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Institut für angewandte Ökologie
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# Rare Earths for the Transformation – Resilient Supply Chains for Climate Neutrality in Germany 2045


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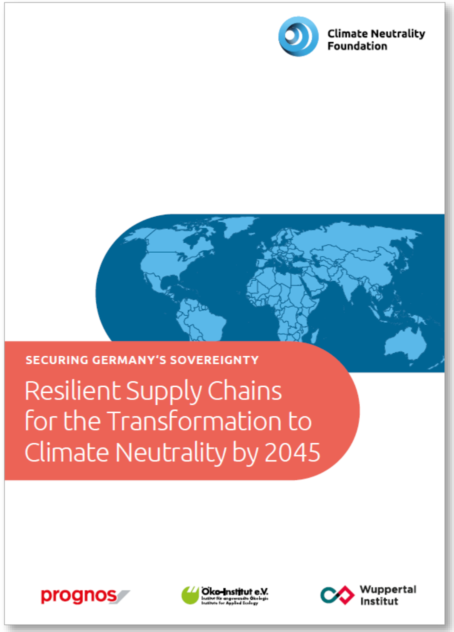
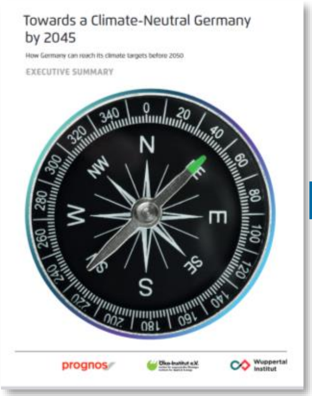
# Motivation




**Technology mix for critical supply chain** → **Quantification of raw material demand** → **Political actions**

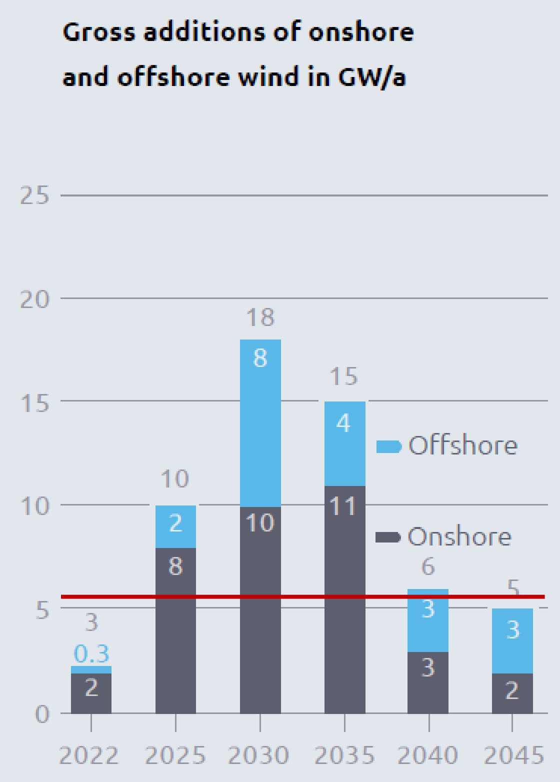
**Actual supply chain** → **Possible supply chain** → **Political actions**

# Outline

# Outline

# Wind power sector: ambitious goals in Germany

- In 2045 60% of electricity generation by wind power (EEG 2023)
- Up to 8 GW per year offshore
- Up to 11 GW per year onshore
- Highest annual addition to date: 5.5 GW in 2017



# Wind power sector: technology mix

- Onshore mainly induction generator
  - Low REE demand
- Offshore mainly synchronous generator with permanent magnet, without gear
  - Very high REE demand
  - Benefit: high efficiencies, low nacelle weight
- Gear would reduce REE demand by 65% to 90%
  - additional weight → reduced power per turbine

**Market share incl. permanent magnets**

| | 2020 | 2045 |
|---|---|---|
| Onshore | 25% | 20% |
| Offshore | 95% | 100% |



