



LEV battery swapping observations and development summary prepared for the Work at the IEC/ISO/TC69/JPT61851-3

Presented by Hannes Neupert of EnergyBus.org
May 29th 2014 Turin ISO meeting

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- Additional material for reference: German VDI newspaper publishes on the 23rd of May 2014 & market review on modular battery solutions by Johannes Dörndofer of Ropa Engineering GmbH compiled on the 17th of March 2014

What need to be settled

IEC/ISO/TC69/JPT61851-3

Part 3-3
Part 3-4
Part 3-2

From >n< different connectors like common in todays market:



To a harmonised single connector for charging and discharging:



Proposal by EnergyBus e.V.
Tanna/Germany

From >n< different communication protocols and vocabulary:

Uart, CAN, Lin, RS485,....

To a harmonised single communication language with precisely defined vocabulary:

Proposal CANopen 454
By CAN in Automation e.V.
Nürnberg/Germany



From >n< different battery shapes like common in todays market:



To a harmonised single shape! This is the most difficult item maybe impossible!
The ropa engineering proposal is at least one existing optional candidate for a solution.



Recommended next steps

Watch the existing programs and let the topic become more mature.

It is still a early stage for a standard on swappable batteries. Even the world would need it urgently. That is why the ISO/IEC working group may be a good location to bring together the facts which are necessary to create it.

- A) Observation of the market and the battery technology
- B) Collection of reference data of existing approaches and creation of a database with all the positive and negative leanings which can be taken out of the existing solutions.
- C) Contact to other applications of mobile energy storage devices and check if this areas overlap enough.
- D) When time is considered as matured start the standardisation work.

Items relevant which need to be observed:

- A) Battery technology in terms of price per Wh, warranted lifetime, energy density, competitive situation in the market
- B) Battery recycling schemes and their practice
- C) Transport regulations (in case they get more tight this may become a driver for battery swapping since vehicles shipped may be shipped without a battery and be equipped at the destination with swappable batteries).
- D) Need for public quick charging/swapping
- E) Common business cases for battery ownership/pay by use options
- F) Emerging battery chemistries which may become game changers or other energy storage technologies which might be relevant and practical for the light electric vehicle application
- G) Commonly used voltage range in the LEV application
- H) Typical electrical current drawn in LEV applications

Observation of the market and the battery technology

Chinese domestic and export market changing rapidly from entry level products utilizing PB battery technology towards vehicles in the middle to upper class utilizing Li-Batteries.

David Howell of the US Department of Energy presented last week during the International Energy Agency Executive Committee Meeting of the Implementing Agreement for Hybrid and Electric Vehicles held at Copenhagen/Denmark.

He presented the expectations on the development of the commercially available battery technology by 2022 in his slides presented in the Parliament building of Denmark at the 22nd of May 2014.

中国国际锂电自行车产业峰会

INTERNATIONAL LI-BATTERY E-BIKE INDUSTRY SUMMIT

2014年4月13日
April 13, 2014



主办单位:
中国自行车协会
全国自行车工业信息中心

HOST:
China Bicycle Association
China National Information Center For Bicycle

承办单位:
上海协升展览有限公司

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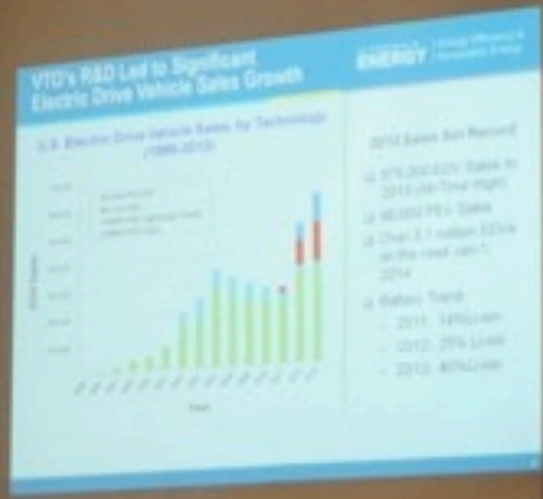
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MEDIA STRATEGIC PARTNER:
China Bicycle
E-Vehicle Times

At the 13th of April 2014 the chinese bicycle associations have explained during the Li-Battery E-Bike Industry summit at the Shanghai Cycle Show the 5 Year plan for lithium batteries in two-wheelers in China.

The Target is to have 10 Million annual sales of lithium battery powered two-wheelers in the chinese domestic market latest by 2019. Another announced target is to increase the quality level in the export market, which should lead to an average unit value of 1000 USD for exported electric two wheelers.



David Howell of US Department of Energy presenting at the IEA HEV-IA ExCo Meeting Copenhagen/Denmark 22nd of May 2014

The EV Everywhere Grand Challenge

Enable U.S. to become, within the next 10 years, the first country in the world to produce PEVs that are as affordable as today's gasoline-powered vehicles.

❑ **Technology Push (R&D):** targets focus on reducing PEV costs

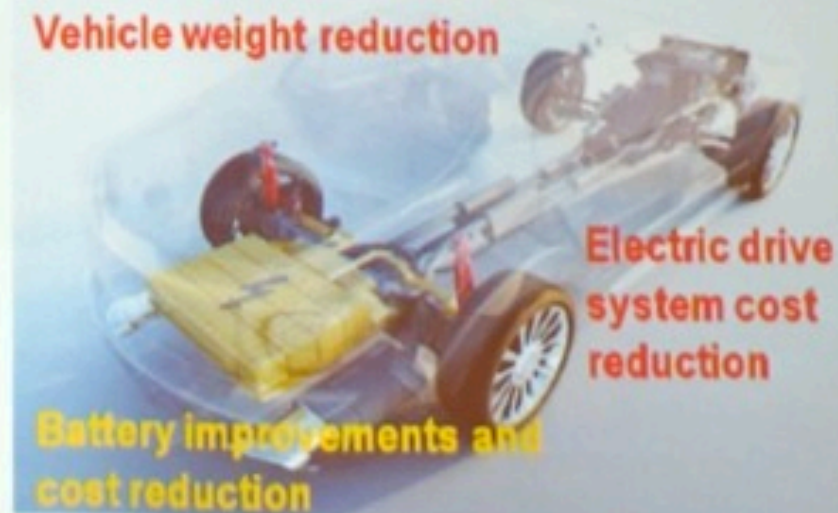
- Advanced batteries,
- electric drive systems,
- Lighter weight structures,
- enabling technologies such as advanced climate control.

❑ **Charging Infrastructure (Enablers):**

Critical issues include codes and standards, siting, grid integration, permitting, and signage.

❑ **Market Pull (Consumer Acceptance):**

Consumer education and exposure to PEVs, innovative PEV ownership incentives, and leadership by example among public and private fleets.



Targets (Year 2022)

- ❑ Battery Technology: \$125/kWh
- ❑ Electric Drive: \$5/kW (peak power)
- ❑ Weight: 30% reduction (structure)

Collection of reference data of existing approaches.

Creation of a database with all the positive and negative leanings which can be taken out of the existing solutions

The work stage reached here is divided in two parts:

A) An overflow on general areas of applications for lithium batteries today and where there is maybe a overlapping use case for standardized batteries.

