Material Demand in Global Energy Scenarios, Distribution of Stocks and the Role of Recycling

The Case of Neodymium, Dysprosium, Lithium and Cobalt

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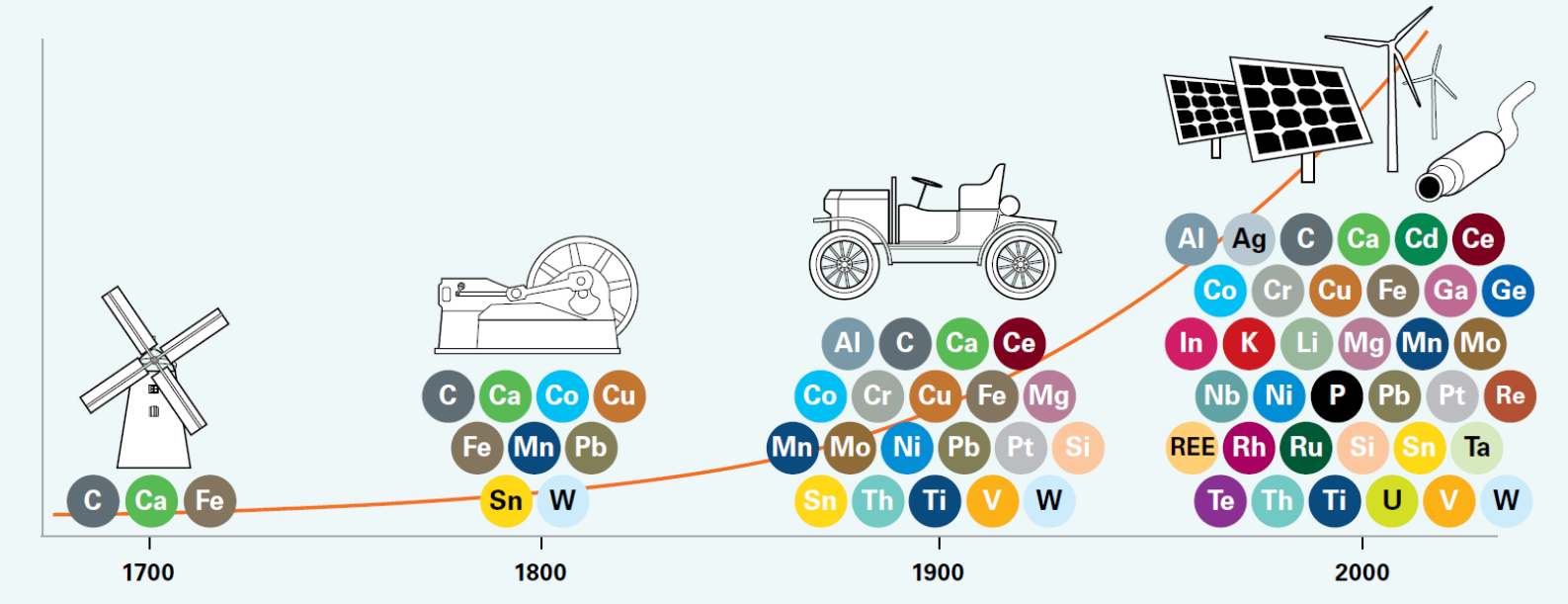
DLR

Introduction

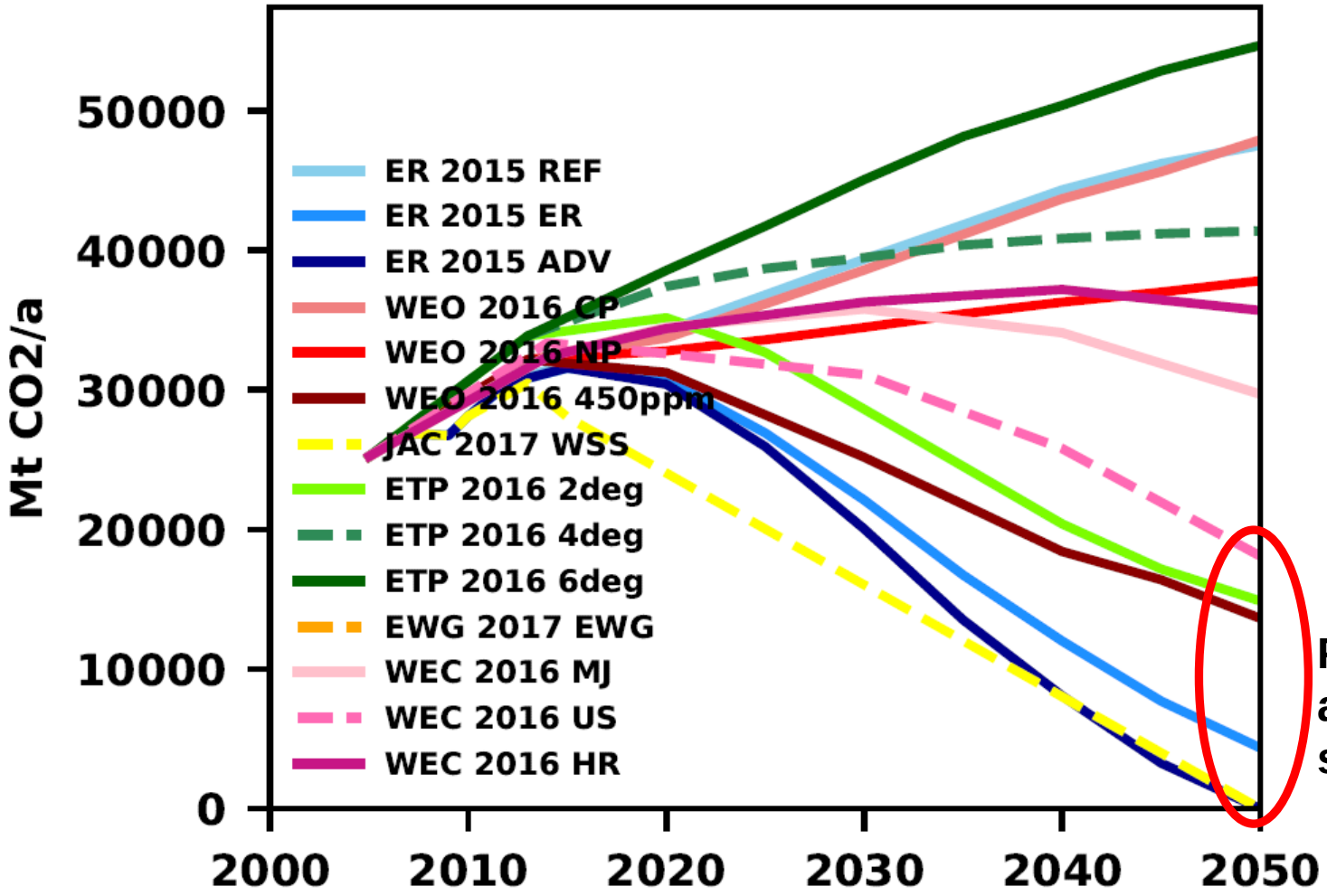
- Increasing use of natural resources in industrial production
- Number of resources used is increasing
- Complex products are also complicated to recycle
- This development raises the question of resource criticality in the future



