

# **broadbit** *Batteries*

**Safe, high performance  
batteries based on  
common/cheap materials**

BroadBit Batteries Oy  
October 2023

david.brown@broadbit.com

**LRQA**  
CERTIFIED

ISO 9001 · ISO 14001  
ISO 45001

# BroadBit Batteries Overview

## Company Stats:

**Founded:** 2015

**Location:** Espoo, Finland

**Turnover:** 500€

**Growth:** 200% year-on-year

**Owners:** Private

**Partnerships:** Cell mfg.

Battery Pack mfg.

Distribution

Supply Chain

**Team:**

10 (all PhD or MSc)

**Investments to date:** 

**2500 k€ private**

**5000 k€ public**



**Tekes**

**BUSINESS  
FINLAND**

European  
Innovation  
Council



## Customers:

**Samples, demos and PoCs**

*+ leading battery, automotive and government customers*

**AIRBUS** *kapsch* >>>  
challenging limits



# Current battery tech limits market

**Fossil fuel world = ~1 kg batteries per person**  
**Electric world = ~100 kg batteries per person**

**~100 B\$  
Today**



## Existing batteries:

Expensive (>150 \$/kWh)  
Harmful (Environment & Users)  
Slow to charge (> 2hrs)  
Low capacity (< 260 Wh/kg)  
Delicate (0C - 40C)  
Resource limited (Lithium, Cobalt, Nickel)

**>1 T\$  
2030**





# BroadBit's Li-ion Innovation vs. Std. Li-ion

## ***Novel BroadBit ProLion™ Electrolyte (for all Li-ion Chemistries):***

- **Safer** (no reaction w/ water creating toxic by-products)
- **10% Higher Voltage Limit** (charging up to 4.5V vs. 4.2 for std. Li-ion)
- **15°C Higher Temperature Limit** (75°C vs. 60 for std. Li-ion)
- **30% Higher Cold Conductivity** (3.2 mS/cm vs. 2.4 for std. Li-ion @ -20°C)
- **100°C Higher Ignition Temperature** (250°C vs. 150 for std. Li-ion)
- **4x Cycle Life** (tested and verified for NMC, LCO, LFP and LMFP)

**= 4x lower leveled cost**

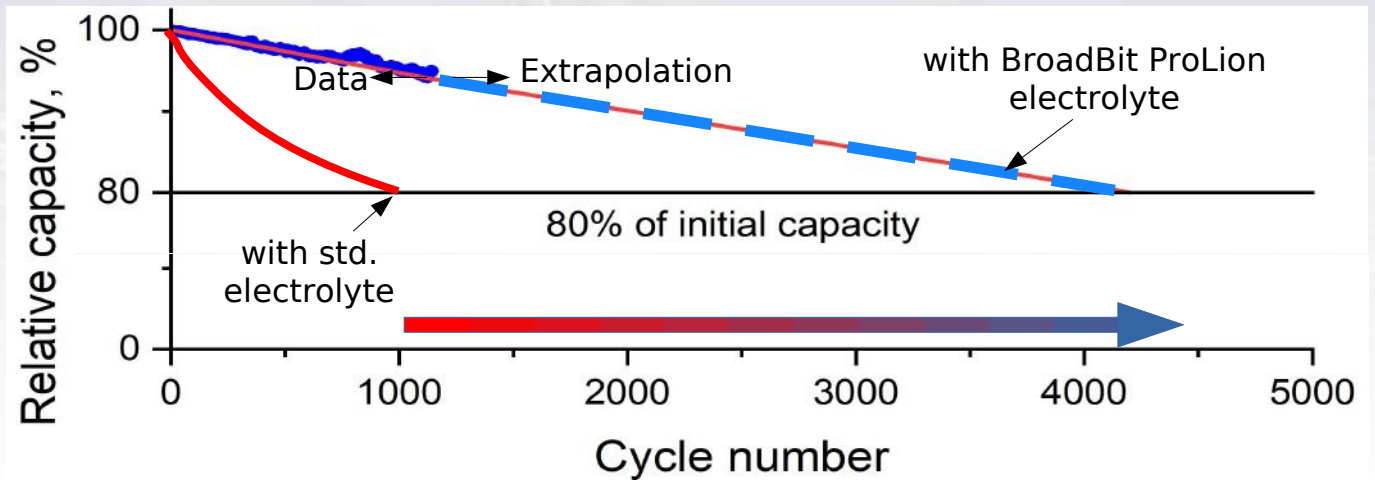
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## **Li-ion NMC**

- BroadBit Electrolyte
- Standard Electrolyte
- ➔ Increase in Cycle Life (80% of initial capacity)



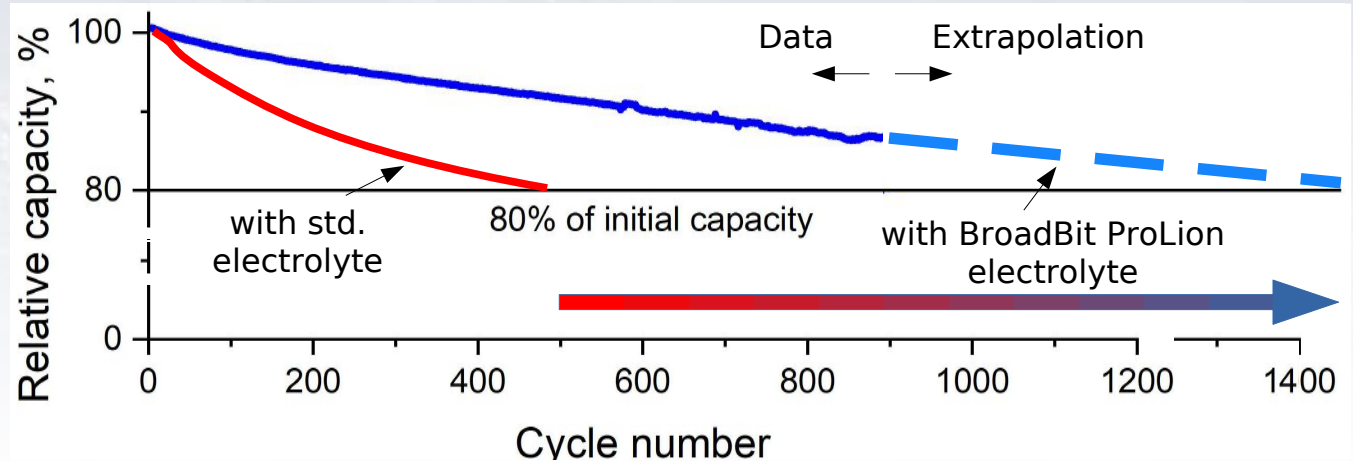
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## **Li-ion LCO**

- BroadBit Electrolyte
- Standard Electrolyte
- ➔ Increase in Cycle Life (80% of initial capacity)



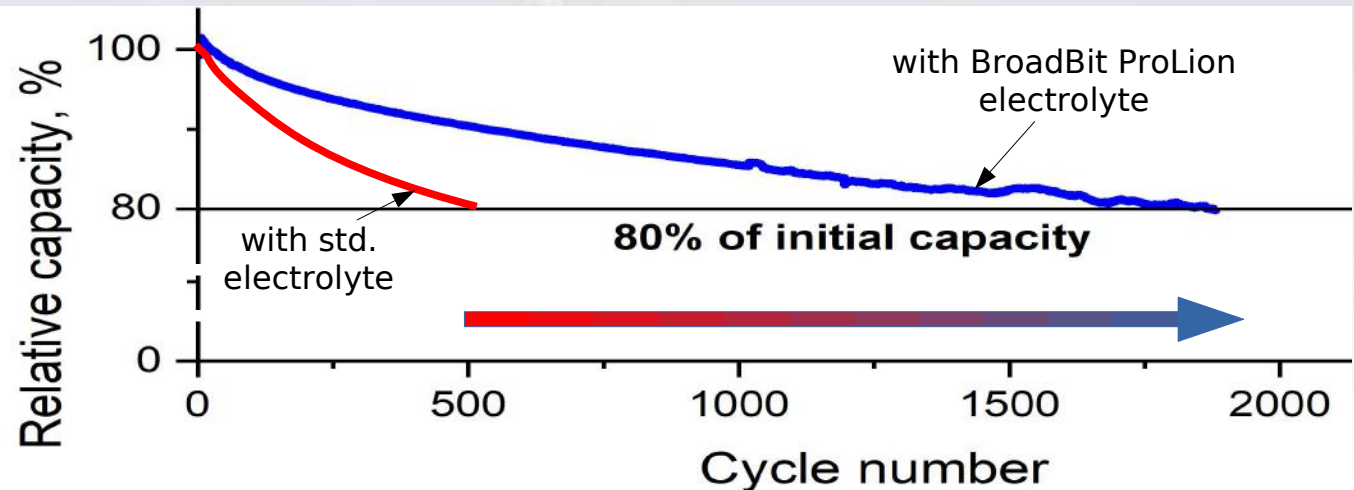
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## **Li-ion LMFP**

- BroadBit Electrolyte
- Standard Electrolyte
- ➔ Increase in Cycle Life (80% of initial capacity)