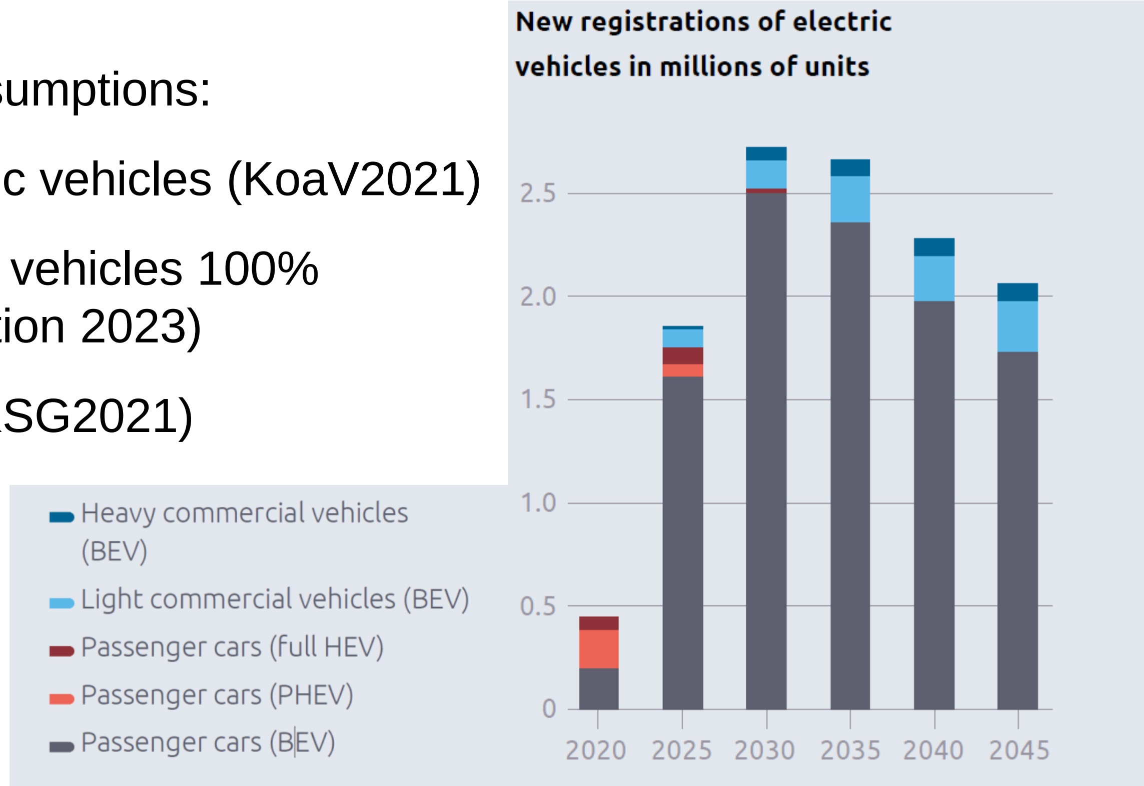
https://commons.wikimedia.org/wiki/File:The_Switch_Permanent_Magnet_Generator_3.jpg

# Outline

# Transport sector: ambitious goals in Germany

Scenario with ambitious assumptions:

- 2030 15 M batterie electric vehicles (KoaV2021)
- 2035 new registrations of vehicles 100% emission free (EU-resolution 2023)
- 2045 climate neutrality (KSG2021)



