# Integrated System Planning: Opportunities and Emerging Practices

EPRI Integrated Strategic System Planning Interest Group

November 5, 2025

Energy+Environmental Economics

Aaron Burdick, Director

# About Energy & Environmental Economics, Inc. (E3)

## Technical and Strategic Energy Sector Consulting

~130 consultants across 5 offices with expertise in economics, mathematics, policy, modeling


San Francisco

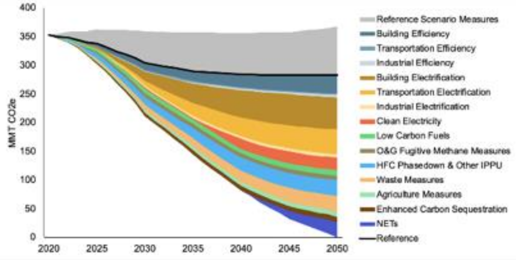

New York


Boston


Denver


Calgary

300+ projects per year across diverse topic areas




### Select Integrated Planning Projects

Hawaiian Electric

SRP®

SaskPower Powering our future®

Public Utilities Commission, State of California (Eureka)

ESIG Energy Systems Integration Group

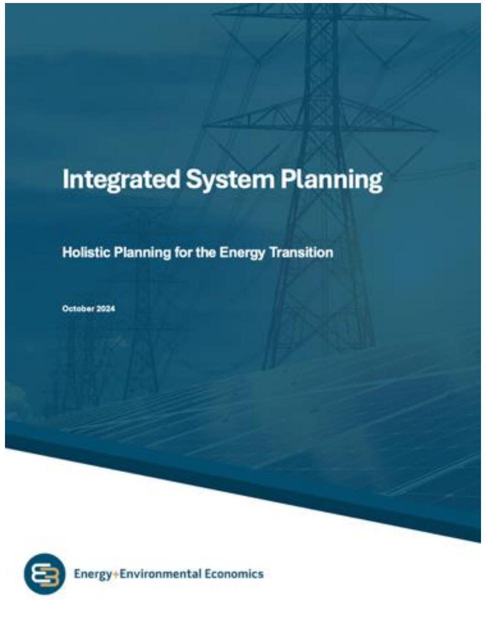
TVA Tennessee Valley Authority

The Electric Company® El Paso Electric

SMUD®

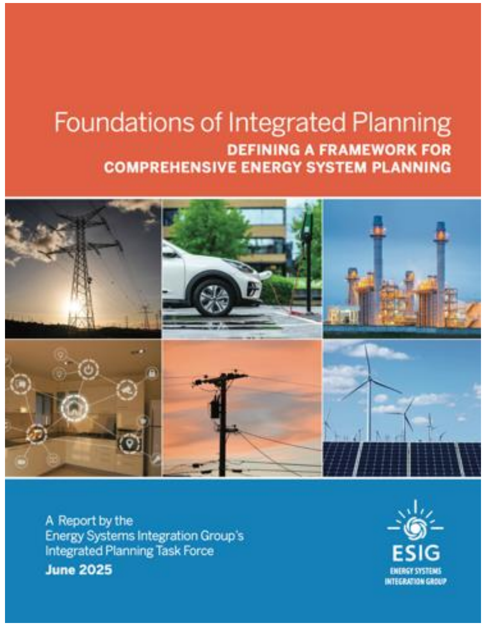
British Columbia

# ISP Knowledge Building Resources



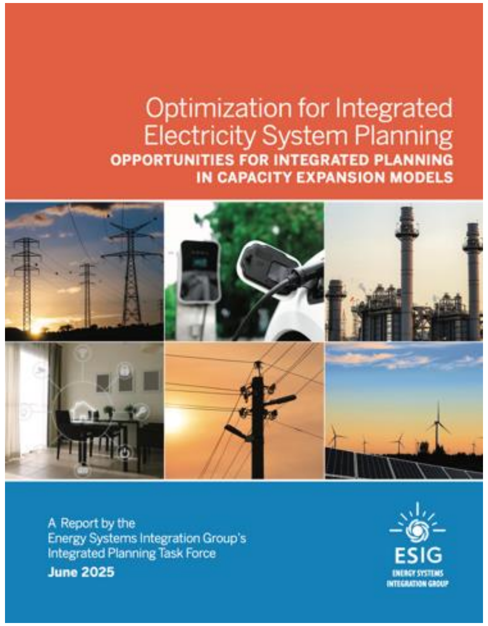

Link

+ Overview of integrated system planning concepts
+ SRP, CPUC, NY electrification case studies



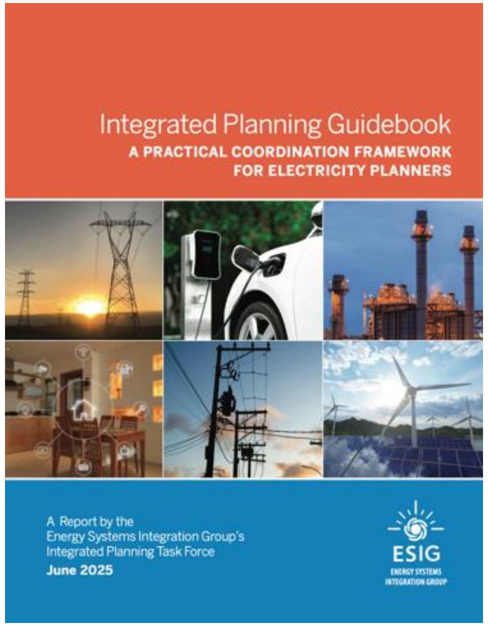

Link

+ ISP definitions + 4 part framework
+ Key data linkages between electric G/T/D/C processes + electricity/gas/economy-wide systems




Link

+ Opportunities and challenges for G/T/D/C co-optimization
+ Practical approaches to the analytical integration of G/T/D/C planning




Link

+ Guidebook of practical recommendations along a walk/jog/run approach to integrated planning


Link

+ Integrated planning case studies + key learnings from NYISO decarbonization scenario analysis
+ Linking generation planning tools, power flow + PCM, and distribution impact assessments

# Why do Integrated System Planning?

## Many forces are driving high investment needs over the coming decades…

- Decarbonization of power system
- Industrial and data center load growth
- Electrification
- Aging infrastructure
- Wildfire risks
- Cybersecurity

## …this creates opportunities and challenges for meeting planning goals:

- Reliable
- Affordable
- Clean

**Need to ensure that planning identifies**

- the right investments…
- in the right locations…
- at the right times

# Integrated planning can identify more optimal investment portfolios across generation, storage, and grid upgrades

**Examples**

## Right investments…

- Optimal mix of dispatchable thermal, renewable, and storage resources to meet reliability and policy goals
- Investments in load flexibility versus utility storage
- Grid investments versus non-wires alternatives

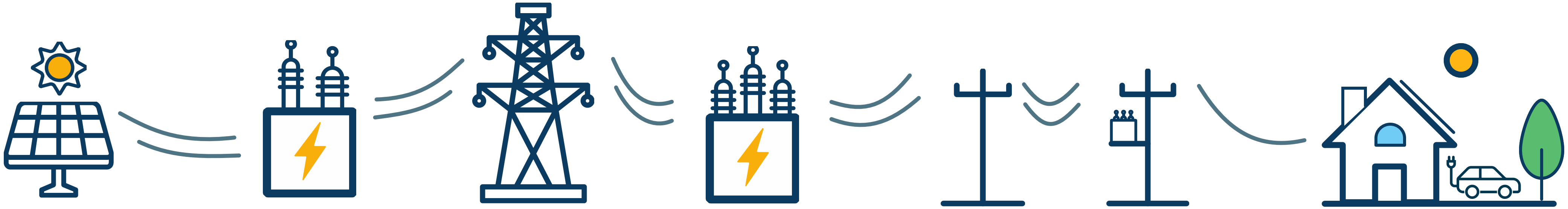
## …in the right places…

- Geospatial forecasting of load growth, DERs, and resource potential
- Where to build new transmission infrastructure to support reliability, economic, and policy objectives
- Optimal siting of storage resources on the bulk grid, distributed in-front-of-meter, or distributed behind-the-meter

## …at the right times

- Proactive vs. reactive grid buildout to support electrification, new large loads, and remote renewables
- Consistent investment signals for the marginal hourly avoided costs between bulk grid planning, customer program and DER valuation, and retail rate design

# System planning has been largely siloed



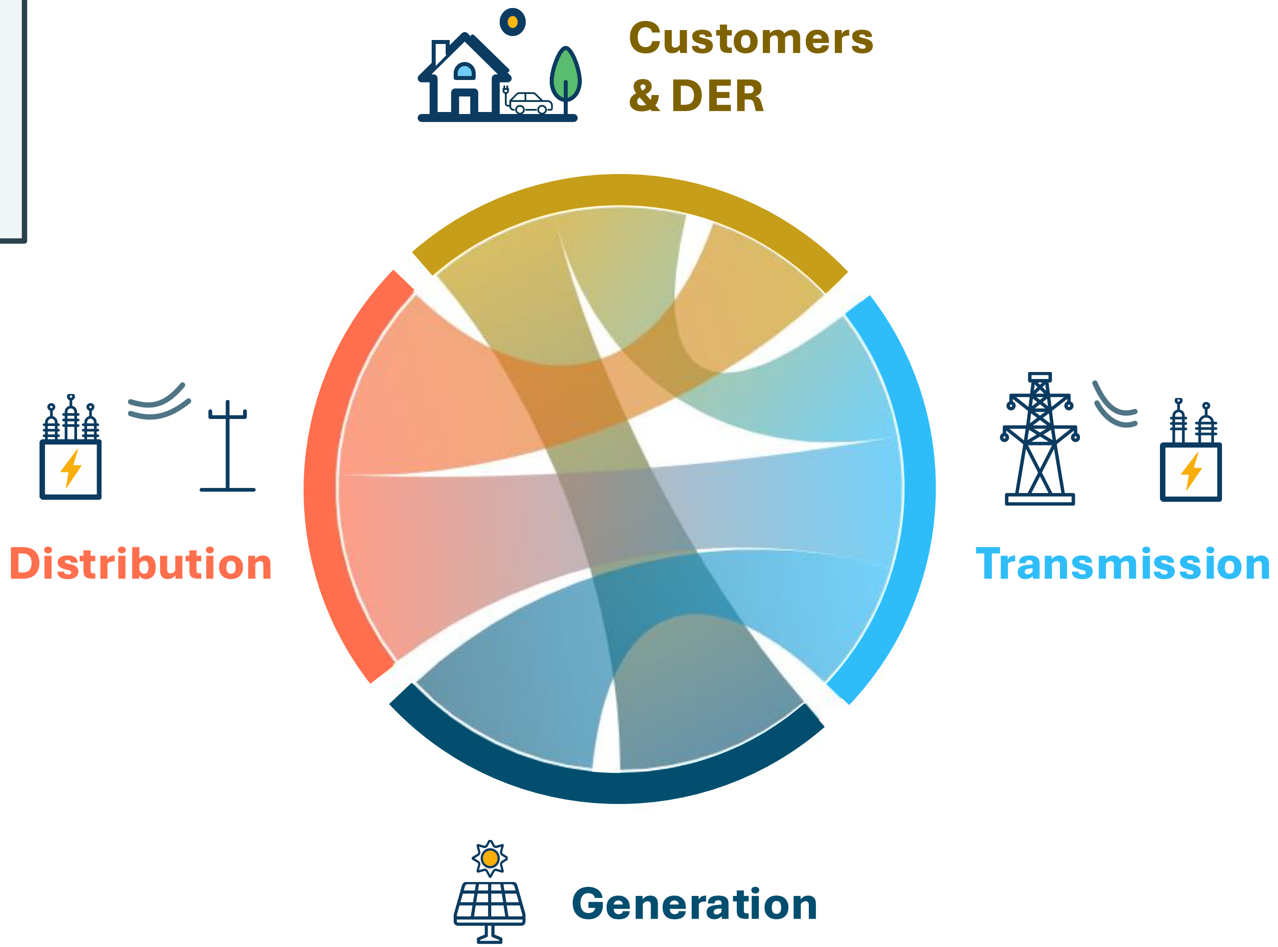
| Generation | Transmission | Distribution | Customers & DERs |
|---|---|---|---|
| • 20+ year IRP<br>• Requests for proposals | • 10-year plan<br>• Interconnection studies | • 3- to 10-year studies | • Simple, coarse forecast<br>• Programs evaluation |

