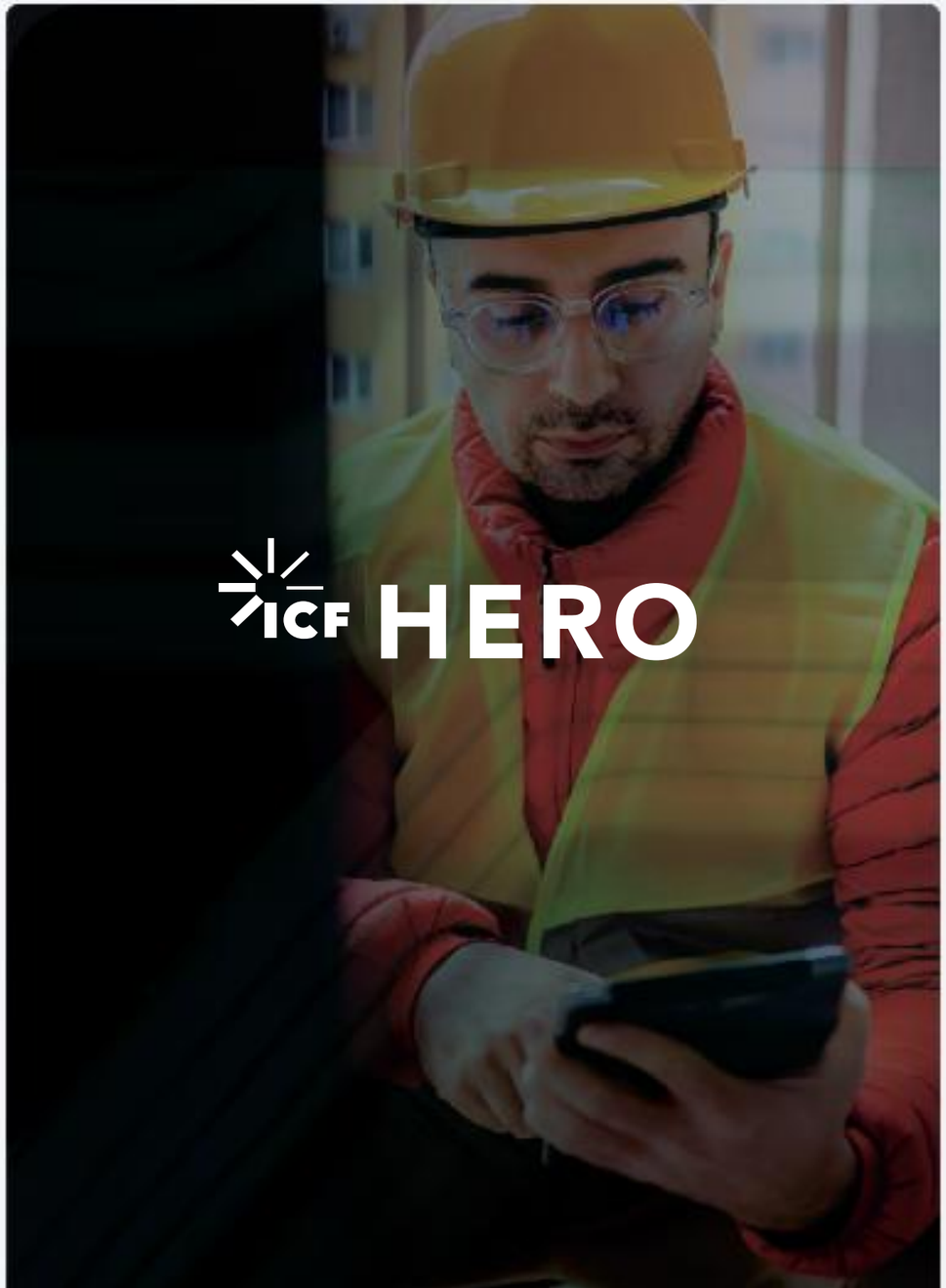


A new paradigm in integrated system planning

Holistic Energy Resource Optimization (HERO) Platform

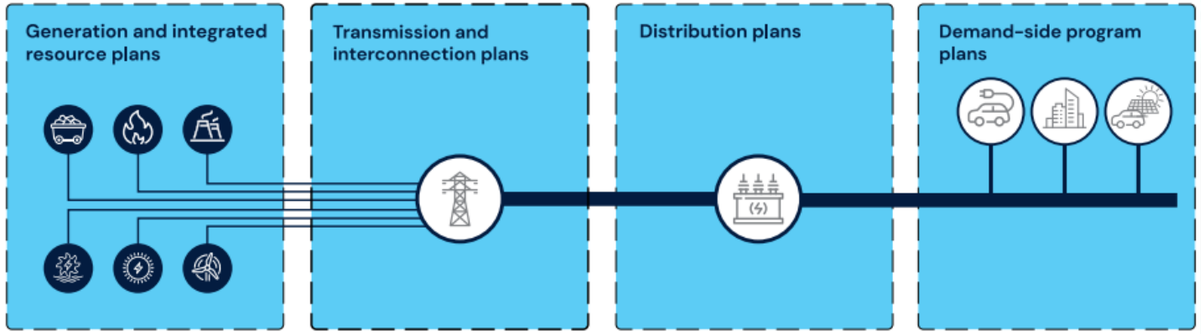
Industry in flux

- **Reliability, clean energy and affordability:** Utilities face immense pressure to maintain reliability, modernize the grid, decarbonize, and accommodate new large loads, all while keeping rates low – emphasis on affordability
- **Speed and uncertainty:** With sudden increases in load growth, utilities need to meet capacity needs quickly, locking in capital spending for long-lived assets under highly uncertain future conditions.
- **Complex analysis and stakeholder sophistication:** As planning questions are becoming more complex, stakeholders are seeking more information.
