CURRENT DIRECT™

Swappable Container Waterborne Transport Battery

Shaun White
Technical Project Manager

The Current Direct project is funded by the European Commission's Horizon 2020 program. Grant number 963603.

Context

- Research and innovation project funded by the European Commission's Horizon 2020
  - H2020-EU.3.4. - SOCIETAL CHALLENGES - Smart, Green and Integrated Transport (€ 6,339.40 million)
  - LC-BAT-11-2020 - Reducing the cost of large batteries for waterborne transport (€ 21.50 million)
  - Current Direct - Swappable Container Waterborne Transport Battery (€ 11.98 million)
- Swappable containerized batteries connected to an Energy as a Service Platform
- **Significantly reduce the total lifetime cost of waterborne transport batteries**
- **Cut GHG emissions of the marine transport sector**
- **Increase the installed energy of containerized energy storage systems**
- **Trigger investments for innovation, employment, and knowledge creation**

Strategic Objectives

Innovative Waterborne Transport Cell

SO1

Certified Battery System

SO2

Certified Integration Standards

SO3

Standardized Shore Infrastructure

SO4

Energy-as-a-Service Business and Financing Model

SO5

Standard Marine Battery Certification Methodology

SO6

Operational Demonstrator

SO7

Dissemination and Stakeholder Management

SO8

Swappable Waterborne Transport Battery

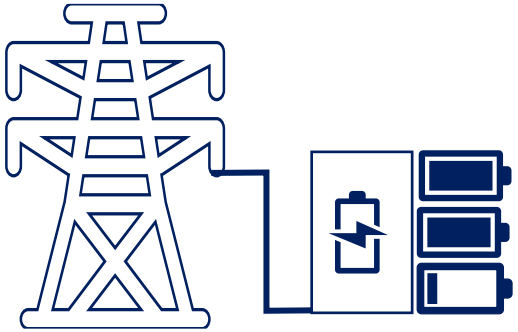
20ft Container

1MW, 3MWh

Energy-as-a-Service Platform

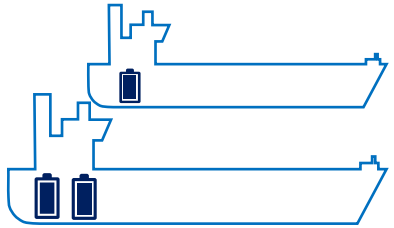
Interfaces and Topology

Shore Side



Swapping Infrastructure

Vessel Side



- **Mechanical and Structural Considerations**
- **National grid standards**
- **- Fire Safety, regulatory**
  - IEC/ISO
- **Swapping Movement and Reach**
- **Electrical and Machinery Interfaces**
- **Supporting Infrastructure Grid Connection**
- **Mechanical and Structural Considerations**
- **Human Interface**
- **Safety, Redundancy, and Regulatory**
- **Vessel Retrofit**

Distribution: Current Direct Consortium, Stakeholders, Advisory Board
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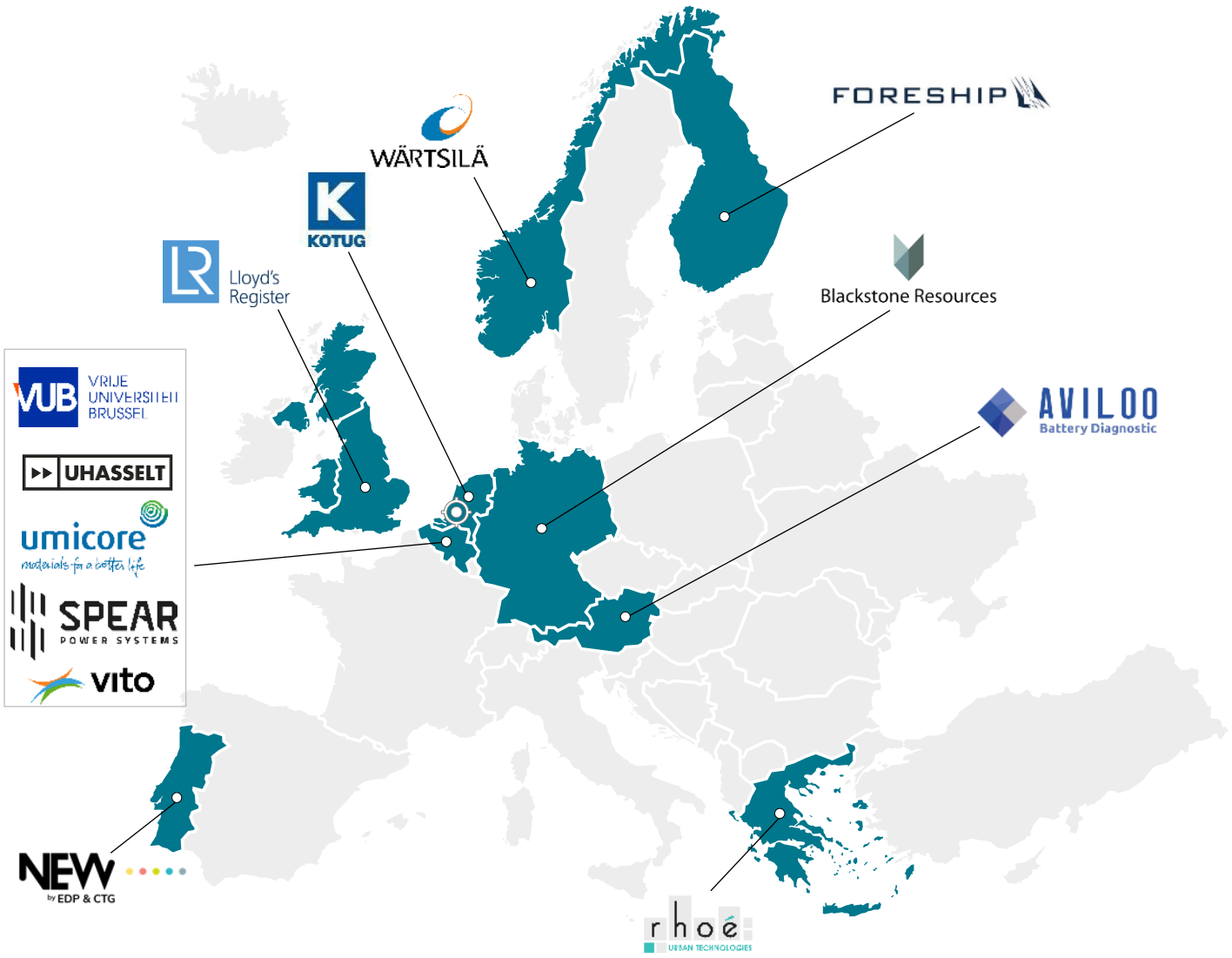
Consortium



