Volkswagen

ID. INSIGHTS

SUSTAINABLE E-MOBILITY

Presentations:

Supply chain
Production
Use phase
Re-use / recycling

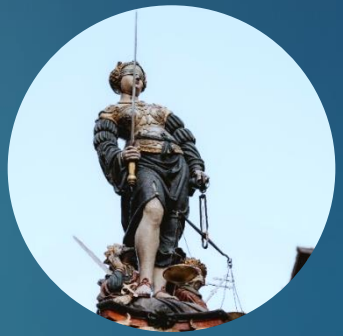
Supply chain
Module 1

Marco Philippi
Corporate Director, Strategy Group Procurement

Proactive management of sustainability through procurement has started

Environmental

Social



Compliance

Requirements for our

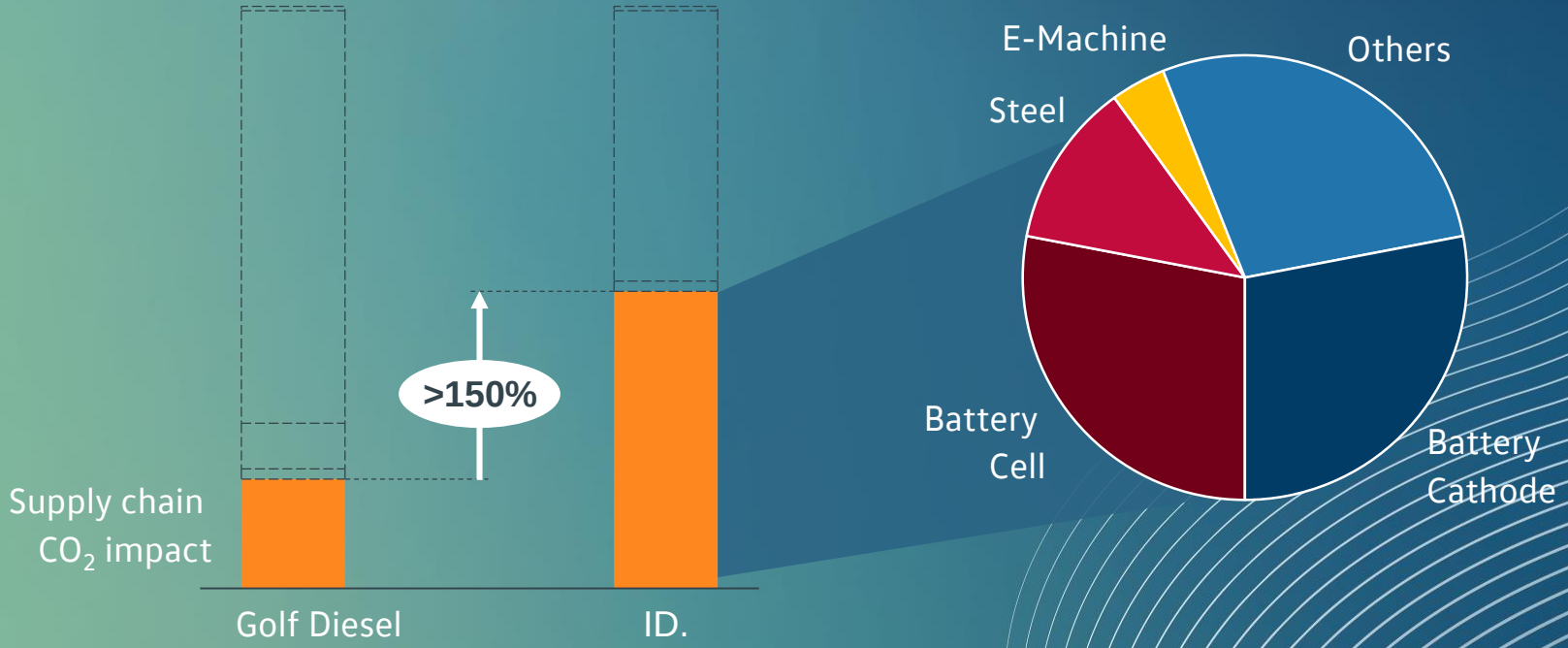
supply Chain

„We have announced the most comprehensive electrification program in the automotive industry. Transparency in the supply chain is a prerequisite for the assessment of social and environmental standards.“

S. Sommer
Group Board Member for
Components and Procurement

Pictures by www.unsplash.com

Batteries bring higher CO_2 emissions in the supply chain



Our activities to optimize CO_2 in the supply chain

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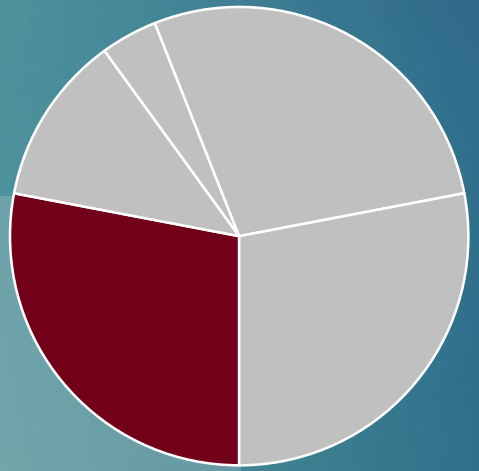
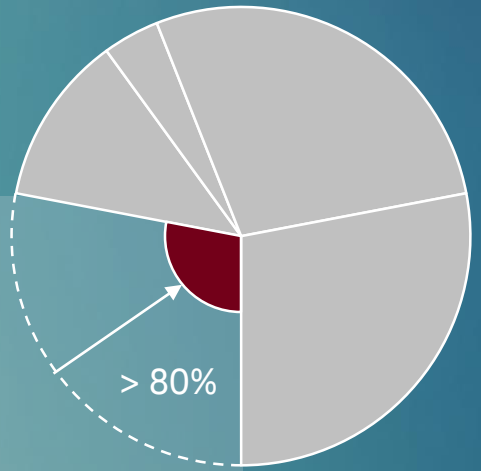


1 HV Battery Cell

Background
- Energy-intense process
- Energy sources: electricity + LNG

Measures
- 100 % green energy, defined in procurement requirements; confirmed by ID. Tier 1 suppliers

1 HV Battery Cell



Background
- Energy-intense process
- Energy sources: electricity + LNG

Measures
- 100 % green energy, defined in procurement requirements; confirmed by ID. Tier 1 suppliers

Reduction Potential
> 80%

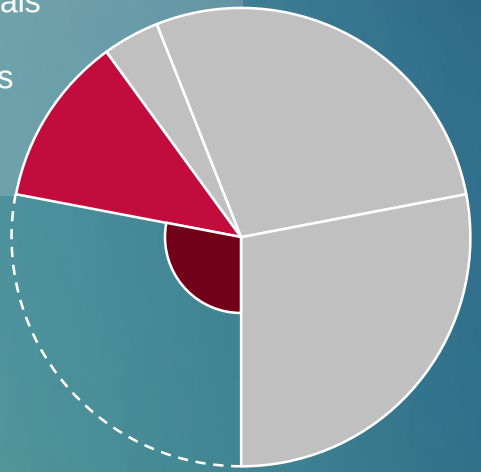
2 Steel

Background

- CO_2 as process-inherent emission (limestone decomposition and iron ore reduction cause CO_2 emissions)

Measures (two general approaches):

- End-of-pipe approach:
  Capture/store/use for synthetic fuels & chemicals
- Process-integrated approach:
  adapted reduction agent avoids CO_2 emissions



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2 Steel

Background

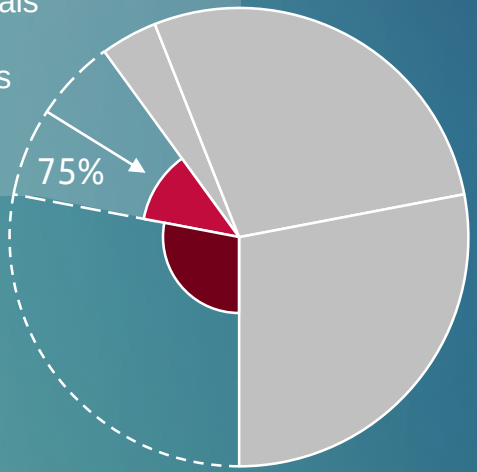
- CO_2 as process inherent emission (limestone decomposition and iron ore reduction cause CO_2 emissions)

