

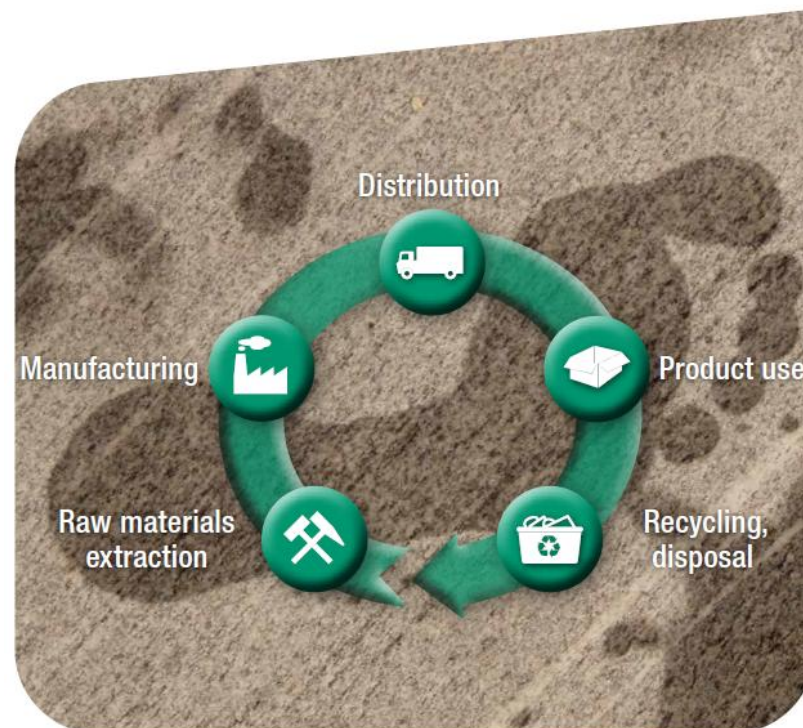
Future Energy Systems and Lifestyle

Charging infrastructure and Life Cycle Assessments

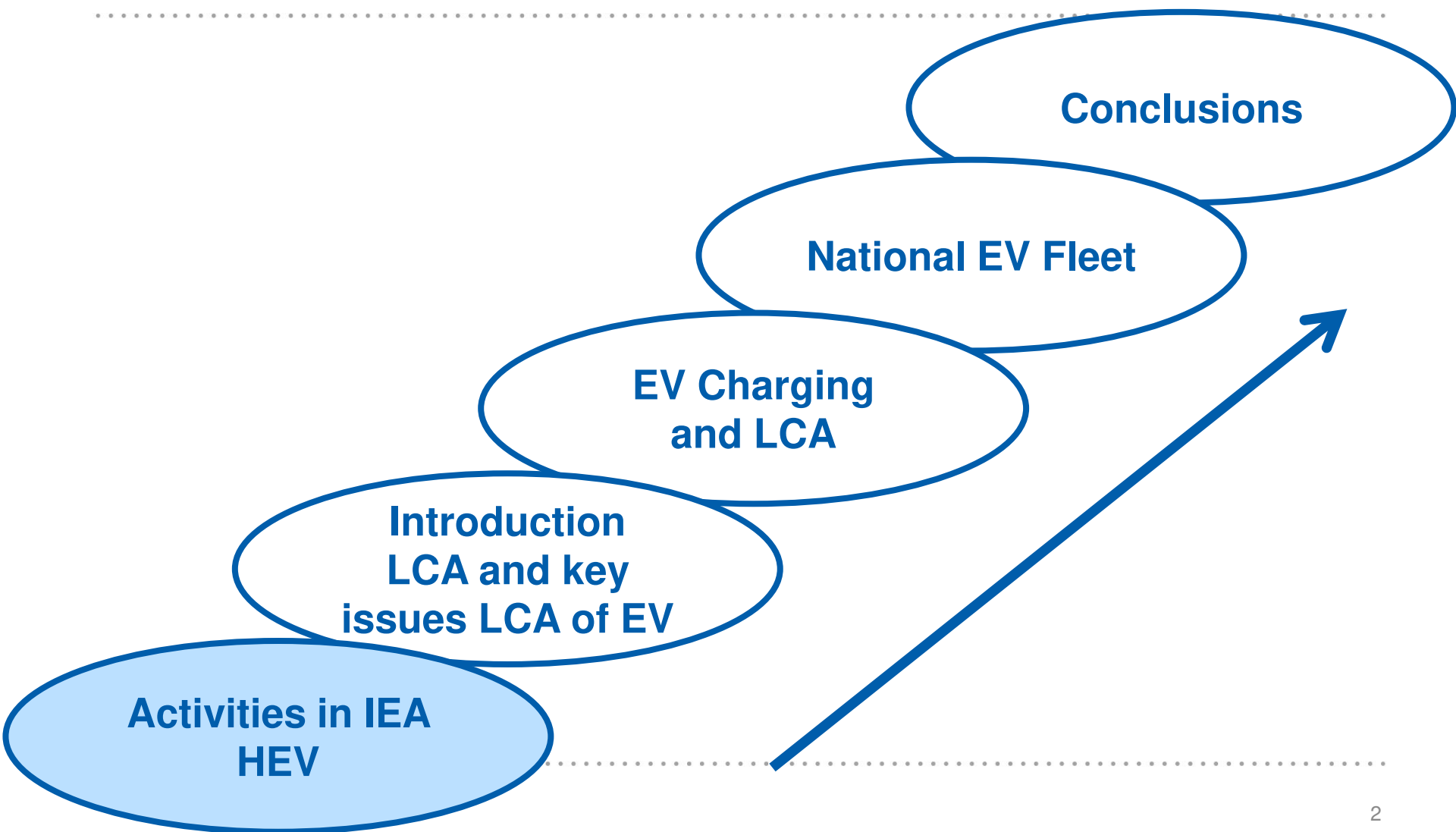
Martin Beermann

Experts Workshop on Energy
Efficiency of Electric Vehicle Supply
Equipment (EVSE)

28 September 2017 in Vienna



Content



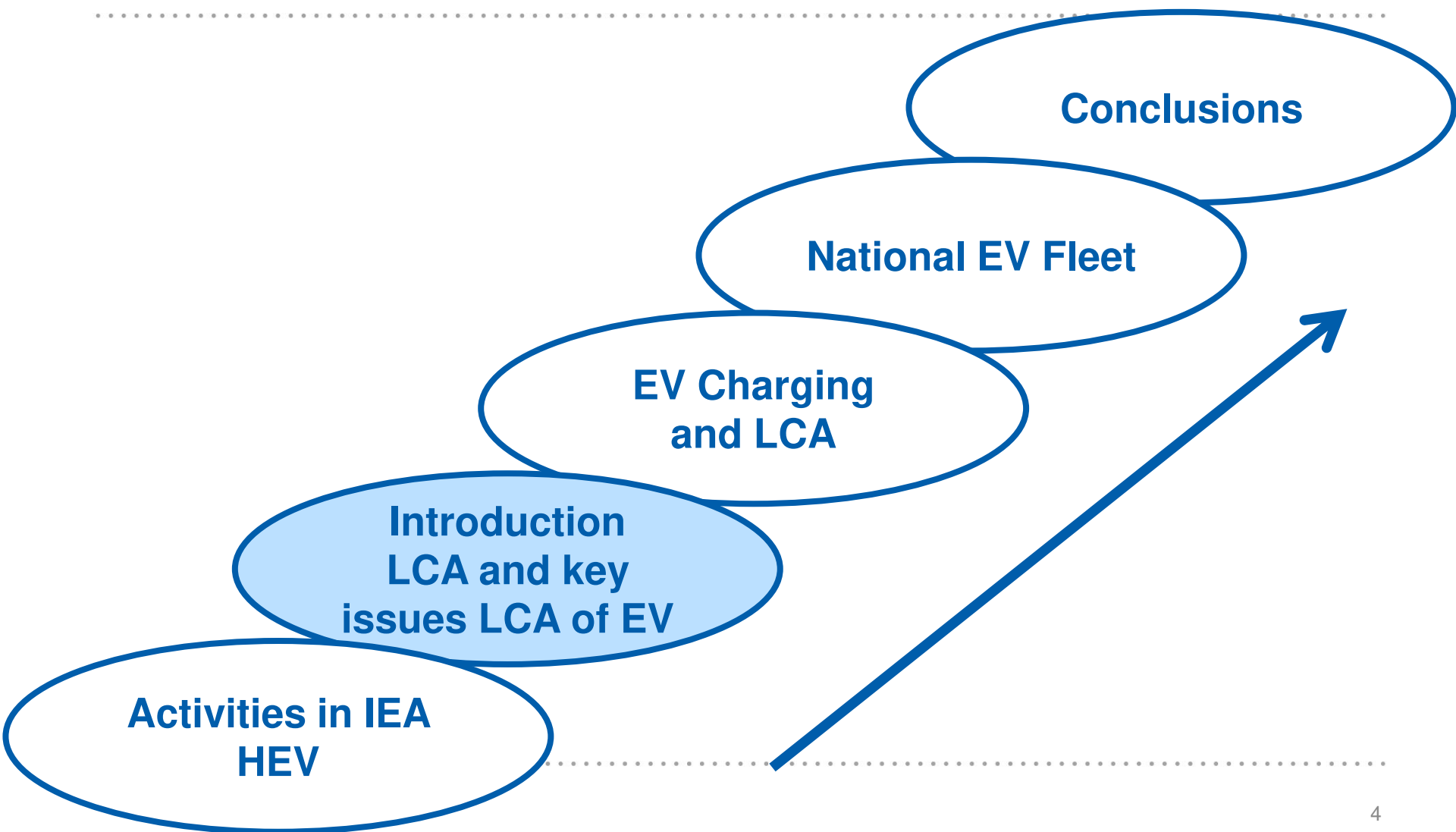
Overview – LCA Activities in IEA HEV

- IEA HEV Task 19 „**Life Cycle Assessment of Electric Vehicles - From raw material resources to waste management of vehicles with an electric drivetrain**” (2011 – 2015)
- IEA HEV Task 30 „**Assessment of Environmental Effects of Electric Vehicles**” (2017 – 2020)
- IEA HEV Task 33 „**Battery Electric Buses**” (2017 – 2019)
- IEA-HEV Project „**Facts and Figures on Environmental Benefits of EVs**“ (2016)

