Capacity Expansion Modeling and Transmission Planning – the E3 Experience

ESIG Webinar

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Energy+Environmental Economics

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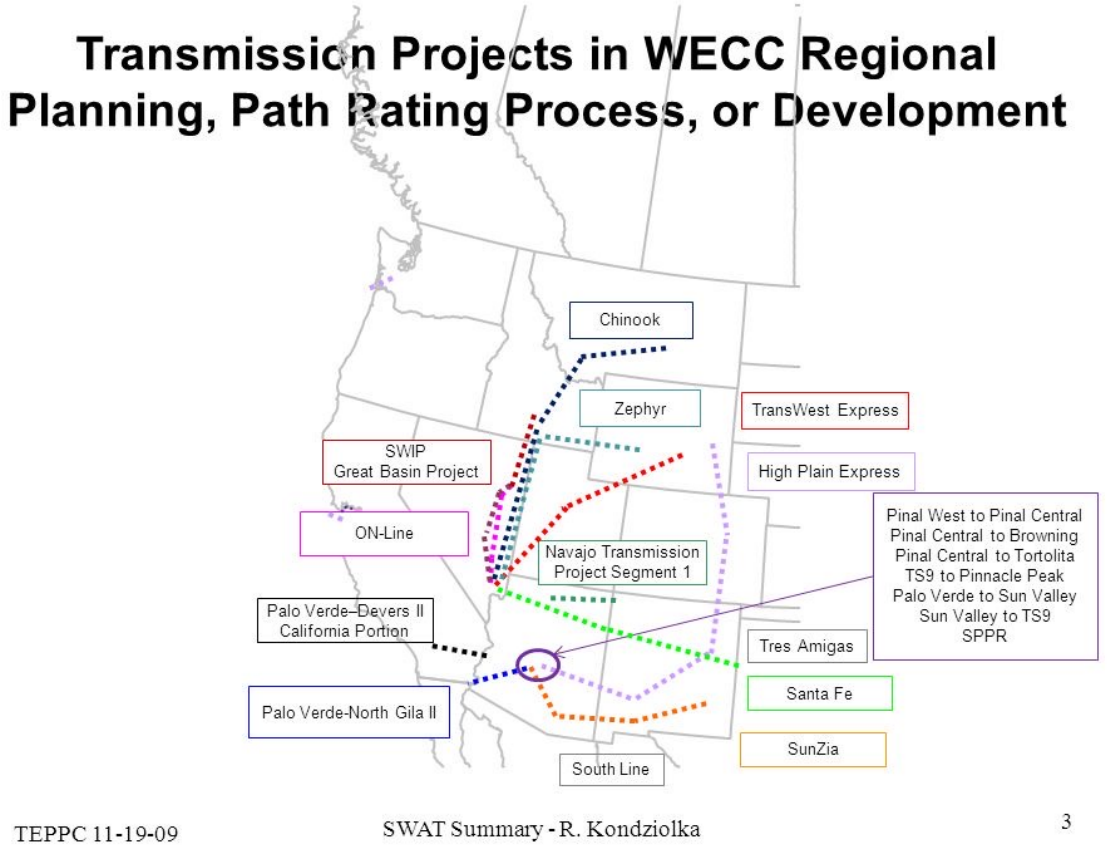
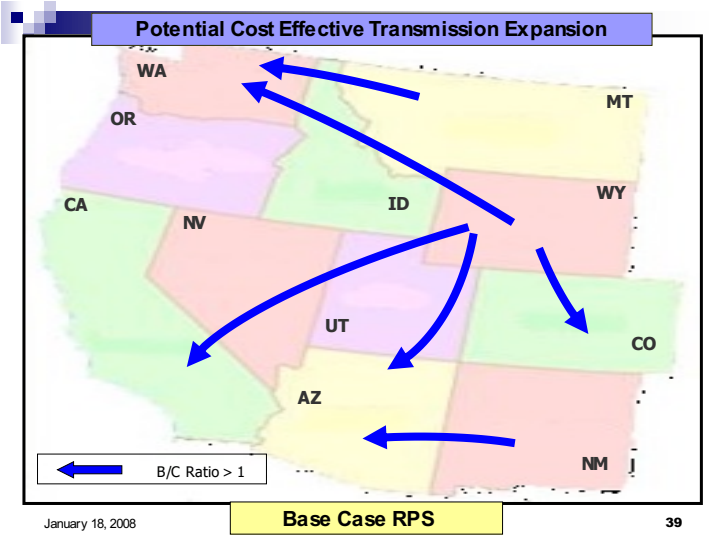
Long-line transmission planning in the West: a condensed history

