolio being mapped, CAISO provides an estimate of the upgrade's in-service date
- Provide feedback on CEC's draft busbar allocations, considering
  - Transmission zone and sub-zone capability limits
  - Interconnection feasibility
  - Status of queued resources in interconnection queues
- CAISO staff make observations, identify problems encountered from past studies, and recommend portfolio modifications if applicable

Battery mapping background

- 2019-20 IRP portfolios include large amounts of battery storage online by 2030
  - RSP includes 8,873 MW
  - 30 MMT EO policy-driven sensitivity portfolio includes 12,657 MW
- Only about 1,000 MW of total installed battery capacity nationwide as of 2018
- California is in a unique situation that necessitates identification of future energy storage locations
  - Examples of entities predicting where storage development will take place for transmission planning purposes are scarce
- Key uncertainties: operating parameters, siting factors

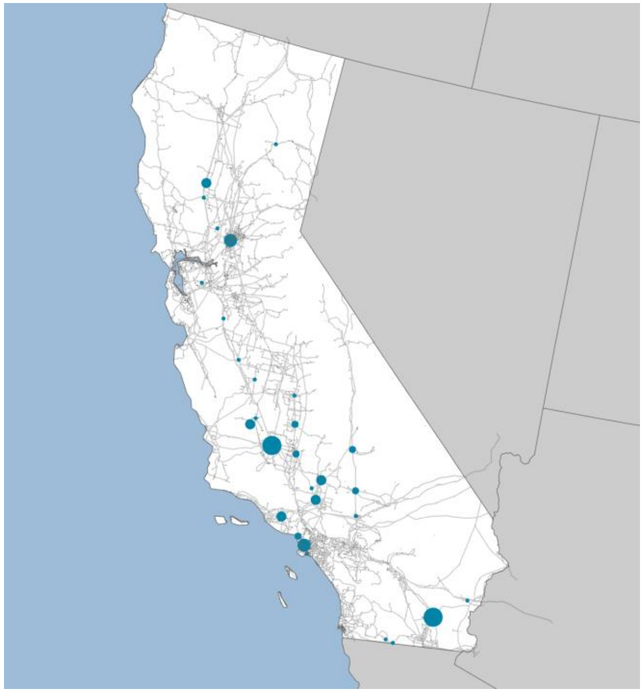
Battery mapping methodology

- The methodology for busbar mapping of battery storage is generally guided by commercial interest as indicated by the CAISO Generator Interconnection Queue and supplemented by the material modification assessment (MMA) requests received by CAISO on December 2, 2019, to add energy storage to existing and active queued projects.
- Commercial interest categories developed by staff
  - High Confidence (3,192 MW)
  - Moderate Confidence (5,428 MW)
  - LCR Solutions (5,830 MW)