■ Main Partners:



Content



Statement on Environmental Assessment of Electric Vehicles

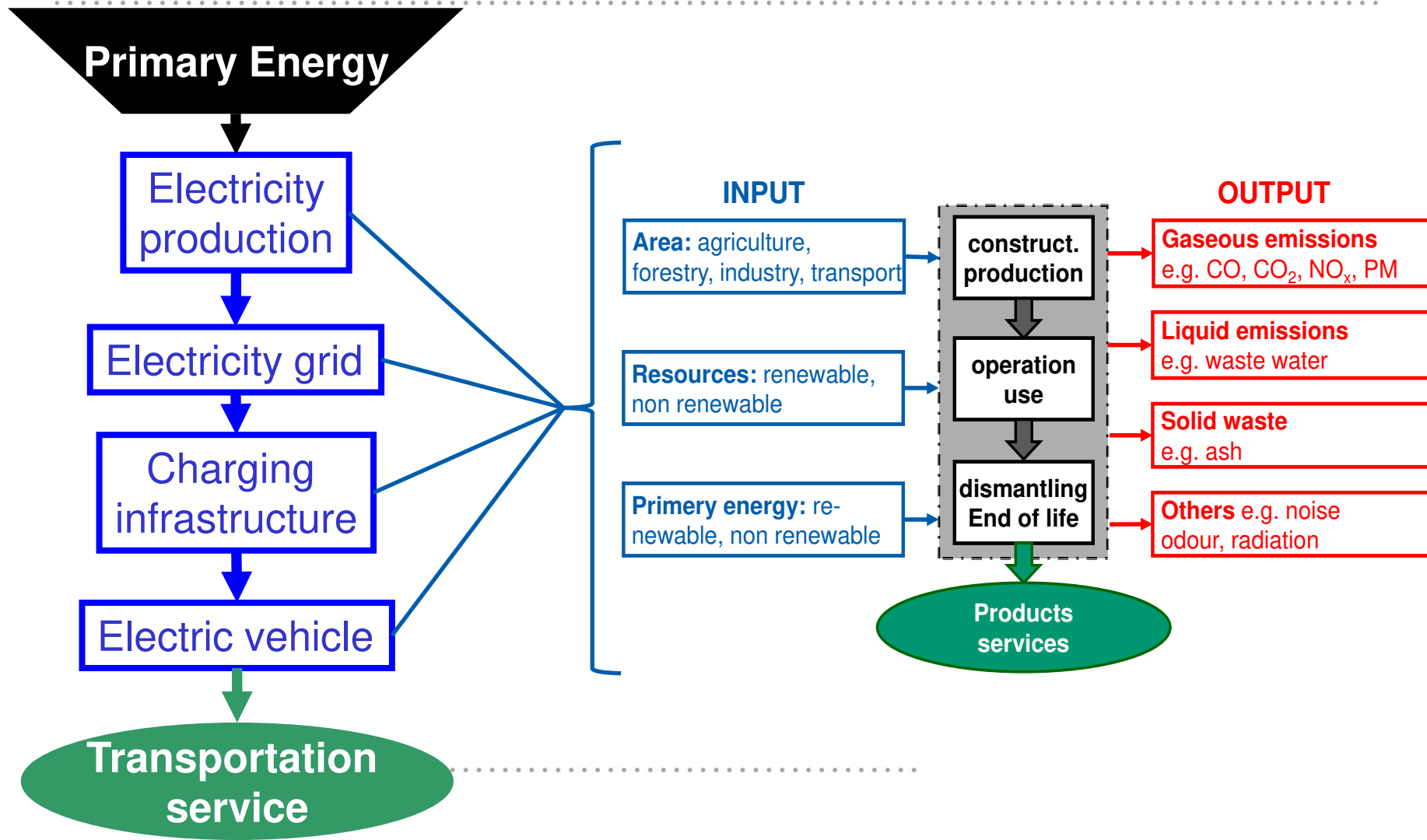
“There is international consensus that the environmental effects of electric vehicles can only be analyzed on the basis of

Life Cycle Assessment (LCA)

including the production, operation and the end of life treatment of the vehicles”

“....and in comparison to conventional vehicles”

Assessment of LCA-Aspects over Full Value Chain





The 7 Key Issues in LCA of EVs

- 1) **General issues**: data availability reflecting the state of technology
- 2) **Life cycle modeling**: end of life-recycling, data quality, allocation, life time
- 3) **Vehicle Cycle**: production—use—end of life, overall energy demand of vehicle
- 4) **Fuel Cycle**: Electricity generation, choice of mix: green↔marginal↔average
- 5) **Inventory analysis**: CO₂, MJ, kg ↔ CSB5 waste water, heavy metals
- 6) **Impact assessment**: GHG, primary energy ↔ biodiversity, toxicity
- 7) **Reference system**: vehicle size, driving range, ≤ 100% substitution?

Example: 100 BEV

- 85% substitute „fossil driven“ ICE kilometres“
- 15% substitute walking, bicycling, public transport and additional mobility

→ 15 additional vehicles?

Source: G. Jungmeier, J. B. Dunn, A. L. Widmer: **Life cycle assessment of electric vehicles**. IEA Technical Report No. 19 of the International Energy Agency (IEA) on Hybrid and Electric Vehicles. Paris, France, April 14-17, 2014.

... D. Özdemir, H. J. Althaus, R. ...
Transport Research Arena 2014, Paris,

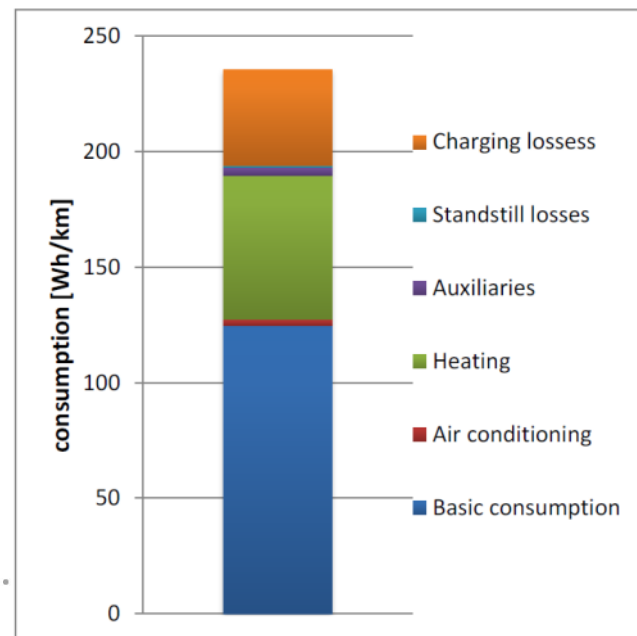
What is LCA of electric vehicles useful for?

- LCA can't answer the questions usually asked („Which system is the best?“), but it can help understanding the question
- LCA fosters the understanding of systems, of causalities and consequences
- LCA can also initiate a discussion on values (how important is which environmental effect?)
- Think in ranges instead of exact numbers, consider system boundaries and assumptions

Vehicle cycle – energy consumption in the use phase

- Drive train (driving from A to B, without the consumption of any device which is not directly needed for propulsion)
- Heating and air conditioning
- Auxiliaries (Light, Radio, Navigation etc.)
- Standstill losses
- Battery charging losses (on-board vehicle)

Charging losses ratio of 2 – 3 means that the highest observed charging losses can be 2 to 3 times higher than the lowest charging losses, whereas in the graph the average absolute charging losses are estimated



Ratio “bad” / “good” *)

