BATMAN Project

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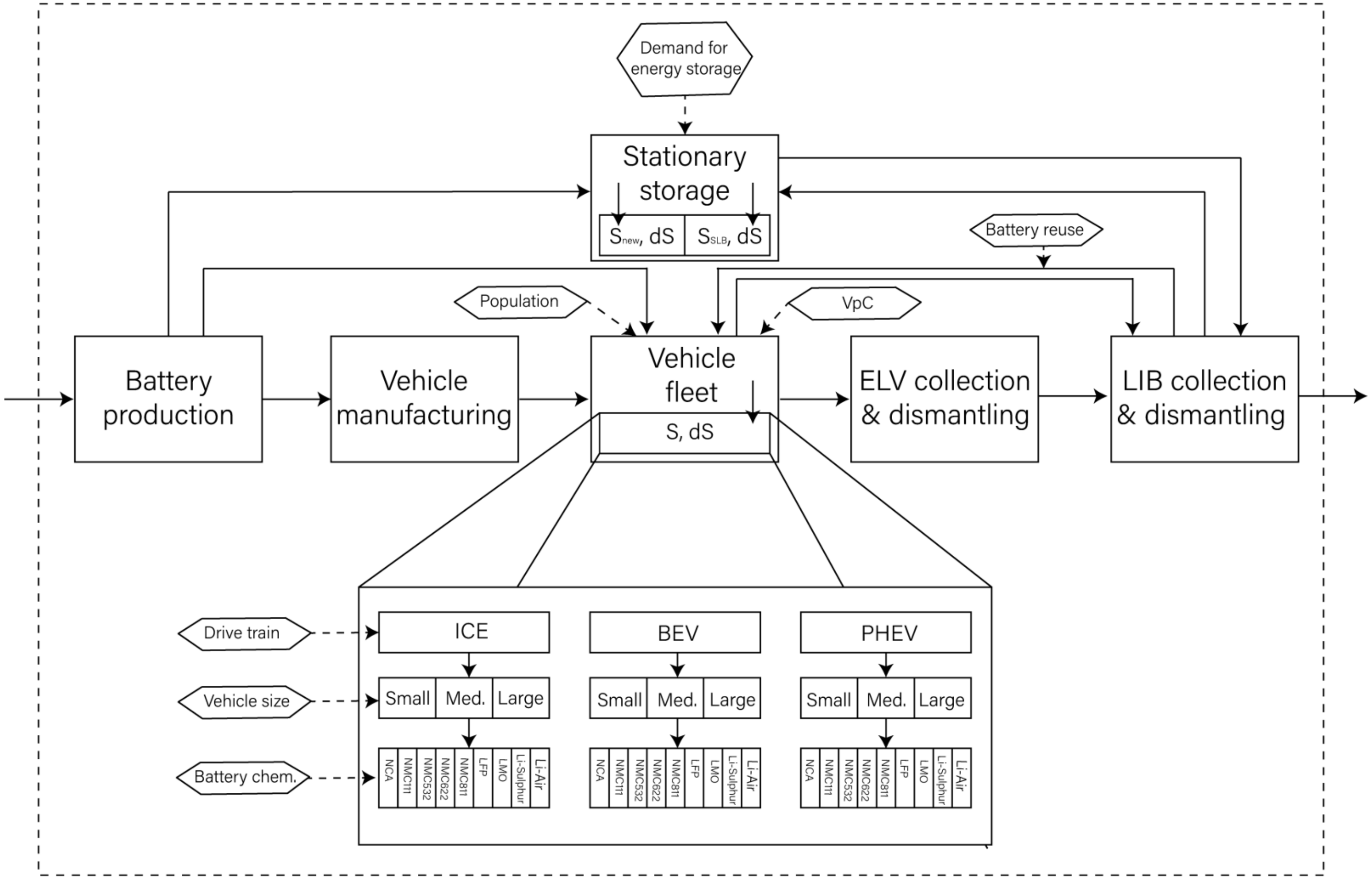
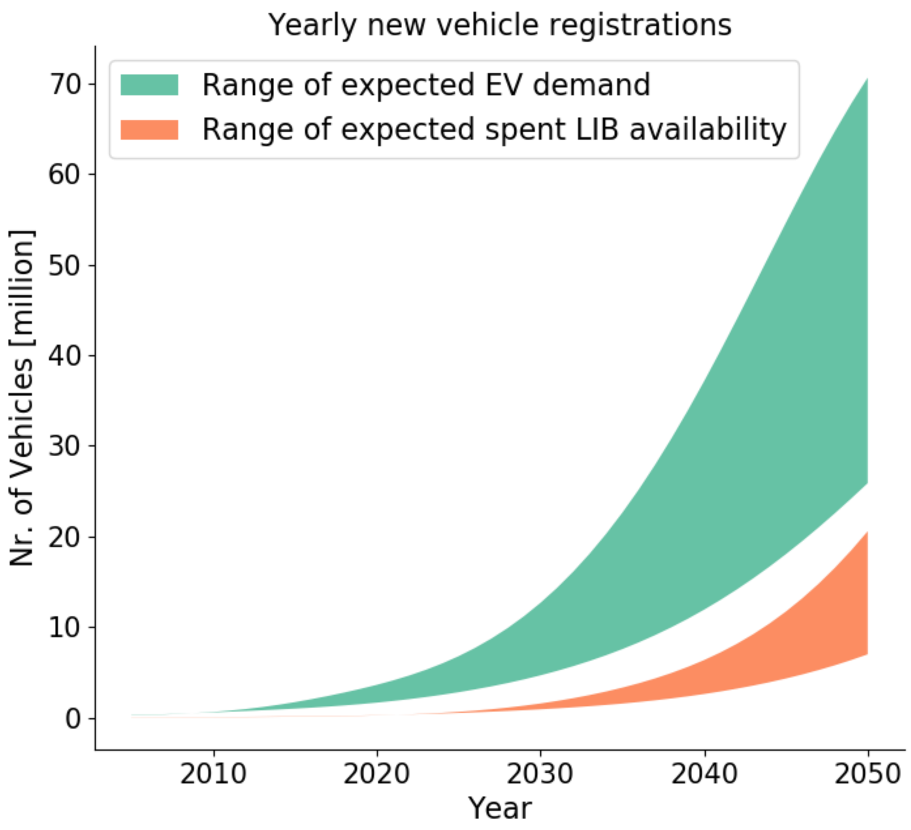
Research questions for global model

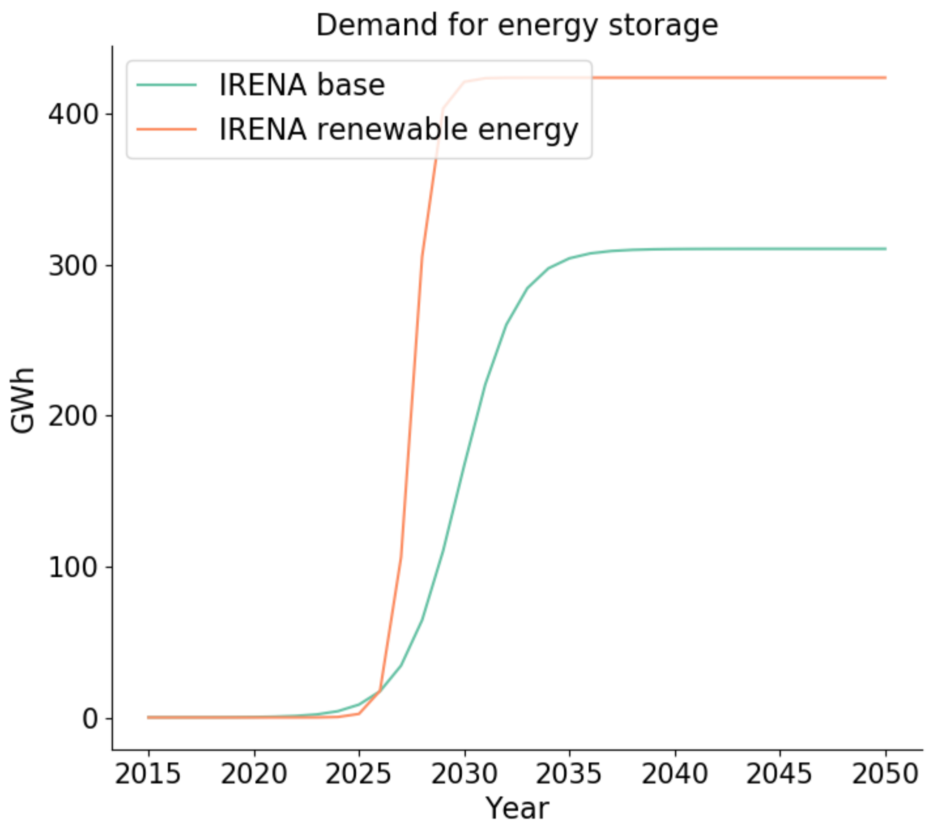
- What is the demand for LIBs at the global level for electric vehicles and for stationary storage?
- How much of the demand for stationary storage can be satisfied by second life batteries and how is their availability influenced by battery replacements?
- How does this affect the recycling potential of LIBs?

