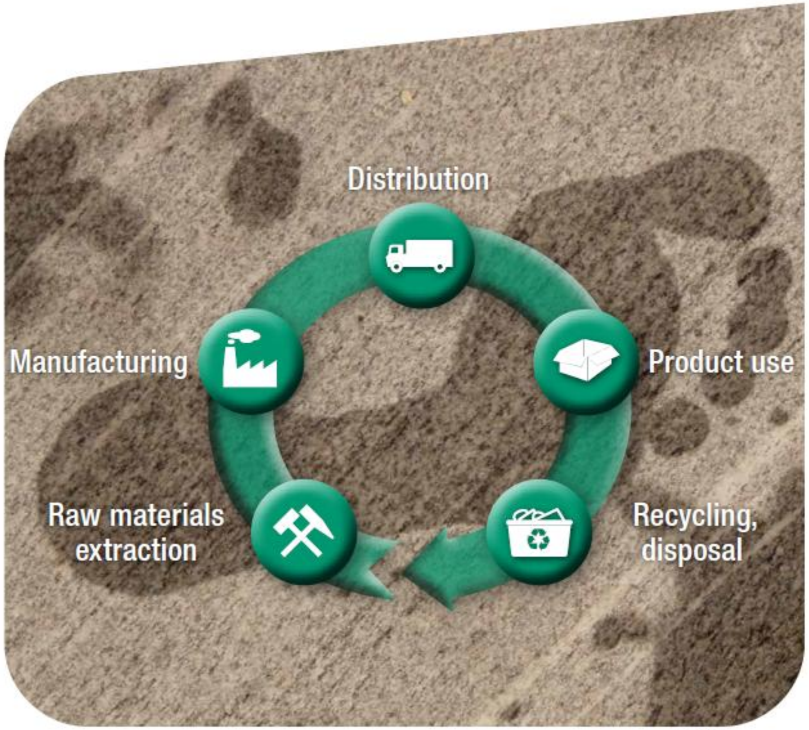
JOANNEUM RESEARCH LIFE

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

- Activities in IEA HEV
- Introduction LCA and key issues LCA of EV
- EV Charging and LCA
- National EV Fleet
- Conclusions

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:**

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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”

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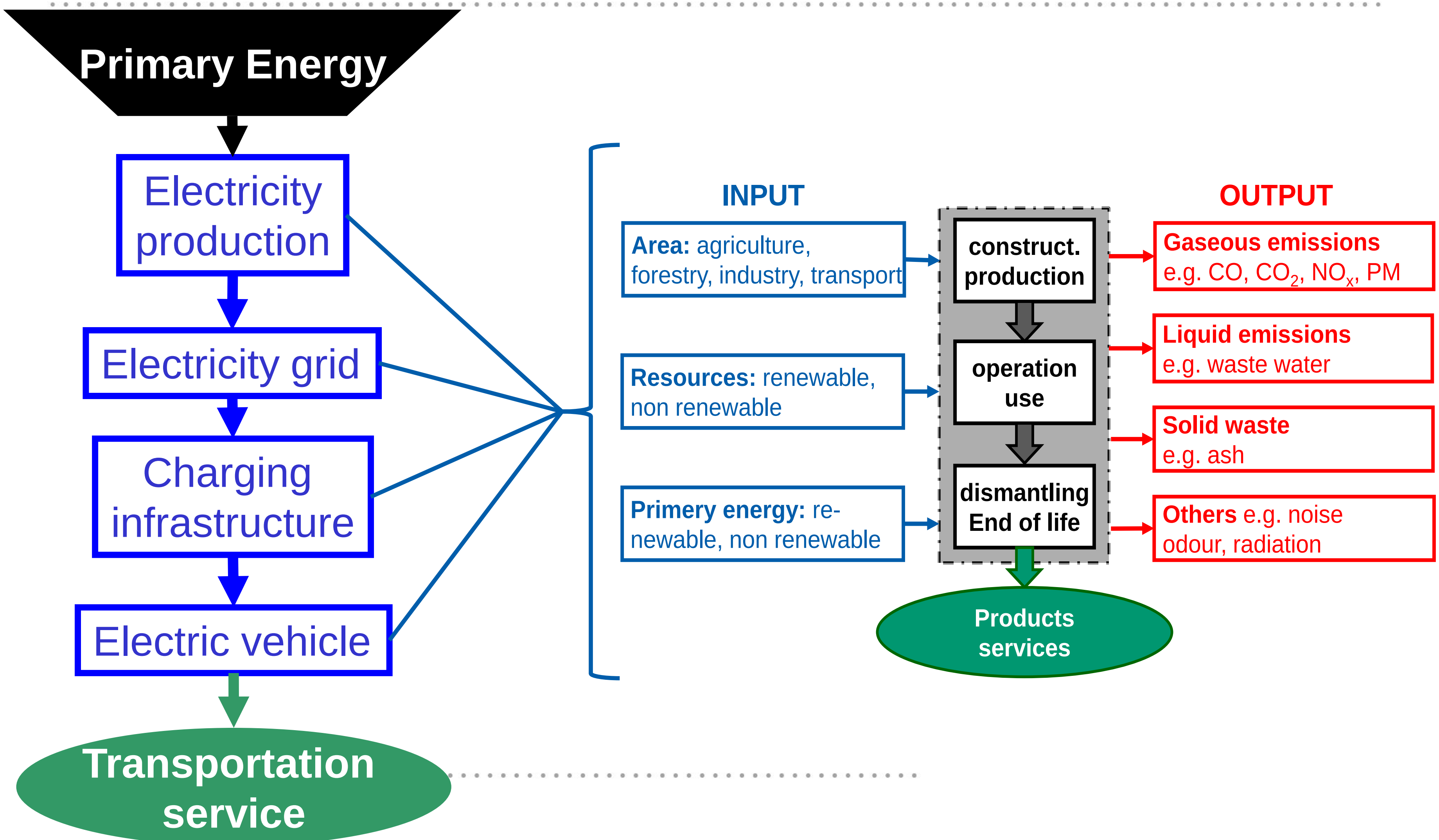
Assessment of LCA-Aspects over Full Value Chain



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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**: CO_2, 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. E... . D. Özdemir, H. J. Althaus, R. Widmer: **Life cycle assessment of elec... 19 of the International Energy Agency (IEA) on Hybrid and Electric Ve...** ...sport Research Arena 2014, Paris, France, April 14-17, 2014.*

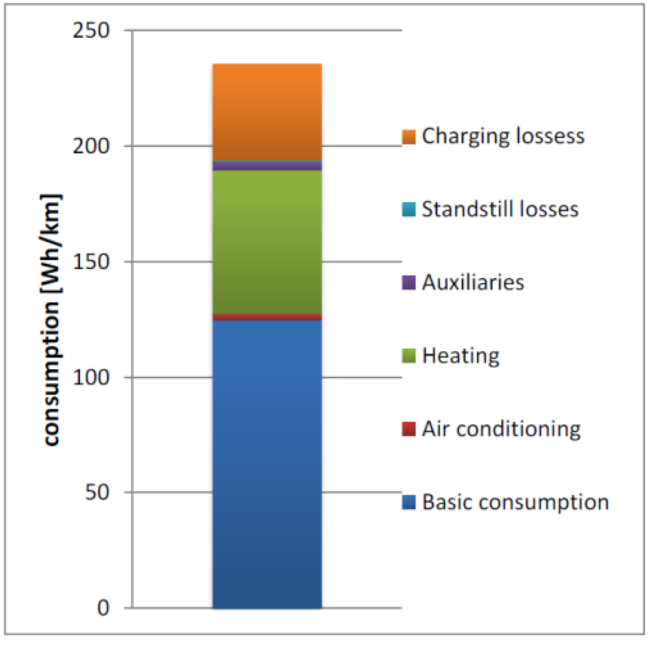
What is LCA of electric vehicles useful for?

- 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



H.J. Althaus, Empa (2013)

Ratio “bad” / “good” *)

Charging:	≈ 2-3
Standstill:	≈ 50
Heating:	≈ 10
A/C:	≈ 5
Basic:	≈ 1.4-3
Overall:	≈ 2-3

*) For the same vehicle!