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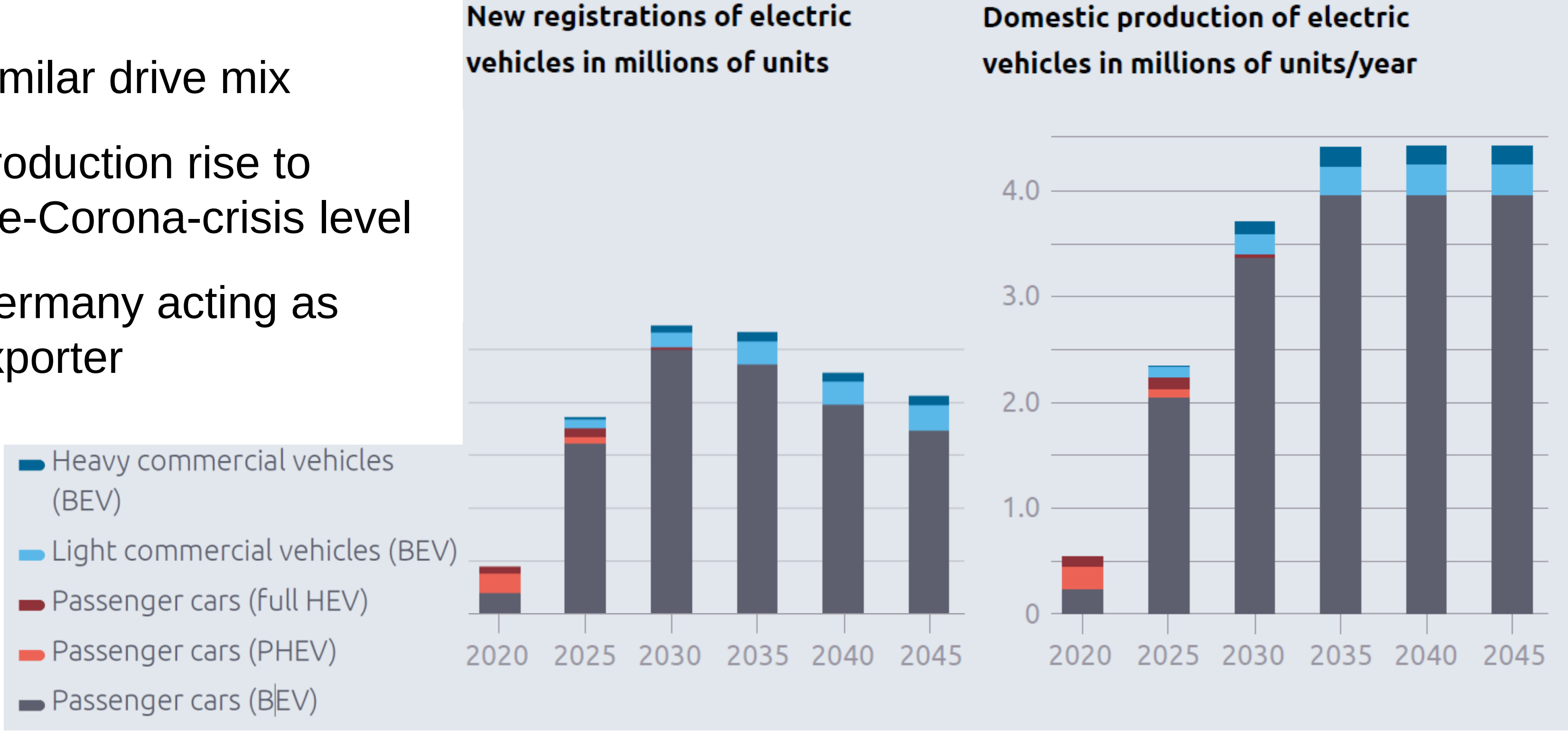
# Transport sector: domestic production scenario

- Similar drive mix
- Production rise to pre-Corona-crisis level
- Germany acting as exporter



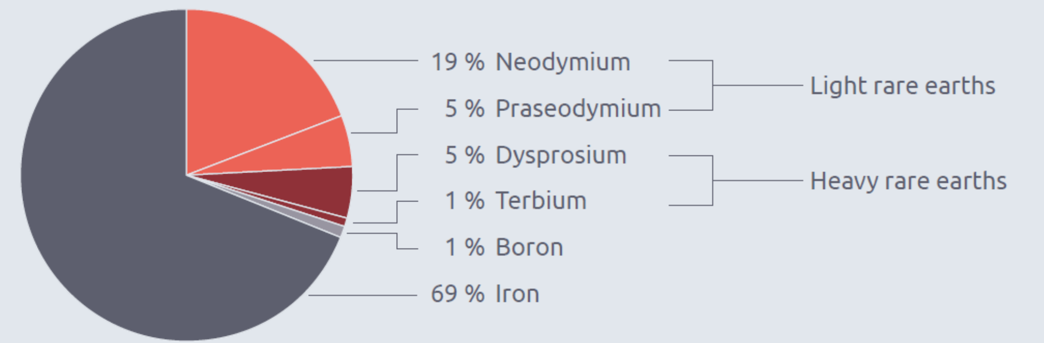
# Transport sector: technology mix

- REE only in synchronous motor with permanent magnets
  - Possibility for metal alloys without REE, but dominance of neodymium-iron-boron
  - Benefit: high efficiencies

**Market share incl. NdFeB magnets**

| | 2020 | 2045 |
|---|---|---|
| Passenger cars | 95% | 80% |
| Trucks | 100% | 100% |