Charging: ≈ 2-3

Standstill: ≈ 50

Heating: ≈ 10

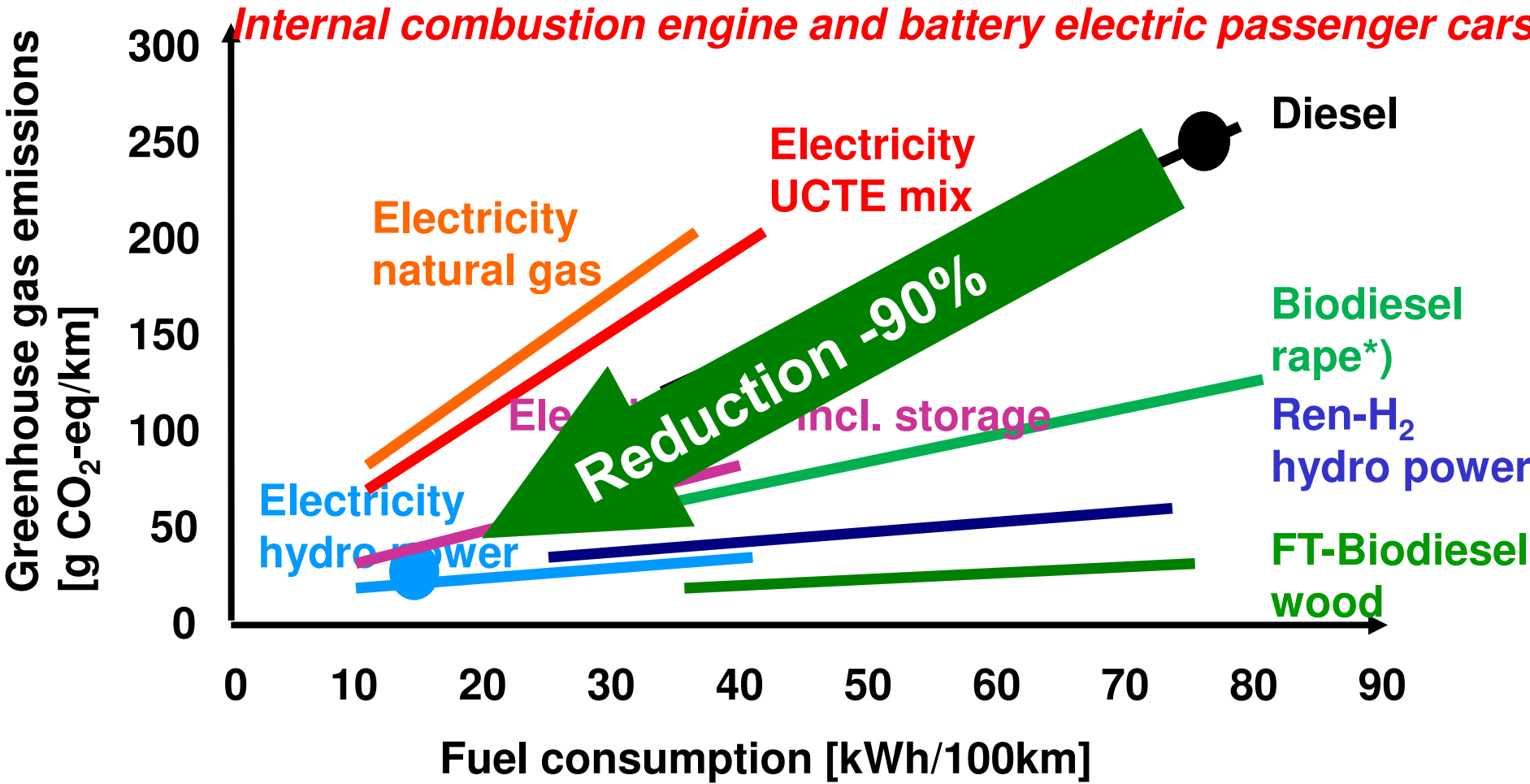
A/C: ≈ 5

Basic: ≈ 1.4-3

Overall: ≈ 2-3

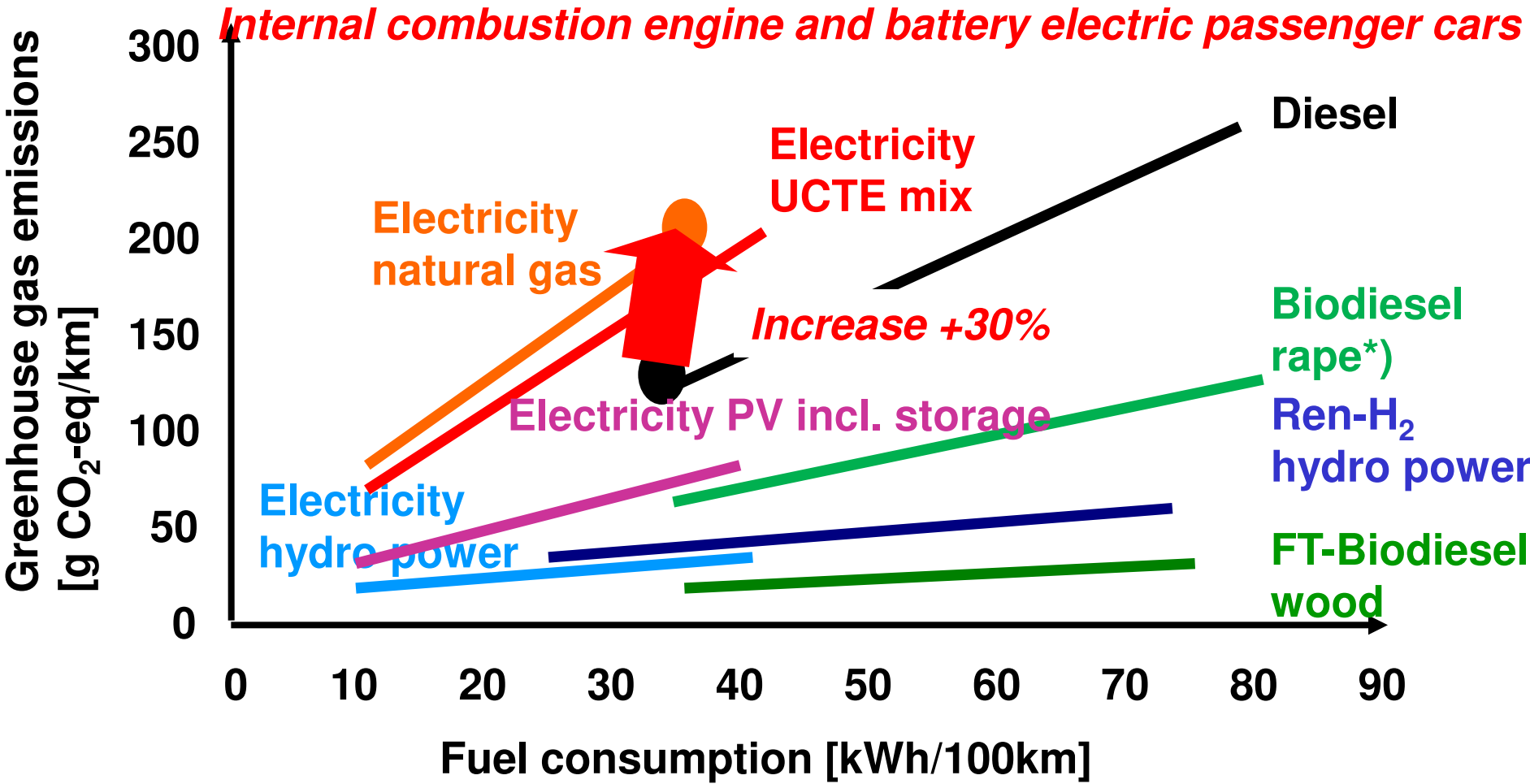
*) For the same vehicle!

The 2 Keys: Renewable & Energy Efficiency



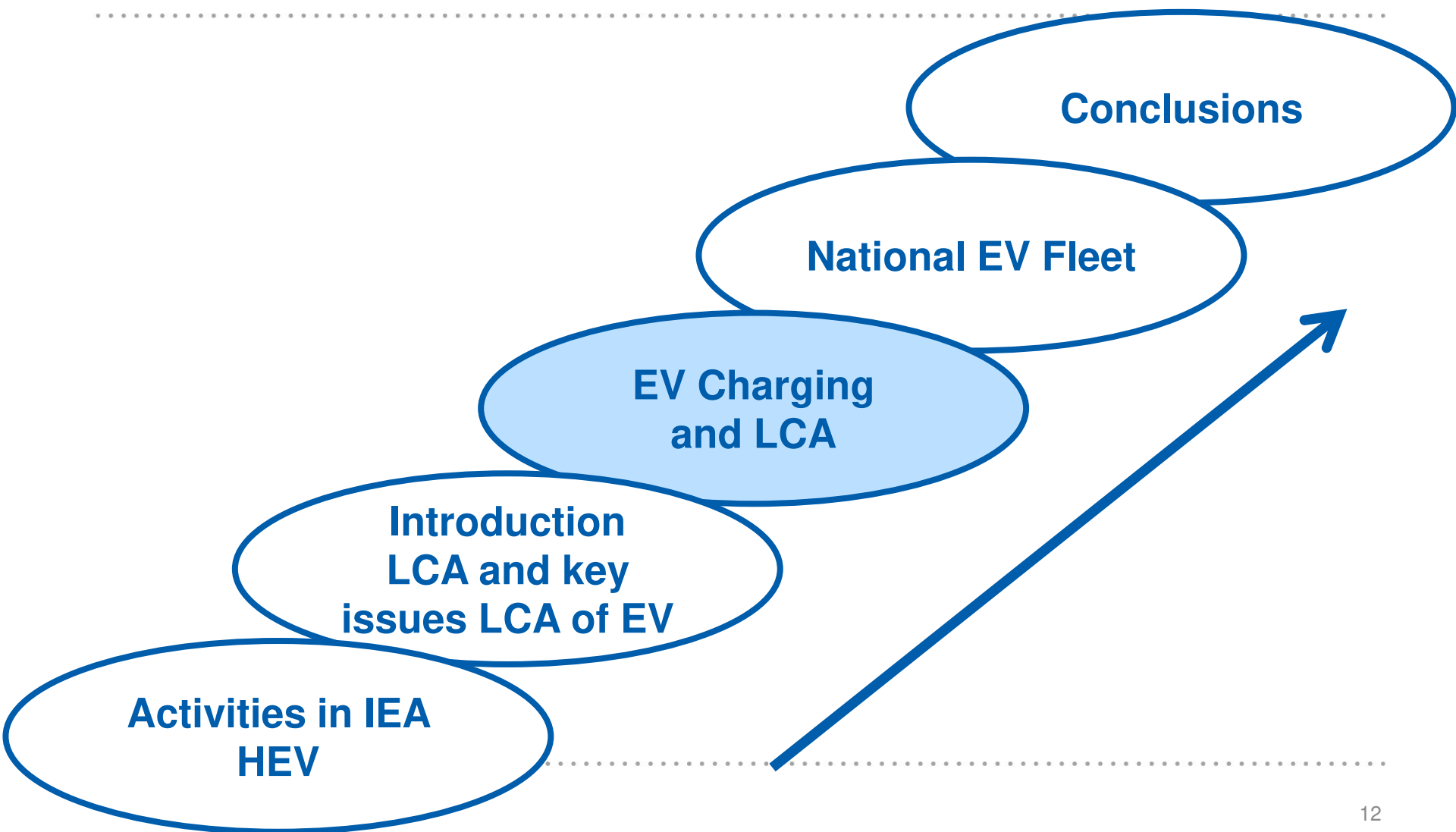
Source: LCA of passenger vehicles, Joanneum Research, *) without iLUC

The 2 Keys: Renewable & Energy Efficiency



Source: LCA of passenger vehicles, Joanneum Research, *) without iLUC

Content



EV Charging and LCA

- Construction of charging points (materials, lifetime, service rate – chargers / car)
- Charging losses of infrastructure (efficiency, electricity mix)

Example from IEA Workshop in Task 19, Barcelona. Oct 2014:

Rita G., Freire F. et al. LCA of electricity generation, distribution and charging of electric vehicles.

