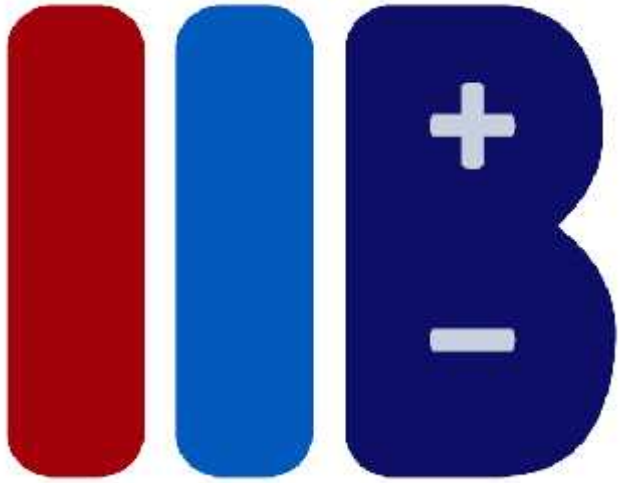
TRIATHLON®

INTELLIGENT BATTERIES



Presentation: Lithium-Ion Battery systems for Industrial trucks

AIM ACCUMULATOREN Nürnberg

AGENDA

(1) „Lithium“ – Perception

(2) Function and Properties of Lithium Ion Batteries

(3) Triathlon battery concept

(4) Charging stations and usage concepts

(5) Customer benefits

(6) Open points and risks

(7) Joint marketing concept

„Lithium“ – Customers perception

Safety

Boeing: Safety is paramount

Accidents

„Lithium“ – Customers perception

Exaggerated promises

Anxious about the origin

„Everything is from China; and of course the user’s manual is in Chinese as well“

A reputable approach is the first commandment

AGENDA

(1) „Lithium“ – Perception

(2) Function and Properties of Lithium-Ion Batteries

(3) Triathlon battery concept

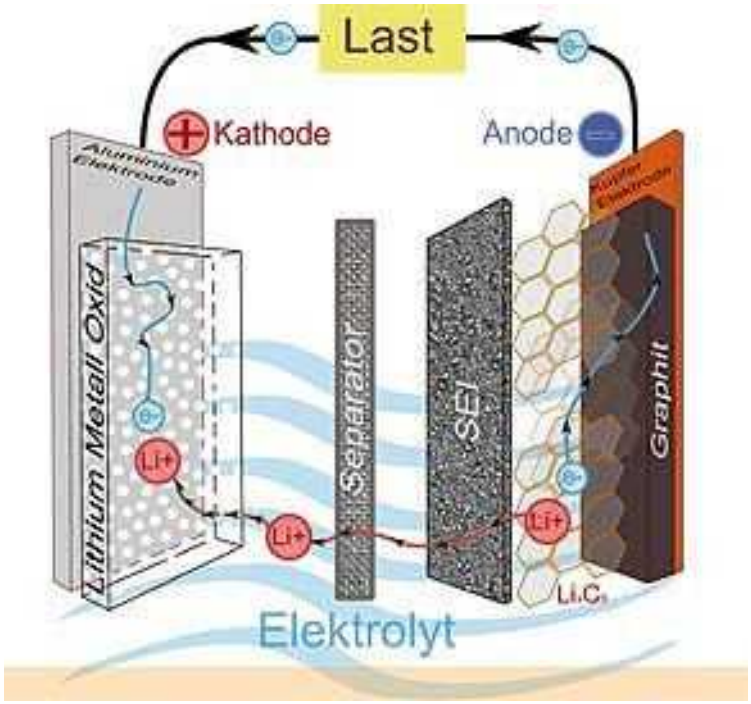
(4) Charging station and usage concepts

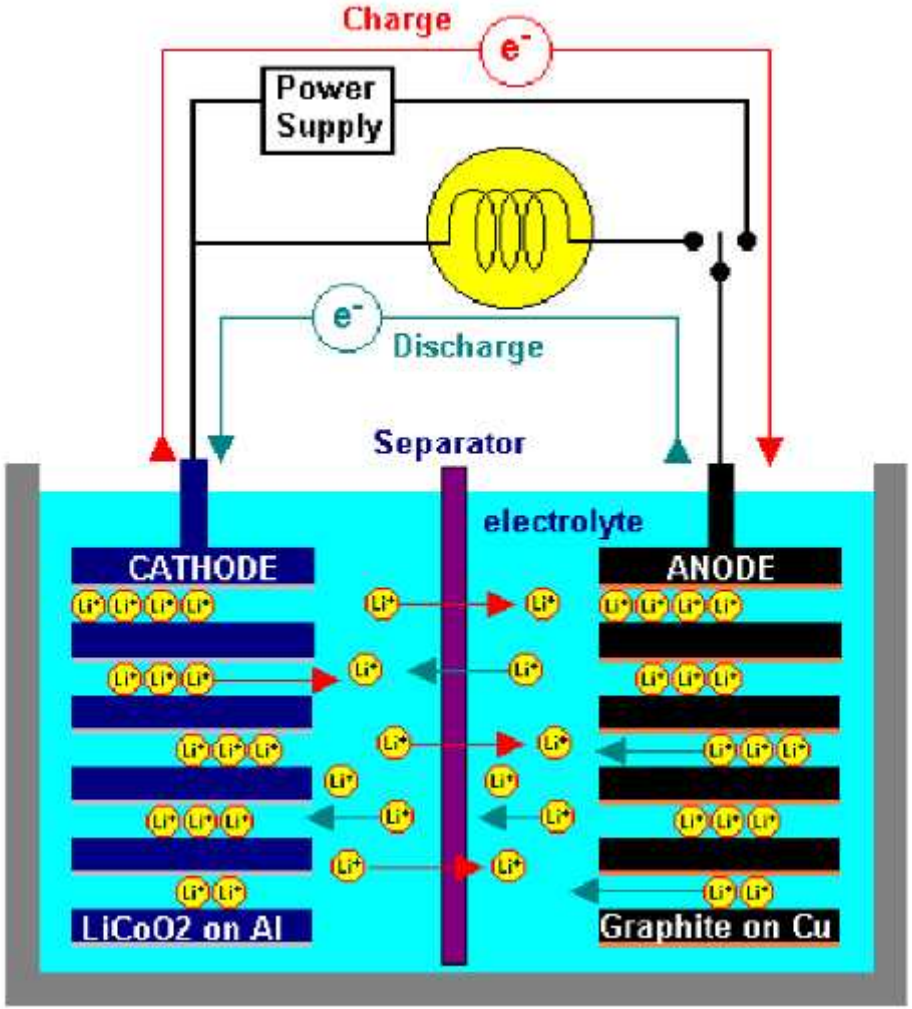
(5) Customer benefits

(6) Open points and risks

(7) Joint marketing concept

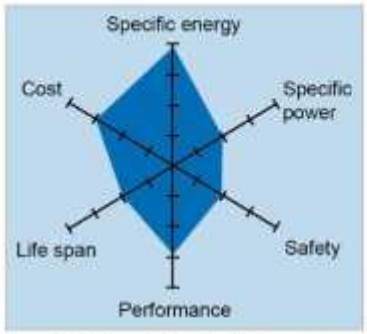
Basic Set-up of Lithium-Ion (LiXX) Batteries



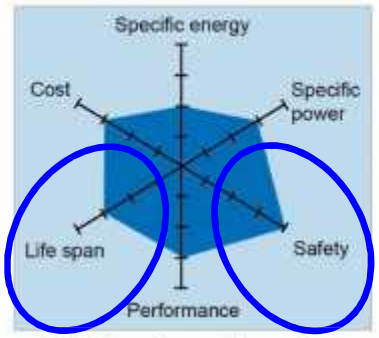


AIM ACCUMULATOREN Nürnberg

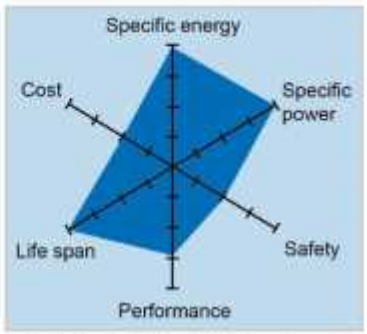
Various chemical Setups



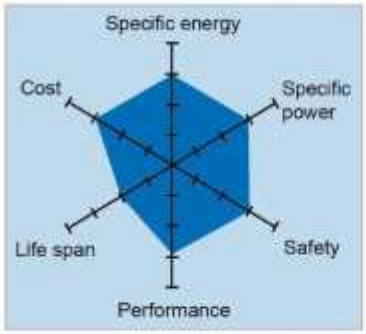
Lithium Cobalt Oxide
Li-cobalt
($LiCoO^2$)



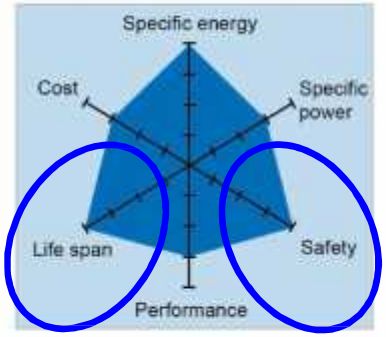
Lithium Iron Phosphate
Li-phosphate
($LiFePO^4$)



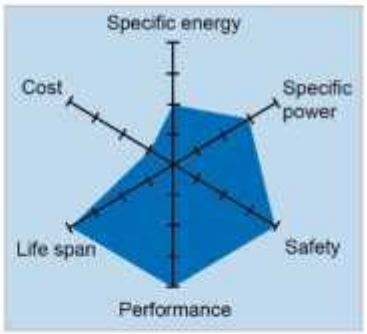
Lithium Nickel Cobalt Aluminum Oxide
NCA
($LiNiCoAlO^2$)



Lithium Manganese Oxide
Li-manganese
($LiMn^2O^4$)



Lithium Nickel Manganese Cobalt Oxide
NMC-TRIATHLON®
($LiNiMnCoO^2$)

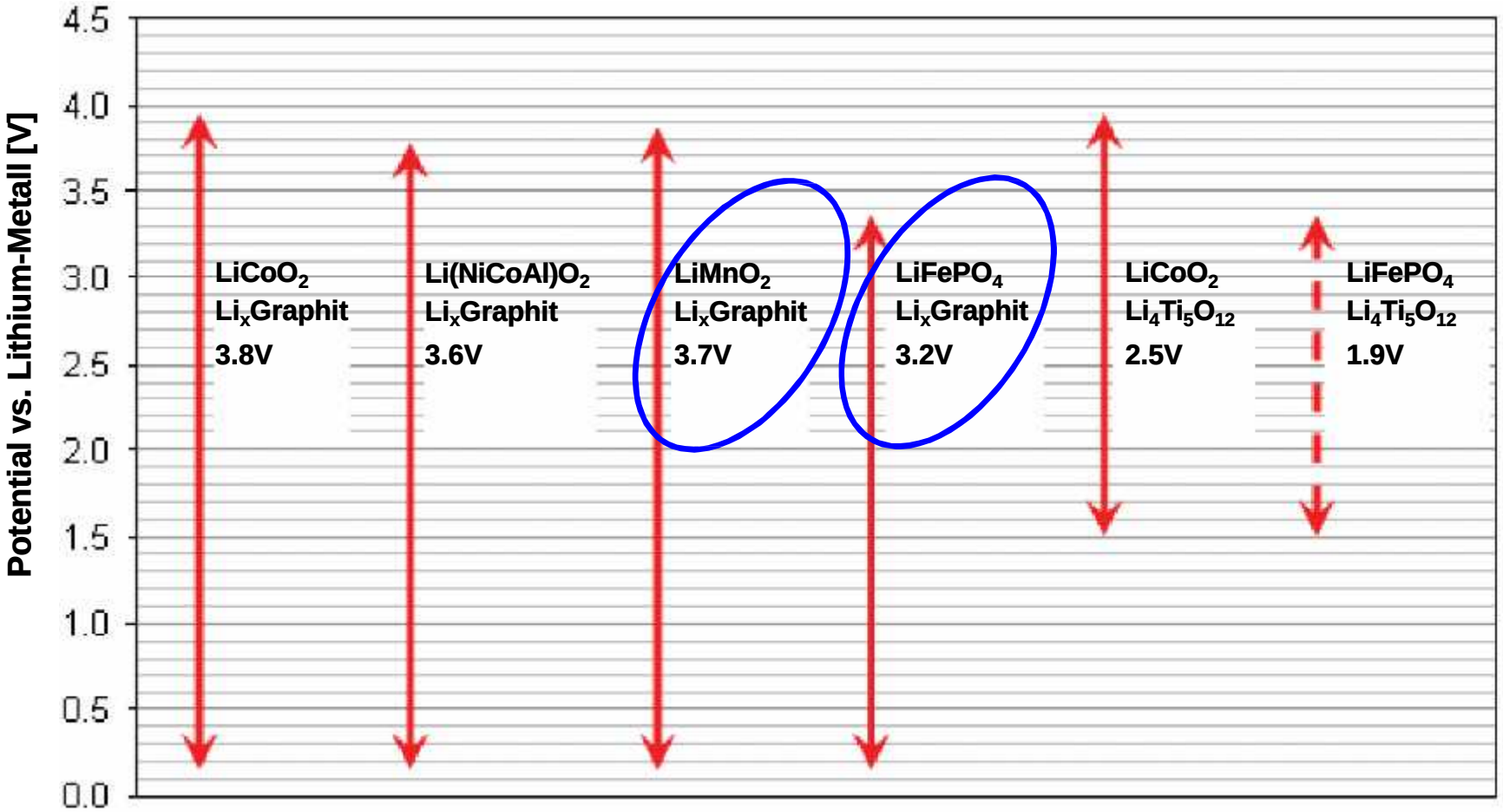


Lithium Titanate
Li-titanate
($Li^4Ti^5O^{12}$)

