# 16th IEA IEF OPEC Symposium on Energy Outlooks


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# Session II: Medium-Term Outlooks: Navigating Headwinds with Resilience

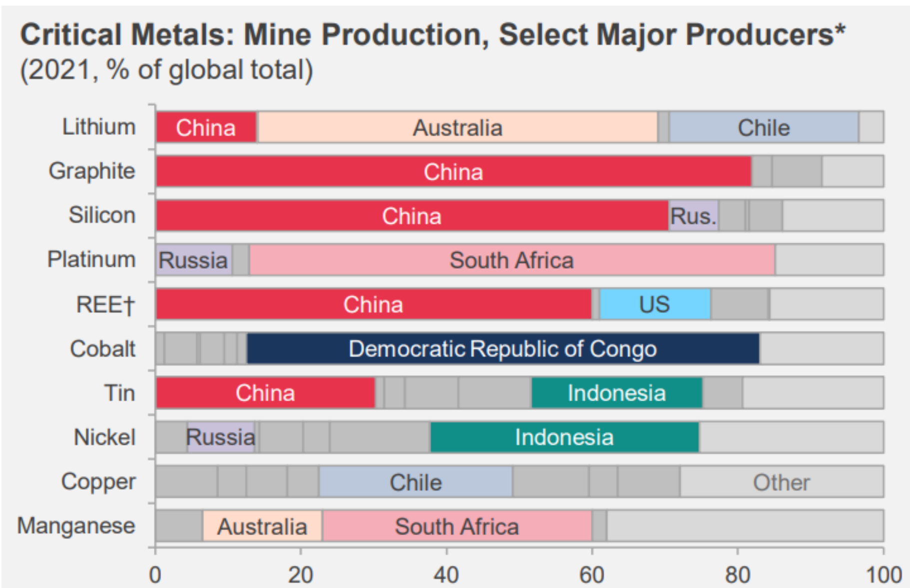
What does the new global risk environment imply for secure, sustainable, and affordable energy?

- What strategies are needed to secure critical minerals and advance clean technologies while ensuring security of supply, diversity, and affordable access?
- How will upstream oil and gas investment be scaled to offset decline rates and low replacement ratios?
- How will data center and mobility energy demand reshape the medium-term energy mix; what roles will nuclear and carbon abatement technologies play, alongside renewables?

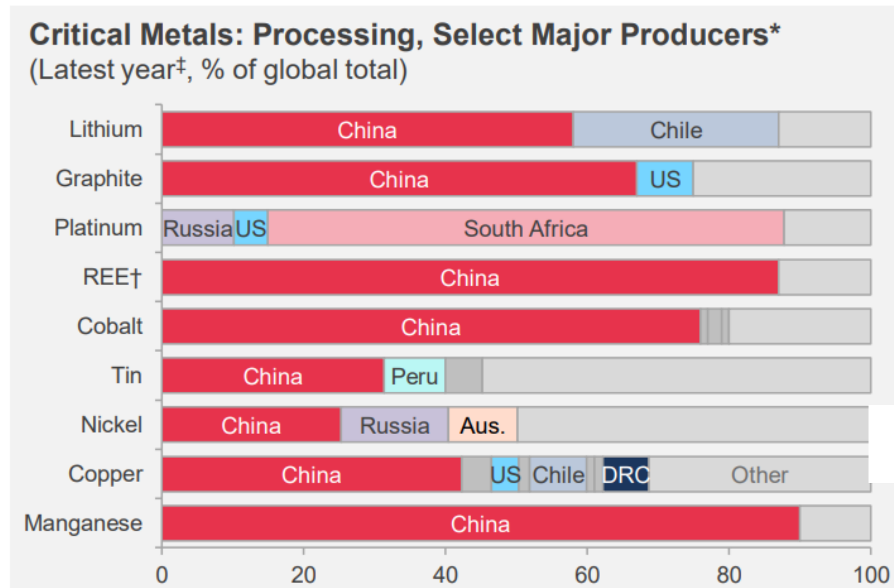
Energy Intelligence

# Risks to Critical Minerals and Clean Tech Metals

1. **Concentration** of mine production and mineral processing in China
2. **Policy** and **security** risks include conflicts, cartels, nationalism and social and environmental concerns




Source: USGS, Energy Intelligence. Notes: *Chart includes data for key producers: China, Russia, US, Australia, South Africa, Brazil, Chile, Peru, Philippines, Indonesia, and DR Congo with only select critical producers highlighted. † REE = Rare Earth Elements.




