Austrian participation financed by

Klimaneutralität und Kreislaufwirtschaft

Stand des Wissens und Zukunftsperspektiven am Beispiel Elektrofahrzeug

Gerfried Jungmeier

IEWT 2023 – 13. Internationale Energiewirtschaftstagung

15. – 17. Februar 2023, Wien

Method for Environmental Assessment

There is an internationa

that environmental

products and services

can only be assessed based o

Life Cycle Assessment (LCA)

taking production, use and end-of-life phase into account

WtW – Well to wheel was yesterday!

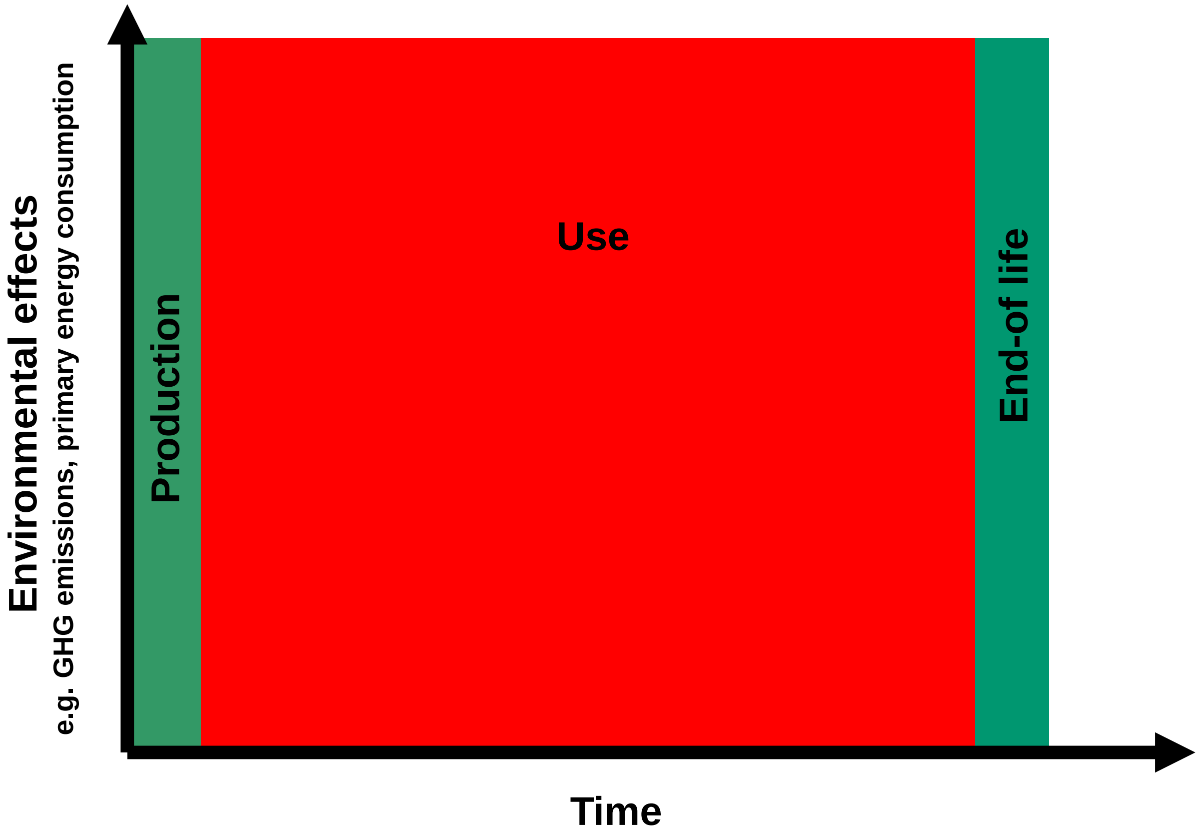
e only adressed by a

Dynamic Life Cycle Assessment

considering the timing of
GHG emissions and
raw material extraction and recycling.

