



Modular Batteries Lunch & Learn

We will begin in a few moments. We encourage you to use a separate phone to dial-in for the audio and use your computer for the presentation material only.

Participants are automatically muted but may ask questions via your control panel.

If there are problems with the audio, please try dialing an alternate (US dial-in is 213-929-4221).

We will be taking questions at the end but feel free to submit questions at any time.

All past & future webinars listed at: www.varta-storage.com/webinars

VARTA Lunch & Learn Series

Past & Future Topics



Jun 25, 2020	Modular Battery Systems - What you need to Know	Upcoming Webinars
Jul 02, 2020	Regulatory Compliance and Battery Certifications	
Jul 09, 2020	Tech Trends for Li-Ion: NMC, NCA, LFP, LCO - Learn what it all means	
Jul 17, 2020	Batteries and Big Data - Multiply Your Business with One Design Change	
Jul 23, 2020	Factory Tour: Automated Battery Pack Assembly Plant	

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Past Webinars

Jun 19, 2020	Transportation Regulations for Li-Ion Batteries
Jun 11, 2020	Batteries 101 - Just the Basics
Jun 05, 2020	Standard Lithium-Ion Batteries for Floor Cleaners
May 29, 2020	10 Things to Know when Choosing a Battery Supplier
May 22, 2020	Logistics AGV / AMR - Powering and Charging
May 15, 2020	Custom Battery Design Tips
May 07, 2020	Spotlight on Innovative Agricultural Robotics Solutions – Powering and Charging
May 01, 2020	Application Specific Standard Battery Workshop
Apr 24, 2020	VARTA Battery Solutions for Robotics (Agriculture and Logistics)
Apr 17, 2020	Custom or Standard – Which Battery is Best for You?
Mar 27, 2020	Learn what VARTA has to offer the mobile robotics industry...

Modular Battery Systems

What you need to Know!



Batteries come in all shapes and sizes - so how do you find the "just right" size to match your needs? We will look at this "Goldilocks problem" and offer solution suggestions using modular battery architectures.

Attend this webinar to:

- ▶ Understand what Modular Battery Systems offer device designers
- ▶ Learn about sizing capacity for power or energy
- ▶ Consider options for charging and Battery Management Systems

Presenter: Dan Friel, National Business Development Manager, VARTA

Linked-In: Dan Friel: <https://www.linkedin.com/in/dan-friel-2004>

Email: dan.friel@varta-microbattery.com



What is the Problem?

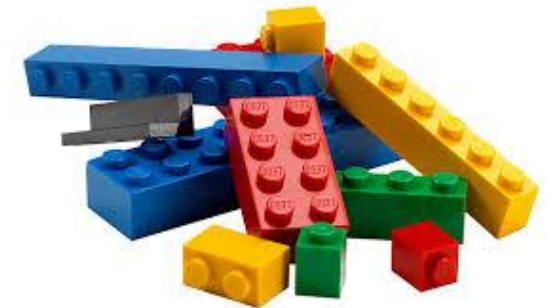
- ▶ Full Custom vs. Application Specific Standard
- ▶ Product Range Variety
 - ▶ Small - Medium - Large
 - ▶ Value - Economy - Premium
- ▶ Finding the Fit
 - ▶ Defined by Requirements: Size, Weight, Run-time, Charge time, Life, etc.
 - ▶ Not 'one size fits all' - but also not 'one size for each'
- ▶ Design Criteria:
 - ▶ Energy Density (capacity per volume or per weight)
 - ▶ Energy vs. Power



Modular Battery Systems



- ▶ Goldilocks Principal meets LEGO
 - ▶ Smallest Element to Build With
 - ▶ Not too big. Not too small.
 - ▶ What is “just right” for requirements?



