43rd LCA Discussion Forum
LIFE CYCLE ASSESSMENT OF ELECTROMOBILITY
ANSWERS AND CHALLENGES

Electric vehicles in a future energy system context

April 6, 2011,
Zürich, ETH Central Building, Semper Aula

Dipl.-Phys. Udo Lambrecht
ifeu – Institut für Energie- und Umweltforschung Heidelberg GmbH

IFEU-Institute:

- Founded in 1978 by scientists from the University of Heidelberg
- Currently has a staff of about 50 persons with 40 scientists
- Main Topics: Environmental impacts of transport, energy supply, LCAs, Air pollution control, Environmental impact assessment, etc.

Expectations (from Gouverment/Politic) in Germany

Electric mobility is to contribute to climate protection targets

Consumption of renewable energy for electric vehicle should support overall introduction of renewable energy

Electric grid should become more efficient by use of modern information technology and integration of electric vehicles

Additional energy consumption from electric vehicles should be based on Renewable Energy. Primary using Renew. by Demand Side Management

3.5 Zielsetzu

Elektromobilität trägt zur Umsetzung der energie- un

1. Die Elektromobilität soll einen signifikanten Beitrag z le leisten.
2. Durch die Nutzung regenerativer Quellen zur Deckur rofahrzeugen soll gleichzeitig ein Beitrag zur Umsetz bare Energien und zur verbesserten Integration fluktu geleistet werden. Damit cherheit geleistet werd
3. Die Stromnetze in De gien und die Integratio
4. Der zusätzliche Bedar erneuerbaren Energie re Strom aus fluktuie ments durch Elektromobilität g Strombedarf für Elektromobili weitere Energien zu erschließen.

Energiekon BMWi/BMU – 28.9.2010

en die Abhängigkeit
rch die Kopplung der
rbaren Strom prak-
zeugen. Sowohl für
g) als für auch private
Erstkäufer liegt im Image als Nullemissions-
fahrzeug (EE-Strom) ein wichtiger Kaufanreiz.

Starkwindzeiten geladen werden.

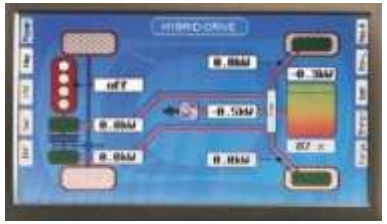
What can be the real contribution of electric vehicles?

Current IFEU projects on electric mobility (Selection)

Life cycle assessments accompanying various fleet tests:

Volkswagen Flottentest („Fleet Test Electric Mobility“)

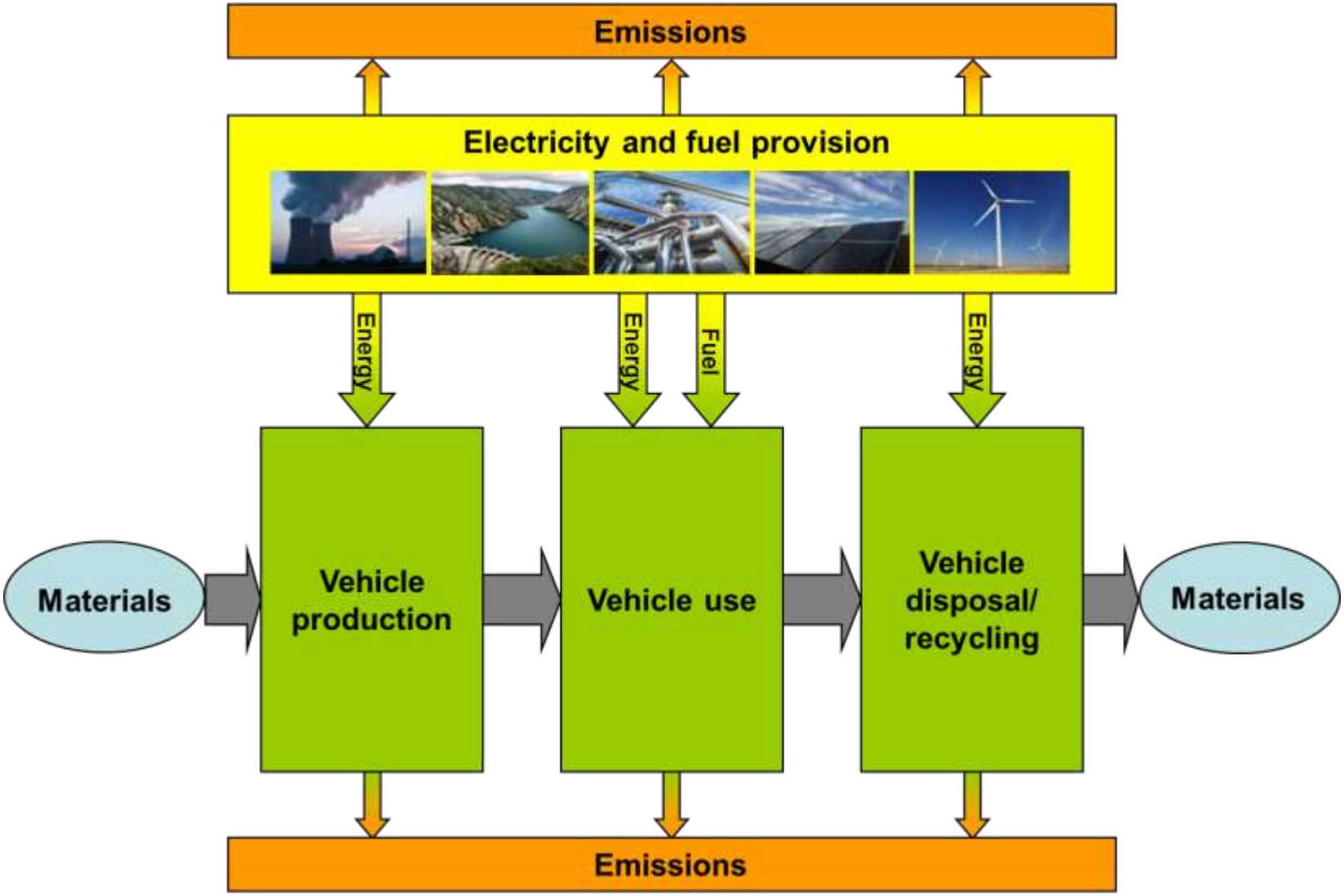
- ➢ Developing and testing of PHEV
- ➢ Accompanying research:
- Scenarios on development of car fleet
- Scenarios on development of power generation system
- Life cycle assessment of conventional and electric cars

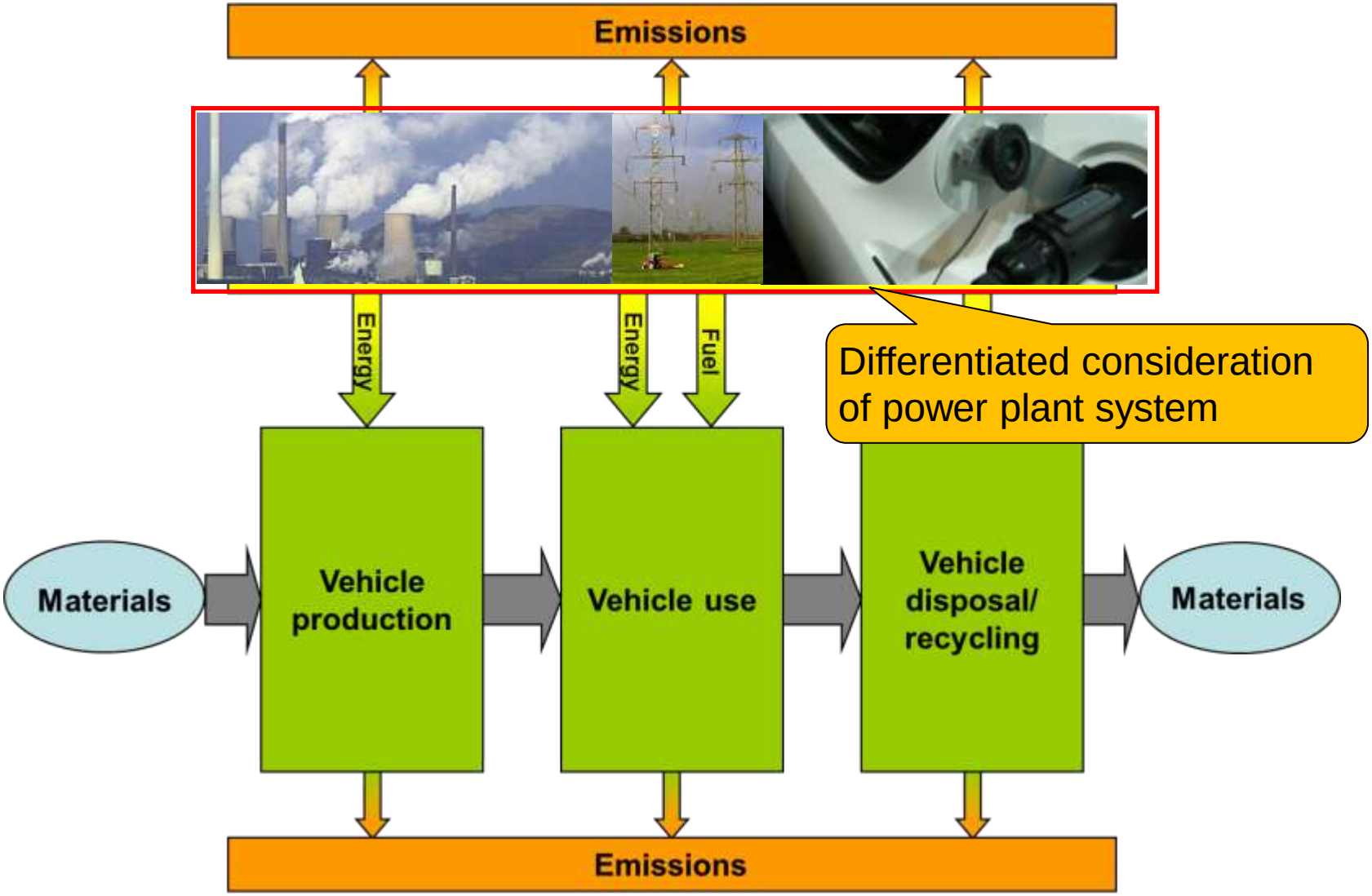


Research accompanying electric mobility projects as part of the German ‚Konjunkturprogramm 2‘:

- ➢ Collection of data and information relevant for LCAs
- ➢ Life cycle assessment of various forms of electric mobility
- ➢ Development of an LCA online tool

What is considered in the life cycle balance?