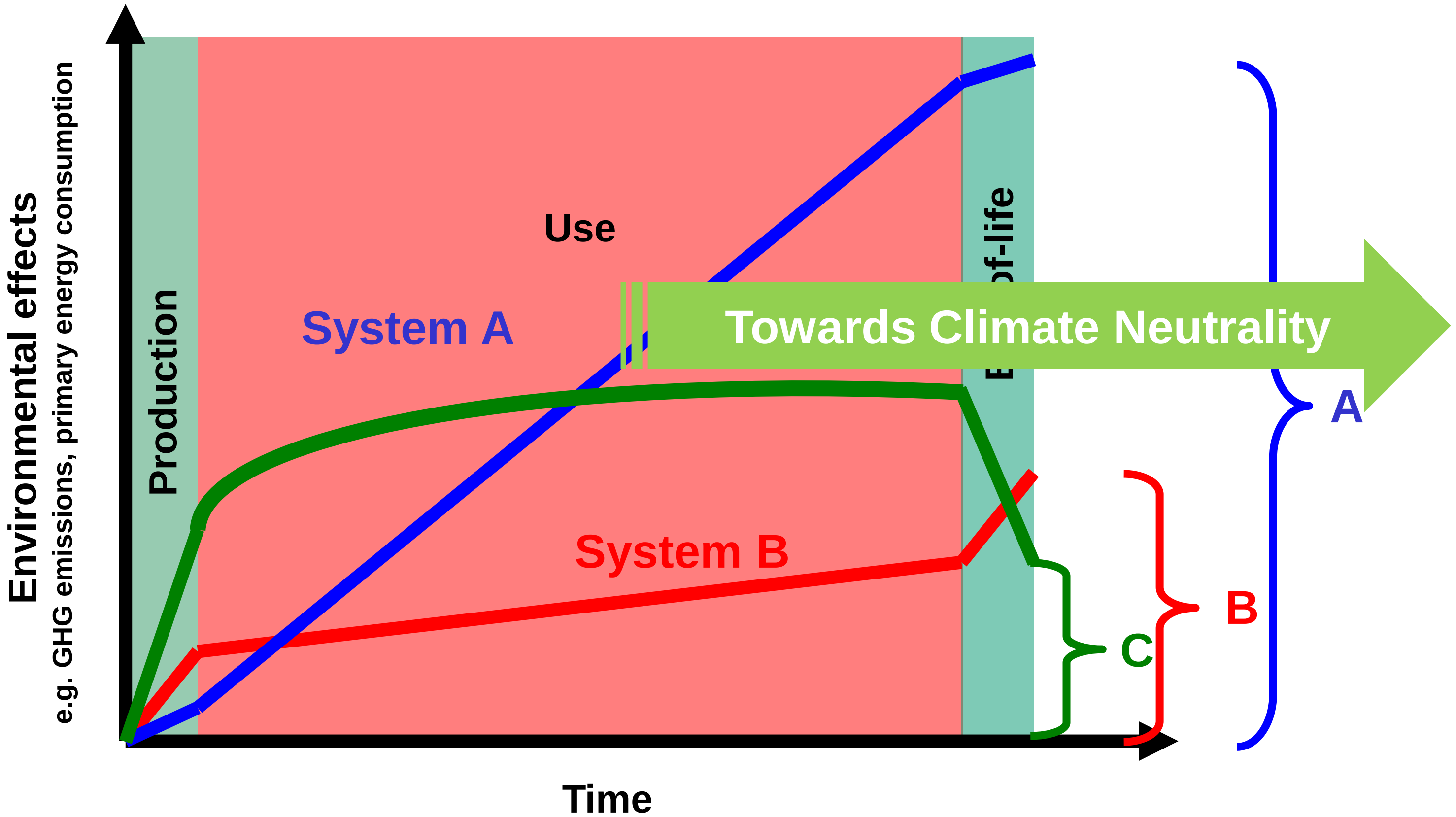
The Three Phases of a Life Cycle

Dynamic LCA considers time of environmental effects



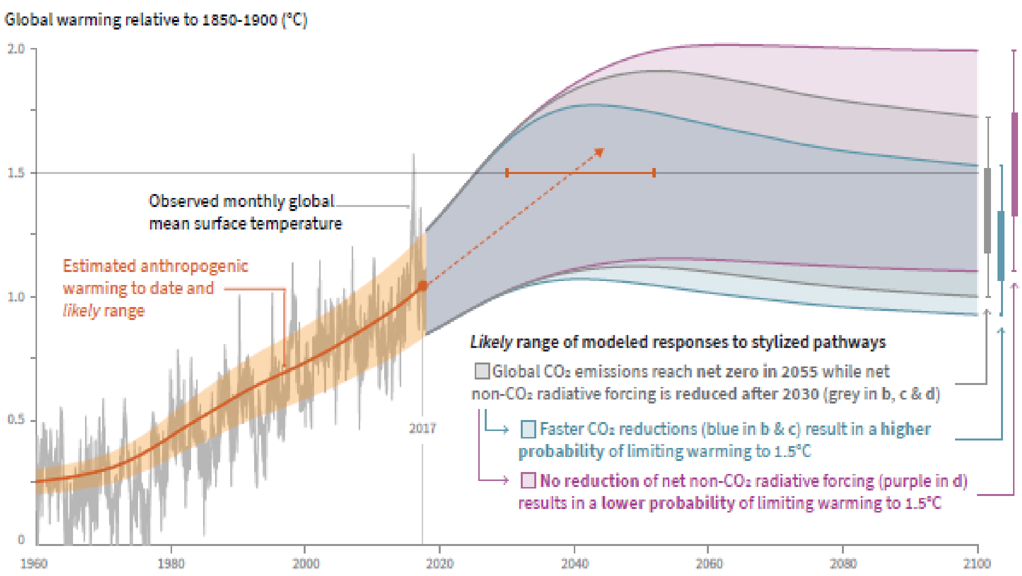
The three Phases of a Life Cycle

Dynamic LCA considers time of environmental effects



The Challenges

Global Warming



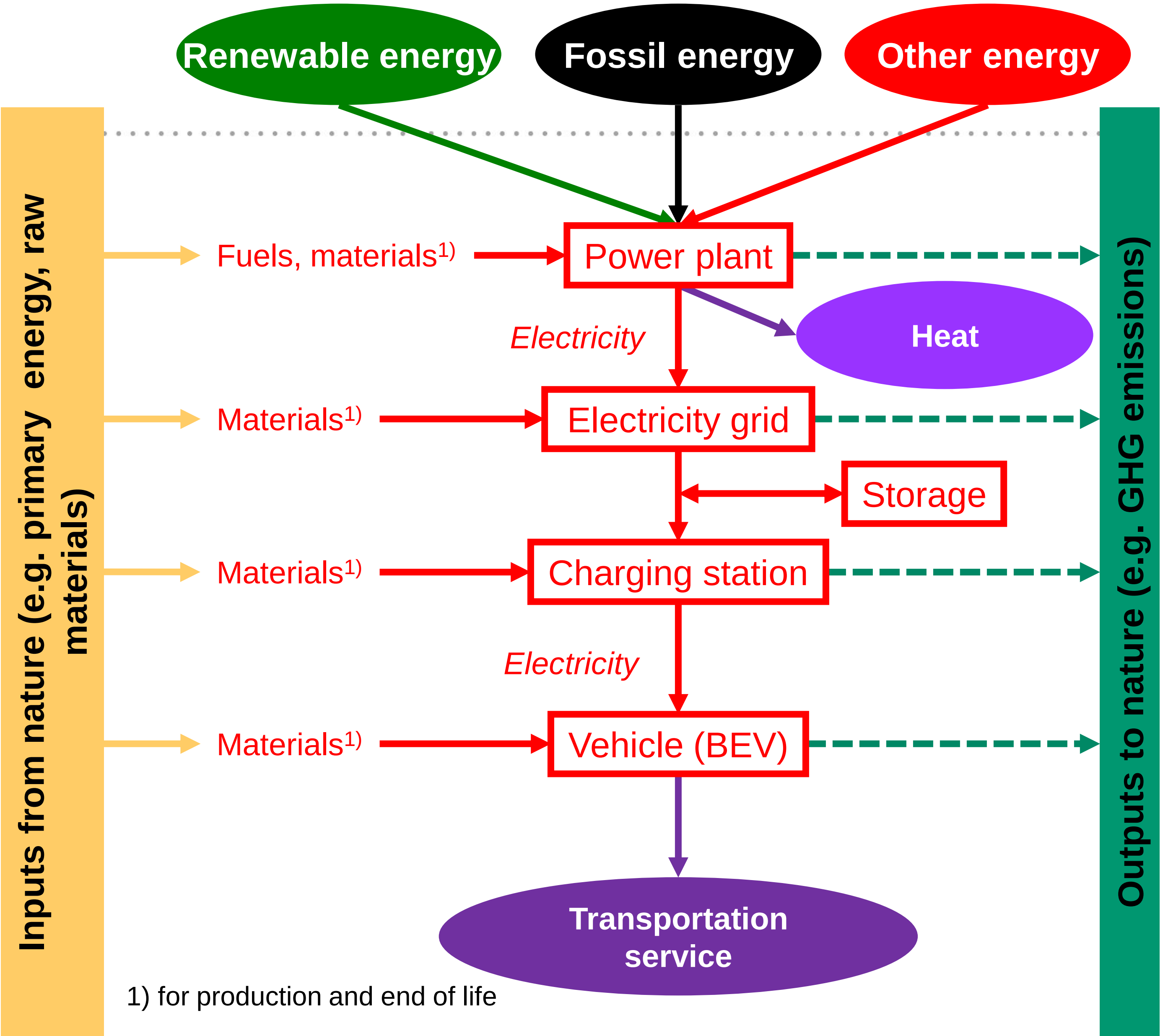
Circularity

Quellen: www.ipcc.ch, www.europarl.europa.eu/news/de

10 Lession Learnt on Environmental Assessmnet of Electric Vehicles

1. **Methodology** for Environmental Assessment: LCA not WtW
2. **System Boundary**
3. Systematic of **Transportation System Description**
4. **Main Factors** Influencing LCA Results
5. Possible **Impacts** and Impact Assessment Methodologies
6. **Minimum Requirement** on Impact Assessment
7. Main **Water Issues** in LCA of ICE and EV
8. Potential **Rebound Effects** of EVs
9. **Recommendations** for LCA of BEV, PHEV and ICE
10. Dynamic LCA and Vehicle Fleets for **Climate Neutrality 2050**

Lession Learnt #2&#3:

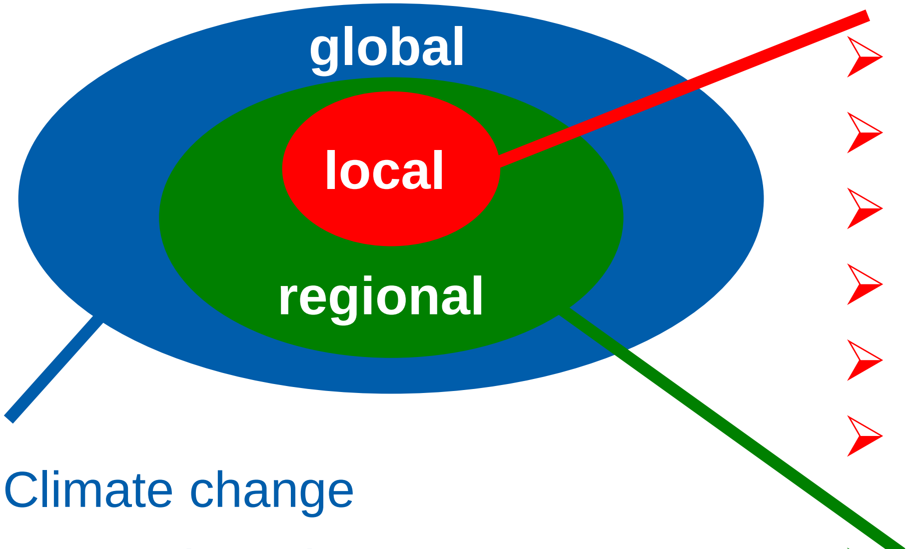


System Boundary and Description

Lession Learnt #4:
Main Factors Influencing LCA Results

- **Main differences** are in the Foreground Data
  - Source of electricity generation and its future development up to 2030/2050
  - Lifetime mileage
  - Energy consumption of vehicle (incl. heating, cooling and electric share for PHEV)
  - Battery
    - production: country, production capacity, source of electricity
    - end of life (material recycling or reuse in 2^{nd} life)
    - battery capacity
- **LCA Comparisons** of different studies better on relative differences (% based on petrol = 100%) than on absolute values (per km)

Lession Learnt #5: Possible Impacts



- Human toxicity: cancer, non-cancer
- Particulate matter
- Land use
- Water scarcity
- Biodiversity
- Ecotoxicity, fresh water & marine aquatic, terrestrial

- Climate change
- Ozone depletion
- Primary energy use (consumption) (fossil and renewable)
- Resource use, minerals and metals
- Water footprint (based on inventory level method)
- Land use (focus on inventory data)