Measures (two general approaches):

- End-of-pipe approach:
  Capture/store/use for synthetic fuels & chemicals
- Process-integrated approach:
  adapted reduction agent avoids CO_2 emissions

Reduction Potential

> 75%



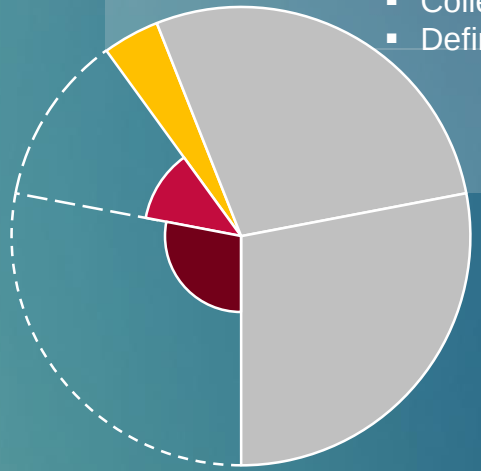
3 E-Machine

Background

- Aluminum used for case & magnet production is CO_2 hot-spot

Measures

- Usage of secondary aluminium
- Green energy usage Tier 1 suppliers
- Collect specific energy demand in sub-supply chain
- Define further measures



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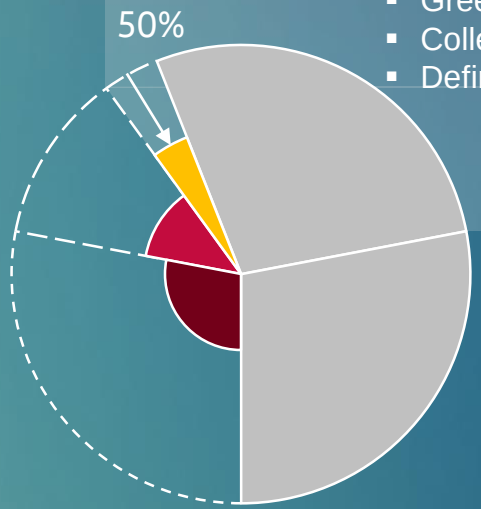
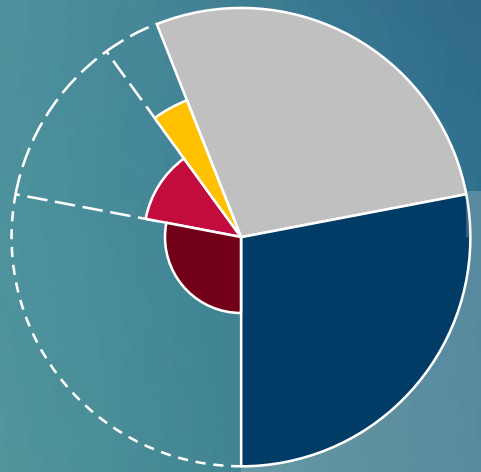


Reduction Potential

50%



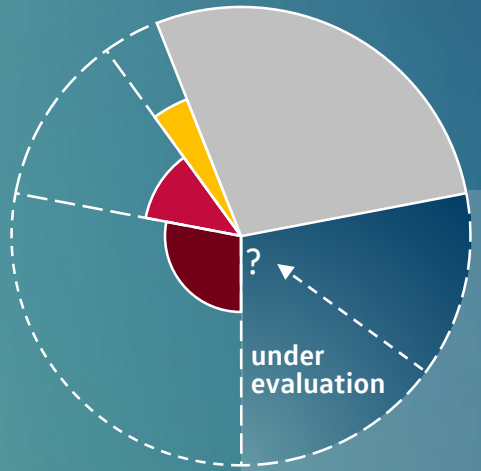
3 HV Battery Cathode

Background

- Cathode production and sub-supply chain (raw material production) expected to be CO_2 hot-spot

Measures

- Collecting specific energy demand in sub-supply chain
- CO_2 reduction with suppliers with reduction program in cooperation with Tier 1



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Background

- Cathode production and sub-supply chain (raw material production) expected to be CO_2 hot-spot

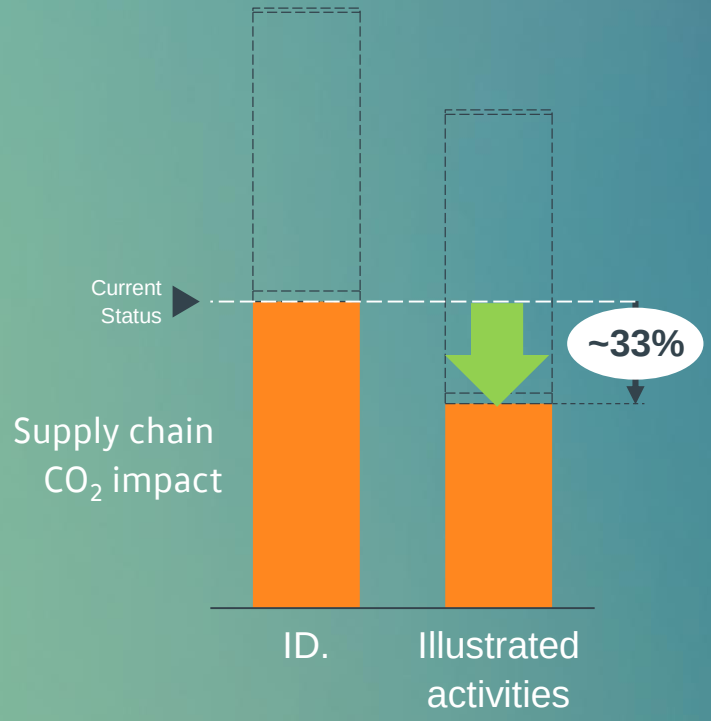
Measures

- Collecting specific energy demand in sub-supply chain
- CO_2 reduction with suppliers with reduction program in cooperation with Tier 1