Emissions
Energy
Energy
Fuel
Differentiated consideration of power plant system
Materials
Vehicle production
Vehicle use
Vehicle disposal/ recycling
Materials
Emissions

Assumptions Vehicle Fleet + Scenarios

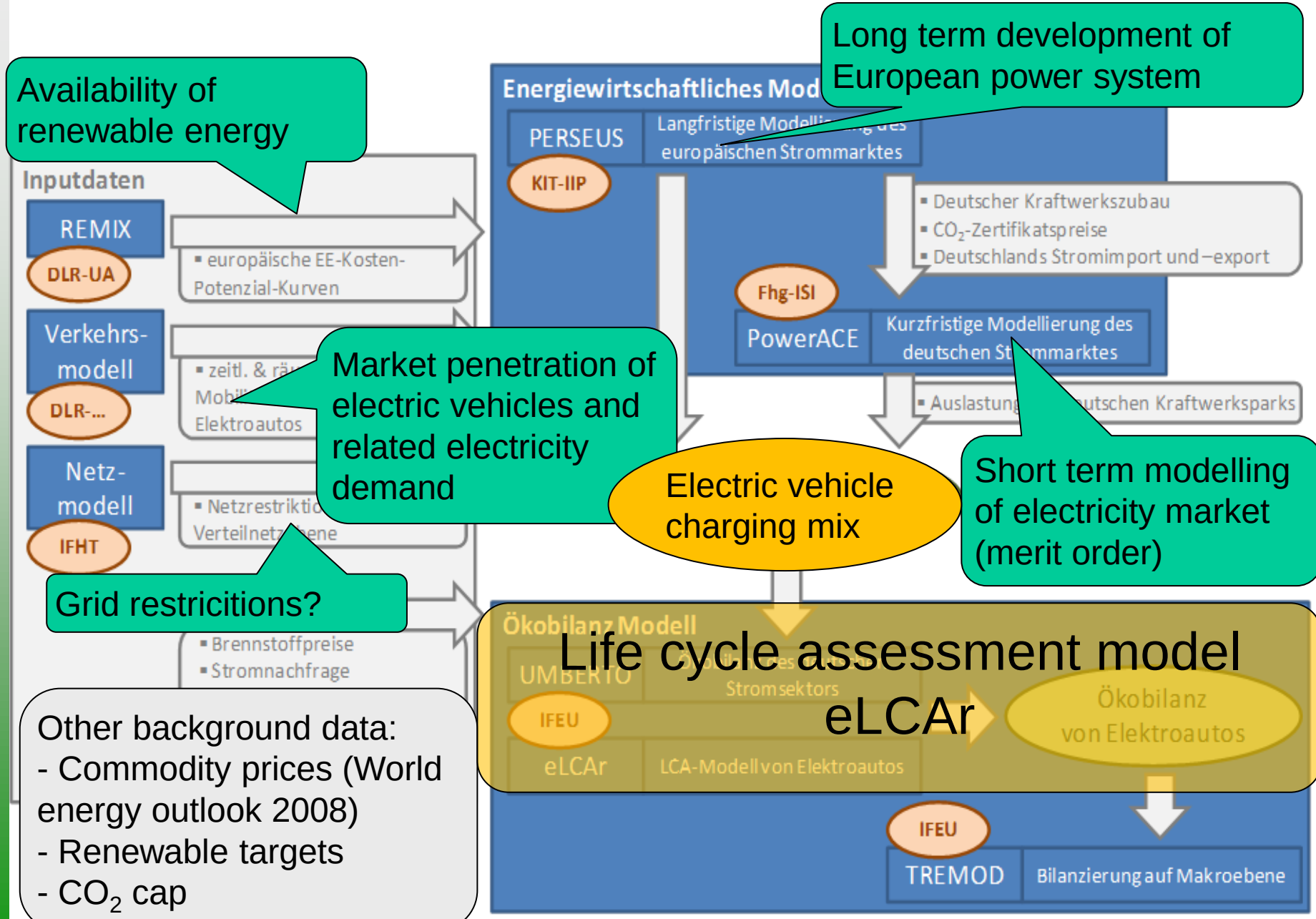
Assumptions Scenario Vehicle Fleet in 2030 in Germany:

- 12 million electric vehicles (ambitious scenario)
- Electricity demand in 2030: 18 TWh

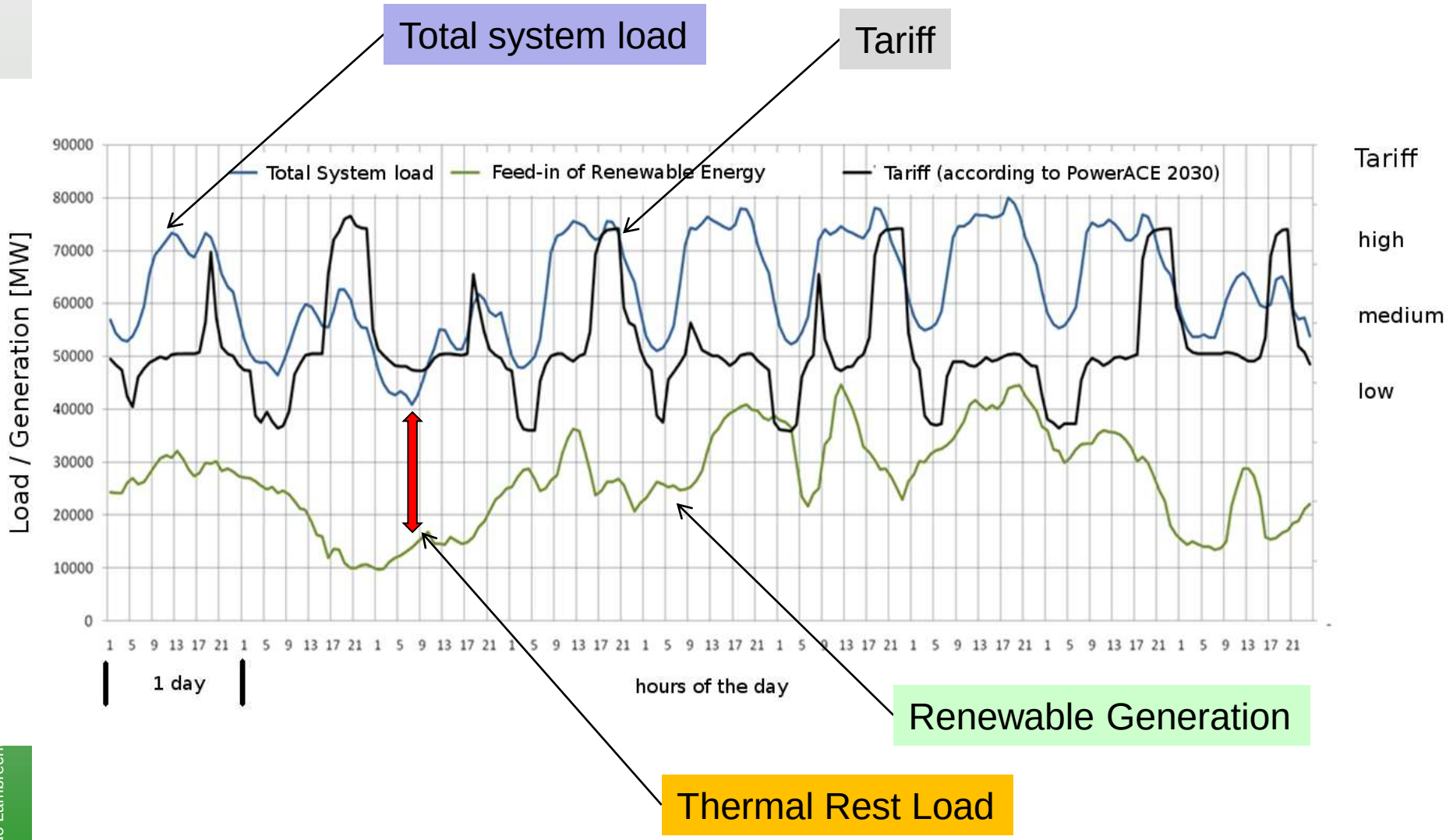
Considered scenarios:

- **„Plug and play“:**
  Vehicles are charged directly after their last daily trip
- **„Demand Side Management“:**
  Incentives based on energy exchange prices; this considers wind power and grid load => Charging is homogenized.
- **„DSM+RES“:** Additional renewable energy production capacity to meet demand of electric vehicles

