Planning for Growth of Distributed Energy Resources: Challenges and Opportunities

National Association of State Utility Consumer Advocates Mid-Year Meeting

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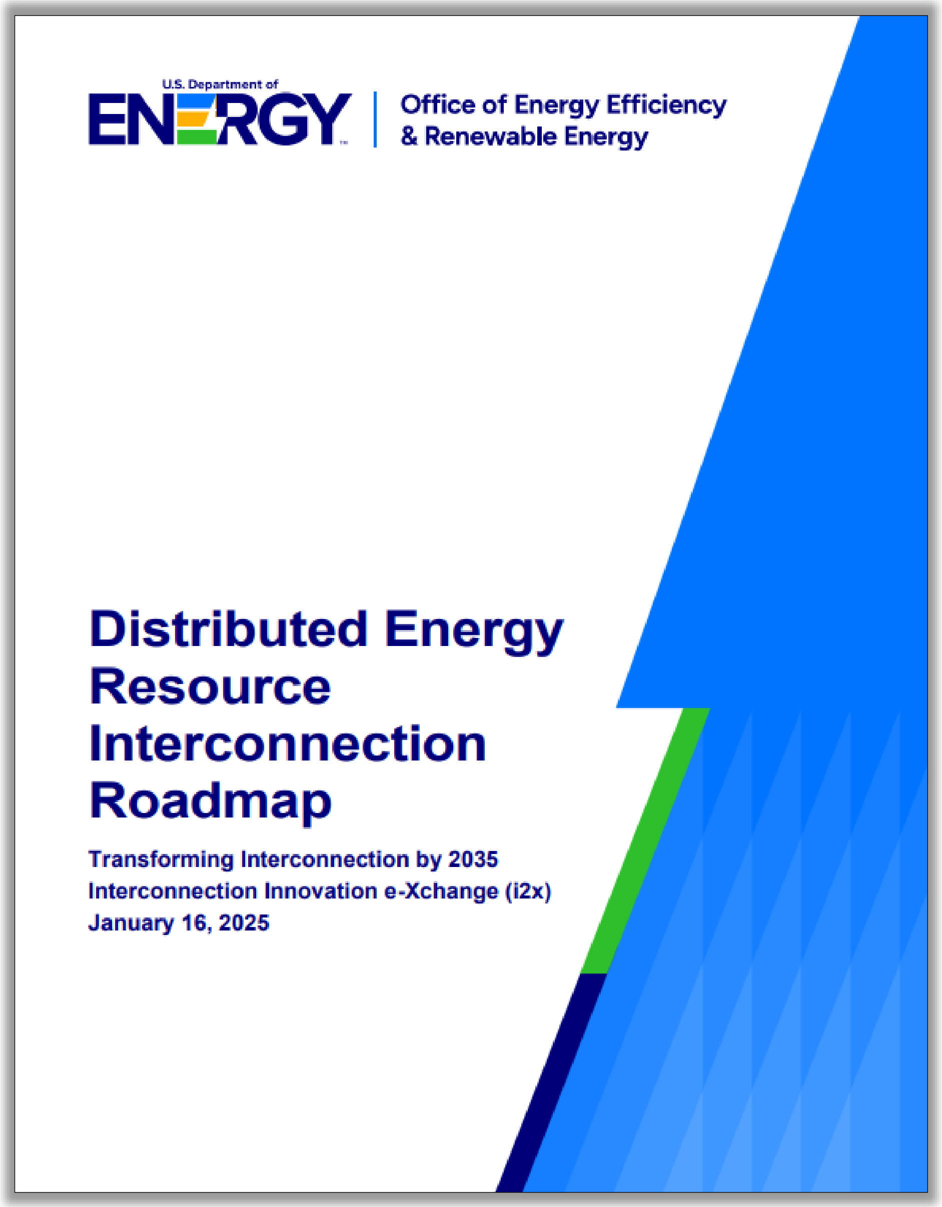
Value of Improved Interconnection Processes

Expedites system and societal benefits of DERs	Improves customer experience	Supports DER development
• Avoided system costs • Delivery of grid services • Reduced emissions and air pollutants • Contributions to grid reliability and resilience • Improved customer choice • Increased market competition	• Reduced time and cost to interconnect • Expedited bill savings and utility customer resilience • Greater satisfaction with utility	• Identification of favorable areas for interconnection • Reduced uncertainty for interconnection costs and timelines • Improved process efficiencies for better business outcomes • Contributions to economic growth and workforce development

Sources: DER Interconnection Roadmap, National Efficiency Screening Project

The U.S. Department of Energy Interconnection Innovation eXchange (i2x) DER Interconnection Roadmap is a guide to actions that can be taken over the next 5–10 years to implement solutions designed to address DER interconnection challenges.

i2X Distributed Energy Resource Interconnection Roadmap


U.S. Department of Energy | Office of Energy Efficiency & Renewable Energy

Distributed Energy Resource Interconnection Roadmap

Transforming Interconnection by 2035
Interconnection Innovation e-Xchange (i2x)
January 16, 2025

i2X Mission

To enable simpler, faster, and fairer interconnection of energy resources while enhancing the reliability, resiliency, and security of electric grids.