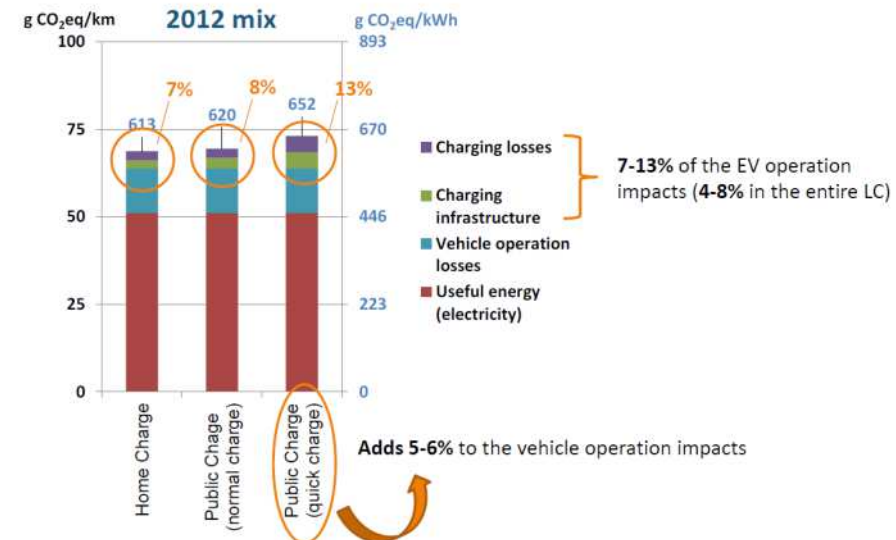
	Model	Voltage	Current	Charging time	Efficiency	Lifetime	Service rate
Home charger	Easy	Single phase	16-32 A	Up to 8h	95%	15 years	1 charger/car
Normal charger	Universal Public	Single phase	16-32 A	5 to 8h	95%	6 years	0.25 chargers/car
Quick charger	AC	Three phase	Up to 630 A	80% charge in 15 to 30 min	91%	12 years	0.15 chargers/car

Source: EFACEC; Faria et al., 2013; Lucas et al., 2011

- Charging losses infrastructure + battery: roughly 15-20%
(90-95% infrastructure, 90% battery)
- EV charging adds roughly 5-10 g CO₂ äq/km

LC impacts of EV operation – Global warming

Comparison of different charging systems (2012 electricity mix)



Fuel cycle – choice of electricity mix

- National consumption mix (commonly used for impact of electric driving)
- National production mix
- Marginal mix (mainly for impact on electricity system)
- Specific technology mix (e.g. 100% renewable)
- Consumption mix at specific time
- Production mix at specific time
- Marginal mix at specific time

Fuel cycle - additional renewable electricity

1. „Direct connection“
2. „Via storage“
3. „Stored in Grid“
4. „Real time charging“

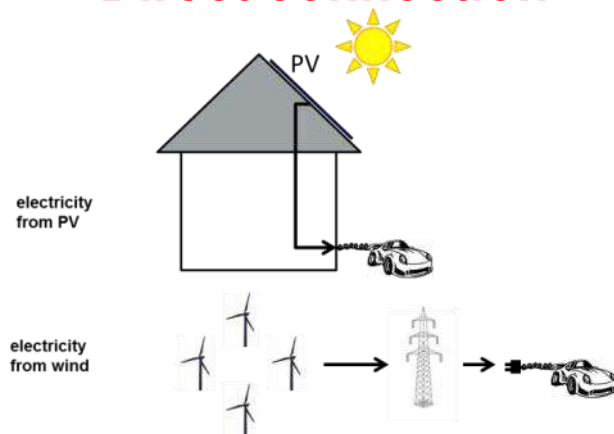


How to
connect?

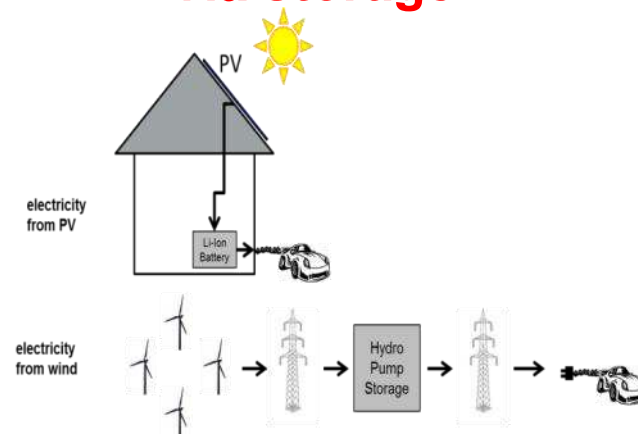


Charging of EVs with Additional Renewable Electricity

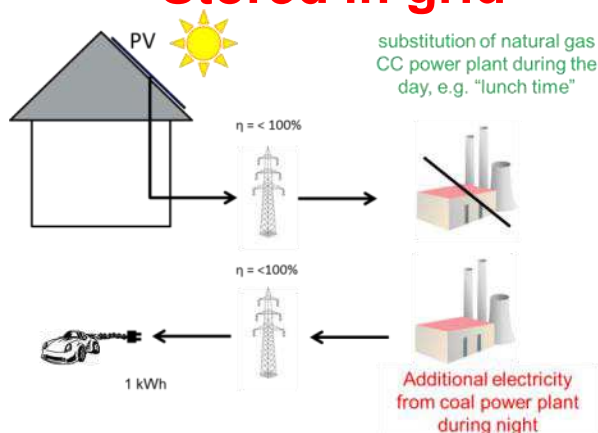
“Direct connection”



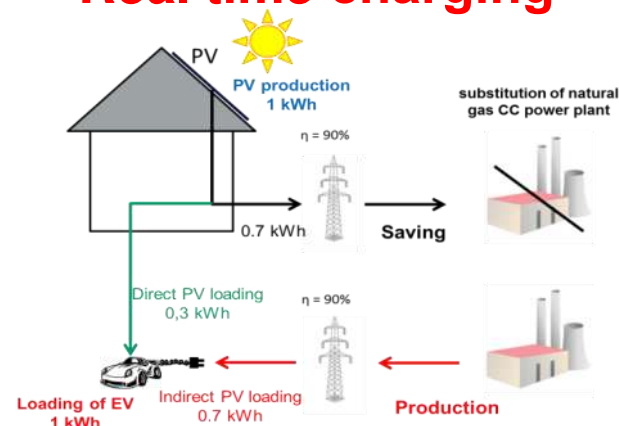
“Via storage”



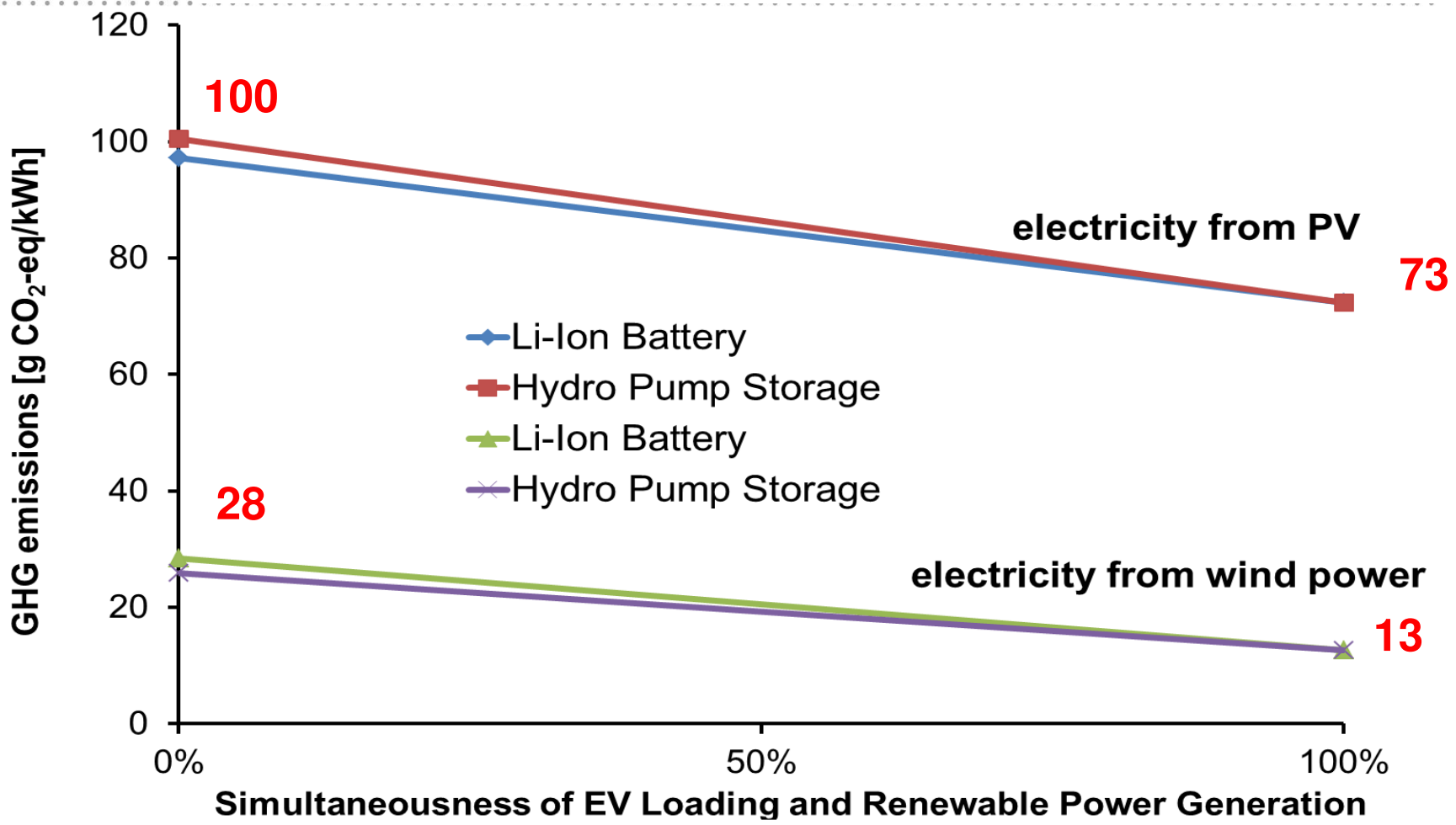
“Stored in grid”