Needs for storage & transport as drivers

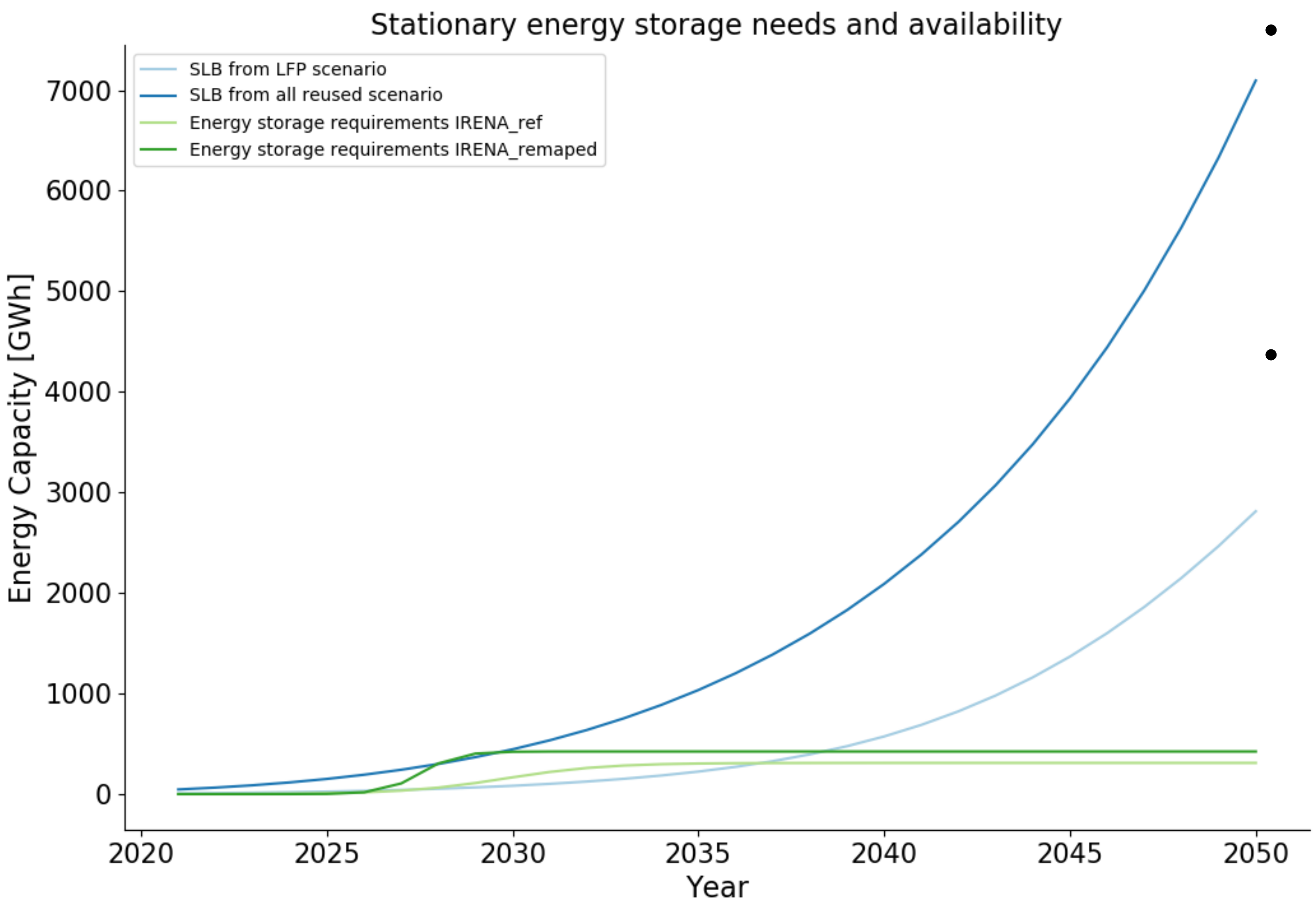


Expected LIB demand entering use





Stationary storage: The role of reuse



- In the short term:
  - Reuse rate can directly affect need for new batteries for stationary storage
  - New battery installations could in turn also have an effect on reuse due to their inertia
- In the long term:
  - SLB availability exacerbates demand
  - The timing for this varies depending on the reuse scenarios

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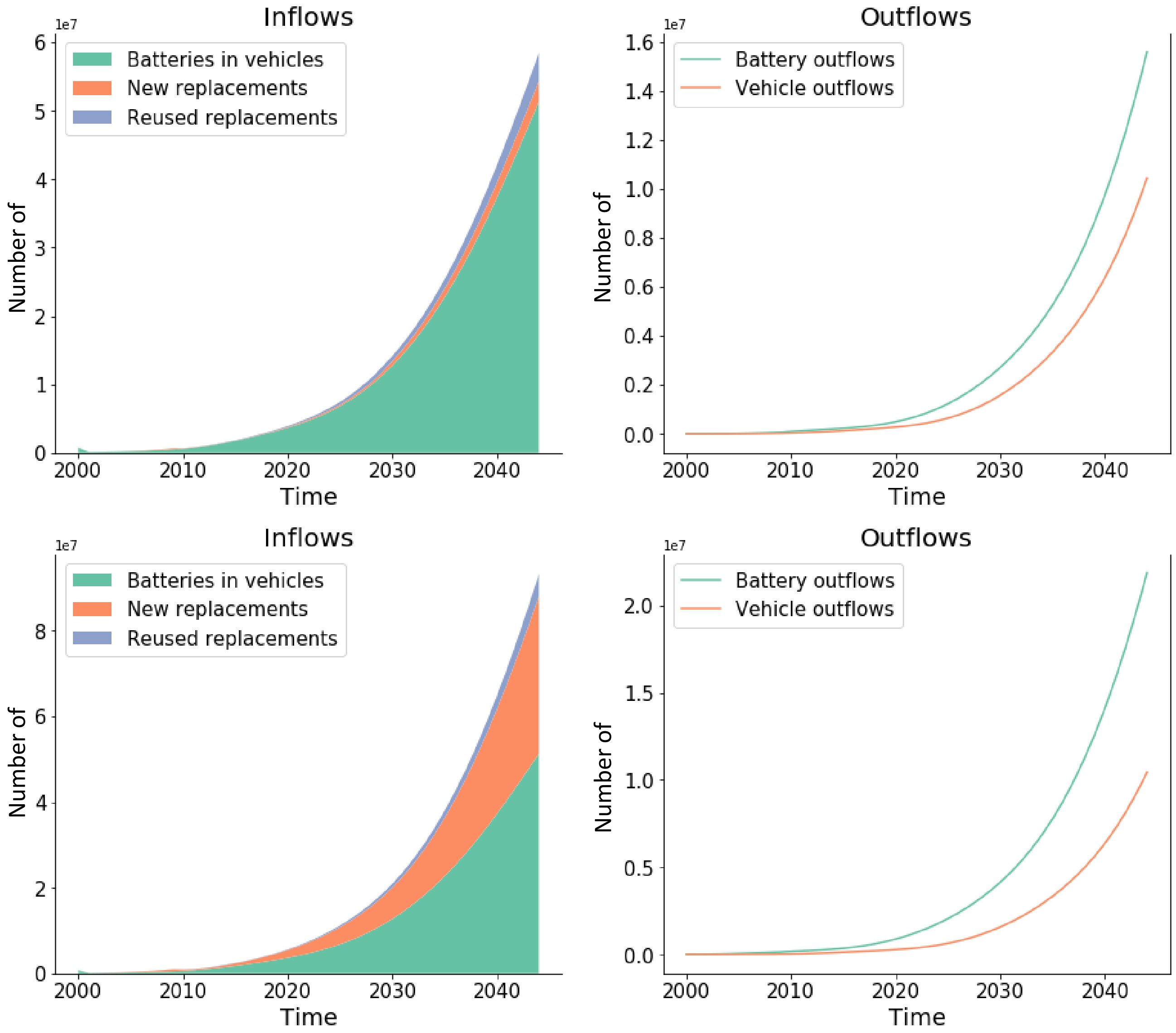
The role of lifetimes

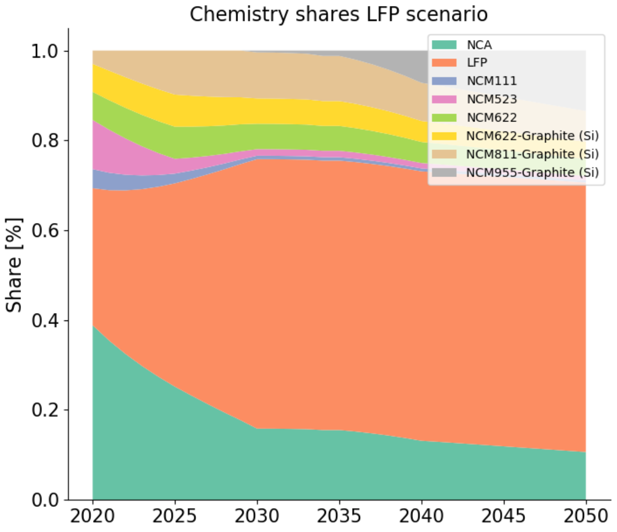


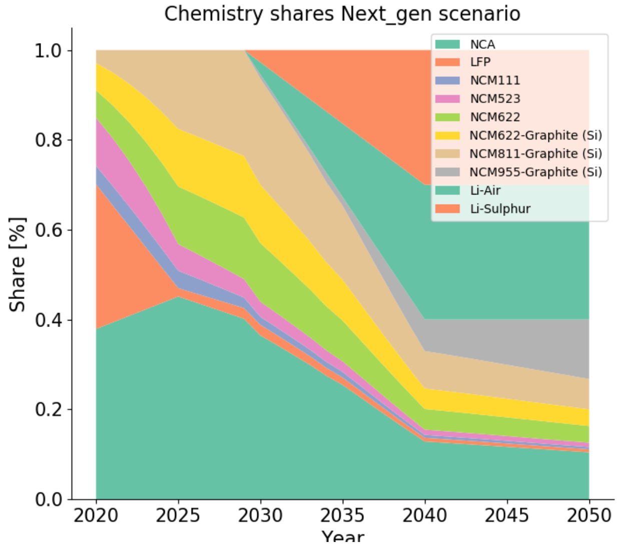
Battery lt: 12
Vehicle lt: 16

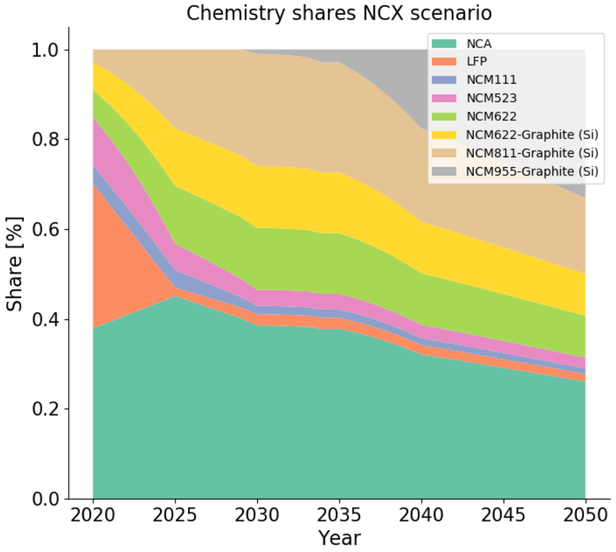
- A difference in lifetimes could also have a significant impact on the LIB demand
  - Battery replacements, repairs, and lifetime extensions need to be explored

