The role of thermal generation in decarbonized electricity systems

Learnings from the ESIG Clean Electricity Planning Task Force

ESIG
ENERGY SYSTEMS INTEGRATION GROUP

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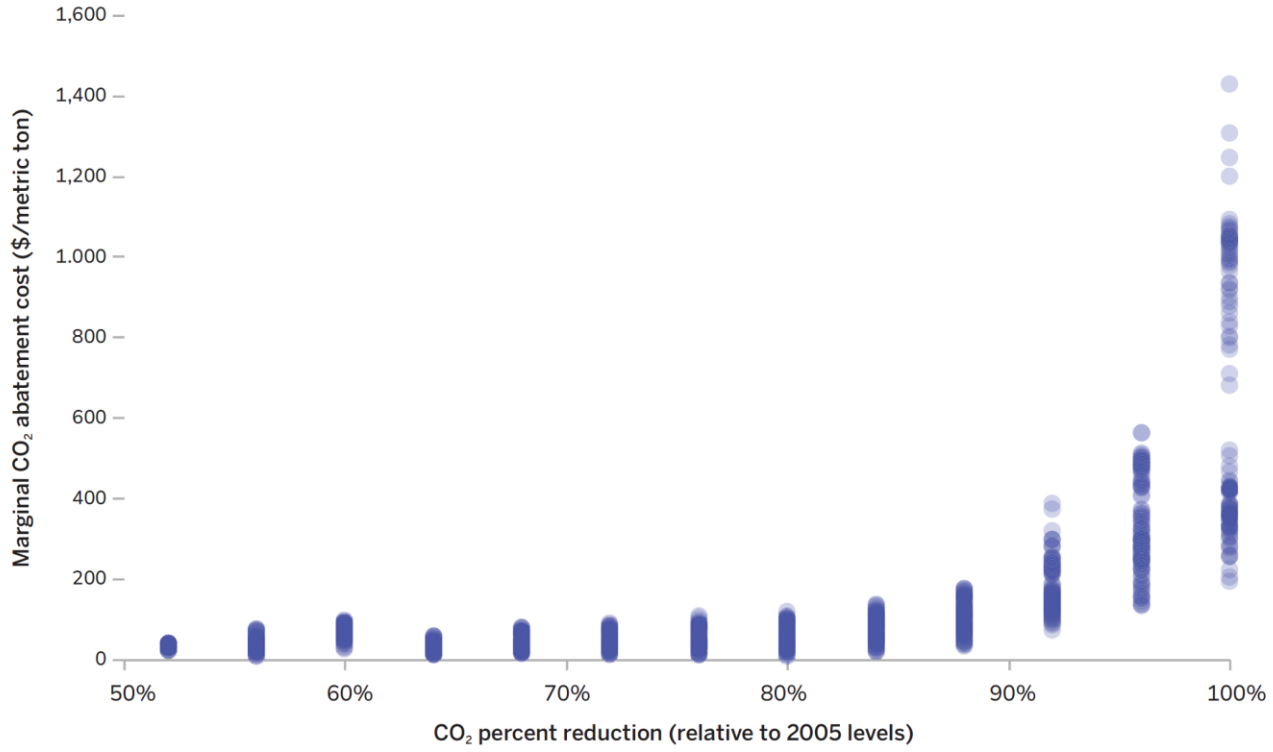
Clean Electricity Planning Task Force

Scope focused on planning for "the last 10%" or "the last mile":

- 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 Net-Zero Carbon electricity systems?