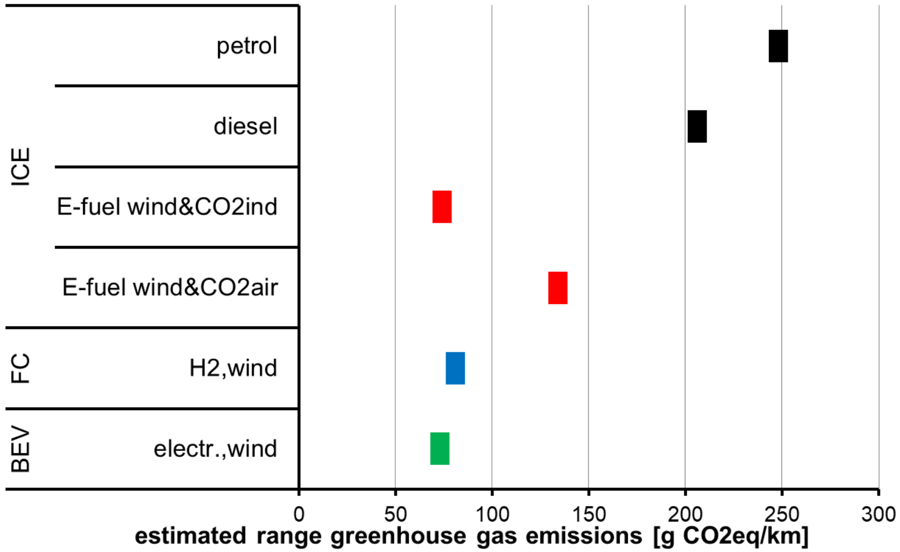
- Acidification
- Photochemical ozone formation
- Smog formation
- Eutrophication, terrestrial
- Eutrophication, freshwater
- Eutrophication, marine
- Ionising radiation

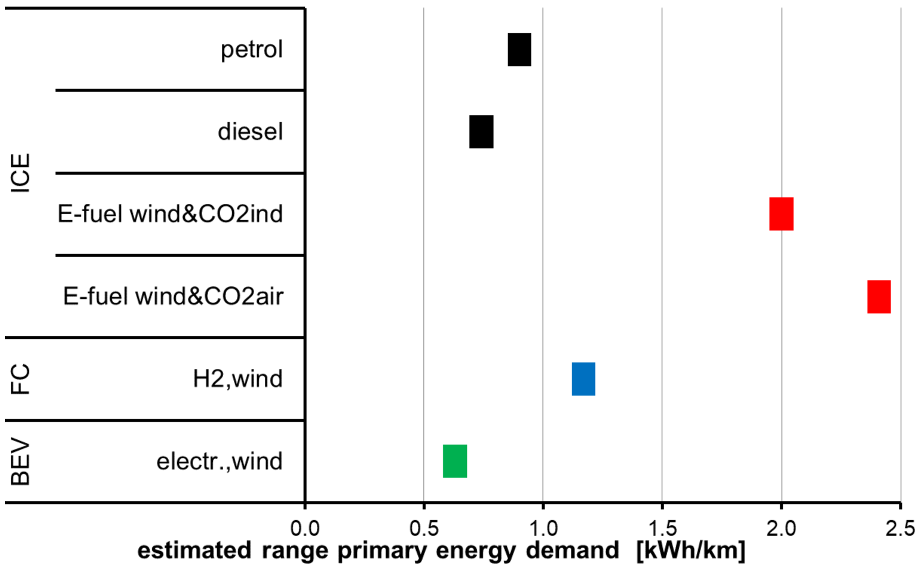
....

Lession Learnt #6: Minimum Requirement on Impact Assessment

GHG emissions and Primary energy demand

Example:
Using Wind Energy for H_2-FCV, E-fuel and BEV passenger vehicle

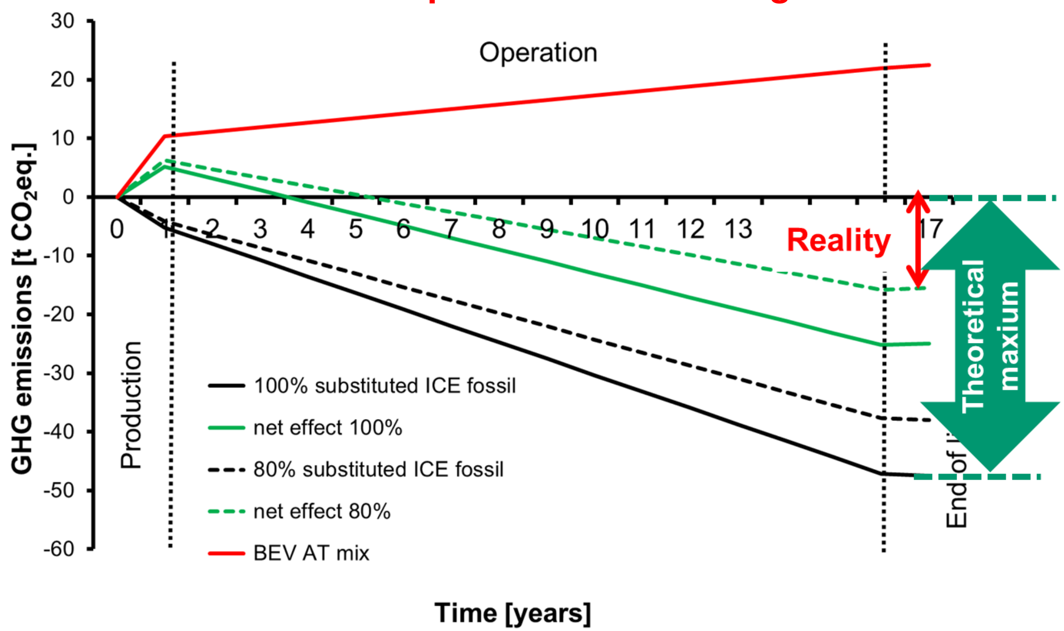




Leasson learnt #8: Potential Rebound Effects of EVs

- **Energy costs** for electricity lower compared to fossil fuels (because of taxation)
  - Direct rebound effect: drive more because of lower energy cost
  - Indirect rebound effect: consume more because money is saved
- Higher investment costs might lead to more driving to be more economic
- **EVs are seen to be „ green“**
  - Germany: EVs drive 2 – 3 times more than average ICE
  - Austria: EVs drive 30% more than average ICEs
  - Use EV instead of walking, biking and public transport
- EVs become **2nd or 3rd car** in household