Key Facts

12 M€ Budget

36 Months (2021-2023)

13 Partners

9 Countries

1 Demo Site

11 Milestones

29 Deliverables

10 Work Packages

44 Tasks

Advisory Board

Port of Rotterdam

CARNIVAL CORPORATION&PLC

ENGIE

VATTENFALL

SOGESTRAN GROUP

IVR

BUREAU VERITAS

Product: BBC LFPC E50Ah A1

Blackstone Technology

be part of our story

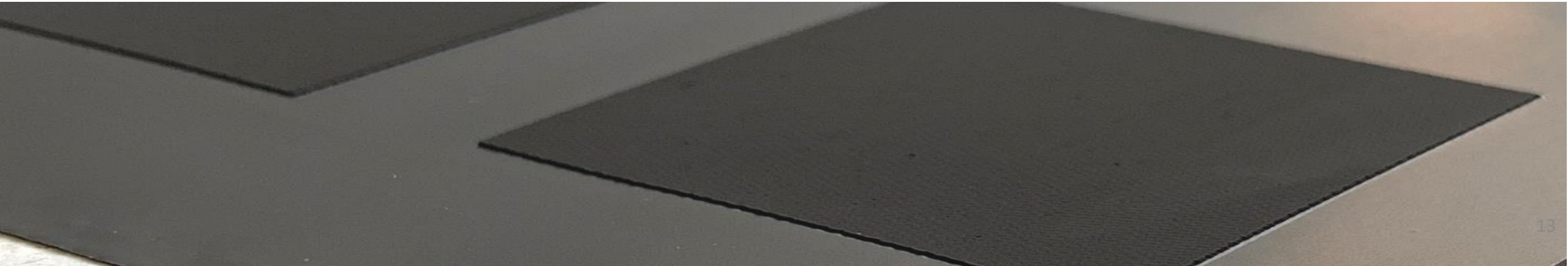
SEABAT Academic Workshop

version: June 2022

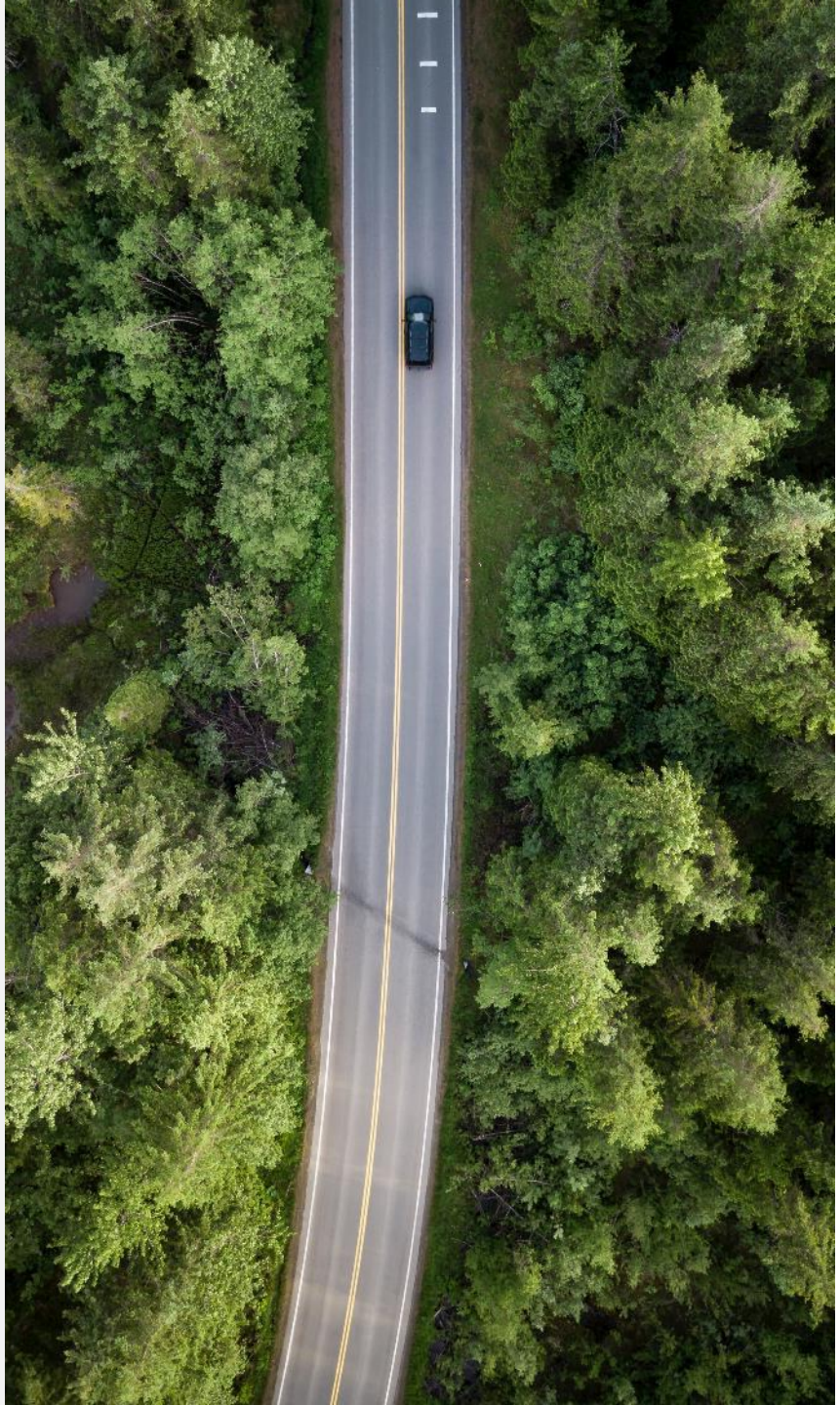
Blackstone Resources

Sustainability, environmental and climate protection through 3D printed battery cells

08.06.2022



Our motivation



Blackstone Resources

The potential for improvement

- Energy density
- Flexibility of formats
- Production costs
- Environmental impact of production and product

The solution

- Increased energy density through **Blackstone Thick Layer Technology©**
- Unparalleled flexibility
- Low energy consumption and low production costs
- No toxic solvents
- Resource-saving battery recycling

Vision

One day we will make battery cells like semiconductors.

With a single machine park, we quickly and cost-effectively print cells in various shapes, different electrodes and electrolyte materials on a large scale.

Production of battery cells every second

Blackstone Group

Blackstone Resources

	Blackstone Technology	Battery Metals	Precious Metals
Division			
Description	Mass production of batteries using proprietary 3D printing technology, with plans to disrupt traditional battery technology via solid-state batteries	Portfolio of mining interests for purposes of supplying Blackstone Technology with raw battery materials for production of batteries	Peruvian gold mill acquired by Blackstone Resources as a source of cashflow
