Potentials of low-carbon aluminium products in automotive applications

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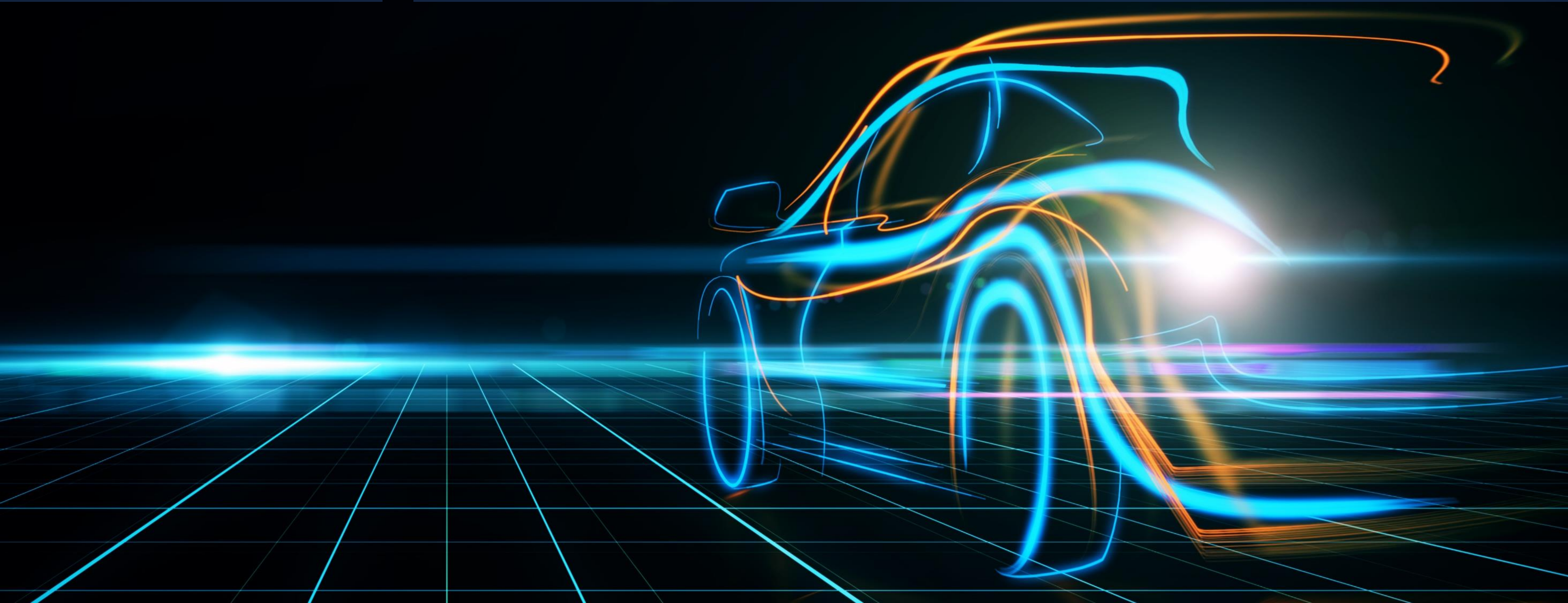
CREATING IDEAS &
DRIVING INNOVATIONS



Agenda

» **Introduction**

» **Motivation**

» **Approach**

» **Results**

» **Summary**

fka – Full Vehicle Engineering Service Provider

CEO
Dr.-Ing. Markus Bröckerhoff

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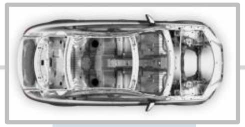
Director
Univ.-Prof. Dr.-Ing. Lutz Eckstein