Example: BEV subsituting ICE



Lession Learnt #9: Recommendations for LCA of BEV, PHEV and ICE

- **Main global impact categories**
  - Climate change
  - Primary energy use (fossil and renewable)
  - Resource use minerals and metals
  - Water footprint (inventory level)
  - Land use (inventory level)
- **Documentation & communication**
  - Total
  - Production
    - vehicle
    - energy/battery storage
  - Operation
    - fuel/energy supply
    - fuel use
    - maintenance
  - End of life
    - recycling and/or reuse
    - substitution of secondary material

cover and address aspects of

- **"Climate Neutrality"**
- **"Circularity"**

Aims of IEA Task 46

Analyse, Discuss and Document the **Environmental Impacts** based on **Life Cycle Assessment**

- of electric (UNECE class)
  - Buses (M)
  - Trucks (N)
  - Two-wheelers (L) and
  - Other vehicles e.g. mining, agriculture, train
- in comparison to
  - Conventional fuels e.g. diesel, petrol, natural gas
  - Renewable hydrogen and
  - E-fuels made from CO_2 and renewable electricity

IEA HEV Task 46 Partners

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  - **TCP AMF**
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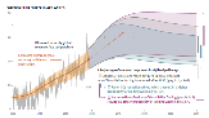
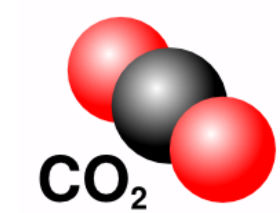
  - **Simone Ehrenberger**, DLR (vice)

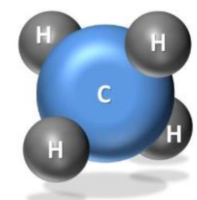
Task manager and Austrian participation financed by

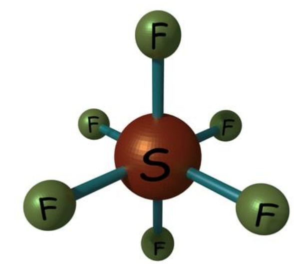


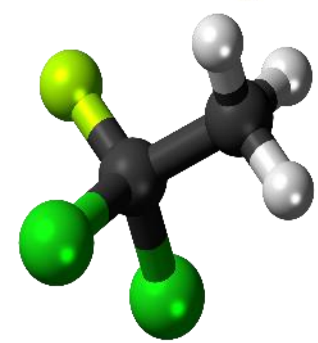
Climate Neutrality – An Initial Definition

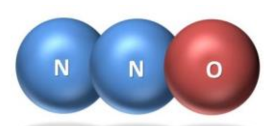
- Climate Neutrality = human activities cause **no changes** of global temperature
- Achieving such a state would require balancing of residual emissions with emission (carbon dioxide) removal as well as accounting for regional or local biogeophysical effects of human activities that, for example, affect surface albedo or local climate (IPPC)
- Products/services are „**climate neutral**“, if in the total life cycle **no GHG emissions** (CO_2, CH_4, N_2O, SF_6, FCKW, etc.) occur
- „**CO_2-neutral**“ only covers CO_2 emissions
- „**Net zero**“: the remaining/unavoidable GHG emissions **are compensated permanently**, e.g. CO_2-fixation and CO_2-storage by CCS and/or CCU
- the **timing** of the GHG emissions is essential and must be considered