AIM ACCUMULATOREN Nürnberg

Various chemical Setups

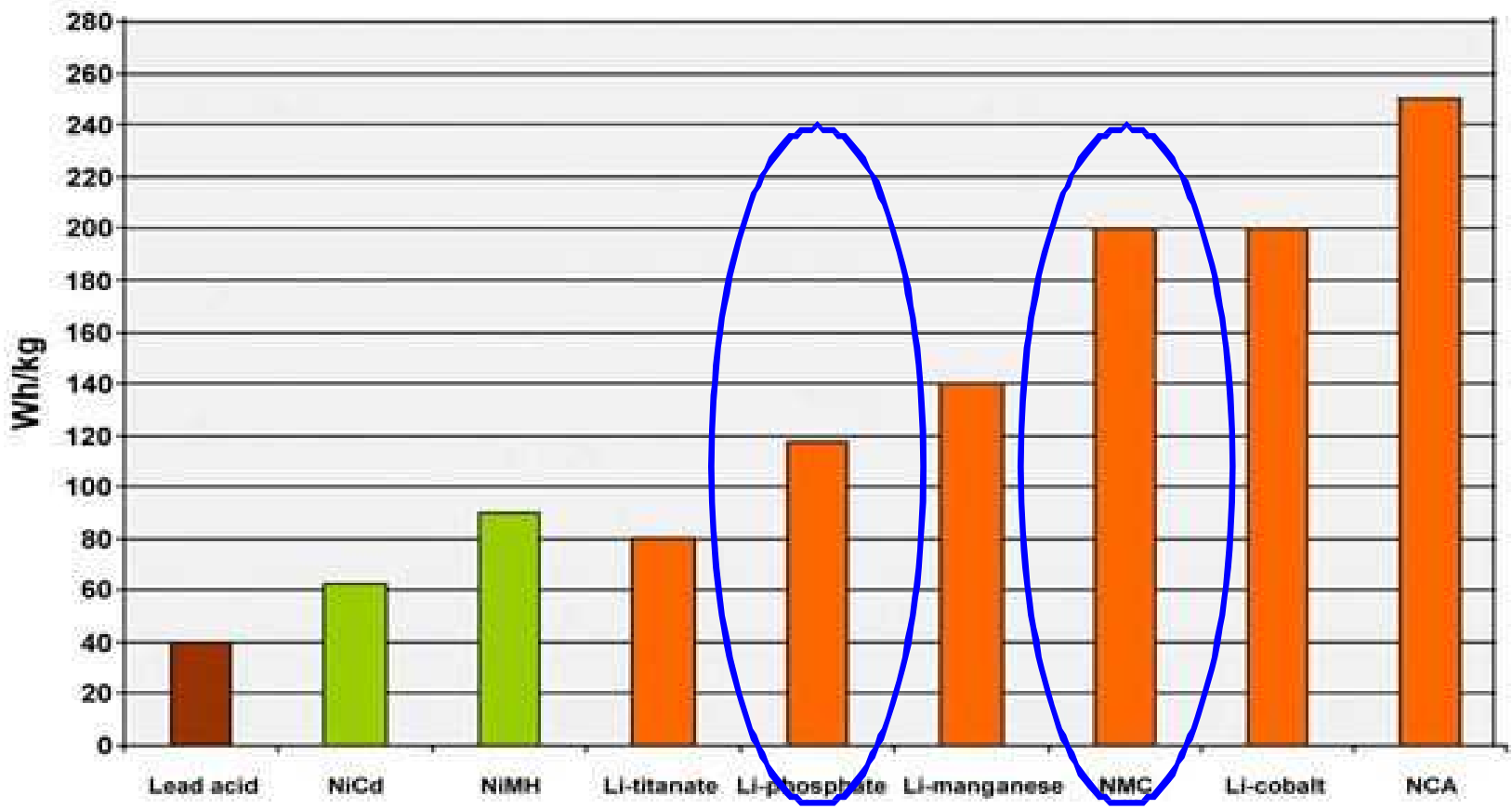
Different cell currents of Li-Ion depending on used alloy



AIM ACCUMULATOREN Nürnberg

Various chemical Setups

Different energy densities of Li-Ion cells



AIM ACCUMULATOREN Nürnberg

Properties of Lithium-Ion (LiXX) Batteries

While overcharging a lithium Ion battery, metallic Lithium can be deposited at the anode. The cathodic material will become the oxidizing element and therefore loses its stability. The battery could then heat up and cause a fire.

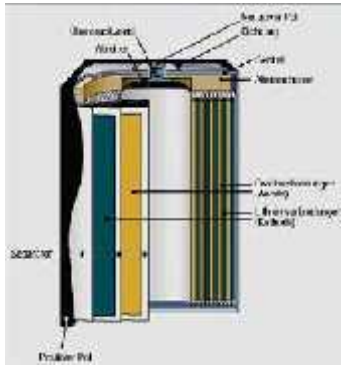
This process is known as “thermal runaway”. Under unfavorable conditions this could even lead to a cell explosion.

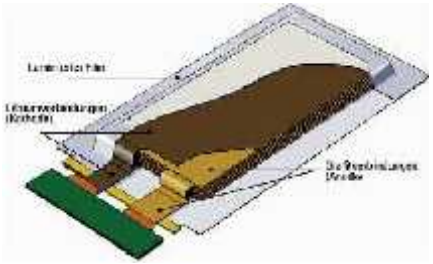
This reaction is not possible for Lithium-Iron-Phosphate batteries because of the chemical setup. Here, no oxygen is released as it is the case with other alloys and chemical setups. Triathlon NMC Batteries are preventing these reactions by constructive measures (Predetermined breaking points).

All Lithium-Ion batteries will be irreversibly damaged when overcharged or deep discharged.

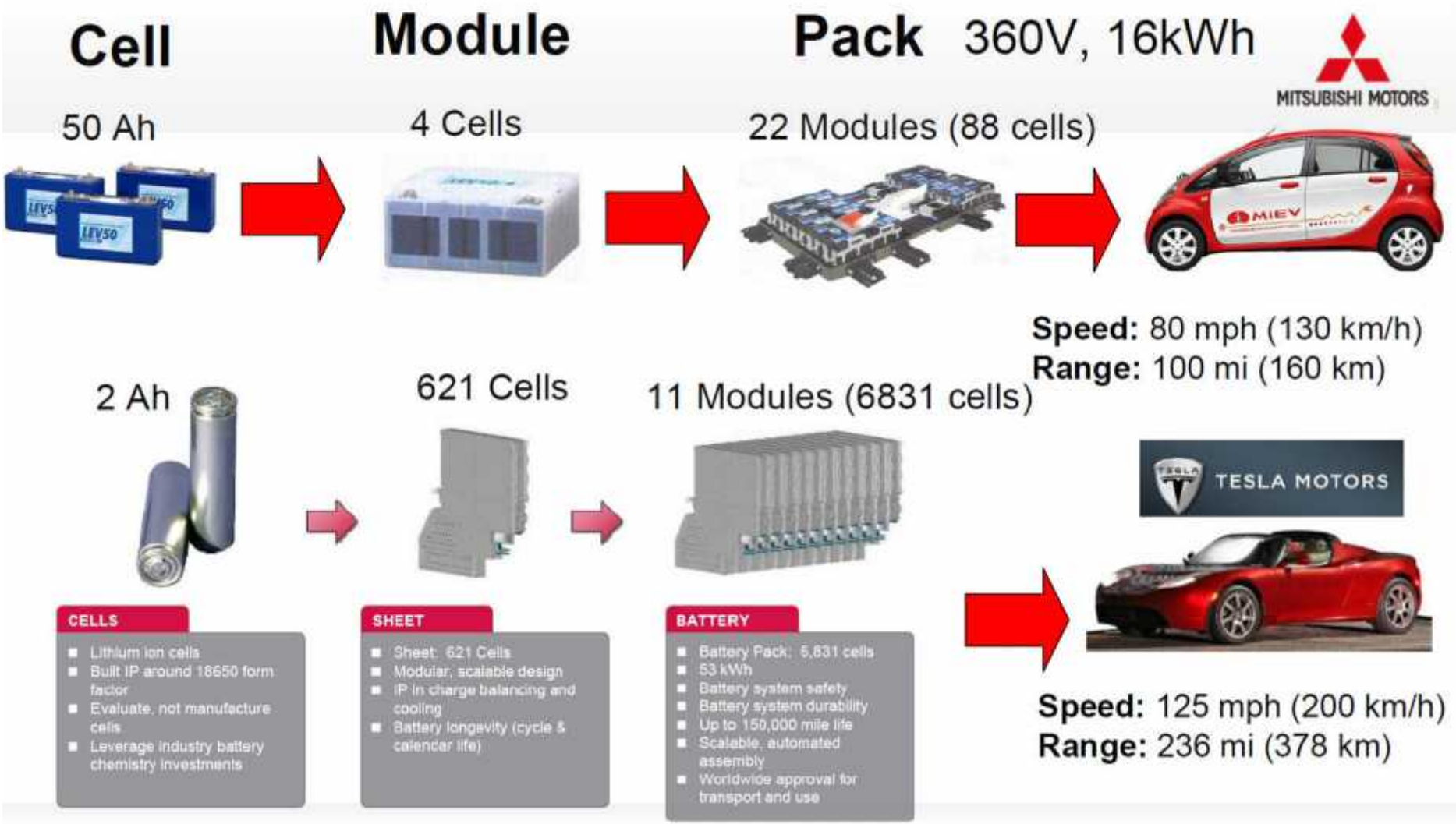
Cell types

Structural shapes





Different cell types in automotive applications



System properties

Energy content

	Lead PzS	LiFePO4	NMC	
Nominal capacity C5	375	240	260	AH
Avergae cell current	1,90	3,20	3,70	Volt
Amount of cells	12	8	7	piece
Permitted depth of discharge	80%	100%	100%	%
Energy content	6,84	6,14	6,73	kWh

System properties

High current

	Lead PzS	LiFePO4	NMC	
Nominal capacity C5	**375**	**240**	**260**	**AH**
Nominal capacity C4	**345**	**240**	**260**	**AH**
Nominal capacity C3	**319**	**240**	**260**	**AH**
Nominal capacity C2	**266**	**240**	**260**	**AH**
Nominal capacity C1	**210**	**240**	**260**	**AH**

System properties

Temperature behavior

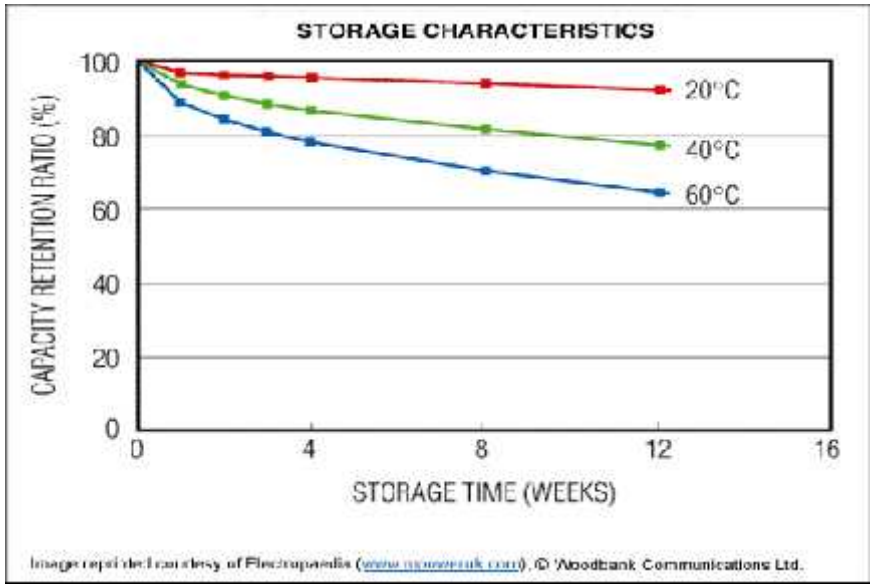
	Lead PzS	LiFePO4	NMC	
Nominal Capacity at 40° C	103	102	104	%
Nominal Capacity at 30° C	100	101	101	%
Nominal Capacity at 20° C	96	100	100	%
Nominal Capacity at 10° C	90	97	98	%
Nominal Capacity at 0° C	82	90	92	%
Nominal Capacity at -10° C	70	81	86	%
Nominal Capacity at -20° C	52	69	73	%

System properties

Self-discharge

- Batteries are losing energy caused by unwanted chemical side reactions and impurities in the electrolyte. Lithium-Ion Systems show the least self-discharge rate of all known battery systems.
- The self-discharge rate is heavily relying on temperature

Technology	Self-discharge/Month
Lead	4% bis 6%
NiCd	15% bis 30%
NiMH	30%
Lithium	2% bis3%



System properties

Energy recuperation

- Kinetic energy is transformed in electric energy. In such cases high currents arise for a short period, that can be absorbed perfectly by lithium-Ion batteries

- Lead-Acid batteries are not capable of absorbing and saving this recuperative energy that well. The energy absorption of Lead-Acid batteries is significantly lower.

System properties

Conclusion

To Compare the capacity of Lead-Acid and Lithium-Ion batteries, it is possible to work with a correction factor of 1.5, while considering the previously mentioned properties.