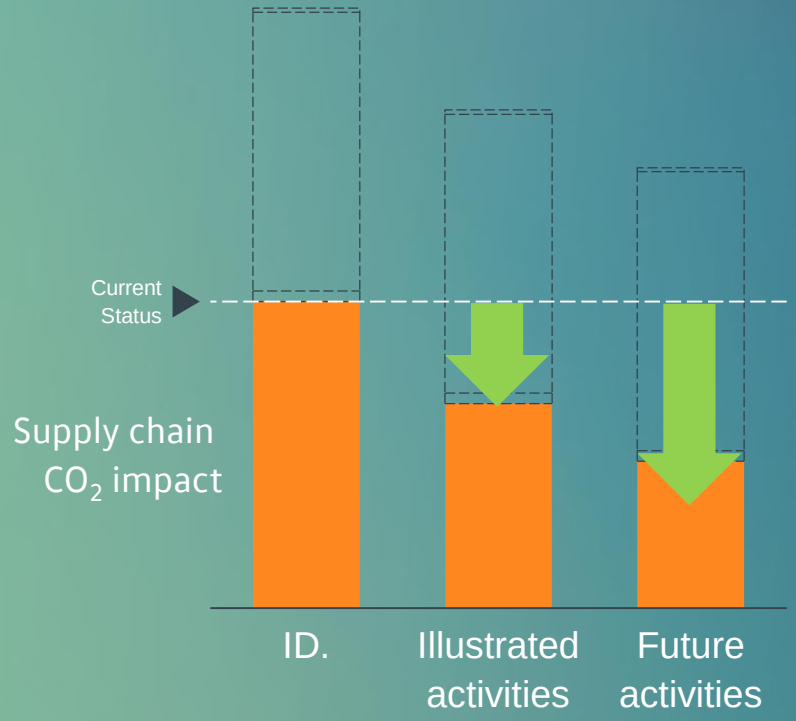
Reduction Potential

under evaluation

Illustrated potential of CO_2 reduction



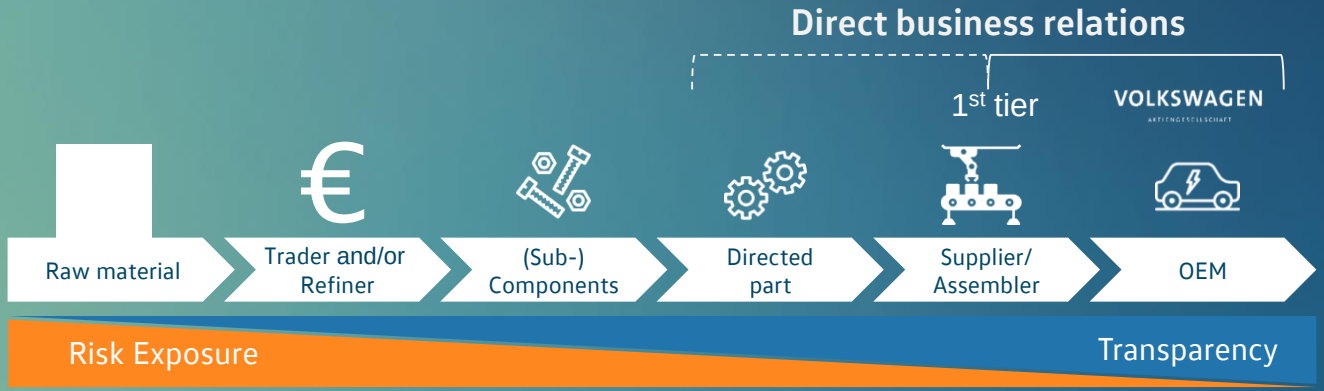
Illustrated potential of CO_2 reduction and outlook



Further measures to decrease CO_2 emissions

- Inclusion in decision-making processes
- Green Energy Requirements for suppliers
- Focus on further materials and key components
- Use of secondary material
- CO_2 workshop with suppliers to define specific action plans
- Switch to other production technologies
- Supplier trainings and consulting

Supply chain transparency is a cross-factor hot-spot



Our approach:

1) Focus on critical parts, e.g. battery cells
2) Form partnerships with first tier suppliers to disclose all supply chain actors
3) Gather data, generate transparency and implement measures
4) Transfer approach to other supply chains

Challenges in our supply chain

- Deep automotive supply chains are complex and bear high risks
- 100% transparency for all parts and materials is currently not possible

Pictures by www.unsplash.com, Icons made by www.flaticon.com

Sustainability as selection criteria on par with quality or price

Volkswagen

NEW

- Costs
- Investments
- Technical rating
- Quality rating
- Logistics rating
- Sustainability „S-Rating“

Sustainability as decision parameter

- Group-wide process for all suppliers
- Supplier assessement on sustainability (environment, social, compliance)
- No contracts with negatively rated suppliers

Sustainability as selection criteria on par with quality or price

Volkswagen

NEW

Costs	Investments	Technical rating	Quality rating	Logistics rating	Sustainability „S-Rating“

- **Code of conduct** for business partners
- Group Policy on **Sustainable Raw Materials**

Sustainability as

decision parameter

- Group-wide process for all suppliers
- Supplier assessement on sustainability (environment, social, compliance)
- No contracts with negatively rated suppliers

Transparency measures mitigate compliance risks

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GLOBAL BATTERY ALLIANCE

Setting standards to ensure the social and environmental sustainability for battery materials.

Platform for exchange and on-the ground work.

RESPONSIBLE MINERALS INITATIVE

Develop and standardise certification systems for cobalt, tantalum, tungsten, tin & gold.

Offering training materials for upstream actors in the supply chain.

DRIVE SUSTAINABILITY

Develop and standardise risk assessment tools (questionaires, raw mat. observatory).

Develop and conduct trainings and educational products / tools.

ALUMINIUM STEWARDSHIP INITATIVE

Global sustainability standard for aluminium.

Apply to all stages of the aluminium value chain from raw material extraction to recycling.

Others:
Econsense
EITI
VDA
…

We want to be a
driving force

Volkswagen

- We engage actively in initiatives in order to
  - trigger broad supply chain improvements
  - develop & introduce tools and standards
  - carry out joint risk assessments
  - design & conduct trainings

Summary: Marco Philippi on the supply chain

- Volkswagen is seeing the first signs of success in supply chain CO_2 reduction
- The battery cell, steel and the e-machine are hot-spots we are addressing
- Given the complexity of the supply chain, 100% transparency for all parts and materials is currently not possible
- Sustainability standards will become a binding selection criterion on a par with quality or price
- Volkswagen actively engages in diverse manufacturer and cross-sector initiatives