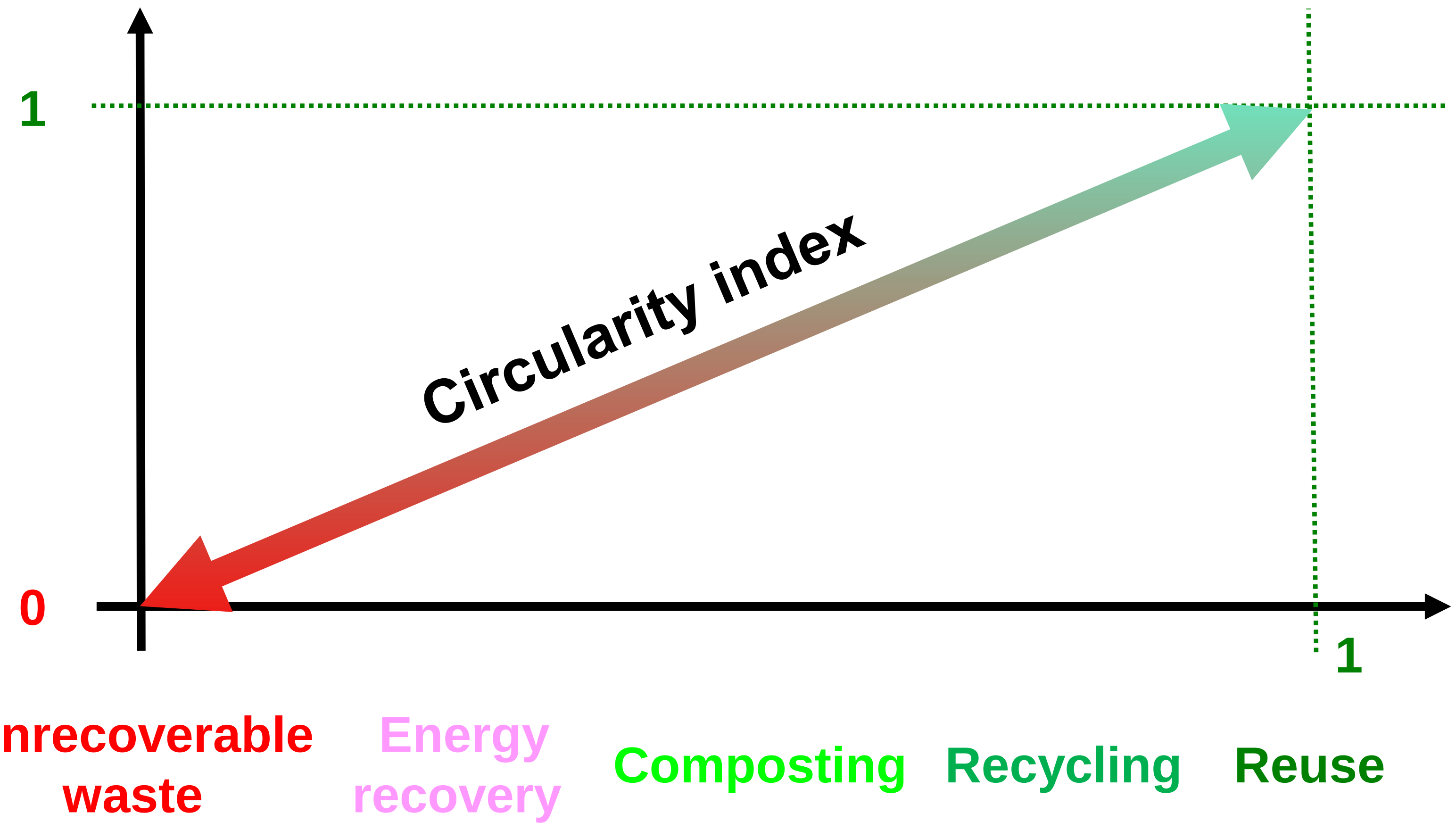




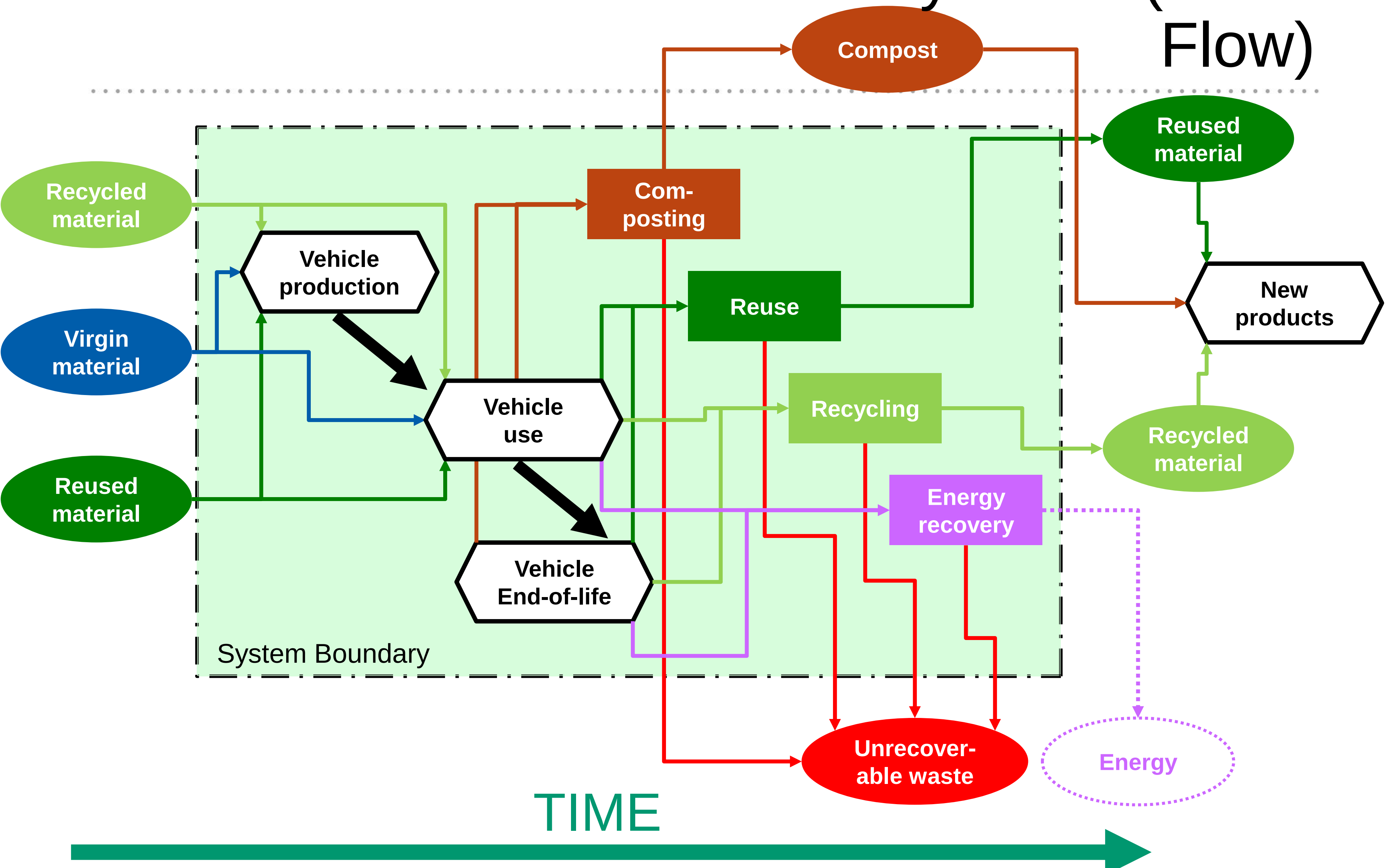
Circularity - An Initial Definition

- Relevance on circularity
  - Lifetime and durability
  - Exchange and/or Reparability of parts
  - Reuse of parts
  - Recycling of materials to
    - Same quality as primary material ($Q_{in} = Q_{out}$ at point of subsitution)
    - Lower quality as primary material ($Q_{out}/Q_{in} < 1$)
  - Composting of biological degradable materials
  - Energy recovery of heating value of materials
    - to power, heat or fuels (quality of energy: $exergy_{out}/exergy_{in}$)
  - Losses and disposal/landfill
- Circularity based on LCI: reuse + recycling + composting + energy recovery ≤ 100%
- Circularity Index (based on Ellen MacArthur Foundation 2015)