- ▶ Goldilocks Principal meets LEGO
 - ▶ Smallest Element to Build With
 - ▶ Not too big. Not too small.
- ▶ Just Right?
 - ▶ Defined by Requirements: Size, Weight, Run-time, Charge time, etc.
- ▶ Decision Criteria:
 - ▶ Energy Density (for Weight or Volume)
 - ▶ Power vs. Energy – Short Bursts of Current or Long Slow Discharge

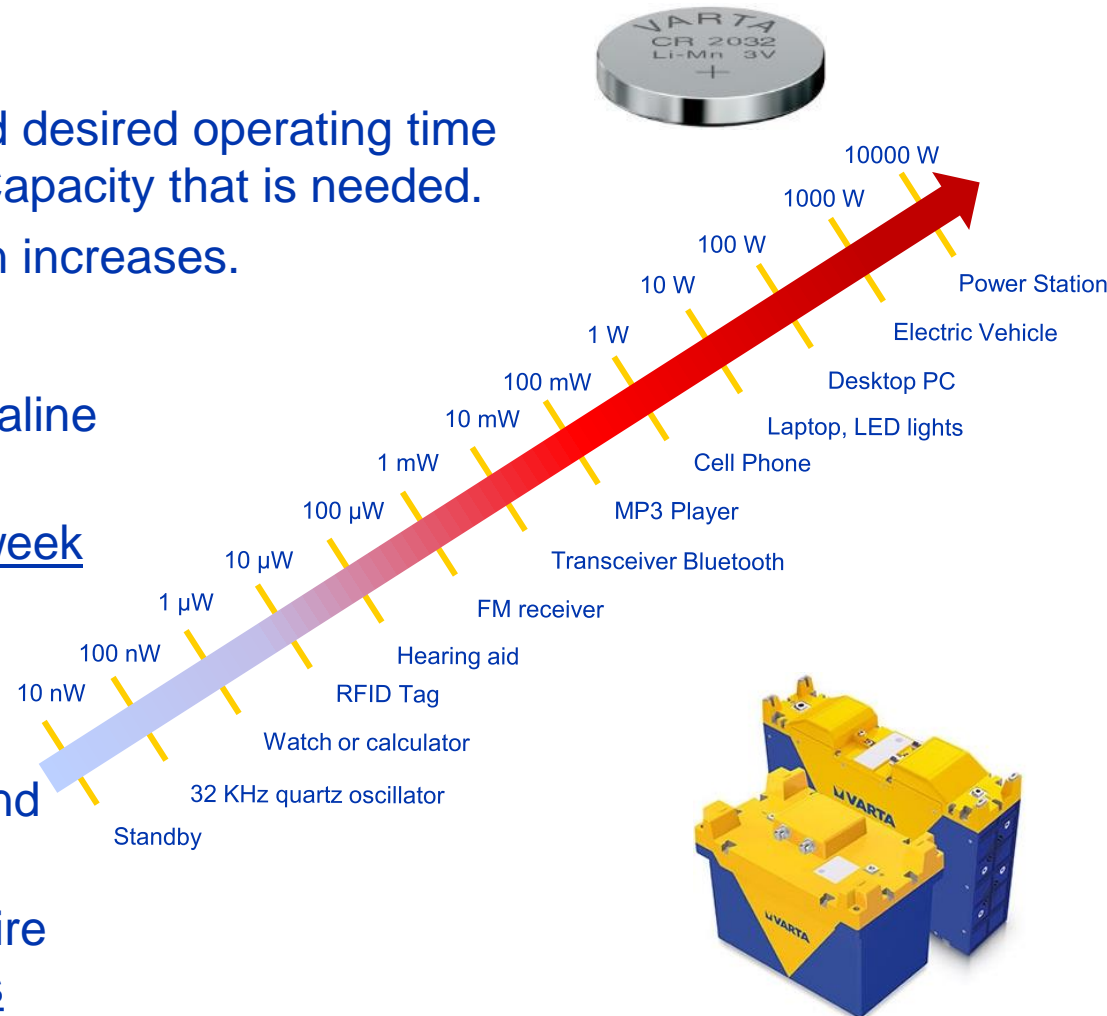


Modular Battery Systems



Sizing for Power and Energy

- ▶ Power Consumption of the Device and desired operating time determines the amount of Energy or Capacity that is needed.
- ▶ Needs change as Power Consumption increases.
- ▶ Here are some examples:
 - ▶ TV remote control with a primary Alkaline or Lithium Cell lasts a year or more
 - ▶ Hearing-aid primary Cell runs for a week
 - ▶ Bluetooth ear-bud prefers a small rechargeable Cell to run for hours
 - ▶ Cell Phones, Laptops require larger rechargeable Batteries (<100 Wh) and last for many hours
 - ▶ Mobile Robotics (fork-lifts, etc.) require larger rechargeable Battery Systems (>100 Wh) to run for multiple hours



Power vs. Energy

- ▶ Power = High Current, Short Duration
 - ▶ Power is rate of current: Usually in Watts = Volts x Amps
- ▶ Energy = Low/Medium Current, Long Duration
 - ▶ Energy is duration of Power: Has a time component, i.e. Amp-Hours, Watt-Hours