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

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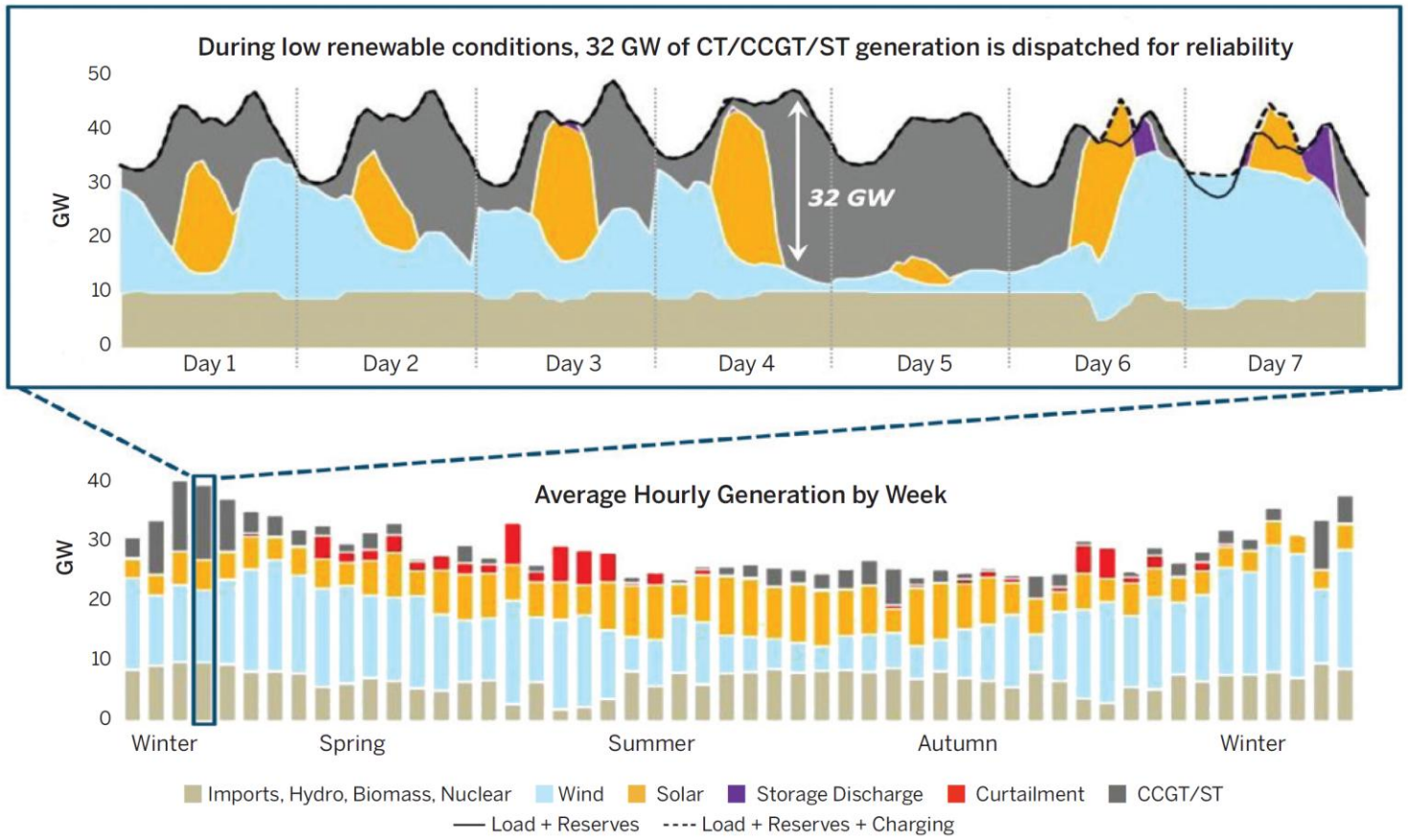
A unique reliability challenge

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.