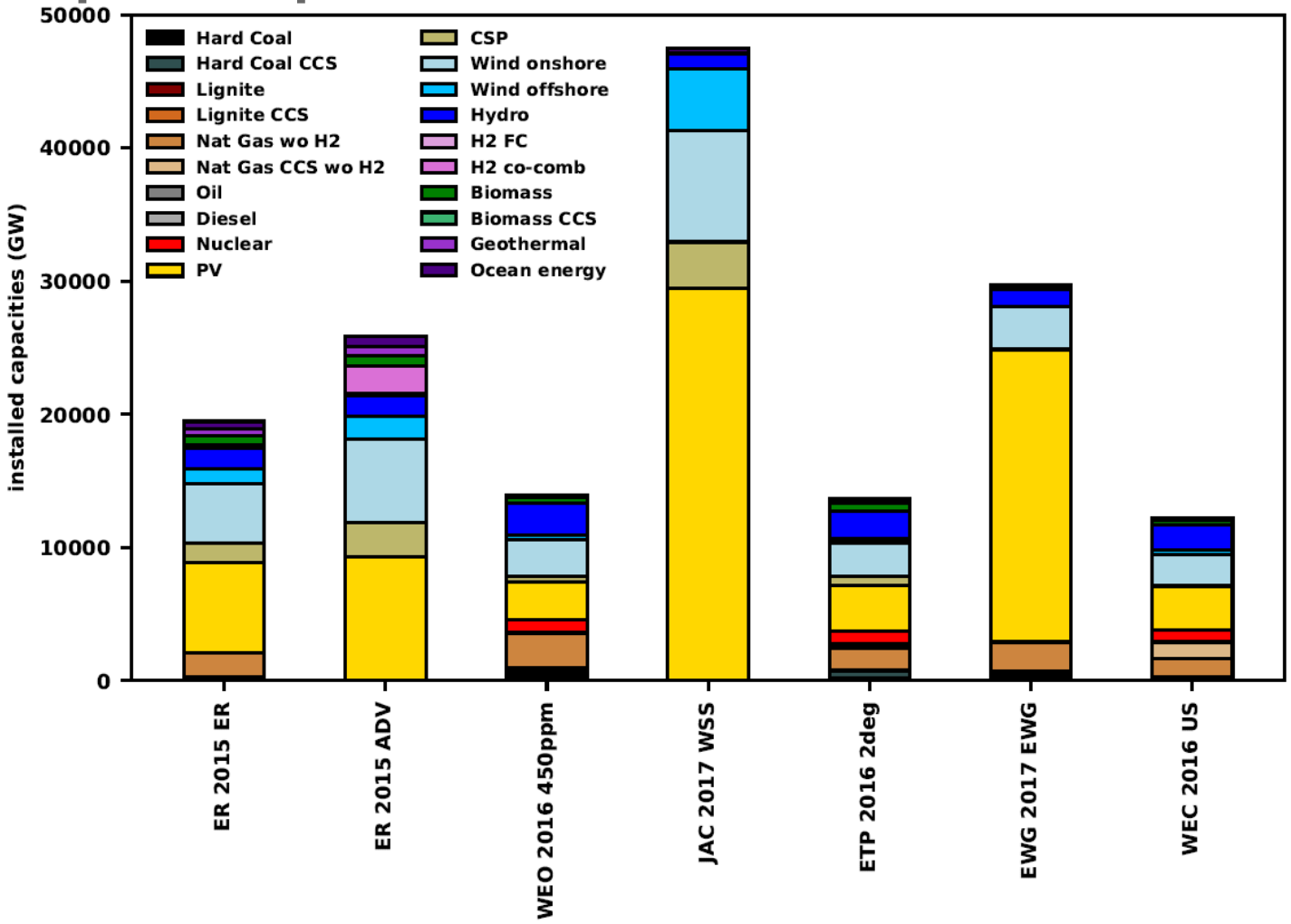
Source: Achzet B., Reller A., Zepf V., University of Augsburg, Rennie C., BP, Ashfield M. and Simmons J.,ON Communication (2011): Materials critical to the energy industry. An introduction.