***Siloed planning worked when investments in one planning domain had limited impact on other planning needs – this is no longer the case***

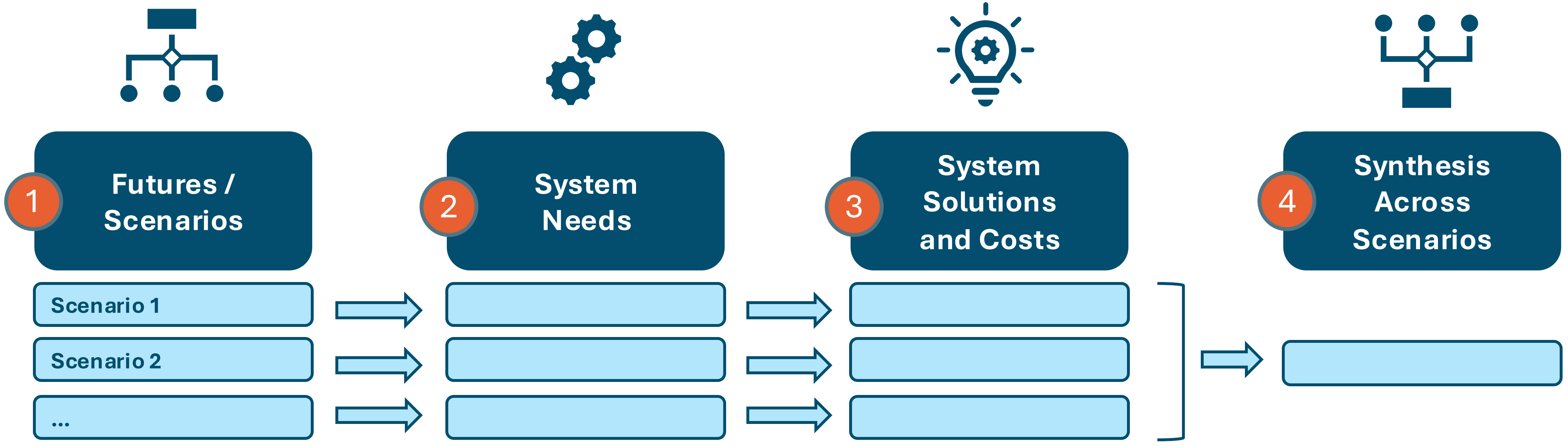
# Integrated system planning harmonizes inputs, analysis, and outcomes across planning processes

Integrated planning is a comprehensive energy system planning approach that links traditionally siloed planning processes to develop affordable, reliable, and robust investment plans.

- Scenario planning
- Common inputs & assumptions
- Coordinated system planning processes
- Harmonized action plans + decision-making



# Integrated scenario analysis of system solutions and costs supports strategic decision-making




**Scenarios capture uncertainty of external factors and decisions controlled by planners**

- Policy options
- Load growth & electrification
- Customer programs
- Supply & Tx options
- Retirements

**Modelling is constrained to meet system needs:**

- Energy
- Resource capacity
- Ancillary services
- Transmission capacity
- Distribution capacity
- Resiliency
- Operational constraints

**Analysis identifies system solutions and costs for each scenario.**

- Bulk-grid resources
- Transmission solutions
- Distribution solutions
- System operations
- DER and customer programs
- Load flexibility
- Market solutions

**Risks, tradeoffs, and alternative pathways for achieving objectives are identified**

- Cost ranges
- Viable pathways for system
- Least-regrets decisions
- Risks to system plans
- Need for long lead-time resources

*"Core" scenarios should be considered across G/T/D/customer/gas system needs*
*Some analyses allow additional scenarios/sensitivities (e.g., IRP capacity expansion)*

# SRP ISP scenarios inform system need and value of strategies across four distinct futures

## Strategic Approaches

| Scenarios | Technology Neutral | No New Fossil | Min. Coal |
|---|---|---|---|
| Desert Contraction | ● | ● | ● |
| Current Trends | ● | ● | ● |
| Strong Climate Policy | ● | ● | ● |
| Desert Boom | ● | ● | ● |

**12 Scenario-Based System Plans**

\+

**30 Sensitivity Cases**

# Load scenarios, including electrification and DERs, must be developed and downscaled for T&D planning

ComEd
An Exelon Company
NVEnergy

## Economy-Wide Decarbonization Impacts

*What? How much?*

E3's PATHWAYS Model

## Load & DER Forecast

*When?*

E3's EVGrid and RESHAPE Models

## Load & DER Downscaling

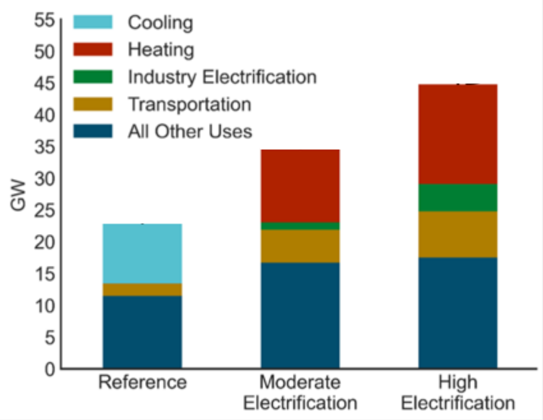
*Where?*

LoadSEER

## System Modeling

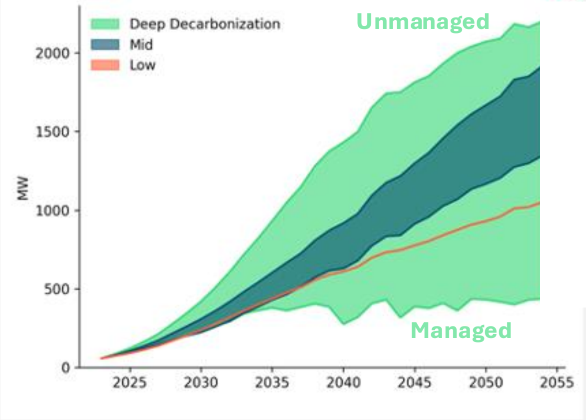
- Distribution
- Transmission
- Generation