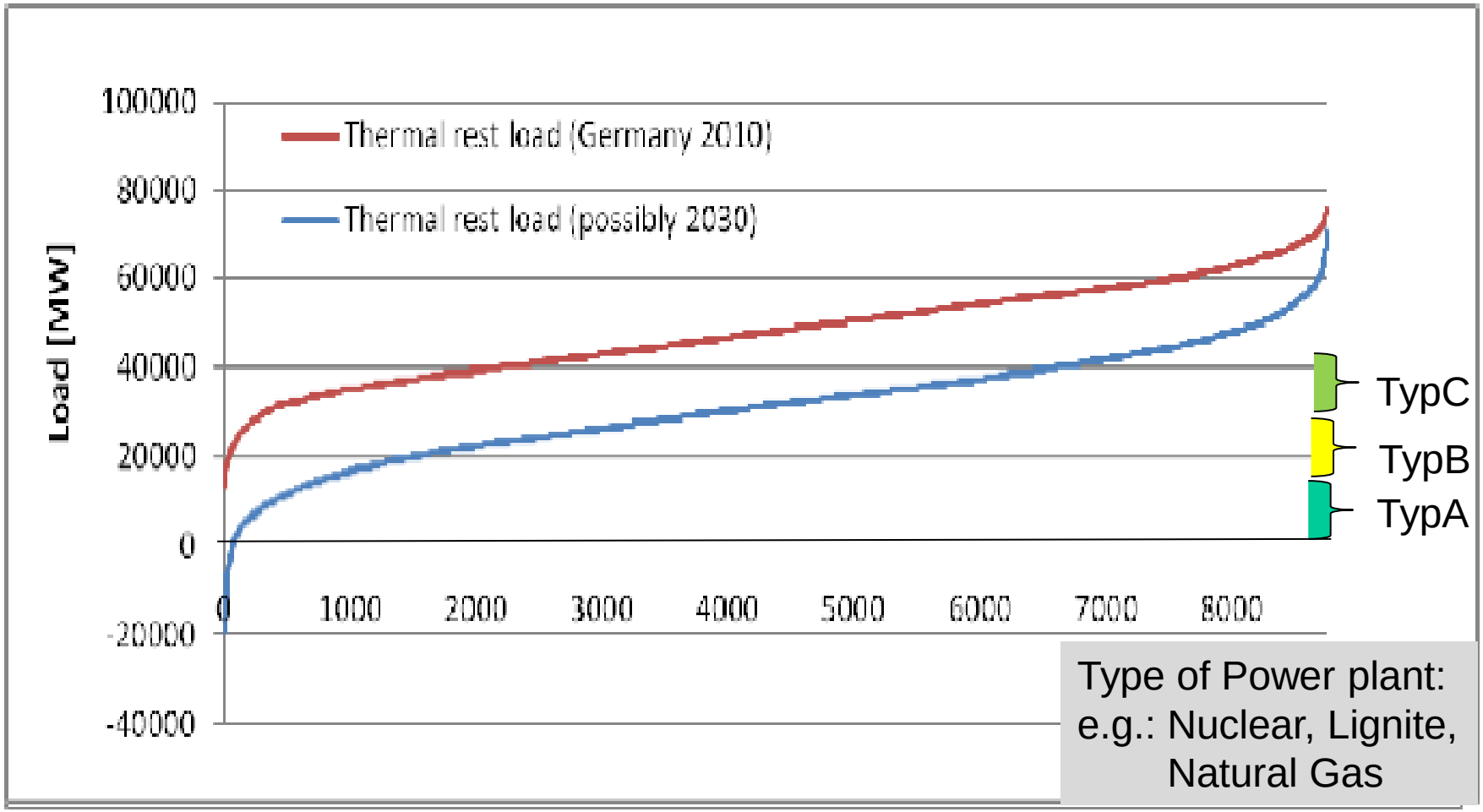
Electricity supply: Overview of models



Total Load, Feed-in of Renewable Energy, Tariff



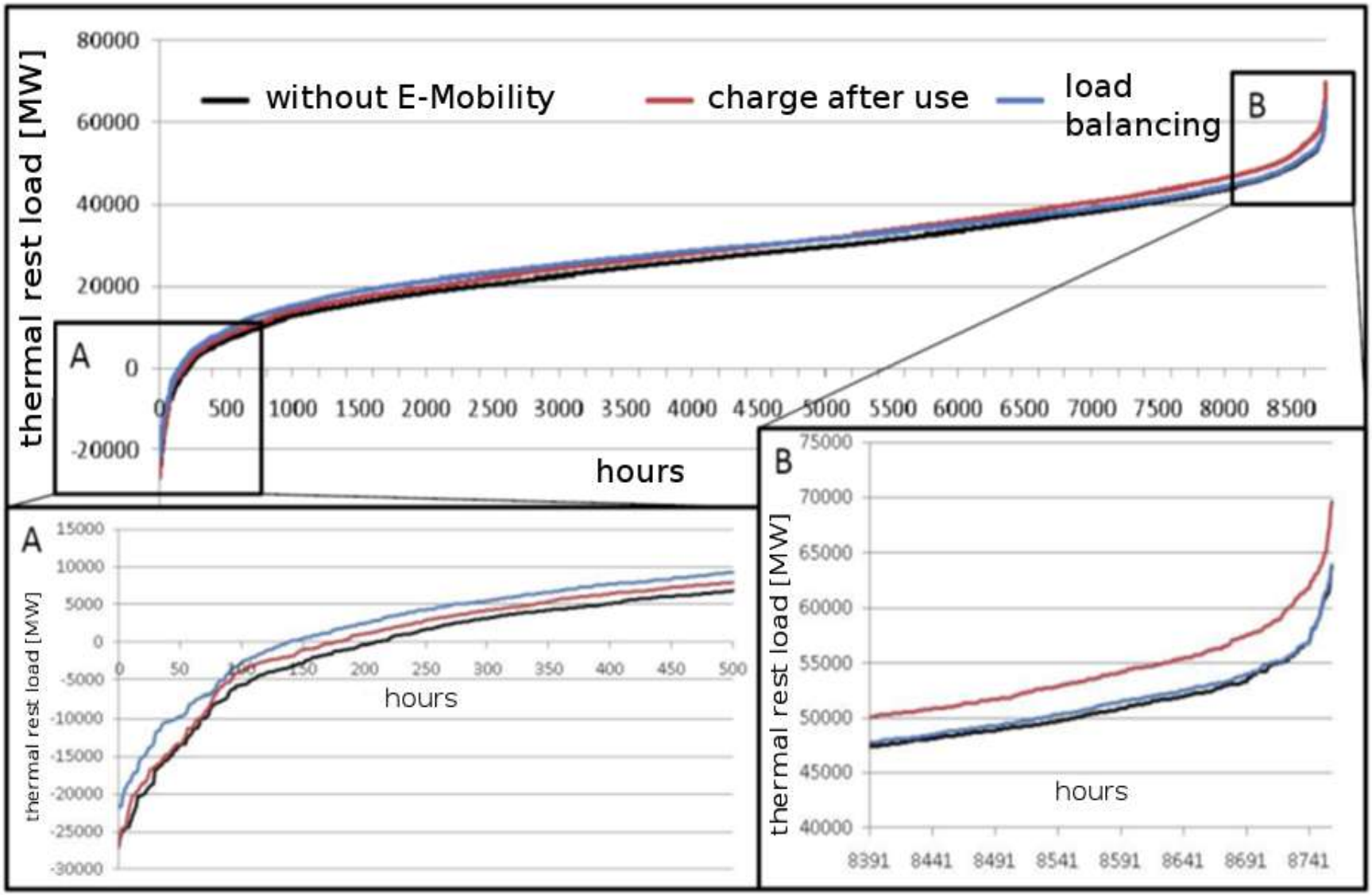
Thermal Rest Load (schematic)



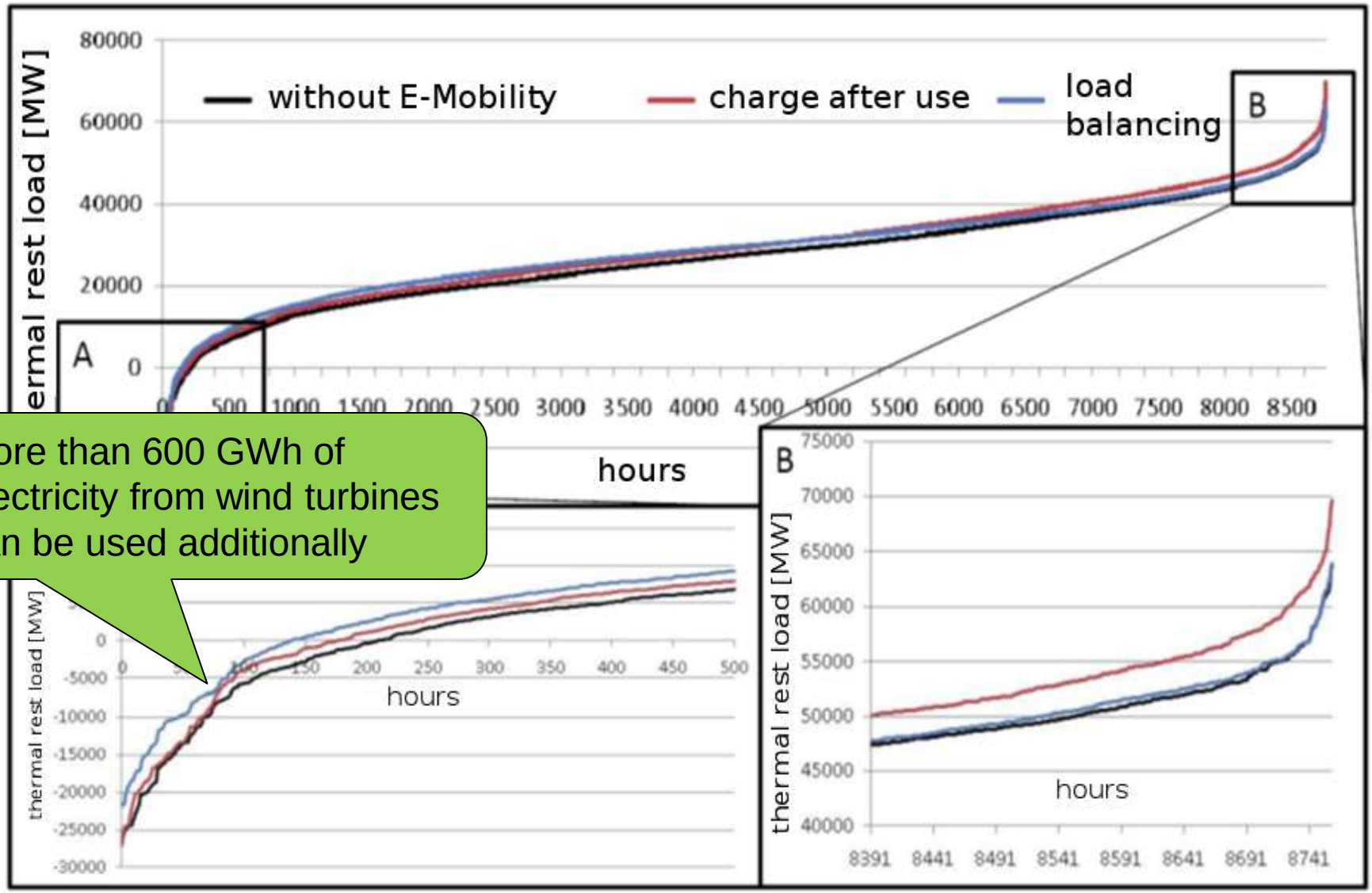
- Scenarios for 2030
- "Negative" thermal rest load: Renewable generation > System Load
- "Negative" thermal load could occur for 10 to 100 hours in the future

