Predicting Energy's High-Impact Technologies Before They Scale

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Imagine making a bet on solar power in 2005

Crystalline Silicon Photovoltaics

Concentrated Solar Power

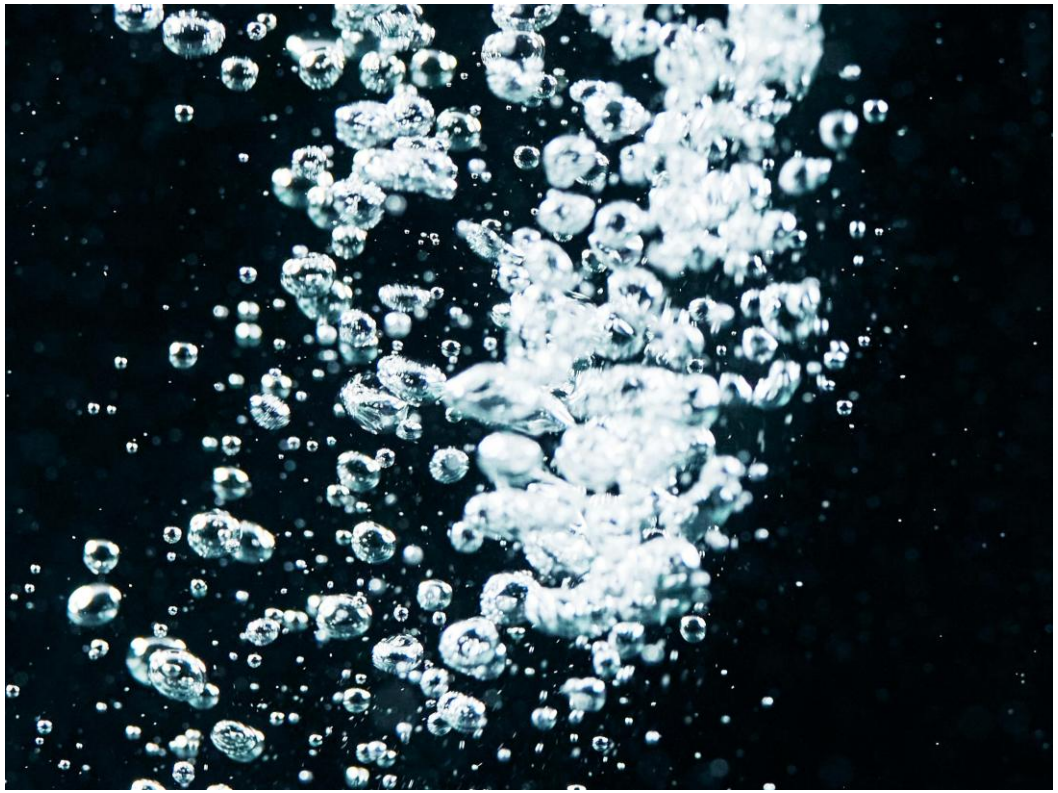
Imagine making a bet on automotives in 2010

Battery Electric Vehicles

Hydrogen Fuel Cell Vehicles

Imagine making a bet on low-carbon steel in 2015

Hydrogen Economy



Carbon Economy

Imagine making a bet on low-carbon fuels in 2020

E-fuels

Biofuels

Agenda

01 | What is happening right now?

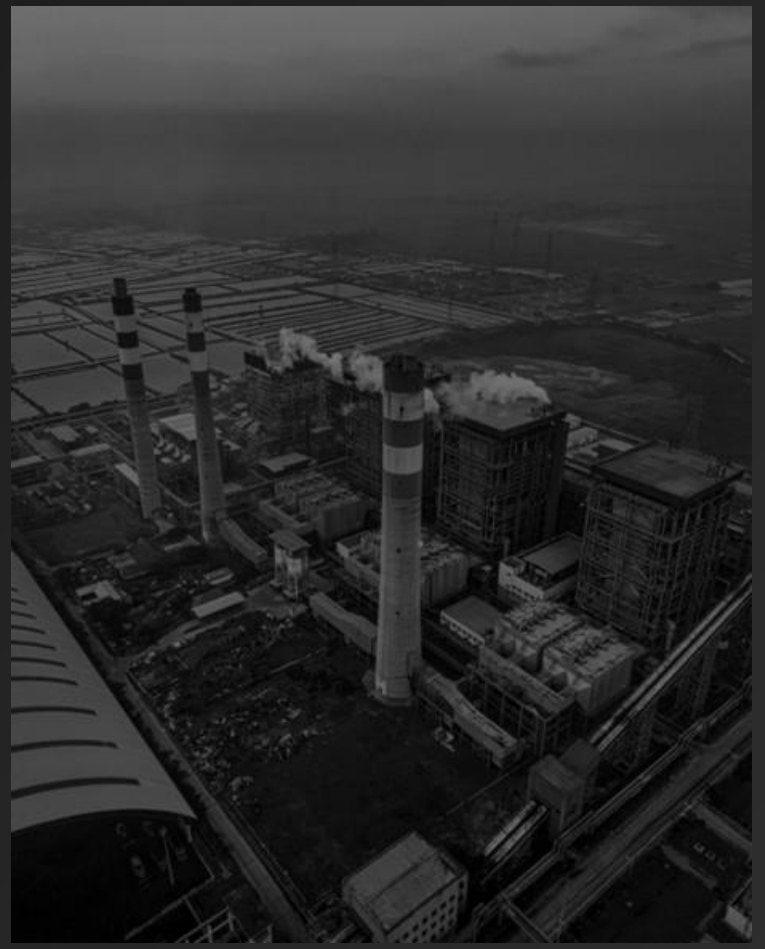
02 | Using Lux's Tech Signal to predict innovation trends

03 | Translating foresight into action

2000s
Solar and Wind

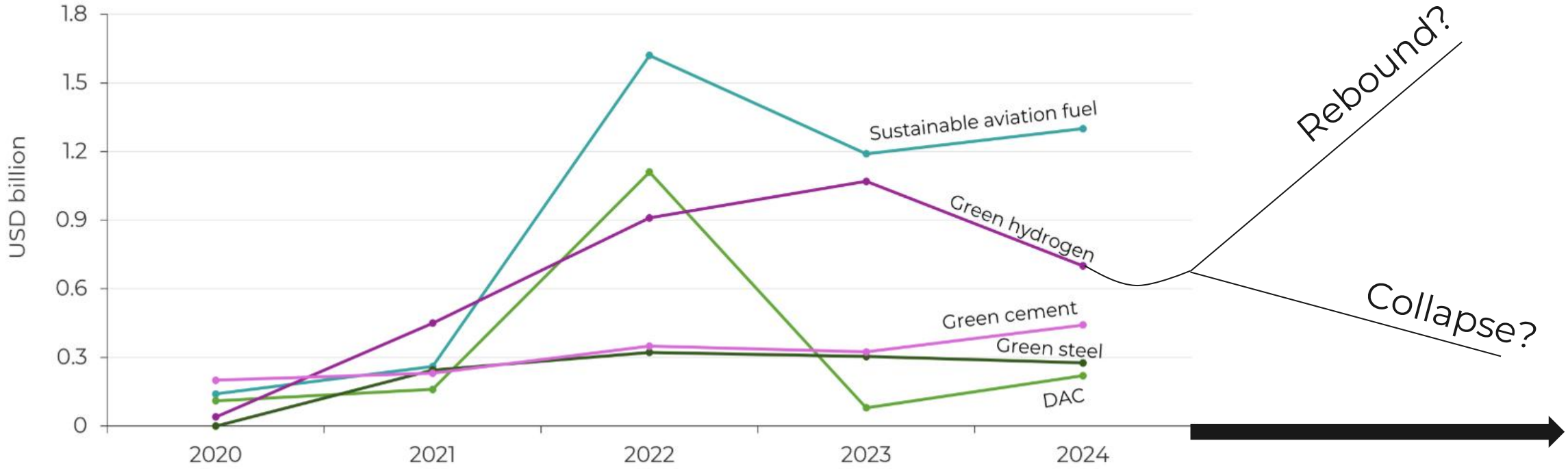
2010s
EVs

2020s
~~Heavy Industry?~~



Investments in “winning” tech are waning

With an unclear future, companies need to prepare for what’s next

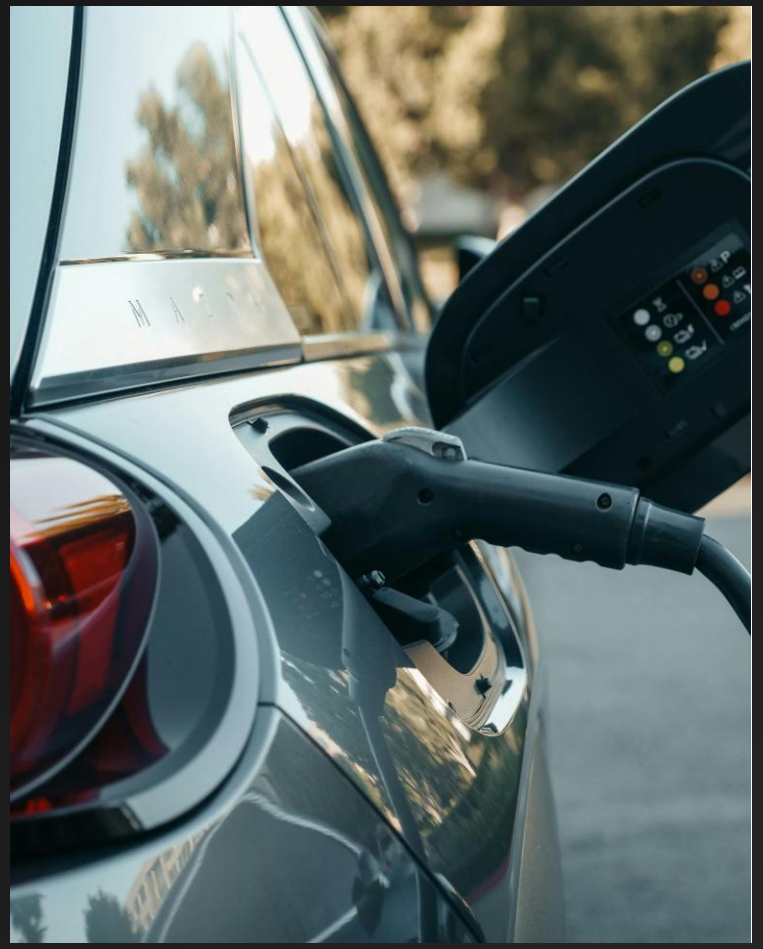


Source: Net Zero Alliance

What era of energy innovation are we in today?