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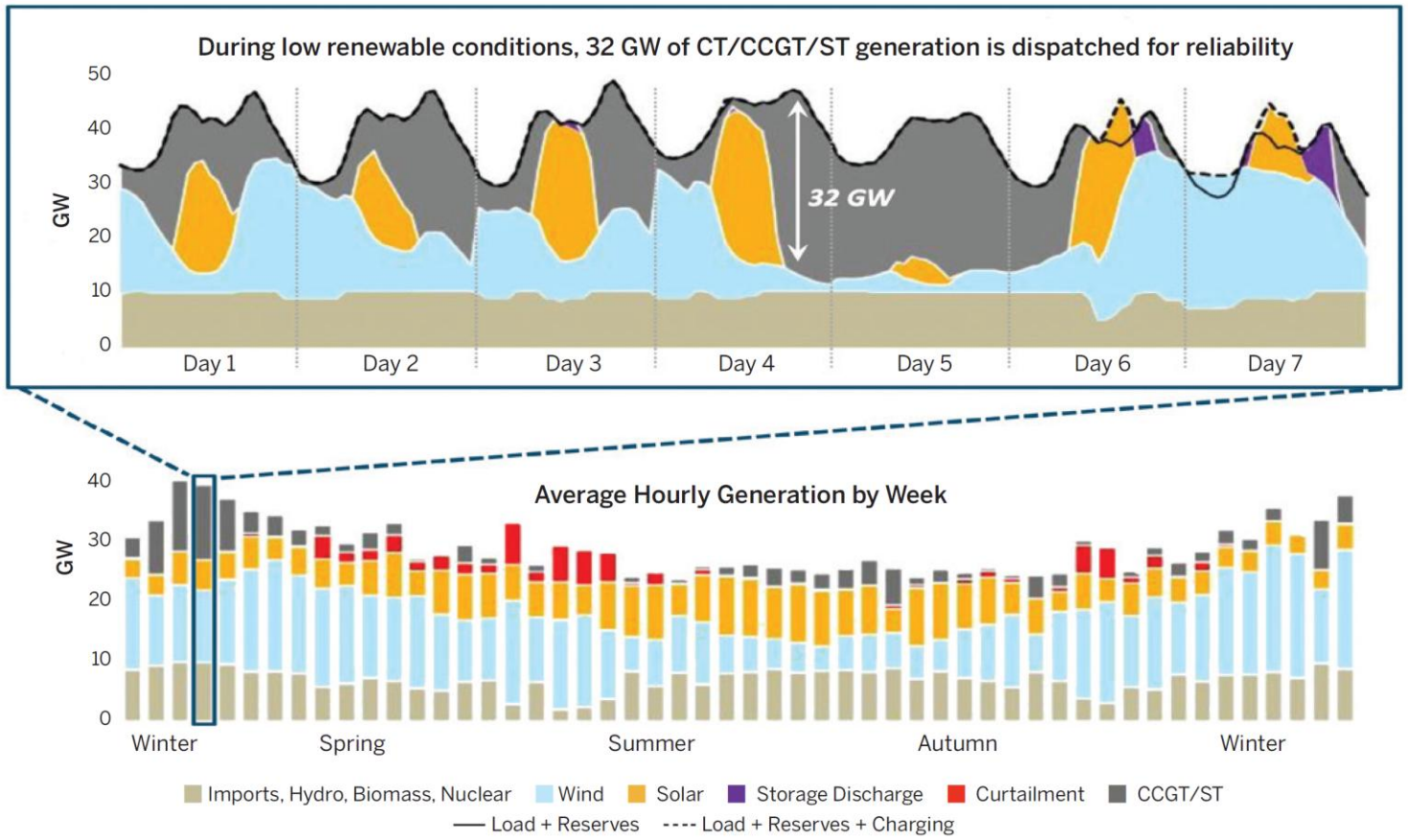

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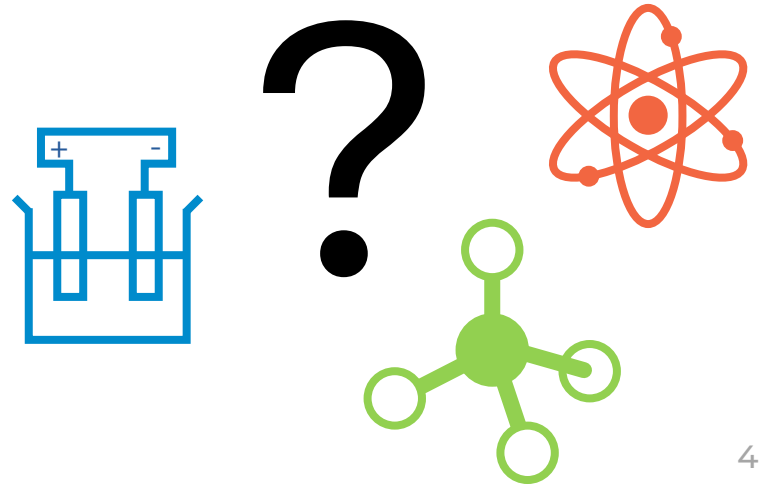