### Electrification Scenario Peak Impacts



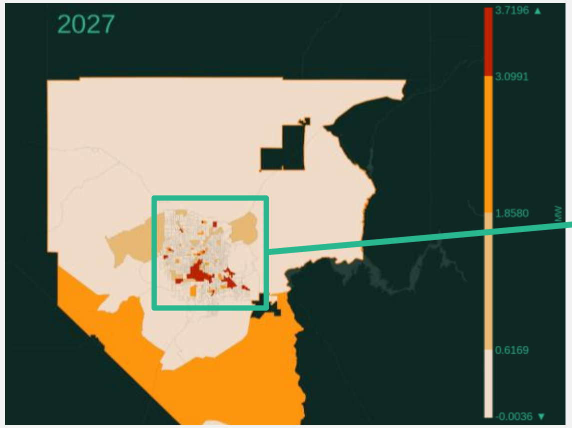

E3's Illinois Decarbonization Study for Commonwealth Edison

### Electric Vehicle Peak Impact Forecast

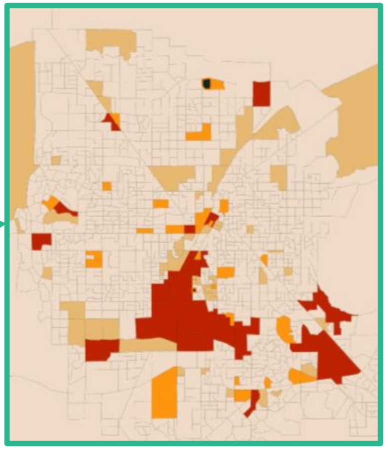



E3 support for NV Energy's 2024 Integrated Resource Plan

### Feeder Level Impacts

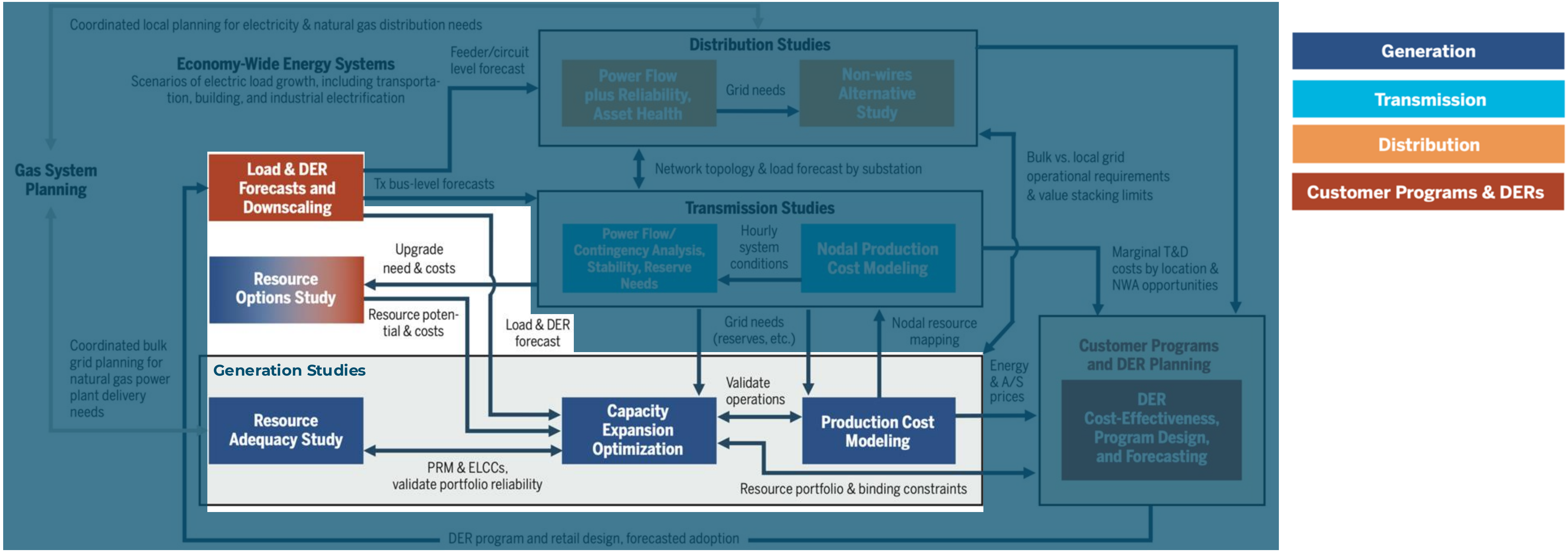



E3 support for NV Energy's 2024 Integrated Resource Plan



Las Vegas Metro Area

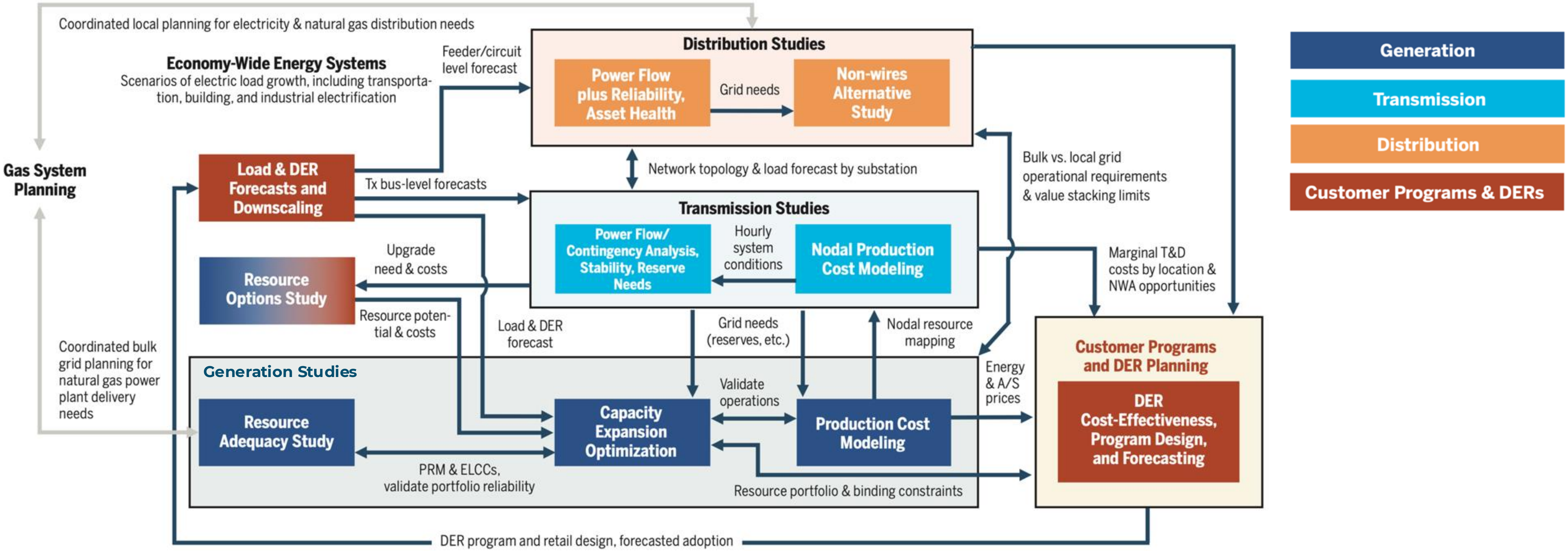
# Integrated resource planning (IRP) already links multiple models




Notes: A/S = ancillary service; DER = distributed energy resource; ELCC = effective load-carrying capability; NWA = non-wires alternative; PRM = planning reserve margin; Tx = transmission; T&D = transmission and distribution

Source: Energy Systems Integration Group, adapted from A. Burdick, J. Hooker, L. Alagappan, M. Levine, and A. Olson, *Integrated System Planning: Holistic Planning for the Energy Transition*, Energy and Environmental Economics, Inc. (2024), https://www.ethree.com/wp-content/uploads/2024/10/E3-ISP-Whitepaper.pdf.

# Integrated system planning (ISP) requires broader linkages




Notes: A/S = ancillary service; DER = distributed energy resource; ELCC = effective load-carrying capability; NWA = non-wires alternative; PRM = planning reserve margin; Tx = transmission; T&D = transmission and distribution

Source: Energy Systems Integration Group, adapted from A. Burdick, J. Hooker, L. Alagappan, M. Levine, and A. Olson, *Integrated System Planning: Holistic Planning for the Energy Transition*, Energy and Environmental Economics, Inc. (2024), https://www.ethree.com/wp-content/uploads/2024/10/E3-ISP-Whitepaper.pdf.

# Hawaiian Electric Integrated Grid Plan

## Iterative links between modeling processes

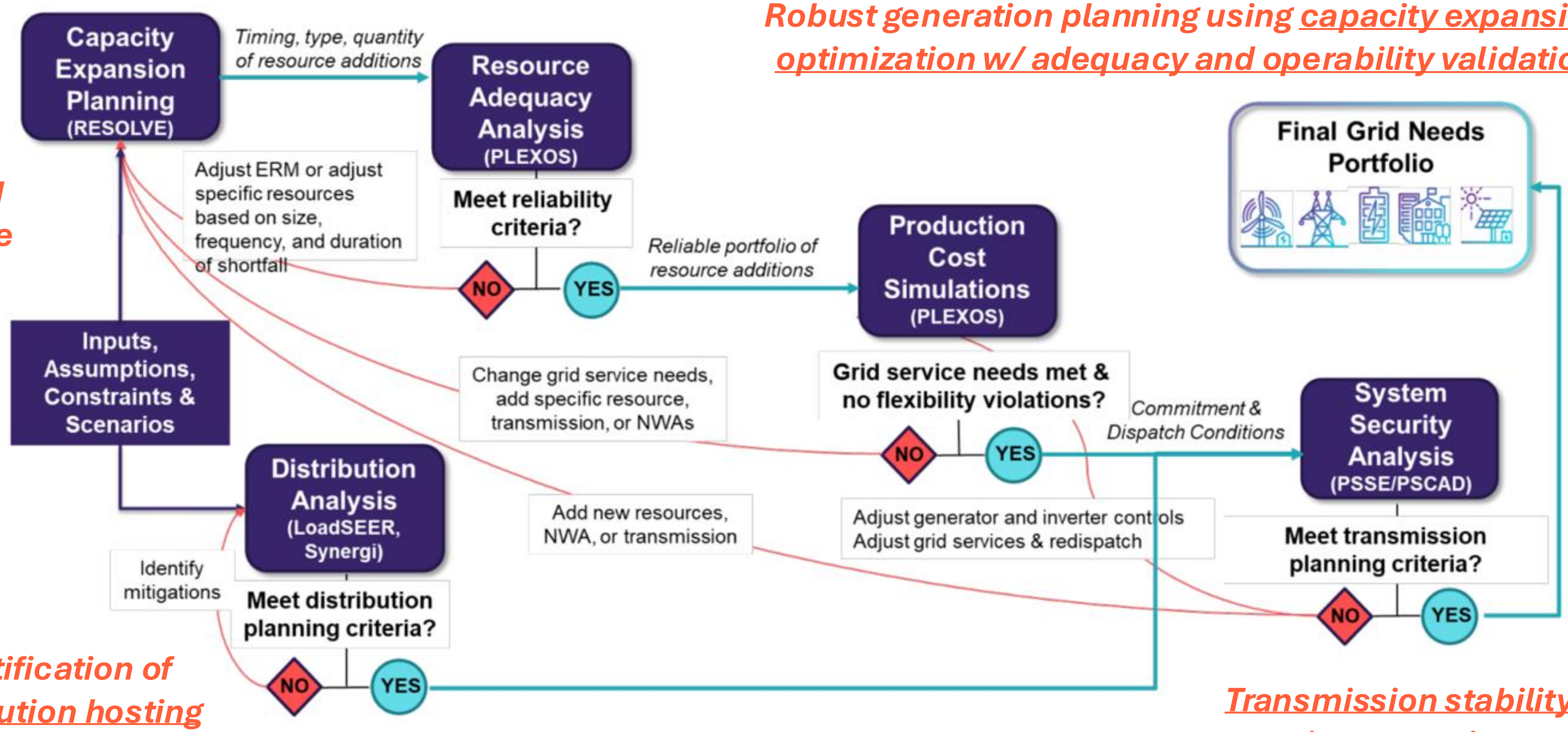
Hawaiian Electric

1

***Resource potential mapping*** *identifies land constraints and transmission upgrade needs*

2

***Robust generation planning using capacity expansion optimization w/ adequacy and operability validation***




3

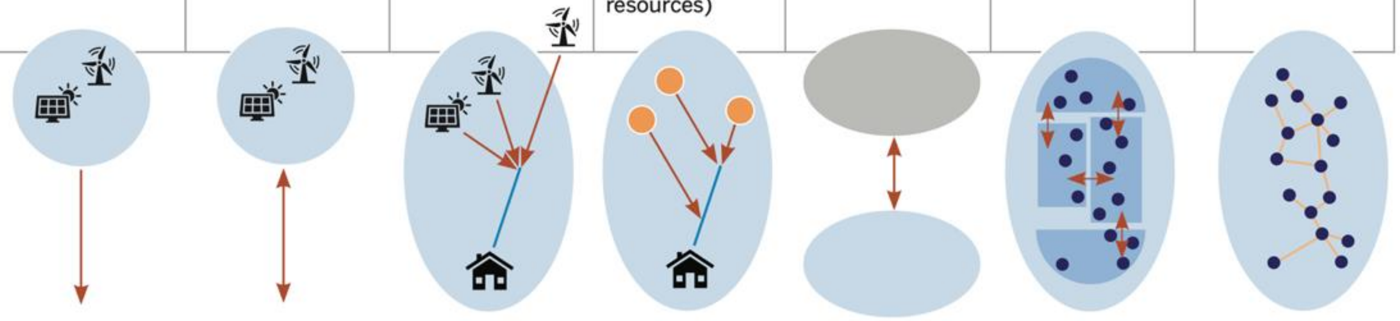
***Transmission stability*** *w/ feedback to generation operations and resource builds*

4

*Identification of* ***distribution hosting capacity*** *and* ***non-wires alternatives*** *opportunities*

# Bulk grid integration G+T co-optimization is feasible today and should generally become standard practice

| | | Integrated Planning Approaches | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Co-optimization Approaches | | | | |
| | No integration | Iteration | Resource or transmission zone limits | | Hourly flow constraints (pipe and bubble representation) | | |
| | One-way flow | G ←→ T Iterative Process | Resource-specific constraints | Transmission zones | Inter-zonal | Intra-zonal (aggregated nodes) | Nodal |
| **Capacity expansion model dispatch** | Zonal | Zonal | Zonal | Zonal | Inter-zonal | Intra-zonal (aggregation of full network nodes) | Nodal |
| **Capacity expansion model transmission limits** | None | None | Resource-level | Transmission zone level (across resources) | Inter-zonal hourly flow | Intra-zonal hourly flow | Nodal hourly flow |
| | Downstream studies address all transmission needs from capacity expansion resource additions | Downstream studies address all transmission needs from capacity expansion resource additions, but include feedbacks to adjust the generation mix (or siting) based on results | Resource-level limits can vary from interconnection to new tie-lines and are useful for connecting a single resource type | Transmission zone-level limits allow for diversity to maximize utilization (e.g., adding solar, wind, storage together) and transmission studies for major renewable energy | Inter-zonal limits allow for study of large-scale interregional upgrades, including impact on investment and production costs | Intra-zonal limits capture intra-zonal constraints but aggregates nodes to limit data needs and runtime impacts | Nodal representation captures full network model nodal constraints; requires modeling nodal-level dispatch, which vastly increases runtime |



Investment Zone — Transmission Investments Options — Transmission Zone — Neighboring Zone — Zones Defined — Node

Source: Energy Systems Integration Group.

# CPUC/CAISO G+T Co-optimization

## Process alignment facilitates iteration and continuous improvement

*Well-established process to co-optimize G+T using transmission zone level constraints**

**MOU**


**Memorandum of Understanding**
**Between**
**The California Public Utilities Commission (CPUC)**
**And**
**The California Energy Commission (CEC)**
**And**
**The California Independent System Operator (ISO)**
**Regarding**
**Transmission and Resource Planning and Implementation**

CAISO Transmission Planning Process

Headroom and upgrade costs by substation and timing (gross peak, net peak, off-peak)

California PUC Integrated Resource Plan

RESOLVE capacity expansion modeling produces resource additions by substation

California PUC busbar mapping

Resource additions mapped to busbars for detailed transmission analysis



* As of 2025, the CPUC RESOLVE model also includes intra-zonal Tx limits and upgrade options to address CAISO North<>South congestion on Path 15 + Path 26.