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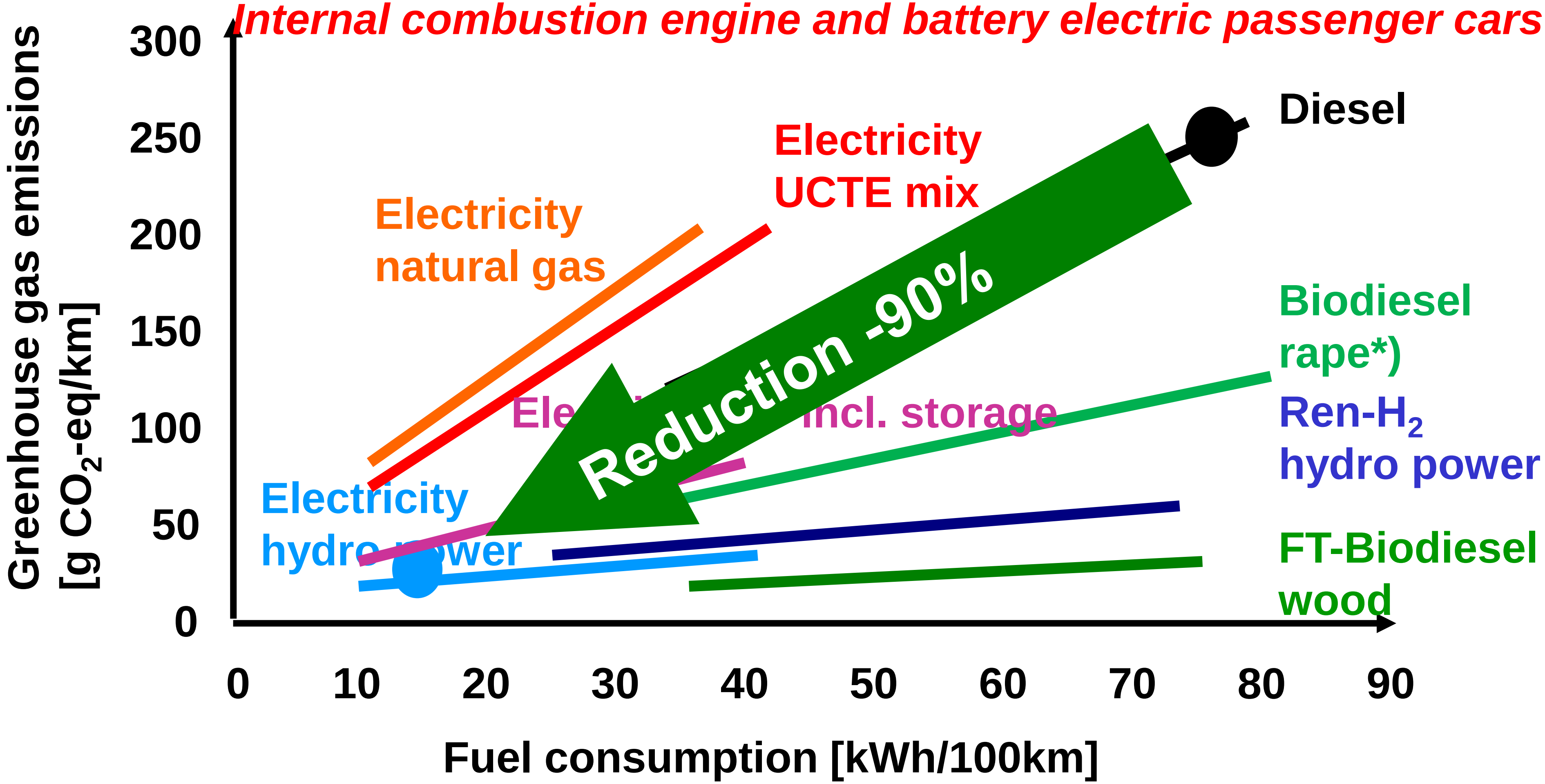
The 2 Keys: Renewable & Energy Efficiency

Internal combustion engine and battery electric passenger cars



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

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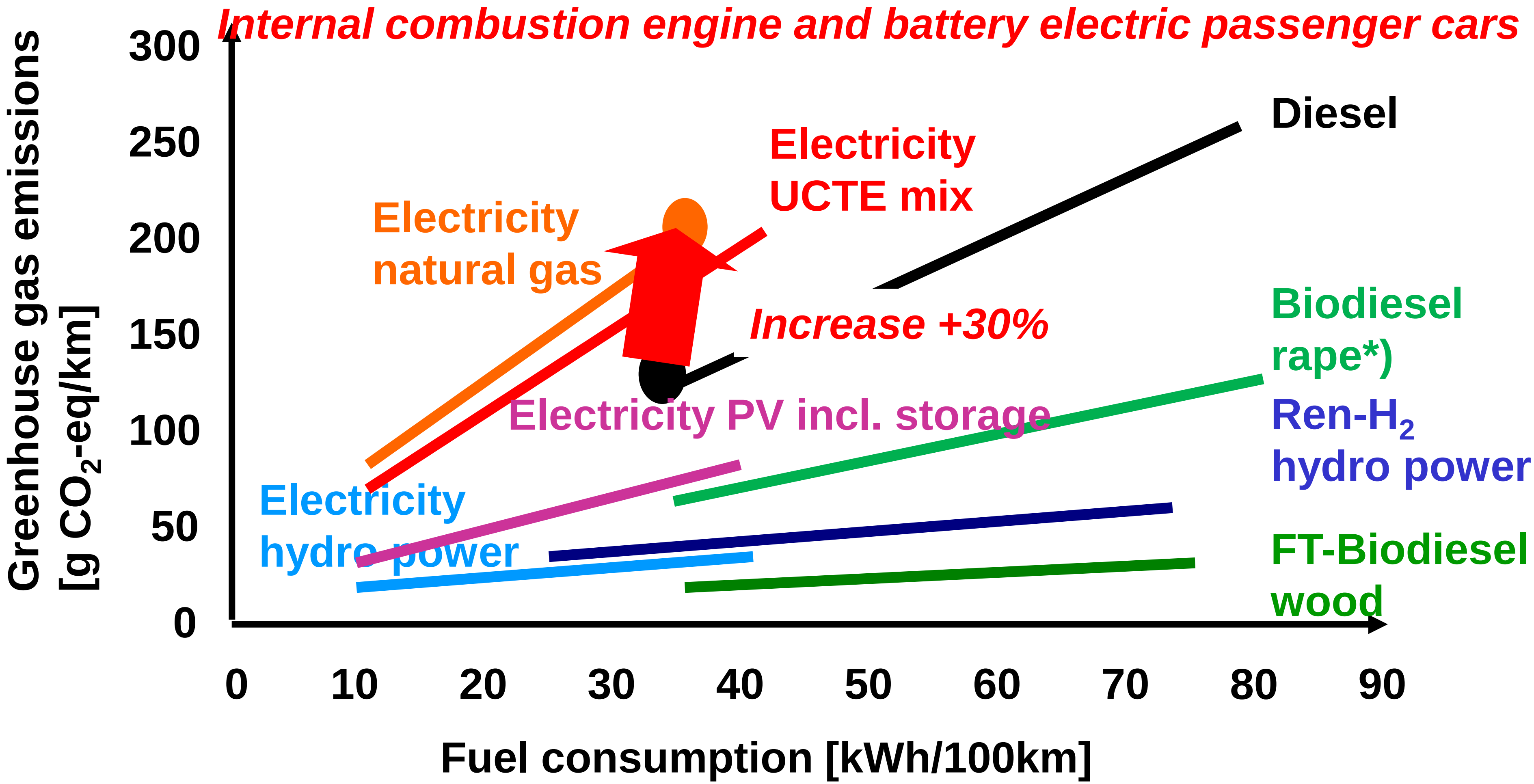
The 2 Keys: Renewable & Energy Efficiency



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

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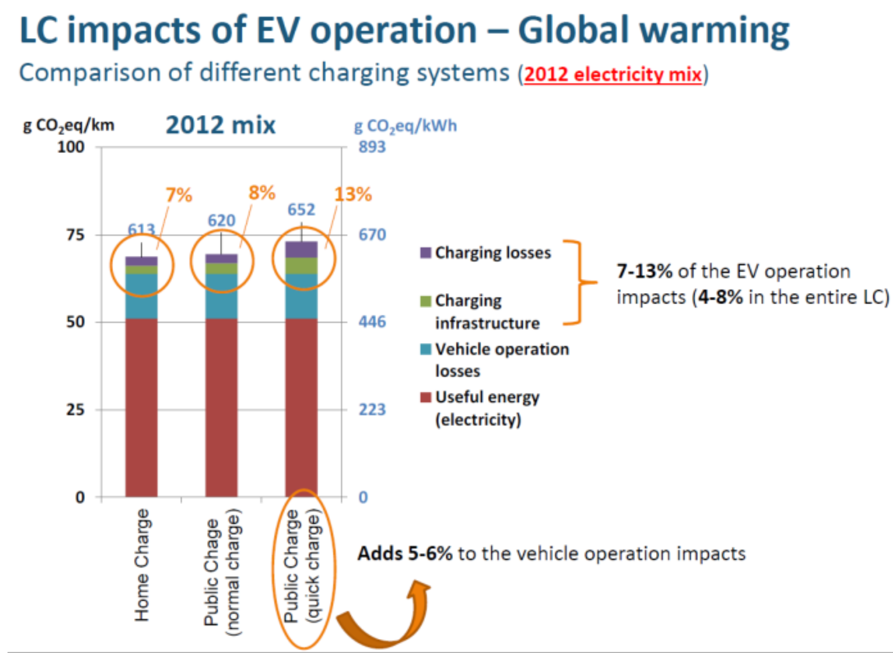
EV Charging and LCA