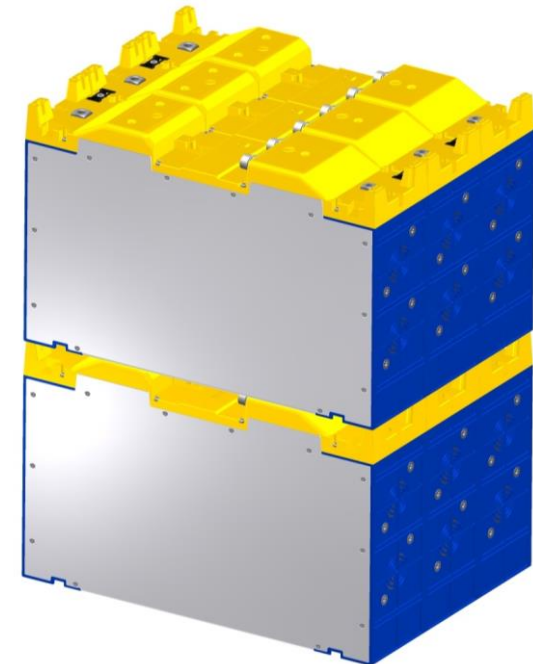


High Power

High Energy

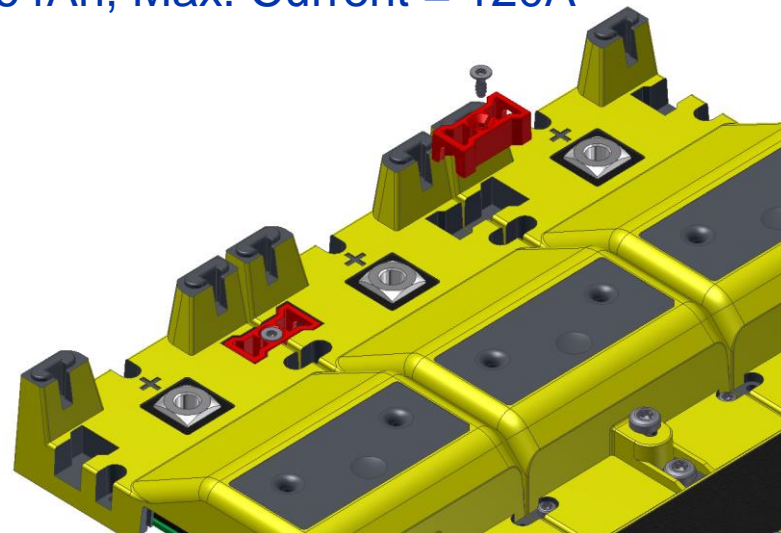
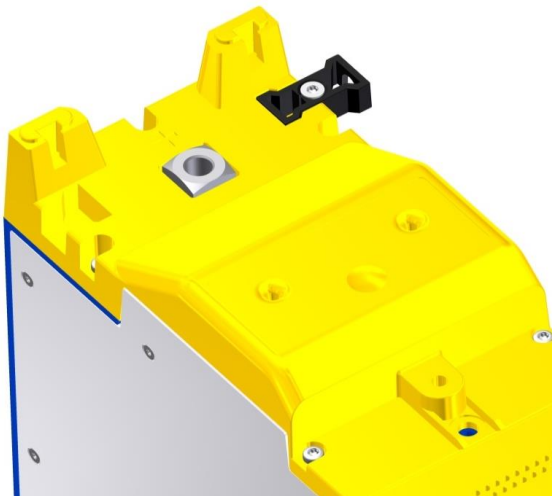
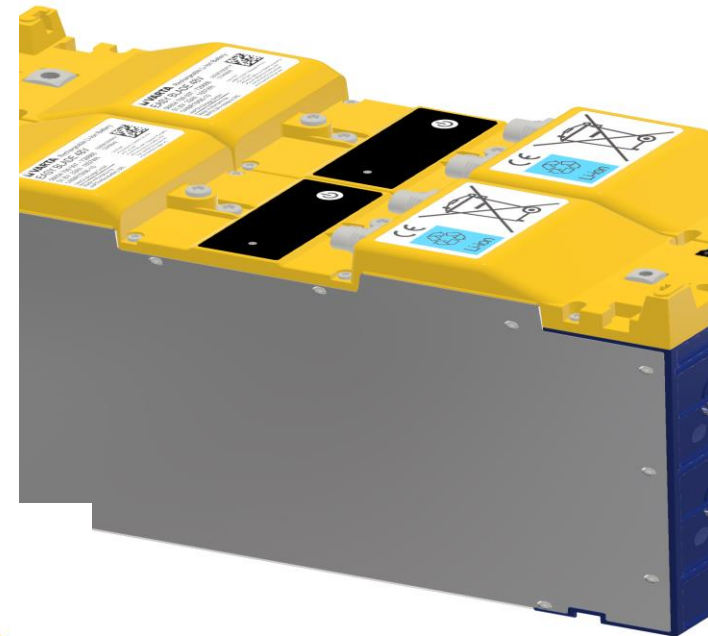
When Voltage Matters

- ▶ Higher Voltage does More Work
 - ▶ Current decreases as Voltage increases: $\text{Power} = \text{Voltage} \times \text{Current}$
 - ▶ Effects of heating are **Current²** x Resistance
 - ▶ Stacking in Series to increase Voltage
 - ▶ Stack in Parallel to increase Capacity
- ▶ Li-Ion Stacking in Series more complex than Parallel



▶ Power & Energy vs. Capacity

- ▶ Energy: Expand with Parallel Capacity
- ▶ Parallel Capacity also increases Power ability
 - ▶ Example: 48V, 32Ah VARTA EasyBlade:
Max. Continuous Discharge Current = 60A
 - ▶ Adding a second EasyBlade in Parallel:
 - ▶ Capacity 64Ah, Max. Current = 120A