Full Vehicle


Chassis


Body

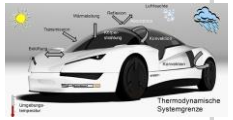

Drivetrain


Electrics/ Electronics


Driver Assistance


Strategy and Consulting


Vehicle Concepts

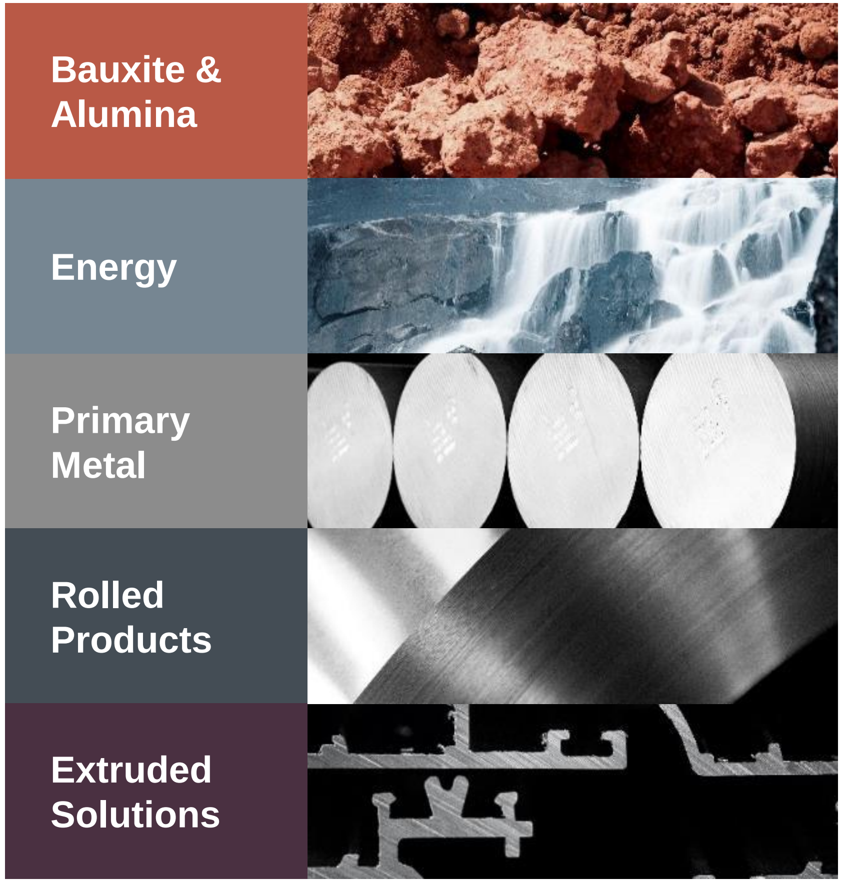

Thermal Management


Acoustics


Driver Experience and Performance

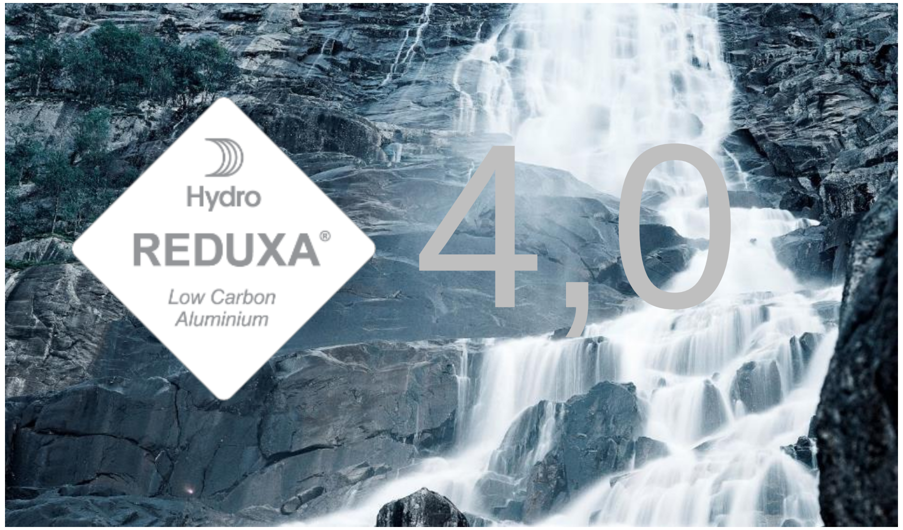
- Founded in 1902 (ika) and 1981 (fka)
- Total staff of more than 500 employees (ika + fka)
  - ~200 engineers
  - ~80 workers, technicians and apprentices
  - ~220 students
- References:
  - Automotive customers from Europe, USA and Asia
  - OEM and suppliers
  - Public funded research

Hydro –
An integrated customer-oriented aluminium company



- Global provider of alumina, aluminium and aluminium products and solutions
- Leading businesses along the value chain; raw materials, energy, primary metal, rolled products, extruded solutions and recycling
- 35,000 employees at 150 locations in 40 countries
- Market cap ~NOK 100 billion/ ~USD 12 billion
- Annual revenues NOK 109 billion (2017)
- Included in Dow Jones Sustainability Indices, Global Compact 100, FTSE4Good

Hydro -
Low carbon products REDUXA® and CIRCAL®



- **Hydro is pushing the boundaries for low carbon aluminum and use of consumer scrap to create recycled alloys and products helping our customers on the path to zero emissions.**
- **Through the use of renewable power and modern technology we are able to produce cleaner aluminum than ever before.**
- **Hydro REDUXA® is a certified, low carbon aluminum with a maximum carbon footprint of 4.0 kg CO_2 per kg aluminum.**
- **Hydro CIRCAL® is a range of prime quality aluminum made with a minimum of 75% recycled, consumer scrap.**
- **Hydro is working to further develop greener alloys partnering with our forward looking customers**

Hydro REDUXA – Primary billet

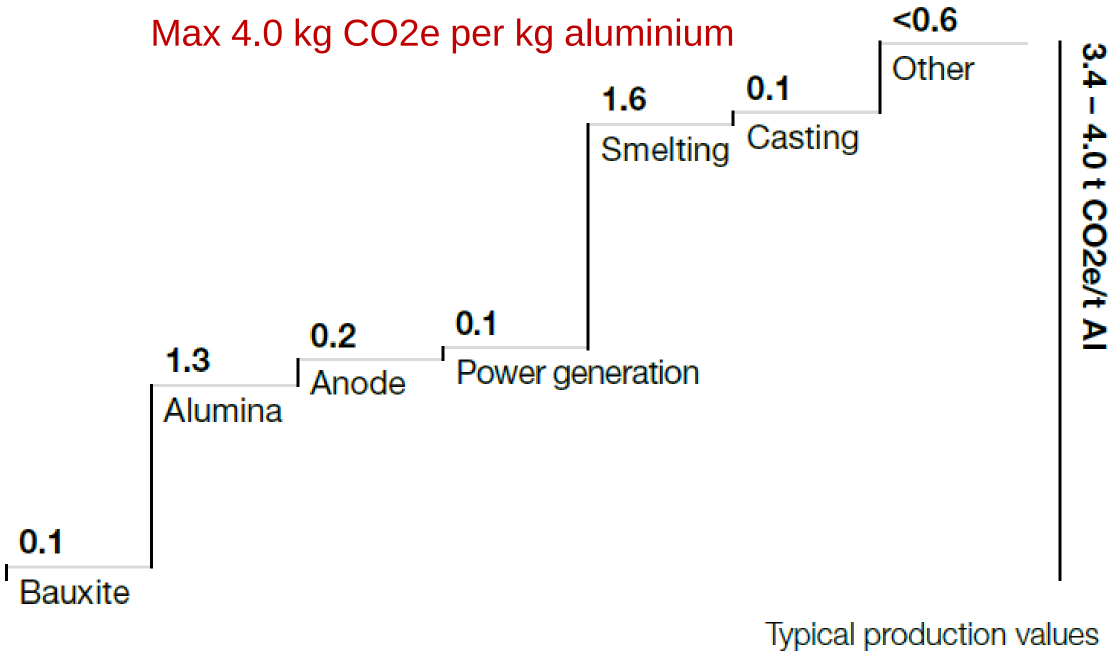
Hydro
REDUXA®
Low Carbon Aluminium

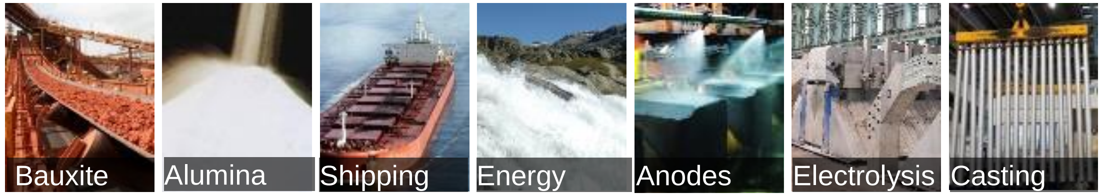
«All-in» approach

Scope 1,2 and 3

Certified ISO 14064

EPD





GHG EMISSIONS VERIFICATION DNV·GL ISO 14064

epd®

REDUXA available in all grades and formats supplied from Hydro's Norwegian aluminium plants(*)

