



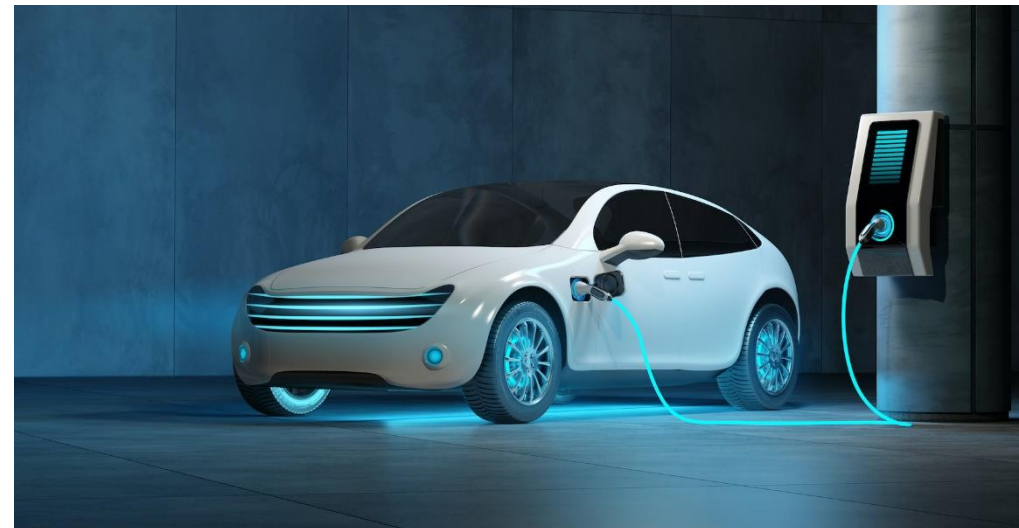
BATTERIES RAW MATERIALS

WHAT EFFICIENT POLICIES TO LOWER METAL DEMAND?

LOUIS-MARIE MALBEC

VINCENT D'HERBEMONT

EMMANUEL HACHE



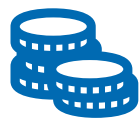
AN INTERNATIONAL SCOPE IN THE FIELDS OF ENERGY, TRANSPORT AND THE ENVIRONMENT



A public sector
R&I body

A training
center

An industrial
group



€120.5m
budget allocation
In 2020



€146.5m
own resources
In 2020



1,635
people



1,190 engineers
and technicians

CLIMATE, ENVIRONMENT AND CIRCULAR ECONOMY

Reducing the impact of
human and industrial
activities on the climate and
the environment

RENEWABLE ENERGIES

Developing solutions to
produce energy, fuels
and chemical intermediates
from renewable sources

SUSTAINABLE MOBILITY

Developing effective,
environmentally-friendly
solutions for the transport
sector

RESPONSIBLE OIL AND GAS

Proposing technologies that
meet the demand for
energy and chemical
products, reducing the
environmental impact

CONTEXT

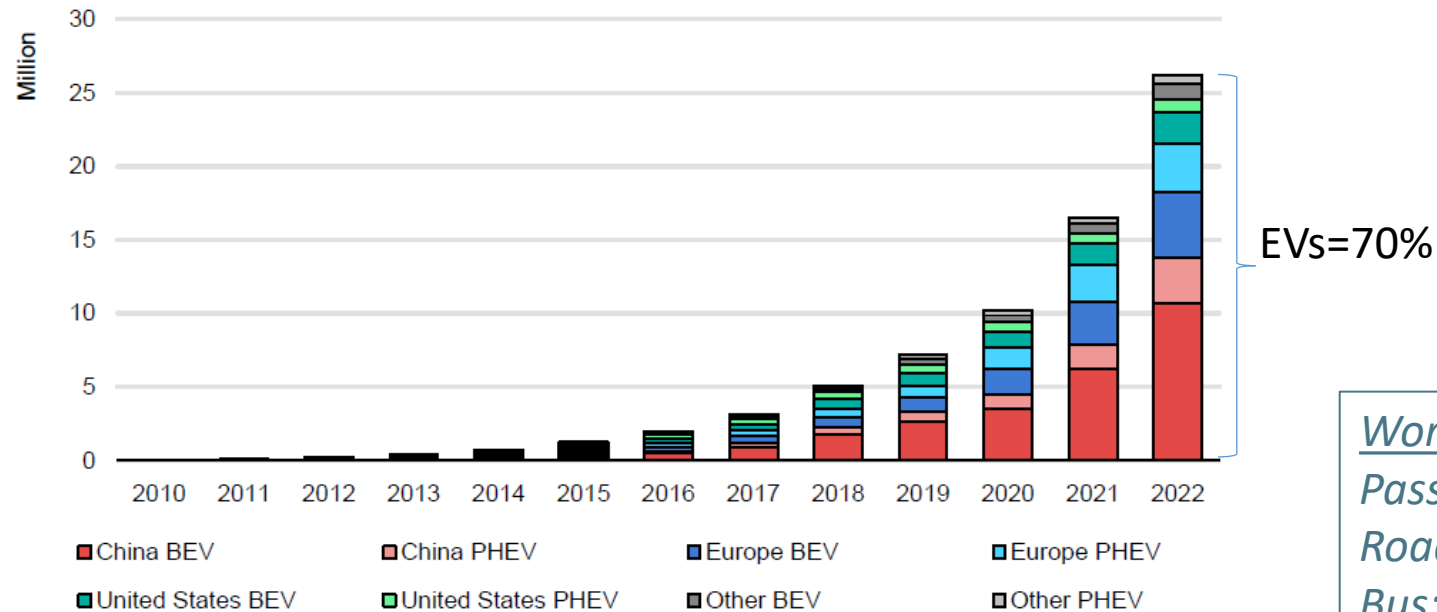
● Rapid growth of EV market share (light-duty)

● EV (BEV+PHEV) sales

- 2012: 0.1 million
- 2017: 1 million
- 2022: 10 millions

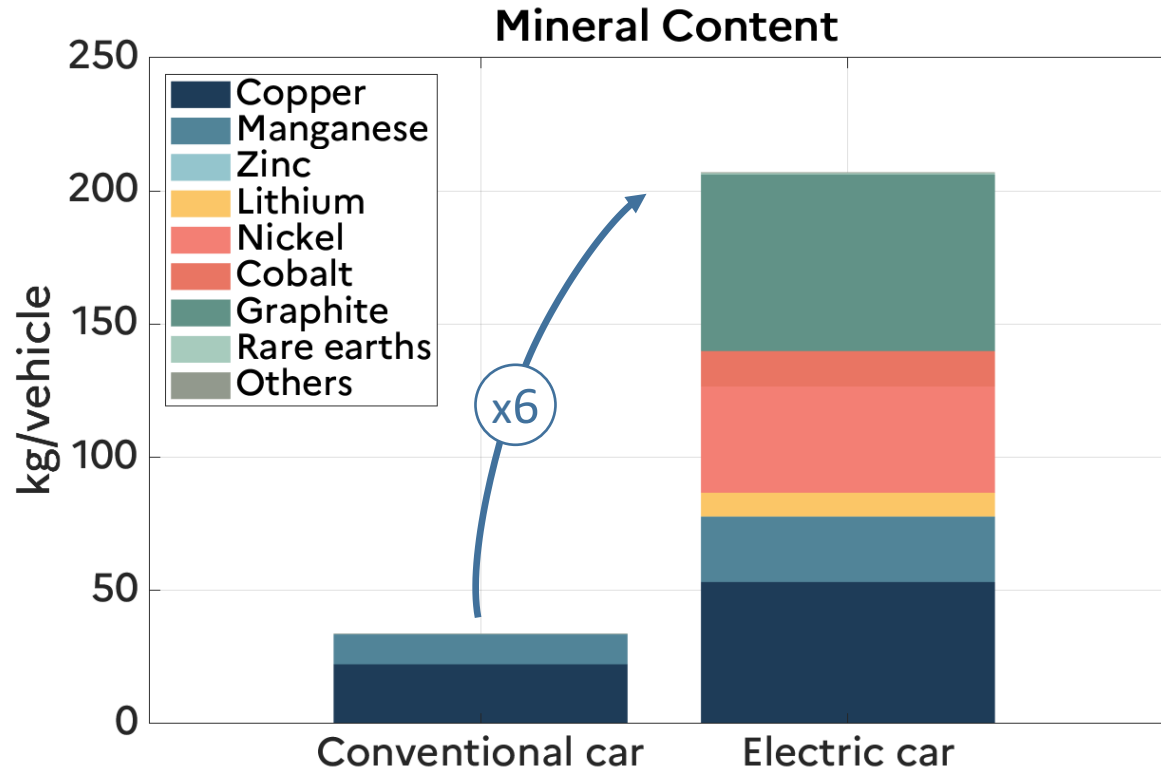
- =14% of total sales (=annual sales of vehicles in EU)
- EVs = 20% of sales in Europe

Figure 1.1 Global electric car stock in selected regions, 2010-2022



World stock in 2020
Passenger Vehicles : 1200 millions
Road freight (LCV+MCV+HCV)=220 millions
Bus: 28 millions

Material content



Challenges:

- Resources / reserves
- Annual production
- Sovereignty

IEA – The Role of Critical Minerals in Clean Energy Transitions

CONTEXT

● European batteries regulation: targets

Collecting



2028	2031
51%	61%

Recycling



	2027	2031
Lithium	50%	80%
Cobalt	90%	95%
Nickel	90%	95%
Copper	90%	95%

Collecting + Recycling



	2027	2031
Lithium	26%	49%
Cobalt	46%	58%
Nickel	46%	58%
Copper	46%	58%

Reincorporation



	2031	2036
Lithium	6%	12%
Cobalt	16%	26%
Nickel	6%	15%

Scraps + Recycled material

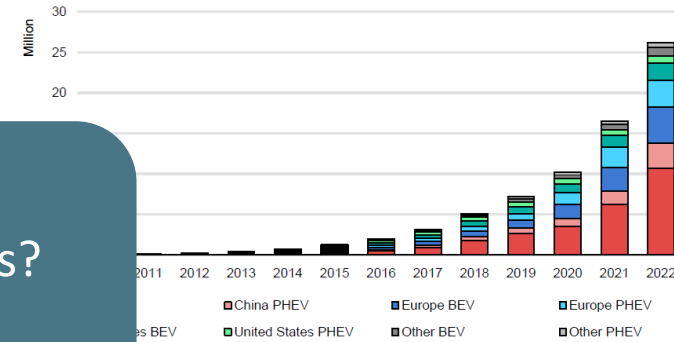
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● Rapid growth of EV market share (light-duty)

● EV (BEV+PHEV) sales

● 2012: 0.1 million

Figure 1.1 Global electric car stock in selected regions, 2010-2022



- What will be the European metal consumption for EVs?
 - A model to compute the metal demand
 - Results for Europe
 - Batteries capacities
 - Metal demand
- What policies could limit that demand?
 - EU27 case

● European batteries regulation

Recycling

	2021	2031
	49%	58%
Nickel	46%	58%
Copper	46%	58%

Reincorporation

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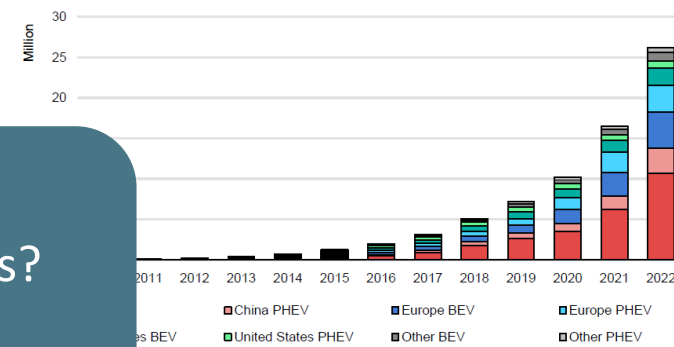
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Figure 1.1 Global electric car stock in selected regions, 2010-2022



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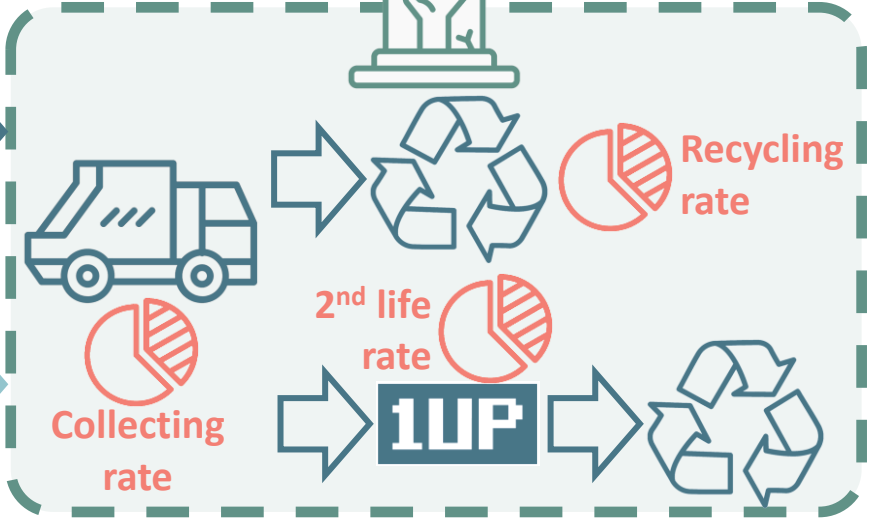
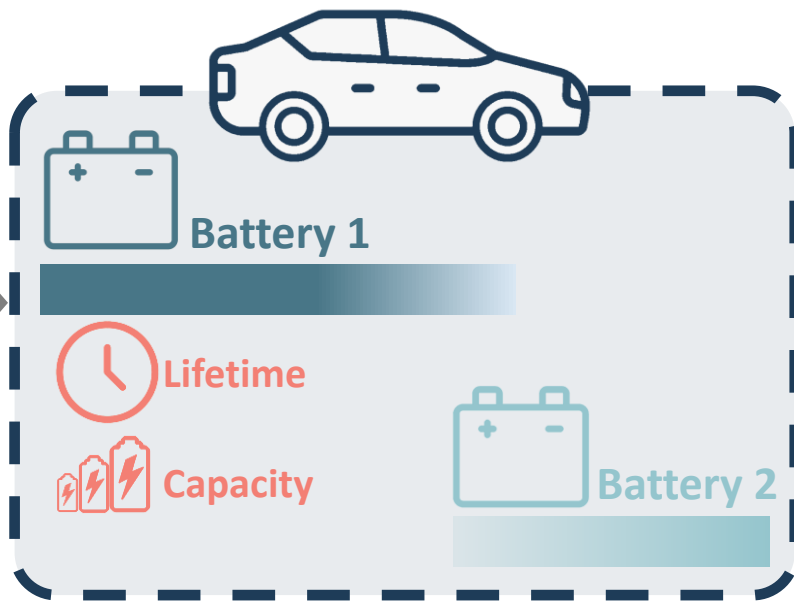
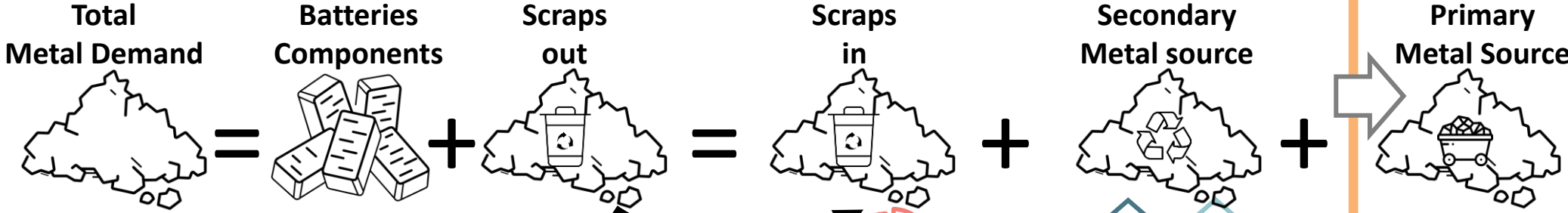
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Scraps + Recycled material