Stakeholder Engagement

Analytics & Progress Tracking

Strategic Roadmaps

Research & Technical Assistance

U.S. Department of Energy's i2X DER Interconnection Roadmap

Goal 1: Increase data access, transparency, and security for interconnection
- Data sharing guidelines
- Strategic use of automation
- Broaden use of hosting capacity analysis

Goal 2: Improve interconnection process and timeline
- Queue management
- Inclusive and fair processes
- Workforce development

Goal 3: Promote economic efficiency in interconnection
- Cost allocation
- Coordination between interconnection and grid planning
- Interconnection studies

Goal 4: Maintain a reliable, resilient, and secure grid
- Interconnection models and tools
- Interconnection standards

Implementation of Solutions

Solutions applicable at different DER deployment levels

- *Low:* Less than 5% of distribution system peak
- *Medium:* 5% –15% of distribution system peak
- *High:* Greater than 15% of distribution system peak

Solutions with different implementation time frames

- *Short-term:* Within 1-3 years (by 2027)
- *Medium-term:* 3–5 years (by 2029)
- *Long-term:* Beyond 5 years (2030 and after)

Solutions outline collaborative actions among key actors

- State public utility commissions
- Other state, local and tribal governments
- Utilities
- Interconnection customers
- **Consumer advocates** and public interest organizations
- Equipment manufacturers, solutions and software providers
- Researchers

Measurable Success Targets for 2030

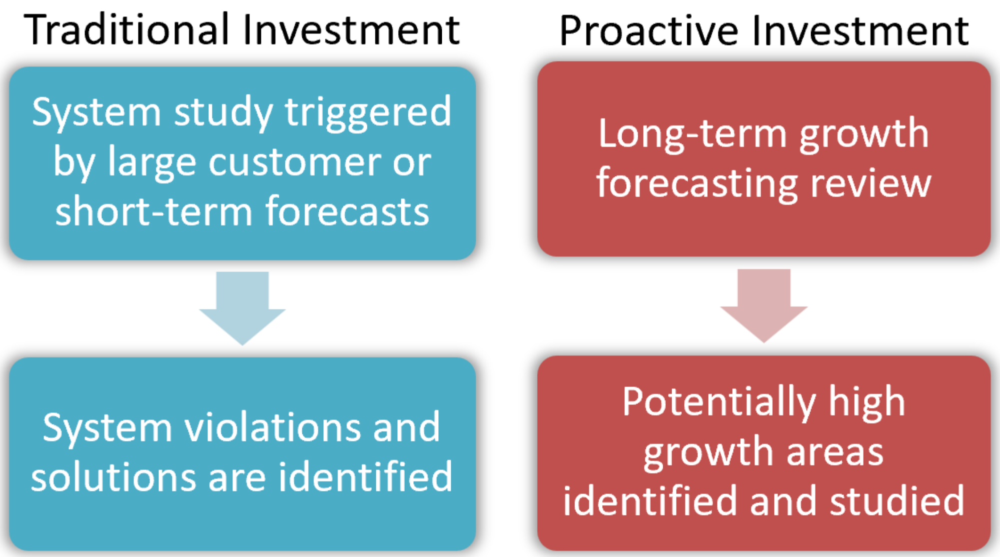
	Target	System Size*	2030 Target Value
Timing	(1) Median time from DER interconnection request to agreement[§]	< 50 kW	Within 1 day[†]
		50 kW–5 MW	< 75 days
		≥ 5 MW	< 140 days
Access	(2) Completion rate from entering the queue to execution of interconnection agreement	< 50 kW	> 99%
		50 kW–5 MW	> 90%
		≥ 5 MW	> 85%
Data	(3) Availability of public state-level interconnection queue data	All	50 states, Washington, D.C., and territories have public, detailed, and current queue data
Reliability	(4) No BPS disturbance events exacerbated by inaccurate DER modeling	All	0
Resilience	(5) Lower Customer Average Interruption Duration Index (CAIDI)[‡]	All	25% improvement (e.g., from 4 to 3 hours per occurrence)

* System size thresholds will vary across utilities and jurisdictions.
[§] For systems that do not trigger system upgrades.
[†] Defined as 1 business day.
[‡] CAIDI with loss of load removed but major event days included.

