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
Batteries bring higher CO₂ emissions in the supply chain

- Supply chain CO₂ impact >150%
- Battery Cell
- E-Machine
- Steel
- Others
- Battery Cathode

Golf Diesel vs. ID.
Our activities to optimize $\text{CO}_2$ in the supply chain

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

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

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**HV Battery Cell**
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%
Steel

Background
- CO₂ as process-inherent emission (limestone decomposition and iron ore reduction cause CO₂ emissions)

Measures (two general approaches):
- End-of-pipe approach:
  Capture/store/use for synthetic fuels & chemicals
- Process-integrated approach:
  adapted reduction agent avoids CO₂ emissions
Steel

Background
- CO₂ as process inherent emission (limestone decomposition and iron ore reduction cause CO₂ emissions)

Measures (two general approaches):
- End-of-pipe approach: Capture/store/use for synthetic fuels & chemicals
- Process-integrated approach: adapted reduction agent avoids CO₂ emissions

Reduction Potential
> 75%
Background
- Aluminum used for case & magnet production is CO₂ hot-spot

Measures
- Usage of secondary aluminium
- Green energy usage Tier 1 suppliers
- Collect specific energy demand in sub-supply chain
- Define further measures
Background
- Aluminum used for case & magnet production is CO₂ hot-spot

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

Reduction Potential
50%
Background
- Cathode production and sub-supply chain (raw material production) expected to be CO\textsubscript{2} hot-spot

Measures
- Collecting specific energy demand in sub-supply chain
- CO\textsubscript{2} reduction with suppliers with reduction program in cooperation with Tier 1
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

**Reduction Potential**
under evaluation
Illustrated potential of CO₂ reduction

Current Status

Supply chain CO₂ impact

ID. Illustrated activities

~33%
Further measures to decrease CO₂ emissions

- Inclusion in decision-making processes
- Green Energy Requirements for suppliers
- Focus on further materials and key components
- Use of secondary material
- CO₂ workshop with suppliers to define specific action plans
- Switch to other production technologies
- Supplier trainings and consulting

Illustrated potential of CO₂ reduction and outlook
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
Sustainability as selection criteria on par with quality or price

- Group-wide process for all suppliers
- Supplier assessment on sustainability (environment, social, compliance)
- No contracts with negatively rated suppliers
Sustainability as selection criteria on par with quality or price

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

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

- Group-wide process for all suppliers
- Supplier assessment on sustainability (environment, social, compliance)
- No contracts with negatively rated suppliers
Transparency measures mitigate compliance risks

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 INITIATIVE

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 (questionnaires, raw mat. observatory).
Develop and conduct trainings and educational products / tools.

ALUMINIUM STEWARDSHIP INITIATIVE

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

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 CO₂ 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.
Production
Module 2

Dr. Liendel Chang
Head of Environmental Production
Volkswagen has addressed sustainable in-house production for many years.
Targets for environmental improvement develop continuously

<table>
<thead>
<tr>
<th>Year</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>One product. One label.</td>
</tr>
<tr>
<td>2010</td>
<td>One attitude. All markets.</td>
</tr>
<tr>
<td>2011</td>
<td>Start of Think Blue. Factory.</td>
</tr>
<tr>
<td>2018</td>
<td>25%</td>
</tr>
<tr>
<td>2025</td>
<td>45%</td>
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Vision Zero Impact Factory

Role model. Sustainable. Resource efficient.
The brand has achieved significant measurable results

Total environmental improvement production

2010 2018

30%

Considerable savings per car

27%

40%

28%

48%

8%

25% target 2018

Data as at January 31, 2019, subject to auditor's confirmation
All plants exchange best know-how and benchmark measures
The paint shop is the most energy-intensive process

Energy consumption:
- Press Shop: < 10 %
- Body Shop: 10-15 %
- Paint Shop: 50-60 %
- Assembly: 10 %

Overhead costs:
- Plant level
- Subsection level: Press Shop, Body Shop, Paint Shop, Assembly

Other overheads: 30% Energy, 70% Other overheads
First we harvested the low-hanging fruits, now we are reaching for the higher branches...
CO₂-efficient energy supply is the second field of action.
Each production site has its individual decarbonisation path.