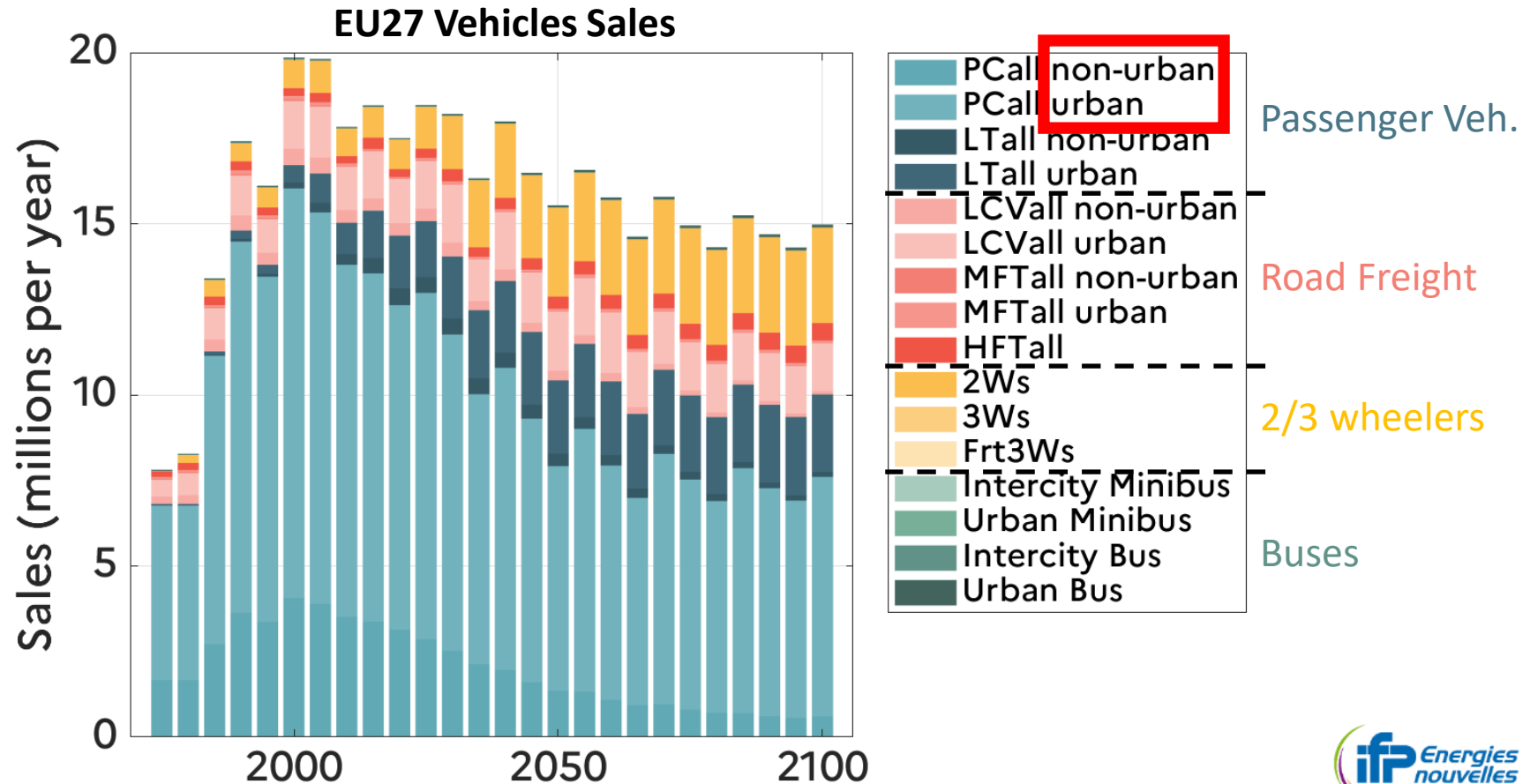
THE METAL BALANCE (MELBA) MODEL

MELBA



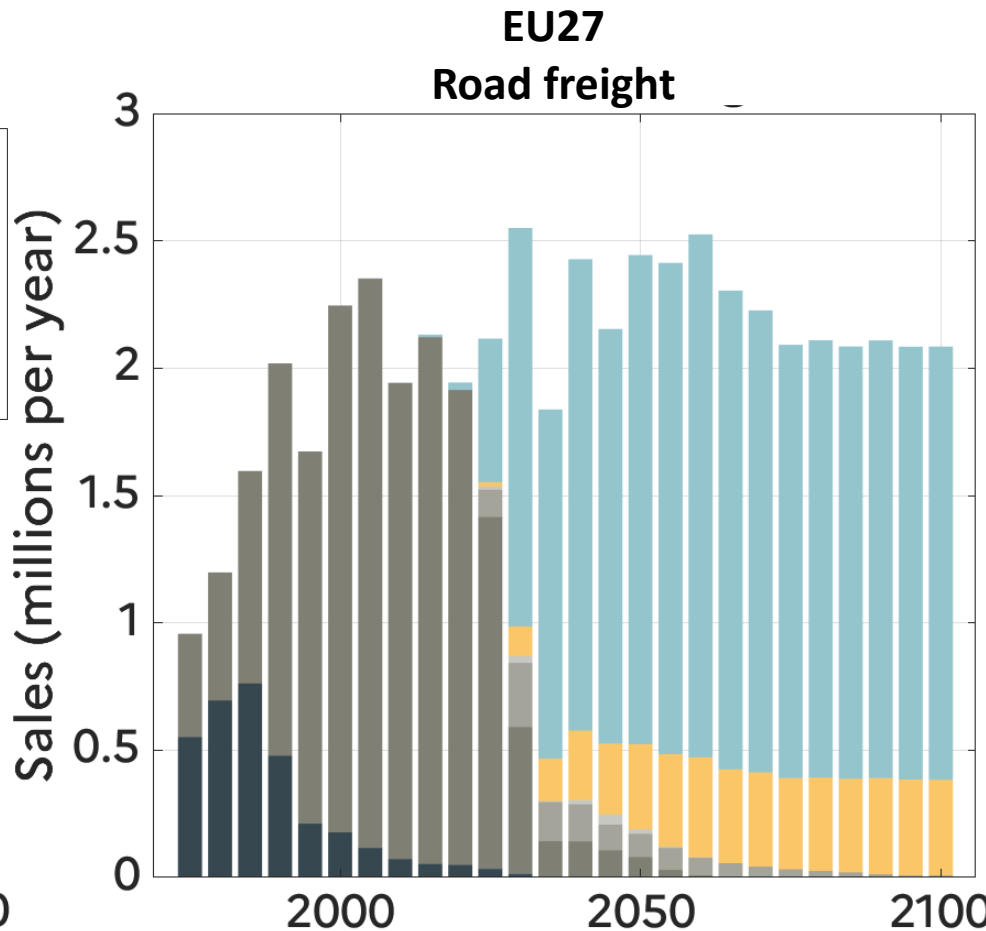
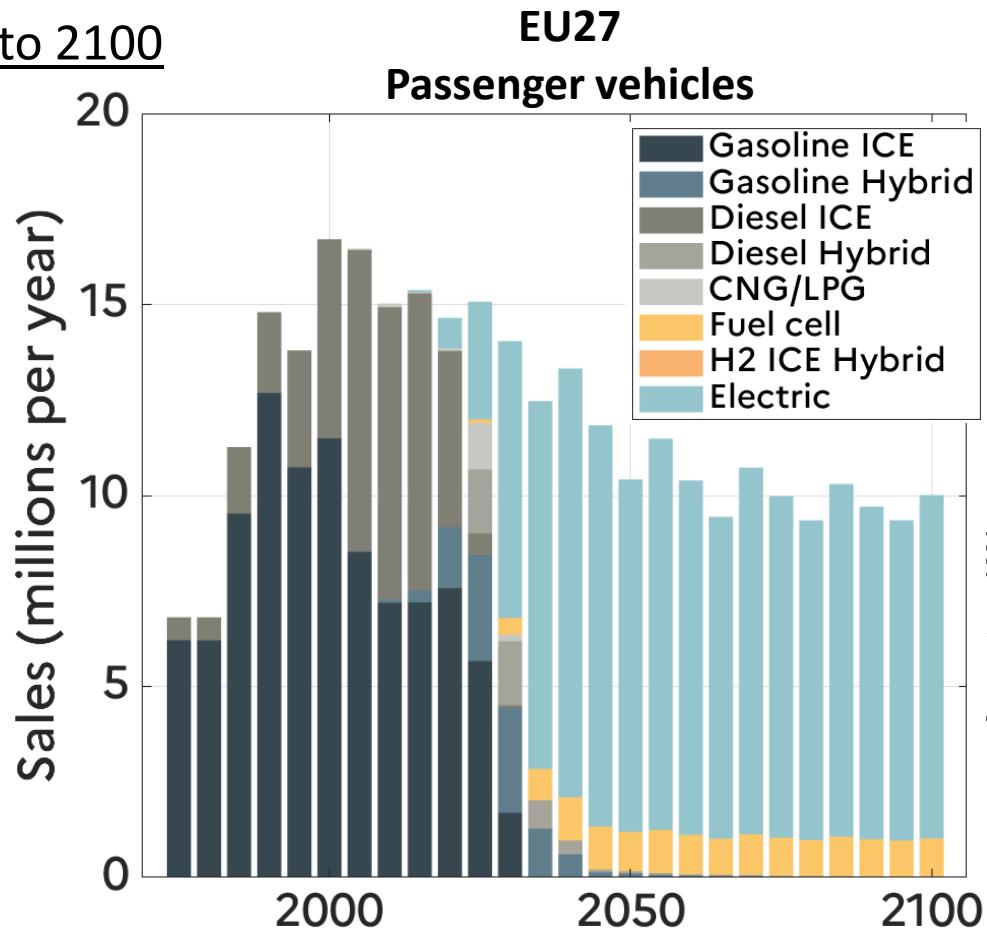
Source: IEA's Mobility Model (MoMo) - Sustainable Scenario Development (SDS) 2019

- Details per vehicles categories (passenger, bus, 2/3 wheelers, road freight)
- Details per countries / geographic area
- Data available up to 2100



