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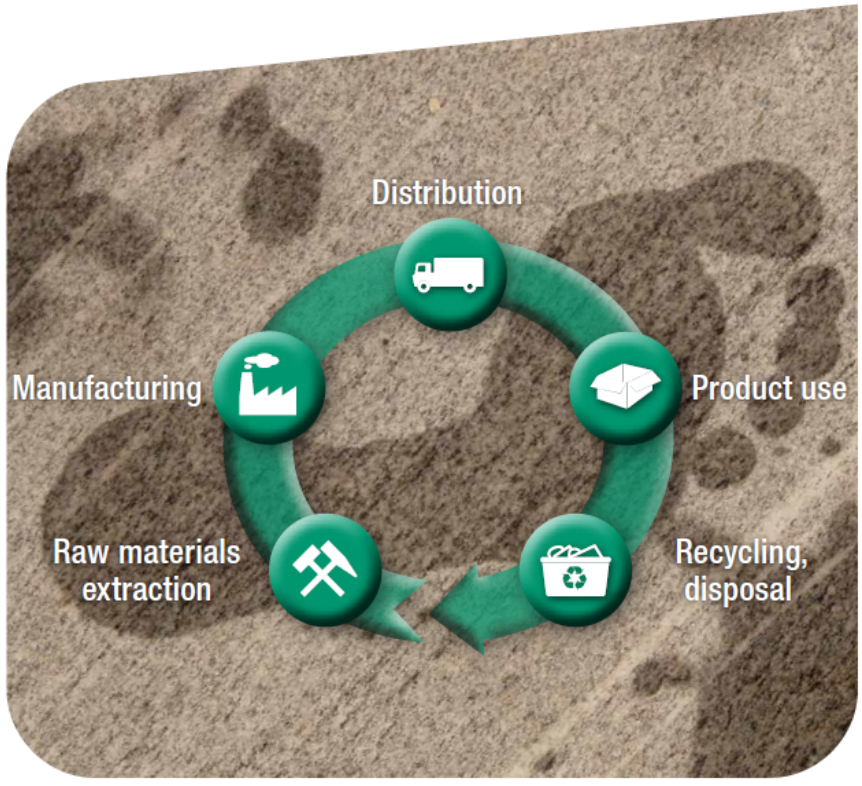
HYBRID & ELECTRIC VEHICLE TECHNOLOGY COLLABORATION PROGRAMME

JOANNEUM RESEARCH LIFE

IEA HEV Task 30 "Environmental Effects of Electric Vehicles"

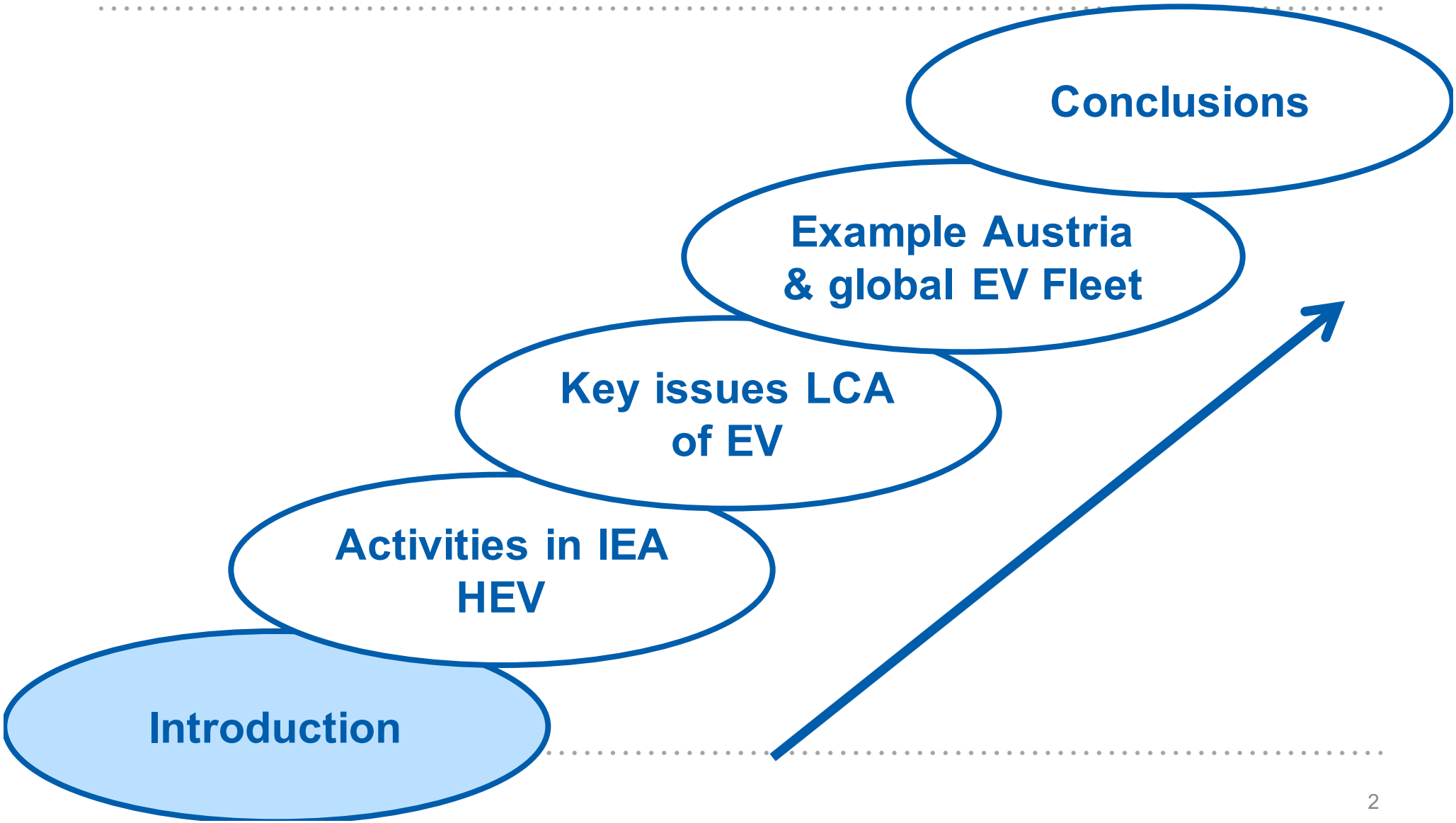
Strategies to Maximize Environmental Benefits of Electric Vehicles Using Life Cycle Assessment



Martin Beermann / Gerfried Jungmeier

MOVE webinar
November 22, 2017

Content


Introduction
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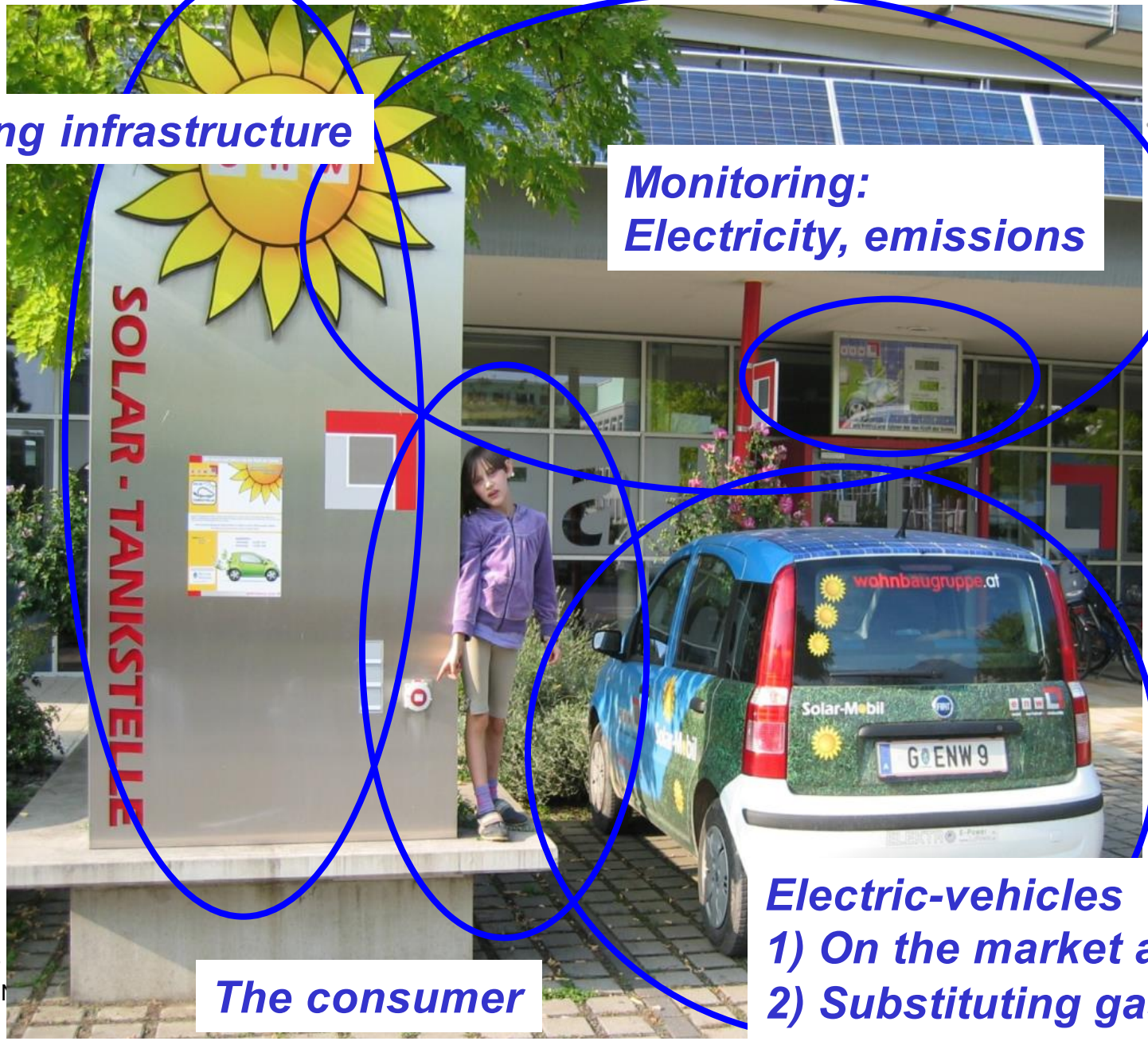
Key issues LCA of EV
Example Austria & global EV Fleet
Conclusions

Challenges for the Successful Market Introduction of Electric-Vehicles



Charging infrastructure

Monitoring:
Electricity, emissions

Additional renewable electricity

The consumer

Electric-vehicles
1) On the market available
2) Substituting gasoline&diesel

THE INI

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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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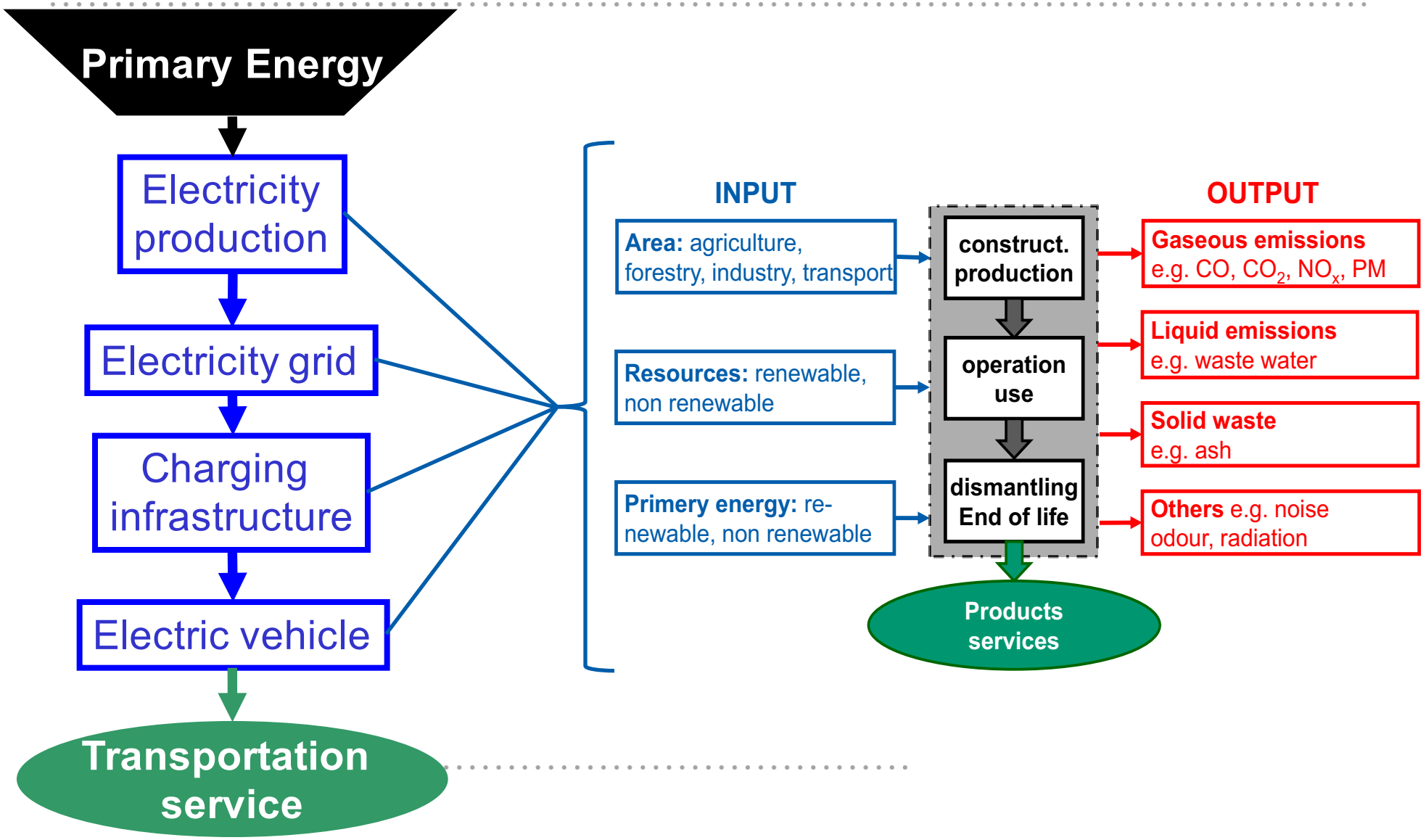
Assessment of LCA-Aspects over Full Value Chain



Sustainability in the Life Cycle based on Whole Value Chain

Sustainability

Resources & raw materials

Products & services

Environment Economy Society

Environmental, economic and social assessment of sustainability based on scientific indicators

Examples of Indicators in Life Cycle Sustainability Assessment (LCSA)

Environment

- ✓ **GHG** emissions (t CO_2-eq/a)
- ✓ **Primary energy** demand (GJ/a) (biomass, renewable, fossil, others)
- ✓ **Area** demand (ha/a)

Economy

- ✓ Production **costs** (€/a)
- ✓ **Revenues** from products (€/a)
- ✓ **Value** added (€/a)
- ✓ **Employment** (persons/a)
- ✓ **Trade** balance (€/a)

Society

- ✓ Workers
- ✓ Consumers
- ✓ **Local community**
- ✓ Society
- ✓ **Value chain actors** (excl. consumers)

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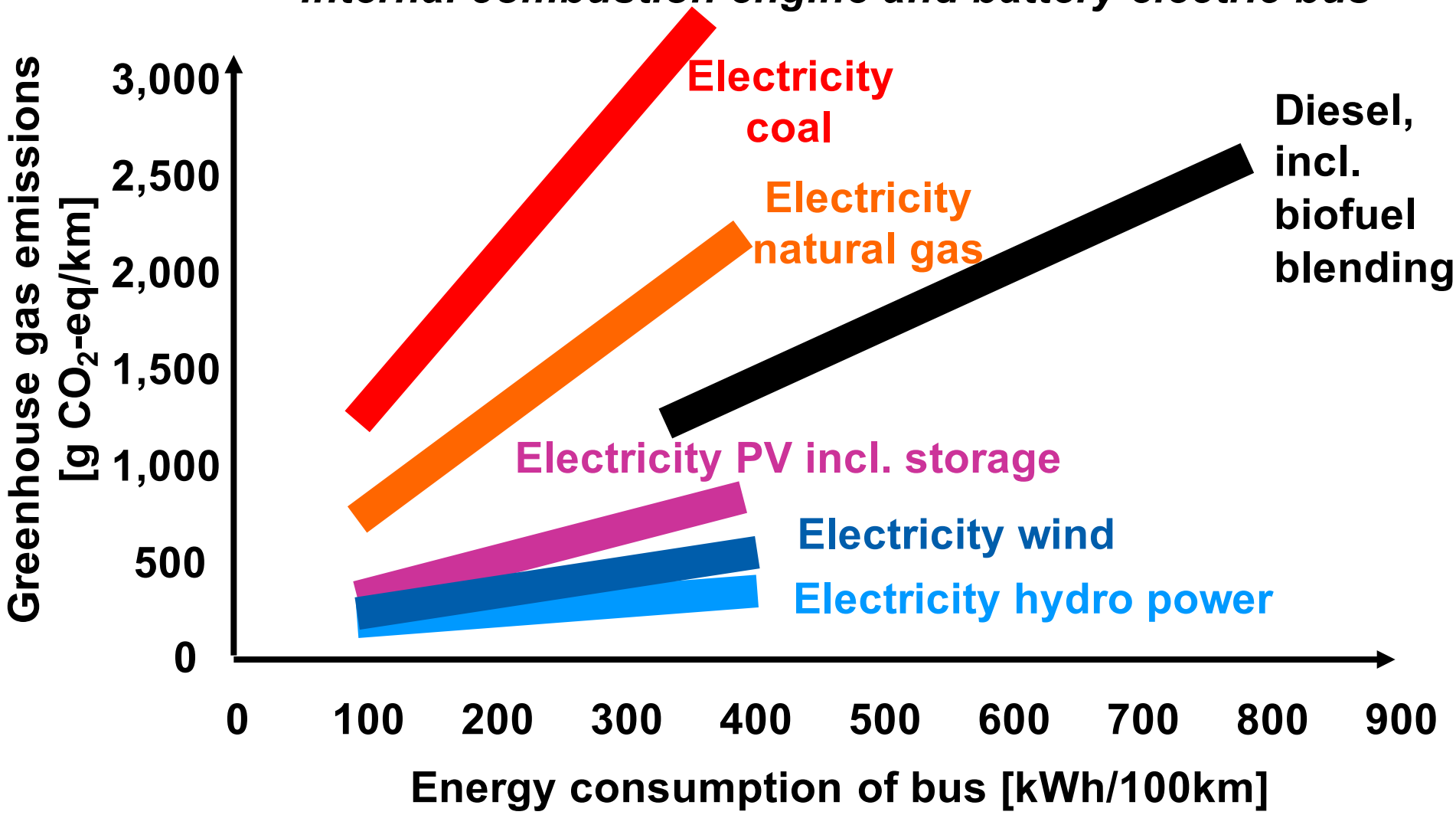
The 2 Keys: Renewable Energy &Energy Efficiency