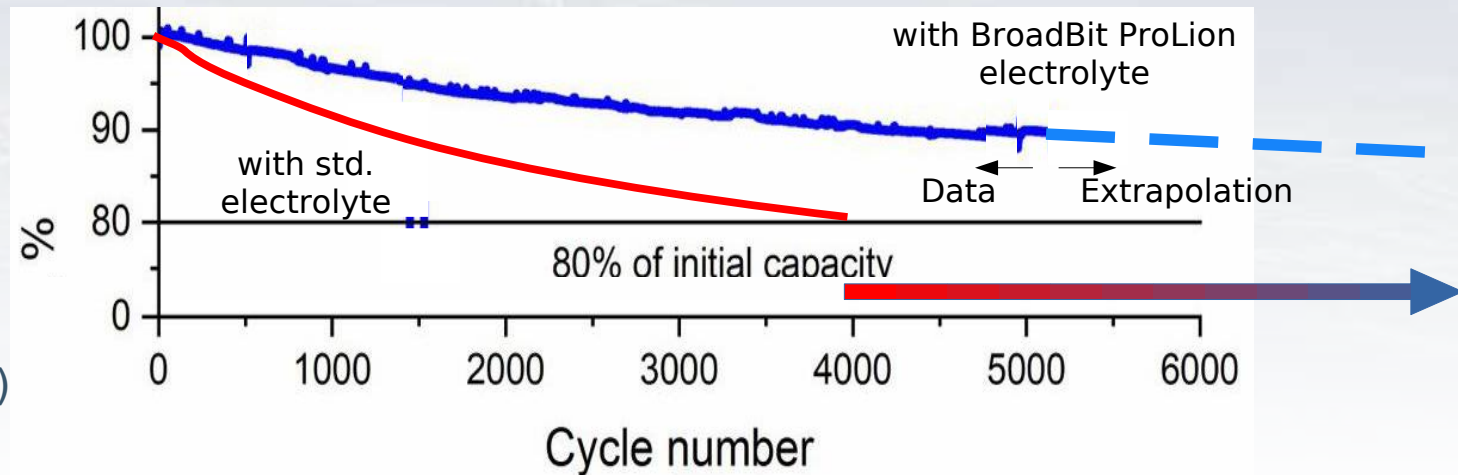
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- **4x Cycle Life** (tested and verified for, e.g., NMC, LCO, LFP and LMFP)

## ***Novel BroadBit Cathode (for Li-ion LFP Replacement):***

- **20% Higher Energy** (discharge voltage 3.6V vs. 3.2 for Li-LFP)
- **More scalable and sustainable** (Cobalt and Nickel free)

Areal mass loading (mg/cm <sup>2</sup> )	21±5%
Areal capacity (mAh/cm <sup>2</sup> )	2,6±5%
Recommended maximum charge voltage	4.2V vs. Li/Li+
Recommended cut-off voltage for discharge	2.5 vs. Li/Li+

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## ***Novel BroadBit Cathode + Electrolyte (for Li-ion LFP Replacement):***

- **Safer, More Robust, Longer Life, Higher Energy**
- **10% lower cell cost / kWh, 25% lower pack cost / kWh**

# BroadBit's core battery innovations

## Better Battery Chemistry

### Evolutionary (Li-Ion):

**Electrolyte:** Long-life/Wide-temp

**Cathode:** Co & Ni Free  
(TRL-9 2023)

### Revolutionary (Na-Salt):

**Anode, Cathode, Electrolyte:**

Rare Earth Metal Free  
(TRL-5, TRL-9 2024)

**Safer, Lower Cost, Higher Performance, Greener, More Scalable**

### Evolutionary:

**Water-based:** Non-Toxic  
(TRL-7, TRL-9 2024)

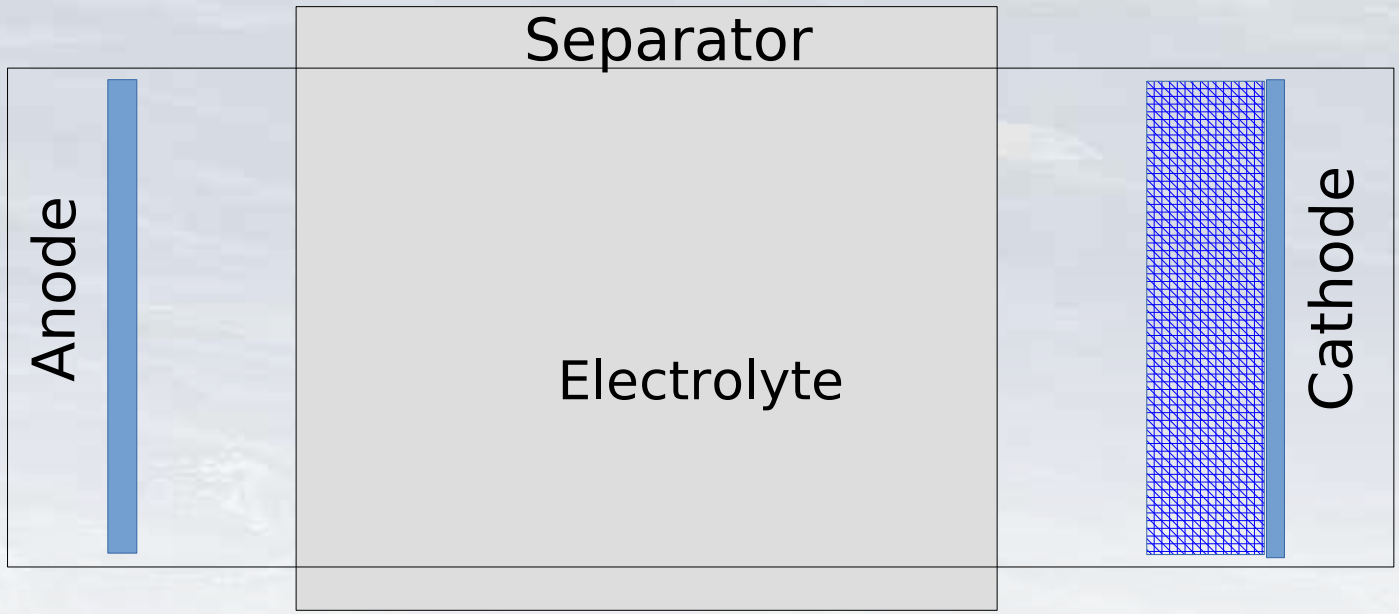
### Revolutionary:

**Dry:** Liquid Free  
(TRL-6, TRL-9 2024)

## Better Battery Manufacturing

# BroadBit's unique sodium technology

Replace all key components with low cost, safe, robust, widely available alternatives



18650-prototype cell



# BroadBit's unique sodium technology

**Unique operating principle**

**Superior Performance**



**Scalable & sustainable (no rare/toxic materials)**



# BroadBit's unique sodium technology

**Unique operating principle**

**Superior Performance**

**Low cost**

High-Energy Version

Salt (NaCl)



**Scalable & sustainable (no rare/toxic materials)**

Sand (SiO<sub>2</sub>)

Coal (C)

Sulfur (S)



# BroadBit's unique sodium technology

**Unique operating principle**

**Superior Performance**

**Low cost**

High-Efficiency Version

Salt (NaCl)



**Scalable & sustainable (no rare/toxic materials)**

Tenorite (CuO)



Coal (C)

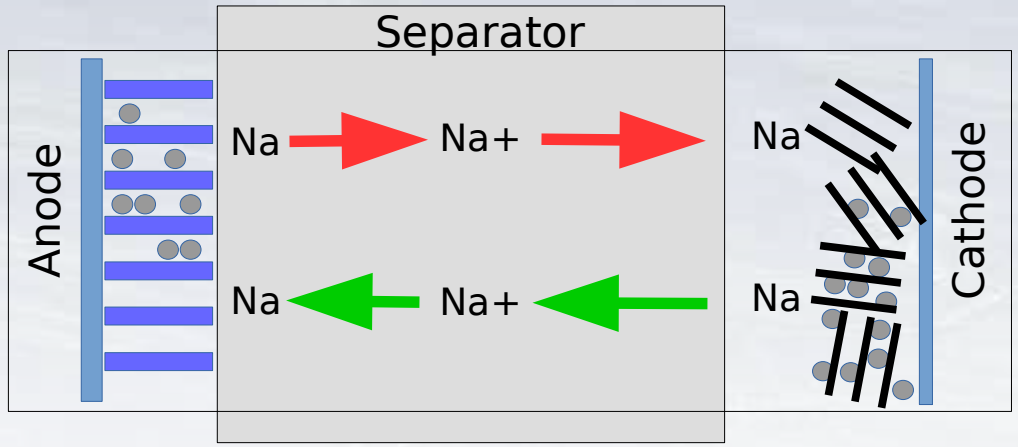


Sulfur (S)



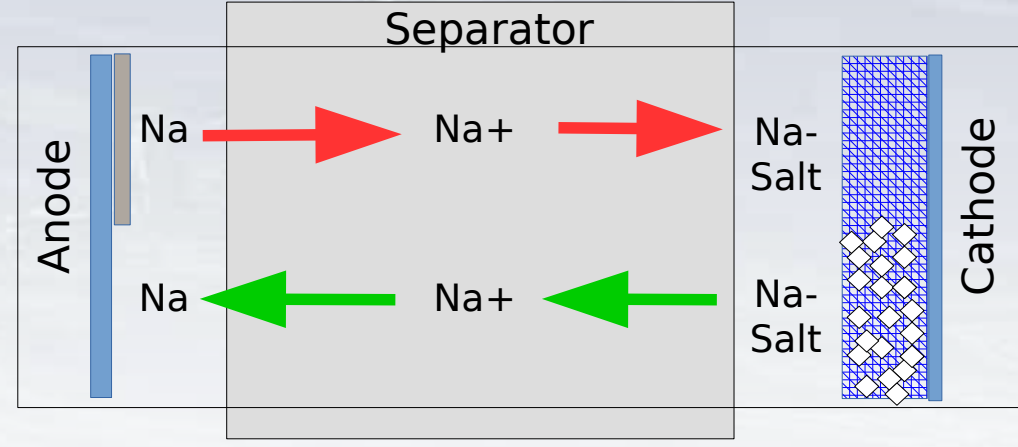
# Fundamentally NOT Sodium-Ion

**Sodium-ion batteries use intercalation to store charge**



**~150 Wh/kg**  
**Flammable**

**BroadBit uses electrodeposition & crystallization to store charge**



**~300 Wh/kg**  
**Non-Flammable**

Na+ = Sodium Ion (in solution)    Na = Elemental (Metallic) Sodium    NaCl = Sodium Chloride (crystal)