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

<u>Example from IEA Workshop in Task 19, Barcelona. Oct 2014:</u>
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



➢ <u>Charging losses infrastructure + battery: roughly 15-20%</u>
<u>(90-95% infrastructure, 90% battery)</u>

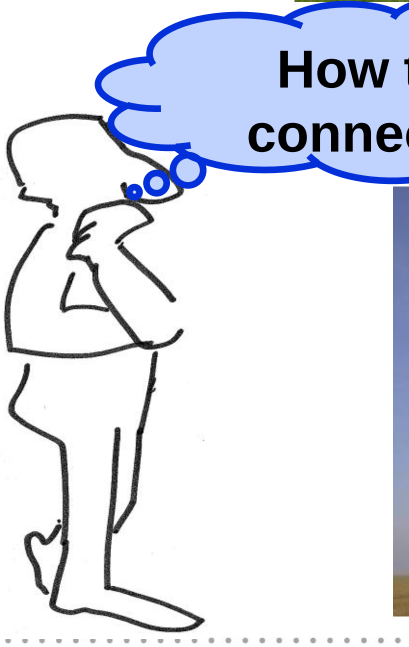
➢ <u>EV charging adds roughly 5-10 g CO2 äq/km</u>

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

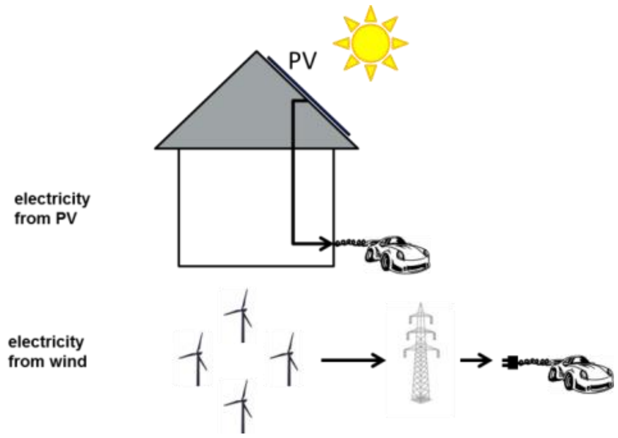
Fuel cycle - additional renewable electricity

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

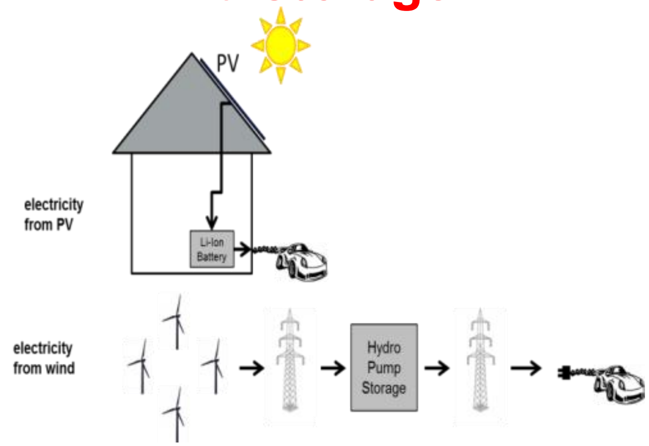


Charging of EVs with Additional Renewable Electricity

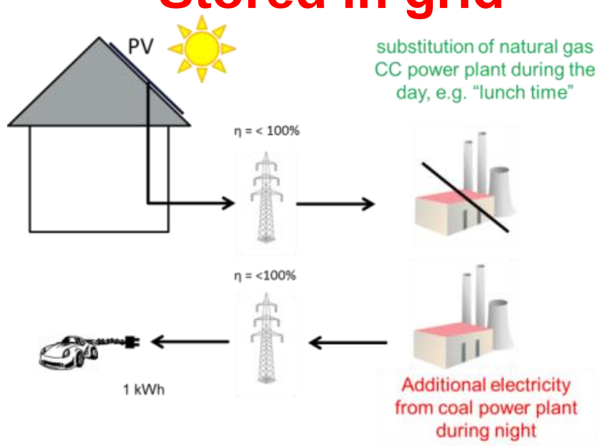
“Direct connection”



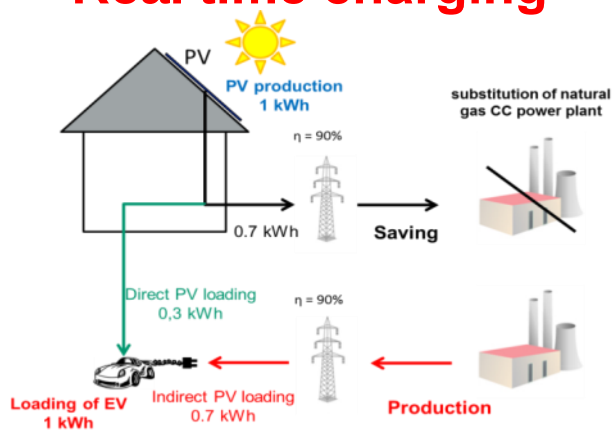
“Via storage”



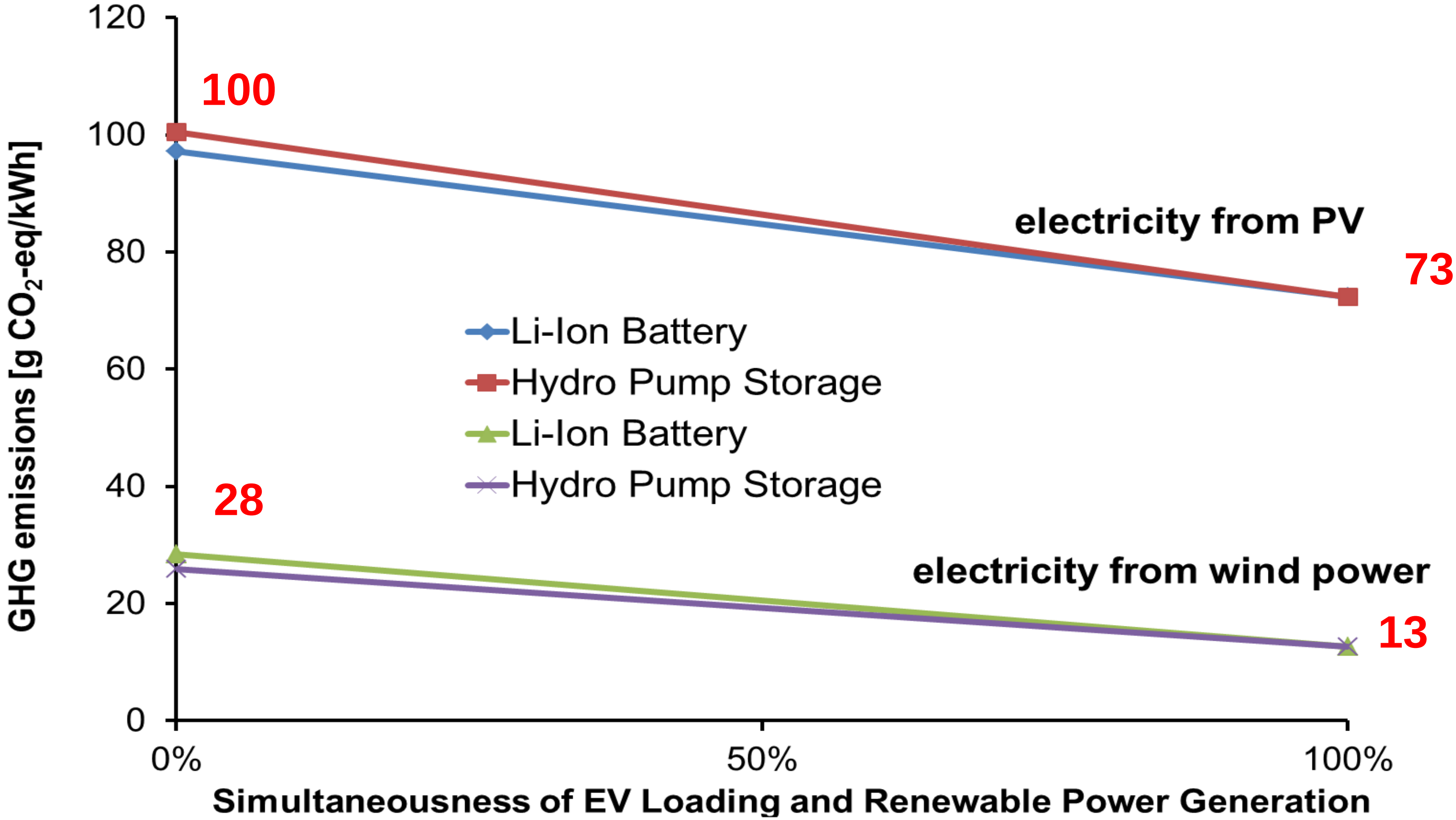
“Stored in grid“



“Real time charging”