Planning for DER Growth - Overview

Proactive vs Reactive Distribution Planning for DERs

- Traditional distribution capacity planning is reactive
  - System changes are relatively slow
  - Utility acting on high-confidence information
    - Known load additions
    - Known DER interconnections
    - Short-term load growth forecast (1–3 years)
- Traditional approach can limit speed of load/DER growth if system changes are faster than utility can build infrastructure
  - 2–5 year lead times for major upgrades or longer in dense urban areas
- Proactive planning considers load/DER capacity further ahead of anticipated growth to enable timely adoption
  - Drawback: Based on less certain information
  - Key consideration: *Risk of incorrect action vs risk of inaction*



Proactive vs Reactive Planning – Differences

Reactive Planning

- **Goals**
  - Minimize risk of unutilized investment
  - DER: Allocate Cost to Cost Causer
    - DER interconnection costs paid by developer/customer
  - Loads: Rate Base or Customer Contribution (or Combination)
- **Risks**
  - Construction timelines (1–2+ years)
    - Load construction timelines generally long (new buildings)

Proactive Planning

- **Goals**
  - Don’t block load / DER growth
    - EV and PV/BESS construction timelines often much shorter
- **Risks**
  - **Risk of under-utilized investment**
  - High reliance on accuracy of long-term forecasts
    - Geospatial – Where is adoption?
    - Temporal – When will they interconnect?
  - Cost allocation
    - Potential complications for loads and DER under existing mechanisms

Risk Overview – Proactive vs "Just-In-Time" Investments

	Risk to stakeholders			
	Ratepayers (all customers)	Adopting customer (individual)	Utility shareholders	Society (Public policy)
Risks of investing just-in-time				
Delayed energization risk		✓		✓
Revenue loss or delay risk	✓		✓	
Fossil fuel technology lock-in risk		✓		✓
Public policy goal risk				✓
Unsuitable investment risk	✓		✓	
Risks of investing proactively				
Stranded asset risk	✓		✓	
Unsuitable investment risk	✓		✓	
Inappropriate cost allocation risk	✓	✓		

Source: Guillermo Pereira, Jeff Deason, and Anthony Sandonato, Berkeley Lab, 2025, Unlocking load growth at the grid edge: Practices for managing, recovering, and allocating distribution system investments"

Key Questions on Proactive Distribution System Investments

- What additional benefits are achieved by investing early?
- What are the downsides of waiting an additional year?
- What is the level of confidence that expected needs will materialize?
- How will the costs of proactive investments be allocated and recovered?

Potential Benefits of Proactive Investments

Anticipate Adoption Speed

Coordinate Impacts

Improve Efficiency

Anticipate Adoption Speed

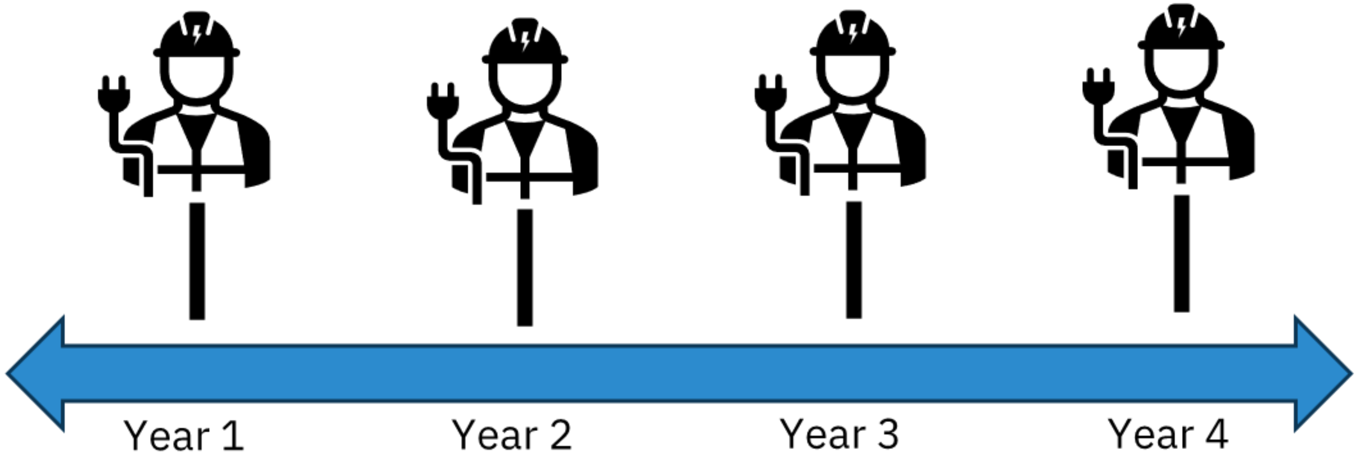
- Goals
  - Prevent utility construction timelines from delaying technology adoption
  - Prevent the grid from being a barrier to achieving state objectives

- How to Consider
  - Focus on areas with the highest risk of load or DER growth occurring faster than infrastructure can be constructed
  - Examine multiple forecast scenarios or sensitivities to changes in forecasting assumptions