- Household battery storage to buffer decentralised generated renewable energy
- Grid buffer batteries to be used to buffer peak energy situations in the network
- Car, bus and truck battery modules
- Cleaning machines, pallet trucks, mobile equipment, robots and military devices
- Airplanes and Trains
- LEVs
- ...

B) Attached to this presentation you can find a summary of todays modular battery solutions by Johannes Dörndorfer of Ropa Engineering GmbH. It is for sure not complete but shows impressively how much is going on in this area.

Contact to other applications of mobile energy storage devices and check if this areas overlap enough to consider to cooperation in the standardisation project

In all mentioned areas proprietary battery solutions are extremely cost intensive in the development, they slow down the implementation into the market as well block financial and human resources in the companies which do apply them.

Since a few years the VDMA (Association of Mechanical Engineering Industry with more than 3000 members) has a working group called „E-Motive Modular Multi Use Battery“. This group formed by a wide range of VDMA members has worked on general requirements for such batteries.

Since the beginning there is a contact between this group and EnergyBus on a loose base. But within the last 12 month the contact has been intensified and finally both industrial organisations teamed up with the target, to make such a multi use battery come reality as soon as possible!

Cooperation VDMA E-Motive Multi Use Battery Project and EnergyBus

The E-Motive group of the German industrial organization VDMA (Association of Mechanical Engineering Industry with more than 3000 members) and the EnergyBus organization have officially announced their partnership on the development of a universal swappable battery at Hannover Industrial show on the 8th of April 2014.

EnergyBus/Can Open 454 will be used as communication interface for the future Multi Use Battery specified by the VDMA E-Motive group. The group will as well join the work of the DKE/GAK 353.0.9 and bring in their requirements into the WD 61851 Part 3-3: Requirements for Light Electric Vehicles (LEV) battery swap systems.

The general understanding is that **a standard swappable battery has to be neutral of any specific application** to have a chance for an international acceptance and success. It should be applicable to many usages from handheld devices to stationary Gigawatt grid buffer storage systems.

It should be prepared to be moved during the lifetime to different applications which suite the state of health of the battery system.



B18 Quelle: VDMA / E-MOTIVE



B19 Quelle: VDMA / E-MOTIVE

Some Pictures of the joint presentation of the VDMA and EnergyBus of Hannover Industrial Show April 2014

Themenplattform „Forum MobiliTec“



- **Inhaltsstark: Industrie, Politik und Wissenschaft im Dialog**

- Bekanntgabe der Projektkooperation von VDMA Forum Elektromobilität und NGO EnergyBus e.V.
- Inhaltsstarke Diskussionsrunden mit Vertretern aus Industrie, Politik und Wissenschaft.



B8 Quelle: VDMA / E-MOTIVE



B9 Quelle: VDMA / E-MOTIVE

Die Akteure

Das VDMA-Forum Elektromobilität, E-MOTIVE, ist die richtige Plattform für die Definition eines industriellen Standards.

Im E-MOTIVE Projekt **Modulares Multi-Use Batteriesystem** sind zahlreiche Unternehmen entlang der gesamten Wertschöpfungskette engagiert sowie namhafte Forschungsinstitute:



Kommen Sie dazu und engagieren Sie sich in der Projektgruppe.
Wir freuen uns über Ihr Interesse!

www.vdma.org

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Forum Elektromobilität



E-MOTIVE Modulares Multi-Use Batteriesystem

Ein Standard für Hochleistungsbatterien

Thiel, Block, Wenzler



The german language brochure of the VDMA „E-MOTIVE Modular Multi-Use Battery System“ showing the Logos of some of the active members.

Von der Elektromobilität profitieren

profitieren

Die Automobilindustrie treibt die Entwicklung von Hochleistungsbatterien mit viel Energie voran.

Viele andere Anwendungen im mobilen und stationären Bereich benötigen ebenfalls Hochleistungsbatterien, die leistungstark, kostengünstig und zuverlässig sind.

Wie können diese Anwendungsbereiche von den Entwicklungen der Automobilindustrie profitieren?



Illustrationen: Andrea Möss

Durch einen industriellen Standard für Hochleistungsbatterien, wie er im Rahmen des Projekts **Modulares Multi-Use Batteriesystem** des VDMA-Forums Elektromobilität erarbeitet wird.

Umsetzung

Umsetzung

Für die Realisierung von standardisierten Hochleistungsbatterien gilt es, verschiedene Anforderungskriterien im Blick zu haben und hierfür einen „gemeinsamen Nenner“ zu finden.

Wichtig ist, die technische Weiterentwicklung und den Wettbewerb im Markt zu fördern, daher liegt der Fokus auf der Definition von Schnittstellen für den universellen Einsatz.

Die Herausforderungen

- **Einsatz:** in vielen Anwendungen über verschiedene Industrien hinweg
- **Handhabung:** manuell sowie automatisiert wechselbar
- **Sicherheit:** bestehende Sicherheitsstandards einhalten
- **Kombinierbarkeit:** Kombination mehrerer Module ermöglichen
- **Technologieoffenheit:** keine Festlegung auf bestimmte Zellen / Technologien
- **Baukastenprinzip:** verschiedene Ausbaustufen des Moduls für individuelle Ausrüstung
- **Kompatibilität:** Rückwärts- / Vorwärtskompatibilität zur langfristigen Anwendbarkeit

www.vdma.org

Mehrwerte und Potenziale

Potenziale

Anwendungsvielfalt und Praxistauglichkeit sind die Kernmerkmale einer standardisierten Hochleistungsbatterie für den modularen Einsatz im mobilen und stationären Gebrauch.

Es bieten sich zahlreiche Mehrwerte und Potenziale:

Batteriehersteller

- Breites Kundenspektrum
- Geringe Materialkosten durch Skaleneffekte

Anwendungshersteller

- Geringe Batteriekosten
- Geringe Entwicklungskosten durch nur einen Batterietypen
- Verbesserte Qualitäts- und Servicesituation durch Standards
- Lieferflexibilität und -sicherheit

Endkunde

- Profitiert von moderner Batterietechnologie zu geringen Kosten
- Vielseitige Verwendung des Batteriemoduls
- Geringe Investitionskosten durch Mehrfachnutzung
- Zuverlässige Batteriequalität



Messestand VDMA-Forum Elektromobilität



- **Premiere: Neues Standkonzept für VDMA Forum Elektromobilität**
 - Erstmaliger Messeauftritt als VDMA-Forum Elektromobilität.
 - Exponierte Lage im Zentrum der MobiliTec, Halle 27.
 - Fokussierung auf Highlight-Projekt „Modulares Multi-Use Batteriesystem“, inkl. Einbindung der Projektpartner.
 - Integration und Präsentation von Projektpartnern am Stand.





B1 Quelle: VDMA / E-MOTIVE

B2 Quelle: VDMA / E-MOTIVE



The booth was centrally located at the Mobility-Tec Hall of Hannover Industrial Show – directly beside the booth of the German government on electric mobility.



B20 Quelle: VDMA / E-MOTIVE



B21 Quelle: VDMA / E-MOTIVE

To show the modularity of the proposed battery design to several applications it was shown for example like pictured here in a industrial floor cleaning machine.