Strategy	To develop the next generation of battery technology serving EVs, e-buses, marine, 5G network, storage and other industrial sectors	Create vertically integrated operations by supplying critical materials from asset portfolio or internal trading department	Stabilize the company's cash flow generation

Battery Value Chain Focus

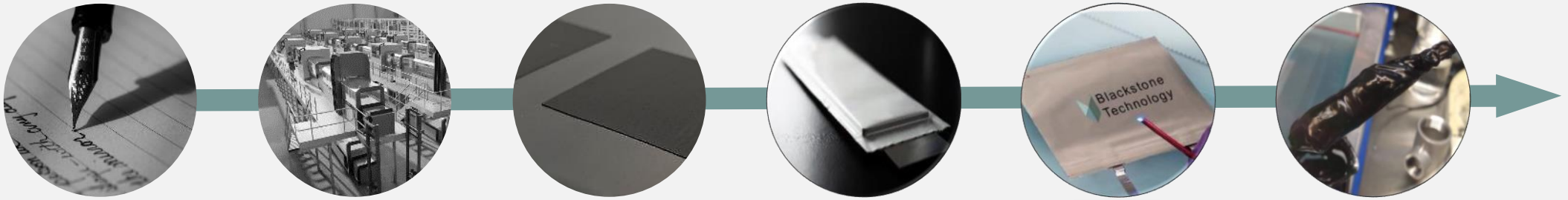
Achievements

Blackstone Resources

Proof of concept 3D Printed electrodes

B-sample of battery cell with 3D printed electrodes

Aqueous NMC & LFP cathode processing



Blackstone Technology Founded

A-sample of battery cell with 3D printed electrodes

Proof of concept 3D Printing solid-state battery

Production

Blackstone Technology Value Proposition

1: Energy efficient production technology

Good for the future and the environment

2: Future secured technology

Solid-State-Batteries can be 3D printed on Blackstone's production lines

3: Unparalleled flexibility

Better performance for our customers without additional costs

4: Vertical integrated Value Chain

Conflict free materials at lower costs and volatility

5: Cost efficient scaling up

3D printing allows for lean production and leverages investments

Novelty

Blackstone Resources

Both, **3D-Printing** and **Li-Ion-Technology** look back on more than 20 years of development and industrialization.

Blackstone is the first to industrialize the combination of both technologies.

In addition to the actual production process, we also develop our production materials ourselves.