-24.3%

Total CO₂ emissions in tons per year

2010  2018

Data as at January 31, 2019, subject to auditor’s confirmation.
Each production site has its individual decarbonisation path

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

Decarbonisation progress generated:

- ½ by switch to gas-powered combined heat and power plants (CHP)
- ½ by switch to green energy supply
- More then ¼ by energy efficiency measures
- Rest achieved by own generation of PV and wind energy

Forecast data for 2018, subject to auditor's confirmation
Decarbonisation outlook at Zwickau Plant

-66% decrease in Total CO₂ emissions [t] from 2010 (158,000) to 2018 (53,000).

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 CO₂-neutral energy supply.

We compensate the remaining emissions by Climate Protection Projects.
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!
Attractive features for customers concerning use phase benefits from new possibilities of the MEB

- Different body styles
- More space for driver and passengers
- Larger wheelbase short overhangs
- Bigger wheel diameter
- No centre tunnel
- Rear- and four wheel drive
- Luggage space ~ combuster (ICE)
- Central computer unit
The ID. in most wanted body styles/sizes

ID.
ID. CROZZ
ID. BUZZ
ID. VIZZION

More to come...
The ID. DNA – defining an entire family

The new e-mobility era is more than just electric

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

Concept Cars
The ID. DNA – defining an entire family

The new e-mobility era is more than just electric

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

Concept Cars
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

Total Cost of Ownership (TCO) parity compared to internal combustion engine (ICE)
Green operation is one of the core aspects of sustainable mobility.
The electric powertrain is the most efficient one

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

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

@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
Green Energy option
Mobility Service Provider (Find, Charge, Pay)
Charge Point Operator

Concept Car
Talking about green energy – its share is increasing worldwide!

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%.

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.

**Elli Green Energy**
- Green energy product for private and small business customers
- 100% CO₂-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
Elli supports B2B fleet consulting for energy products

**Analyze**
- Analyze the individual e-mobility potential

**Recommend**
- Recommend best fit electric cars

**Implement**
- Implement Elli portfolio to ensure carbon neutral operation

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

**Evaluation of e-mobility potential per car**

- @Work
  - Elli
  - Green energy

- @Home
  - Best fit wallbox
  - Green energy

- @Public
  - Charging card
  - Charging app
Elli fully integrates into customers’ electric life

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

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.
Volkswagen offers carbon neutral car sharing, starting with 2,000 cars in Berlin.

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\textsubscript{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
Yet, awareness is the key to success
Information and knowledge have an high impact on purchase interest

**Germany**
- **Before general e-mobility information:**
  - Definitely: 41%
  - Possibly: +61%

**France**
- **Before general e-mobility information:**
  - Definitely: 80%
  - Possibly: +16%

[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

- 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 CO₂ delivery to your doorstep – keep it that way!

Safe choice - access to all cities
Summary: Silke Bagschik and Martin Roemheld on the use phase

- CO₂-neutral use of e-drive is a core aspect of sustainable e-mobility
- Customers decide whether they want to drive CO₂-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
Re-use / recycling
Module 4

Thomas Tiedje
Head of Technical Planning, Volkswagen Group Components
Sustainable e-mobility includes innovative end-of-life solutions

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\textsubscript{2}-footprint
   - Diesel
     - Vehicle production (cradle to gate) 29
     - Fuel provision (well to tank) 11
     - Use phase (tank to wheel) 100
   - BEV (EU mix)
     - Vehicle production (cradle to gate) 51
     - Fuel provision (well to tank) 37
     - Use phase (tank to wheel) 62
   - Hot-spot: High CO\textsubscript{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.

Our focus today:

- Cell production
- Battery systems
- 1st Life
- Analyse
- 2nd Life
- Recycling
Second life safeguards sustainable re-use of batteries

Center of Excellence (CoE) Salzgitter

Analysis

Disassembly

2nd Life

Recycling

Shredding

Drying

Sieving

Air classification

Material returned to production process

Black powder

Steel Separator Aluminium, copper

Group Components plant Hanover

Battery returns

Criteria
Volkswagen invented the first power bank for e-cars

- 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

End-of-life battery
Disassembly

Cell modules
Crushing
Drying
Sieving
Fraction separation

Pilot line

Material returned
- Cables
- Electronics
- Steel
- Aluminium

Volkswagen and partners

Hydrometallurgy

Usable nickel, manganese, cobalt

Black powder

Steel
Separator
Aluminium, copper
The pilot line will improve recycling efficiency considerably

State of the art: **53%**

Planning Salzgitter pilot line: **72%**

Target: **97%**

- Material recycling
- No material recycling

* Percent by weight per battery system
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.

Summary: Thomas Tiedje on re-use / recycling