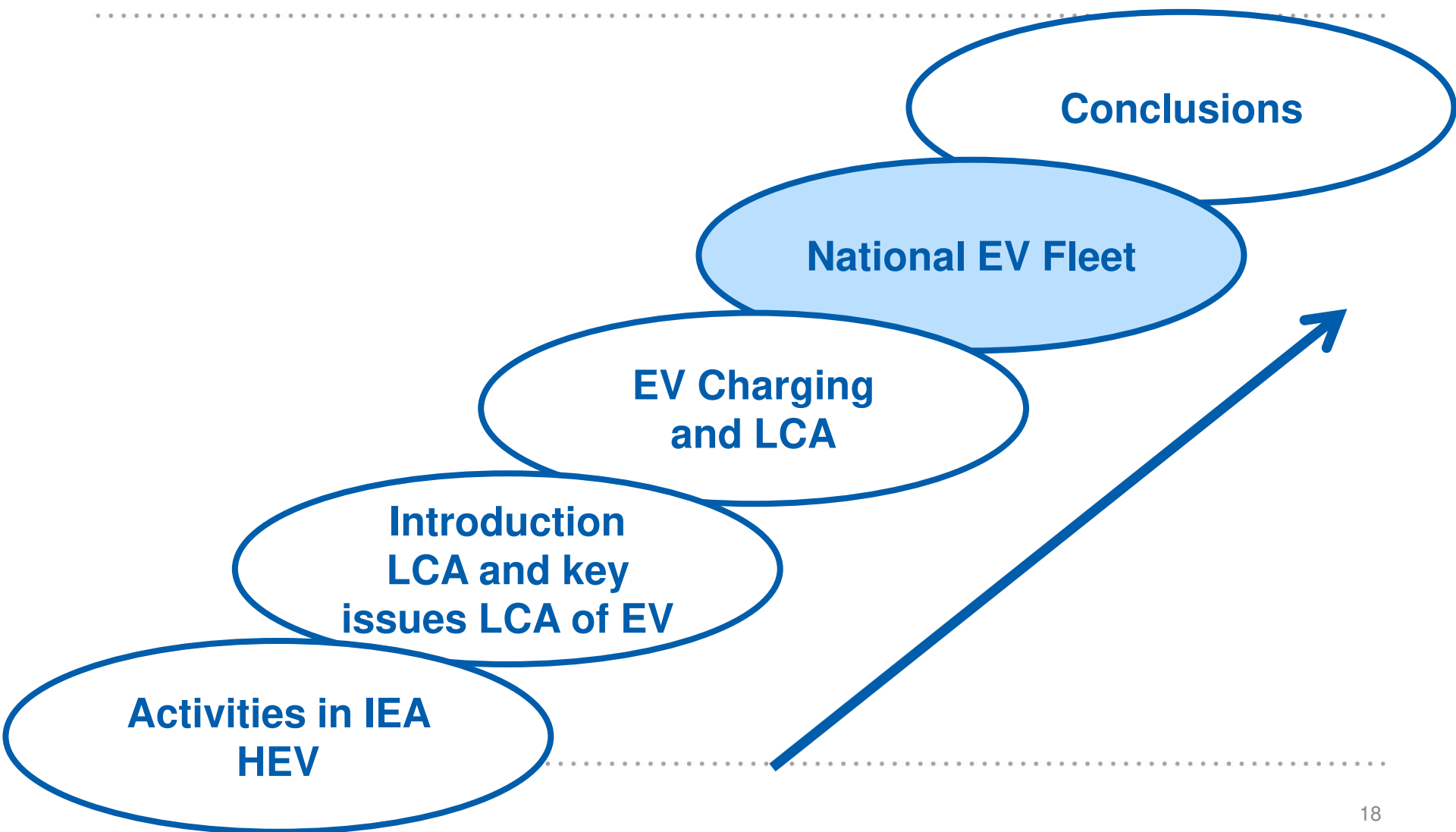
“Real time charging”



Emissions of Loading Strategies with Additional Renewable Electricity



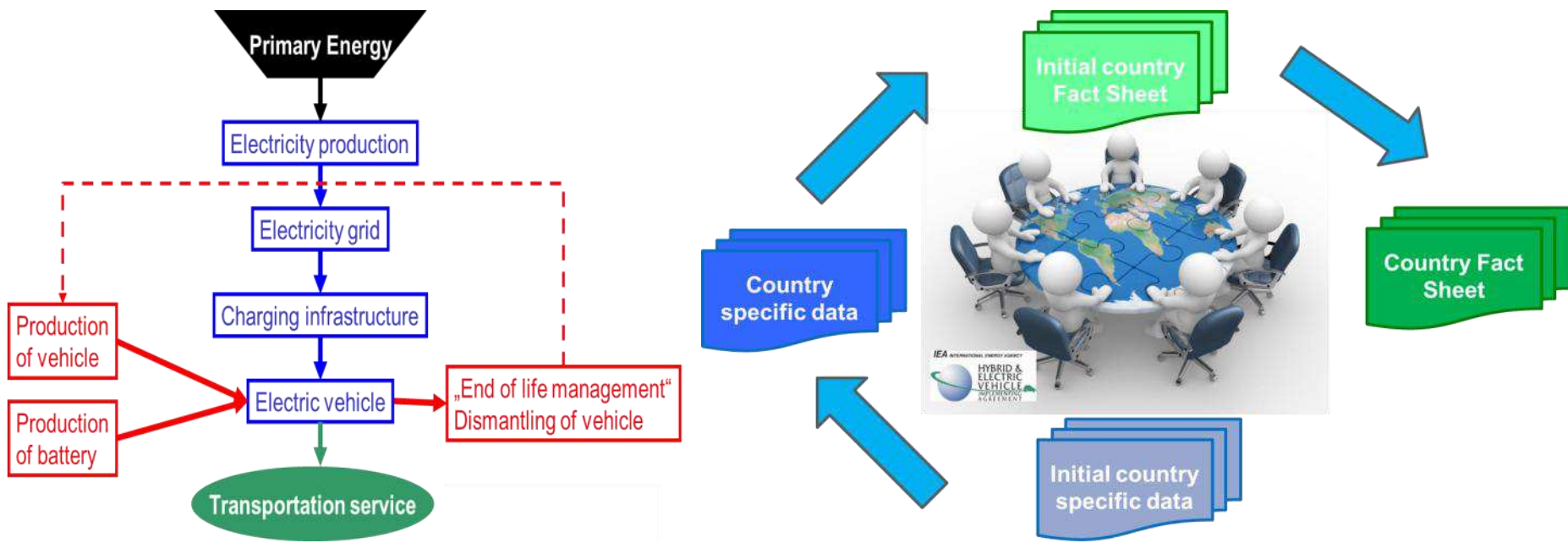
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Aim of IEA-HEV Project “FACTS & FIGURES”

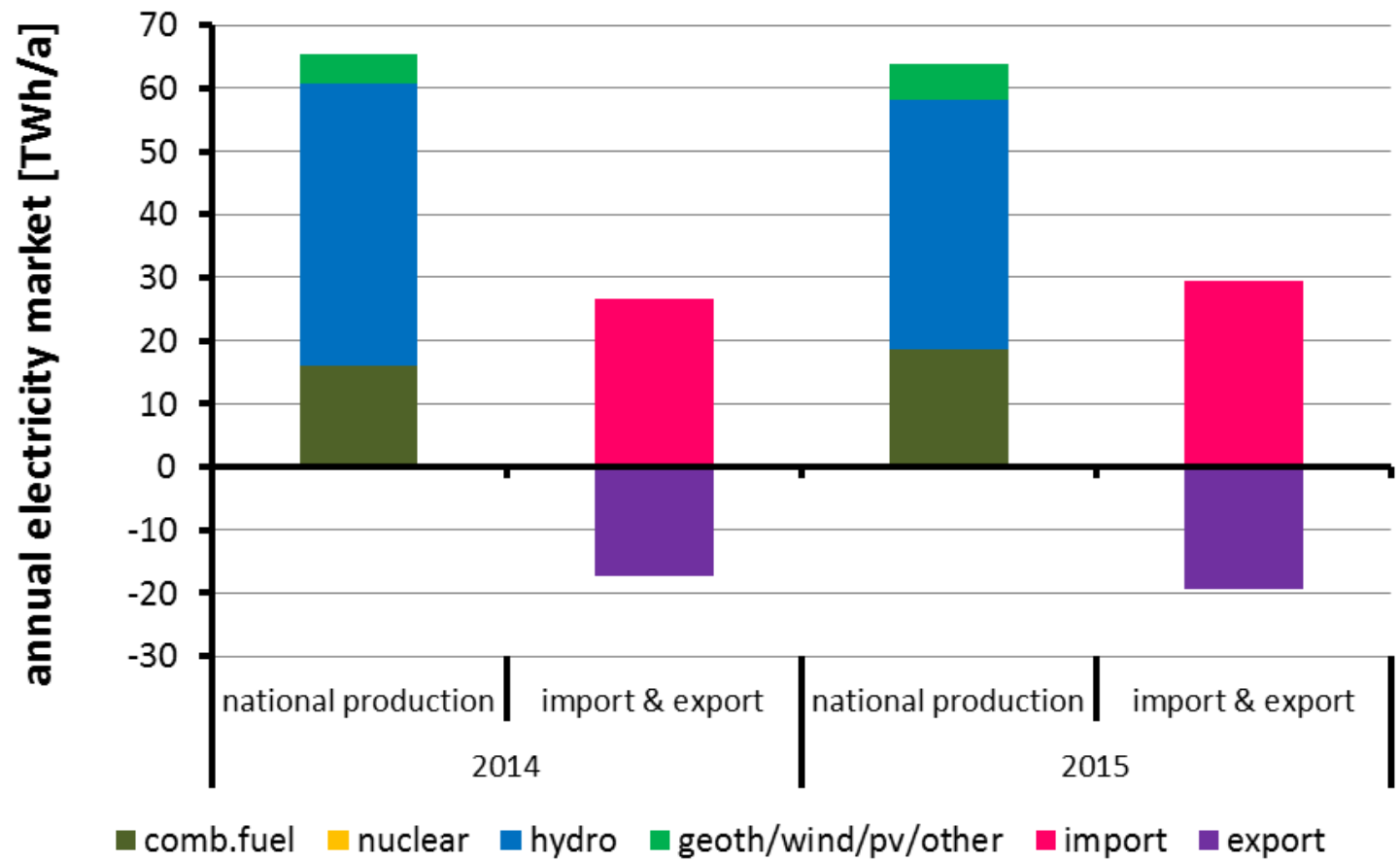
Provide annually **FACTS & FIGURES** on life cycle based environmental benefits of EVs worldwide and country specific in comparison to conventional vehicles