**Composition of NdFeB magnets in electric vehicles today**

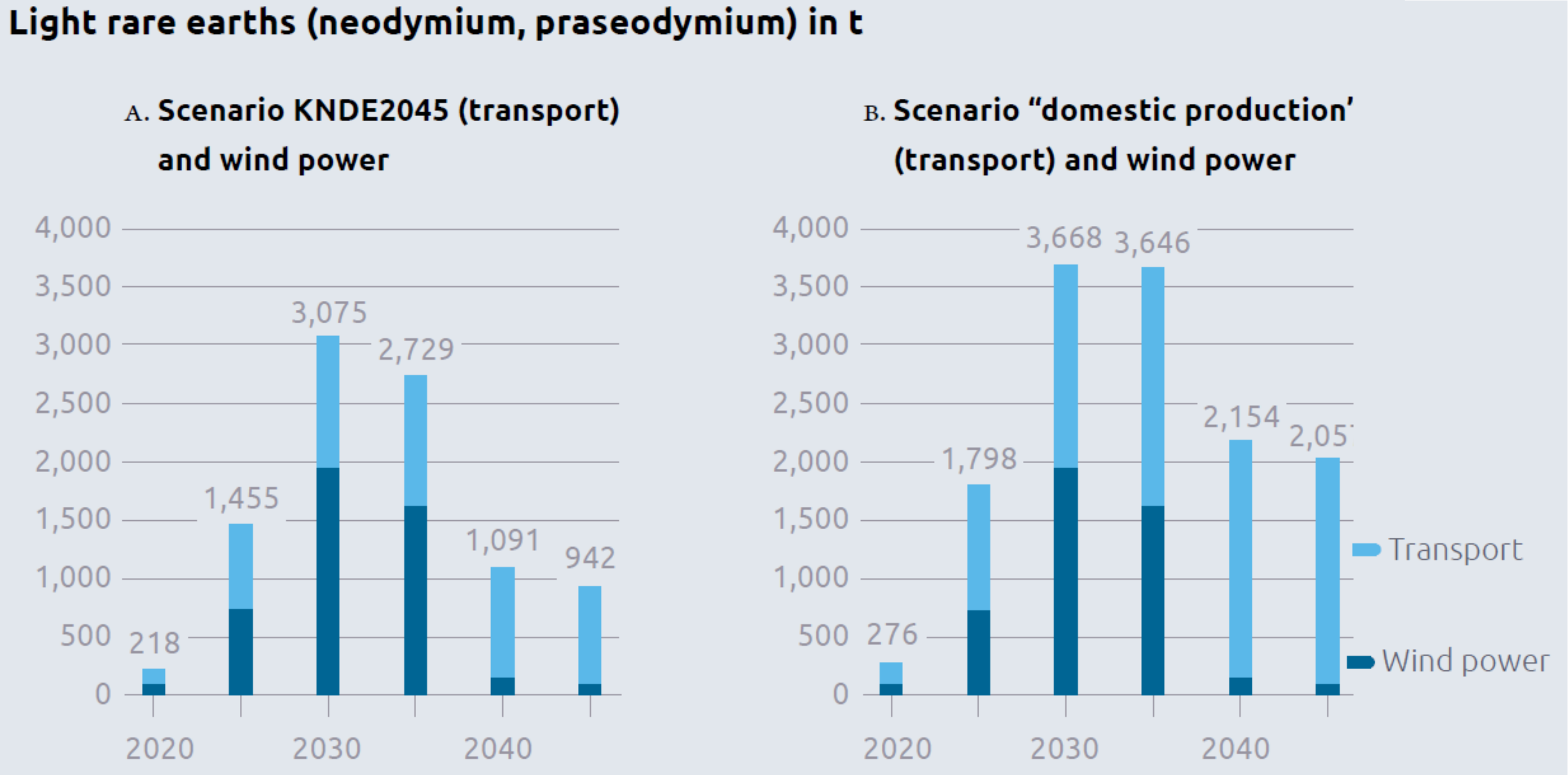



2045:

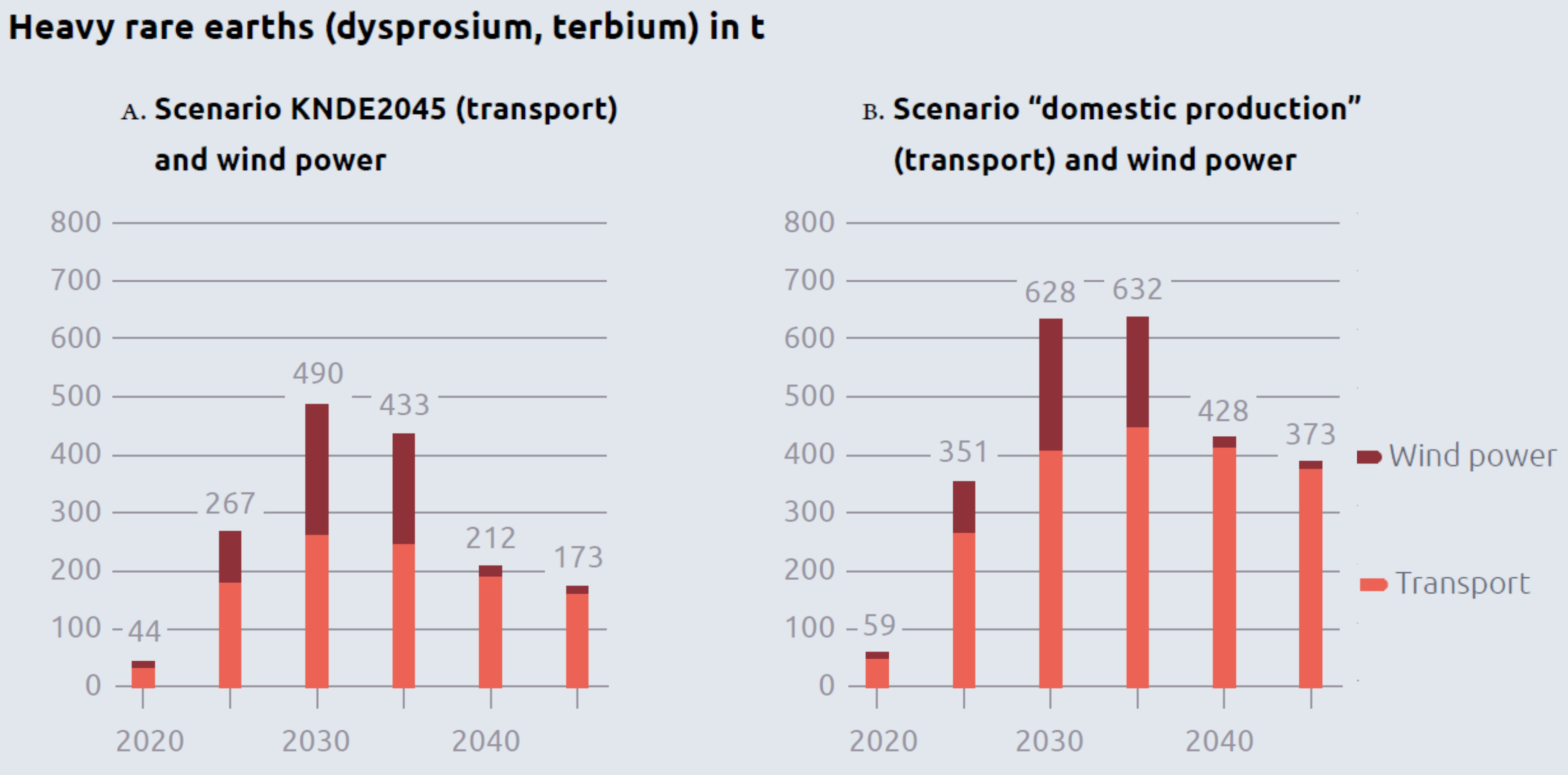
- Reduction of HREE to 4.8%
- Increase of LREE to 25.2%