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Technology solutions for addressing the net-zero/100% clean reliability challenge

Existing clean thermal technologies

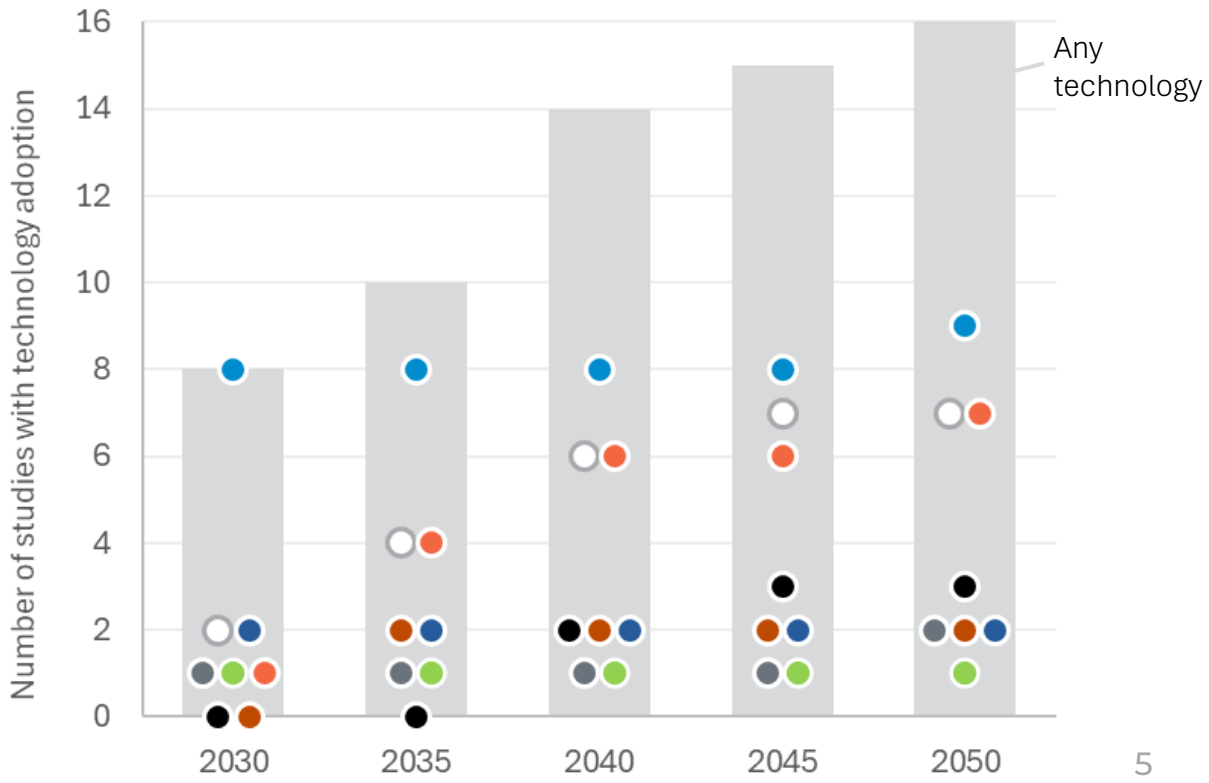
- Conventional geothermal (site-limited)
- Biofuels (supply-limited)

Emerging technologies

- Clean e-fuels (e.g., electrolytic hydrogen) ●
- Advanced nuclear ●
- Enhanced geothermal ●
- Fossil (w/ CCS) ● + a negative emissions technology (e.g., DAC ● or BECCS ●)
- Multiday storage ●

Most 100% clean and net-zero planning studies rely on emerging technologies to solve the reliability challenge, but none 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.