(*) Årdal, Karmøy , Sunndal, Høyanger, Husnes

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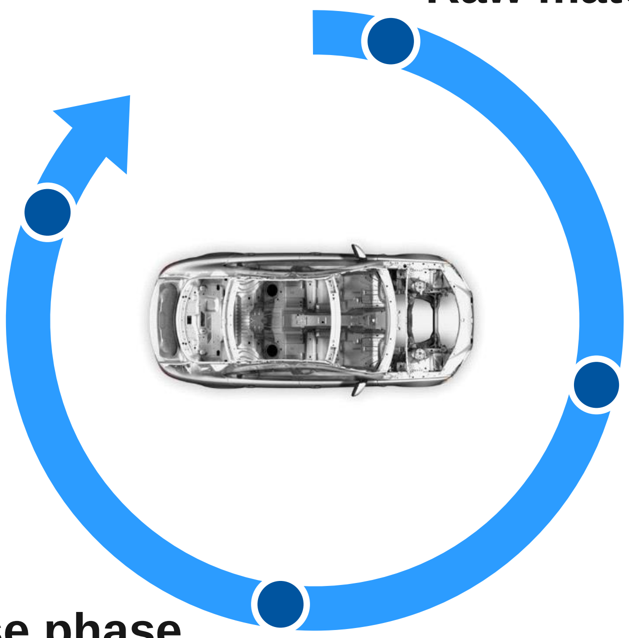
Motivation
Impact from an automotive perspective

- Current legislative regulations mainly focus on emissions generated in the use-phase of vehicles
- Reduction of tailpipe emissions (by i.e. electrification) leads to increased share of emissions generated in the Production and End-of-Life (EoL) phase
- Lightweight design reduces use-phase emissions significantly, but usually generates a higher emission impact in the production phase compared to a conventional steel intensive design
- Holistic approach required to assess lightweight technologies and other CO_2 reduction measures from a life-cycle perspective in order to evaluate the ecological break-even point and economical implications

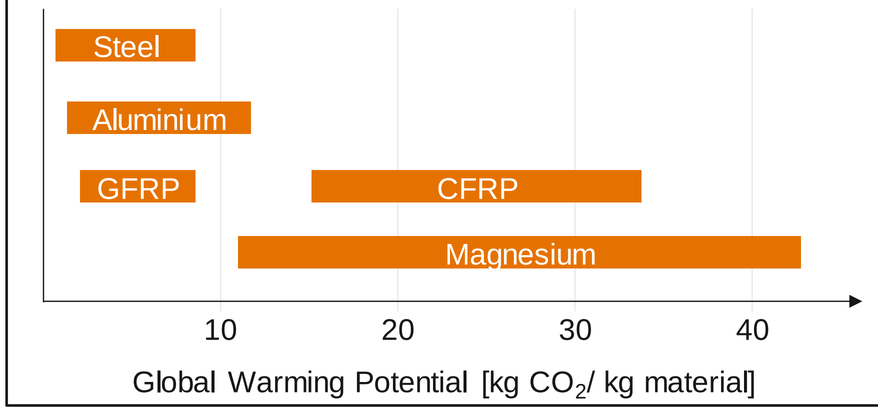
Life Cycle Assessment (LCA) of Vehicles



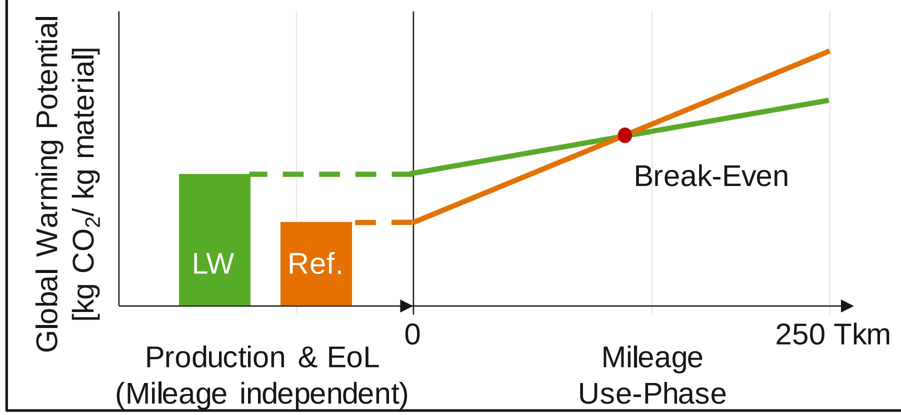
Motivation
The role of aluminium

- **Application of aluminium in vehicles offers significant weight reduction potential compared to conventional materials**
- **Production of aluminium is often related to a higher ecological footprint compared to steel and dependent on the boundary conditions (energy sources, recycling rate, etc.)**
- **Considering the weight saving potential and vehicle use scenarios, the application of aluminium could lead to an ecological benefit**
- **Open Question: How does aluminium and especially low-carbon aluminium impact the LCA of vehicles?**