Source: USGS, ITA, IEA, industry sources, Energy Intelligence. Notes: *Chart includes data for select key processing countries (shown for certain critical materials only): † REE = Rare Earth Elements. ‡ Data for latest year available.

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# Exposure of Critical Minerals and Clean Tech Metals

Increased demand for EVs and batteries in particular raise concerns over exposure to higher costs, possible supply shortfalls and exposure to geopolitical risks

| Selected Key Materials Used in Clean Energy Technologies | Share of Global Use* | Risk Exposure Level | | | Selected Technologies Impacted |
|---|---|---|---|---|---|
| | | High Costs | Supply Shortfalls | Geopolitical Risks | |
| • **Cobalt**, **lithium** and **manganese** are key metals in the cathode of most electric batteries, with **graphite** used in anodes. As battery chemistries evolve, demand for some cheaper metals like manganese is likely to increase at the expense of cobalt. | Co: **35%** Graphite: **33%** Li: **29%** | Very High | Very High | High | **EV Batteries** |
| • **Rare earth elements** like dysprosium and neodymium are used in permanent magnets in rotating electrical equipment, notably including wind turbines and other uses like EV motors. | **16%** | Very High | Very High | Very High | **Wind Turbines, EV Motors** |
| • **Nickel** is a key material in the cathode of most electric batteries; other materials, such as sulfur, could be alternatives. | **15%** | High | Very High | High | **EV Batteries, Wind Turbines** |
| • **Copper** is a key input across technologies, used for electrical wiring, with demand from the EV and power sectors expected to increase. | **15%** | Moderate | Moderate | High | **Everything** |
| • **Silicon**, is the main semiconductor material used in solar PV cells, which also use **silver** and may contain **germanium** and other materials. | Si: **14%** Ag: **10%** | Low | Moderate | Low | **Solar PV** |
| • **Aluminum** is increasingly used to make vehicles (due to its light weight) and in EV battery packs, and is used in electricity transmission. | **3%** | Low | Low | Low | **EVs, Power Grids** |
| • **Tin** is used in solder for electrical components. Around 5x more solder is used in EVs than in ICE vehicles. | **2%** | Low | Low | Moderate | **Everything** |
| • **Steel** is primarily used in infrastructure and construction, but also has uses in wind turbine towers, automobile bodies and other areas. | **1%** | Moderate | Low | Low | **Wind Turbines, Vehicle Bodies** |

Source: Energy Intelligence, industry reports.
Note: * Approx. 2022 share used by clean energy tech.