- **System interactions:** T&D modernization enables more interaction of supply and demand side resources but planning tools struggle to integrate these opportunities.

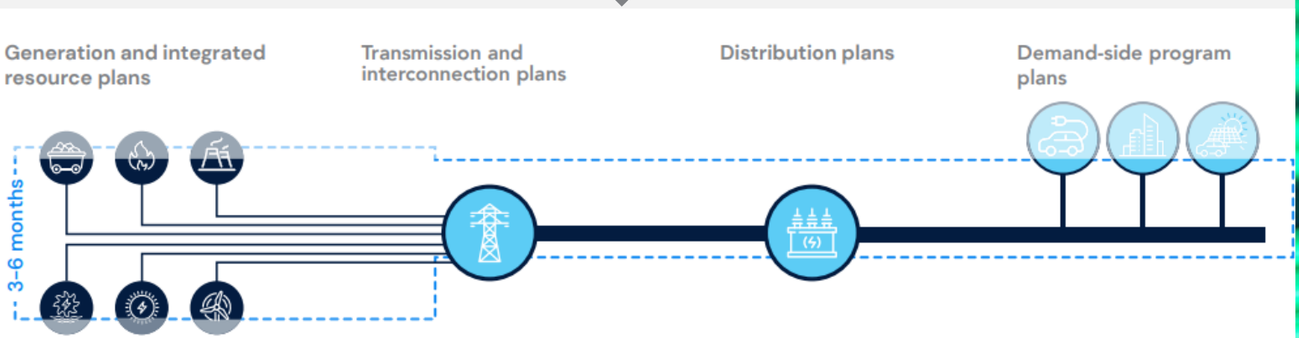
HERO objectives

- ✓ ***Clarity on tradeoff:*** Providing understanding of the tradeoffs to consumers and local economy of alternate decision pathways.
- ✓ ***Efficiency:*** Reduced form problem can address hundreds of scenarios in the time utility planners would typically do a handful.
- ✓ ***Transparency and collaboration:*** Increasing comprehension through visualization of results.
- ✓ ***Full utility value chain:*** HERO addresses load-serving related investments for generation, transmission, distribution and demand side programs simultaneously.

