From Goals to Plans:
Improving Rigor, Transparency, and Decision-Making in Electricity Plans with Ambitious Policy Targets

ESIG WEBINAR

Featuring:

Elaine Hart
Sylvan Energy Analytics

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From Goals to Plans:
Improving Rigor, Transparency, and Decision-Making in Electricity Plans with Ambitious Policy Targets

ESIG
ENERGY SYSTEMS INTEGRATION GROUP

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January 22, 2026

ESIG's Clean Electricity Planning Task Force

The Clean Electricity Planning Task Force was formed to examine the unique challenges of planning for 100% clean and net zero emissions electricity systems

Report authors: Elaine Hart (Sylvan Energy Analytics), Trieu Mai (ESIG), James Okullo (ESIG)

Additional contributors: Jaxon Stuhr (Sylvan Energy Analytics), Jeanne Currie (Clean Energy Transition Institute), Stacia Dreyer (Clean Energy Transition Institute)

Task Force members included experts from utilities, ISOs/RTOs, national laboratories, research organizations, and consulting firms. A complete list of Task Force members can be found in the report online.

Disclaimer: This report was produced by a task force made up of diverse members with diverse viewpoints and levels of participation. Specific statements may not necessarily represent a consensus among all participants or the views of participants' employers.

ESIG's Clean Electricity Planning Task Force

The Clean Electricity Planning Task Force was formed to examine the unique challenges of planning for 100% clean and net zero emissions electricity systems

Key questions:

- What are the common findings across studies that achieve 80-100% reductions in GHGs?
- Why is going from 90-100% so challenging?
- What technology solutions might be needed for maintaining reliability and affordability in the last mile?
- How should planning studies approach the last mile given significant technology uncertainty?
- What modeling innovations and data improvements are needed to support better analysis of 100% clean and net zero emissions electricity systems?

*The Task Force did not weigh in on whether systems should or should not adopt 100% clean or net zero emissions polcies

Literature Review

With help from the Clean Energy Transition Institute, the Task Force reviewed 16 industry-focused 100% clean and net zero emissions studies conducted since 2020

Four key challenges were identified:

- A unique reliability challenge
- Uncertainty around emerging technologies
- Steeply increasing costs
- The speed of the transformation

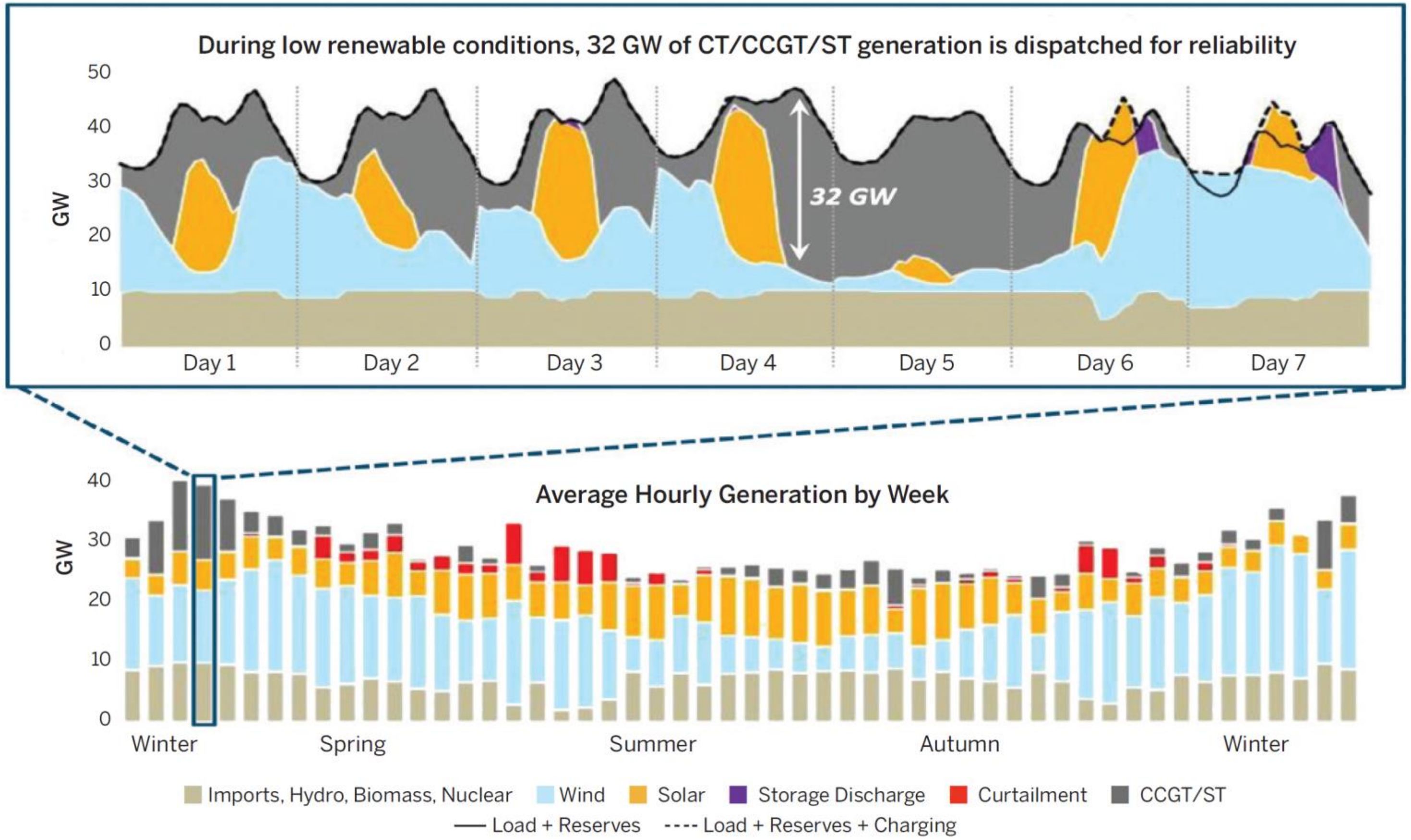
TABLE 2

Industry-Focused Planning Studies Reviewed by the Task Force

Organization or Footprint	Policy or Goal[a]	Target Year	Analytical Scope[b]	Reference
Ameren Missouri	Net-zero emissions electricity	2045	Electricity only	Ameren Missouri (2025)
California	100% clean electricity	2045	Economy-wide + electricity	California Energy Commission (2021)
Colorado	100% clean electricity	2040	Electricity only	Colorado Energy Office (2024)
Com-Ed	Net-zero emissions economy-wide	2050	Economy-wide + electricity	Energy and Environmental Economics (E3) (2022)
Hawaiian Electric Company	100% clean electricity	2045	Electricity only	Hawaiian Electric Company (2023)
ISO New England	Net-zero emissions economy-wide	2050	Economy-wide + electricity	Energy and Environmental Economics (E3) and Energy Futures Initiative (2020)
Los Angeles Department of Water and Power	100% clean electricity	2035	Electricity only	LADWP (2022)
National Energy System Operator (Great Britain)	Net-zero emissions economy-wide	2050	Economy-wide + electricity	NESO (2025)
New York Independent System Operator	100% clean electricity	2040	Electricity only	The Brattle Group (2020)
New York Independent System Operator	100% clean electricity	2040	Electricity only	NYISO (2024)
Omaha Public Power District	Net-zero emissions electricity	2050	Economy-wide + electricity	OPPD (2022)
Orlando Utilities Commission	Net-zero emissions electricity	2050	Electricity only	Siemens (2020)
Portland General Electric	100% clean electricity	2040	Electricity only	PGE (2023)
Puget Sound Energy	100% clean electricity	2045	Electricity only	PSE (2023)
Seattle City Light	100% clean electricity	2045	Electricity only	SCL (2024)
Snohomish Public Utility District	100% clean electricity	2045	Electricity only	SnoPUD (2023)

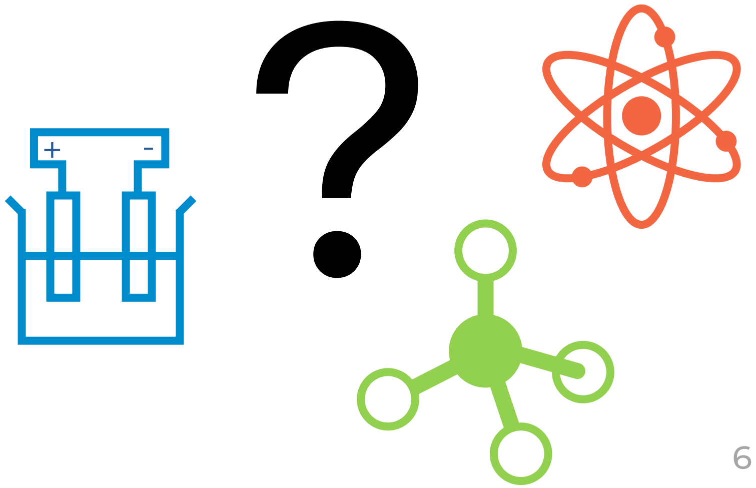
1. A unique reliability challenge

An Example of the Winter Reliability Challenge in ISO New England



In deeply decarbonized systems:
Fossil-based resources support reliability during the most challenging weather conditions

In completely decarbonized systems:

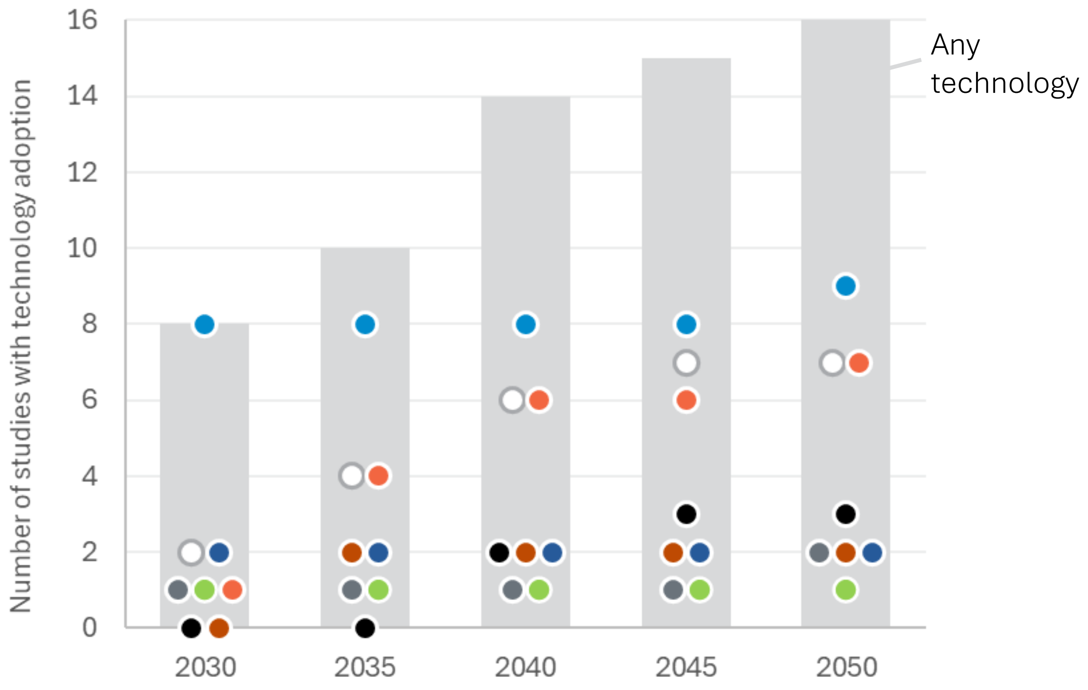


Source: E3 and Energy Futures Initiative, *Net-Zero New England*, 2020.

2. Uncertainty around emerging technology

- All of the reviewed studies relied on one or more of the following emerging technologies to achieve the policy target while maintaining reliability
  - Clean e-fuels (e.g., electrolytic hydrogen) ●
  - Advanced nuclear ●
  - Enhanced geothermal ●
  - Fossil (with CCS) ● + a negative emissions technology, such as direct air capture (DAC) ● or bioenergy with CCS (BECCS) ●
  - Multiday storage ●
- Despite their potentially central roles in electricity decarbonization studies, none of these technologies have been commercialized at scale

Timing of earliest emerging technology adoption in 16 recent industry planning studies with 100% clean or net-zero emissions requirements.