← = Charge

→ = Discharge

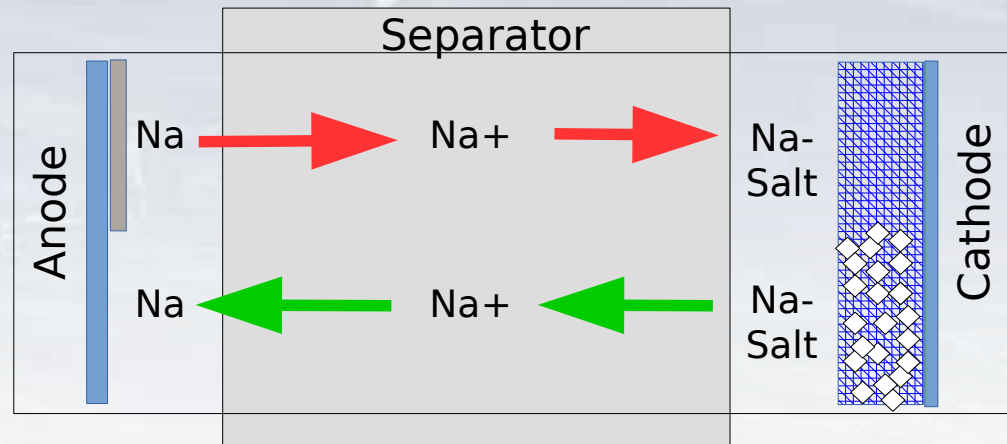
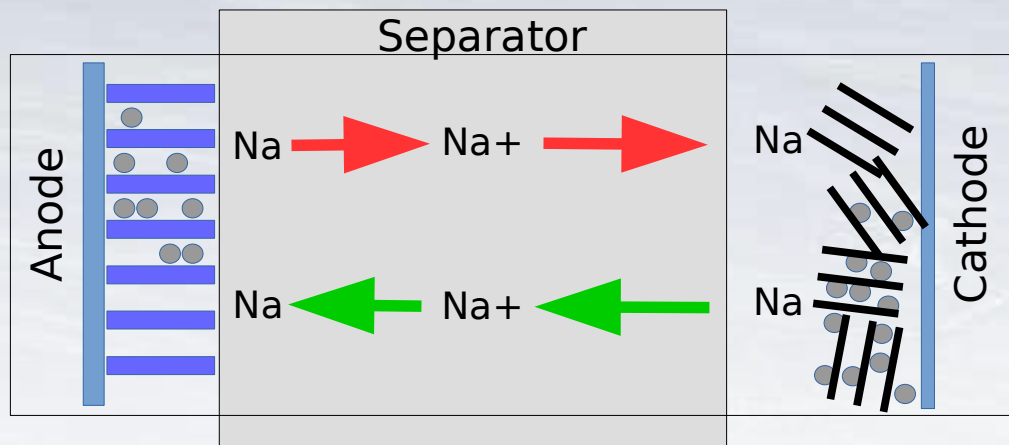




# Fundamentally NOT Saltwater

**Saltwater batteries use  $H_2O$  as the electrolyte solvent**

**BroadBit uses  $SO_2$  as the electrolyte solvent**



**~50 Wh/kg**  
**10 hr to charge**

**~300 Wh/kg**  
**0.5 hr to charge**

Na = Elemental (Metallic) Sodium

Na+ = Sodium Ion (in solution)

NaCl = Sodium Chloride (crystal)

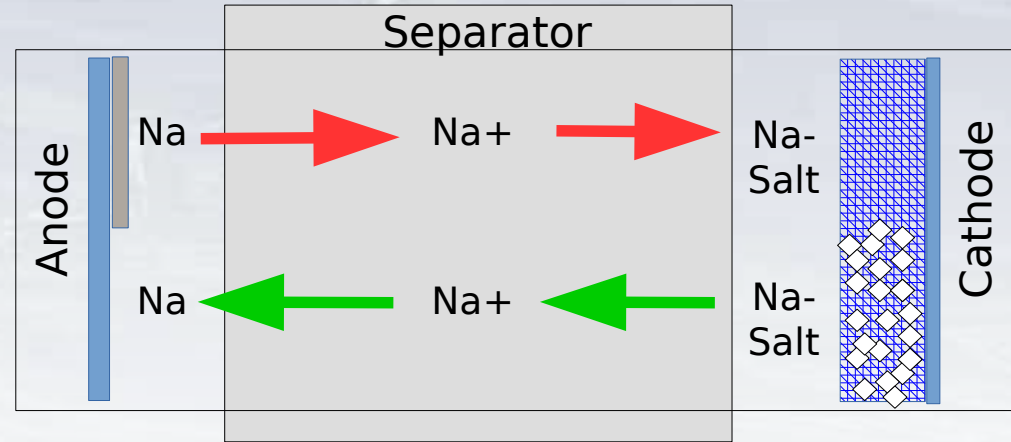
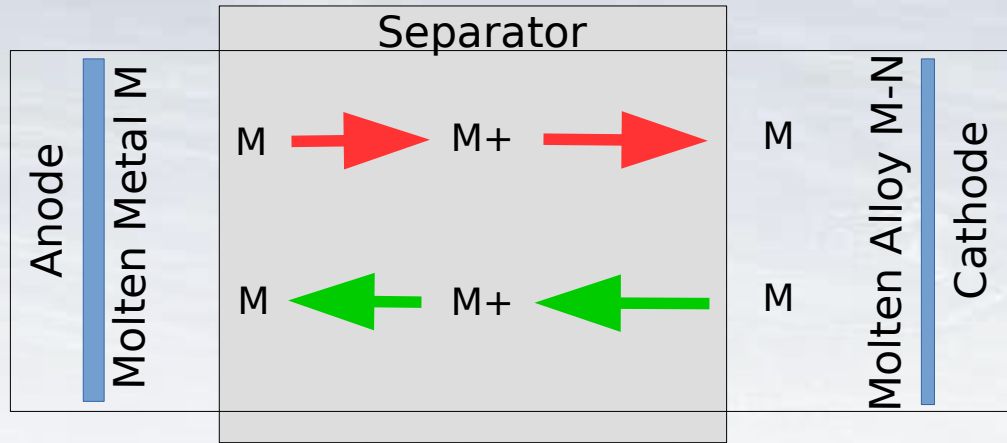
← = Charge

→ = Discharge

# Fundamentally NOT Molten Salt

**Molten salt batteries use melted salt\* as the electrolyte**

**BroadBit uses table salt (NaCl) as the active material**



**~300 Wh/kg**

**~300 Wh/kg**

**>300 C operating range**

**-20C - +60C operating range**

Na = Elemental (Metallic) Sodium

Na+ = Sodium Ion (in solution)

NaCl = Sodium Chloride (crystal)

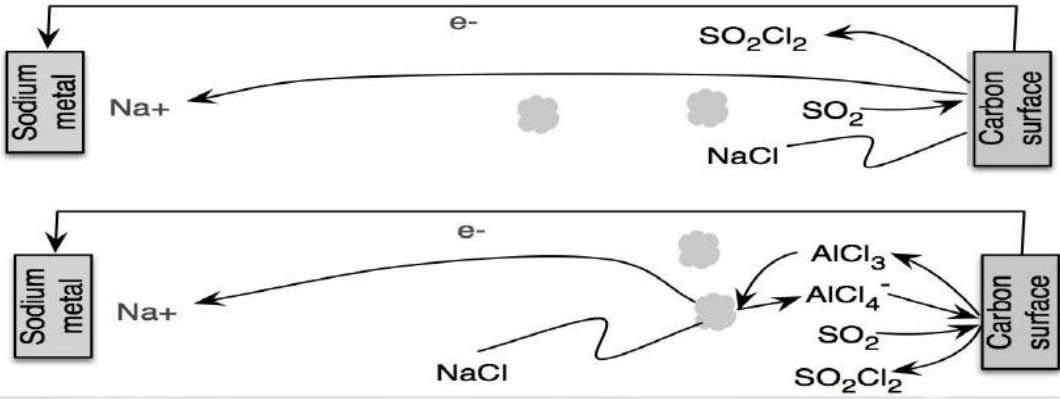
\* as in "an ionic compound"

= Charge

= Discharge

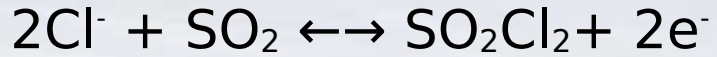
# BroadBit's Na-Salt Battery Chemistry

Charge

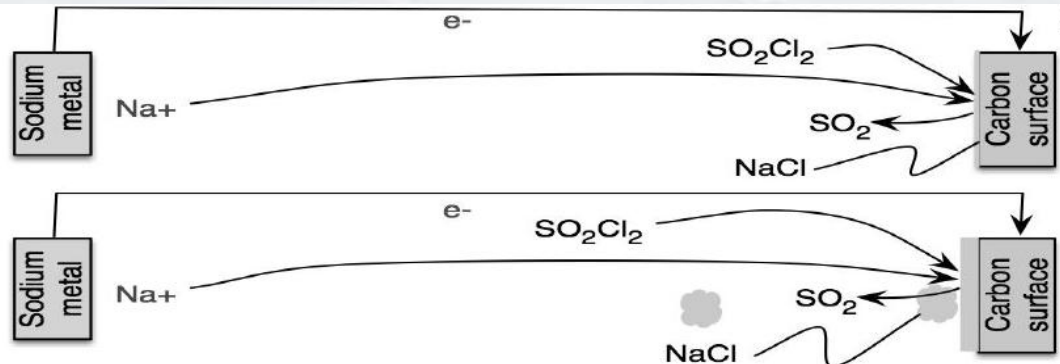


Direct oxidation of Sodium-chloride surface layer

Oxidation of fully or partially detached Sodium-chloride particles through the electrolyte-mediated redox cycle



Discharge



External circuit

Sodium-chloride deposition on the cathode surface

Detached Sodium-chloride particle accumulation. Particles may be fully or partially detached.