Concept Car

Production
Module 2

Dr. Liendel Chang
Head of Environmental Production

Volkswagen has addressed sustainable in-house production for many years

Volkswagen

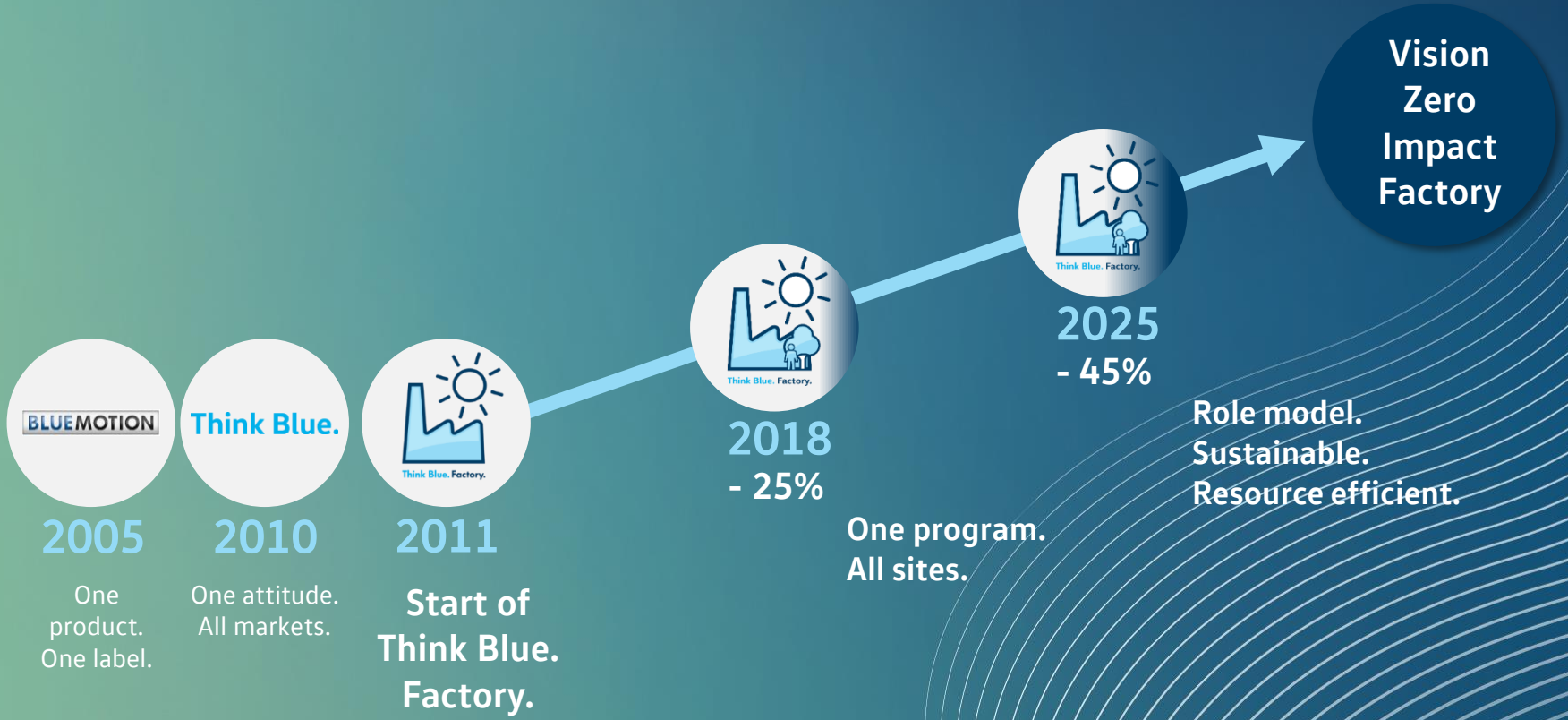
Energy Efficiency

Energy Supply

Climate Projects

Targets for environmental improvement develop continuously

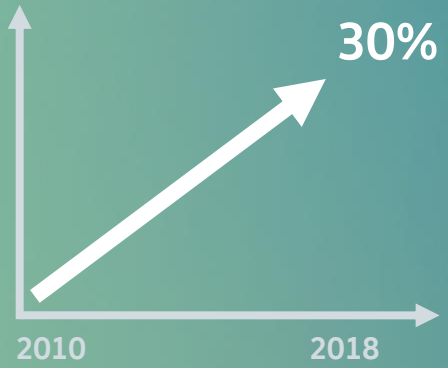
Volkswagen

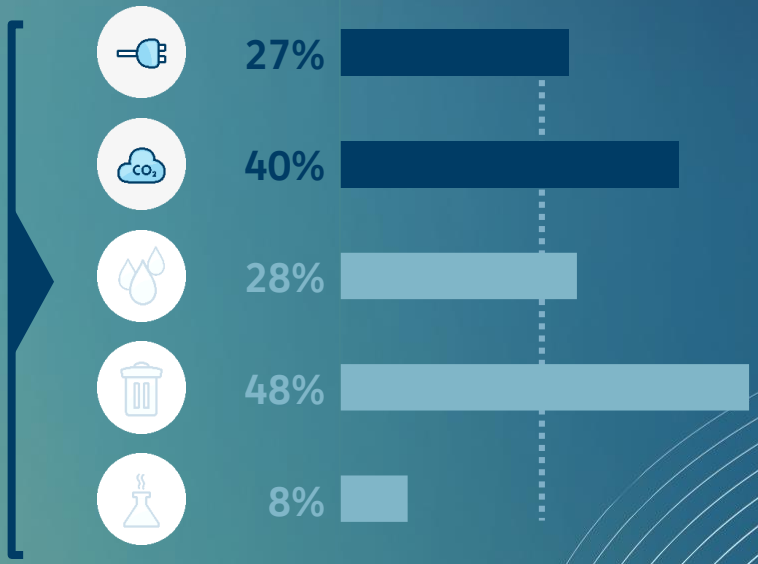


The brand has achieved significant measurable results

Volkswagen

Total environmental improvement production





25% target 2018

Considerable savings per car

Data as at January 31, 2019, subject to auditor's confirmation

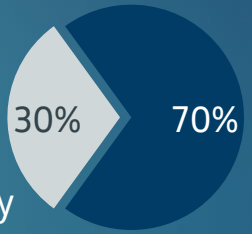
All plants exchange best know-how and benchmark measures

Volkswagen

The paint shop is the most energy-intensive process

Volkswagen

Plant level



Overhead costs

Subsection level

Press Shop

Body Shop

Paint Shop

Assembly

Energy consumption	< 10 %	10-15 %	50-60 %	10 %

First we harvested the low-hanging fruits, now we are reaching for the higher branches…

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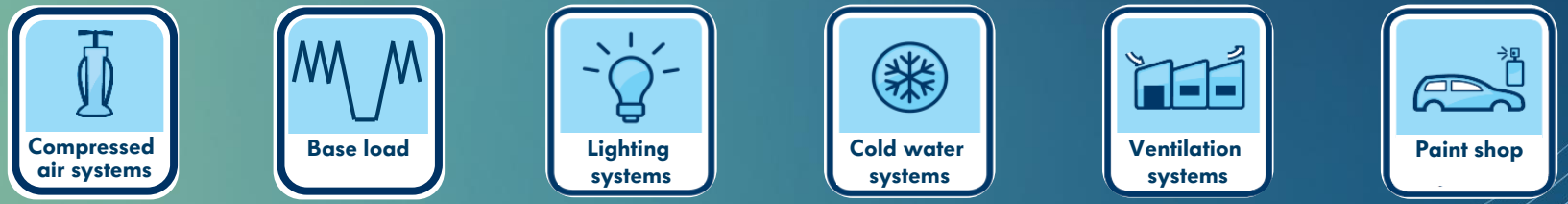