Example:

375 Ah PB Battery	/1.5	Corresponds a 250 Ah Lithium Battery
775 Ah PB Battery	/1.5	Corresponds a 510 Ah Lithium Battery

AGENDA

(1) „Lithium“ – Perception

(2) Function and Properties of Lithium Ion Batteries

(3) Triathlon Battery concept

(4) Charging stations and usage concepts

(5) Customer benefits

(6) Open points and risks

(7) Joint marketing concept

Product charachteristics

REPLACEMENT

Basic idea: „Lead out – Lithium-Ion in",

Phase1

- Dimensions correspond to the know Lead-Acid dimensions
- Up weighting with steal („Free of heavy metals")
- No change of the industrial truck needed
- External multifunctional display with separate discharge monitor

Phase 2

- Dimensions correspond to the know Lead-Acid dimensions
- Up weighting with steal („Free of heavy metals")
- Communication via CAN-BUS to the industrial truck

Phase 3

- Dimensions will be adjusted to the industrial truck. Optimized truck dimensions.
- Communication via CAN-BUS to the industrial truck
- Battery integrated into the trucks electric system

Product charachteristics

REPLACEMENT

Basic idea: „Lead out – Lithium-Ion in",

Phase1

- Dimensions correspond to the know Lead-Acid dimensions
- Up weighting with steal („Free of heavy metals")
- No change of the industrial truck needed
- External multifunctional display with separate discharge monitor

Phase 2

- Dimensions correspond to the know Lead-Acid dimensions
- Upweighting with steal („Free of heavy metals")
- Communication via CAN-BUS to the industrial truck

Phase 3

- Abmessungen und Masse werden an das Flurförderzeug angepasst Optimierte Fahrzeugabmessungen
- Kommunikation über CAN Bus zum Flurförderzeug
- Integration der Batterie in die Fahrzeugelektronik

Product charachteristics

INTEGRATION

Phase1

- Abmessungen und Masse entsprechen den bekannten Bleibatterien
- Auflastung mit Stahl (schwermetallfrei")
- Keinerlei Veränderung des FFZ
- Externes Multifunktionsdisplay mit separatem Entlademonitor

Phase 2

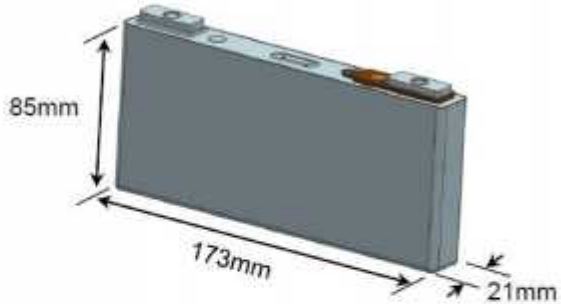
- Abmessungen und Masse entsprechen den bekannten Bleibatterien
- Auflastung mit Stahl (schwermetallfrei")
- Kommunikation über CAN Bus zum Flurförderzeug

Phase 3

- Dimensions will be adjusted to the industrial truck. Optimized truck dimensions.
- Communication via CAN-BUS to the industrial truck
- Battery integrated into the trucks electric system

Product charachteristics

Battery cells



AIM ACCUMULATOREN Nürnberg

Product charachteristics of cells

Contents

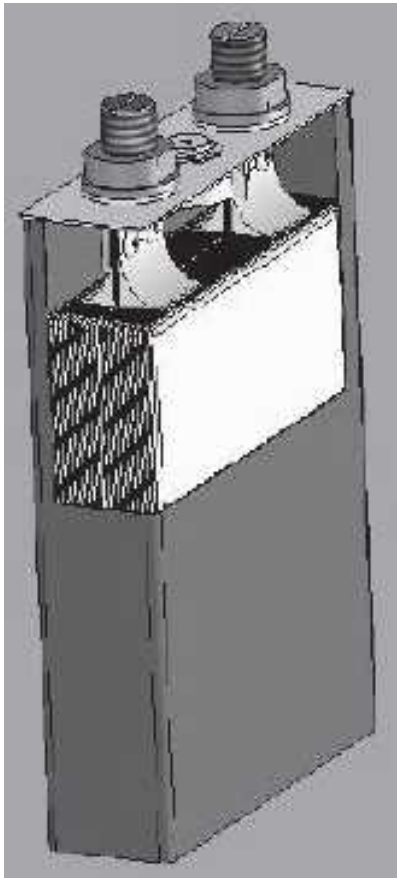
What´s in it ?

- Only 1% of the battery contains Lithium
  (resp. 5% Li2CO3) 0.008kg Li for 1kWh.
- Approx. 40% of a cell consist of AL (~23%) and CU (~13%)
- Approx. 40% consist of active electrode material.
  Cathode LiMn2O4 ~24%, Anode Graphite ~16%
- Approx 20% consist of Electrolyte

- Lithium Cells consist of 99% metals (Al, Cu. MN/Co/Ni/Fe) carbon, plastics and electrolyte
- Majority of components is not hazardous
- Metals such as CU, Al, Mn, Fe can be recycled
- Graphite, electrolyte and Li are often not recycled because of cost-efficiency reasons