B27 Quelle: VDMA / E-MOTIVE



B28 Quelle: VDMA / E-MOTIVE

In a huge fork lift, in a cargo bicycle as well small cleaning machines. In every machine a different number of modules was applied.



German vice Kanzler and Minister of Energy and Economy Mr Sigmar Gabriel visited the joint booth of VDMA E-Motive Multi-Use Battery and EnergyBus at Hannover Industrial show at the 9th of April 2014. (Picture: Hannover Messe)



A very radical approach was present within the EnergyBus display at the joint booth of VDMA. EnergyBus member ropa created a stackable energy storage system which treats electric energy like a liquid to be sold in bottles – called energy tube.

The system called EnergyTube is based on the common 18650 cell format, The pack connection uses a combination out of NFC communication and conductive power contacts.

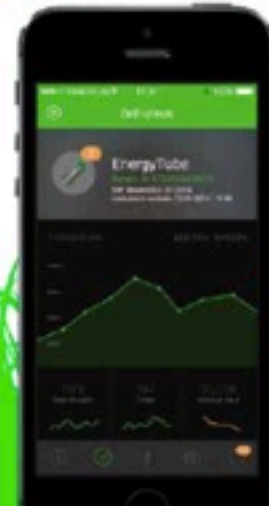
More information available at:
www.ropa-engineering.com

EnergyTube

Ropa engineering - VDMA

Johannes Dörndorfer

Version: 01.04.2014



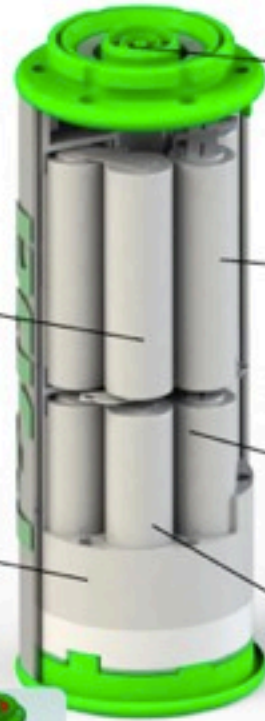
On the next pages a presentation of ropa engineering is embedded for your detailed reference on the EnergyTube approach.

EnergyTube construction details

70 mm diameter
180 mm length
ca. 800 g weight

thermal optimized cell
structure

patent for the battery
system is pending

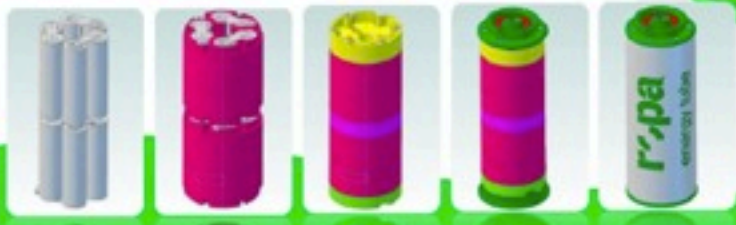


48 V / 50A network
less than 60V contact voltage.
Regulated voltage by integration
of a DC/DC converter.

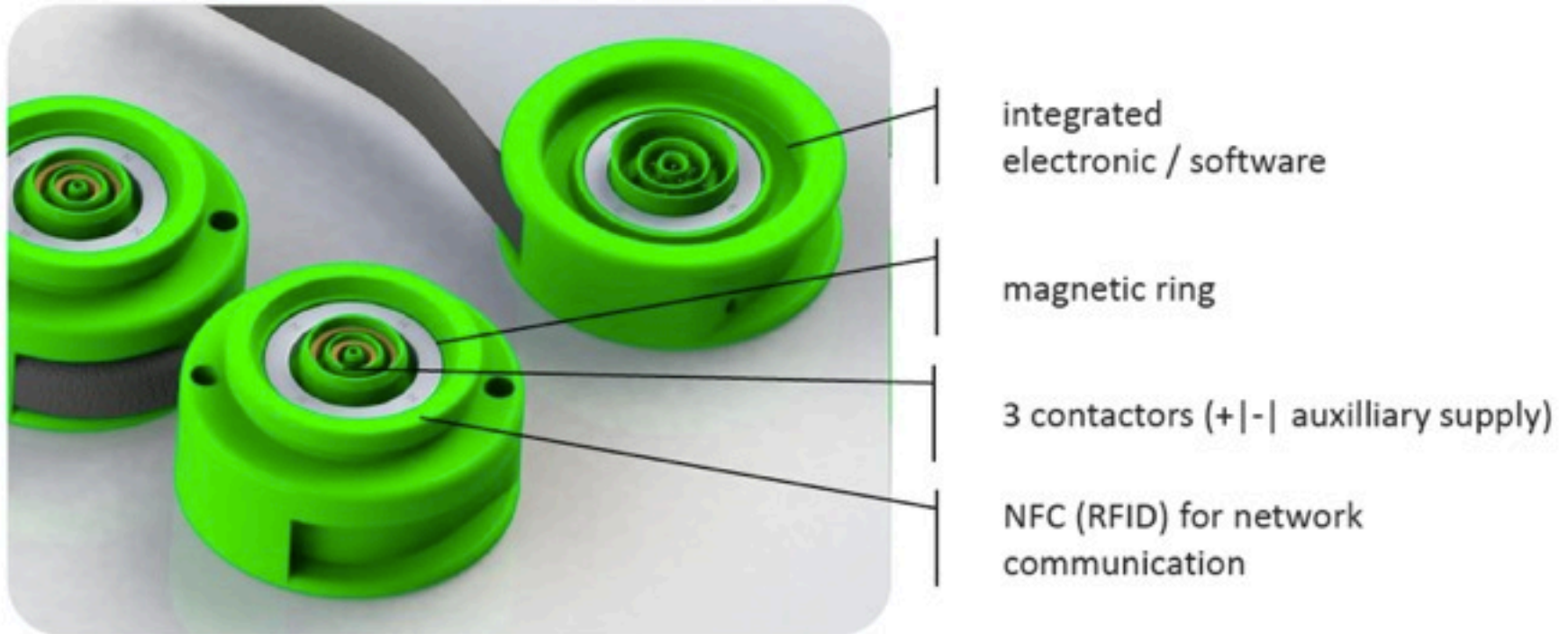
capacity: 100 Wh
no dangerous goods
=> laptop-battery

power:
200W/ 2400W max.

equipped with
12x 18650 cells



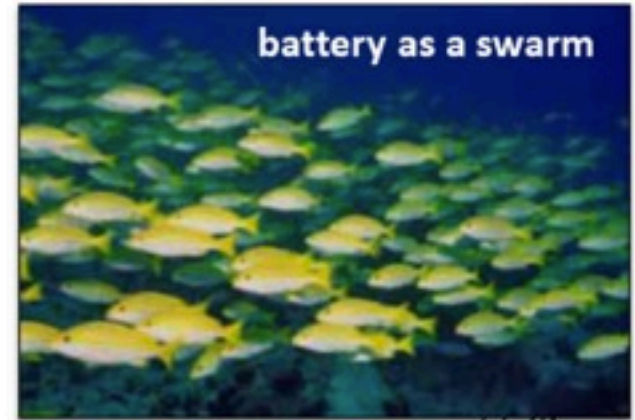
EnergyTube connector
with integrated swarm intelligence and network communication