2000s
Solar and Wind

2010s
EVs



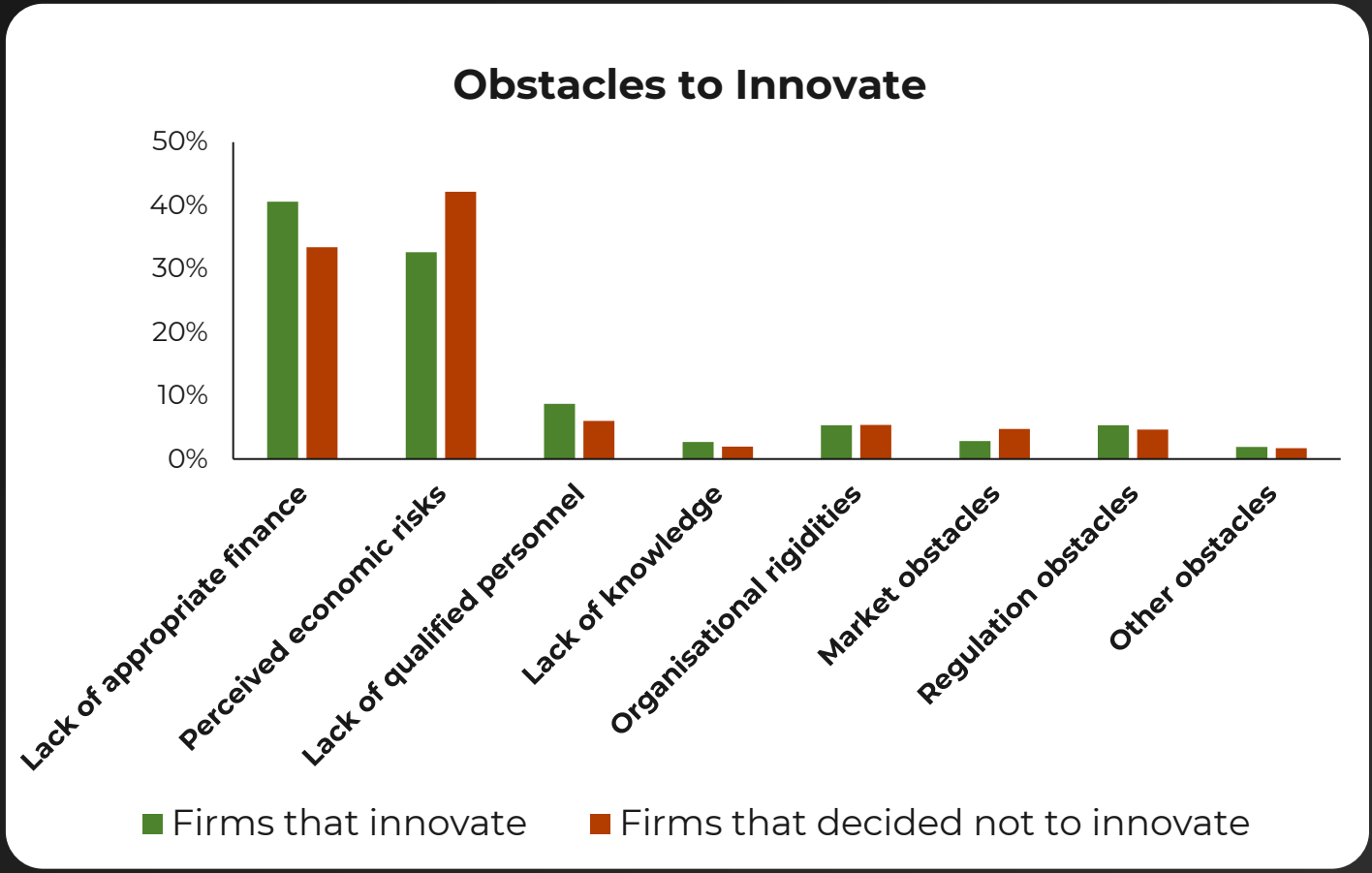
2020s
Uncertainty

An era of uncertainty makes all of the barriers to innovation harder

The barriers preventing companies from innovating are becoming more significant.

- Financial constraints are tightening.
- Economic and regulatory volatility are increasing.

Now, more than ever, it's important to make the right bets and be ready for when the innovation pendulum swings.



Agenda

01 | What is our current innovation era?

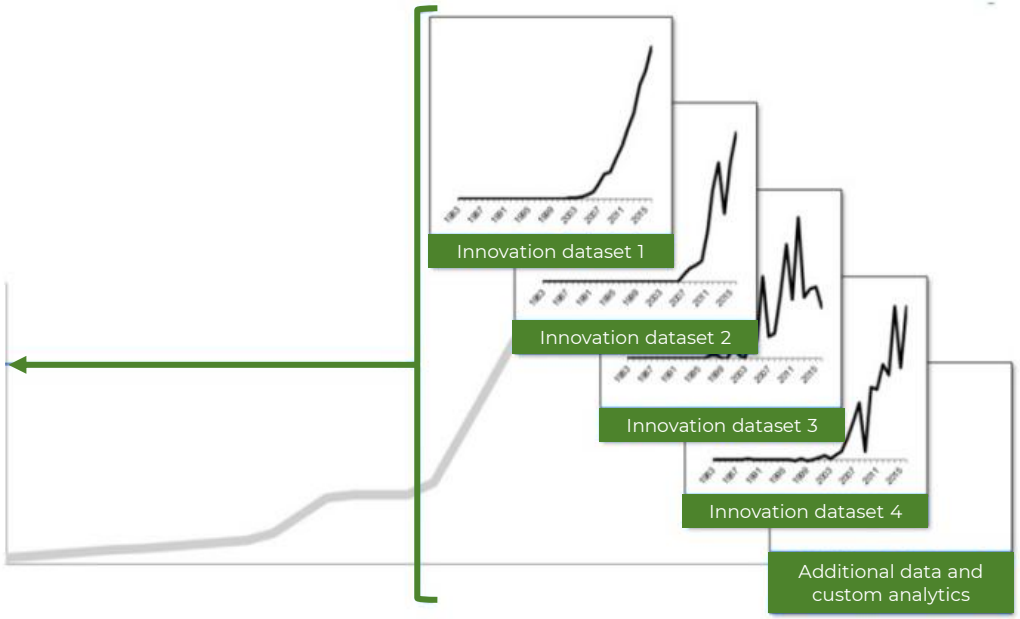
02 | **Using Lux's Tech Signal to predict innovation trends**

03 | Translating foresight into action

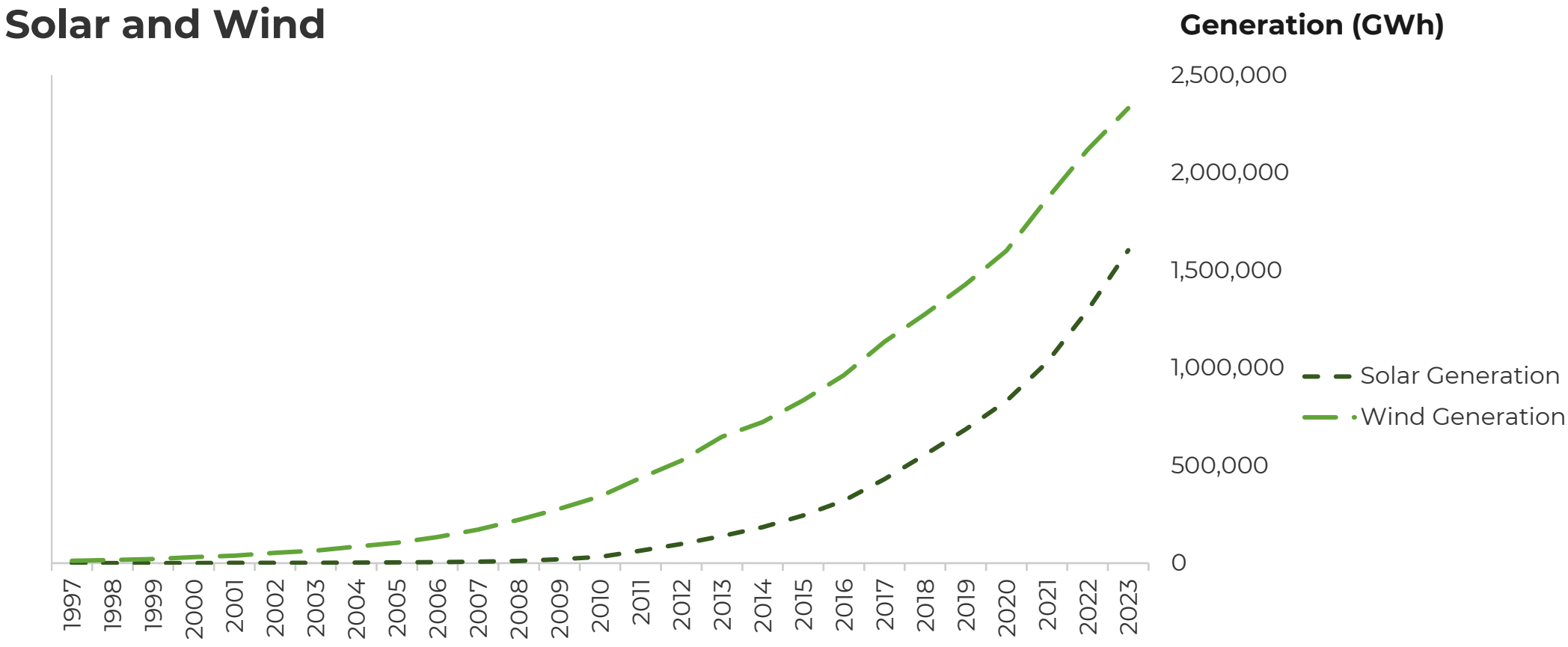
The Lux Tech Signal

The Tech Signal provides foresight into the future of innovation. It is:

- **Data driven –** A unitless innovation signal normalizes unique data sets .
- **Data backed –** It combines patents, academic publications, venture funding, early stage government funding, and Lux proprietary data.
- **Predictable –** It pinpoints early indicators of technology breakthroughs and bursting hype bubbles.