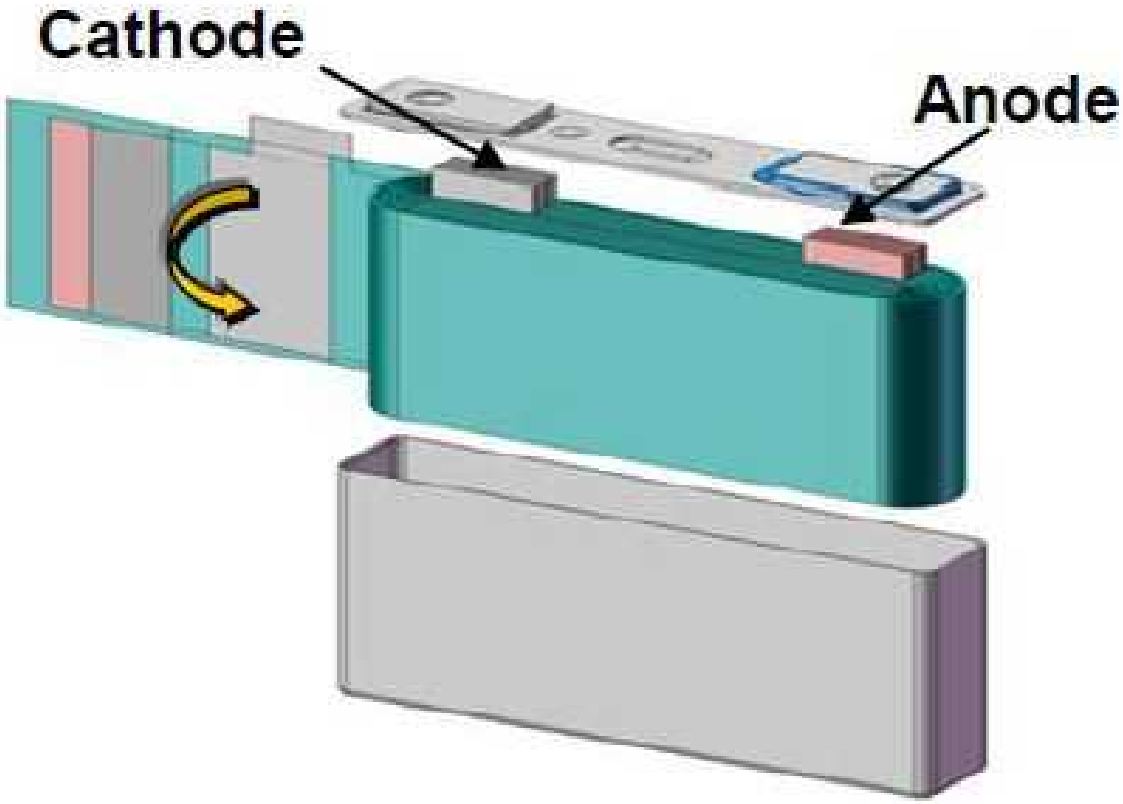
Product charachteristics of cells

Internal buildup of cells



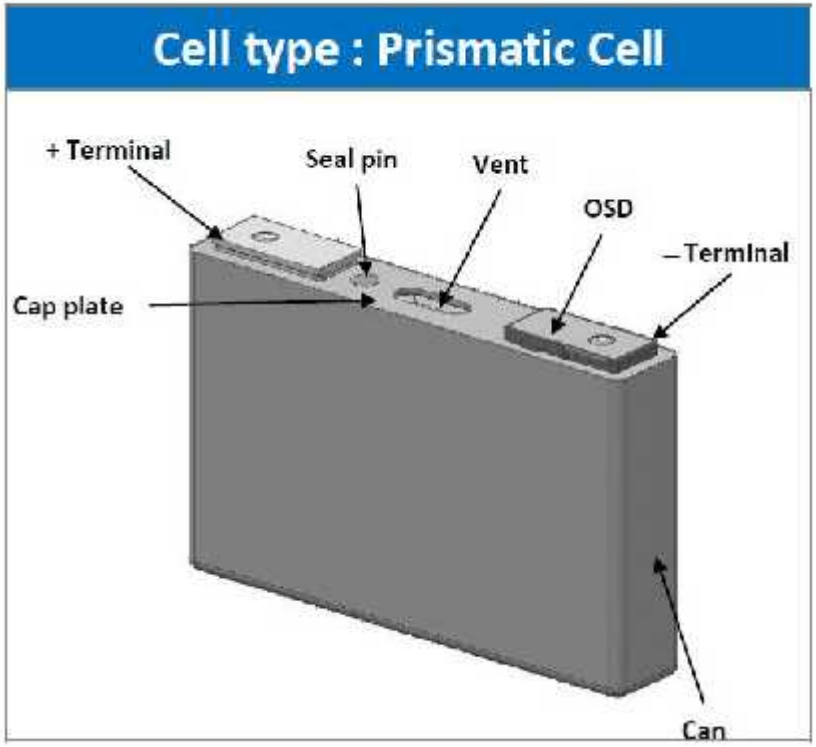
Product charachteristics of cells

Internal buildup of cells



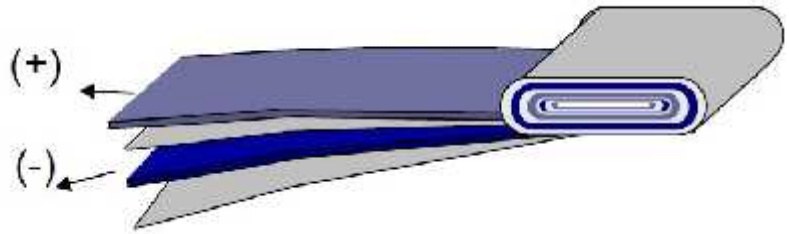
Product charachteristics of cells

Internal buildup of cells

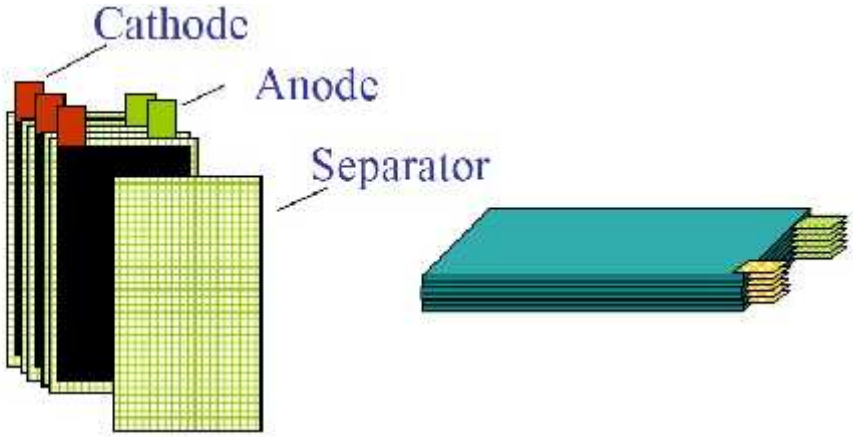


AIM ACCUMULATOREN Nürnberg

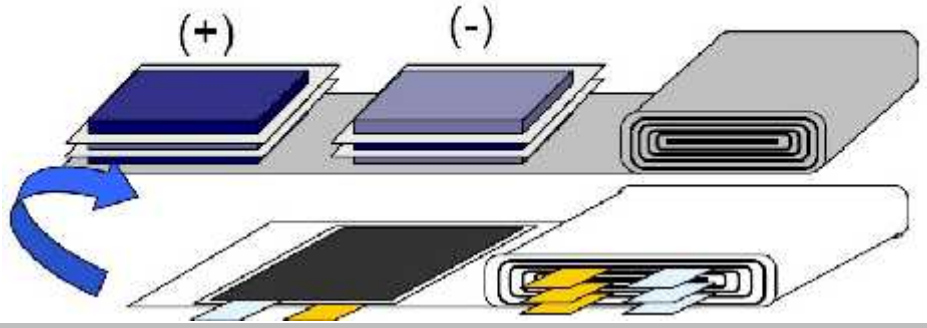
Product charachteristics of cells



„Wrapped“



„Stacked“

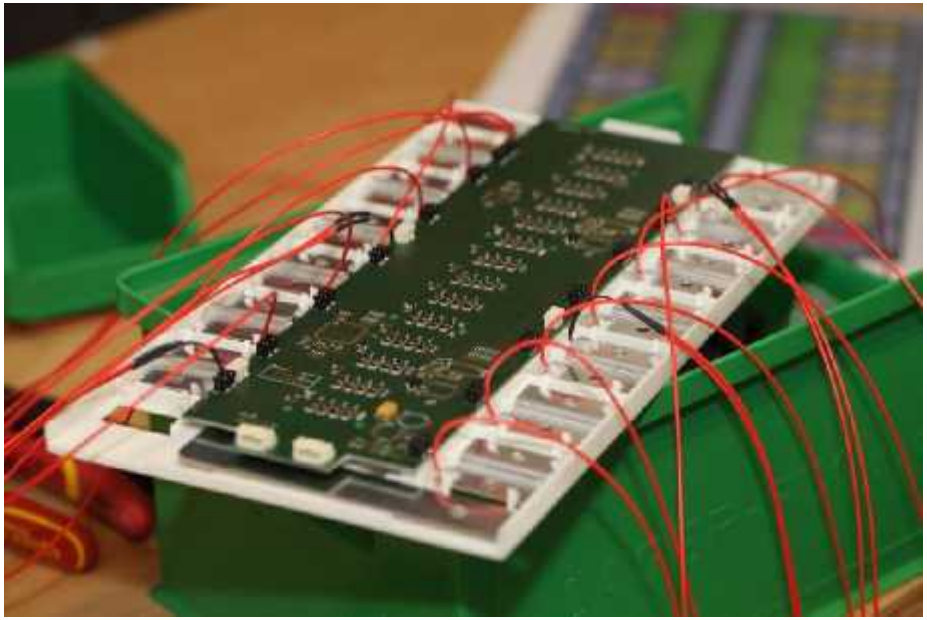


„Stacked-Wrapped“

AIM ACCUMULATOREN Nürnberg

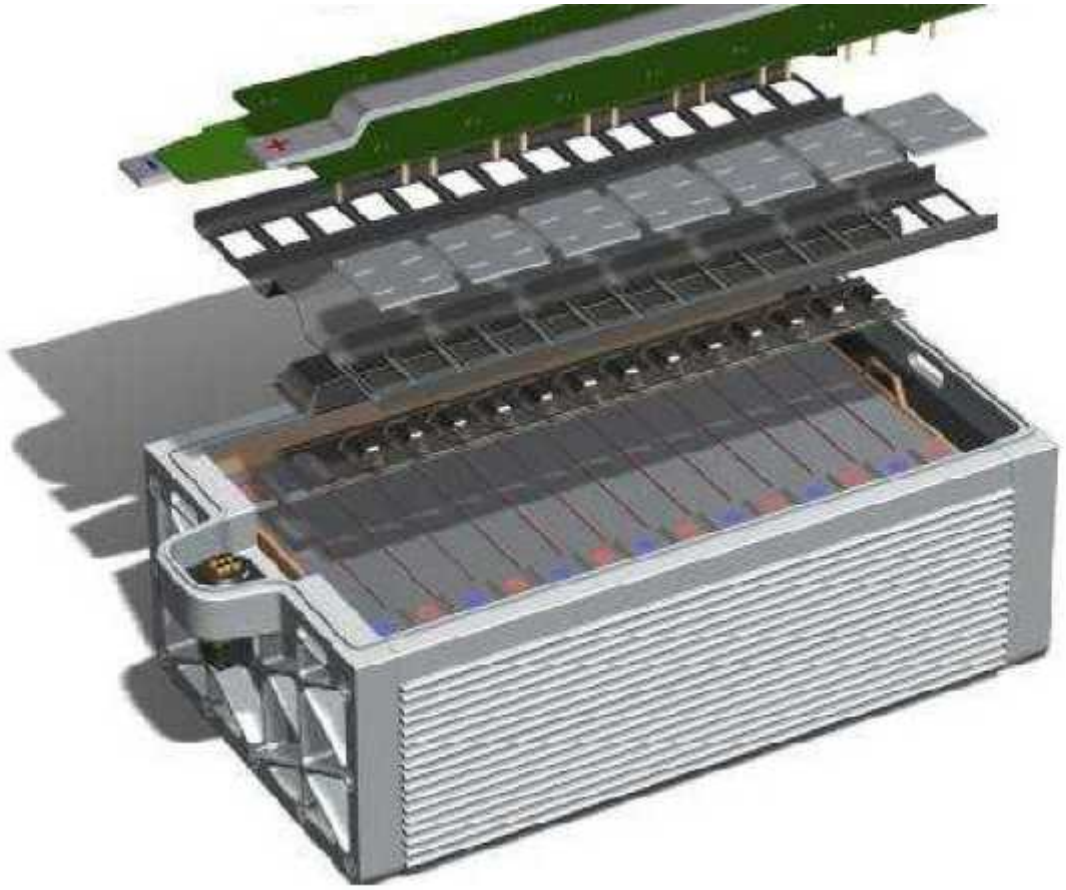
Product charachteristics

Single - Cell over watch – Current, Temperature, ID



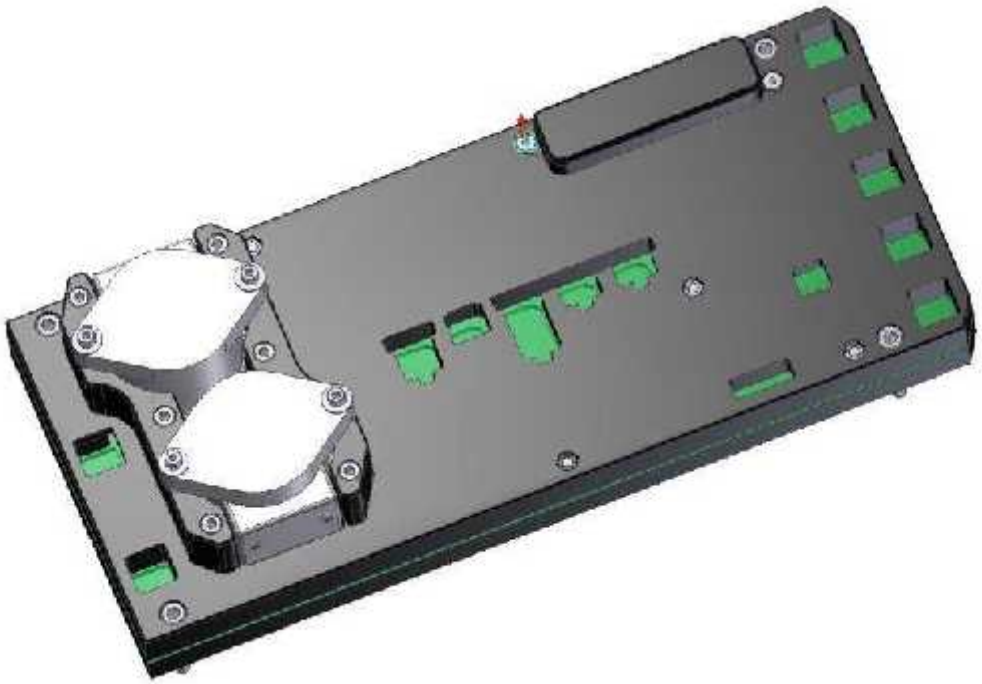
Product charachteristics

Battery module

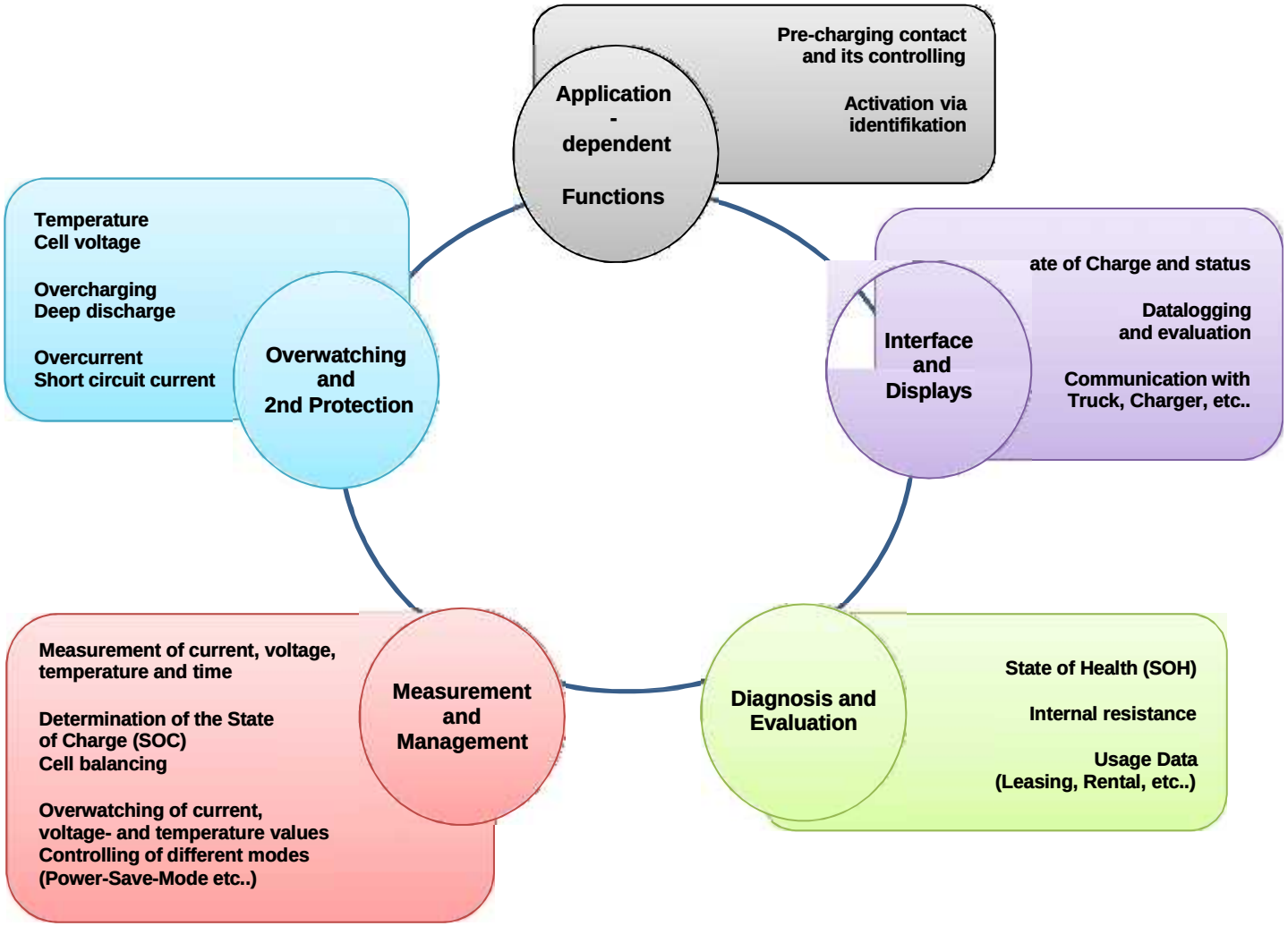


Product charachteristics

Zentralsteuergerät ZSG 1.0 (Central Steering Unit)



Product charachteristics



AIM ACCUMULATOREN Nürnberg

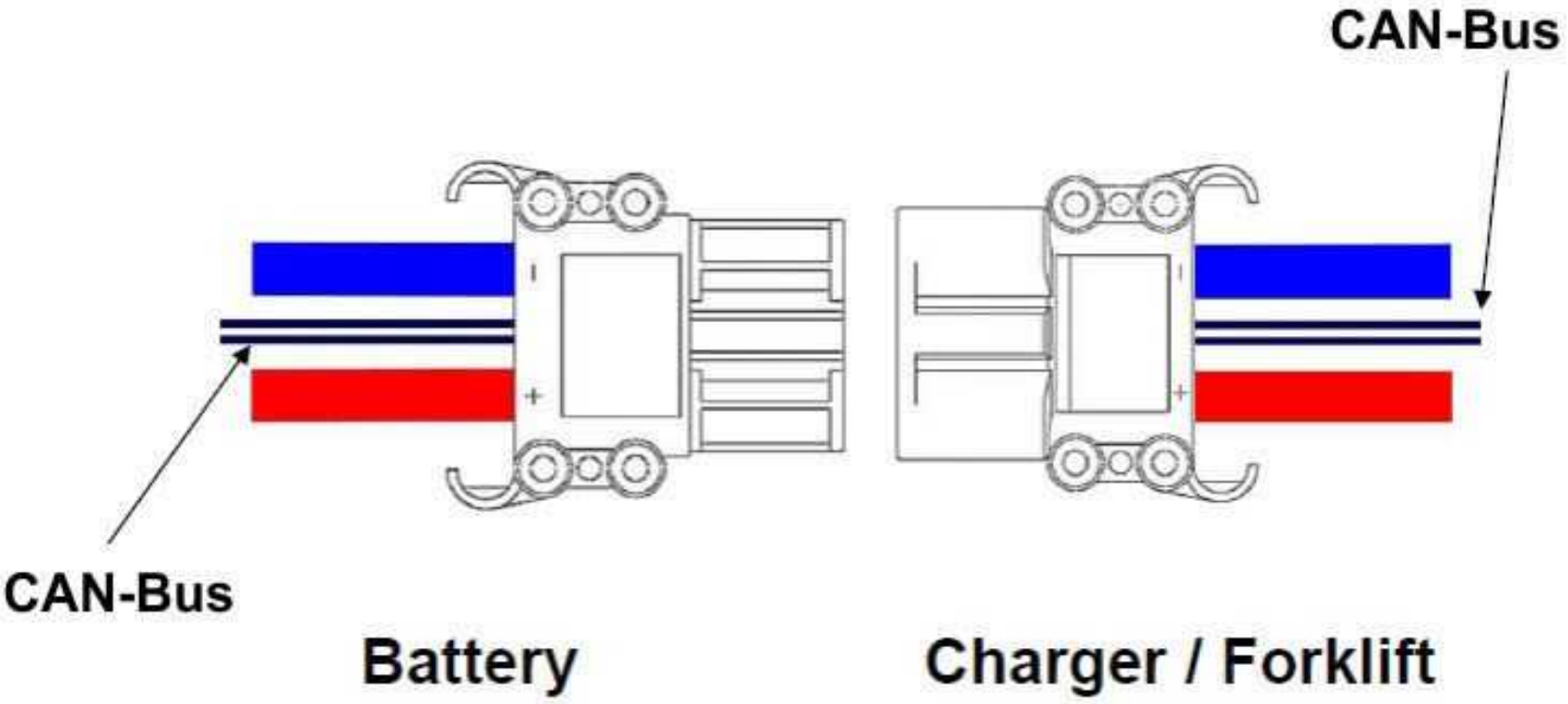
Product charachteristics

Ion Battery Guard 2.0 Display

Ion Battery Guard 3.0 Display

Product charachteristics

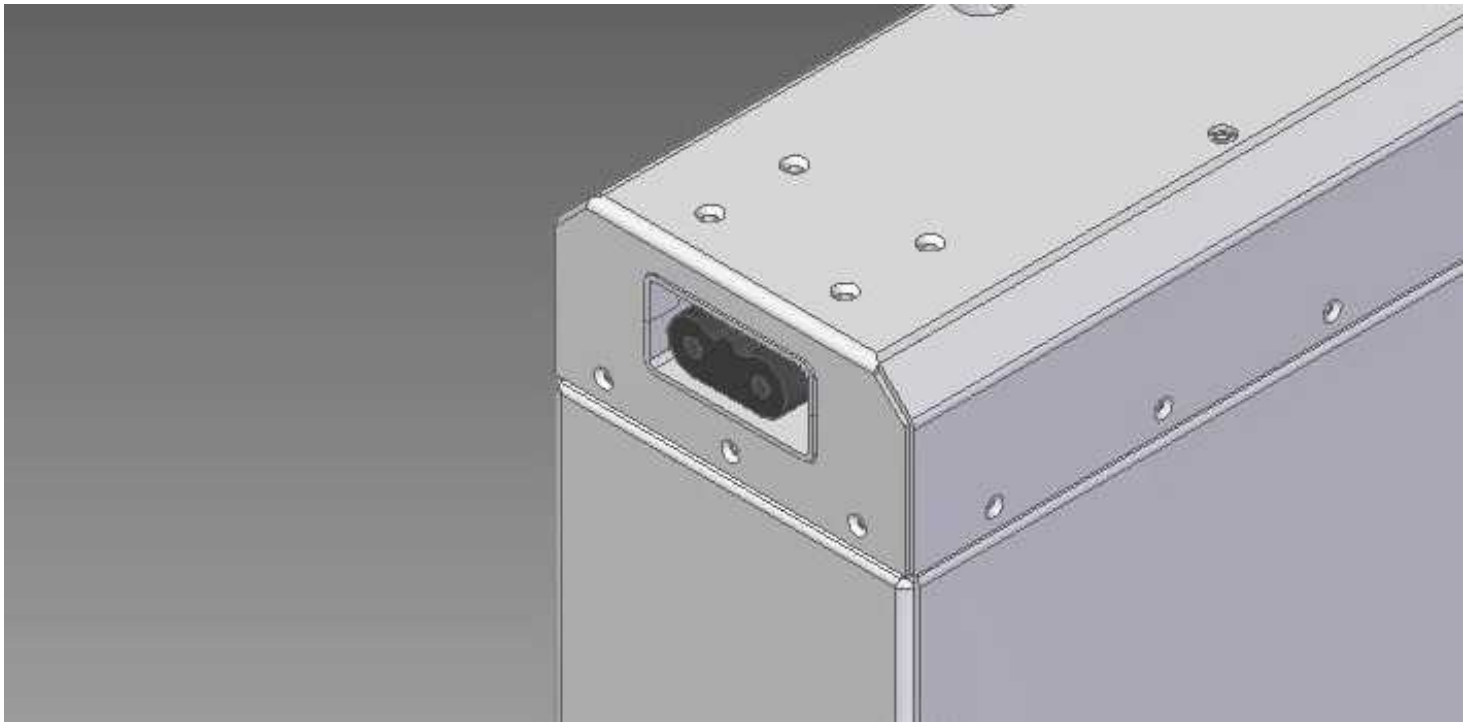
Communications CAN BUS



Product charachteristics

Easy Opportunity Charging

Separate charging plug with integrated blocking system for unintended startup.