EnergyTube battery as a swarm compared to the classical concepts



- exact dimensioning
- smallest possible number of components
- easy information processing



- quantity determines size and power
- social and smart behavior
- mixture of old, young, powerful, low batteries ...
- multiple security
- quick development time
- good crash behavior, good fire protection
- good thermal behavior

EnergyTube connector
performance classes and sizes

70 mm



x 14

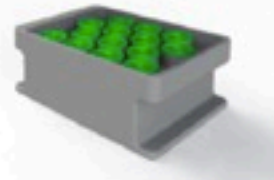


48V / 50A
max. 2,4 kW

300 x 400 mm



x 8



48V / 700A
max. 33,6 kW

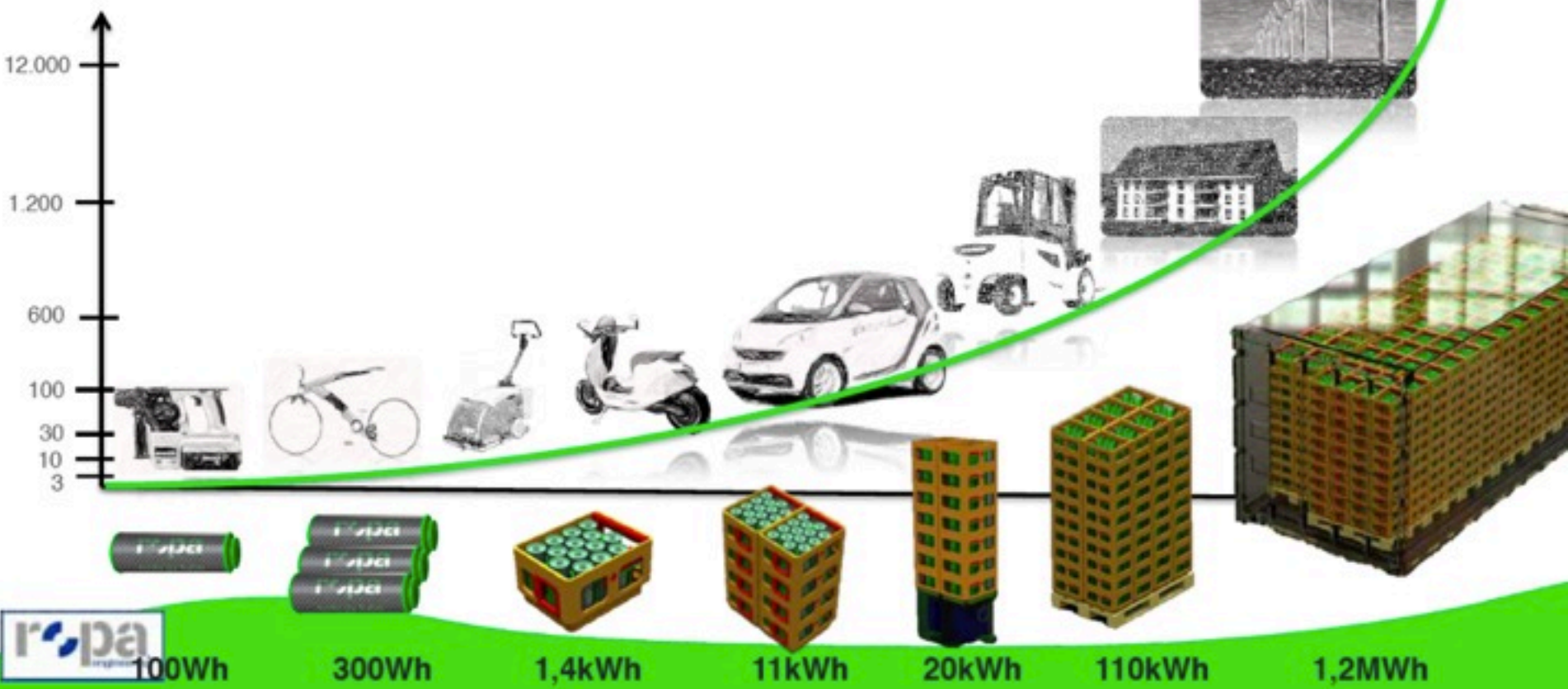
1200 x 800 mm



48V / 5600A
max. 269 kW

EnergyTube application:

tube quantity



100Wh

300Wh

1,4kWh

11kWh

20kWh

110kWh

1,2MWh

EnergyTube distinctive features compared to the market:

flexibility

scalable without limits starting from 100Wh
Flexible decision for the user in case of different components -> Plug and Play

security

compensation in case of an error through distribution to multiple cells small size of each pack <100Wh! No high-voltage 48V!

reliability

individual packs can be turned down or off
old and new EnergyTubes can be combined also with different chemicals

reduced price

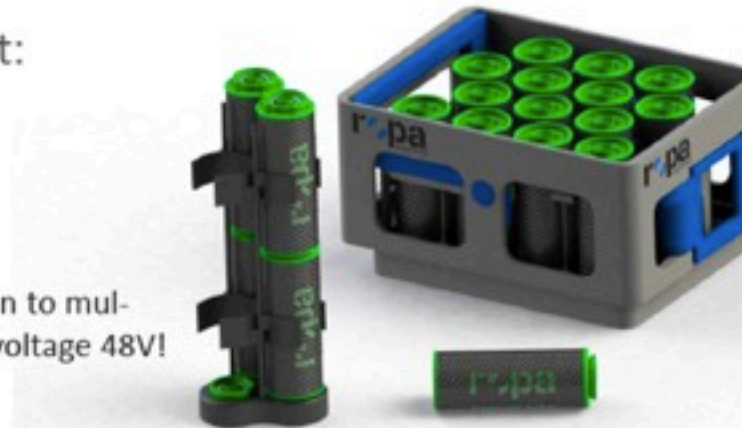
cheap production of many small battery units
price structure : 80 % of cells / 20 % Packing and intelligence

standardized

an intelligent battery pack for any application
suitable for a big part of the battery market