Internal combustion engine and battery electric bus



Source: LCA of busses, Joanneum Research

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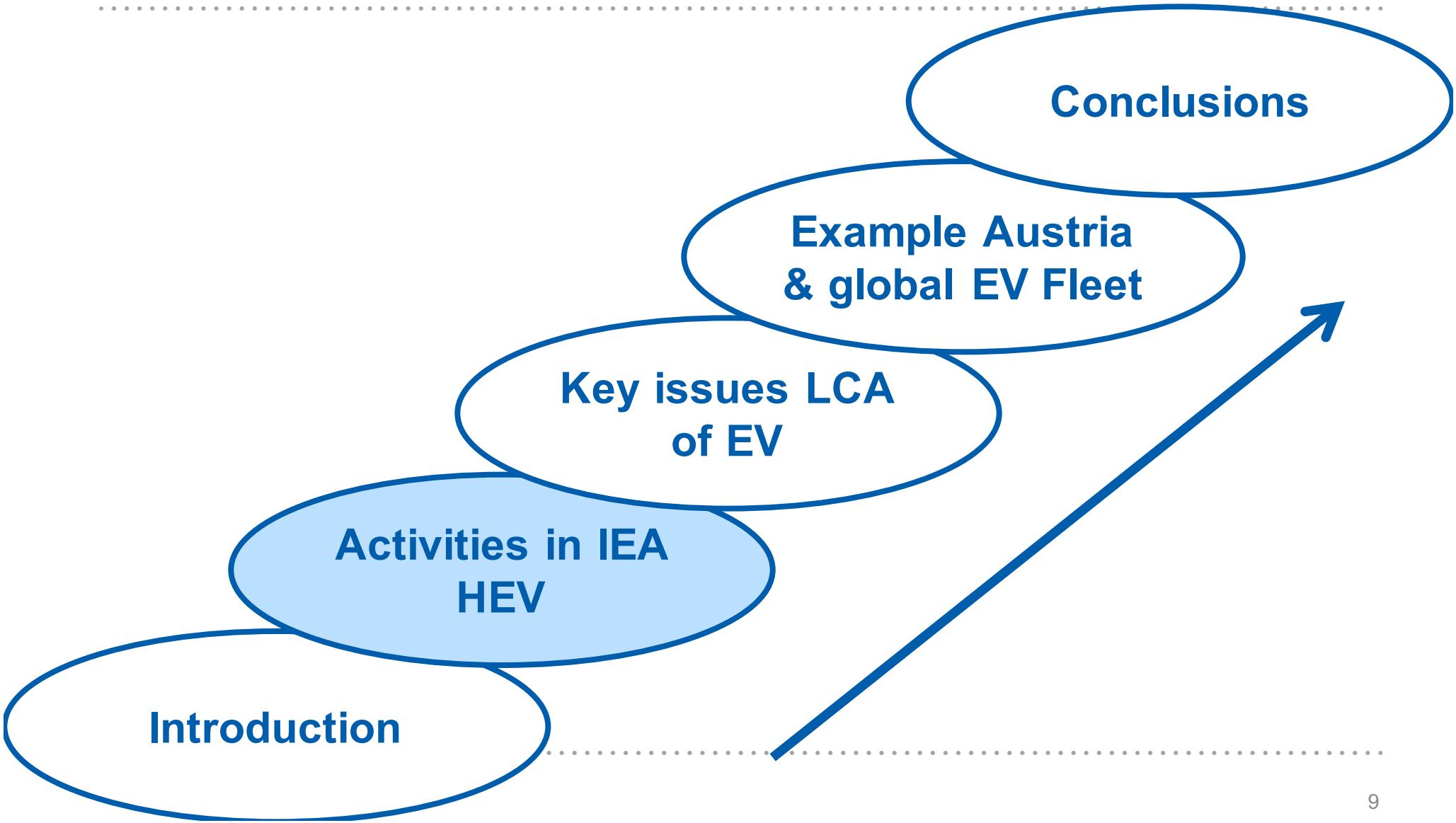
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Overview – LCA Activities in IEA HEV

- 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" (2016 – 2019)**
- IEA-HEV Project **„Facts and Figures on Environmental Benefits of EVs" (2016)**
- **Main Partnes:**

Argonne NATIONAL LABORATORY

IREC Institut de Recerca en Energia de Catalunya Catalonia Institute for Energy Research

EMPA Materials Science & Technology

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DLR Deutsches Zentrum für Luft- und Raumfahrt German Aerospace Center

CIRAIG

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Series of Workshops: 2016 – 2019

2016 | **2017** | **2018** | **2019**

CIRAIG

Final Results of Task

IREC Institut de Recerca en Energia de Catalunya Catalonia Institute for Energy Research

WS IV:"Overall environmental assessment of EVs", Barcelona/Spain 05/2019

WS III: „Effects of EVs on land use/resources/waste", Washington/USA 06/2018

Argonne NATIONAL LABORATORY

WS II: „Effects of EVs on air", Stuttgart/GERMANY, 01/2018

DLR Deutsches Zentrum für Luft- und Raumfahrt German Aerospace Center

WS I: „Effects of EVs on water", Graz/AUSTRIA 01/2017

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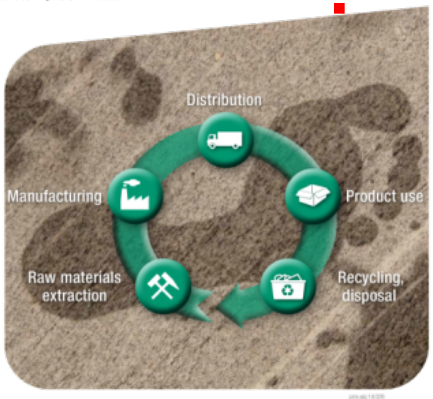
Kick-off meeting



THE INNOVATION COMPANY

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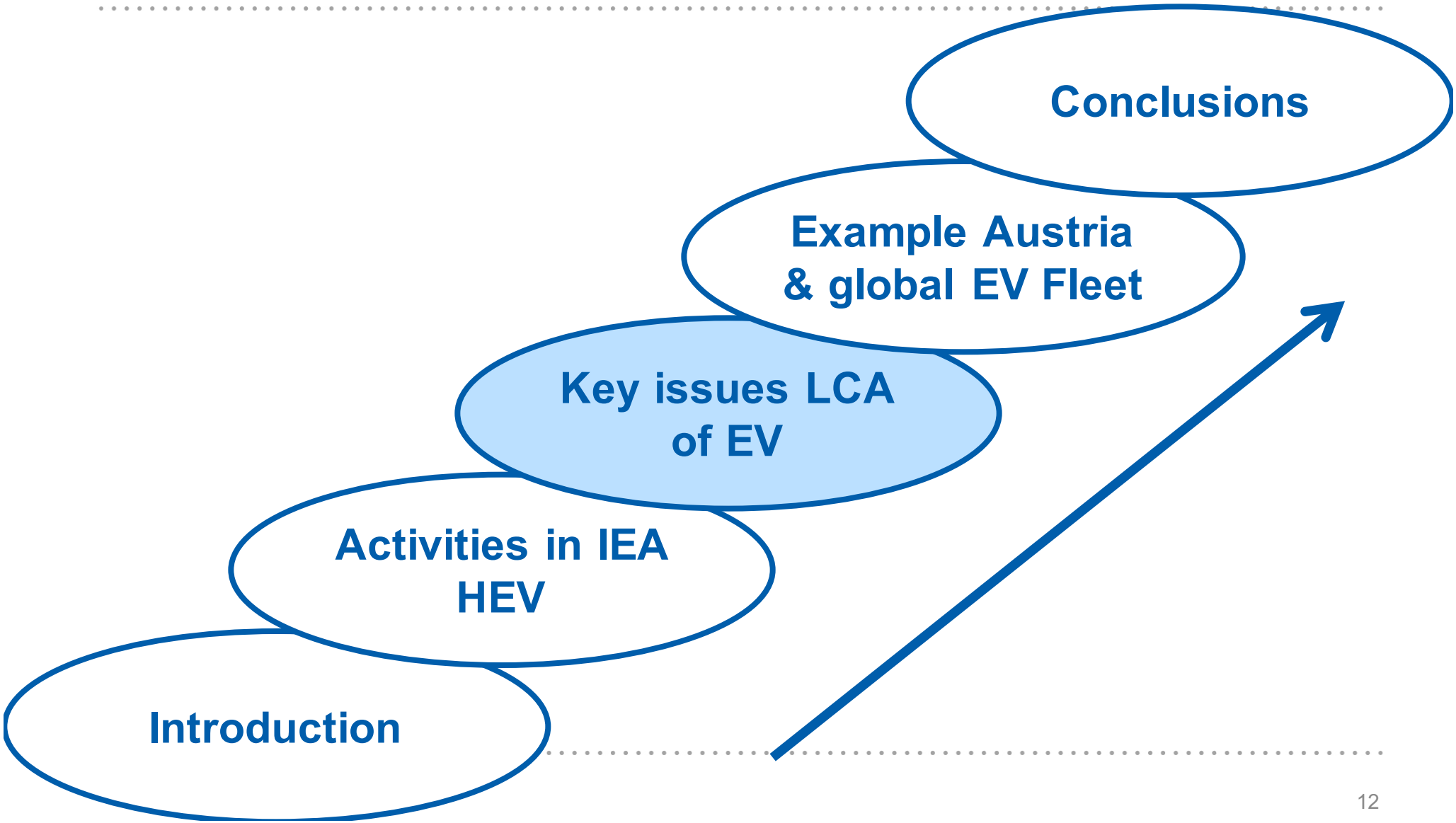
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What is LCA of electric vehicles useful for?

- 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

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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. L… …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…*** *…nsport Research Arena 2014, Paris, France, April 14-17, 2014.*

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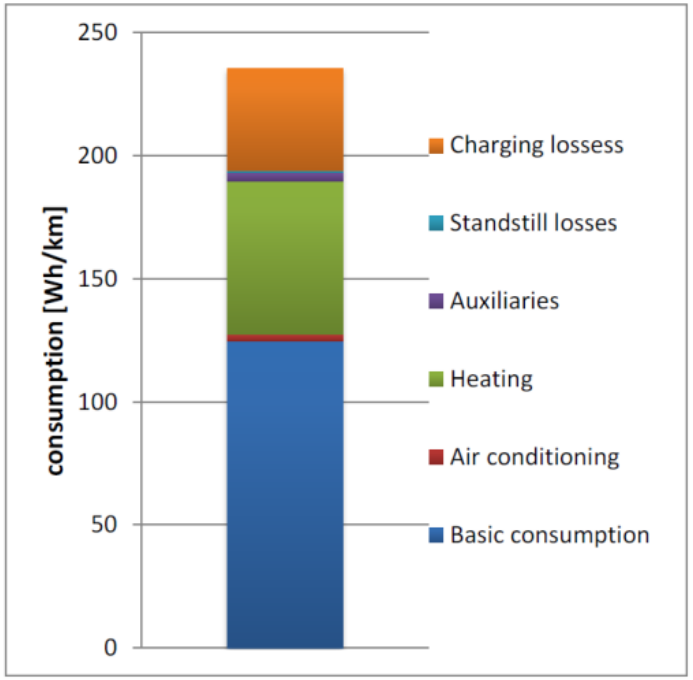
Vehicle cycle – energy consumption in the use phase

- 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!**

H.J. Althaus, Empa (2013)

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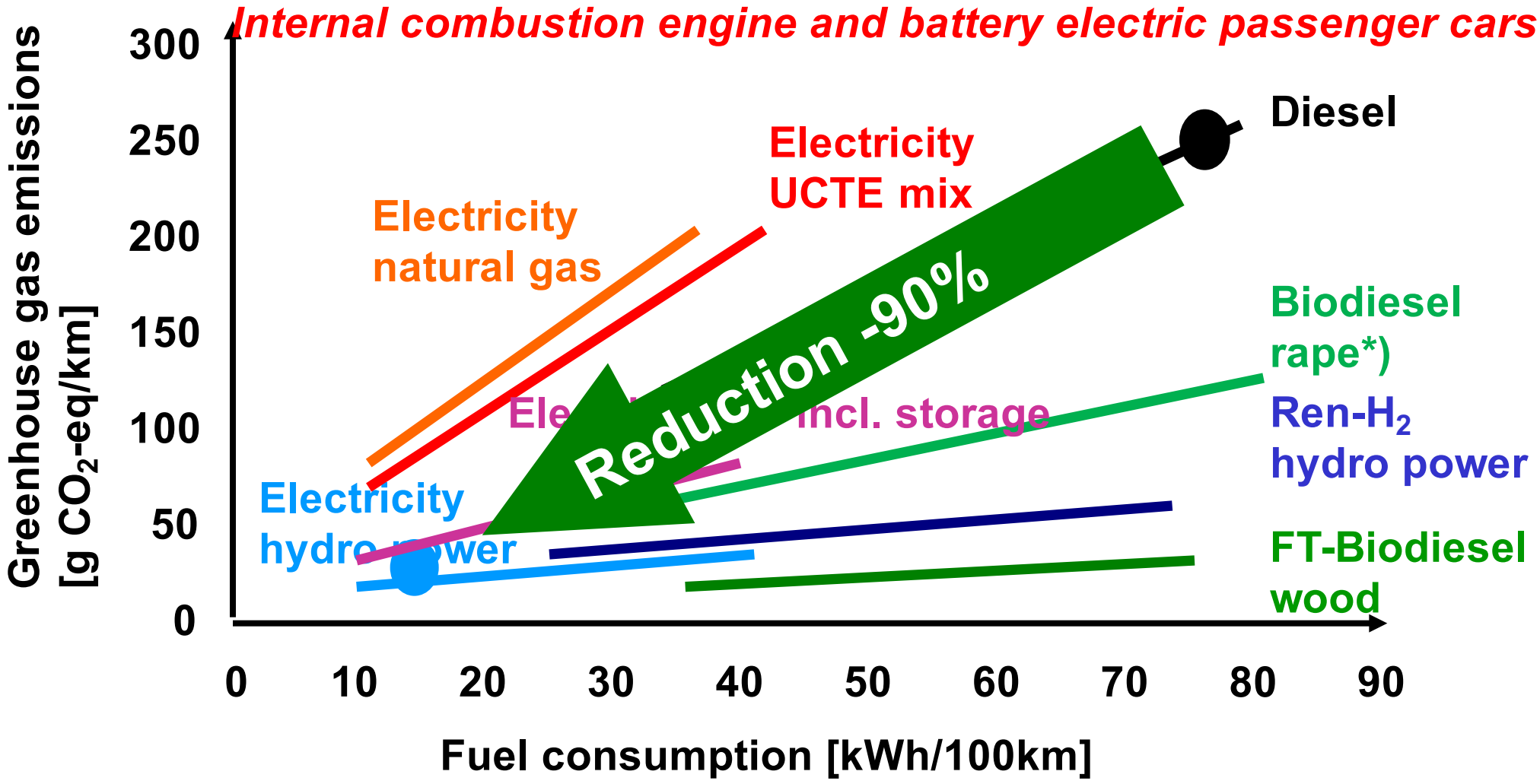
The 2 Keys: Renewable & Energy Efficiency



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

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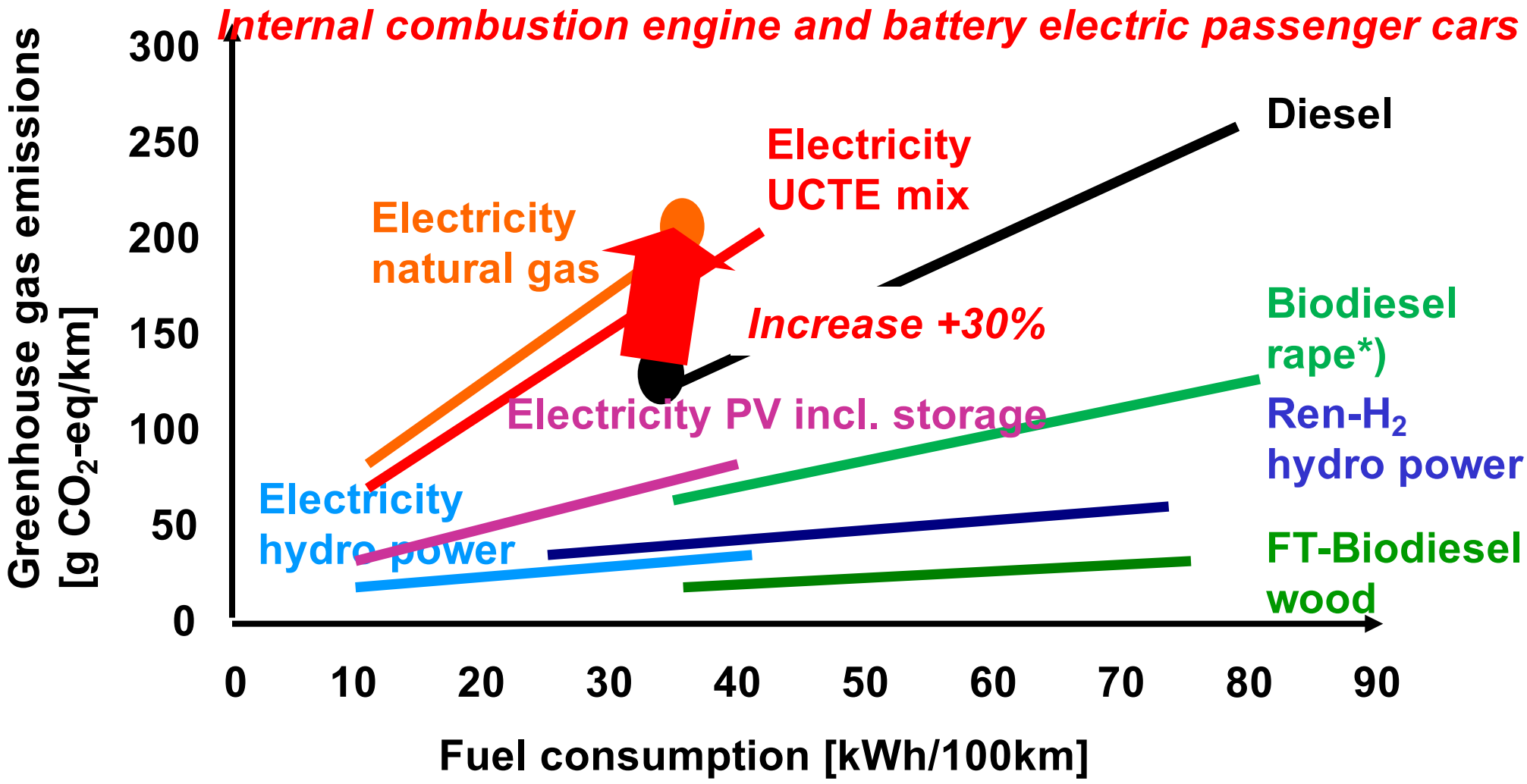
The 2 Keys: Renewable & Energy Efficiency