Business Strategy

Blackstone Resources

Based on:

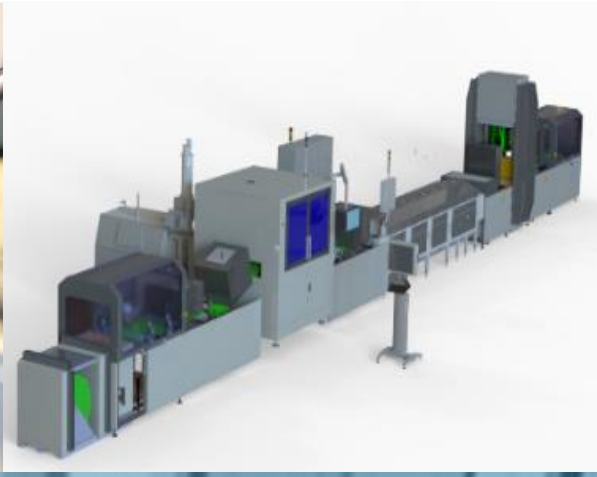
- Our own raw materials and resources
- proprietary printing paste formulation
- Disruptive 3D printing technology

Production of:

- Li-Ion electrodes and cells
- Solid-state batteries
- Solid-state electrolyte

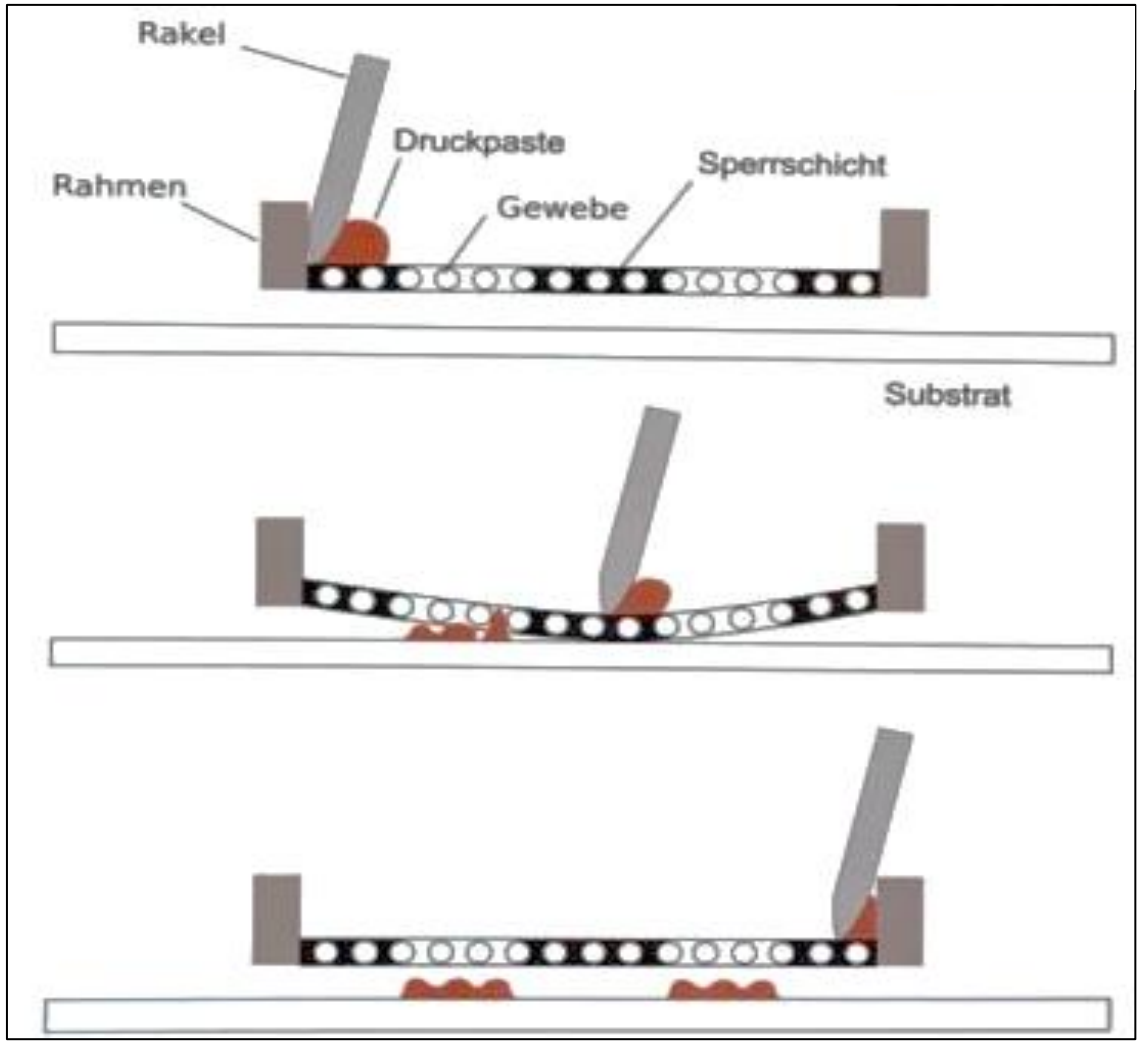
&

Licensing of production technology



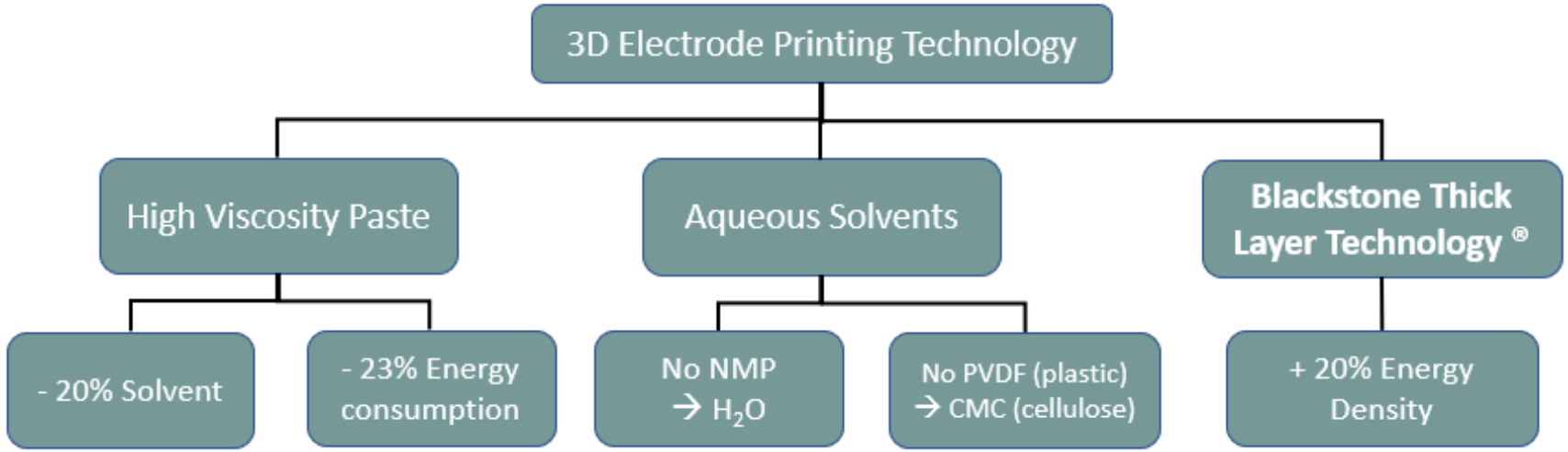
Advantages of Screen Printing

- Lower material consumption and 20% higher energy density (**Blackstone Thick Layer Technology®**)