Circularity Index for EoL

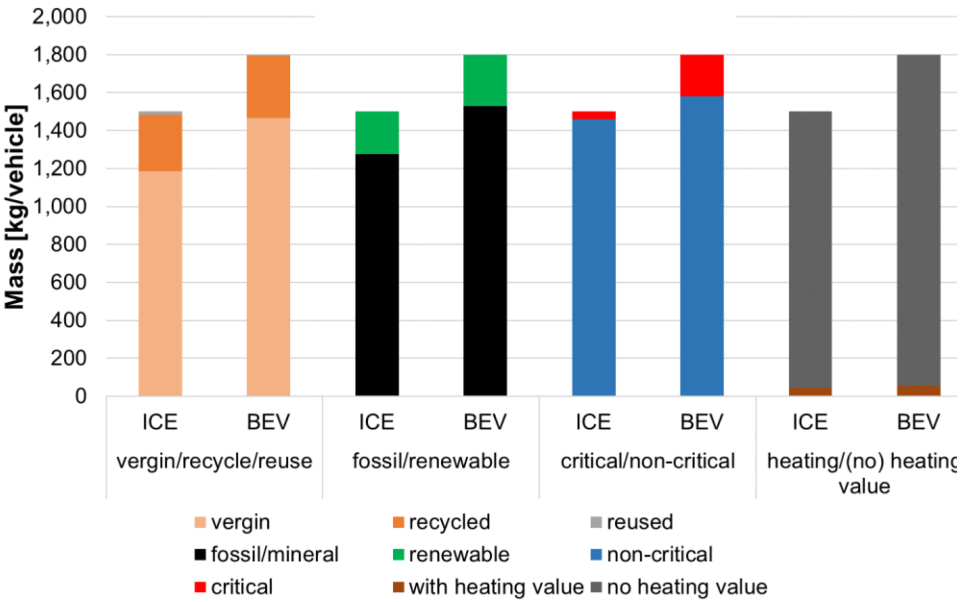


Vehicle Material Circularity Index (Mass Flow)

