



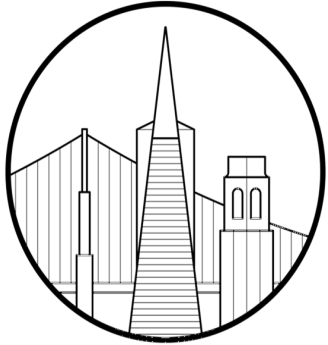
# Next-gen batteries powering the future of mobility

Bruno Vanzieleghem

© 2021 by Cuberg

Published by The Aerospace Corporation with permission





## Based in Silicon Valley

---

- + Cuberg spun out of the Stanford battery research program in 2015
- + Our team is based in the East Bay and deeply connected to the battery innovation community in and around the San Francisco Bay Area



## Lithium Metal Technology

---

- + Cuberg batteries combine a lithium metal anode and advanced cathode with novel electrolytes enabled by deep materials innovation and advanced cell engineering, to deliver outstanding performance



## Next gen mobility

---

- + The range of applications for better batteries is huge and growing
- + Our team has focused on addressing the needs of next gen mobility, where the outstanding performance of our technology will have the biggest impact in the near term



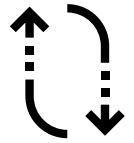
- 
- + Cuberg will serve as the Advanced Technology Center for Northvolt in Silicon Valley, driving materials research and development for best-in-class lithium-ion anode and electrolyte technologies
  - + Cuberg is focused on developing next generation battery technologies, principally focused on liquid electrolyte lithium metal cells
  - + Cuberg will lead pilot scale production of next gen batteries, focused on aviation and mobility applications



- 
- + Northvolt AB, headquartered in Stockholm, is a global battery manufacturer
  - + Since its founding in 2016, Northvolt has raised over \$3B in capital, and has combined order volumes of over \$13B
  - + Northvolt is currently building a Gigafactory in Sweden, aiming to bring >40GWh of production online by 2025
  - + Northvolt manufactures batteries to support its automotive, industrial, storage, and power tool customers

**Cuberg and Northvolt will collaborate to produce next gen batteries, combining innovation and scale in a unique way**

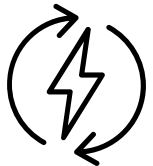
# Northvolt's unique business model and value proposition



