
E-MOBILITY
START
JOY BH18AC
Voltabox electrifies!
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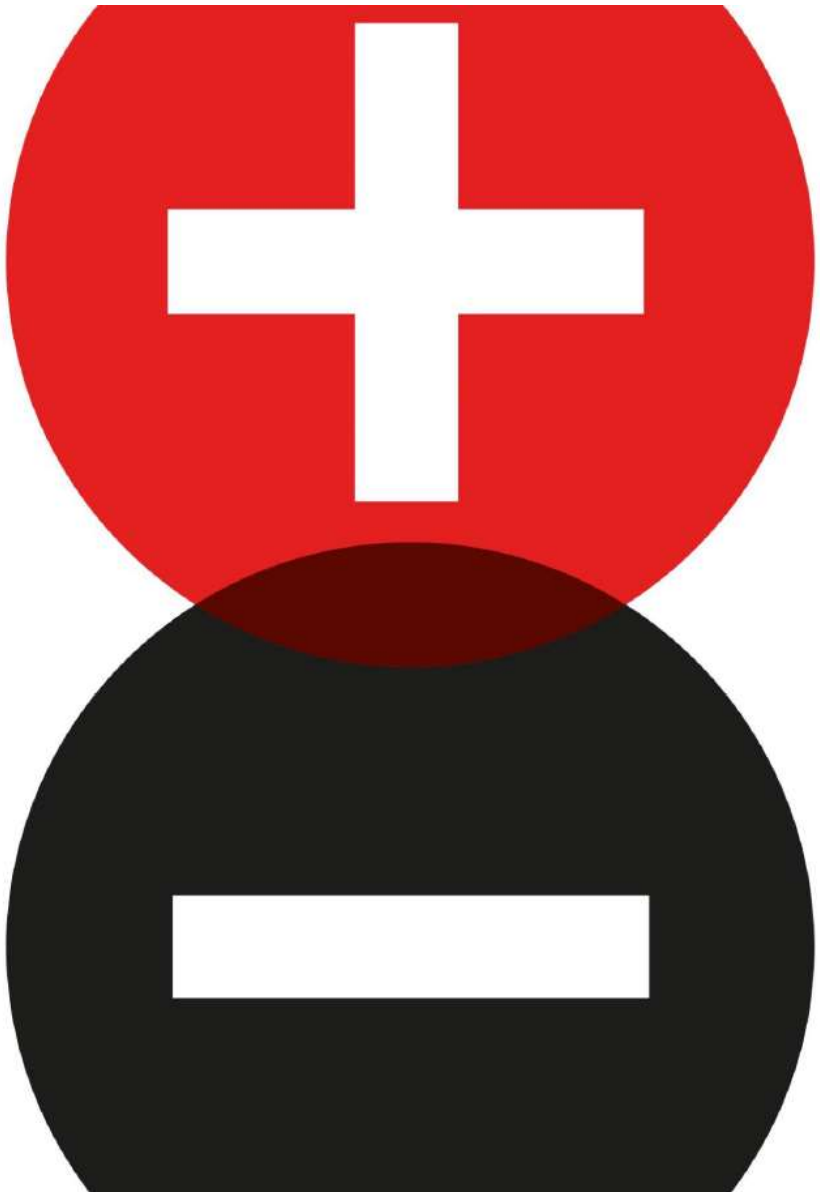