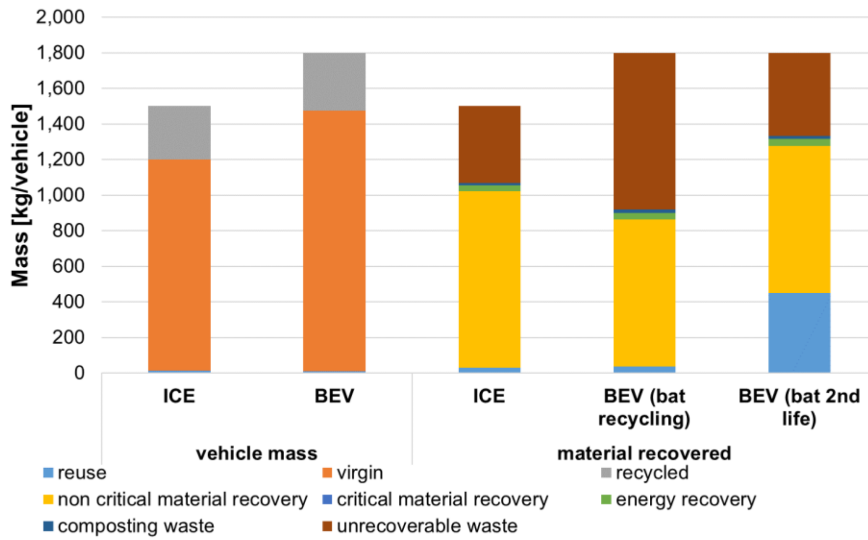


Necessary Inventory Data for Assessing Circularity

Vehicle „Production“



Vehicle „End of life“



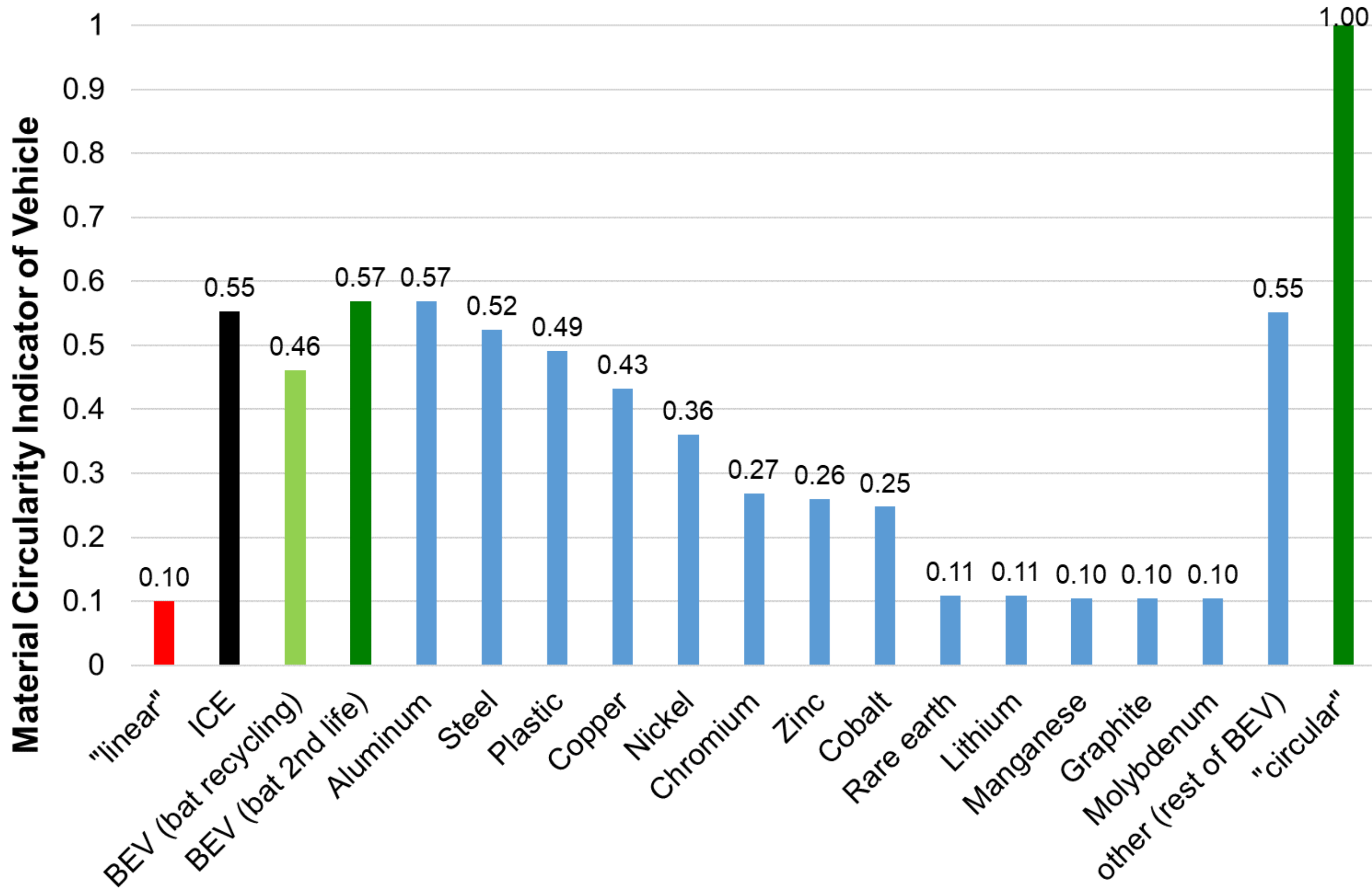
„Critical“ materials from IEA report

- Copper
- Lithium
- Nickel
- Manganese
- Cobalt
- Graphite
- Chromium
- Molybdenum
- Zinc
- Silicon
- Rare earth
- others

„Rare Earth“:

- Ce: Cerium
- Pr: Praseodymium
- Nd: Neodymium
- Pm: Promethium
- Sm: Samarium
- Eu: Europium
- Gd; Gadolinium
- Tb: Terbium
- Dy: Dysprosium
- Ho: Holmium
- Er: Erbium
- Tm: Thulium
- Yb: Ytterbium
- Lu: Lutetium

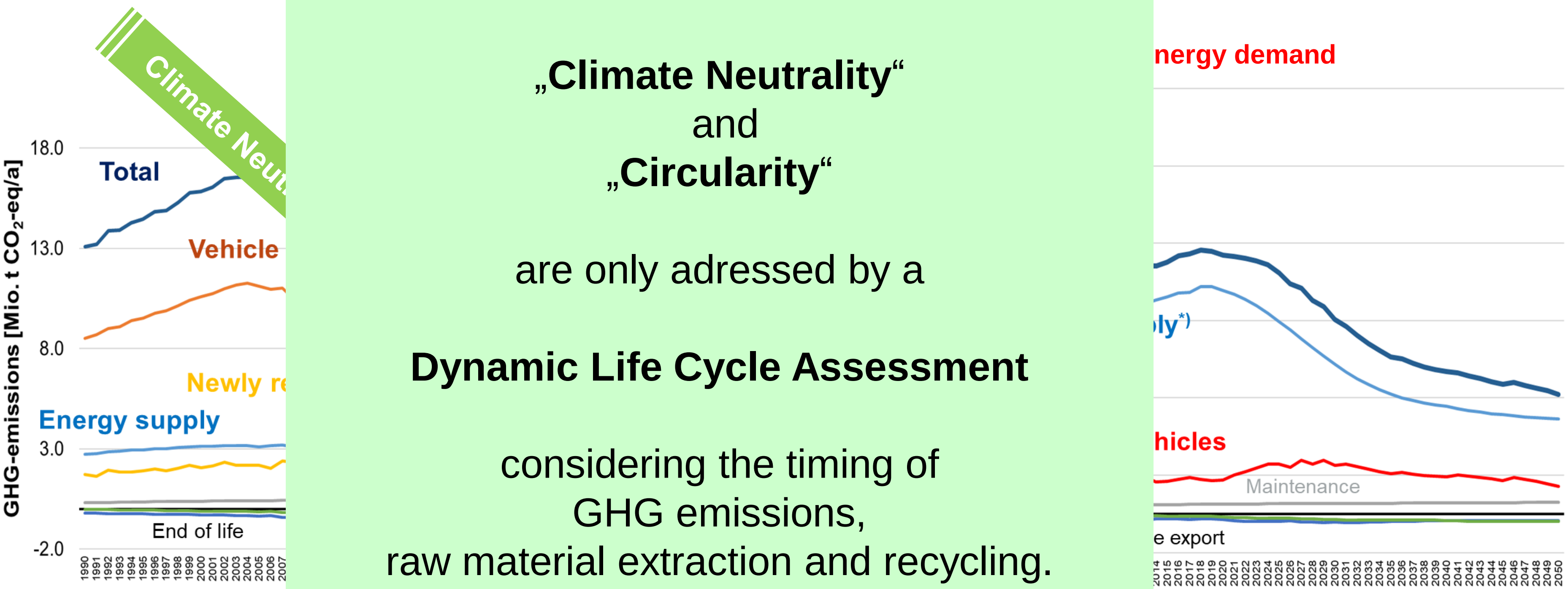
Material Circularity Indicator: Vehicle



Based on calculation of „Circularity Indicators“ of Ellen MacArthur Foundation 2015

Leasson learnt #9: Dynamic LCA and Vehicle Fleets for Climate Neutrality 2050

Example Austria: Passenger Vehicle Fleet



„Climate Neutrality“
and
„Circularity“

are only adressed by a

Dynamic Life Cycle Assessment

considering the timing of
GHG emissions,
raw material extraction and recycling.

*) incl. energy for vehicle operation

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