Case study – prototypical utility



Frequency	2–5 years	3–5 years	3–5 years	3–5 years
Timeline	1–2 years	1–2 years	1–2 years	6–12 months
Planning horizon	15 years	10 years	5–10 years	3–5 years



HERO key findings

- New **energy efficiency economics** at 2–3% of sales
- **Gas generation critical** to support resource adequacy
- **10%** peak reduction from Demand Response and DER
- **30%** of distribution system investment $ avoided by demand side resources
- **15%** cost premium for Net Zero by 2045
- **+/- 14%** rate variance due to capital decisions

HERO Platform Architecture

Capacity Expansion
- Fuel Prices
- Policies
- Load
- Tech. cost and performance

Transmission
- Import / export capability
- Network upgrade costs
- Miles of infrastructure upgrades

Distribution
- Substation and feeder infrastructure costs to serve new loads

DER
- DER cost and performance
- DER deployment potential

Optimization Model
Generation and DER solved simultaneously across Transmission & Distribution systems
- Energy & capacity prices
- Capacity mix (builds/retirements)
- Solved distributed resource selection
- Generation mix and emissions profiles
- Total system cost (CAPEX, OPEX, fuel, storage)

Rate Impact
- Retail rate changes
- T&D changes
- Deferral comparisons

Economic and Social Benefits
- Jobs, GDP, income
- Tax revenues
- Prices, productivity changes

Scenario Comparison & Visualization
- Scenario analysis (base, high gas, transmission constrained, demand growth)
- Sensitivity analysis (base, cost assumptions, growth shortfalls)

Distribution Module

DATA INPUT

Distribution System Inputs

Input data from client utility or generalized input values compiled by ICF:

- System ratings and loadings (substation and feeder ratings and average loadings)
- System characteristics (feeders per substation, average dx line lengths, Tx Stations per Dx station)
- Infrastructure costs (Dx & Tx substations, Dx & Tx feeders per-mile, grid modernization per mile)

TOOLS

Computational model

Data inputs are used to:

- Apply demand growth to the model system
- Identify substation and distribution feeder overloads
- Add new substations and distribution feeders to meet demand
- Calculate total capital cost of new infrastructure

DATA OUTPUT

Intermediate Outputs:

- Cost of distribution substations
- Cost of distribution feeders
- Cost of sub-transmission to serve distribution

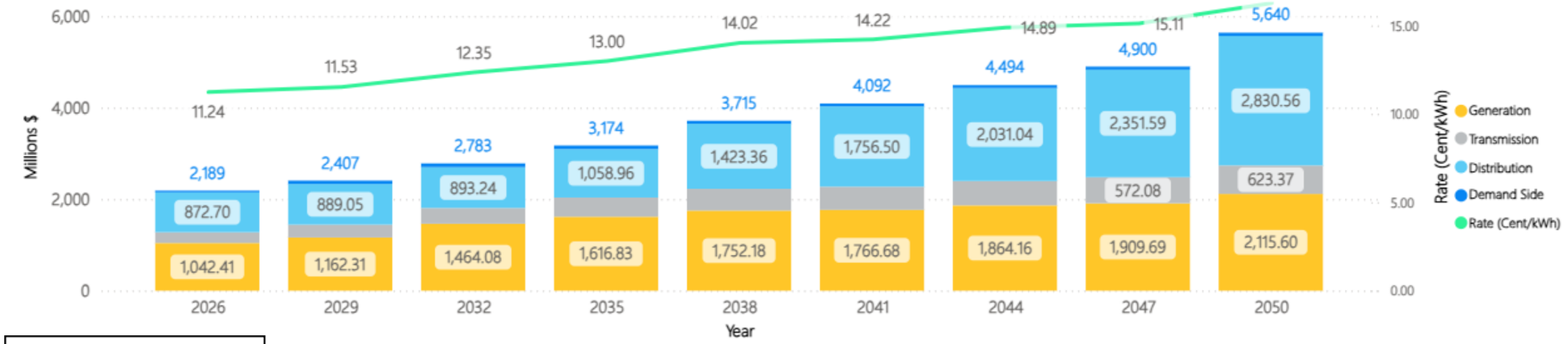
Understanding the Components of Revenue Requirements & Rates across Scenarios