Coordinate Impacts

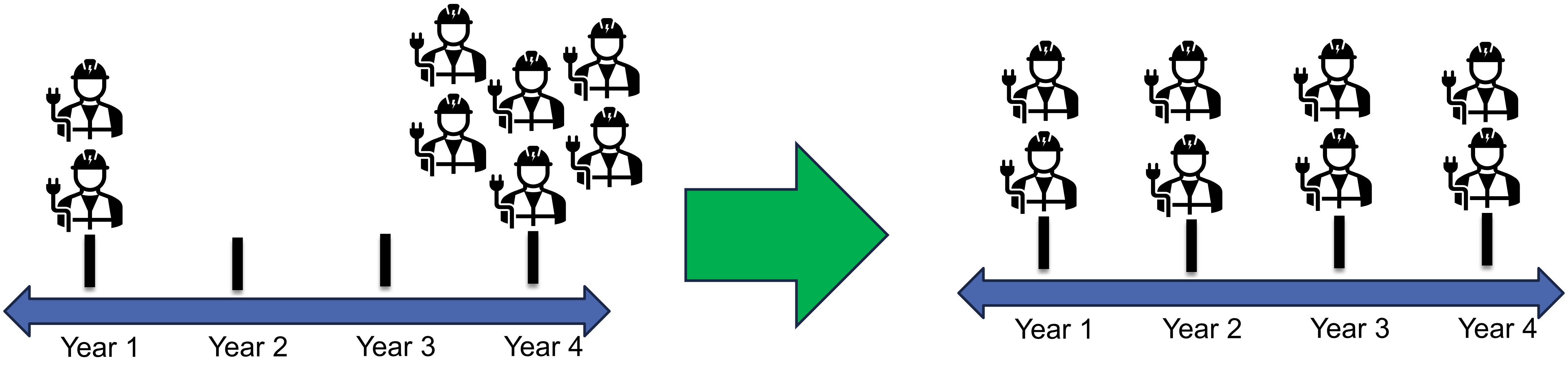
- Goals
  - Spread investment and construction over time to prevent:
    - Rate shock
    - Construction bottlenecks
    - Supply chain procurement bottlenecks

- When to Consider
  - Forecast volume of projects/costs significantly exceed historical baseline



Coordinate Impacts – Workforce and Logistics Limitations

- Workforce and materials limitations can make it impractical or costly to construct too many facilities in a given year
  - Scarcity of specialized labor
  - Scarcity of materials and equipment
  - Limited system switching capability
  - Limited availability of mobile substations



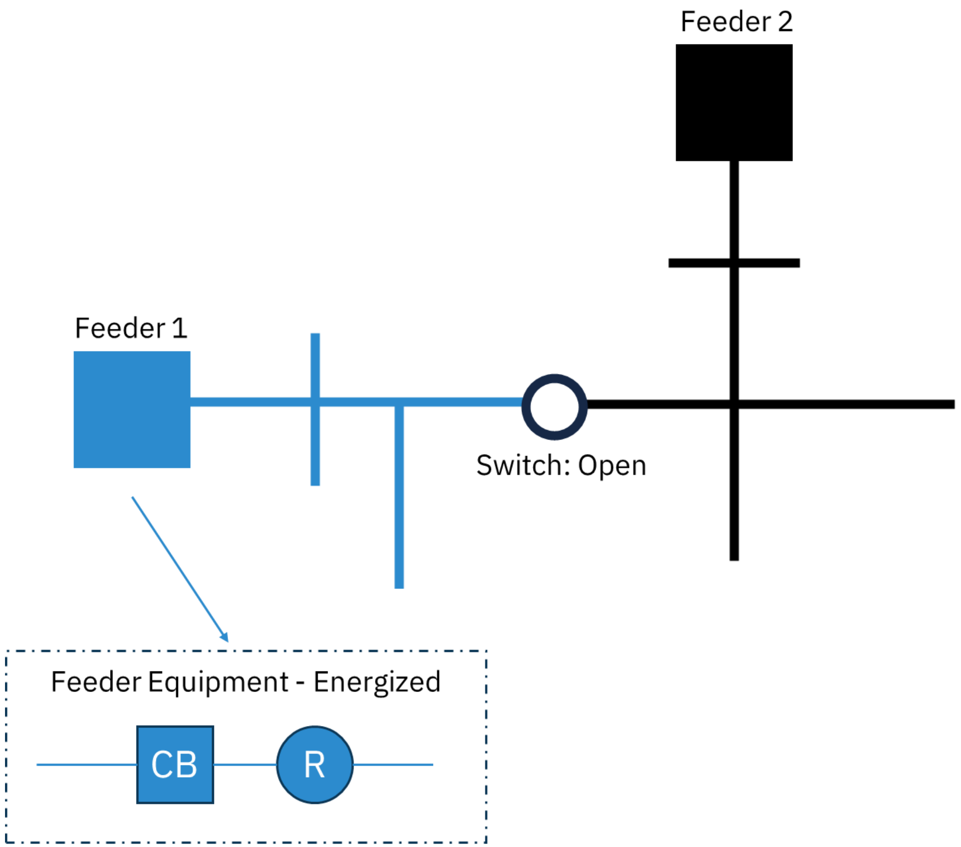
Improve Efficiency

- Goals
  - Minimize overall spending and lifecycle costs by proactively considering future needs