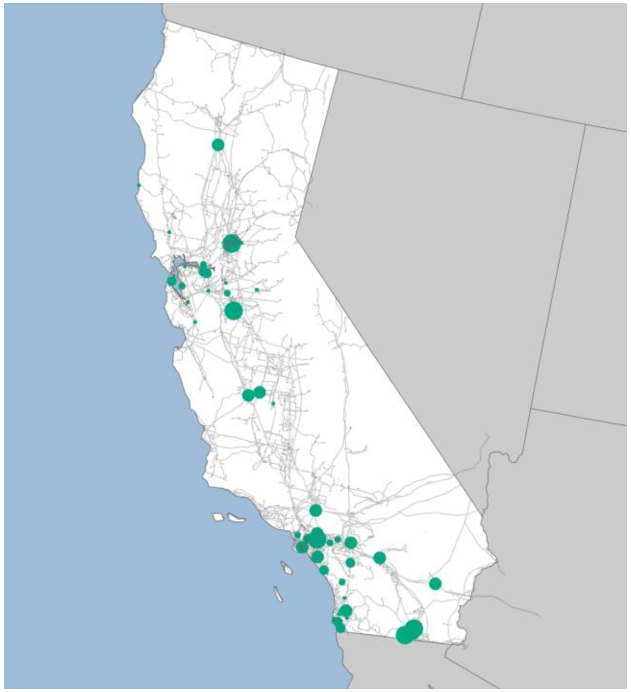
RESULTS

Results: Battery energy storage

Hybrid



Standalone

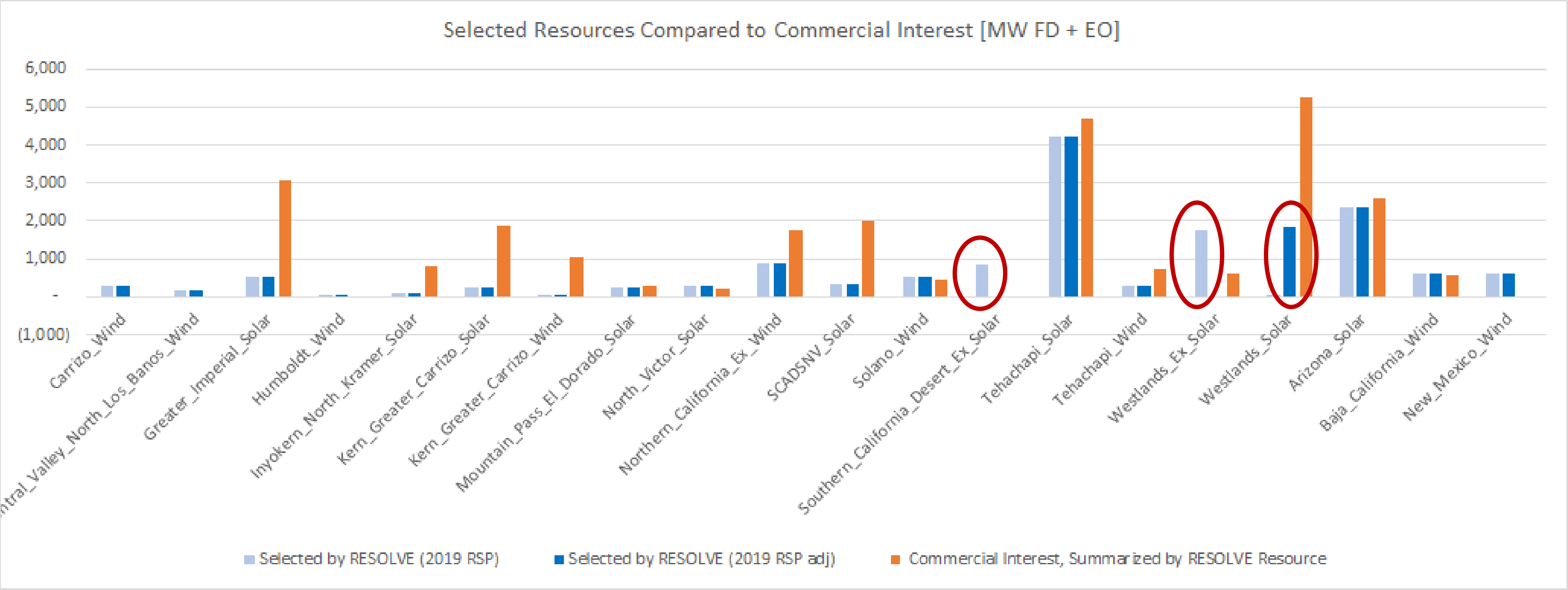


Battery Storage Type	RESOLVE Portfolio	Method	% Standalone	% Hybrid (co-located)
High Confidence (MMA)	1,215	Full amount of commercial interest	Not available	Not available
High Confidence (non-MMA)	1,977	Full amount of commercial interest	26%	74%
Moderate Confidence	4,564	Percentage of the portfolio total	19%	81%
LCR Area solutions	4,902	Percentage of the portfolio total	68%	32%
Total	**12,657**			

Criteria definitions

1. Distance to transmission
   – 15-50 mi
2. Transmission capability limits
   – Should not exceed transmission capability limits (FD or EO)
   – Note: RESOLVE already solves for the portfolio to comply with these limits, however this criterion is checked during busbar mapping in case of manual changes impacting this; also important for when LSE plans, rather than RESOLVE, are used to develop portfolios
3. Land use and environmental constraints
   – Should not exceed available land (20% of total or low-impact land)
4. Commercial interest
   – Should generally align with commercial interest per the interconnection queues and/or LSEs' plans as applicable
5. Consistency with prior year
   – Should generally align with busbar mapping allocations submitted to CAISO in prior comparable TPP portfolios
   – < 60% or < 1,000 MW change