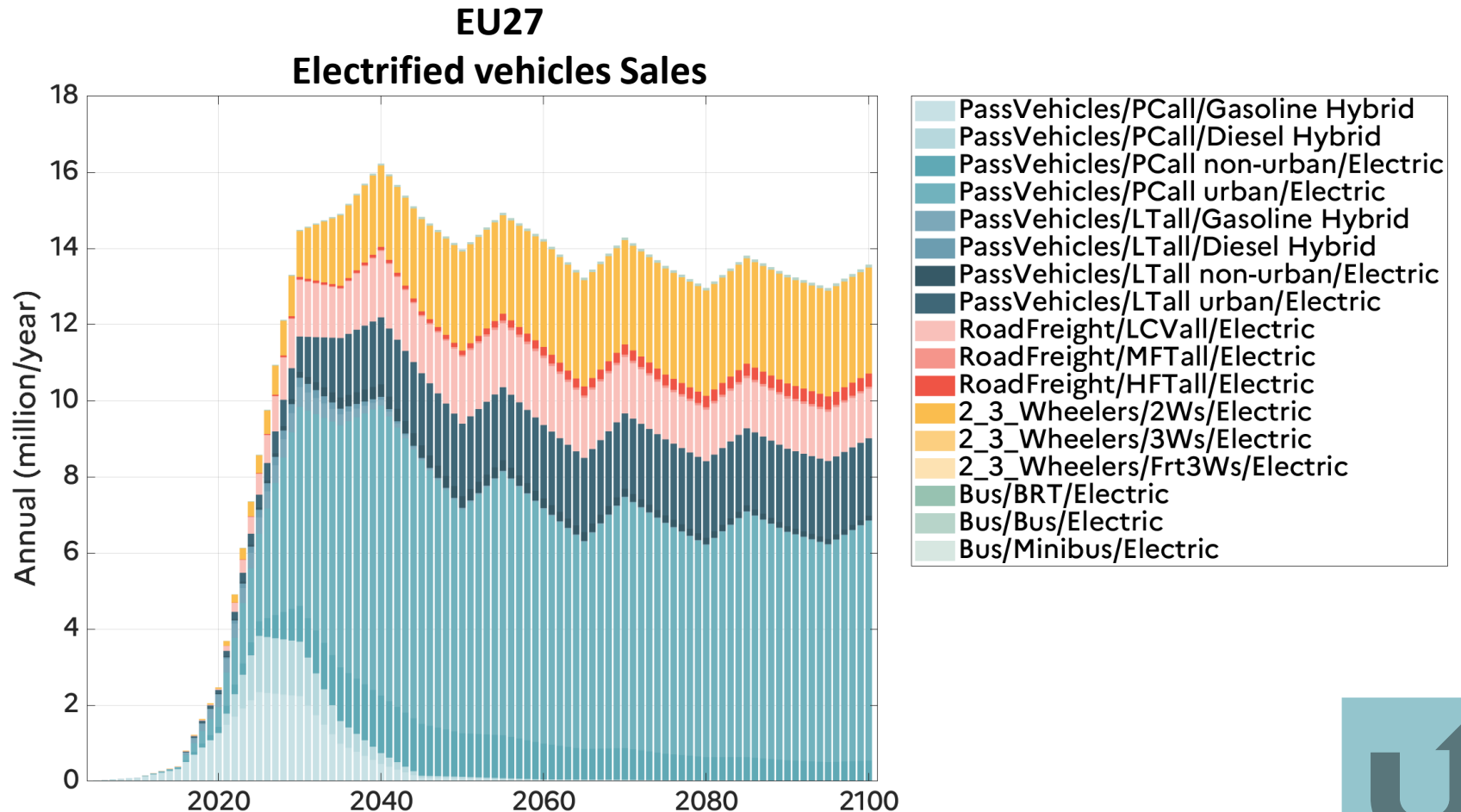
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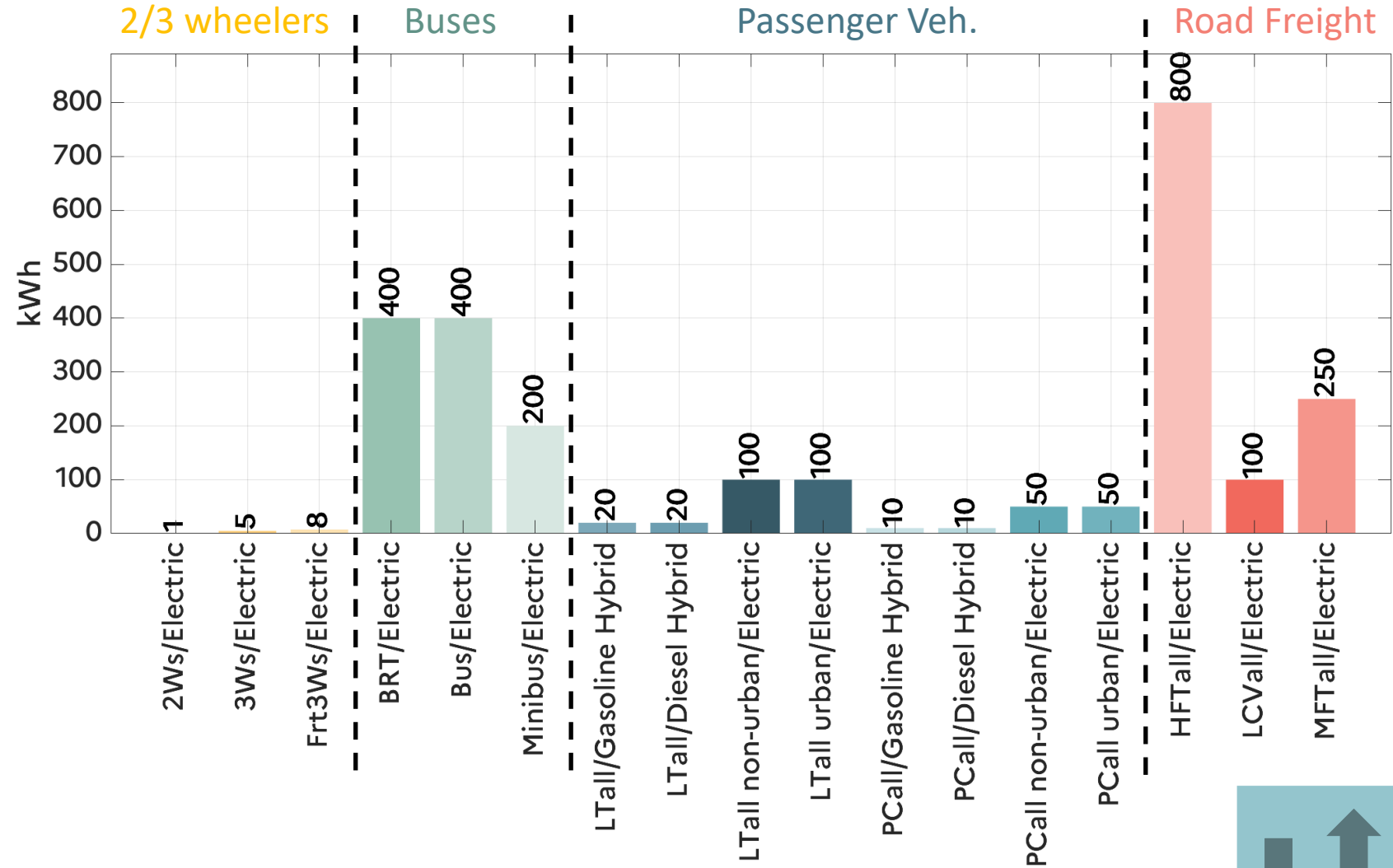
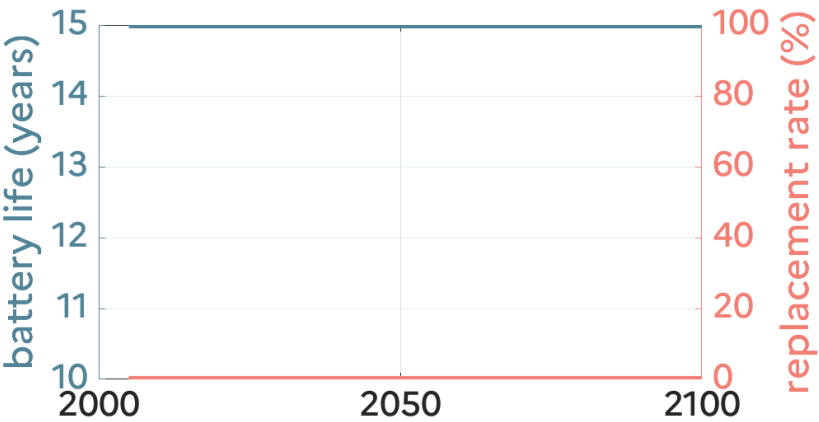
MELBA: HYPOTHESIS



Lifetime

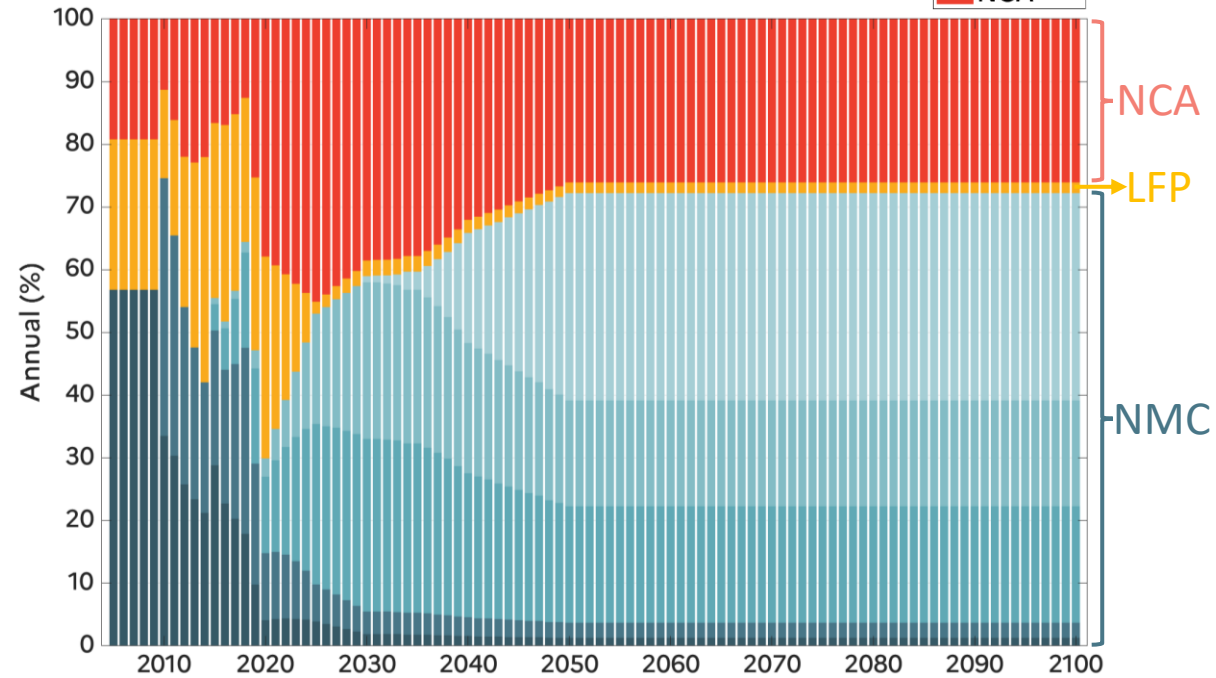
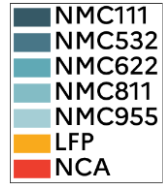


Capacity

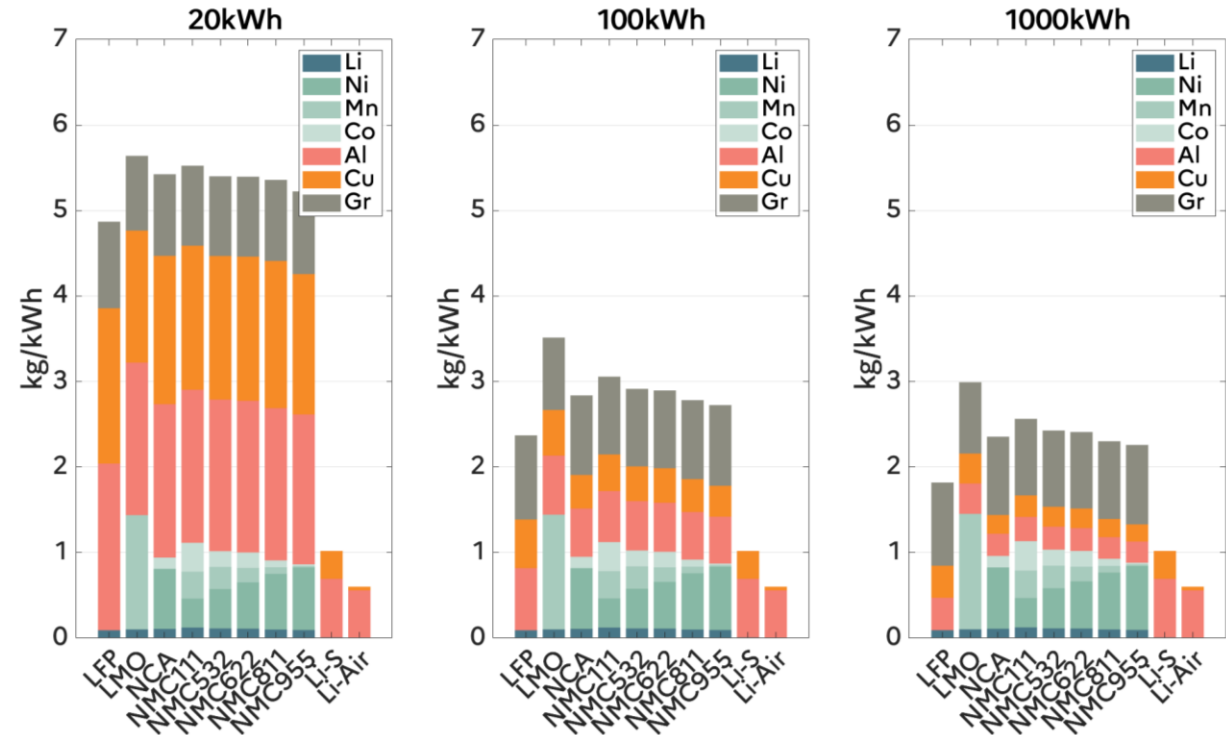


MELBA: HYPOTHESIS

Batteries Market shares



Batteries Material Intensities



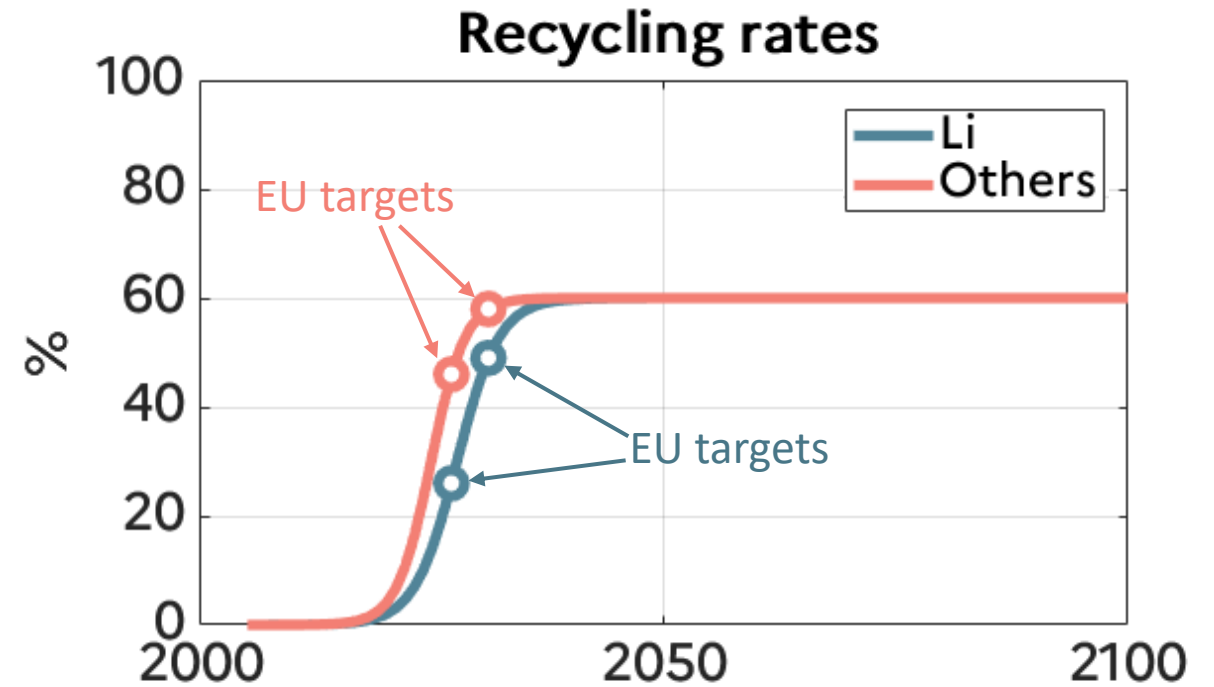
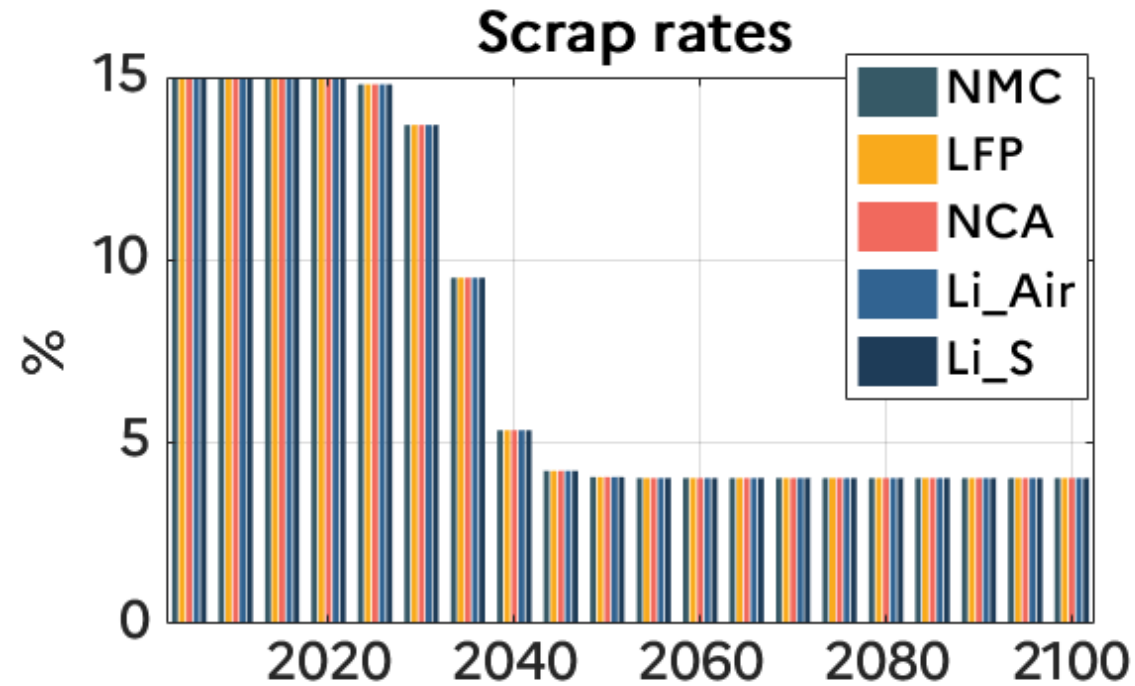
Xu et al. (2020) Communications Materials, vol. 1, n° 1, p. 99.95-x.

