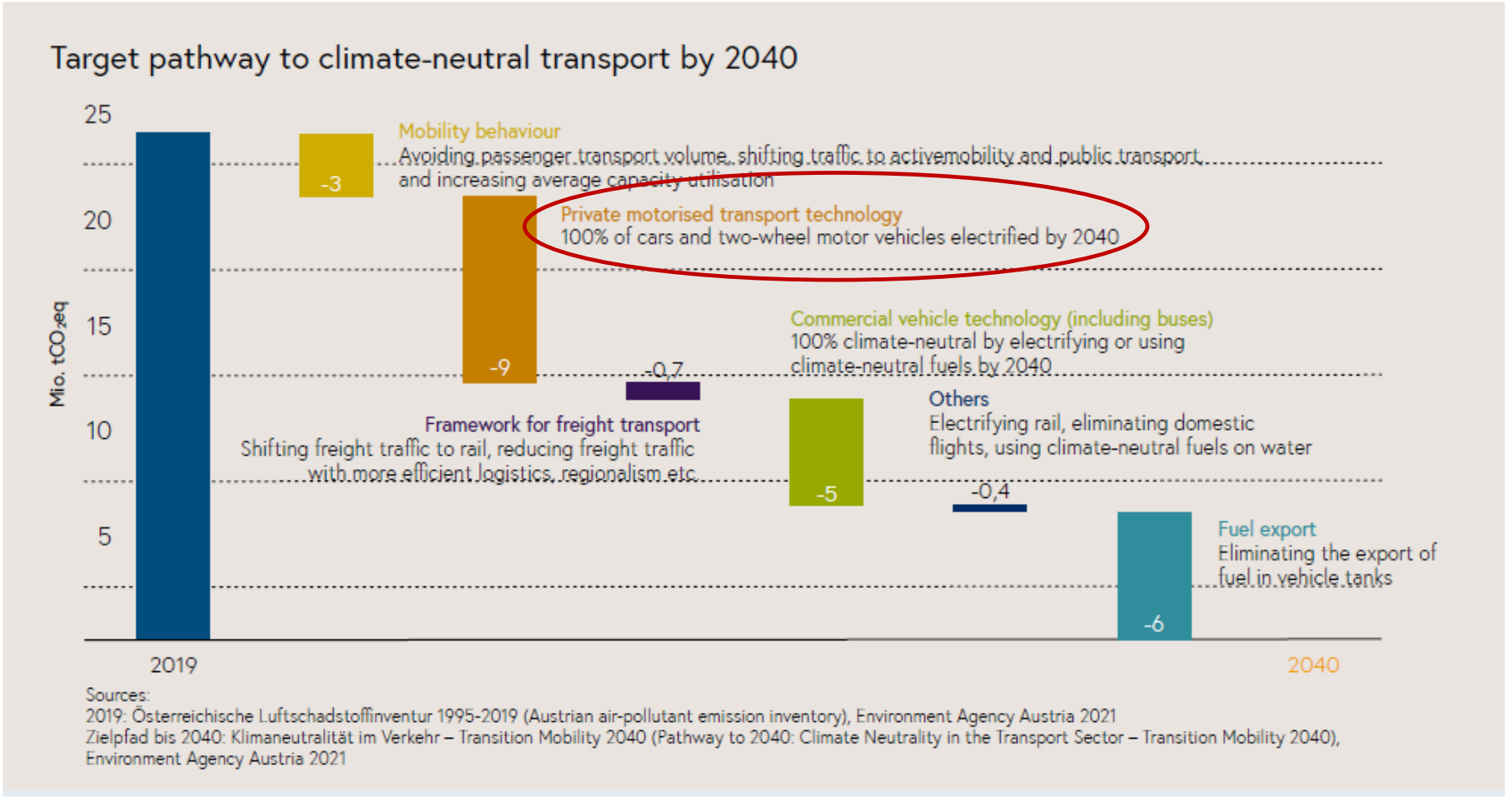
Austrian vehicle fleet scenarios to reach climate neutrality and CRM demand

Martin Beermann, Gerfried Jungmeier

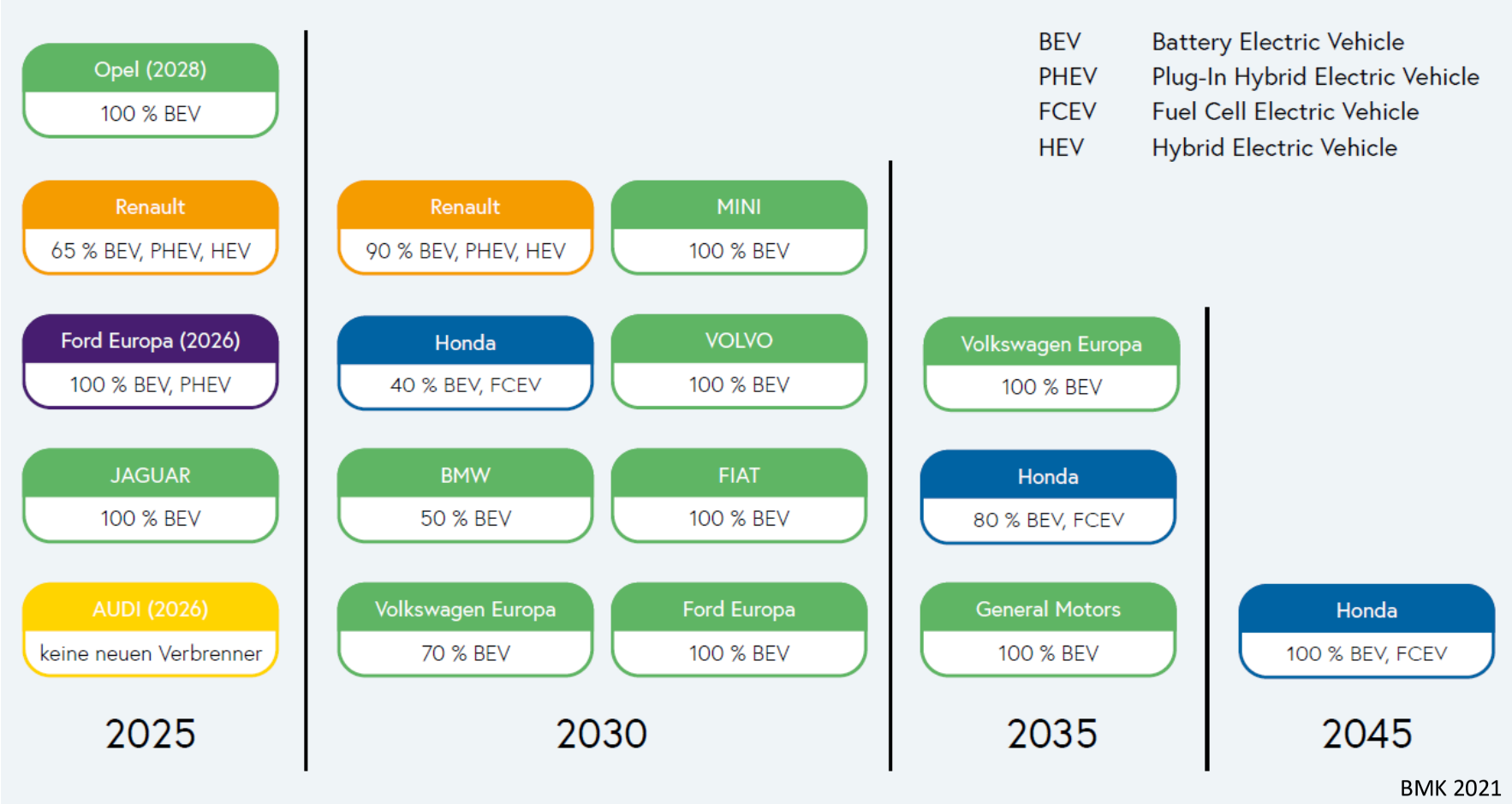
Final Workshop
Task 40 CRM4EV
29.04.2022, online

JOANNEUM RESEARCH LIFE

Austria's 2030 Mobility Master Plan
(BMK, 2021)



OEM targets



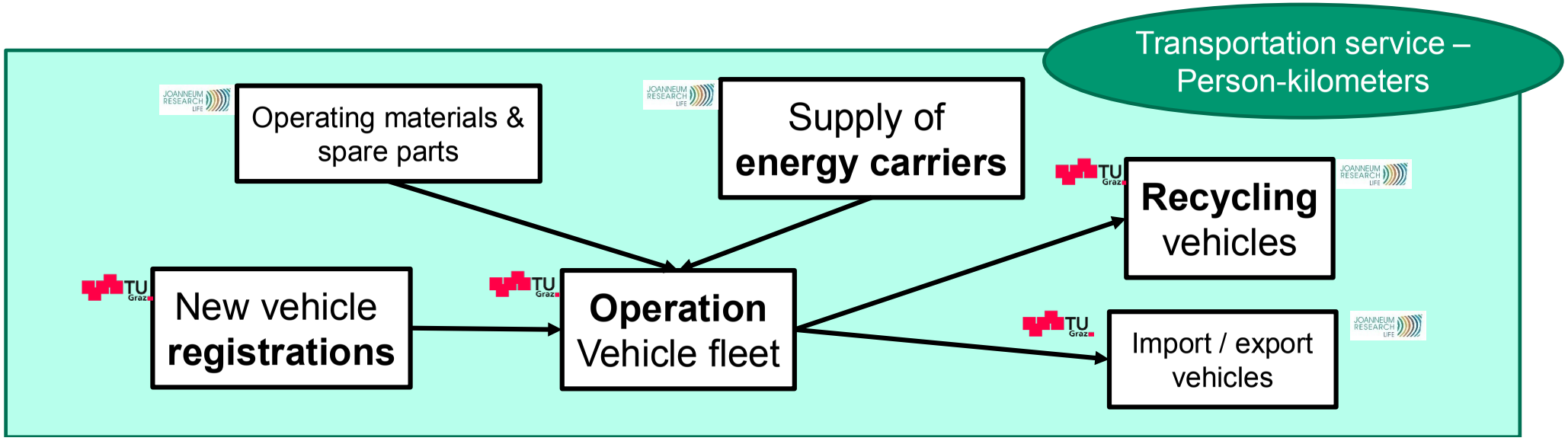
BMK 2021

Passenger vehicle fleet model Austria: 2 scenarios to reach climate neutrality in 2040/2050: „BEV“ and „e-Fuel“

- **GHG reduction goals**
  - 2030: Austria about 55% reduction (based on 1990)
  - 2040: Austria „climate neutral“ transportation sector
  - 2050: EU and USA climate neutral
  - 2060: Rest of the world climate neutral
- **Fleet modelling** with NEMO (Network Emission Model) used for OLI (Österreichische Luftschadstoff-Inventur)
  - **Different shares of new registrations** from 2021: BEV and ICE/PHEV
  - Only **domestic passenger vehicles** (without „tank tourism“)
  - **Vehicle fleet:** constant from 2025
  - **Total annual kilometres:** constant from 2020
- **Renewable electricity** for BEV generated in new power plants in Austria/abroad integrated in existing renewable electricity mix
- CO_2-sources for **e-Fuels**:
  - 50 – 100 kt/a from biomass (e.g. fermentation, combustion)
  - > 100 kt/a from air
- **Amount of biofuels** for passenger vehicles remain constant from 2020 (about 250 kt)
- **Cooperation**
  - JOANNEUM RESEARCH (LCA & modelling)
  - Graz University of Technology (vehicle fleet)
  - IEA HEV Task 30 and Task 40 (methodology)