Emissions of LoadingStrategies with Additional Renewable Electricity



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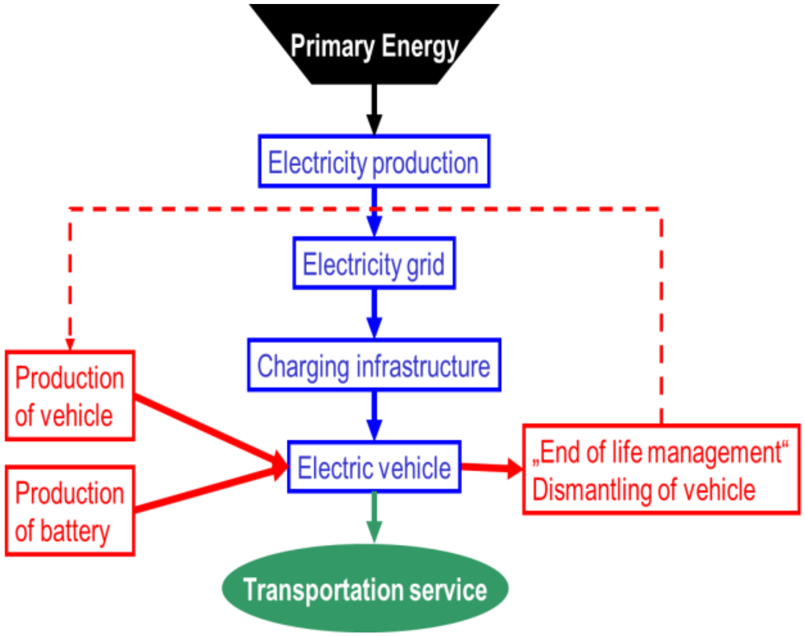
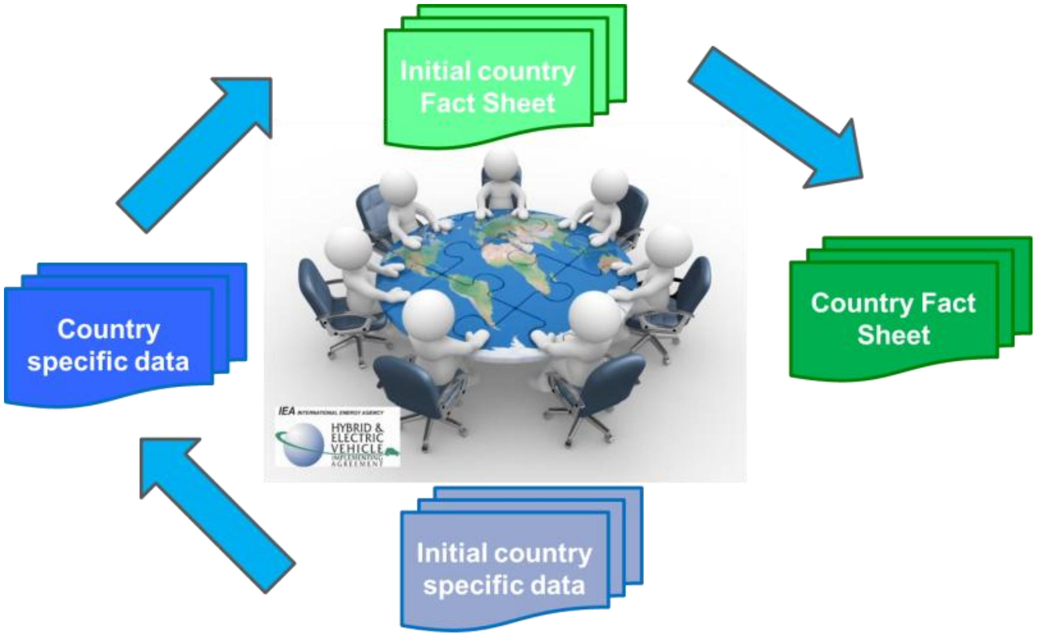
Aim of IEA-HEV Project "FACTS & FIGURES"

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

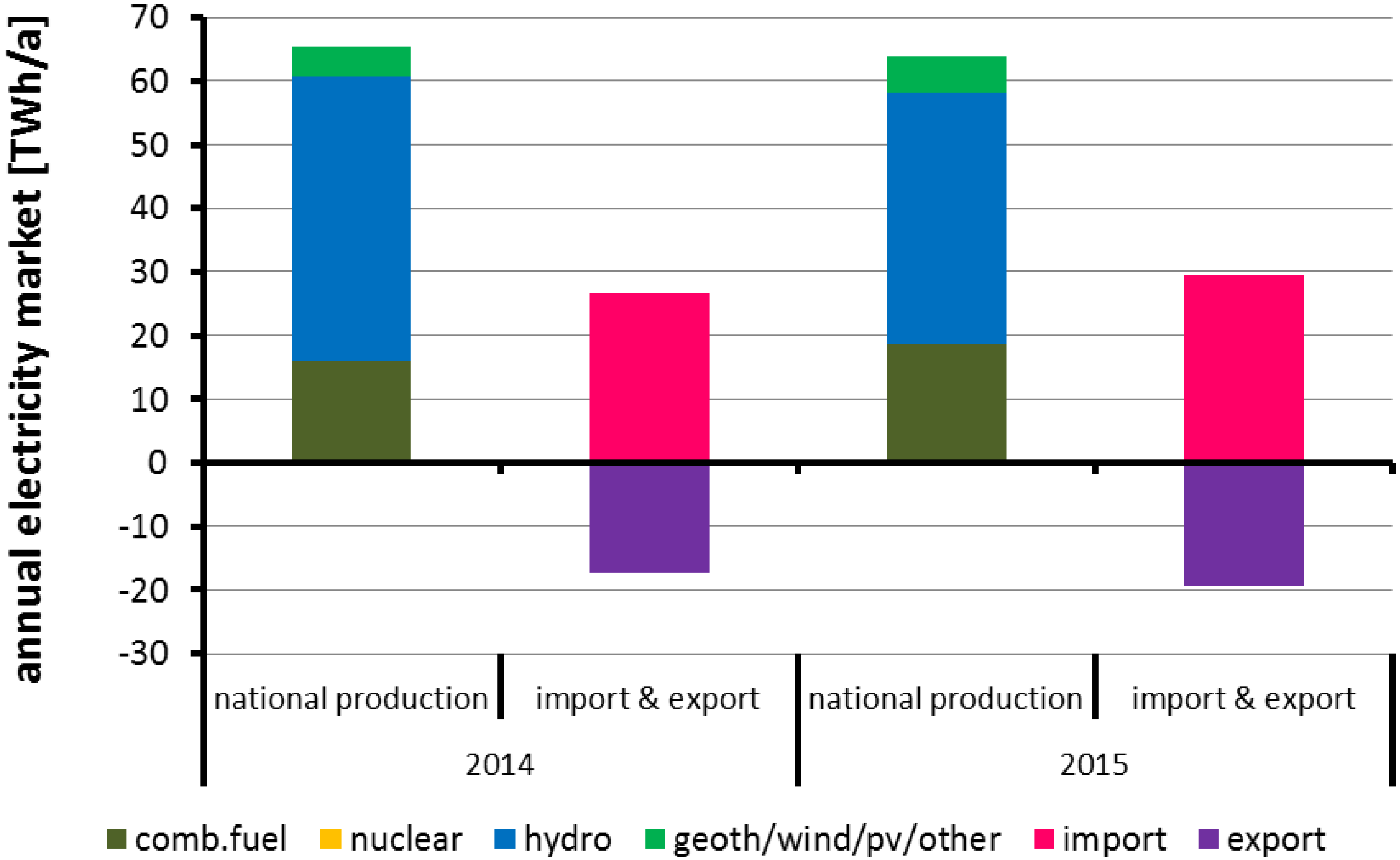
Based on LCA achievements in IEA HEV since 2011