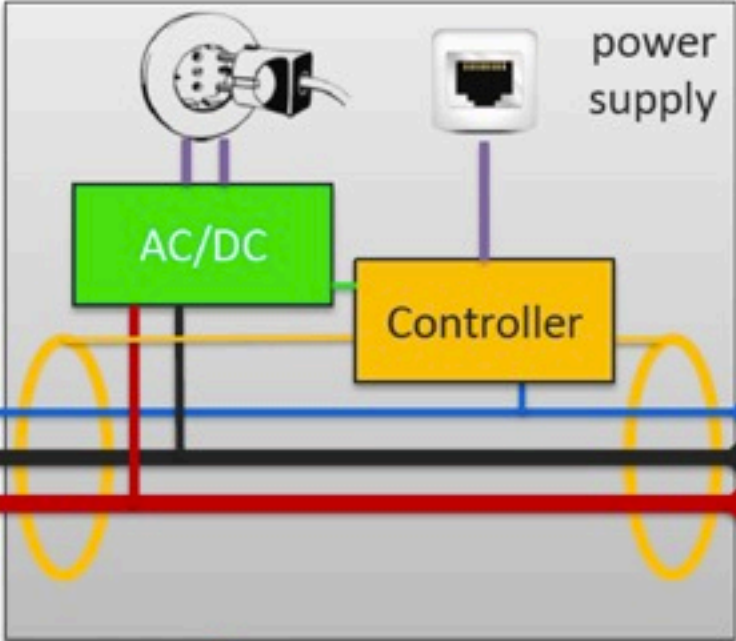
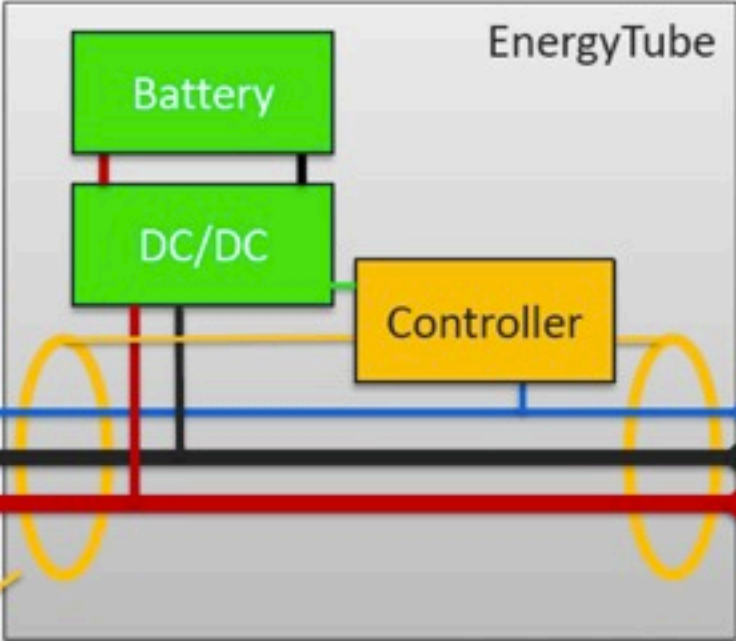
networked

allows rental systems
allows determination of the remaining value
enables the configuration from external device and out of the app-world



=> mobiles smart grid with swarm intelligence

EnergyTube electric supply network



+12V
auxiliary voltage

GND / 50A

+48V / 50A

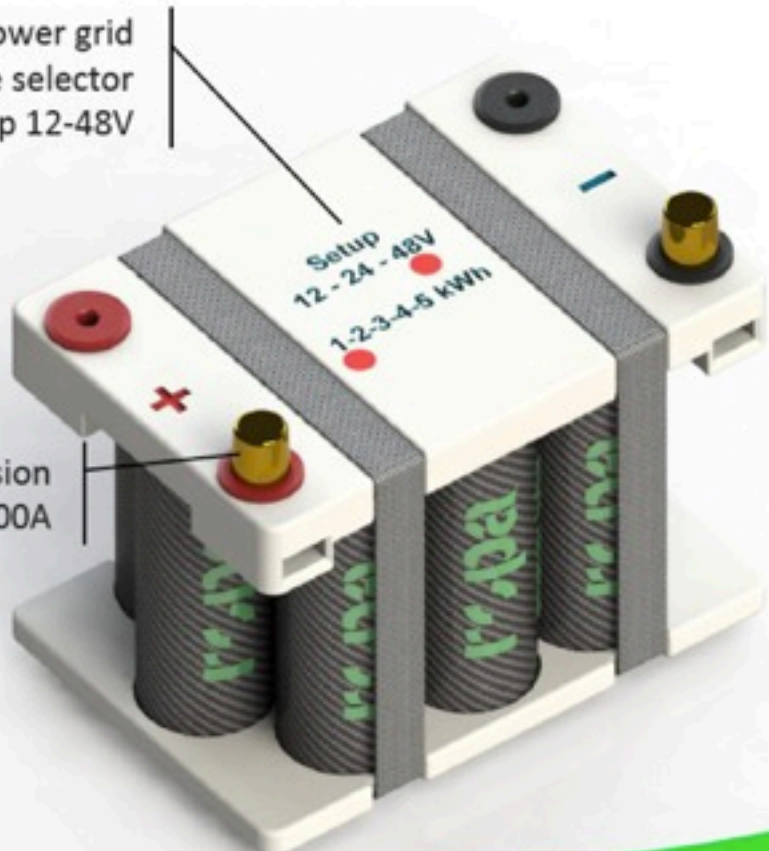
NFC (Near Field Communication)



EnergyTube outer packaging for compatibility with lead-acid batteries



closed power grid
Free voltage selector
software-setup 12-48V

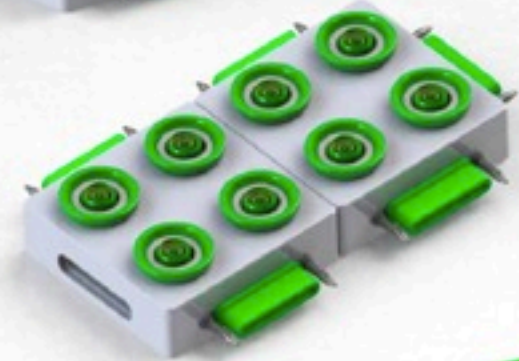
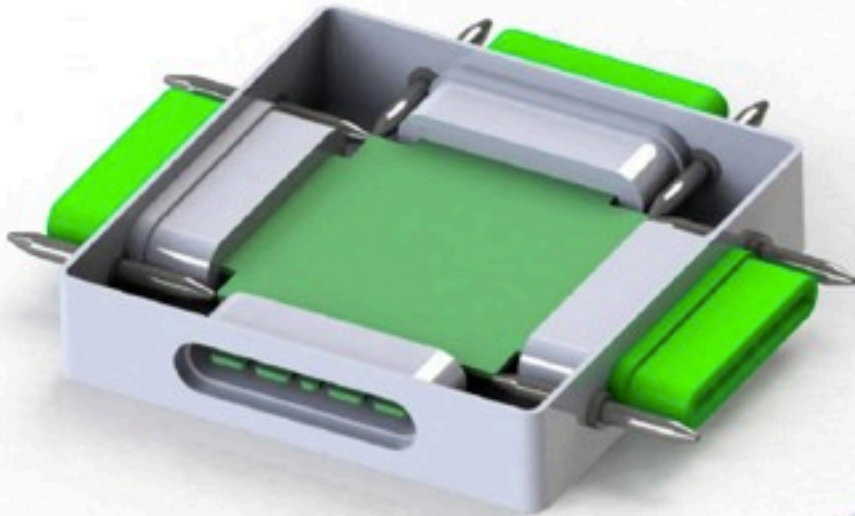


screws conclusion
max. 500A

construction height
determines capacity
1-10 kWh



EnergyTube High Current Connections



EnergyTube High Current Connections

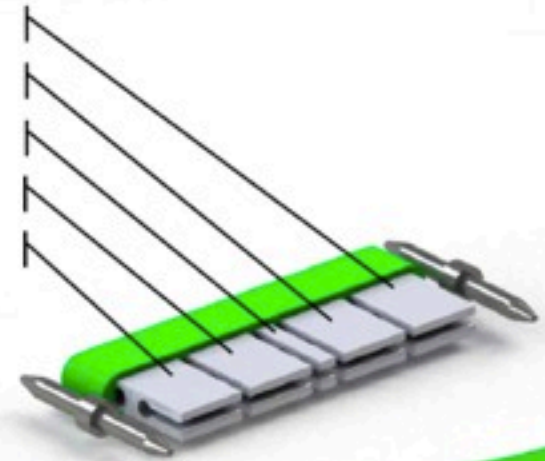
12-48V 200A
2x 10mm Contacts
P-GS2-D 11000437