# BroadBit's core battery innovations

## Better Battery Chemistry

### Evolutionary (Li-Ion):

**Electrolyte:** Wide-temp/Hi-Volt

**Cathode:** Co & Ni Free  
(TRL-9 2023)

### Revolutionary (Na-Salt):

**Anode, Cathode, Electrolyte:**

Rare Earth Metal Free  
(TRL-5, TRL-9 2024)

**Safer, Lower Cost, Higher Performance, Greener, More Scalable**

### Evolutionary:

**Water-based:** Non-Toxic  
(TRL-7, TRL-9 2024)

### Revolutionary:

**Dry:** Liquid Free  
(TRL-6, TRL-9 2024)

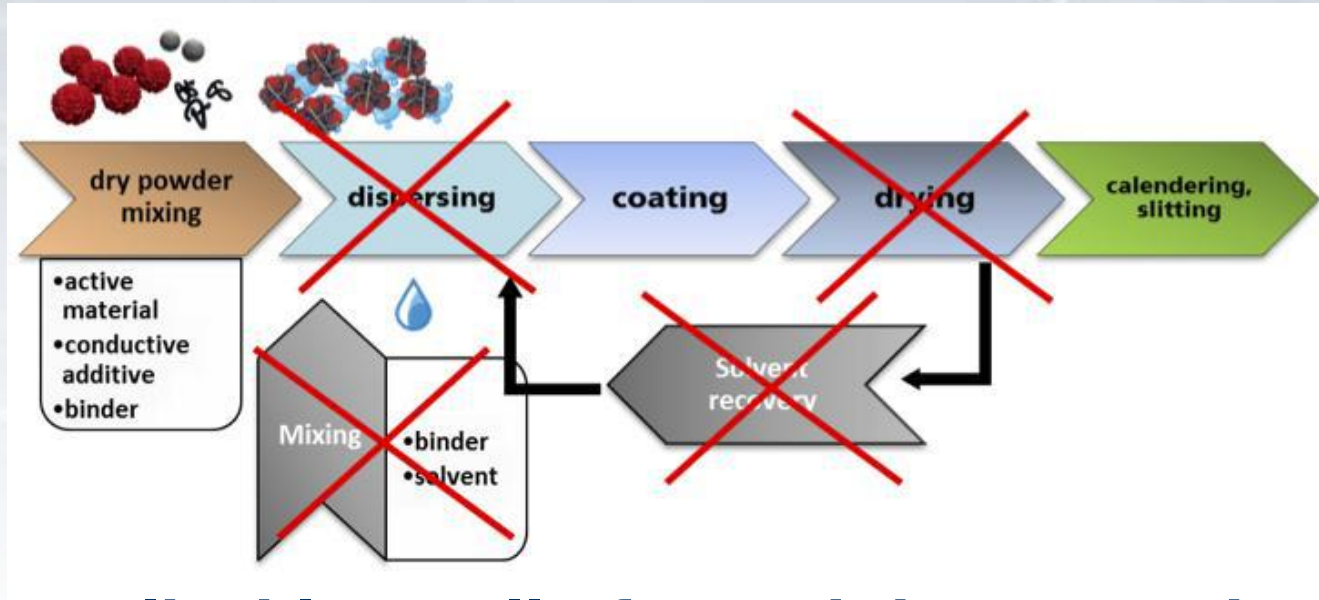
## Better Battery Manufacturing



# BroadBit has better manufacturing

**Cheaper, faster, safer, greener, cathode production**

**Dry, solvent free, contamination resistant process**



**Applicable to all of BroadBit's Batteries**

# BroadBit's unique dry mfg. tech



## BroadBit Dry Process



**CapEx Cost:** 15 M€

**Energy Cost:** 500 kW

**Process Material Cost:** 5 €/L

**Factory Area:** 600 m<sup>2</sup>

**Health, Safety & Environment:** Flammable/Toxic

—▶ 0.5 M€

—▶ 10 kW

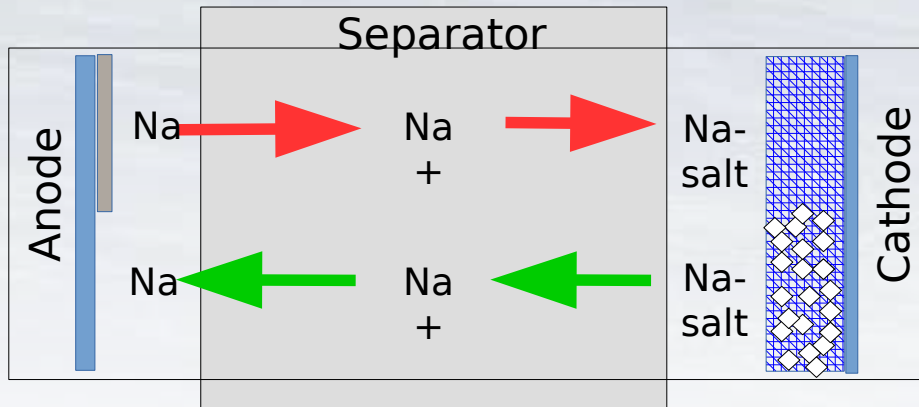
—▶ 0

—▶ 10 m<sup>2</sup>

—▶ Inert

# BroadBit sodium batteries are flexible

Using the same core concept, BroadBit's cell chemistry can be optimized for various applications:



## High energy density

300 Wh/kg vs. 270 for Li-ion  
e.g., electric vehicles

## High energy efficiency

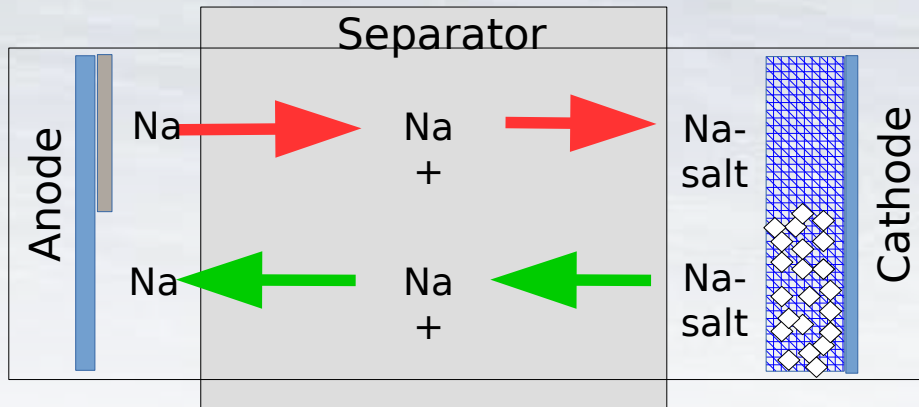
95% efficient vs. 90% for Li-ion  
e.g., grid storage & stabilization

## High power density

5-min charging vs. 30 for Li-ion  
e.g., starter, drones & power tools

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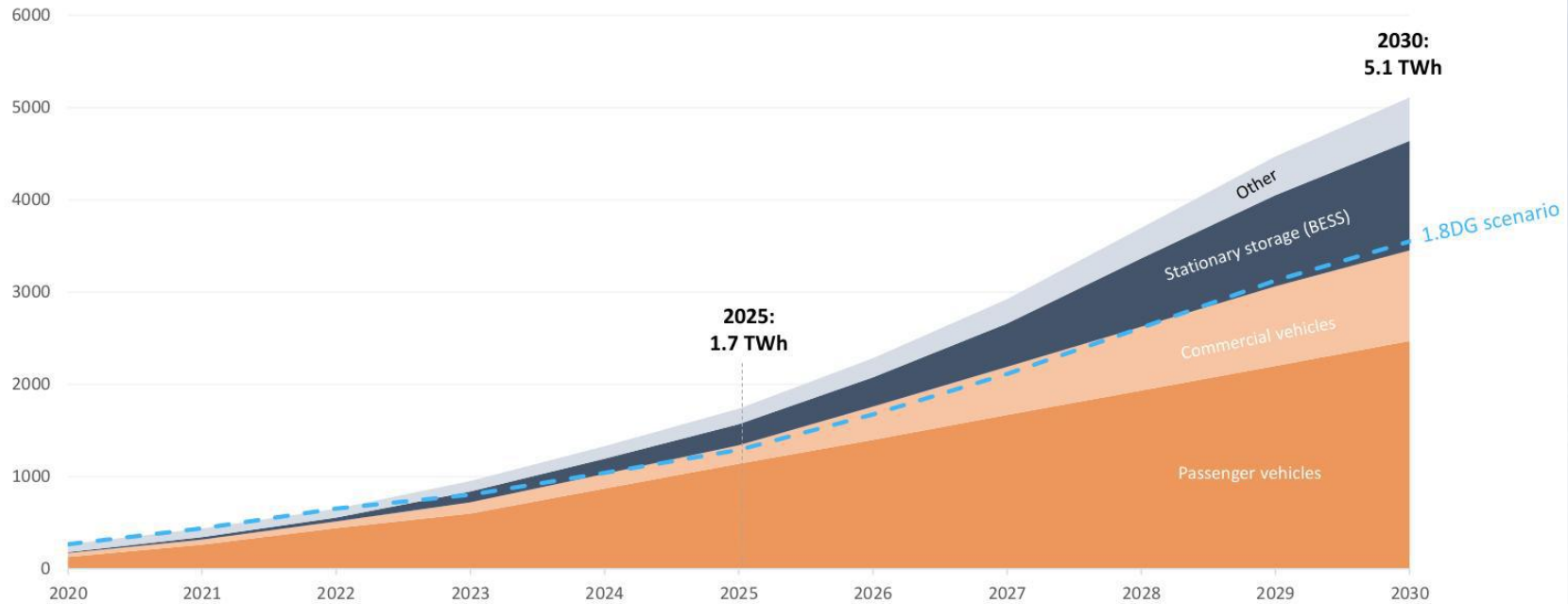
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e.g., starter, drones & power tools