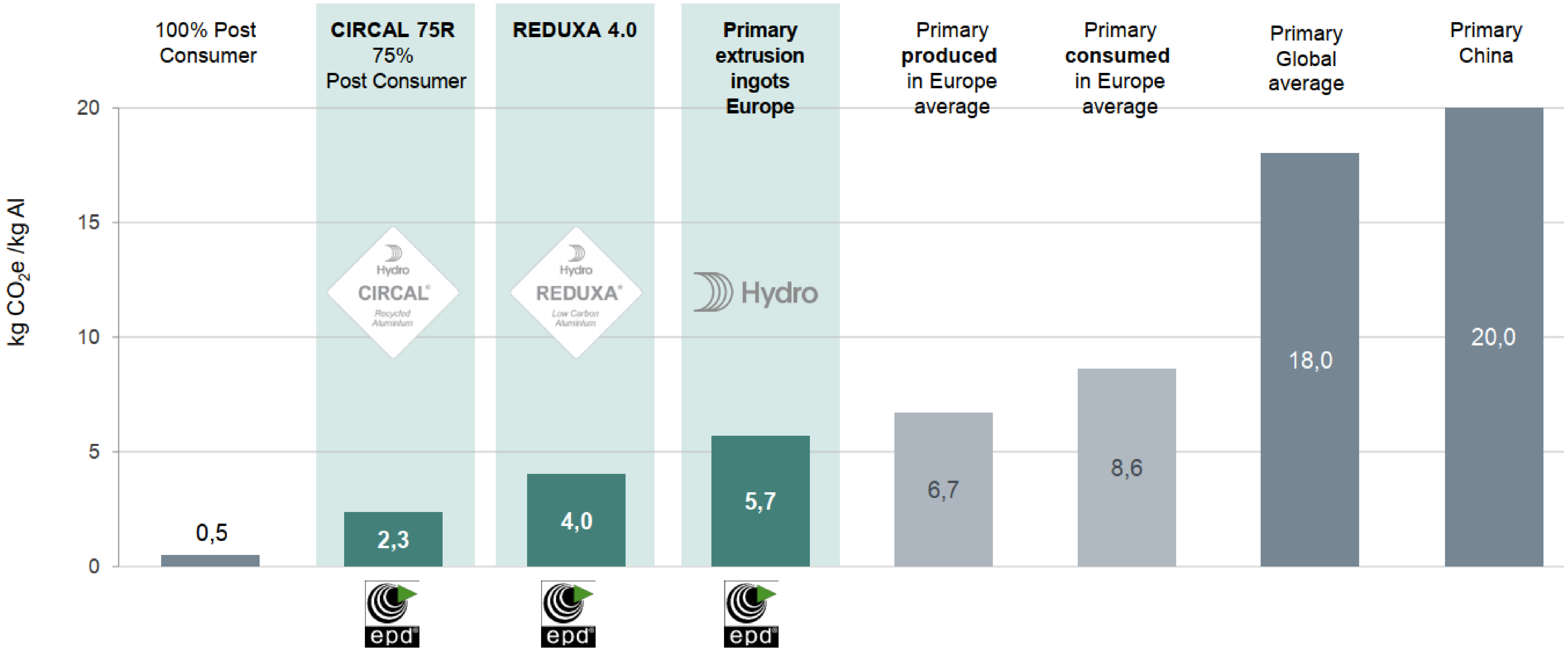
Material assessment



Break-Even Analysis



Motivation
CO_2eq footprints by origins



Source: IAI/EAA/Hydro

Motivation
The fka vehicle assessment model as a baseline

1 Full Vehicle Configuration

- Definition of reference vehicle based on general data (dimensions, engine configuration, etc.)
- Determination of vehicle specific parameters (mass, material distribution, energy consumption, etc.)

2 Full Vehicle Pre-Assessment

Pre-assessment of full vehicle towards:

- Vehicle Mass
- Energy Consumption
- LCA
- LCC

3 Adaption of Technologies

- Implementation of light weighting technologies in specific applications of the body structure
- Consideration of alternative material an manufacturing technologies
- Consideration of secondary weight reduction potentials

4 Comparison of results

- Comparison of reference vehicle and light weight variant
- Evaluation of impact towards:

- Vehicle Mass
- Energy Consumption
- LCA
- LCC

- Derivation of measures

→ Methodical assessment of light weighting technologies at an early concept phase of the vehicle development process without an actual layout

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Approach
Definition of generic vehicles & lightweight variants

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	C-Segment				SUV-Segment	
Reference variants	ICEV	BEV (200 km)	BEV (400 km)	ICEV	BEV (400 km)	BEV (600 km)
Lightweight variants	ICEV	BEV (200 km)	BEV (400 km)	ICEV	BEV (400 km)	BEV (600 km)

Aluminium application

- Incl. consideration of primary and secondary weight saving effects (downsizing of chassis & engine, scaling of energy storage system, etc.)

Approach
Aluminium Application in Car Bodies

» Outer Panels	Deep drawing	EN AW 6016
» Body Structure		
■ Structural Sheets	Deep drawing	EN AW 5182
■ Structural Profiles (low performance, i.e. cockpit carrier)	Extrusion	EN AW 6060
■ Structural Profiles (high performance, i.e. rocker)	Extrusion	EN AW 6082
■ Strength relevant components (i.e. A-Pillar, roof cross member)	Deep drawing	EN AW 6061
■ Complex structures	Casting	AlSi9Mn

→ Replacement of entire steel materials in Body-In-White through aluminium

Approach
Life Cycle Assessment (LCA)

- LCA according to DIN EN ISO 14044:2006
  „Consideration of all in and outflows (material and energy), as well as potential environmental impact of a product system throughout all life-cycle stages"

GWP Values (Primary):

- AL European Average: 6,70 $kgCO_2$-eq./kg
- Steel: 2,08 $kgCO_2$-eq./kg
- REDUXA®: 4,00 $kgCO_2$-eq./kg

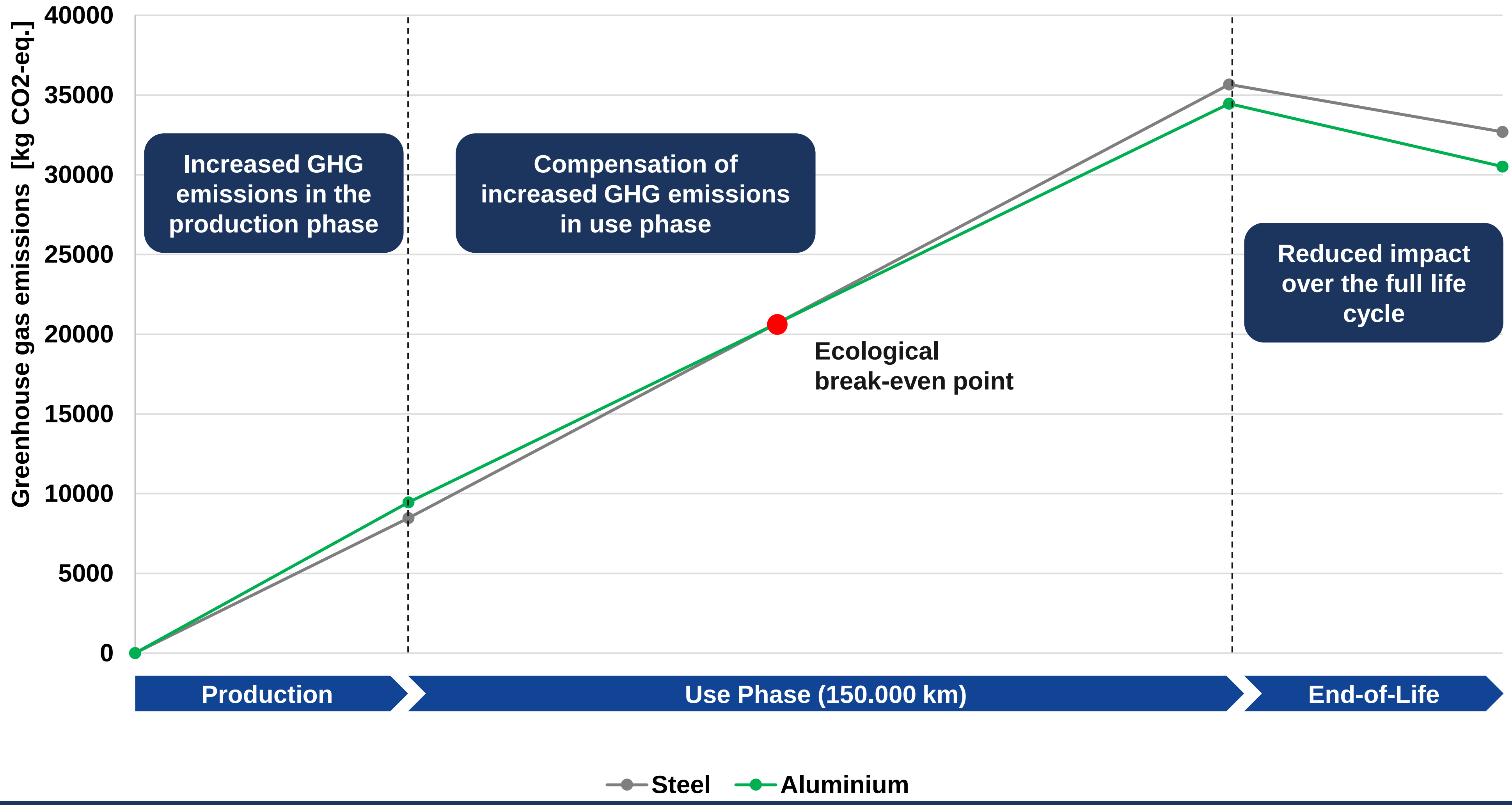
- Consideration of different representative grid-mix scenarios for the use phase of BEV
- Definition of use phase mileage scenario: 150.000 km