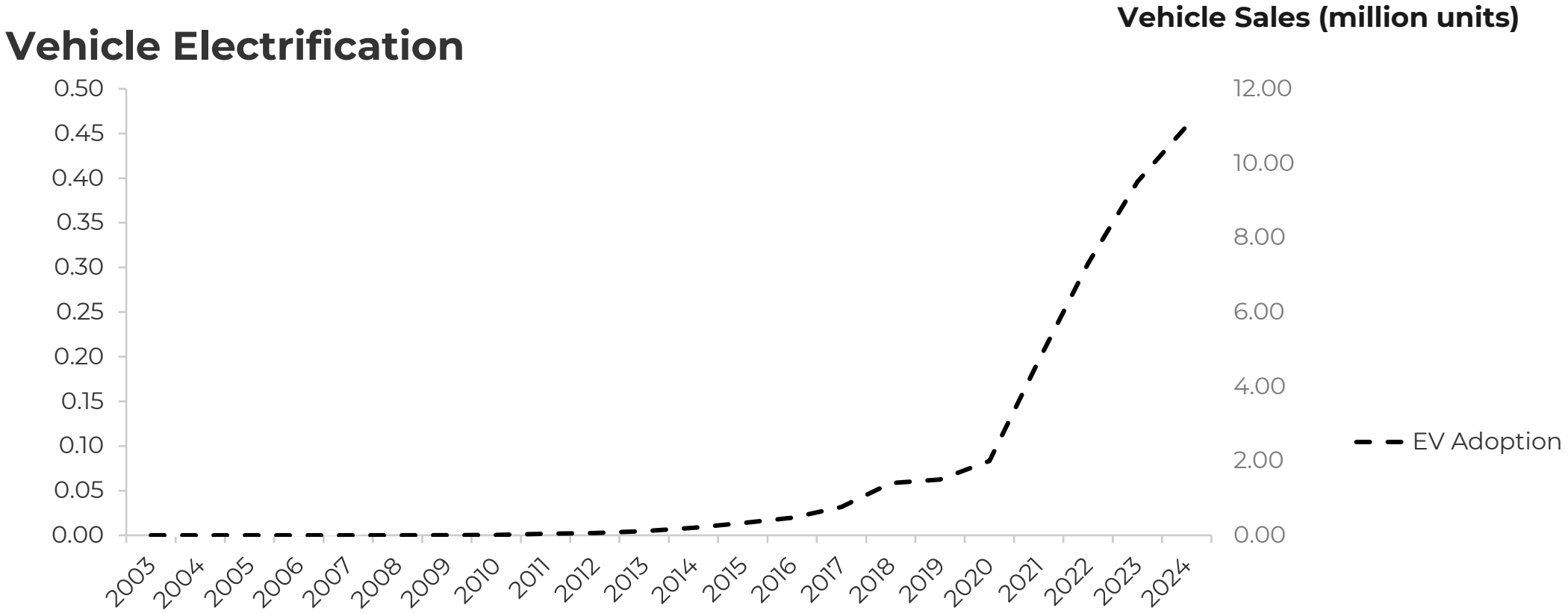


Wind and solar are the two largest sources of new capacity addition today

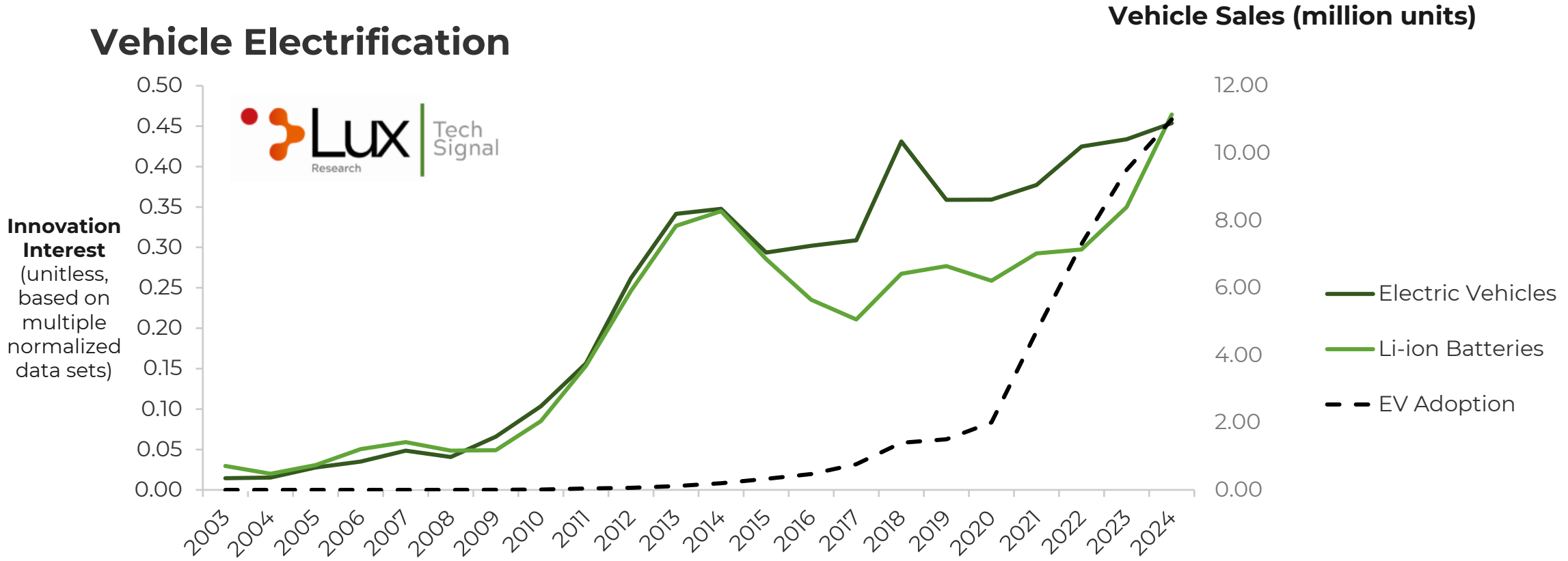


The tech signal provided an early warning that these technologies were ready to scale

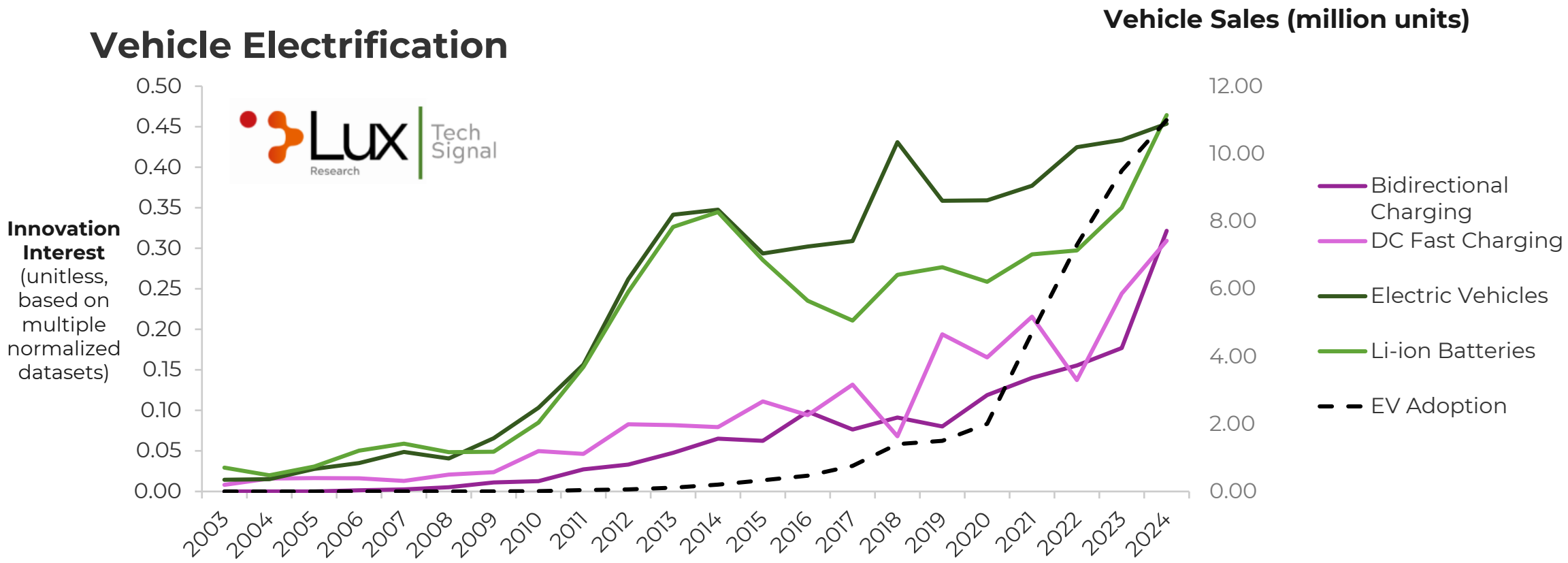
1 in 5 vehicles produced globally is now electric



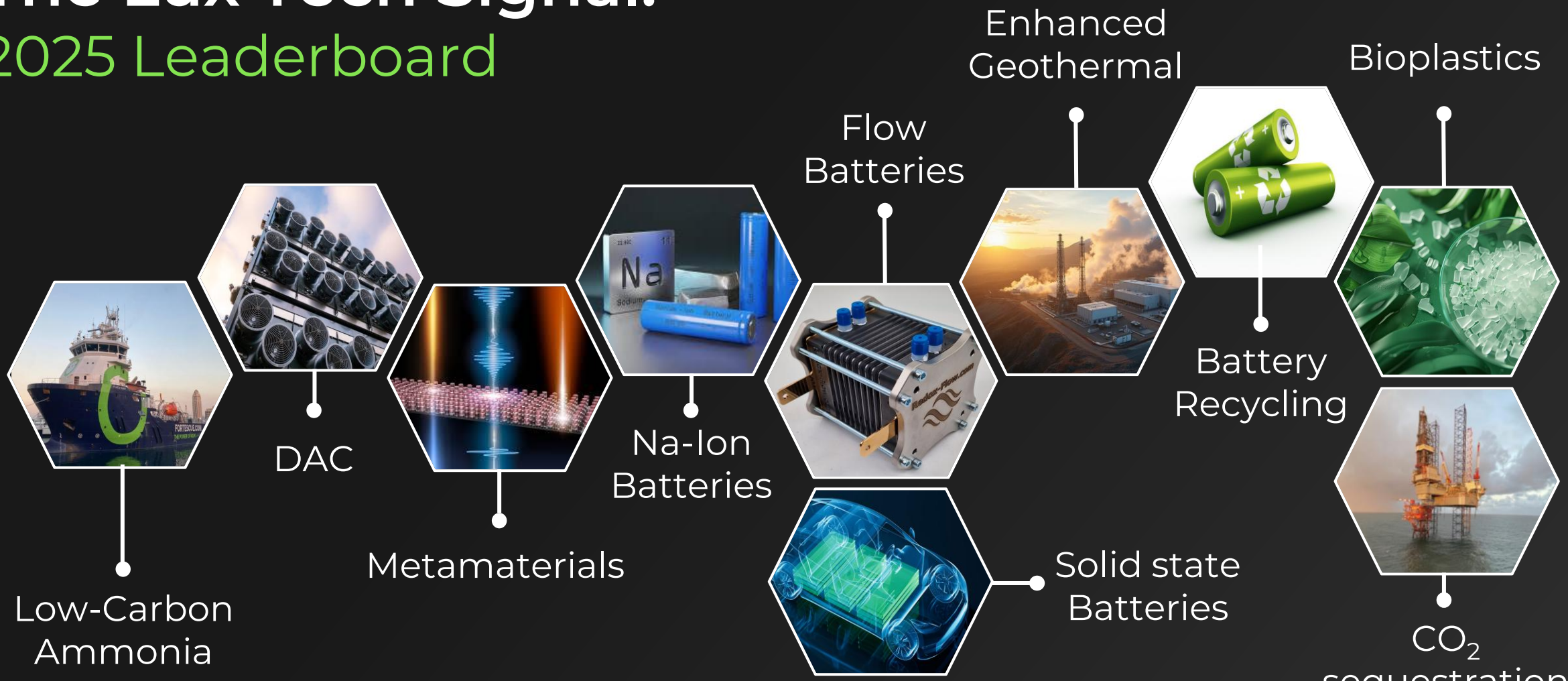
The tech signal for electric vehicles accelerated as adoption started



Supporting infrastructure is now on the rise, as EV sales grow



The Lux Tech Signal:
2025 Leaderboard



The Lux Tech Signal

Biggest jumps in 2025

Which technologies are rising today?