Based on LCA achievements in IEA HEV since 2011



BASIC DATA: National Electricity Market

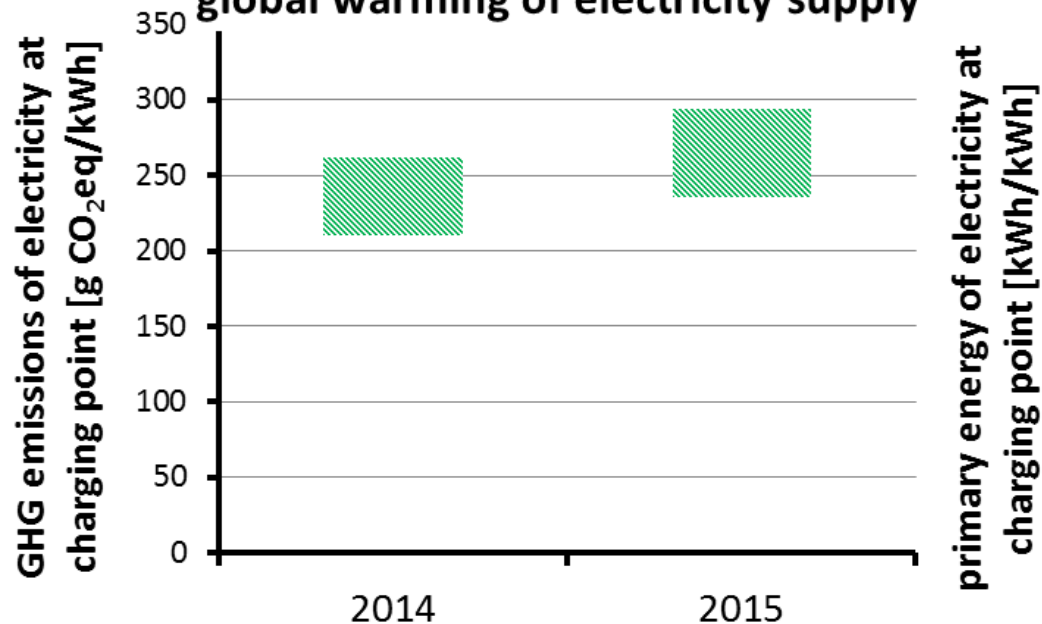
Austria



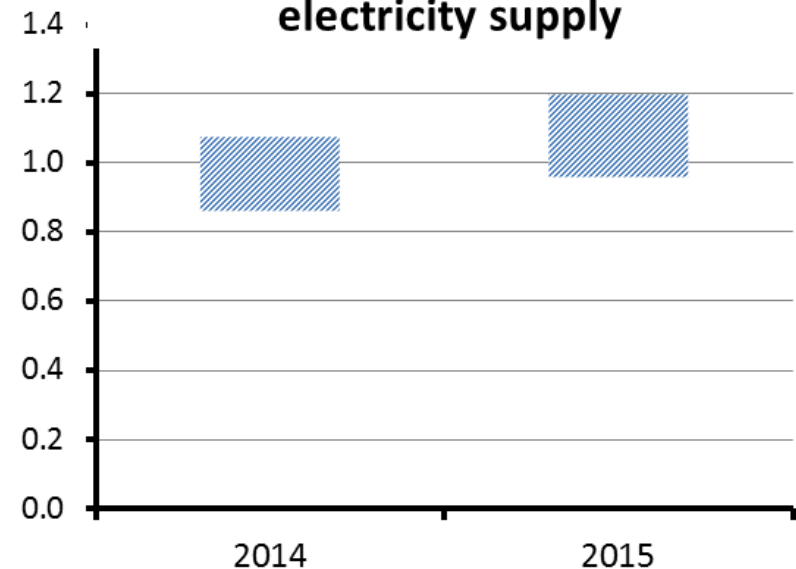
BASIC DATA: Estimated Environ. Effects of Electricity

Austria

global warming of electricity supply



primary energy of electricity at charging point

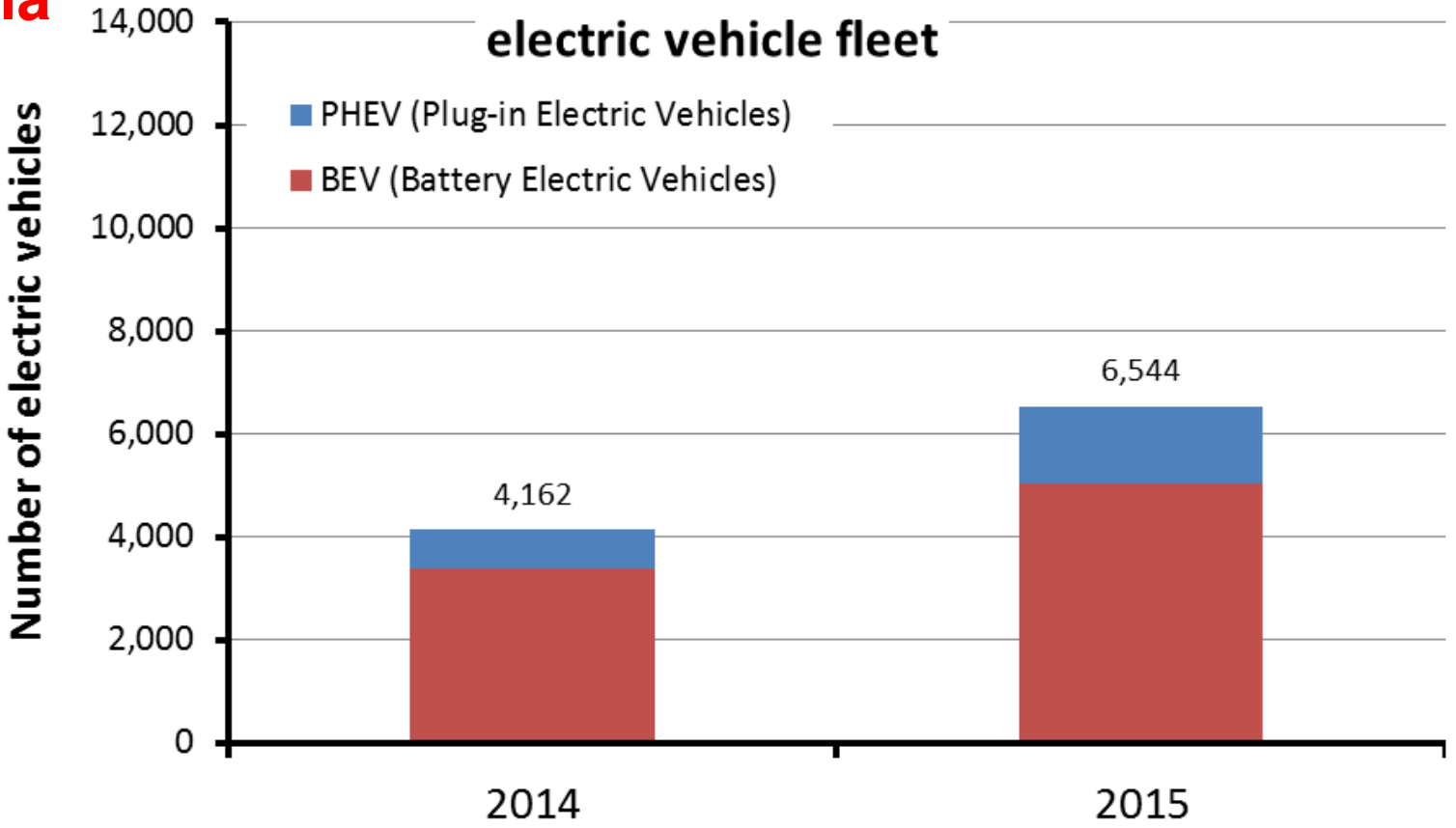


Source: own calculations using data from ecoinvent and GEMIS

BASIC DATA: Number of Electric Vehicle

total number of passenger vehicles in Mio. (2015): 4.7

Austria



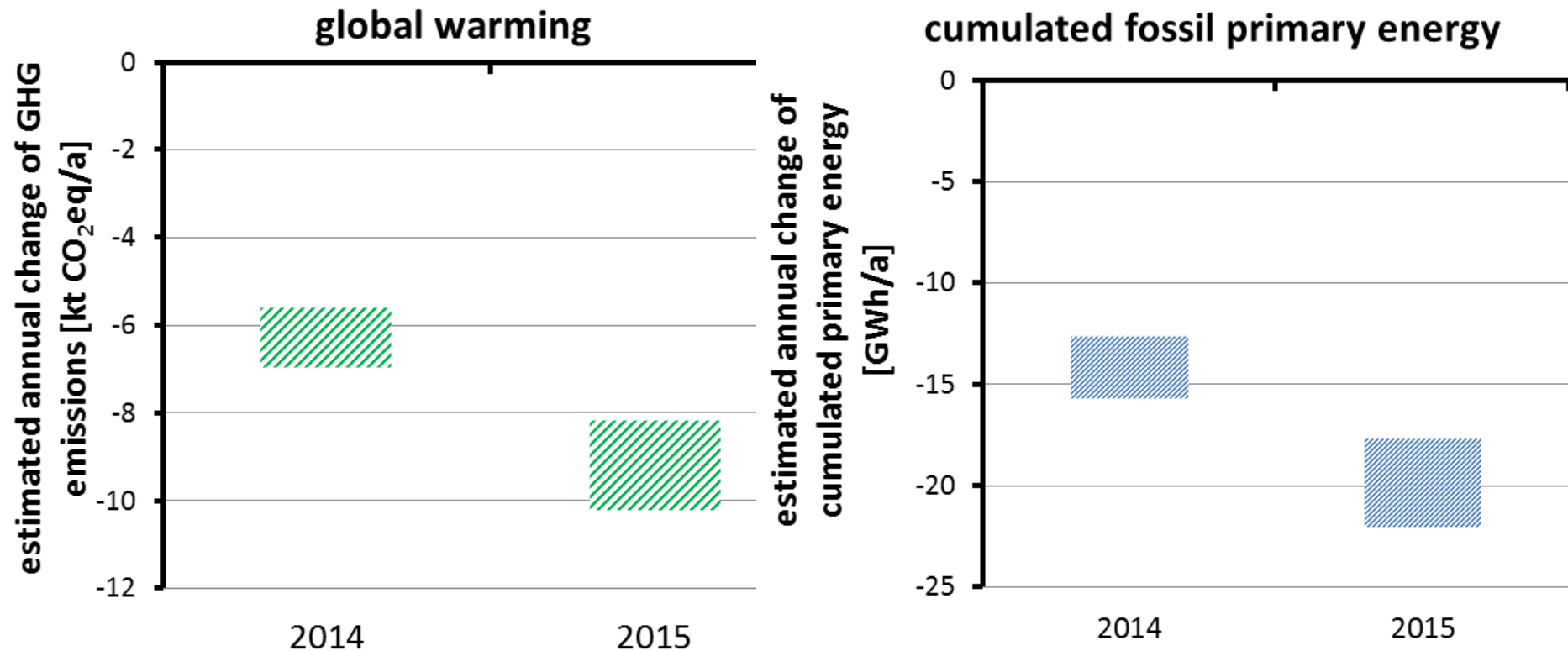
Source: IEA HEV annual report, EVI, ExCo members