BATPAC 5.0, Argonne National Laboratories

Metal contained in cathode, anode, electrolyte
and connections



MELBA: HYPOTHESIS



THE METAL BALANCE (MELBA) MODEL

MELBA

Total
Metal Demand

Batteries
Components

Scraps
out

Scraps
in

Secondary
Metal source

Primary
Metal Source

- What will be the European metal consumption for EVs?
 - A model to compute the metal demand
 - **Results for Europe**
 - ➔ **Batteries capacities**
 - **Metal demand**
- What policies could limit that demand?
 - EU27 case

Scraps
rates

Recycling
rate

2nd life
rate

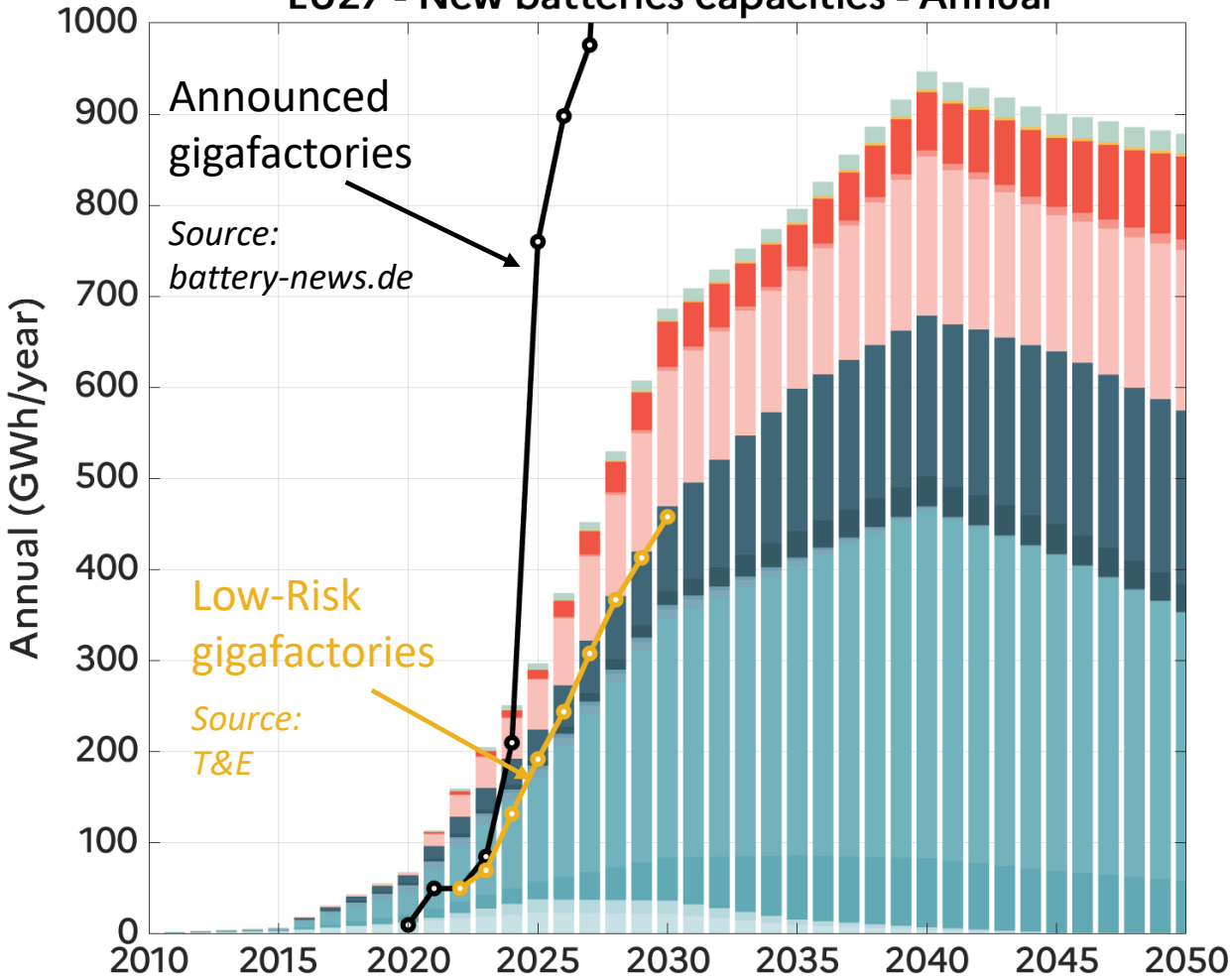
1UP

 Batteries
Market shares

 Batteries
Material Intensities

EU27: NEW BATTERIES CAPACITIES

EU27 - New batteries capacities - Annual



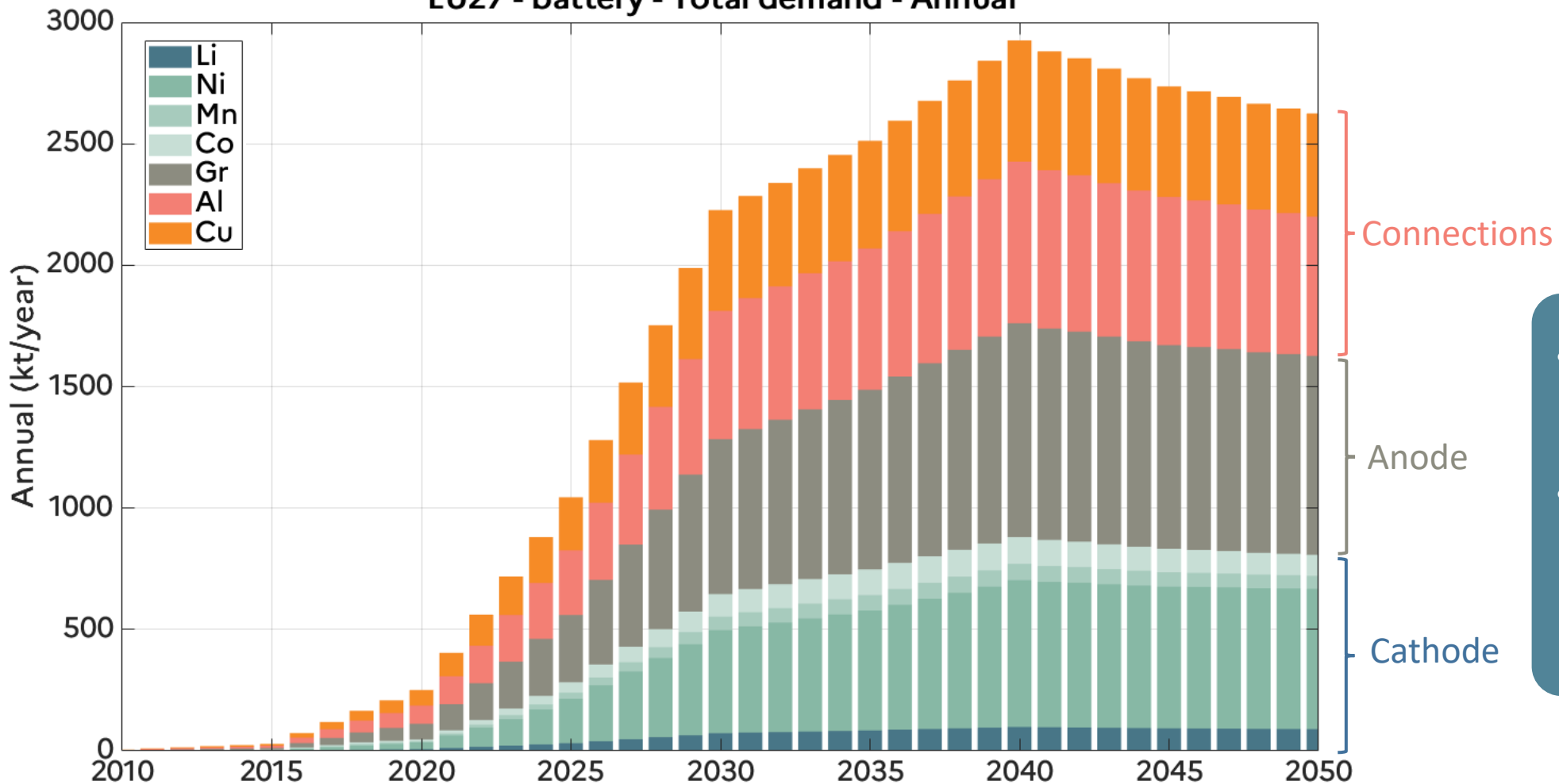
- PassVehicles/PCall/Gasoline Hybrid
- PassVehicles/PCall/Diesel Hybrid
- PassVehicles/PCall non-urban/Electric
- PassVehicles/PCall urban/Electric
- PassVehicles/LTall/Gasoline Hybrid
- PassVehicles/LTall/Diesel Hybrid
- PassVehicles/LTall non-urban/Electric
- PassVehicles/LTall urban/Electric
- RoadFreight/LCVall/Electric
- RoadFreight/MFTall/Electric
- RoadFreight/HFTall/Electric
- 2_3_Wheelers/2Ws/Electric
- 2_3_Wheelers/3Ws/Electric
- 2_3_Wheelers/Frt3Ws/Electric
- Bus/BRT/Electric
- Bus/Bus/Electric
- Bus/Minibus/Electric

New batteries capacities REQUIRED

- 2035: ~800GWh/an (75% for passenger veh.)
- 2050: ~900GWh/year (65% for passenger veh.)

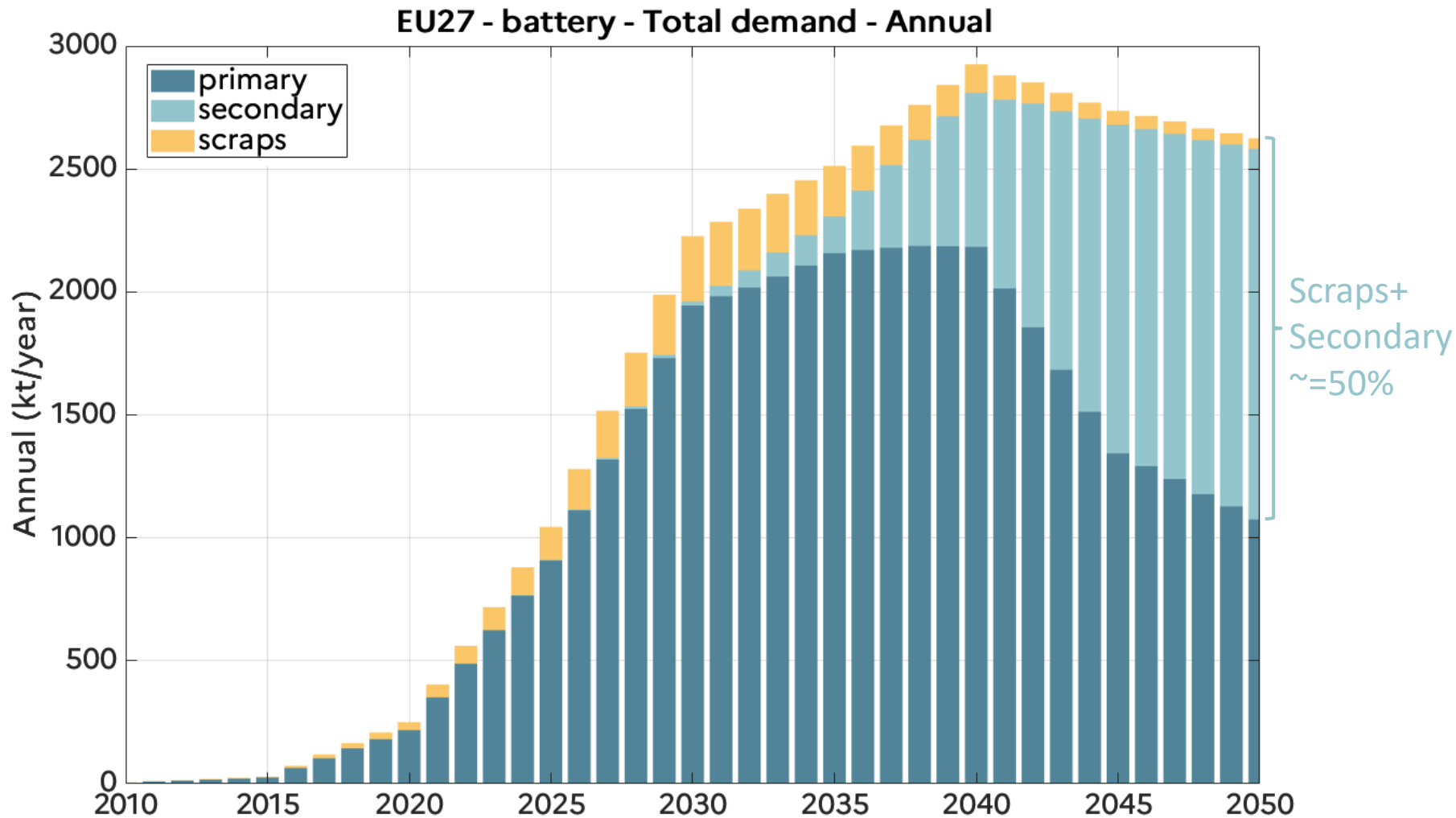
EU27: TOTAL METAL DEMAND

EU27 - battery - Total demand - Annual



- Lithium represents only a small part of total metal demand
- 1/3 for cathode (Li, Ni, Mn, Co), 1/3 for anode (Gr), 1/3 for connections (Al, Cu)