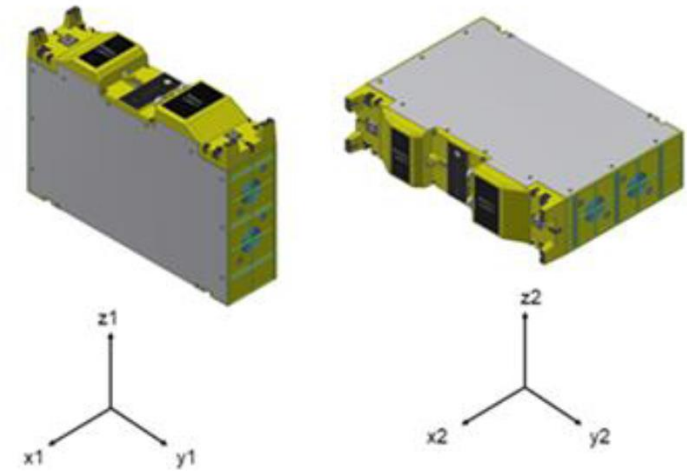


VARTA Storage – VARTA Microbattery

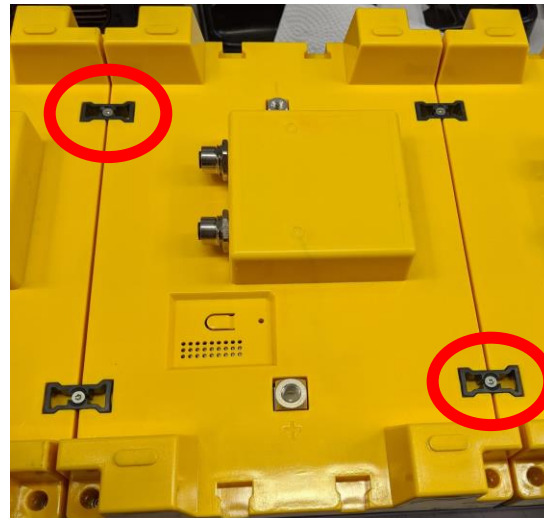
Modular Battery Systems



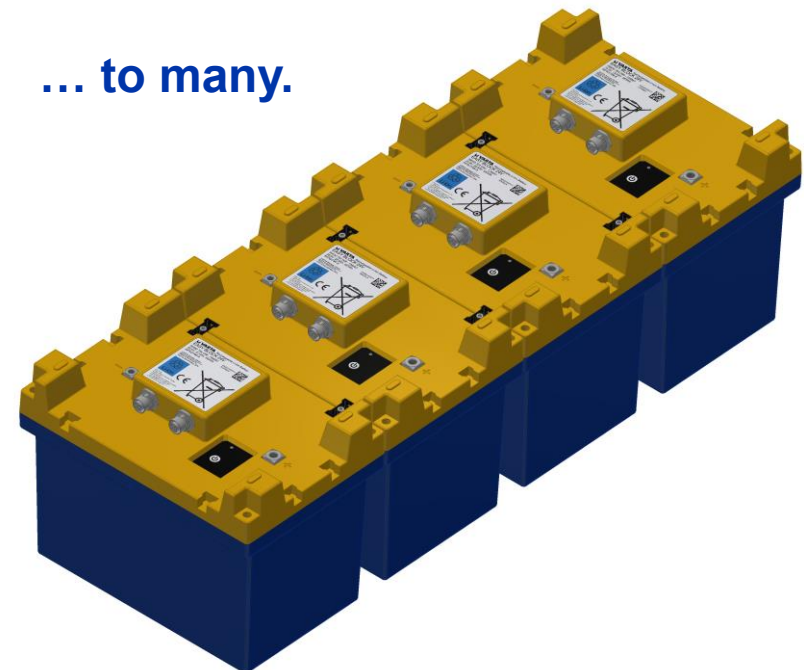
- ▶ Simplicity of Capacity Expansion
 - ▶ Easy of Parallel Connections
 - ▶ Mechanical & Electrical – Robust, Reliable, Safe
 - ▶ Multiple Mounting Orientations & Options



From one ...



... to many.



Modular Battery Systems Range of Requirements



Value Product



Economy Product



Performance Line Products



Battery & Product Performance

Basic Battery
(24V)

Enhanced Battery
(48V)

Standard Run-Time
(48V Battery x2)

Extended Run-Time
(48V Battery x3)