- **1950s-1980s: regional projects built through multilateral agreement to connect remote resources to loads and interconnect large regions**
  - Large hydro and mine-mouth coal
- **1990s-2000s: gas as marginal resource shifted regional action to gas pipeline expansion**
- **2000s-2010s: Many clean energy-based projects proposed – and many abandoned**
  - Frontier Line, BC-NW-CA, Chinook, Zephyr, High Plains Express
  - Mostly designed to bring wind to the coast
- **Early 2010s: regional transmission planning institutionalized first through WECC/TEPPC then Regional Entities**



Evolution of E3 transmission planning models

- Sunrise Powerlink (2006): Spreadsheet model evaluating benefits of delivering renewable energy and RA capacity from Imperial Valley to San Diego
- WEIL Group Towards 2020 (2007): West-wide spreadsheet model comparing clean energy supply curves across multiple regions
- CPUC RPS Calculator (2009-2018): West-side spreadsheet model comparing clean energy supply curves for delivery to California
- RESOLVE (2015-present): Zonal capacity expansion model with renewable energy zones



New Transmission Required for 33% RPS Reference Case

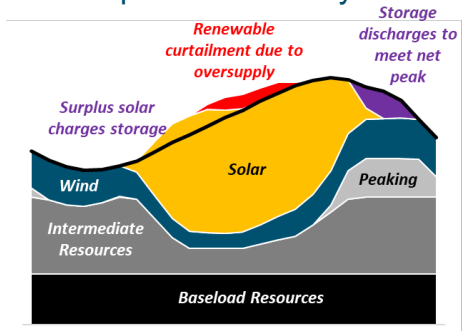
RESOLVE

Proactive capacity expansion to meet decarbonization goals

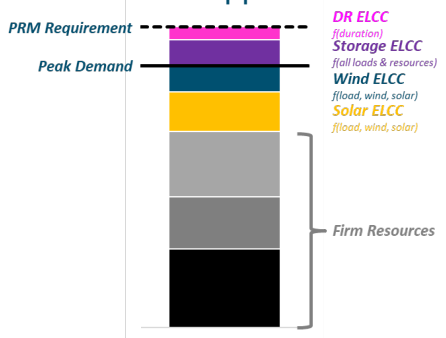
+ **RESOLVE grew out of E3's work on California's RPS Calculator to support generation portfolio plans to inform transmission needs**

+ **Zonal optimization co-optimizes investments and operations to minimize total net present value (NPV) of electric system costs**
  - Portfolios are designed to meet planning constraints (RPS, emissions, resource adequacy)
  - Investments are made with perfect foresight, proactively expanding generation & transmission at least-cost over modeling horizon