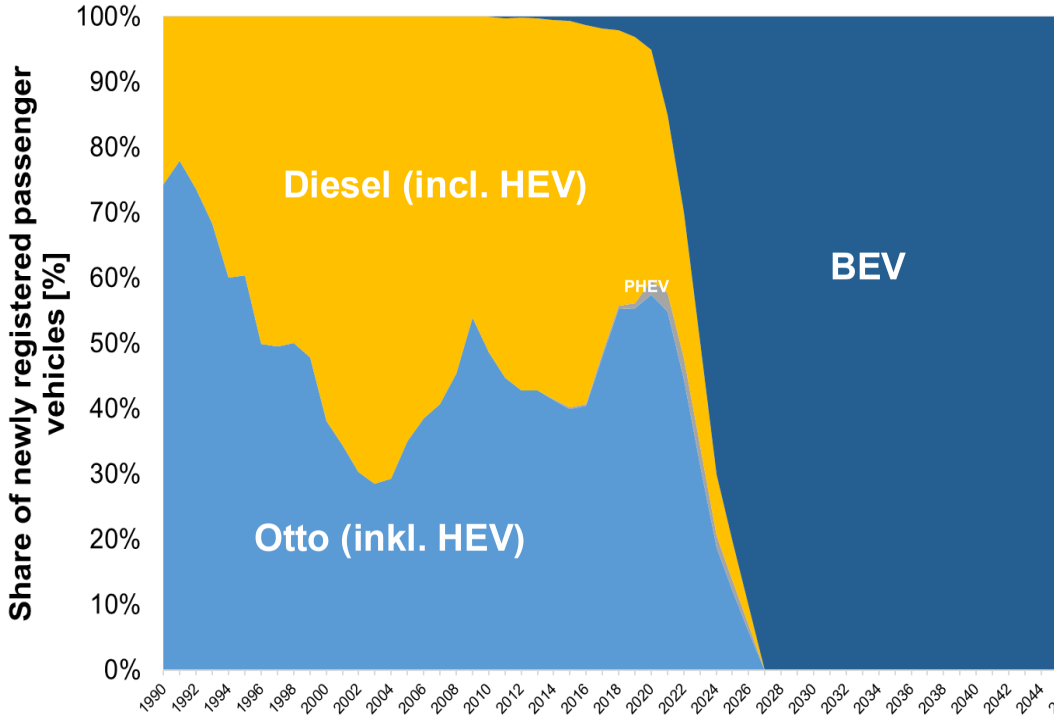
Yearly GHG-emissions of passenger vehicle fleet in Austria from 1990 to 2050, based on LCA

- Vehicle **production** of new registrered passenger cars
- Imported **second use vehicles**
- **Operation of vehicle fleet**
  - Supply of energy carriers
  - Operating materials and spare parts
  - Direct vehicle emissions
- Vehicle **end-of-life**
  - Recycling
  - Export of used vehicles (second life)



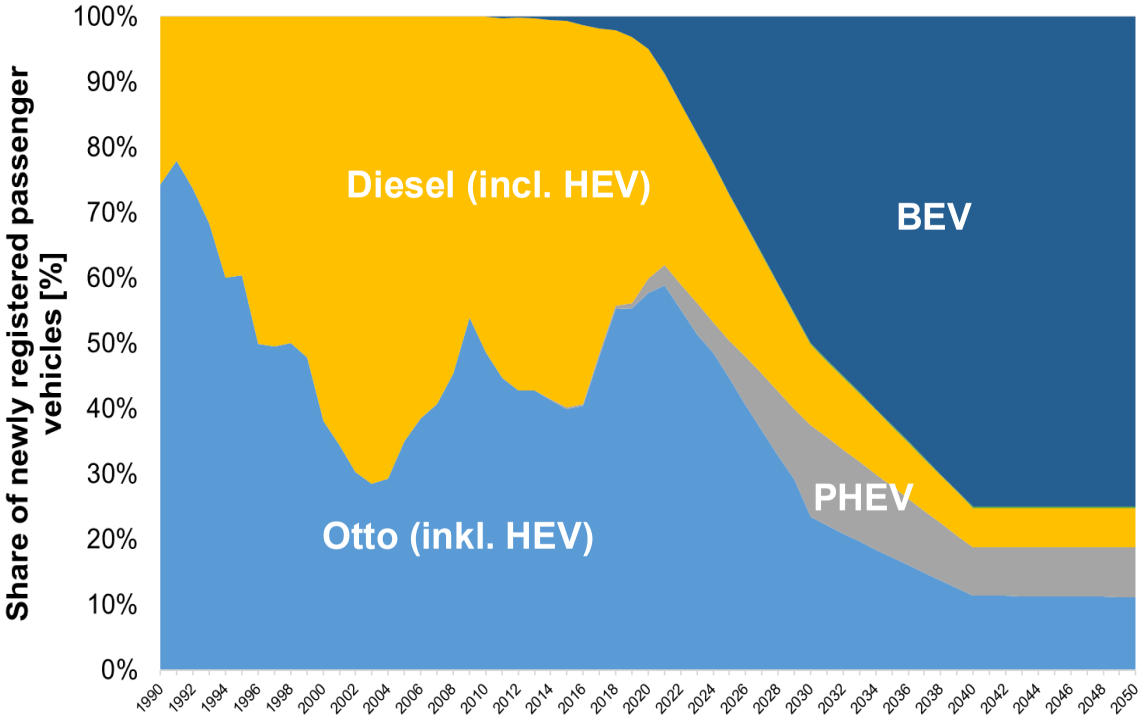
Share of Newly Registered Passenger Vehicles

