Roadmap E
The most comprehensive electrification initiative in the automotive industry of all times

Joris De Bock, E-Mobility Business Models
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The challenge: transforming Volkswagen Group along 2+1 dimensions

### Future vehicle concepts
- Autonomous
- Electrified
- Connected

### Advanced mobility solutions
- Robotaxi
- Shuttle I Vans

### Today’s vehicle concepts
- SUV/CUV trends
- Budget cars

### Sharing & Mobility On Demand
- Shared
- Conventional drive system

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**TRADITIONAL** | **BUSINESS MODEL INNOVATION** | **REVOLUTIONARY**
Building blocks to provide sustainable mobility solutions

Sustainable Mobility

Efficient ICEs & alternative powertrains
Battery
Charging Business Models
Mobility Services
Self Driving System

Focus today

VOLKSWAGEN
AKTIENGESELLSCHAFT
Most comprehensive electrification initiative in the automotive industry
with

- 80 new EVs (50 BEVs + 30 PHEVs)
- 20–25% Group sales intended to be purely battery-powered
- Own e-fleet requirements over 150 GWh of battery capacity

2017
- 3 BEVs, 8 PHEVs

2025
- At least one electrified version for each of the Group's 300 or so models

2030
Battery costs will decrease significantly by 2020

Target: < 100€ / kWh

- MQB
- MEB

€ / kWh

2013 2020

battery system
battery cell
Advances in Battery Technology will improve Range

Roadmap battery cell chemistry and energy density

- 2014: 190 km, 230 Wh/l
- 2017: 300 km, 410 Wh/l
- 2018: 380 km, 650 Wh/l
- 2020: 420 km, 700 Wh/l
- 2025: 700 km, 1000 Wh/l

* basis: eGolf with comparable battery volume

Lithium ion technology

New battery technologies

- 700 km, 1000 Wh/l: all solid state
- 500 km, 800 Wh/l: improved anode and cathode
## Competencies needed across the whole battery value chain

<table>
<thead>
<tr>
<th>Constituent examples</th>
<th>Module types</th>
<th>Stationary applications</th>
<th>Recycling process</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Housing - Electrolyte - Al foil for cathode - Cu foil for anode</td>
<td>- Cylindrical - Prismatic - Pouch</td>
<td>- Small scale e.g. for private homes - Large scale e.g. for grid stabilization and charging stations</td>
<td>- Disassembly - Disintegration - Metallurgy - Re-use</td>
</tr>
</tbody>
</table>

### Value chain
- Raw materials
- Constituents
- Cell production
- Module production
- Pack assembly
- Vehicle installation
- Qualification
- Repurposing
- Recycling

### Material types
- Lithium
- Nickel
- Cobalt
- Manganese
- Graphite

### Cell types
- Cylindrical
- Prismatic
- Pouch

### Logistical factors
- Weight
- Requirements/specifications e.g. dangerous goods, customs duties, ...
- Special containers
- Examination of process limits/production sites

### Repair events
- ...if the customer wishes a “refresh” of the battery
- ...if mechanical damage to some modules has occurred
VW Group is taking direct control of all charging use cases

Charging Use Cases

- Daily short/medium use
- Charging @home & @work
- Destination charging
  - Potential compensation to home & work
- Long distance driving
  - High power charging along highways
- High power charging in inner cities
- Next envisioned HPC use case
Since January 2017 the Volkswagen Group became a shareholder of Hubject

• Since 2012, Hubject has been connecting different market players in order to create a digital and cross-border charging network for electric vehicles – the intercharge network.

• Hubjects portfolio addresses:
  • Charge point operators
  • Emobility service providers
  • Energy suppliers
  • Fleet operators
  • Car sharing companies
  • Service card providers
  • Automotive manufacturers

Source: Hubject website
IONITY: The pan-european high-power-charging network enabling e-mobility on long-distance routes

- High-powered DC charging network for battery electric vehicles (BEV) covering long-distance travel routes in Europe
- Installation of 20 stations in various European countries in 2018; full deployment by 2020
- Power levels up to 350 kW significantly reduce charging time compared to available systems
- 400 ultra-fast charging sites planned in Europe with an average of 6 charge points per station; distance between stations ~ 120km
- Network is based on the Combined Charging System (CCS) standard which uses a connector that is fully compatible with most current and next generations BEVs
- Cooperation with several partners such as Tank & Rast, Circle K, OMV, Enel

Source: Ionity website
Latest news from our HPC Joint Venture Ionity

IONITY opens its first charging station in Switzerland
- Station is based in Neuenkirch near Lucerne on the A2 motorway (key north-south transit route)
- Station is equipped with six high performance chargers
- Support vehicles equipped with the CCS charging system

A61 Brohltal Ost: operations start with welcome offer
- Ionity has announced that it is commencing operations at its Brohltal-Ost site (Rhineland Palatinate)
- Drivers of an EV fitted with a CCS charging plug are welcome to use the station free of charge until May 31, 2018.

DESIGN CONCEPT - Ionity hedges its bets on futuristic form language
- At the Geneva International Motor Show, Ionity has revealed the design concept for its HPC network in Europe
- Simple structures and surfaces, smart interfaces and a mixture of robust lightweight materials merge together into a seamless ‘charging experience’
Electrify America: Powering electric mobility from coast to coast and everyday stops in between

**Investment of $2 billion over the next 10 years** in Zero Emission Vehicle (ZEV) infrastructure and education programs in the U.S.

**Open network for all (even non VW Group) OEMs and business partners**

**1st cycle:**
- We will establish a network of ~4,700+ non-proprietary electric vehicle chargers in 17 metros and on highways in 39 states

**Station chargers will be extremely powerful, capable of delivering 150 kW or 350 kW to vehicles**

**Highway sites every 70 miles on average, but no more than 120 miles apart,** so shorter range ZEVs available today will be able to use this network.

**Public access for all ZEV drivers will be ensured through multiple technologies (Level 2 and DC fast charging: CCS Combo and Chademo connectors)**

Source: Electrify America website
Ongoing process also at Electrify America

Electrify America Announces Partnerships to Install Ultra-Fast Electric Vehicle Chargers

- Installation will take place at more than 100 major retail, convenience and refueling locations in the United States
- Partners include Target Corporation, Brixmor Property Group, Kimco Realty Corporation, Sheetz, Casey’s General Stores, DDR Corporation, and Global Partners LP’s Alltown

April 23, 2018

Electrify America Installing Electric Vehicle Chargers at more than 100 Walmart locations

- Charging stations will feature Electrify America’s DC 350kW Fast Charger
- “The expansion of Walmart’s electric vehicle charging facilities with our ultra-fast charging systems will provide consumers with a quick and convenient way to charge their vehicles in the time it takes to make their Walmart purchases.” (ElAm CEO Mark McNabb)

April 18, 2018

Electrify America selects ABB, BTC Power, Efacec and Signet as charging equipment suppliers

- DC Fast Chargers to provide charging speeds of up to 20 miles of range per minute

April 17, 2018

Source: Electrify America website
From strategy to reality
2025: Volkswagen ...

... remains one of the largest automakers.

... is #1 in e-mobility worldwide.

... sets standards in mobility services.

... acts as role model for environment, safety and integrity.