# Why chose Energy Storage 1<sup>st</sup>?

Battery cell demand in 2030 expected to pass 5 TWh - over 1.2 TWh from Stationary Storage

**1.6 DG scenario battery cell demand split by sector**  
GWh

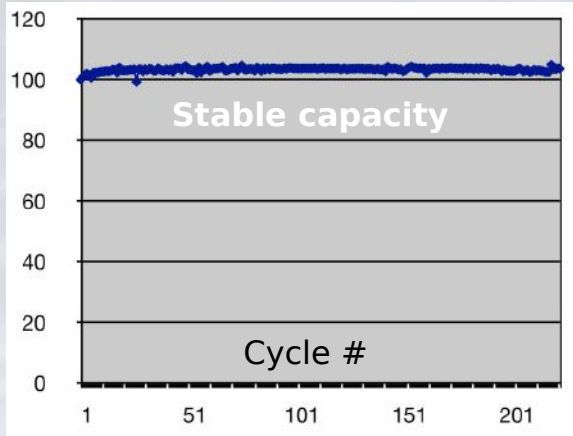


Source: Rystad Energy research and analysis

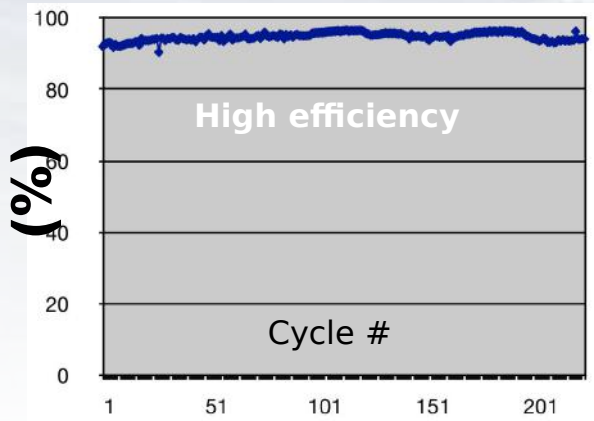


# BroadBit's durable/efficient chemistry

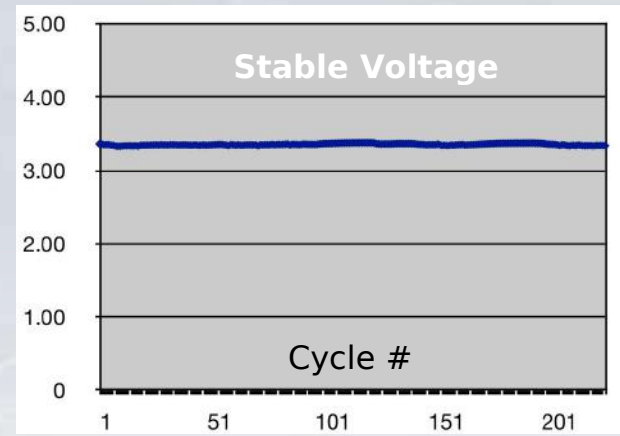
**Capacity Retention (%)**



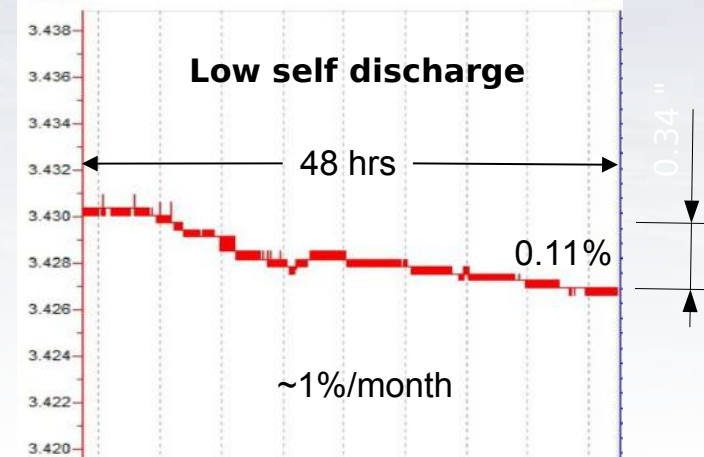
**Energy Efficiency (%)**



**Cell Voltage (V)**

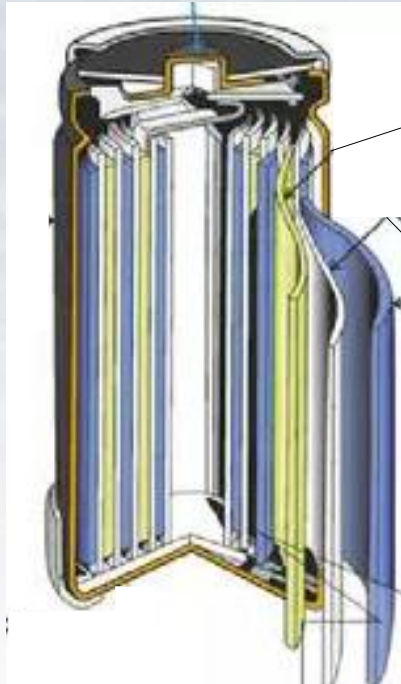


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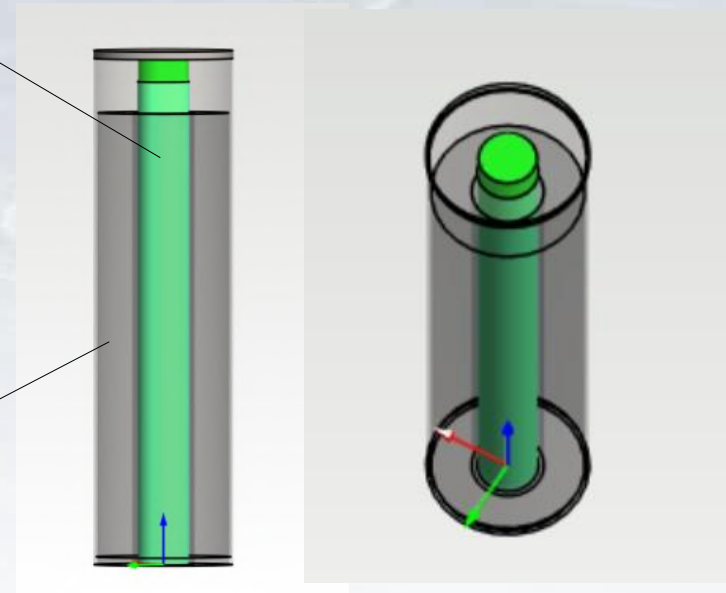
# BroadBit's simplified battery design

## Typical Li-ion



0.01 cm thick cathode

## Na-Salt Prototype A



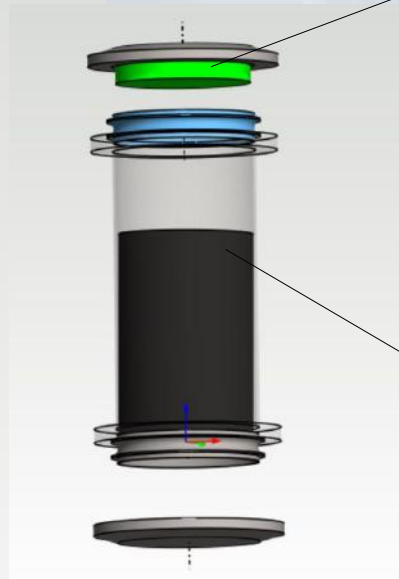
0.2 cm thick cathode

Anode

Cathode

# BroadBit's simplified battery design

## Na-Salt Prototype B

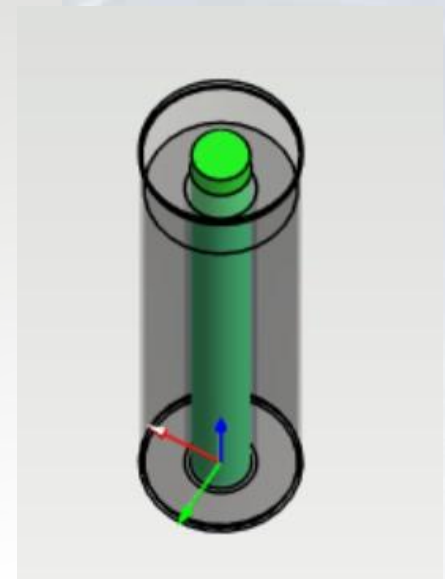
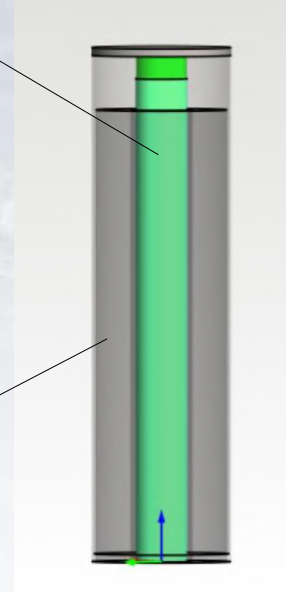