BEV-Scenario



2028+: 100% BEV

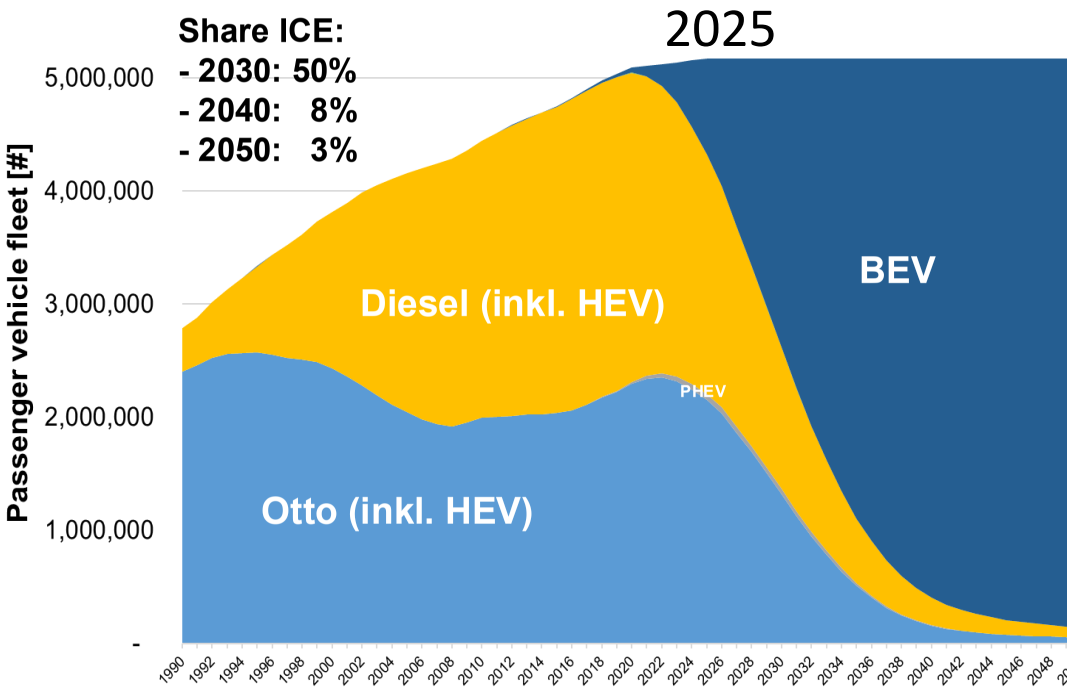
e-Fuel-Scenario



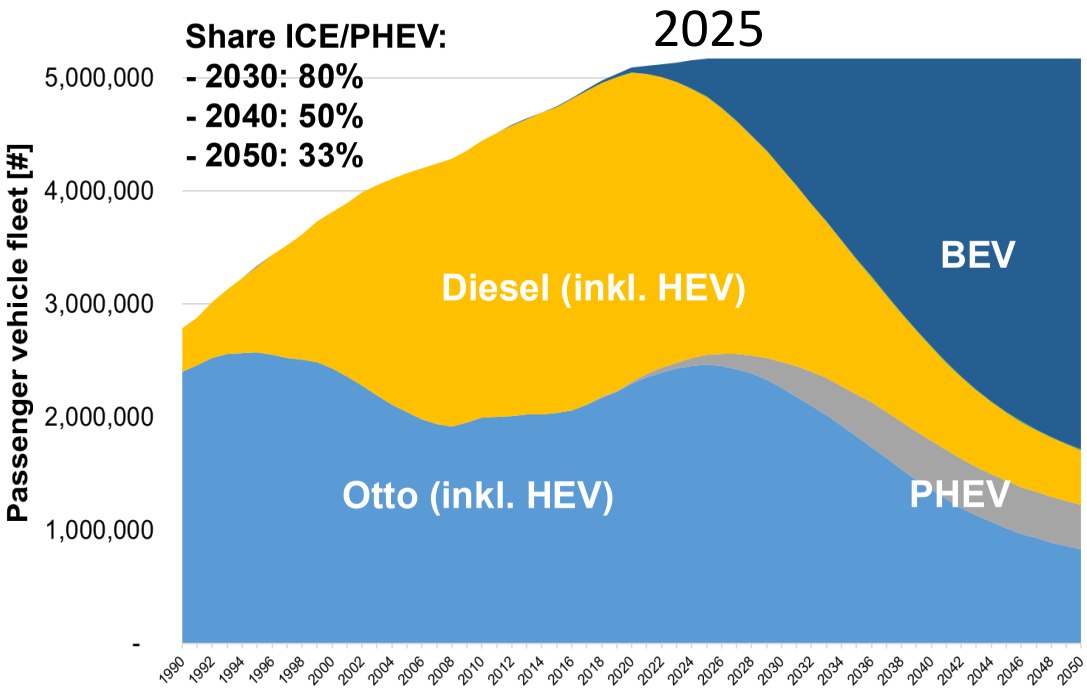
2040+: 25% ICE/PHEV

Development of Passenger Vehicle Fleet

BEV-Scenario



e-Fuel-Scenario

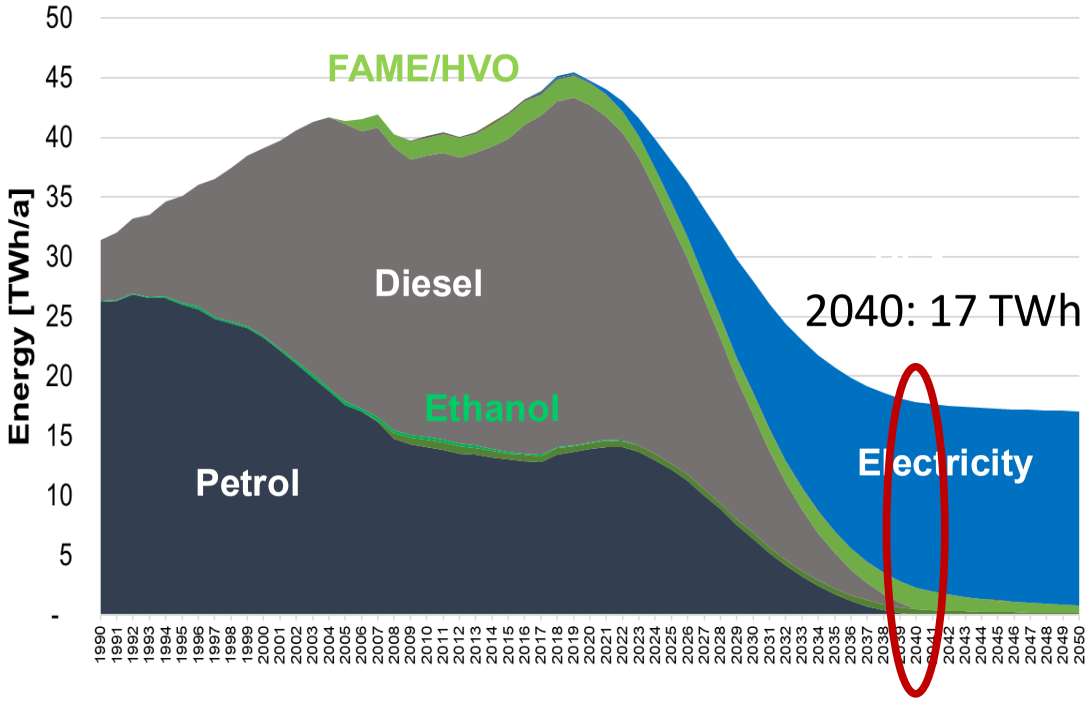


More rapid fleet renewal

1990: 2.7 Mio. passenger vehicles
2019: 5.0 Mio. passenger vehicles

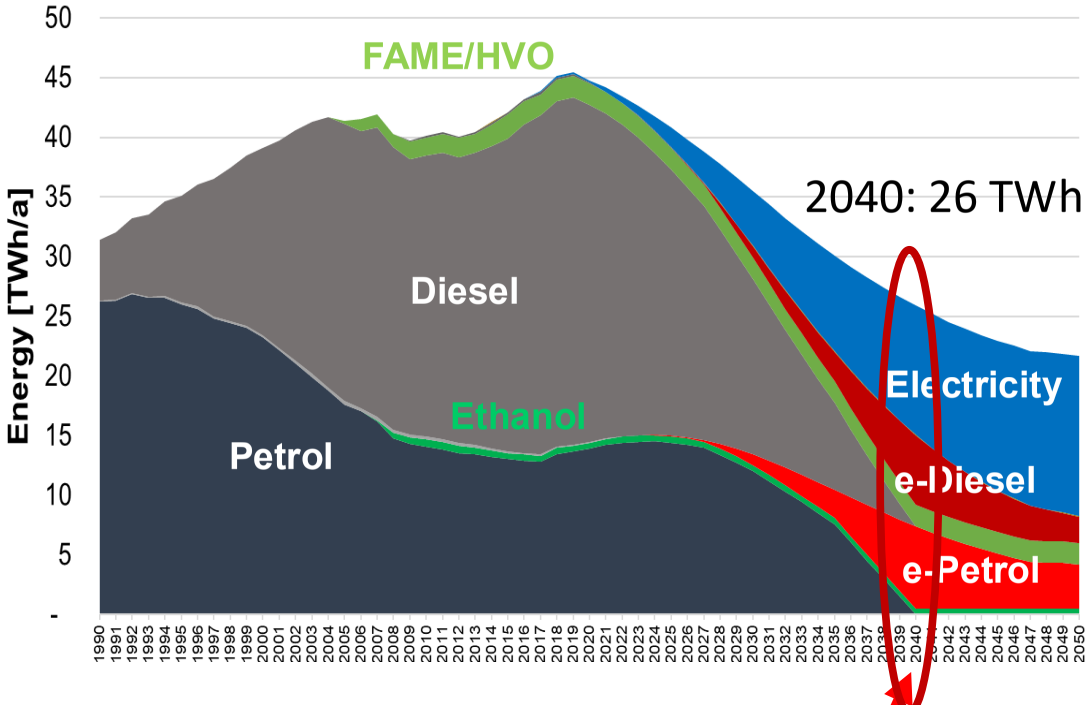
Passenger Vehicle Energy Consumption

BEV-Scenario



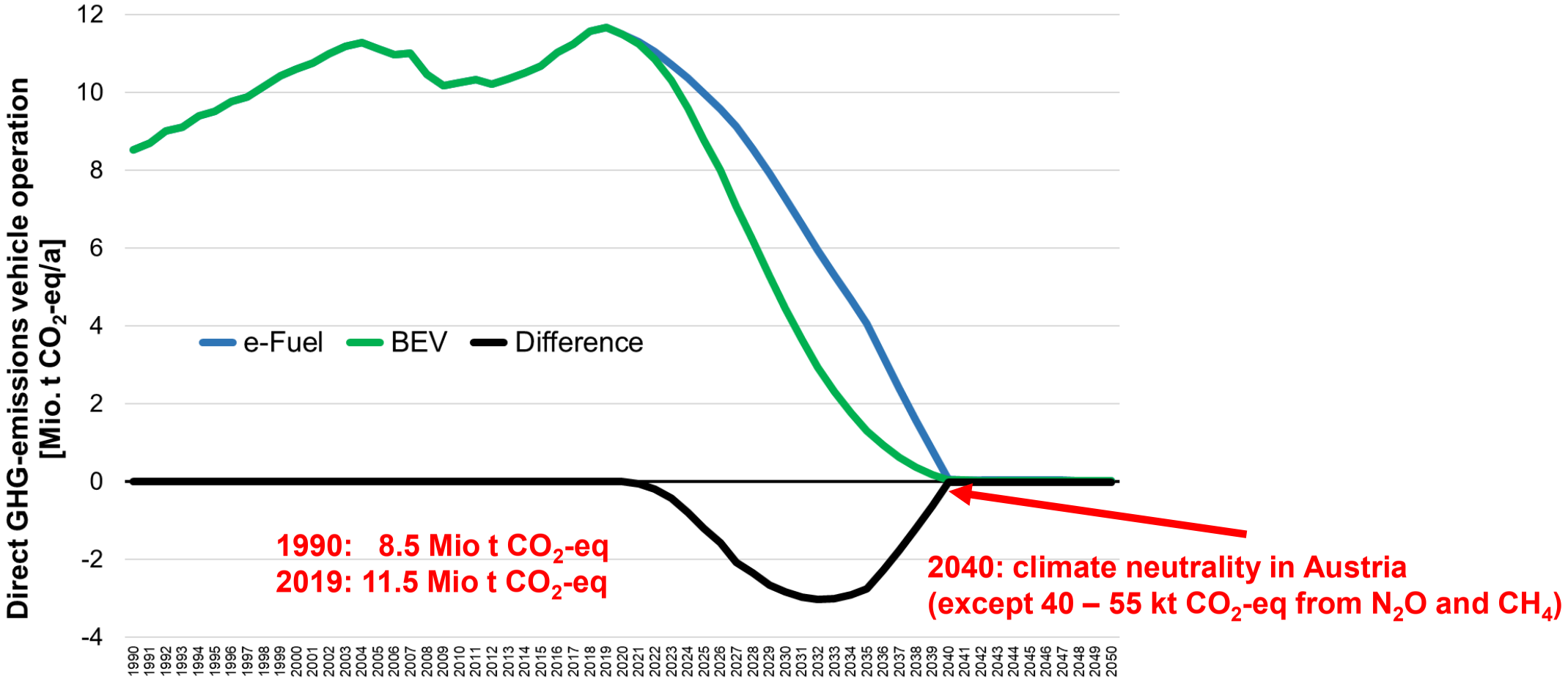
1990: 31 TWh
2019: 45 TWh

e-Fuel-Scenario



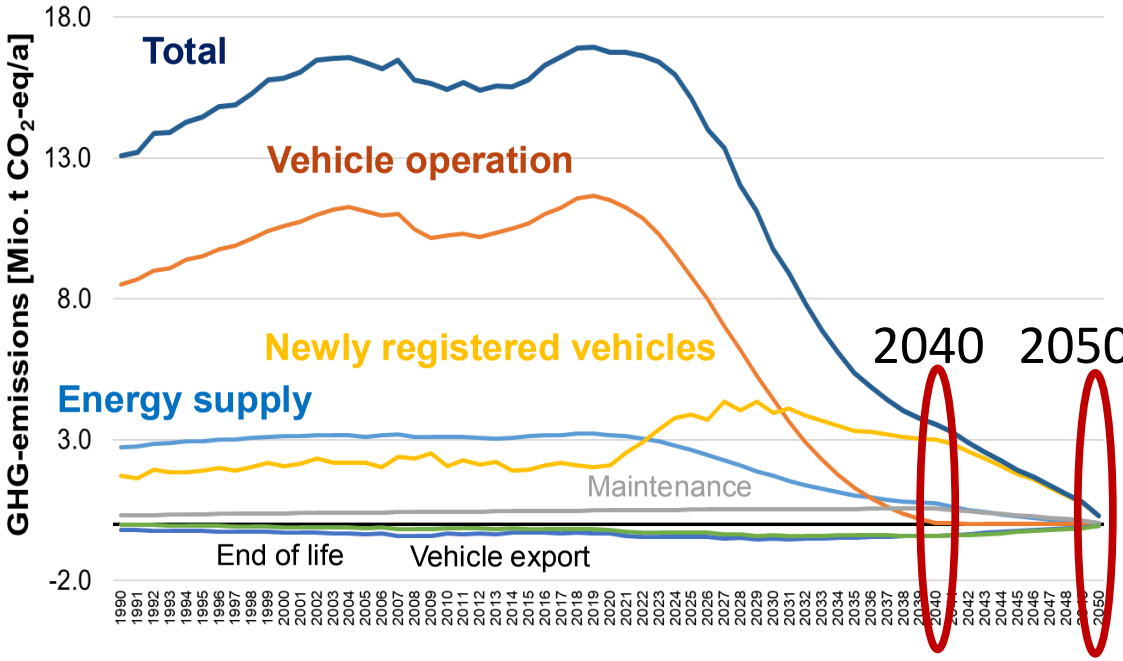
e-fuel (demand / energy share):
- 2040: about 1 Mio. t / 50%
- 2050: about 0.5 Mio t / 30%

Direct GHG-Emissions: Passenger Vehicle Fleet Operation



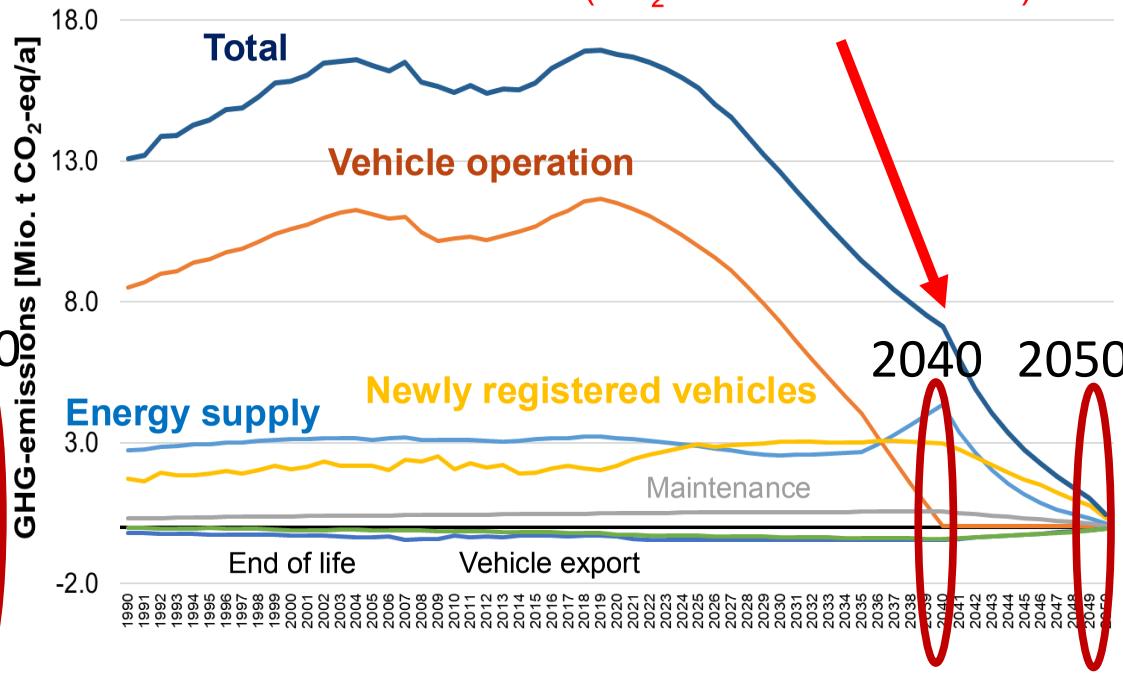
LCA Based GHG-Emissions of Passenger Vehicle Fleet