Commercial interest (solar and wind)



Results for 2019 RSP (generation resources)

Pre Round 1 - Adjusted with inter-resource Reallocations	Selecte Resour	Selecte Resour	Adjuste Resour	Compliance with Criteria [1=Yes, 2=Possible/Moderate, 3=Materially in Breach]					
Resource	Total MW (2018 PSP)	Total MW (2019 RSP)	Total MW (2019 RSP adj)	1. Distance to Trans.	2. Trans. Capability	3a. Available Land Area	3b. High Env. Impl.	4. Comm. Interest	5. Consistency with Prior Year's Mappi
Greater_Imperial_Geothermal	1,256	-	-		1			1	3
Carrizo_Wind	160	287	287		1			1	2
Central_Valley_North_Los_Banos_Wind	146	173	173		1			1	1
Greater_Imperial_Solar	-	548	548		1			2	2
Humboldt_Wind	-	34	34		1				2
Inyokern_North_Kramer_Solar	554	97	97		1			1	2
Kern_Greater_Carrizo_Solar	-	242	979		3			1	2
Kern_Greater_Carrizo_Wind	-	60	60		1			1	2
Mountain_Pass_El_Dorado_Solar	-	248	248		3			1	2
North_Victor_Solar	-	300	300		1			1	2
Northern_California_Ex_Wind	-	866	866		1			1	2
Riverside_Palm_Springs_Solar	1,622	-	1,000		3			1	1
Riverside_Palm_Springs_Wind	42	NA	NA		1			1	
SCADSNV_Solar	-	330	330		1			1	2
Solano_Wind	644	542	542		1			1	1
Southern_California_Desert_Ex_Solar	-	862	-		1			1	1
Southern_Nevada_Solar	3,006	-	862		3			1	3
Tehachapi_Solar	1,153	4,202	3,202		1			1	3
Tehachapi_Wind	-	275	275		1			1	2
Westlands_Ex_Solar	-	1,779	(0)		1			1	1
Westlands_Solar	-	58	1,099		3			3	3
Arizona_Solar	428	2,352	2,352		1			1	3
Baja_California_Wind	-	600	600		1			1	2
New_Mexico_Wind	-	606	606		1			1	2
Sub Total - Renewables	**9,011**	**14,460**	**14,459**						

ftp://ftp.cpuc.ca.gov/energy/modeling/Modeling_Assumptions_2020_2021_TPP-Report-Release2.pdf

Results for 2019 RSP (generation resources)

Post Round 2	Selected Resources	Selected Resources	Adjusted Resources	Compliance with Criteria [1=Yes, 2=Possible/Moderate, 3=Materially in Breach]					
Resource	Total MW (2018 PSP)	Total MW (2019 RSP)	Total MW (2019 RSP adj)	1. Distance to Trans.	2. Trans. Capability	3a. Available Land Area	3b. High Env. Impl.	4. Comm. Interest	5. Consistency with Prior Year's Mapping
Greater_Imperial_Geothermal	1,256	-	-	1	1	1	1	1	3
Carrizo_Wind	160	287	287	1	1	2	2	1	2
Central_Valley_North_Los_Banos_Wind	146	173	173	1	1	2	2	1	1
Greater_Imperial_Solar	-	548	548	1	1	1	1	2	2
Humboldt_Wind	-	34	34	1	1	2	2		2
Inyokern_North_Kramer_Solar	554	97	97	1	1	1	1	1	2
Kern_Greater_Carrizo_Solar	-	242	242	1	1	1	1	1	2
Kern_Greater_Carrizo_Wind	-	60	60	1	1	1	1	1	2
Mountain_Pass_El_Dorado_Solar	-	248	248	1	1	1	1	1	2
North_Victor_Solar	-	300	300	1	1	1	1	1	2
Northern_California_Ex_Wind	-	866	866	1	1	2	1	1	2
Riverside_Palm_Springs_Solar	1,622	-	-	1	1	1	1	2	3
Riverside_Palm_Springs_Wind	42	#N/A	#N/A						
SCADSNV_Solar	-	330	330	1	1	1	1	1	2
Solano_Wind	644	542	542	1	1	2	2	1	1
Southern_California_Desert_Ex_Solar	-	862	-	1	1	1	1	1	1
Southern_Nevada_Solar	3,006	-	862	1	1	1	1	1	3
Tehachapi_Solar	1,153	4,202	4,202	1	1	1	1	1	3
Tehachapi_Wind	-	275	275	1	1	2	1	1	2
Westlands_Ex_Solar	-	1,779	(0)	1	1	1	1	1	1
Westlands_Solar	-	58	1,836	1	3	1	1	3	3
Arizona_Solar	428	2,352	2,352		1			1	3
Baja_California_Wind	-	600	600		1			1	2
New_Mexico_Wind	-	606	606		1				2
Sub Total - Renewables	**9,011**	**14,460**	**14,459**						
Pumped Storage Hydro	-	973	974	1	1			1	2
Total	**9,011**	**15,433**	**15,433**						