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

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

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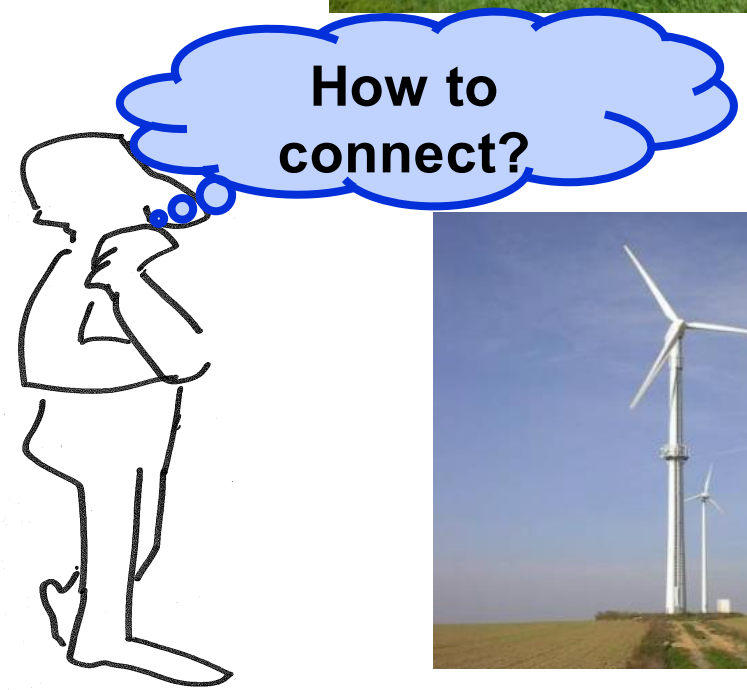
Additional Renewable Electricity Production and Electric Vehicles

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



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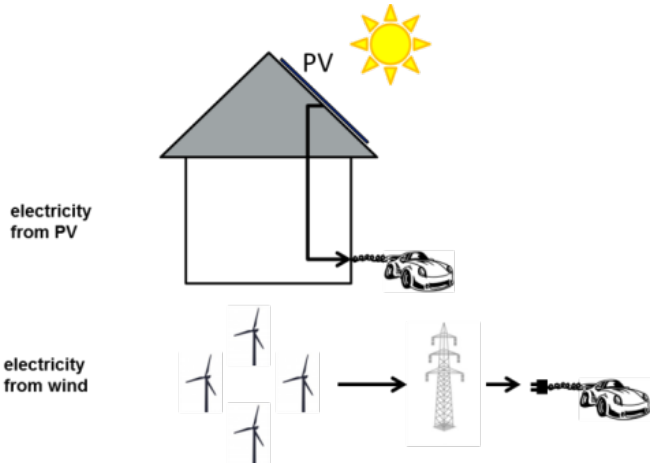
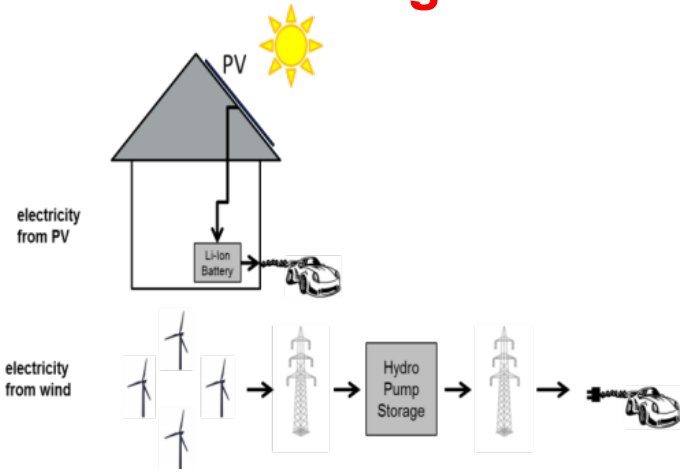
Charging of EVs with Additional Renewable Electricity

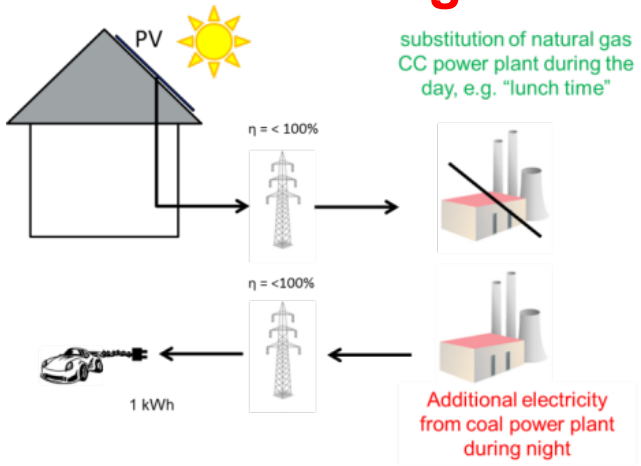
"Direct connection"



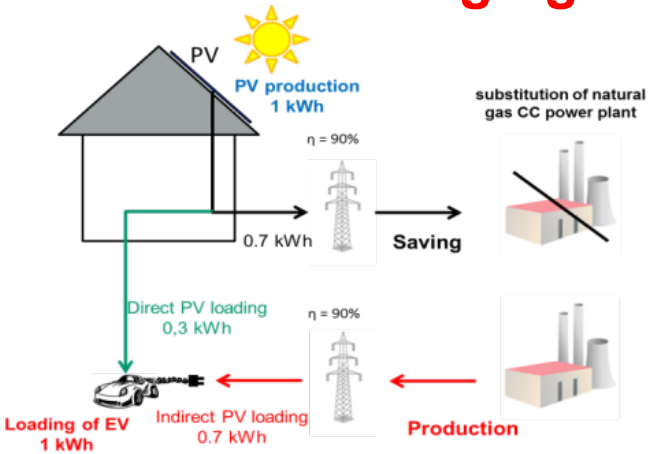
"Via storage"



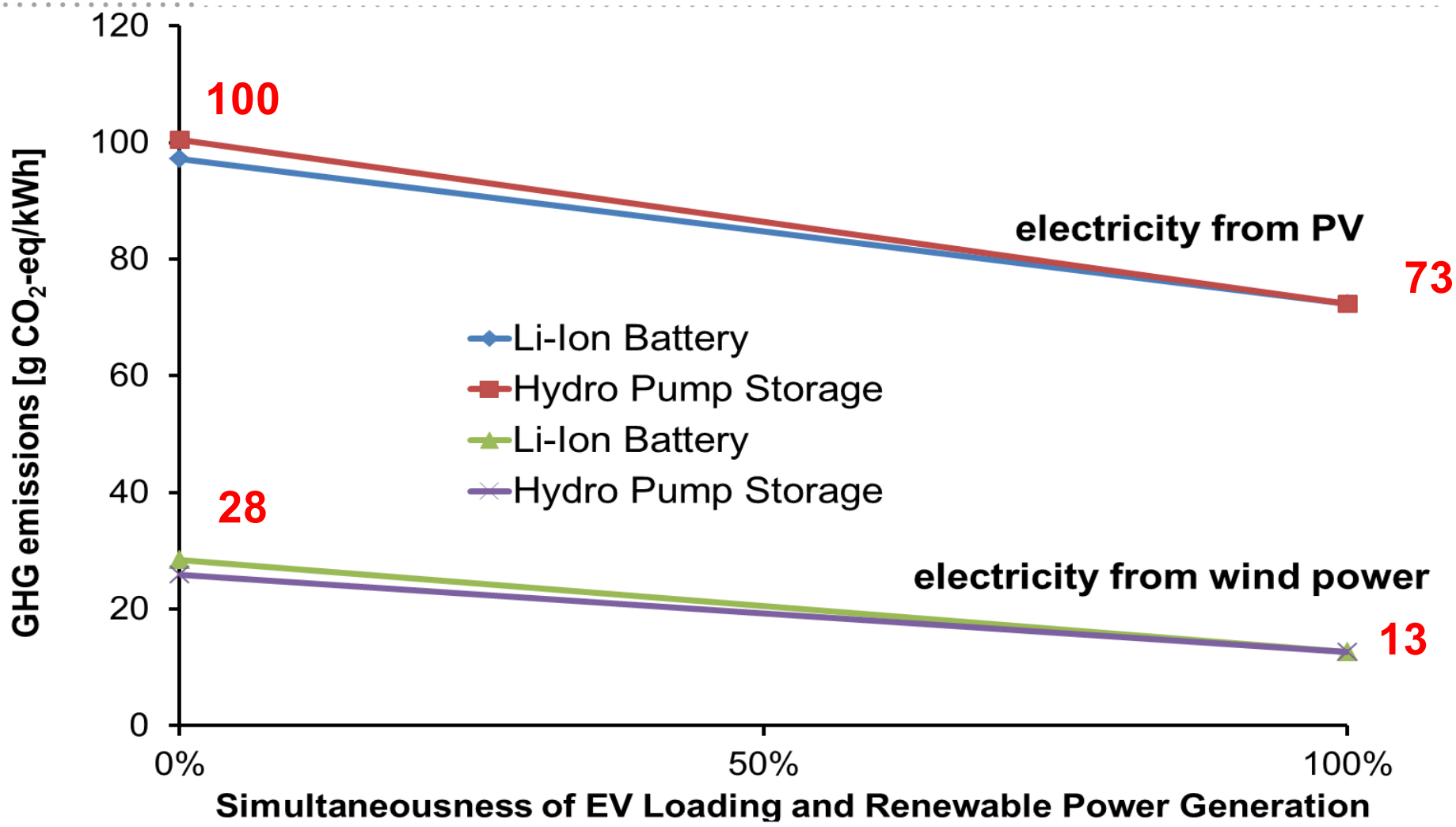
"Stored in grid"



"Real time charging"



Emissions of LoadingStrategies with Additional Renewable Electricity



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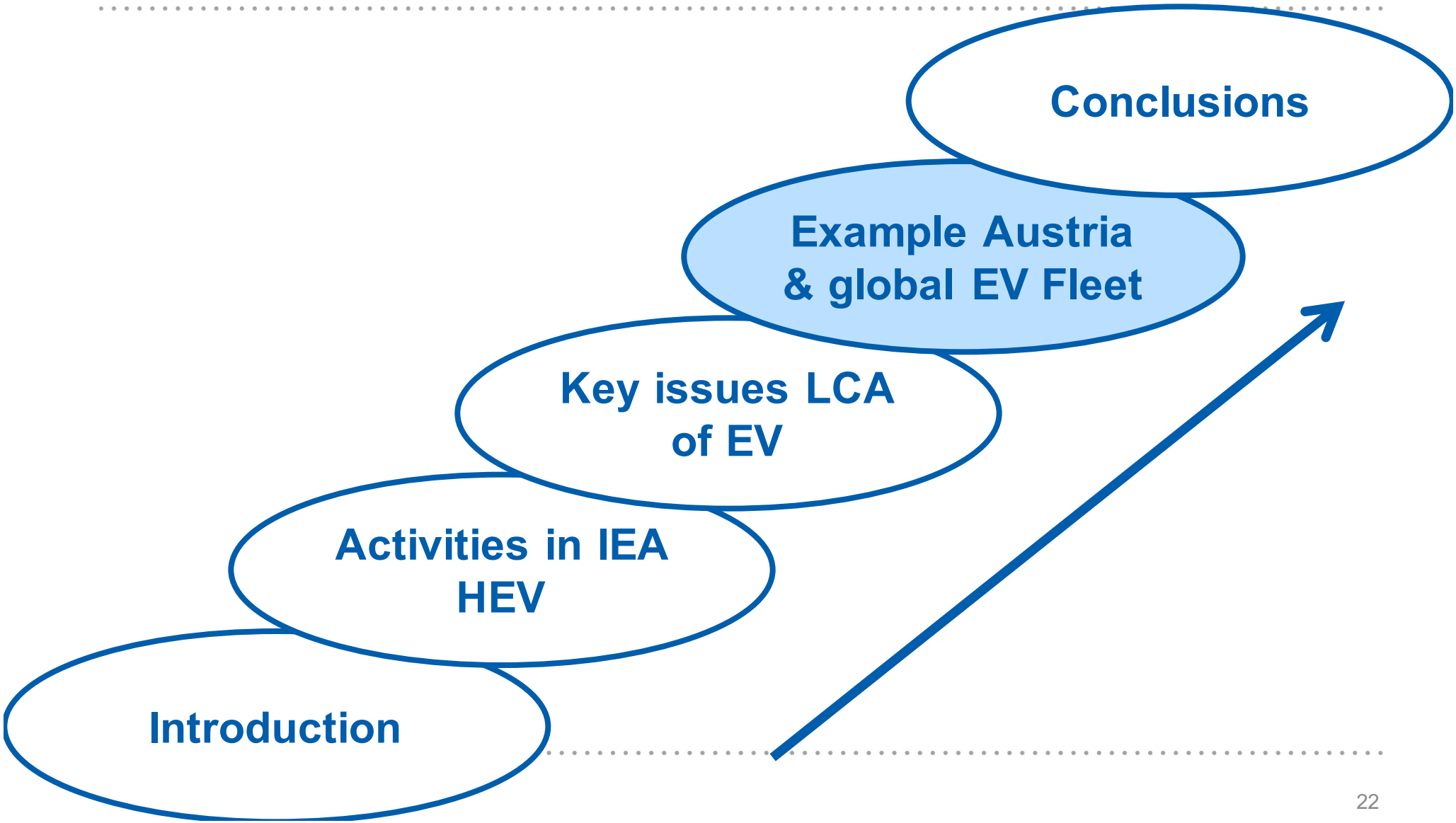
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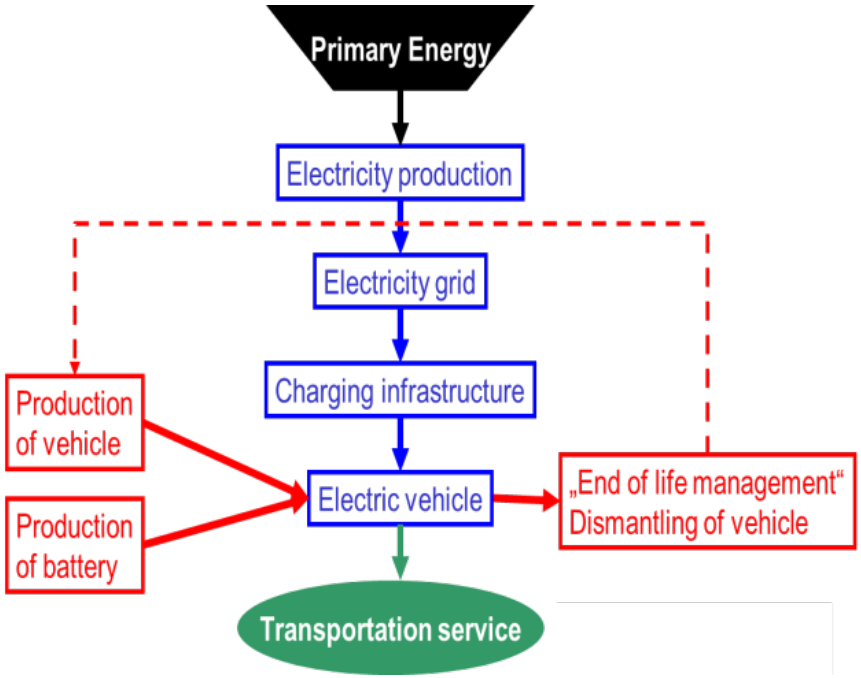
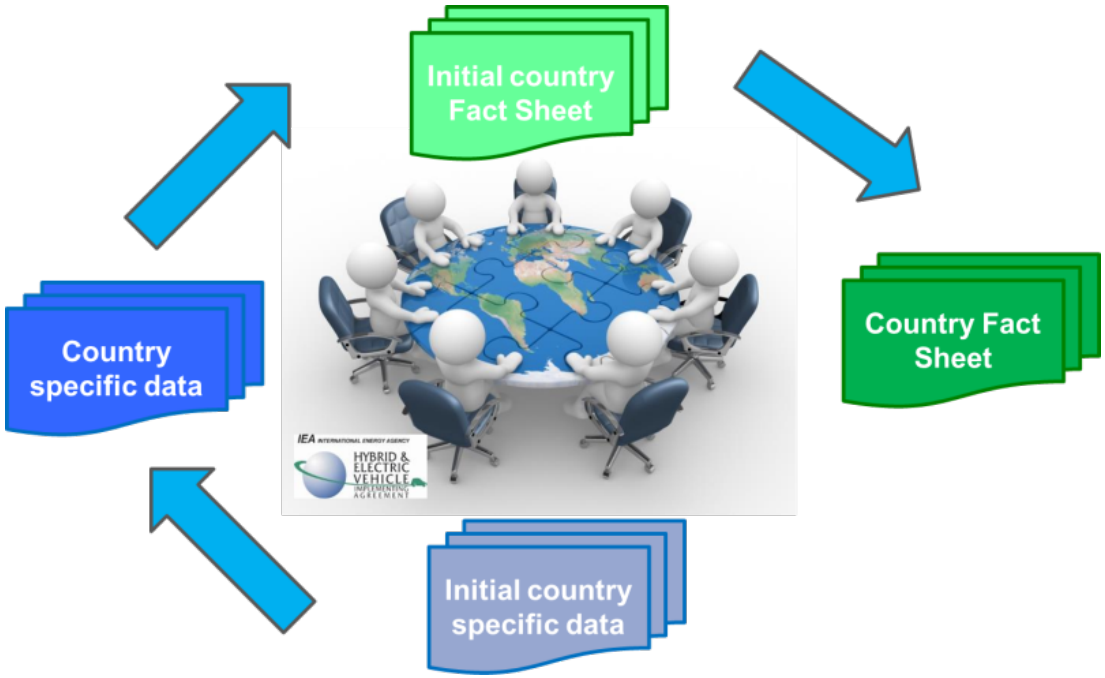
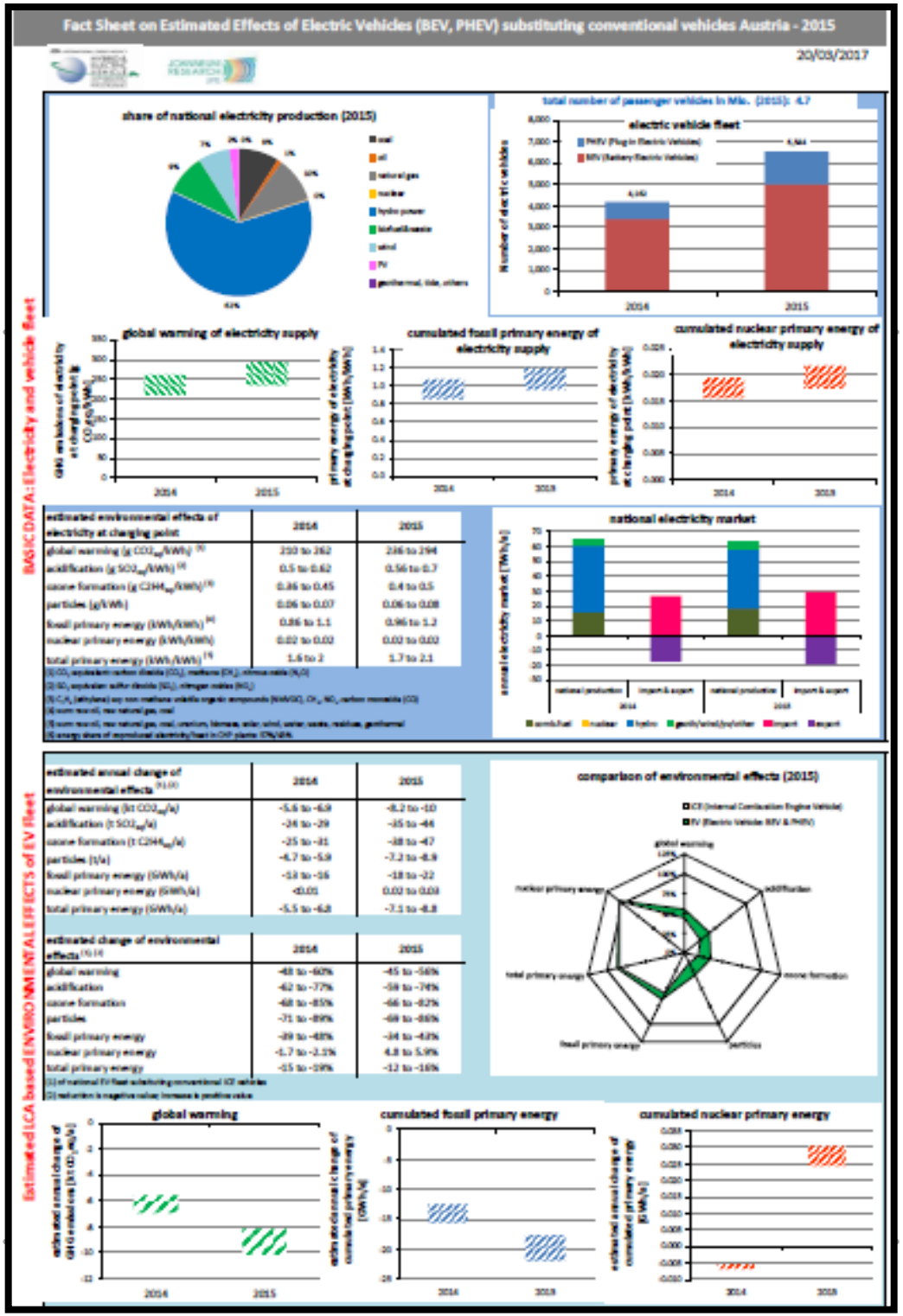
Aim of Project "FACTS&FIGURES"