Source: ISI

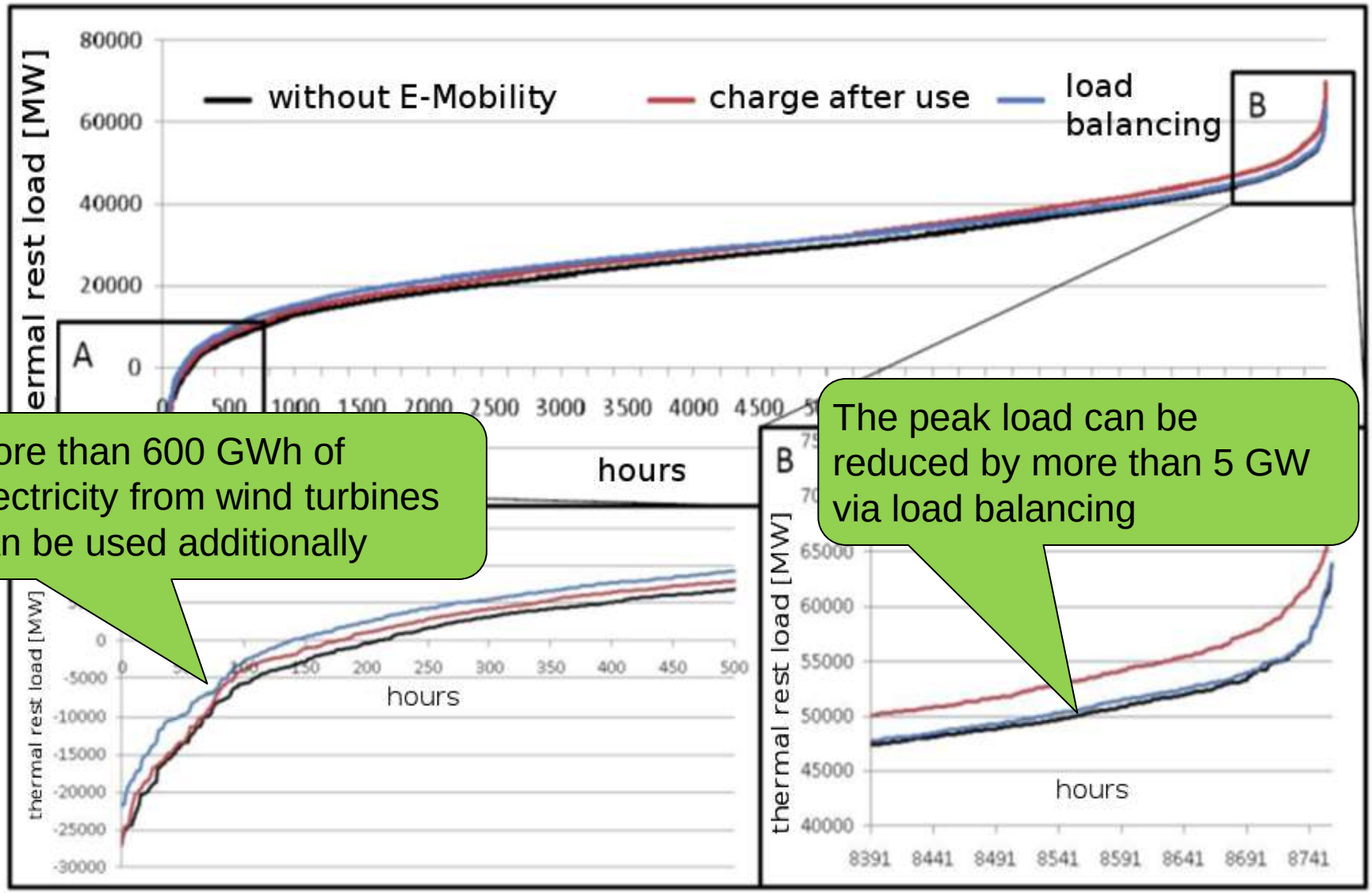
Thermal Rest Load – Model Results



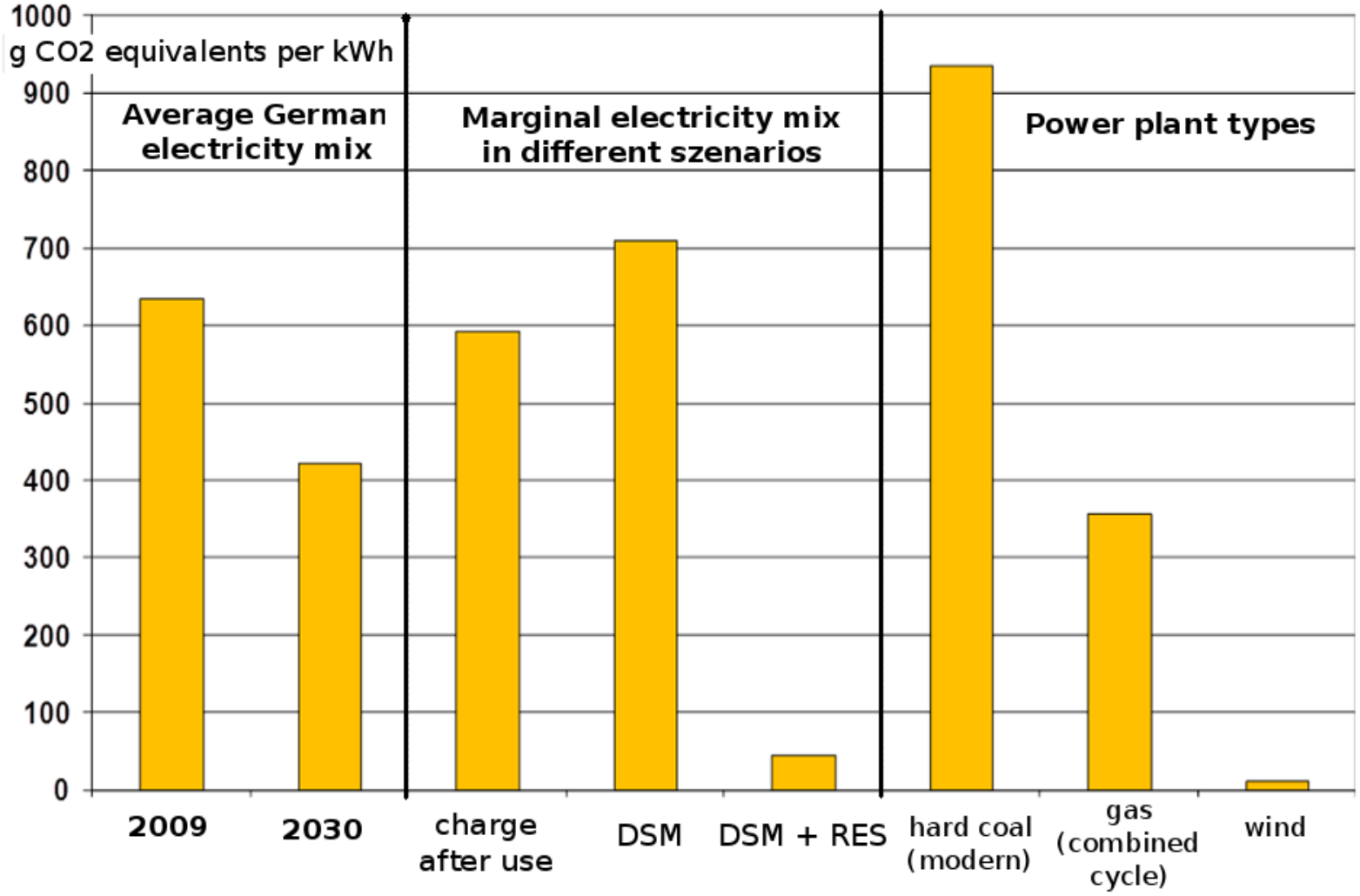
Thermal Rest Load – Model Results



Thermal Rest Load – Model Results



Electricity mix for elelectric cars

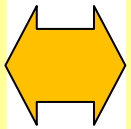


LCA electromobility - example

- Compact car (VW Golf type)
- Life-time mileage of 150’000km
- 30% urban, 40% extra urban and 30% highway driving
- Real world cycles including auxiliary consumers
- Geographical reference: Germany
- Represented timeframe: current (2010) and future (2030)

Electric vehicle:

- Electric engine
- 25kWh Li-Ion Battery
  (1.5 batteries (2010) and
  1 battery (2030) in life-time)
- **Electricity generation:**
  - average
  - marginal



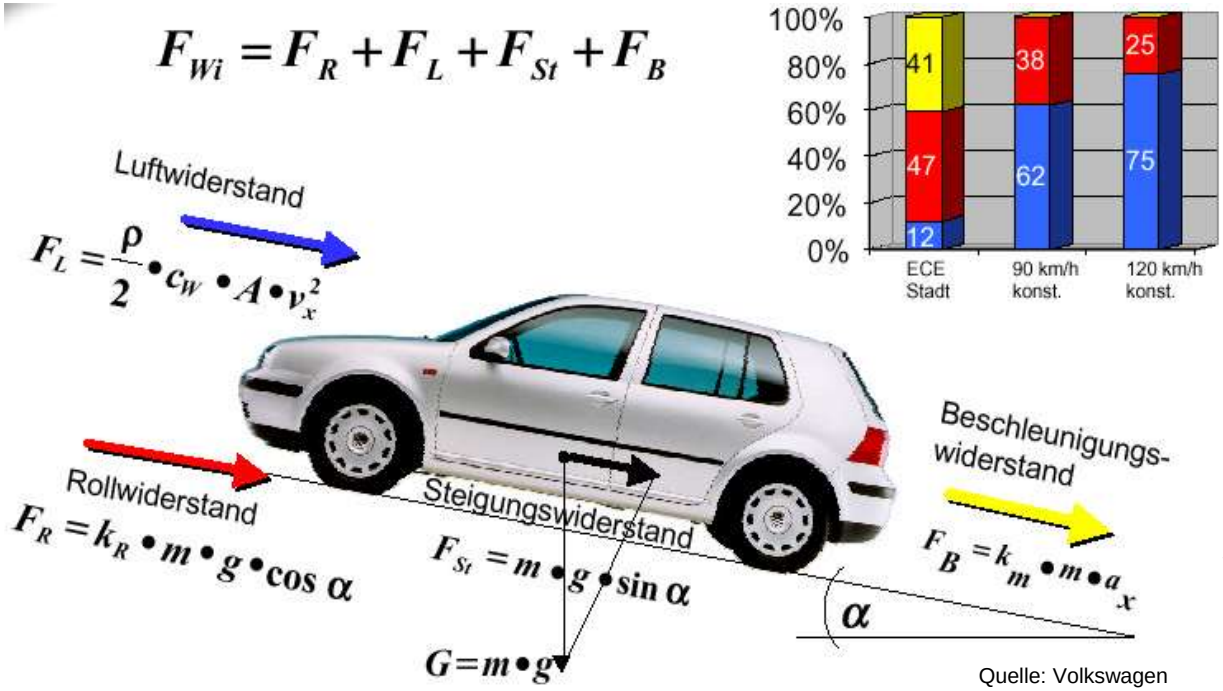
Combustion vehicle:

- Combustion engine
- Euro-6 emission standard

Modeling of vehicle energy consumption

Fuel (diesel, gasoline, ..), electricity..

Energy consumption



Quelle: Volkswagen

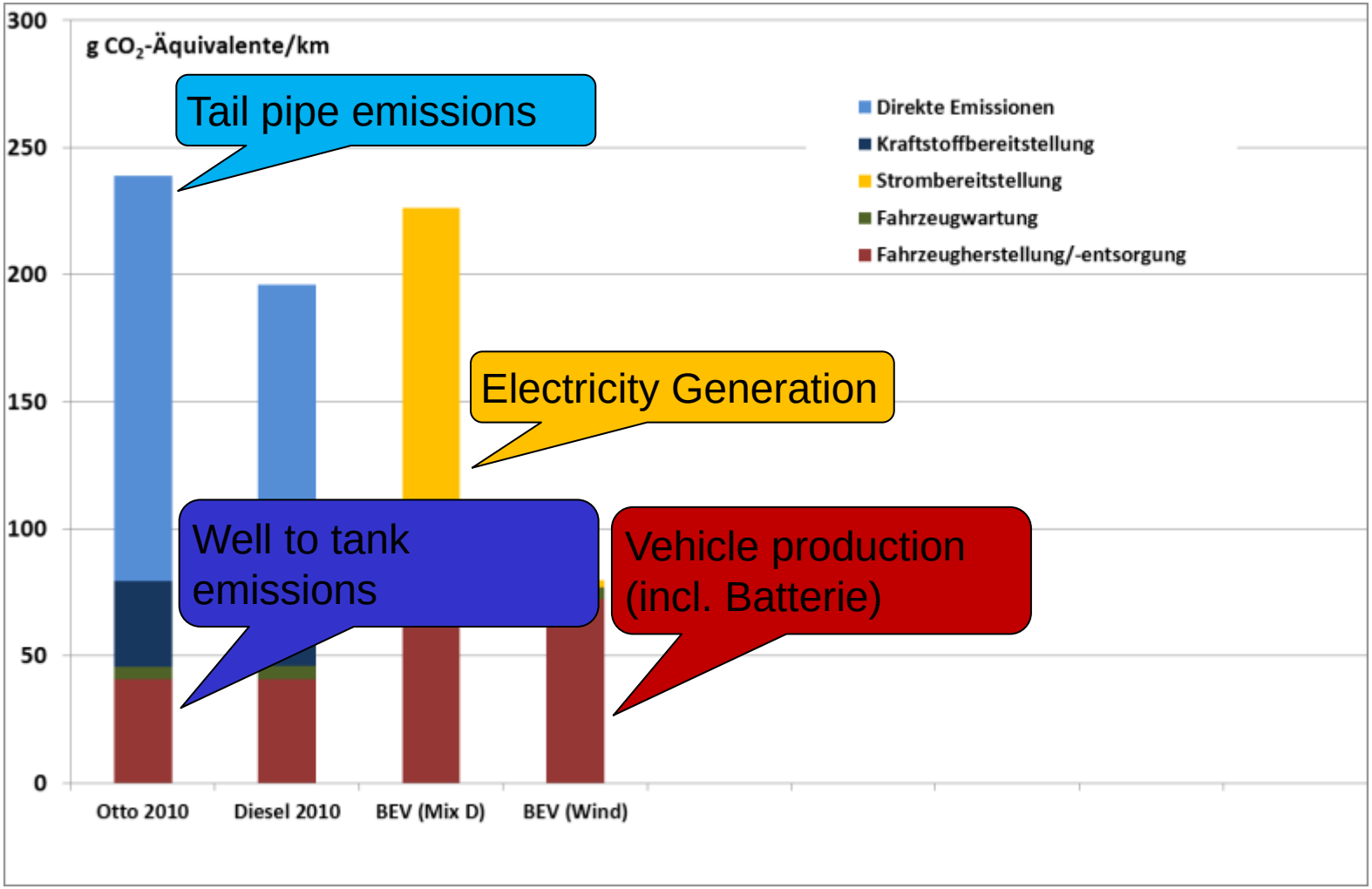
Auxiliary consumers, e.g. air conditioning

Efficiencies:
- Engine
- Battery, etc.