# Outline

# Annual demand in Germany: light REE



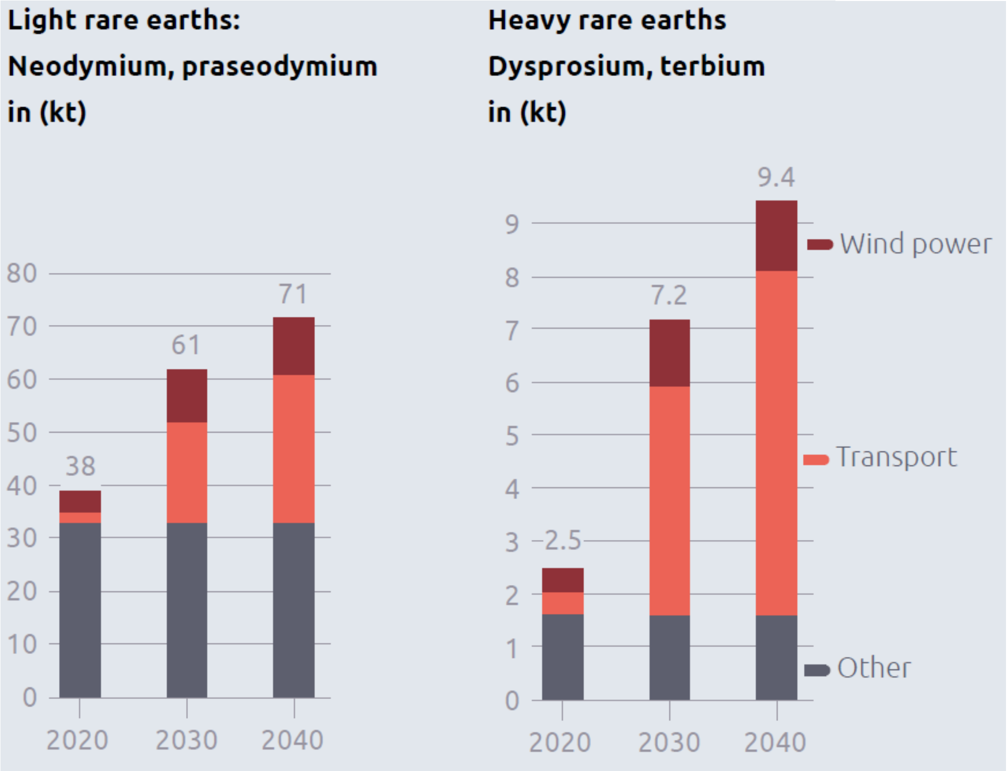
# Annual demand in Germany: heavy REE



# Annual demand of REE worldwide

REE demand worldwide:

- IEA scenarios in 2021
  - Demand of LREE doubled
  - Demand of HREE quadrupled
  - No peak till 2040



# Interim conclusions

- Ambitious goals for wind power and transport sector
- Offshore: manly synchronous generator with very high REE demand
- In BEV motors: Dominance of motors with magnets only slightly decreases

- German demand for REE drops after 2035 but stays high
- Worldwide demand for REE until 2040:
  - Demand of LREE doubled
  - Demand of HREE quadrupled

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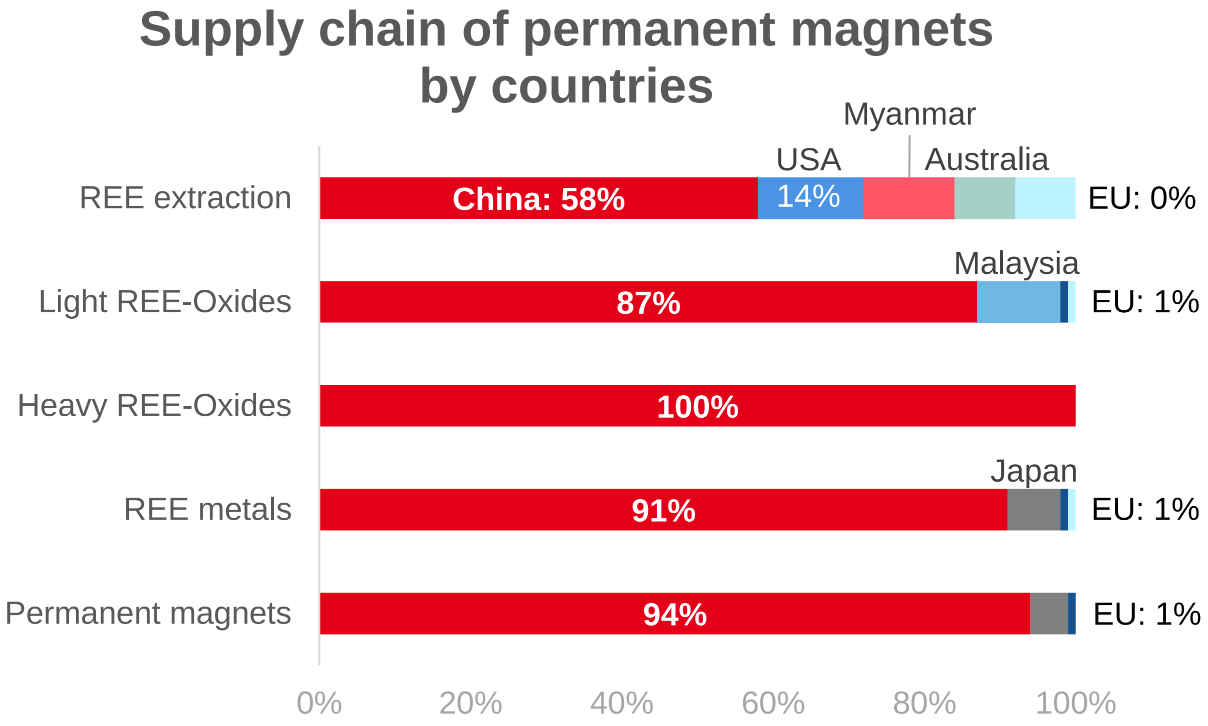
# Outline