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







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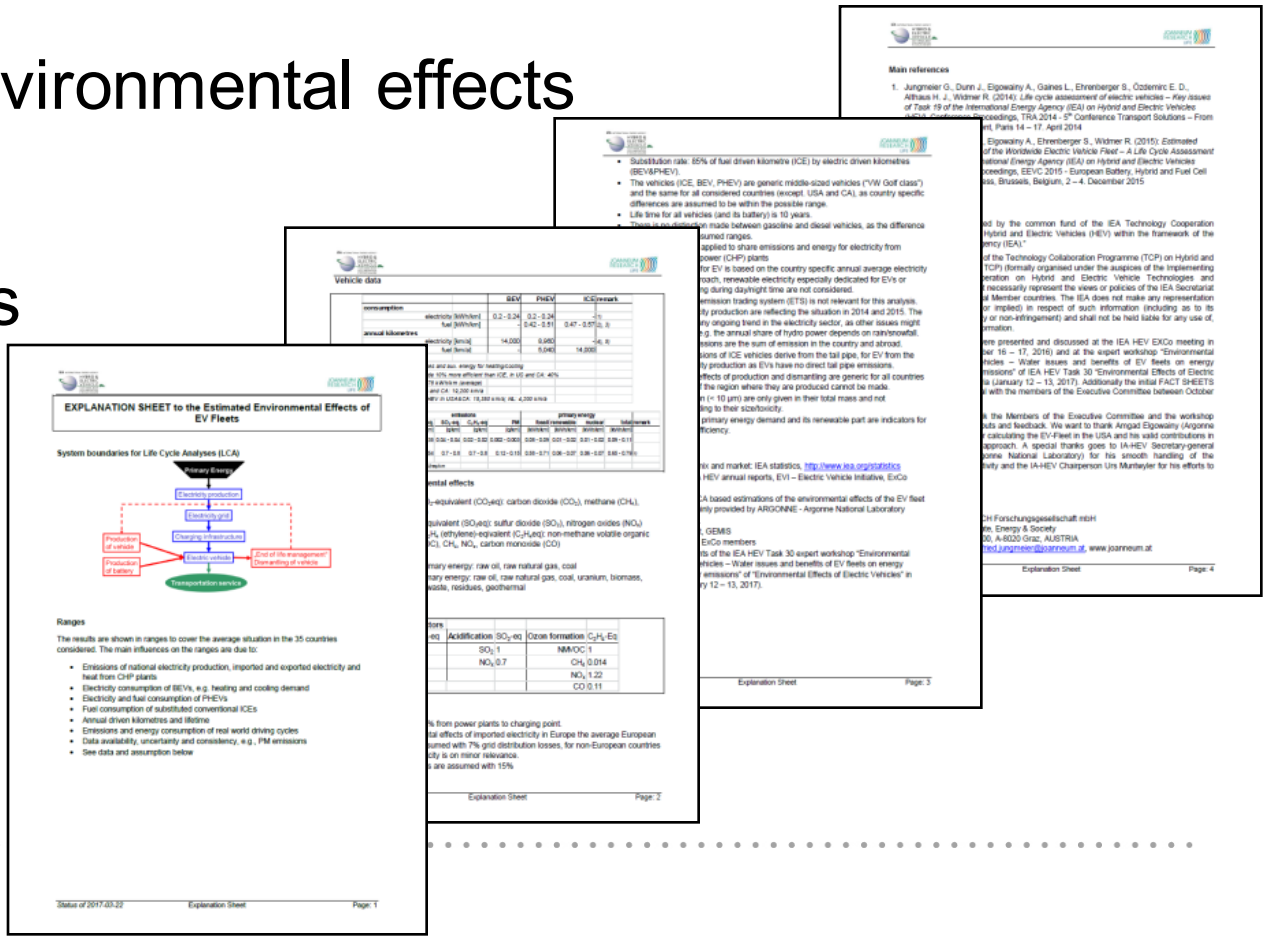
Country FACT SHEET

Explanation Sheet

- System boundaries
- Vehicle data
- Emissions and environmental effects
- Assumptions
- Main data sources
- Main references
- Aknowledgement
- Contact



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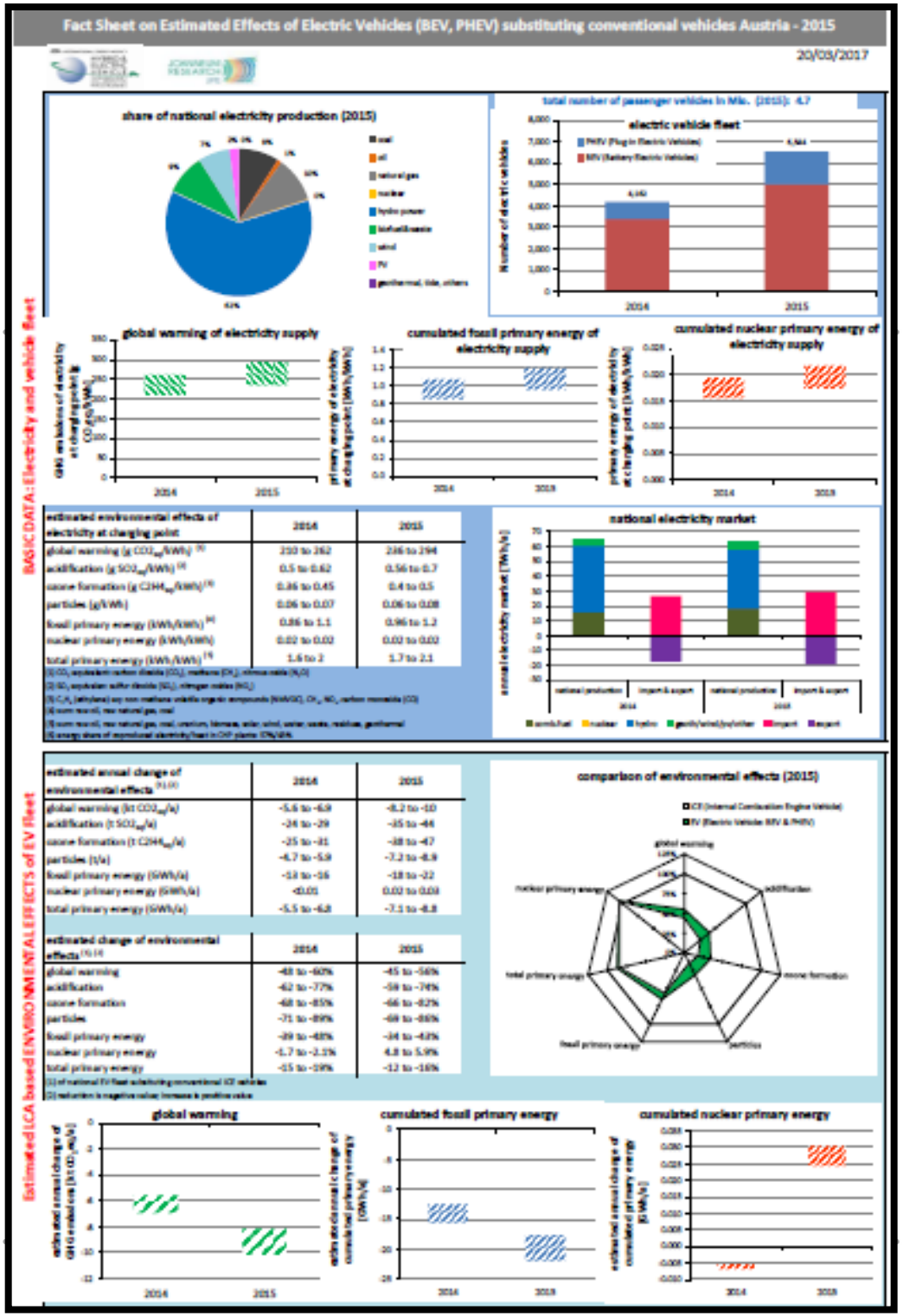
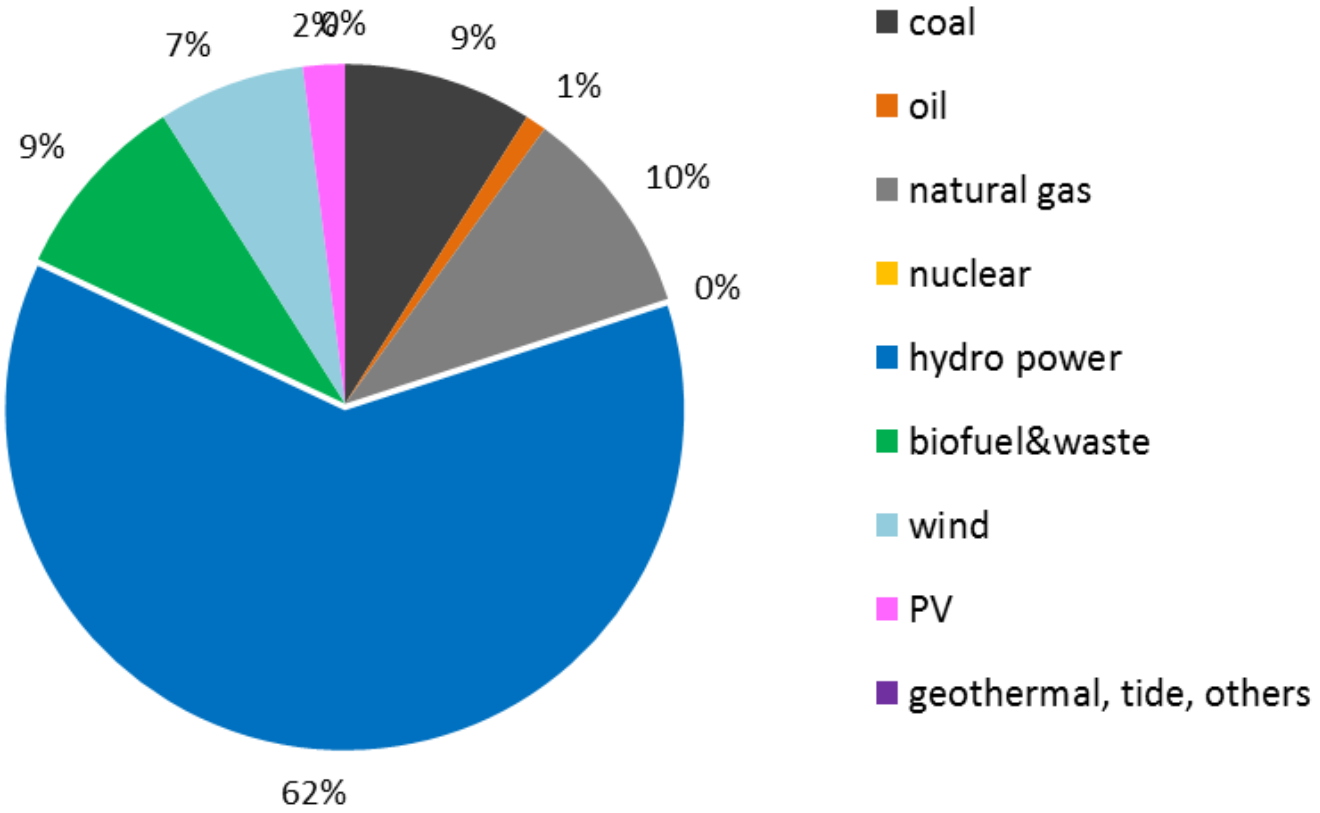