Site questionnaire

On site analyses

Additional measures of the plants

Forum of Experts

CO_2-efficient energy supply is the second field of action

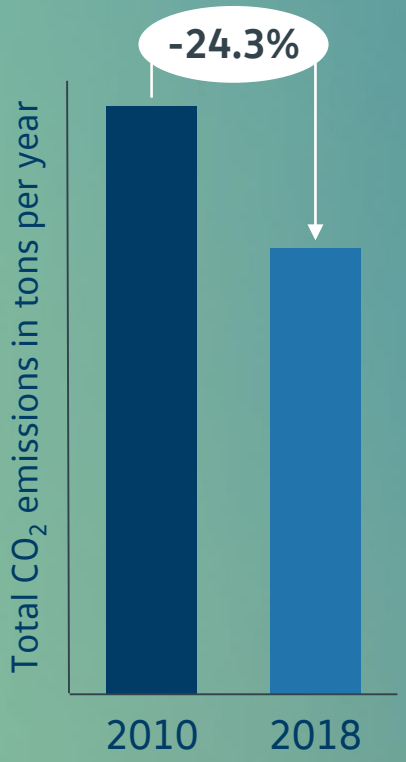
Volkswagen

Energy Efficiency

Energy Supply

Climate Projects

Each production site has its individual decarbonisation path



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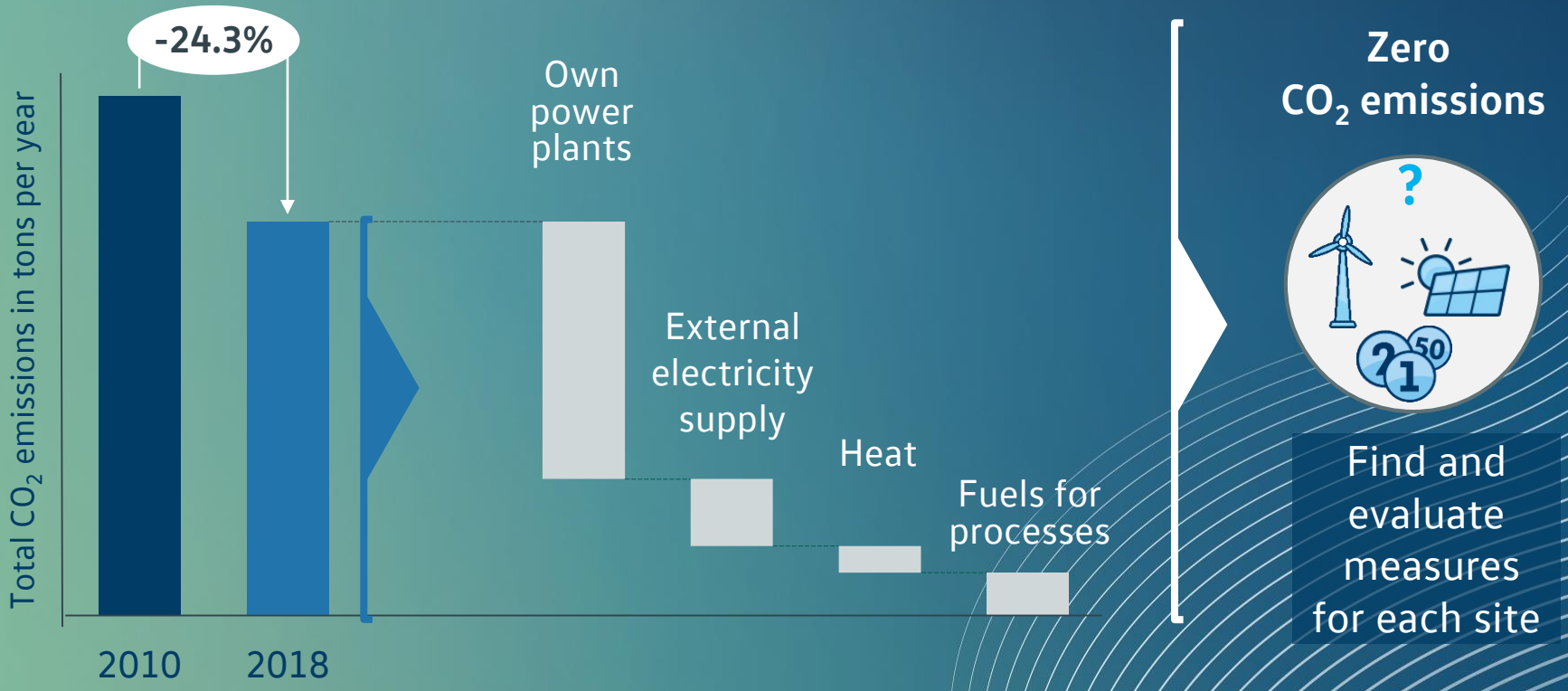
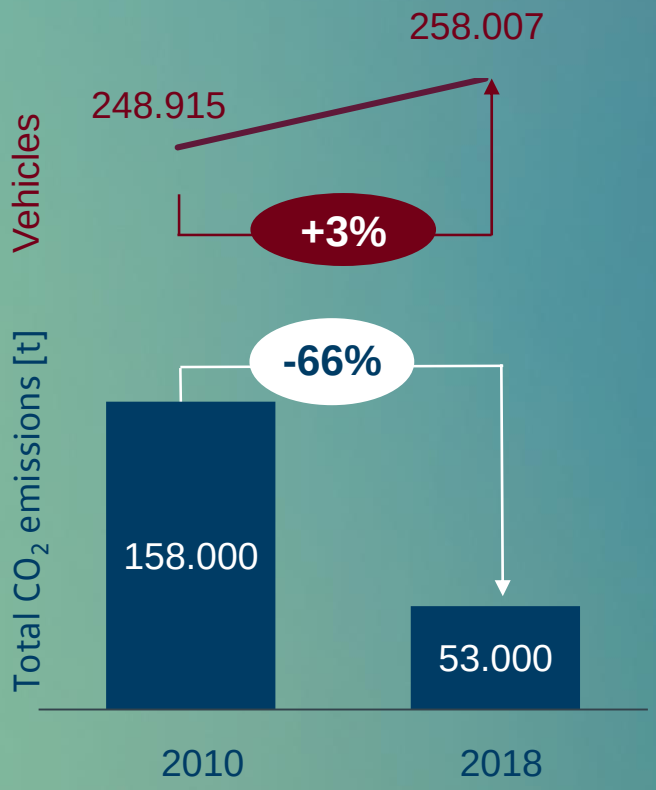


Data as at January 31, 2019, subject to auditor's confirmation

Zwickau plant: Despite production increase, absolute CO2 emissions have been reduced by 66% since 2010

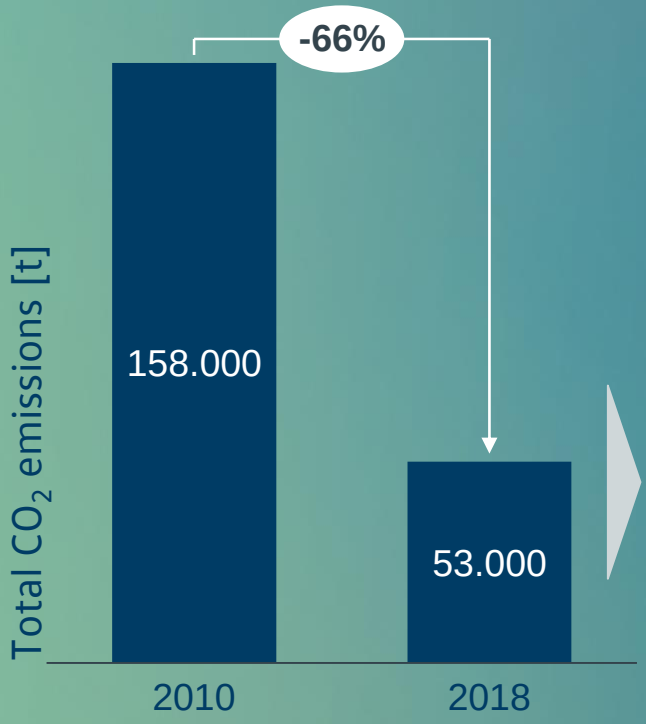


Forecast data for 2018, subject to auditor's confirmation

Decarbonisation progress generated:

- → ⅓ by switch to gas-powered combined heat and power plants (CHP)
- → ⅓ by switch to green energy supply
- → More then ¼ by energy efficieny measures
- → Rest achieved by own generation of PV and wind energy

Decarbonisation outlook at Zwickau Plant



Continuous optimization

3 Main Consumers

- **Heat**
  → electrification with green electricity
- **Paint shop**
  → optimization planning and operation
- **Air conditioning**
  → intelligent controlling system

Compensation of the remaining emissions

Climate Protection Projects

Summary: Liendel Chang on sustainable production

- Every unit of energy that does not have to be produced is the most carbon-efficient one
- Volkswagen focuses on CO_2-neutral energy supply
- We compensate the remaining emissions by Climate Protection Projects

Concept Car

Use phase
Module 3

Dr. Silke Bagschik
Head of Sales and Marketing, Product Line e-Mobility

Martin Roemheld
Head of e-Mobility Services, Product Line e-Mobility

Our planet is in danger!

Volkswagen

Attractive features for customers concerning use phase benefits from new possibilities of the MEB

Volkswagen

Larger wheelbase
short overhangs

Bigger wheel
diameter

Different
body styles

More space for
driver and passengers

No centre tunnel

Rear- and four
wheel drive

Luggage space
~ combuster (ICE)

Central
computer unit

The ID. in most wanted body styles/sizes

Volkswagen

More to come ...

ID.

ID. CROZZ

ID. BUZZ

ID. VIZZION

Concept Cars

The ID. DNA – defining an entire family

Volkswagen

The new e-mobility era is more than just electric

ICONIC DESIGN	INSPIRING DIMENSIONS	INTELLIGENT DATA	INFINITE DRIVE	INTUITIVE DEVICE
				

Basic requirements: Affordable // Large battery range // Fast charging // Strong residual value

The ID. DNA – defining an entire family

Volkswagen

The new e-mobility era is more than just electric

ICONIC DESIGN

INSPIRING DIMENSIONS

INTELLIGENT DATA

INFINITE DRIVE

INTUITIVE DEVICE

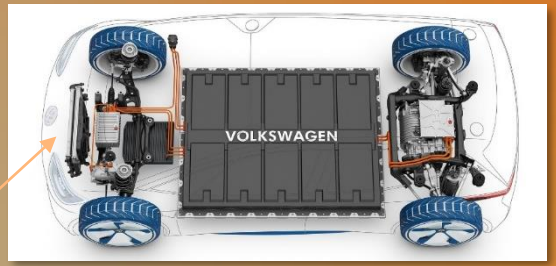
Basic requirements: Affordable // Large battery range // Fast charging // Strong residual value

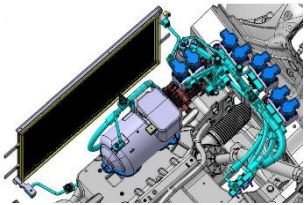
Scalable battery offers customers individual ranges suitable for daily use

Scalable battery offers
individual ranges
from 330 to 550 km (WLTP)

* winter operation at -7 degree celsius

Optional heat pump makes comfortable climate in winter without reducing battery capacity and range