Driving behavior, road profile, vehicle characteristics...

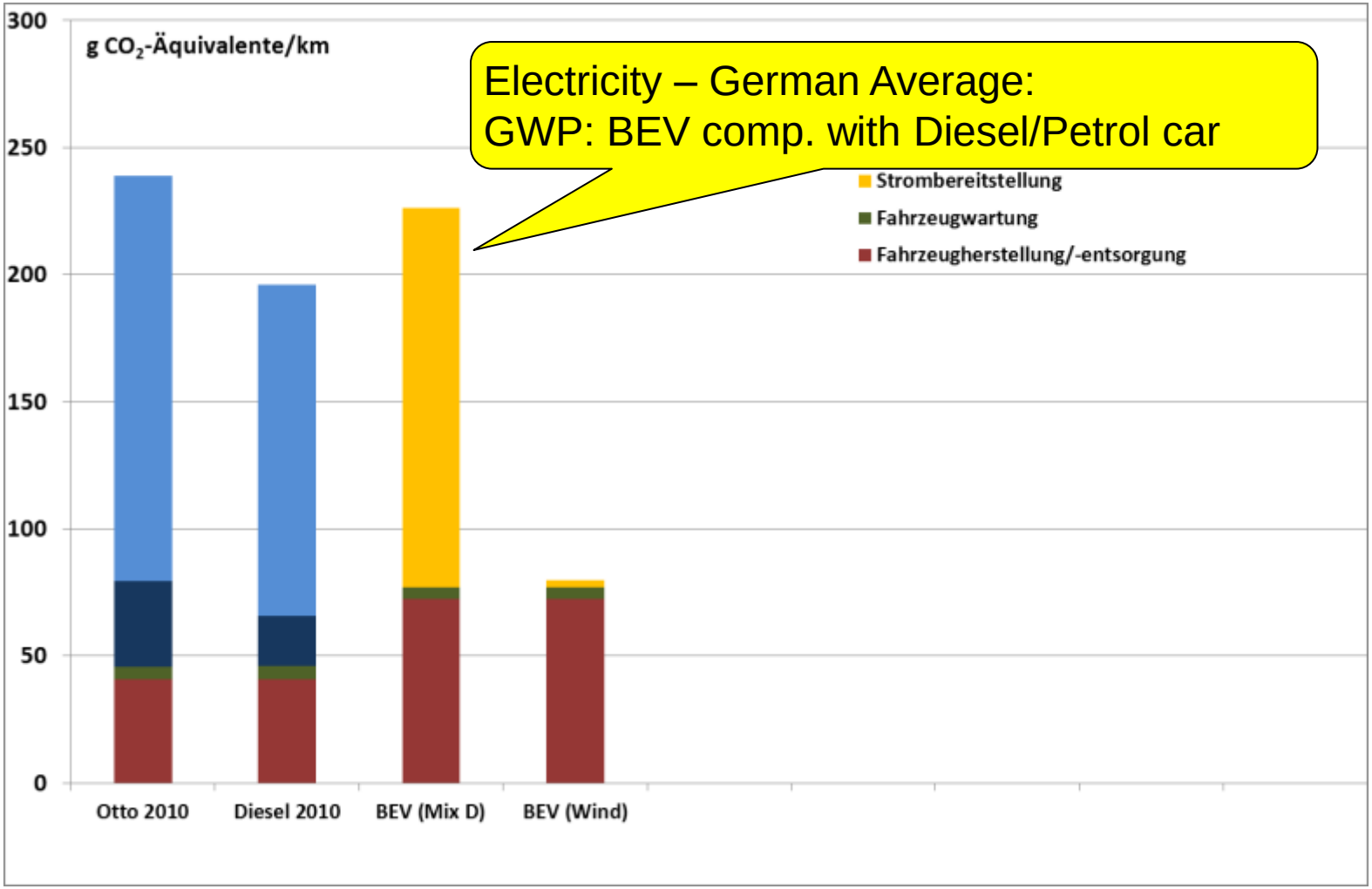
„Real world cycles“

GHG emission - life time mileage 150.000 km



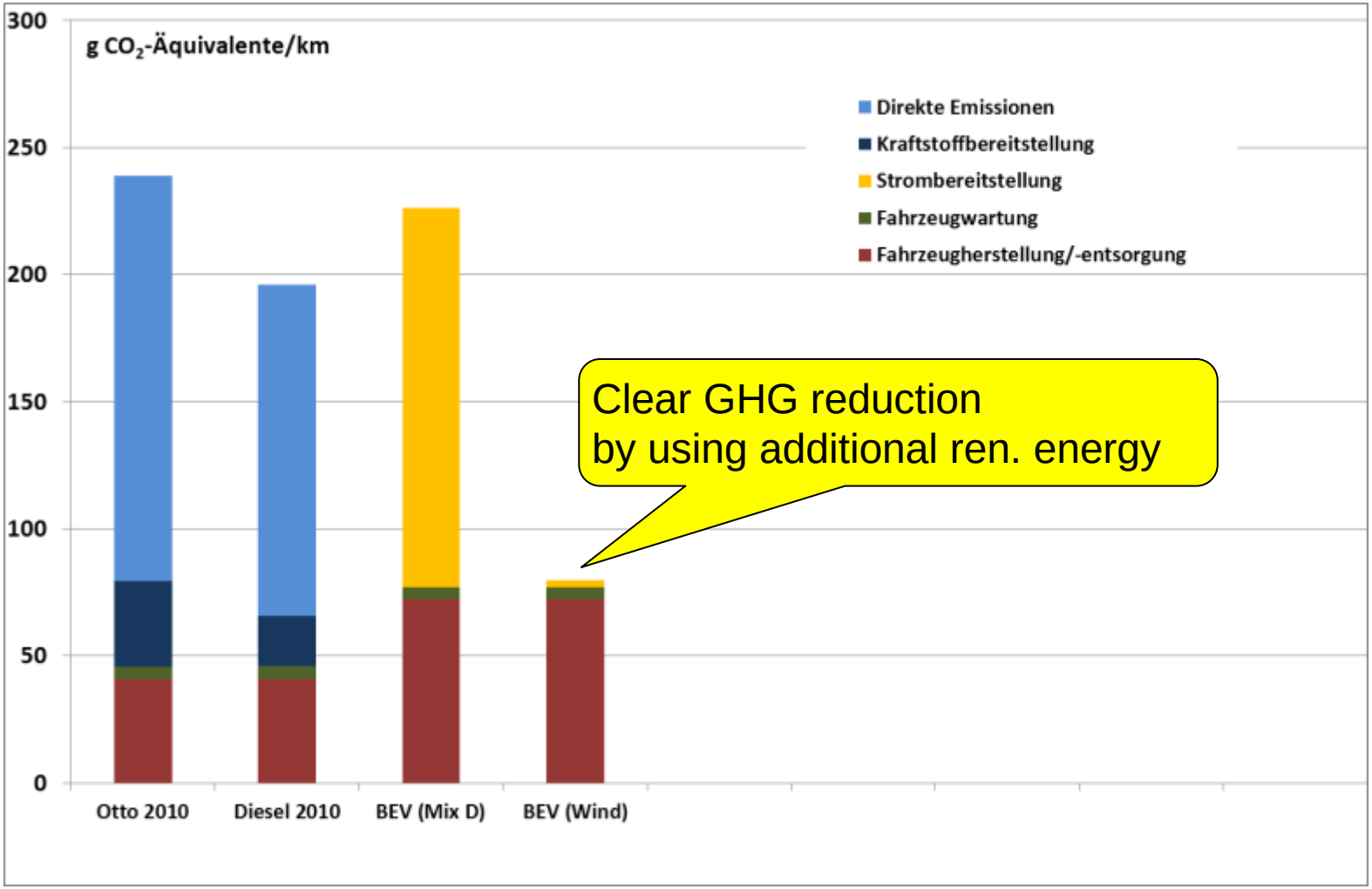
2010

GHG emission - life time mileage 150.000 km