EU27: TOTAL METAL DEMAND



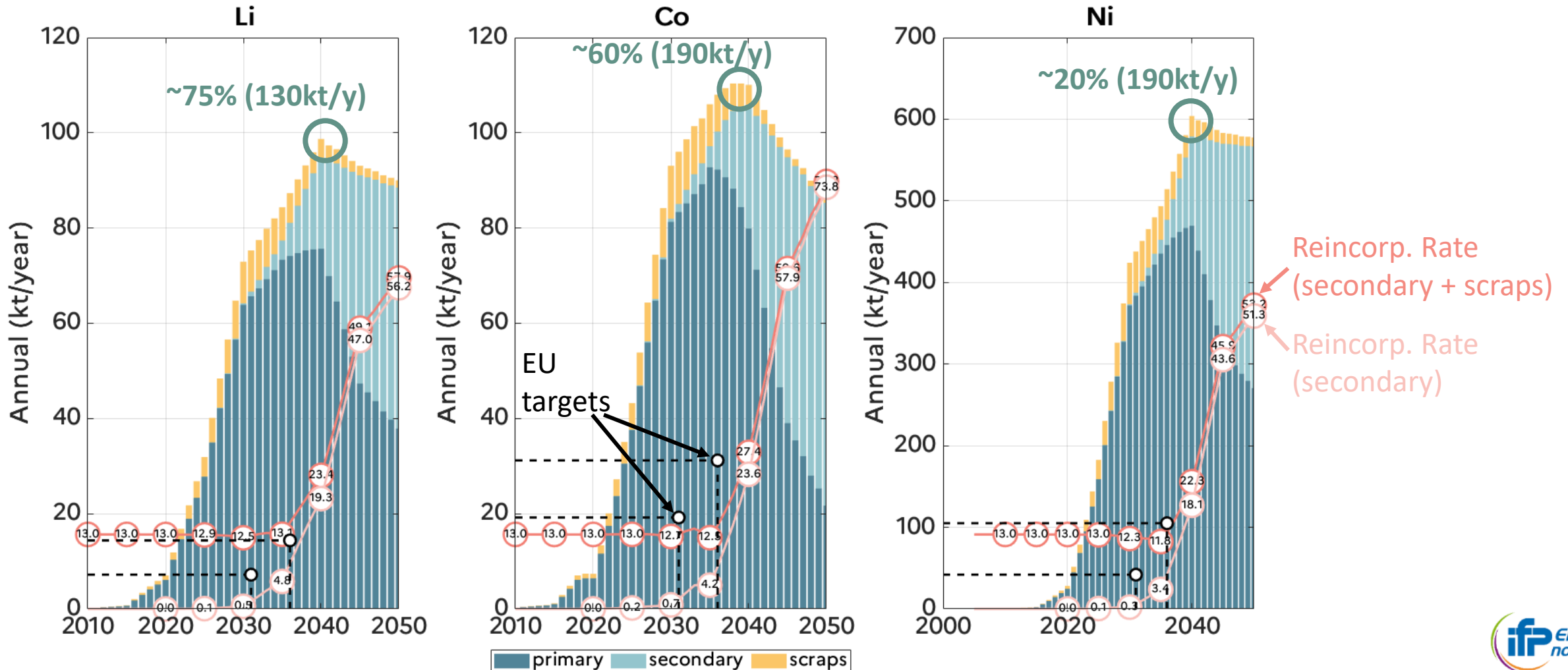
- 2030-2040: Primary demand is stable
- >2040: Decrease of primary demand
- The complement is brought by secondary sources (50% of total demand after 2050)

EU27: TOTAL METAL DEMAND: PER ELEMENTS

Share of EU27 total sales (passenger cars):

- 2020: ~20%
- 2050: ~10%

World annual production (2022 USGS data)



THE METAL BALANCE (MELBA) MODEL

MELBA

Total
Metal Demand

Batteries
Components

Scraps
out

Scraps
in

Secondary
Metal source

Primary
Metal Source

- What will be the European metal consumption for EVs?
 - A model to compute the metal demand
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- What policies could limit that demand?
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Scraps
rates

Recycling
rate

2nd life
rate

1UP

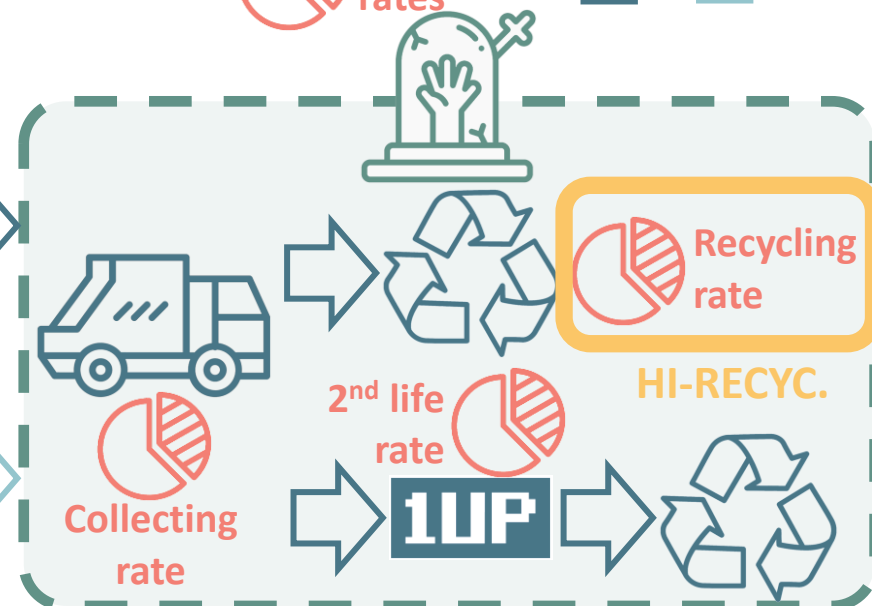
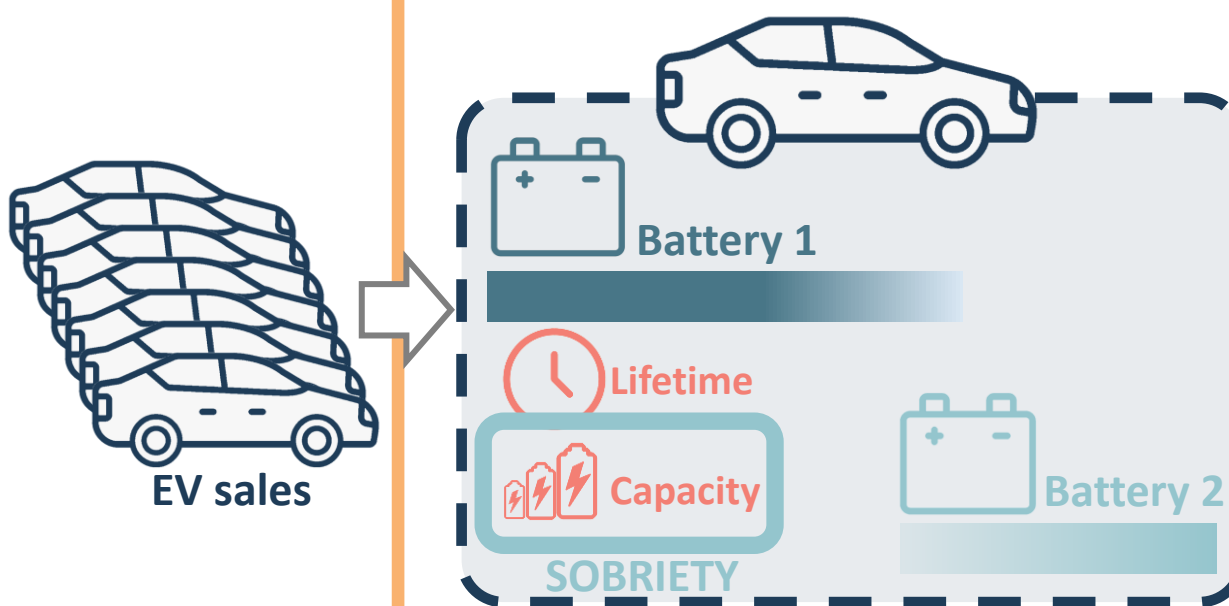
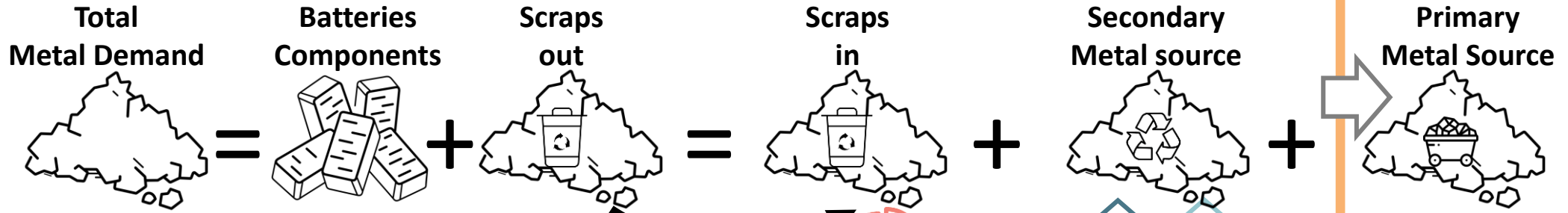
Batteries
Market shares

Batteries
Material Intensities

SENSITIVITIES

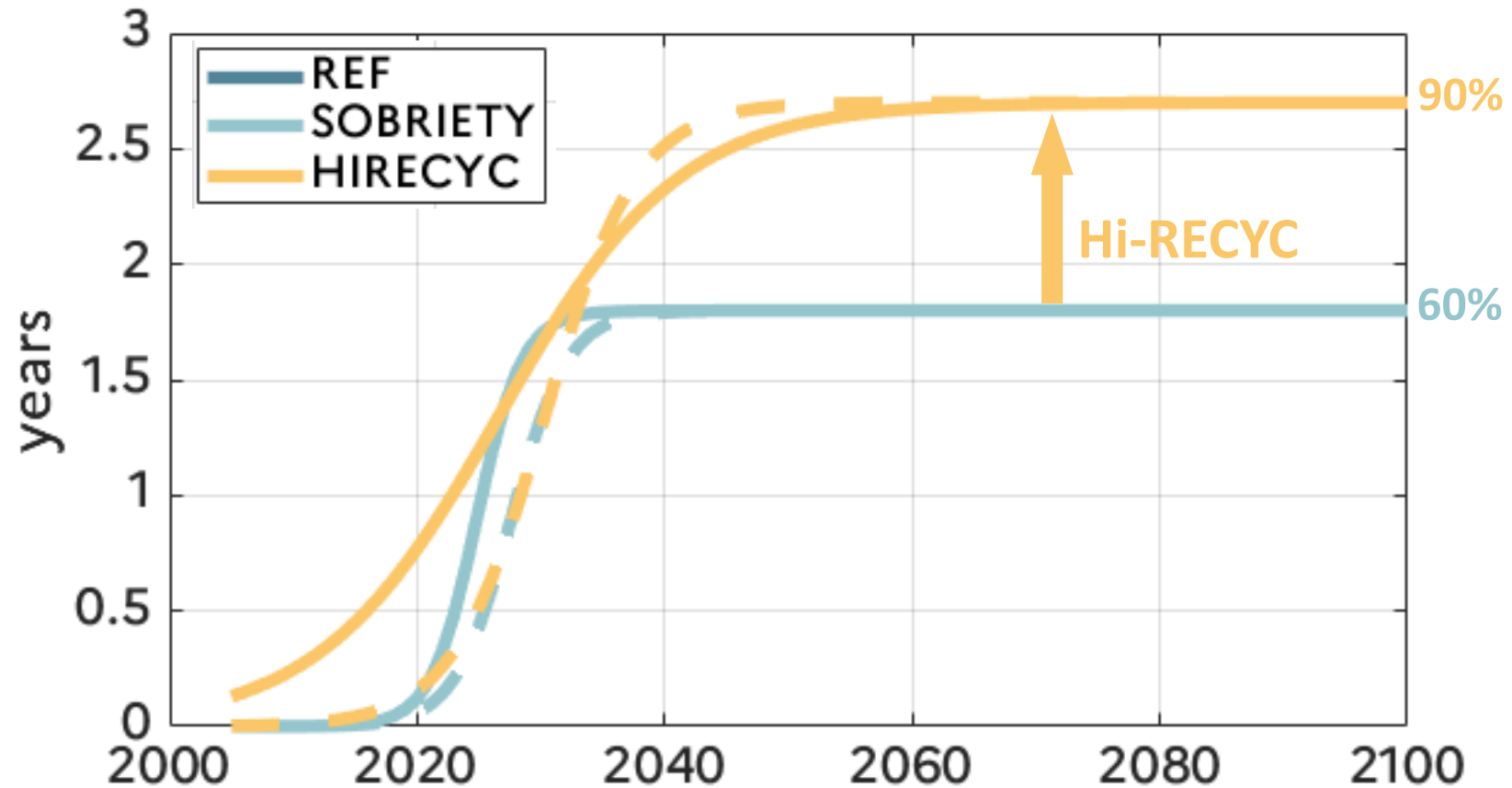
Climate,
environment
and circular
economy