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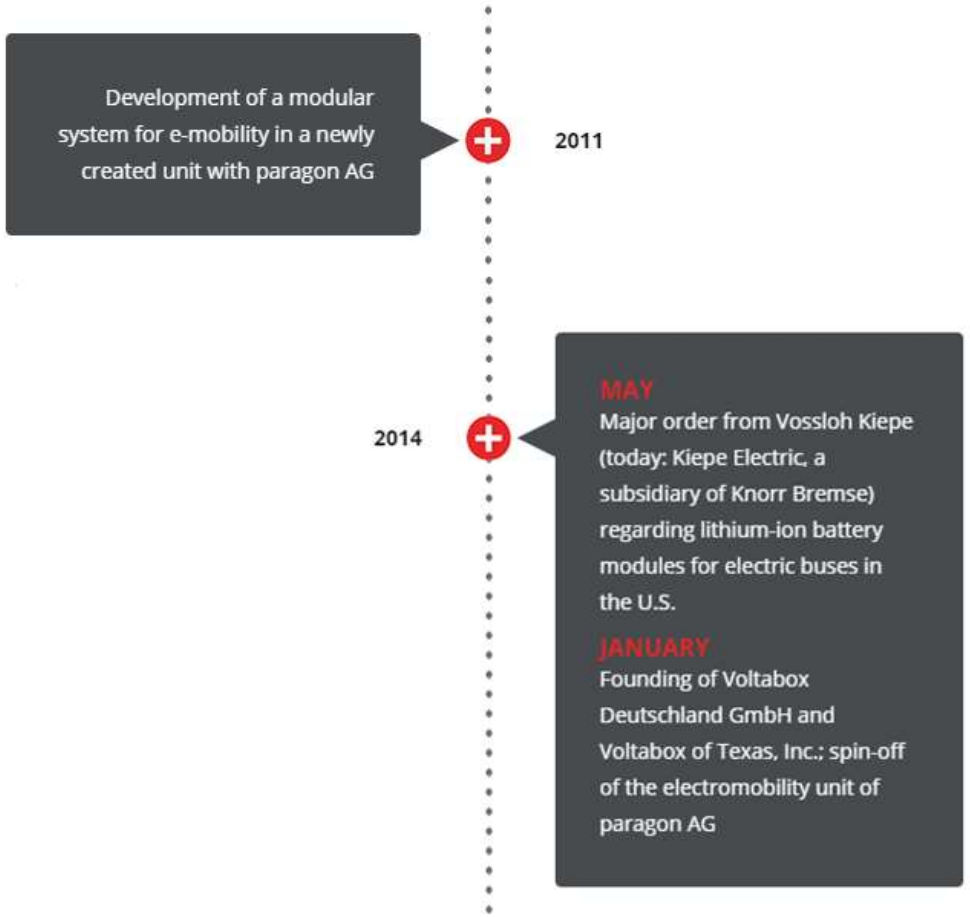
Core business: System provider for e-mobility in industrial applications

History:

- 2011: Founded as a business unit of paragon AG
- 2014: Spin-off as GmbH



2017

MAY
Conversion of Voltabox Deutschland GmbH into a stock corporation

MARCH
Major order for lithium-ion battery modules with more than 10 megawatt hours (MWh)

2016

OCTOBER
Finalization of a long-term partnership with KUKA (battery systems for automated guided vehicles)

JUNE
Strategic partnership with Joy Global Inc. (today: Komatsu Mining Corp.) regarding batteries for various mining vehicles

2015

MARCH
Strategic partnership with Triathlon Batterien GmbH (lithium-ion batteries for intralogistics applications)

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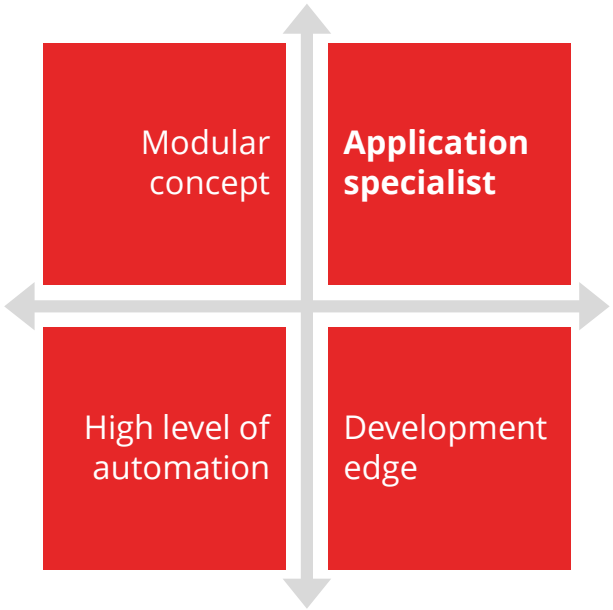
“First-Mover-Advantage” in Superior Technology

Technology leader…	
1	**Access to R&D roadmap of top-suppliers** (Short time-to-market approach due to integration of new cell technology in own product developments)
2	**Industry leading standards to ensure safety requirements** (Patented module design ensures superior safety standards; constant monitoring with automatic shut-down)
3	**Best-in-class energy density** (Enabling longer range of vehicles)
4	**Unsurpassed Battery Management System** (Novel prediction capabilities for highest battery efficiency and longer range)
5	**Proven, available products** (Not only prototypes, but proven, validated, safe, and above all: immediately available - significant edge over competitors)