Motivation – Large amount of energy scenario studies

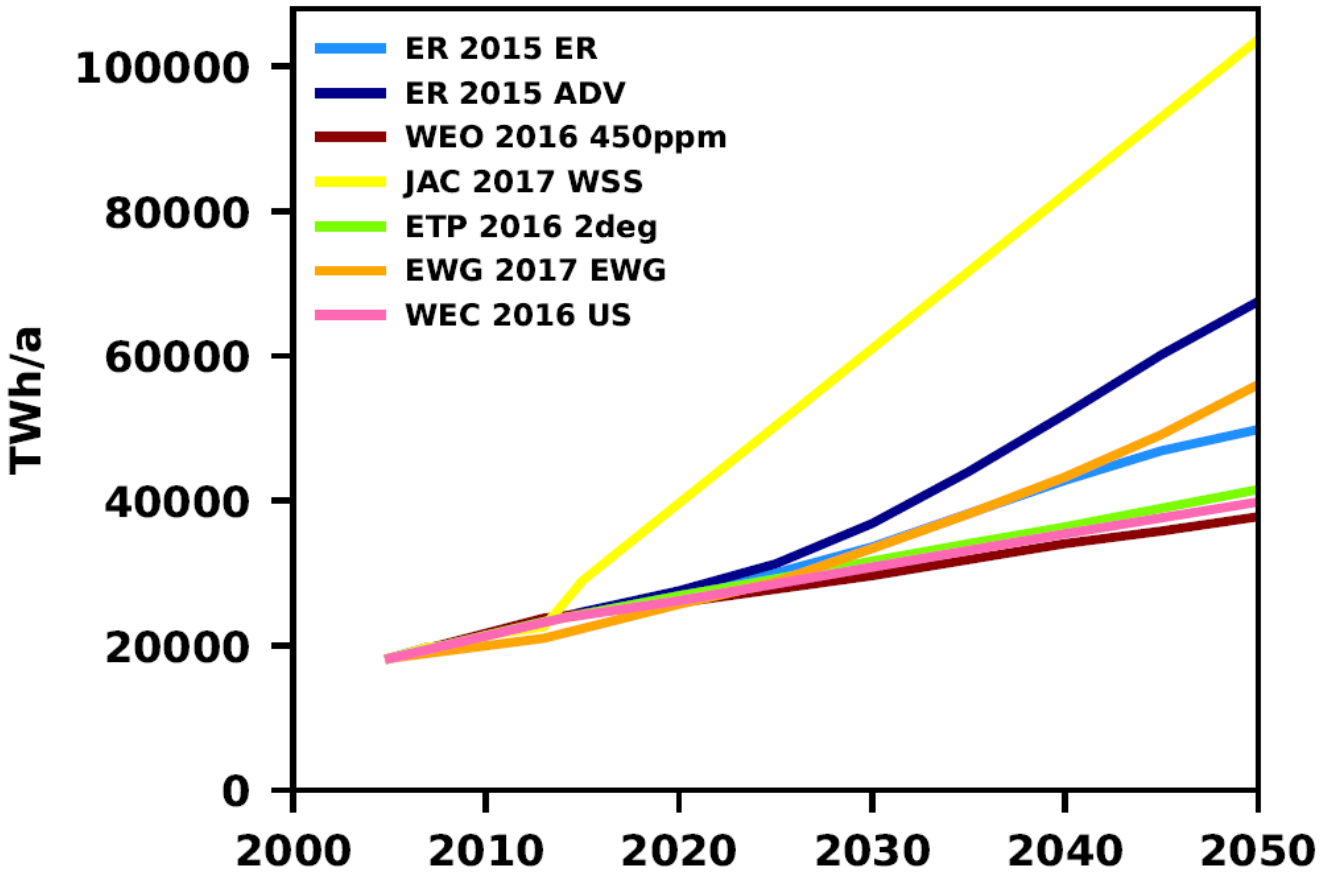
Motivation - Development of energy-related CO2 emissions



Motivation - Very different assumptions on installed power plant capacities



Motivation – Different degree of electrification



Method – Input data and assumptions

Global energy scenarios

available information

(for specific scenario years)

- Installed capacity of power generation
- Power generation per technol.
- Electricity demand mobility
- ...

Material requirements for global energy scenarios

- Annual gross and net demand
- Annual recycling potential
- Cumulated net/gross demand
- Neodymium, Dysprosium, Lithium, Cobalt

Assessment

- Comparison to reserves and resources (also geographically)
- The role of recycling
- Discuss implications for energy system modeling

Additional estimation

- Short-term and long-term storage demand
- Electricity demand to peak load
- Number and type of electric cars
- Material use in other end-use sectors

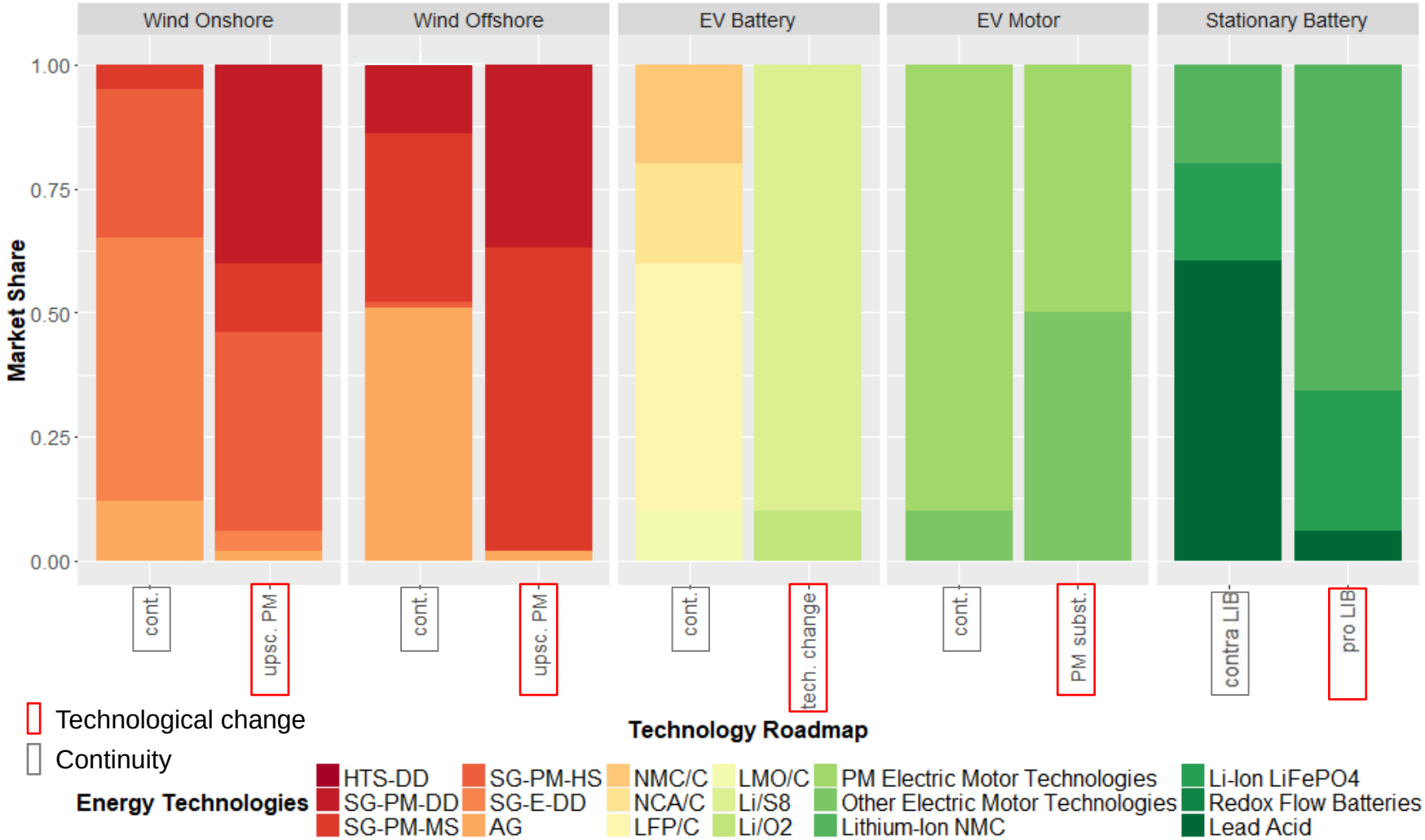
Database on specific material requirements