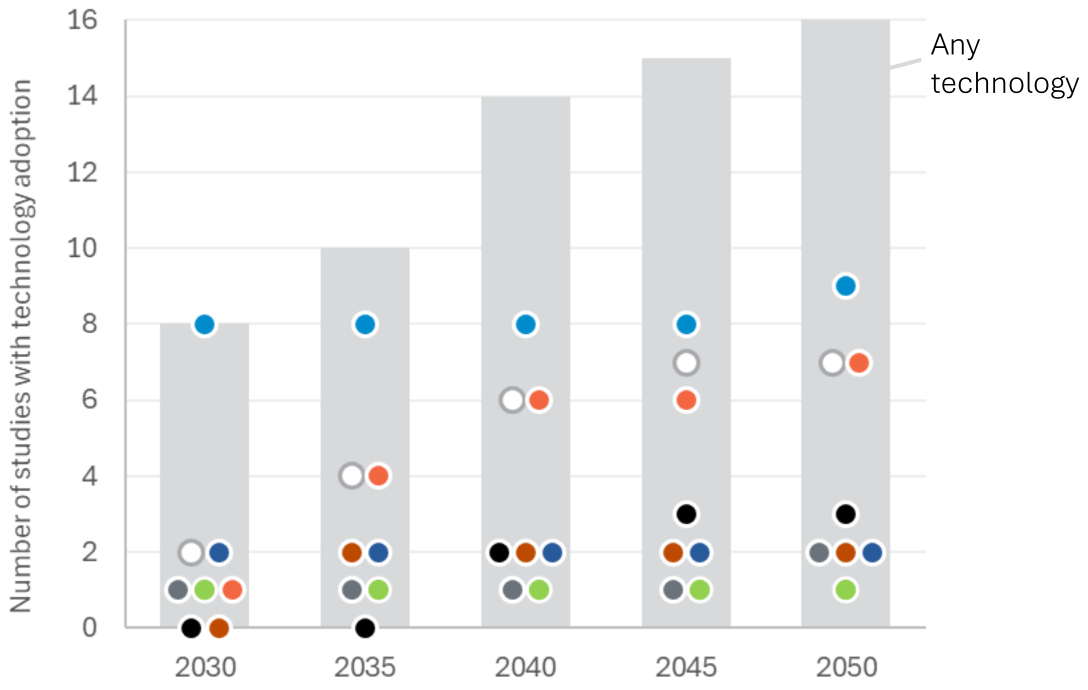


Poll #1: What's your emerging tech outlook?

Rank order the following emerging technologies from most (1) to least (6) likely to be commercialized at scale (beyond pilots and demonstrations) in the next 15 years:

- Clean e-fuels, such as hydrogen or ammonia
- Advanced nuclear
- Enhanced geothermal
- Carbon capture and storage
- Direct air capture
- Multiday storage

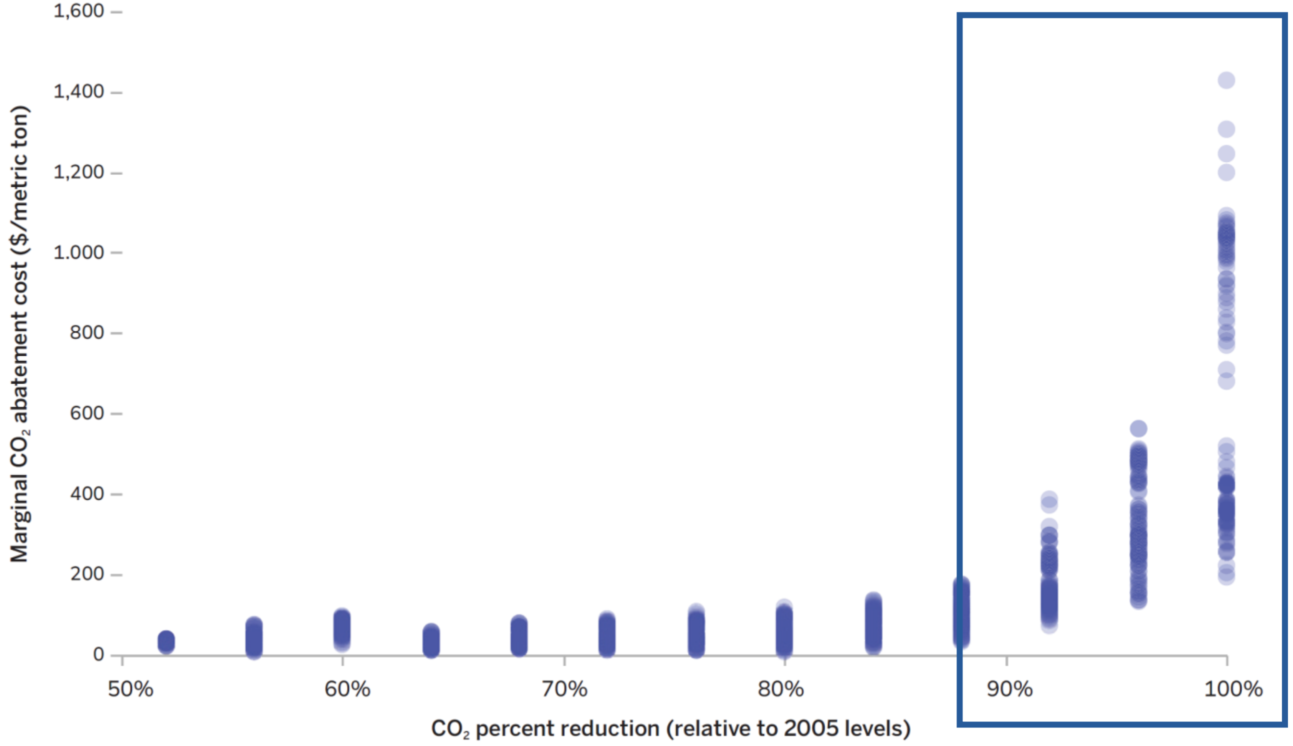
Timing of earliest emerging technology adoption in 16 recent industry planning studies with 100% clean or net-zero emissions requirements.



3. Steeply increasing costs

- Avoiding the last increments of GHGs or emitting generation could lead to steeply increasing costs due to:
  - Low availability of wind and solar during the most challenging weather circumstances; and
  - High technology costs for emerging technologies that have greater availability during these periods

An Example of the Cost Escalation as a System Approaches Zero Emissions



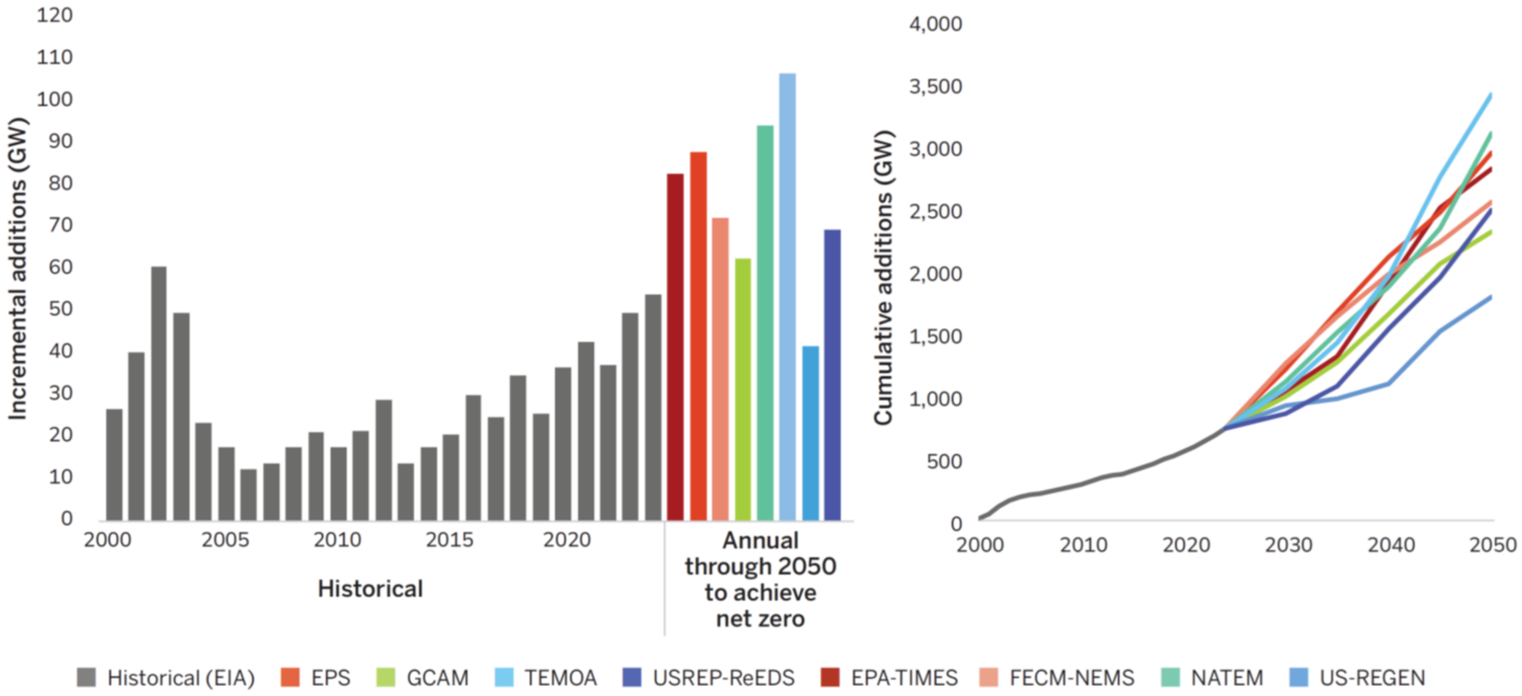
Source: Mai et. al, "Getting to 100%: Six strategies for the challenging last 10%," Joule. 6(9), 2022. https://www.sciencedirect.com/science/article/pii/S2542435122004056#bib7

4. The speed of the transformation

- Under most scenarios, achieving 100% clean or net zero emissions requires sustained clean energy buildout that far exceeds the historical pace of development (before considering recent data center forecasts)
- Beyond resource build, the scale and pace of transformation required across all aspects of the electricity sector – operations and controls, markets, regulations, etc. – should not be overlooked.

FIGURE 4

Multimodel Comparison of Generation Build Across Net-Zero Emissions Scenarios Compared to Historical Generation Additions



Left: Average incremental resource additions per year across eight models that achieve net-zero emissions economy-wide in the U.S., compared to historical annual resource additions. Right: Corresponding cumulative resource additions across the eight models, compared to historical cumulative additions.

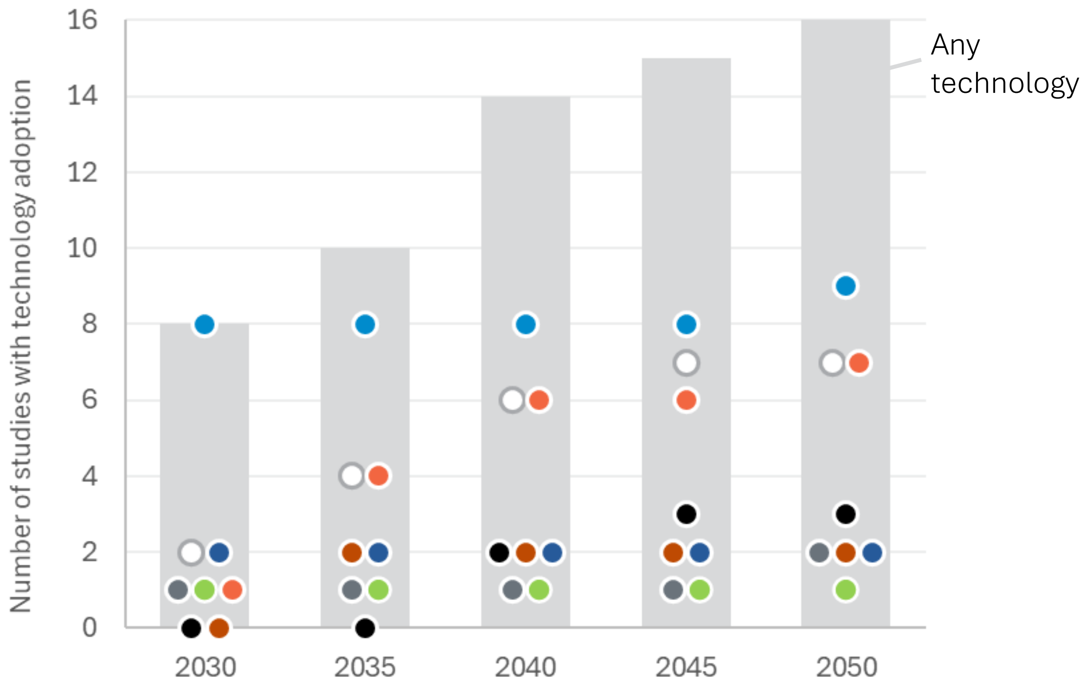
Source: Energy Systems Integration Group; data from EPRI.

Poll #1 Results!

Rank order the following emerging technologies from most (1) to least (6) likely to be commercialized at scale (beyond pilots and demonstrations) in the next 15 years:

- Clean e-fuels, such as hydrogen or ammonia
- Advanced nuclear
- Enhanced geothermal
- Carbon capture and storage
- Direct air capture
- Multiday storage

Timing of earliest emerging technology adoption in 16 recent industry planning studies with 100% clean or net-zero emissions requirements.



High level recommendations for 100% clean and net-zero electricity plans

Poll #2: Help us choose one topic for a deeper dive

- Address technology uncertainty head on
- Look beyond your electricity system
- Embrace transparency in new areas of complexity
- Translate long-term findings into practical near-term decisions

Recommendations for 100% clean and net-zero electricity plans

Address technology uncertainty head on

- ✓ Design scenarios to assess technology risk and cost uncertainty
- ✓ Develop portfolios that complement multiple emerging technology pathways
- ✓ Quantify risks associated with near-term commitment when optimized portfolios diverge
- ✓ Apply technology-agnostic approaches with care

Recommendations for 100% clean and net-zero electricity plans

Look beyond your electricity system

- ✓ Capture impacts of emerging technologies such as e-fuels and direct air capture on electricity demand
- ✓ Include costs associated with storage, transport, and distribution of e-fuels, biomass, and carbon
- ✓ Account for competition for clean fuels with other sectors

Recommendations for 100% clean and net-zero electricity plans

Embrace transparency in new areas of complexity

- ✓ Clearly describe 100% policy implementation details
- ✓ Verify policy and reliability compliance using a suite of detailed models
- ✓ Track and report policy compliance instruments directly in planning models
- ✓ Quantify policy compliance risks
- ✓ Directly address non-jurisdictional dependencies and supporting infrastructure needs

Recommendations for 100% clean and net-zero electricity plans

Translate long-term findings into practical near-term decisions

- ✓ Rely on scenario analysis findings to inform new infrastructure decisions
- ✓ Consider policy compliance value in demand-side management evaluations
- ✓ Test potential near-term fossil resource decisions across planning scenarios to examine reliability and policy compliance risks
- ✓ Proactively plan for future fossil retirements
- ✓ Consider participating in emerging technology demonstrations

High level recommendations for 100% clean and net-zero electricity plans

Poll #2 Results!