Revenue Requirement And Rate

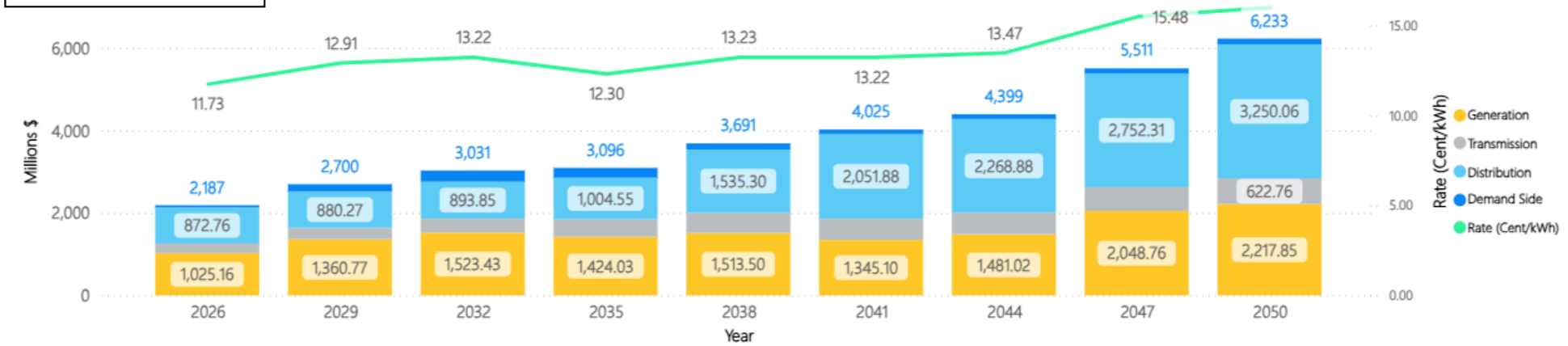
Champion Portfolio

Stringent Climate > Distributed

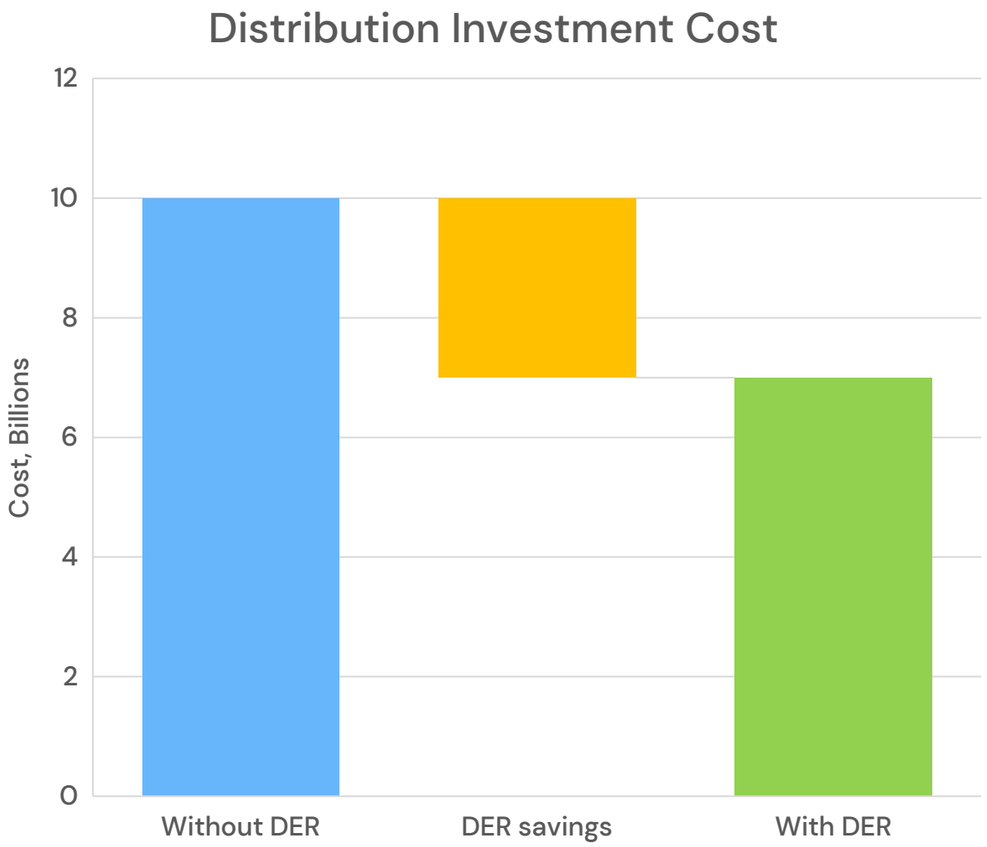
Scenario A

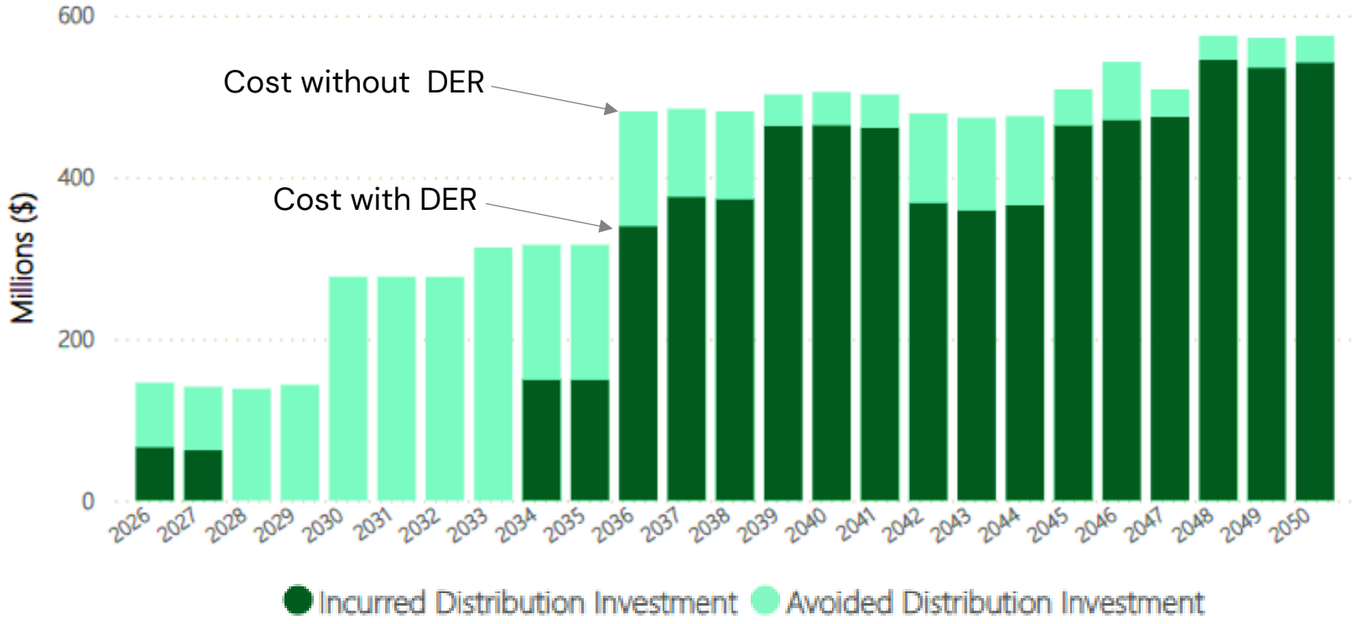