BASIC DATA: Share of National Electricity Production

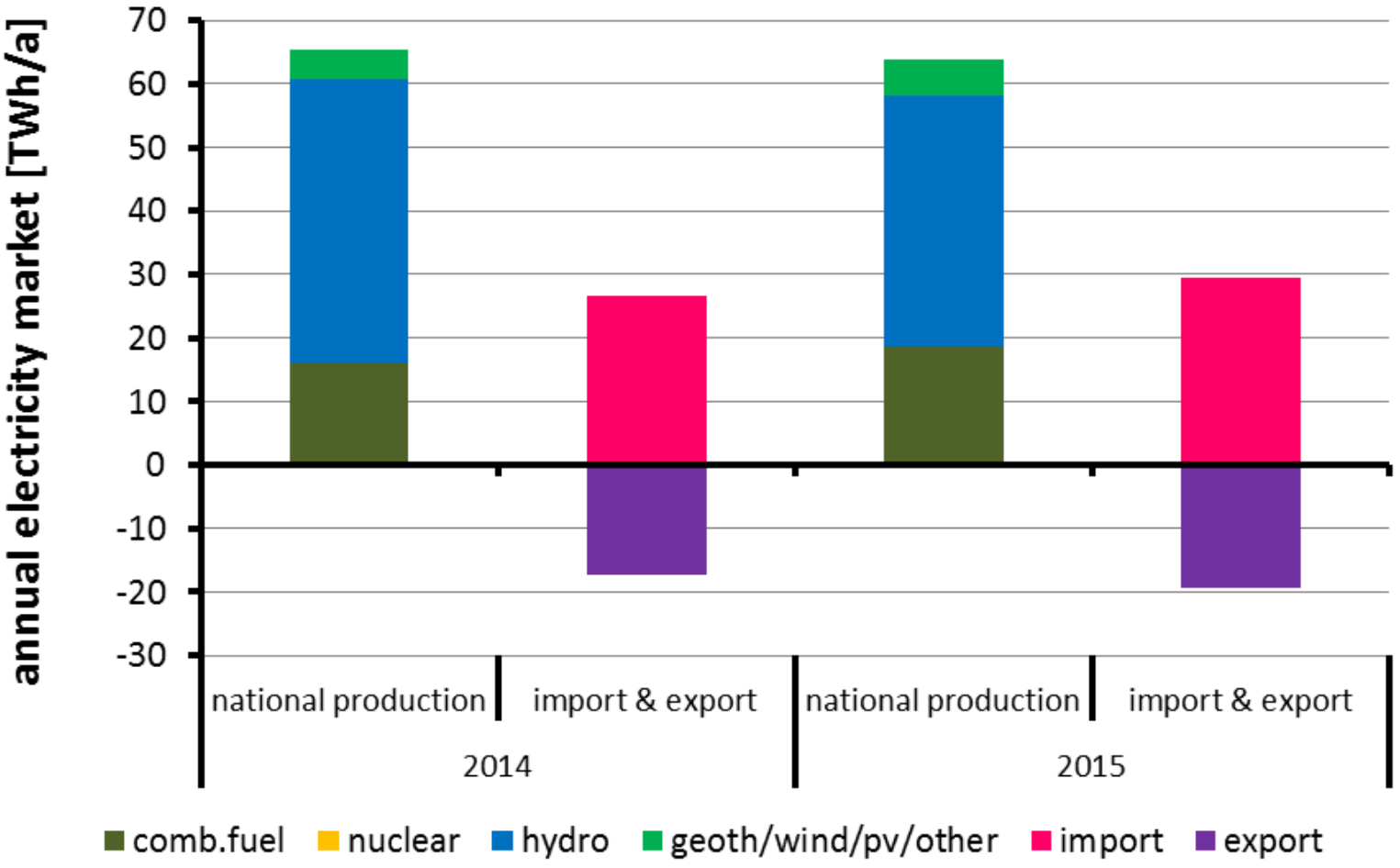
Austria



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

BASIC DATA: National Electricity Market

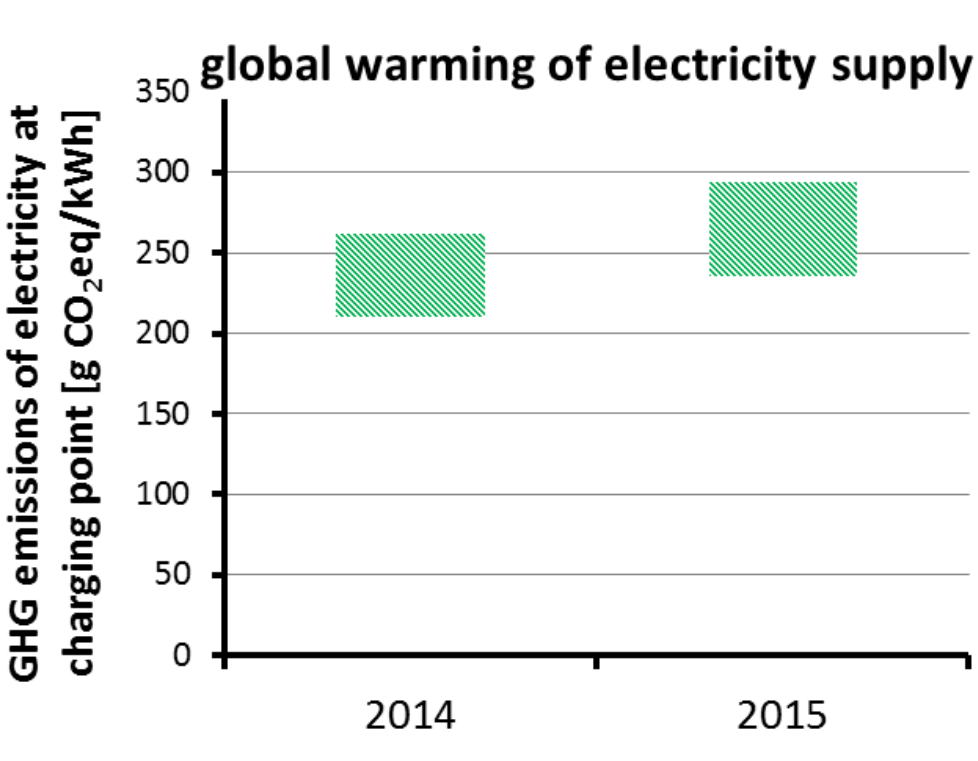
Austria

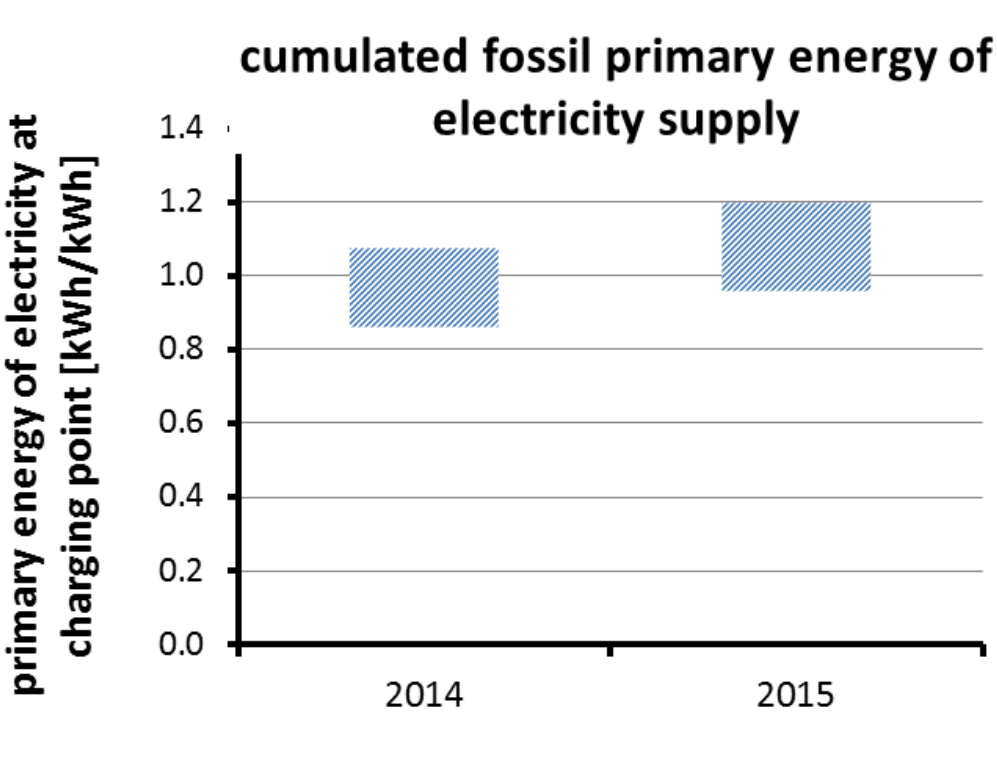


Source: IEA statistics
http://www.iea.org/statistics/statisticssearch/report/?country=ITALY&product=electricityandheat&year=201x

BASIC DATA: Estimated Environ. Effects of Electricity (II)

Austria



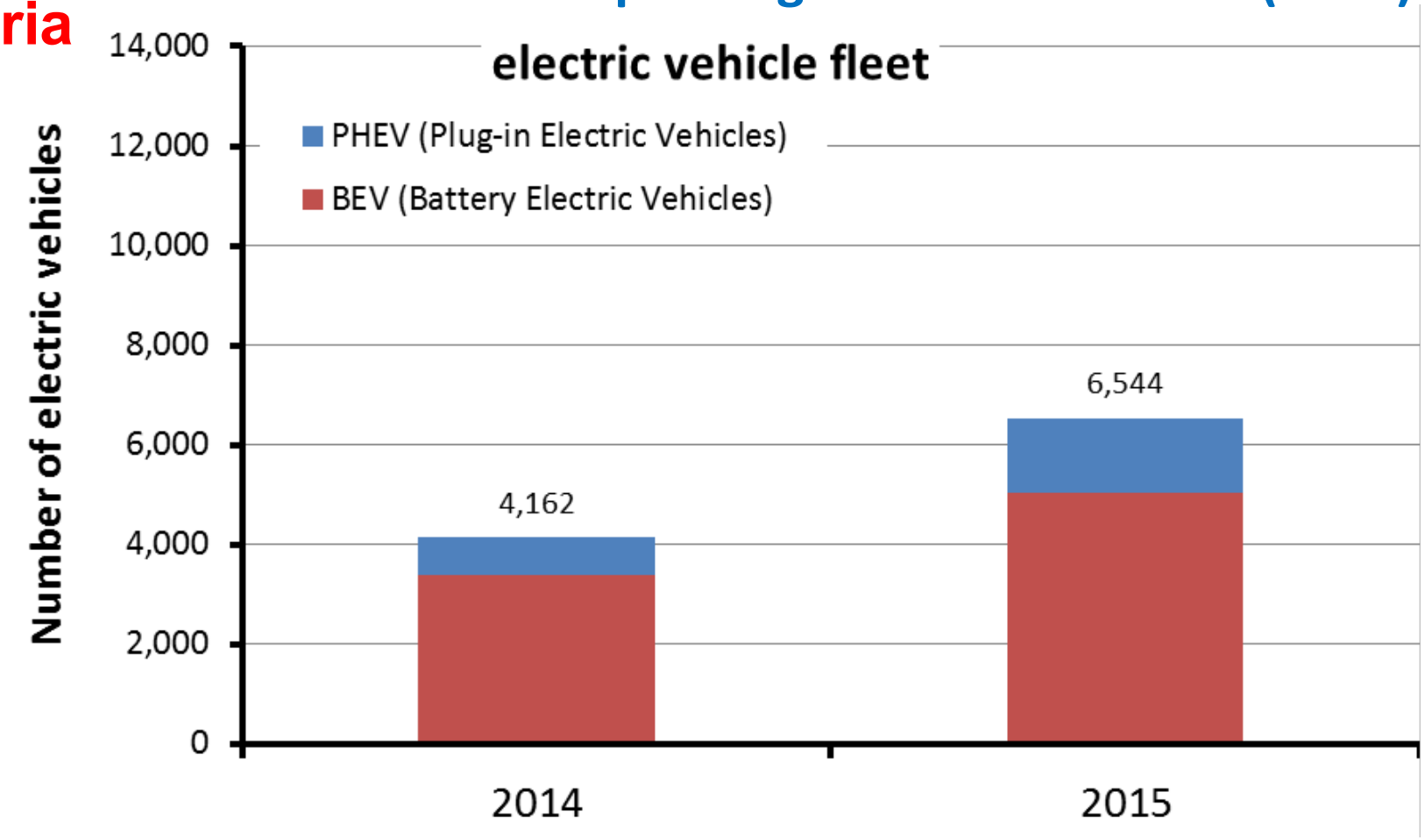


Source: own calculations using data from ecoinvent and GEMIS

BASIC DATA: Number of Electric Vehicle

Austria

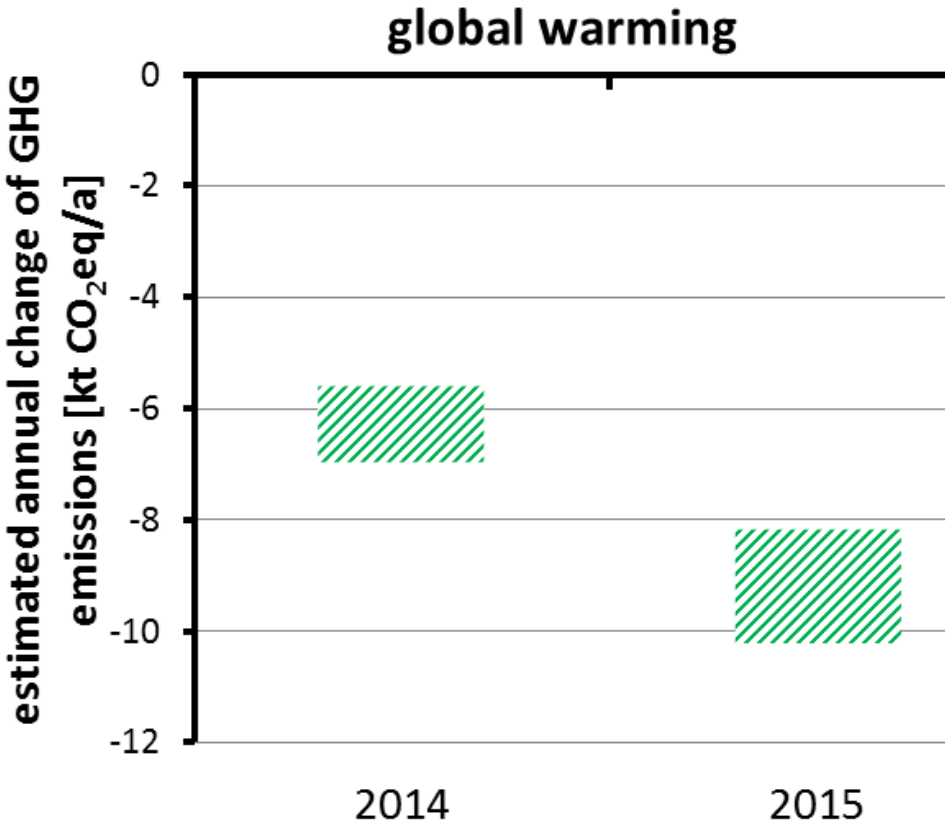
total number of passenger vehicles in Mio. (2015): 4.7