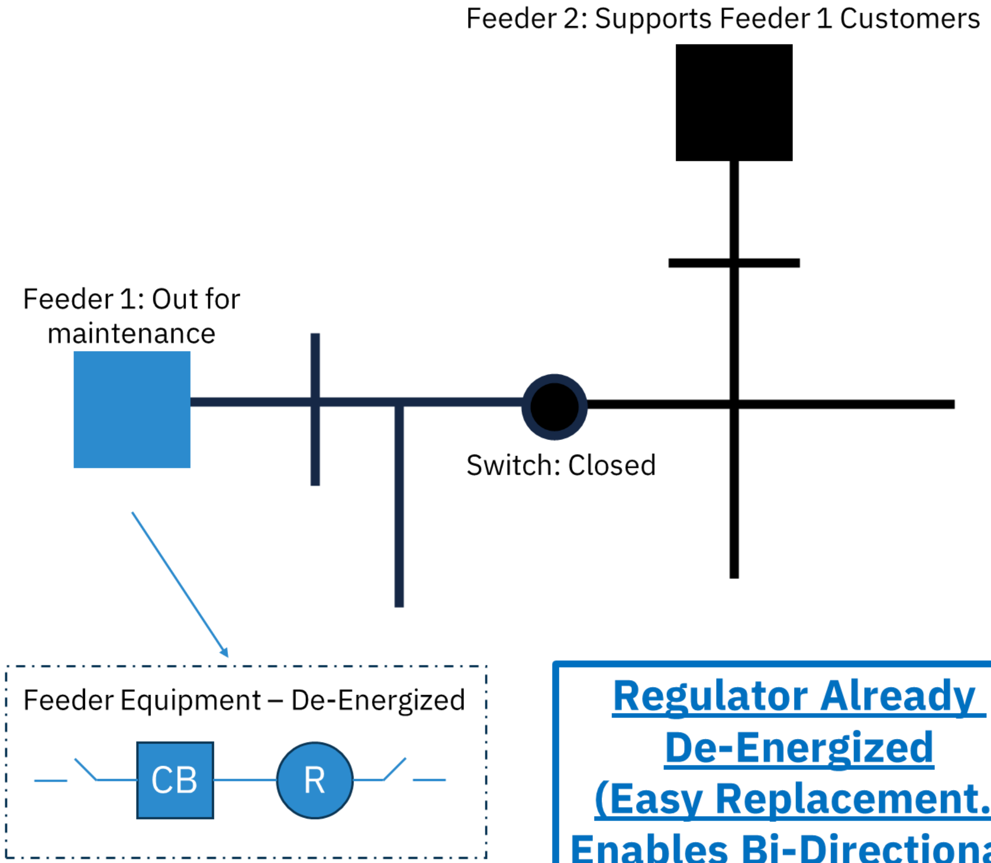
- How to Consider
  - Incorporate into equipment sizing decisions for other planned investments to prevent repeated work
  - Coordinate proactive upgrades with other capital and maintenance work to improve efficiency