MELBA

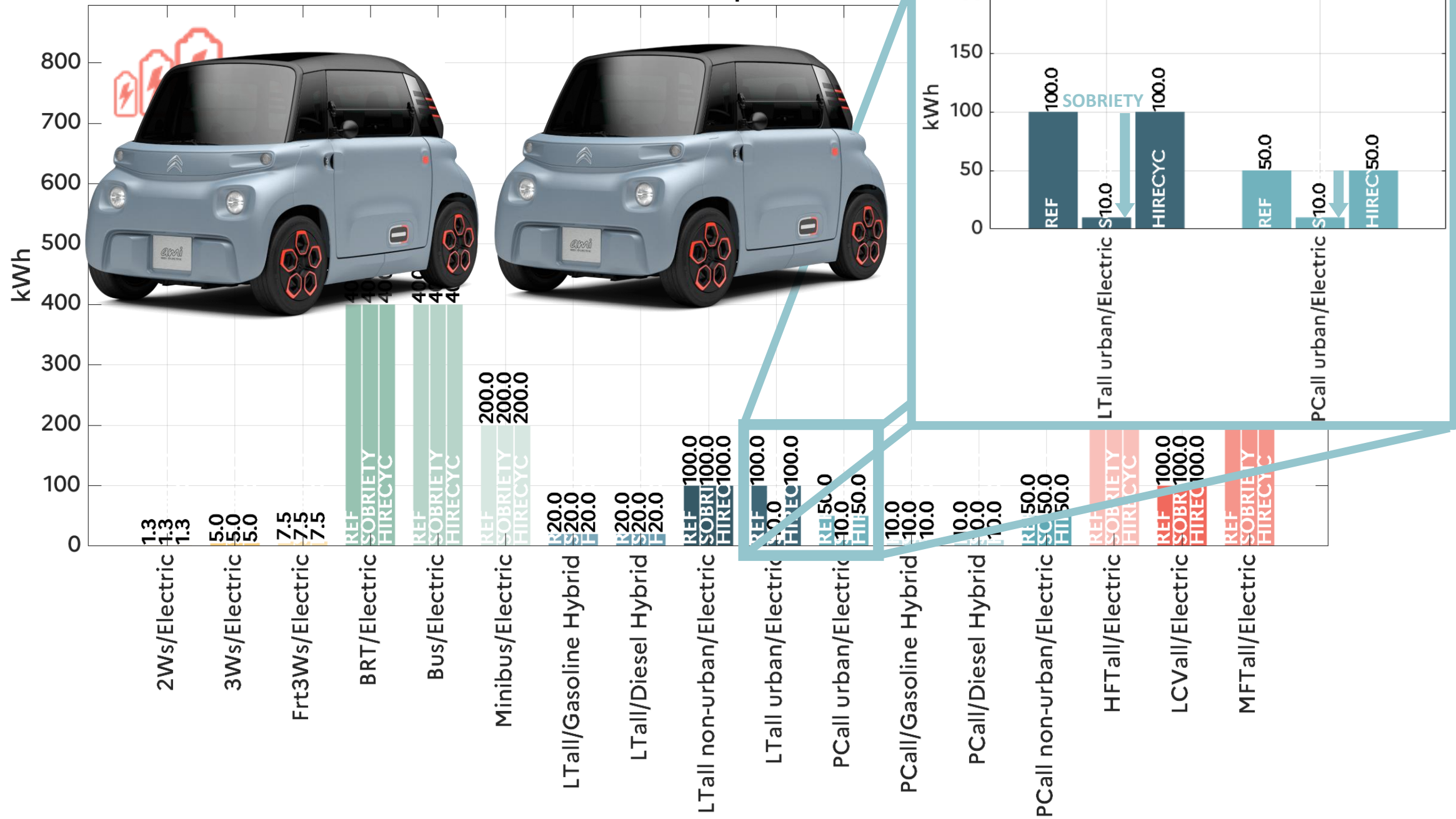


 Batteries Market shares
  Batteries
  Material Intensities

SENSITIVITIES



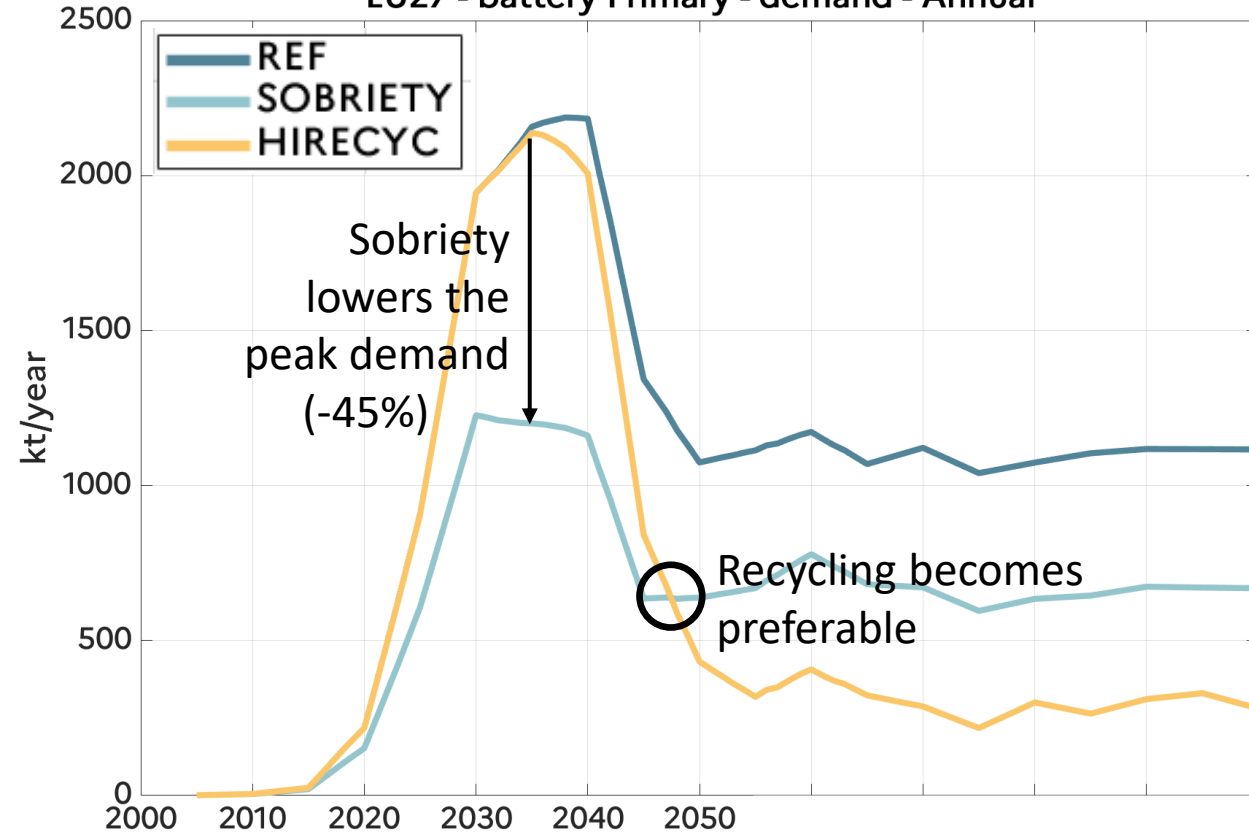
batteries capacities



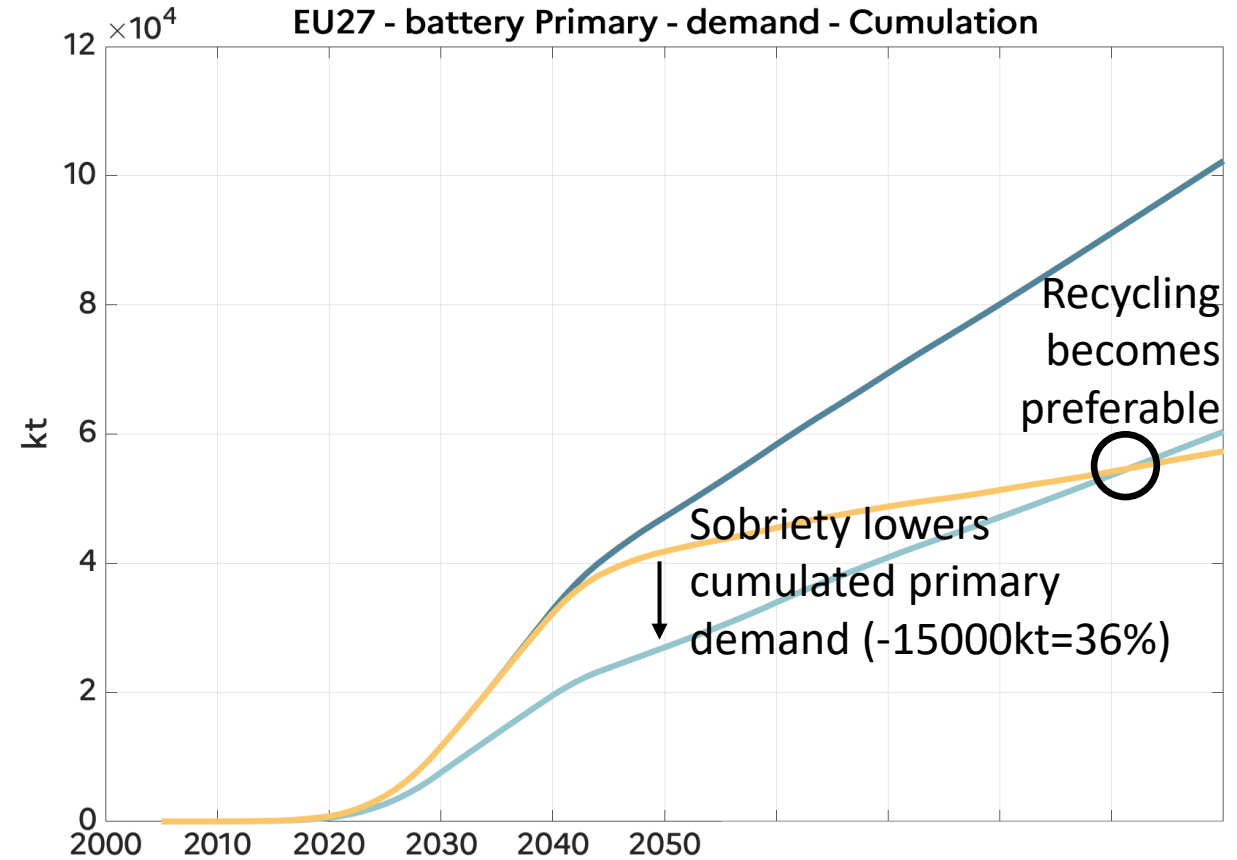
SENSITIVITIES – EU27 RESULTS

	EU27
2050	
2075	
2100	

EU27 - battery Primary - demand - Annual



EU27 - battery Primary - demand - Cumulation



CONCLUSIONS / PERSPECTIVES

● MELBA model

- Estimation of the total batterie capacities requirements
- Translation into metal demand (total, primary, secondary, scraps)
- Different hypothesis can be tested in scenarios

● EU27 metal demand

- Tensions to produce enough Li, Ni, Co for European markets
- Sobriety is the best way to limit the annual demand in the short term
- Recycling will be preferable in the long term

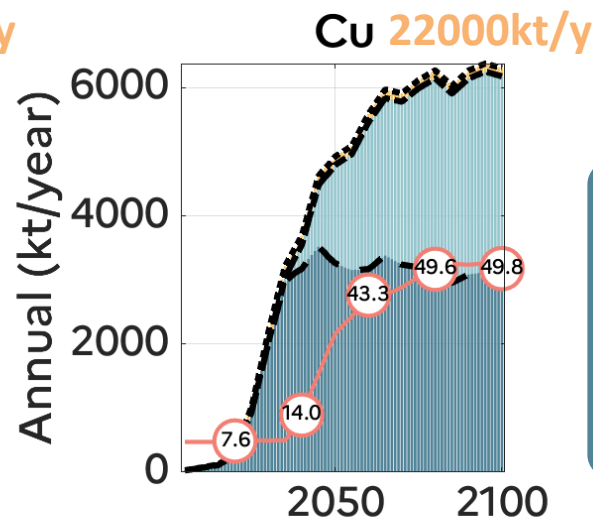
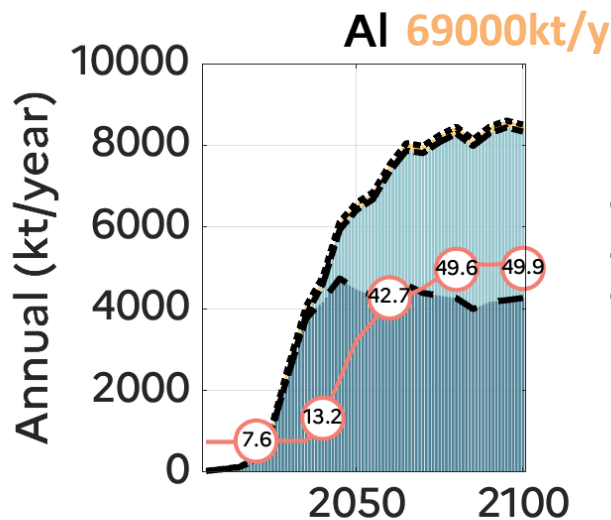
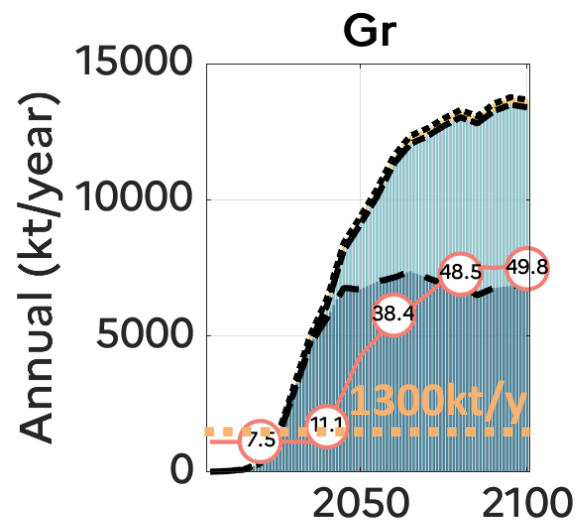
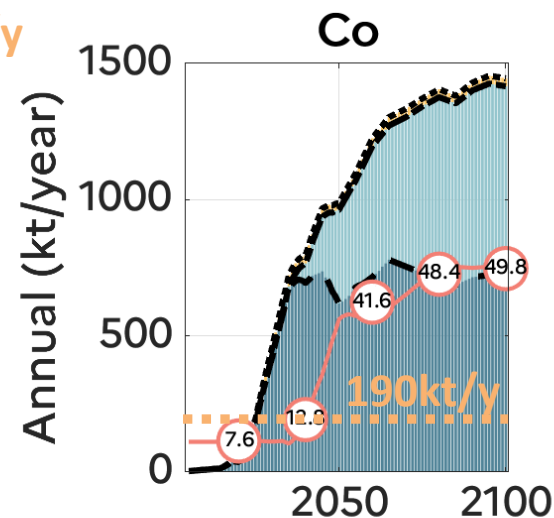
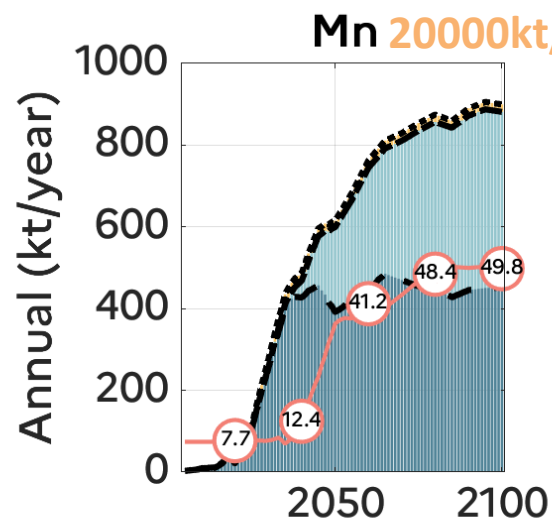
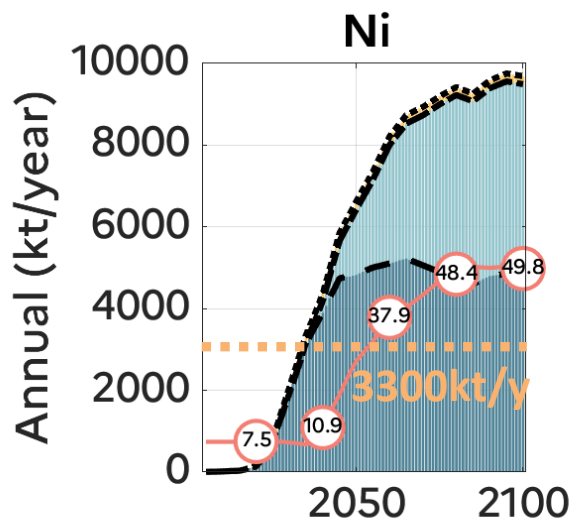
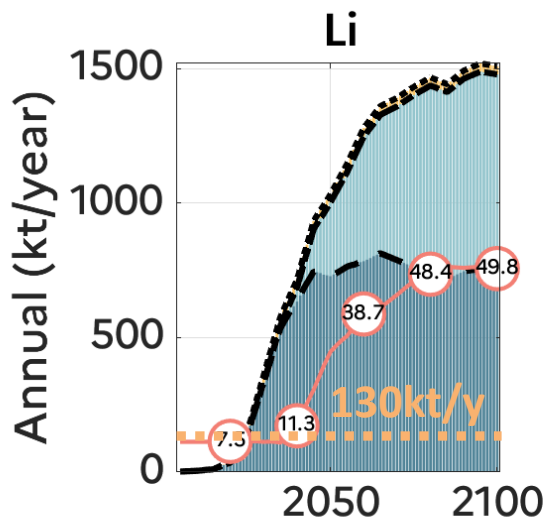


ANNEXES



WORLD: TOTAL METAL DEMAND

2022 USGS data



- Li, Ni, Co and Graphite need to increase their annual production before 2030.