- **Independence** from cathode material
- **Any geometry** can be printed within a single attachment
- Printing multi-layer battery cells with **higher voltage**
- Printing **embedded electronic** components (e.g. sensors)
- Manufacture of **3D battery structures**
- Printing of Battery **cell enclosures**



Environmental advantages

- Less Energy consumption
- Environment friendly
- Recycling friendly
- Improved Performance



Increase in energy density

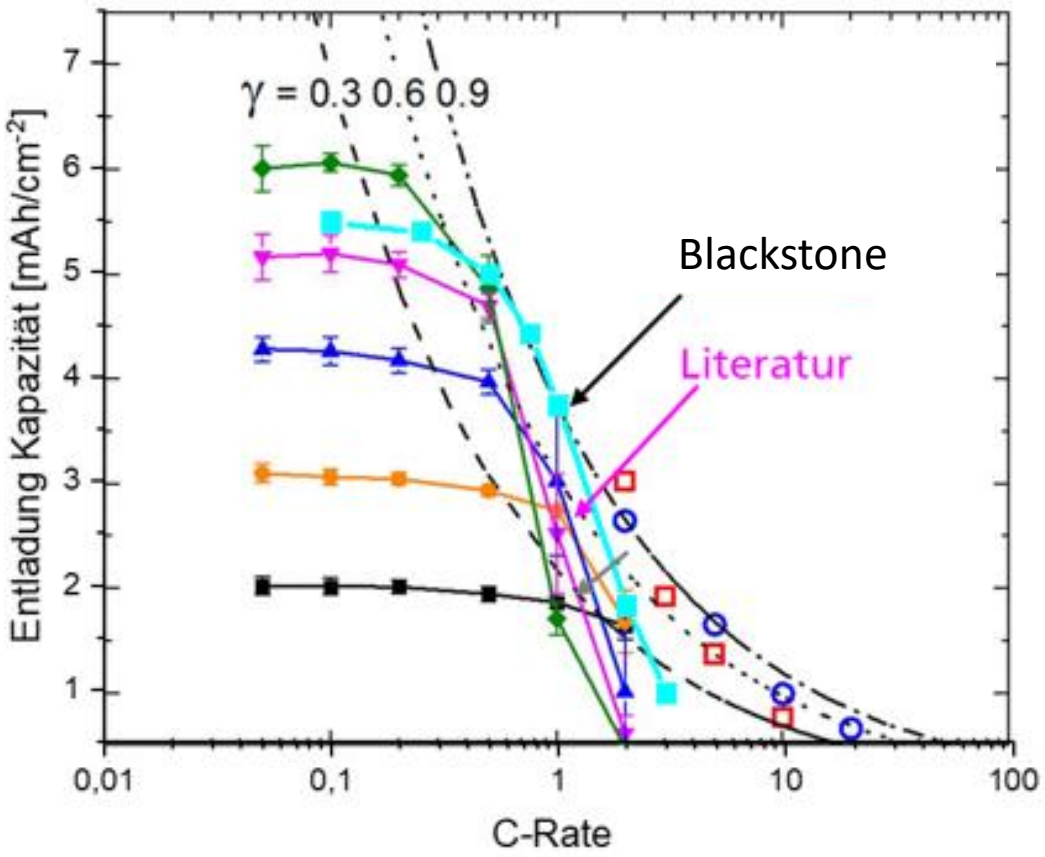
Best in Class

Blackstone 3D printing technology allows variable layer thicknesses.