…with clear competitive advantages

Short time-to-market
Minimum initial costs for customers

Tailored systems for any application
Maximizing customer benefits



Consistent quality standards
Efficiently controlled series production

“First-Mover-Advantage” due to early market entrance and adopted electronic expertise of paragon

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Voltabox Solutions/ E-Mobility Pure Play

- Module cases with integrated
  - Cooling Devices
  - BMS Slave Circuit Board
  - Sensors
  - Wiring Loom
  - Lids
  - Sealings
  - Rupture Discs

in various low and high voltage versions

- Separator
- Anode
- Cathode
- Electrolyte
- Cell Housing
- Insulation Strips

E-Mobility Value Chain

- Recycling
- Electric Vehicles
- **Drivetrain components** *Power Electronics*
- **Battery Systems** *BMS & Assembly*
- **Battery Modules** *Packaging*
- Battery Cells
  Cell-agnostic approach
- Raw and Processed Materials

The Sweet Spot of Electromobility

- Robust housing with integrated fixing points
- Master ECU
- Data interfaces
- Power switchers
- DC/DC converters
- Compensators
- Fuses / Resistors
- Climate systems
- (Chargers, cable rewinds)

- Cylindrical cells
- Prismatic cells
- Pouch cells

in various Li-Ion chemistries

- LFP
- NMC
- LTO
- NCA

VOLTABOX BMS Technology

Enhanced BMS Levels

- Although common levels of functionality with regulation architecture, high flexibility with customization of variants.
- Experience with over 140 data points

Software Engineers

- Customize BMS for each application to maximize performance of vehicle and battery
- Consultative & Collaborative Approach to Design
- Automotive Compliant

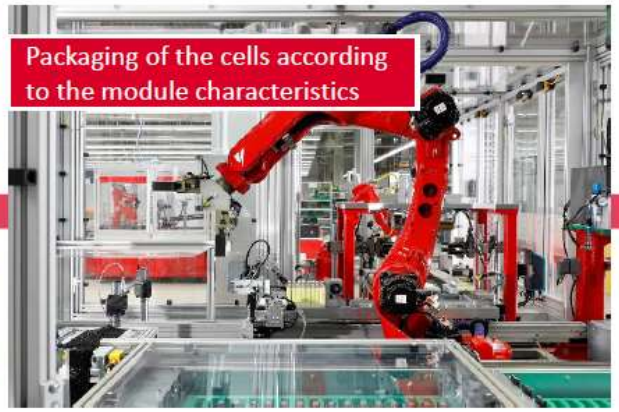
Hardware Components

- Automotive Compliant Control Units
- PCBA production in house, automotive certified facility
- Communication by CAN, Bluetooth, 5G Fleet Mgt, AI/Self Learning , Telemetric Monitoring

Battery System

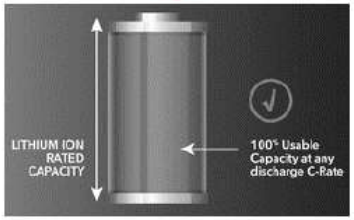
- Module / Slave BMS
- Battery System / Master BMS
- Fully Integrated TMS to maximize calendar & cycle life

Production Steps - From the Cell to the Complete System



TCO-Advantages Driving Substitution of Lead-Acid by Li-Ion

Li-Ion Technology

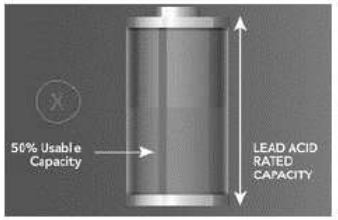


Additional advantages:

- No memory effect (opportunity charging)
- Very low self-discharge
- No maintenance
- Full functionality at low temperatures
- Optimum control and (remote) monitoring

Li-Ion Technology		Lead-Acid Technology
Up to 240 Wh/kg	Energy density	40 Wh/kg
Up to 95%	Charging efficiency	Up to 70%
Up to 30,000 cycles at 80% DOD	Cycle life	1,200
Up to 80% in 6 min (10C)	Fast charging	50% in 3 hrs.
Zero emissions	Emissions	Gassing & water loss

Lead-Acid Technology



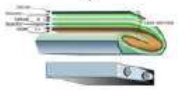
Voltabox is Cell Agnostic!