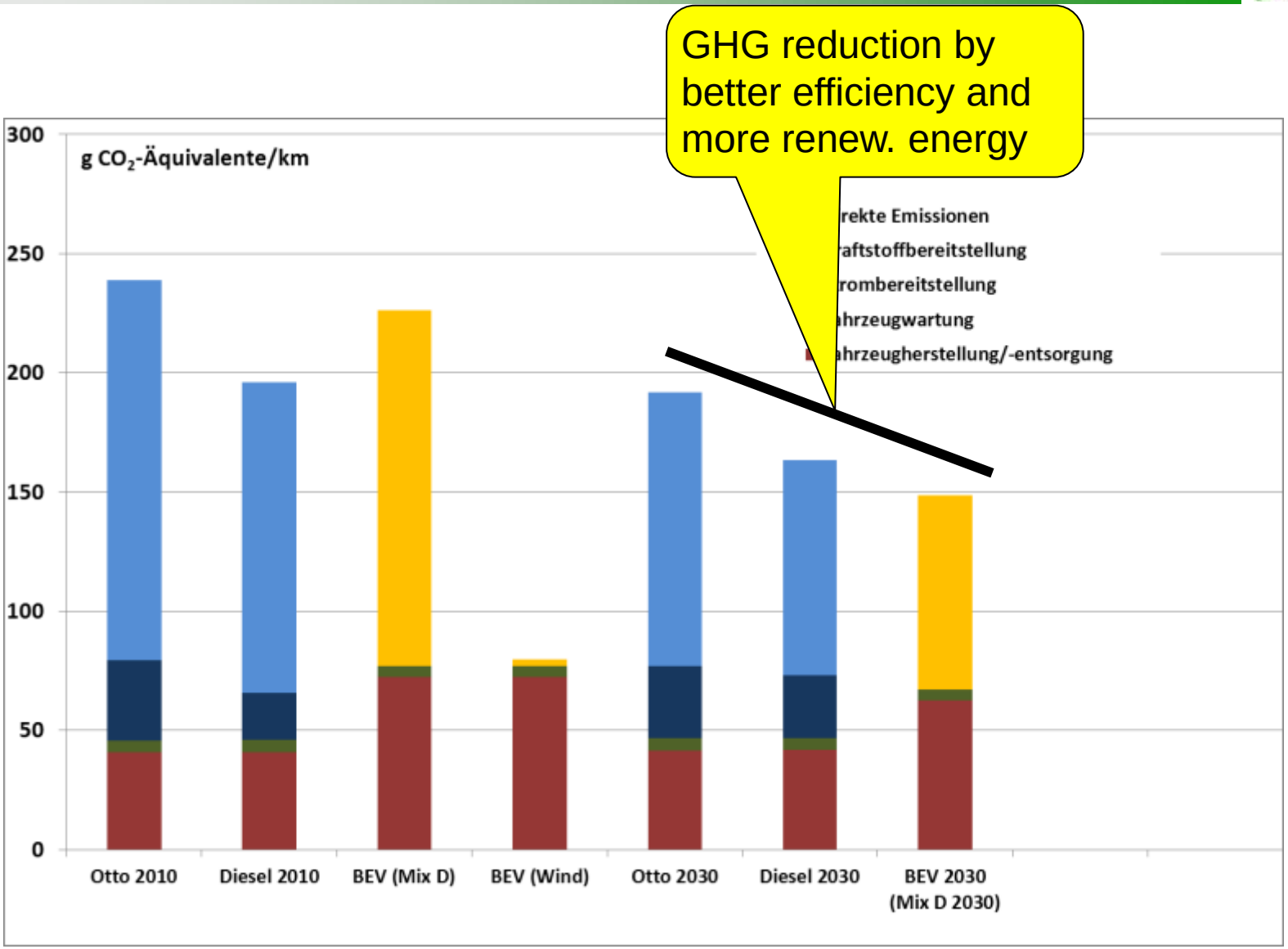
2010

GHG emission - life time mileage 150.000 km

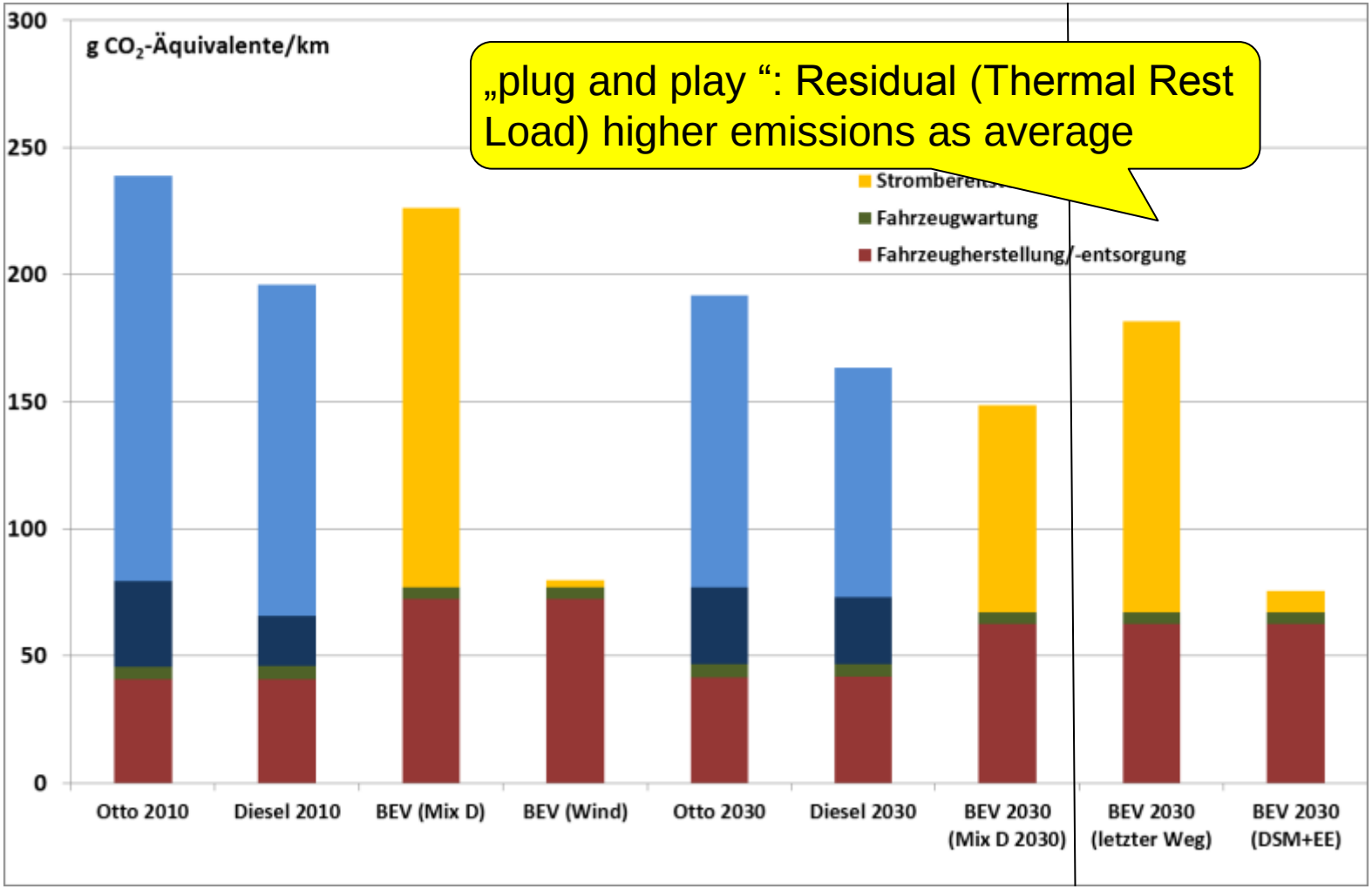


2010

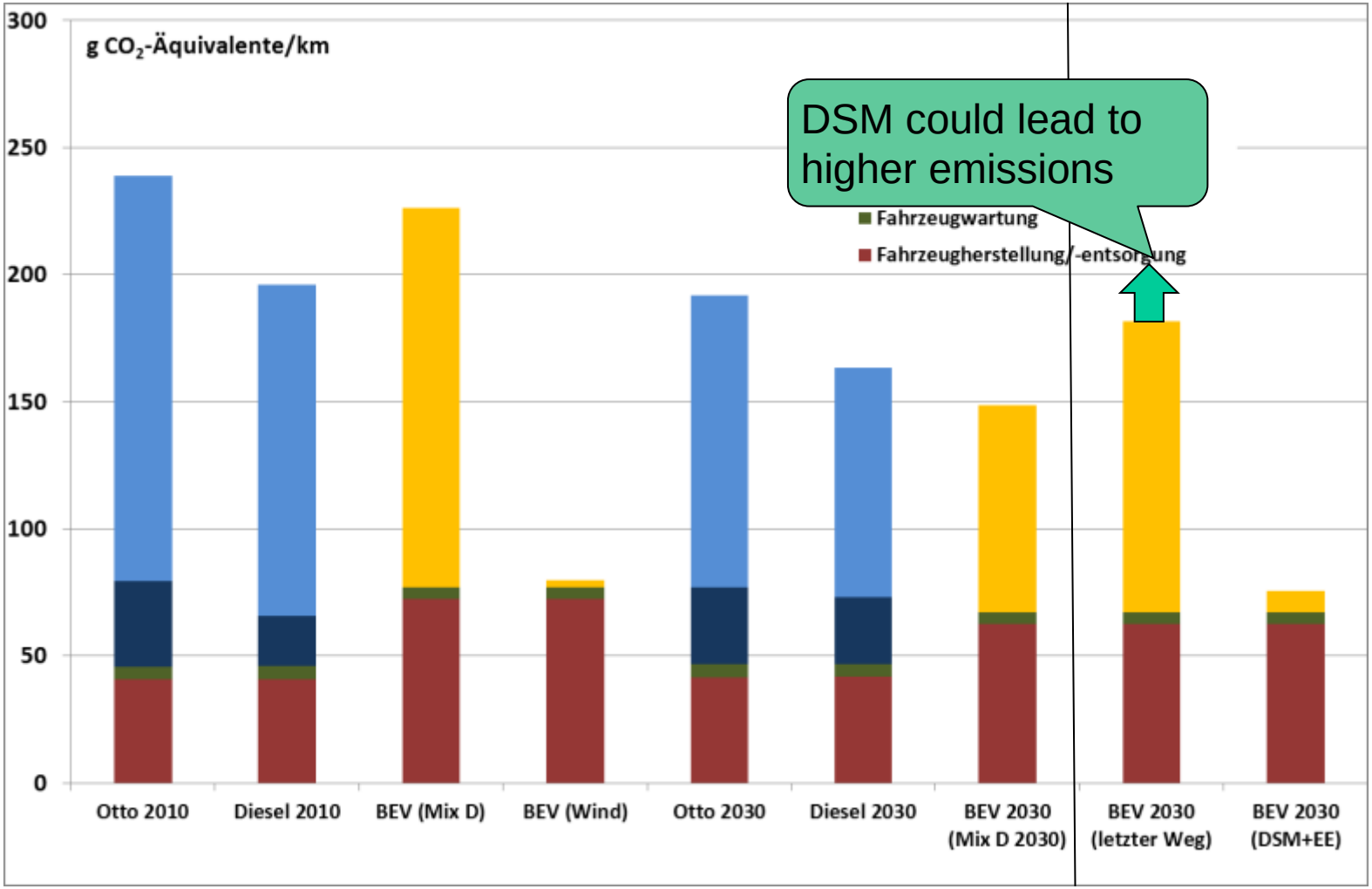
GHG emission - life time mileage 150.000 km



