



Reframing Energy Security in the Clean Energy Transition under Cross-Border Risks and Solutions

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The SHIELD project



Safeguarding Ireland's Energy Transition against Critical Materials Supply Disruption and Geopolitical Dynamics

SHIELD Key objectives:

- Identifying global risks that may impact the resilience of energy system transition across energy security, affordability, and environmental sustainability.
- Mapping interactions between global risks, especially geopolitical conflicts and critical materials supply chain disruptions, and their effects on Ireland's energy system.
- Quantifying the impacts of the identified global risks on energy supply and demand in Ireland.
- Analysing vulnerabilities and uncertainties related to critical materials supply disruptions and their effects on Ireland's energy transition.
- Identifying potential risk mitigation solutions that could strengthen Ireland's energy resilience. This includes exploring the benefits and trade-offs of electrification, diversifying, interconnection, storage, and demand-side solutions.
- Assessing potential solutions for building a resilient energy system and prioritise actions to secure energy, ensure affordability, and mitigate environmental impacts
- Assessing the implications of regional and global disruptions in energy imports on Ireland's energy security.

Qualitative appraisal



1. Bibliometric: to capture general trends in the literature;

&

2. Systematic Review: Examine and synthesise themes in depth.

Qualitative appraisal



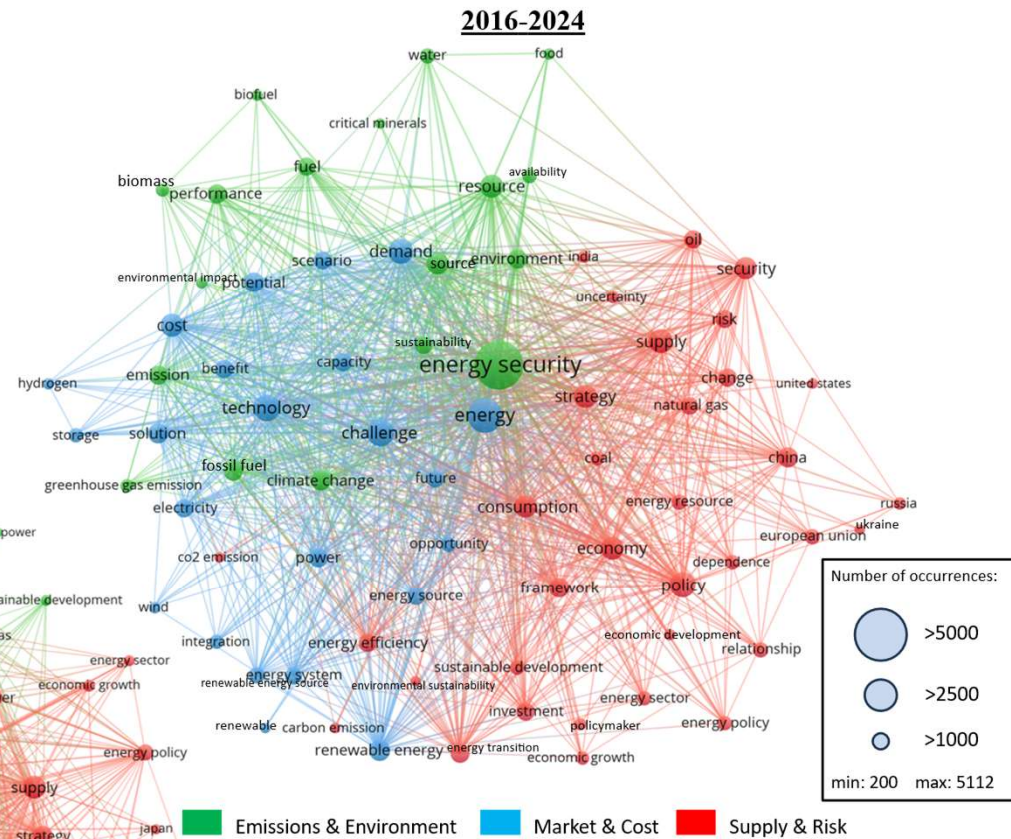
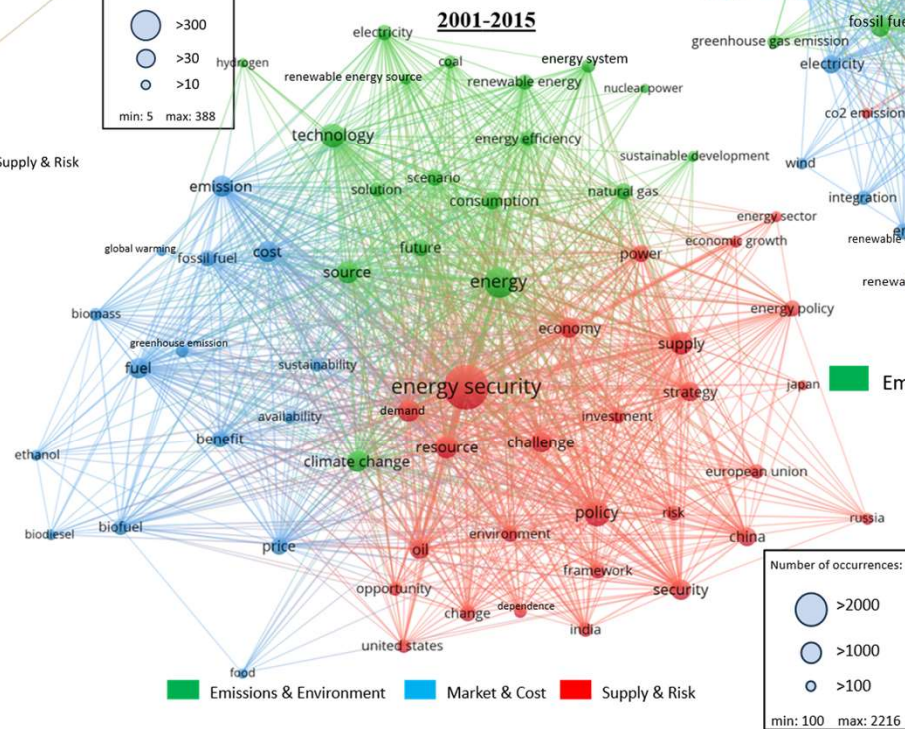
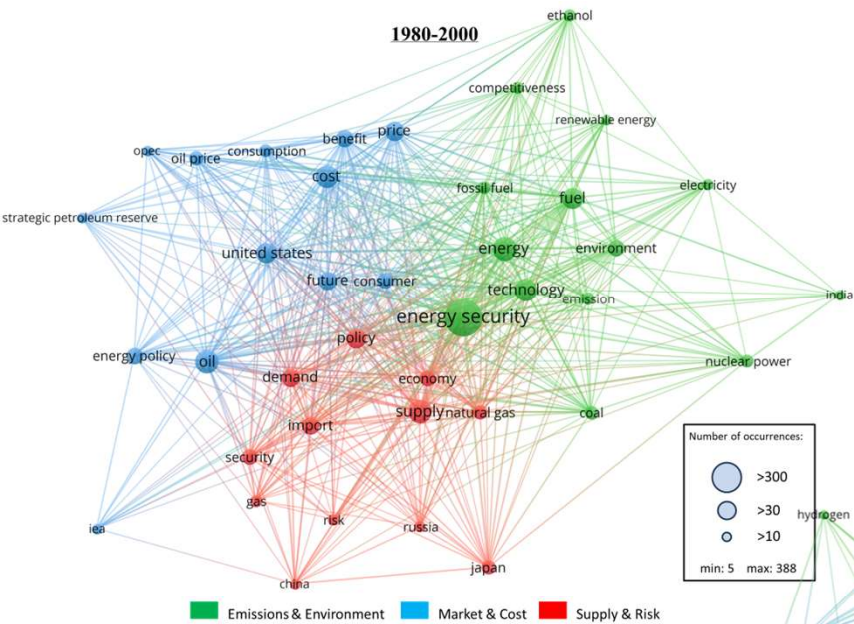
Search strategy and final sample of the bibliometric analysis