- AI-based technologies
- Membrane-related technologies
- Materials extraction and subsurface technologies

Large language models	↑ 96%
Multi-modal AI models	↑ 84%
AEM water electrolysis	↑ 78%
Membranes in direct air capture	↑ 109%
Materials informatics (polymers)	↑ 48%
Critical minerals extraction	↑ 51%
Solar PV recycling	↑ 53%
CO_2 sequestration	↑ 44%
Methanol to jet	↑ 119%
Seasonal thermal energy storage	↑ 189%

The Lux Tech Signal

What is falling today?

Falling innovation interest does not necessarily mean it is a poor technology.

- Innovation traction transforms into commercial traction
- Complex deployment with unclear benefits

Advanced closed-loop geothermal	↓ 36%
Liquefied hydrogen storage	↓ 20%
Pyrolysis for plastic recycling	↓ 22%
CO_2 electrolysis (ethanol)	↓ 20%
Industrial open-loop heat pumps	↓ 36%
Self-erecting wind turbines	↓ 31%
Novel reinforcement (composites)	↓ 24%
Ocean thermal energy conversion	↓ 27%
Pressurized water fission	↓ 19%
Li-ion anode material	↓ 13%

Deglobalized Transition

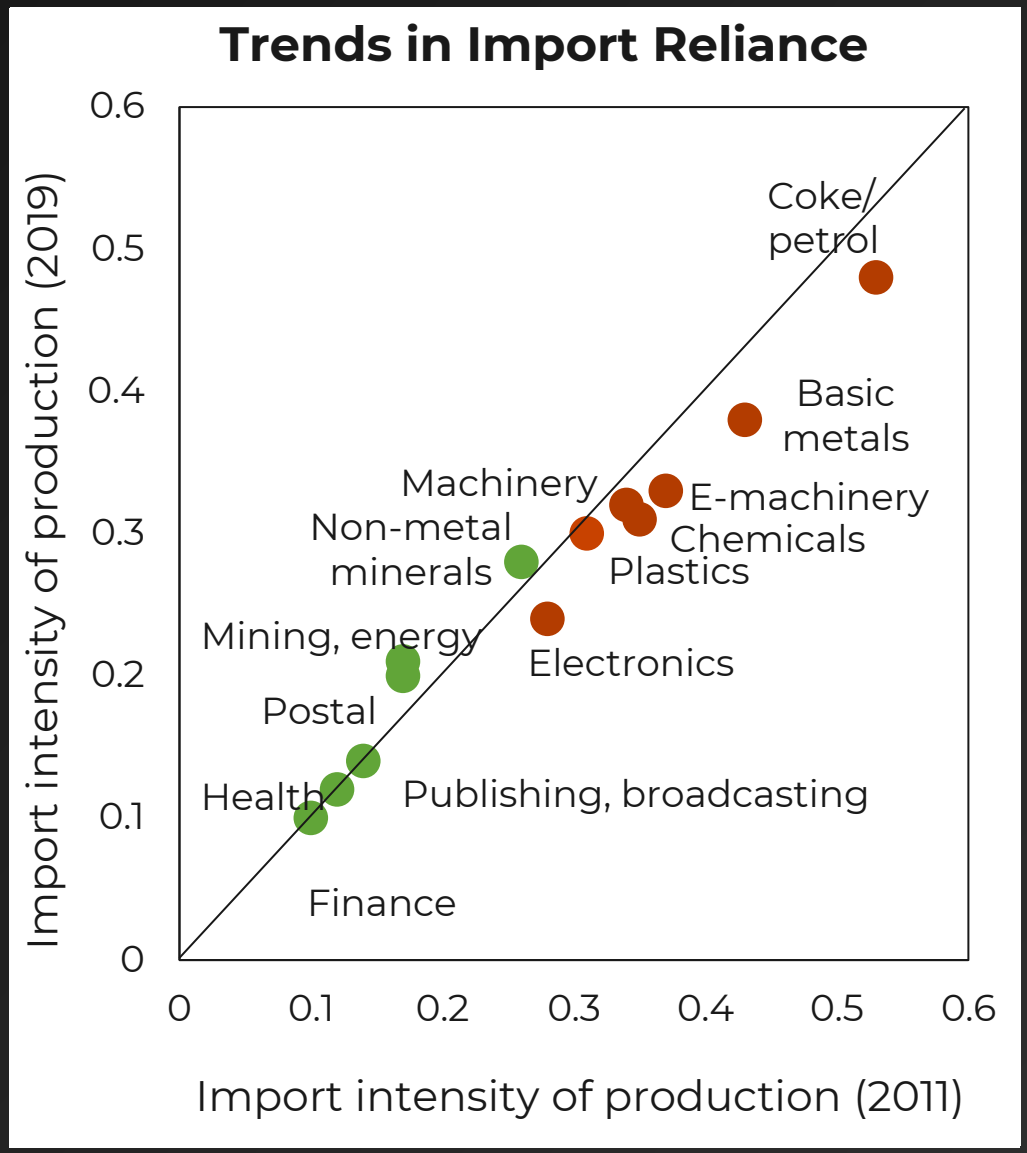
Electricity-constrained transition

Gas as the Backbone

Deglobalized transition

Decisions and technology adoption are driven by geopolitics and changing trade structures.

- **Resource independence** – Maintaining output is non-negotiable, making systems more feedstock flexible
- **Building industrial sovereignty** – Making new and stronger manufacturing facilities
- **Paying the Security Premium** – Shifting the positioning of the green premium
- **Expanding supply frontiers** – Looking to new terrains like space, deep seas, and arctics



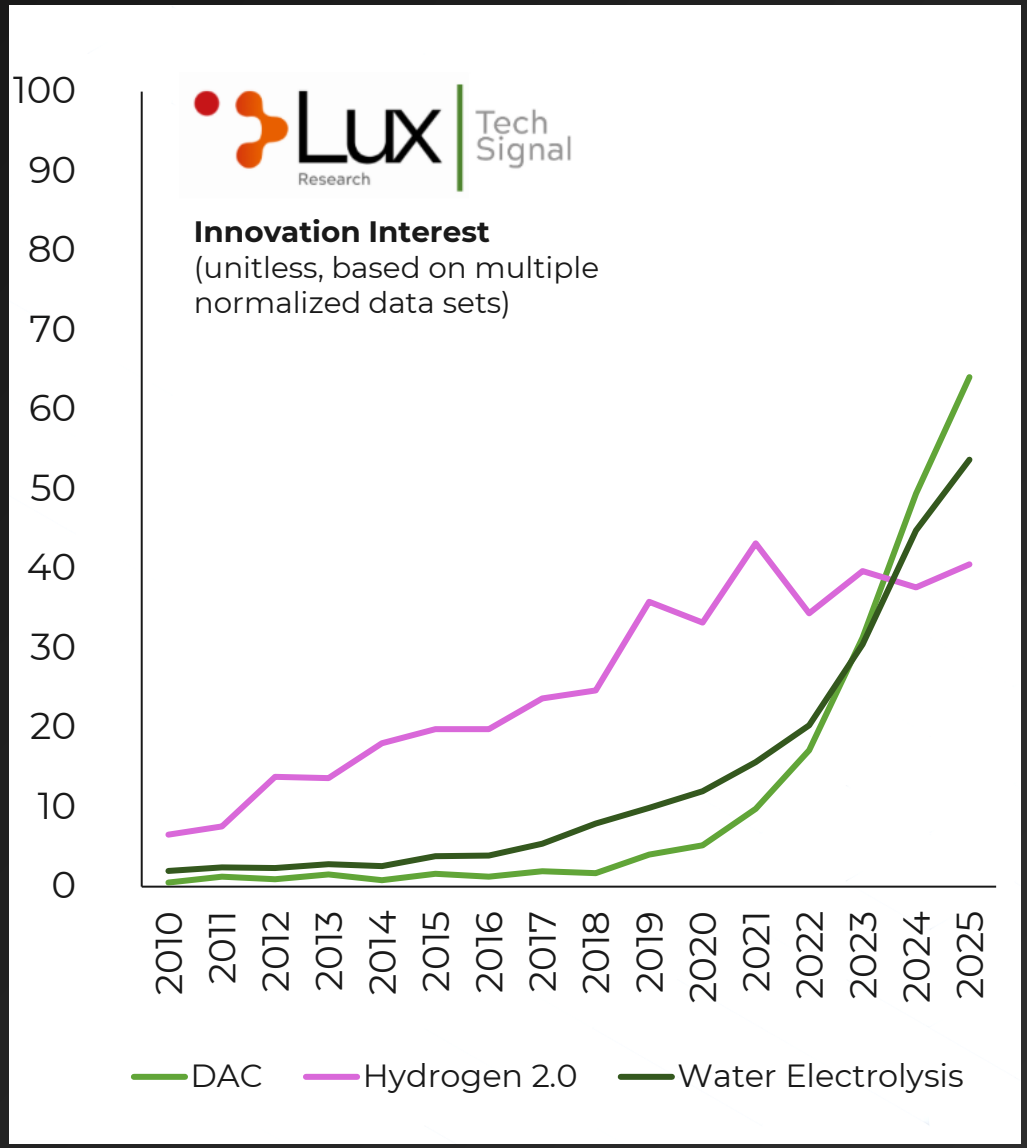
Source: OECD

Deglobalized transition

Paying the security premium

DAC and water electrolysis innovation has not faltered despite challenges in commercial deployment. Innovation focus is on capex optimization and revenue stream flexibility.

In addition to cost, deployment will be driven by timing, shifting narrative beyond net-zero.