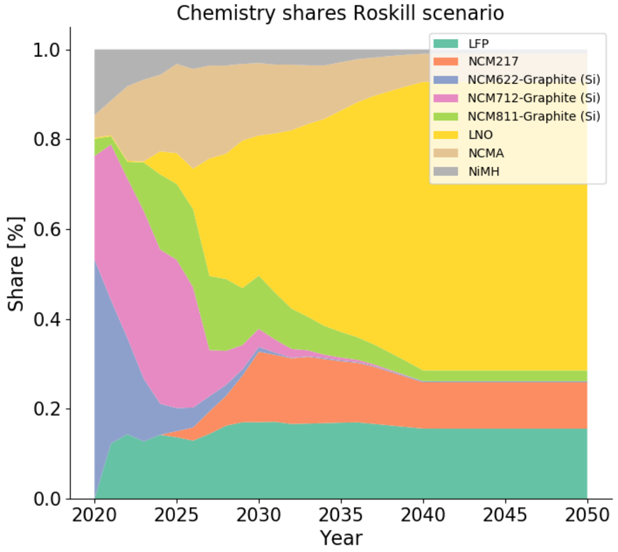
Battery lt: 8
Vehicle lt: 16

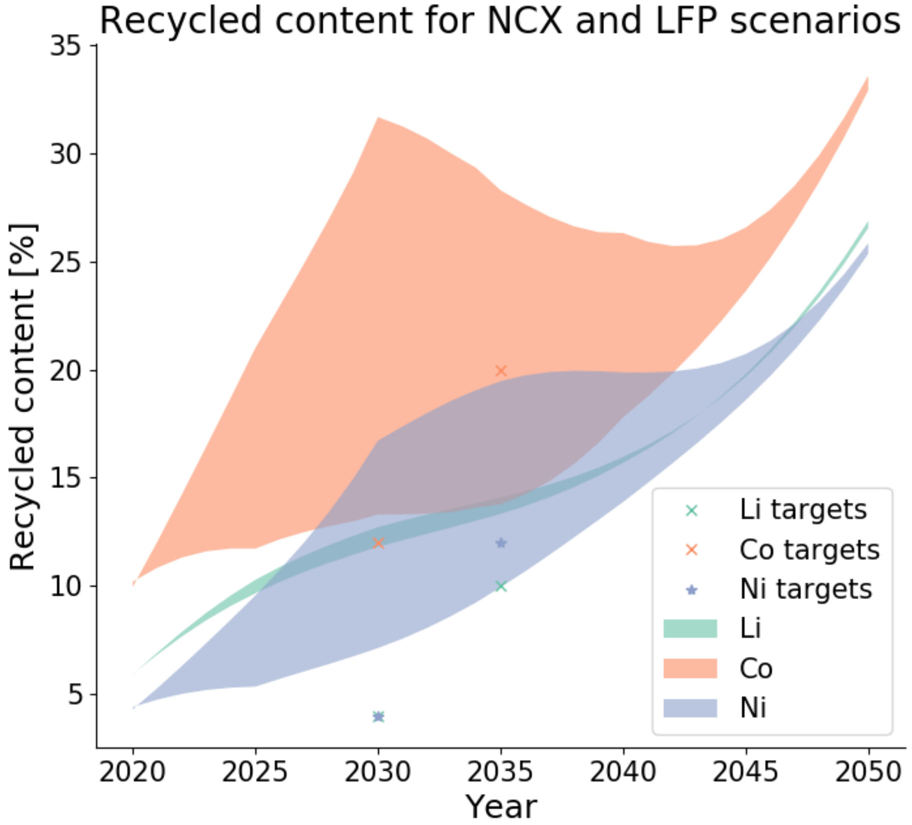
Recycled content for different chemistries