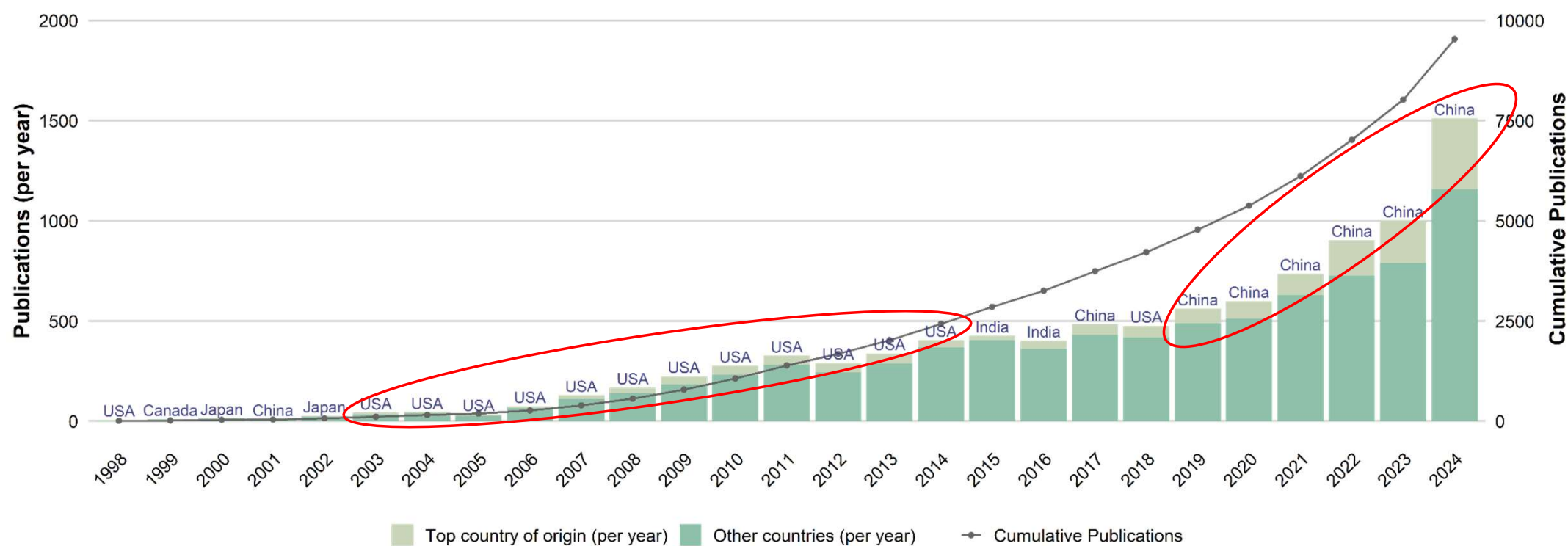
Search	Search string	Studies retrieved	Publication years
1	“energy security”	9,624	1980-2024
2	“energy security” AND “energy system*”	1,017	1985-2024

Before 2000s

Up to Paris Agreement

After Paris Agreement





Qualitative appraisal



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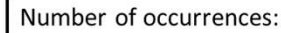
india



3	
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1,017 documents in Scopus