BASIC DATA: National Electricity Market

Austria

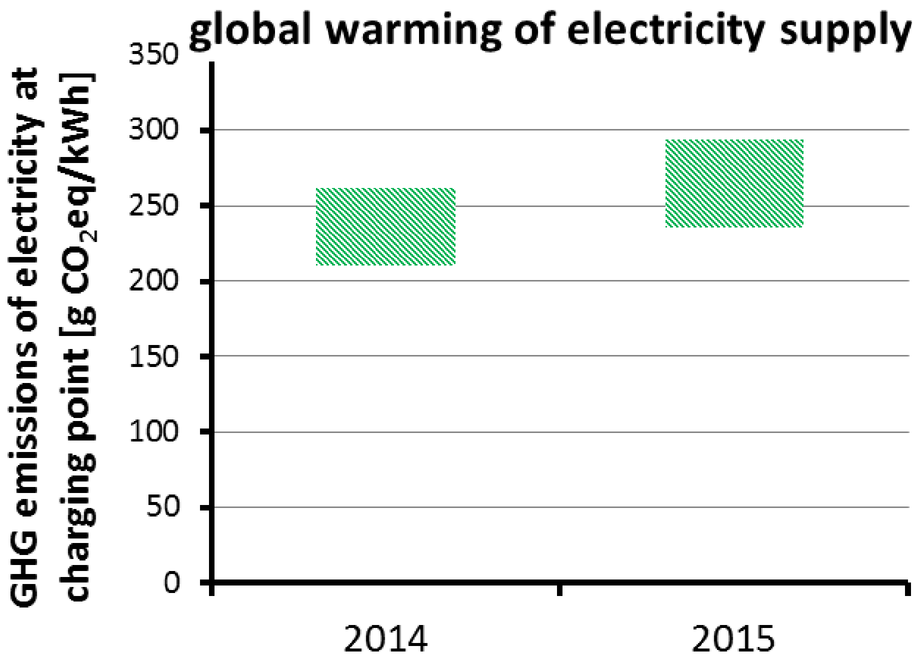


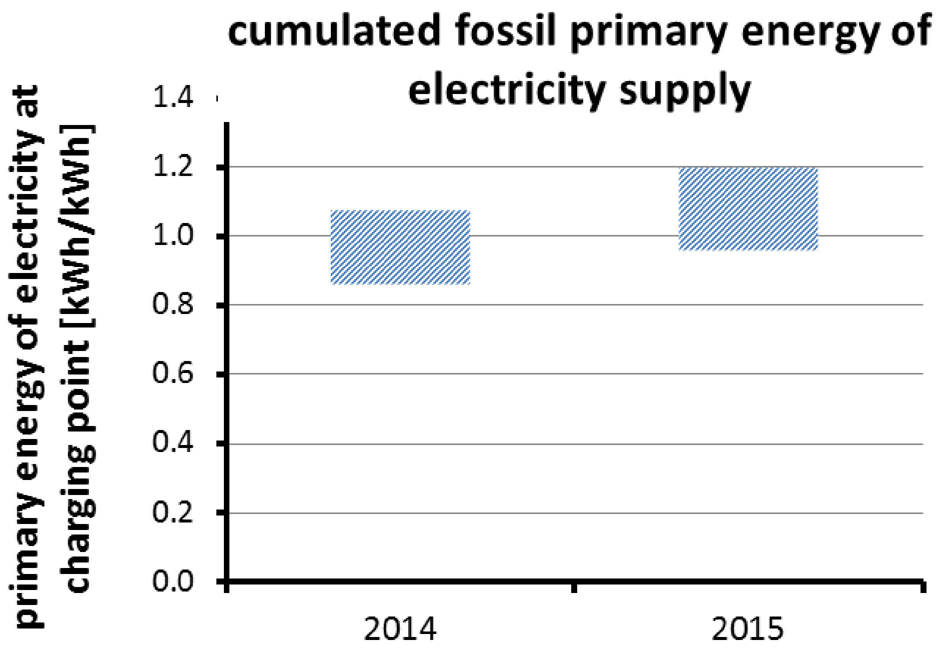
Source: IEA statistics

http://www.iea.org/statistics/statisticssearch/report/?country=ITALY&product=electricityandheat&year=201x