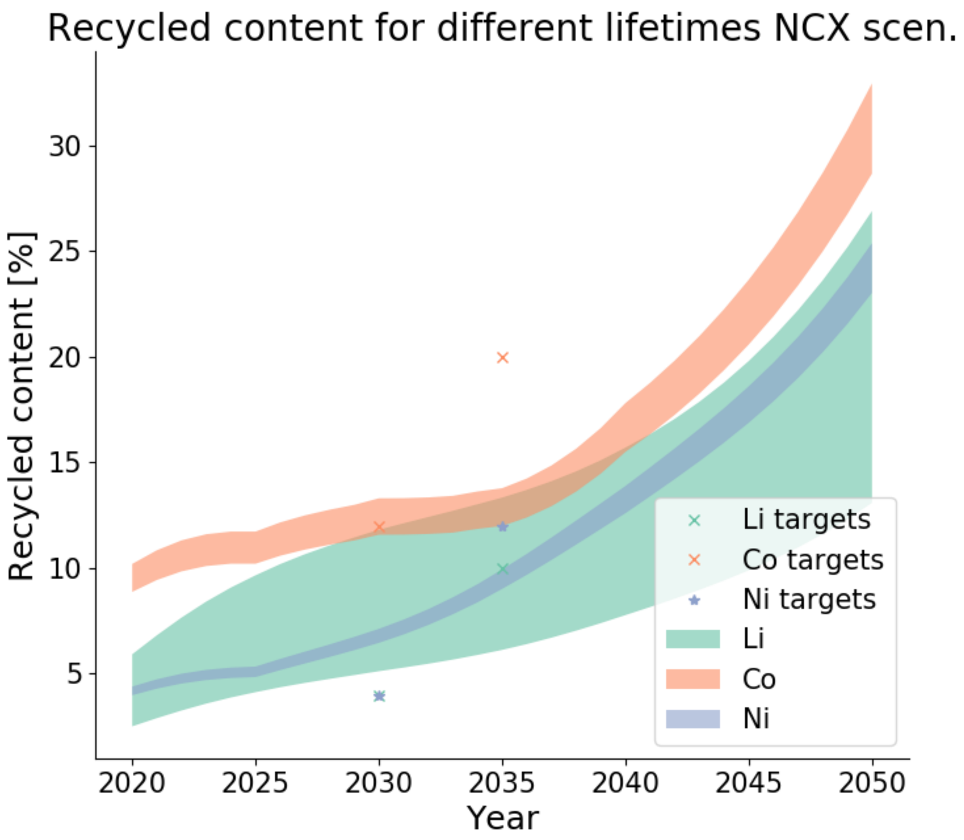


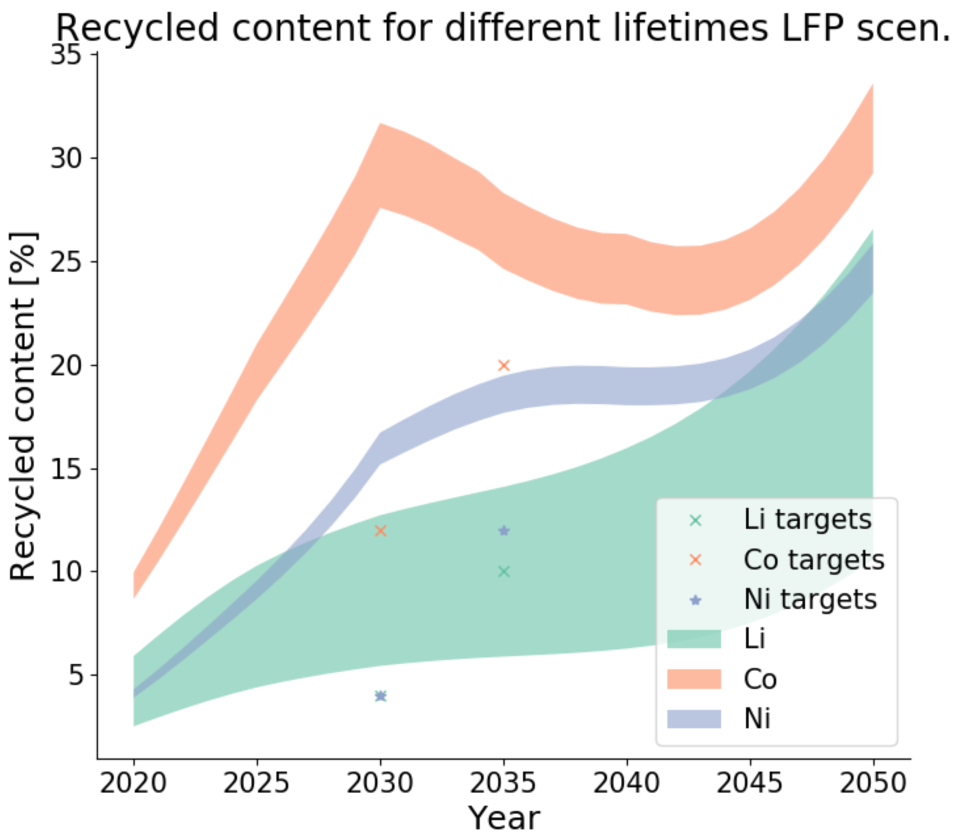




Lifetime is 16 years and all recycling is assumed to be direct recycling

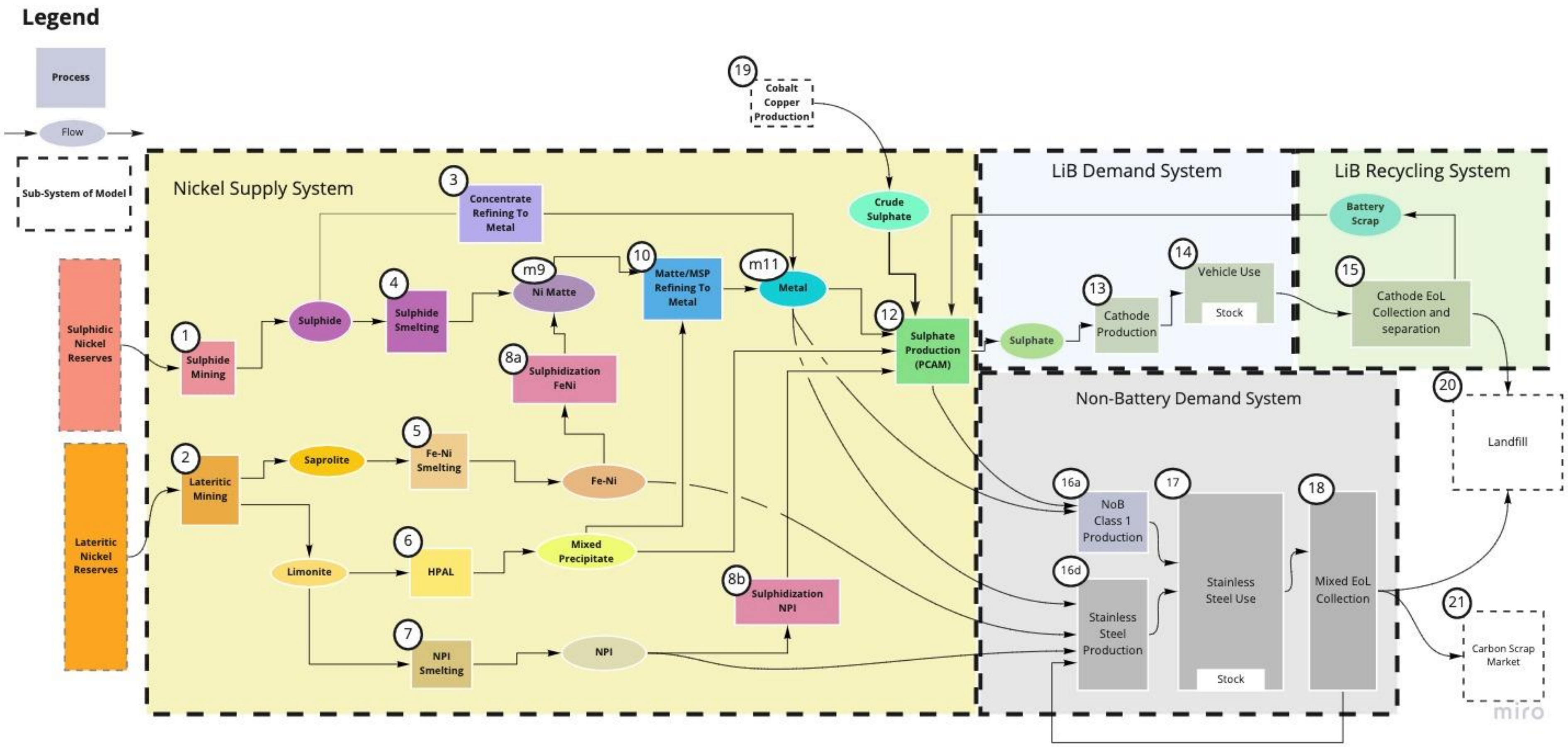
Recycled content for NCX and LFP scenarios with different lifetimes



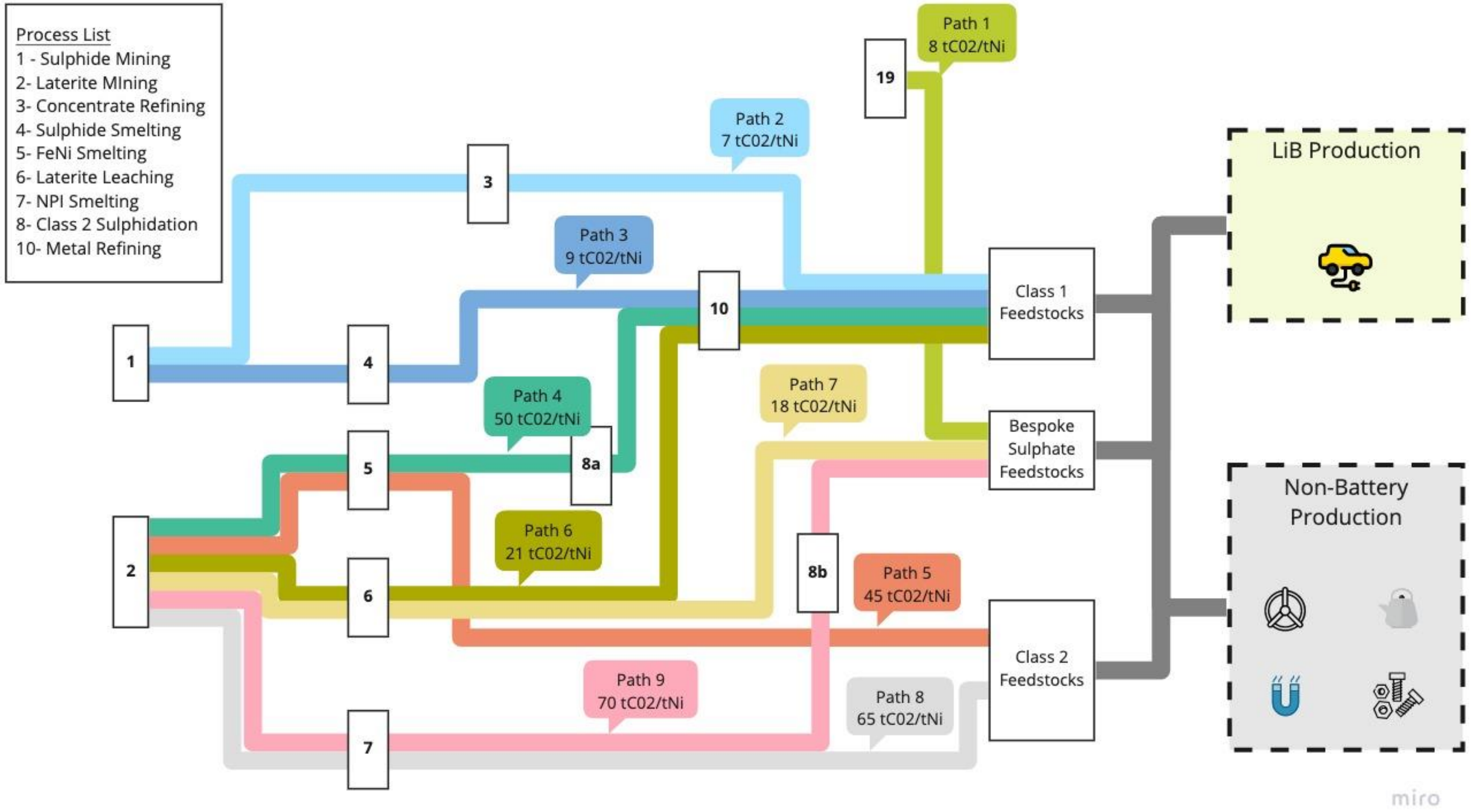


- Lower end bands: Lifetime of 20 years, all direct recycling
- Upper end bands: Lifetime of 16 years, all direct recycling

Nickel case study



Carbon footprints on production pathways



- Different pathways use different ore types and processing technologies
- 10x difference between the most environmentally friendly and the most carbon intensive pathways

Thanks for your attention!

Global carbon footprint of Aluminium in cars

How current trends in the passenger car market increase the demand for Aluminium and the need for a greener metal cycle

Romain Billy, NTNU

BATMAN Scenario Workshop
01.09.2021

Global carbon footprint of Aluminium in cars

PROBLEMS

- New trends impact the Al cycle:
  - Lightweighting
  - Electrification
  - SUV penetration
  - Population and car ownership growth
- More focus on embedded emissions
- Risk of castings scrap surplus

OPPORTUNITIES

- Better EoL management:
  - Challenge the current alloy use
  - Alloy-sorting
  - Closed-loop battery recycling
- Cleaner primary Al production:
  - Reduce direct emissions
  - Higher energy efficiency
  - Greener electricity mix