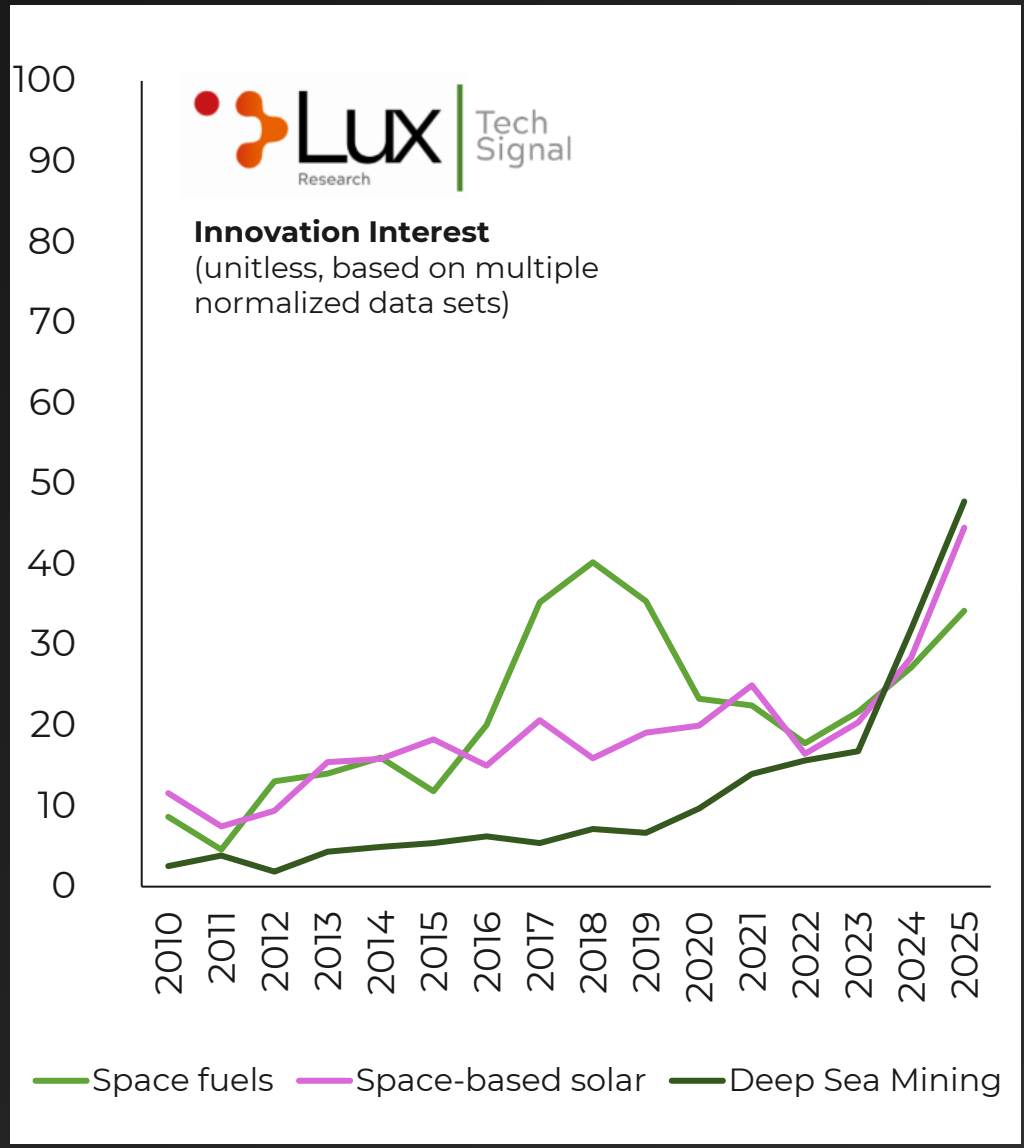


Deglobalized transition

Expanding supply frontiers

Push to sustain domestic PV and battery manufacturing without trade security.

Space and defense applications become a testing bed for novel technologies.



Tech innovation still accelerates in a cool market

Technologies lacking cost competitiveness will not be the norm in the absence of regulatory support.

Innovation can become commercially relevant if deglobalization (over net-zero) ushers regulatory support.

LUX TAKE

Companies should avoid overcorrection and continue monitoring innovations. As drivers for certain low-carbon technologies shift, project development may continue out of need for security.

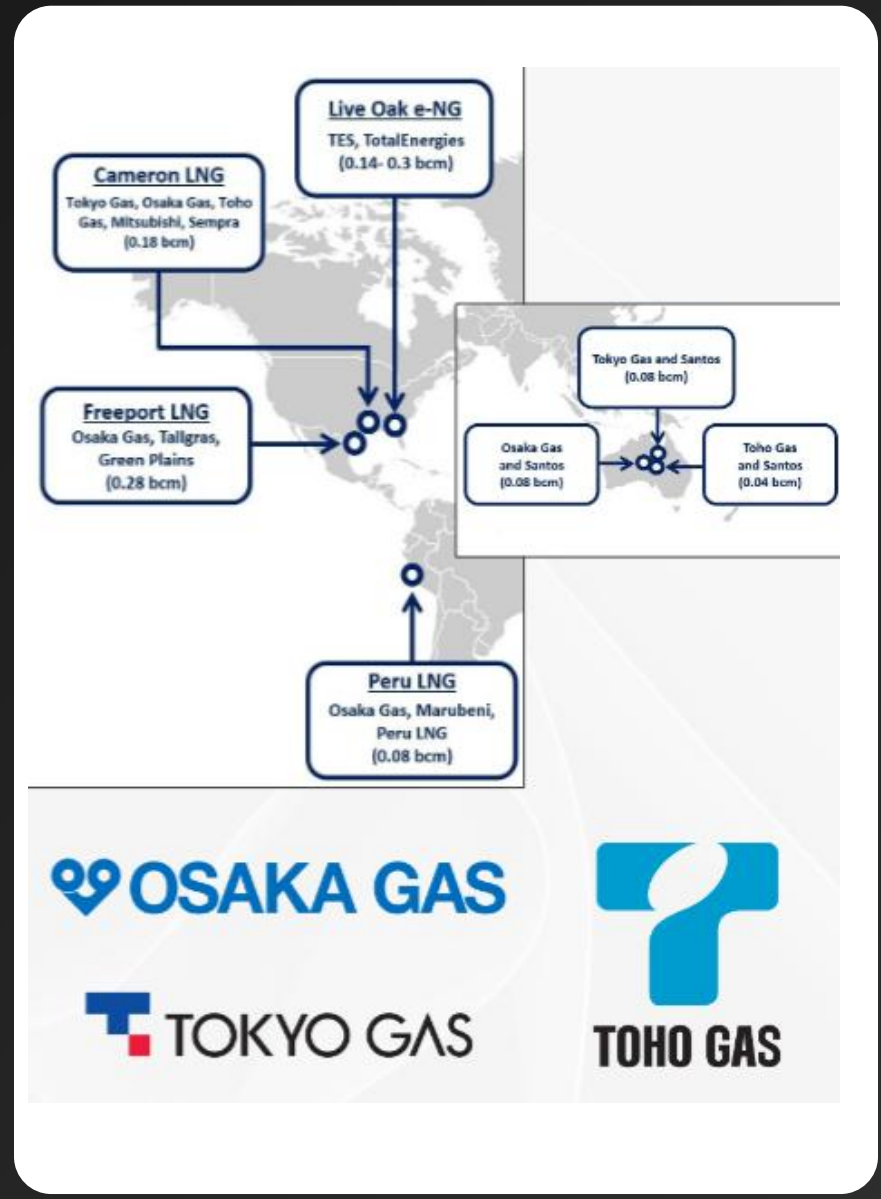
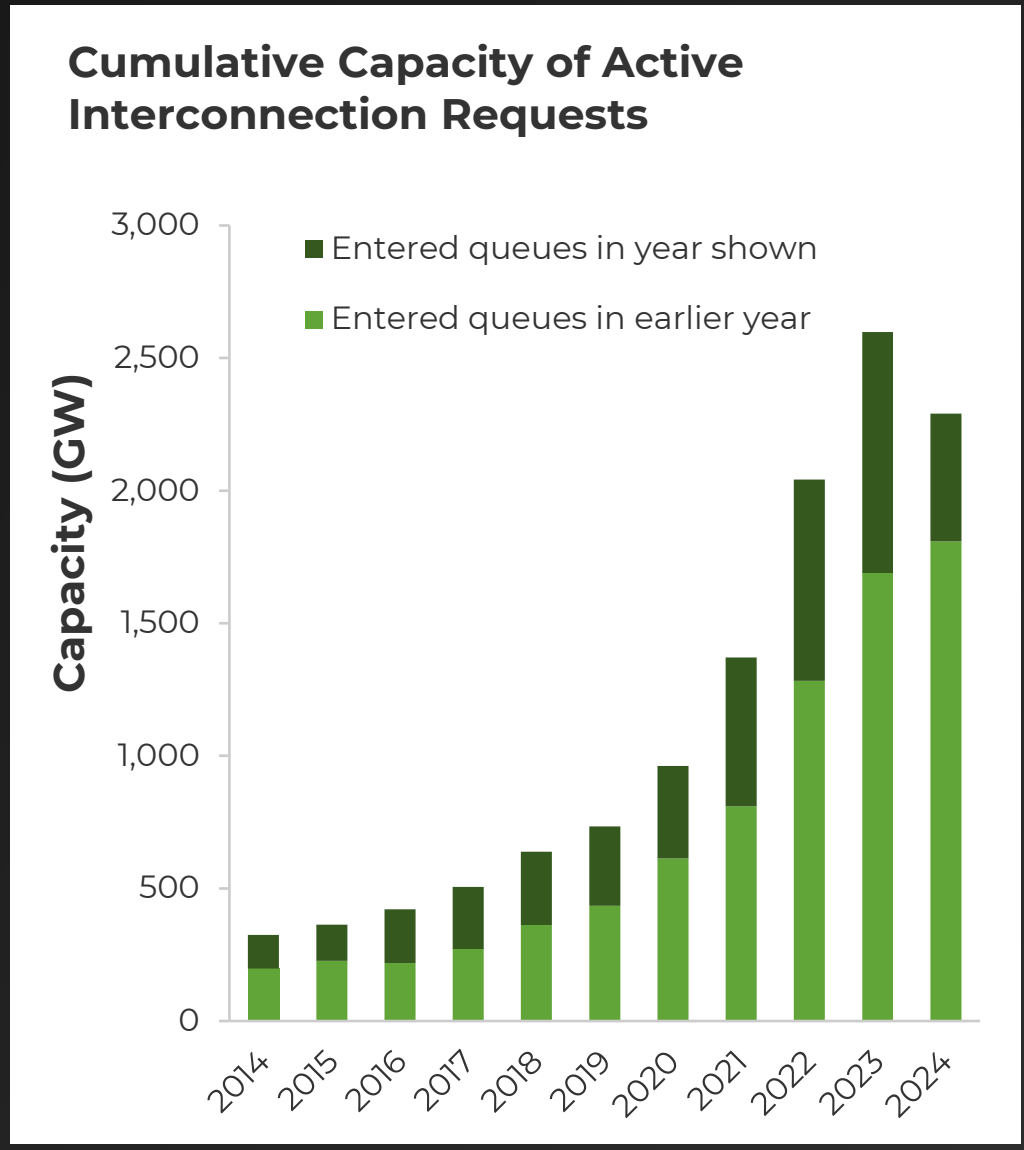


Image source: Energy security prompts Japan's extensive e-methane strategy

Electricity constrained

Access to electricity is constrained, resulting in rising costs and timelines to electrify processes.