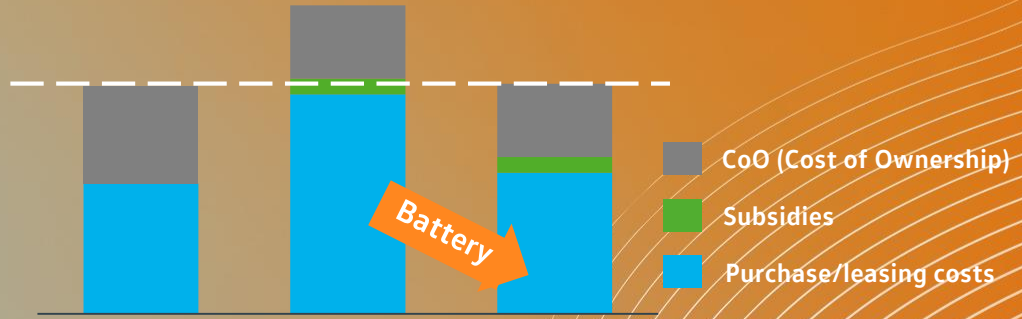
Using waste heat from power train and energy from ambient air, the optional heat pump raises range by about 30% and saves about 3 to 4 kwh /100km of battery capacity

* winter operation at -7 degree celsius

The ID. will realize attractive costs of ownership

Volkswagen

Total Cost of Ownership (TCO) parity compared to internal combustion engine (ICE)



Concept Car

Green operation is one of the core aspects of sustainable mobility

Volkswagen

Green Operation

Efficient Powertrain

Green sharing

Green Energy

Green routing

Concept Car

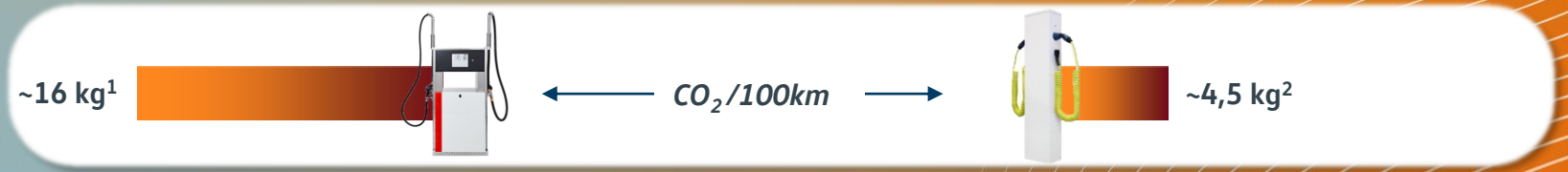
The electric powertrain is the most efficient one

Volkswagen

Efficient Powertrain

Electric vehicles are much more efficient. With the same energy input, they can drive four times as far as a comparable diesel.

6 l diesel = 60 kWh



1) Based on DEKRA article 1 l Diesel emits 2.65 kg CO2 | 2) Based on European Energy Agency (0.296 kg per kWh for European electricity mix)

Volkswagen offers green energy for all charging use cases

Volkswagen

@Home

50% of use cases

- Affordable VW Wallbox
- Foundation of power supplier Elli

@Work

20% of use cases

- VW Fleet Consulting
- electrifying Volkswagens production locations

@Public

25% of use cases

- Equipping dealer infrastructure

@Highway

5% of use cases

- IONITY Joint Venture

Activity	• Affordable VW Wallbox • Foundation of power supplier Elli	• VW Fleet Consulting • electrifying Volkswagens production locations	• Equipping dealer infrastructure	• IONITY Joint Venture
Green Energy option	✓	✓	✓	✓
Mobility Service Provider (Find, Charge, Pay)	We Charge			
Charge Point Operator	Elli	Elli	Misc.	IONITY

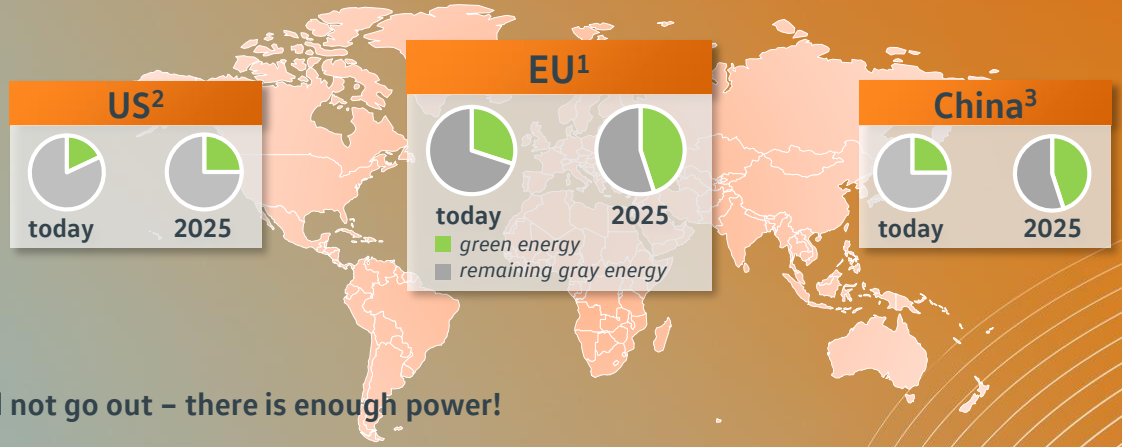
Concept Car

Talking about green energy – its share is increasing worldwide!

Volkswagen

Efficient Powertrain | Green Energy

Even **today**, the global power mix makes **e-mobility greener than any combustion engine**.
According to BloombergNEF the overall share of sustainable energy supply will be 63% by 2040.



The lights will not go out – there is enough power!

The German Federal Government announced **1 million electric vehicles in Germany by the end of 2022**. These will **increase the power consumption by only 0.5%**[4]

Sources: 1. Statista, Federal Ministry for Economic Affairs and Energy | 2. Statista, U.S. Energy Information Administration | 3. International Energy Agency | 4. Based on the following assumptions: 16 kWh / 100 km energy demand, average mileage per vehicle and year: 15,000 km, overall electricity consumption in Germany per year: 517 TWh.

Volkswagen supports sustainability and easy charging by offering green energy and wallboxes

Volkswagen

Efficient Powertrain

Green Energy

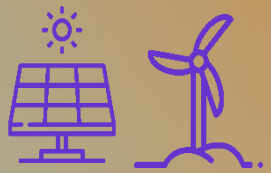
@Home

@Work

@Public

@Highway

Elli Green Energy



- Green energy product for private and small business customers
- 100% CO_2-neutral
- Supports new sustainable energy facilities

+

Wallbox Portfolio

- Modular AC Wallbox with up to 11 kW
- DC Wallbox offers up to 22 kW
- Market introduction together with ID. Neo
- Cost-effective and safe

Concept Car

Elli supports B2B fleet consulting for energy products

Volkswagen

Efficient Powertrain

Green Energy

Analyze

Analyze the individual e-mobility potential

Recommend

Recommend best fit electric cars

Implement

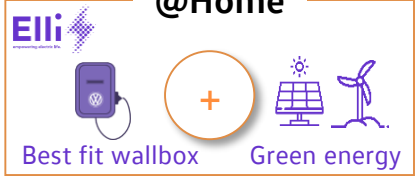
Implement Elli portfolio to ensure carbon neutral operation

Evaluation of e-mobility potential per car

- ✓ **Reduce overall fleet energy consumption by up to 75%**
- ✓ **Cover remaining energy demand with green energy**

@Work

@Home



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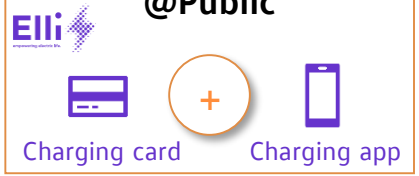
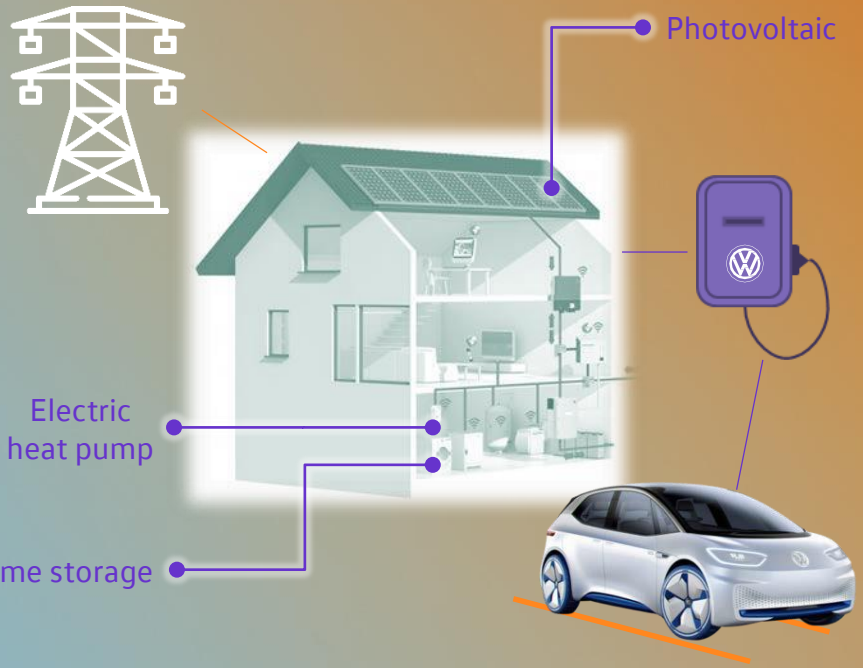


Elli fully integrates into customers' electric life

Volkswagen

Efficient Powertrain

Green Energy



Elli
empowering electric life.