BEV-Scenario



e-Fuel-Scenario

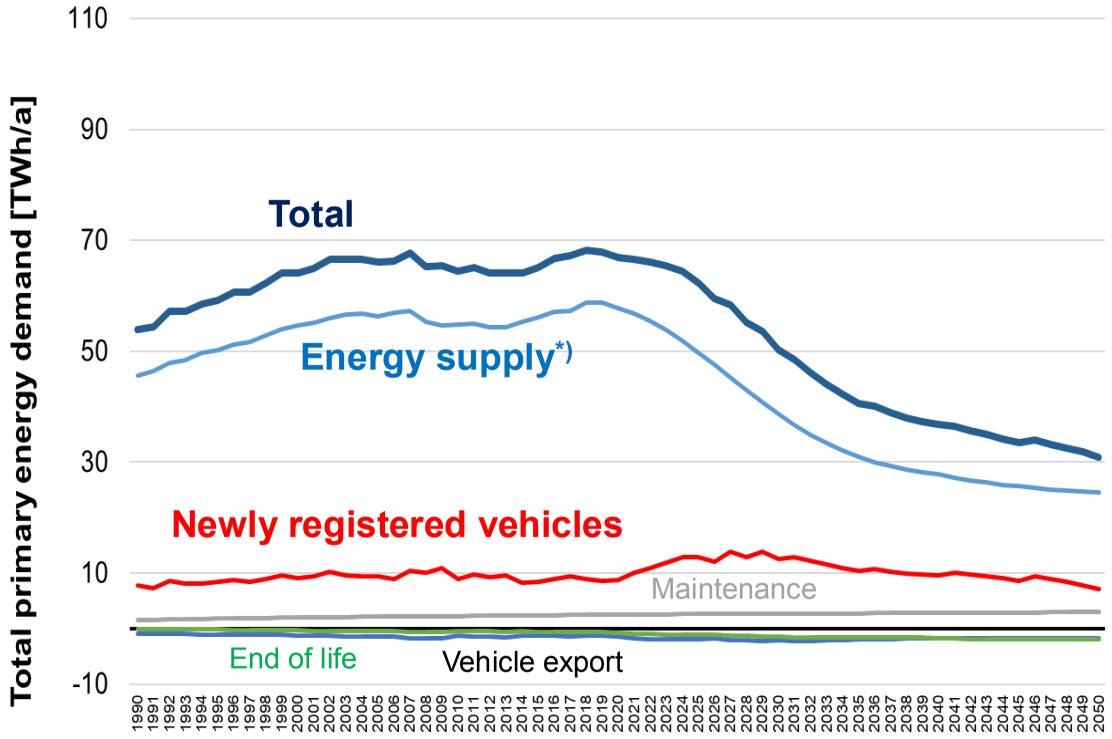
2040: about 1 Mio. t e-Fuel
(CO_2 from air and biomass)



1990: 13 Mio t CO_2-eq
2019: 17 Mio t CO_2-eq

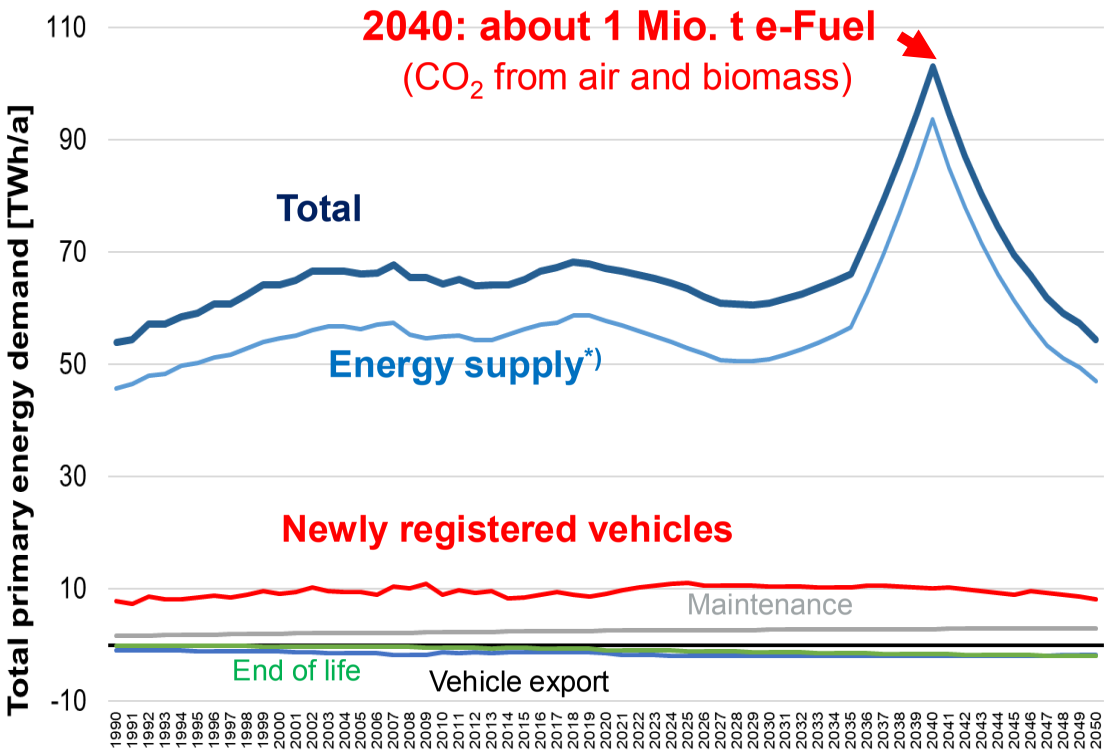
LCA based Total Primary Energy Demand of Passenger Vehicle Fleet