Scenario B



DER can avoid as much as $3 billion in distribution grid investment



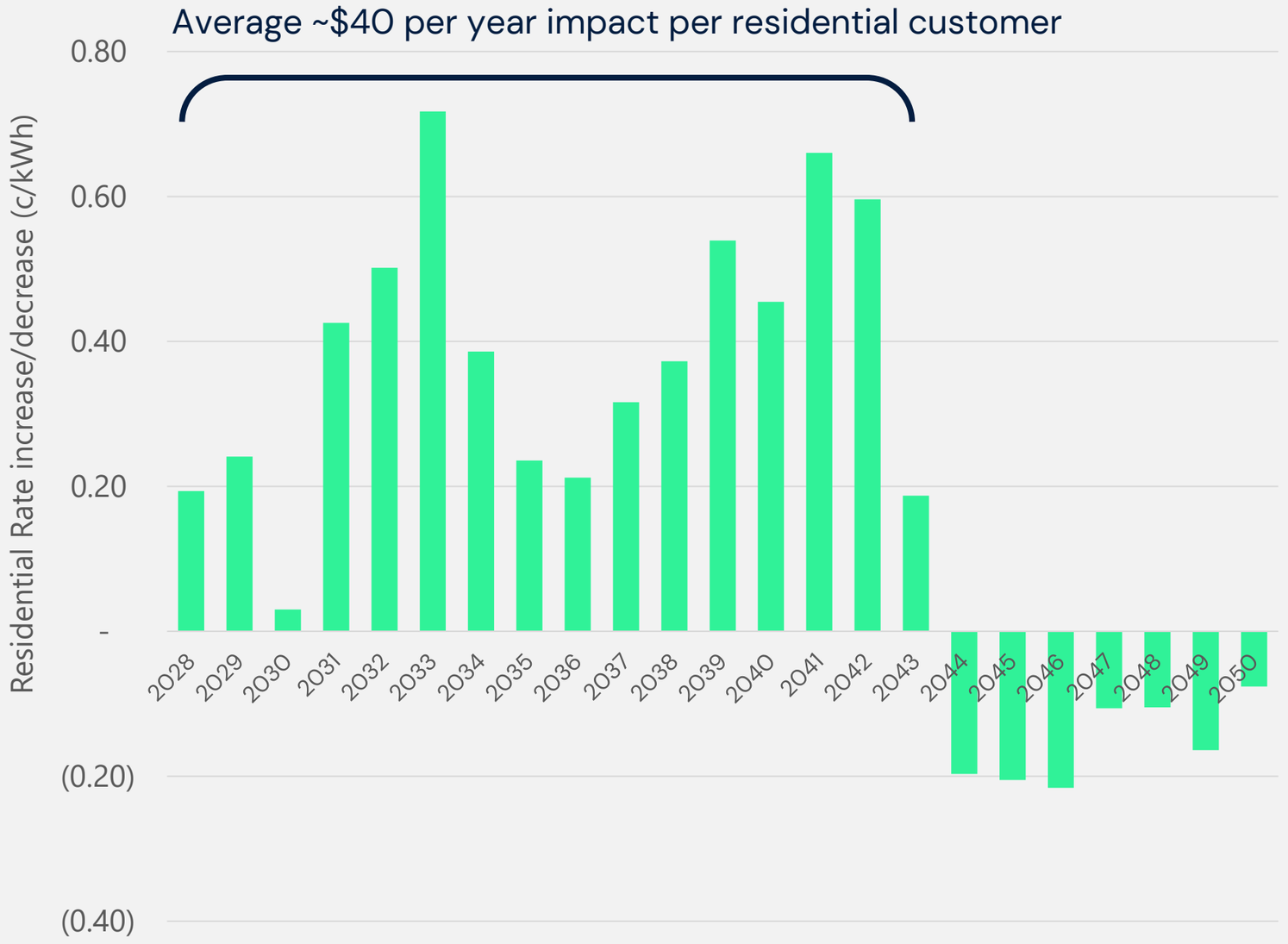


Scenario: Strong Climate - Distributed

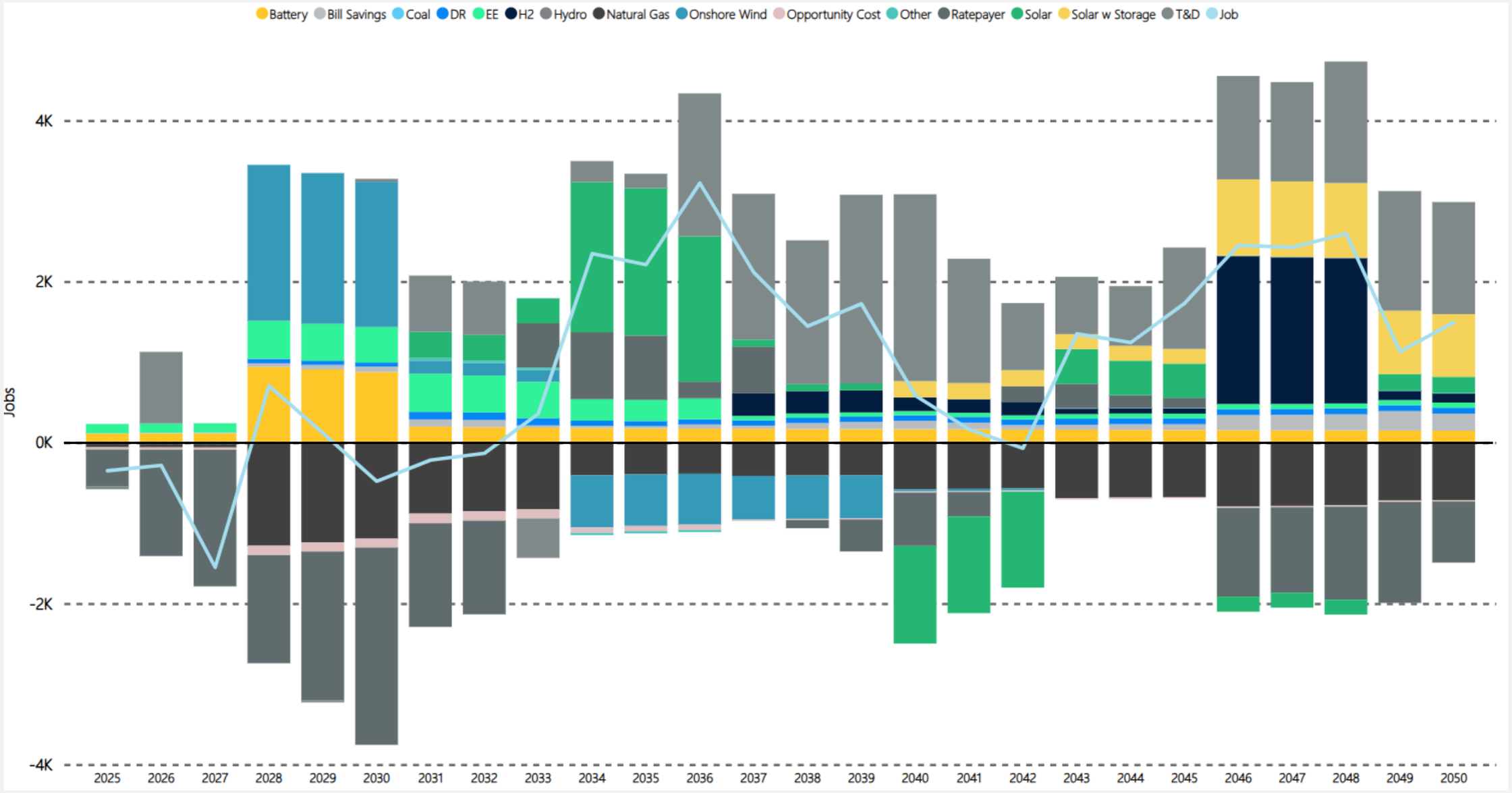