ftp://ftp.cpuc.ca.gov/energy/modeling/Modeling_Assumptions_2020_2021_TPP-Report-Release2.pdf

Other Results

- 2018 Updated PSP
  - Generation resources added to the 2019 IRP baseline since the formation of the 2018 Preferred System Portfolio were identified, and then subtracted from the selected new resources in the 2018 Preferred System Portfolio, to avoid double-counting of resources in TPP
  - Northern California Geothermal substituted with solar and battery storage to improve compliance with distance to transmission and commercial interest criteria
  - Southern Nevada Solar: substation allocations adjusted to improve compliance with transmission capability limits and land area
- 30 MMT EO Portfolio
  - Similar mapping approaches for 2019 RSP were applied to this portfolio

Results: Generation resources

2018 PSP with Baseline Reconciliation	02-21-2012					
Selected Renewables by Location						
Renewable Resource Summary by Location (MW)					**Busbar Allocation**	
RESOLVE Resource	**Tx Zone**	**2030 FD**	**2030 EO**	**TOTAL**	**SUBSTATION**	**MW ASSIGNED**
Greater_Imperial_Geothermal	Greater_Imperial	604	652	1,256		
					Bannister 230kV (IID)	628
					Hudson Ranch 230kV (IID)	628
Carrizo_Wind	Carrizo		160	160		
					Templeton	160
Central_Valley_North_Los_Banos_Sola	Central_Valley_North_Los_Banos			-		
Central_Valley_North_Los_Banos_Win	Central_Valley_North_Los_Ba	146		146		
					Los Banos 230kV	146
Inyokern_North_Kramer_Solar	Inyokern_North_Kramer	554		554		
					Caldwell	263
					Calcite (Proposed)	191
					Kramer 230kV	100
Riverside_Palm_Springs_Solar	Riverside_Palm_Springs	192	1,430	1,622		
					Red Bluff	1,074
					Colorado River	548
Riverside_Palm_Springs_Wind		42		42	Devers	42

Accessed online: https://caenergy.databasin.org/galleries/eab0ce3a5be447ce928a310e80c65c8d#expand=208848