BEV-Scenario



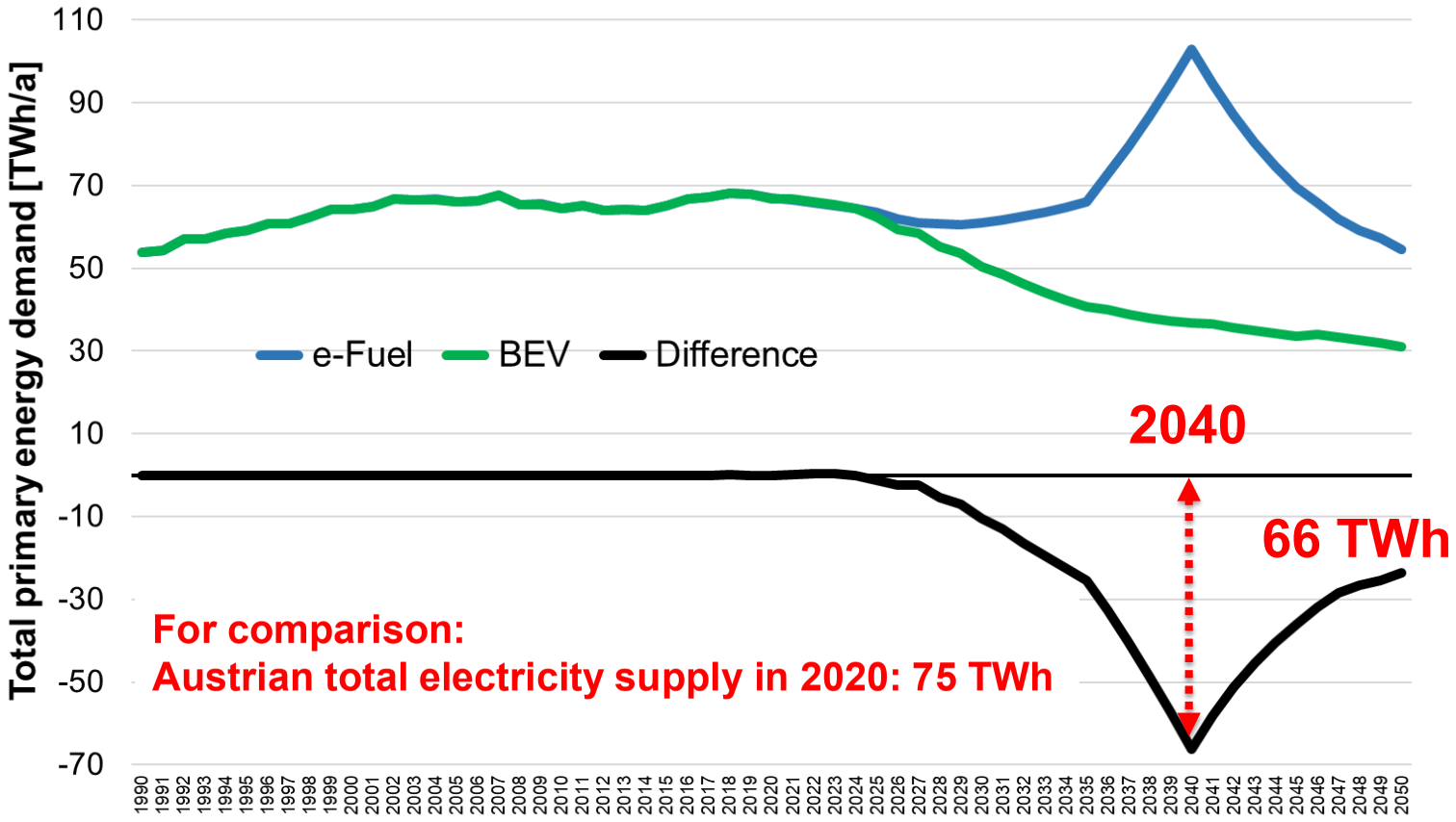
*) incl. energy for vehicle operation

e-Fuel-Scenario



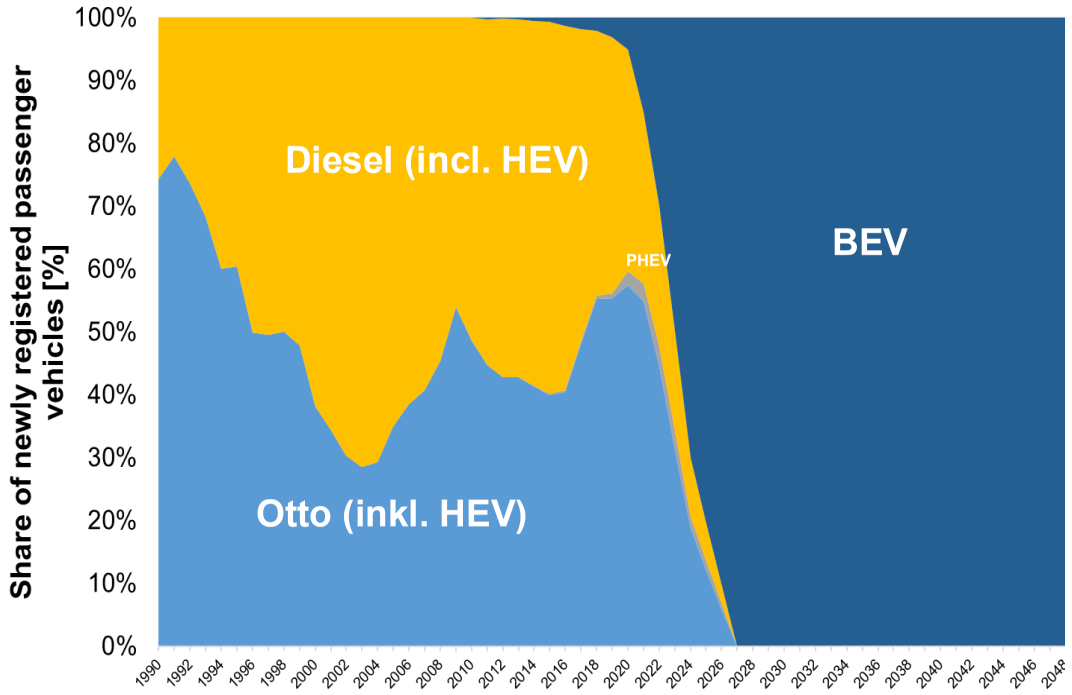
1990: 54 TWh
2019: 68 TWh

Difference of LCA Based Total Primary Energy Demand of Passenger Vehicle Fleet



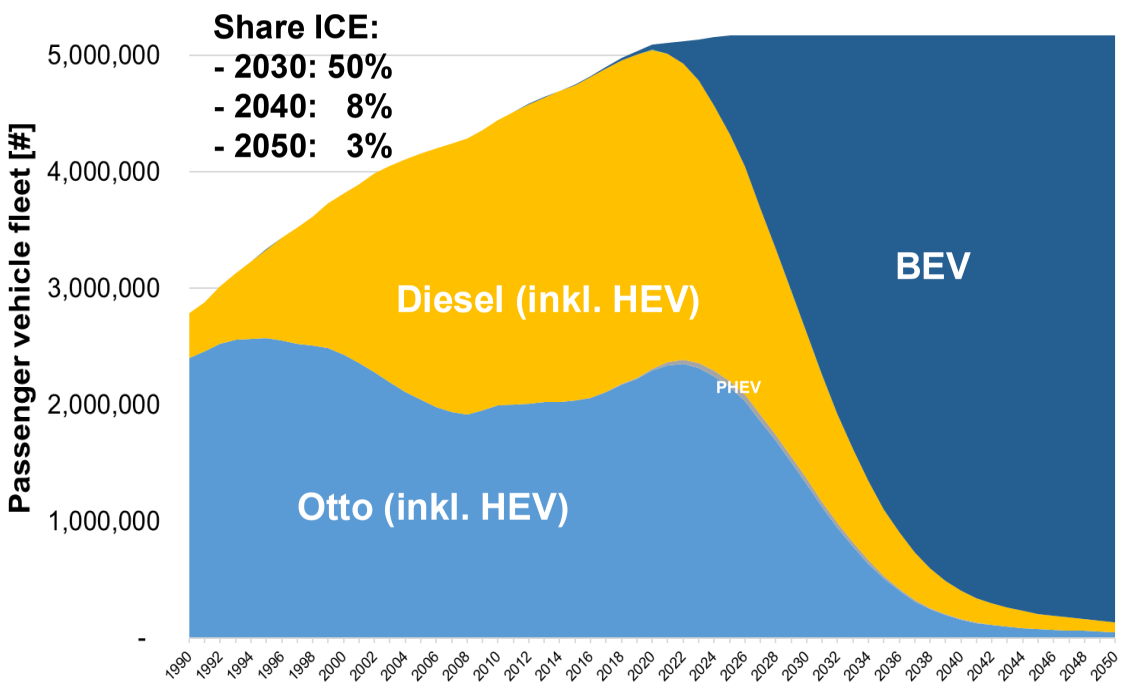
Development of passenger vehicle fleet in Austria

New vehicle registrations



2028+: new registered vehicles: 100% BEV

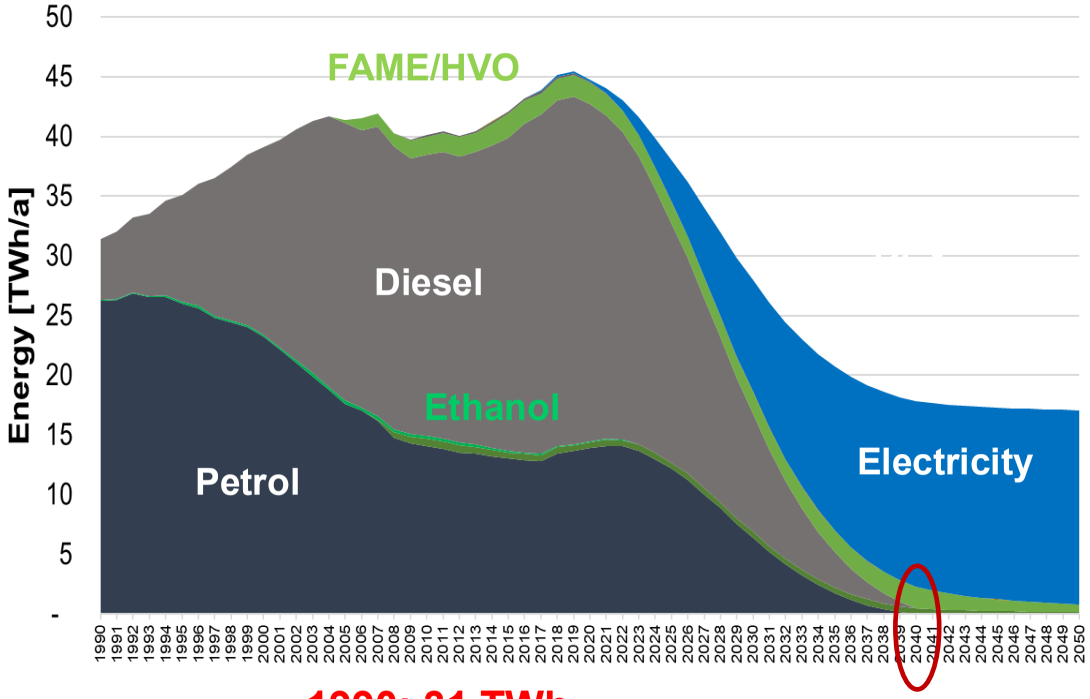
Vehicle fleet



2025+: constant vehicle fleet

Passenger vehicle energy consumption BEV-scenario

Energy consumption vehicle fleet

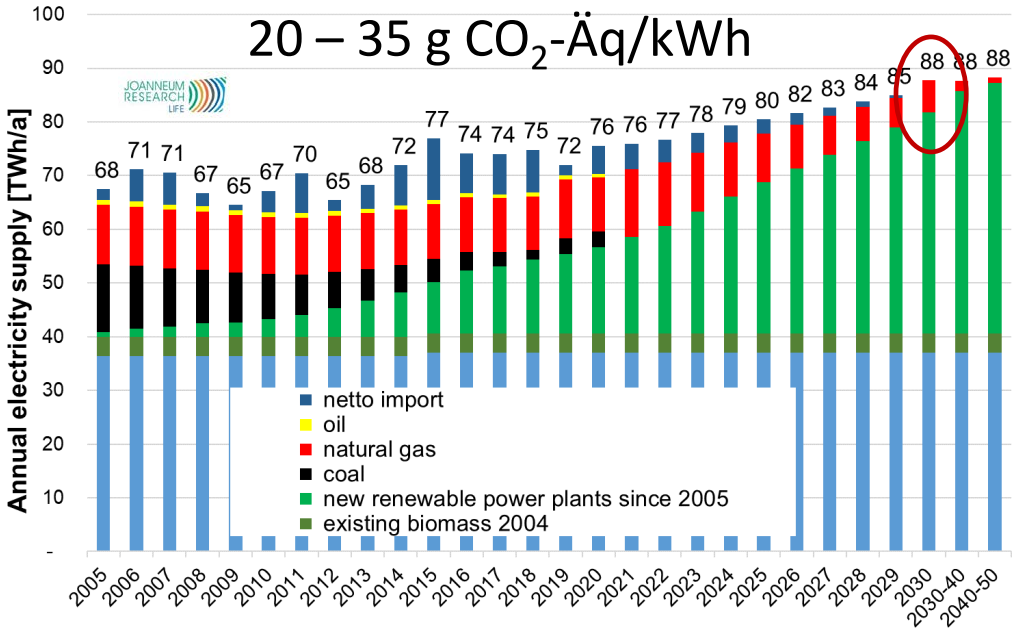


1990: 31 TWh
2020: 45 TWh
2030: 27 TWh

2040: 17 TWh

100% Renewable electricity in Austria 2030

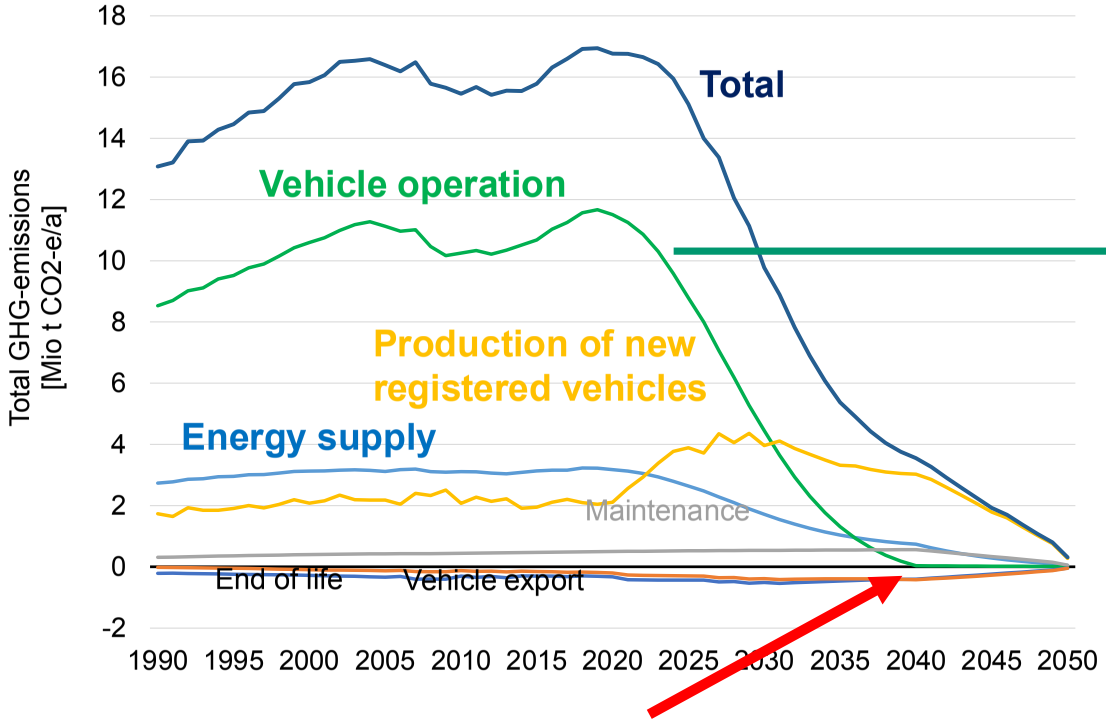
(based on EE-Ausbaugesetz 2021)



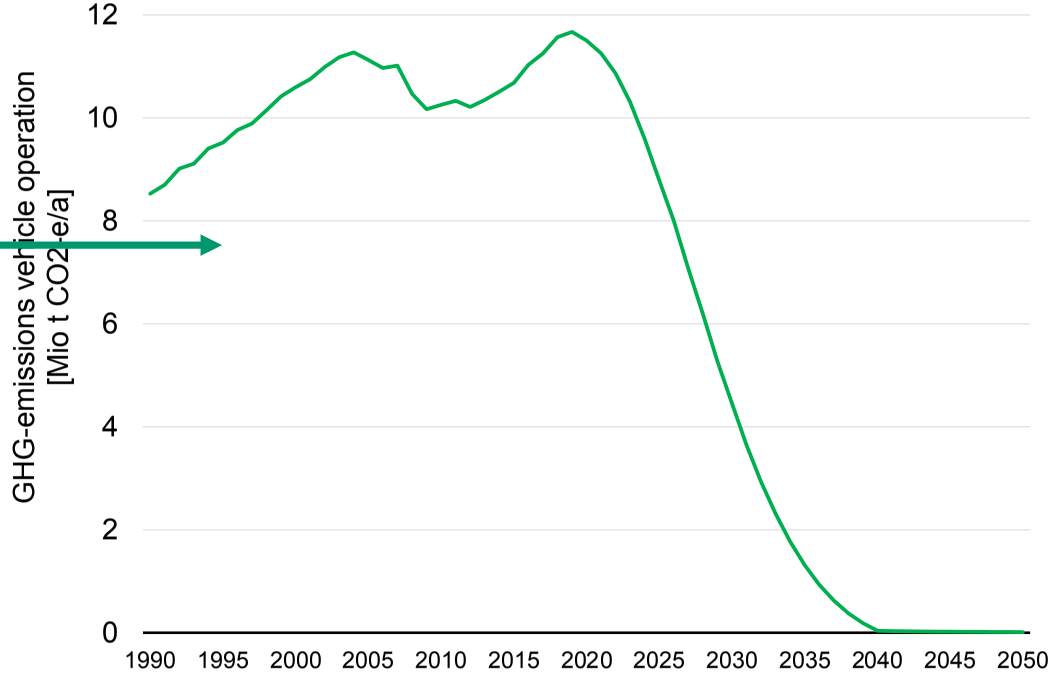
Source: Electricity supply 1.0, JOANNEUM RESEARCH