- Address technology uncertainty head on
- Look beyond your electricity system
- Embrace transparency in new areas of complexity
- Translate long-term findings into practical near-term decisions

Address technology uncertainty head on

- ✓ Design scenarios to assess technology risk and cost uncertainty

TABLE 5

Recommended Scenarios for 100% Clean Studies That Explore Emerging Technology Uncertainty

Scenario	Description
No emerging technologies	No emerging technologies become commercially viable at scale before the 100% clean requirement goes into effect. For some systems, particularly those with limited renewable resource potential, achieving 100% clean may not be feasible in this scenario.
Hydrogen economy	A hydrogen economy develops. The scenario may describe: • When large-scale hydrogen production becomes commercially viable • How the hydrogen would be used in the electricity sector, whether through blending into the gas supply, in retrofitted gas plants, or in new hydrogen-ready gas plants • Whether hydrogen is produced on- or off-system; if off-system, how it is produced and delivered to the system and the resulting all-in delivered costs
Emerging clean baseload	Enhanced geothermal and/or advanced nuclear become commercialized at scale. The scenario may describe: • When these technologies become available and how quickly they can be deployed • Technology costs and (for enhanced geothermal) resource potential
Carbon capture and sequestration (CCS) (where applicable)	CCS technologies become cost-competitive for use in the electricity sector. The scenario may describe: • When CCS becomes commercially available • How CCS is used (on existing gas plants, on new gas plants, on bioenergy facilities, or as direct air capture) • Technology costs and operational parameters
Combined	Multiple emerging technologies emerge. When multiple emerging technologies are allowed to compete with one another in portfolio analysis, care should be taken in interpreting the results, as the selection of technologies may depend strongly on assumed relative costs.

Source: Energy Systems Integration Group.

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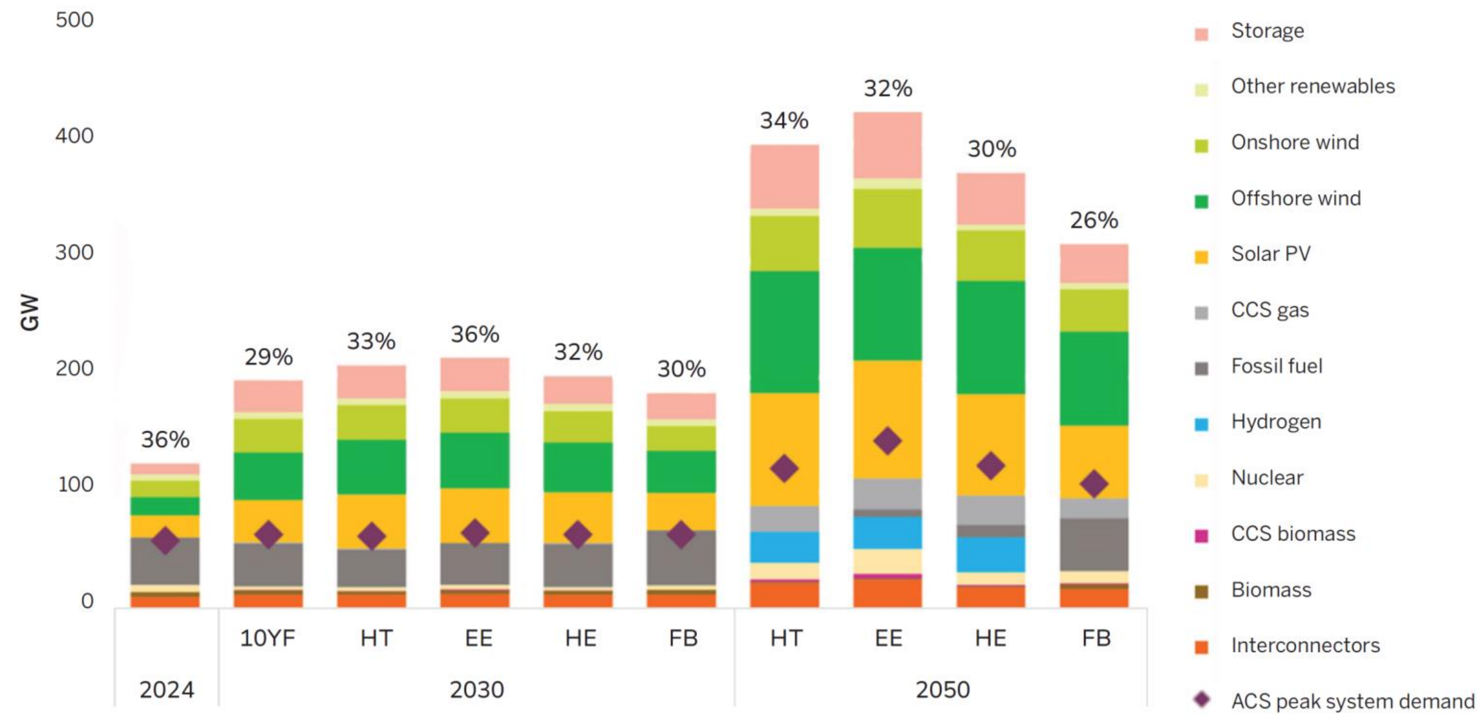
Address technology uncertainty head on

- ✓ Design scenarios to assess technology risk and cost uncertainty
- ✓ Develop portfolios that complement multiple emerging technology pathways

FIGURE 5

Optimized Electricity Portfolios for Four Economy-wide Planning Scenarios in NESO's *2025 Future Energy Scenarios: Pathways to Net Zero*



Optimized electricity portfolios for four economy-wide planning scenarios in NESO's *2025 Future Energy Scenarios: Pathways to Net Zero*. Percentage values correspond to percentage of decentralized generation.

Notes: HT = holistic transition; EE = electric engagement; HE = hydrogen evolution; FB = falling behind; 10YF = ten-year forecast; ACS = average cold spell.

Source: National Energy System Operator, *2025 Future Energy Scenarios: Pathways to Net Zero* (2025).

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Address technology uncertainty head on

- ✓ Design scenarios to assess technology risk and cost uncertainty
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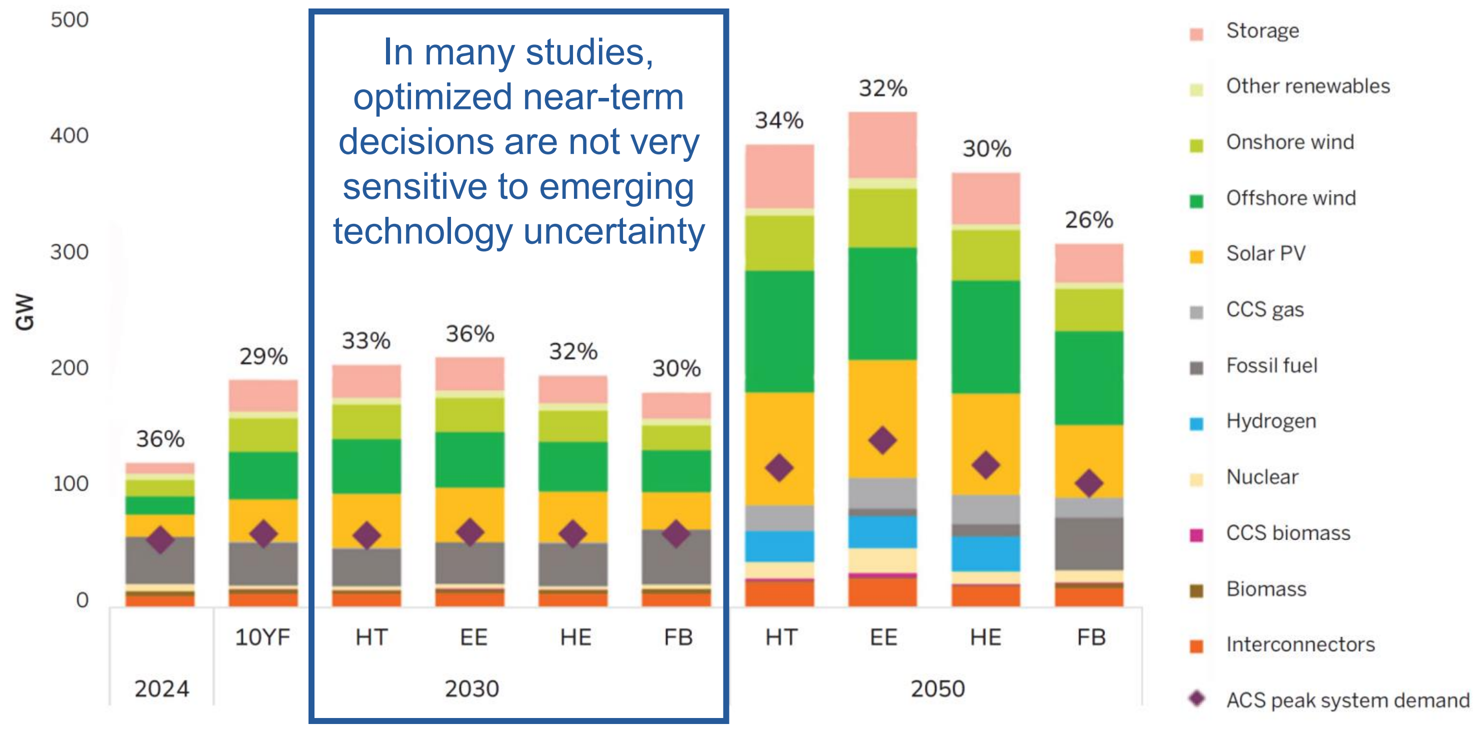
FIGURE 5

Optimized Electricity Portfolios for Four Economy-wide Planning Scenarios in NESO's *2025 Future Energy Scenarios: Pathways to Net Zero*



Optimized electricity portfolios for four economy-wide planning scenarios in NESO's *2025 Future Energy Scenarios: Pathways to Net Zero*. Percentage values correspond to percentage of decentralized generation.

Notes: HT = holistic transition; EE = electric engagement; HE = hydrogen evolution; FB = falling behind; 10YF = ten-year forecast; ACS = average cold spell.

Source: National Energy System Operator, *2025 Future Energy Scenarios: Pathways to Net Zero* (2025).

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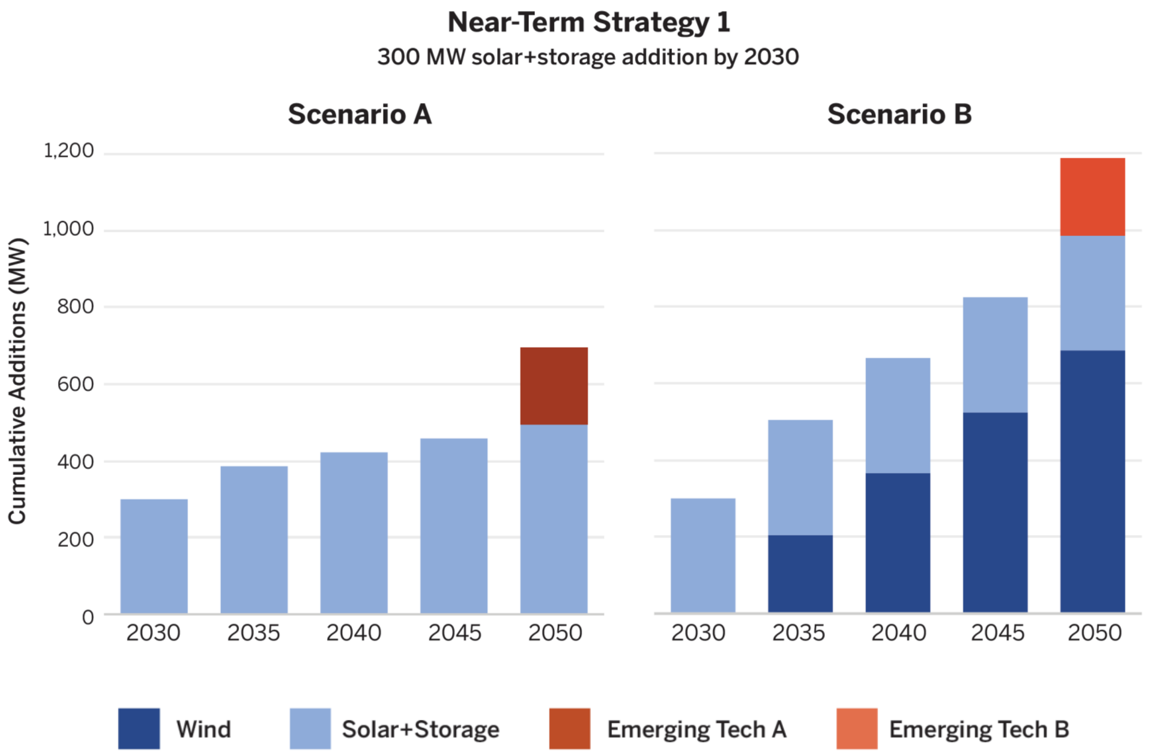
Address technology uncertainty head on