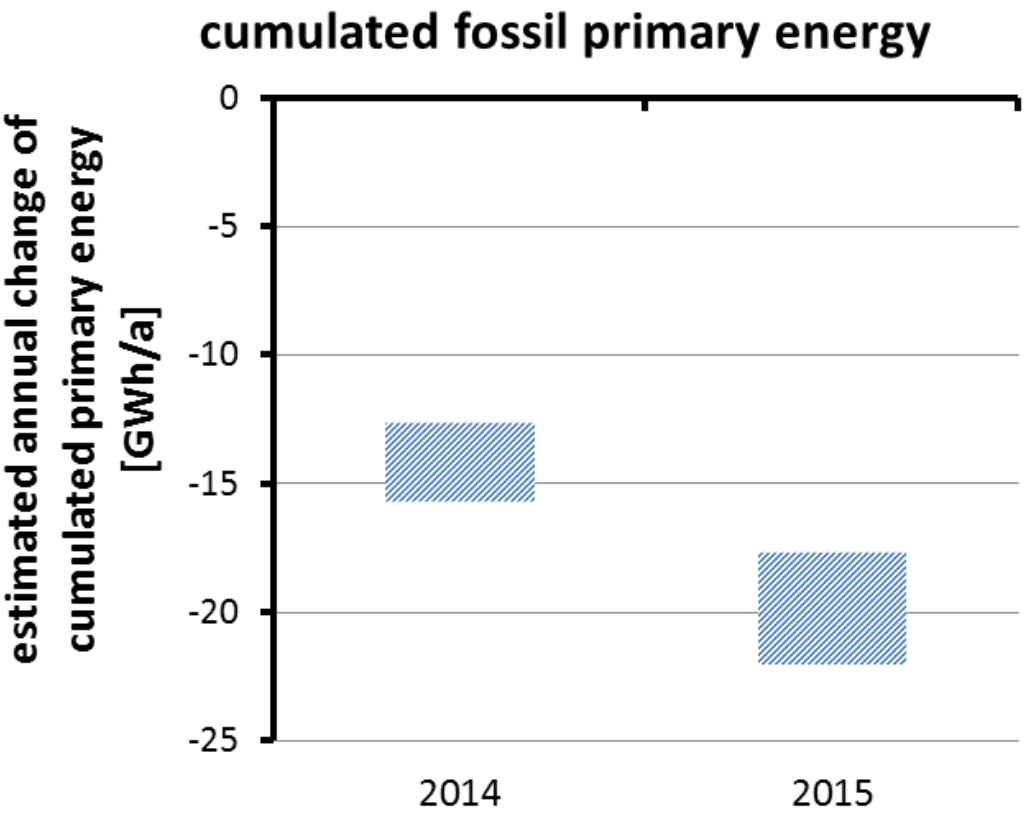


Source: IEA HEV annual report, EVI, ExCo members

ENVIRONMENTAL EFFECTS: Estimated Annual Change of national EV Fleet

Austria

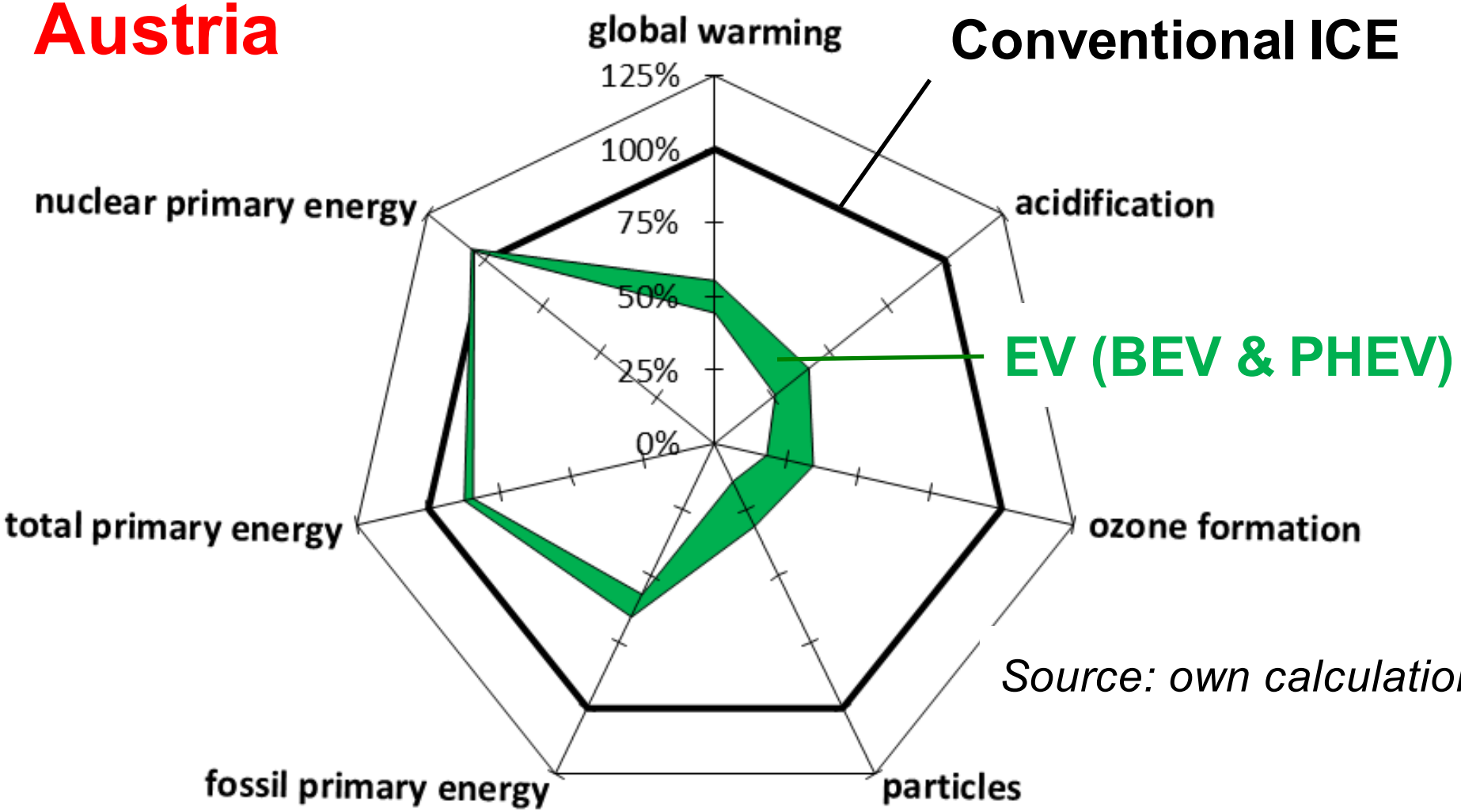




Source: own calculations

ENVIRONMENTAL EFFECTS: Comparison ICE and BEV&PHEV

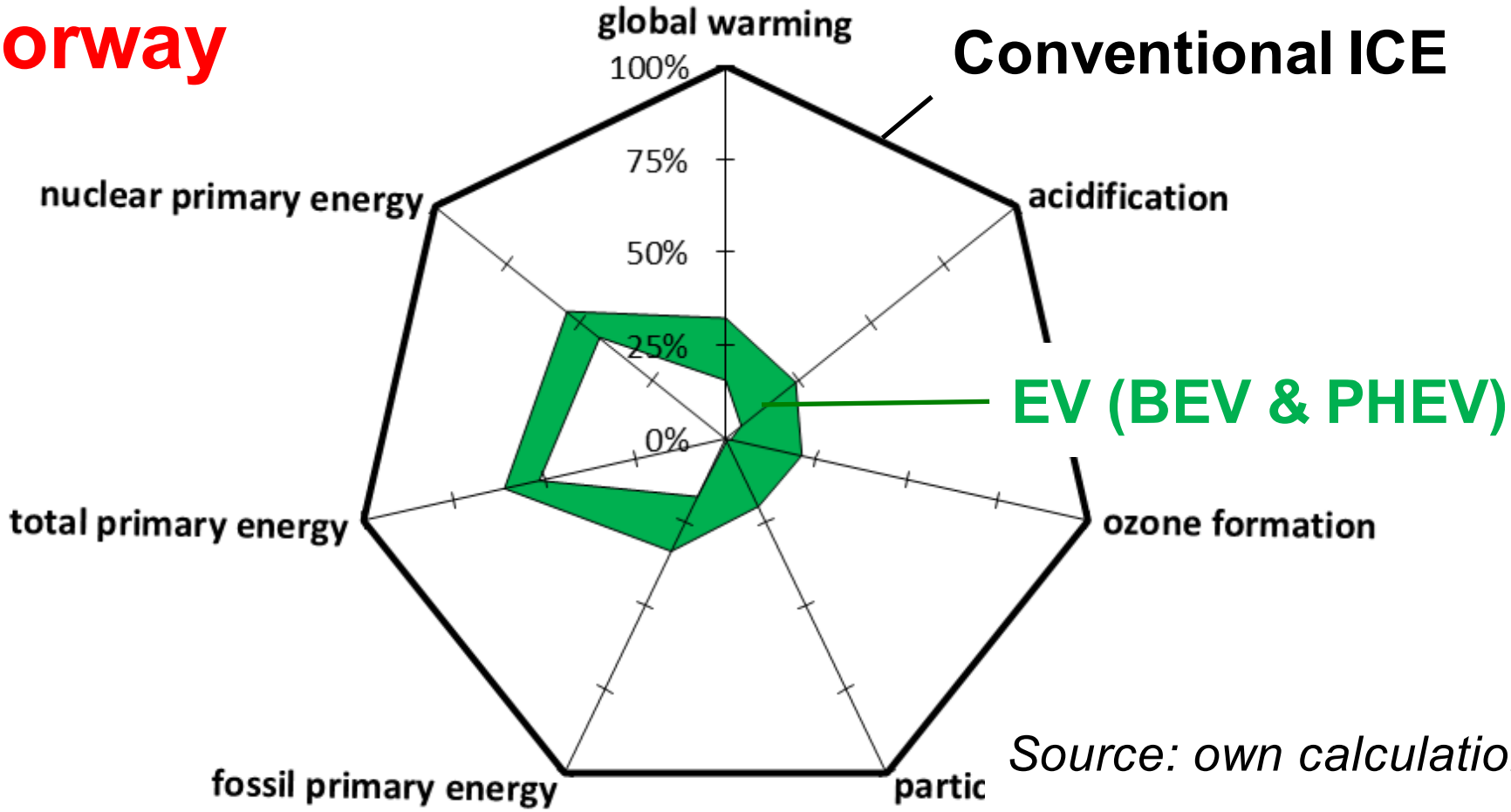
Austria



Source: own calculations

ENVIRONMENTAL EFFECTS: Comparison ICE and BEV&PHEV

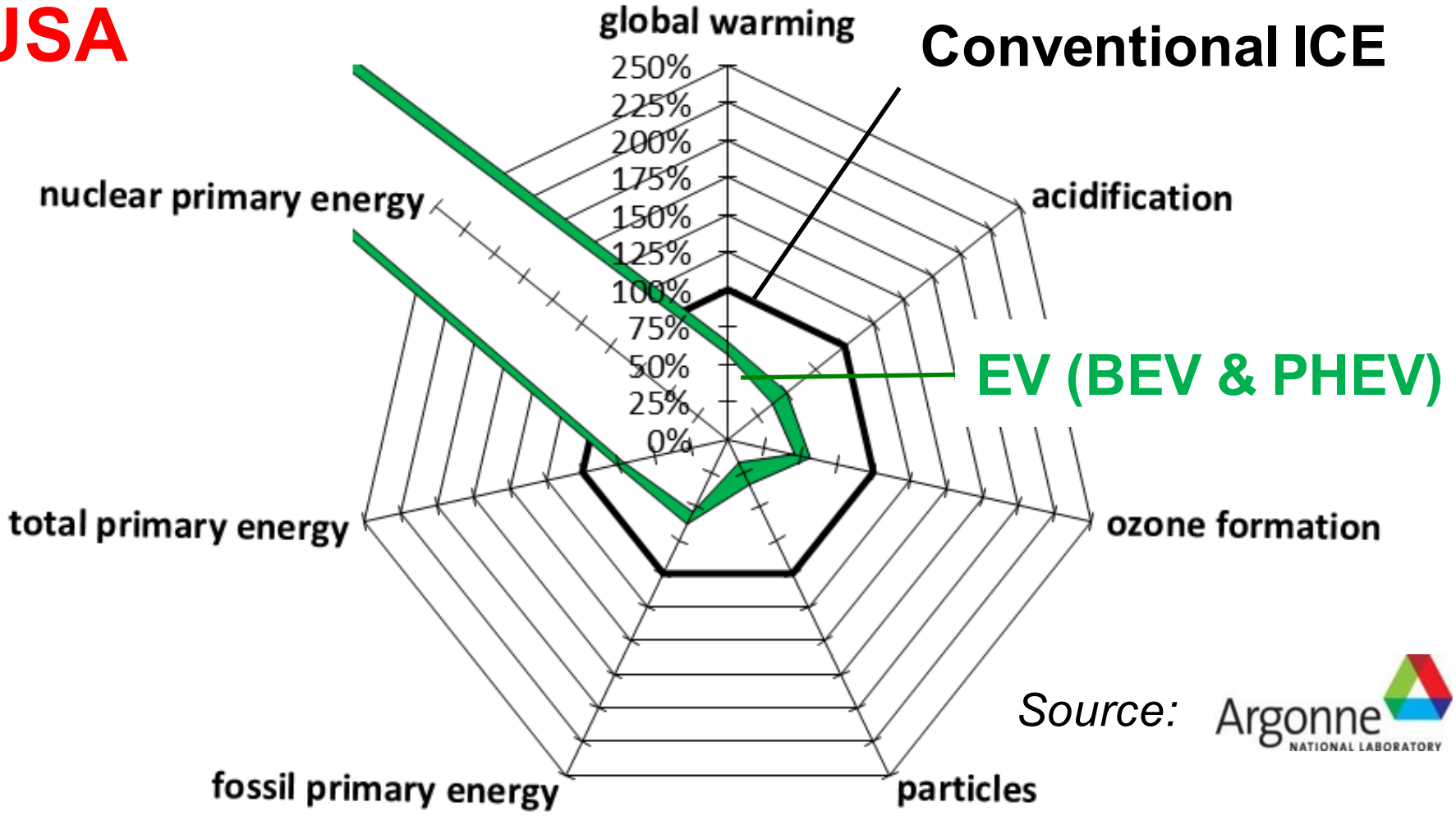
Norway



Source: own calculations

ENVIRONMENTAL EFFECTS: Comparison ICE and BEV&PHEV

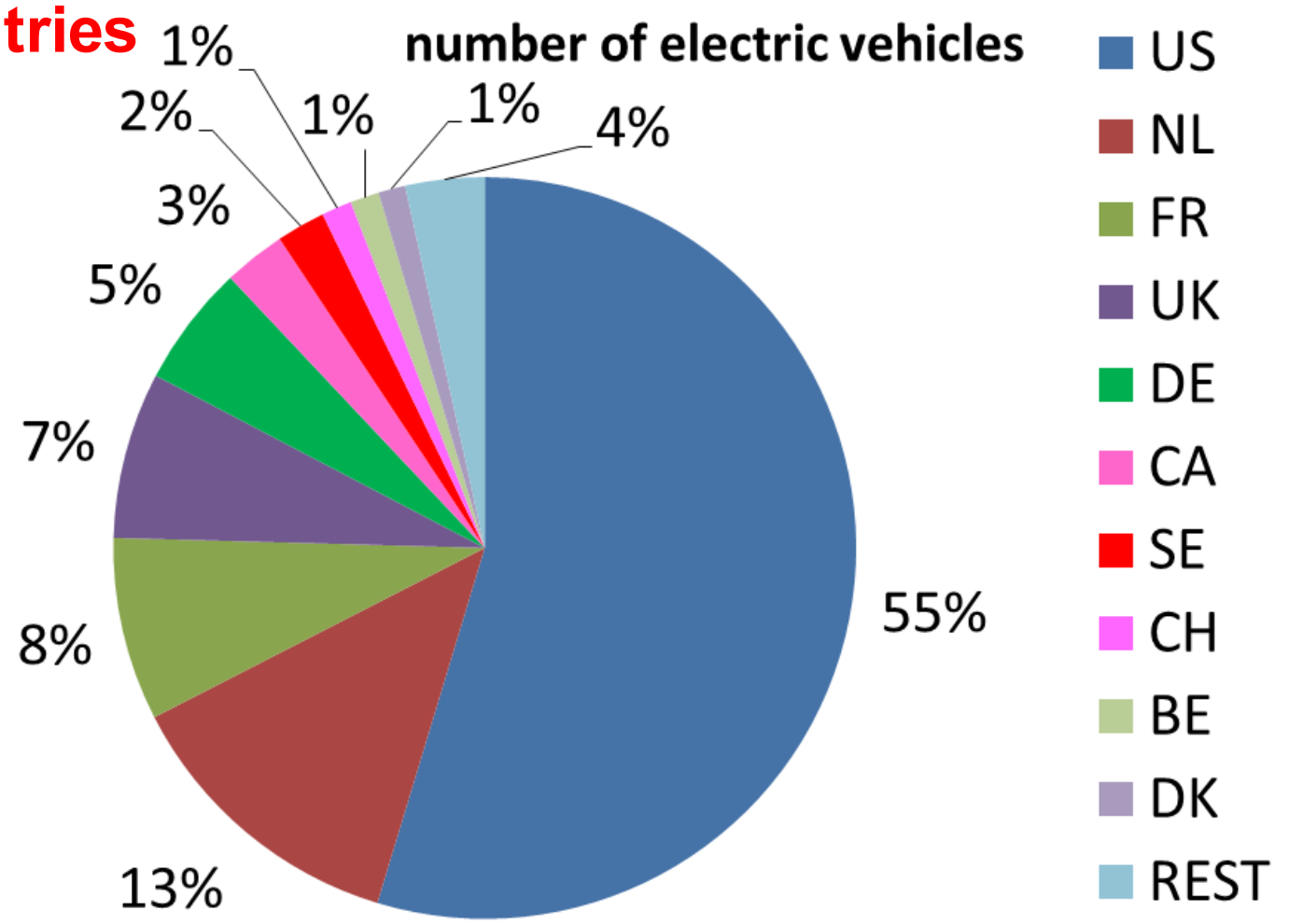
USA



Source: Argonne NATIONAL LABORATORY

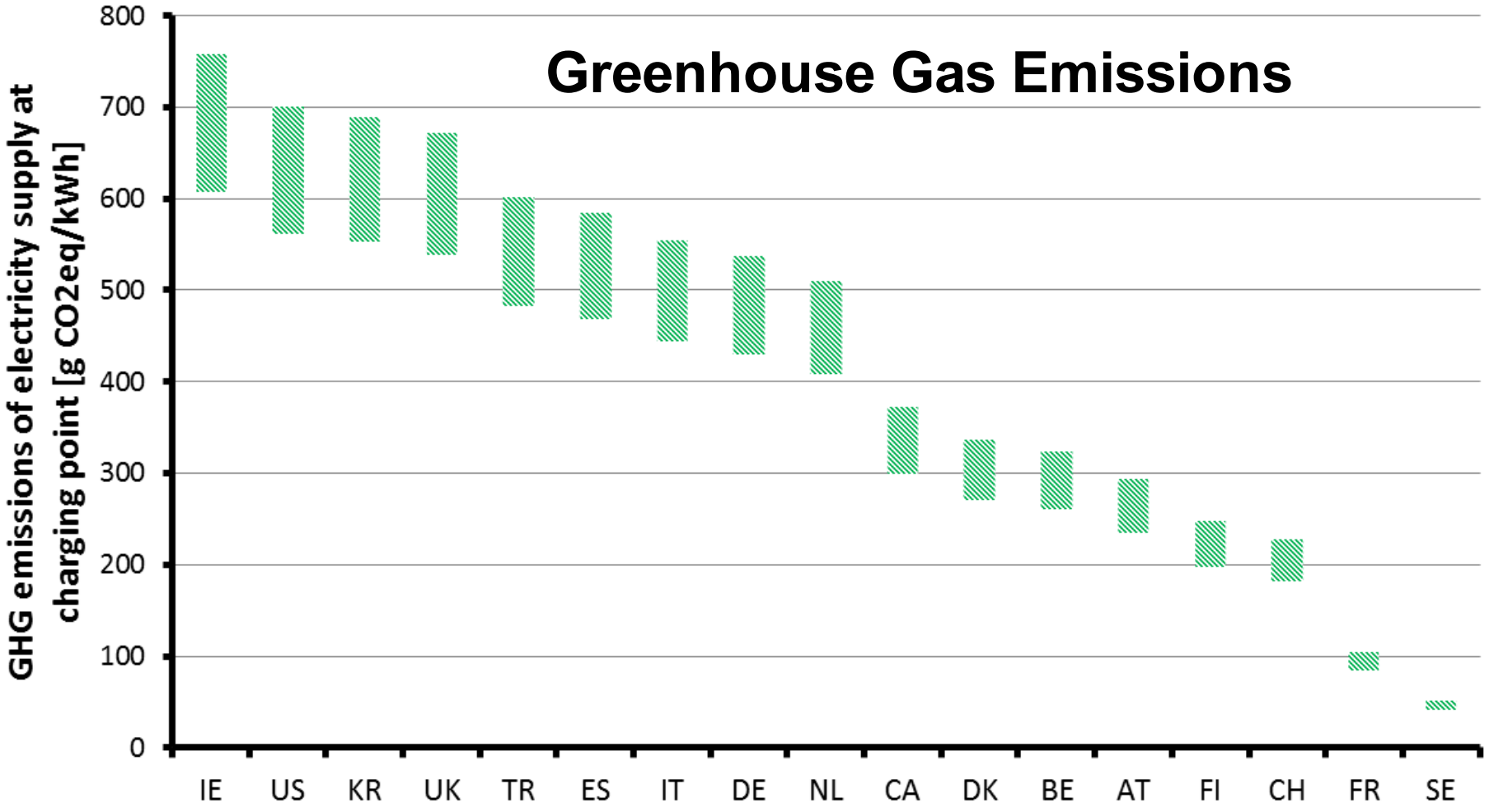
BASIC DATA: Number of Electric Vehicle

IEA HEV Countries
Total: 684,700



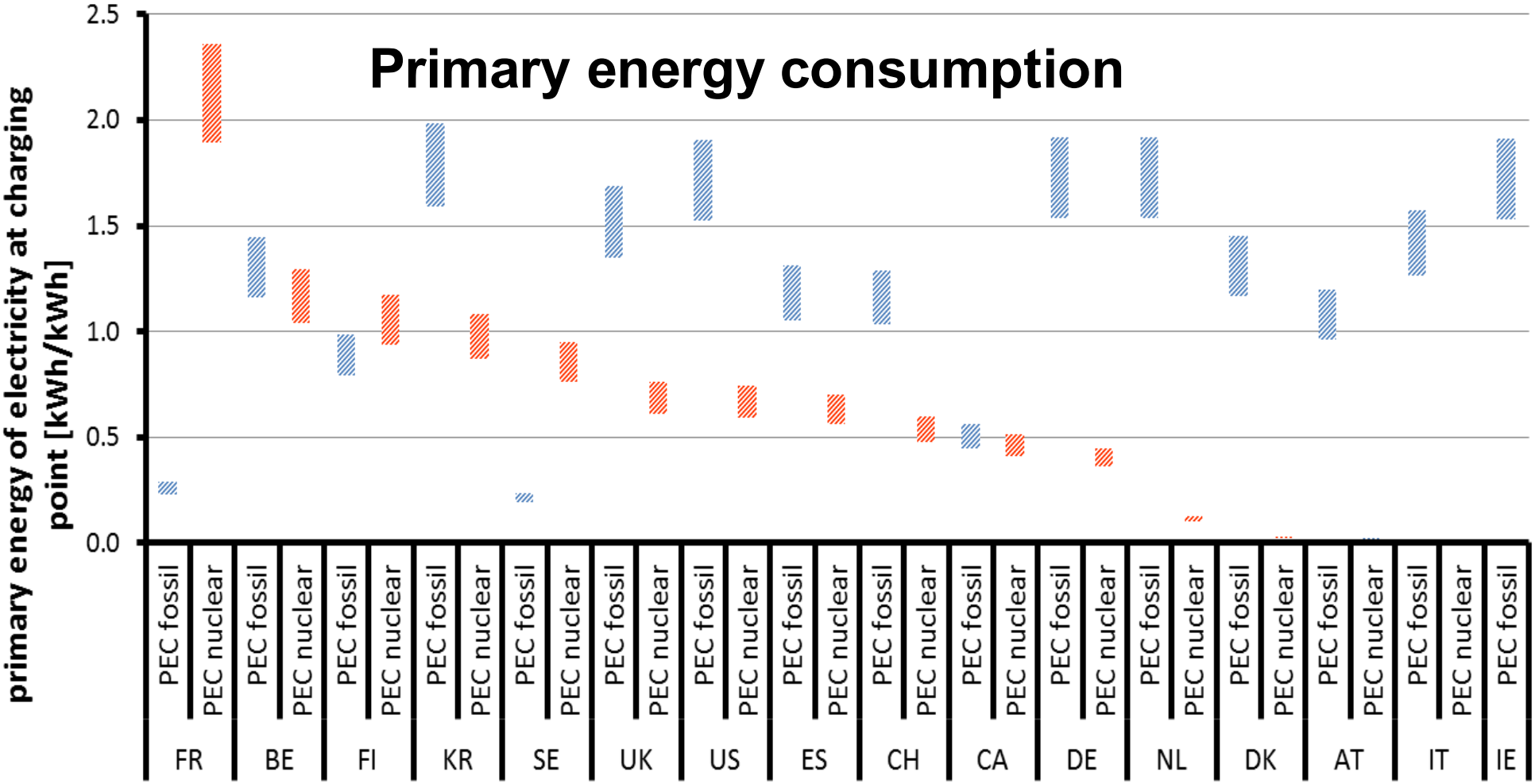
Source: IEA HEV annual report, EVI, ExCo members