- Neodymium, Dysprosium, Lithium, Cobalt

Specific technology scenarios and end-use in other sectors

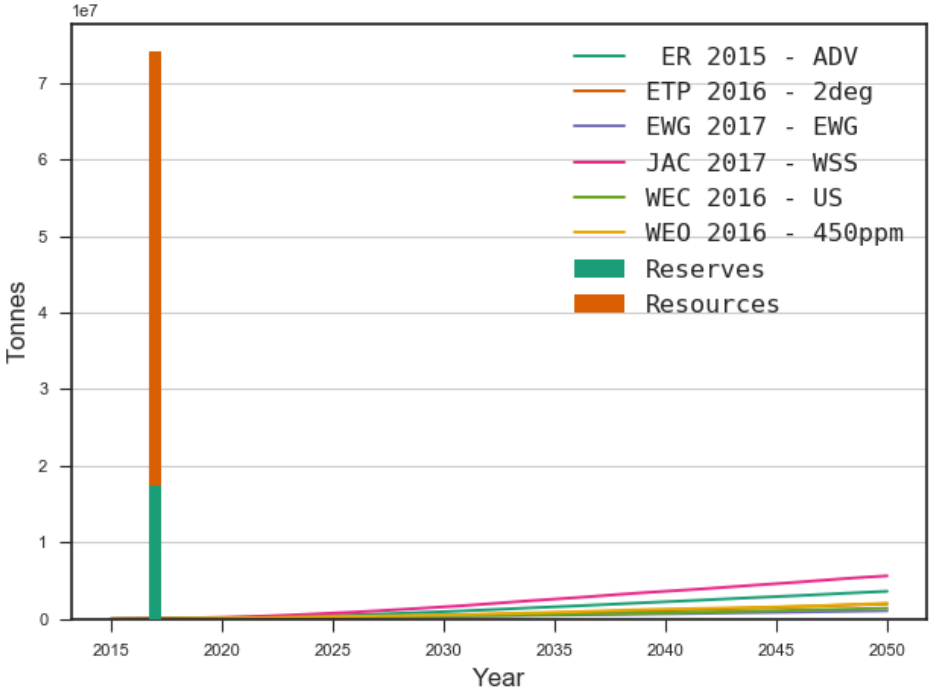
- Shares different technologies:
  - Wind on-/offshore
  - Transport (EV, PHEV, H2)
- Current use in other sectors, growth estimates and lifetime