- **Green energy for the complete household**
- **Intelligent charging**
  e.g. by integration of home storage solutions and photovoltaic
- **Grid integration**
  Vehicle-to-gGrid technology to support grid stability
- **Share your Wallbox**
  Increasing semi-public charging infrastructure especially by fleet customers

Concept Car

Volkswagen enables green routing to public charging stations

Volkswagen

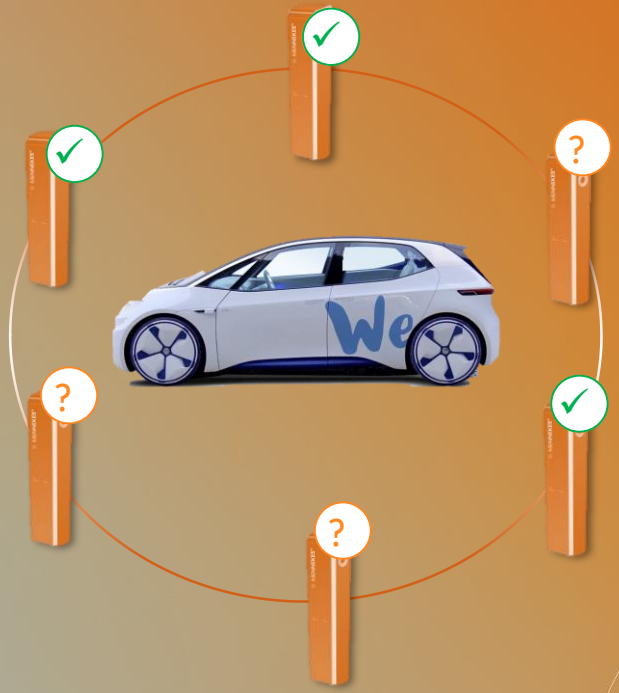
Efficient Powertrain | Green Energy | Green routing

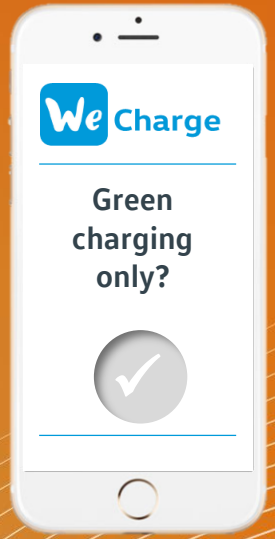
@Home

@Work

@Public

@Highway





It is difficult to evaluate the type of energy used for public charging

Using We Charge the customer can decide easily whether to use green energy or not

Concept Car

Volkswagen offers carbon neutral car sharing, starting with 2.000 cars in Berlin

Volkswagen

Efficient Powertrain | Green Energy | Green routing | Green sharing

Our holistic mobility offer includes:

- Right car with right powertrain (100% electric)
- Right energy (100% green)
- Acceptance thru right fleet size
- Easy usability

e-Golf - Electrical consumption in kWh/100 km: combined 12.7, CO2 emissions combined in g/km: 0, efficiency class: A+

ID. owners have all options for carbon neutrality during use phase

- **Volkswagen covers all the aspects of CO_2-neutral driving particularly in the use phase**
  - e.g. Elli green energy, affordable wallbox, fleet consulting, equipping dealer infrastructure and production locations, green routing, carbon neutral car sharing

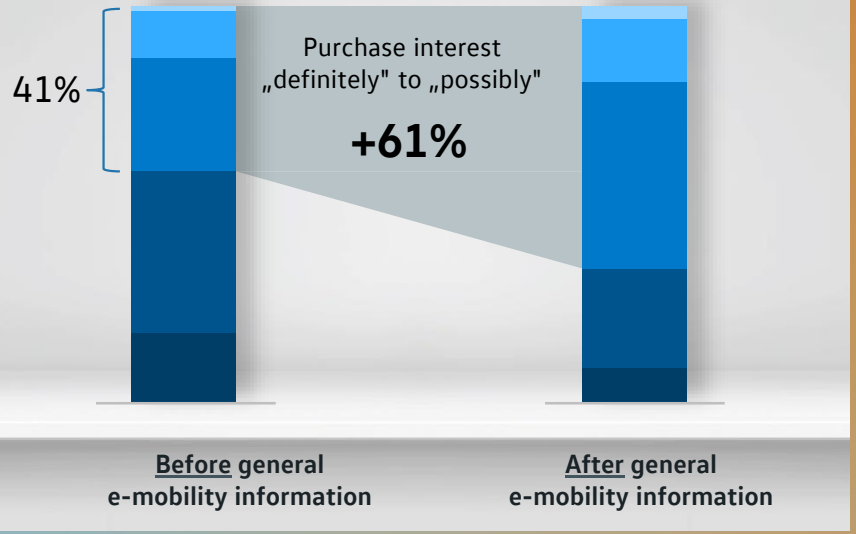
Concept Car

Yet, awareness is the key to success

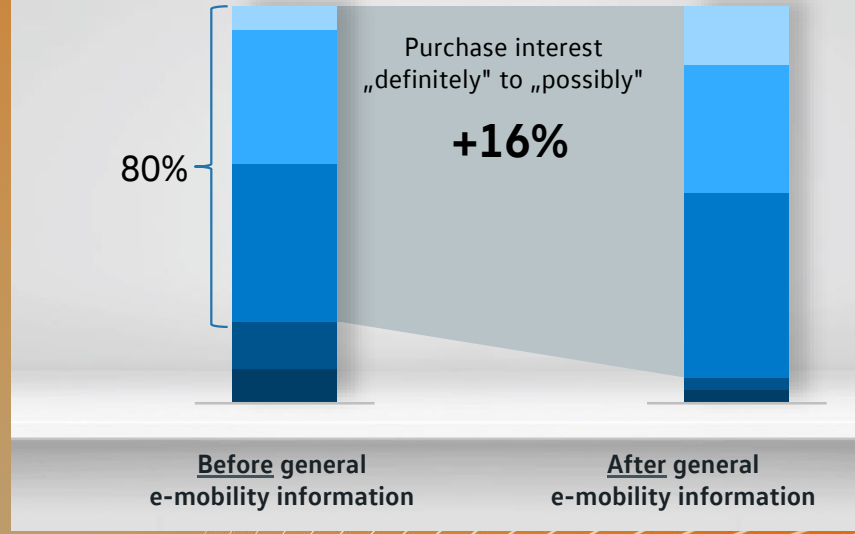
Information and knowledge have an high impact on purchase interest

Volkswagen

Germany



France



Definitely
Likely
Possibly
Not likely
Definitely not

[PC35a]: How likely are you to purchase an electric car in the next three years?
[V9145]: Considering all information you have received, how likely is it that you will purchase an electric vehicle within the next 3 years? Base: Germany n=807 / France n=99
Reference: 2017 EU Clinic

Many customer concerns of today will be solved soon

Volkswagen

Price level of a Golf with comparable power output and equipment

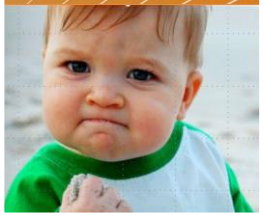
330km to 550km WLTP

Charging 80 % in only 30 minutes

Shopping experience: Fun to buy – where & how I want it

SML Flatrate approach, 8 years warranty

Zero CO_2 delivery to your doorstep – keep it that way!