Product charachteristics

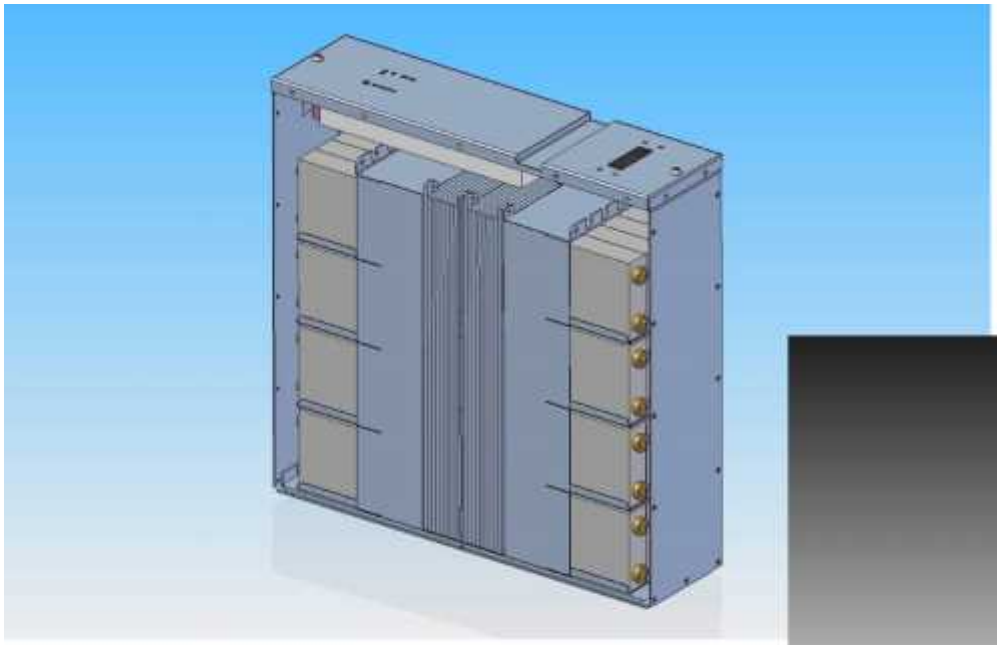
Battery types

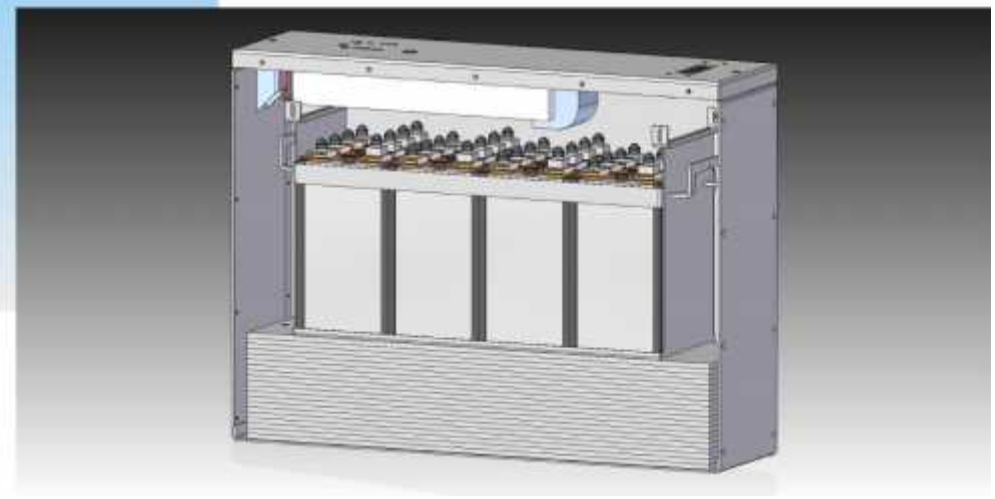
TA = LiFePO4 Singlecells - prismatic
TB = LiFePO4 Modular Concept - prismatic
TC = NMC Modular Concept - prismatic
TD = LiFePO4 Modular Concept – Cylindric
T?

„Absolute free of gassing, maintenance free - sealed battery system.