BASIC DATA: Estimated Environ. Effects of Electricity (I)



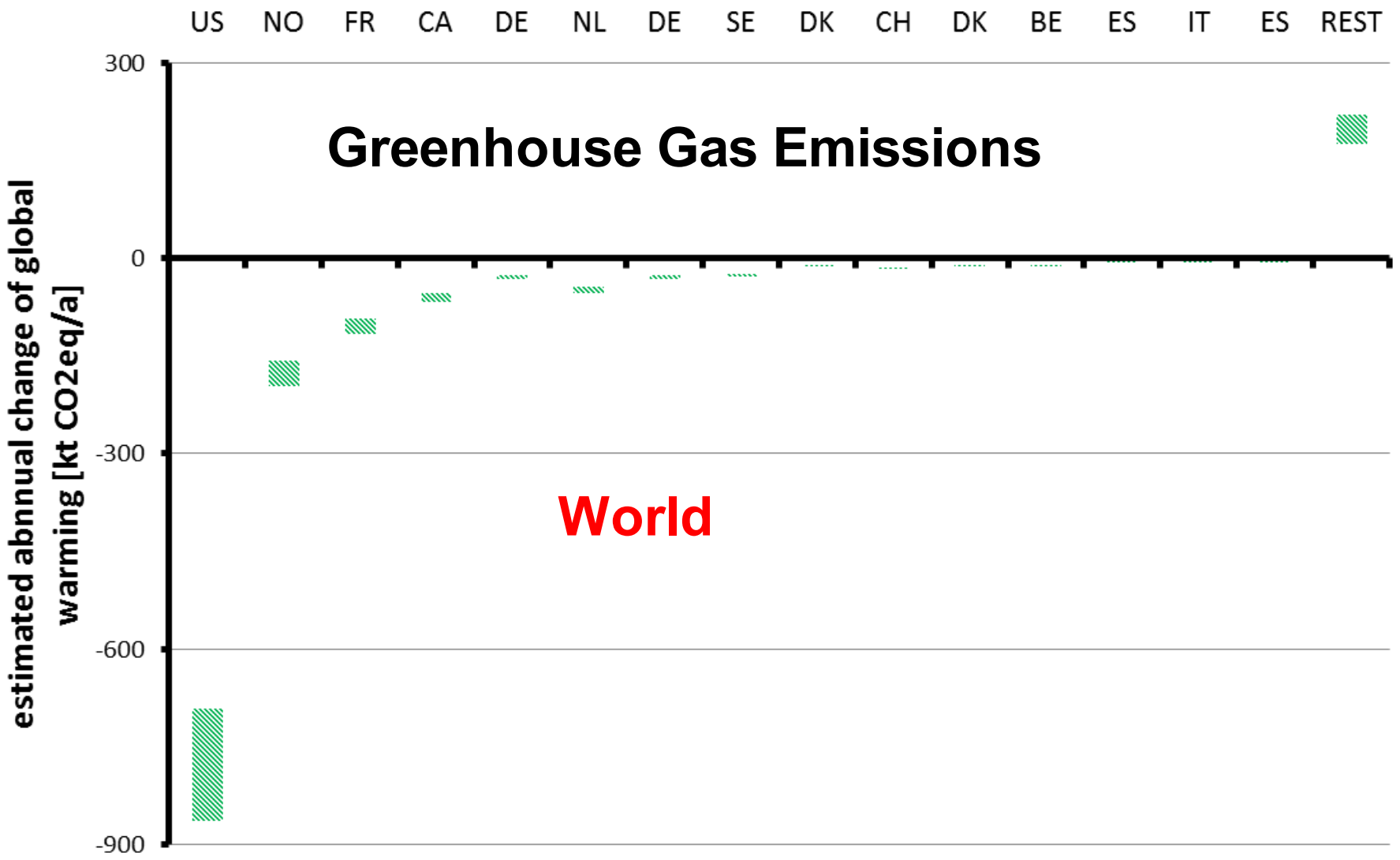
Source: own calculations using data from ecoinvent and GEMIS

BASIC DATA: Estimated Environ.Effects of Electricity (II)

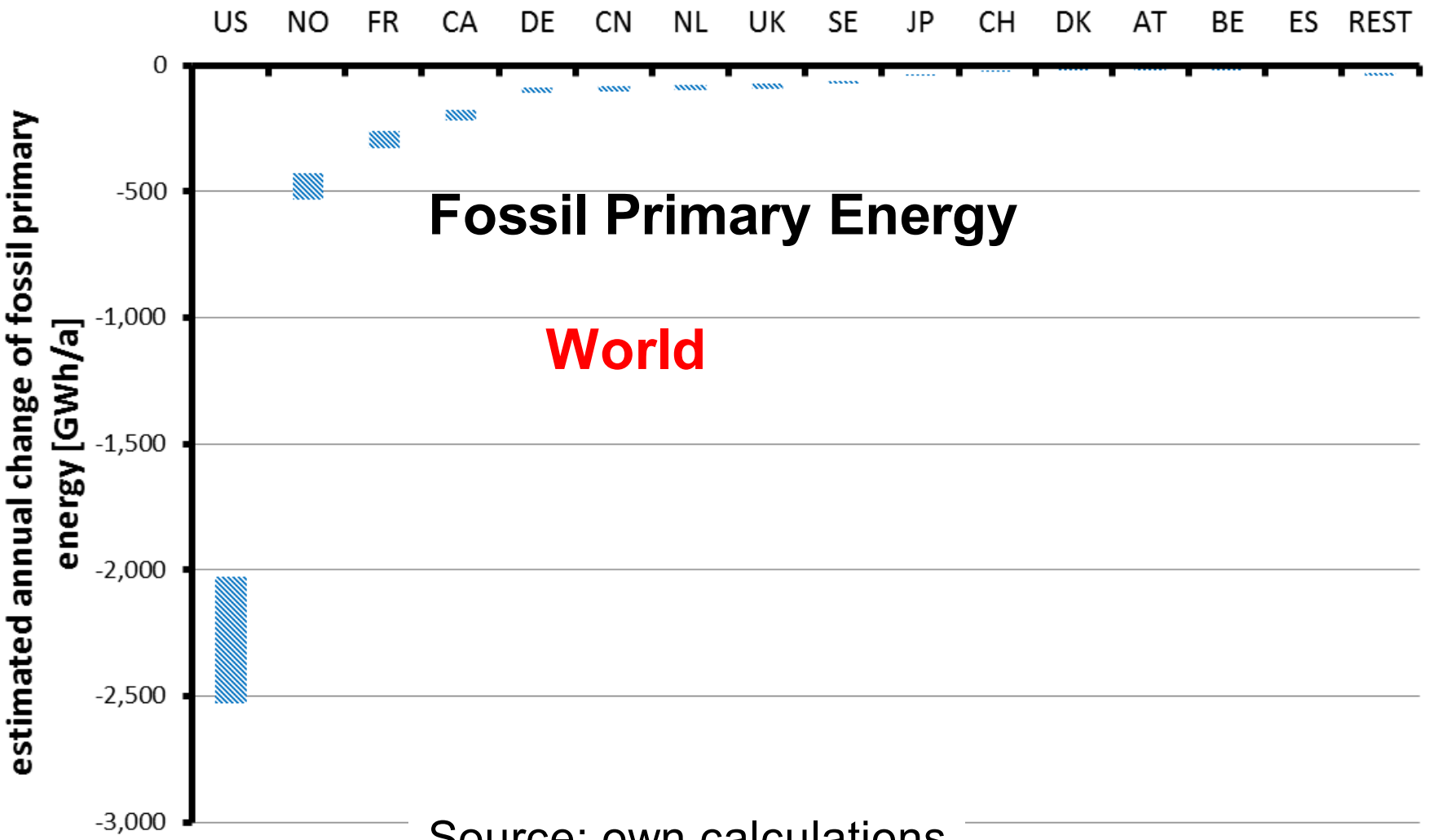


Source: own calculations using data from ecoinvent and GEMIS

ENVIRONMENTAL EFFECTS: Estimated Annual Change of EV Fleet (I)

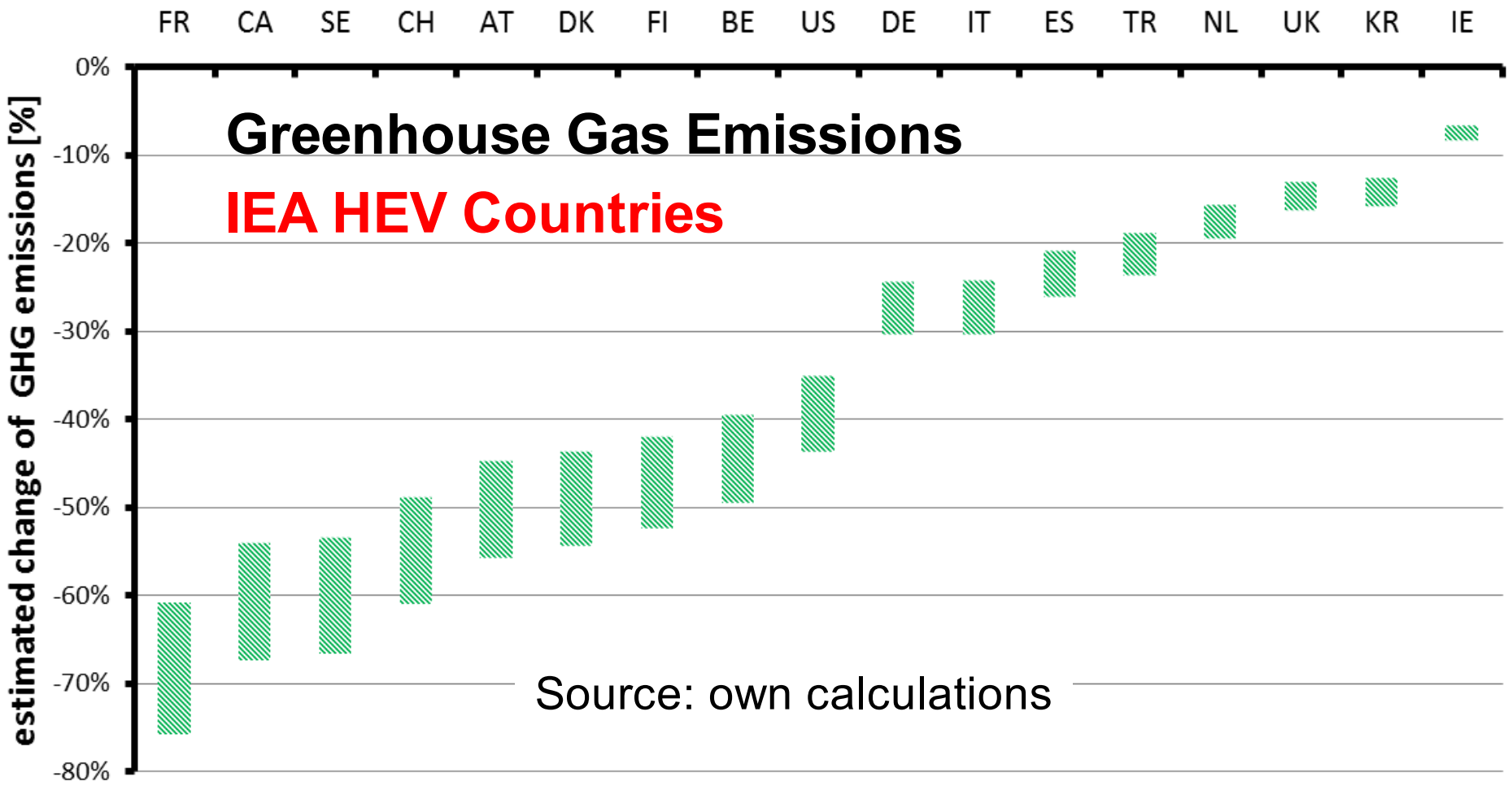


ENVIRONMENTAL EFFECTS: Estimated Annual Change of EV Fleet (II)

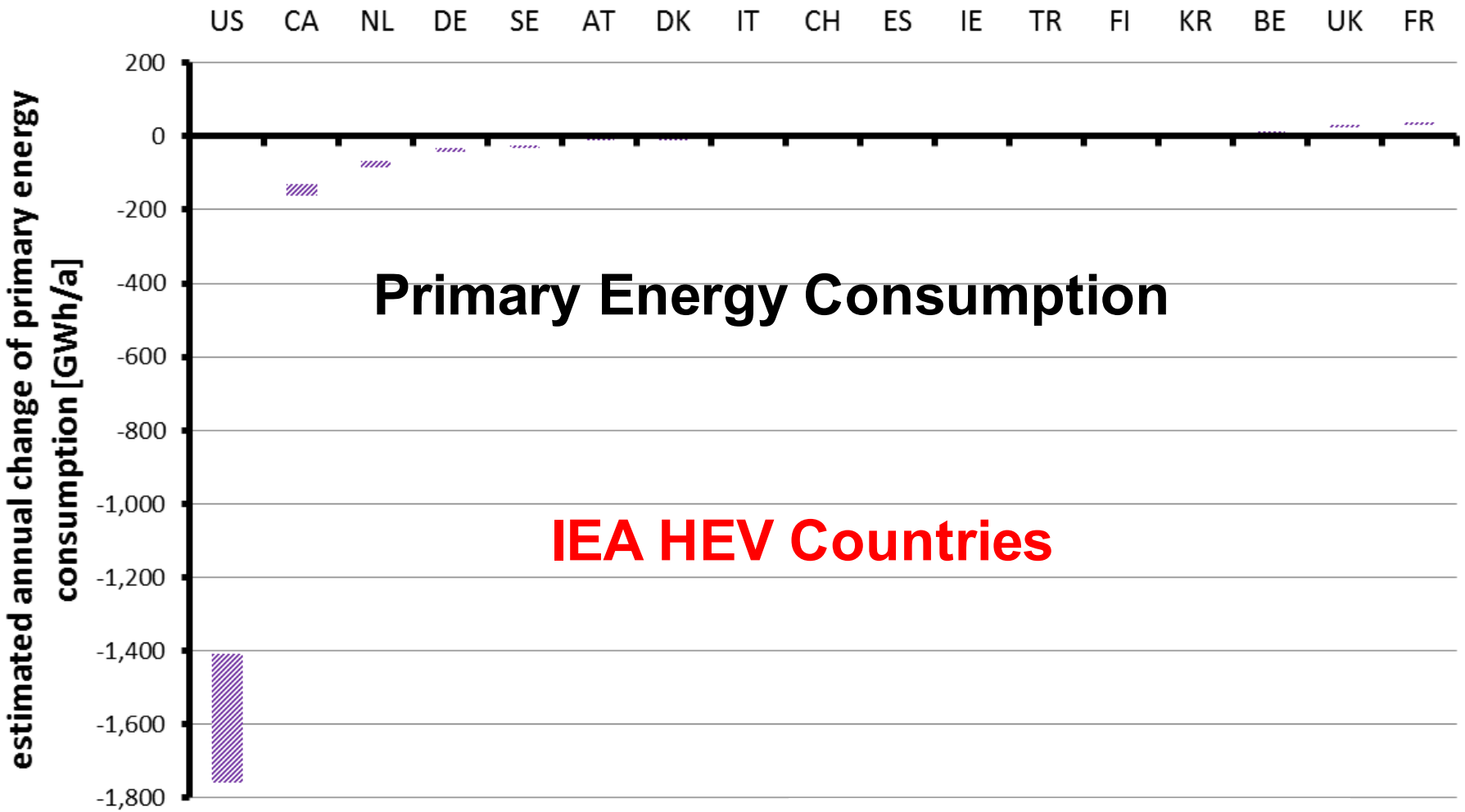


Source: own calculations

ENVIRONMENTAL EFFECTS: Estimated Change (I)