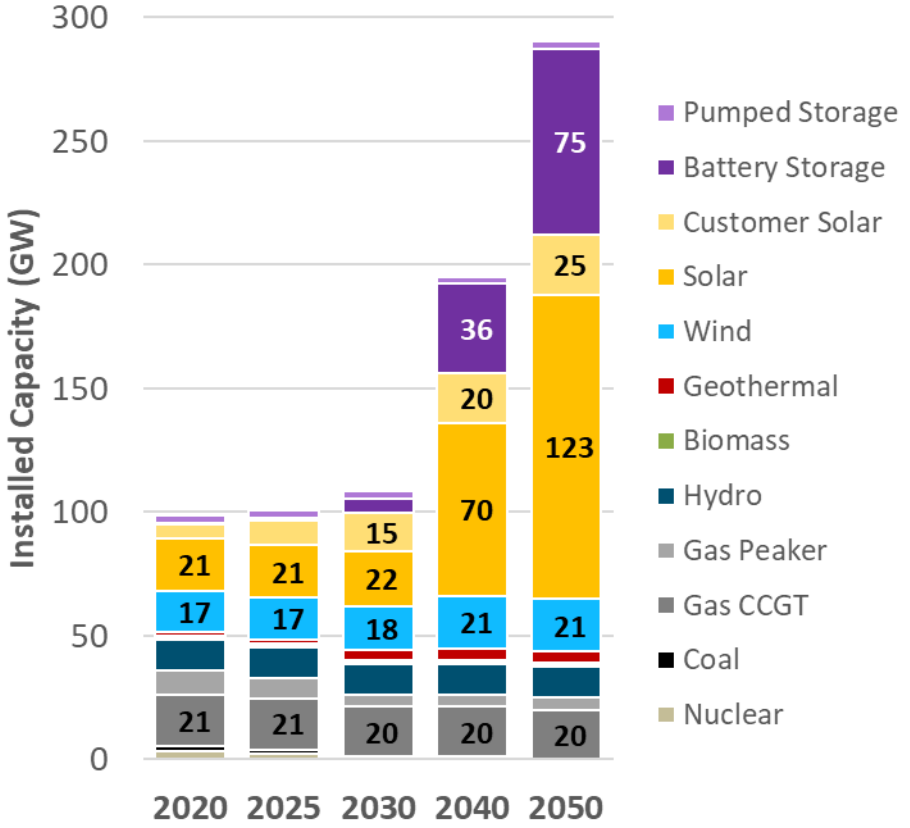
Operational module simulates hourly system operations for a sample of representative days



Reliability module ensures portfolio can meet load during extreme conditions using an ELCC approach



Least-cost plan co-optimizes investments and operations to meet clean energy policy targets, selecting from a diverse set of potential resources including wind, solar, storage, DSM, and natural gas