**Legend:** Potential impact on clean energy sectors: ● Very High, ● High, ● Moderate, ● Low

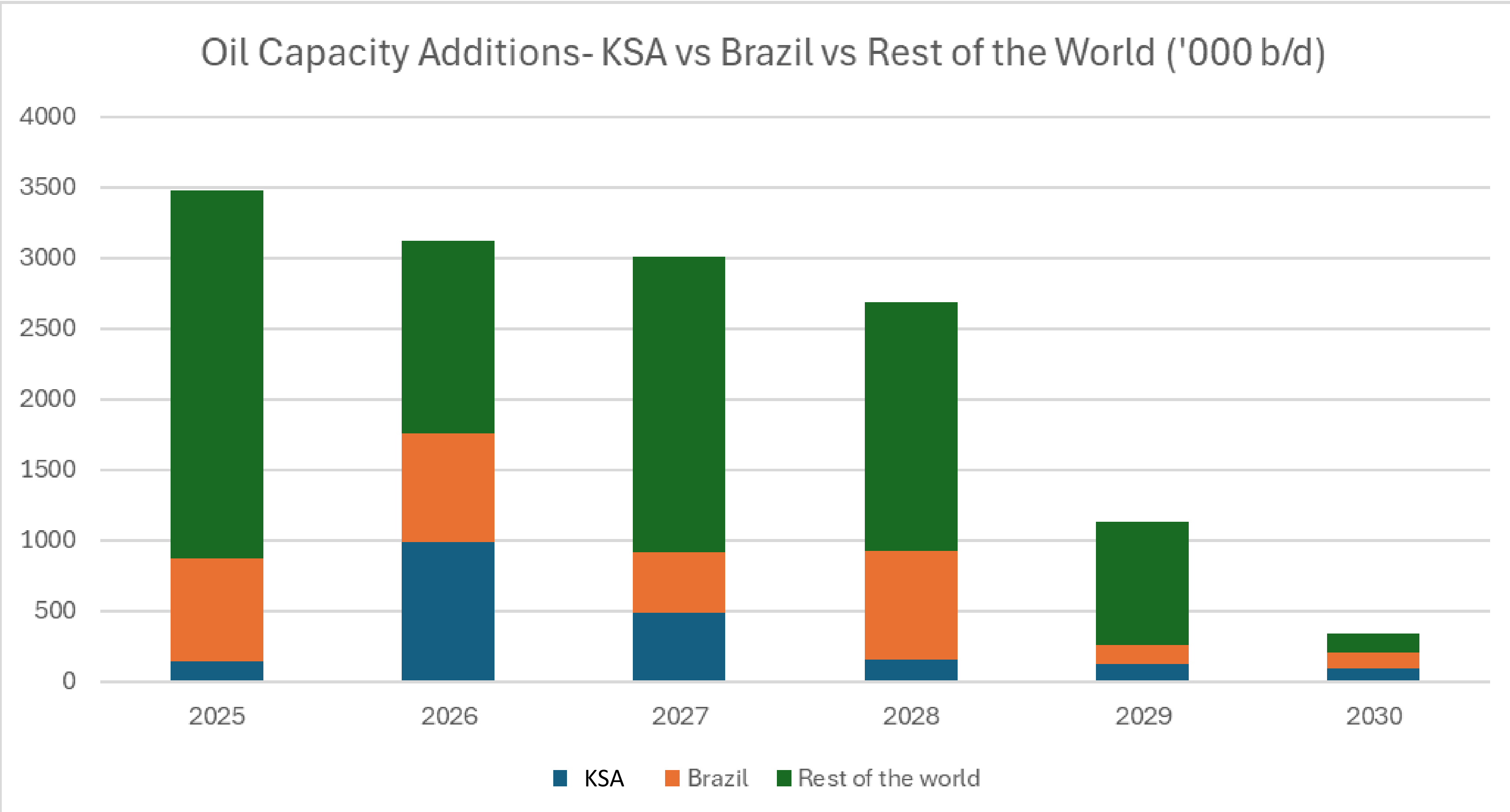
# Medium-Term Solutions to Mitigate Exposure

Global mineral resources are sufficient to meet rising future demand, but expanding local mining output and processing capacity will take time, leaving scope for disruption into the mid 2030s and beyond

- EV/Battery storage: Quickly evolving chemistries set to play key role in overcoming potential mineral shortages
- Solar PV: Producers are continuing their efforts to boost efficiency, cut costs and also minimize materials usage
- Wind: Using bigger turbines (with longer blades and taller towers) increases capacity and boosts efficiency and cuts material requirements per unit of capacity
- Expanding Policy Action on Critical Minerals
  - Financial Support
  - Reducing Production Barriers
  - Anchoring Demand
  - Encouraging Recycling
  - Stockpiling