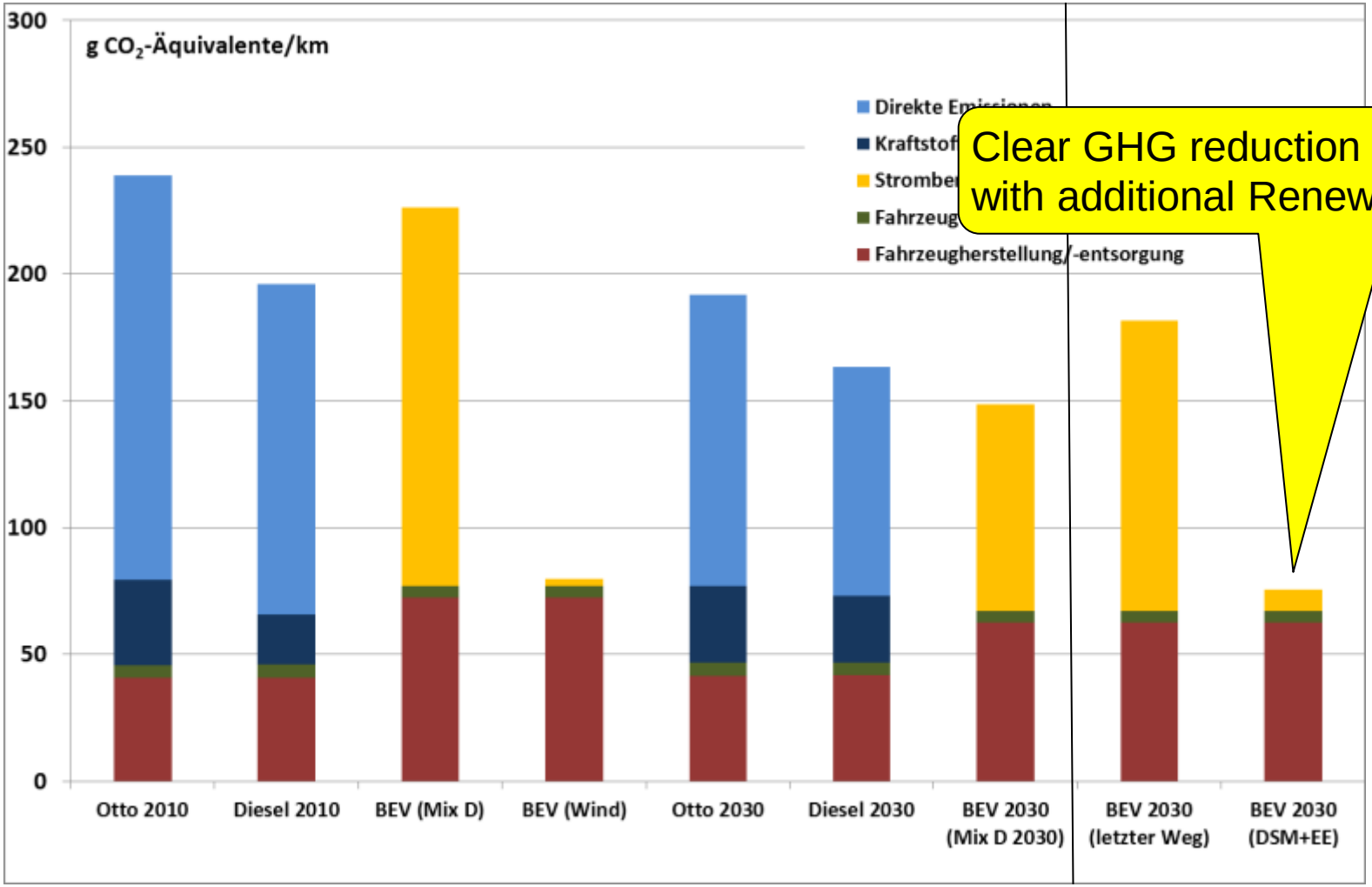
GHG emission - life time mileage 150.000 km



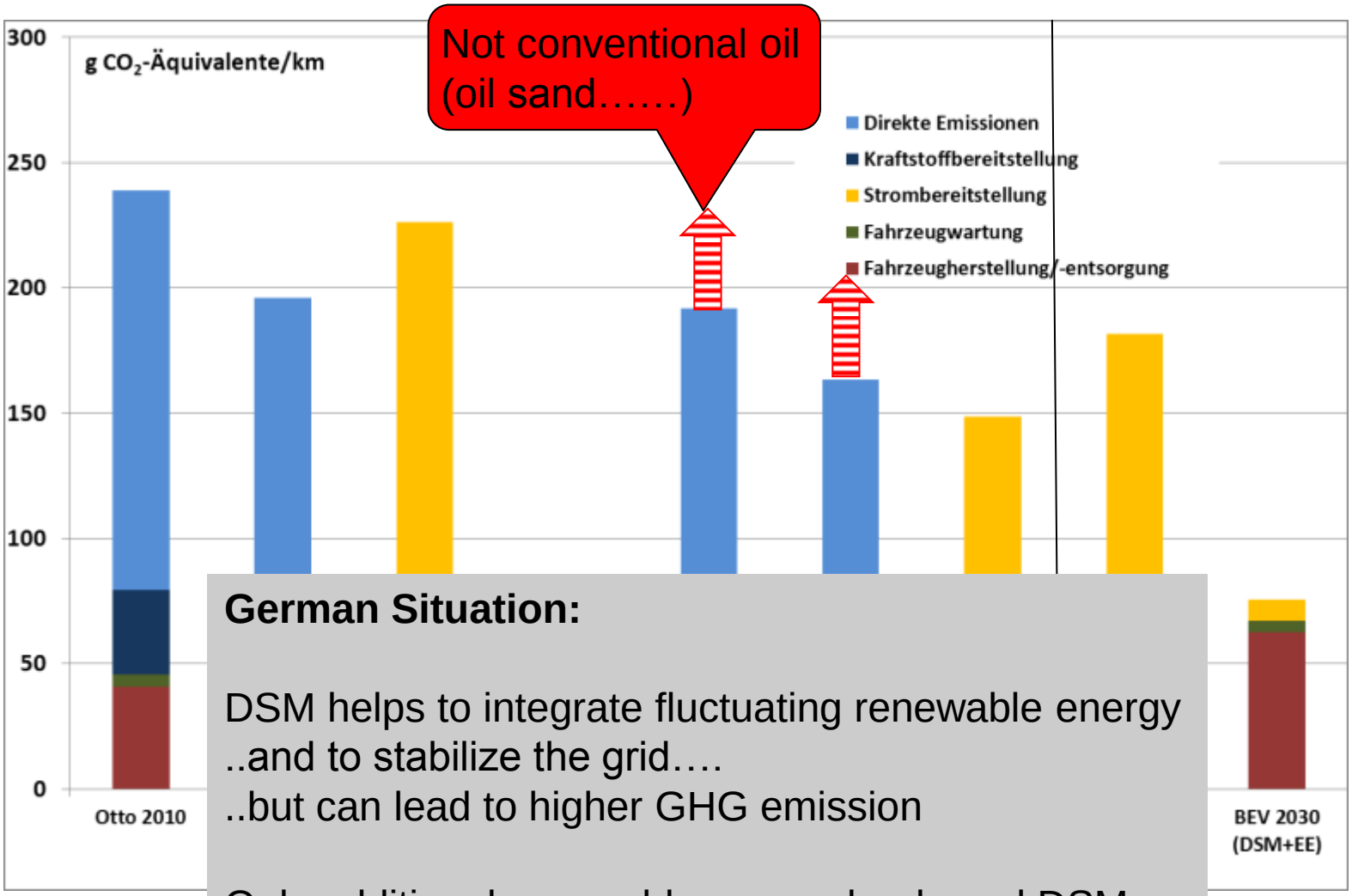
GHG emission - life time mileage 150.000 km



GHG emission - life time mileage 150.000 km



GHG emission - life time mileage 150.000 km



German Situation:

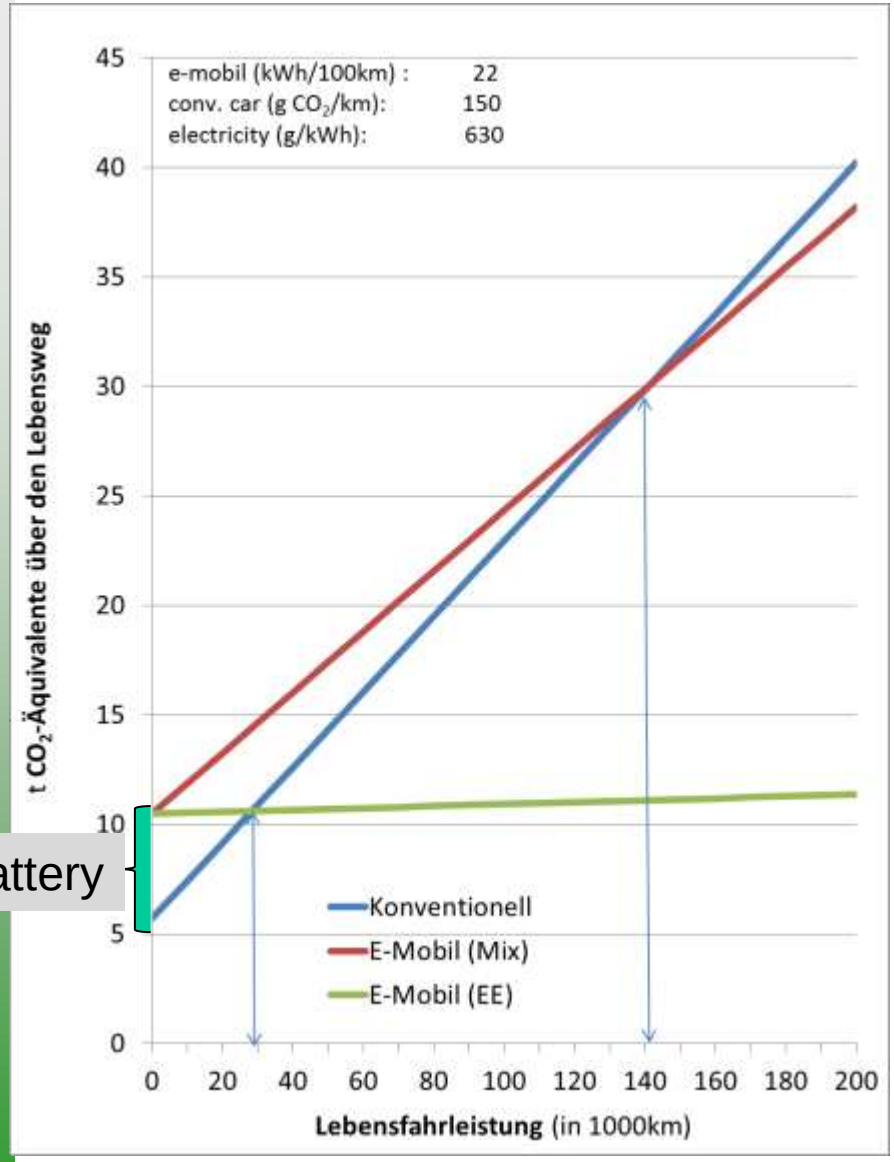
DSM helps to integrate fluctuating renewable energy
..and to stabilize the grid….
..but can lead to higher GHG emission

Only additional renewable energy leads and DSM to clear GHG advantages for electric vehicles!