Modular Battery Systems

Range of Requirements = Range of Options



One Size Does Not Fit All

One Size Fits Many

Value Product

Economy Product

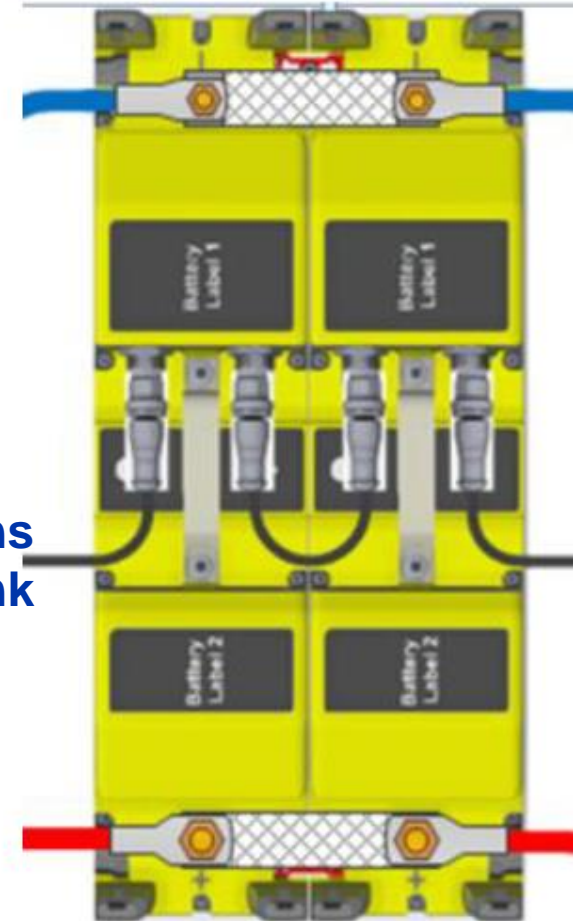
Performance Line Products

Battery enables Product Performance Variation

Battery Management System (BMS)

- ▶ Integrated BMS
 - ▶ Simplifies Parallel Connections
 - ▶ Modules at Fixed Voltage Levels
 - ▶ Robust Multi-Battery Communications
- ▶ External BMS
 - ▶ Allows Series and Parallel Combinations
 - ▶ Added Complexity, More Flexibility

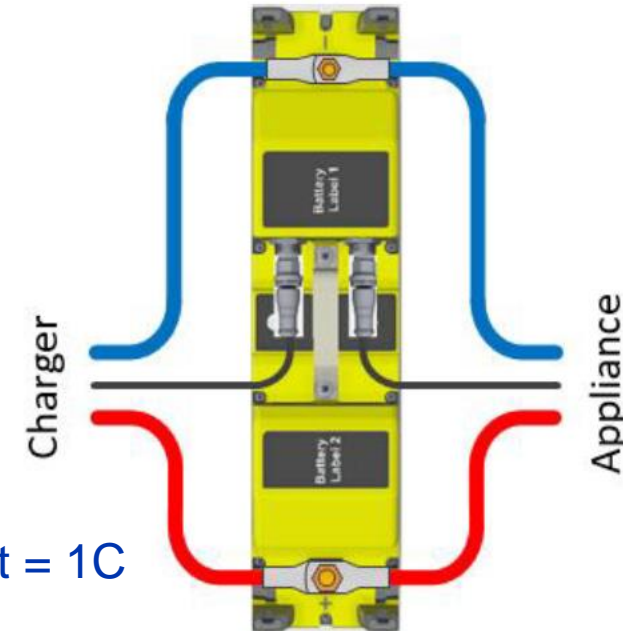
Communications Link



Modular Battery Systems Charging



- ▶ Fixed Voltage Systems
 - ▶ Reduced Charging Complexity
 - ▶ Charge Power limited by lowest Parallel configuration
- ▶ Example:
 - ▶ EasyBlade 48V Battery prefers 32A max Charge Current = 1C
 - ▶ Two in Parallel (64Ah total capacity) will be charged at 0.5C
 - ▶ Three in Parallel (96Ah capacity) will be charged at 0.33C
 - ▶ So more Capacity with same Charger = Slower Charge



Modular Battery Systems Range of Requirements



Value Product



Economy Product



Performance Line Products



Basic Battery
(24V)

Enhanced Battery
(48V)

Standard Run-Time
(48V Battery x2)

Extended Run-Time
(48V Battery x3)