BASIC DATA: Estimated Environ. Effects of Electricity

Austria



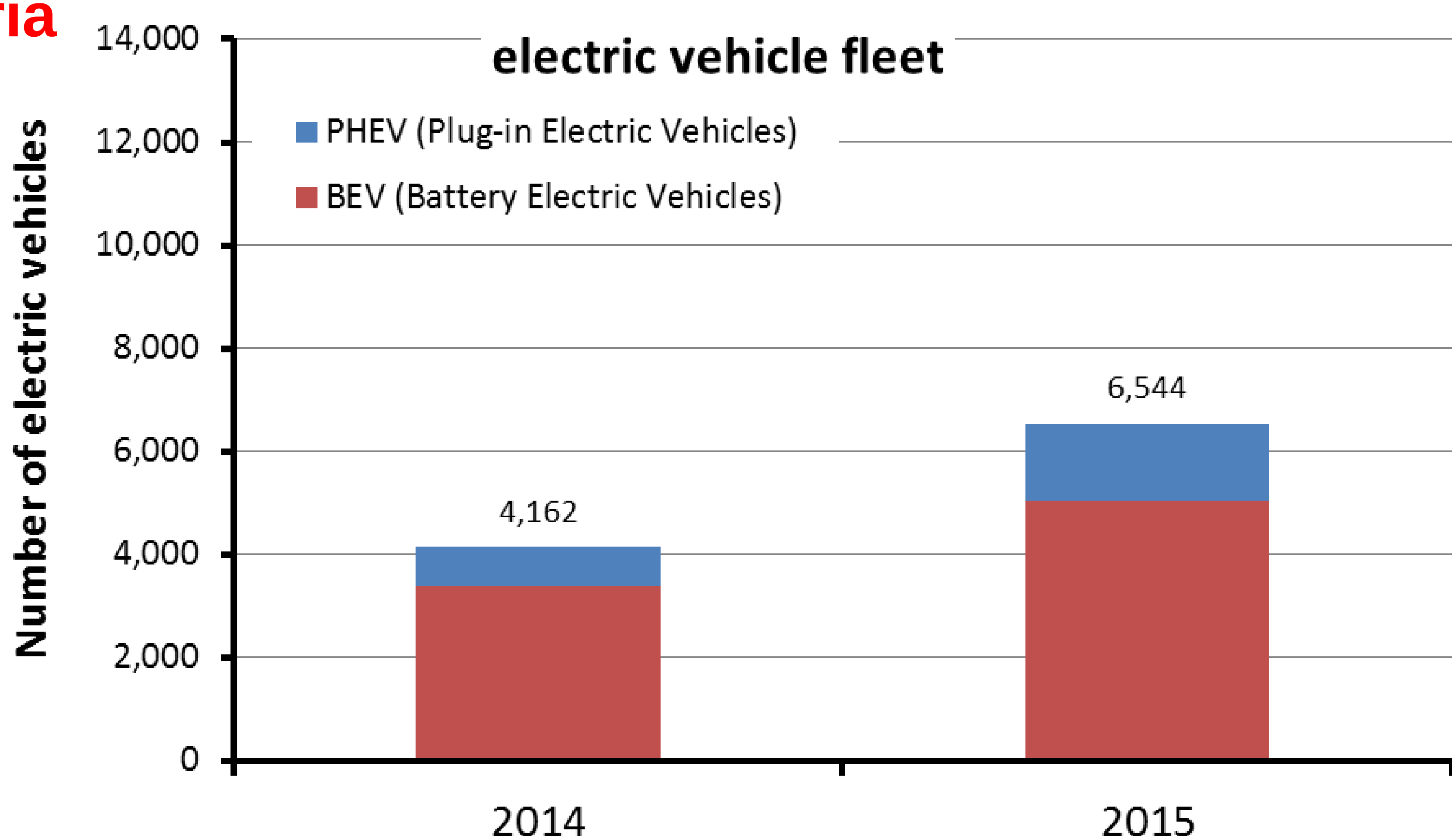


Source: own calculations using data from ecoinvent and GEMIS

BASIC DATA: Number of Electric Vehicle

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

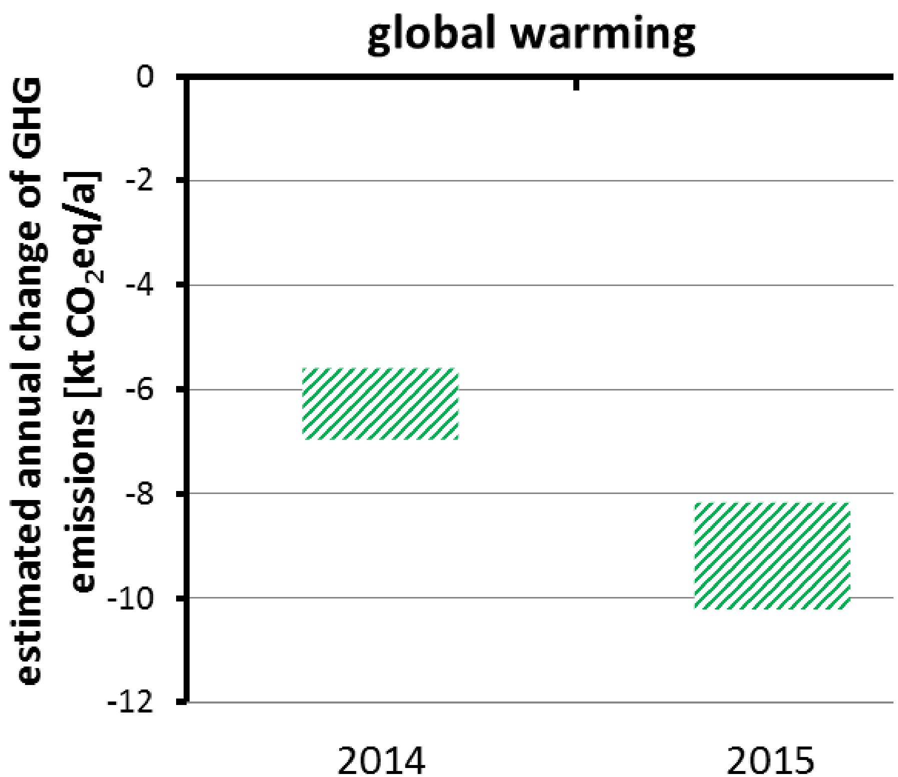
Austria