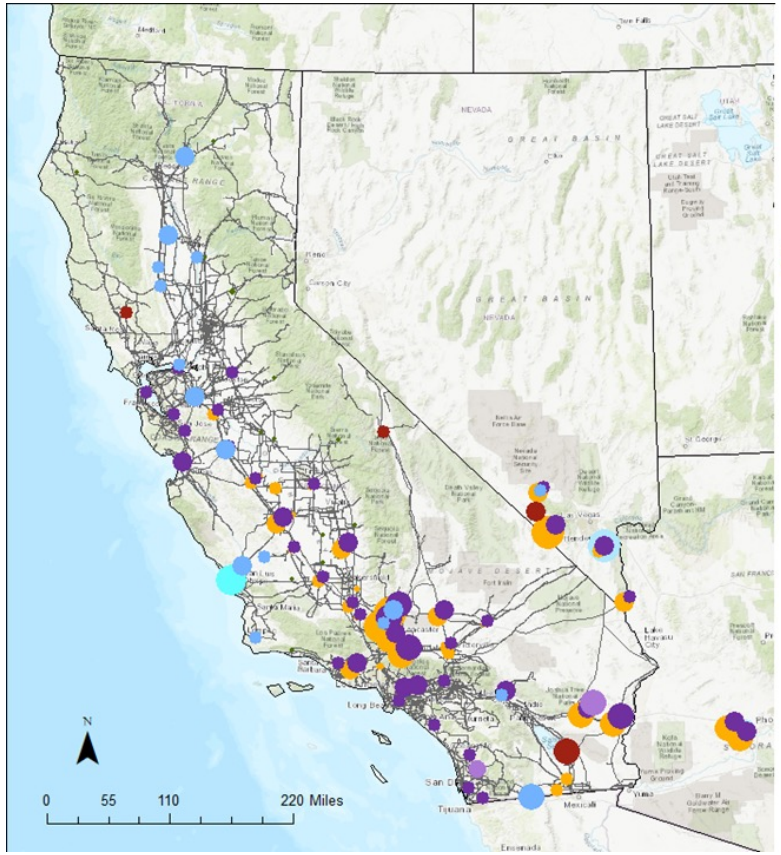


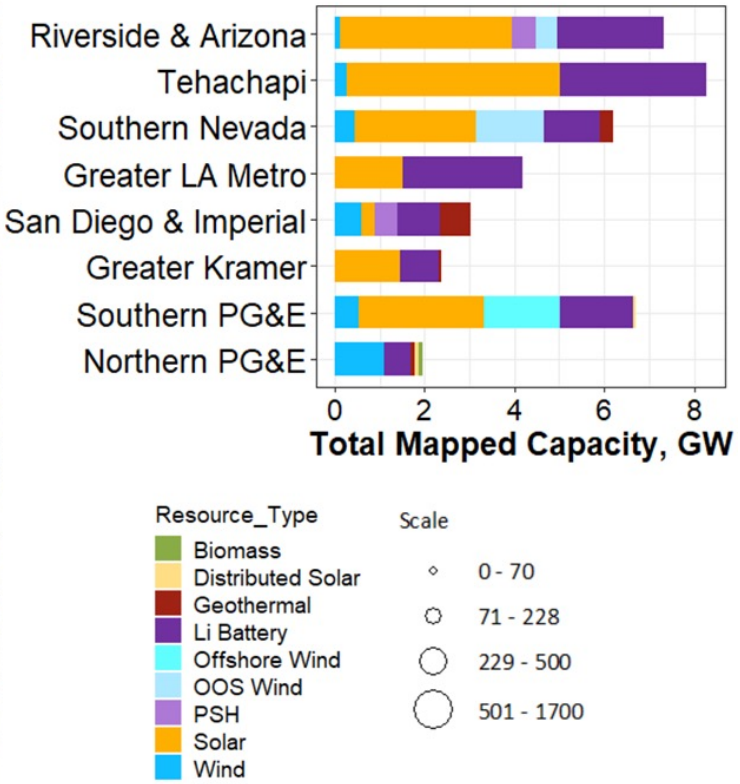
Example RESOLVE result from *Long-Run Resource Adequacy under Deep Decarbonization Pathways for California* (Calpine, 2019)

Case Study

Using RESOLVE to support CPUC IRP and CAISO TPP

+ **E3's RESOLVE model for California Public Utilities Commission uses the *cost adder* approach to capture transmission costs**
  - Cost adders are provided by CAISO to capture tx upgrade costs ***beyond the available tx capacity***
+ **CPUC IRP RESOLVE builds resource portfolio and feeds back into the CAISO's Transmission Planning Process (TPP):**
  - ***Busbar mapping*** analysis maps RESOLVE's zonal resource build decisions to CAISO transmission busbars
  - TPP identifies and approves transmission investments to support the generation portfolio
+ **Generation & transmission plans from previous IRP cycles are seeded as inputs to next IRP cycle**