# CPUC/CAISO G+T Co-optimization

**Technical details**

## Step 1. Develop detailed geospatially screened resource potential

### Raw Resource Potential

- Solar insolation
- Wind speed
- Known geothermal fields
- EGS temperature-at-depth estimates
- Pumped hydro storage sites

### Techno-Economic Screen

- Minimum capacity factor thresholds
- Ground slope
- Urban areas and population density
- Feasibility screens (e.g. setback from airports)

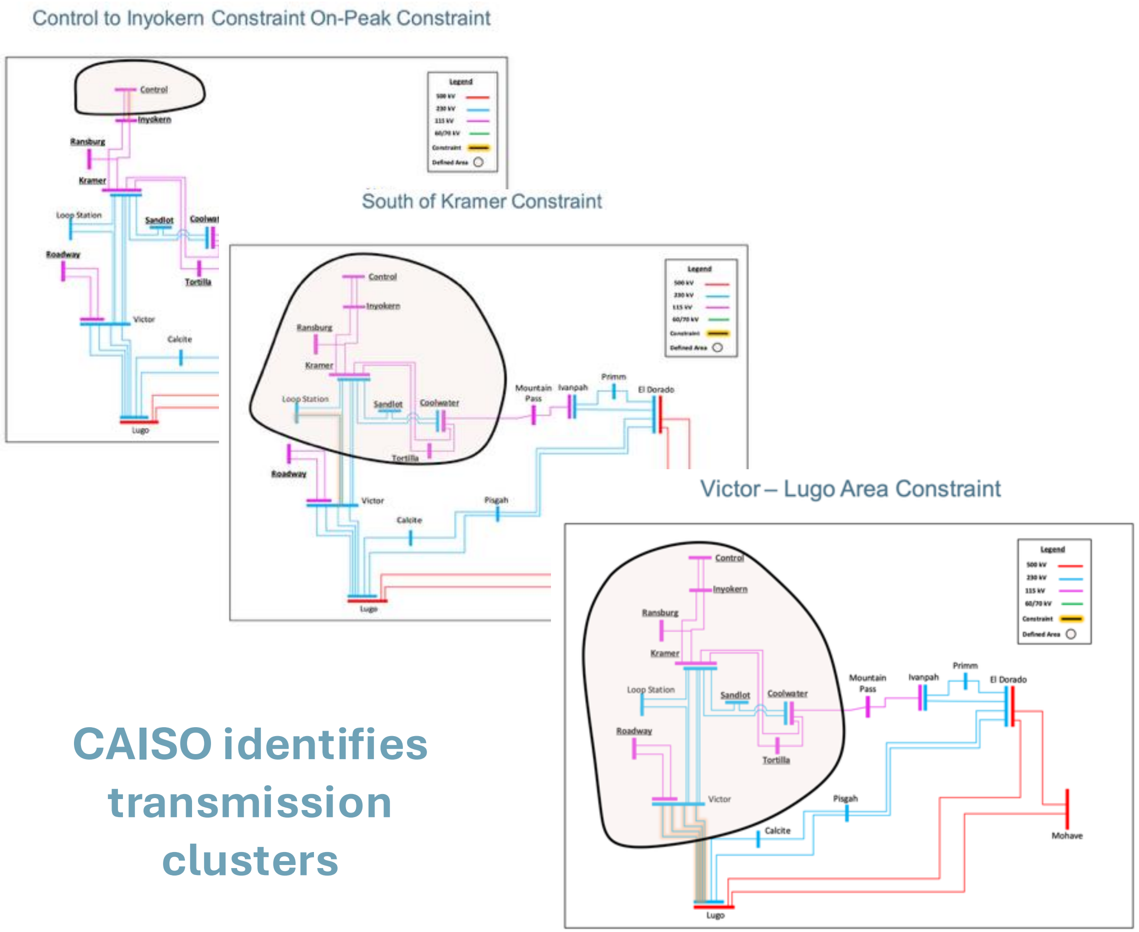
### Environmental Screen

- CEC Core Land-Use Screen:
  - Protected areas
  - Farmland
  - Habitats
  - Endangered species

# CPUC/CAISO G+T Co-optimization

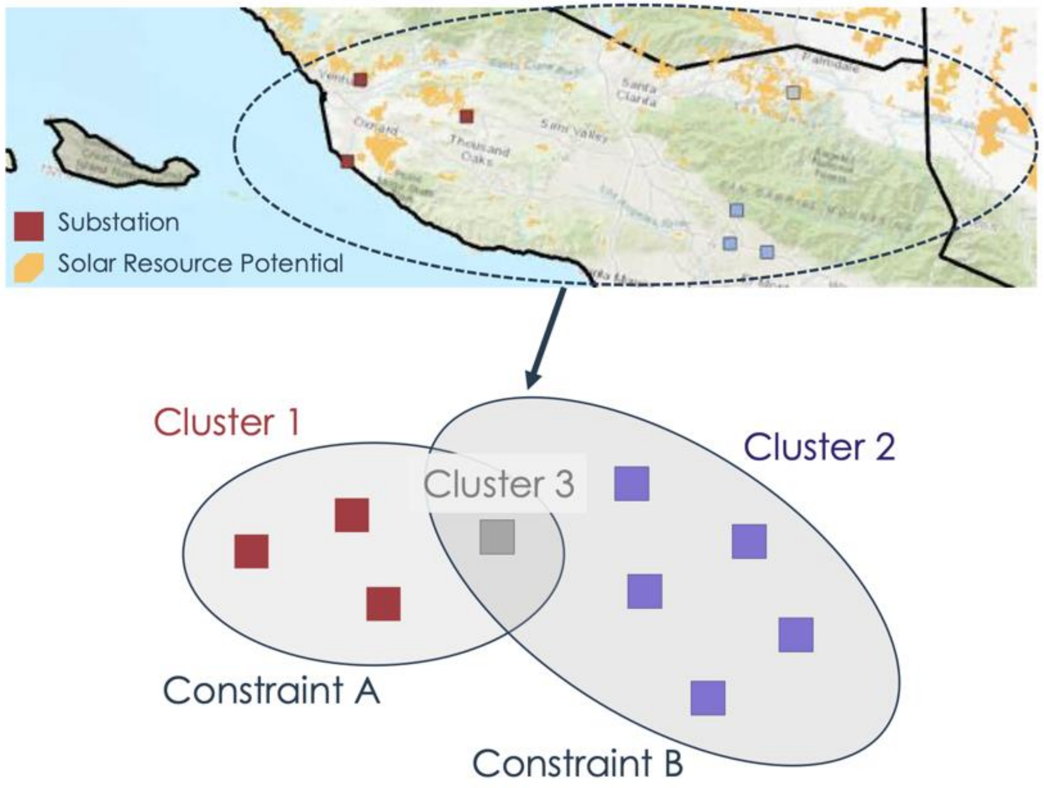
## Technical details

### Step 2. Develop transmission clusters + map resource potential




**CAISO identifies transmission clusters**

Source: CAISO 2024Deliverability Constraint Boundary Diagrams




**E3 + other consultants map resource potential to clusters**

Source: CPUC 24-26 IRP Cycle Draft Inputs and Assumptions

# CPUC/CAISO G+T Co-optimization

## Technical details

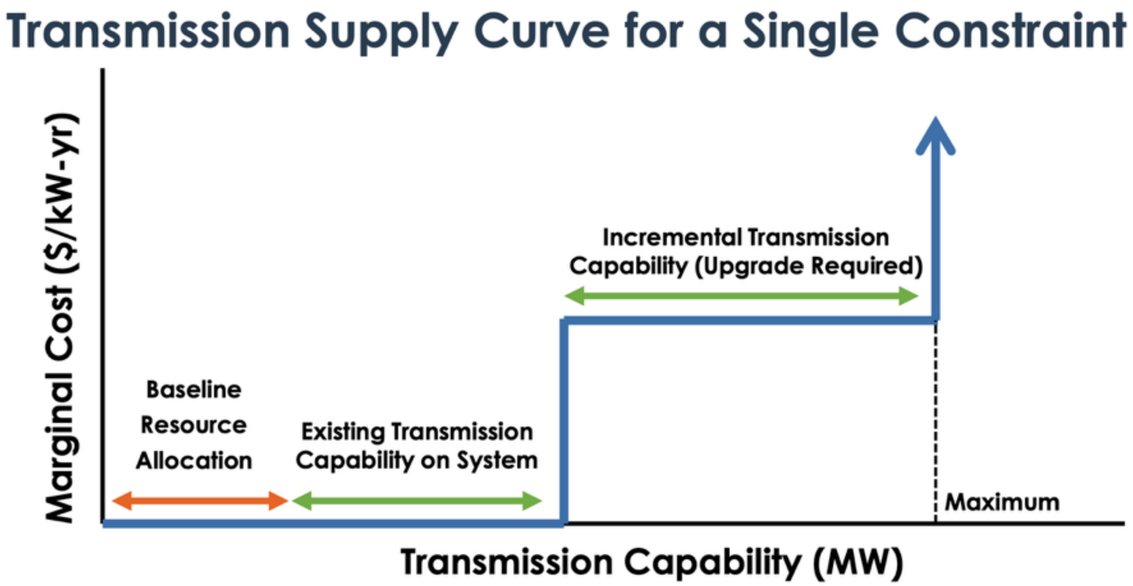
## Step 3. Use Tx planning outputs to develop capacity expansion constraints

**On-Peak Deliverability Multipliers**

| Resource type | PG&E | SCE | SDGE | VEA |
|---|---|---|---|---|
| Solar | 15% | 13% | 6% | 8% |
| Wind | 50% | 48% | 35% | 48% |
| Non-Intermittent resources | NQC or 100% | | | |
| Energy storage | 100% if duration is ≥ 4-hour or 4-hour equivalent if duration is < 4-hour | | | |
| Hybrid | [The lesser of Net MW to Grid (ISC) or the sum of the study amounts of the individual paired resources]/ISC | | | |
| New Mexico Wind | 67% | | | |
| Wyoming/Idaho Wind | 67% | | | |
| Off Shore Wind | 85% | | | |

**Off-Peak Deliverability Multipliers**

| Resource type | Wind Area | | | Solar Area | | |
|---|---|---|---|---|---|---|
| | SDG&E | SCE | PG&E | SDG&E | SCE | PG&E |
| Solar | 68% | | | 79% | 77% | 79% |
| Wind | 69% | 64% | 63% | 44% | | |
| Hydro | 30% | | | | | |
| Off-shore Wind | 100% | | | | | |
| New Mexico Wind | 67% | | | | | |
| Wyoming/Idaho Wind | 67% | | | | | |
| Thermal | 0%[8] | | | | | |
| Energy storage | 100% in charging mode if duration is ≥ 4-hour or 4-hour equivalent if duration is less than 4-hour[9] | | | | | |