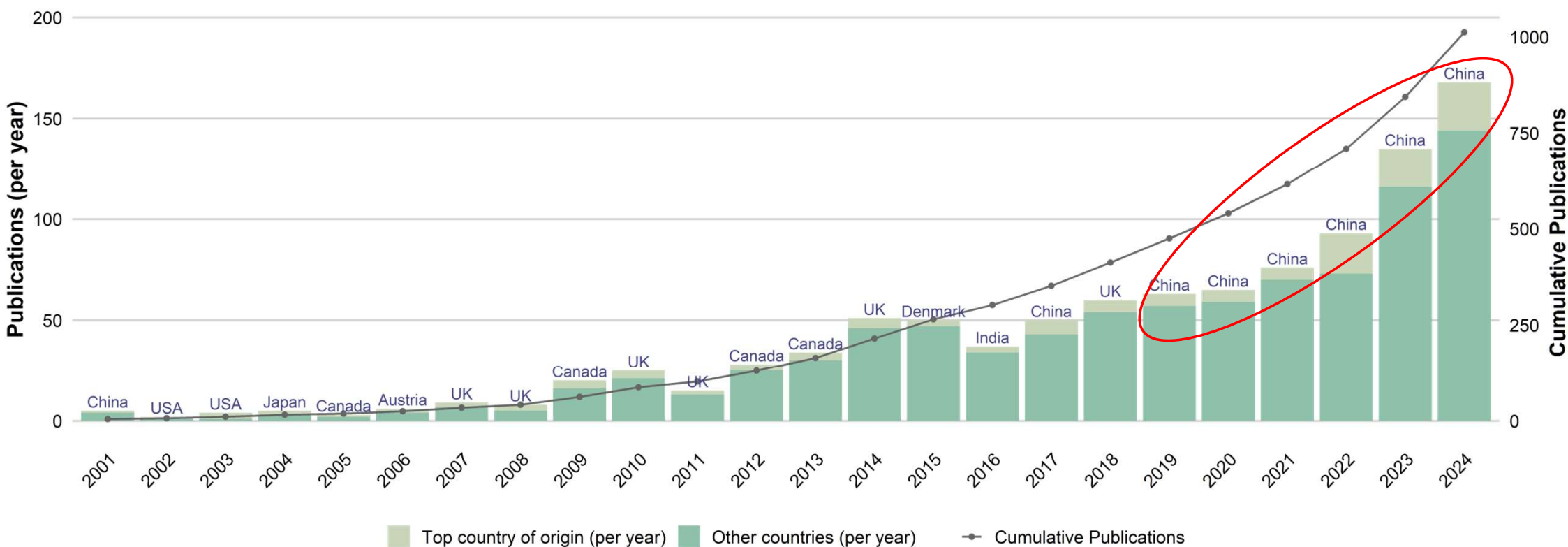


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Qualitative appraisal



1. Bibliometric: to capture general trends in the literature;

&

2. Systematic Review: Examine and synthesise themes in depth.

Systematic Lit. Review



Search string:

"energy security" OR "security of" AND "energy system*" AND ("model*" OR "analy*" OR "measur*" OR "quant*")

Filters: Energy security only on the title; Only Articles. Source type: only journal publications. Only papers written in English.

Inclusion Criteria: Studies that measure energy security in vital energy systems by conceptualizing it as **low vulnerability**, where vulnerability is defined as a function of both exposure to risks and the energy systems' resilience (Cherp and Jewell, 2014; Cherp et al., 2016; Kosai & Unesaki, 2024).

Exclusion Criteria 1: Studies that measure the resilience of vital energy systems but do not measure exposure to risk.

Exclusion Criteria 2: Studies that measure the exposure to risk in vital energy systems but do not measure resilience.

Exclusion Criteria 3: Studies that do not measure exposure to risk or resilience.

Exclusion Criteria 4: Studies that use a dimension approach with a complex energy security index that do not allow for an analysis of vulnerabilities (Kosai & Unesaki, 2024).