Anode

Cathode

>1 cm thick cathode

## Na-Salt Prototype A



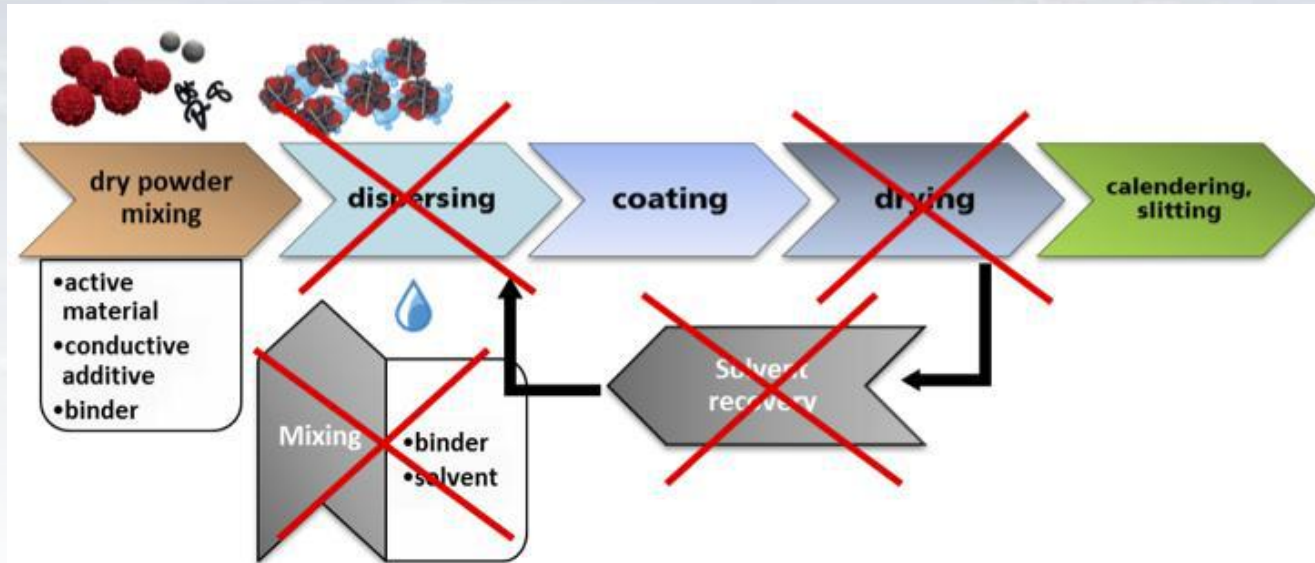
0.2 cm thick cathode



# BroadBit has better manufacturing

## Thick cathode cell format

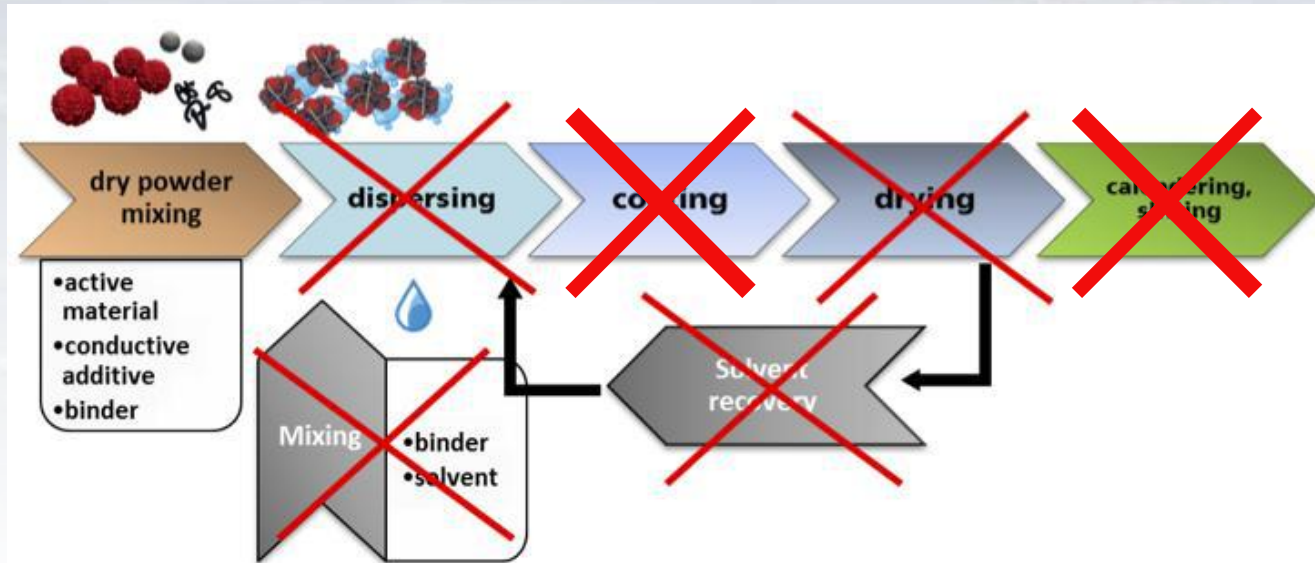
Further reduces manufacturing complexity and cost  
further reducing cost from 50\$/kWh to 30\$/kWh



# BroadBit has better manufacturing

**Thick cathode cell format**

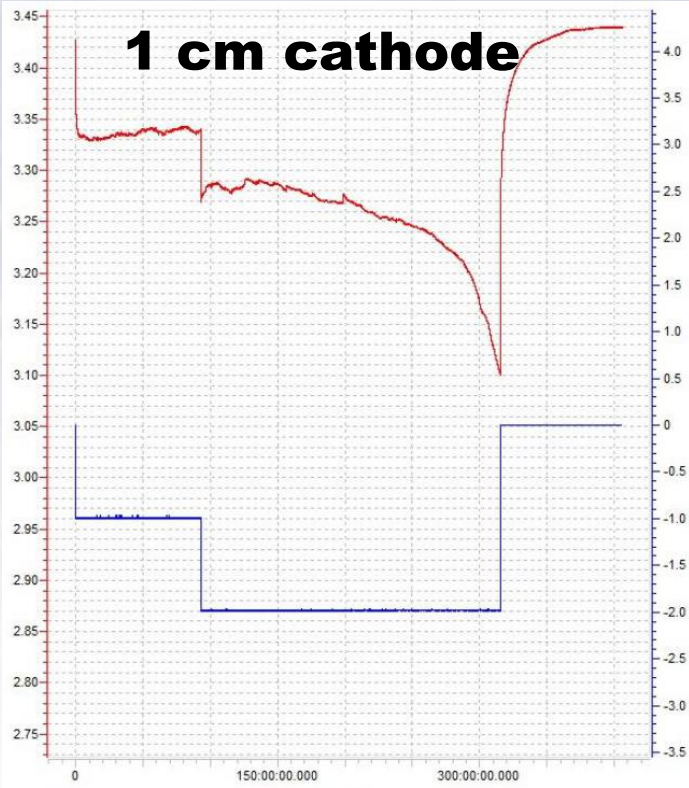
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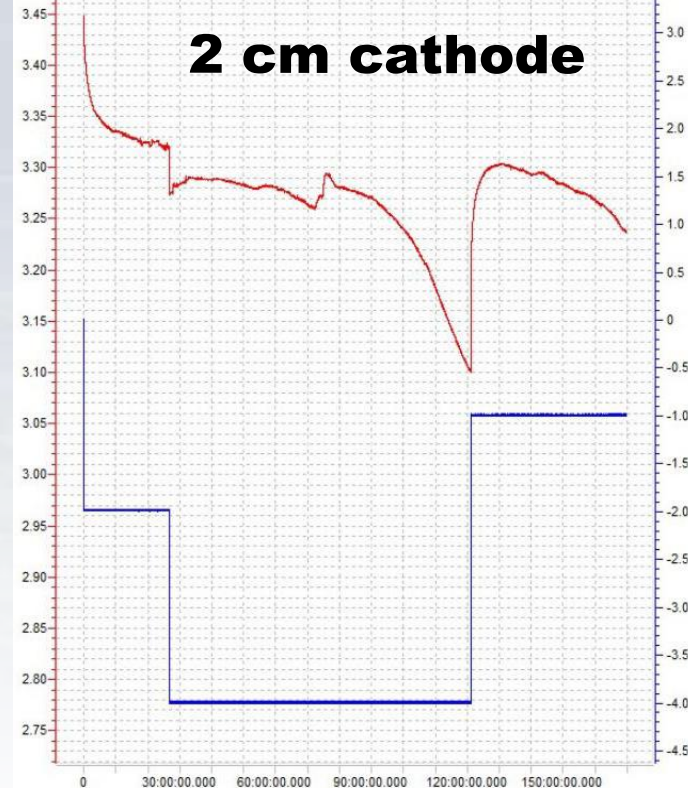
# BroadBit's thick cathode seasonal cell



**Voltage (V)**



**Time**



**Time**

**Current (mA)**





# BroadBit's hybrid Na-Salt battery

- **Current Technology Status**

- Technology validated in cylindrical cells (18650 and larger)
- Years of cycling data