……some thoughts

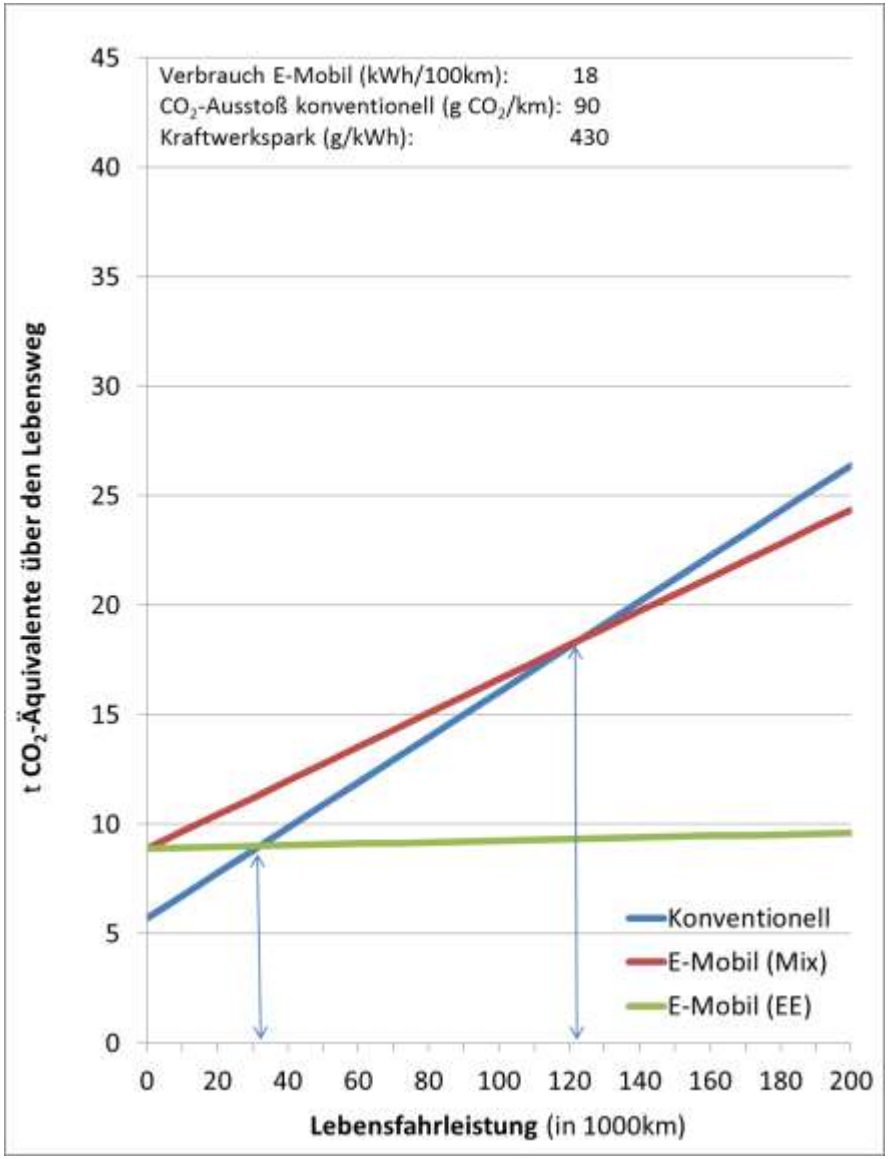
……..battery

How many kilometres a electric vehicle has to drive……..



Life time mileage

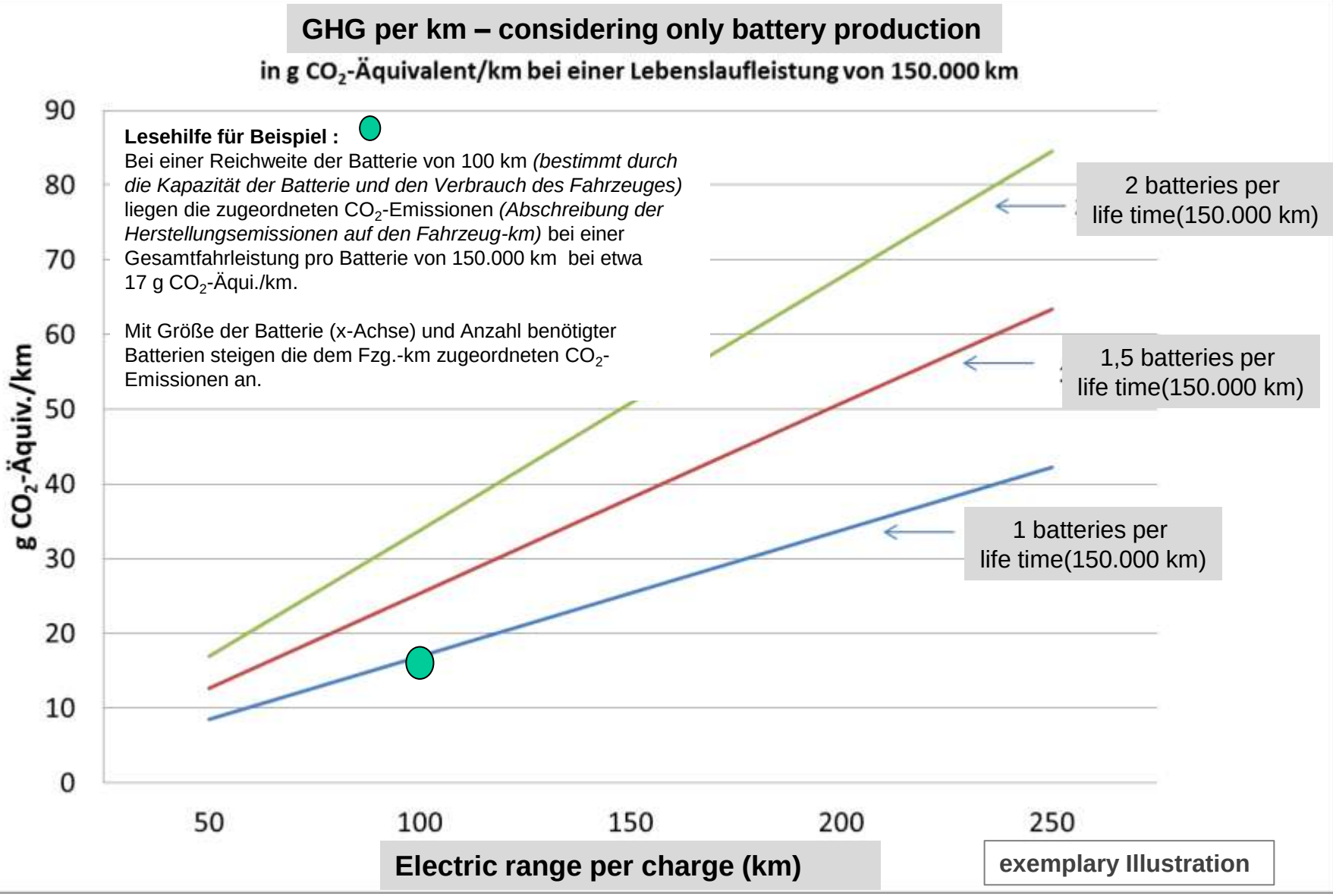
exemplary Illustration



Life time mileage

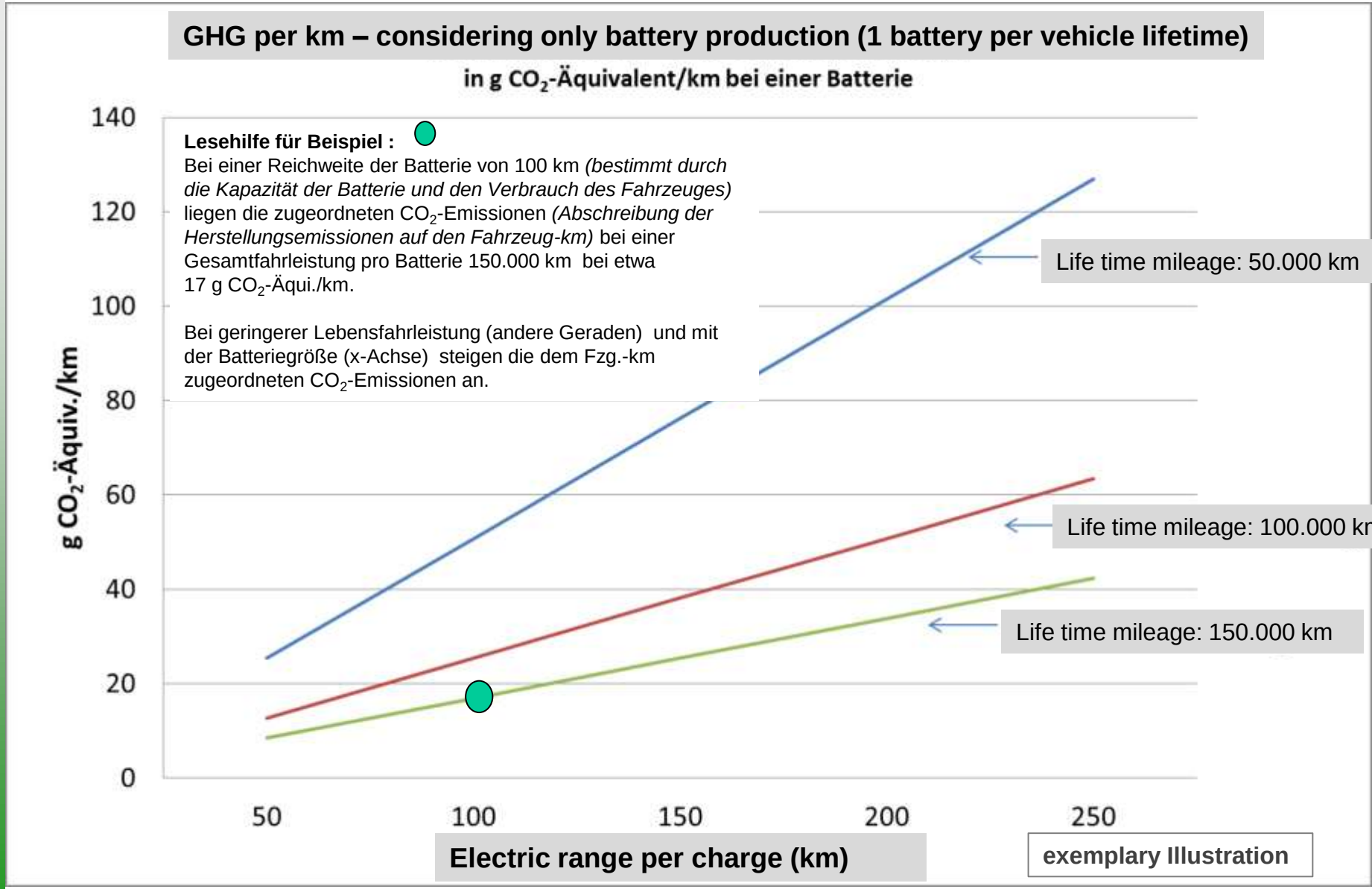
exemplary Illustration

GHG per km – only considering battery production



spielhafte Berechnung

GHG per km – only considering battery production



spielhafte Berechnung

Factors influencing impact of battery in LCA

1. **Battery size**
   - Start-Stopp to „pure“ electric vehicle
   - Electric Range

2. **Further development of battery**
   - very dynamic:
     Material composition (anode, cathode, electrolyth)
     Energy density
     Life time / cycles

3. **Production**
   - …mass production…
   - …alternative materials
   - …energy mix in mining and production

4. **Recycling**
   - Why (econ. [Cobalt] vs. autonomy)
   - technique/procedure

Factors influencing impact of battery in LCA

1. **Battery size**
   - Start-Stopp to „pure“ electric vehicle
   - Electric Range
2. **Fur**
   - ve
     - M
     - E
     - Li
3. **Pro**
   - …
   - …
   - …
4. **Rec**
   - W
   - technique/procedure

Assumptions/Informations neccessary:

- materials
- Life time (calendar – cycles)
- Environmental profiles (…2030…)
- Recycling
- ……

=> DATA have to be generated!

Thank you for your attention

and thanks BMU and others for support

Further information:

www.ifeu.de

www.ifeu.de/emobil

Udo.Lambrecht@ifeu.de