Agenda

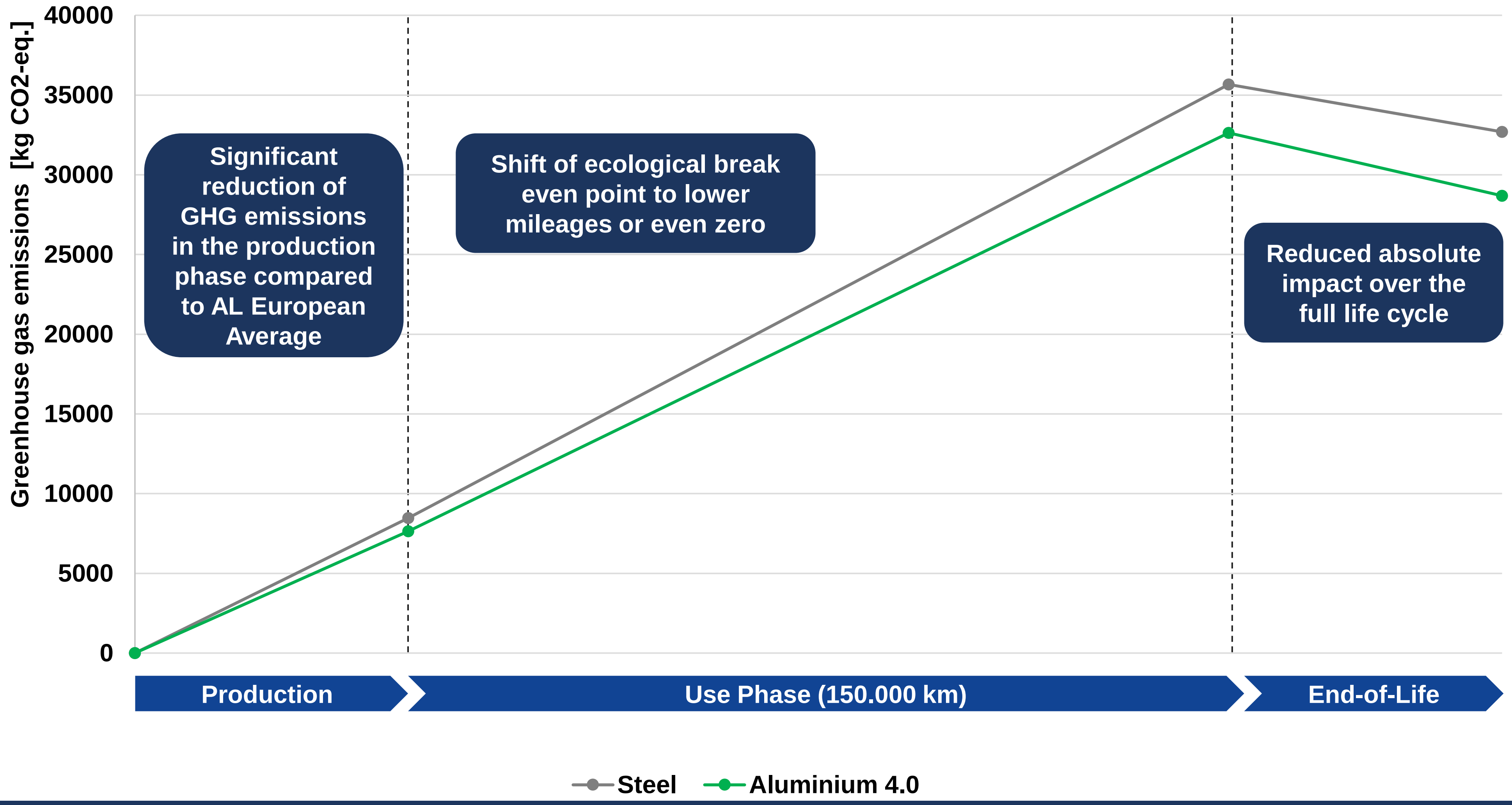
Results
Weight Impact

Vehicle	Compact Class Segment: Range	Compact Class Segment: Before	Compact Class Segment: Change	Compact Class Segment: After	SUV Segment: Range	SUV Segment: Before	SUV Segment: Change	SUV Segment: After
Combustion Engine Vehicle (ICE)		1255.7 kg	-13,7 % (incl. 4,6 % secondary reduction)	1083.7 kg		1553.3 kg	-13,6 % (incl. 4,6 % secondary reduction)	1342.5 kg
Battery Electric Vehicle (BEV)	200 km Range	1493.6 kg	-13 % (incl. 4,5 % secondary reduction)	1299.5 kg	400 km Range	2306.6 kg	-10,7 % (incl. 3,7 % secondary reduction)	2059.3 kg
	400 km Range	1610.4 kg	-11,8 % (incl. 4,0 % secondary reduction)	1420.5 kg	600 km Range	2619.5 kg	-9,4 % (incl. 3,2 % secondary reduction)	2372.8 kg