Source: CPUC 24-26 IRP Cycle Draft Inputs and Assumptions

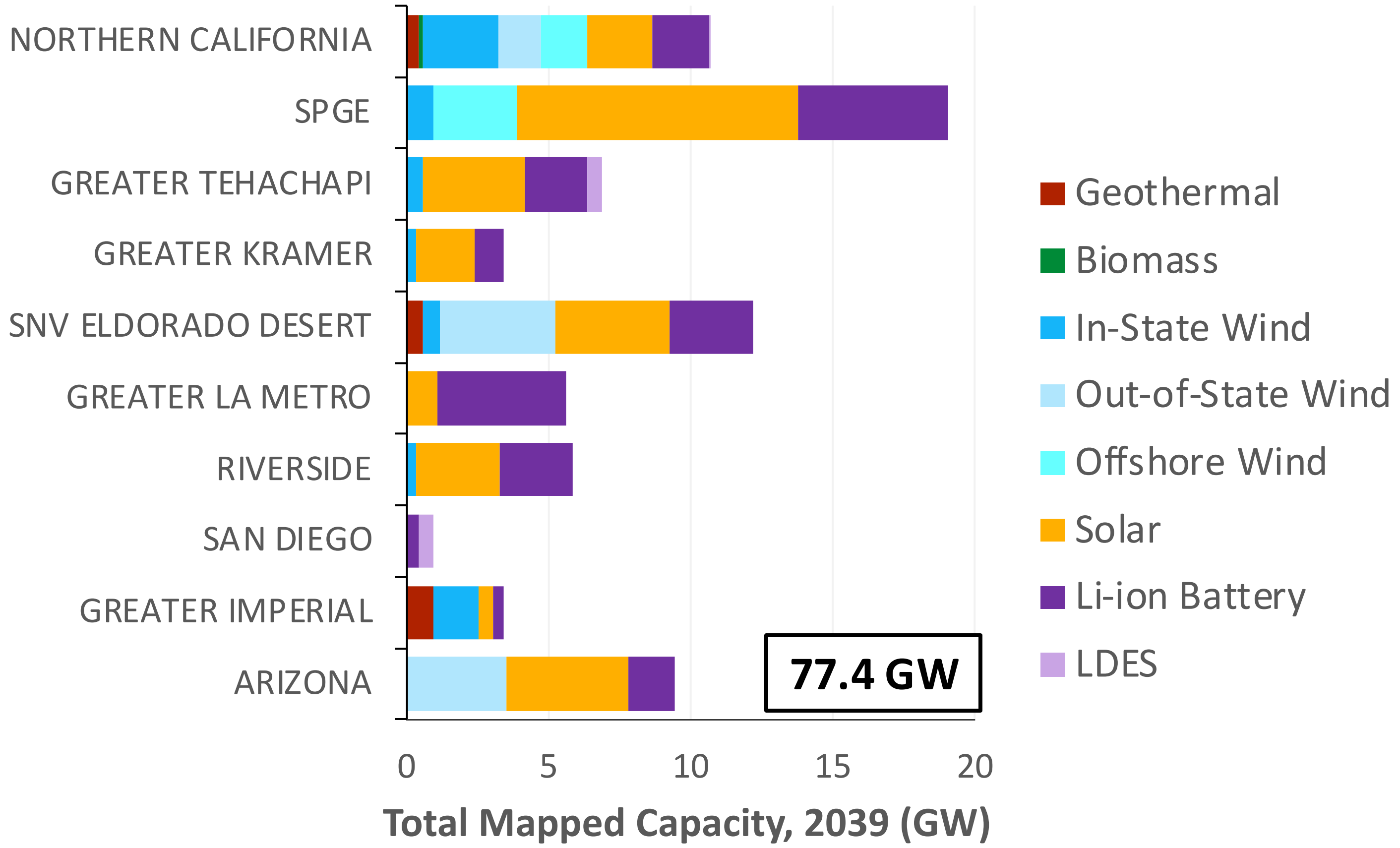
**E3 develops RESOLVE modeling constraints**

**CAISO defines resource contributions to each constraint**

# CPUC/CAISO G+T Co-optimization

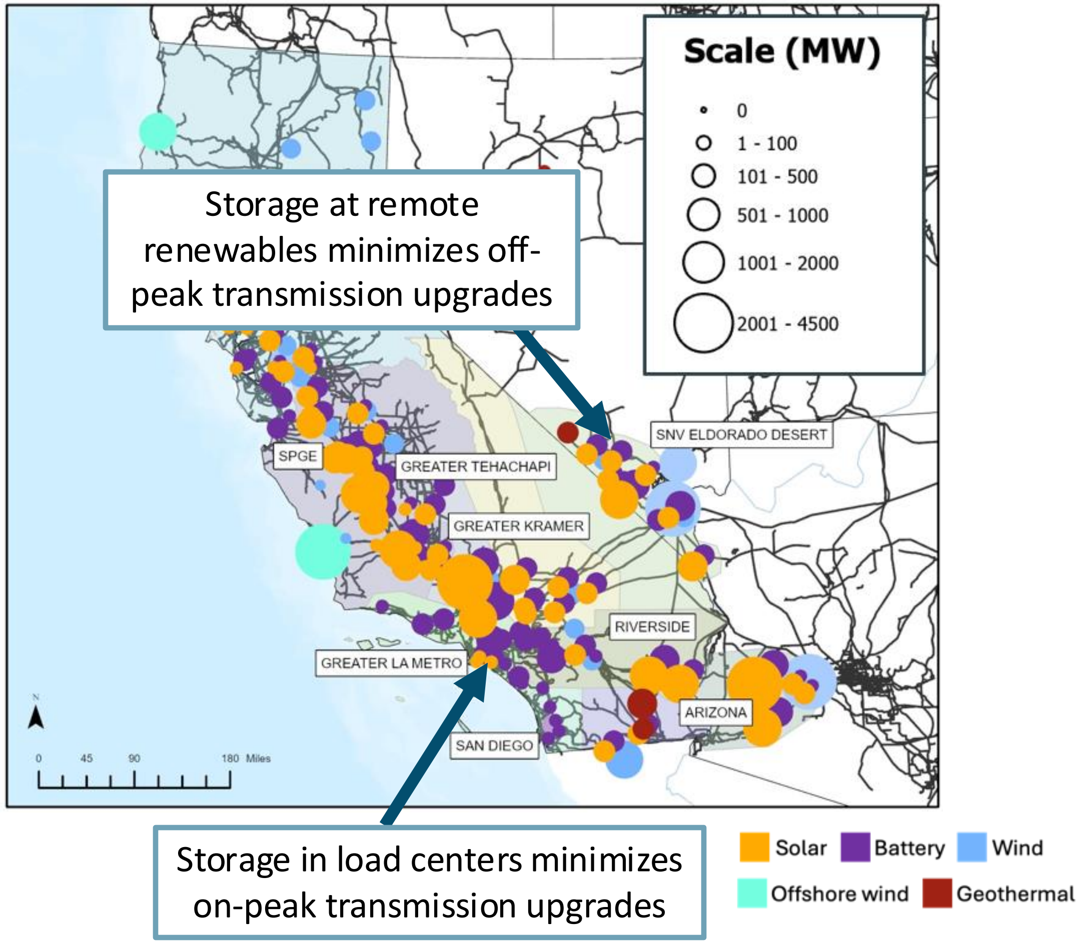
## Diverse resources in diverse locations supported by storage

### CAISO-level New Resource Additions, 2023-2039




### CPUC IRP Resource Additions by Substation

2024-25 Transmission Planning Process, 2039 Snapshot

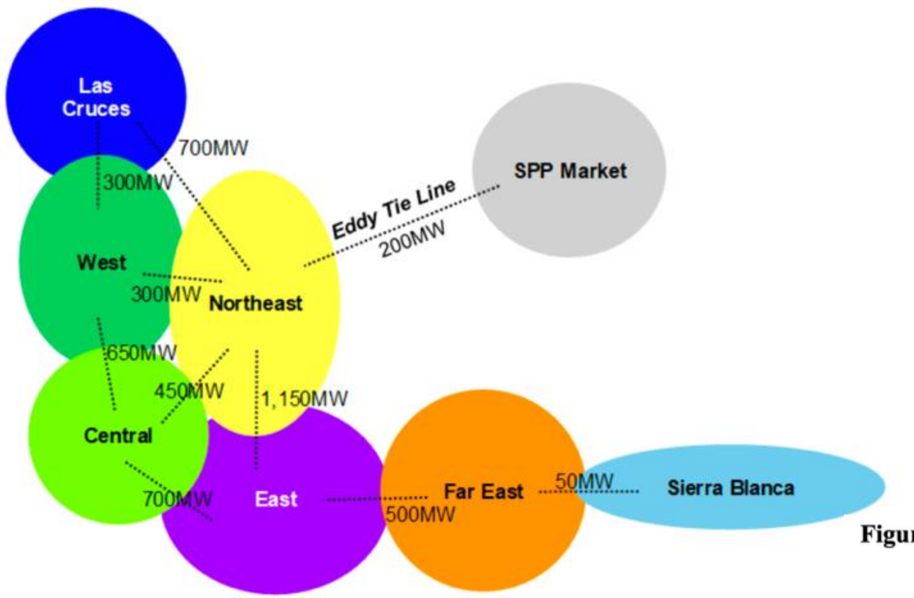


# El Paso Electric 2025 IRP

## Multi-zone G+T Co-optimization + Scenario Analysis

**Co-optimization**
7 zone pipe-and-bubble representation with candidate internal Tx upgrades

Figure 48: Topology with Eddy Tie

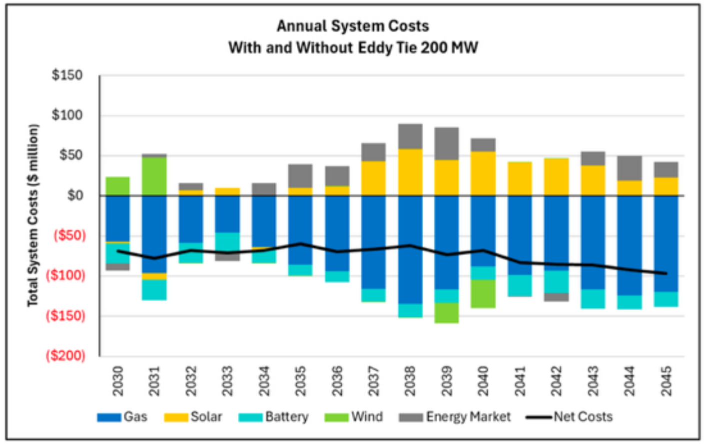



**Scenario analysis**
Value of external Tx expansion to SPP

Table 33: Candidate Transmission Expansion - Capacity and Cost

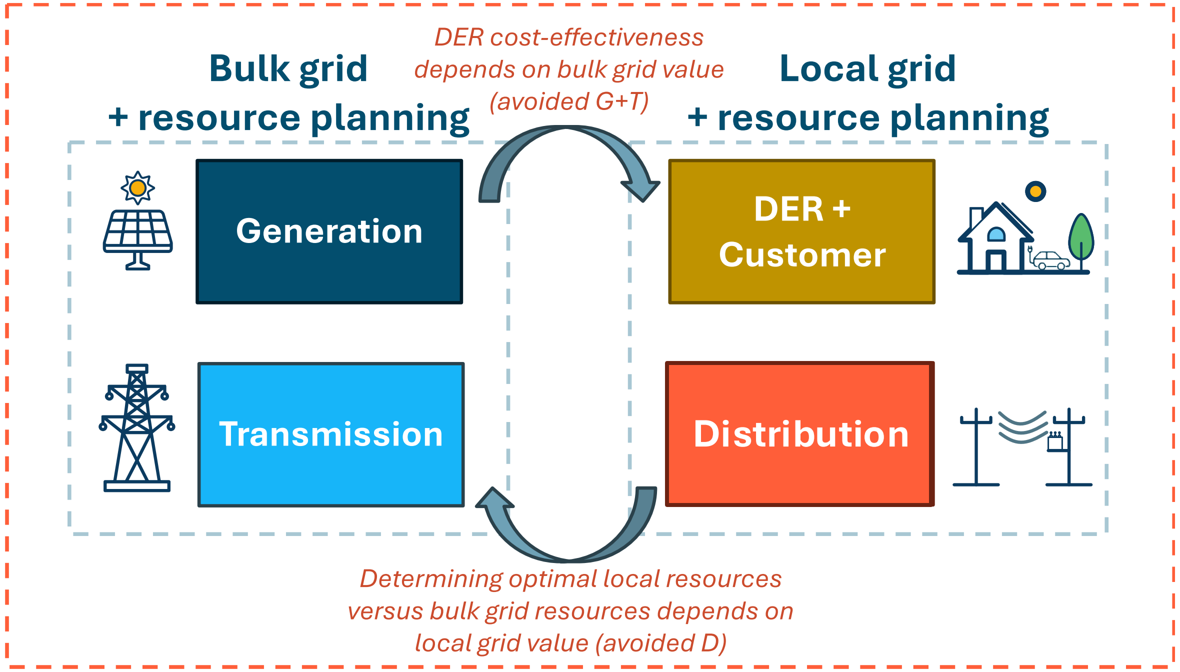
| Candidate Transmission Expansion Lines | Upgrade Build Cost (Millions $) | Incremental Capacity (MW) |
|---|---|---|
| East to Central | $40 | 250 |
| Far East to East | $150 | 1,000 |
| Las Cruces to Northeast | $160 | 1,000 |
| Las Cruces to West | $100 | 250 |
| Northeast to Central | $35 | 250 |
| Northeast to East | $60 | 1,000 |
| Northeast to West | $130 | 1,000 |
| Sierra Blanca to Far East | $200 | 250 |
| West to Central | $60 | 250 |