Cell Types

Cylindrical

A spirally wound design (jelly-roll). Designated by size, e.g. 26650 cylindrical battery (Diameter: 26mm, length: 65.2 mm; code for cylindrical shape: 0)

Prismatic



A prismatic design indicate a flat battery design. The stacks can be wound (as shown in the photo) or stacked (with alternating cathode/separator/anode structure). The stacks are usually inserted into rigid casing to form prismatic

Pouch

Rather than rigid metallic casing, conductive foil-tabs are welded to the electrodes and seal the battery fully. The tacks inside can be wound or stacked. Swelling and gassing could be a concern for pouch cells

Cell Chemistries

Lithium Iron Phosphate (LFP)

- Nominal cell voltage: 3.2 V to 3.3 V
- No risk of thermal runaway (in case of an accident)
- High cycle stability of up to 4,000 cycles at 80% DoD
- Large operating temperature range -20/+ 55 °c
- High energy density (125 Wh/kg and 292 Wh/l)
- Using only a small portion of rare earths

Nickel Manganese Cobalt (NMC)

- Nominal cell voltage: 3.6 V to 3.7 V
- High cycle stability of at least 6,000 cycles at 80% DoD
- Great operating temperature range of -30/+ 60 °C
- High energy density (136 - 230 Wh/kg and at least 309 Wh/l)

Lithium Titanium Oxide (LTO)

- Nominal cell voltage: 2.3 V
- Highest cycle stability of up to 30,000 cycles at 80% DoD
- High level of safety thanks to LTO anode
- Great operating temperature range of -30/+ 55 °C
- Energy density of 96 Wh/kg or 202 Wh/l
- Great SoC range useable with the highest performances

Nickel Cobalt Aluminum Oxide (NCA)

- Nominal cell voltage: 3.6 - 3.7 V (vs. graphite)
- Very wide operating temperature range of -20 /+75°C
- High cycle stability of up to 1,500 cycles at 80-70% DoD
- High energy density (140 - 280 Wh/kg and 300 - 590 Wh/L)
- Currently being tested or upscaled by many cell manufacturers

Source: IDTechEx.

Li-Ion Battery System Supplier for Defying Applications

- Voltabox is a **pioneer** in the **electrification of industrial applications**. In 2018, the Group **expanded** its **solution portfolio** in order to open up **further mass markets** in the future.
  - **Mindset focus on applications** *(authentic added value solutions)*
  - **Exceptional integration power** *(experience in automotive interfaces)*
  - **Superior realization processes** *(short time-to-market with modular kit)*

Applications: Electrification of Commercial & Industrial Vehicles with High Performance Battery Systems

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Public Transport (Buses)

Intra-logistics

Mining

Agriculture & Construc-tion

** Excerpt from customer/application portfolio.*

Applications: E-mobility and Stationary in Mass Markets

Motor-cycles

Pedelecs/ E-Bikes

i.a. Auto-motive

Stationary power

** Excerpt from customer/application portfolio.*

Future Presence

- Commercial & Industrial Vehicles: Retrofit solution to electrify combustion engine vehicles that is fast, sustainable & affordable.

- Expanding in current markets: Enhanced electrification and hybridization solutions for mining, bus, locomotive, personal/passenger vehicles, and commercial & industrial vehicles

- Stationary Power: On-site ESS, Back-up power, new & customizable Mobile Power Unit, Peak Shaving, more integration with renewables

- Energy Density: Continual Process of selecting and validating new cells to design next generation modules with superior energy density and excellent overall value.

- New Markets/New End Uses, and New Collaborations

Global Presence with State-of-the-Art Production Facilities

41 FTE* in Research & Development

- **Identical set-ups:**
- **High automation** and **fully monitored**

Current Voltabox Loc.