- ✓ Design scenarios to assess technology risk and cost uncertainty
- ✓ Develop portfolios that complement multiple emerging technology pathways
- ✓ **Quantify risks associated with near-term commitment when optimized portfolios diverge**

Stylized example:

- **Scenario A** considers a future in which Emerging Tech A achieves commercialization
- **Scenario B** considers a future in which Emerging Tech B achieves commercialization
- **Near-Term Strategy 1** commits to 300 MW of solar + storage in the near term, which appears to be complementary to Emerging Tech A in the long term



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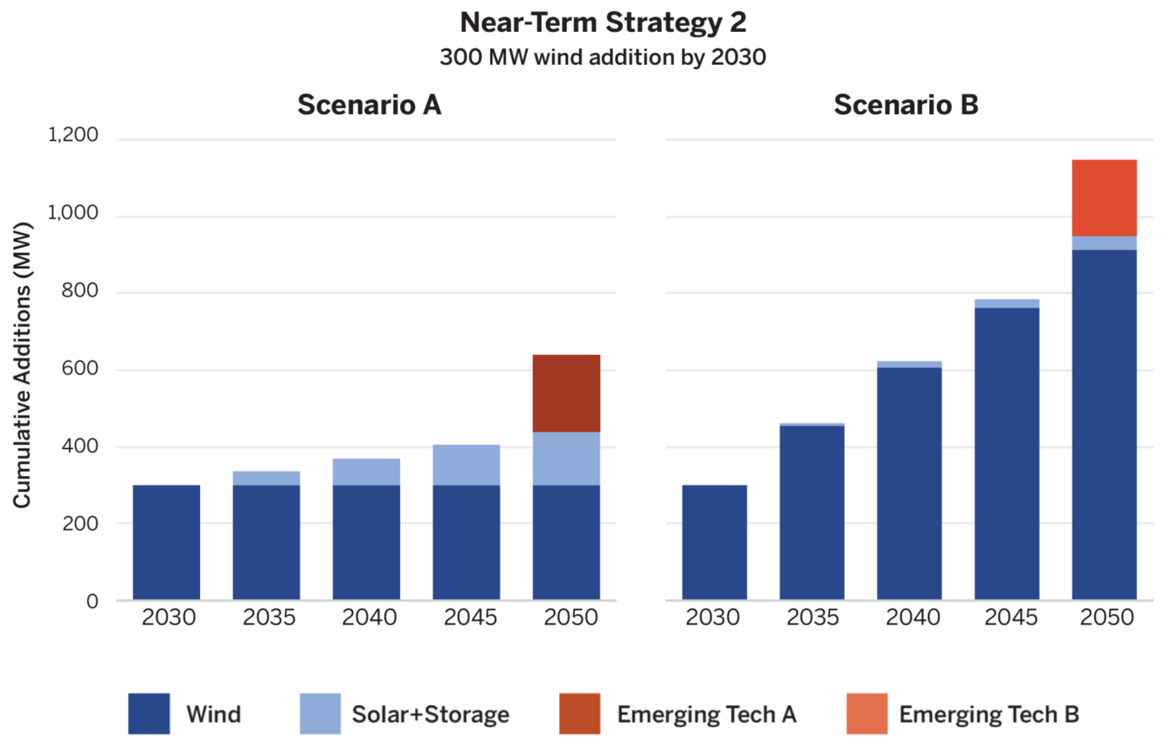
Address technology uncertainty head on

- ✓ Design scenarios to assess technology risk and cost uncertainty
- ✓ Develop portfolios that complement multiple emerging technology pathways
- ✓ **Quantify risks associated with near-term commitment when optimized portfolios diverge**

Stylized example:

- **Scenario A** considers a future in which Emerging Tech A achieves commercialization
- **Scenario B** considers a future in which Emerging Tech B achieves commercialization
- **Near-Term Strategy 2** commits to 300 MW of wind in the near term, which appears to be complementary to Emerging Tech B in the long term



Address technology uncertainty head on

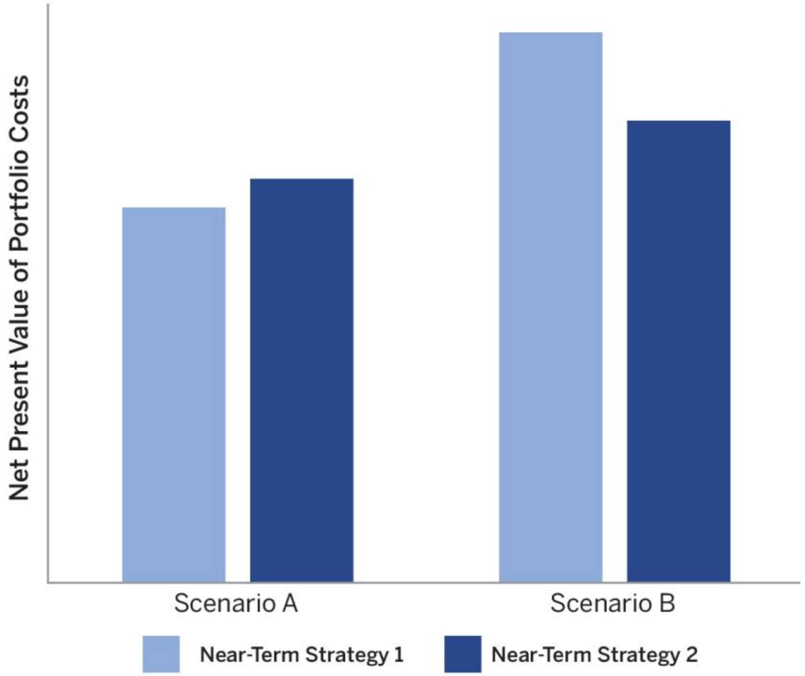
- ✓ Design scenarios to assess technology risk and cost uncertainty
- ✓ Develop portfolios that complement multiple emerging technology pathways
- ✓ Quantify risks associated with near-term commitment when optimized portfolios diverge

Stylized example:

- A planner who thinks **Scenario A** is more likely might choose **Strategy 1**
- A planner who thinks **Scenario B** is more likely, or who is most concerned with avoiding the highest cost outcomes, might choose **Strategy 2**, even though it is slightly more expensive under **Scenario A** than the alternative

FIGURE 7

Relative Costs for Portfolios That Test the Risk of Near-Term Commitments Under Emerging Technology Uncertainty



This shows the net present value of portfolio costs for the four portfolios shown in Figure 6 (p. 22), evaluated in the scenario for which the long-term resource selections were re-optimized. In this hypothetical example, Scenario B is expected to lead to higher costs than Scenario A, but the planner cannot control which scenario comes to fruition. Instead, the planner focuses on the relative performance of the near-term strategies within each scenario.

Source: Energy Systems Integration Group.

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Address technology uncertainty head on

- ✓ Design scenarios to assess technology risk and cost uncertainty
- ✓ Develop portfolios that complement multiple emerging technology pathways
- ✓ Quantify risks associated with near-term commitment when optimized portfolios diverge
- ✓ Apply technology-agnostic approaches with care

TABLE 6
Summary of Technology-Agnostic Approaches and Applicable Emerging Technologies

Technology-Agnostic Option	Applicable Emerging Technologies
Proxy clean drop-in fuel	Biogas, e-fuels produced off-system, or natural gas for which emissions are removed via off-system direct air capture
Proxy clean peaking capacity	New peaking plants that combust biogas, e-fuels produced off-system, or natural gas for which emissions are removed via off-system direct air capture
Proxy clean baseload generation	Enhanced geothermal and advanced nuclear
Proxy multi-day storage	Multi-day grid storage and on-system e-fuels

Source: Energy Systems Integration Group.

Reasons a planner may adopt a technology-agnostic approach:

- Planning questions and decisions only require high level insight into emerging technology opportunities
- On-system potential to develop emerging technologies is limited (e.g., e-fuels are more likely to be delivered to the system than produced on-system)

Common pitfalls to avoid:

- Neglecting or obscuring infrastructure needs (e.g., additional renewables, fuel or carbon transport infrastructure) associated with applicable emerging technologies
- Interpreting “optimized” portfolios as least cost

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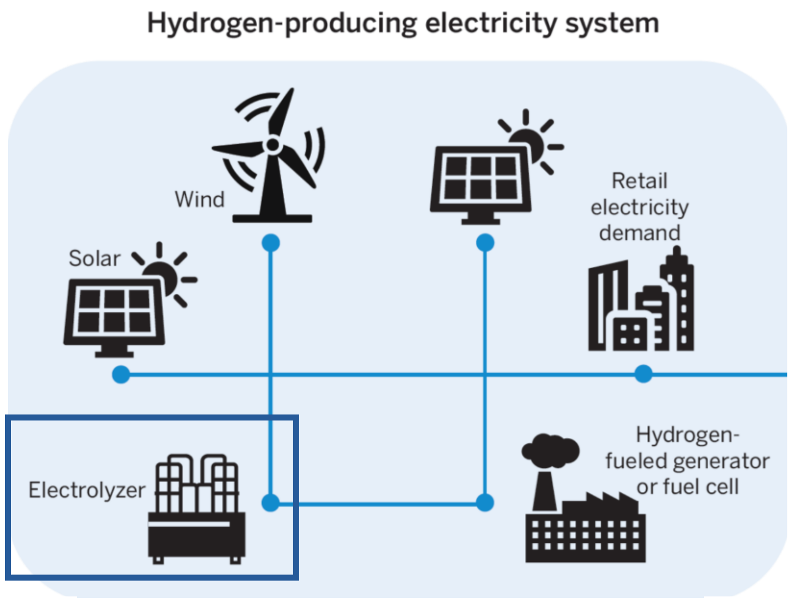
Look beyond your electricity system

✓ Capture impacts of emerging technologies such as e-fuels and direct air capture on electricity demand



- Technologies like e-fuels (e.g., electrolytic hydrogen) and direct air capture (DAC) are electricity intensive
- Their deployment would increase electricity demand and require additional clean energy generation

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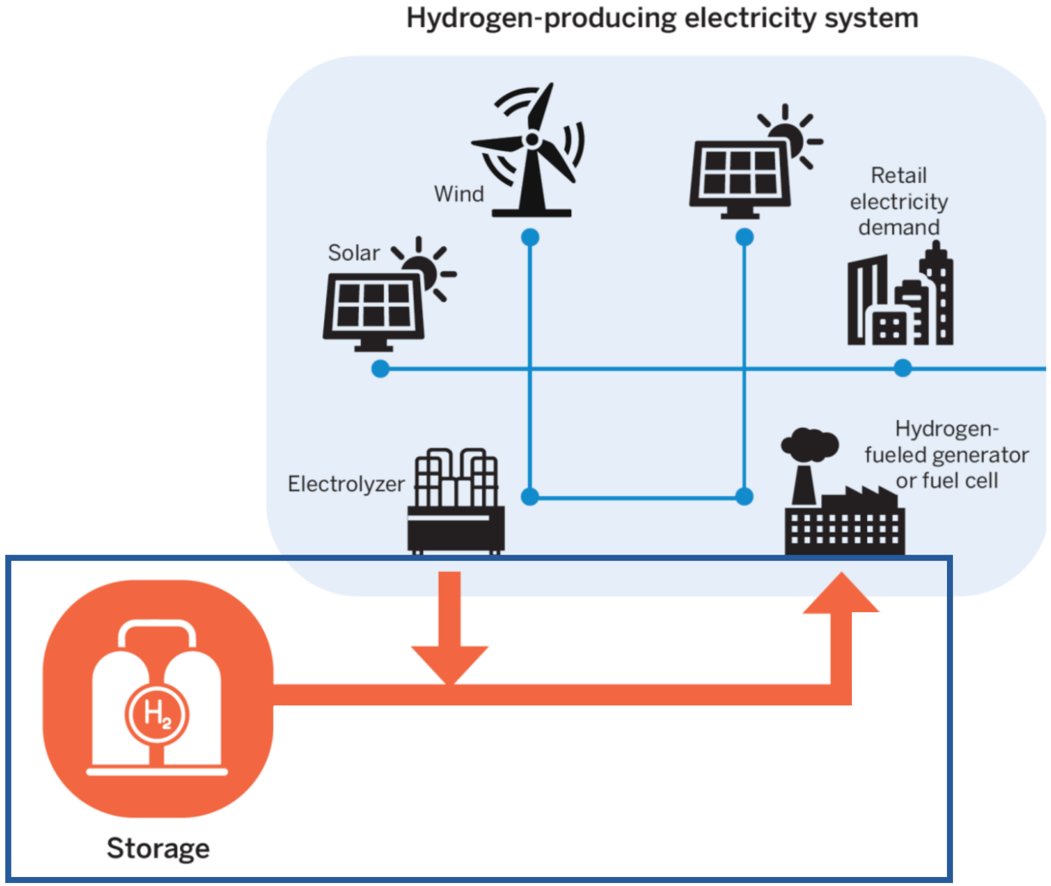
Look beyond your electricity system