Figure 50: EPE System Incremental Cost of SPP Market Enhancement (200 MW) compared to Least-Cost + REA



# Linking Demand Side and Supply Side Resource Valuation

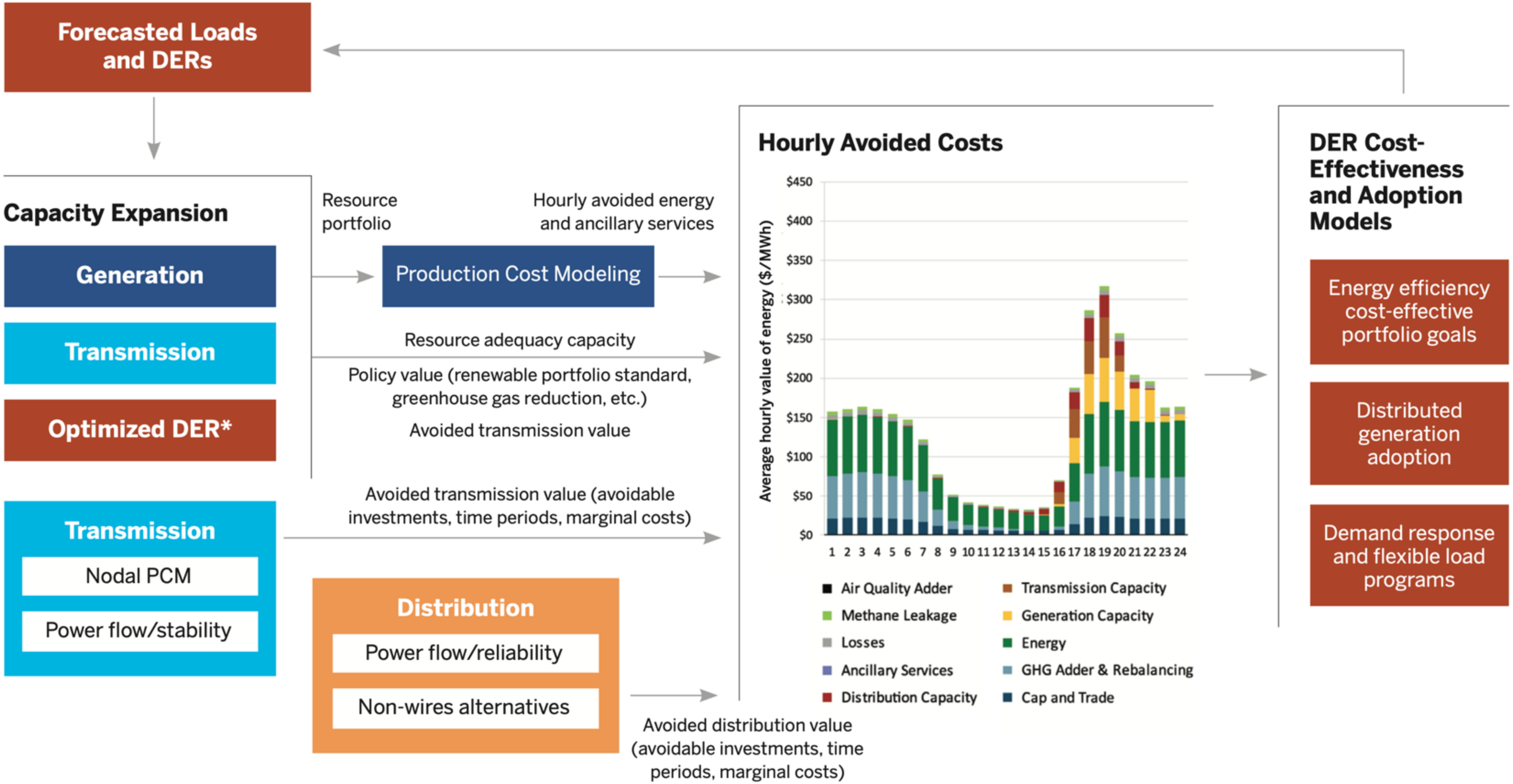
**The theory: a single optimization enables the lowest cost solution**




**Practical reality: a single optimization requires key tradeoffs versus traditional DER planning methods**

- Detailed DER measures **require bundling** (too many individual options to model)
- **Locational values are challenging** to calculate and capture in a system-wide optimization
- DER planning often considers **multiple perspectives** ("cost tests")
  - Social costs (TRC) vs. participant costs (PCT) vs. non-participating customer impacts (RIM), etc.

# Alternative 1: Marginal hourly avoided costs




Source: Energy Systems Integration Group.

# Evolution of bulk grid loads and resources informs DER values (CPUC Avoided Cost Calculator example)

**CAISO Marginal Avoided Energy Value (2022$/MWh) from CPUC's Avoided Cost Calculator**

**2025**

| Month \ Hour | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 66 | 65 | 63 | 63 | 63 | 67 | 67 | 64 | 52 | 46 | 44 | 43 | 43 | 42 | 41 | 44 | 60 | 72 | 70 | 65 | 64 | 65 | 66 | 67 |
| 2 | 61 | 60 | 60 | 60 | 60 | 60 | 57 | 53 | 37 | 27 | 25 | 25 | 22 | 22 | 20 | 21 | 44 | 70 | 66 | 60 | 59 | 58 | 61 | 63 |
| 3 | 48 | 48 | 47 | 48 | 49 | 50 | 51 | 34 | 14 | 11 | 10 | 11 | 11 | 11 | 7 | 10 | 37 | 60 | 58 | 58 | 57 | 51 | 49 | 48 |
| 4 | 52 | 54 | 55 | 54 | 53 | 52 | 45 | 10 | 7 | 8 | 8 | 7 | 4 | 1 | 1 | 1 | 7 | 58 | 55 | 51 | 51 | 52 | 51 | 52 |
| 5 | 51 | 52 | 52 | 53 | 51 | 47 | 37 | 16 | 10 | 9 | 10 | 8 | 5 | 4 | 4 | 8 | 19 | 55 | 59 | 52 | 49 | 49 | 51 | 53 |
| 6 | 53 | 52 | 52 | 53 | 54 | 54 | 49 | 33 | 27 | 26 | 24 | 24 | 26 | 24 | 22 | 22 | 32 | 62 | 61 | 61 | 58 | 55 | 53 | 56 |
| 7 | 51 | 49 | 49 | 47 | 48 | 49 | 44 | 38 | 32 | 34 | 33 | 33 | 31 | 29 | 31 | 31 | 42 | 66 | 65 | 69 | 62 | 56 | 53 | 54 |
| 8 | 62 | 60 | 57 | 57 | 58 | 55 | 48 | 43 | 43 | 42 | 42 | 40 | 41 | 42 | 43 | 47 | 58 | 74 | 126 | 162 | 79 | 68 | 62 | 62 |
| 9 | 63 | 61 | 59 | 59 | 59 | 59 | 49 | 38 | 36 | 36 | 35 | 35 | 35 | 35 | 37 | 41 | 57 | 72 | 91 | 88 | 66 | 64 | 64 | 64 |
| 10 | 61 | 59 | 59 | 57 | 59 | 58 | 52 | 43 | 37 | 36 | 36 | 35 | 34 | 34 | 34 | 41 | 63 | 72 | 70 | 64 | 62 | 66 | 65 | 62 |
| 11 | 62 | 61 | 59 | 59 | 61 | 63 | 60 | 49 | 41 | 39 | 37 | 37 | 35 | 34 | 34 | 43 | 66 | 66 | 63 | 61 | 61 | 64 | 64 | 63 |
| 12 | 63 | 61 | 59 | 57 | 59 | 61 | 63 | 56 | 46 | 38 | 38 | 35 | 35 | 34 | 34 | 44 | 66 | 67 | 65 | 63 | 63 | 63 | 64 | 63 |

*Low/negative prices concentrated in the spring*

**2050**

| Month \ Hour | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 102 | 82 | 88 | 78 | 85 | 78 | 84 | 76 | 63 | 39 | 34 | 13 | 11 | 11 | 11 | 15 | 70 | 26 | 59 | 76 | 79 | 96 | 106 | 120 |
| 2 | 70 | 56 | 55 | 73 | 81 | 64 | 53 | 56 | 14 | 13 | 14 | 11 | 9 | 8 | 9 | 12 | 26 | 42 | 31 | 40 | 49 | 68 | 65 | 69 |
| 3 | 37 | 48 | 59 | 65 | 55 | 47 | 38 | 17 | 13 | 11 | 11 | 9 | 8 | 7 | 7 | 9 | 14 | 75 | 70 | 55 | 51 | 45 | 47 | 43 |
| 4 | 20 | 27 | 36 | 29 | 21 | 16 | 15 | 9 | 7 | 7 | 6 | 6 | 4 | 3 | 2 | 2 | 1 | 7 | 80 | 77 | 29 | 18 | 12 | 13 |
| 5 | 34 | 45 | 48 | 28 | 15 | 10 | 6 | 5 | 6 | 6 | 7 | 6 | 5 | 4 | 3 | 2 | 2 | 18 | 89 | 81 | 30 | 26 | 21 | 18 |
| 6 | 30 | 36 | 57 | 32 | 25 | 24 | 16 | 10 | 10 | 10 | 10 | 9 | 10 | 9 | 9 | 7 | 6 | 20 | 92 | 65 | 31 | 34 | 32 | 32 |
| 7 | 46 | 66 | 76 | 62 | 54 | 35 | 31 | 14 | 9 | 10 | 10 | 9 | 10 | 5 | 4 | 3 | 4 | 35 | 79 | 42 | 53 | 52 | 48 | 44 |
| 8 | 77 | 71 | 78 | 95 | 75 | 80 | 62 | 14 | 17 | 12 | 13 | 11 | 10 | 7 | 8 | 8 | 12 | 61 | 87 | 75 | 82 | 80 | 99 | 102 |
| 9 | 61 | 51 | 50 | 59 | 57 | 63 | 48 | 16 | 13 | 12 | 10 | 9 | 8 | 7 | 7 | 9 | 12 | 59 | 48 | 68 | 77 | 66 | 68 | 67 |
| 10 | 59 | 57 | 70 | 80 | 71 | 58 | 48 | 20 | 16 | 12 | 11 | 11 | 12 | 14 | 10 | 10 | 48 | 57 | 48 | 53 | 62 | 71 | 77 | 71 |
| 11 | 75 | 57 | 62 | 81 | 78 | 84 | 60 | 37 | 20 | 16 | 14 | 14 | 14 | 16 | 17 | 20 | 60 | 40 | 60 | 56 | 62 | 73 | 84 | 74 |
| 12 | 111 | 91 | 93 | 109 | 110 | 100 | 87 | 59 | 52 | 24 | 21 | 19 | 19 | 22 | 15 | 27 | 92 | 52 | 70 | 68 | 81 | 84 | 82 | 103 |

*Load growth from winter space heating + higher gas/carbon prices increase energy values during winter months*