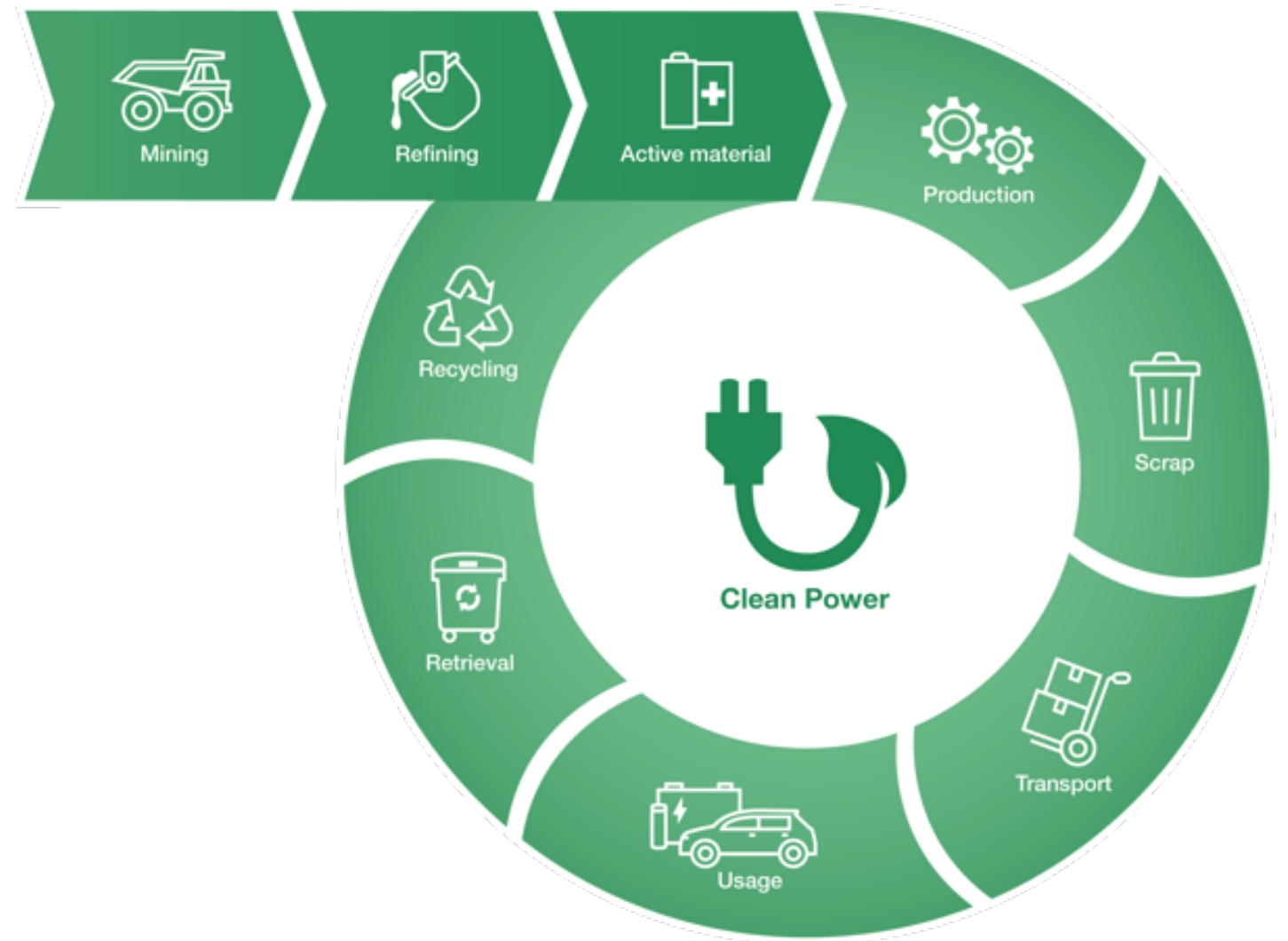
Vertical integration



European advantage



World's greenest battery



# Cuberg brings together critical capabilities for driving battery innovation

## **World class R&D team**

---

- + Cuberg's R&D team brings diverse material science and battery engineering backgrounds to tackle the challenge of lithium metal

## **Deep manufacturing expertise**

---

- + Commercializing next gen batteries requires the robust manufacturing expertise – our team understands how to build and scale production in high growth environments

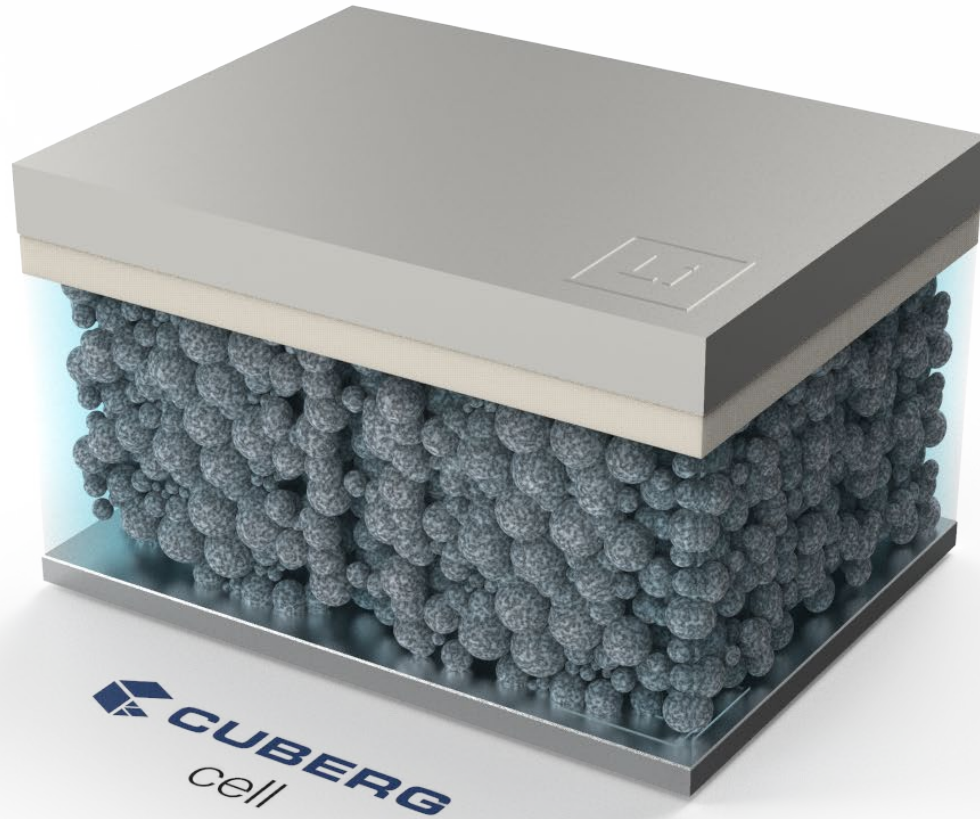
## **Supported by machine learning**

---

- + In order to accelerate the pace of innovation, Cuberg is deploying advanced machine learning tools across materials development and battery lifecycle testing