Assumptions – Technology roadmaps until 2050

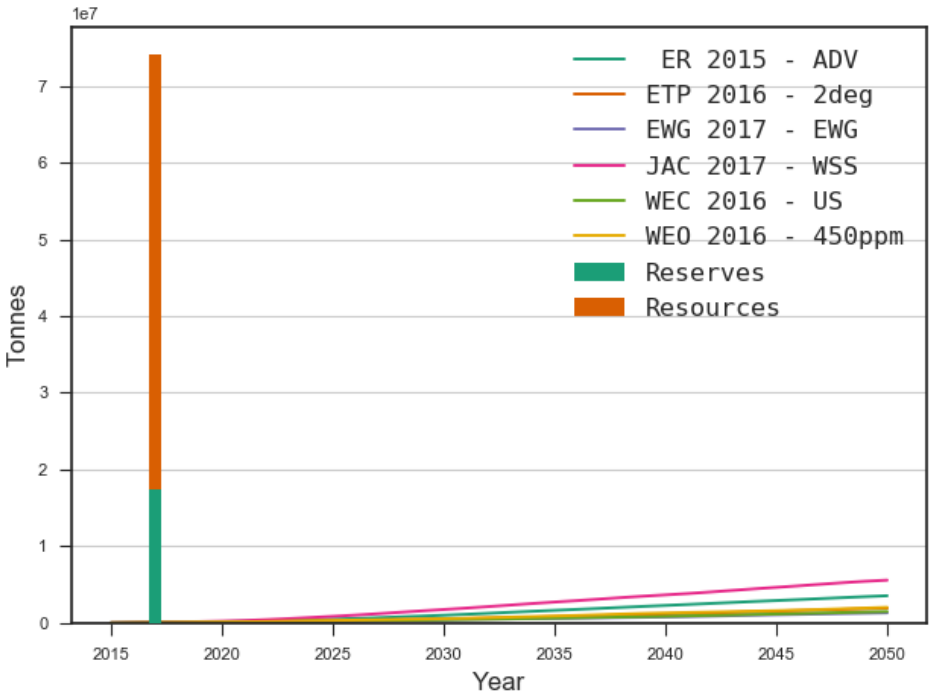


Results – Cumulated demand for neodymium

Roadmap: Continuity



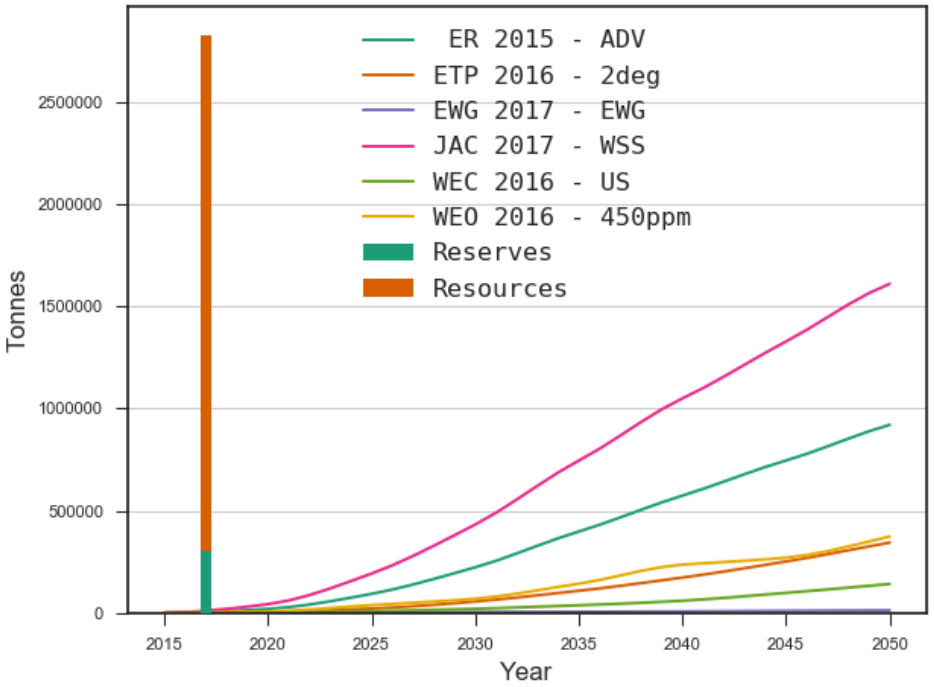
Roadmap: Technological Change



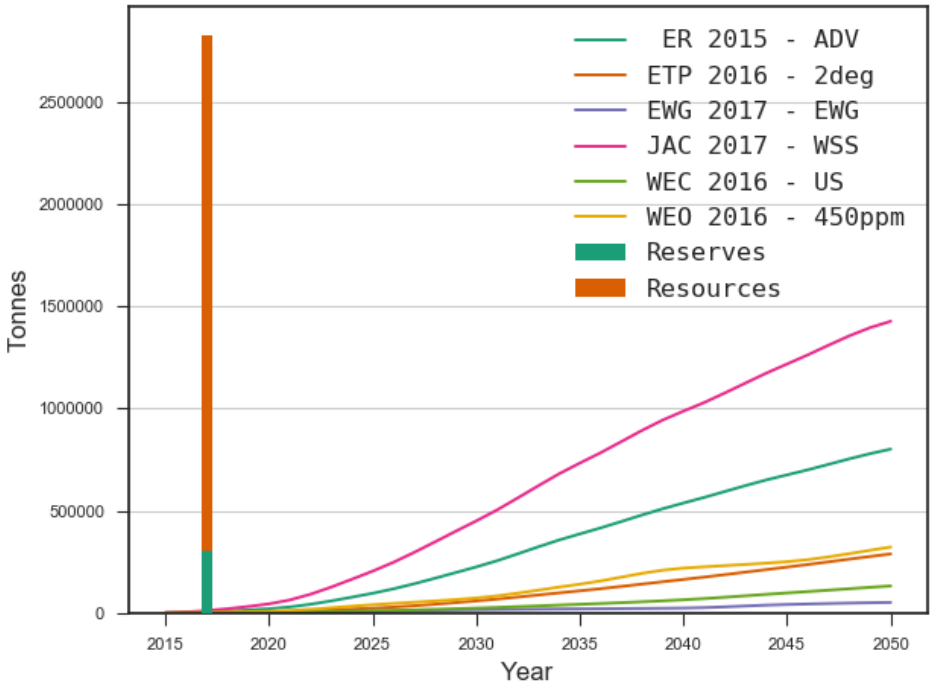
- No bottlenecks are to be expected for neodymium
- However, rare earths are associated, the extraction of a single mineral oxide is not possible → balance problem