NEXT STEPS & FUTURE CHALLENGES

Next Steps: Battery Storage

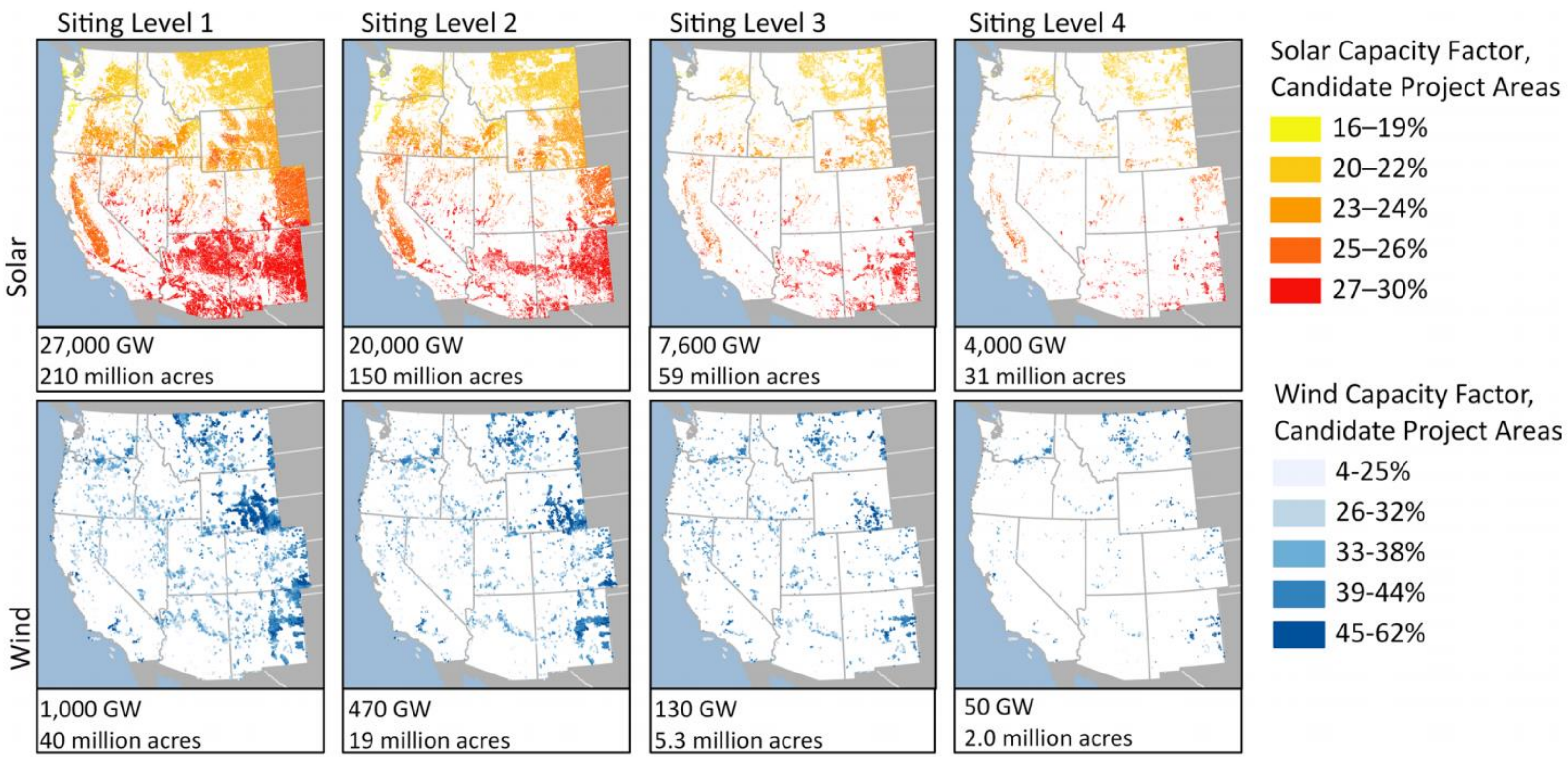
- CAISO results may answer questions such as:
  - What are the **transmission implications** of portfolios that rely on a large amount of battery storage?
  - How can storage **help reduce curtailment**, and how does this compare to transmission upgrades, which would typically be considered for this purpose?
  - Can storage **effectively replace** thermal generation? In LCR areas, can storage be sufficiently charged if power plants are retired?
- In May 2020 CAISO published results on limitations of charging batteries in LCR areas and will use them to inform TPP assessments
- TPP preliminary results will be available in November 2020, and final results available in January 2021
- In the meantime, continued collaboration between CPUC and CAISO, with increased involvement of parties, to improve storage busbar mapping for the IRP Preferred System Plan

Next steps

- 2020-2021 TPP
  - Early June 2020: CAISO to hold an additional stakeholder call as part of 2020-2021 TPP
- 2021-2022 TPP
  - September 2020: Indicative timing for IRP stakeholder engagement regarding busbar mapping workplan

Future challenges: land use implications of deep decarbonization?