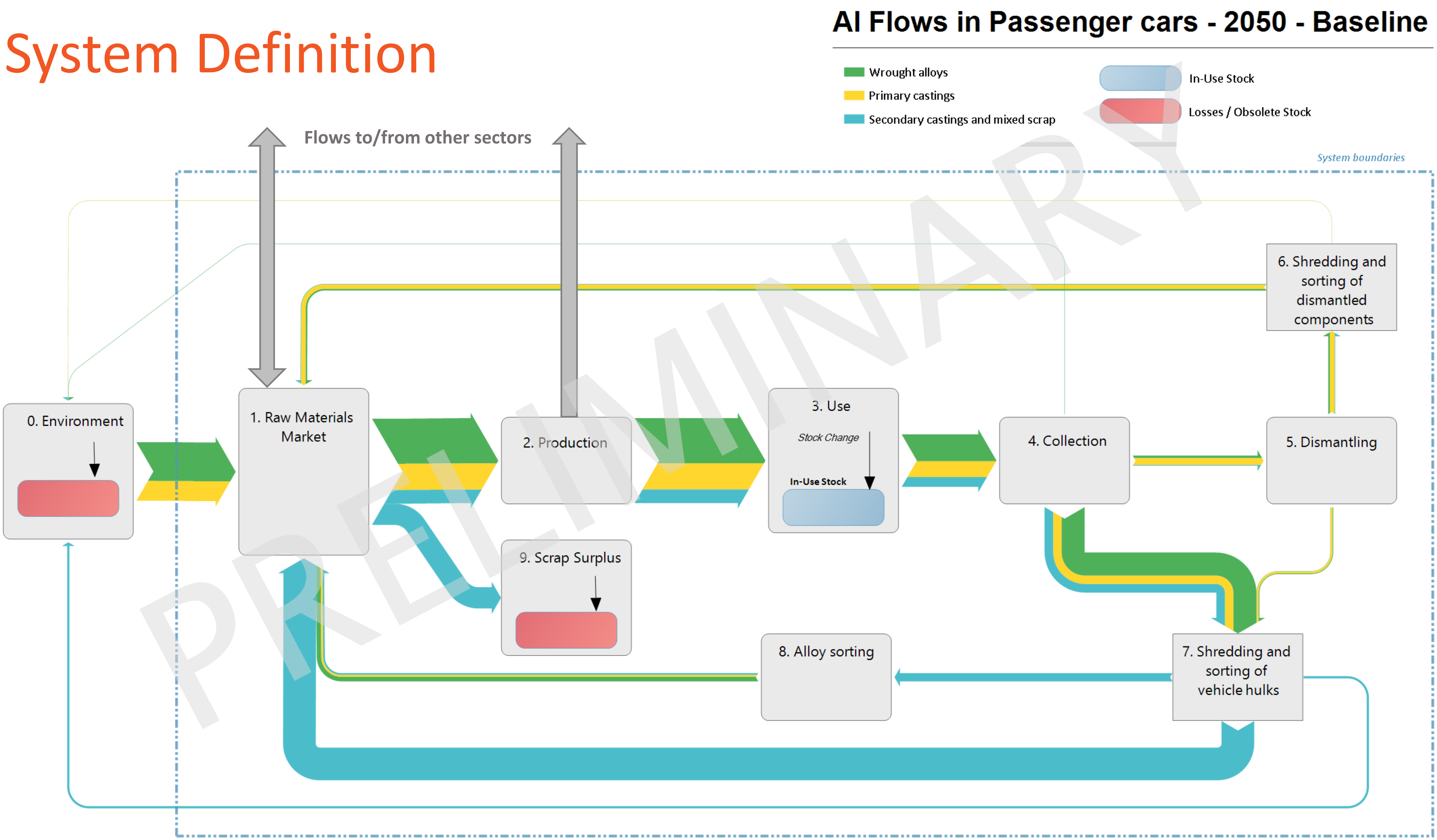
POLICIES

- Problem shifting to material production is not addressed enough
- Al is mostly ignored in battery directives
- Al is used in both the battery and the rest of the car: need for car level policies
- Meaningful system-level methods and indicators to track progress are missing

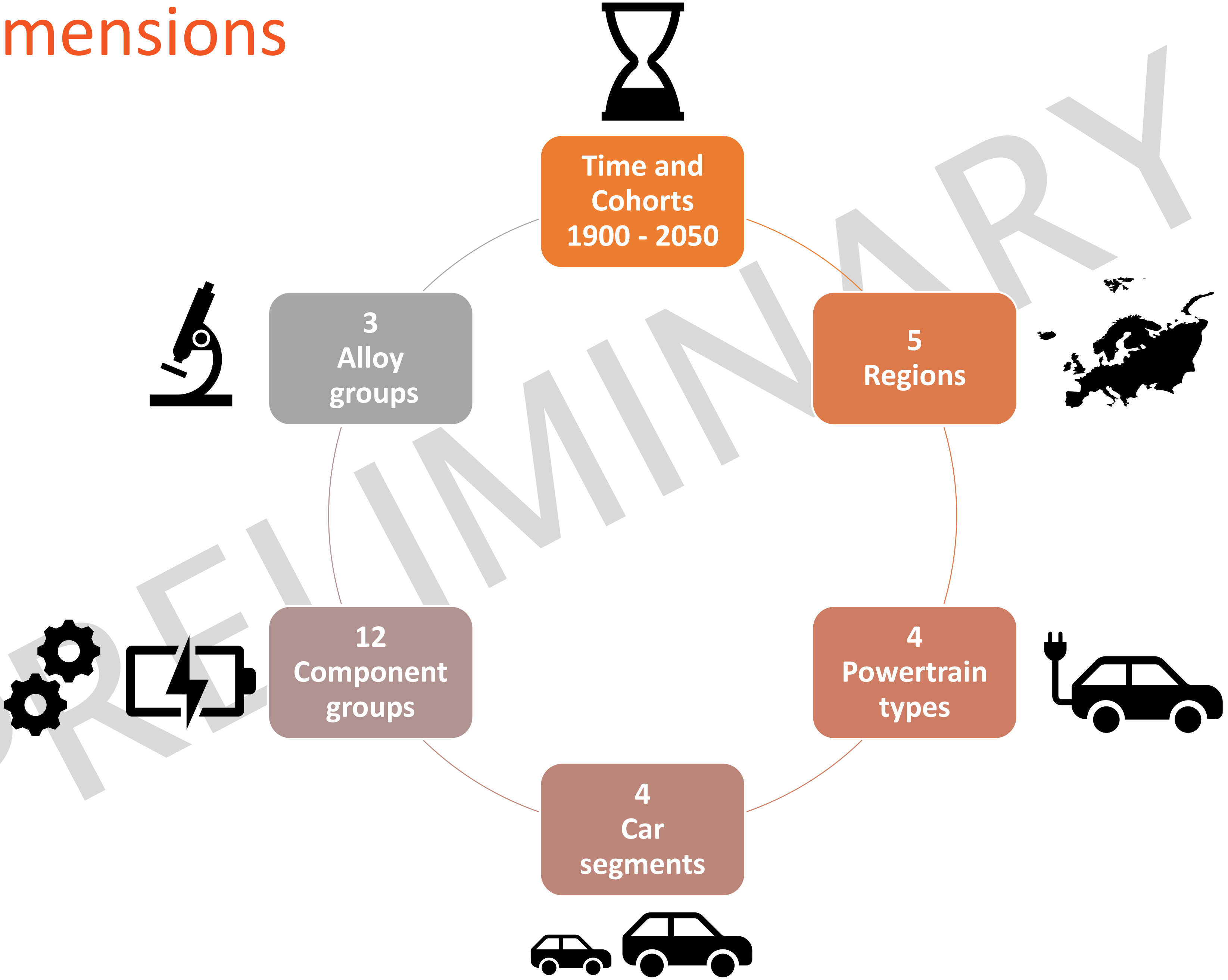
RESEARCH QUESTIONS

1. What will be the increase in Al demand and associated carbon footprint up to 2050, under different scenarios? What are mitigation options?
2. Will these changes in demand lead to a secondary castings scrap surplus? Which measures could limit the consequences?
3. How could current and future policies ensure a sustainable Al use in transport?

System Definition



Model dimensions



Model Parameters

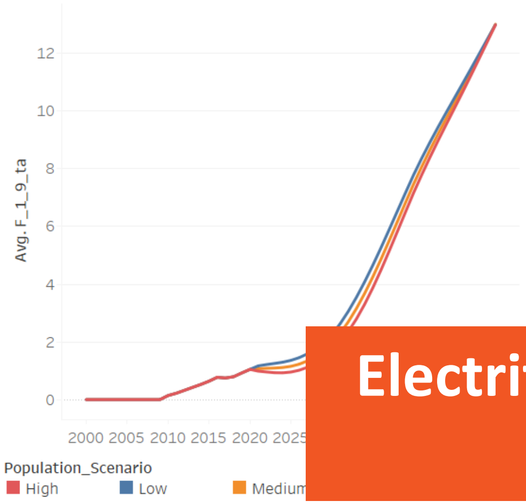
The model uses 8 independent parameters to build scenarios:

1. **Population** per world region
2. **Car ownership** per capita
3. **Powertrain** split
   (share of ICE, HV, PHEV, EV)
4. **Segment** split
   (share of different marketing segments, proxy for the size of vehicles)
5. Average **aluminium content** per car
   (normalized value, independent of segment and powertrain to measure lightweighting)
6. Average car **lifetime**
7. Use of **alloy sorting** technology
8. **Carbon footprint** of primary and secondary production

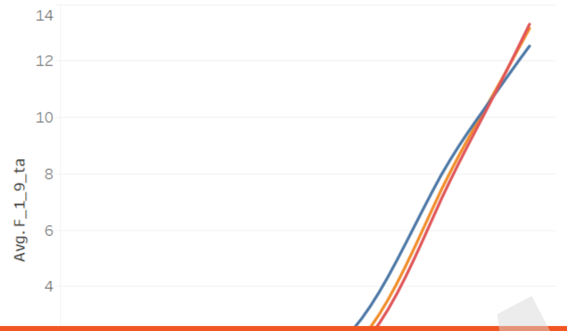
The combinations of all independent projections for parameters give a set of 11 664 scenarios.