# China dominates market in 2021

- China dominates in all steps
- EU maximum of 1% market share



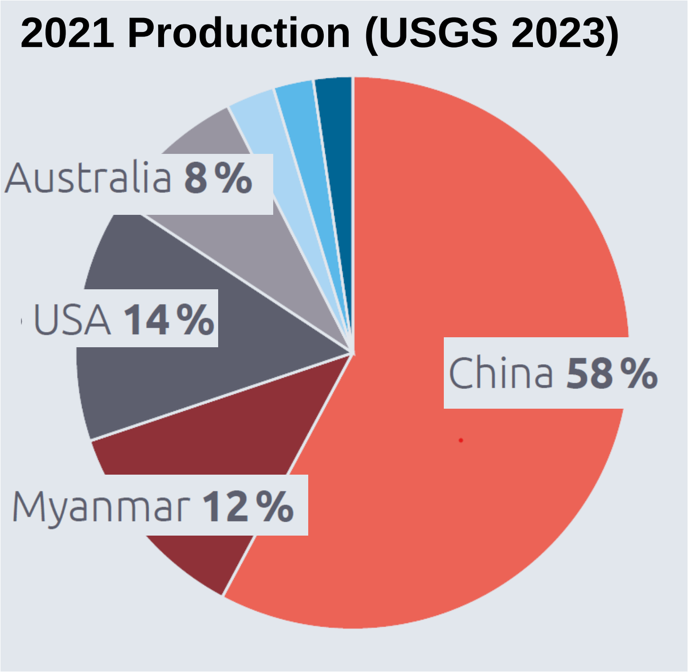
# Three main pillars of dependency reduction

- Diversification of supplier countries
- Expansion of European supply chain
- Recycling

- Material efficiency & substitution not much potential

# Diversification of supplier countries possible

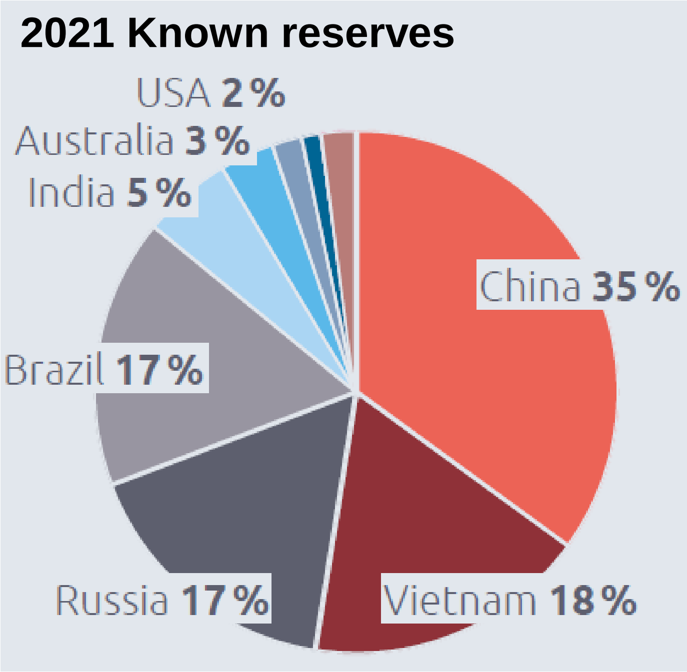
- China’s production share of REE decreased further over the last years (80% in 2017)
- Myanmar’s production is dominated by Chinese companies
  - Export of ores and concentrates mainly to China for processing



# Diversification of supplier countries possible

Brazil, Vietnam, India:

- ➢ Negligible mining production
- ➢ Huge reserves
- ⇒ Possible change in the countries' share of mining production
- ➢ However, mining is not the most crucial step to diversify