primary secondary scraps

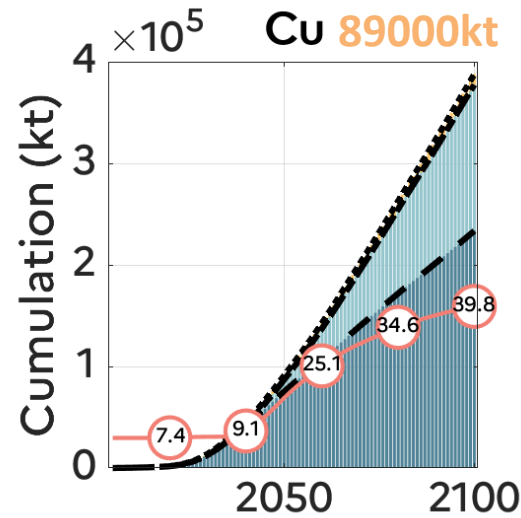
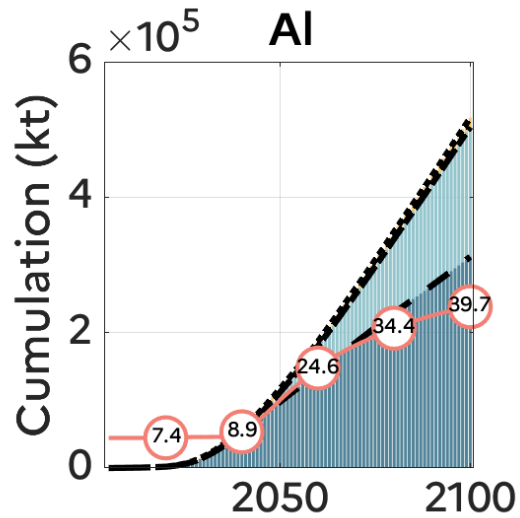
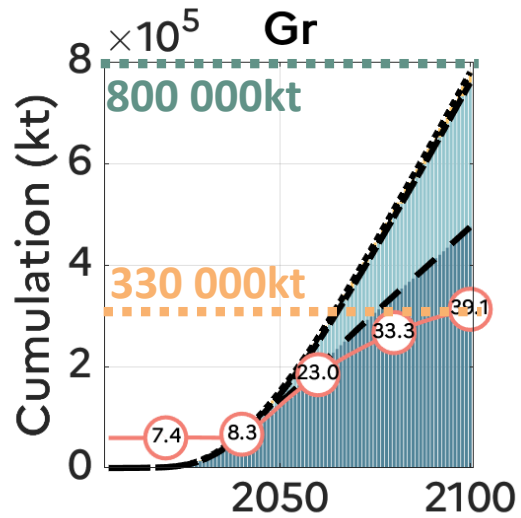
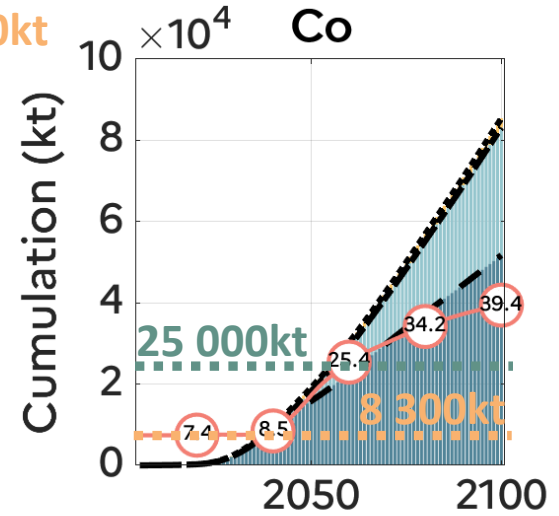
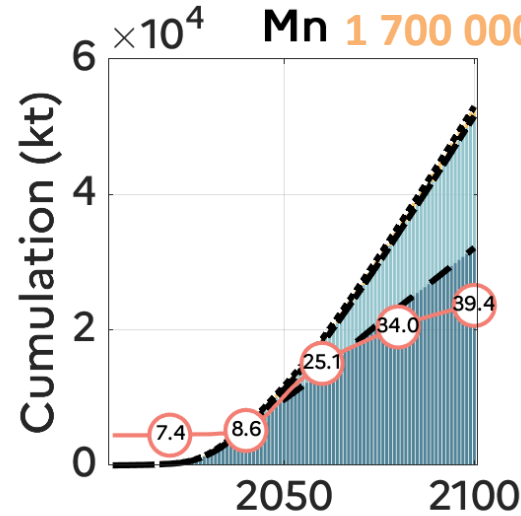
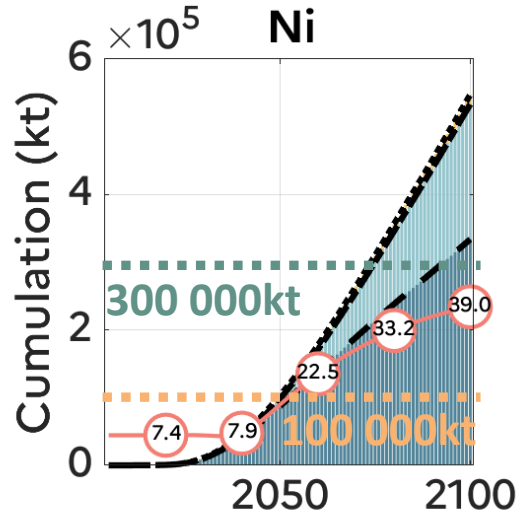
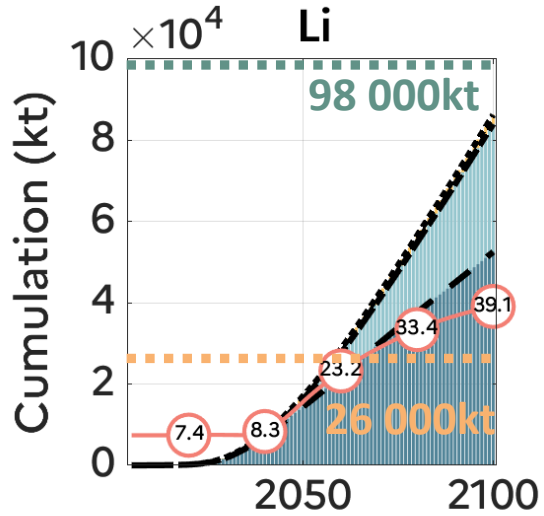
WORLD: TOTAL METAL DEMAND

2022 USGS data:

Resources

Reserves

Climate,
environment
and circular
economy



primary secondary scraps

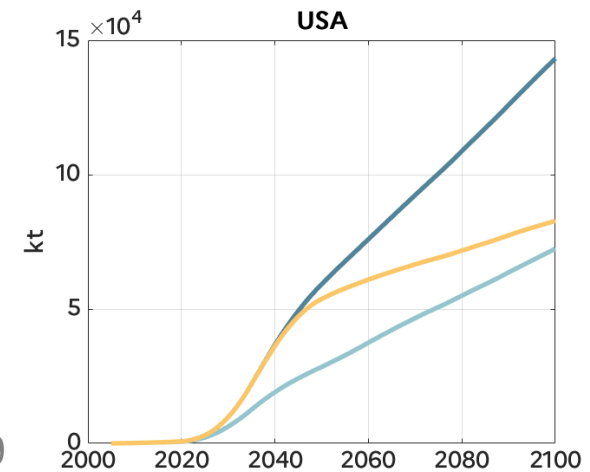
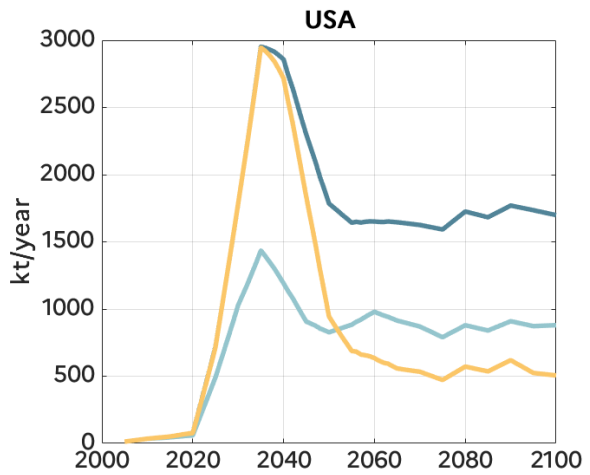
Li, Ni, Co and Graphite show insufficient reserves or even resources (Ni, Co)

SENSITIVITIES – GEOGRAPHIC AREAS

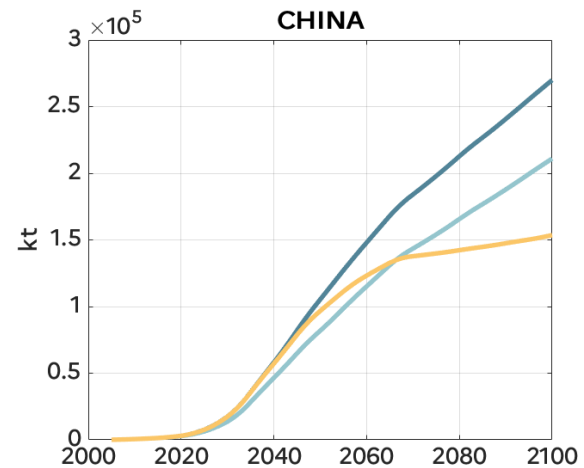
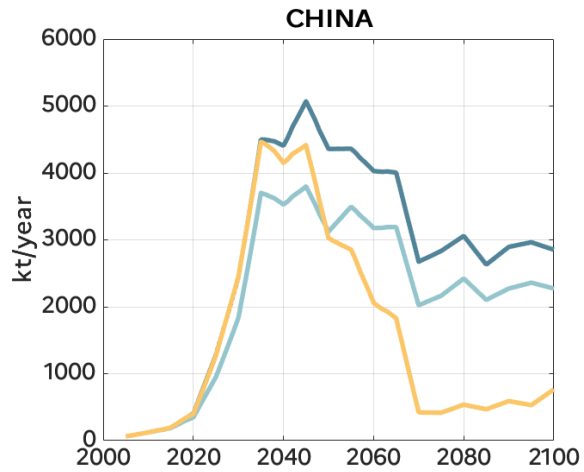


	EU27	CHINA	USA	AFRICA
2050	REF	REF	REF	REF
2075	REF	HIRECYC	REF	REF
2100	HIRECYC	HIRECYC	REF	REF

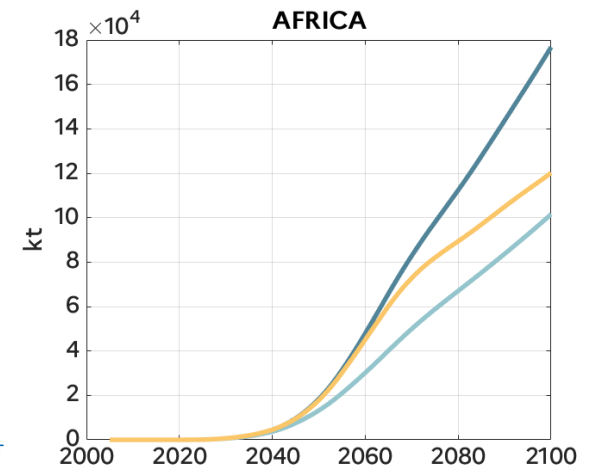
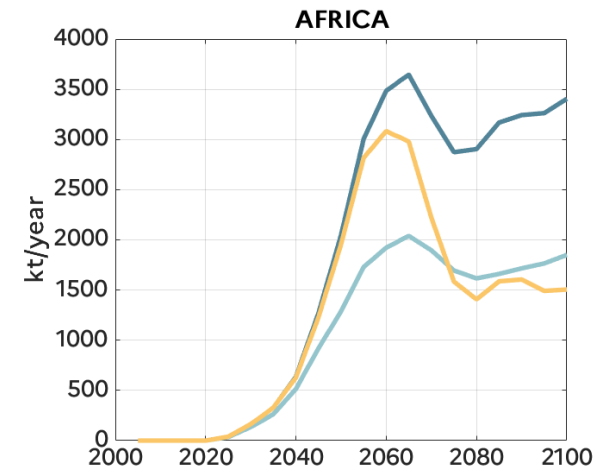
USA



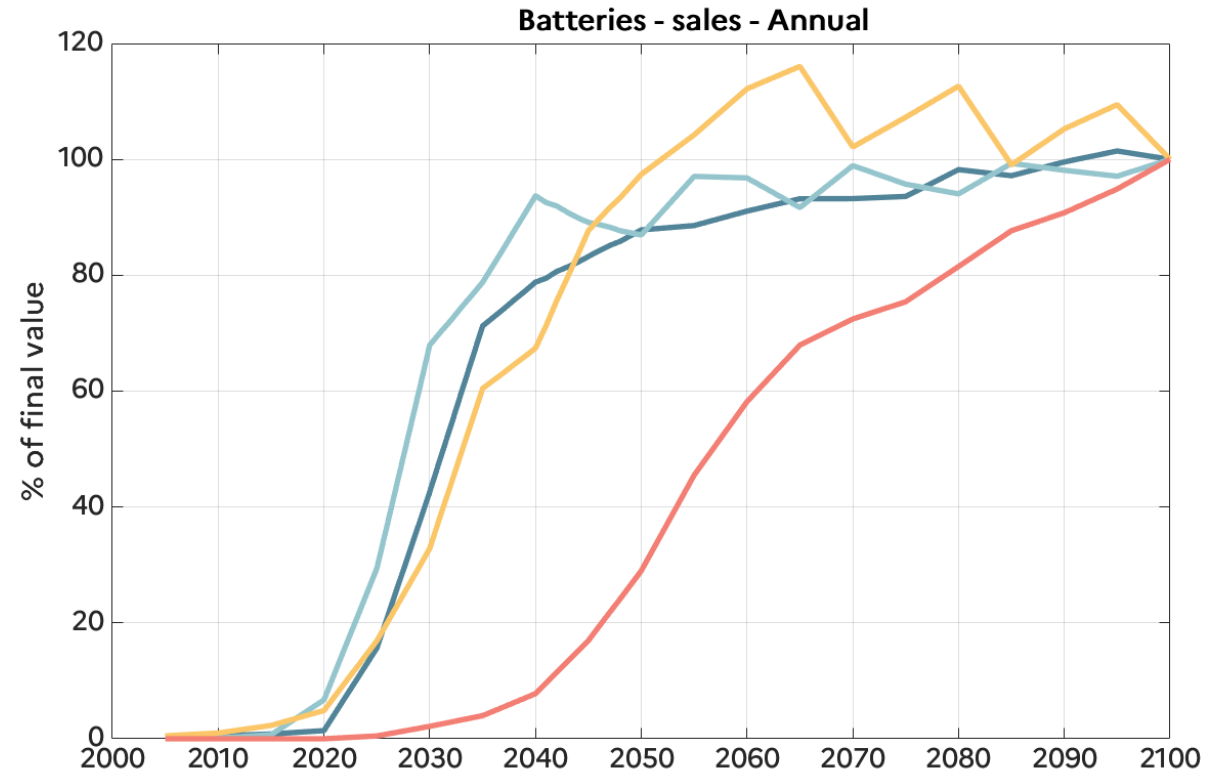
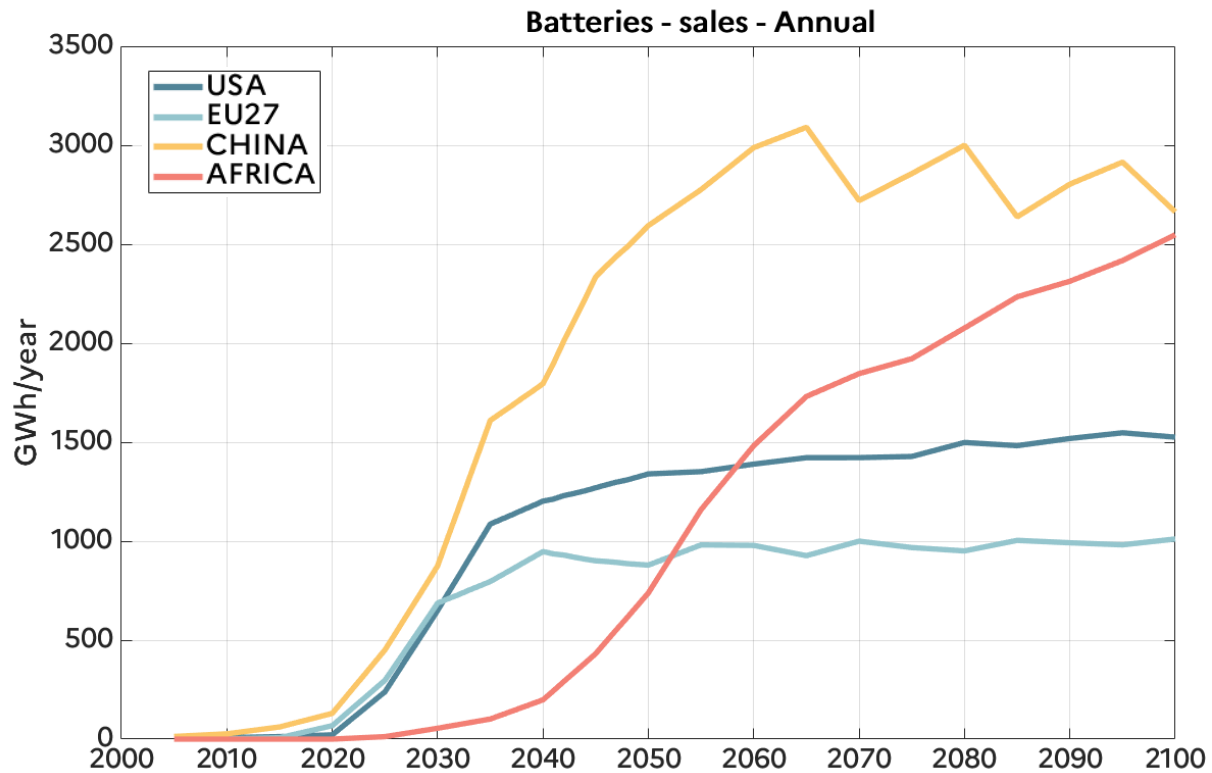
CHINA