ENVIRONMENTAL EFFECTS:

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Estimated Annual Change of national EV Fleet

Austria

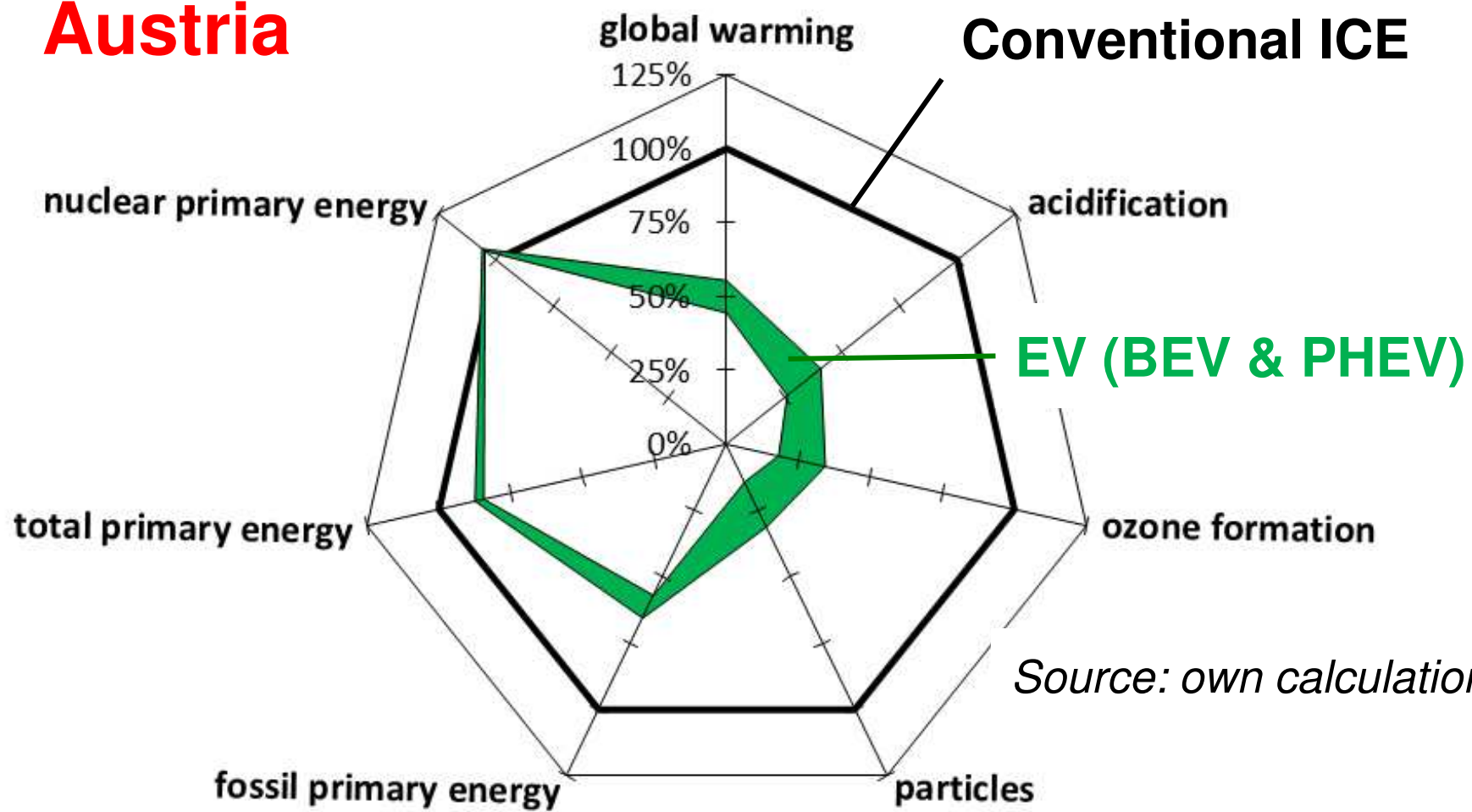


Source: own calculations

ENVIRONMENTAL EFFECTS: Comparison ICE and BEV&PHEV

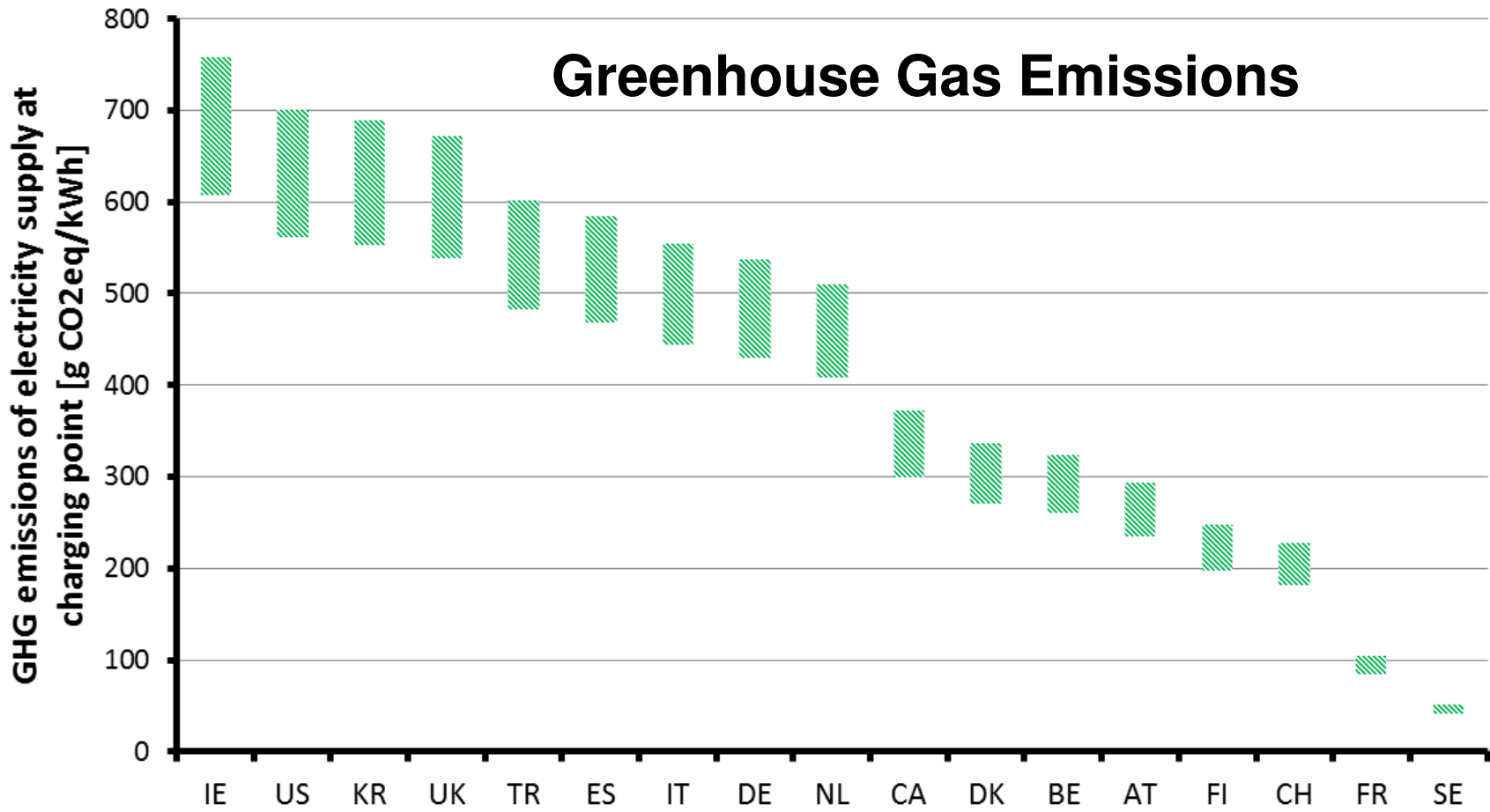
Austria

Conventional ICE



Source: own calculations

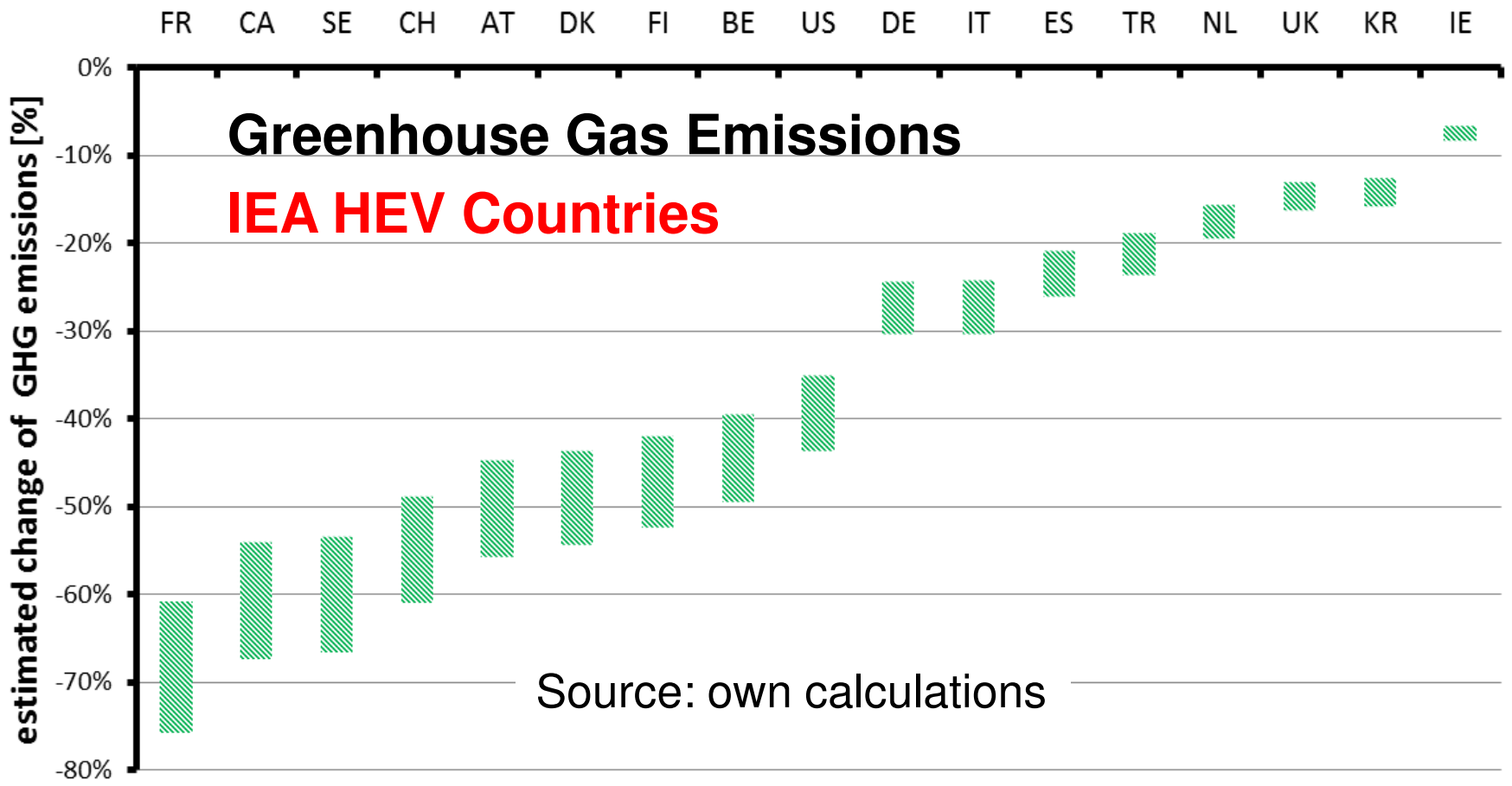
BASIC DATA: Estimated Environ. Effects of Electricity