Systematic Lit. Review

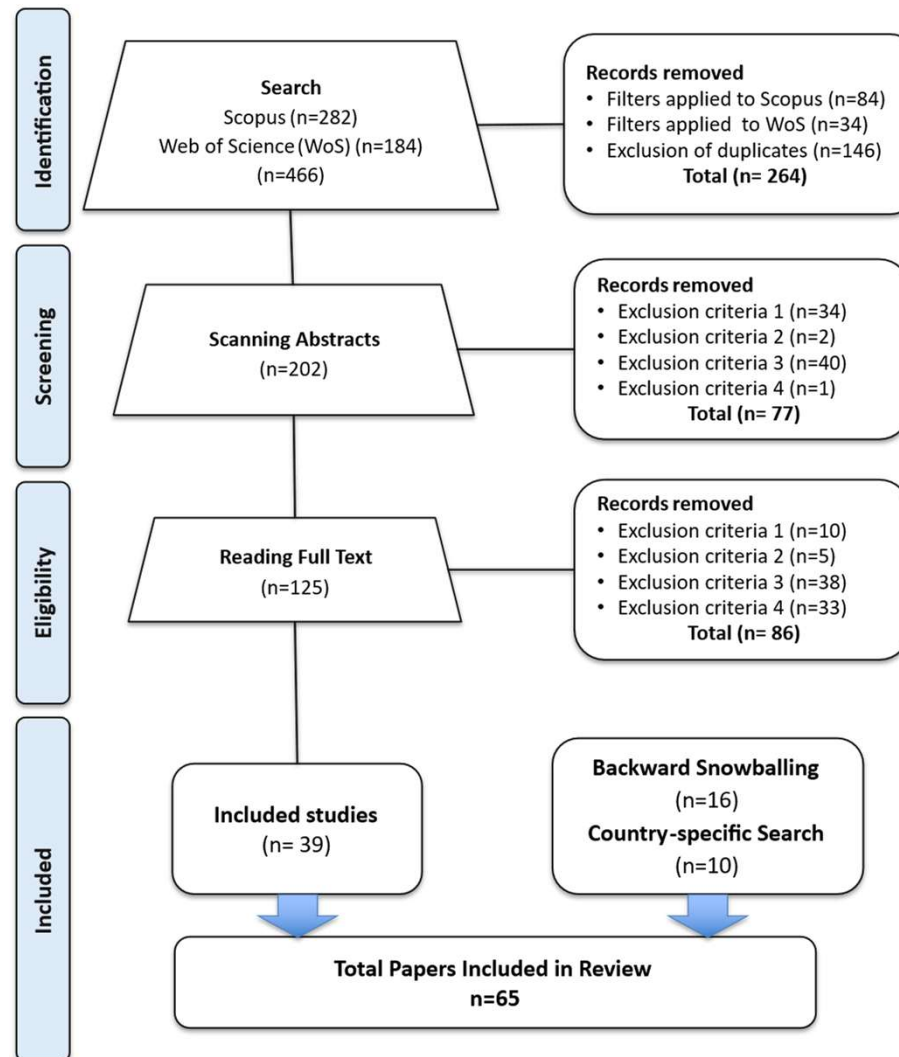


Table 3. Reviewed studies

Study region and citation	Energy focus	Time period	Strategy	Key Indicators
Global [21]	Fossil fuels, materials	2000-2100	Diversifying both fossil and metal supply chains, integrating critical minerals into energy planning, strengthening midstream processing capacities, and managing the material-intensive low-carbon transition.	- Supply concentration (HHI) of materials and fossil fuels - Demand in the energy mix
Global (focus on Europe) [22]	LNG	2040	Diversifying LNG suppliers, relying on a mix of long-term and flexible short-term contracts, and maintaining domestic natural gas production with CCS.	- LNG import volume and costs - Diversity of LNG suppliers - Domestic supply
Global [23]	Biomass, electricity	2020-2100	Maximising domestic forest biomass production, participating in international trade, and using BECCS to reduce fossil fuel dependence.	- Biomass import share - Diversification of the electricity mix