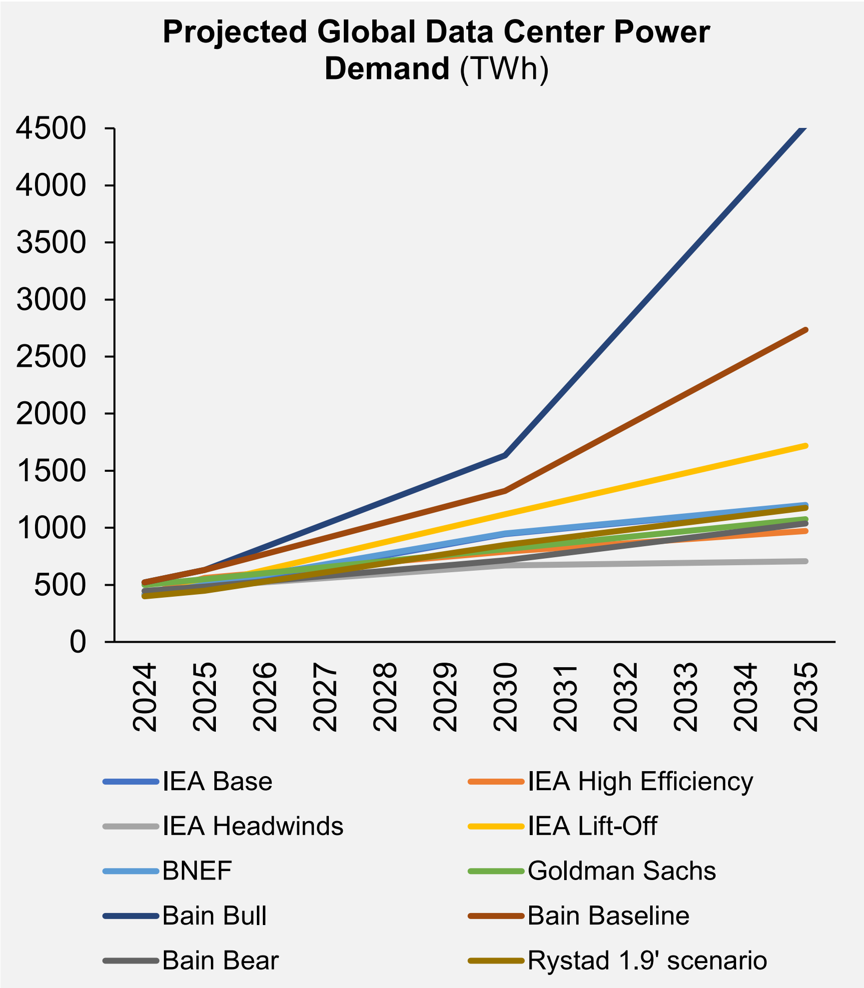
# Medium-Term Oil Supply Outlook

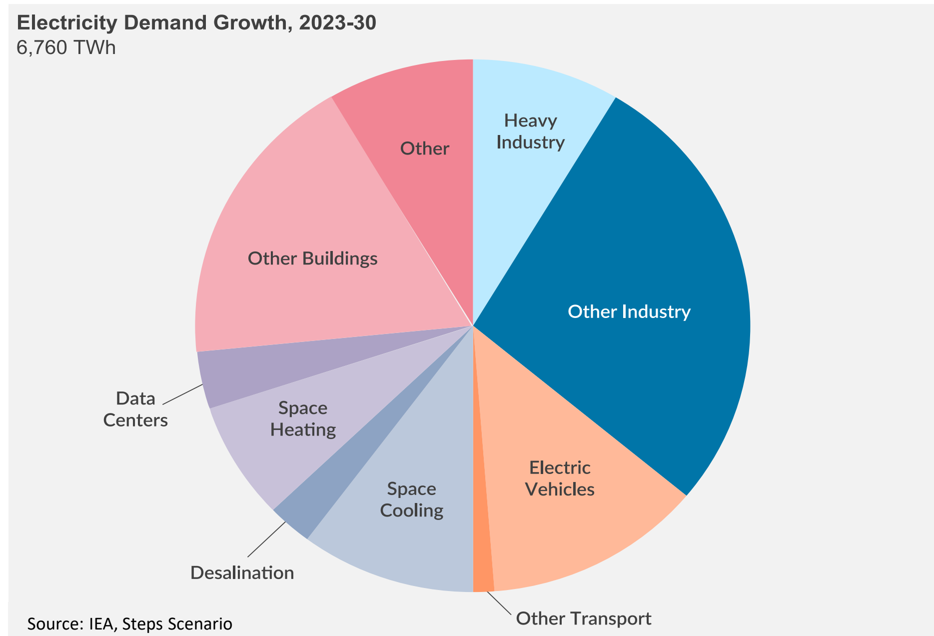
Key investment sites provide reassurance