- **Existing Technology Advantage**

- Exceptionally High: Efficiency

Power

Safety

Scalability/Sustainability

- Exceptionally Low: Self discharge

Materials, processing & assembly costs

- **Technology Introduction Strategy**

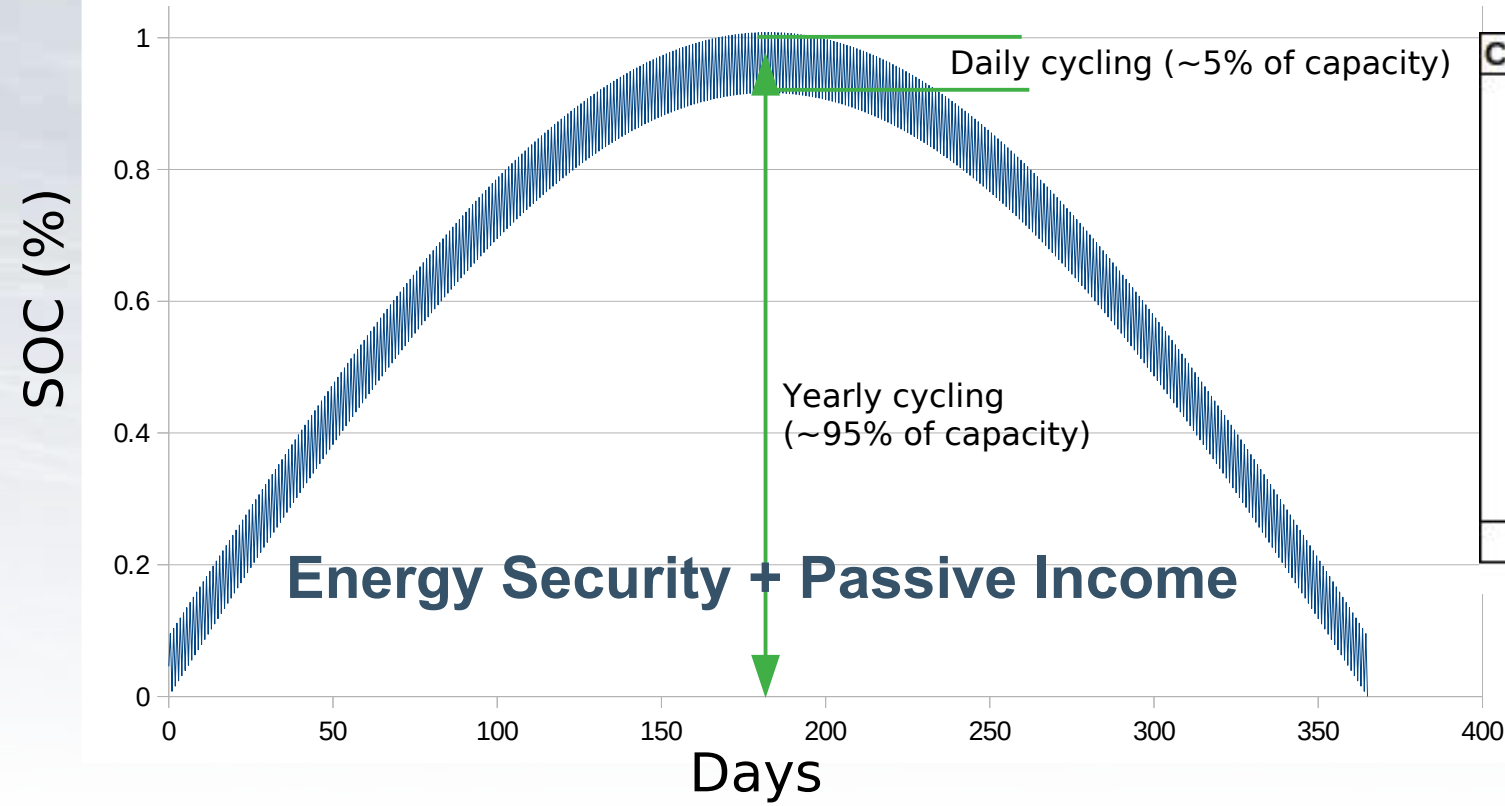
- Already meet ALL key cost/performance parameters for a hybrid daily/seasonal cell
- Ready to begin field trials





# Hi-efficiency hybrid battery use

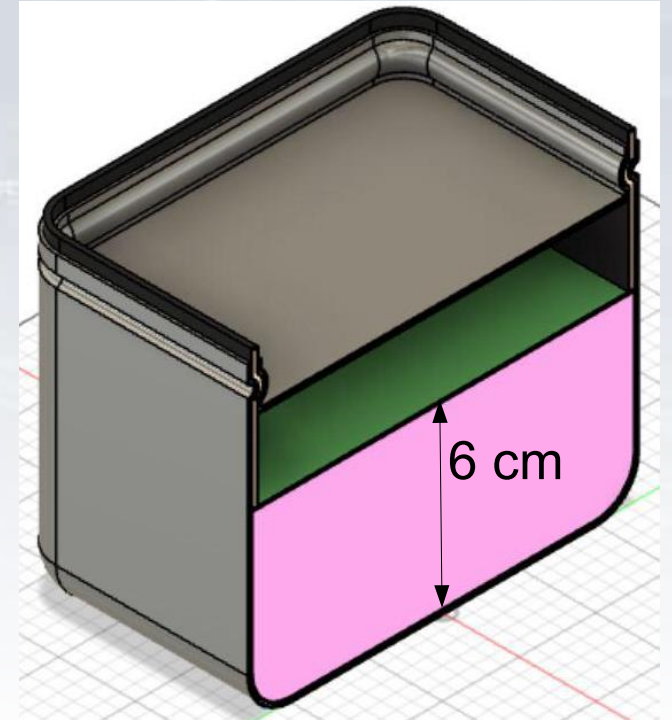
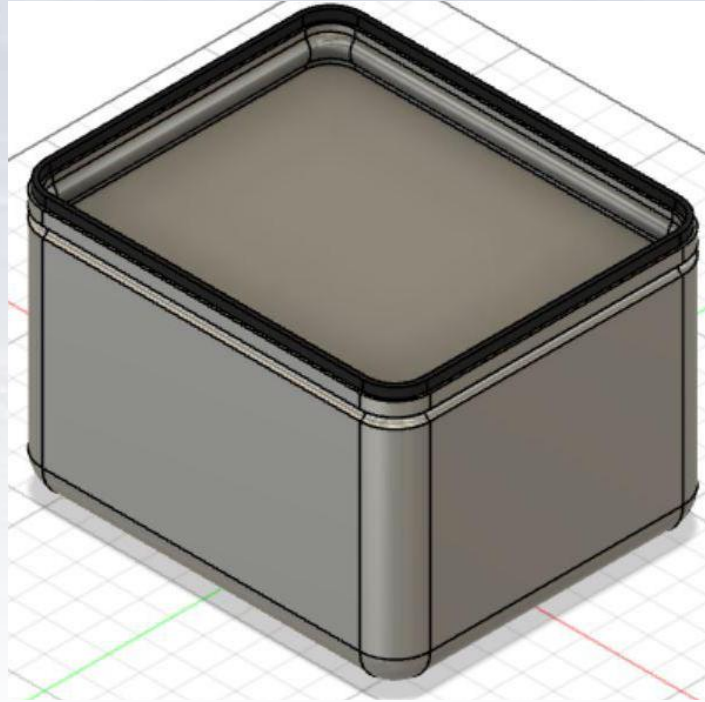
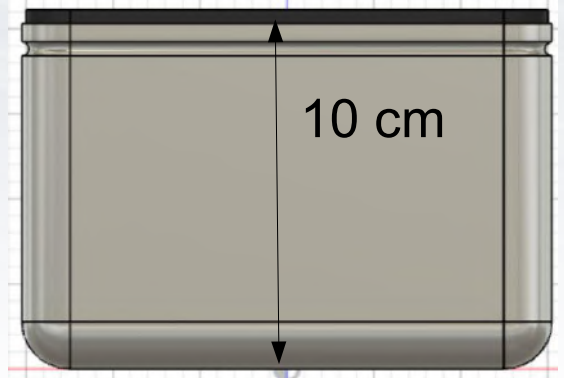
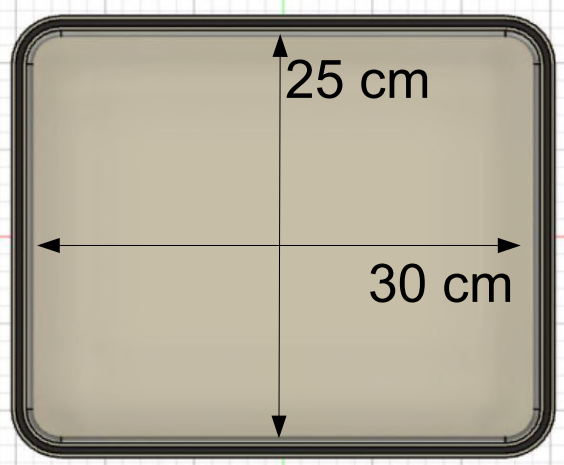
## World's 1<sup>st</sup> Hybrid Daily / Seasonal Battery



Combined seasonal and daily	
365 days/yr	
5.13% discharge/d	
50 yr/life	
1.003 charges/d	
366 Partial charges/yr	
18300 Partial charges/life	
960 Full charges/life	
17.6 €/kWh (cost)	
0.018 €/kWh/life	
1.08 €/kWh (avg. German)	
98% margin	
<b>0.85 Payback time (yrs)</b>	