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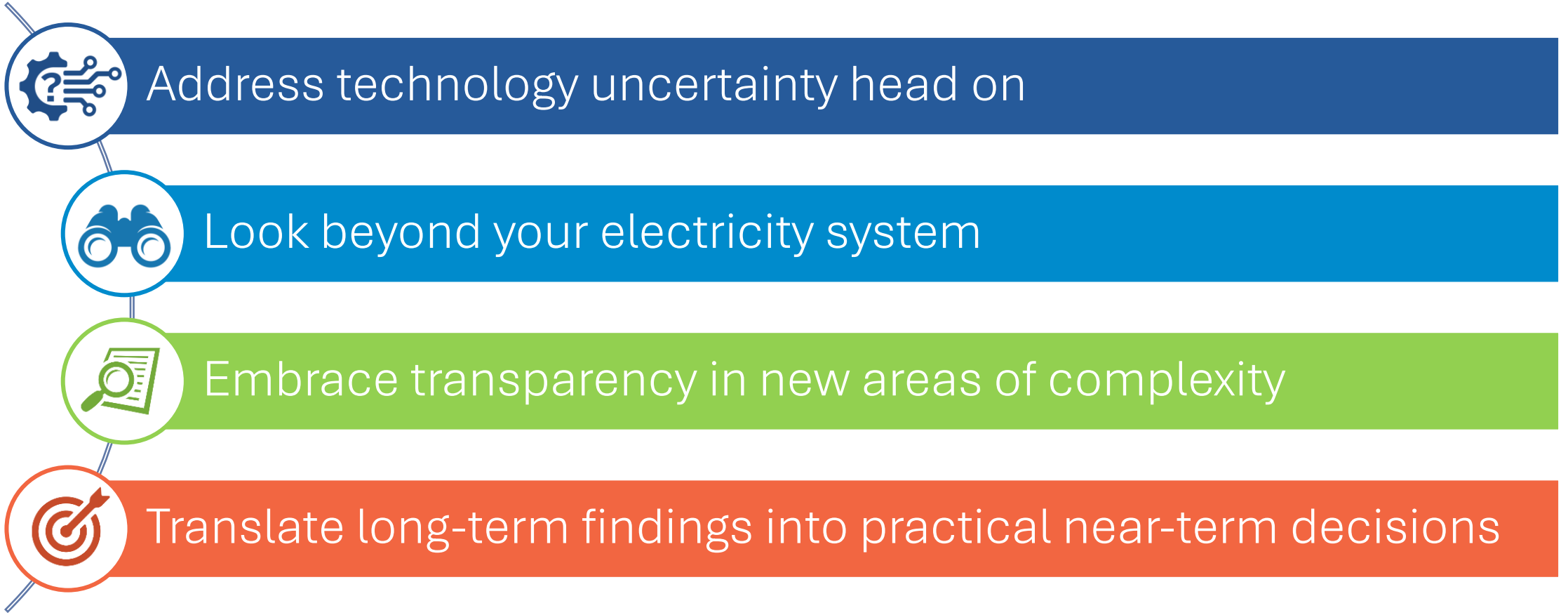
High level recommendations for 100% clean and net-zero electricity plans



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The long-term fate of fossil resources will depend on which technologies emerge

To inform fossil resource plans in net-zero and 100% clean plans:

- Describe the fate of fossil resources under each technology scenario
- Include potential costs associated with policy-compliant operations under each scenario when comparing to clean alternatives

When weighing near-term options:

- Test near-term commitments and viable alternatives across all planning scenarios
- Identify near-term commitments that perform well or avoid risk across the planning scenarios (these may not be least cost in any scenario)