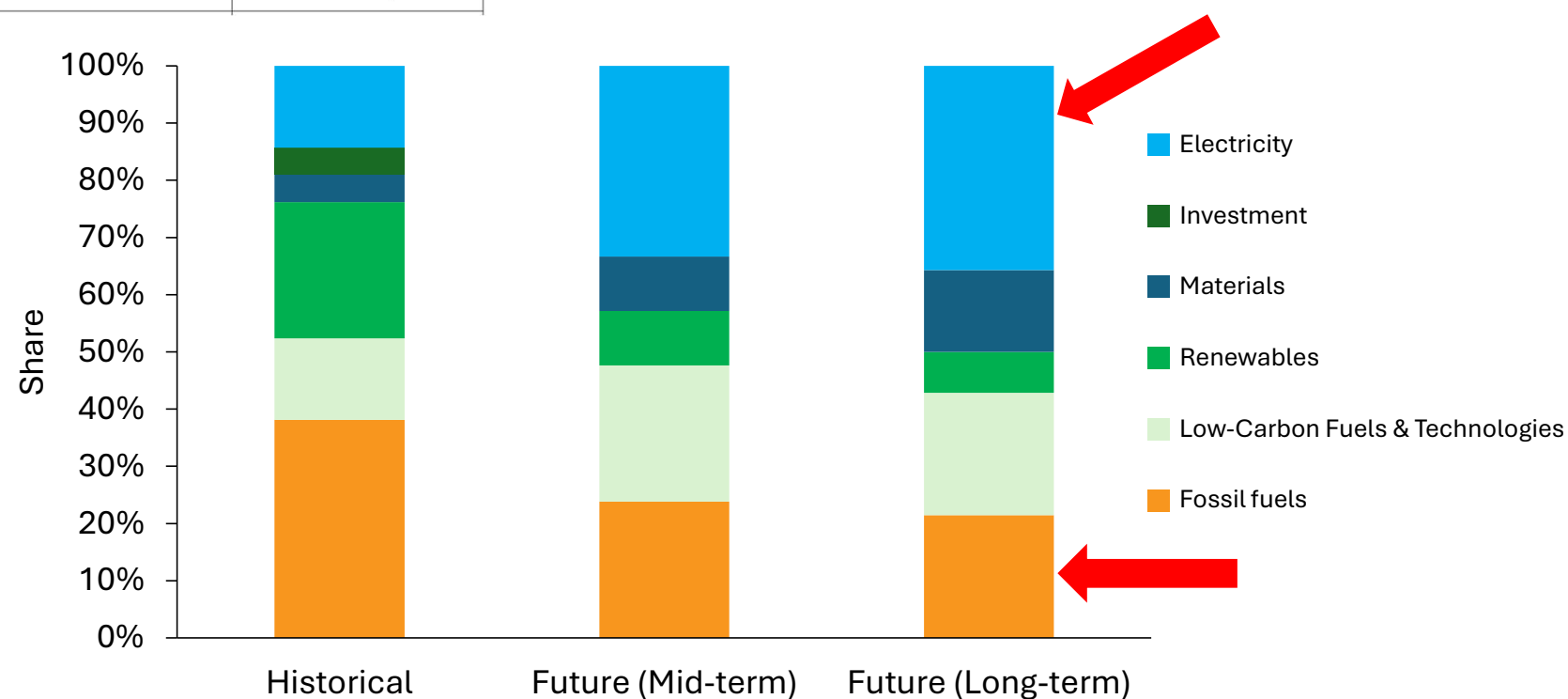


Figure 6. Shifts in energy security focus in studies by timeframe.

Table 4. Cross-border risks.

Risk	Cross-border element discussed
Geopolitical	Disruptions to international trade of energy commodities, critical materials, and technologies caused by geopolitical instability, conflicts, and diplomatic tensions; exposure to global price shocks and supply shortages.
Financial	Cross-border financial exposure from stranded fossil-fuel assets, lock-in costs, and consequent constraints on investment flows; and financial-market interdependence and spillovers through which energy price and market shocks propagate across economies.
Technological	Dependence on international knowledge spillovers, foreign technology supply, and cross-border investment for innovation, cost reductions, and deployment of low-carbon energy technologies; risk of technological lock-in.