Sensitivity analysis of scrap surplus

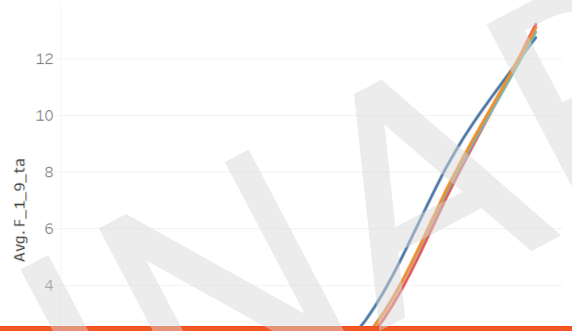
Sensitivity to Population



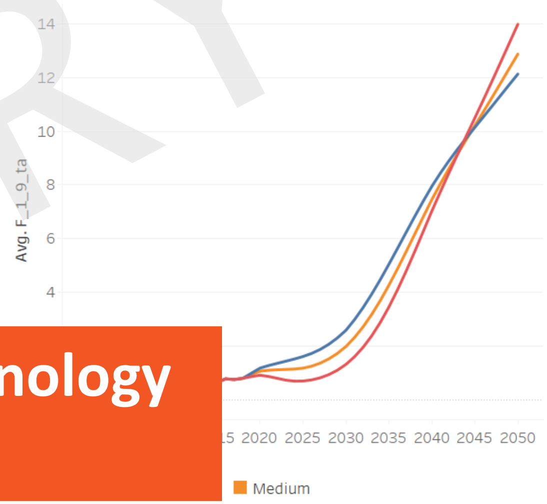
Sensitivity to vehicle ownership



Sensitivity to segment split

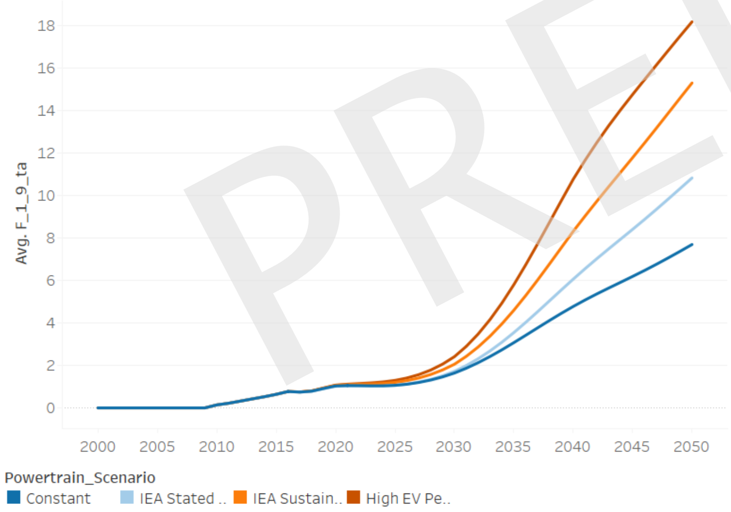


Sensitivity to Al content

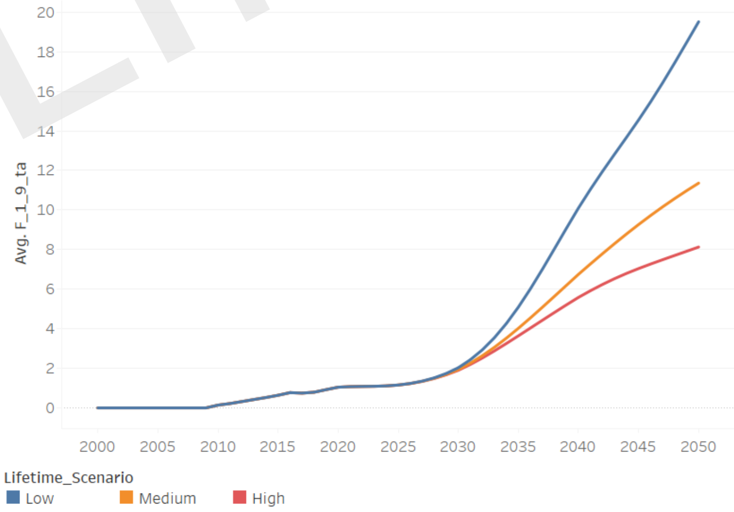


Electrification, Car lifetime and alloy sorting technology have the largest effect on scrap surplus

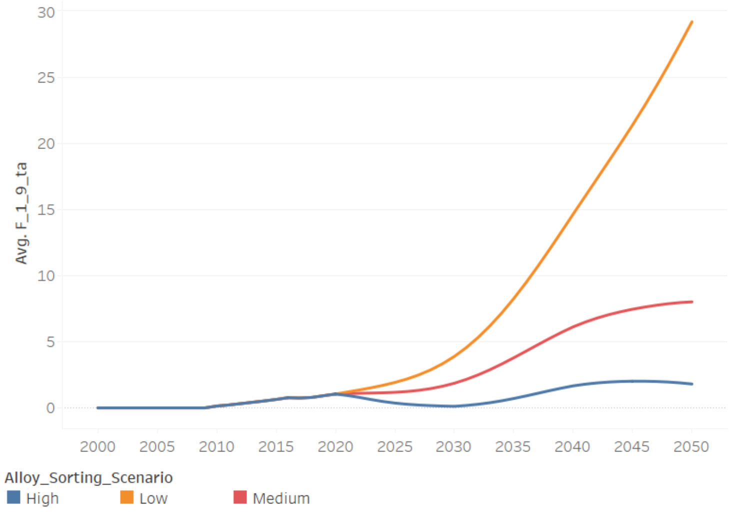
Sensitivity to powertrain type



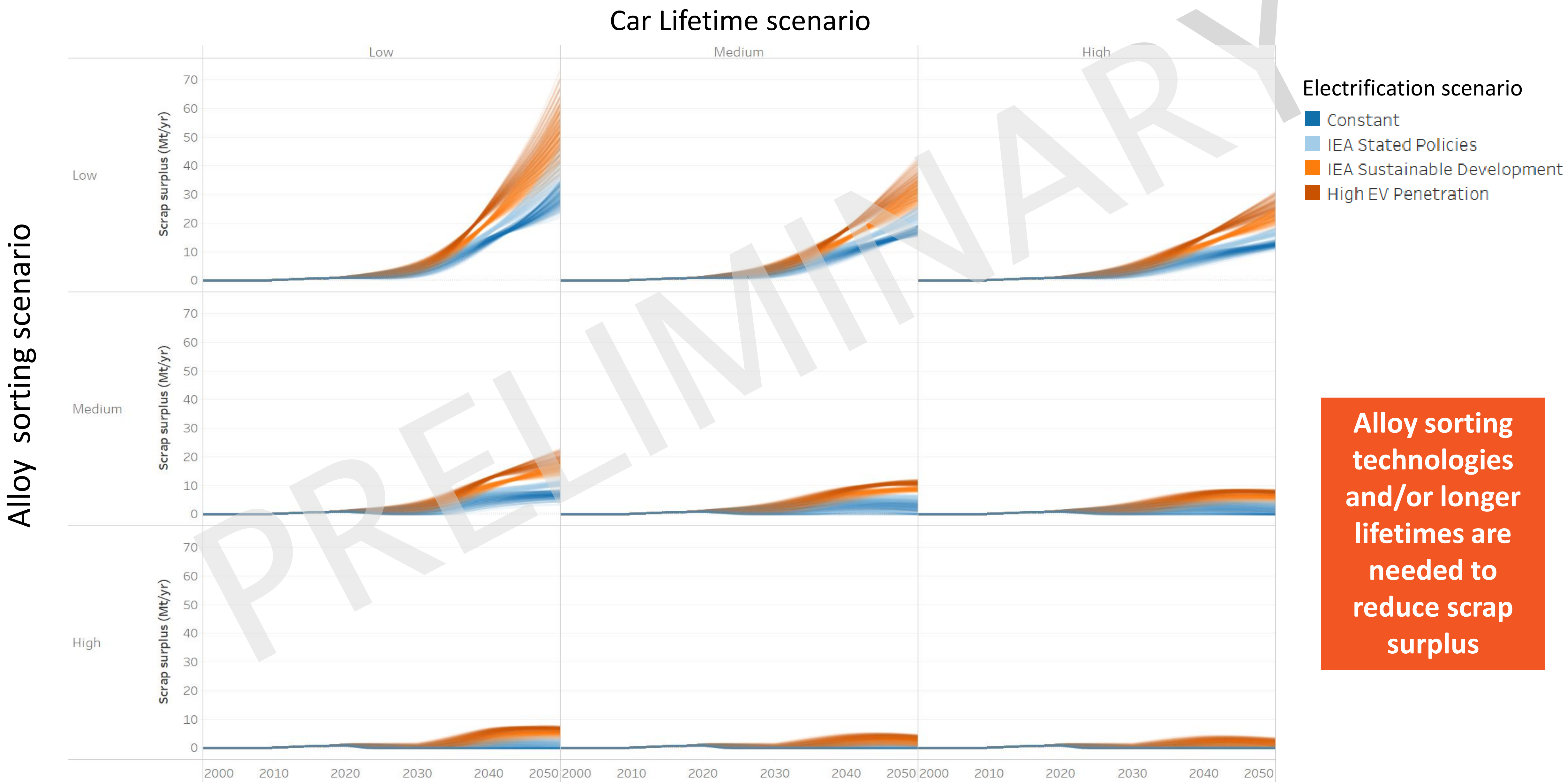
Sensitivity to car lifetime



Sensitivity to alloy sorting technology



Sensitivity analysis of scrap surplus

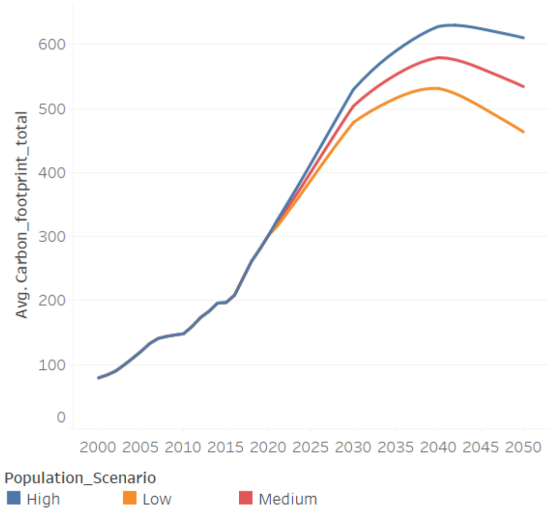


Alloy sorting technologies and/or longer lifetimes are needed to reduce scrap surplus