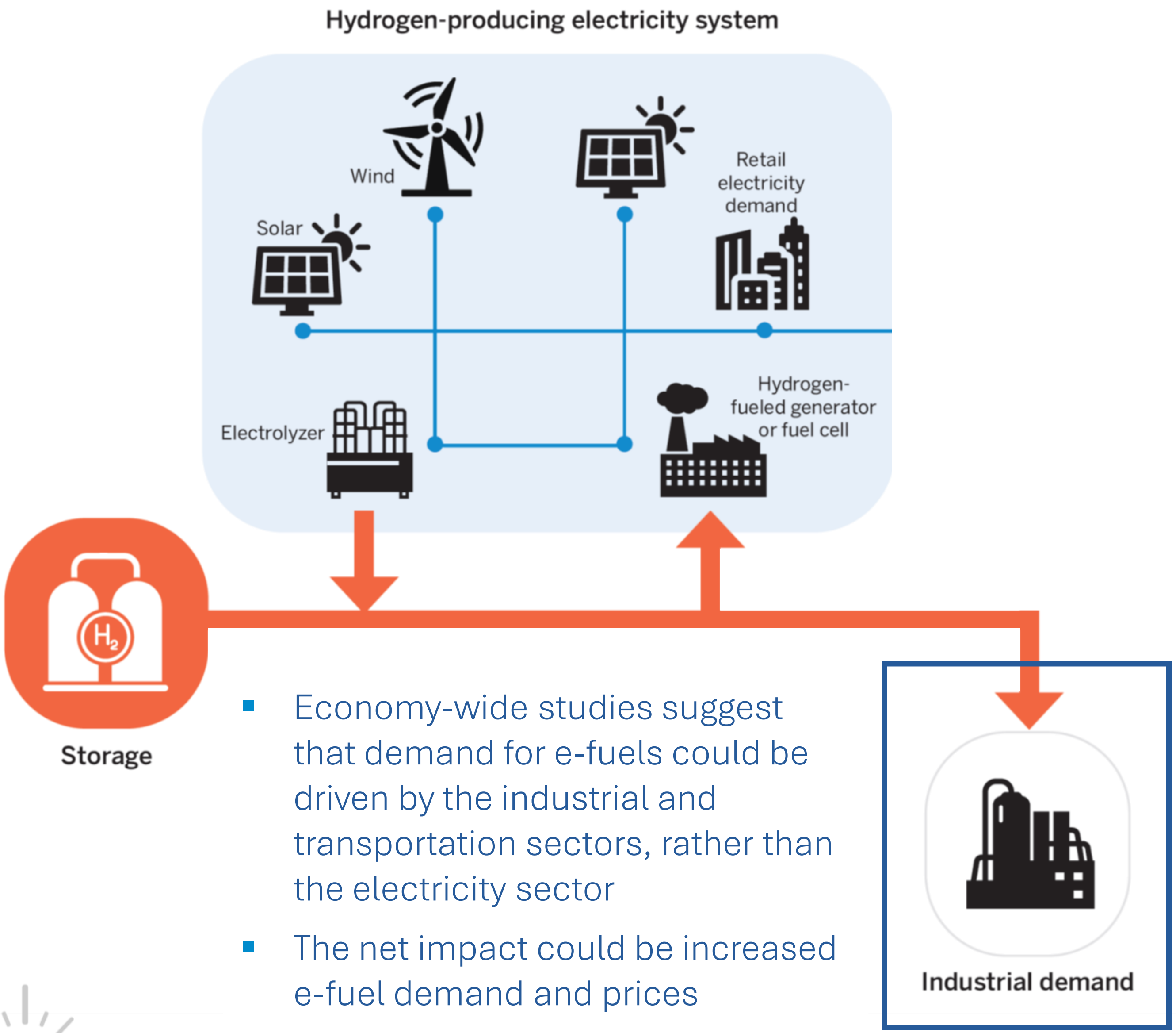
- ✓ Capture impacts of emerging technologies such as e-fuels and direct air capture on electricity demand
- ✓ Include costs associated with storage, transport, and distribution of e-fuels, biomass, and carbon



- Unless e-fuel production is co-located with the facilities that consume the fuels, e-fuels will require transport infrastructure
- Flexible operation of these technologies would require storage, either on-site or accessed via a transport network

Look beyond your electricity system

- ✓ Capture impacts of emerging technologies such as e-fuels and direct air capture on electricity demand
- ✓ Include costs associated with storage, transport, and distribution of e-fuels, biomass, and carbon
- ✓ **Account for competition for clean fuels with other sectors**



- Economy-wide studies suggest that demand for e-fuels could be driven by the industrial and transportation sectors, rather than the electricity sector
- The net impact could be increased e-fuel demand and prices

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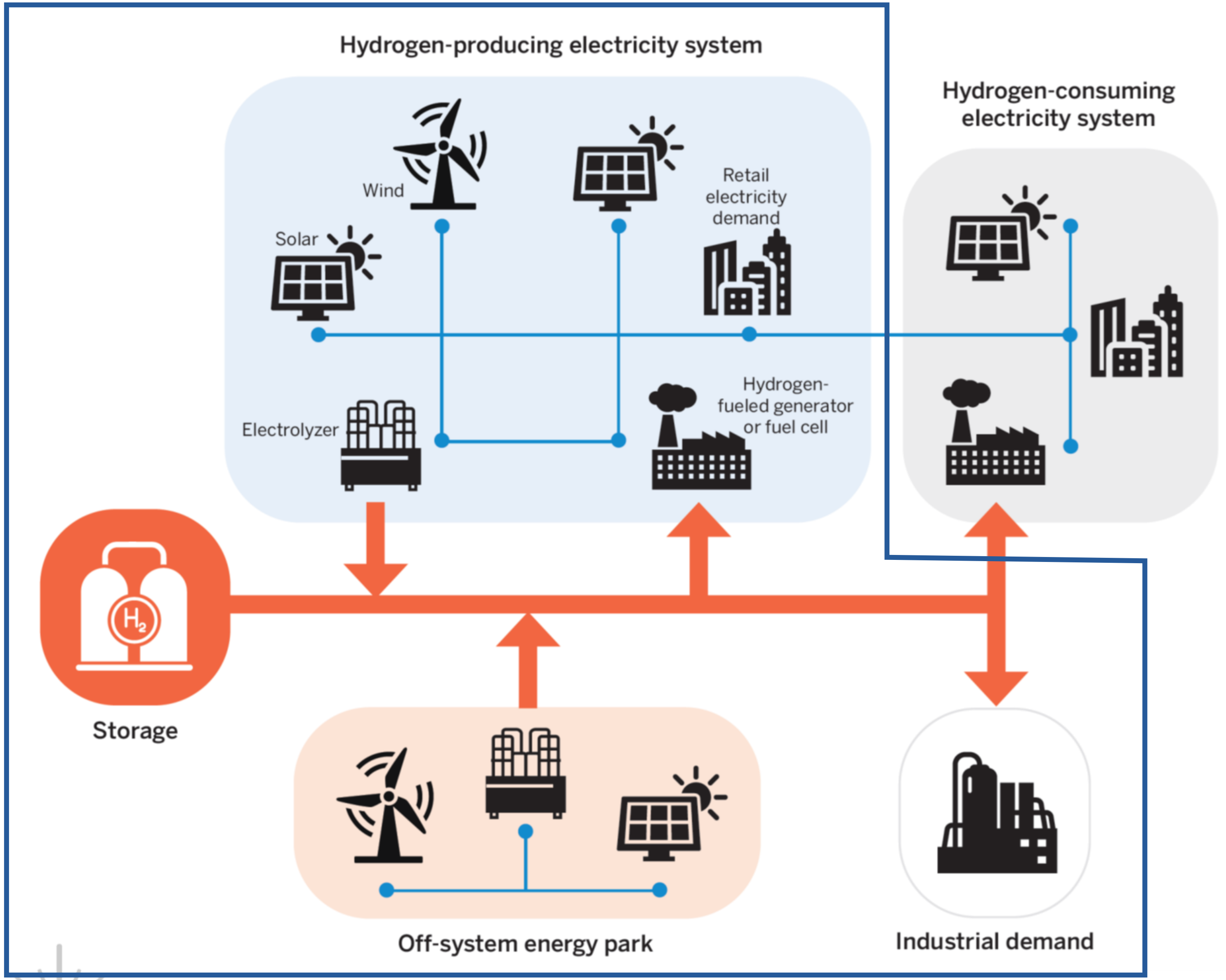
Look beyond your electricity system

- ✓ Capture impacts of emerging technologies such as e-fuels and direct air capture on electricity demand
- ✓ Include costs associated with storage, transport, and distribution of e-fuels, biomass, and carbon
- ✓ Account for competition for clean fuels with other sectors



Even when these technologies are assumed to be off-system (e.g., relative to a hydrogen-consuming system), planners must still address these interactions to estimate availability and costs

Embrace transparency in new areas of complexity

✓ Clearly describe 100% policy implementation details

TABLE 7

Priorities for Additional Transparency in 100% Clean Studies

Topic	Areas Where More Transparency or Detail Is Needed in 100% Clean Plans
Policy compliance and accounting	The design of the 100% clean or zero-emissions requirement being studied, including the clean energy eligibility rules and/or emissions accounting rules (including any accounting of upstream emissions) for generators, energy storage, imports or purchases, exports or sales, and carbon capture and sequestration technologies
	A detailed description of how the mechanics of the 100% clean or net-zero emissions requirement is incorporated into each planning model, including treatment of any of the compliance flexibility levers described in Table 1 (p. 4)
	Assumptions regarding interactions with neighboring systems, including approaches to clean energy or emissions accounting for imported or purchased and exported or sold power
Resource options	Assumptions regarding resource potential and any constraints placed on resource development over time, including lead-time constraints and constraints on the rate of deployment
	Assumptions regarding the availability and cost of emerging technologies in each planning scenario, including when the technology is assumed to be available and how quickly it can be deployed once it is available
Planning environment	Assumptions related to decarbonization of other sectors including electrification, non-electricity-sector demand for e-fuels such as hydrogen, and non-electricity-sector demand for biofuels
	Assumptions regarding infrastructure outside the planner's jurisdiction that is necessary to support the plan (for example, transport and storage infrastructure for e-fuels, biofuels, and captured carbon)

Source: Energy Systems Integration Group.

Policy design details matter!

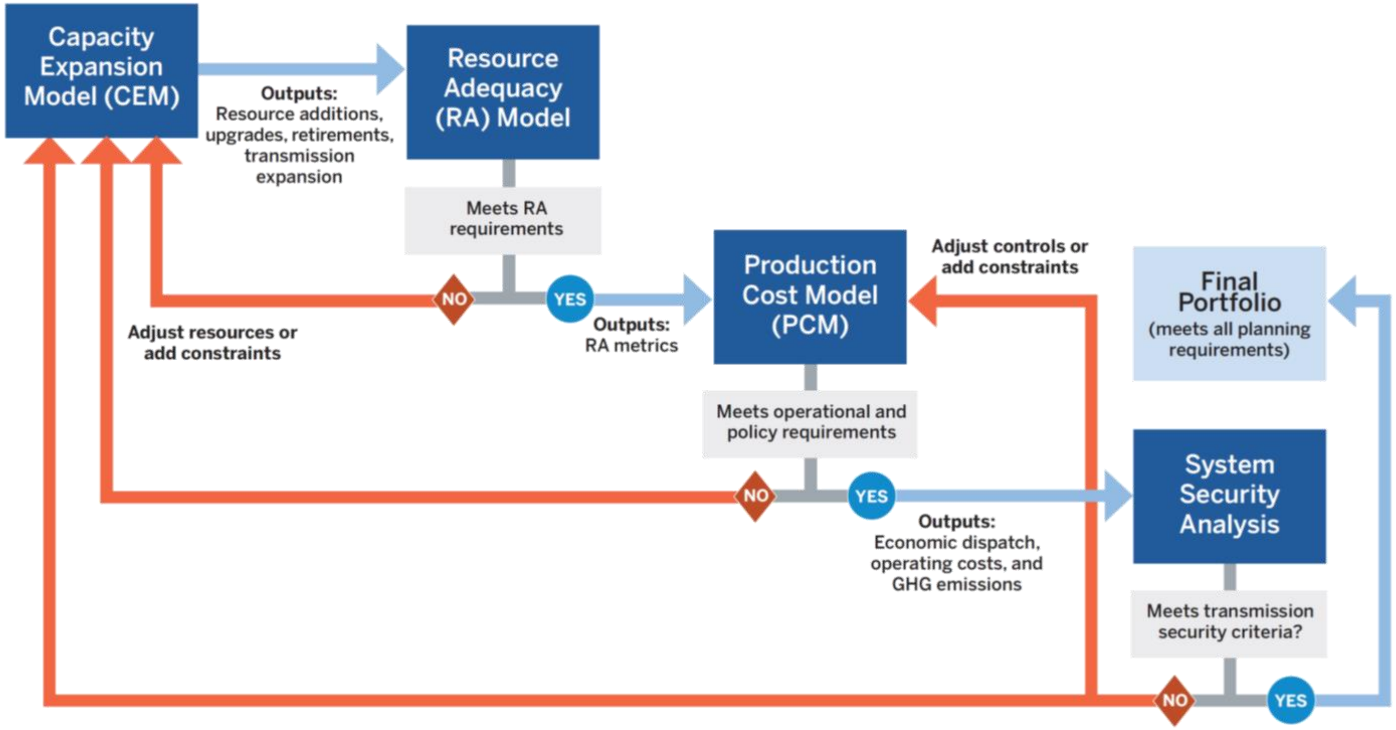
- Many of these clean policies do not actually require complete decarbonization
- Table 1 in the main report describes some of the policy design levers that are often used to make these policies more or less stringent

Embrace transparency in new areas of complexity

- ✓ Clearly describe 100% policy implementation details
- ✓ Verify policy and reliability compliance using a suite of detailed models

FIGURE 10

Example Iterative Modeling Approach for Ensuring Reliability and Verifying Policy Compliance in Electricity Planning Analyses



Planners typically use multiple models to develop and evaluate resource portfolios. Capacity expansion models solve for resource selections, conversions, upgrades, and retirements that are expected to enable the system to meet planning requirements at least cost. Resource adequacy models, production cost models, and in some cases, AC power flow and stability models are used to more realistically evaluate how a portfolio is expected to perform in terms of operations, reliability, and cost. In some planning processes, such as Hawaiian Electric Company's Integrated Grid Planning process, planners iterate between these models to arrive at portfolios that meet all planning constraints.