Sales

Production

R&D

As of February 1st, 2018 *Full time equivalent (FTE)

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Summary – Key Highlights

1. E-Mobility “Pure Play” benefitting from attractive megatrends around the vehicle electrification
2. Leading in specialized industrial markets characterized by low competition & high margins
3. “First-mover-advantage” in superior Lithium-Ion technology disrupting current battery standards
4. Immediately available and industry proven modular kits meet application-specific demands and highest safety requirements
5. Comprehensive order backlog with leading market players offer high visibility and underpin growth momentum
6. Experienced management benefitting from outstanding expertise in the field of automotive electronics and Li-Ion battery technology

https://www.voltabox.ag/fileadmin/user_upload/voltabox-imagefilm-4.mp4

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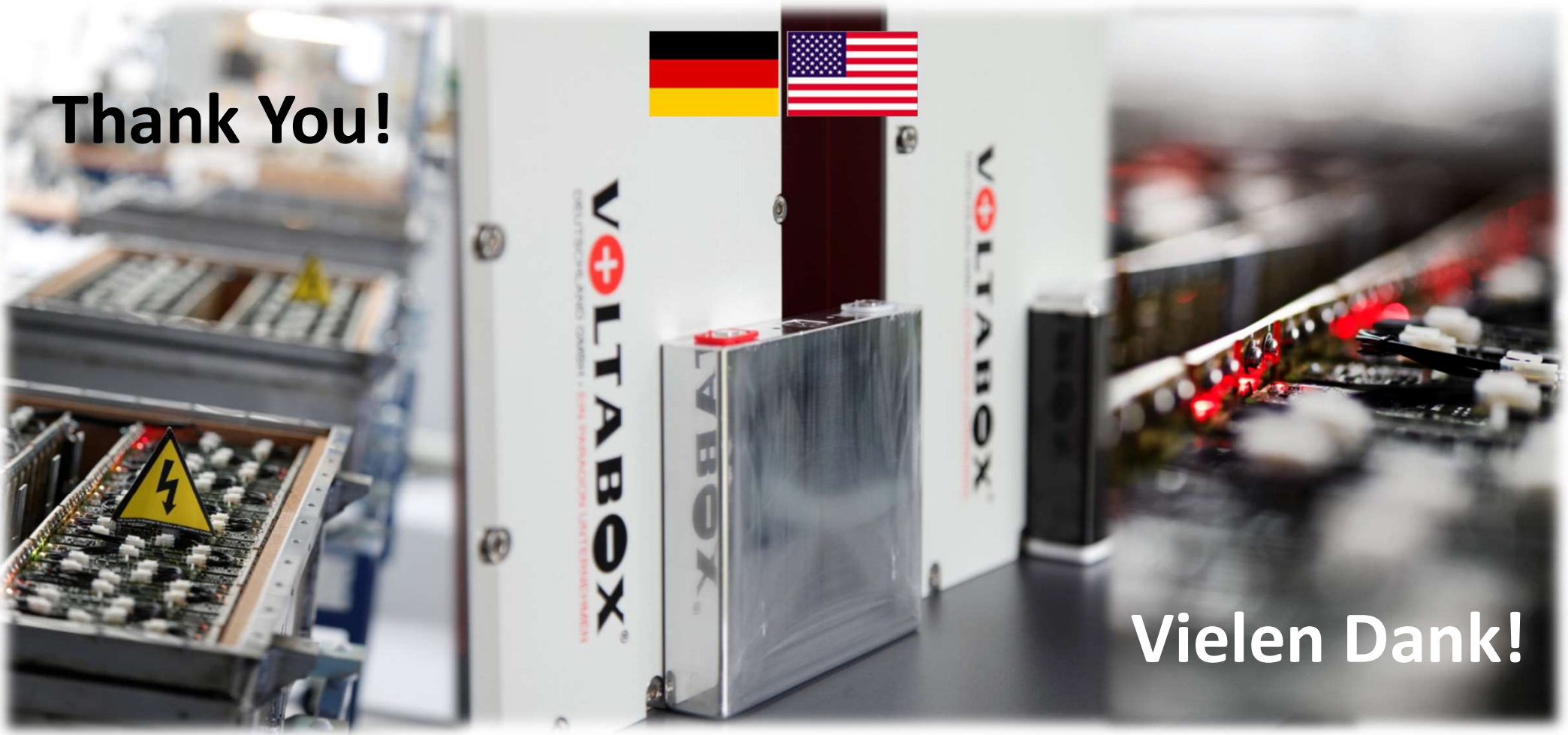
Thank You!



Vielen Dank!

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