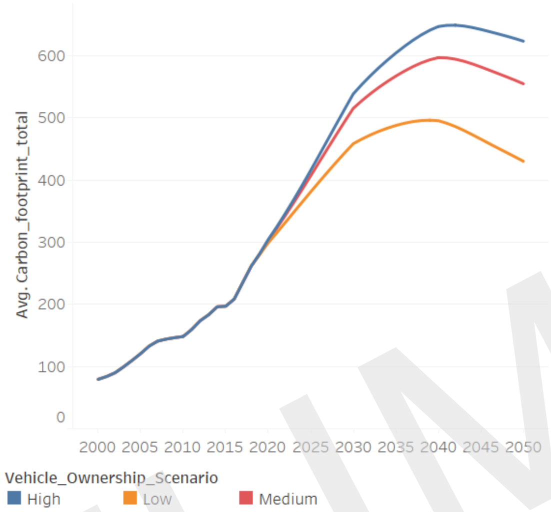
Sensitivity analysis of global Al carbon footprint

Sensitivity analysis of yearly carbon footprint of aluminum production to parameter scenarios

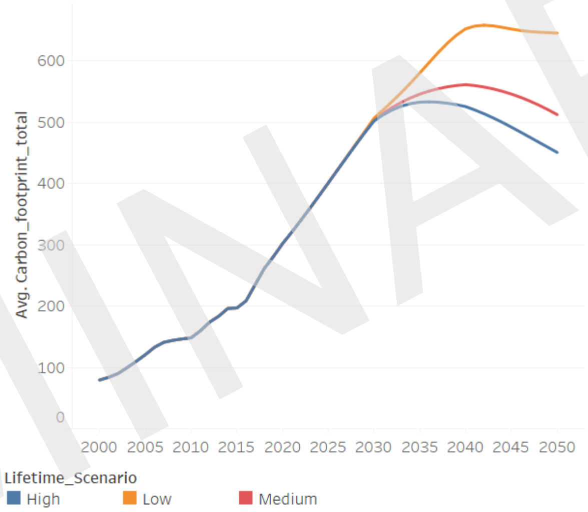
Population scenario



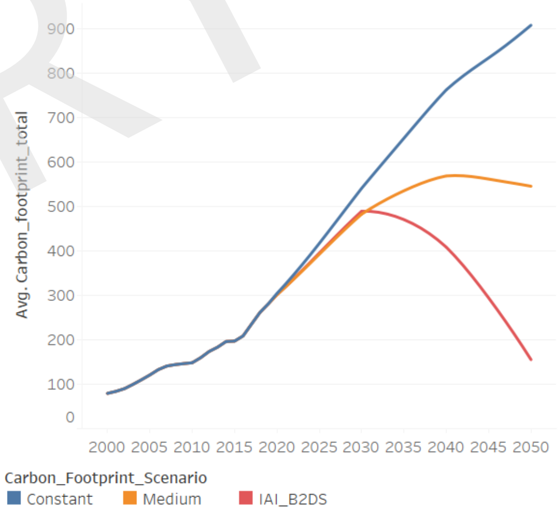
Vehicle Ownership scenario



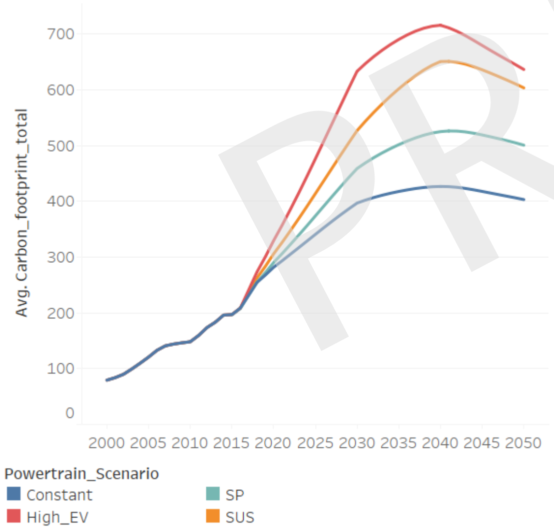
Lifetime scenario



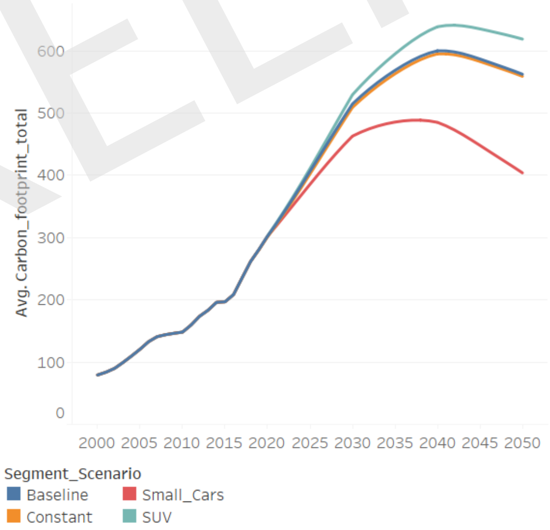
Carbon footprint scenario



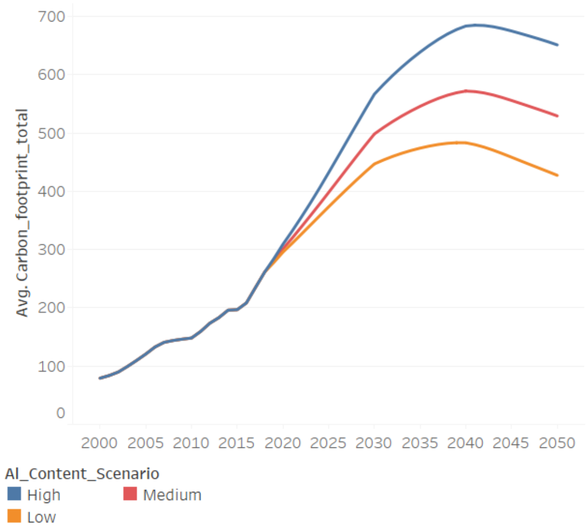
Powertrain scenario



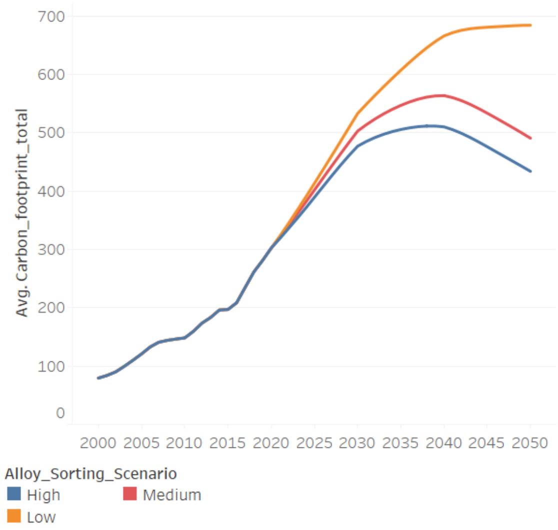
Segment scenario