Sources: Energy Intelligence

# 3. Medium-Term Outlooks: AI and Electricity Demand




Sources: Energy Intelligence, IEA, BNEF, Goldman Sachs, Bain, Rystad. Some data points are linear extrapolations.

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# Powering AI: Generation Types

No single type of power generation is best-suited to AI

## Natural Gas

- **Pros:** Reliable and dispatchable, which is useful for meeting data centers' varying requirements. Cheap in many parts of the world.
- ***Cons:*** *Reliant on reliable and affordable supply – not straightforward in many parts of the world. Exposed to price variations. Availability of gas turbines and permitting hurdles are leading to long lead times: Current estimates are that the wait for turbines could now be 2034-35.*

## Coal

- **Pros:** Remains a reliable and relatively inexpensive option for power generation in many markets. Delays to natural gas projects make prolonging coal plants an attractive stopgap for quickly meeting AI's growing power needs.
- ***Cons:*** *Unabated coal emissions make it problematic for climate-conscious countries and companies. Where applicable, carbon prices increase the cost of using coal.*

## Nuclear

- **Pros:** Provides reliable baseload power that data center operators can count on. Advances in nuclear technology – including SMRs – make them potentially an excellent fit for large energy users like data centers.
- ***Cons:*** *Nuclear LCOE remains expensive everywhere but China. Advanced reactor designs and SMRs have not yet been demonstrated at commercial scale. Safety, security and cleanup costs add issues.*

## Wind and Solar

- **Pros:** Often the quickest means of building new generating capacity, and in some places, the cheapest.
- ***Cons:*** *Intermittency poses a challenge for data center operators who need to be able to rely on power whenever they need it, whether supplied from grids or dedicated facilities. Storage adds to costs and can only mitigate intermittency to an extent.*

# AI and Energy Supply: Strategic Divergence

## Countries are pursuing very different approaches to powering AI – with geopolitical consequences

- There is a strategic divergence in countries' approaches to powering AI – a battle between those looking to lean primarily on fossil fuels, led by President Donald Trump's **US**, and those who are looking to use low-carbon energy, led by **China** and the **EU**. **GCC** and **ASEAN** states are adopting mixed strategies.
- There are geopolitical considerations to the energy for AI calculus:
  - AI security will be linked to energy security and vice versa – countries will want to develop AI ecosystems built on solid foundations of energy independence or sovereignty, where possible;
  - Export controls on chips, competition over gas supplies and efforts to influence language model development could all be geopolitical flash points that affect AI's development for better or worse;
  - Fragmentation of standards, resource nationalism, and security vulnerabilities in grids and subsea cables all present geopolitical vulnerabilities, leading to AI demand potentially reshaping alliances and trade flows.

| | | Preferred Energy Source for AI | Regulatory Burden on AI Energy Projects | Safety vs. Speed |
|---|---|---|---|---|
| | US | All-of-the-above, trending to fossil fuels and nuclear | Medium, trending to low | Speed |
| | China | Low-carbon | Low | Speed |
| | EU | Low-carbon | High | Safety |
| | GCC | All-of-the-above | Medium | Balanced |
| | ASEAN | All-of-the-above | Medium | Balanced |

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