# Diversification of supplier countries

- Partnerships with traditional partners:
  - USA, Australia, Canada
- Partnerships with new partners:
  - Important: political stability, infrastructure, governance
  - Examples: Brazil, Kenya, Colombia, Malawi, Namibia
  - Focus not on raw-material-partnerships
    - Establishing of transformation partnerships on eye level
    - Selling point compared to other possible partners
    - Important for long-term gain (economic participation, knowledge transfer, social sustainability, …)



https://pxhere.com/en/photo/1451265

# Expansion of European supply chain

- EU recognises major deficits and need to catch up
- European players need investment security and expertise

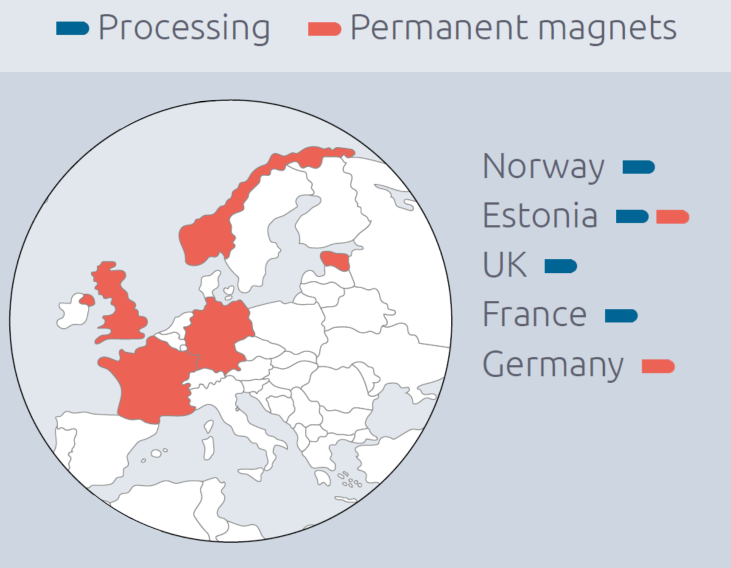
2030:

- Expansion from 500 t/a to 7000t/a

⇒ Covering of 20% of European demand for permanent magnets possible (ERMA 2021)

- Mining planned in Sweden (LKAB)

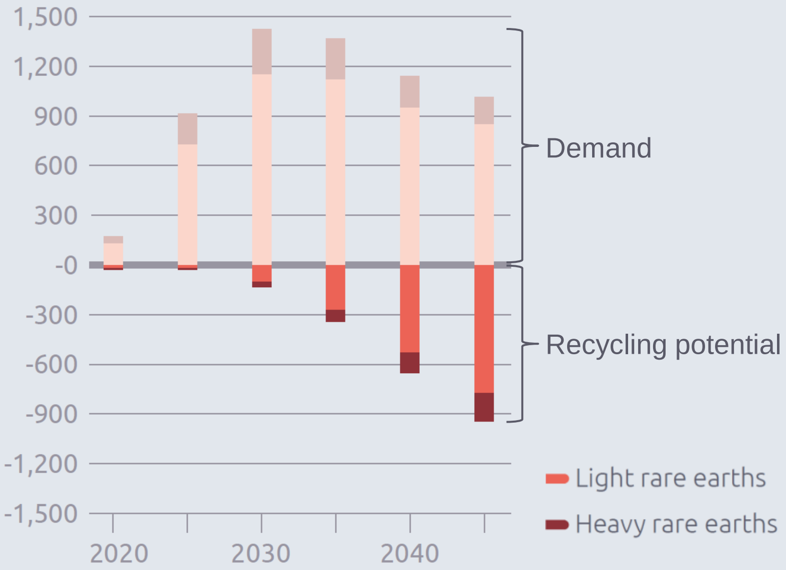
**Short- and medium-term European projects**



# Recycling

- Advantages:
  - Growing potential for end-of-live material
  - High concentration of REE (30%)
- Disadvantages:
  - Only medium- & long-term effects (after 2030), but political guidelines necessary now
  - Still research necessary (collection, deconstruction, separation, etc.)
- First pilots in Germany under construction

**Annual recycling potential and demand of REE because of electric vehicles based on KNDE2045**



# Conclusions

- Wind power and BEV need an enormous amount of permanent magnets
- German demand for REE drops after 2035 but stays high
- Global demand for REE will double at least by 2040
- China strongly dominates the market for permanent magnets
- Actions to reduce dependencies:
  - Diversification of supplier countries with partnerships on eye level
  - Expansion of European supply chain
  - Resources from recycling relevant in the medium- & long-term

# Thank you very much!

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