ALL THE SAME PHYSICAL SIZE BATTERY



VARTA Storage VARTA Microbattery



Our brands;



Modular Battery Systems



Large



- ▶ 24V, 36V, 48V, +++
 - ▶ 200 to 2000 Ah
 - ▶ Majority Lead-Acid
 - ▶ Battery easily removed
 - ▶ Flexible usage
- VARTA Storage – VARTA Microbattery

Medium



- ▶ 24V, 36V, 48V
- ▶ 10 to 100Ah
- ▶ Mostly Li-Ion
- ▶ Battery embedded
- ▶ Dedicated usage profile

Small



- ▶ 12V, 24V
- ▶ 5 to 50Ah
- ▶ Majority Li-Ion, Some Lead
- ▶ Embedded or removable
- ▶ Variety of usage models

Large



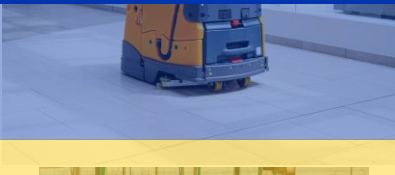
Medium



Small



Wide Product Range – One Size Does Not Fit All



Modular Solution: One Size Fits Many

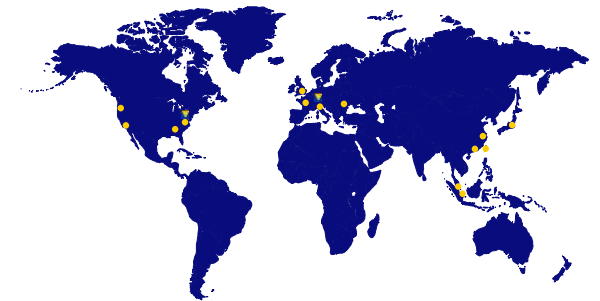
- ▶ 24V, 36V, 48V, 144V
- ▶ 200 to 2000 Ah
- ▶ Majority Lead-Acid
- ▶ Battery easily removed
- ▶ Flexible usage

- ▶ 24V, 36V, 48V
- ▶ 10 to 100Ah
- ▶ Mostly Li-Ion
- ▶ Battery embedded
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- ▶ 12V, 24V
- ▶ 5 to 50Ah
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- ▶ Embedded or removable
- ▶ Variety of usage models

Finding the Right Battery Partner:

- ▶ Technology Leader
- ▶ Well known in the Industry
- ▶ Standard line of products in a variety of sizes
- ▶ Previous Custom designs with well known customers
- ▶ History and Industry Experience in Battery systems
- ▶ High-volume Manufacturing Expertise (not just a Design House)
- ▶ Worldwide Reach & Support
- ▶ Multiple Manufacturing & Design locations
- ▶ Reputable firm – ideally a public company
- ▶ Financially Stable & Reliable