*Low/negative prices year-round during solar hours*

Source: CPUC 2024 Avoided Cost Calculator

# Alternative 2: Local-grid optimization with bulk-grid avoided costs

Initial bulk-grid resource plan

### Capacity Expansion

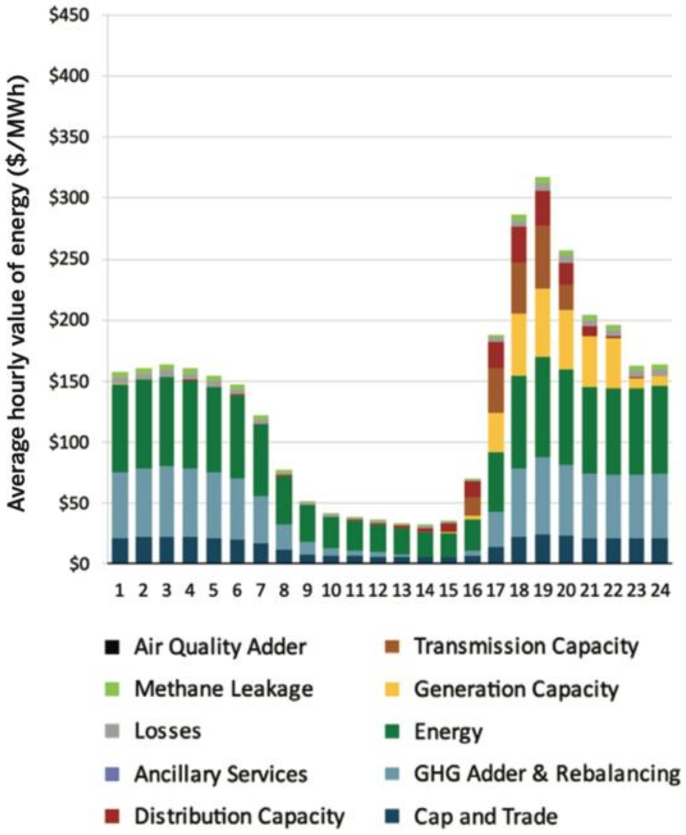
**Generation**

**Transmission**

**Forecasted and/or Optimized DER**

Bulk-grid values and performance requirements, resource adequacy, etc.

### Hourly Avoided Costs




Local grid and resource plan

### Integrated Distribution System Planning

**Substation- or feeder-level economic optimization**

Distribution grid investments vs. incremental DER investment or operational changes

**Incremental DERs**

**Distribution**

Final bulk-grid resource plan

### Final G+T Capacity Expansion

Including initial and incremental DER forecast

Source: Energy Systems Integration Group.

# Integrated Distribution System Planning

1. Granular locational load + DER forecast

2. Longer-term distribution planning scenarios

3. Sourcing strategies for DERs as non-wires alternatives

| | Utility Ownership and Control | Competitive Solicitations | Customer Programs | Markets | Tariffs |
|---|---|---|---|---|---|
| Sourcing timeline and resource performance drivers | Utility construction timelines and distribution operational model | Utility procurement process and contract requirements | Customer adoption and behavioral response | Market clearing and wholesale price signals | Customer adoption and behavioral response |
| Uncertainty | Low | Low-Medium | Medium | Medium-High | High |
| Key use cases | Specific time-dependent grid needs (non-wires alternatives, etc.) | Specific time-dependent grid needs (non-wires alternatives, resource adequacy, etc.) | Identifying cost-effective measures, incentivizing customer adoption, enabling market transformation | Using market-based wholesale pricing (via energy or distribution services markets) to drive customer adoption and/or behavioral changes | Using wholesale or retail pricing (rates) to drive customer adoption and/or behavioral changes |

Planners can be confident in optimizing ⟷ Planners may need additional validation if optimizing

Source: Energy Systems Integration Group.

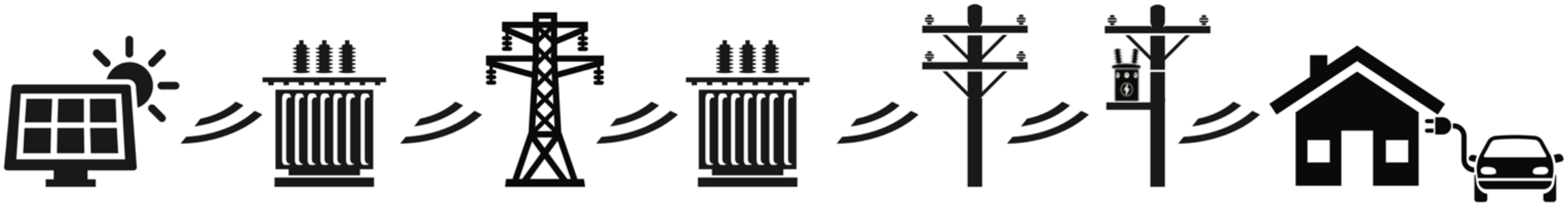
**Xcel Minnesota proposes 'first-of-its-kind' distributed capacity procurement**

Xcel requested the Minnesota Public Utilities Commission approve the program with a budget range of $152 million, based on a minimum procurement of 50 MW, to $430 million if it deploys all 200 MW.

Source: Utility Dive

# Harmonized action plans drive near-term investments and regulatory approvals

## Components of an Action Plan Resulting from an Integrated Planning Process



| Generation | Transmission | Distribution | Customer Programs & DERs |
|---|---|---|---|

**Action plans are consistent with integrated planning and require coordination across teams**

**Generation resource action plan**

- Recource investments and/or procurement need
- All-source request for propos-als
- Requests for proposals tar-geted by location

**Transmission action plan**

- Transmission asset invest-ments
- Storage providing transmission service
- Regional transmission project participation

**Distribution action plan**

- Investments in substation/ lines/grid modernization
- Development of targeted DER/customer programs
- Non-wires alternatives solici-tations

**Customer/DER programs and rates action plan**

- Customer program evaluation and design for efficieincy and equity
- Rate design updates

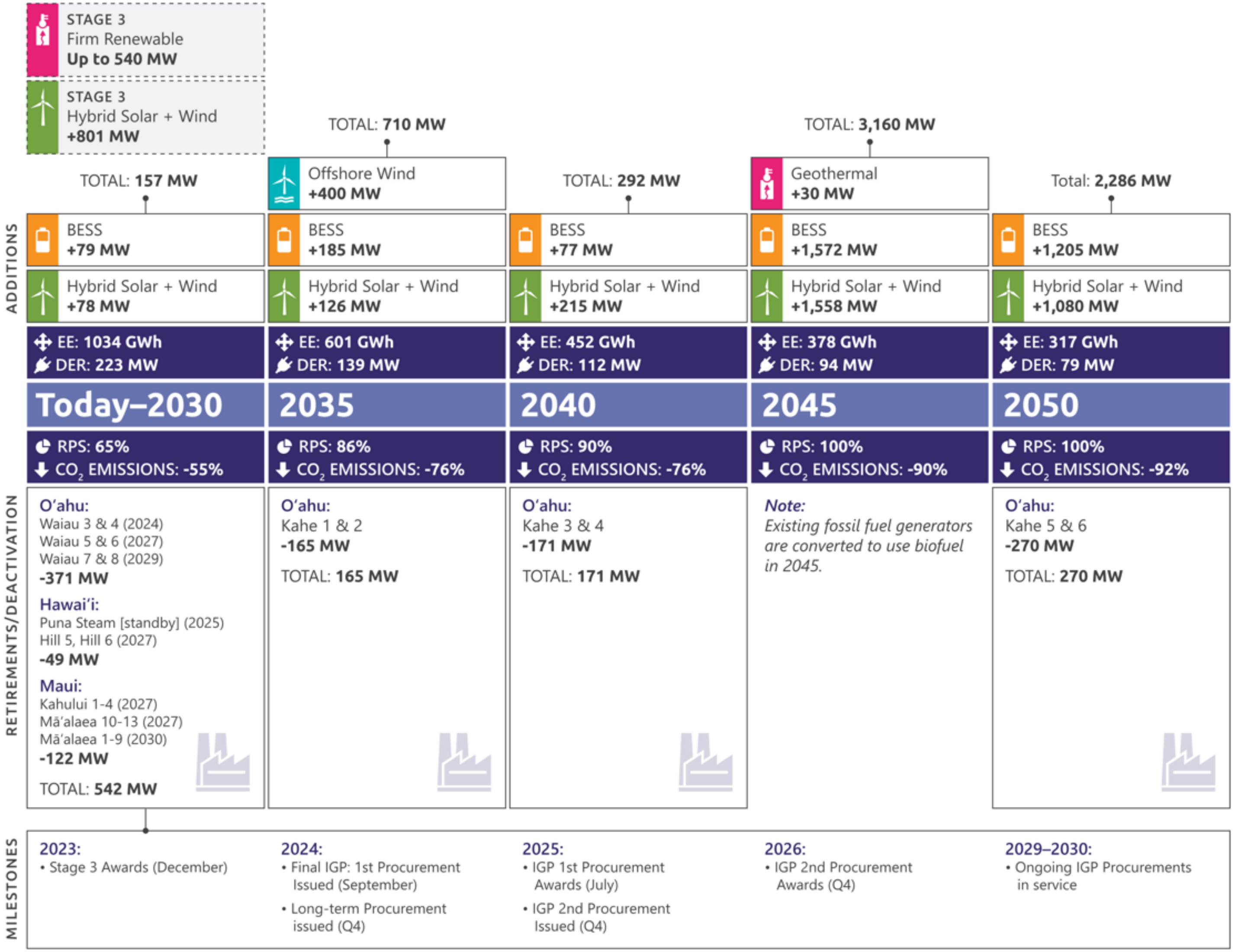
**Plus pilot programs to validate planning assumptions (technology pilots, commercial pilots, operational pilots, etc.)**

Source: Energy Systems Integration Group, adapted from A. Olson, J. Hooker, A. Burdick, and L. Alagappan, "Integrated System Planning: From Vision to Reality," Energy and Environmental Economics, Inc., ISP Webinar Series presented September 26, 2024.