Efficiency Improvement – Coordination with Maintenance Activities

Normal Configuration



Maintenance Configuration



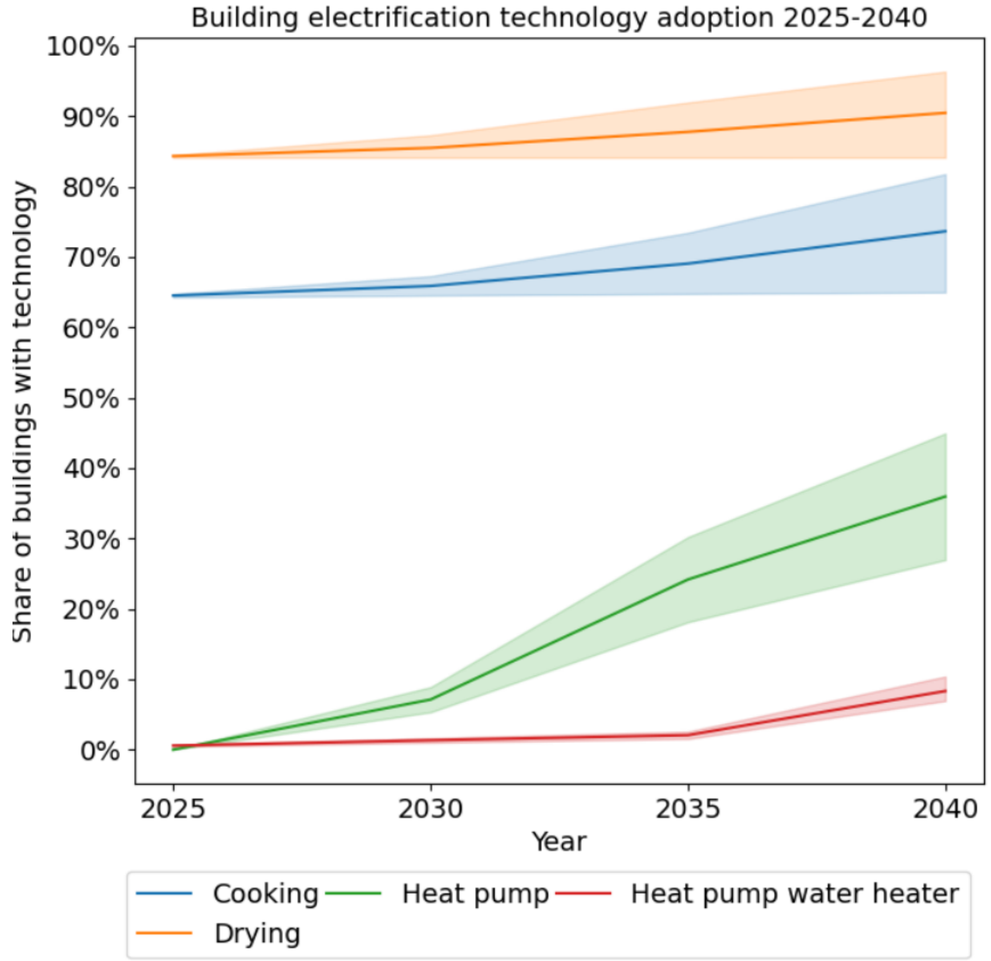
Regulator Already De-Energized (Easy Replacement. Enables Bi-Directional Power Flow)

Handling Uncertainty for Proactive Investments

Understanding Uncertainty in Forecasting

- Magnitude and Timing – "How Much, How Fast"
  - Speed of adoption of DER technologies significantly impacts the degree of need for proactive investments
  - Scenario-based (see graph) and probabilistic approaches can be used to understand potential adoption timelines and magnitudes
- Allocation – "Where"
  - Adoption forecasts are often created at the state or utility level and then allocated across specific substations, feeders, or individual customer or land parcels
  - Granular, locational adoption forecasts are a key input to identifying and justifying proactive investments

Example County-Level Technology Adoption Forecast Scenarios



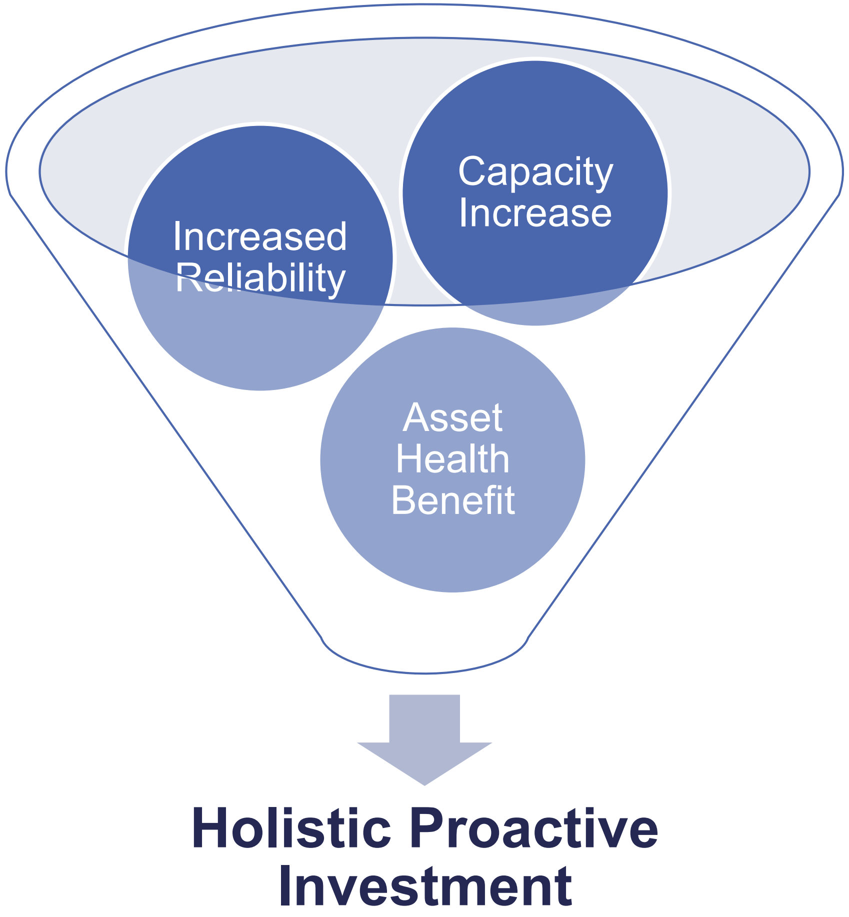
Central lines indicate medium growth scenario. Upper and lower edges of color band indicate high and low growth scenarios.