- **On-site power and heat** – Microgrids with enough generation and storage can meet energy needs.
- **Latent grid capacity** –Unused capacity is available when demand is low.
- **Dense power generation** – Source of power generation can have high spatial density.
- **Novel pipes and wires** – High amounts of energy moves through existing rights of way.



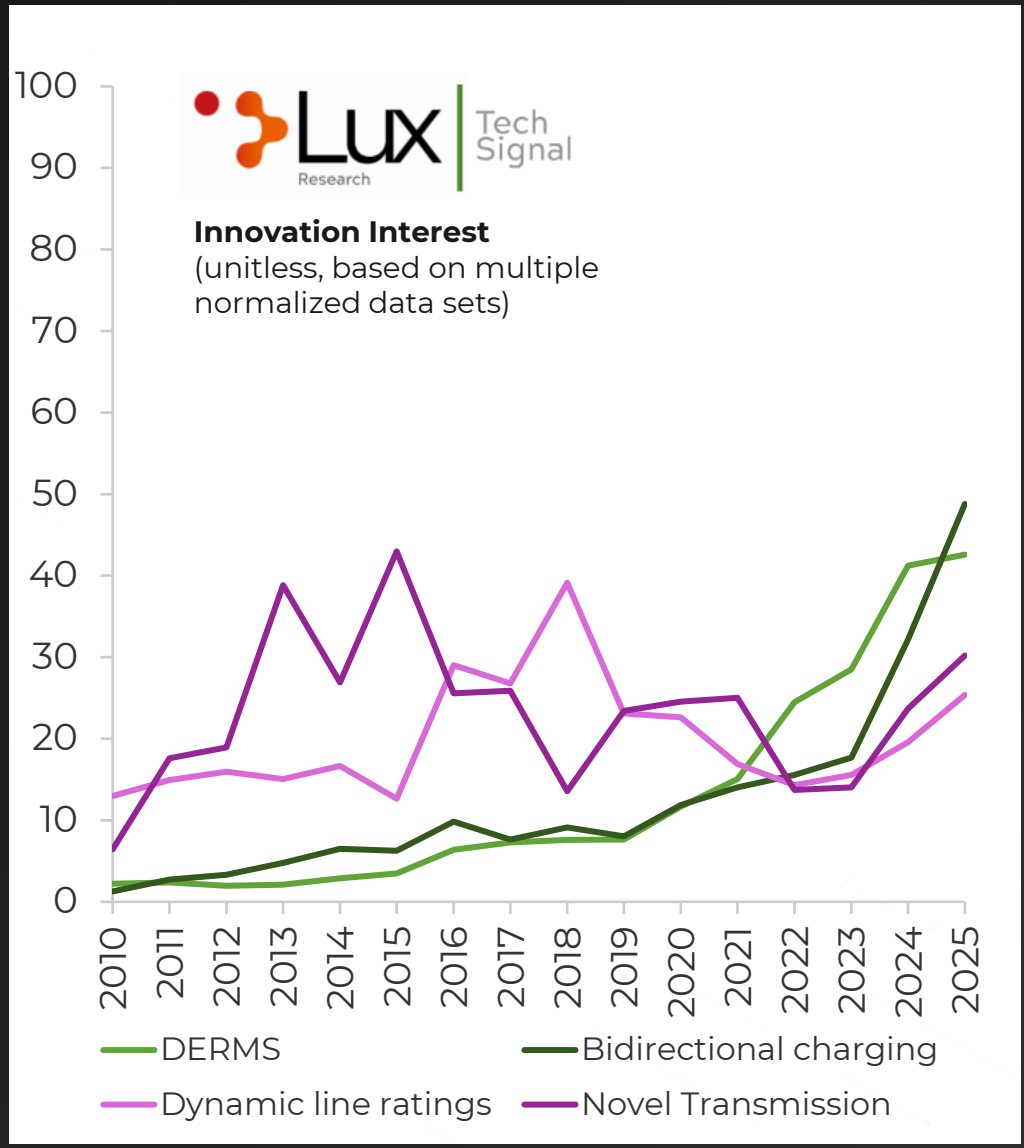
Data source: Lawrence Berkeley National Lab

Electricity constrained

Latent grid capacity

Load shifting unlocks capacity to enable new grid connections.

Novel transmission maximizes capacity through existing rights of way.

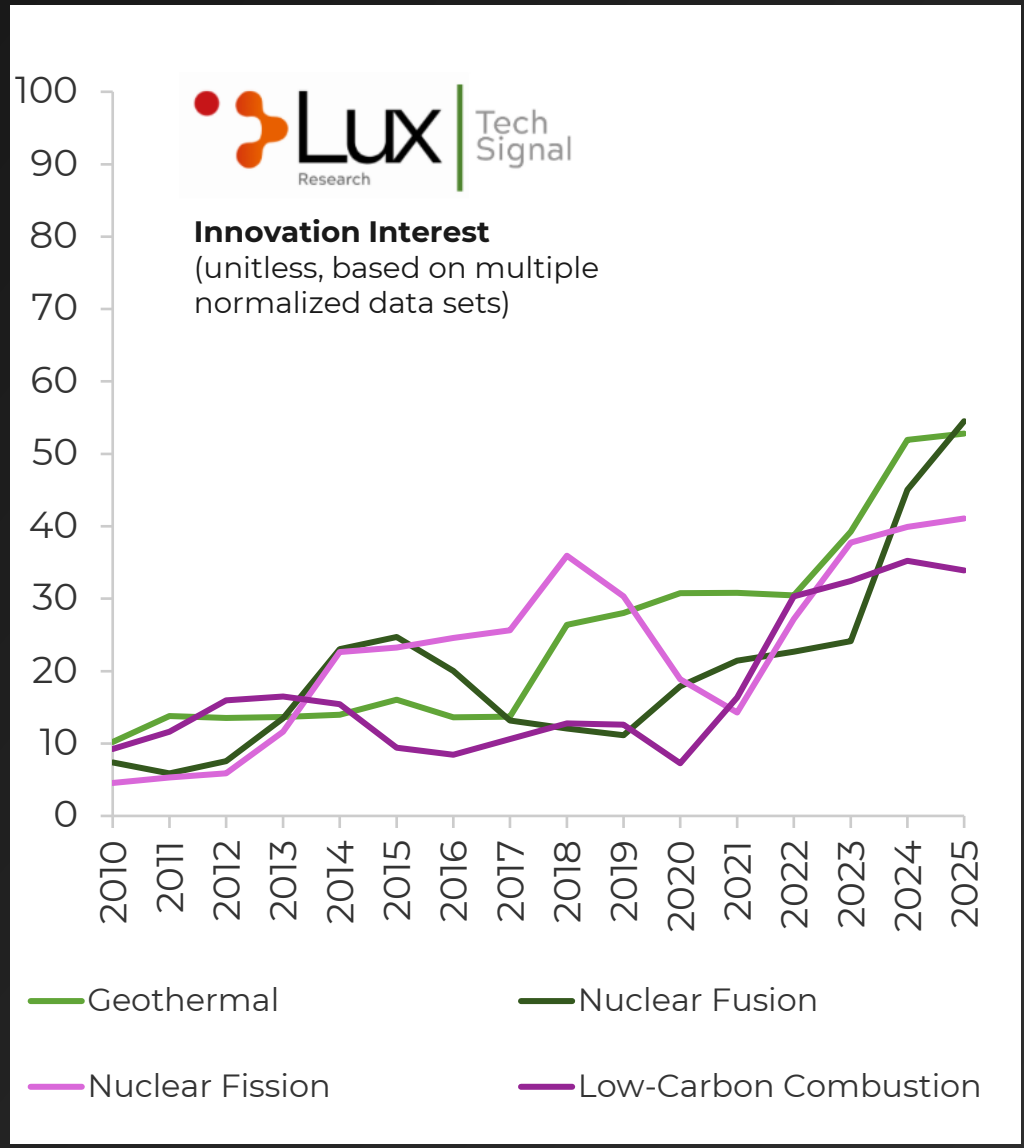


Electricity constrained

Dense power generation

Nuclear and geothermal power innovations can unlock new geographies.

Carbon capture solutions can keep existing thermal generation solutions relevant.



Flexibility will define innovation in power grids

Transmission is emerging as the biggest bottleneck to electrification today.

Watch for data centers to pave the way for how we build flexibility products for large loads.

LUX TAKE

Data centers will pioneer opportunities to manage large loads; residential batteries and EVs are the best assets for distributed flexibility.

Aligned's Hillsboro, OR, data center provides a good map for flexibility:

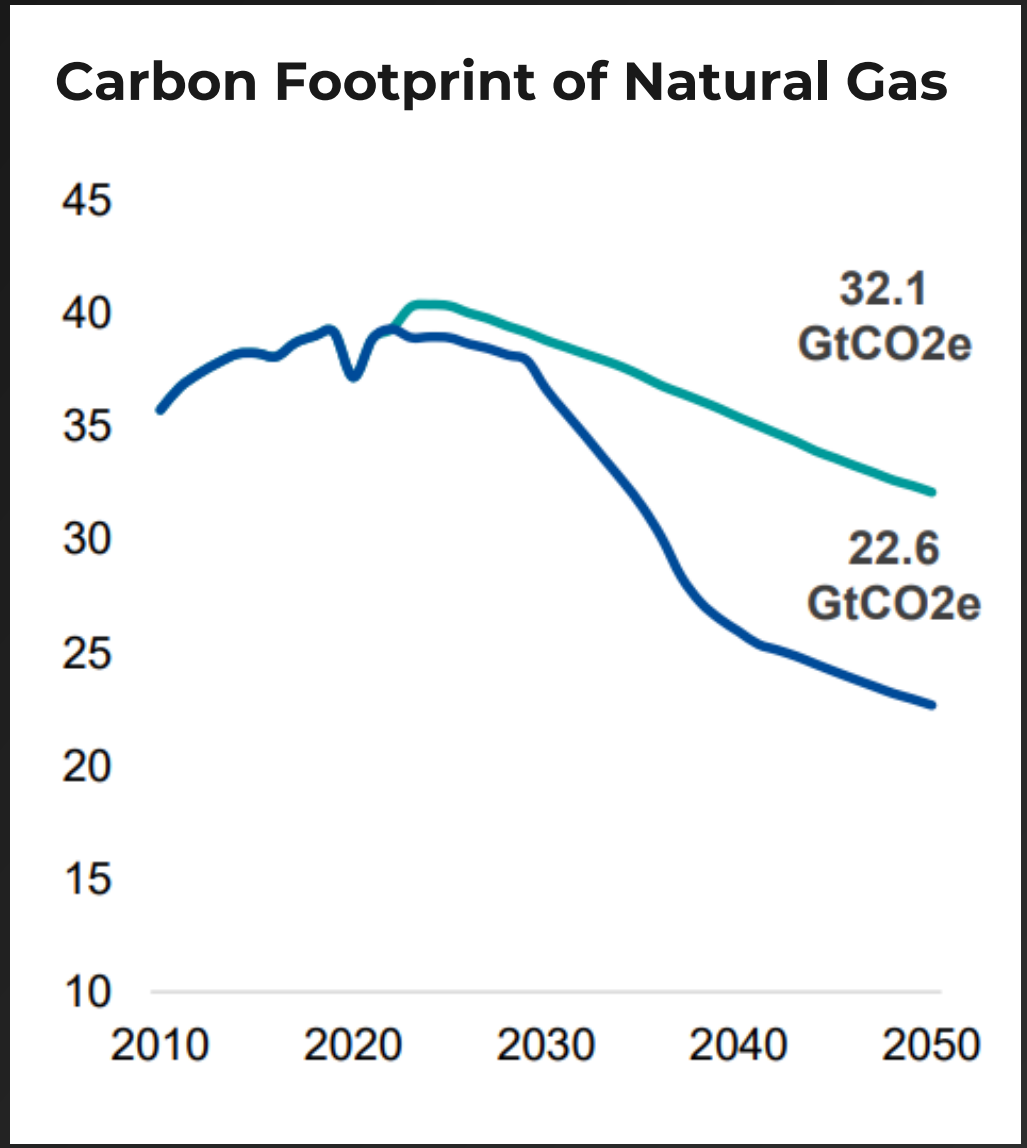
- Flexible interconnection
- On-site generation and storage
- Spatial flexibility

Image source: Aligned

Gas as a Backbone

Growing need for reliable and dispatchable power keeps natural gas at the core of the energy system

- **Clean: Decarbonize, not replace** – Reducing carbon footprint of natural gas
- **Move: Hyperconnected gas markets** – Exploiting distributed methane sources, increasing terminal productivity
- **Upgrade: Methane-to-Value platforms** – Producing chemicals and fuels from methane, in addition to blue molecules
- **Intelligent infrastructure** – Operating with precision, identifying inefficiencies and leaks



Source: Gas Exporting Ccountries Forum

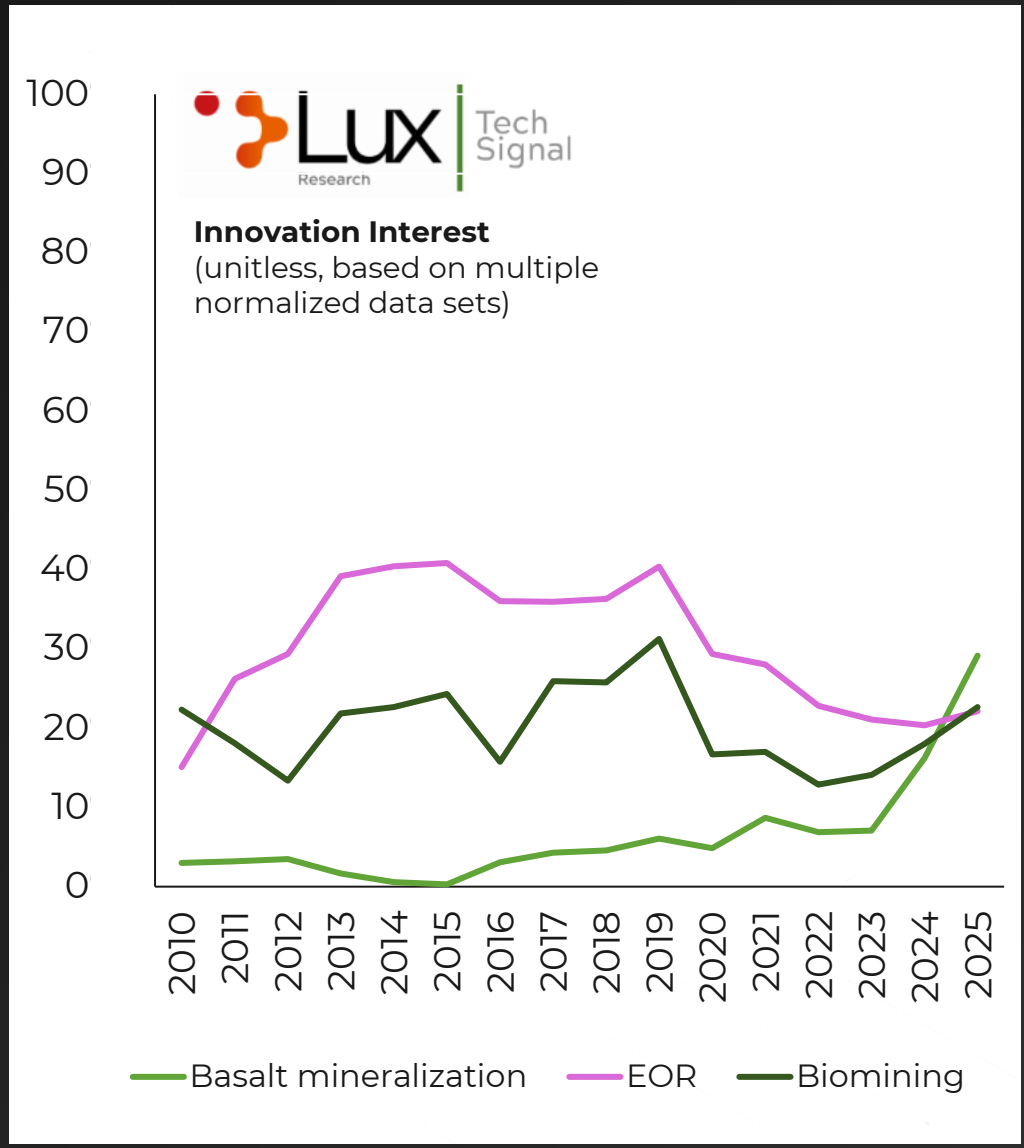
Gas as a Backbone

Innovations in subsurface

Basalt mineralization reduces monitoring timeline to 2–5 years.

Diversify CO_2 sequestration revenues by combining technologies:

- Decahydron: Geologic H_2 + sequestration
- Factor2: Geothermal power + sequestration

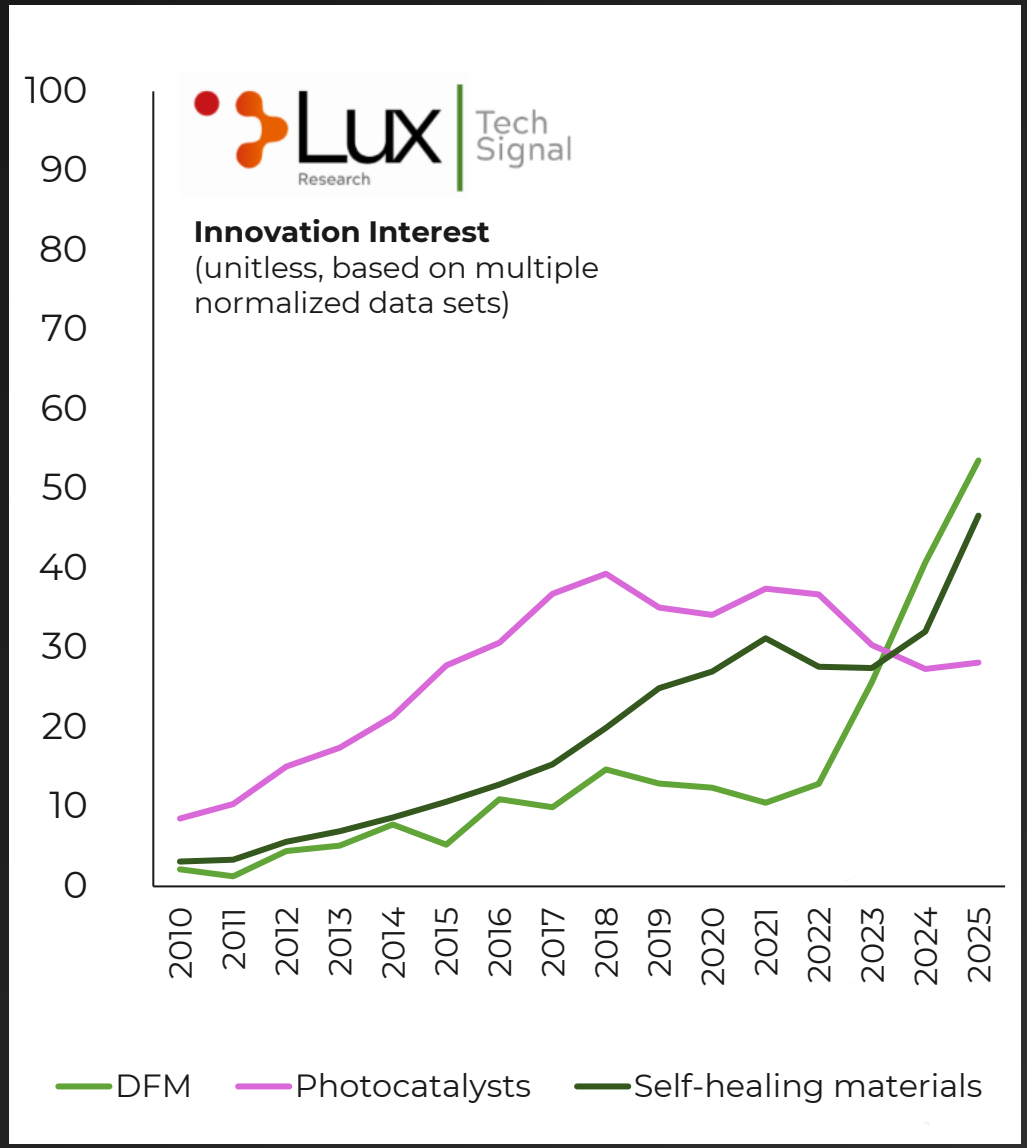


Gas as a Backbone

Materials for and from methane

Innovations in converting methane conventional derivatives of oil and CO_2, or bypassing intermediates.

Advanced materials and robotics systems for methane leak detection and automatic repair.