Comparison of *Blackstone Thicklayer Technology®* electrode with conventional electrode leads to untypically high capacity with low retention at elevated C-rates

3D printing further allows for 3-dimensional structure of electrodes and therefore adjustable C-rate.

NMC622/C



Journal of The Electrochemical Society, **163** (2) A138-A149 (2016)

Savings & Benefits

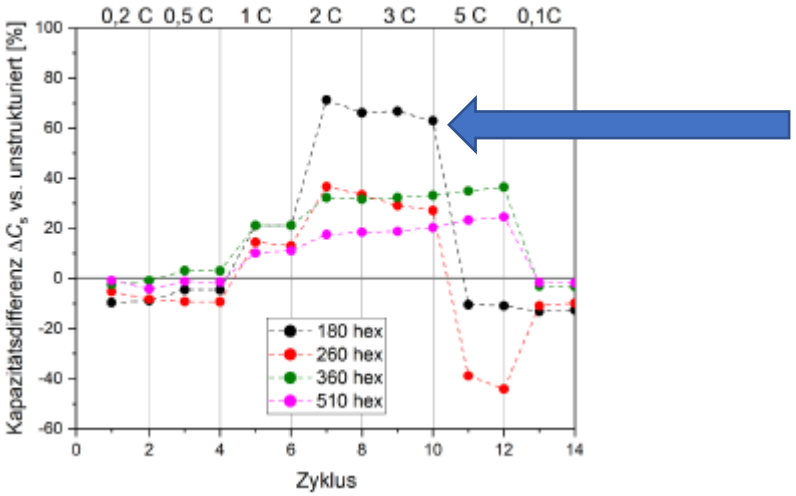
Blackstone Resources

3D-printing leads to

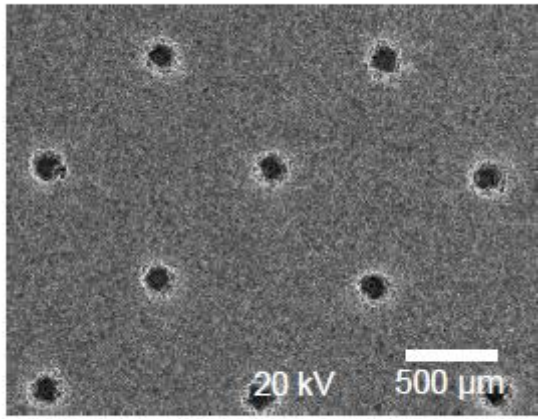
- significant improvement in energy density
- flexibility in shape and size
- additional features
- less inactive material
- higher performance

- Modification of electrodes in z-dimension (material and geometric)
- Same machines are used to
  - manufacture printed solid-state batteries
  - bipolar or unipolar electrodes
  - printed separator
- Sensors can be printed on the electrode
- Flexibility in shape and size (x, y, z)

etc.