# Hawaiian Electric's 2023 Integrated Grid Plan

*Incremental bulk-grid and demand-side (EE, DER, etc.) additions → RFPs and DER sourcing*

*Retirement schedule for aging legacy firm diesel generators…*




*Pathway(s) to meet clean energy policy objectives (100% RPS by 2045)*

*…and long-term plan for continued firm capacity needs*

*+ T+D Needs, Non-wires alternative solicitations, etc.*

Source: Hawaiian Electric, Integrated Grid Plan: Preferred Plan and Next Steps. https://hawaiipowered.com/igpreport/IGP_SupplementalResponse_Nov-14-2023.pdf

# Key steps to create an integrated planning process

## The walk, jog, run framework supports incremental improvements + change management

Walk → Jog → Run

| Organizational Evolution | Technical Evolution |
|---|---|
| Determine integrated planning objectives | Align key inputs and develop integrated scenarios |
| Perform a gap assessment for existing planning processes | Redesign analytical framework to better connect existing analytical processes |
| Adapt stakeholder engagement plans to support an integrated planning process | Develop new analytical methods and tools to facilitate planning integrations |
| Consider organizational re-alignment and/or formalized agreements between planning organizations | Implement co-optimization methods across planning domains |

# Thank You

aaron.burdick@ethree.com

Energy+Environmental Economics

# Appendix

Energy+Environmental Economics

# Planning the entire system requires coordinating across multiple analyses

| ISP Analysis Component | Description | C/DER | D | T | G |
|---|---|---|---|---|---|
| **Economywide Energy Modeling** | Forecasts alternative economy-wide energy pathways and informs electrification impacts to the load forecast | ● | | | |
| **Load & DER Forecasts** | Forecasts customer energy demand, incorporating electrification, and customer program + DER adoption forecasts | ● | | | |
| **Load & DER Downscaling** | Downscales system-wide load forecast to transmission buses and distribution circuits | ● | ● | ● | ● |
| **Resource Options Study** | Evaluates resource options, potential, costs, transmission costs for remote resources, etc. | ● | | ● | ● |
| **Resource Adequacy Study** | Determines system total resource need for ensuring resource adequacy and contributions of resources at various penetration levels | ● | | ● | ● |
| **Distribution Studies** | Identifies distribution infrastructure needed to accommodate load growth and distributed resources, considers non-wires alternative opportunities | ● | ● | | |
| **Capacity Expansion Optimization** | Identifies generating resource portfolio, including bulk grid generators, enabling transmission investments, storage, distributed energy resources, etc. | ● | | ● | ● |
| **Production Cost Modeling** | Assesses zonal and/or DC power flow based nodal resource operations and quantifies production costs at granular hourly or sub-hourly timescales | ● | | ● | ● |
| **Nodal Resource Mapping** | Maps generation and storage resources across the network to help minimize transmission investment needs and inform detailed transmission studies | | | ● | ● |
| **Transmission Studies** | Identifies transmission infrastructure via AC power flow and stability studies to accommodate load and resource additions, ensures reliability and stability | | ● | ● | ● |
| **Avoided Costs** | Translates infrastructure planning needs into granular marginal avoided costs to value customer programs and inform rate design | ● | ● | ● | ● |

# A staged approach to integrated system planning

| | Walk Stage<br>Get started | Jog Stage<br>Increasing connections | Run Stage<br>Full integration |
|---|---|---|---|
| **Scenario Planning** | **Standardize scenarios and key inputs** | **Standardize planning process timelines and inputs** into an ISP cycle (data development, load forecasts, etc.) | Integrate scenario development across all planning processes |
| **Technical Analysis** | Improve each individual process to industry best practice<br>Add connections between individual models | **Increase model + data connections** between processes. Some **bidirectional exchange** of information. | **Fully integrate modeling processes.** Well-established **bidirectional exchange** of information. Some **co-optimization.** |
| **Procurement Integration** | Increase **planning to procurement connection** across Customer Programs and G, T, & D Asset Management | Initiate **new procurement pilots using ISP results** (e.g., non-wires alternatives) | **Fully integrate procurement processes** with **feedback** to and from the ISP process |
| **Organizational Alignment** | **Thought leaders drive integration** and increase cross-team coordination | Formalize **integrated planning function** | **Fully integrate ISP function with other business units** (strategy, finance, rate design, etc.) |

**Increasingly integrate planning over multiple planning cycles**

# Key steps to create an integrated planning process

## Data development to support integrated planning

Economywide Energy Modeling
(E3's PATHWAYS Models)

Vehicle and Building Load Shapes
(E3's EVGrid and RESHAPE Models)

Geospatial forecasting
(E3 + IA's Forecasting Anywhere Model)

E3's RECOST Model
and GIS Toolkit

Nodal production cost models

Transmission deliverability + stability power flow models

Distribution planning tools

**Load + DERs Forecasts**
- Integrated, aligned scenarios across G/T/D planning
- Geospatially allocated to T&D system
- Weather aligned w/ RE shapes

**Candidate Resource Options**
- Geospatially allocated to T+D system
- Sensitivities considering emerging technologies
- DER / flex load inputs

**Grid Upgrades**
- Locationally based MW upgrades
- Detailed cost estimates
- Feasibility screened non-wires alternatives

Resource Adequacy
(E3's RECAP Model)

**Optimized Capacity Expansion Model**

DER Bulk-grid Aligned Valuation
(E3's Avoided Cost Calculator
and IDSM Toolkit)

Bulk grid Generation + Transmission Co-optimization
(E3's RESOLVE Model)

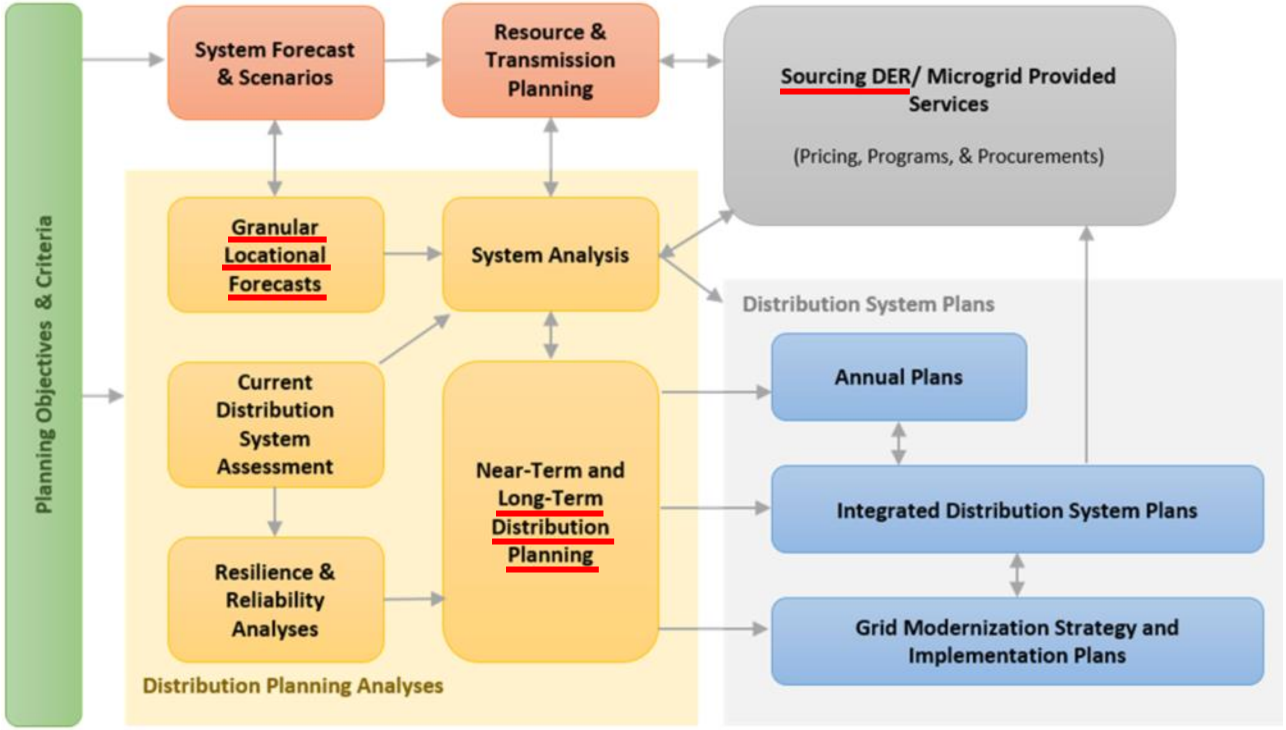
PLEXOS

LOADSEER

Local grid DER + distribution planning
(IA's LoadSEER Model)

# Integrated Distribution System Planning

1. Granular locational load + DER forecast
2. Longer-term distribution planning scenarios
3. Sourcing strategies for DERs as non-wires alternatives




From Modern Distribution Grid Guidebook, DSPx Volume 4, June 2020,
PNNL: Grid Architecture - Modern Distribution Grid Project

# DERs as Non-wires Alternatives for Distribution System Needs

## Hawaiian Electric IGP Example

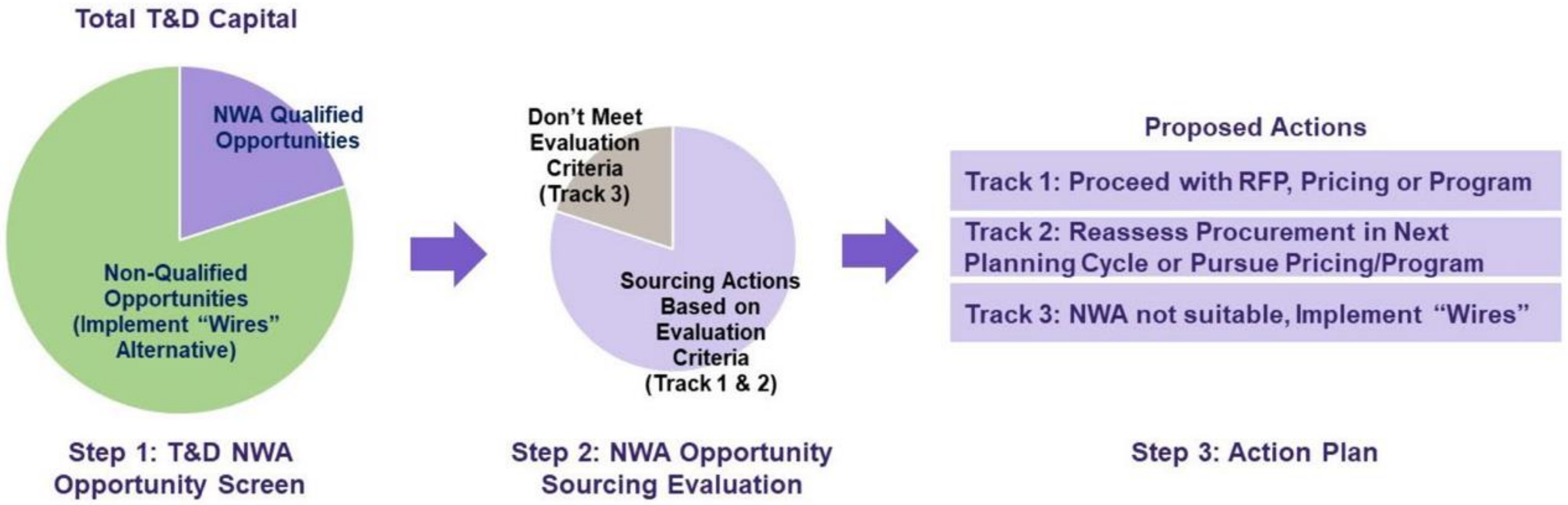
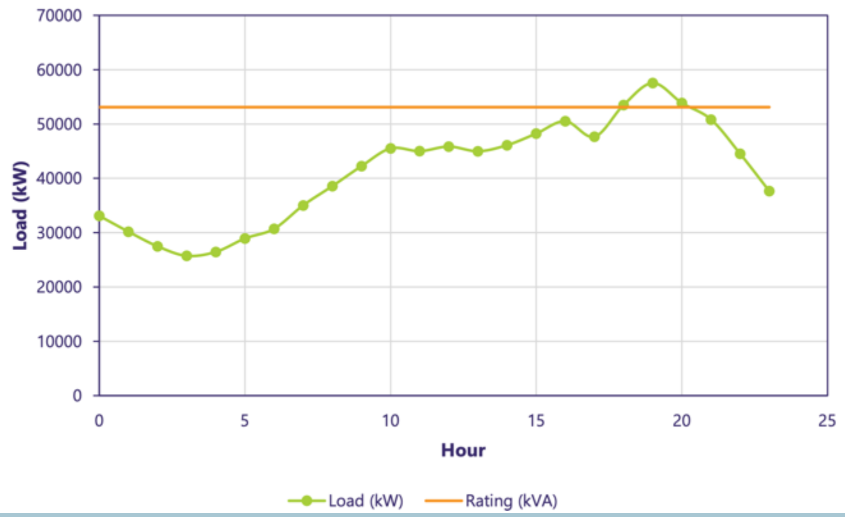



Figure F-12: Kewalo T3 2027 Peak Day Overload




| Transformer | Timing | Overall Performance | Economics |
|---|---|---|---|
| Kewalo T3 (Normal, Base) | 2027 | • Capacity: 4.43 MW<br>• Duration: 3 hours<br>• 12 calls per year | $ 22M |

Hourly analysis sets target capacity, timing, and avoided cost