Results - Cumulated demand for dysprosium

Roadmap: Continuity



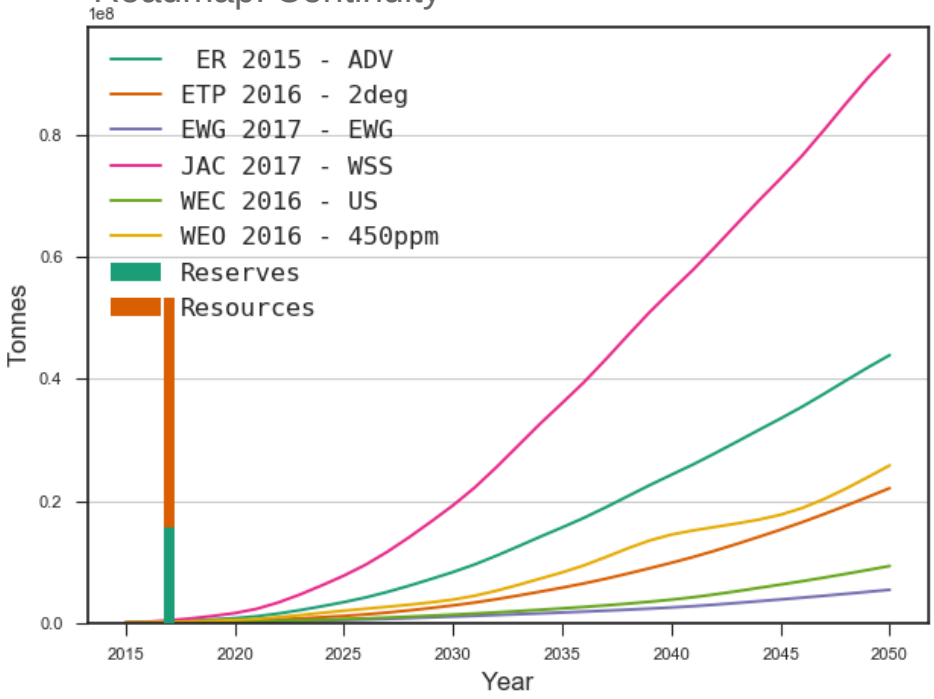
Roadmap: Technological Change



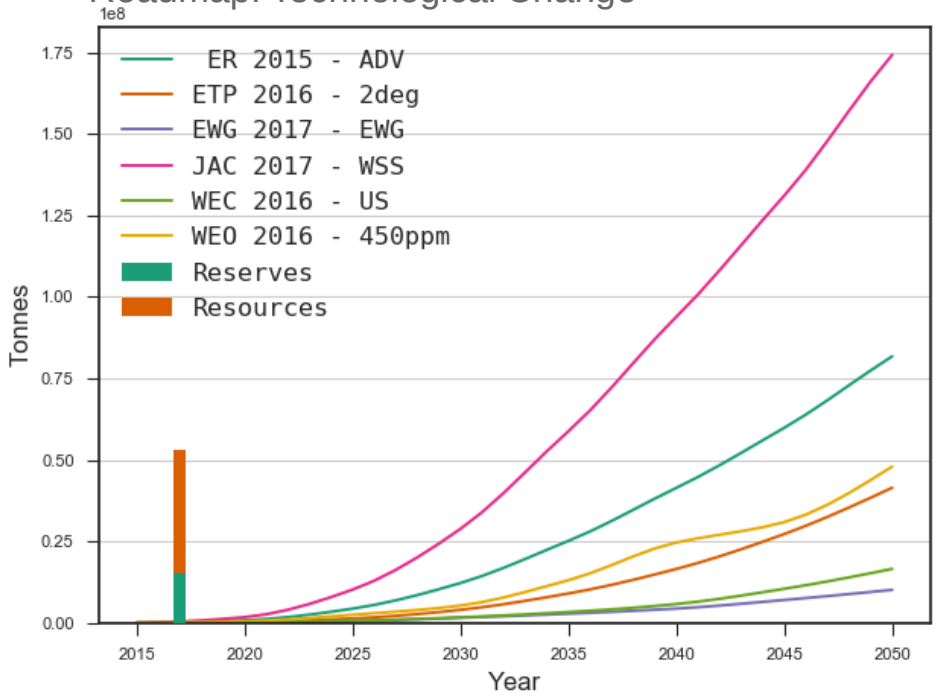
- A large uptake of wind power (especially offshore) and/or pm-based electric motors for PHEV, EV and H_2V will lead to a rapid depletion of dysprosium reserves

Results - Cumulated demand for lithium

Roadmap: Continuity



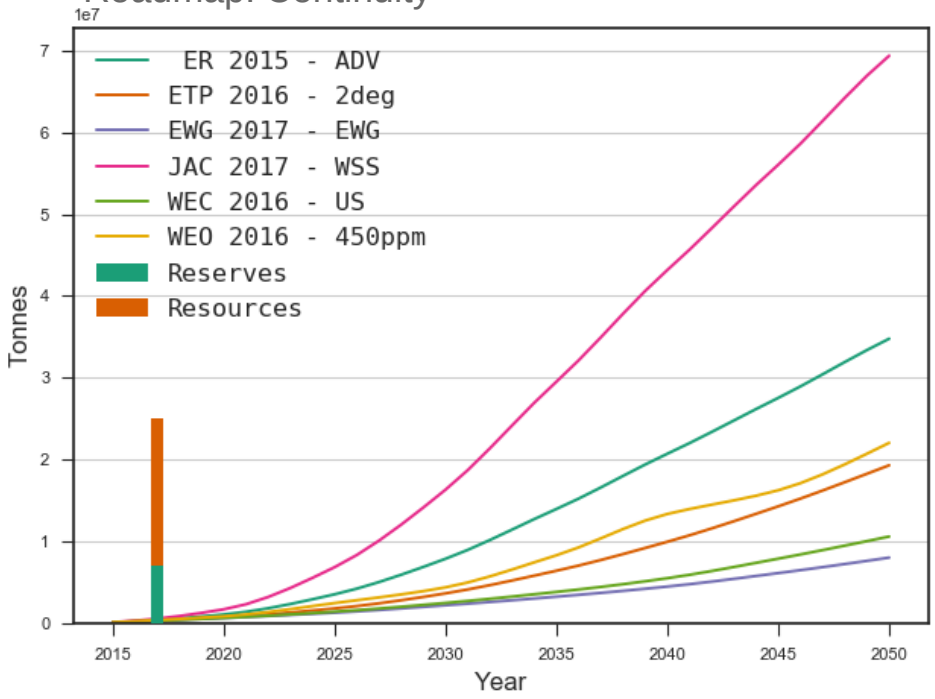
Roadmap: Technological Change



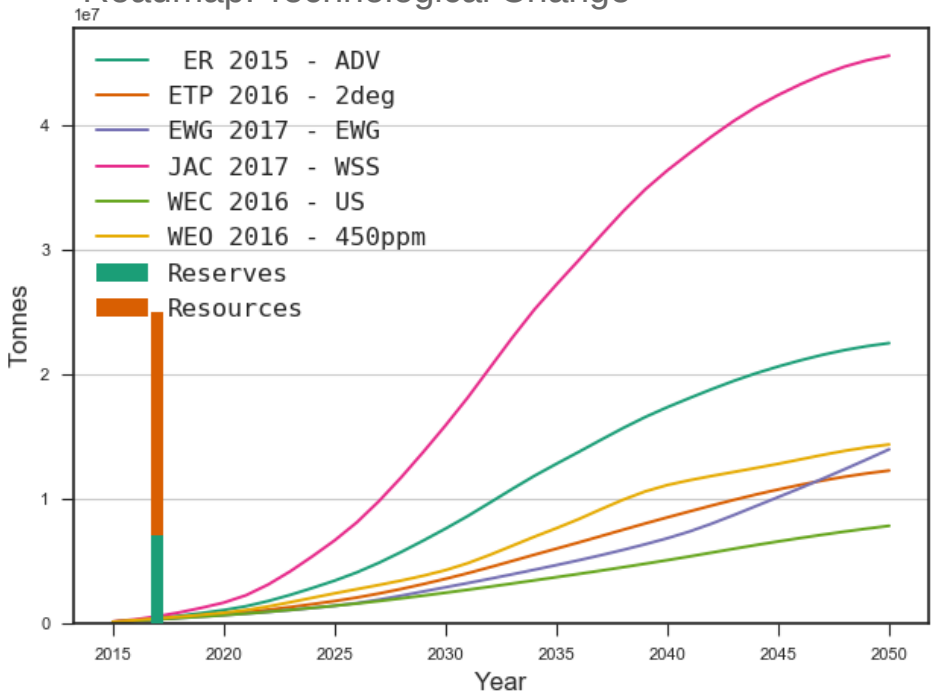
- The electrification of the mobility sector seems not to be plausible with batteries only based on lithium