12-48V 400A
2x 20mm Contacts
P-GS2-D 11000437



Power +
Power -
12V Auxilliary Voltage
Power -
Power +



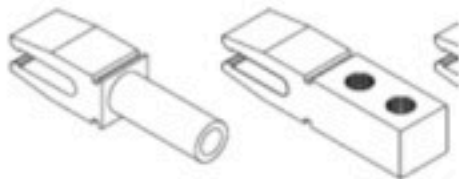
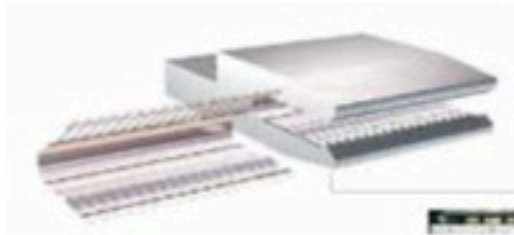
EnergyTube High Current Connections

Advanced Contact Technology

Multi-Contact

MC

STAUBLI GROUP



Beispiele von Gabelstecker Spezialanfertigungen

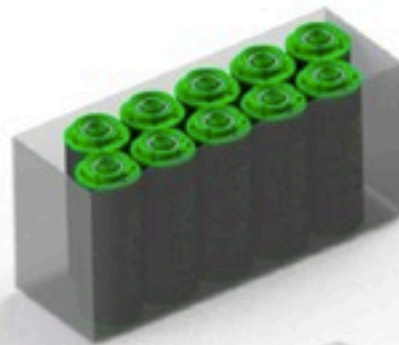
Examples of special versions of fork plugs

Exemples de fourches de contact spéciales

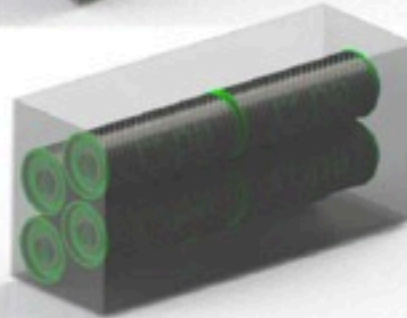
Profilzeichnung Profile drawing Plan du profilé	Referenz Reference Référence	Nennweite = Schienenabmessung Rated size = Size of the busbar Dimension nominale = Epaisseur des barres	Lamellen-Typ Typ of Multibar® Contact à lamelles	Benennungssystem pro 10mm Profilhöhe Rated out-ent per 10mm busbar height Intensité assignée pour 10mm de long. de profilé	Anschlusssystem Connection system Raccordement	Profilmaterial Material of profile Matériau du profilé
	P-GSR2 11000443	1,57 – 2mm ^H 2mm ^B	LAspez. LAIII/0,2	= 100 A	S ^H + C ^B	CuZn
	P-GS2-D 11000437	1,57 – 2mm ^H 2mm ^B	LAspez. LAIII/0,2	= 100 A	-	CuZn



Hako
Clean ahead



10 tubes
10x 0,1 kWh -> 1,0 kWh
10 kg



8 tubes
8x 0,1 kWh -> 0,8 kWh
8 kg



24V 25Ah
0,6 kWh
22 kg





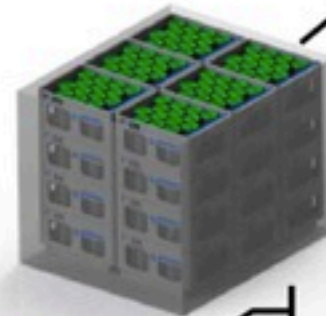
12 tubes
12x 0,1 kWh -> 1,2 kWh

25,2V 40Ah
1,0 kWh

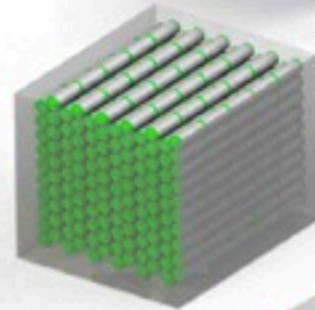
EFG 540k/540/545k/545/550/S40/S50
battery measure: L/B/H 1028x855x784mm



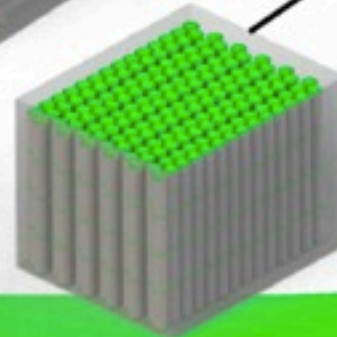
80V 775Ah
62 kWh
1.9 t



2x3x4 -> 24 boxes
24x 1,4 kWh -> 33,6 kWh
336 kg

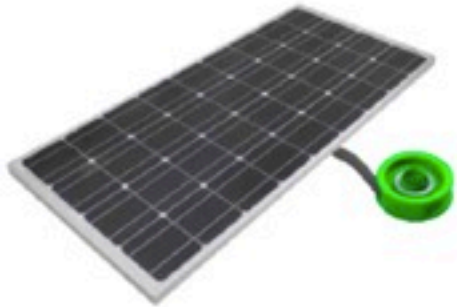


10x12x5 -> 600 tubes
600x 0,1 kWh -> 60,0 kWh
600 kg



14x12x4 -> 672 tubes
672x 0,1 kWh -> 67,1 kWh
670 kg

EnergyTube application in the household



Multitalent:
trade station
home storage
emergency power supply
charger inverter...