Source: Adapted from Hawaii Natural Energy Institute, University of Hawaii.

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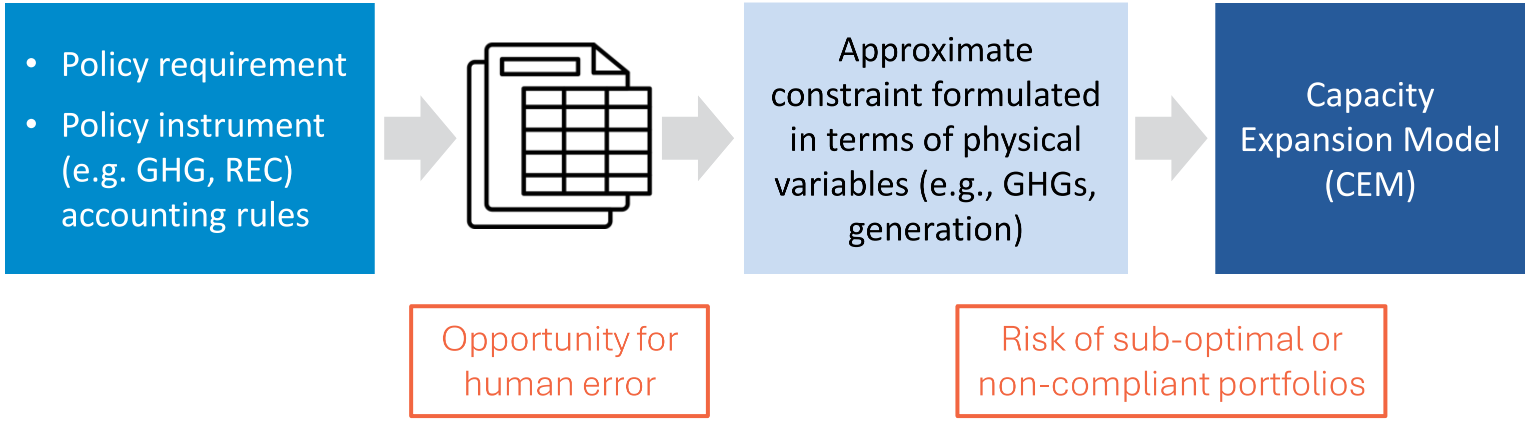
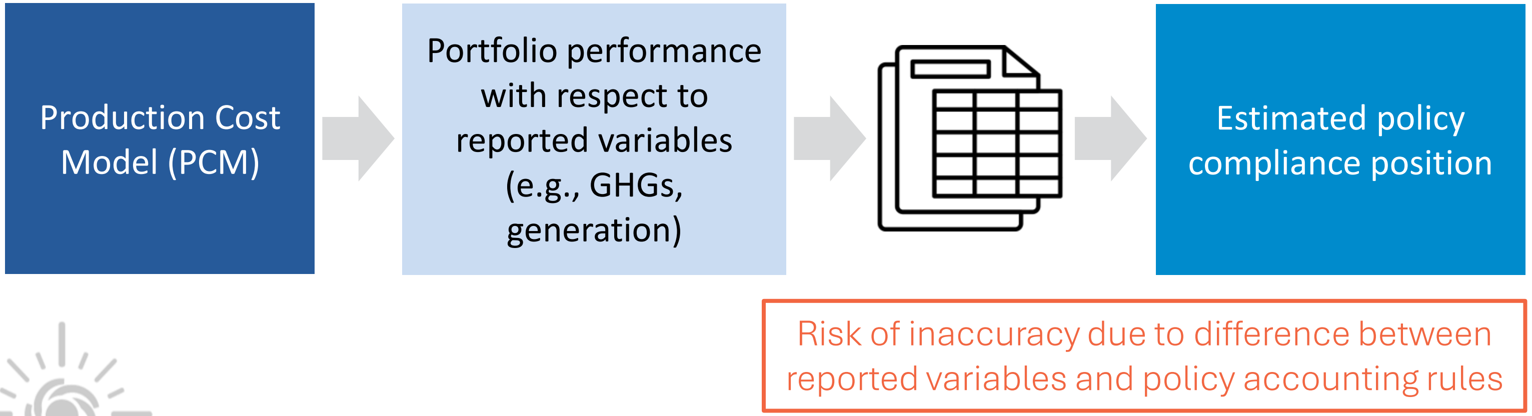
Embrace transparency in new areas of complexity

- ✓ Clearly describe 100% policy implementation details
- ✓ Verify policy and reliability compliance using a suite of detailed models
- ✓ Track and report policy compliance instruments directly in planning models

In **Capacity Expansion Models**, policy constraints are often imposed as approximations that are derived in spreadsheet models based on policy design:



In **Production Cost Models**, policy compliance is often estimated after-the-fact, based on whatever physical variables are reported by the software:



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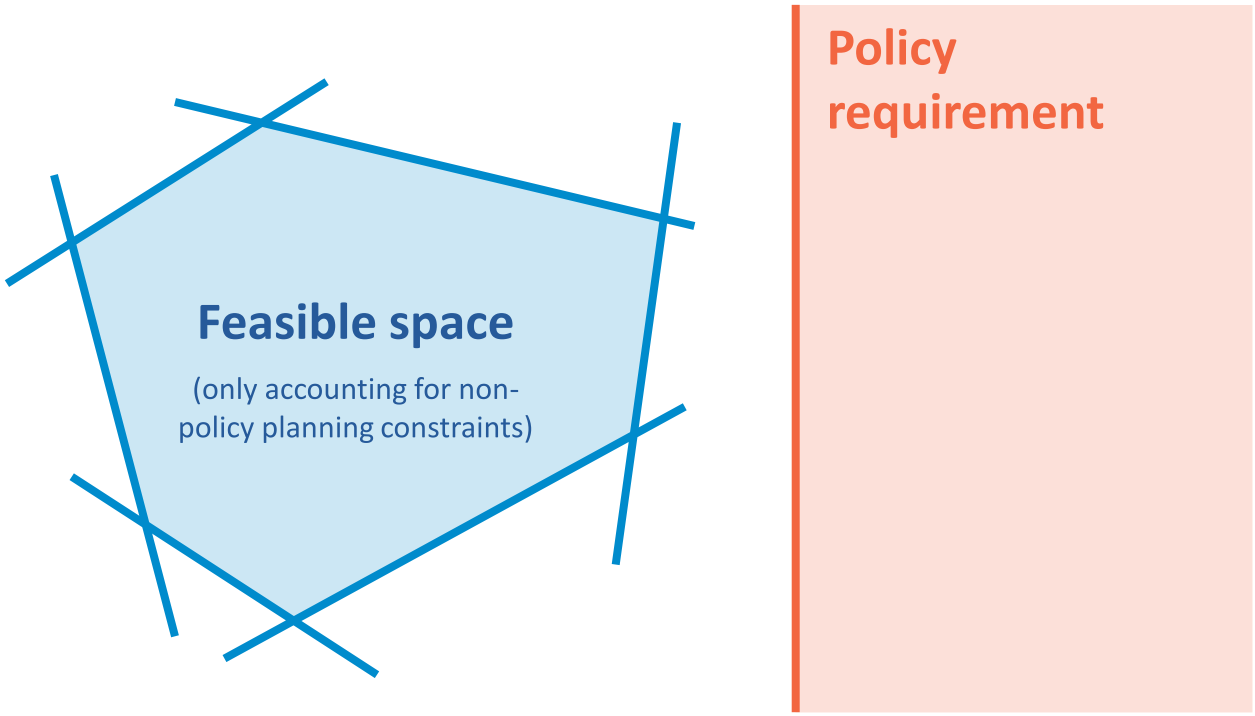
Embrace transparency in new areas of complexity

- ✓ Clearly describe 100% policy implementation details
- ✓ Verify policy and reliability compliance using a suite of detailed models
- ✓ Track and report policy compliance instruments directly in planning models
- ✓ Quantify policy compliance risks

When there are no feasible portfolios that meet all planning constraints… there are two options.

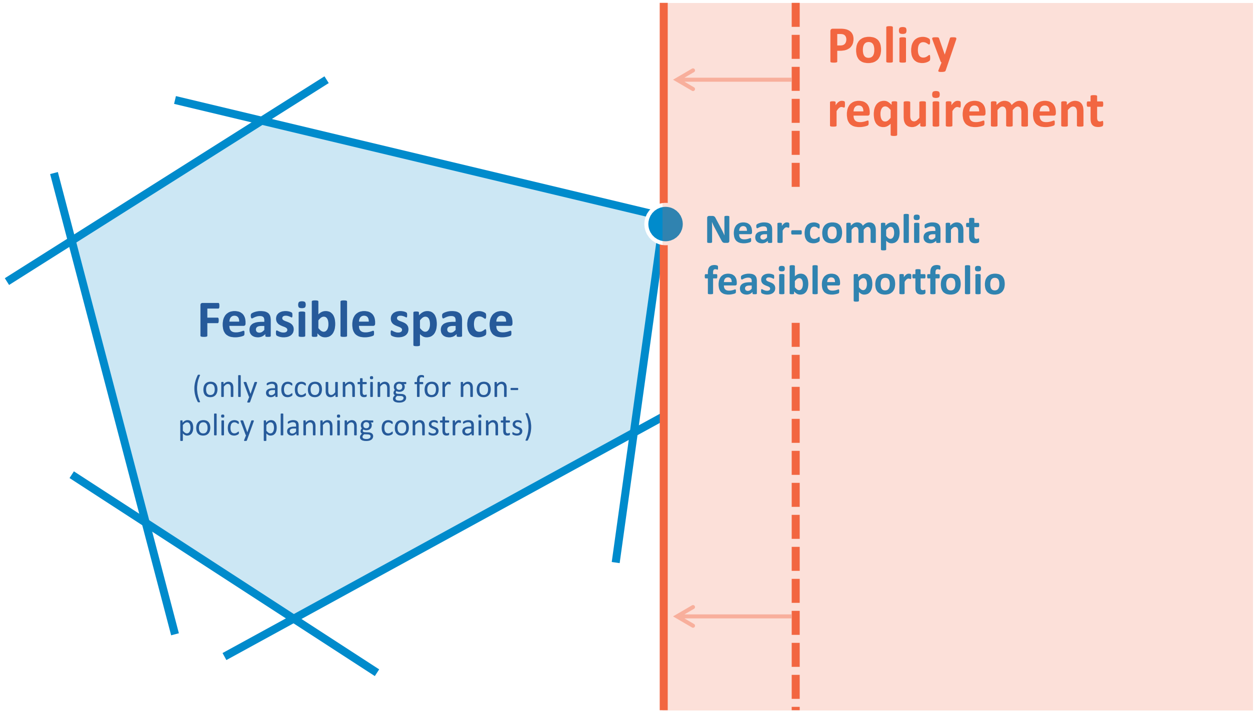


Embrace transparency in new areas of complexity

- ✓ Clearly describe 100% policy implementation details
- ✓ Verify policy and reliability compliance using a suite of detailed models
- ✓ Track and report policy compliance instruments directly in planning models
- ✓ **Quantify policy compliance risks**

When there are no feasible portfolios that meet all planning constraints… there are two options.