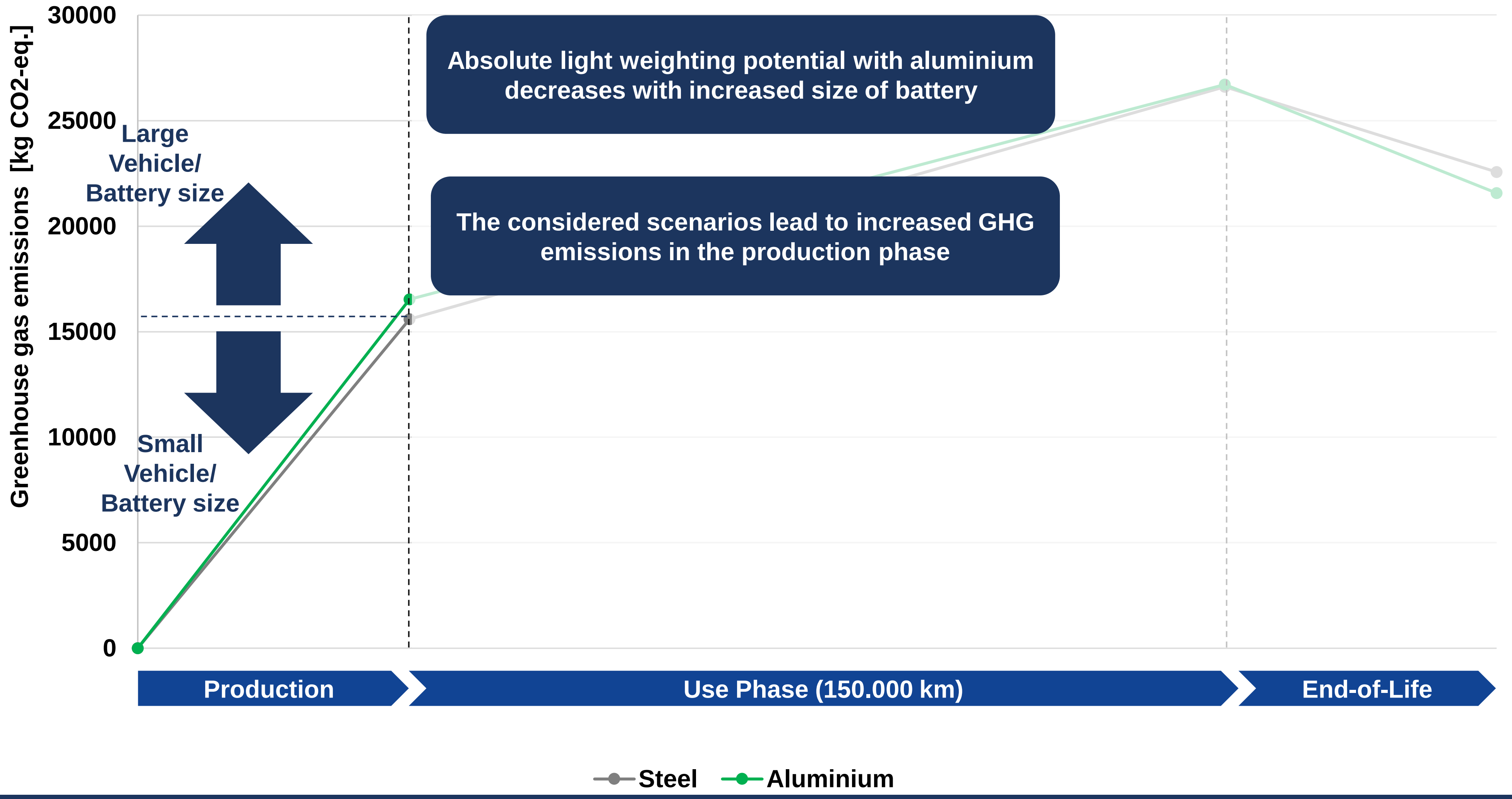
General Results - Internal Combustion Engine Vehicles
Impact of Aluminium European Average