Product charachteristics

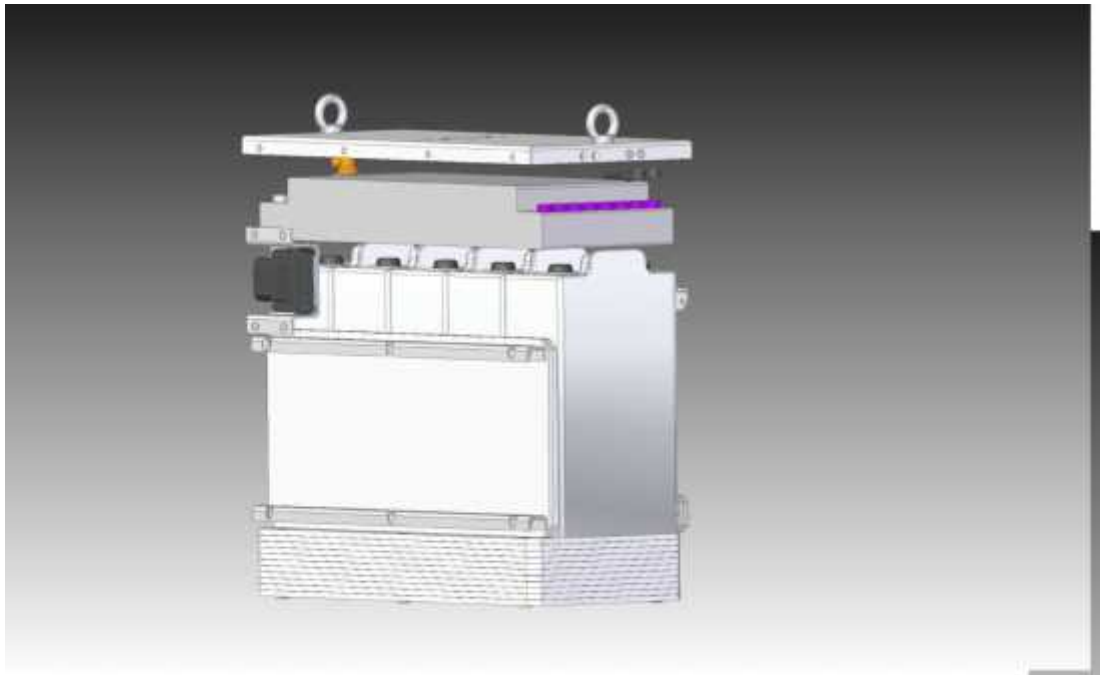
Exemplary battery buildup - Series TA

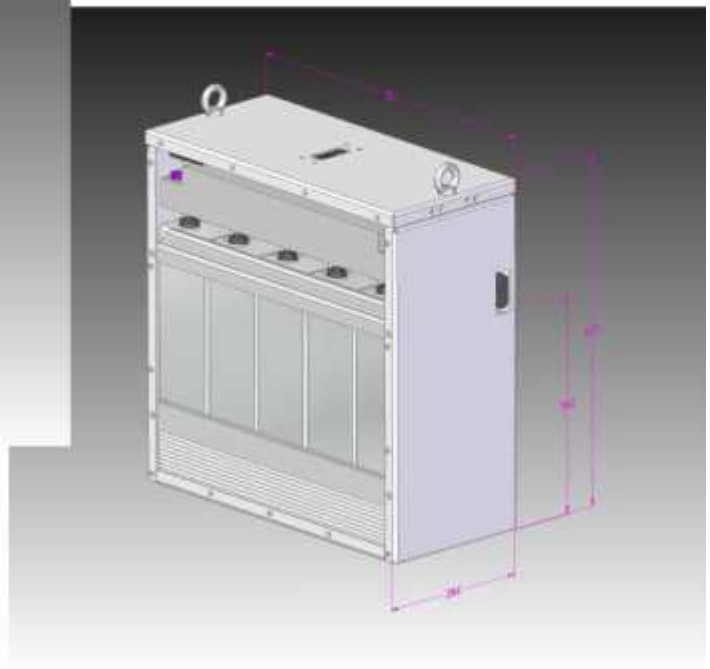




Product charachteristics

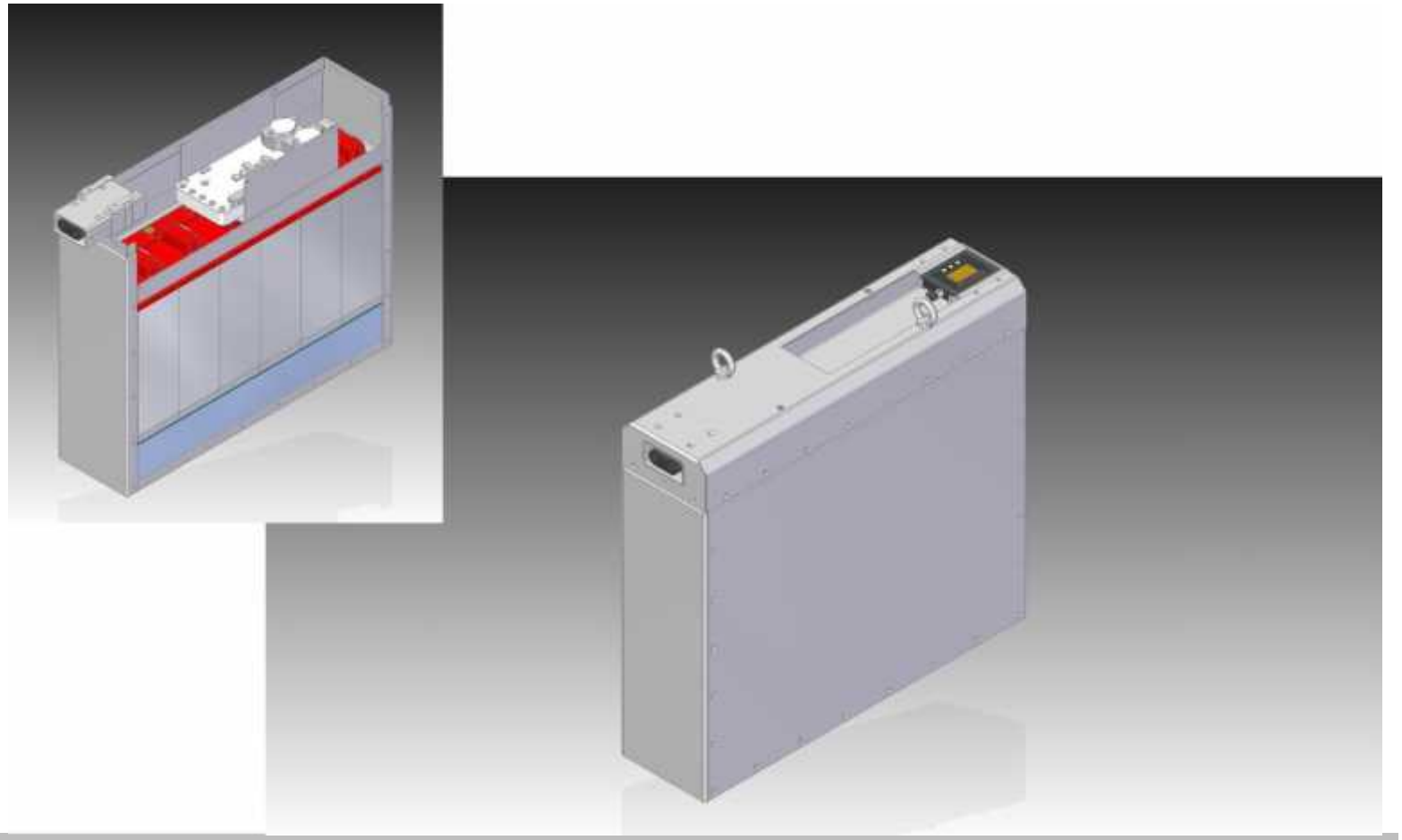
Exemplary battery buildup - Series TC





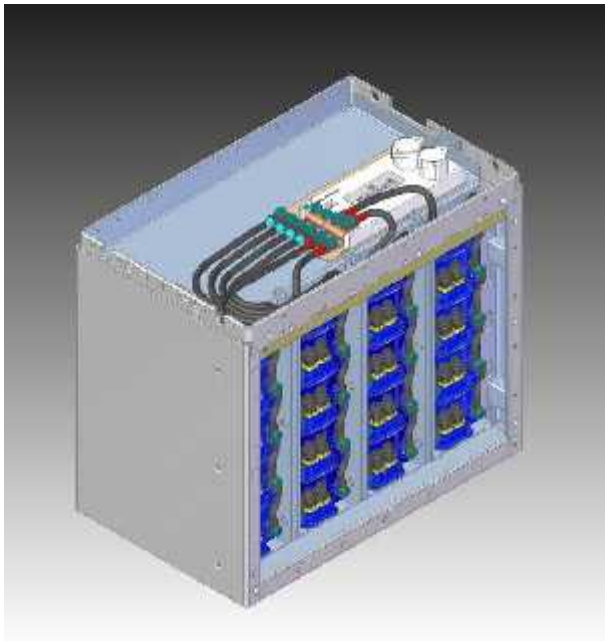
Product charachteristics

Exemplary battery buildup - Series TC



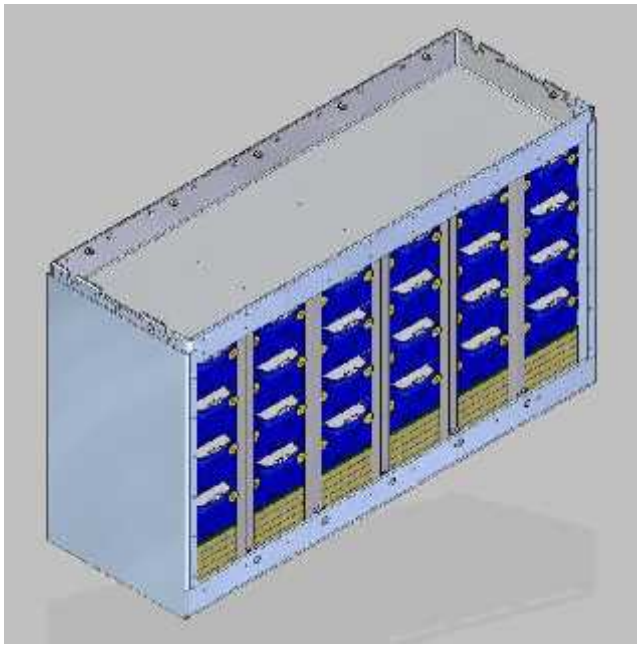
Product charachteristics

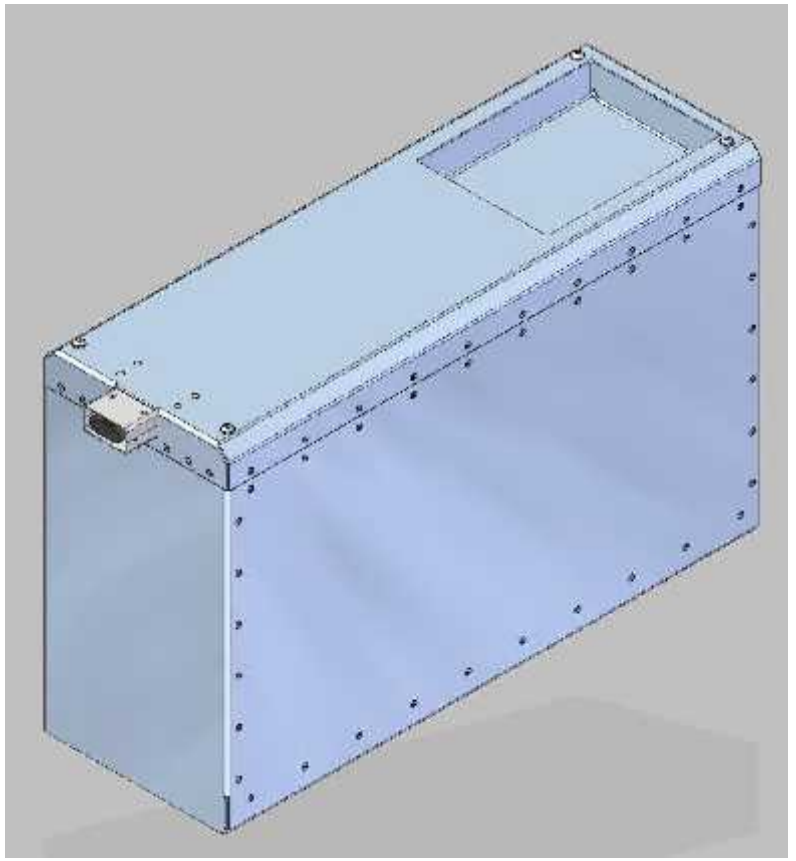
Exemplary battery buildup - Series TC



Product charachteristics

Exemplary battery buildup - Series TC





Product charachteristics

High frequency charger TriCOM ion TC

High frequency charger

- **IU-characteristic, regulated by the battery**
- **BUS Communication via Charging Plug**
- **Automatic battery detection**
- **Battery can be charged independent of capacity and current.**
- **Multicharge – One charger capable of charging up to 5 Batteries**
- **High efficient charging with a charging factor of approx. 1.02**

Product charachteristics

Safety features

- UN 38.3 for cells, Modules and Batteries
- Mechanical fuse in every single cell
- Electronic over watch of every single cell
- Electronic over watch of every module
- Electronic and mechanic hedge of the battery
- Electronic and mechanic hedge of the charging line

Documents

- Safety data sheet
- User’s manual
- CE Conformity declaration for battery and charger
- KIT Statement - Safety First

Product charachteristics

Safety advantages

- Active safety components: The TRIATHLON Battery System is actively over watched and secured. Battery short circuits are almost ruled out.
- Free of gassing: The TRIATHLON Battery System is not emitting any gases. No explosion hazard generated.
- Sealed: The TRIATHLON Battery System is absolute maintenance free. No safety hazard generated through electrolyte contact.
- Active Controlling: The Triathlon Battery System over watching every cell and warns and prevents therefore from misuse of the end-user
- Communication: Integrated TRIATHLON Battery systems are communicating with the industrial truck

Result

- TRIATHLON Lithium Ionen Batteries are significantly safer then Lead-Acid batteries