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	

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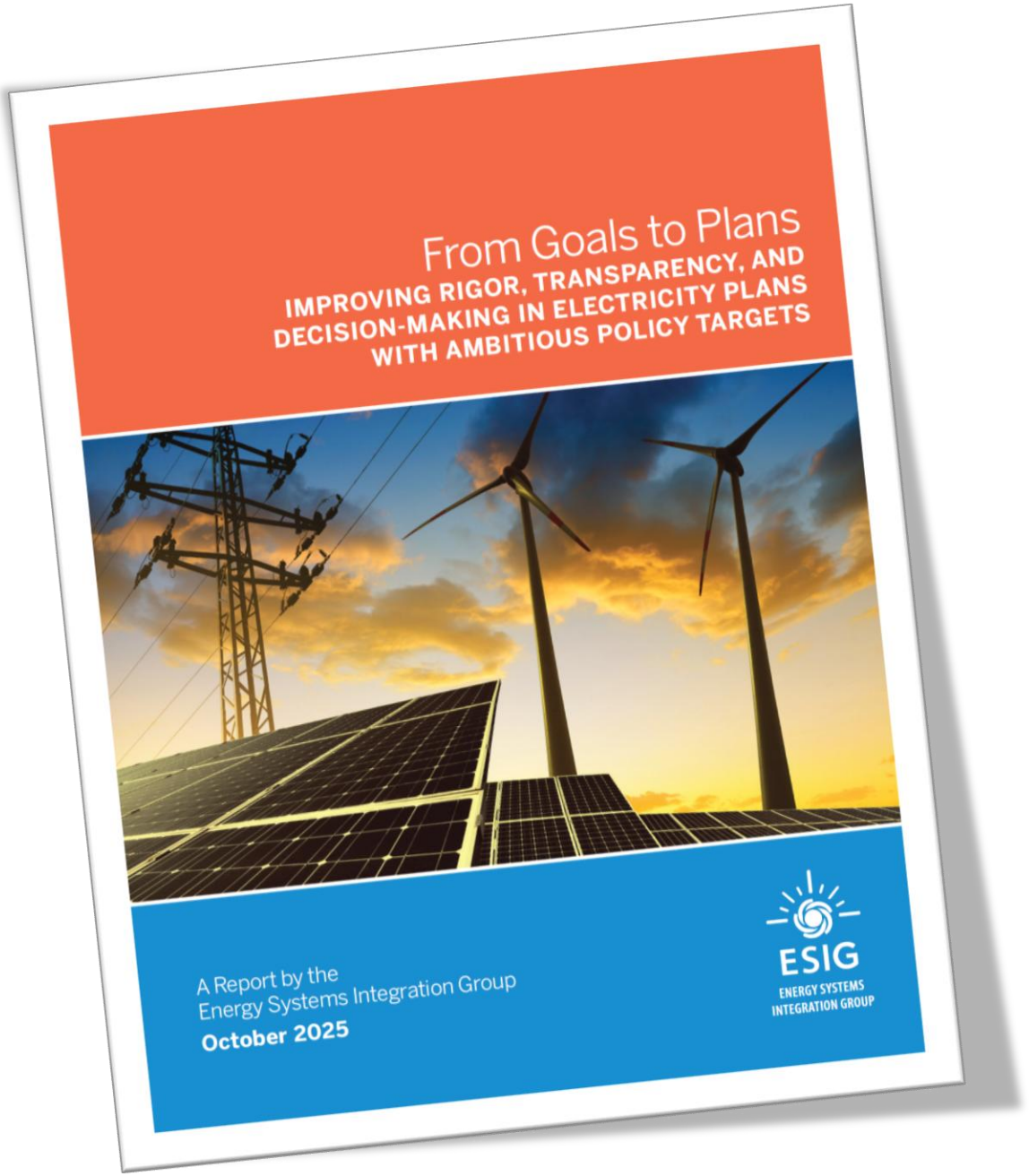

THANK YOU

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

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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

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Emerging technology solutions could address limitations of existing technologies

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**

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