DFM, dual-functional material

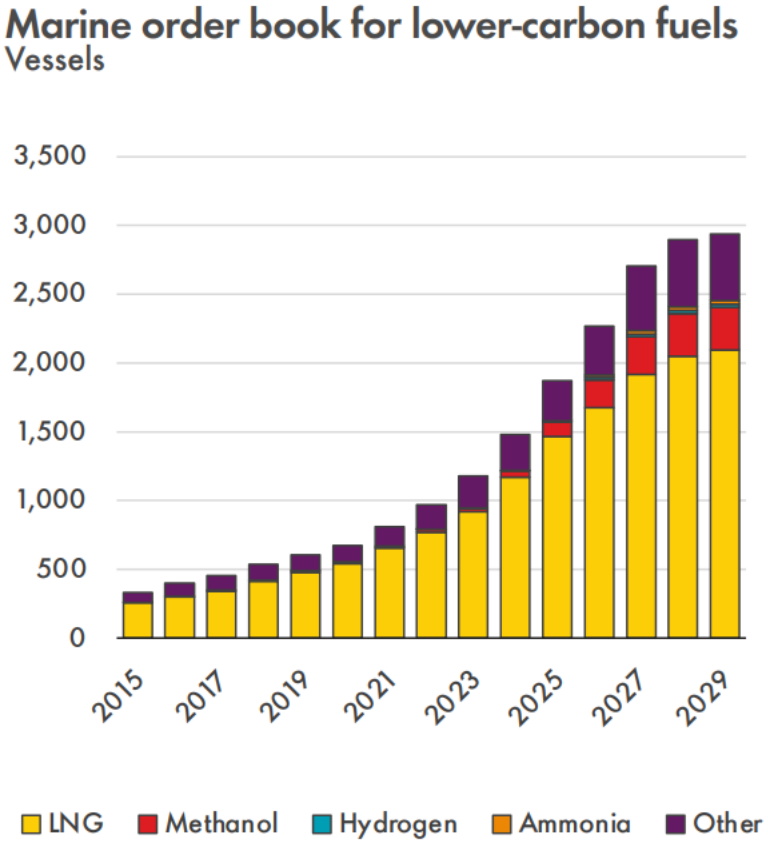
Finding a balance: Near-term wins and innovation

LNG is already an established transition fuel, but its lifetime can extend, making gas a continued profitable business for the next few decades.

Process intensification tools are necessary to boost efficiency and extract value from distributed sources.

LUX TAKE

A gas-dominant future is not synonymous with business as usual. There is room to improve operational efficiency, strengthen system integration, and diversify sourcing.



Source: DNV

All of these scenarios are simultaneously happening.

They manifest when the system is shocked

Agenda

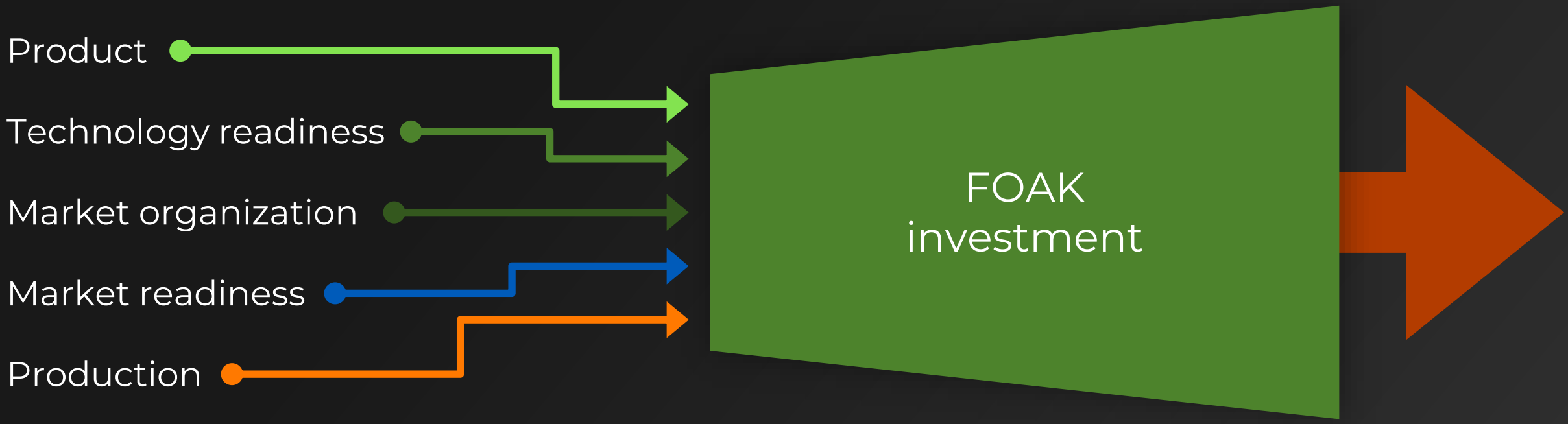
01 | What is our current innovation era?

02 | Using Lux's Tech Signal to predict innovation trends

03 | **Translating foresight into action**

You need a structured innovation process to navigate turbulent times

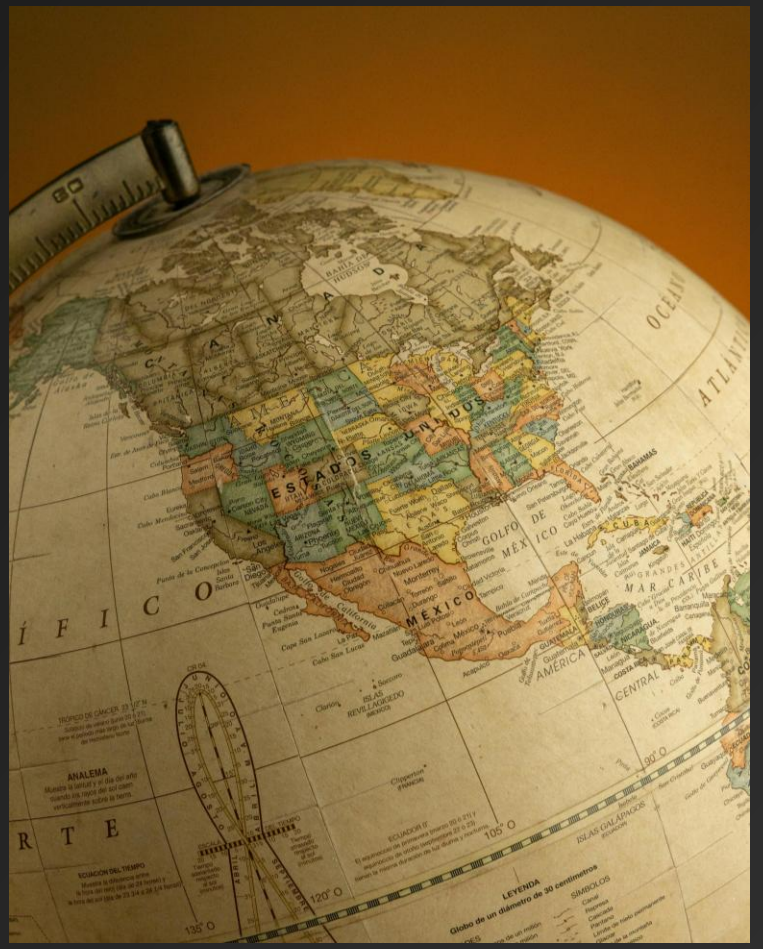
Consider five signals you should monitor as you scout for new technologies.



2010s
EVs

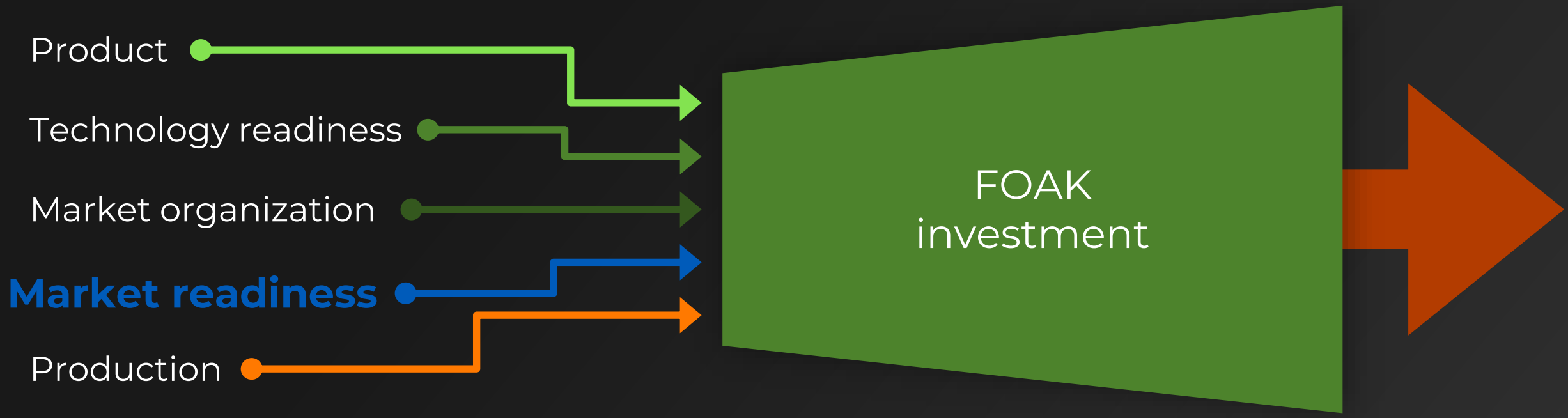
2020s
Uncertainty

2030s
Industrial Decentralization



These signals are trending favorably for large-scale decentralization

Volatility in prices for fossil hydrocarbons increases market readiness for the decentralization of industry.



Key Takeaways

1

We are in the era of uncertainty.

The energy system is experiencing shocks at an increasing frequency.

2

Uncertainty breeds change.

Watch for current uncertainty to translate into systemic changes that factor in hydrocarbon supply risk.

3

Energy security will shape innovation trends

Watch for the “security premium” to replace the “green premium”, and for governments to focus on energy security.

Thank you

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About Lux

Lux Research fuels innovators to not only imagine what's possible in the future but also operationalize innovation success in the near term. We deliver research and advisory services to inspire, illuminate, and ignite innovative thinking that reshapes and grows businesses. Using quality data derived from primary research, fact-based analysis, and opinions that challenge traditional thinking, our experts focus on finding truly disruptive innovations that are also realistic and make good business sense.

The "Lux Take" is trusted by innovation leaders around the world, many of whom seek our advice directly before placing a bet on a startup or partner — our clients rely on Lux insights to make decisions that generate fantastic business outcomes. We pride ourselves on taking a rigorous, scientific approach to avoid the hype and generate unique perspectives and insights that innovation leaders can't live without.

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