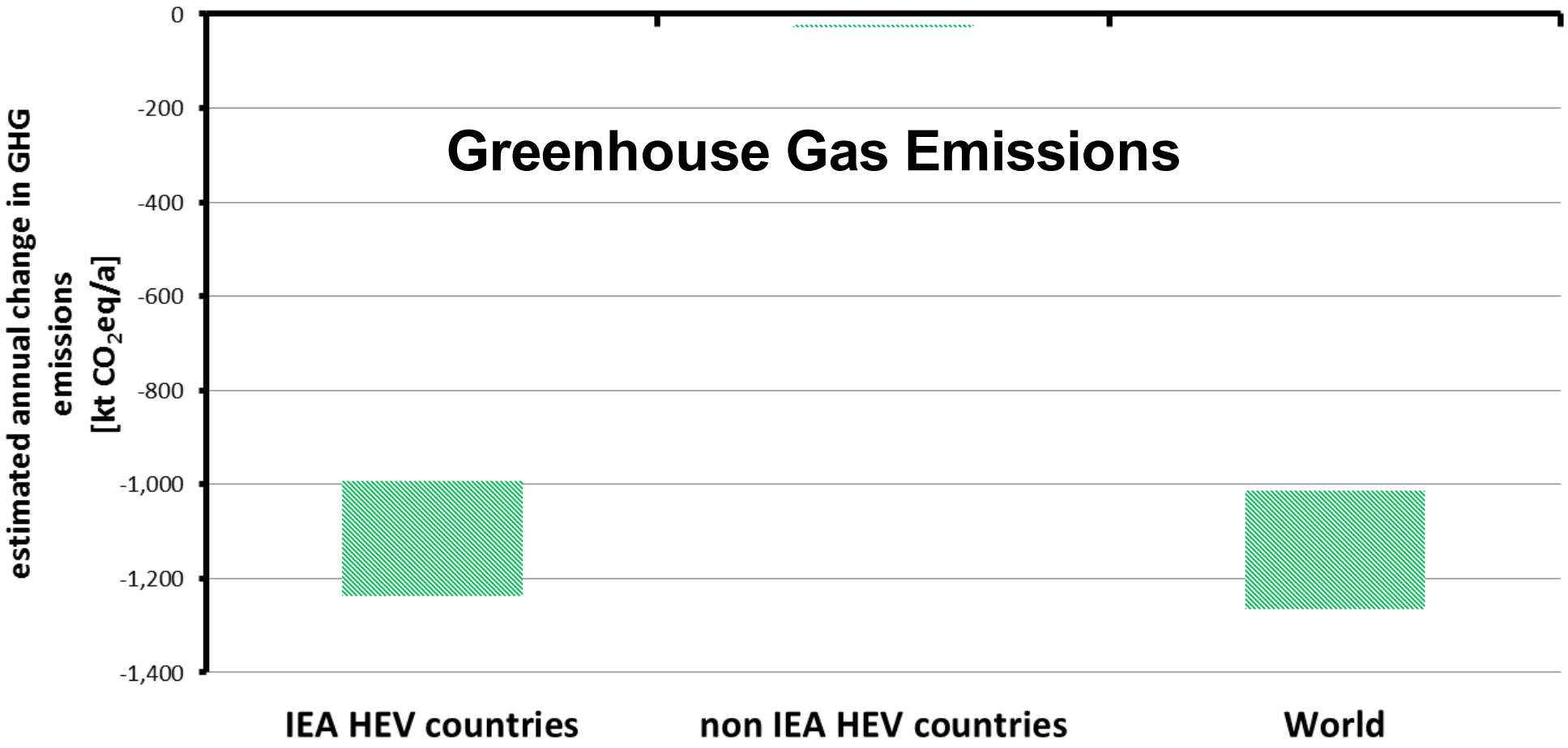


ENVIRONMENTAL EFFECTS: Estimated Change (II)

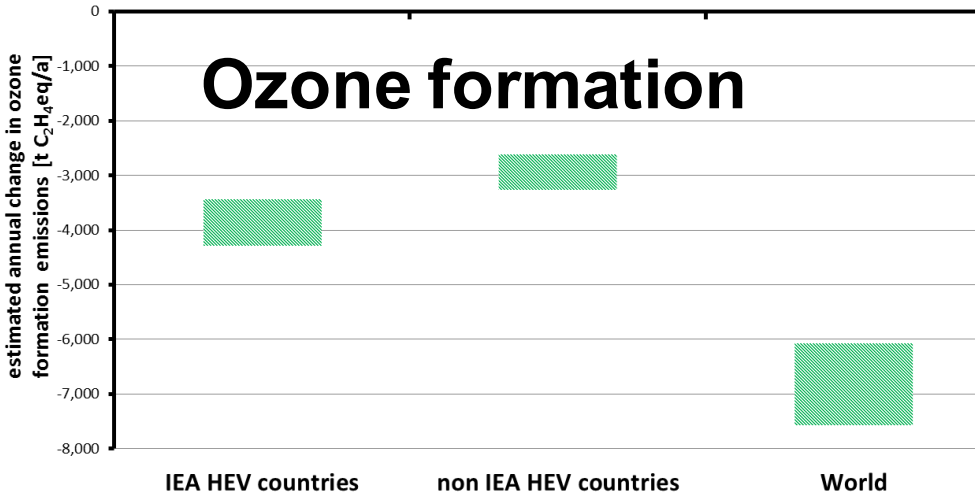


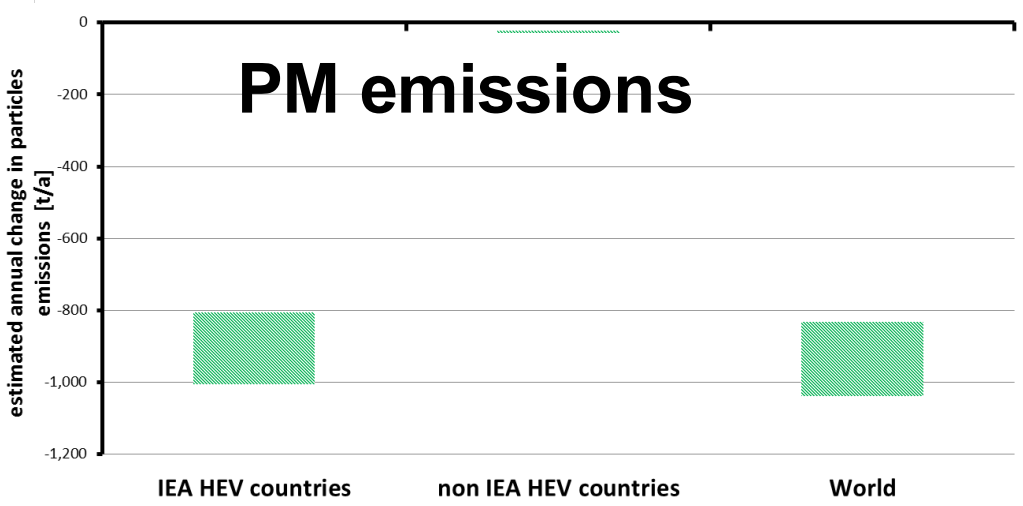
Source: own calculations

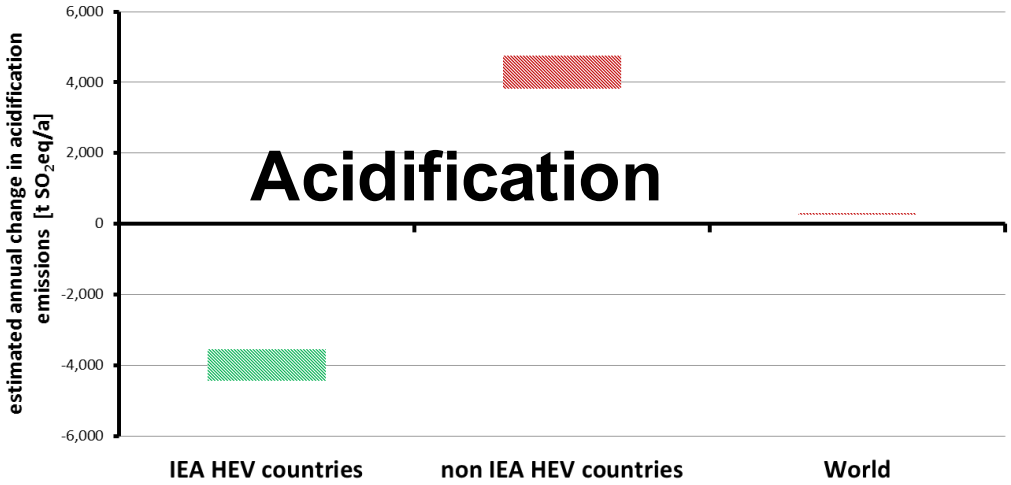
World EV-Fleet (2015): 1,234,999 BEV&PHEV of which 684,700 in IEA HEV countries



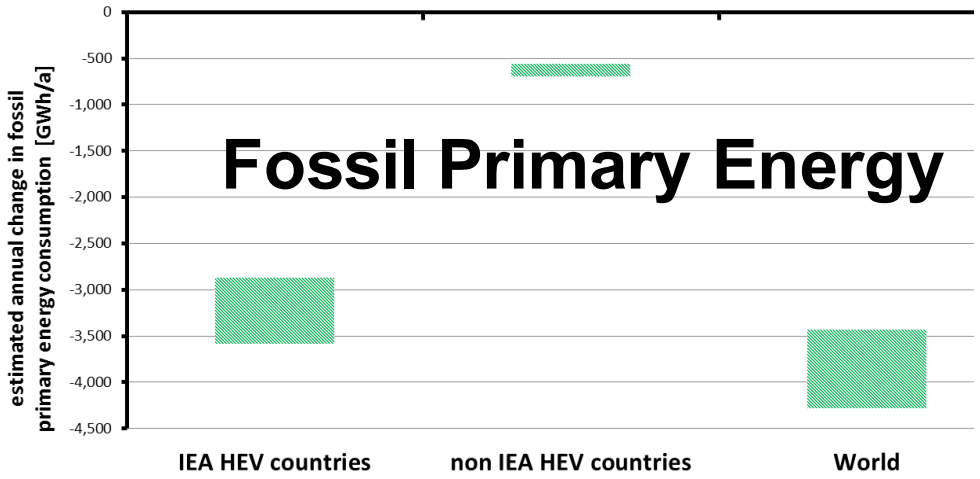
EV-Fleet in 2015: 1.2 Mio. Vehicles (I)

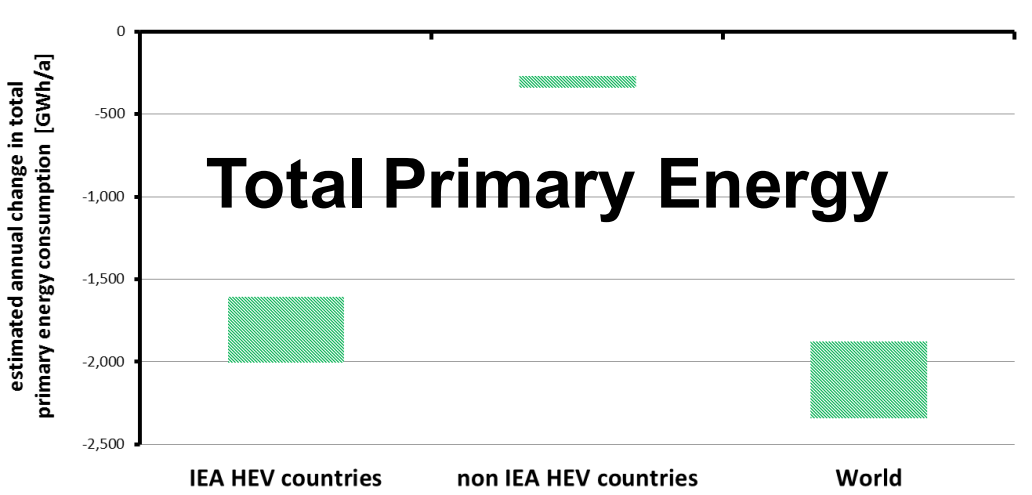


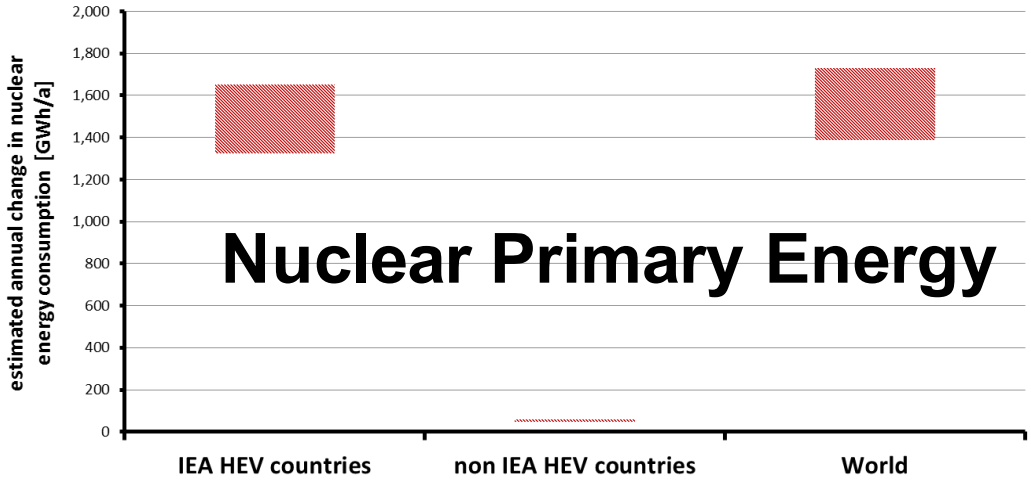




EV-Fleet in 2015: 1.2 Mio. Vehicles (II)





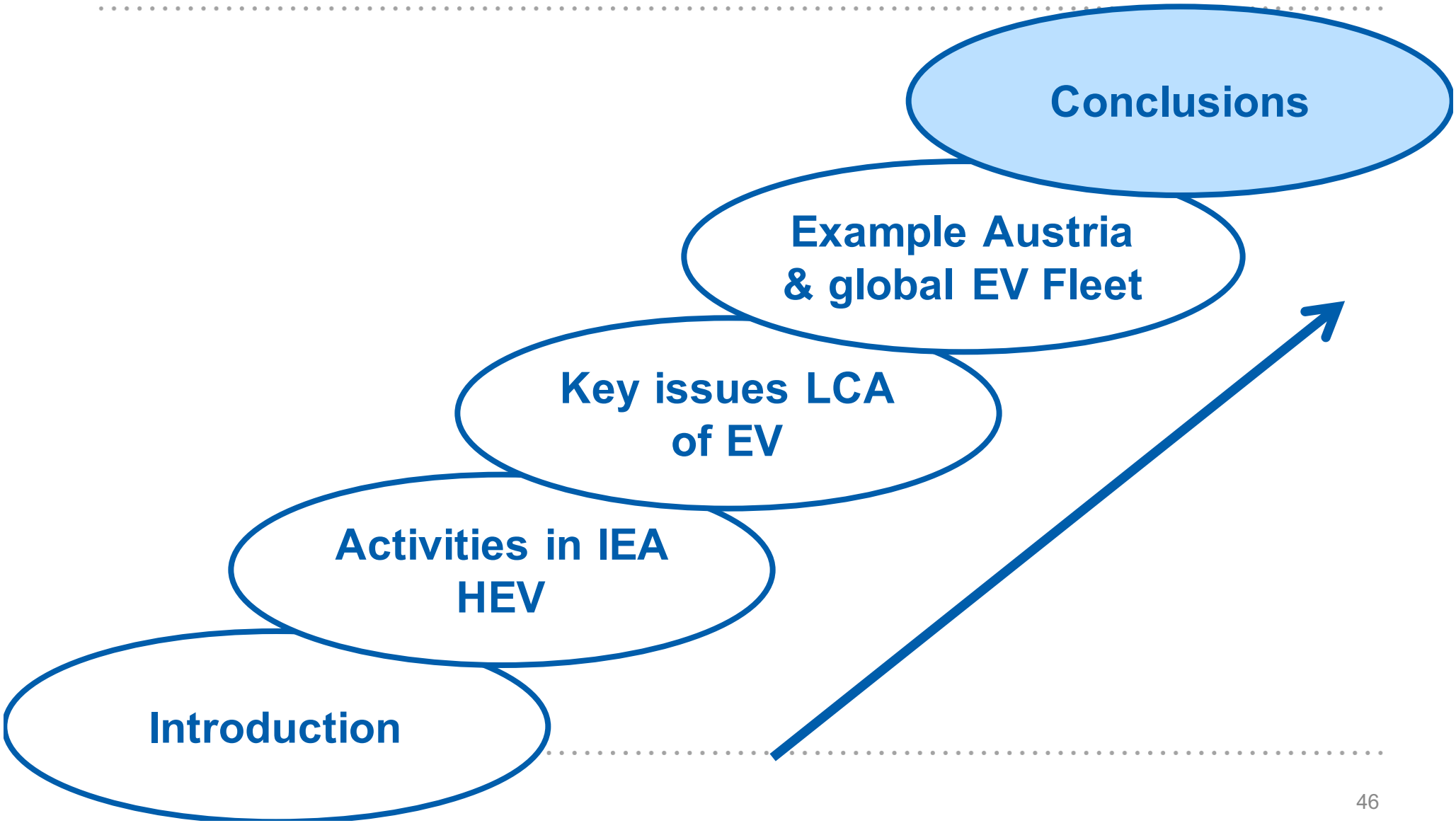


Total Results

Estimation of the **average environmental benefits** of BEVs and PHEVs substituting diesel and gasoline globally shows

GHG-reduction:	- 25% to - 30%
PM < 10 reduction:	- 40% to - 50%
Acidification:	0% to - 5%
Ozone reduction:	- 50% to - 60%
Fossil primary energy reduction	- 25% to - 30%
Renewable primary energy increase	+ 10% to + 15%
Nuclear primary energy increase	+ 600% to + 800%
Total primary energy reduction	- 15% to - 20%

Content


Conclusions
Example Austria & global EV Fleet
Key issues LCA of EV
Activities in IEA HEV
Introduction

IEA INTERNATIONAL ENERGY AGENCY

HYBRID & ELECTRIC VEHICLE TECHNOLOGY COLL PRO

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mary

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, e.g. PM

Estimation of environmental effects substituting diesel/gasoline show positive results by 1.2 Mio. EVs in 2015

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

Gerfried Jungmeier

JOANNEUM RESEARCH Forschungsgesellschaft mbH.

LIFE – Centre for Climate, Energy and Society

Future Energy Systems and Lifestyles

Elisabethstraße 18

A-8010 Graz

AUSTRIA

+43 316 876-1313

www.joanneum.at/eng

gerfried.jungmeier@joanneum.at

www.ieahev.org/tasks/task-19-life-cycle-assessment-of-evs

www.ieahev.org/tasks/task-30-assessment-of-environmental-effects-of-electric-vehicles/