- The Nature Conservancy's Power of Place Report 2019

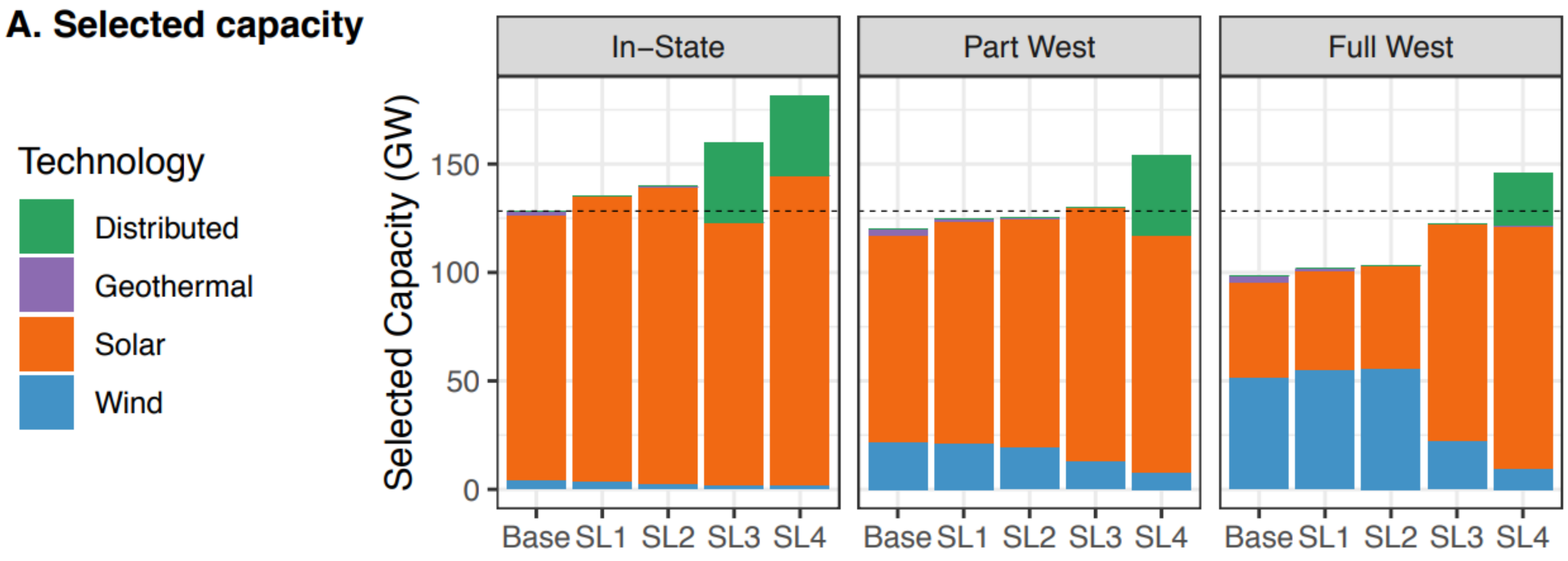


https://www.scienceforconservation.org/products/power-of-place

Future challenges: land use implications of deep decarbonization?

- The Nature Conservancy's Power of Place Report 2019

Figure 4a: Selected capacity of renewable technologies by geography and siting level



https://www.scienceforconservation.org/products/power-of-place

Questions?

- Please "raise your hand" in the Participants view within Webex
- Panelists:

Neil Raffan	CPUC
Emily Leslie	Energy Reflections
Femi Sawyerr	E3
Jimmy Nelson	E3
Scott Flint	CEC
Sushant Barave	CAISO
Karolina Maslanka	CPUC

Further information

- Thank you for your participation. If you have any questions following the webinar please contact:
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- CPUC staff acknowledge the collaboration with CEC and CAISO staff, led by:

Scott Flint	Program Manager, Energy Resource and Land Use Planning	CEC Siting, Transmission and Environmental Protection Division
Sushant Barave	Sr. Advisor – Regional Transmission	CAISO

Important links:
IRP Events and Materials