Results - Cumulated demand for cobalt

Roadmap: Continuity



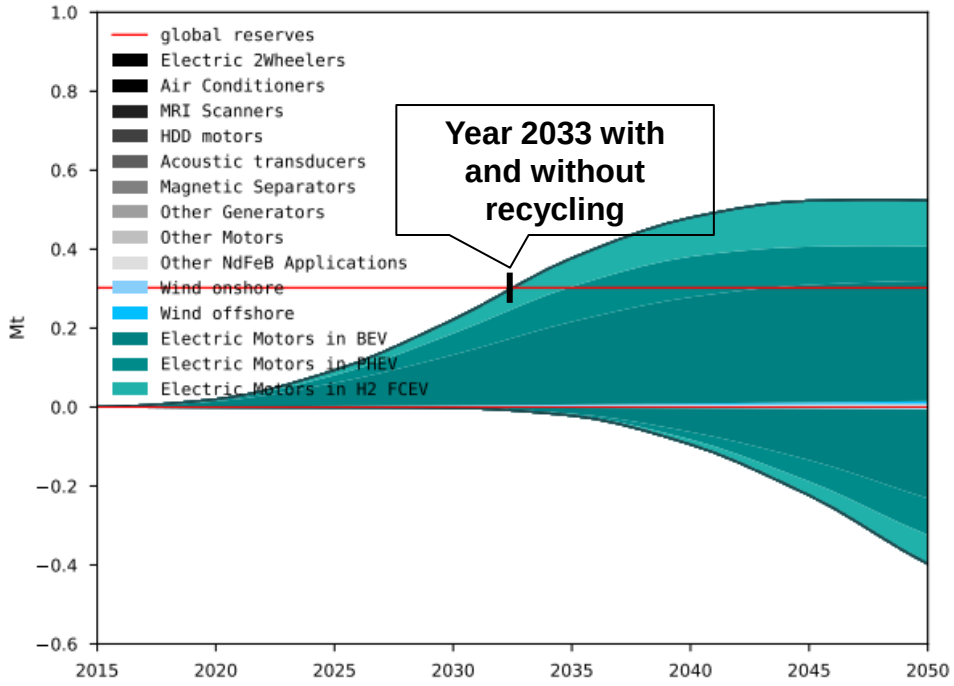
Roadmap: Technological Change



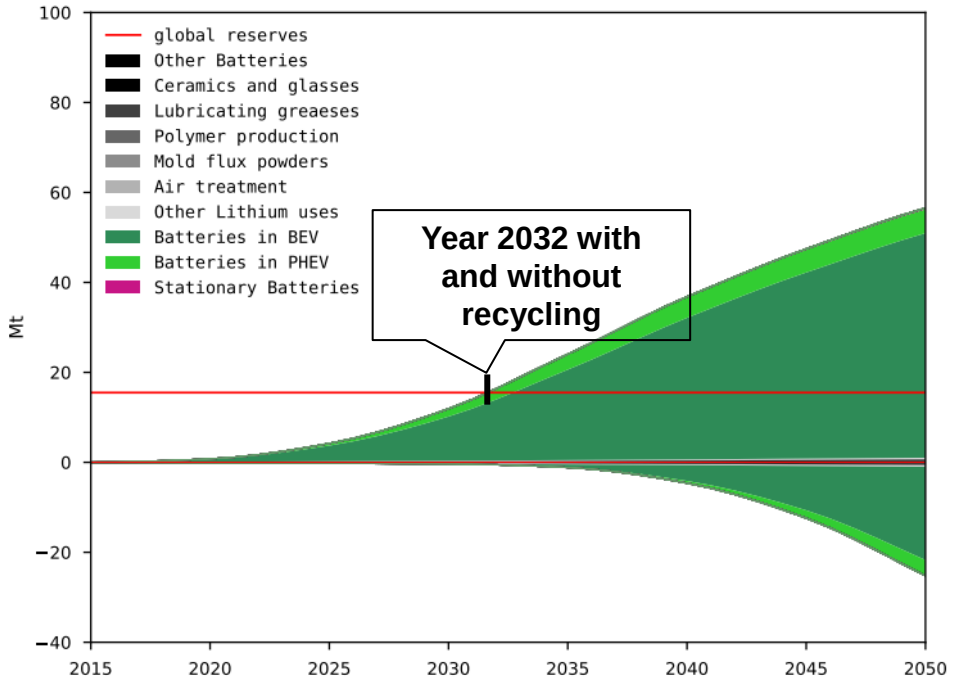
- Next to lithium, a battery uptake is highly restricted by cobalt reserves and resources