AGENDA

(1) „Lithium“ – Perception

(2) Function and properties of Lithium Ion Batteries

(3) Triathlon Battery concept

(4) Charging stations and usage concepts

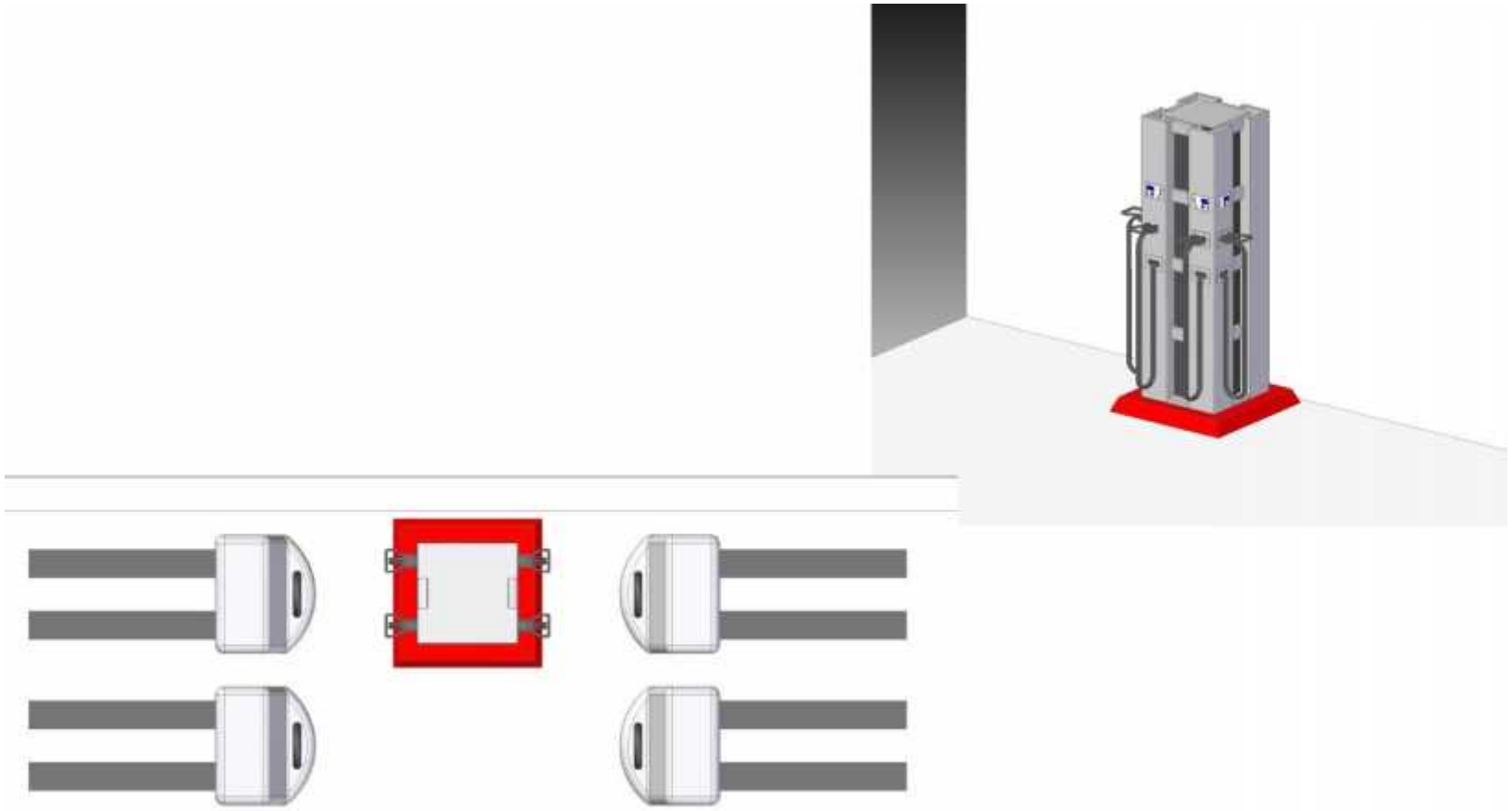
(5) Customer benefits

(6) Open points and risks

(7) Joint marketing concept

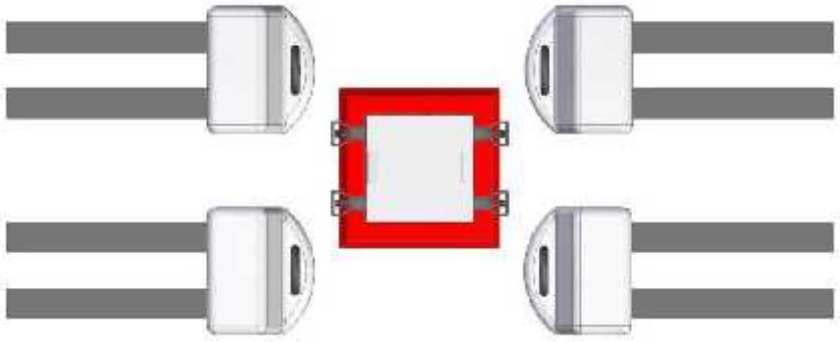
Charging stations

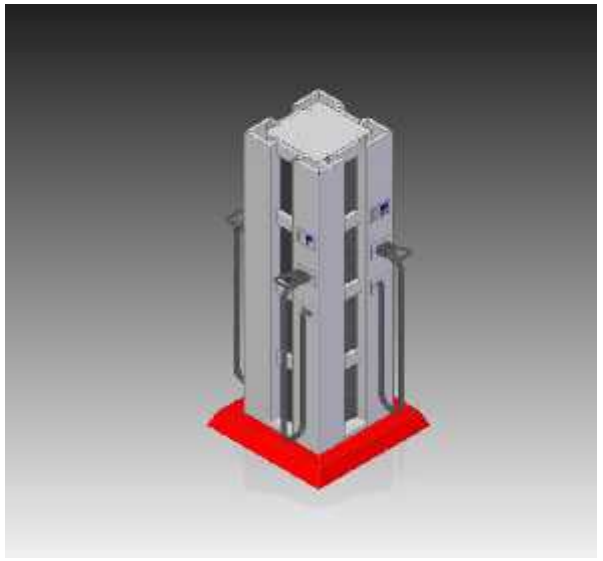
Decentralized charging stations



Charging stations

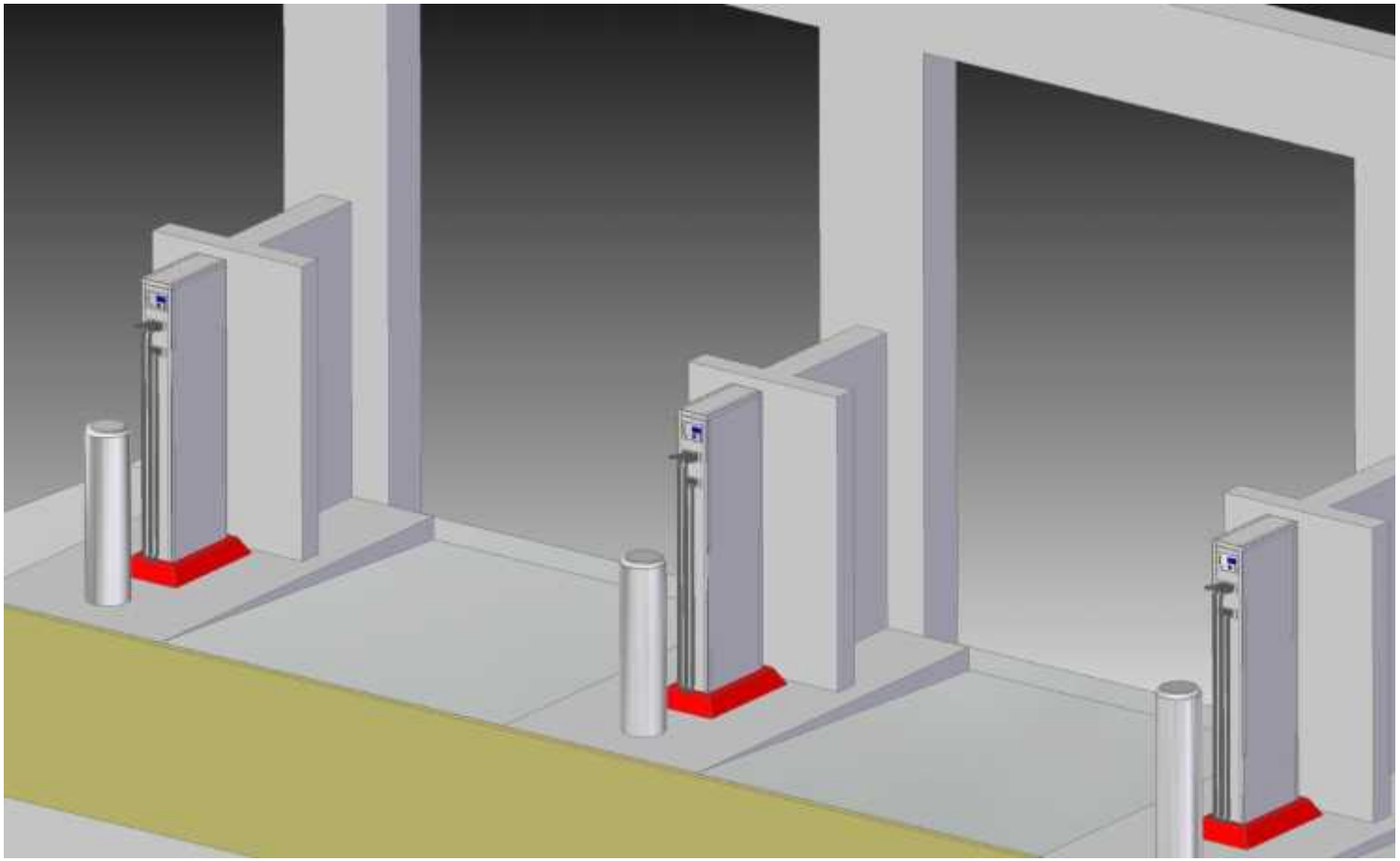
Decentralized charging stations





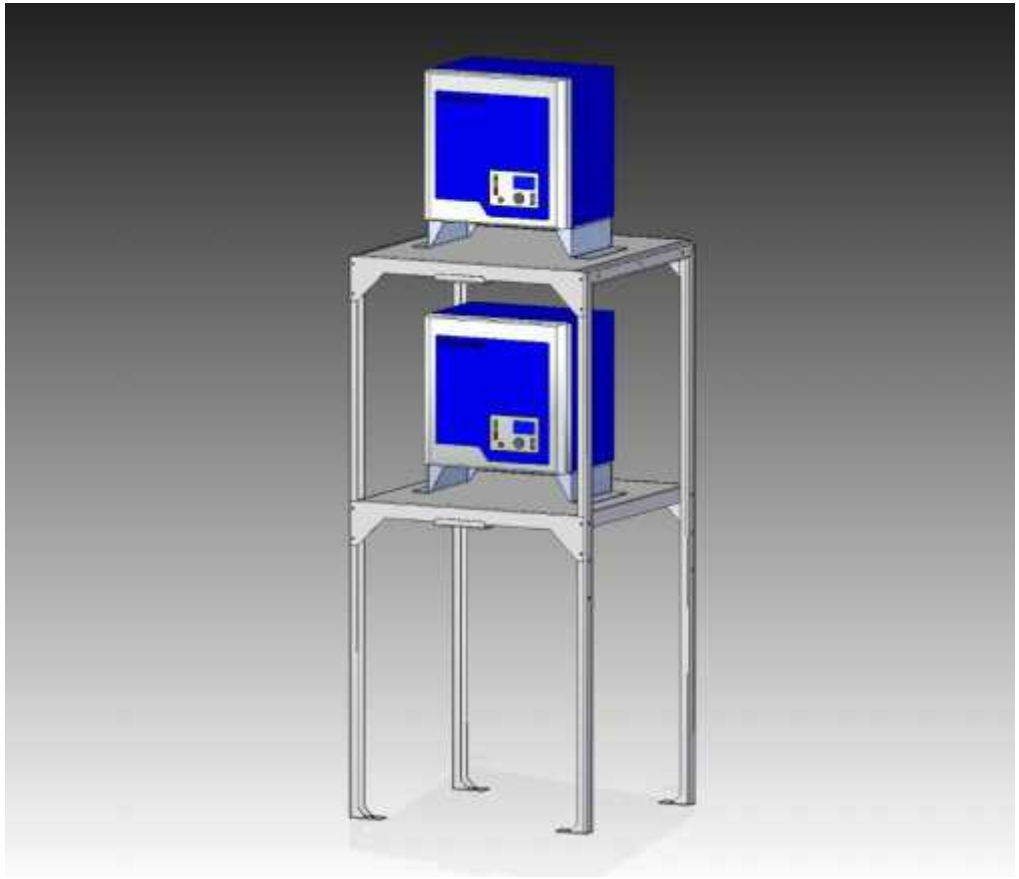
Charging stations

Decentralized charging stations



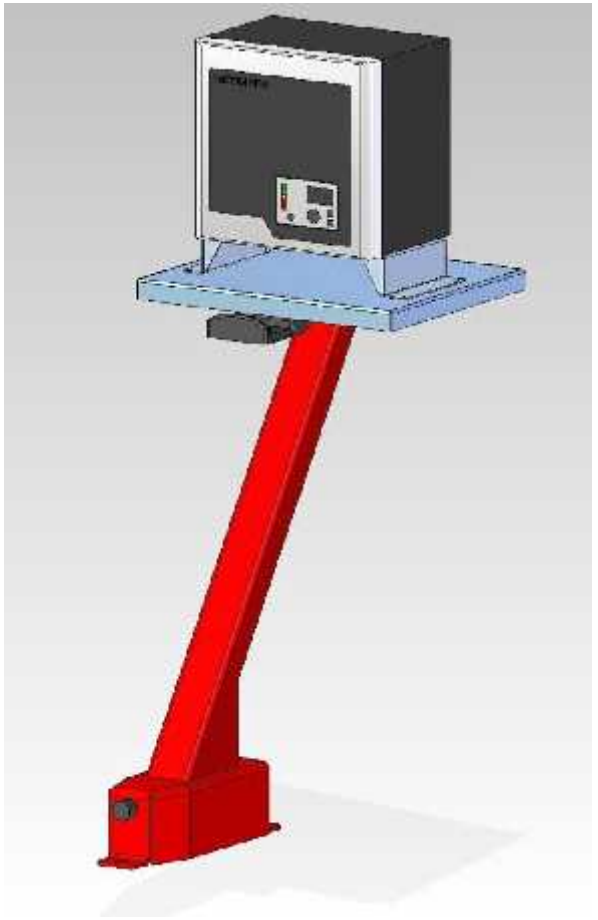
Charging stations

Decentralized charging stations



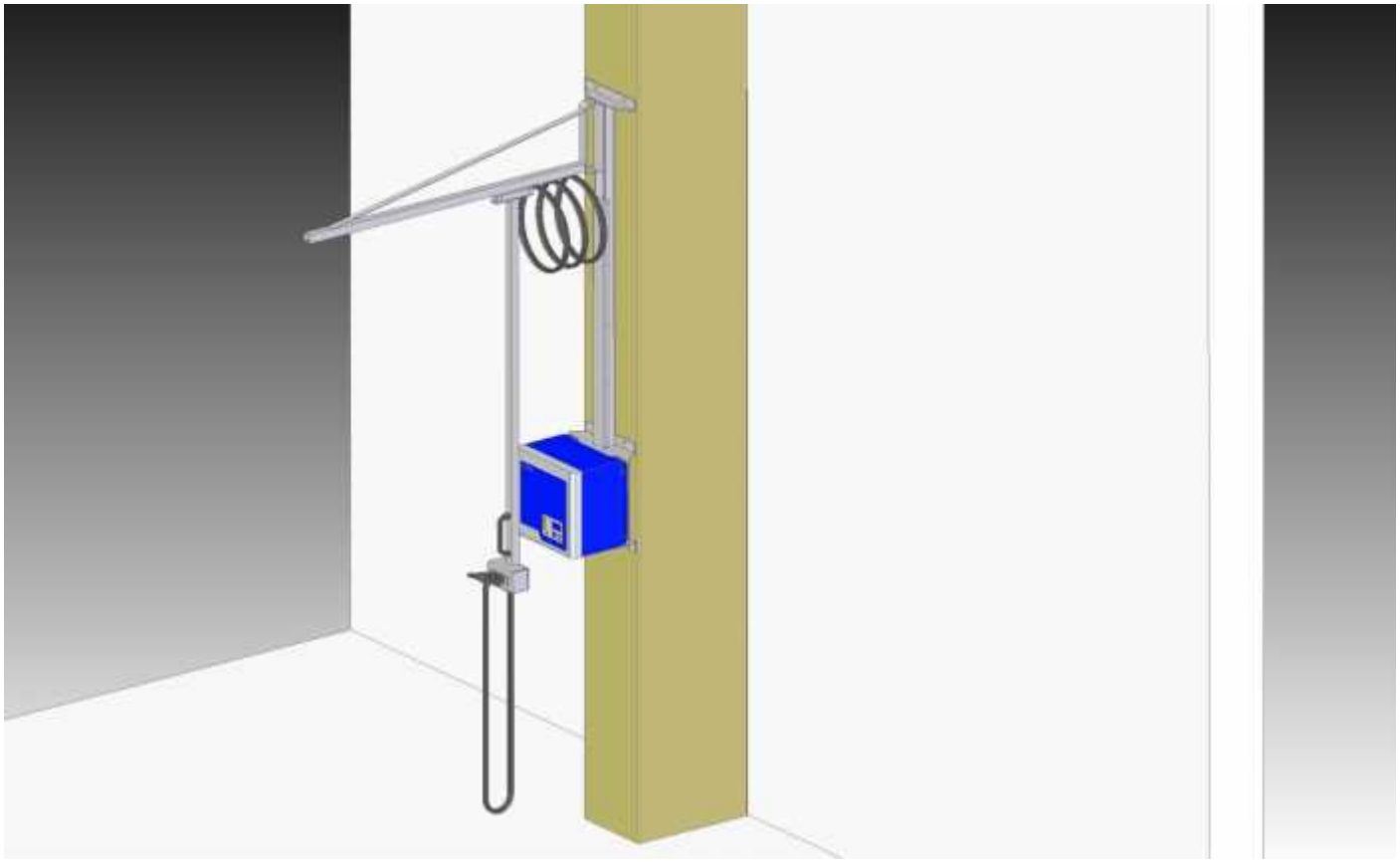
Charging stations

Decentralized charging stations



Charging stations

Decentralized charging stations



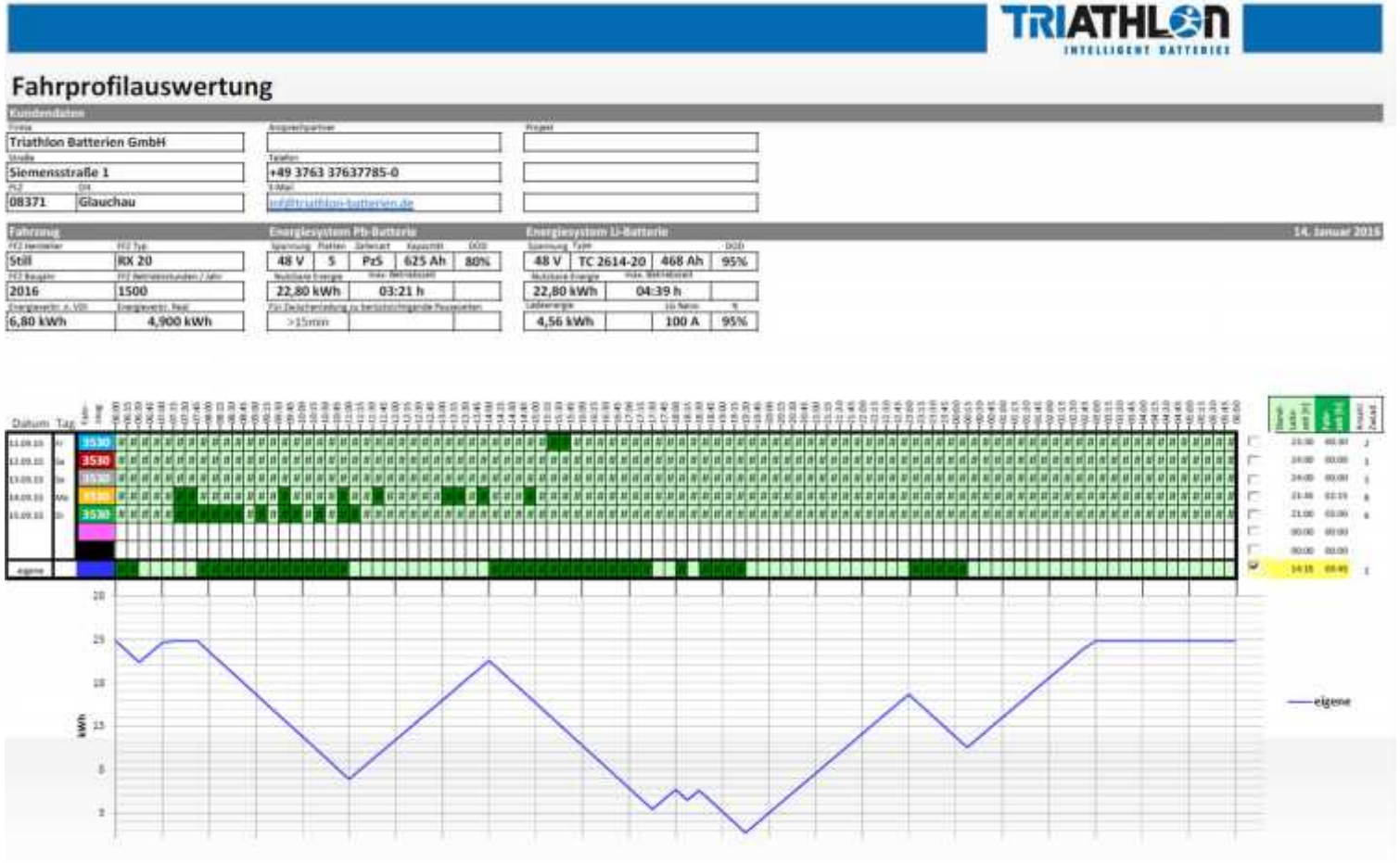
Charging stations

Decentralized charging stations

- Current projects – with CAN Integration in the Truck

Current projects – with external Display ion BG 2.0

Intelligent analyzing



TRIATHLON
INTELLIGENT BATTERIES

Fahrprofilauswertung

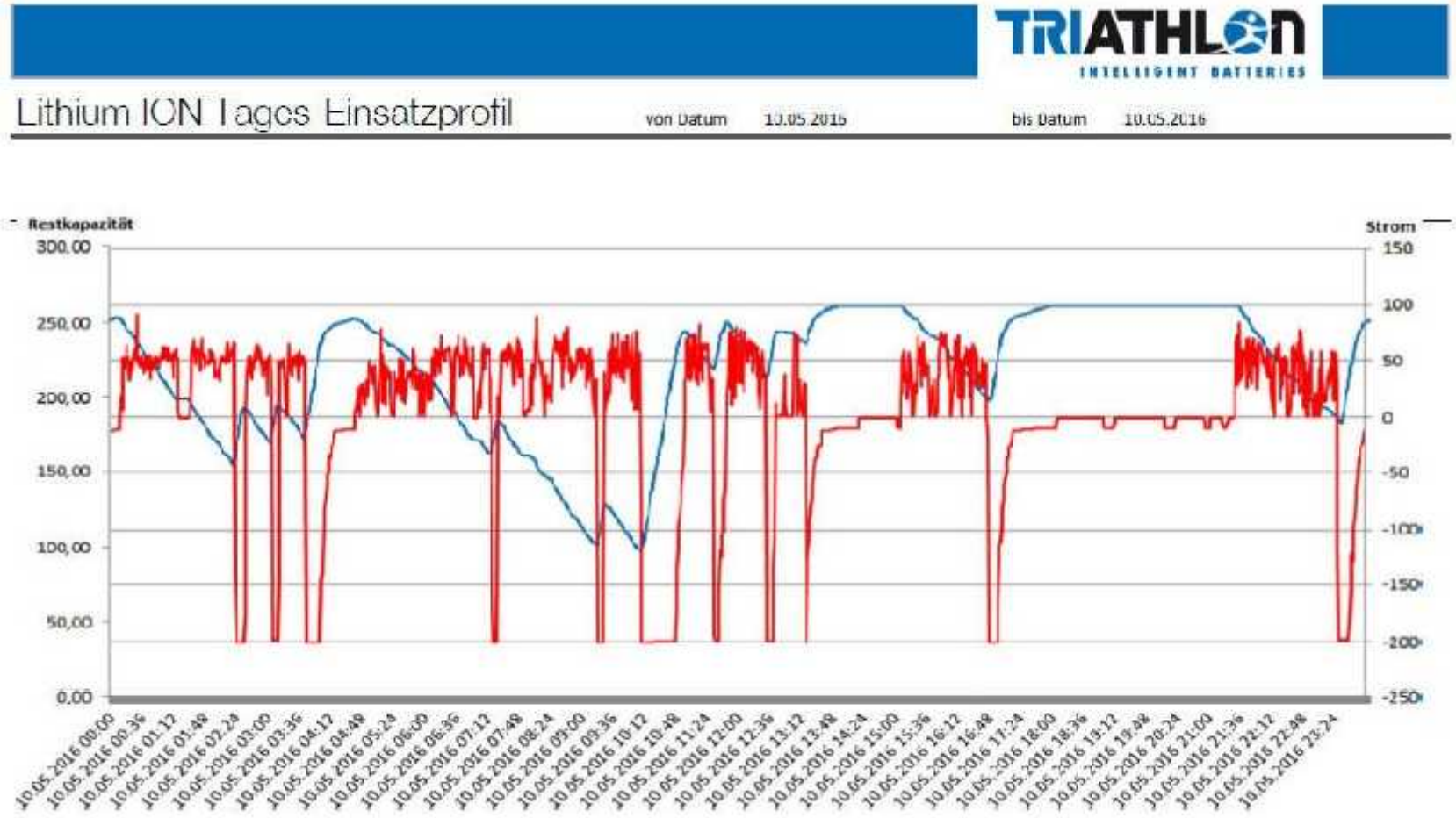
Kundendaten

Triathlon Batterien GmbH		
Siemensstraße 1	+49 3763 37637785-0	
08371 Glauchau	info@triathlon-batterien.de	