status

SOC 62% 2,60 kWh

SOC	100%
SOC	75%
SOC	10%
SOH	95%

uncritical reference:
tube 1C damaged

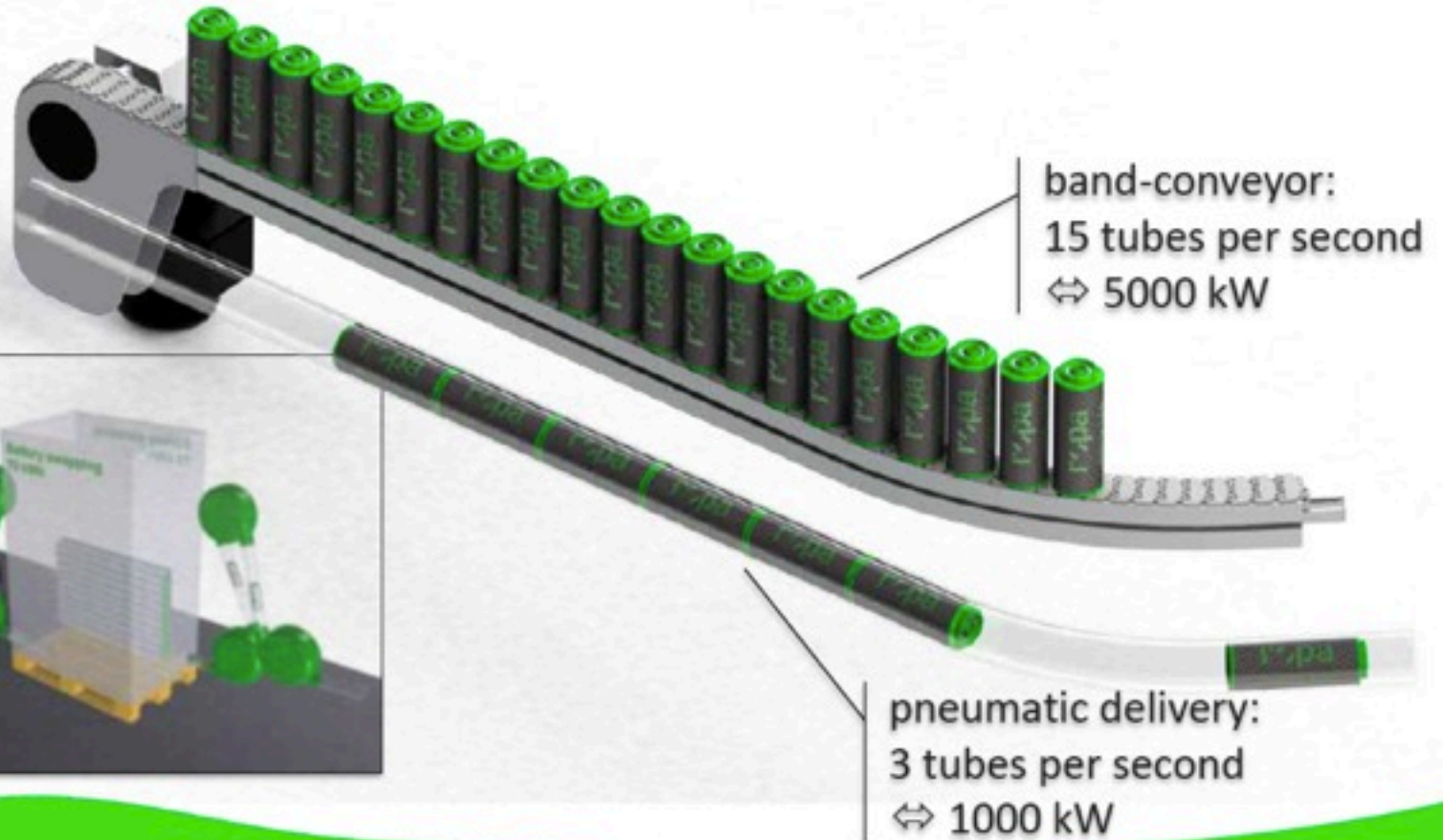


EnergyTube buy or rent batteries in the supermarket

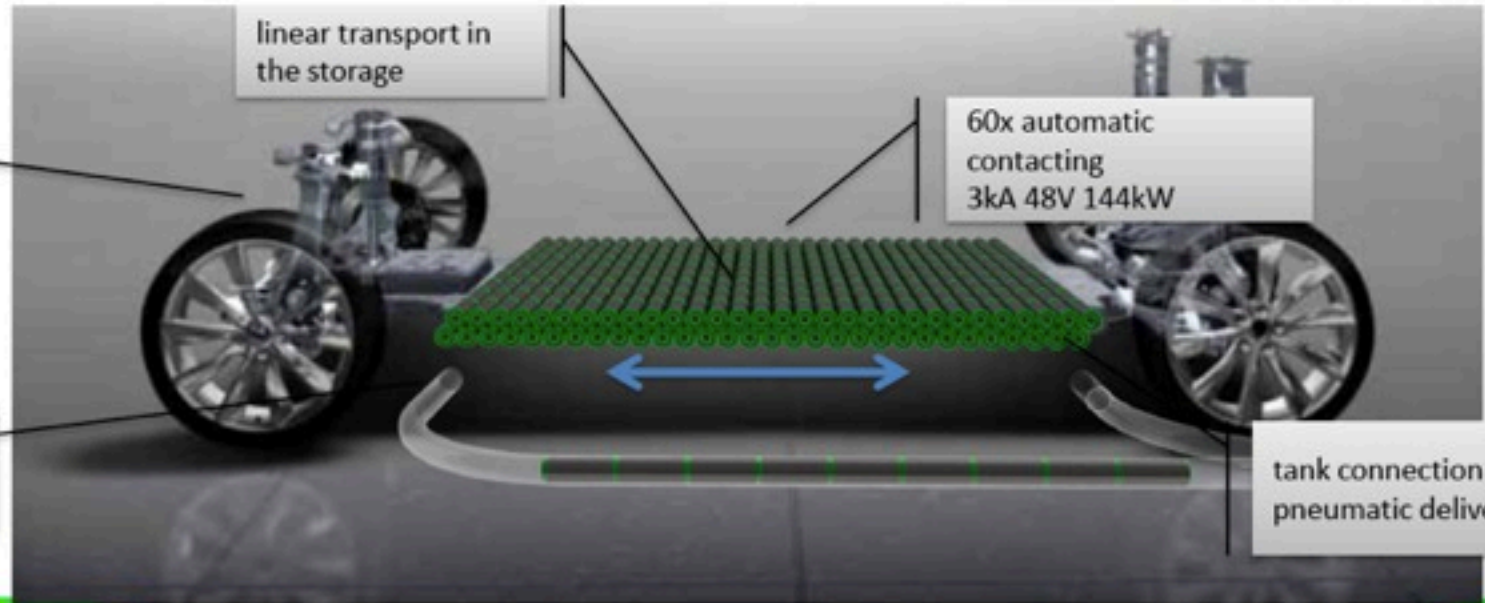
- unique ID
- unique classification
- independent analysis
- Enables the configuration from external device
- value and price calculation
- find apps for the shop