1. Relax the policy constraint until it can be met



This approach can tell you how much you might be out of compliance under a set of planning assumptions

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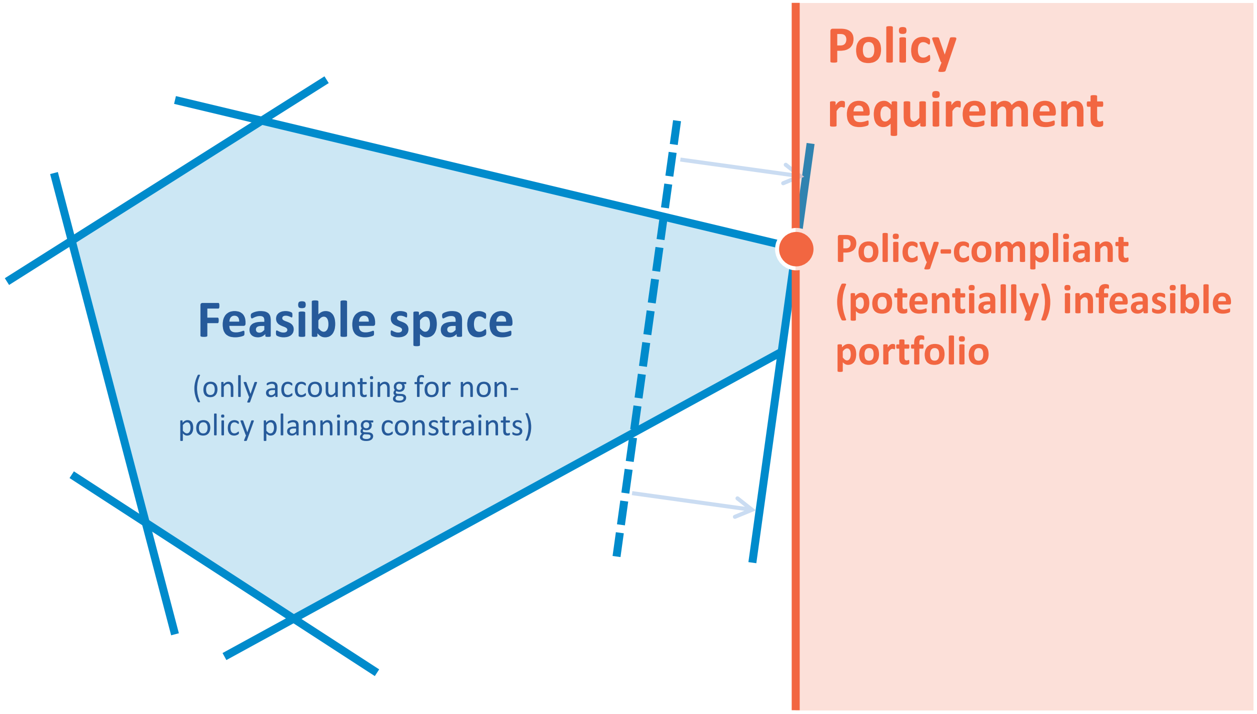
Embrace transparency in new areas of complexity

- ✓ Clearly describe 100% policy implementation details
- ✓ Verify policy and reliability compliance using a suite of detailed models
- ✓ Track and report policy compliance instruments directly in planning models
- ✓ Quantify policy compliance risks

When there are no feasible portfolios that meet all planning constraints… there are two options.

2. Relax a planning constraint (e.g., maximum resource build) until the policy can be met



This approach can tell you how much your planning constraints would need to change to comply

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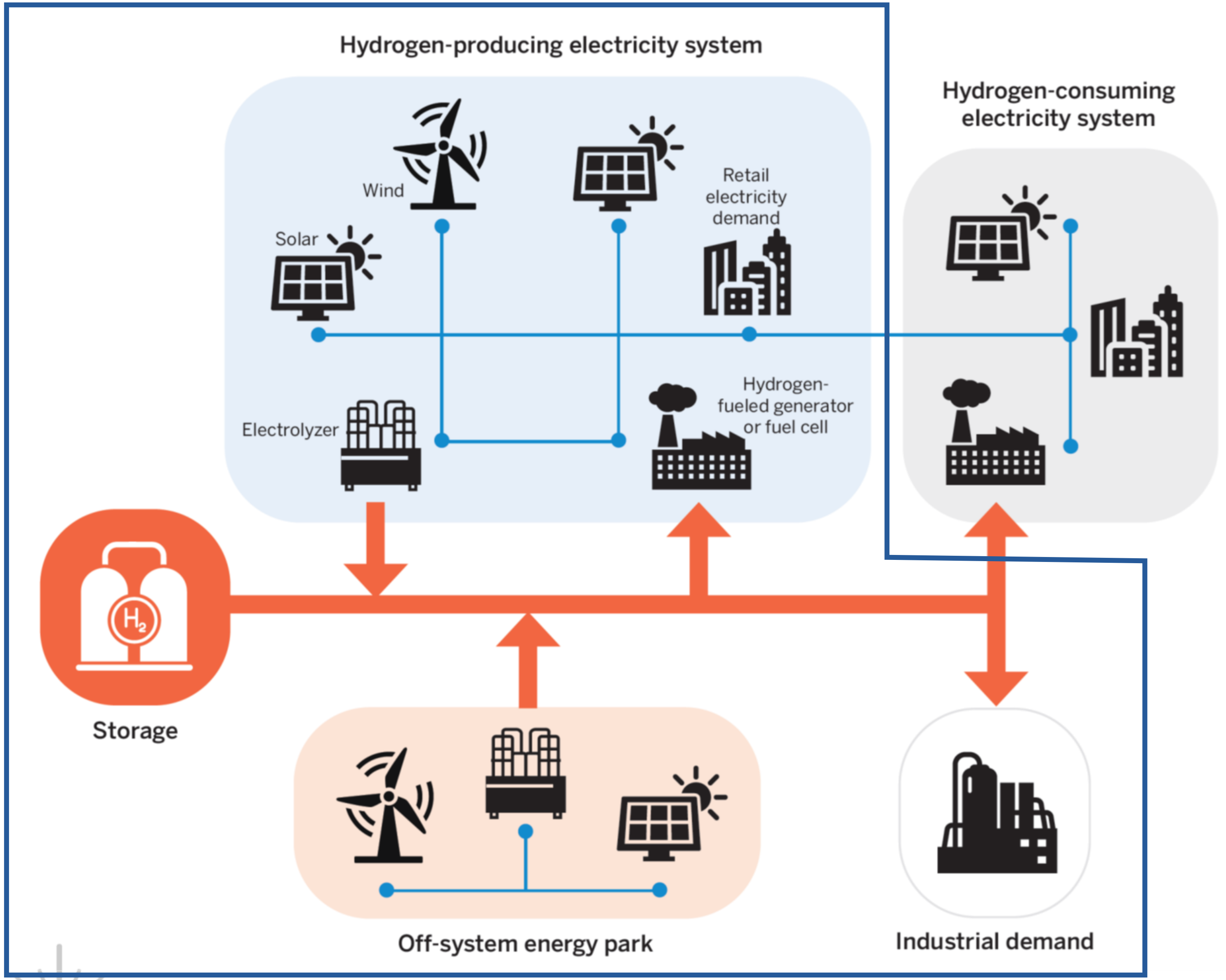
Embrace transparency in new areas of complexity

- ✓ Clearly describe 100% policy implementation details
- ✓ Verify policy and reliability compliance using a suite of detailed models
- ✓ Track and report policy compliance instruments directly in planning models
- ✓ Quantify policy compliance risks
- ✓ **Directly address non-jurisdictional dependencies and supporting infrastructure needs**



If a plan involves e-fuels or carbon capture, communicating the scope and scale of the necessary supporting infrastructure (e.g., transport and storage) is crucial for assessing the reasonableness of the plan

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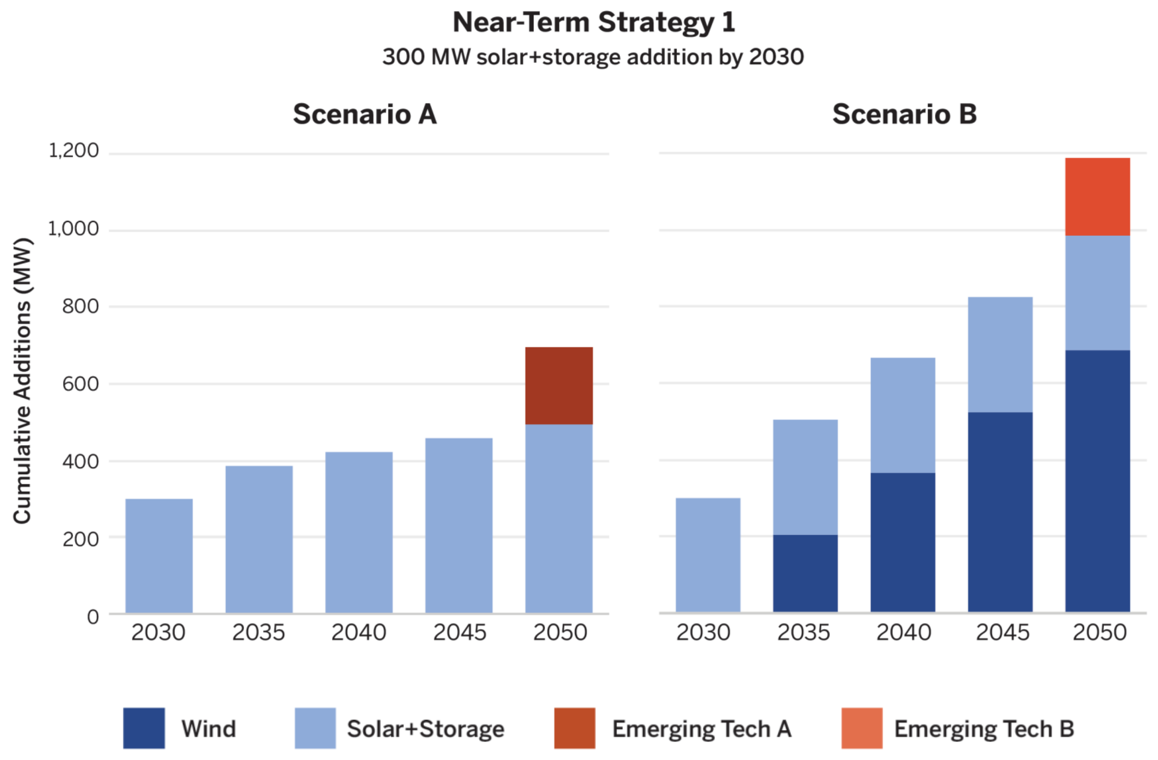
Translate long-term findings into practical near-term decisions

✓ Rely on scenario analysis findings to inform new infrastructure decisions

Stylized example:

- **Scenario A** considers a future in which Emerging Tech A achieves commercialization
- **Scenario B** considers a future in which Emerging Tech B achieves commercialization
- **Near-Term Strategy 1** commits to 300 MW of solar + storage in the near term, which appears to be complementary to Emerging Tech A in the long term



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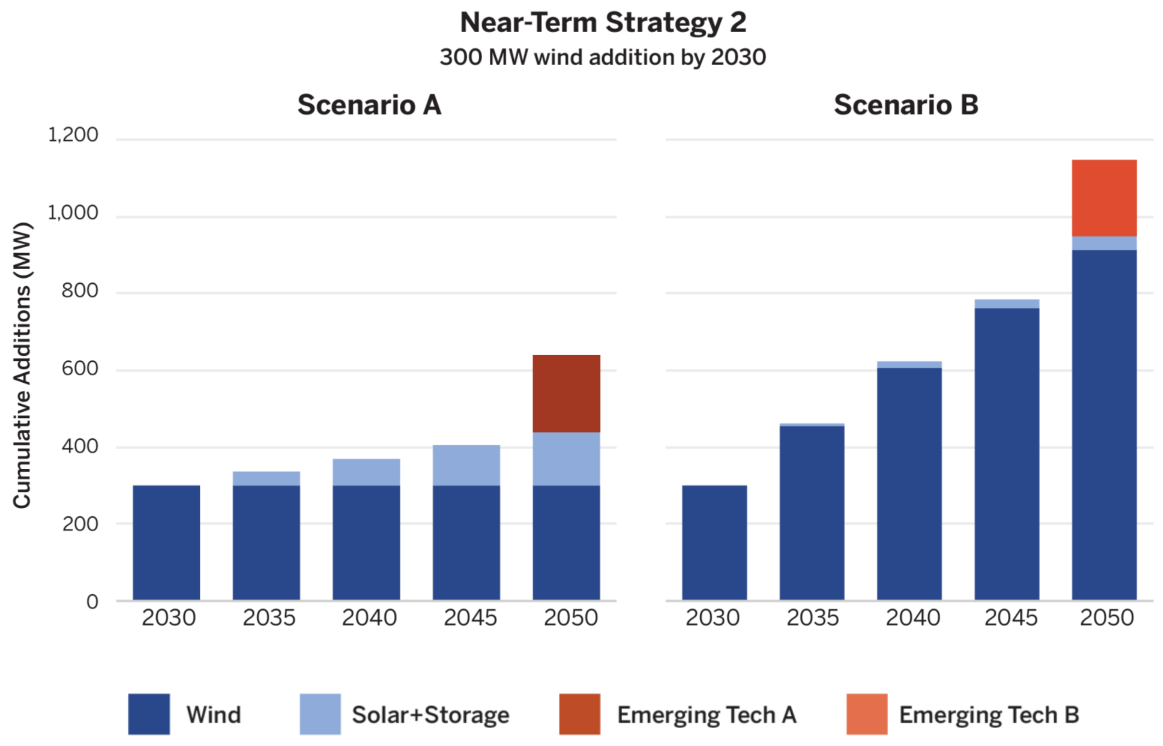
Translate long-term findings into practical near-term decisions

✓ Rely on scenario analysis findings to inform new infrastructure decisions

Stylized example:

- **Scenario A** considers a future in which Emerging Tech A achieves commercialization
- **Scenario B** considers a future in which Emerging Tech B achieves commercialization
- **Near-Term Strategy 2** commits to 300 MW of wind in the near term, which appears to be complementary to Emerging Tech B in the long term