Safe choice- access to all cities

Summary: Silke Bagschik and Martin Roemheld on the use phase

Volkswagen

- CO_2-neutral use of e-drive is a core aspect of sustainable e-mobility
- Customers decide whether they want to drive CO_2-free
- Volkswagen enables green use – no matter where the vehicle is charged
- ID. answers all purchasing concerns: Attractive price-performance ratio throughout the life cycle, sufficient range, charging experience, and carbon neutrality

Concept Car

Re-use / recycling
Module 4

Thomas Tiedje
Head of Technical Planning, Volkswagen Group Components

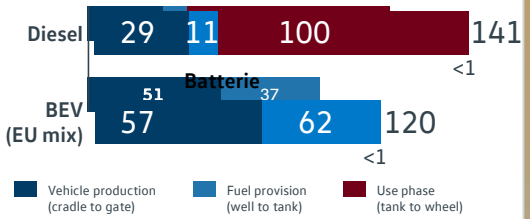
Sustainable e-mobility includes innovative end-of-life solutions

Volkswagen

The lithium-ion-battery is a key factor in the Volkswagen e-mobility offensive

For several reasons, strategic goals include holistic concepts for re-use and recycling

1 Smaller CO_2-footprint

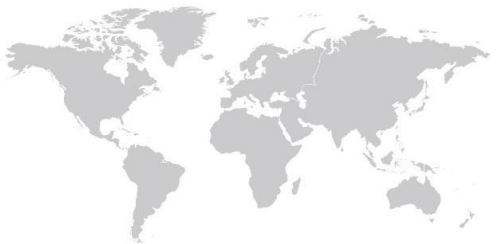


- Hot-spot: High CO_2 emissions during battery production

2 Less recycling expenses

- Avoidance of logistic and disposal costs

3 More resource security



- Preserving strategically important resources
- Closed loop recycling enables resource security

Volkswagen Group Components has end-to-end responsibility for the entire service life of the battery

Volkswagen

Our focus today

VOLKSWAGEN GROUP COMPONENTS

Cell production

VOLKSWAGEN GROUP COMPONENTS

Battery systems

1st Life

VOLKSWAGEN GROUP COMPONENTS

Analyse

VOLKSWAGEN GROUP COMPONENTS

2nd Life

VOLKSWAGEN GROUP COMPONENTS

Recycling

Concept Car

Second life safeguards sustainable re-use of batteries

Volkswagen

Center of Excellence (CoE) Salzgitter

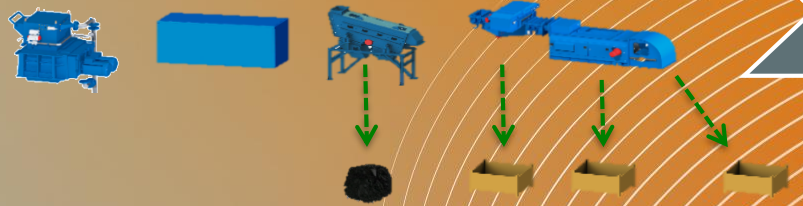
Criteria

Group Components plant Hanover

VOLKSWAGEN GROUP COMPONENTS Hannover

Battery returns → Analysis → Disassembly → 2nd Life

Analysis → Recycling → Shredding → Drying → Sieving → Air classification → Material returned to production process



Black powder | Steel | Separator | Aluminium, copper

Volkswagen invented the first power bank for e-cars

Volkswagen

- Battery storage: 200 kWh – 360 kWh
- 2 x DC and 2 x AC charging

✓ Enables second life of HV batteries

✓ Charges up to 4 cars simultaneously

✓ Flexible and self-sufficient

✓ Production ramp-up as of 2020

Recycling processes are safe, validated and scalable

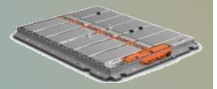
Salzgitter pilot plant scales proven recycling process as of 2020

Volkswagen

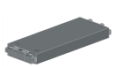
End-of-life battery

Cell modules

Disassembly → Crushing → Drying → Sieving → Fraction separation



Pilot line



Material returned

- Cables
- Electronics
- Steel
- Aluminium

Steel | Separator | Aluminium, copper

Volkswagen and partners

Black powder

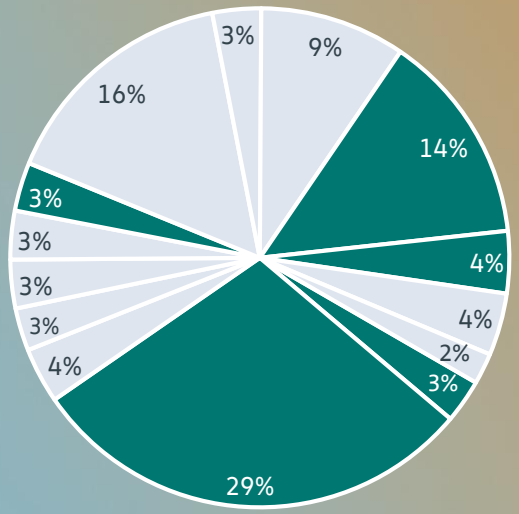
Hydrometallurgy

Usable nickel , manganese, cobalt

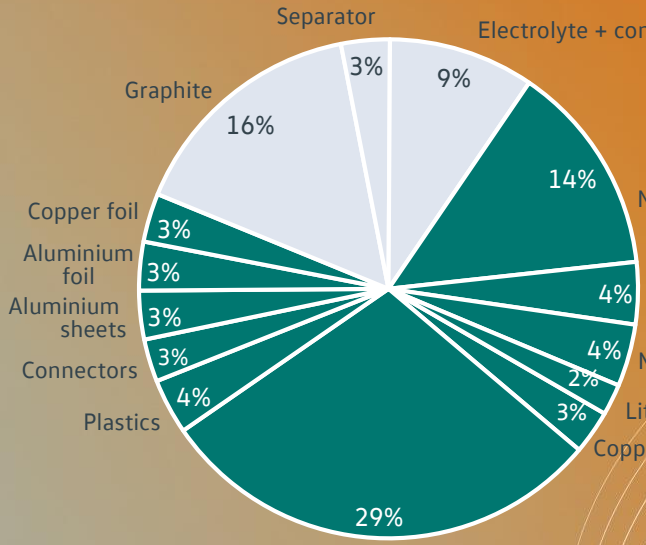
The pilot line will improve recycling efficiency considerably

Volkswagen

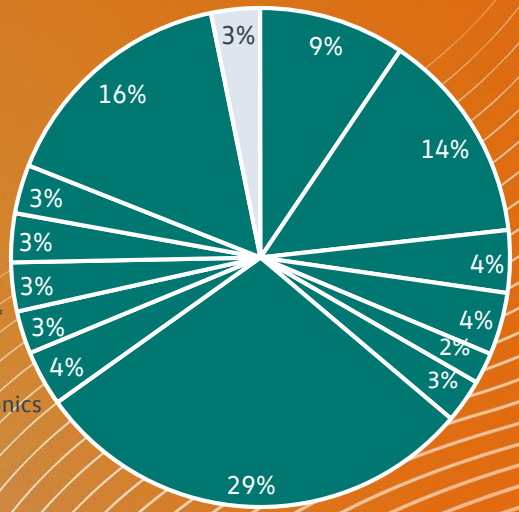
State of the art: **53%***



Planning Salzgitter pilot line: **72%***



Target: **97%***



Material recycling
No material recycling

* Percent by weight per battery system

Summary: Thomas Tiedje on re-use / recycling

- The Volkswagen brand is doing everything it can to make e-mobility sustainable
- Together with Volkswagen Group Components, we are working on a battery recycling concept to return raw materials to the production process chain
- The battery is either recycled at the end of its vehicle life cycle – or put to second use in new products such as flexible charging stations

Concept Car