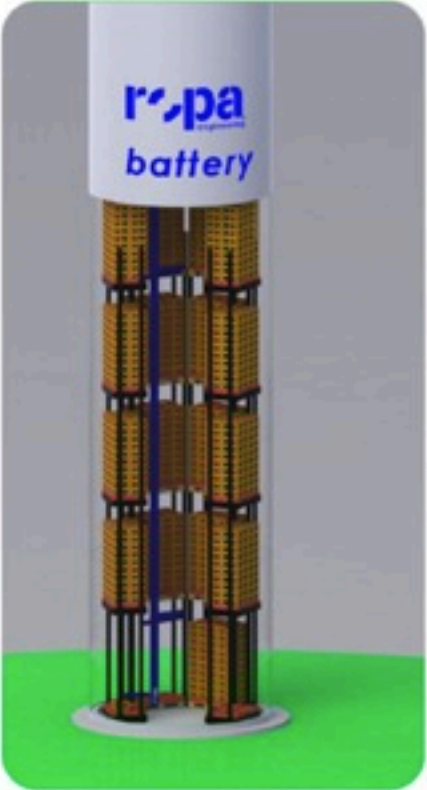
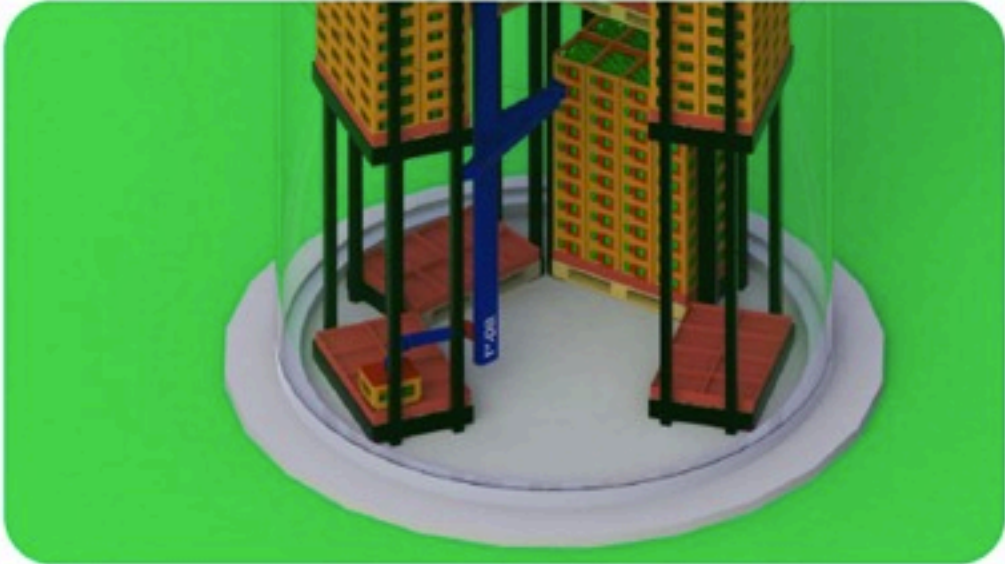
EnergyTube fast exchange vs. fast charge



EnergyTube fast exchange vs. fast charge



EnergyTube wind energy / storage hybrid system



What about you?



We are looking for investors and partners ...

Prototype phase starts at the end of 2014

Commercial launch of the first applications will be in 2015



www.ropa-engineering.de

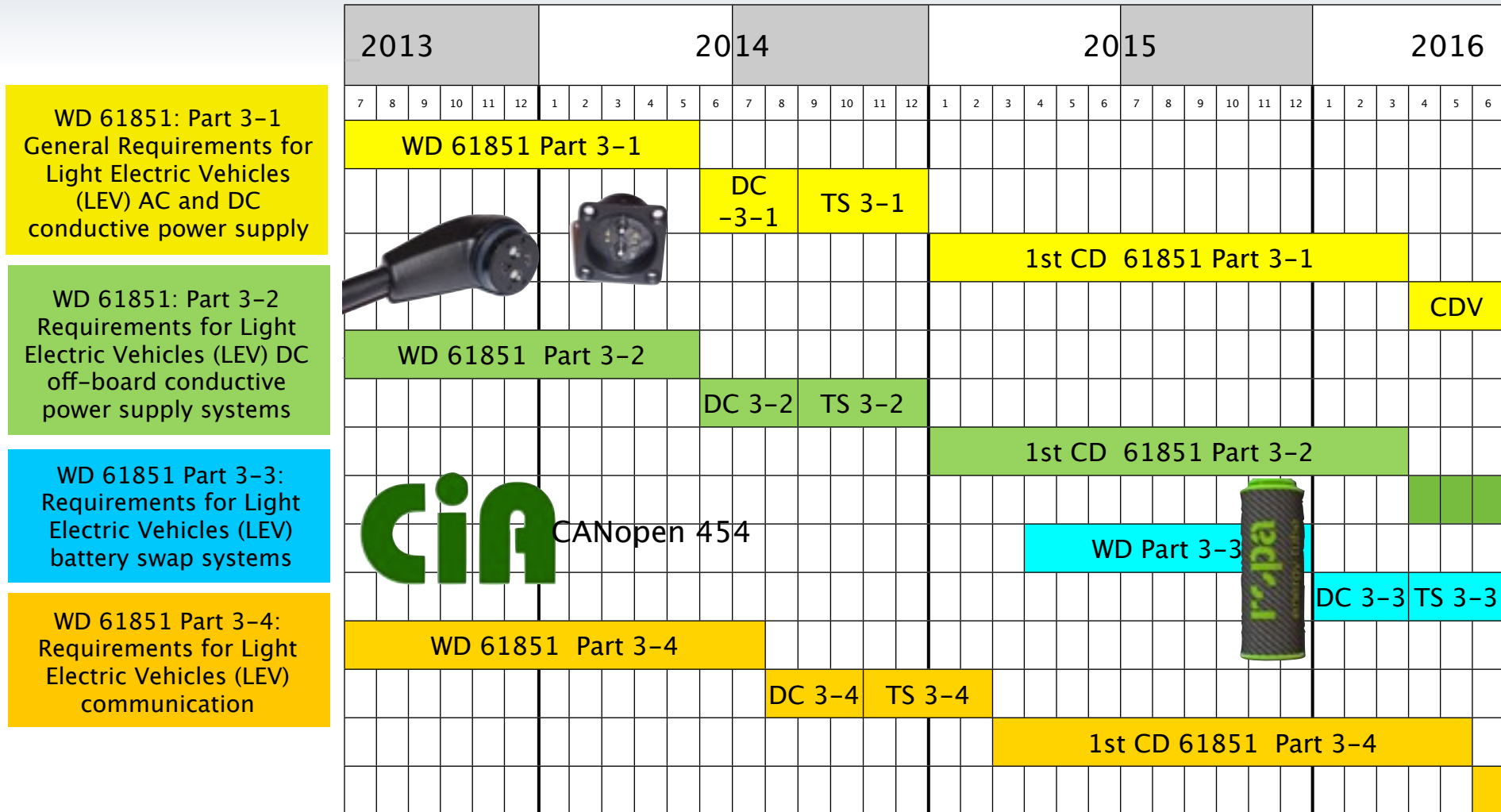


When time is considered as matured to start the standardisation work?

VDMA and EnergyBus agreed to bring in together the work on a standard multi use battery approach developed within the last years into the standardisation process by transferring the past experience into the WD 61851 Part 3-3: Requirements for Light Electric Vehicles (LEV) battery swap systems through the german mirror group DKE/GAK 353.0.9.

The idea is to start with this work immediately to prepare some proposal to be provided by spring 2015 when this topic is due in the international standardisation roadmap of IEC/ISO/TC69/JPT61851-3.

Standardisation roadmap:



Executive Summary:

Many parallel developments are happening, but commonly they are focussed on a specific requirement.

It seems to me not possible to look on a single application of batteries only when considering standardisation for a really universal battery pack.

Since batteries need to be able to float between applications during their retirement process to make the most use of the energy investment done to produce them.

The availability of a affordable and widely available standard battery would have a strong impact on many developments worldwide.



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Additional Material:

Please consider that the attached material is only for IEC ISO internal use only not for publication.

- German VDI Newspaper publishes on the 23rd of May 2014 an article on the danger potential of Lithium Ion Battery energy storage devices installed at private households to store renewable energy
- Market review on modular battery solutions by Johannes Dörndofer of Ropa Engineering GmbH compiled on the 17th of March 2014