# BroadBit's seasonal battery demo

## 25 kg cell concept



# >90 Patents (>20 already granted)

#	Description	Status	Priority	WO, PCT Numbers (ID)
1a	ELECTROCHEMICAL SECONDARY CELLS FOR HIGH-POWER BATTERY USE -High power NaCl with NaBF <sub>4</sub> or NaBH <sub>4</sub>	FIN	2015.09.30	WO2017/055678A1, PCT/FI2016/050133 (99077LN)
1b	ELECTROCHEMICAL SECONDARY CELLS FOR HIGH-ENERGY BATTERY USE -Discharge state assembled, high energy sodium / sodium salt	PCT, EUR, USA, JAP, KOR, CHN, CAN, ISR, RUS, BRA, IND, TWN	2015.09.30	WO2017/055678A1, PCT/FI2016/050133 (99077LN)
2	RECHARGEABLE SODIUM CELLS FOR HIGH ENERGY DENSITY BATTERY USE -Non-aqueous electrolyte, SO <sub>2</sub> additive and SEI forming salt	FIN, PCT, EUR, USA, JAP, KOR, CHN, CAN, IND, IND, HNK, TWN, ISR, RUS, AUS, MEX, BRA, PER	2016.03.04	WO2017/149204, PCT/FI2017/050139 (99096LN)
3	ELECTROLYTE FOR SUPERCAPACITOR AND HIGH-POWER BATTERY USE -NaClO <sub>4</sub> electrolyte in nitrile solvent	FIN, PCT, TWN, EUR, USA, JAP, KOR, CHN, IND, ISR, AUS, BRA, CAN, MEX, PER, RUS	2017.03.17	WO2018/167365, PCT/FI2018/050182 (105598LN)
4	IMPROVED ELECTROCHEMICAL CELLS FOR HIGH-ENERGY BATTERY USE -Anode current collector for SO <sub>2</sub> solvent with C-coated metal/alloy	FIN, PCT, TWN, USA, EUR, JAP, KOR, CHN, IND, IND, RUS, ISR, AUS	2017.08.04	WO2019025663A1, PCT/FI2018/050571 (107989LN)
5	A DISCHARGE STATE ASSEMBLED RECHARGEABLE ELECTROCHEMICAL CELL COMPRIZING METALLIC ELECTRODES -Discharge state assembled metal-metal battery.	FIN, PCT, USA, EUR, JAP, KOR, CHN, IND	2018.09.17	WO2020058572A1, PCT/FI2019/050663 (114412LN)
6	IMPROVED RECHARGEABLE BATTERIES AND PRODUCTION THEREOF -Electrolyte with Carbonate - Nitrile solvent with alkali salt	FIN, PCT, USA, EUR, JAP, KOR, CHN, IND	2018.10.02	WO2020070391A1, PCT/FI2019/050714 (114723KM)
7	IMPROVED ANODE MATERIAL AND ANODE FOR A RECHARGEABLE BATTERY -Composite anode of metal matrix and distributed material	FIN, PCT, USA, EUR, JAP, KOR, CHN, IND	2018.10.10	WO2020084197A1, PCT/FI2019/050759 (114857LN)
8	AN ELECTRODE MATERIAL AND COMPONENTS THEREFROM AND PROCESSES FOR THE MANUFACTURE THEREOF -Dry blends and pastes and manufacturing methods for batteries	FIN, PCT, USA, EUR, JAP, KOR, CHN, IND, BRA, ISR, TWN	2019.08.13	WO2021028619A1, PCT/FI2020/050525 (119960KM)
9	IMPROVED ELECTROLYTE FOR ELECTROCHEMICAL CELL -An electrolyte comprising a solvent comprising at least two carbonate solvents	FIN, PCT, USA, EUR, CHN, JAP, KOR, TWN, RUS, IND, CAN, ISR, BRA, PER	2020.06.26	WO2021260274A1, PCT/FI2021/050493 (139177LN)

Applied, Acceptance soon, Accepted, **Granted**

Confidential and proprietary

LRQA  
CERTIFIED

ISO 9001: ISO 14001  
ISO 45001

**brodbit**



# BroadBit Premises

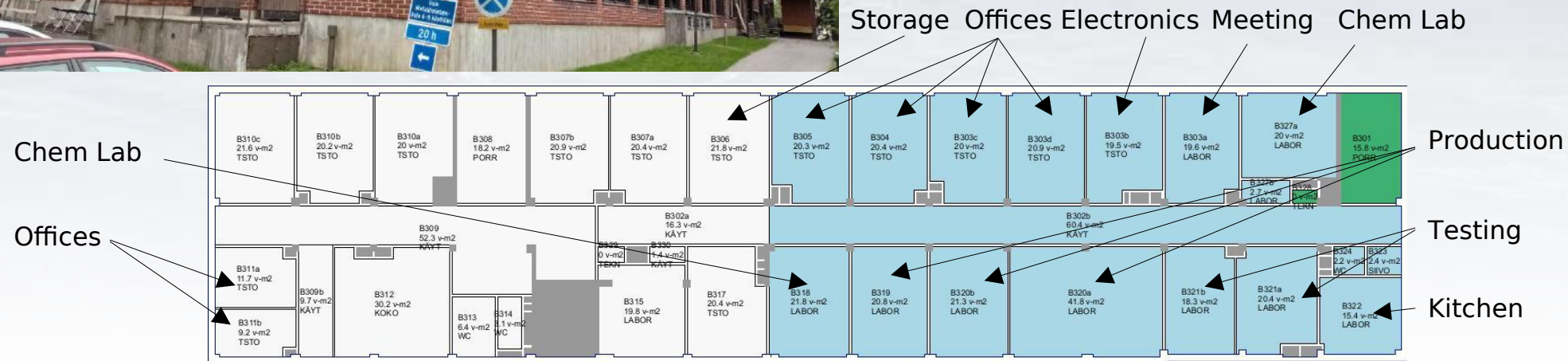


BroadBit HQ  
Metallimiehenkuja 8

~600 m<sup>2</sup> 2 floors

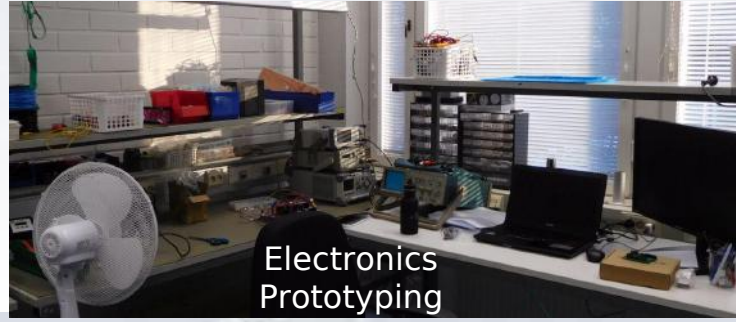
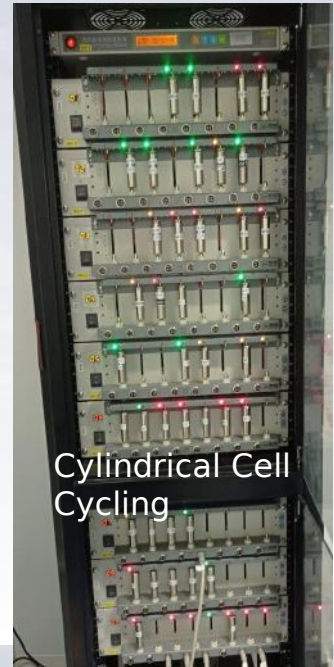
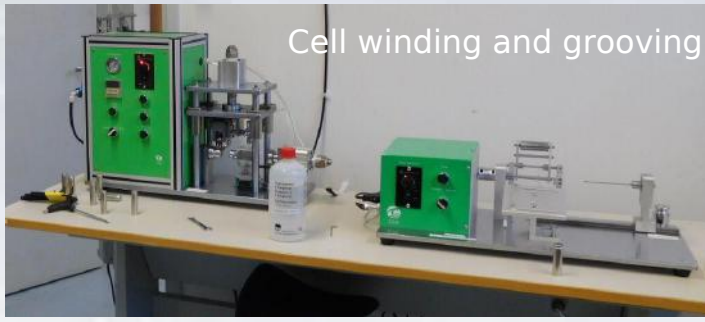
3<sup>rd</sup> floor (below) for offices, assembly, testing and chemistry labs.

1<sup>st</sup> floor (not shown) for cathode and electrolyte production and machine shop





# Capability: Raw materials to full demos





FREE ELECTRONICS

# broadbit

## Batteries

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Contact: David Brown, PhD  
david.brown@broadbit.com

PROSPECT MINING STUDIO AT NEW LAB

SINO TRACK

4YFN | Connecting Startups

THE ONE INITIATIVE

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InnoEnergy Knowledge Innovation Community

NORDIC IMPACT BUSINESS SUMMIT

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation

GLOBAL STARTUP AWARDS NEW ENERGY CHALLENGE



munichnetwork collaborative innovation

STARTER business acceleration

EVS Cleantech Award EUROPEAN VENTURE SUMMIT

kapsch challenging limits FACTORY

White Bull summits BULLY AWARD

NVF NORDIC VENTURE FORUM Cleantech Award

Award International Venture Club CTS CLEANTECH SUMMIT ROTTERDAM

4YFN SHANGHAI

K-STARTUP GRAND CHALLENGE

INNOVATION RADAR Prize

PIONEERS InnoVest

IDTechEx EVES Launchpad

Runar Backstrom Grant

WEBIT FESTIVAL EUROPE ENTERPRISE | POLICY | STARTUPS Green Award

MILStartup Award

STLC

GLOBAL PITCH

CAMBRIDGE CLEANTECH Member

Airbus BizLab Aerospace Accelerator

NORDIC STARTUP AWARDS Best Social Impact

Accenture INNOVATION AWARDS

Katapult Accelerator

SEAL OF EXCELLENCE European Commission