General Results - Internal Combustion Engine Vehicles
Impact of REDUXA®



General Results – Battery Electric Vehicles
Impact of Aluminium European Average



General Results – Battery Electric Vehicles
Impact of Aluminium European Average

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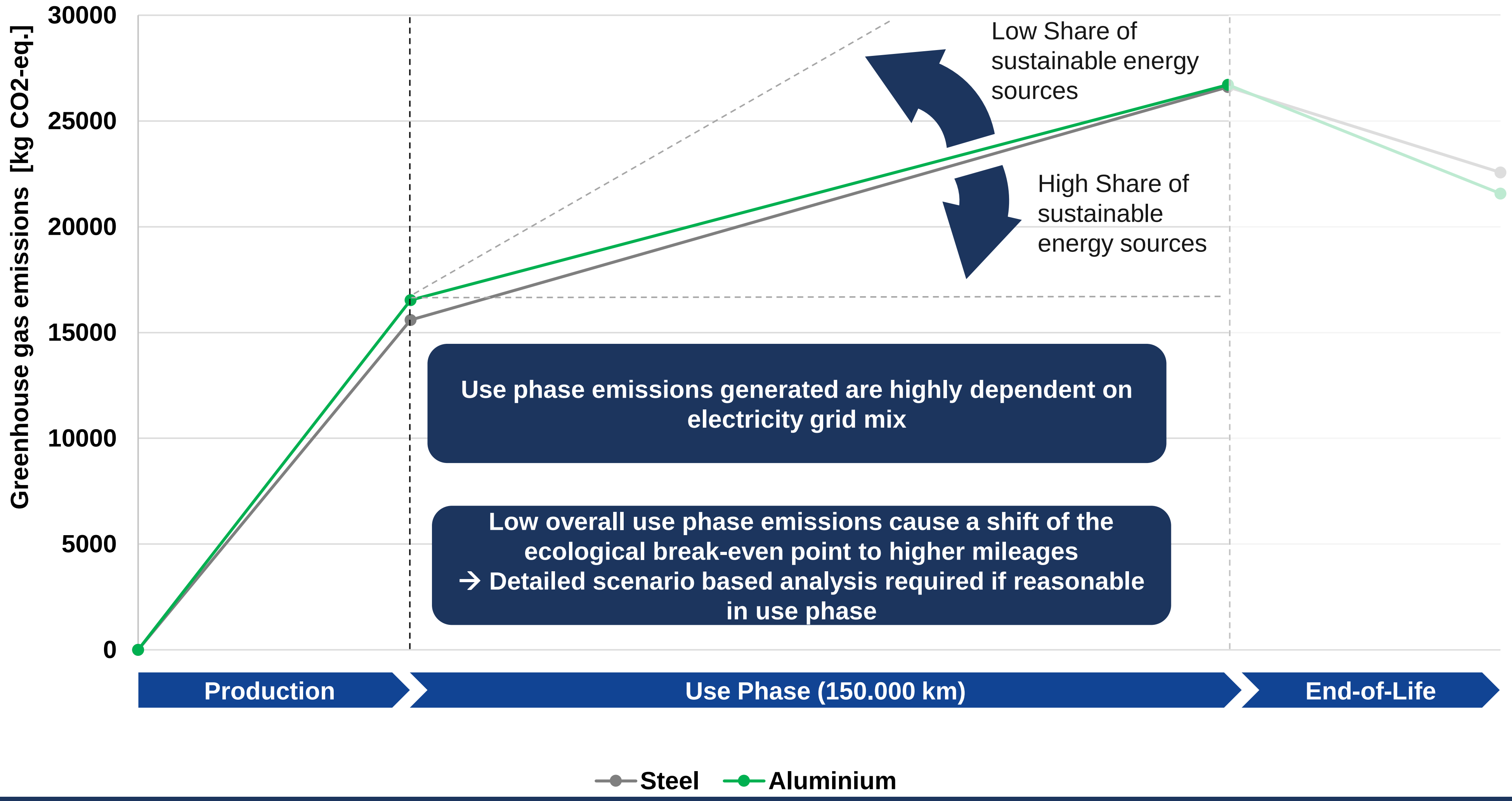
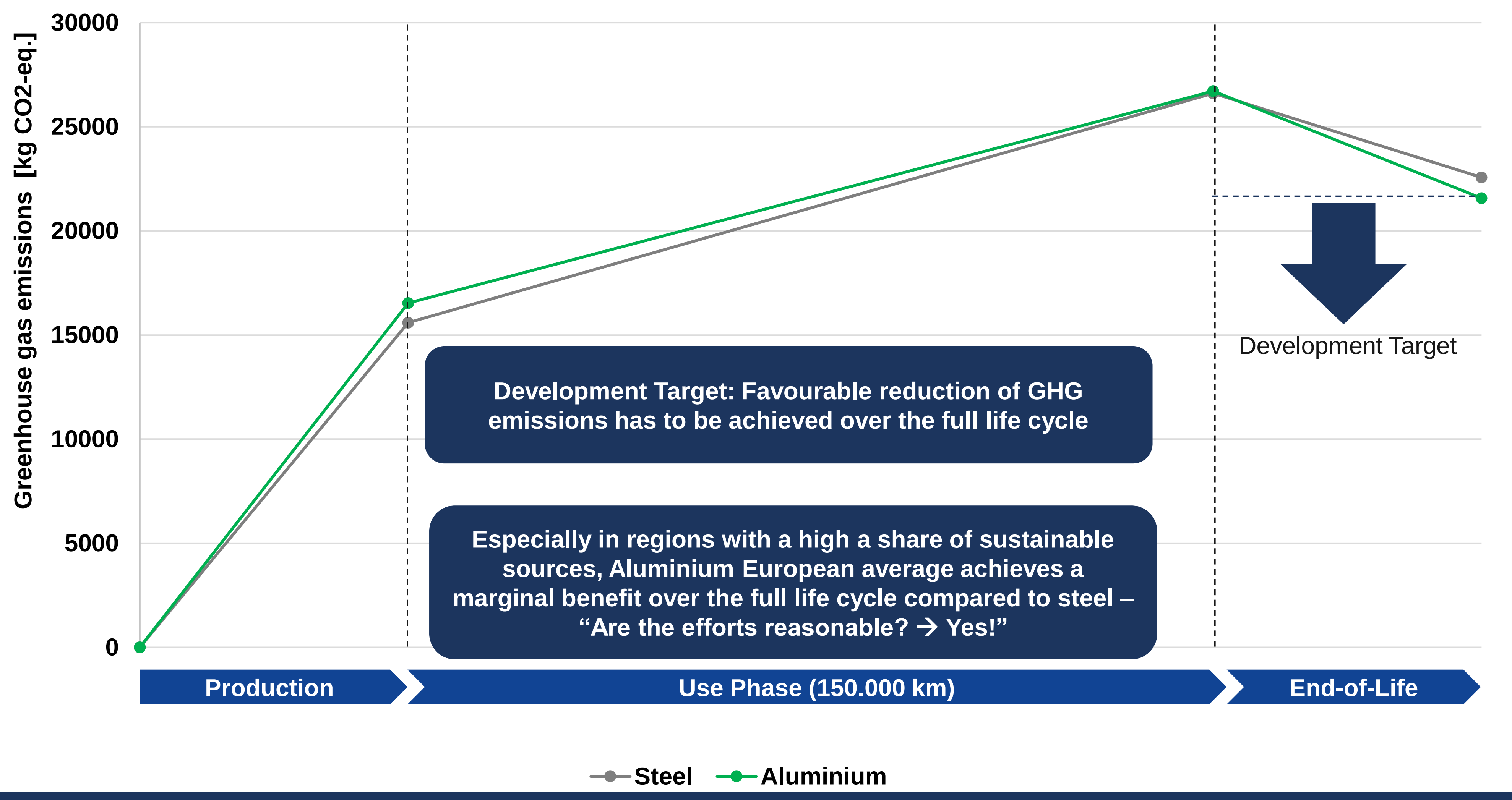
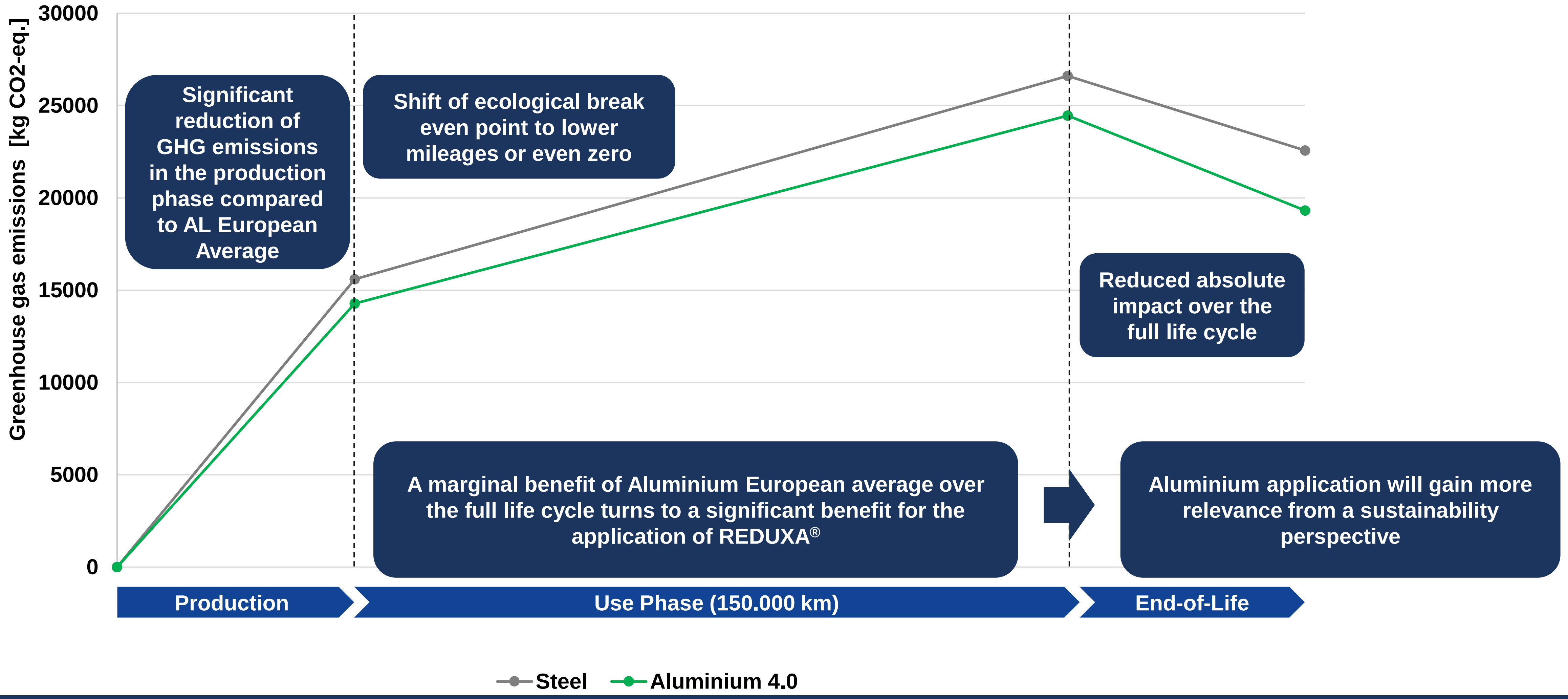