Results – The role of recycling

Dysprosium, Roadmap: Continuity



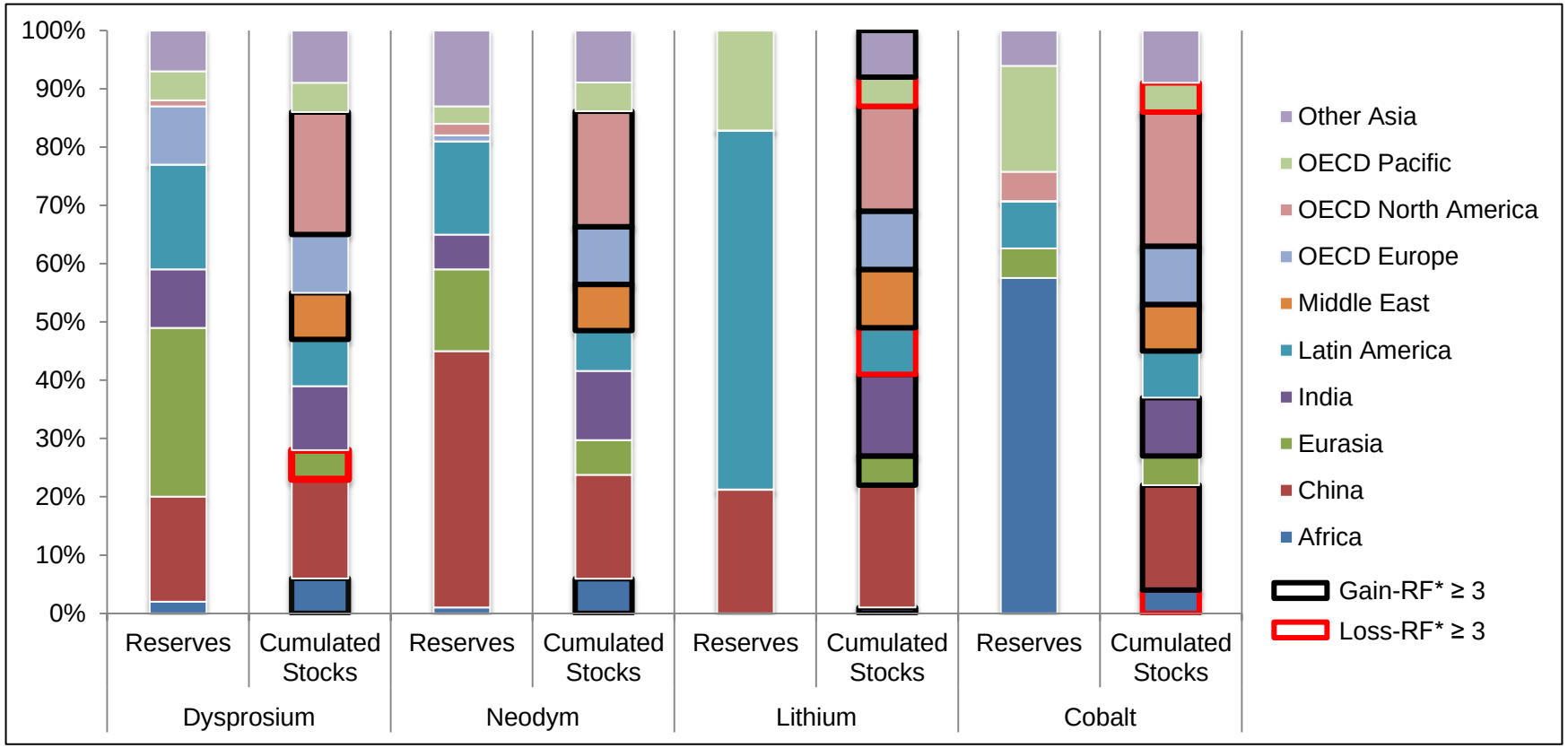
Lithium, Roadmap: Technological Change



- Recycling cannot delay depletion of reserves but will play a major role in the years 2030+
- Only large scale technological shifts may overcome this problem

Results – Hyprothetical global distribution of materials

E[R] World ADV



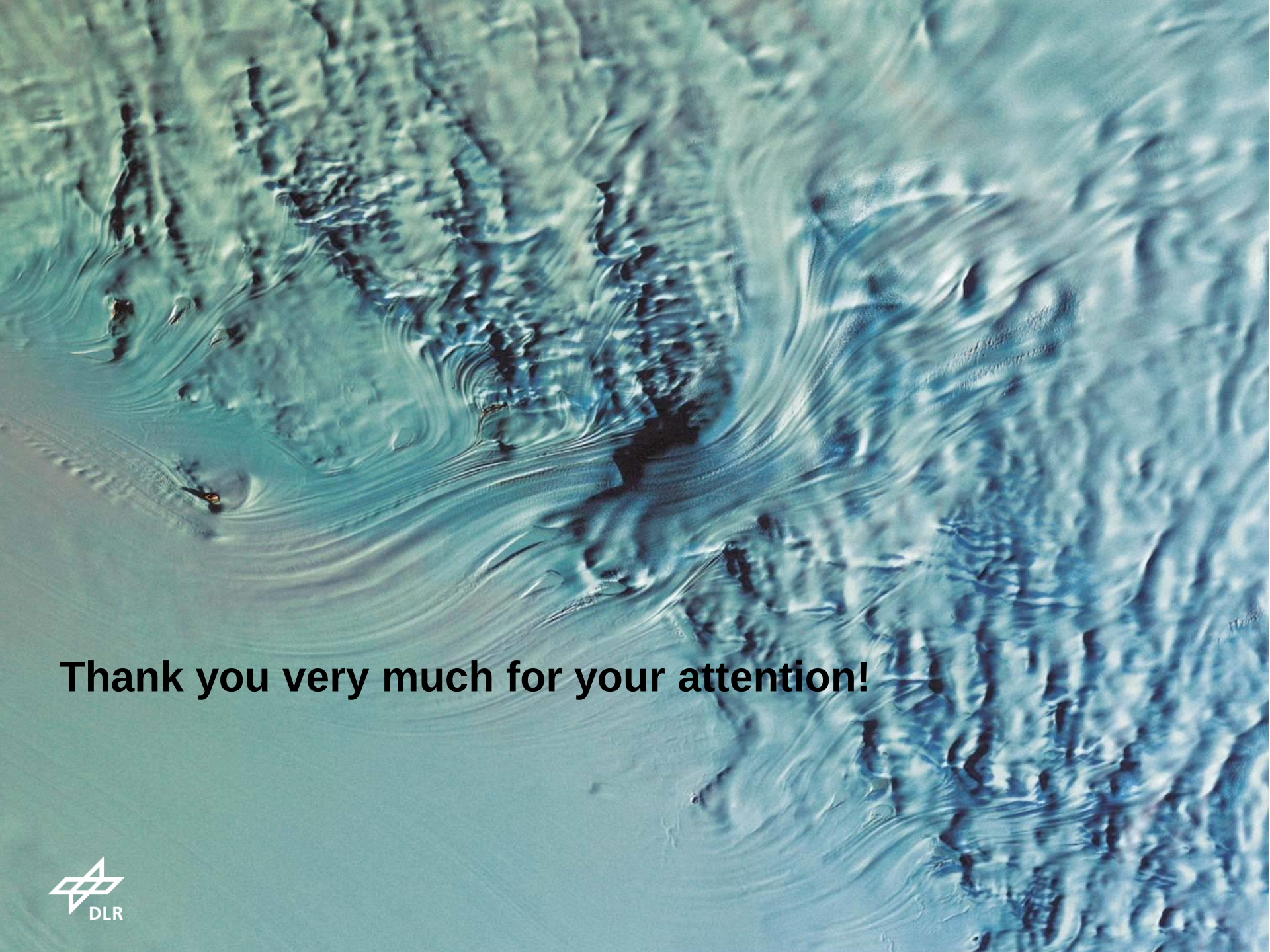
- Middle East, OECD North America , Africa and OECD Europe have the largest relative gains
- Biggest losses occur in OECD Pacific and Other Asia

*RF = Redistribution Factor, threshold subjectively chosen by authors

Discussion and outlook

- Very ambitious scenarios seem to be impossible to implement with current material composition (even if *currently* foreseeable substituting technologies gain higher market shares)
- So far, no feedback effects between material consumption and technology costs are taken into account in energy system modeling
- Outlook: When substituting material, component or technology levels, efficiency losses are to be expected which should have a decisive influence on the technology portfolio (systemic cost vs. resource related risk trade-off)

⇨ Combining material demand and associated risks or cost implications with energy system modelling represents a yet largely unexplored field of research


Thank you very much for your attention!

Back-up slides

Determination of long-term and short-term storage requirements as a function of wind and solar power components

Short-term storage demand