Source: own calculations using data from ecoinvent and GEMIS

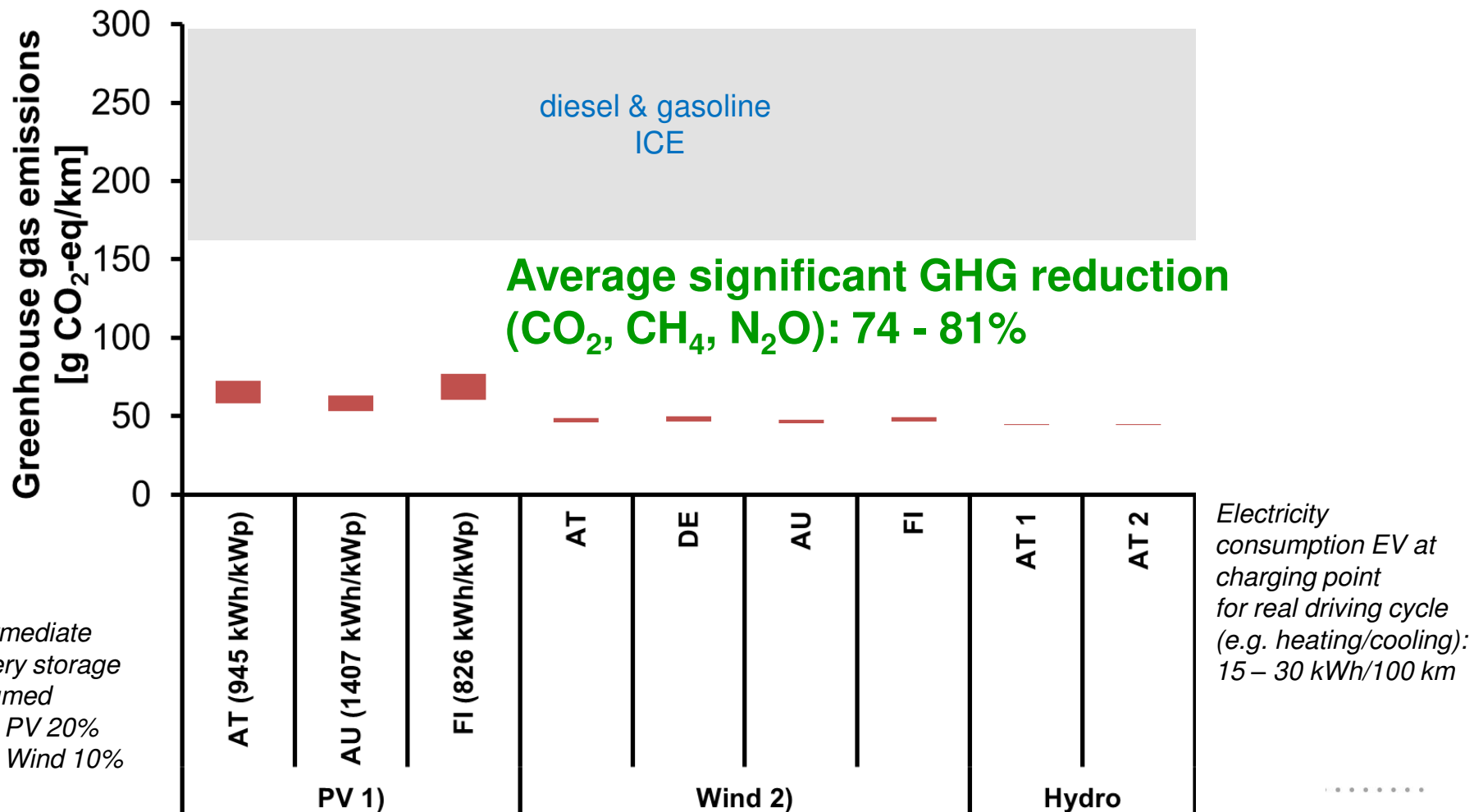
ENVIRONMENTAL EFFECTS: Estimated Change ICEV – EV

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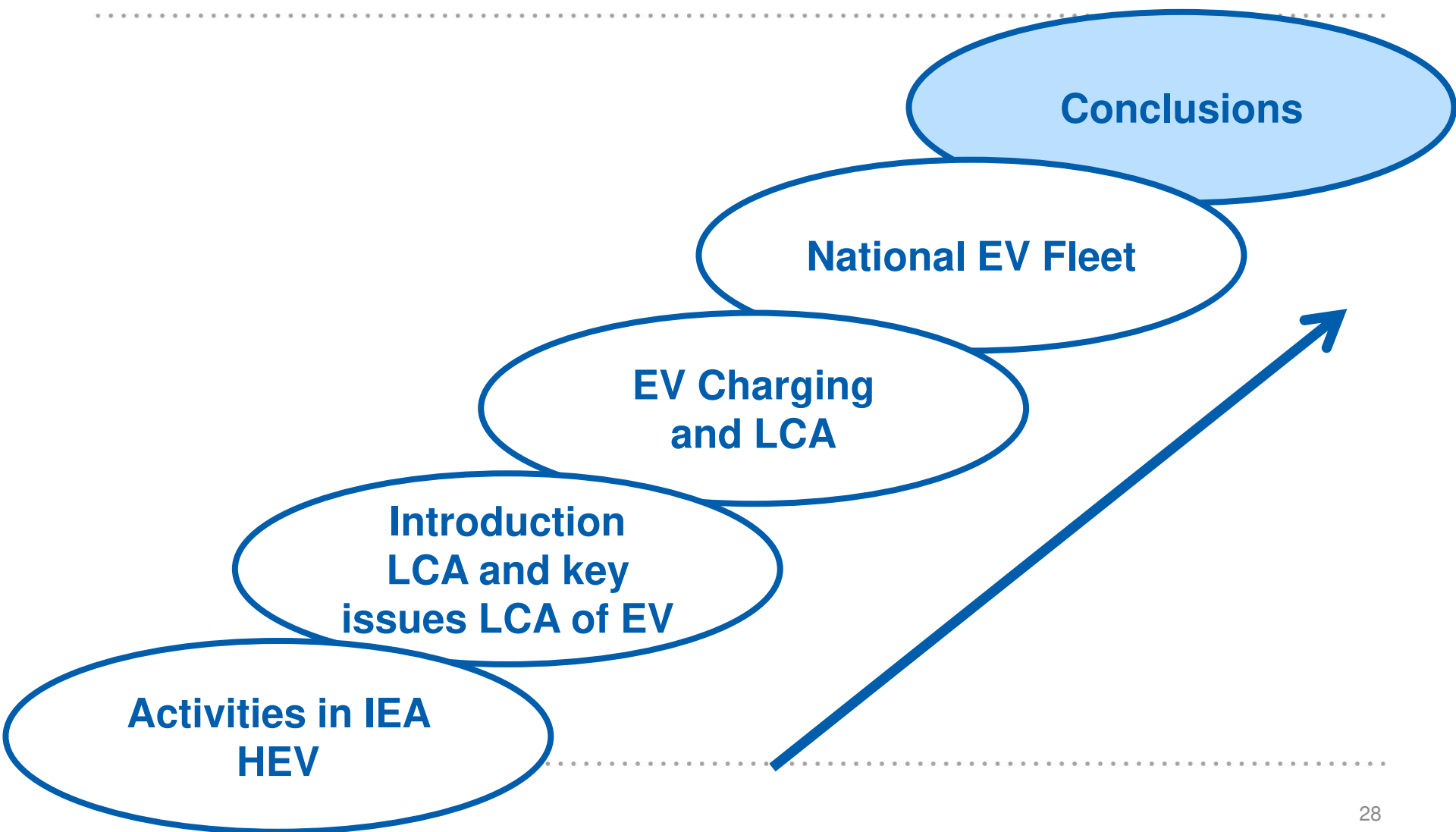


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GHG Emissions of Electric Vehicles - Renewable Electricity



Content





Summary

Communication strategies are essential: Interaction with stakeholders, show database, explain assumptions

Additional renewable electricity with adequate charging strategies is essential for further significant reductions

Broad estimated ranges mainly due to

- Emissions of national electricity production
- Electricity consumption of EVs at charging point
- Fuel consumption of substituted conventional ICEs
- Data availability, uncertainty and consistency

Key issues in **LCA methodology** and key data for electric vehicles are **harmonized** in IEA HEV

Environmental Assessment of EVs only possible on
Life Cycle Assessment compared to conventional vehicles

Your Contact

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