General Results – Battery Electric Vehicles
Impact of Aluminium European Average



General Results – Battery Electric Vehicles
Impact of REDUXA®



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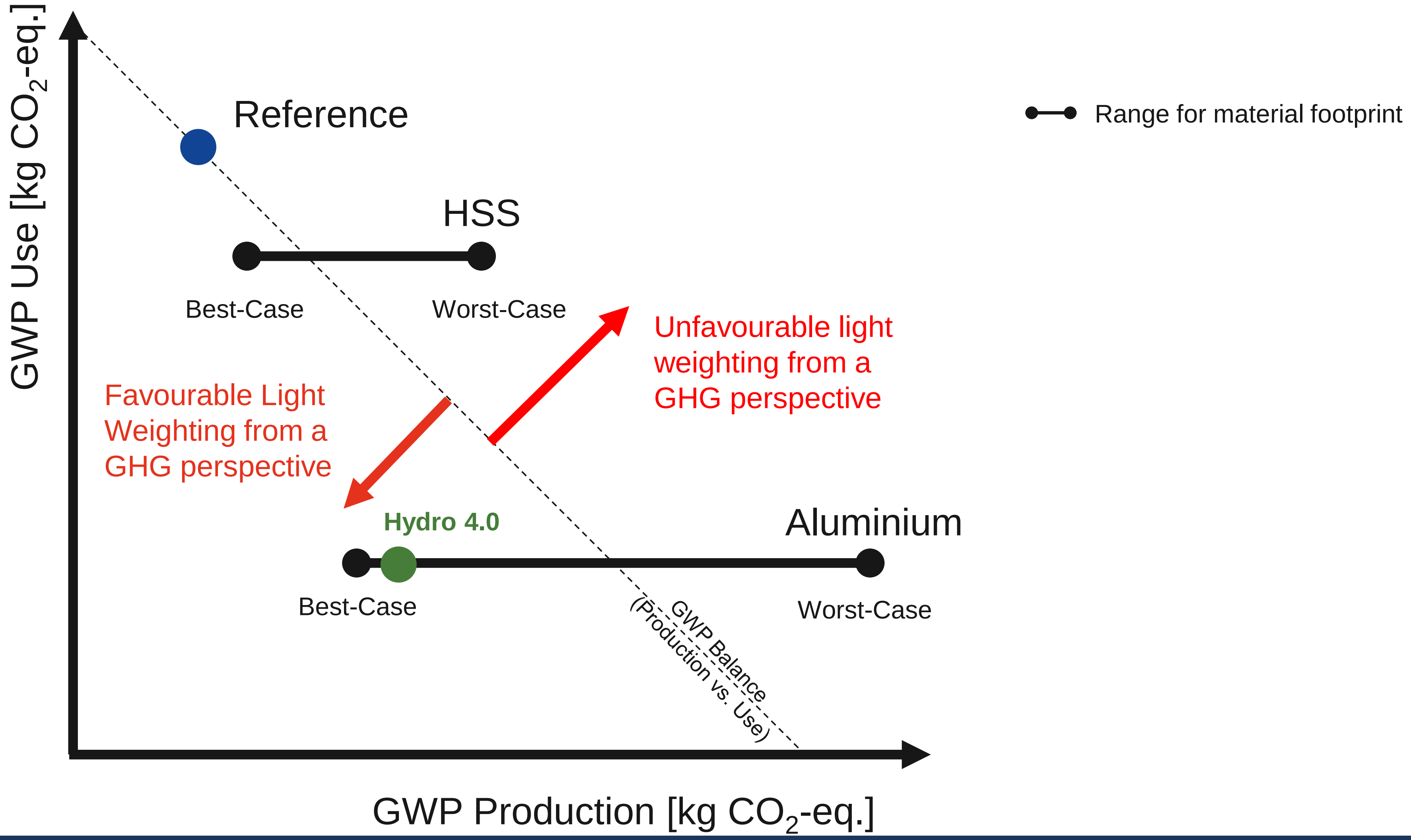
Summary
Key Findings

- The electricity mix of the specific regions have a big influence on the CO_2 footprint of a BEV
- REDUXA® 4.0 is a key enabler to reduce full vehicle production emissions and allow a better CO_2 footprint from the first kilometre onwards
- While the application of Aluminium European Average in BEV is not not favorable from a GHG perspective in the production and use phases for regions with a high share of sustainable energy sources, REDUXA® 4.0 can cause a lower environmental impact in all life-cycle stages
- The highest absolute environmental benefit from light weighting with aluminium in BEVs can be achieved in regions with a high share of fossil energy sources
- A reduction of the use phase emissions by light weighting results in a higher overall relevance of the production phase, thus materials like REDUXA® 4.0 gain more importance
- Lighter cars lead to smaller battery packs for the same driving range. Further work in a separate study will focus on the economic trade off between light weighting costs and battery/ drivetrain costs under varying conditions

Summary
Key Findings – Schematic Impact Illustration



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