ESIG

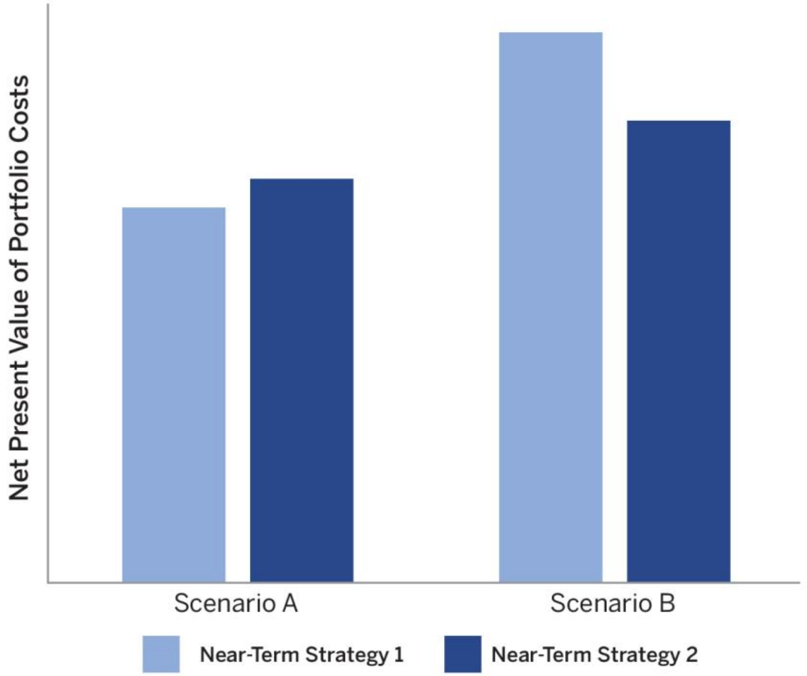
Translate long-term findings into practical near-term decisions

✓ Rely on scenario analysis findings to inform new infrastructure decisions

Stylized example:

- A planner who thinks **Scenario A** is more likely might choose **Strategy 1**
- A planner who thinks **Scenario B** is more likely, or who is most concerned with <u>avoiding the highest cost outcomes</u>, might choose **Strategy 2**, even though it is slightly more expensive under **Scenario A** than the alternative

FIGURE 7
Relative Costs for Portfolios That Test the Risk of Near-Term Commitments Under Emerging Technology Uncertainty



This shows the net present value of portfolio costs for the four portfolios shown in Figure 6 (p. 22), evaluated in the scenario for which the long-term resource selections were re-optimized. In this hypothetical example, Scenario B is expected to lead to higher costs than Scenario A, but the planner cannot control which scenario comes to fruition. Instead, the planner focuses on the relative performance of the near-term strategies within each scenario.

Source: Energy Systems Integration Group.

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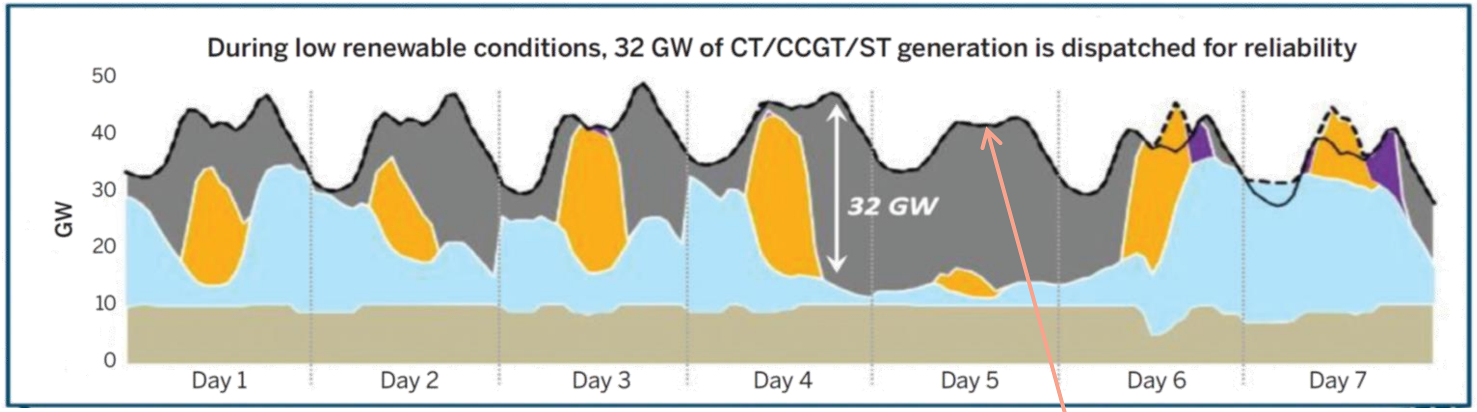
Translate long-term findings into practical near-term decisions

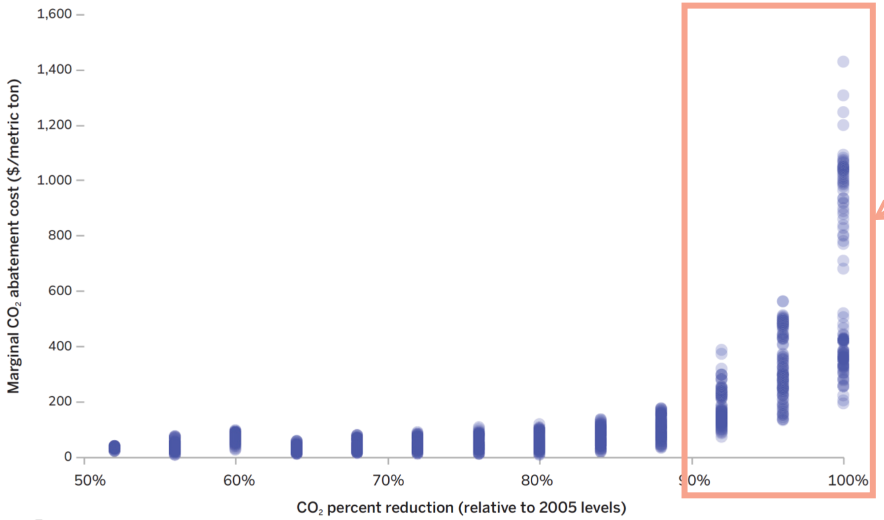
- ✓ Rely on scenario analysis findings to inform new infrastructure decisions
- ✓ Consider policy compliance value in demand-side management evaluations

An Example of the Winter Reliability Challenge in ISO New England



Source: E3 and Energy Futures Initiative, *Net-Zero New England*, 2020.

An Example of the Cost Escalation as a System Approaches Zero Emissions



Source: Mai et. al, "Getting to 100%: Six strategies for the challenging last 10%," Joule. 6(9), 2022. https://www.sciencedirect.com/science/article/pii/S2542435122004056#bib7

Measures that can reduce demand during the most challenging circumstances to decarbonize may bring more value in jurisdictions with 100% clean or net zero requirements than traditional DSM evaluation methodologies identify because they help avoid the most costly alternatives.

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Translate long-term findings into practical near-term decisions

- ✓ Rely on scenario analysis findings to inform new infrastructure decisions
- ✓ Consider policy compliance value in demand-side management evaluations
- ✓ Test potential near-term fossil resource decisions across planning scenarios to examine reliability and policy compliance risks
- ✓ Proactively plan for future fossil retirements

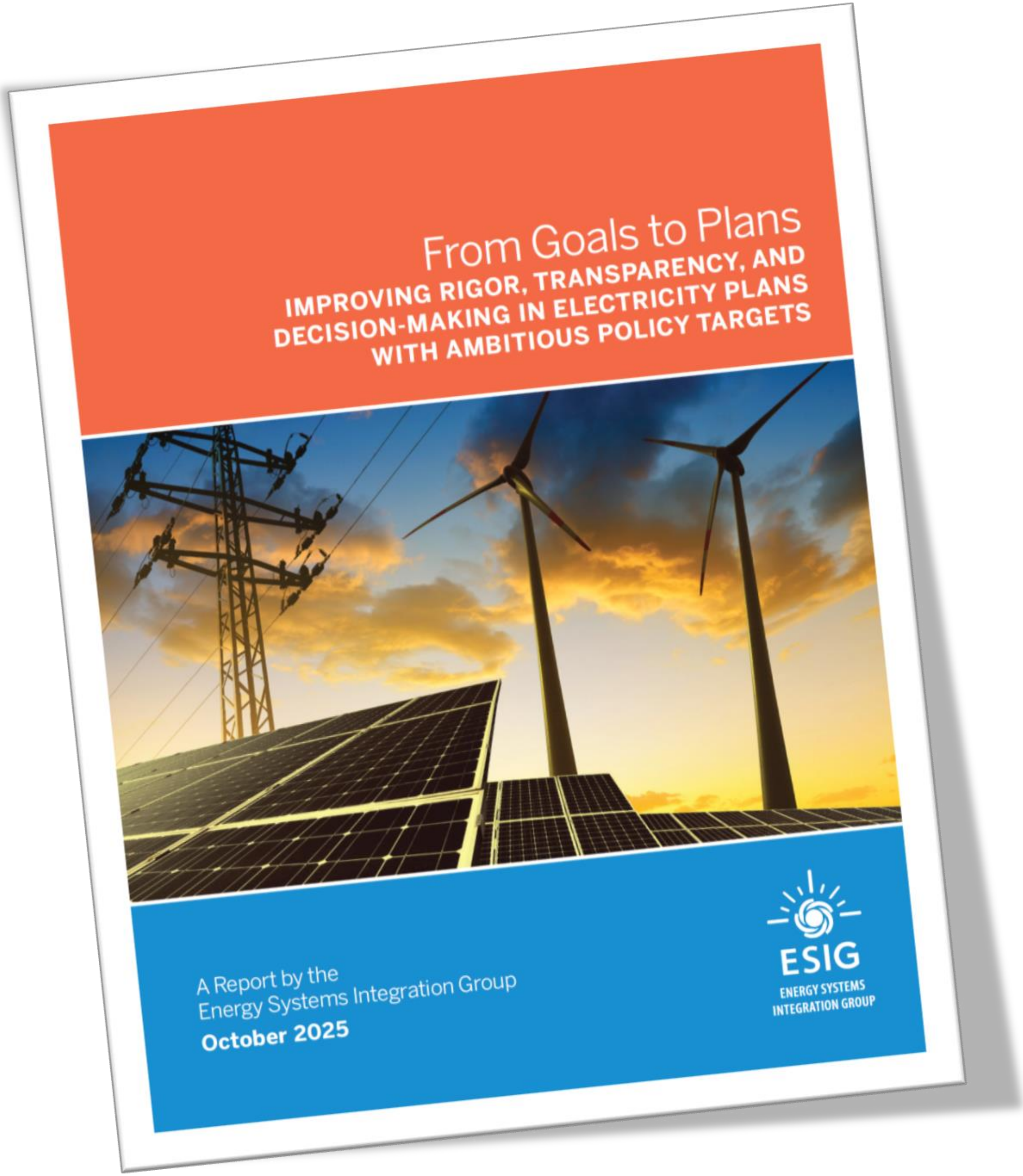
Example mappings between fossil resource options, corresponding economic considerations, and technology scenarios in a resource plan

	Technology Scenarios				
	Enhanced geothermal or advanced nuclear	Multiday storage	CCS & DAC	Hydrogen economy	Biogas or power-to-gas
Long-term fossil resource options	Retire				
			Retrofit		
					Retain
Potential costs associated with policy compliance	Short financial lifetimes to reduce stranded asset risk				
			Upgrades or future retrofits		
				Very high future fuel costs	

Translate long-term findings into practical near-term decisions

- ✓ Rely on scenario analysis findings to inform new infrastructure decisions
- ✓ Consider policy compliance value in demand-side management evaluations
- ✓ Test potential near-term fossil resource decisions across planning scenarios to examine reliability and policy compliance risks
- ✓ Proactively plan for future fossil retirements
- ✓ Consider participating in emerging technology demonstrations

Subject to cost and risk considerations...



THANK YOU

For more information, you can find our report at https://www.esig.energy/electricity-plans-with-ambitious-policy-targets/

Contact:

elaine@sylvan.energy

Additional slides

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Existing Options for Pursuing 100% Clean Electricity

Option	Potential	Availability During Constrained Conditions	Primary Barriers or Risks
Wind and solar	Geographically specific	**Limited availability**	Siting, permitting, interconnection, and supply chain
Short-duration storage	Relatively unconstrained	**Limited availability**	Supply chain
Pumped storage	**Limited and geographically specific**	Depends on the duration and conditions	**Siting, permitting, interconnection, and long lead time**
Bioenergy	**Limited feedstocks**	High availability	Supply chain and competition with other sectors
Conventional geothermal	**Limited and geographically specific**	High availability	Siting, permitting, interconnection, and long lead time
Energy efficiency	**Limited**	Depends on the measure	Consumer adoption
Load flexibility	**Unknown**	Depends on program or tariff design	Consumer participation
Interregional transmission	Depends on regional dynamics	Depends on regional dynamics	**Siting, permitting, administrative challenges, and long lead time**
Regional market development	Depends on regional dynamics	Depends on regional dynamics	**Political, regulatory, and administrative challenges**

Few constraints | Some constraints | Unknown or significant constraints

Emerging technology solutions could address limitations of existing technologies

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Emerging Technology Options for Addressing the Unique Challenges of 100% Clean Electricity

Option	Potential	Availability During Constrained Conditions	Primary Barriers or Risks
Clean e-fuels	Uncertain	Depends on fuel storage and conditions	Technology risk, fuel supply chain, and infrastructure needs
Enhanced geothermal	Medium	High availability	Technology risk, siting, and permitting
Advanced nuclear	Relatively unconstrained	High availability	Technology risk, siting, permitting, and safety concerns
Multi-day grid storage	Relatively unconstrained	Depends on the duration and conditions	Technology risk, siting, and permitting (depending on the technology)
Carbon capture and sequestration	Uncertain	High availability	Technology risk, siting, permitting, and infrastructure needs

Few constraints — Some constraints — Unknown or significant constraints