Graph source: Murphy, S., Pigman, M., Mims Frick, N. (LBNL): https://eta-publications.lbl.gov/sites/default/files/fort_collins_final_public_20240524.pdf

Considering Other Benefits of Proactive Distribution System Projects

Lower risk by diversifying benefit streams

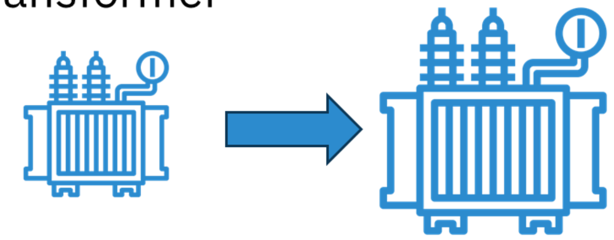
- Most utility investments have multiple positive impacts
  - Capacity
  - Reliability improvement
  - Asset health improvement
- Consider all relevant benefits of proactive investment options to minimize risk of stranded assets



Example Investments with Multiple Benefit Streams

25-year old 10 MVA transformer

New 22 MVA transformer

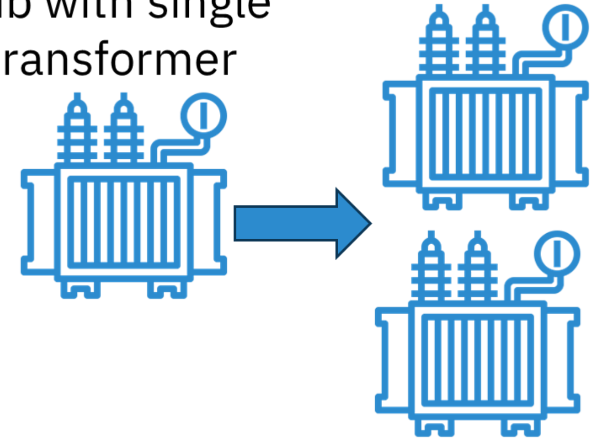


Transformer Replacement

- Capacity
- Asset Health
- LTC Controller Upgrade
    - If Present

Sub with single transformer

Sub with two transformers

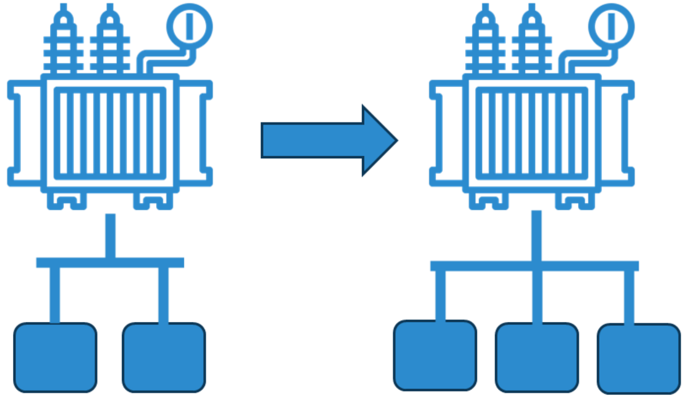


Add Second Transformer

- Capacity
- Reliability
- Switching Flexibility

Transformer with two feeders

Transformer with three feeders



New Substation or Feeder

- Capacity
- Reliability
- Switching Flexibility

Cost Allocation Considerations

DER Interconnection Cost Allocation – Challenges and Mitigations

Typical practice is "cost-causer pays," where the DER project that triggers the need for distribution upgrades pays the full cost, despite other customers also using upgraded infrastructure.

Issue	Description	Possible Mitigations
Free riders	DERs that trigger upgrades pay, allowing other interconnecting resources to benefit from that equipment without paying.	• Incorporate grid usage costs into tariffs • Require future beneficiaries to reimburse customer who paid for upgrade they benefit from • Implement a reserve fund from all interconnection customers
Cost uncertainty	Without information on grid congestion and required upgrades, customers may face unexpected and high costs to interconnect.	• Provide up to date and granular grid data • Consider proactive grid upgrades in planning processes
High costs for certain customers	Causer-pays cost allocation and serial review of applications may result in exorbitant charges to a single customer.	• Consider group interconnection studies • Consider multiple benefits of resources in cost allocation (e.g., contributions to resolving pre-existing grid issues)

Sources: DOE DER Interconnection Roadmap, McDonnell, M., R. Nelson, and N. Mims Frick, 2025