GHG-emissions of passenger vehicle fleet BEV-scenario

Total GHG emissions of the fleet



GHG emissions from fleet operation

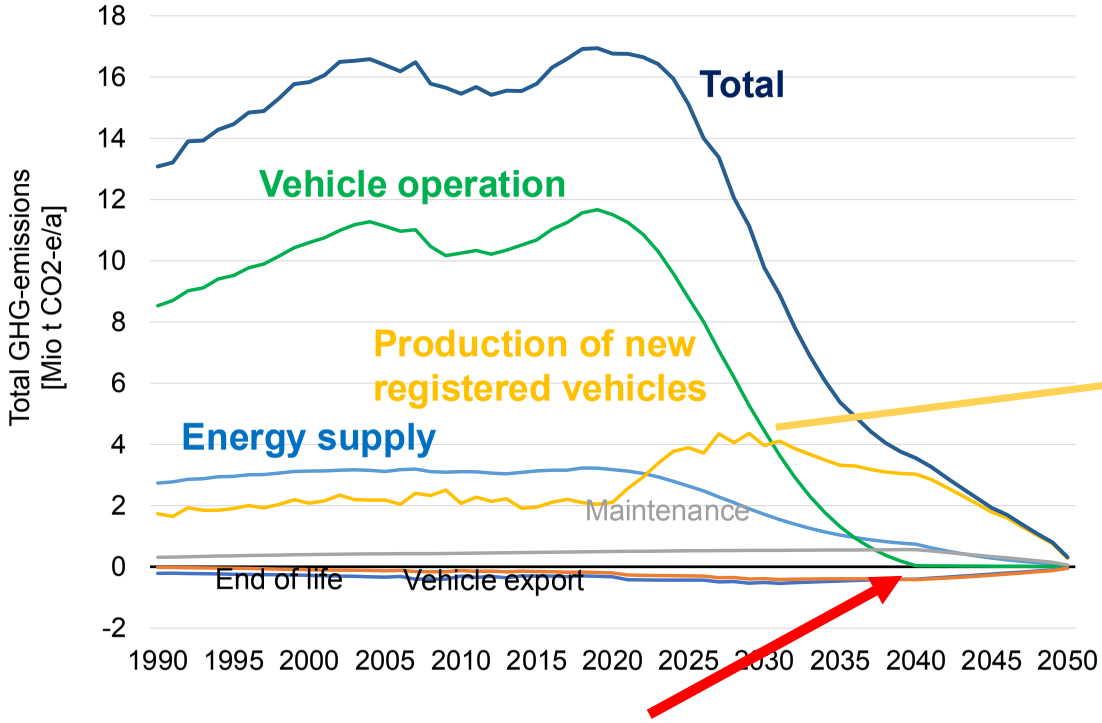


2040: climate neutrality in Austria
(except 40 – 55 kt CO_2-eq from N_2O and CH_4)

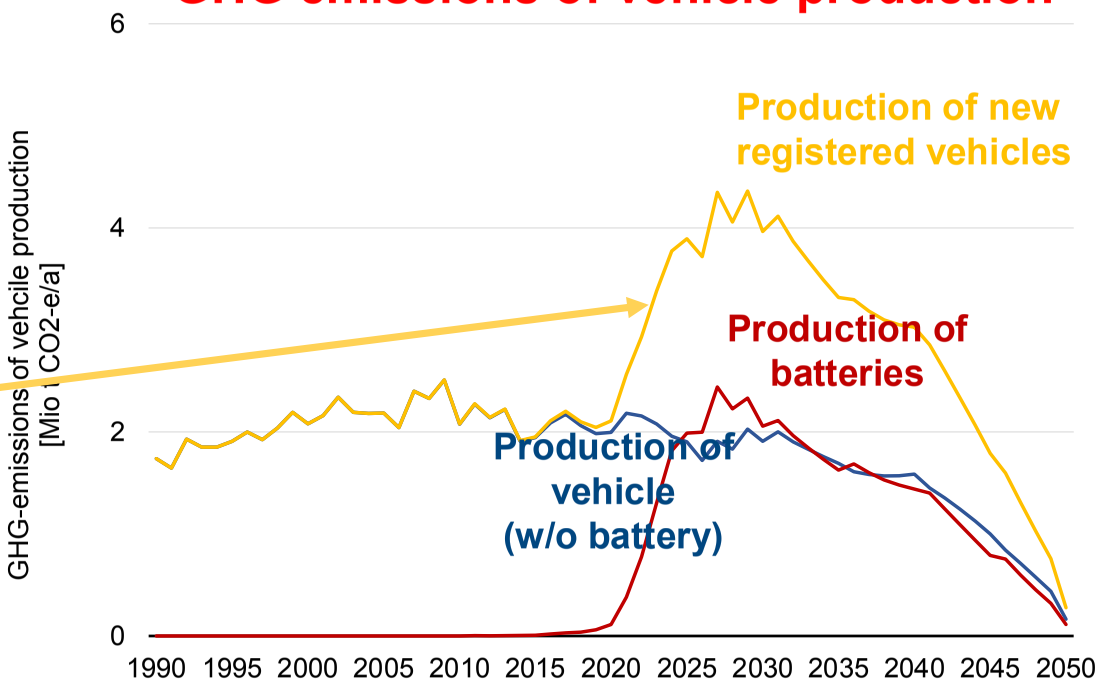
1990: 8.5 Mio t CO_2-eq
2020: 11.5 Mio t CO_2-eq
2030: 4.5 Mio t CO_2-eq
2040: 0 Mio t CO_2-eq

GHG-emissions of passenger vehicle fleet BEV-scenario

Total GHG emissions of the fleet



GHG emissions of vehicle production



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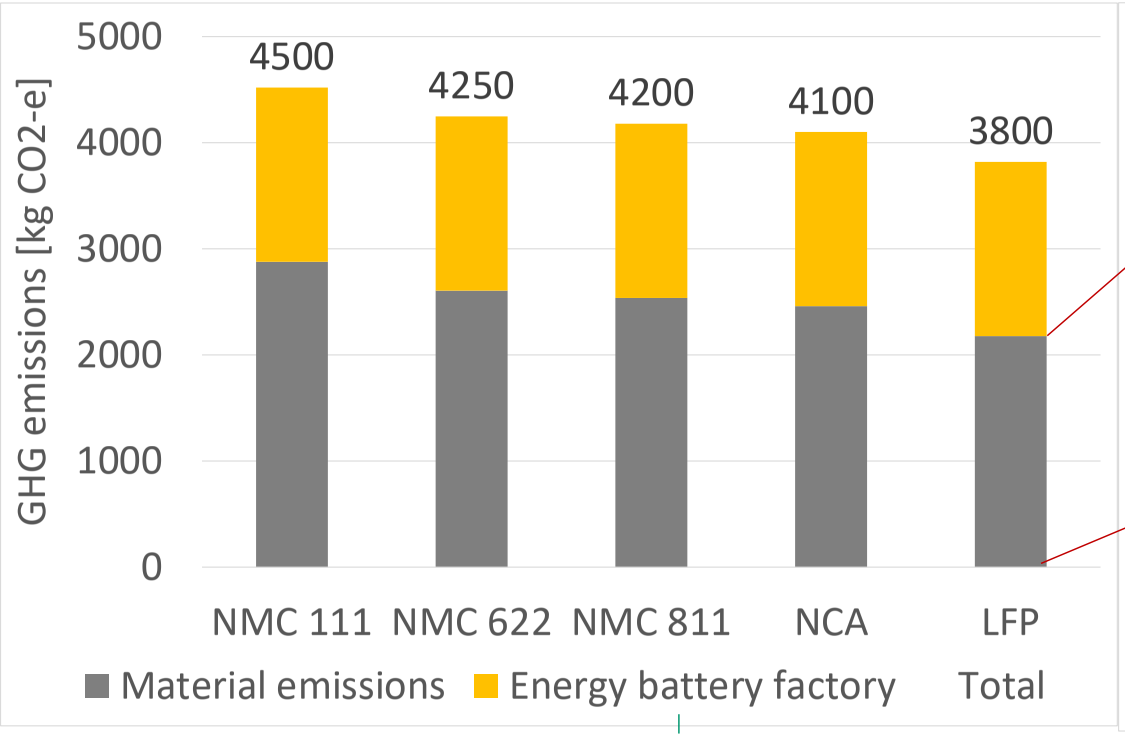
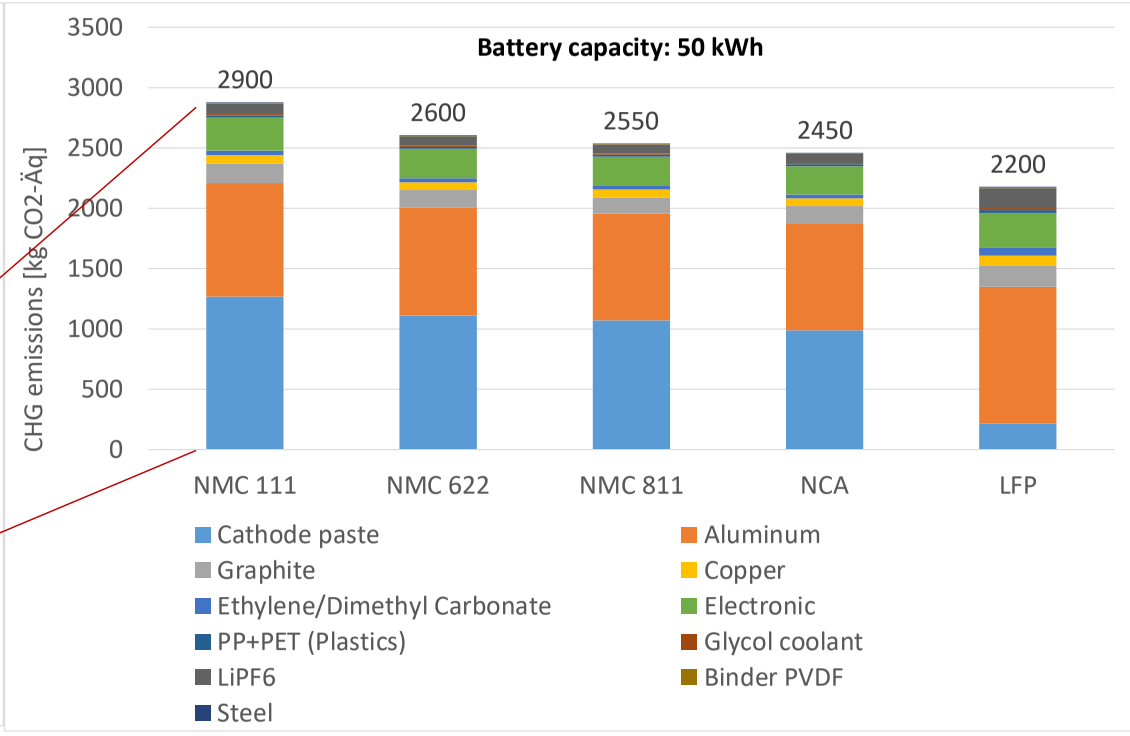
(except 40 – 55 kt CO_2-eq from N_2O and CH_4)

GHG emissions of battery pack production (example 50 kWh, China, 2020)