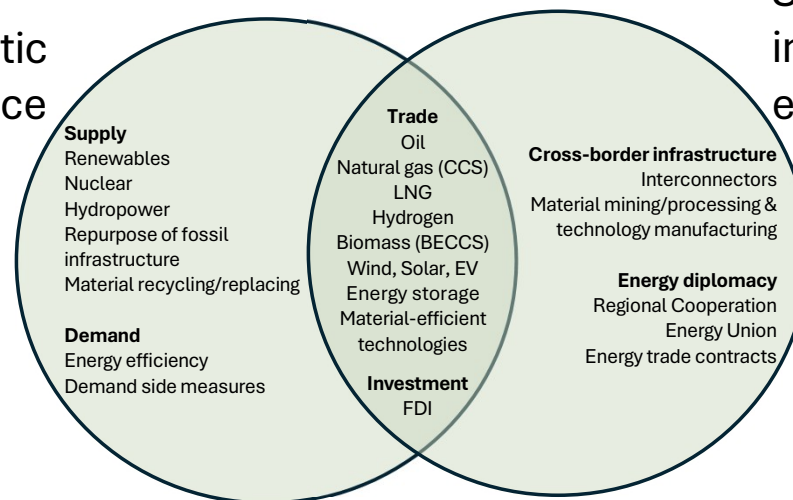
WHAT THE LITERATURE SHOWS

Geopolitical shocks affect trade, prices and supply

Financial exposure affects investment capacity and transition costs

Technology dependence creates new vulnerabilities and lock-in

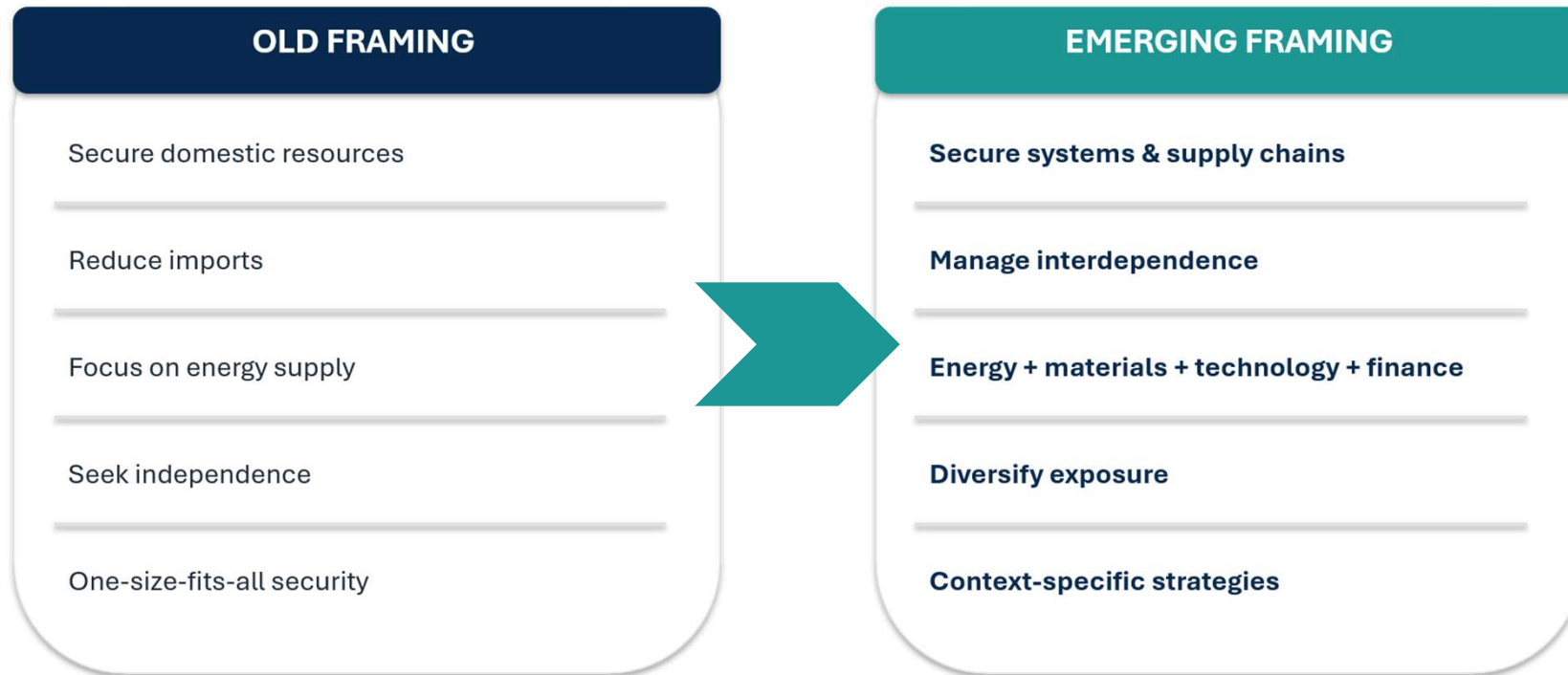
Domestic
resilience



WHAT THIS MEANS

- Risks cannot be managed in isolation
- Domestic resilience alone is insufficient
- External dependence cannot simply be eliminated
- **Security depends on how interdependence is governed**

Conclusions



BOTTOM LINE: Energy security is increasingly a question of whom energy systems depend on and how those dependencies are governed.

Key takeaways

1

Energy security is changing

From securing resources → to securing materials, manufacturing & technology

Cherp & Jewell (2014); Ren et al. (2025); Cheng et al. (2025)

2

Risks are increasingly interconnected

Geopolitical, financial and technological risks reinforce one another across borders

Ren et al. (2025); Cheng et al. (2025)

3

Diversification ≠ elimination of risk

Infrastructure, efficiency, interconnection, diversified sources & partners strengthen the ability to adapt to disruption

Martišauskas et al. (2018); Rosenow (2025); Sovacool (2013)

4

The paradigm shift: managed interdependence

The goal is not self-sufficiency, but governing exposure across domestic and international systems

Mišík & Prachárová (2016); Bazilian et al. (2019); Smith Stegen (2023)

5

Policy must be context-specific

Different resource endowments and national contexts imply different pathways to resilience

Demski et al. (2018); de la Mata Pérez et al. (2019)

What does this mean for policymakers?

DON'T ASK: How do we eliminate external dependence?

ASK: How do we make unavoidable (inter)dependence more resilient?

DIVERSIFY

- Suppliers
- Technologies
- Trade partners

Vivoda (2014); Cheng et al. (2025)

GOVERN

- Strategic reserves
- Long-term contracts
- Energy diplomacy
- Regional coordination

Austvik (2016); Mišik (2016); Bazilian et al. (2019)

BUILD CAPACITY

- Domestic manufacturing
- Infrastructure
- Technology transfer
- Recycling / circularity
- Demand flexibility

Kim & Verdolini (2023); Creutzig et al. (2024); Taifouris & Martín (2023)

Thank you!

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