Source: iPAT



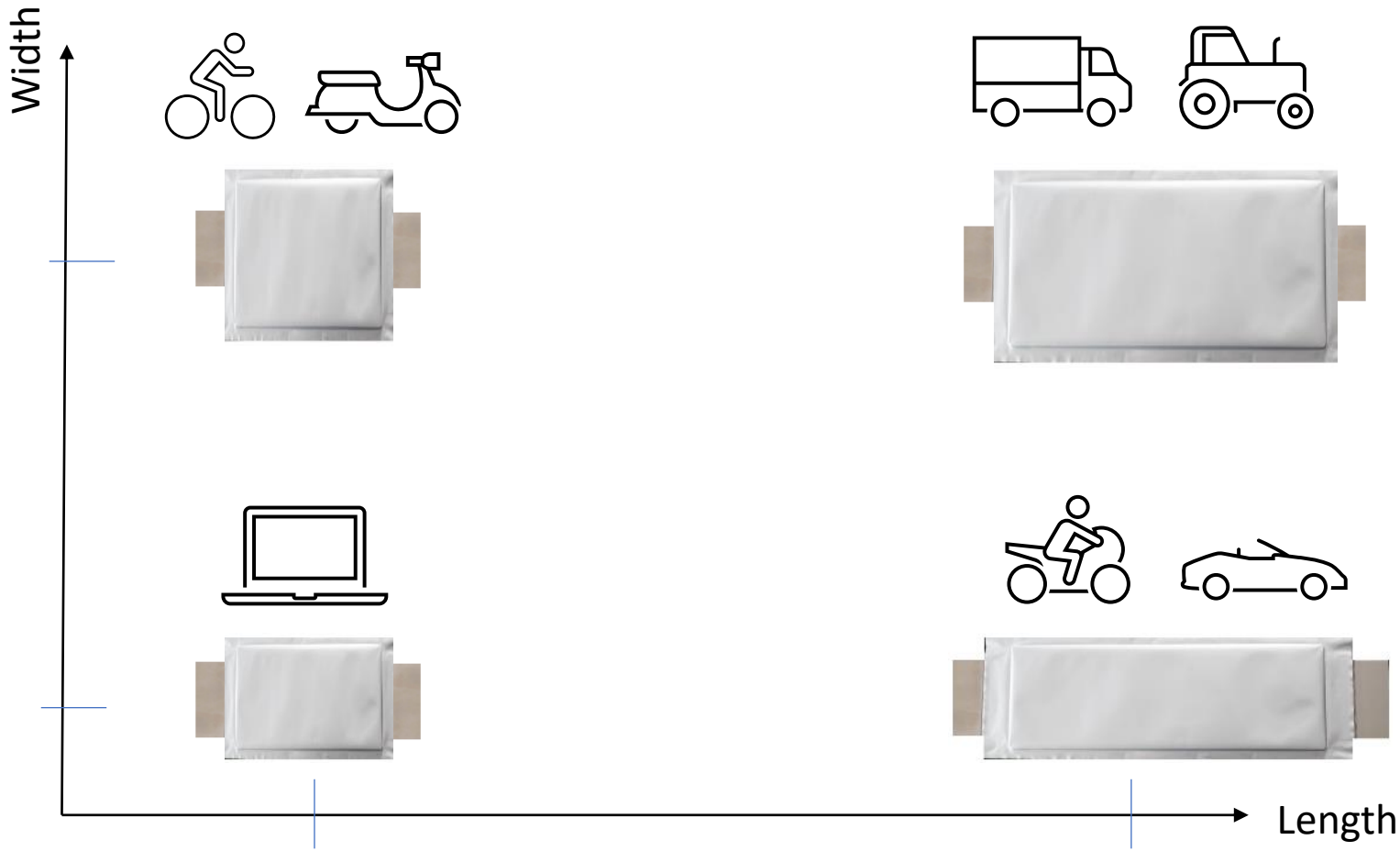
SEM image of a structured electrode

Flexibility

Different applications demand for different batteries and cells.

With our 3D printing technology, we are able to mass produce various and unconventional form factors on the same machines at fixed costs

Furthermore, we are able to alter the cell thickness as well as cell chemistry according to our customers need without major changes to our processes.



Solid state battery

Solid state battery

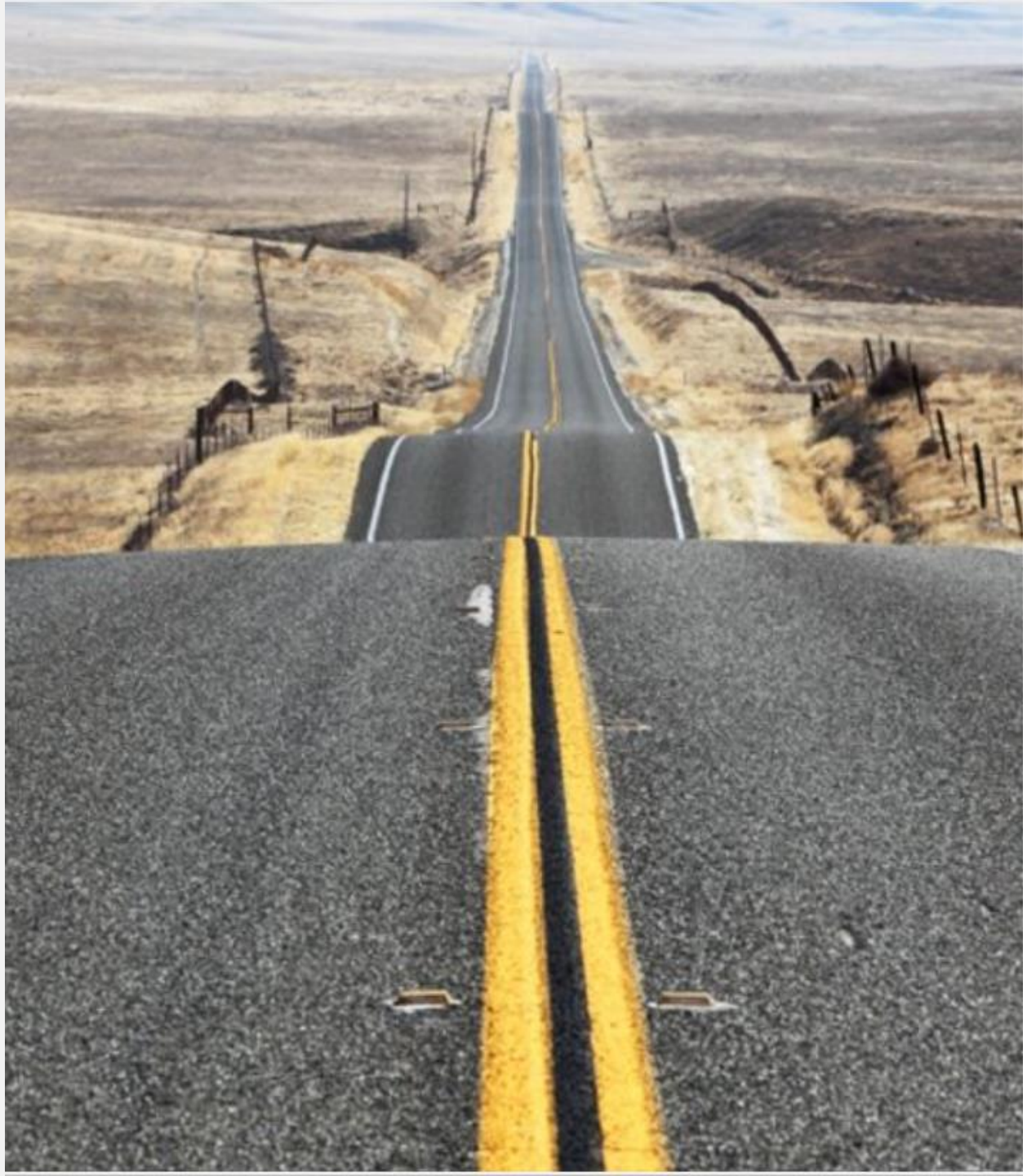
+ 70% energy (vol)

larger battery

100kWh -> 170kWh

longer driving distance

600km -> 1020km



Blackstone Resources

Achievements

- Proof of concept of 3D printed Solid State Battery (functional)
- Without additional support structure
- TRL (technical readiness level) 2-3 reached
- Project TRL 3 -7 started