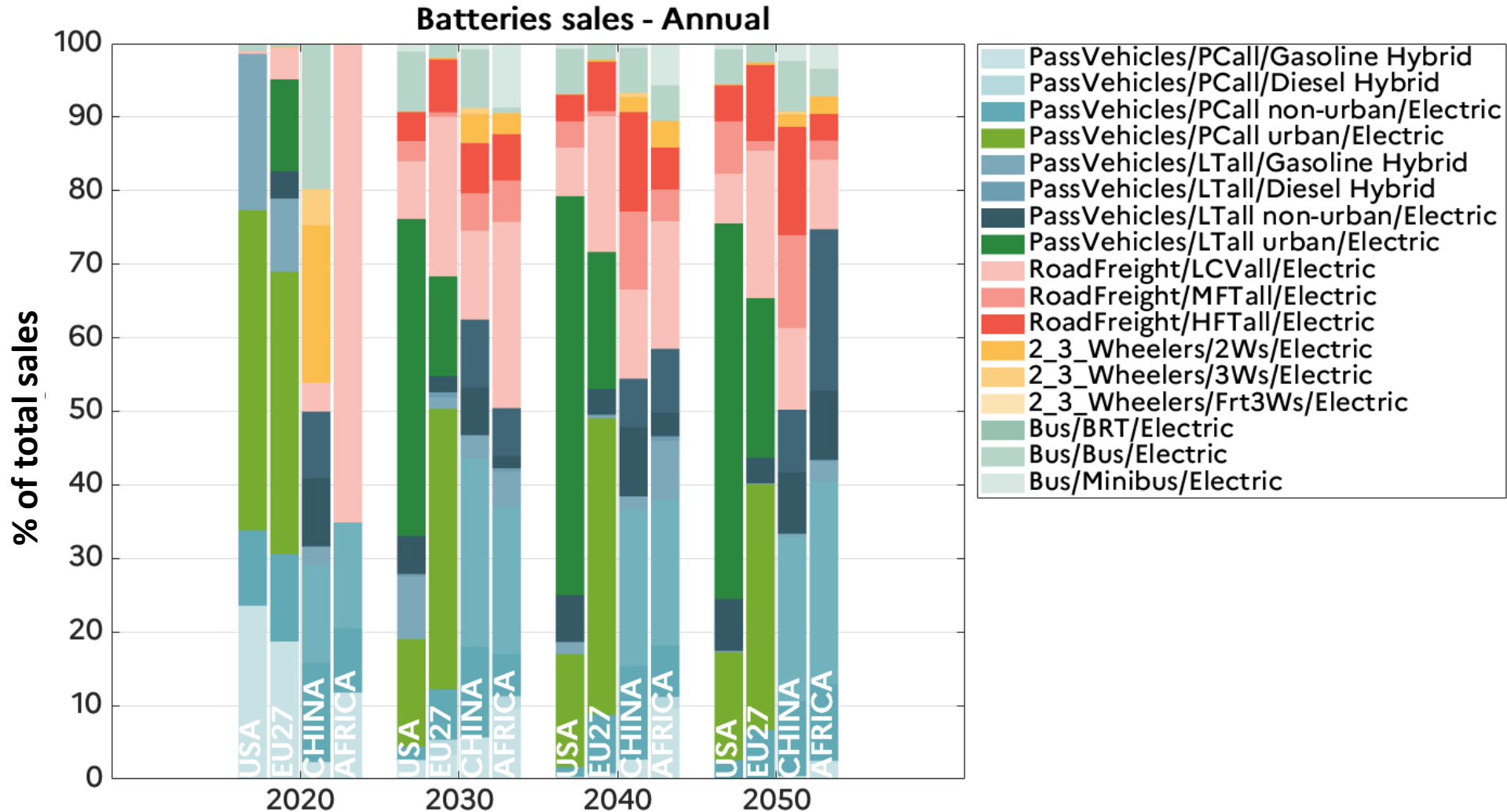
AFRICA



SENSITIVITIES – GEOGRAPHIC AREAS

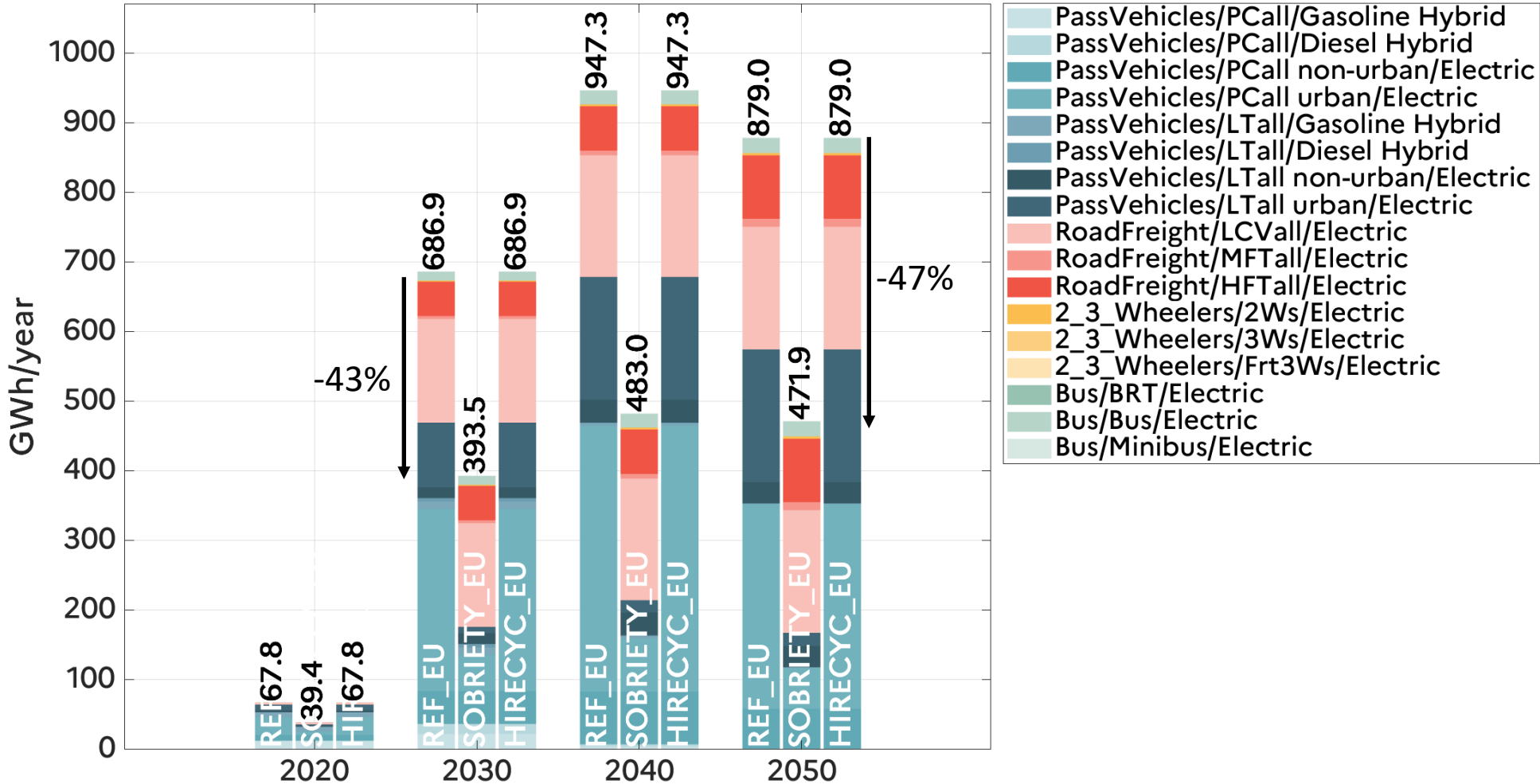


SENSITIVITIES – GEOGRAPHIC AREAS



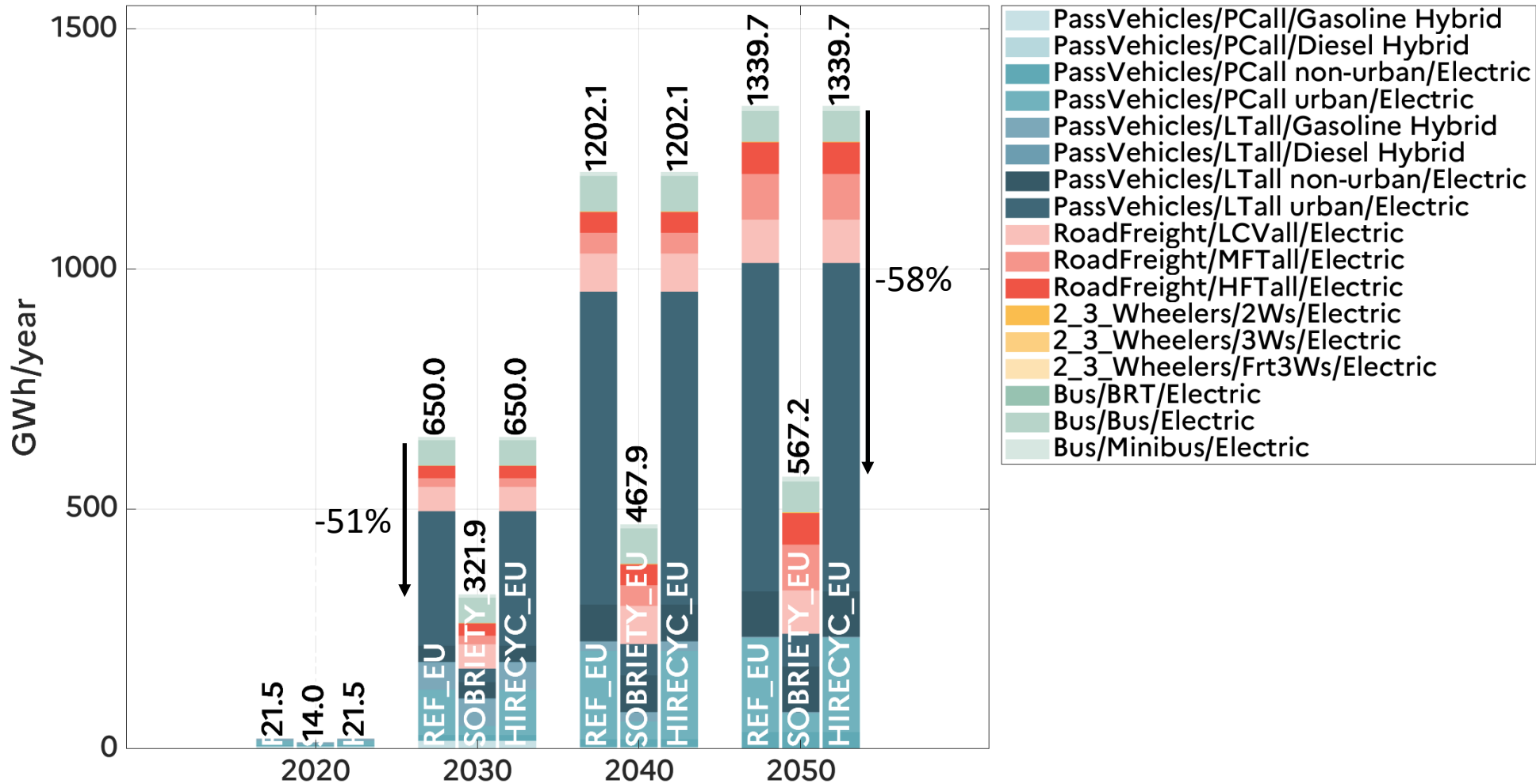
SENSITIVITIES – GEOGRAPHIC AREAS

EU27 - Batteries sales - Annual



SENSITIVITIES – GEOGRAPHIC AREAS

USA - Batteries sales - Annual



- PassVehicles/PCall/Gasoline Hybrid
- PassVehicles/PCall/Diesel Hybrid
- PassVehicles/PCall non-urban/Electric
- PassVehicles/PCall urban/Electric
- PassVehicles/LTall/Gasoline Hybrid
- PassVehicles/LTall/Diesel Hybrid
- PassVehicles/LTall non-urban/Electric
- PassVehicles/LTall urban/Electric
- RoadFreight/LCVall/Electric
- RoadFreight/MFTall/Electric
- RoadFreight/HFTall/Electric
- 2_3_Wheelers/2Ws/Electric
- 2_3_Wheelers/3Ws/Electric
- 2_3_Wheelers/Frt3Ws/Electric
- Bus/BRT/Electric
- Bus/Bus/Electric
- Bus/Minibus/Electric