Fahrzeug		Energiesystem Pb-Batterie					Energiesystem Li-Batterie				14. Januar 2016
Still	RX 20	48 V	5	PzS	625 Ah	80%	48 V	TC 2614-20	468 Ah	95%	
2016	1500	22,80 kWh		03:21 h			22,80 kWh		04:39 h		
6,80 kWh	4,900 kWh	>15mm					4,56 kWh		100 A	95%	

AIM ACCUMULATOREN Nürnberg

Intelligent reporting



AIM ACCUMULATOREN Nürnberg

AGENDA

(1) „Lithium“ – Perception

(2) Function and Properties of Lithium Ion Batterien

(3) Triathlon battery concept

(4) Charging stations and usage concepts

(5) Customer benefits

(6) Open poin ts and risks

(7) Joint marketing concept

Customer Benefits

- **Opportunity charging: Unlike Lead-Acid batteries the Triathlon Lithium Ion System can be charged whenever you want. No need for full recharge.**

- **Fast charging: Full recharge within 1 hour is possible. Through to the fast charging, capacities can often be reduced depending on the usage profile**

- **Absorption of peaks: High energy peaks are absorbed without negative influences for the plates. Recuperated energy increases operating times**

- **Battery exchange: No need for battery changes anymore. No risk of physical damaging the battery while exchanging. No safety issues, no exchange equipment needed.**

Customer Benefits

- **Safety: absolute gassing free sealed battery system (Safety, decentral charging) – No risk of explosion, no need for ventilation systems and additional protection measures. No unpleasant smells**
- **Higher energy density: Possibility to increase operating times**
- **Active Battery Management: Integrated protection system prevents from misuse - die Users can not damage the battery by misuse or while maintaining the battery (except for physical damage).**

Customer Benefits

- **Energy efficency: Charging factor is around 1.02. This leads to savings in energy and CO_2 - emissions. – calculated savings from up to 40% possible (in comaprison to a standard Lead-Acid battery.**

- **High currents: Nearly linear discharging curves. Even in demanding applications (High currents) the voltage remains stable. – Highest truck performance throughout the whole time of discharge**

- **Environment friendly: The battery system is free of heavy metals and sealed. The battery can be fast- and opportunity charged, preferable with power from renewable energies**

AGENDA

(1) „Lithium“ – Perception

(2) Function and Properties of Lithium Ion Batteries

(3) Triathlon battery concept

(4) Charging stations and usage concepts

(5) Customer benefits

(6) Open points and risks

(7) Joint marketing concept

Open points and risks

Technichal points to pay attention:

- **Dimensioning of the Lithium-Ion battery system**
- **Opportunity charging possible?**
- **Check warehouse for possible charging spots**
- **Check grid connection for charging spots**
- **Inform your fire insurance**
- **Transport regulations – Dangerous goods**
- **How to handle damaged batteries**

Risks:

- **Max. durability of the battery system not yet field tested**
- **Higher default risk – backup solutions possible**

Open points and risks

Economical points to pay attention:

- No standardized product – this is influencing
- The definition of the „Lifetime“
- The definition of the max. Depth of Discharge
- A statement of max. cycles possible
- The definition of the end of the lifecycle of the product
- Comparability of costs for Lithium-Ion battery systems
- Lithium Ion: Cyclic lifetimes possible from 350-20.000 cycles or 4-25 years of calendrical lifetime.

Risks:

- Selection of partners regarding future economic stability and warranty agreements

Open points and risks

To pay attention after the usage of a Lithium-Ion Battery:

- **Downgrade able**
  - **Second life of the old Truck**
  - **Possibility to refurbish the Lithium-Ion Battery**

Risks:

- **Need of a cheap, used Lead-Acid battery solution for the old truck**

AGENDA

(1) „Lithium“ – Perception

(2) Function and Properties of Lithium Ion Batteries

(3) Triathlon battery concept

(4) Charging stations and usage concepts

(5) Customer benefits

(6) Open points and risks

(7) Joint marketing concept

Sales concept

Essentials:

- Assessment of demands at the interested customer
- Analyzation of usage by checklist
- Determine the necessary Lithium-Ion system on basis of your collected information
- Coordination of the basic data for TCO consideration
- Prepare comparison of system costs to calculate economical efficiency

Sales concept

Essentials:

- Use quick charge plug on the side of the tray

- 24V Batteries Standard version:
  - Discharge cable with plug out of the „drawer“
  - quick charge plug out of trays side or optional charging cable with plug out of the „drawer“

- 48/80V Batteries Standard version:
  - Discharge cable with plug out of the „drawer“
  - quick charge plug out of trays side or optional charging cable with plug out of the „drawer“

- Determine grid connection and charging spots

Sales concept

1. **Utilization concepts on basis of monthly rates (rental)**

- **rentflex – flexible contract period and flexible working hours**
- **rentfix – fixed contract period with runtimes from 24-120 months with fixed working hours**

Sales concept

2. <u>Purchase of utilization – Purchase Secure (battery has to be returned)</u>

Basis for the purchasing price are the demanded annual working hours and the agreed period of use

The Product „Purchase secure“ is up- and downgrade able and provides highest flexibility for the customer.

Sales concept

3. Purchase with obligation to return – sale and return

The constructional concept meets today's demands of sustainability as the battery gives us the possibility to refurbish or to recycle certain components. Rebates for parts we are able to recycle are given today. This leads to an obligation of return for the battery after the end of its lifetime.

The battery will shut down because of safety purposes after it is depleted.

The criteria for a shut-down is determined by the artificial intelligence of the central steering unit (ZSG)

Sales concept

Example purchase with obligation of return – sale and return

Lithium-Ion system competitor :	**SP**	**EUR 3.500,--**
Disposal after lifetime:	**Costs**	**EUR 750,--(3,--/kg)**
Competitor total :	**SP**	**EUR 4.250,--**
TRIATHLON Lithium-Ion System sar:	**SP**	**EUR 3.750,--**
Disposal after lifetime:	**Obligated return (free of charge)**	
Total TRIATHLON sar:	**SP**	**EUR 3.750,--**

Sales concept

4. Purchase without obligation of return - sale

The battery will shut down because of safety purposes after it is depleted (End of lifetime). The disposal of the battery is guaranteed by Triathlon and free of charge.

The criteria for a shut-down is determined by the artificial intelligence of the central steering unit (ZSG)

Sales concept

5. Service

By completing a service contract the utilization for sales concepts 1 +2 is guaranteed by the partner. For the sales concepts 3+4 the warranty time is extended.

Sales concept

Scope of service for service agreements

- Expanded warranty and functional guarantee
- All future software updates included to secure highs performance and efficiency of the battery system
- Free of charge return of the battery and switch to lead acid by dissatisfaction
- Complete annual safety check of the battery system
- User instructions during regular battery maintenance
- Total repair costs for the time of usage including travel costs.
- Performance of all necessary tests including BGV-A3/ DGUV regulation 3 of the charger
- Cleaning of the battery system and the charger during the annual inspection
- Free of charge take back of the battery after the end of the contract
- Possibility to purchase used Lead-Acid batteries for the second life of the truck

Sales concept

Warranty conditions:

1. <u>Without service contract</u>

12 months full warranty and additional 36 months

or

24 months full warranty

2. <u>With service contract</u>

rentfix:	**Full warranty for the period of use**
rentflex:	**Full warranty for the period of use**
Kauf secure:	**Full warranty for the period of use**
Kauf sar:	**24 months full warranty and additional 36 months Pro Rata**
Kauf sale:	**24 months full warranty and additional 36 months Pro Rata**

Sales concept

- **Contracts**
  - **Contract secure**
  - **Rental contract rentfix**
  - **Rental contract rentflex**
  - **Service contract**

- **Delivery and handing over of the battery system with detailed instruction for the customer**

- **Lithium offers with so called „4 eyes principle“. Offers have to be overviewed from technical and economical standpoints**

Sales concept

- **Lead times:**

  24 and 48Volt
  Starting January 2016: ca. 6-8 Weeks
  36/72 and 80Volt
  Starting October 2016: ca. 8-10 Weeks
  Kauf secure
  Starting June 2016: ca. 6-8 Weeks

Sales concept

Flyer

Rollups

Sales concept

AIM ACCUMULATOREN Nürnberg

Sales concept

AIM ACCUMULATOREN Nürnberg

Sales concept

Documents

- Checklist to determine the necessary battery capacity and the respective charger
- System cost-comparison calculator (ROI Calculator)
- Industrial truck working profile analysis
- Roll-Ups for important customers
- Flyer
- Brochures

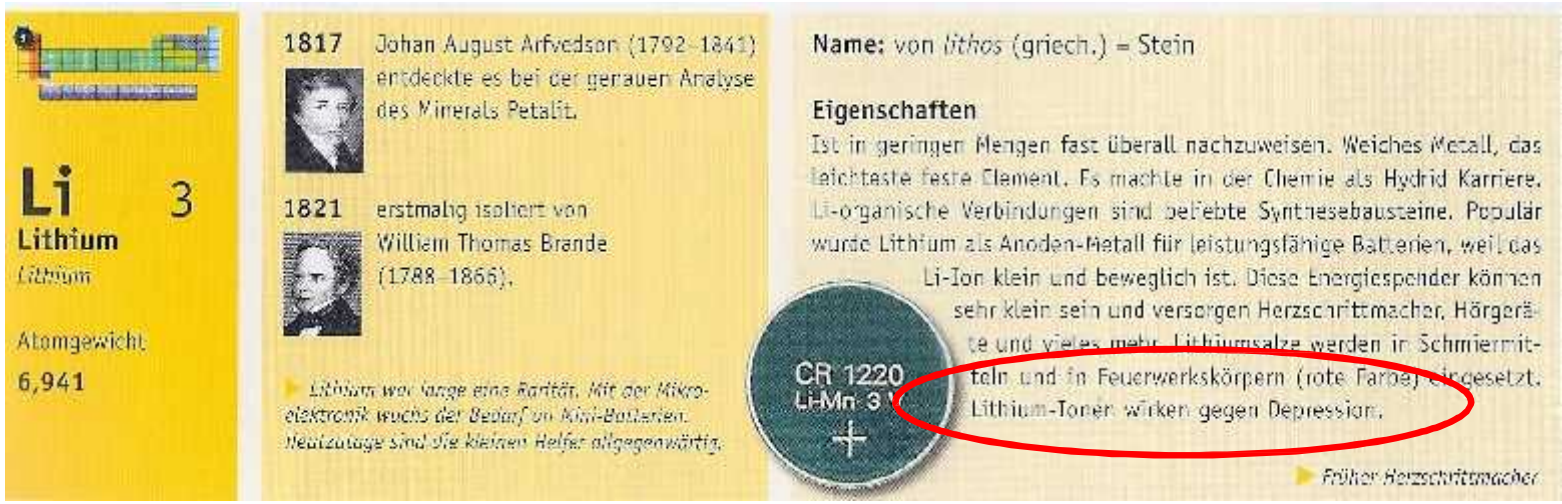
Conclusion – TC product advantages

- Modular construction of the “TRIATHLON Lithium Battery system“
- Battery system scalable in 1,35 kWh steps
- Charger scalable in 50 A steps
- Flexible energy content for all types of usage
- Own R&D department for hard and software
- Flexible integration to all industrial trucks including a possible CAN-Bus communication
- Fast and flexible implementation of innovative product developments due to a highly trained employee staff
- Permitted temperature Charge -10 to 45 °C
- Permitted temperature Discharge -25 to 55 °C
- Significantly higher lifetime than comparable Lead-Acid batteries
- More than double the lifetime of a comparable PzV Battery.
- Highest safety standards
- Very good price- performance

Conclusion – TC product advantages

- Shared Know-How. Widespread regional consulting for application and technical support
- Consulting for all safety topics
- Preparation of working profiles and ROI-calculations
- Planning and consulting for power supply and grid connection
- Planning and consulting for central and decentral charging concepts
- Support for Test- and Pilot projects with Lead-Acid batteries
- Highly flexible rental- and utilizing concepts of Lithium-Ion systems
- Intelligent and highly valuable reporting
- Expanded warranty options
- Back-Up solutions for Lithium Projects
- Full Service with runtime guarantee option
- Full Service support for the whole period of use
- Proven service concept for possible downtimes
- Transport of damaged battery systems
- Used Lead-Acid batteries for the second life of the industrial trucks
- Refurbishment of used Lithium Battery Systems
- Disposal of depleted Lithium-Ion Batteries

Last but not least



Most well-known brand with Lithiumcitrat:
„Bid-Label Lithiated Lemon-Lime Soda“

1929 a more memorable name was implemented
As the mood was improved (Up) und Lithium has the atomic weight of 7 (Seven), a new brand was born: **7Up.**

Thank you

Explore new Horizons