Working lab demonstrator of a 3D printed all solid state battery

Development Project 3D printed Na-Solid State battery

Budget: 32.000.000€

Grants BST: 17.000.000€

Start: 03/2022

End: 02/2025

Consortium Leader:

Blackstone Technology

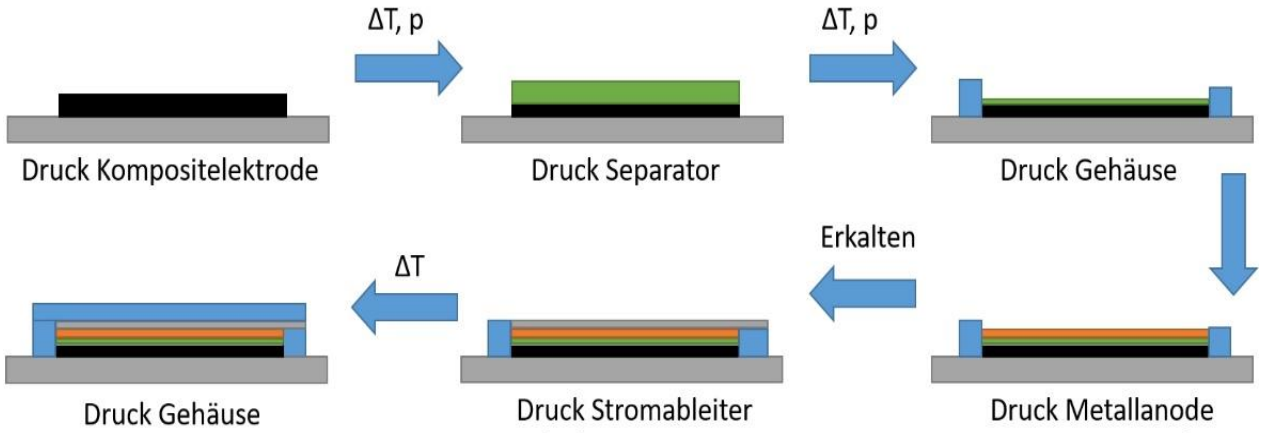
Partner:

FhG Institute IKTS, IFAM, IST

iPAT,

Zeiss, Eurabus,

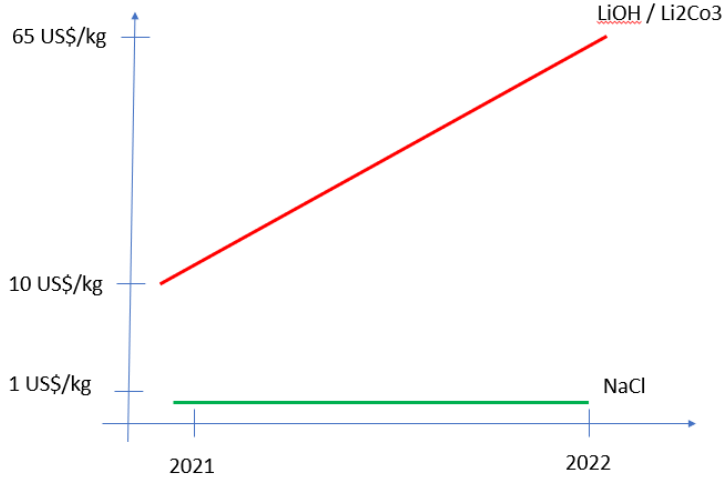
Quantron AG, Empa



Sodium (Na) instead of **Lithium (Li)**

1. Sodium occurs 1000 times more on earth than Lithium

2. Sodium costs only a fraction compared to lithium



Our Customers

Blackstone Resources

Our unique technological solution led to a first customer in marine application “Current Direct”.

Expressions of interest from all leading vehicle manufacturers in USA, Germany and France

EVs

E-Buses

Aerospace

Energy Storage Systems

Industrial Vehicles

Marine Applications

CURRENT DIRECT™

Awards

- **Green Product Award Winner 2022**

  THE AWARD FOR SUSTAINABLE PRODUCTS

- **German Innovation Award 2022 GOLD**

The German Innovation Award honors cross-industry products and solutions that differ from previous solutions primarily in terms of user-centricity and added value.


Blackstone
Technology

We look forward to working with you!

Shaun White
Current Direct – Technical Project Manager
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CURRENT DIRECT™ Revolutionize the way we move goods and people by water with the use of swappable containerized batteries connected to an Energy as a Service Platform

www.currentdirect.eu

www.linkedin.com/company/currentdirect

The Current Direct project is funded by the European Commission's Horizon 2020 program. Grant number 963603.