VARTA AG

MICROBATTERIES & SOLUTIONS

HOUSEHOLD BATTERIES



**Largest Manufacturer of
Hearing Aid Cells (1B/yr)**
www.VARTA-Microbattery.com

**Standard & Custom Battery
Packs and Energy Storage**
www.VARTA-Storage.com

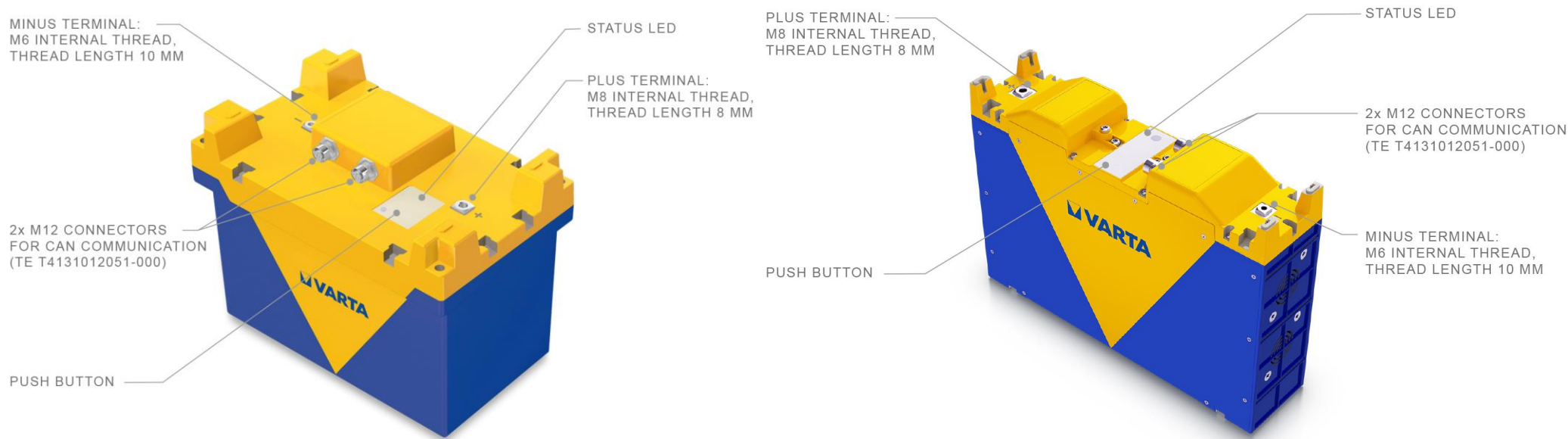
**Consumer Coin & Cylindrical Cells;
Home Energy Storage**
www.VARTA-Consumer.com

Modular Battery Systems

Easily Expandable Capacity – VARTA ASB



- ▶ All batteries can be connected in parallel up to **25 battery units**
- ▶ **No Master BMS (Battery Management System) required**



Model	Easy Block (LiFePO4)	Easy Blade (NMC)
24V	14.5 kWh (570Ah)	41.3 kWh (1600Ah)
48V	14.5 kWh (285Ah)	41.3 kWh (800Ah)

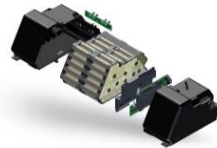
More than 130 years of innovation



**VARTA
Primary Lithium
Cell assembly**
+
Wire connector



**VARTA
PowerPack
Solutions**
+
Mechanical and
Electrical Design



**VARTA Storage
Residential Energy
Solutions**
+
Cell and charge balancing,
Power interface



**VARTA Storage
Commercial Storage
Solution**
+
Adressing multiple
energy management
functionalites



Production
+
Massive Investments in
production in lithium ion
cells in Ellwangen and
Noerdlingen

VARTA has a long history in research, development, and mass production of a variety of electro-chemistry and battery systems.

**VARTA
Lithium Cells**



**VARTA
Customized Lithium-
Polymer Pouch**
+
Safety Electronic



**VW VARTA
Joint Venture**
+
New material
technologies



**VARTA
CoinPower Series**
+
Innovative
Cell-Design for highest
Performance & Safety



**New VARTA
CoinPower types**
+
form factors



Batteries 101

VARTA

VARTA's Family Cells & Batteries:

- ▶ Voltages 1.5V to 48V
- ▶ Capacities 10mAh to >1500Ah
- ▶ Multiple Chemistry Options
- ▶ Coin & Cylindrical Sizes
- ▶ Pouch & Prismatic Sizes
- ▶ Embedded Battery Packs
- ▶ Consumer Removable Packs
- ▶ Industrial, Mobile Robotics Batteries
- ▶ Custom Designed Batteries
- ▶ Application Specific Standard Batteries



Cells



Easy Block/Blade/Pro



CellPac LITE



EasyPack





Thanks for
joining us!

Lunch & Learn

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Presenter: Dan Friel, National Business Development Manager, VARTA
Linked-In: Dan Friel: <https://www.linkedin.com/in/dan-friel-2004>
Email: dan.friel@varta-microbattery.com