To what extent does Downward Modification of Load Forecast result in Stranded Costs?

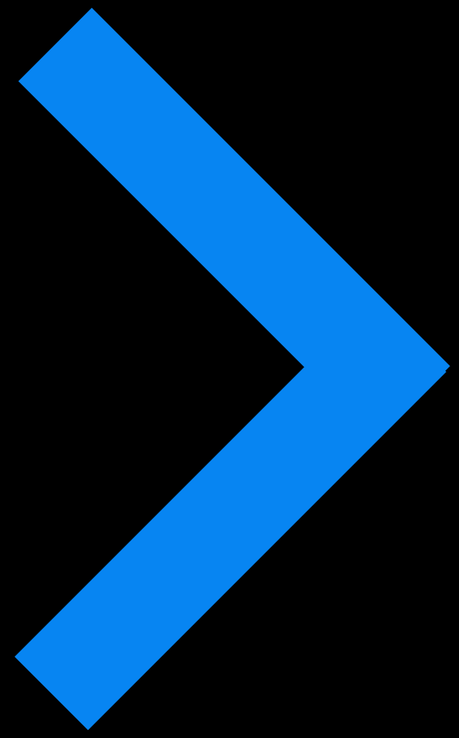
	Expected	Actual
Average Annual Energy Growth • 2026-2031 • 2032-2050	3.3%	2.4% 1.3%

Capacity Type	Capacity Delta	Cumulative Investment Delta
Unit	MW	Million $2022
Period	Year 2032	2028-2032
Total	753	$926



Economic impacts can be assessed relative to a “Reference Case”





Questions?

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