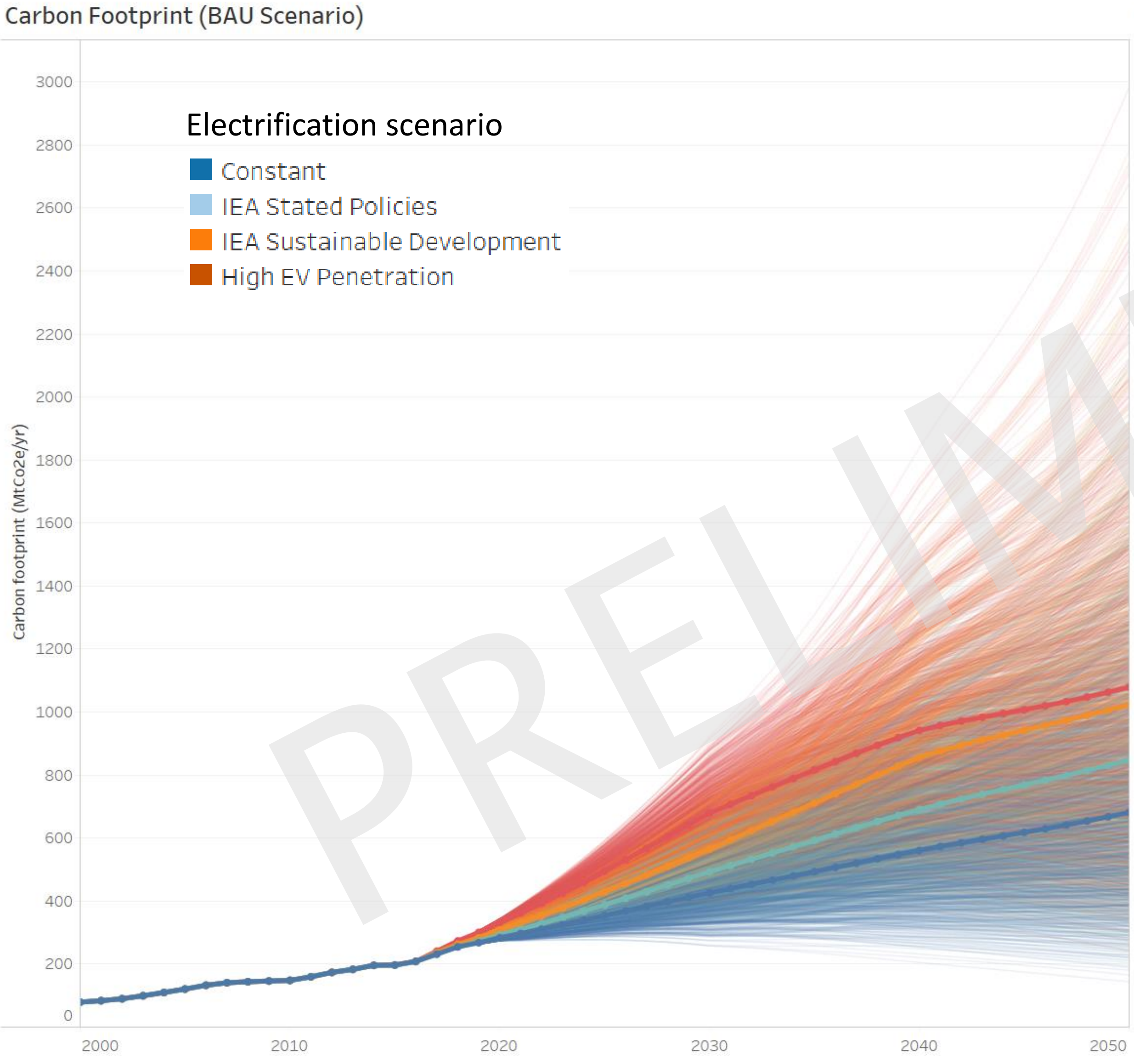
Al Content scenario

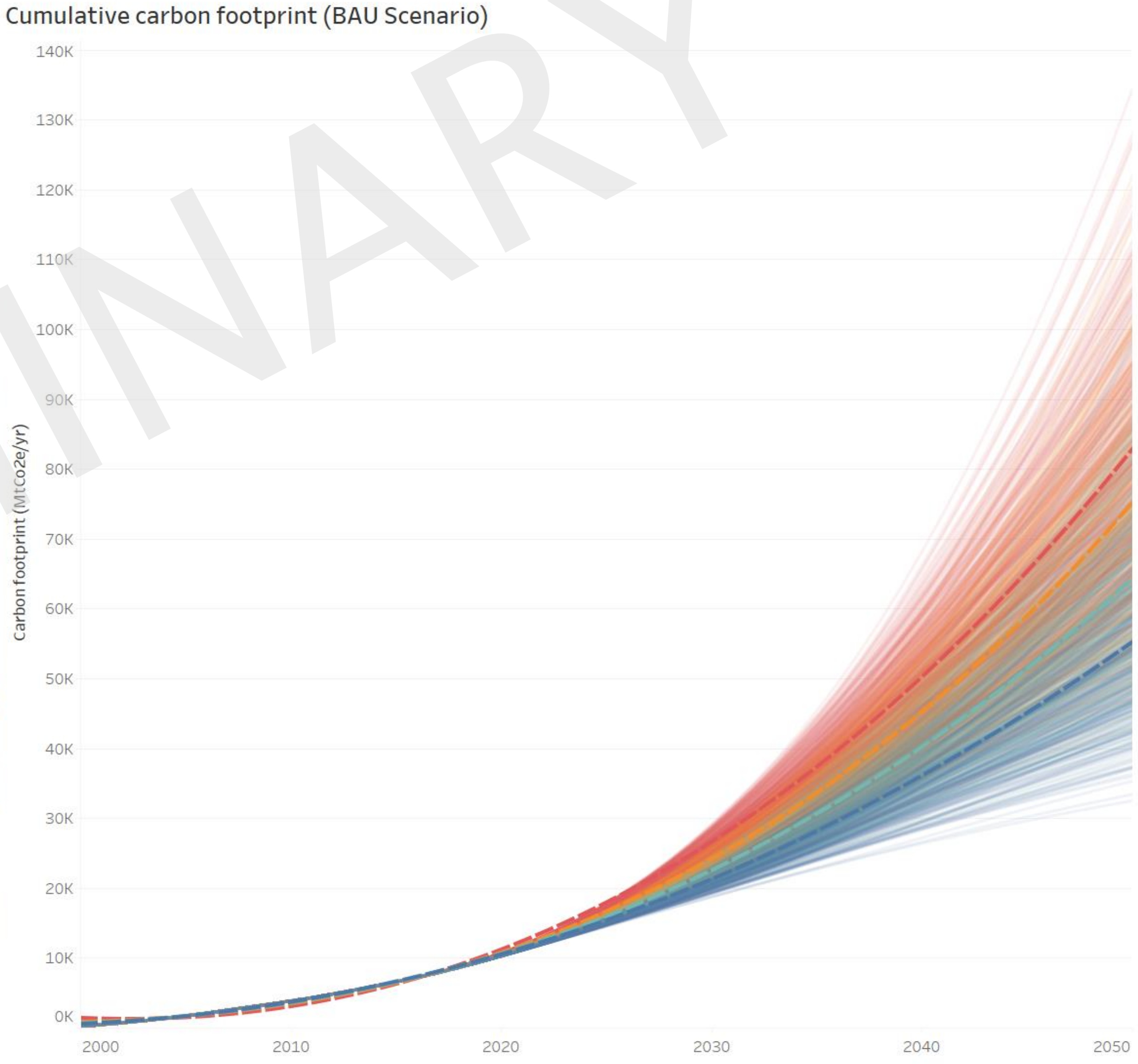


Alloy sorting scenario

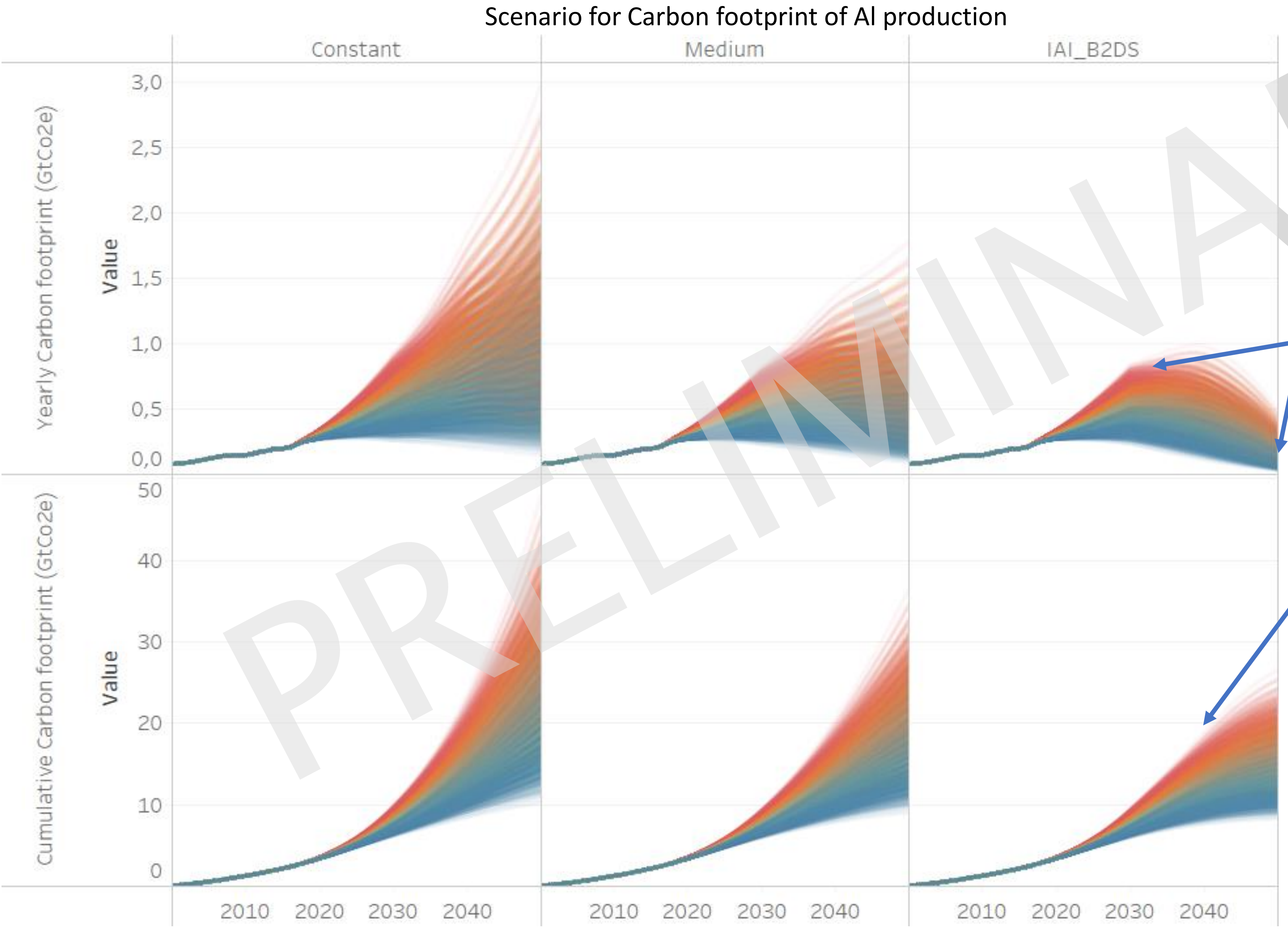


Global carbon footprint of AI in cars (BAU)





Can we mitigate the carbon footprint of Al production?



- Mitigation efforts in Al production can bring the carbon footprint back to current levels in 2050
- However, EV penetration happens faster than changes in Al industry
- Making it challenging to mitigate cumulative emissions:
  Change is needed now!

Thank you!

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