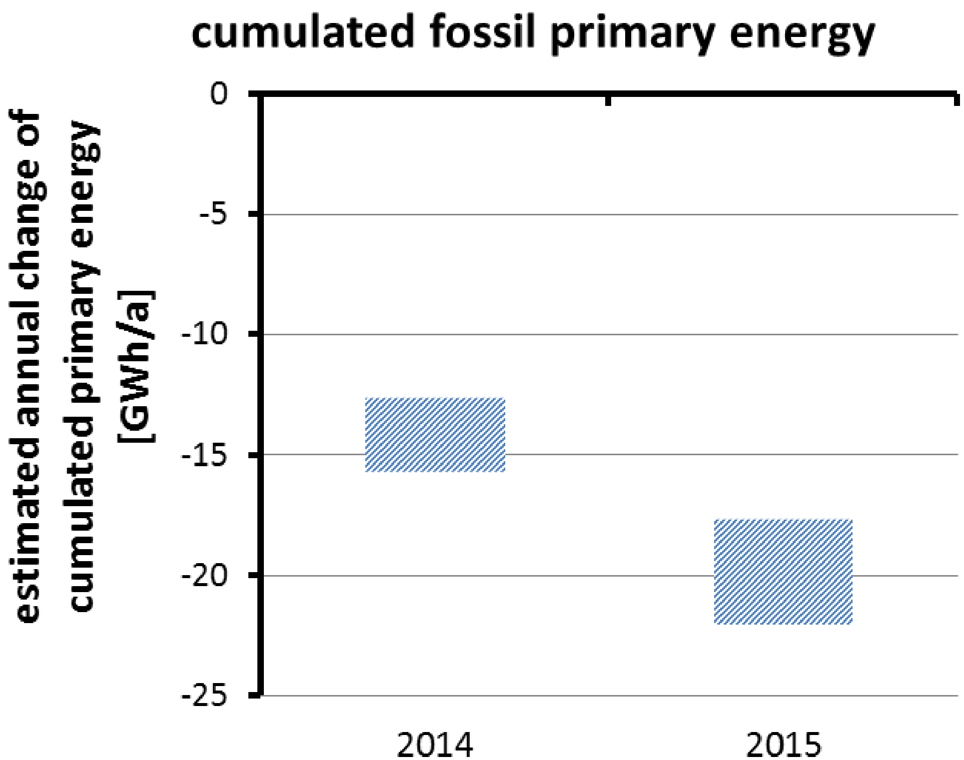


Source: IEA HEV annual report, EVI, ExCo members

ENVIRONMENTAL EFFECTS: Estimated Annual Change of national EV Fleet

Austria

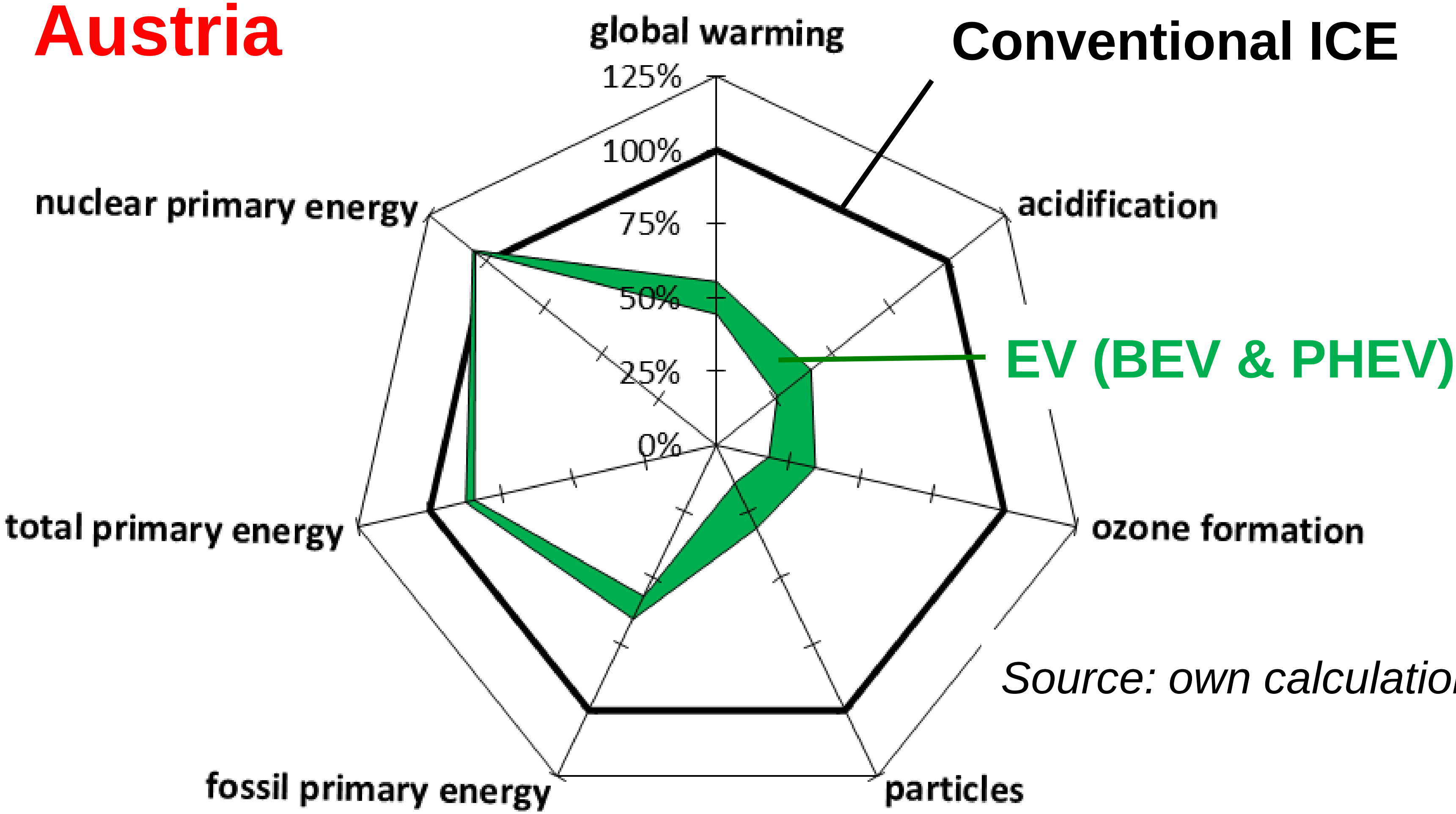




Source: own calculations

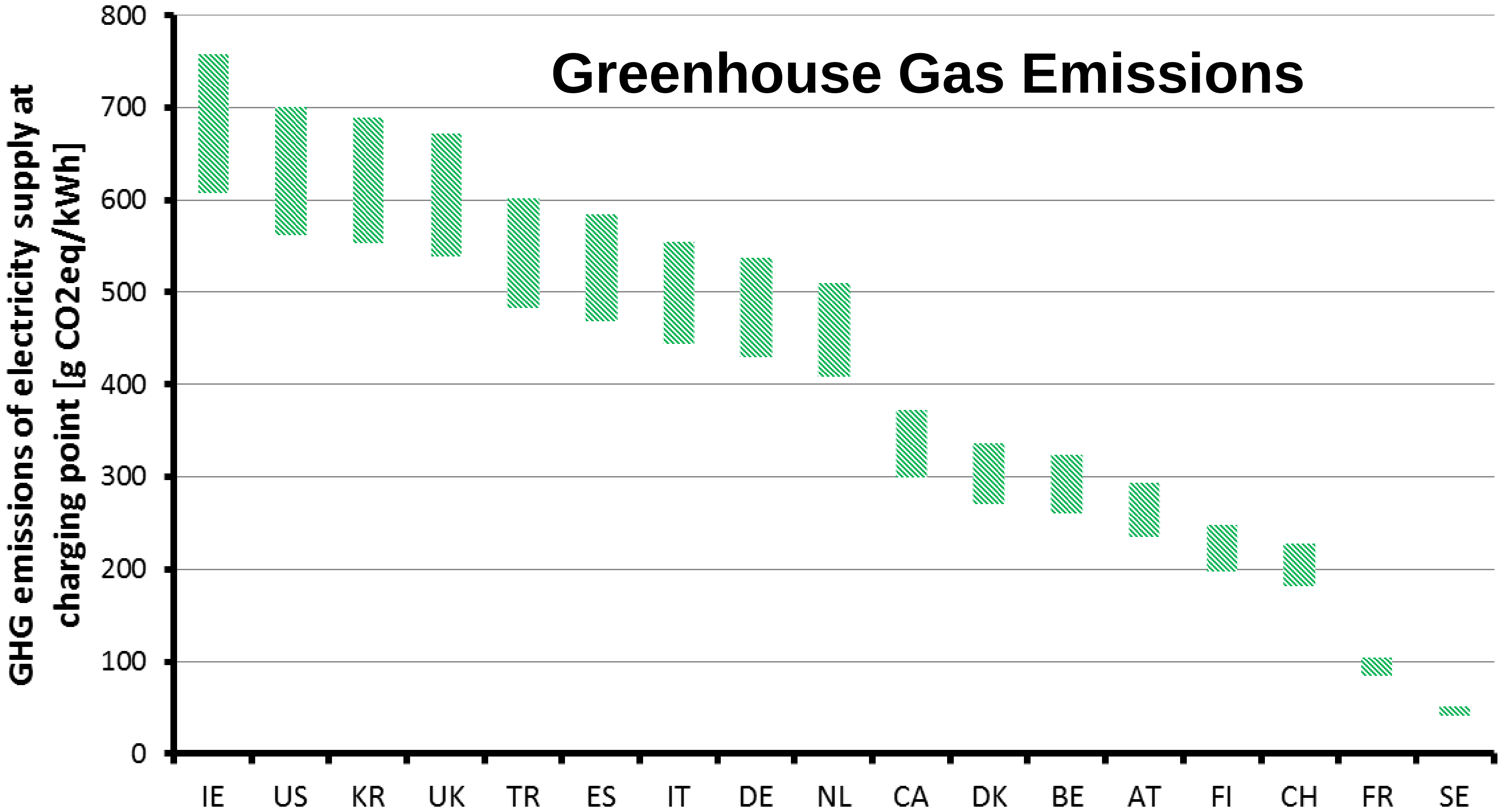
ENVIRONMENTAL EFFECTS: Comparison ICE and BEV&PHEV