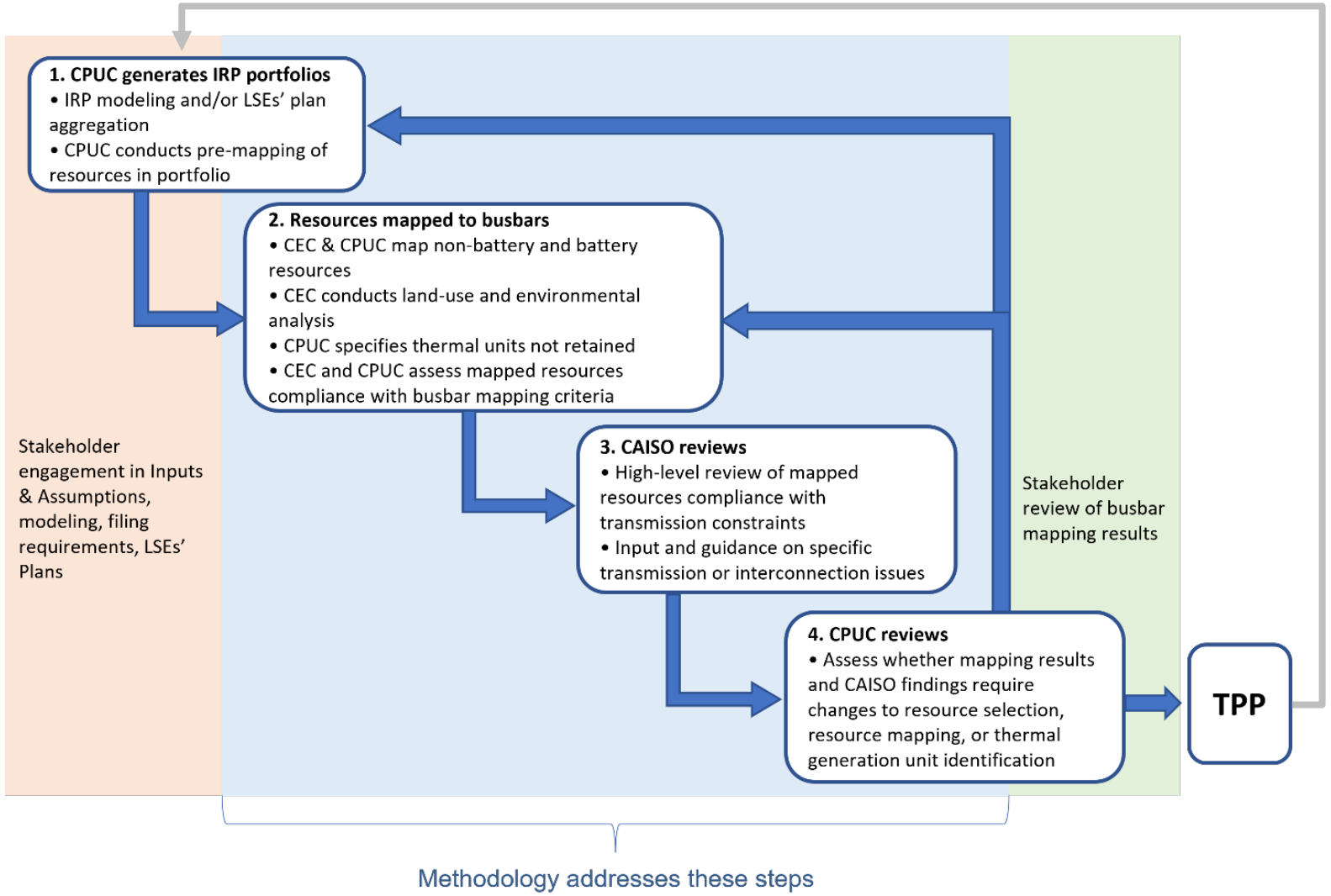




Case Study

Role of Busbar Mapping in IRP and TPP

+ **Busbar Mapping refines geographically coarse portfolios developed through IRP to specific interconnection locations (i.e. substations) for analysis in the CAISO's annual Transmission Planning Process (TPP).**
  - Conducted by working group comprised of CPUC, CEC, and CAISO staff
  - Busbar allocations should generally represent the expected outcome of LSE procurement activity in response to the three key elements
  - The allocations should strive to minimize transmission congestion by respecting transmission constraint limits
  - Process should result in IRP portfolios that minimize post-processing in the CAISO's TPP analysis
  - Consistency with prior years' mapping results for equivalent TPP cases



Challenges with using capacity expansion models to co-optimize generation and transmission planning

1. **Imprecision – capacity expansion models typically require simplification of operations and network topology**
   - Simulate a vast range of operating and investment decisions over many years
2. **Uncertainty – value streams are subject to a significant uncertainty and risk as key value drivers change over very long lifetimes**
   - Sensitivity analysis is needed to understand when the optimal solution might be wrong
3. **Agency – transmission and generation decisions are made at different times, by different entities, in different processes**
   - Modeling needs to be designed to inform key decisions

Where do we go from here?

1. **Develop forward-looking transmission planning processes that identify beneficial projects far ahead of actual need**
   - Use capacity expansion modeling to identify solutions that are **robust under a range of uncertainties**
   - Scenario based load projections
   - Incorporate land use into resource supply
   - Supplement with production simulation, power flow & LOLP models to identify full range of potential project benefits
2. **Focus is to inform transmission**
   - *"If you build it, he will come…"*

Thank You

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