Cost Allocation Under Proactive Planning – Challenges

Large Load Customer Interconnection

- Customers adding large loads generally pay a portion of system upgrade costs
  - Based on expected revenue that will offset the costs
  - Contribution in Aid of Construction
  - If a large load interconnects in an area impacted by a proactive upgrade, it is **hard to determine and recover its contribution**

DER Interconnection

- DERs often bear all costs for hosting capacity upgrades to accommodate interconnection
  - "Cost Causer Pays"
- There are cost allocation **challenges to rate-basing any hosting capacity upgrades**
- If a large DER interconnects in an area impacted by a proactive upgrade, it is **hard to recover its contribution**

Flexible Interconnection Considerations

- Flexible interconnection attempts to **maximize** utilization of **existing infrastructure**
- Proactive capacity build-out can create **disincentives** for customers **to pursue or utilize flexible interconnection**

Cost Allocation Methods – Potential Solutions

Large Load Customer Interconnection

- Track large load interconnections in areas impacted by proactive investment
- Apply traditional cost allocation mechanisms to the cost of the completed upgrade
  - Contribution in Aid of Construction: Interconnection cost based on upgrade and line extension cost, expected bill contribution, and relative utilization of upgrade

DER Interconnection

- Incorporate within existing or potential DER cost-sharing frameworks
  - Determine if reasonable to socialize to prevent “closed” feeders that can’t accommodate new small solar interconnections
- Track large DER interconnections in areas impacted by proactive investments
  - Recover avoided DER interconnection cost

Flexible Interconnection Considerations

- Customers who elect to use flexible interconnection options could be exempted from avoided interconnection cost recovery

Source: ESIG – A Proactive Approach for Accommodating High Penetrations of Distributed Generation Resources (link)

Cost Allocation Reform: State Example

- Massachusetts adopted provisional reforms to cost allocation for interconnection.
- Utilities can propose to recover interconnection costs from ratepayers and be reimbursed by interconnections over time if the costs will:
  - Be incurred in identified areas affected by high interconnection costs
  - Enable multiple interconnections
  - Be at or under a cost cap of $500/kW per customer
  - Be recovered within established timeframes

Eversource Initial Proposal

Objectives	Status Quo	Eversource Balanced Approach Parallel Planning & Allocation
1. Enable DERs in the current queue	✓ Yes – upgrade sized to current DER queue	✓ Upgrades tested in DER Interconnection Planning Studies to mitigate all identified system constraints from Loadflow and Dynamic analyses
2. Mitigate DER Cost Barriers	✘ Requires first movers to front Capital. Likely favors large developers	✓ Where the upgrades are aligned with long-term planning needs, that portion of EDC benefits and associated cost (allowed rate recovery) are carved out – resulting in reduction to DER allocation: Mitigating 'first mover' cost barrier
3. Minimize Free-Rider Opportunities	✘ 2nd mover partially incentivized to wait for upgrade costs funded by 1st mover	✓ A unique $/kW rate established in each study area for all current and future interconnections downstream of that station ensures future DER customers pay exactly the same Interconnection cost as the current customers
4. Maintain efficient price signals	✘ Inefficient because prices surges after short-sighted upgrade out of capacity	✓ Pre-Upgrade: DER allocation reduced only in stations where system benefits and DER interconnections align Post-Upgrade: $/MW rate + MWs Enabled ensures that future DERs migrate to stations with increased capacity not locations where $/MW is high
5. Avoid wasteful expenditure	✘ EDC would be placed in reactive mode replacing long-life assets	✓ If upgrades are sized to be short-sighted, DER development would stall. Because upgrades would be sized to future grid needs EDC would NOT need to go back into station replacing assets that otherwise are 30-40 yr. life
6. Support MA Clean Energy Goals	✘ Upgrade reactive to prevailing DER queue. Queue backlog with new incentives	✓ Eversource Balanced approach ensures the tactical solutions to address near term DER queue interconnection & allows MA Clean Energy Goals
7. Ensure upgrades built in-synch with future grid reliability needs	✘ Upgrade reactive to prevailing DER queue	✓ Scenario Planning incorporating growth in EV, EE, Rooftop Solar in addition to DER PV and Storage conducted on an annual basis ensures infrastructure needs are identified, planned and constructed proactively

EVERSOURCE

Source: Eversource Massachusetts, MA DPU

Targeting Proactive Investments – Small Customer Growth

- Upgrades to provide load and DER hosting capacity for residential and small commercial customers can be prioritized for proactive investments
    - Investments for small customer load growth are rate-based under current practices
    - Cost-sharing mechanisms for small customer DER interconnection can be considered
  - Forecasting growth for large numbers of customers is typically more reliable than forecasting the magnitude, location, and timing of large customers
  - It also is more feasible to develop feeder-specific forecasts for growth of small customer loads with sufficient accuracy to justify the proactive investment

- If large customers are allowed to use capacity from proactive investments, utilities can propose, and regulators can determine, large customers' cost contribution

Q&A

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