Austria



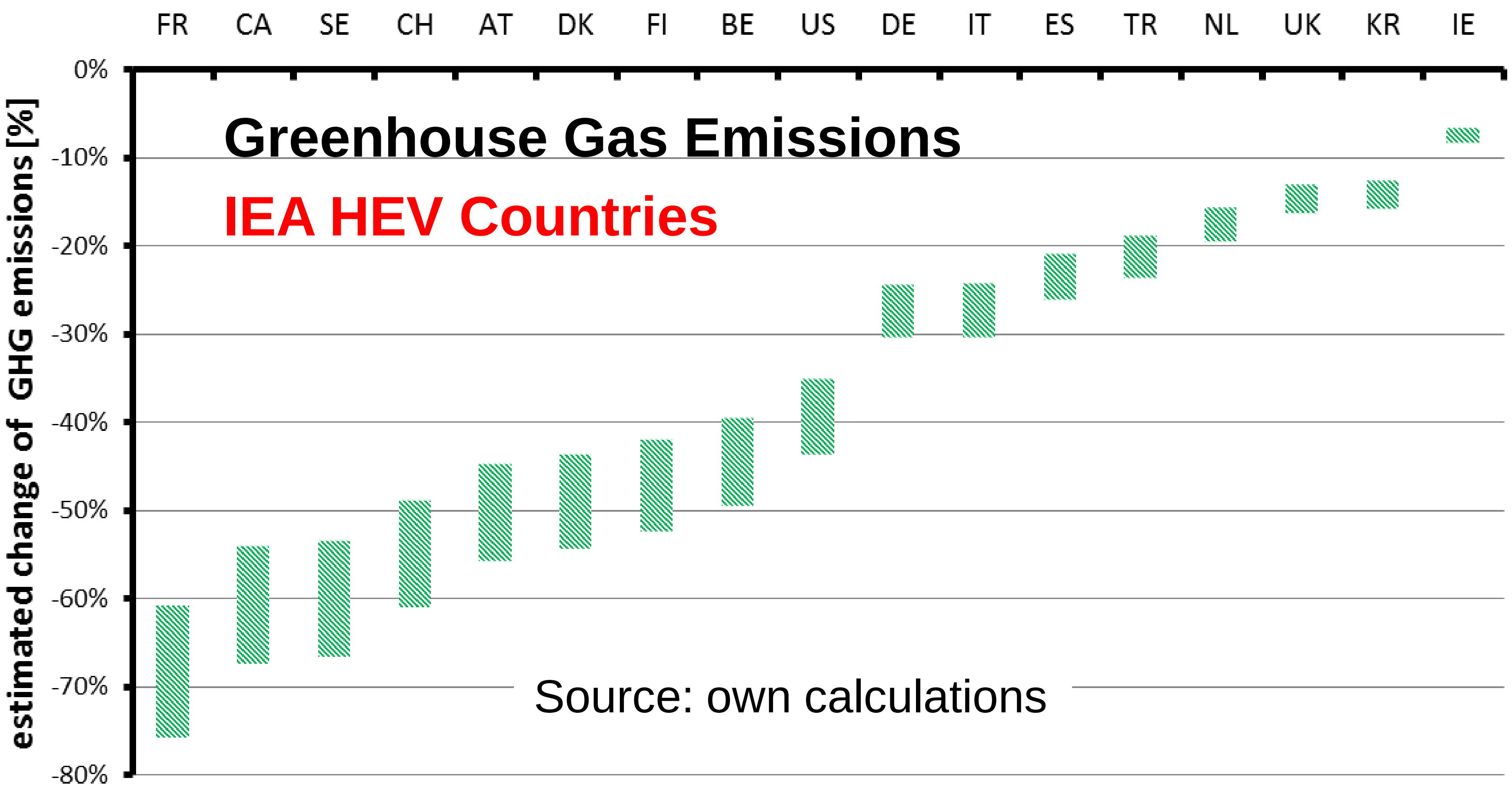
Source: own calculations

BASIC DATA: Estimated Environ. Effects of Electricity

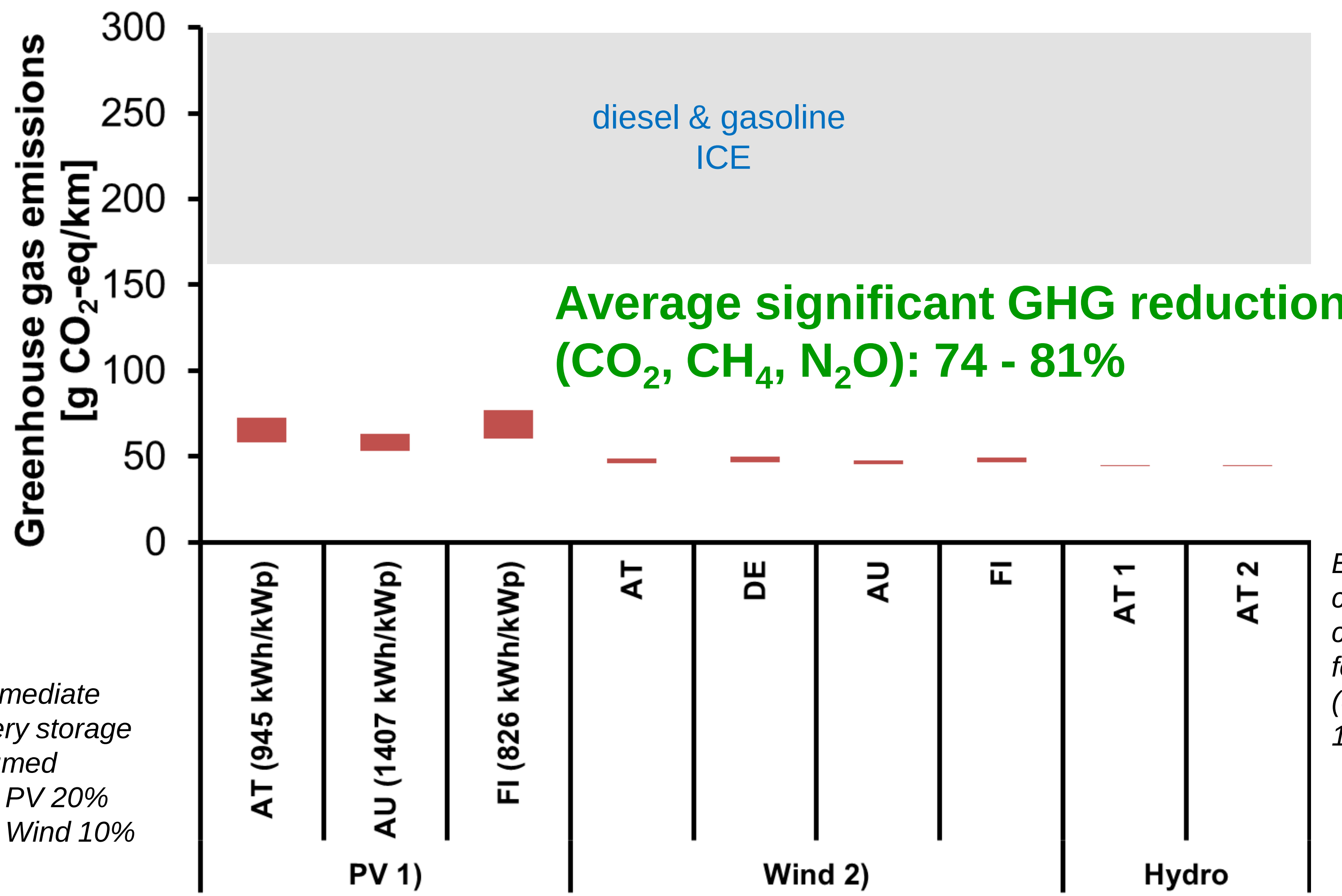


Source: own calculations using data from ecoinvent and GEMIS

ENVIRONMENTAL EFFECTS: Estimated Change ICEV – EV



GHG Emissions of Electric Vehicles - Renewable Electricity



Electricity consumption EV at charging point for real driving cycle (e.g. heating/cooling): 15 – 30 kWh/100 km

Intermediate battery storage assumed

1) PV 20%

2) Wind 10%

Source: own calculations using data of ecoinvent

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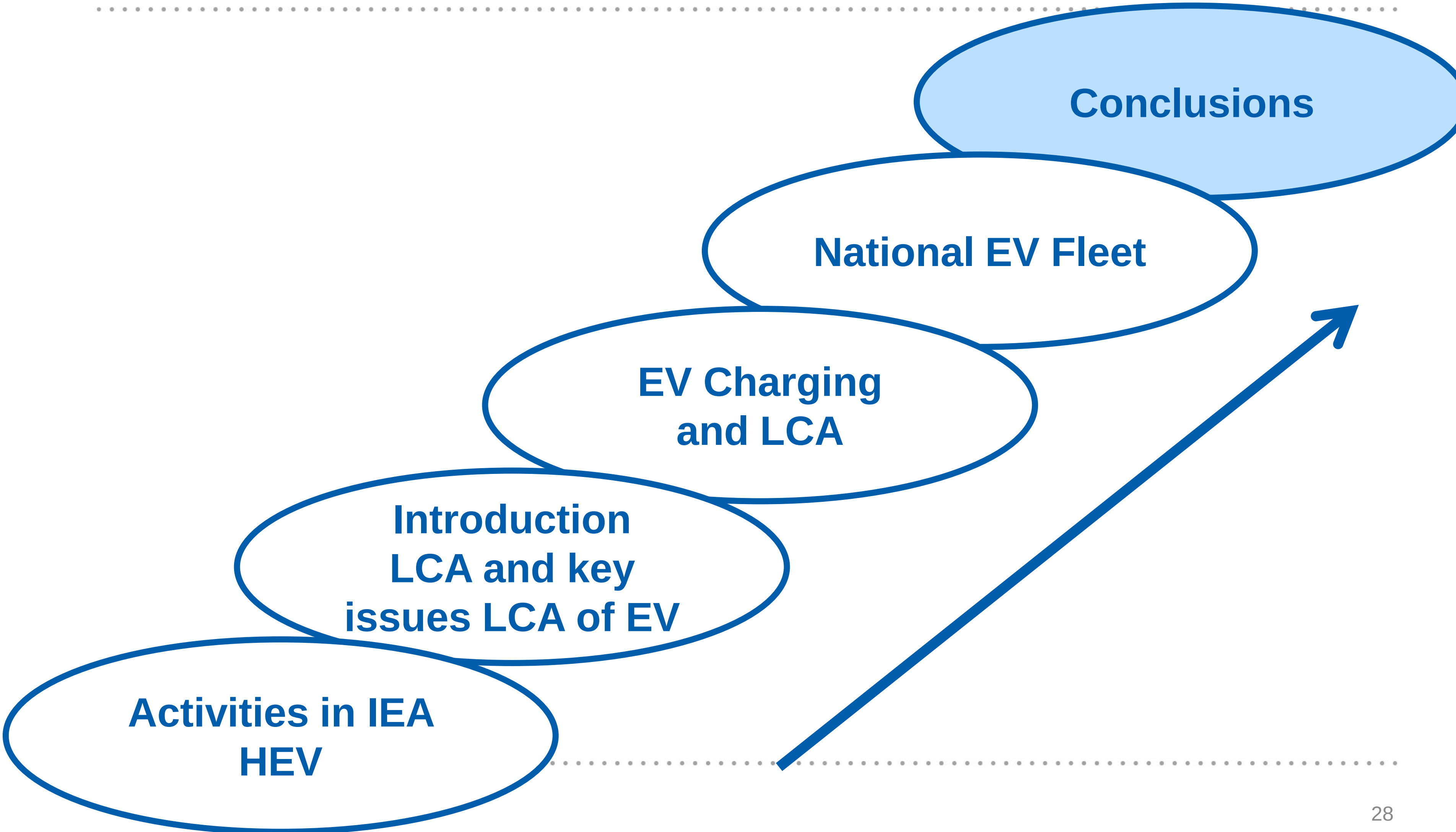
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Summary

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

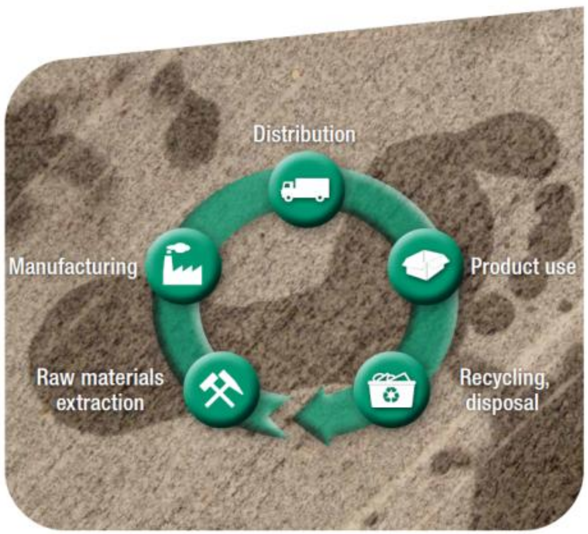
Additional renewable electricity with adequate charging strategies is essential for further significant reductions

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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