GHG emissions of battery production



GHG emissions of material production

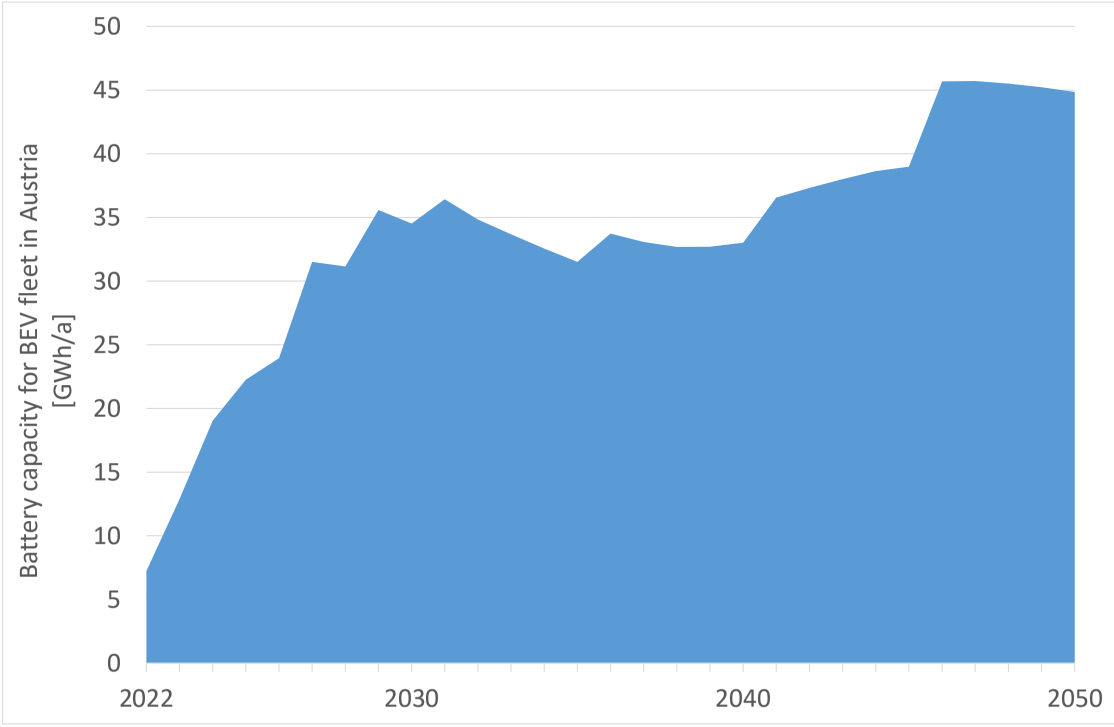


Energy demand battery factory: 55-65 kWh / kWh battery capacity

Source: Battery Lifecycle model, Joanneum Research

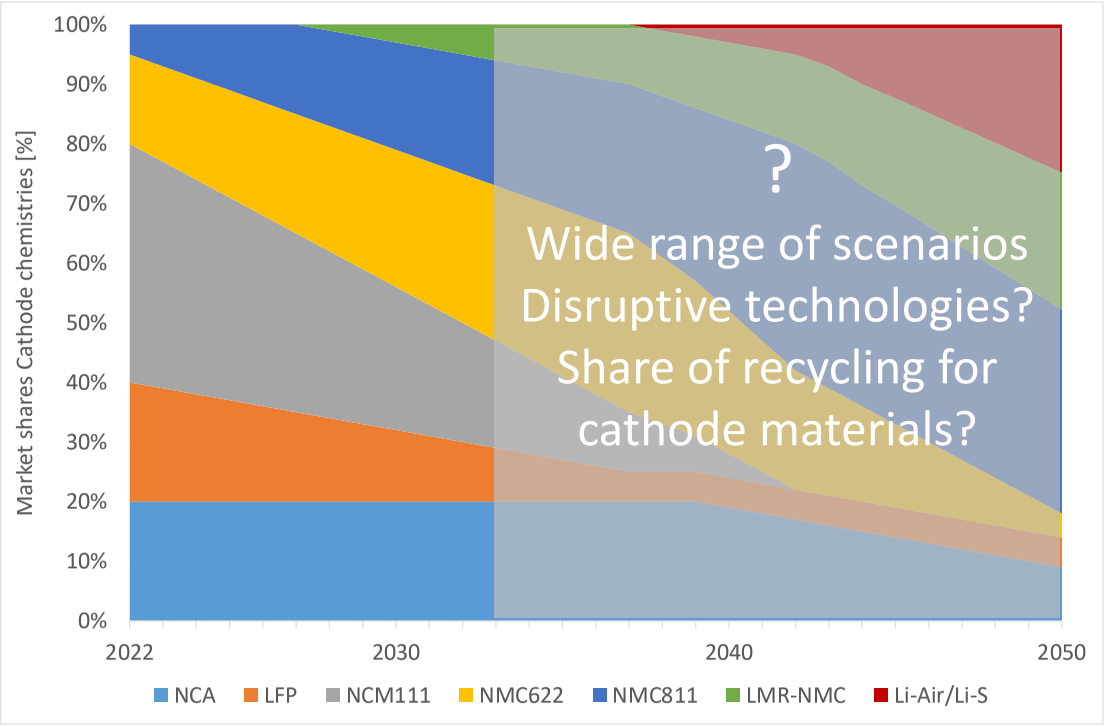
Batteries for BEV scenario

GWh battery capacity for the BEV fleet in Austria



2020: 75 kWh/battery
2030: 100 kWh/battery
2040: 110 kWh/battery
2050: 140 kWh/battery

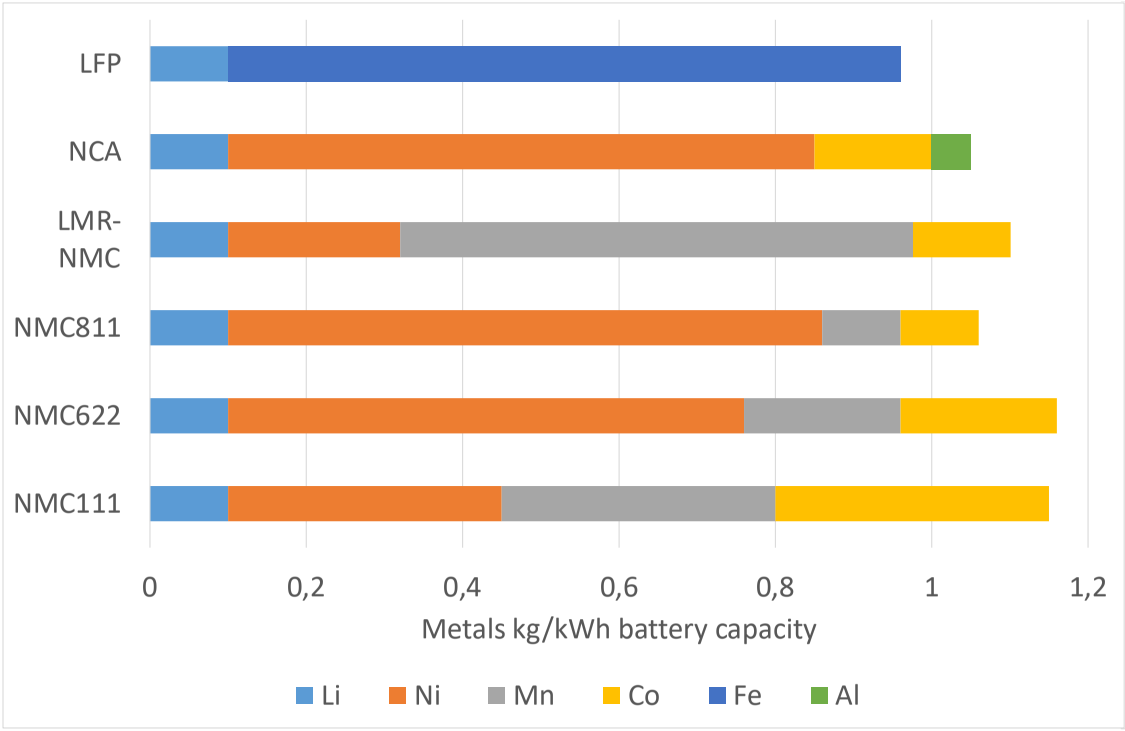
Market shares of cathode chemistries



NMC-scenario with 60-70% NMC batteries

Critical raw material demand for BEV fleet

Metal demand for cathode chemistries



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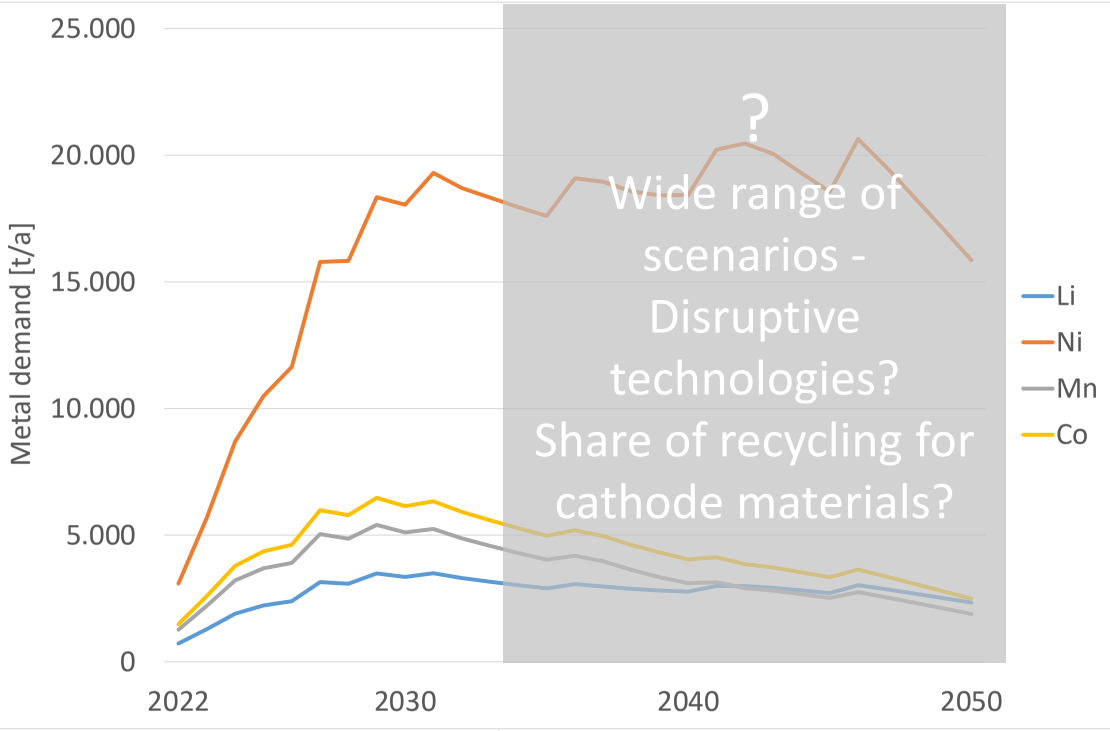


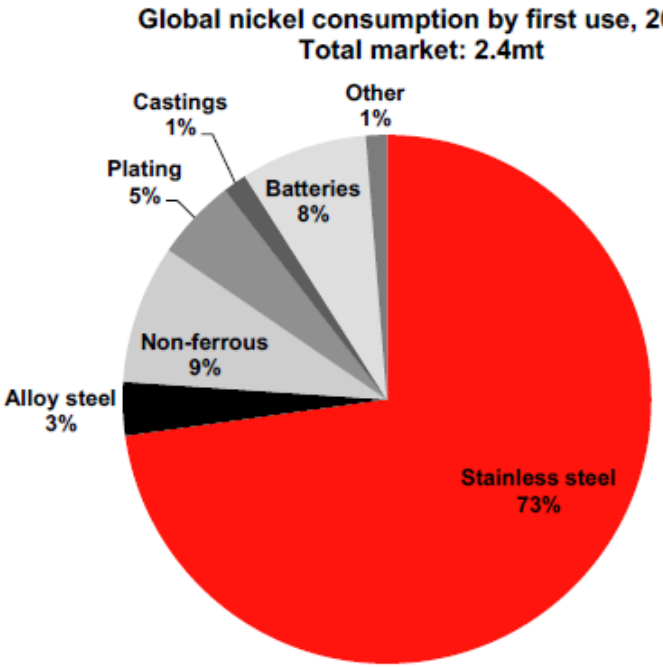
Example Nickel:

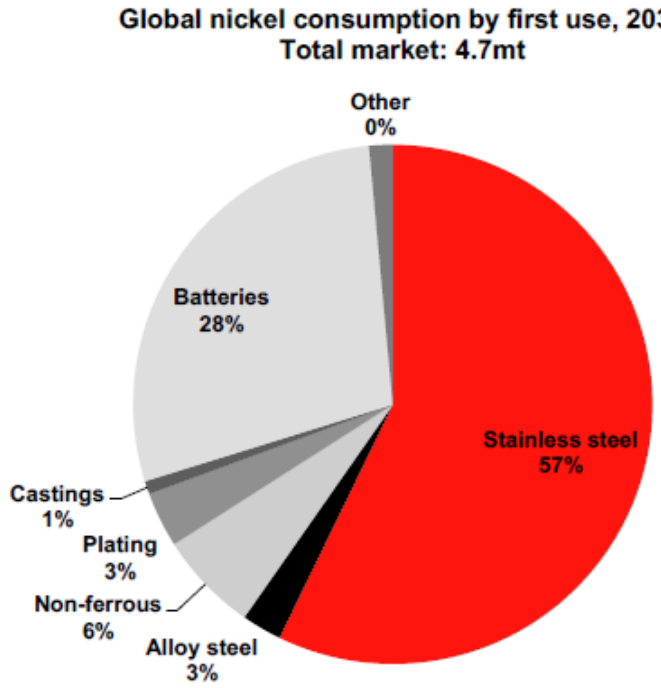
Future demand BEV fleet in Austria ~ 18-20 kt/a

Todays demand by industry in Austria ~ 24 kt/a (Source: Country factsheet Ni-Institute)

Future Nickel supply for batteries

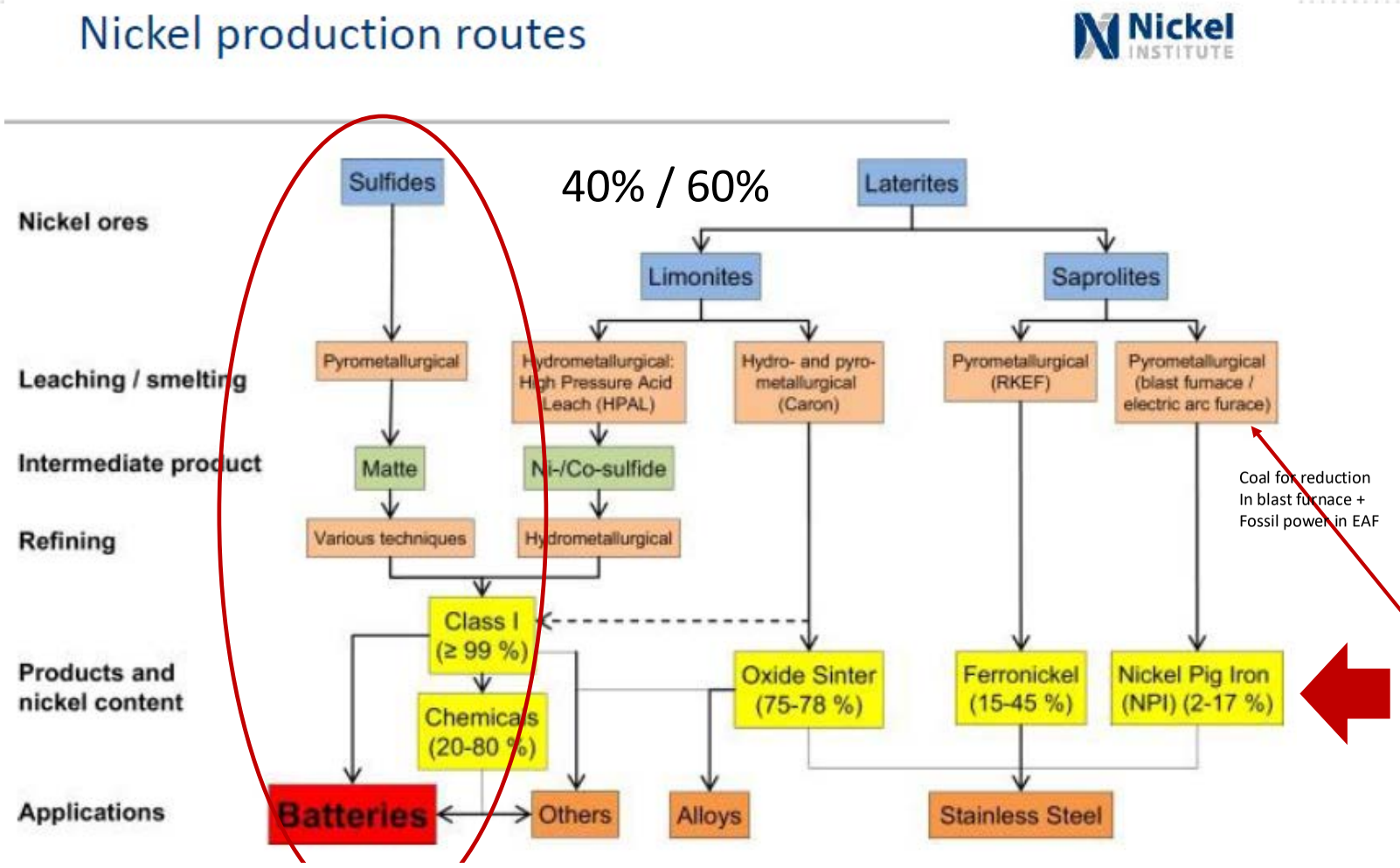
Batteries to become almost 30% of nickel market by 2030





Source: INSG, Macquarie Commodities Strategy, October 2021

How to cover the additional Nickel demand for batteries? Nickel is complicated…



Significant growth in NPI production (SE-Asia) due to stainless steel production in China

BUT

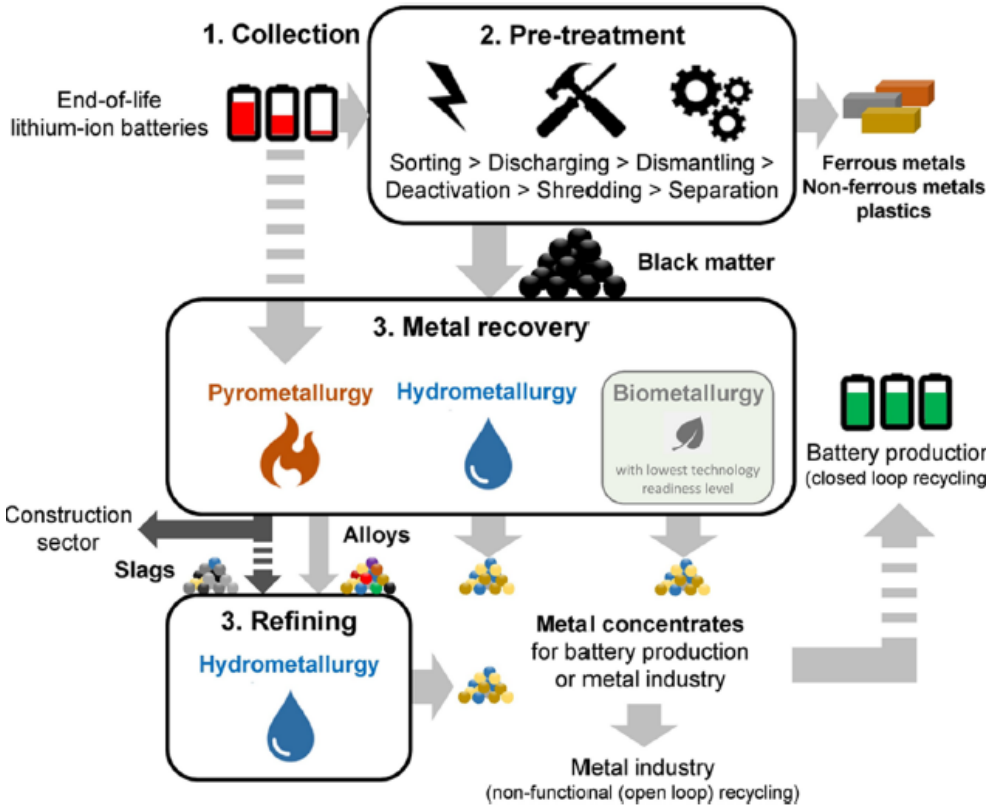
CO_2-emissions per ton Ni via NPI 3-10 times higher (40-80 t CO_2-e/t Ni) than via sulfidic Ni (8-12 t CO_2-e/t Ni)

Update EU battery-directive
(expected for July 2023)

- Minimum recycling rate:
  - 2026: 35 % Lithium, 90 % Nickel, Lead, Copper, Cobalt
  - 2030: 70 % Lithium, 95 % Nickel, Lead, Copper, Cobalt
- **Minimum share of recyclate:**
  - **2030: 12% Cobalt; 85% Lead; 4% Lithium; 4% Nickel**
  - **2035: 20 % Cobalt; 85 % Lead; 10 % Lithium; 12 % Nickel**
- Carbon Footprint-(CF) declaration [kg CO2-Äq/kWh] of total electricity stored during lifetime
  - from 1.7.2024: obligatory CF-declaration
  - from 1.1.2026: Classification based on CF-classes (t.b. defined by EC)
  - from 1.6.2027: Compliance with maximum CF (t.b. defined by EC)
  - valid also for imported batteries
- Reporting supply chains, social due diligence for Cobalt, Grafite, Lithium, Nickel (based on guideline UNEP s-LCA)
- IT-technologies – battery pass, EU-battery-database

State-of-the-art processes and challenges of battery-recycling

- **Pre-treatment** (**State-of-the-art**)
  - Challenges: thermal runaway, reduced aluminium yield with higher temperatures
- **Pyrometallurgy** (**State-of-the-art**)
  - Challenges: metal recovery as alloy (Ni, Co, Cu), requires hydrometallurgical refining for metal recovery. Li, Mn, Al into slag (recovery is challenging), energy intensive process.
- **Hydrometallurgy** (**in development**)
  - Challenges : pre-treatment / sorting of different battery chemistries for constant process input, long process time, waste water treatment
- **Direct recycling** (**in development**)
  - Challenges: sorting of different chemistries, very sensitive to changes in input material
- **Sequence and interplay of processes depending of input quality and chemistry, required quality of output material as biggest technical challenge to reach EU recycling targets**



Source: Nigl 2021

Findings

- **Climate Neutrality 2040** in Austria passenger vehicle fleet is possible with BEV
- **Main challenges** are
  - rapid renewal of fleet with high share of BEV registration
  - Renewable power supply covering the demands of all sectors (mobility, industry, buildings)
- Main **influences to reach climate goals** in passenger vehicle fleet are:
  - Increasing high number of newly registered BEV
  - Development of vehicle stock
  - Development of annual driven mileage of vehicle fleet
  - Generation of additional renewable electricity for BEV
  - Climate neutral raw material processing in the main resource countries remains big challenge
- **Next:** discussion and scenarios for climate neutral mobility in Austria for persons & goods using all transportation modes

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International Collaboration

This work is done in the **Technology Collaboration Programm** (TCP) of the **International Energy Agency** (IEA) on **Hybrid & Electric Vehicle** (HEV) in Task 40 with JOANNEUM RESEARCH as Austrian representative.

- Task 40: CRM4EV Critical Raw Materials for Electric Vehicles (12 countries)

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- www.ieahev.org

Contact

DI Martin Beermann
DI Dr. Gerfried Jungmeier
JOANNEUM RESEARCH
Forschungsgesellschaft mbH

LIFE – Institut für Klima,
Energie und Gesellschaft

Science Tower
Waagner-Biro-Straße 100, 8020 Graz
Tel. +43 316 876-7632
Martin.beermann@joanneum.at

www.joanneum.at/life

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RESEARCH
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