The Cuberg team is ~35 strong, and growing at 25% per quarter

# The Cuberg battery: A high performance design



- + High performance, scalable architecture:
  - + Energy dense lithium-metal anode, providing exceptional specific energy and power
  - + Proprietary non-flammable electrolyte to stabilize high energy anode and enable long cycle life
- + Cuberg manufactures 5-Ah pouch cells
  - + Scalable production process built on existing Li-ion battery manufacturing processes
  - + Prototype samples available now
- + We design around your application, and can grow with your team's needs

# Our focus: Enabling electric aviation

	Q1 2021	Q4 2021
<i>Range</i>	370 Wh/kg	370 Wh/kg
<i>Payload</i>	>2,000 W/kg	>3000 W/kg
<i>Cycle Life</i>	>370 cycles	500 cycles
<i>Max Charge rate</i>	C/2	1C
<i>Safety</i>	Meet FAA/EASA requirements	

All our current performance metrics have been **independently verified** by the US Department of Energy

# Our focus: Development goals

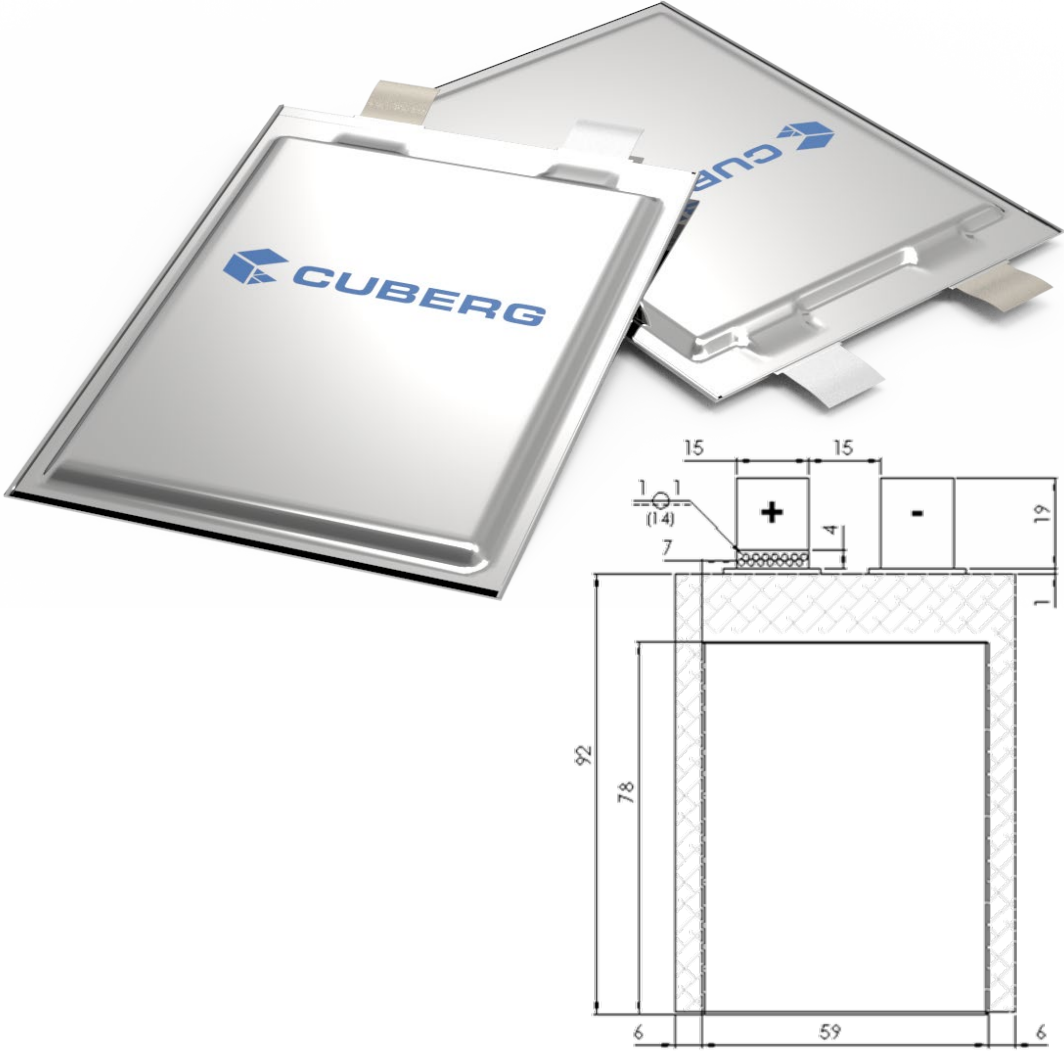
<i>Cycle Life</i>	Improved electrolytes
<i>Max Charge rate</i>	Improved cell materials
<i>Safety</i>	Improved cell engineering



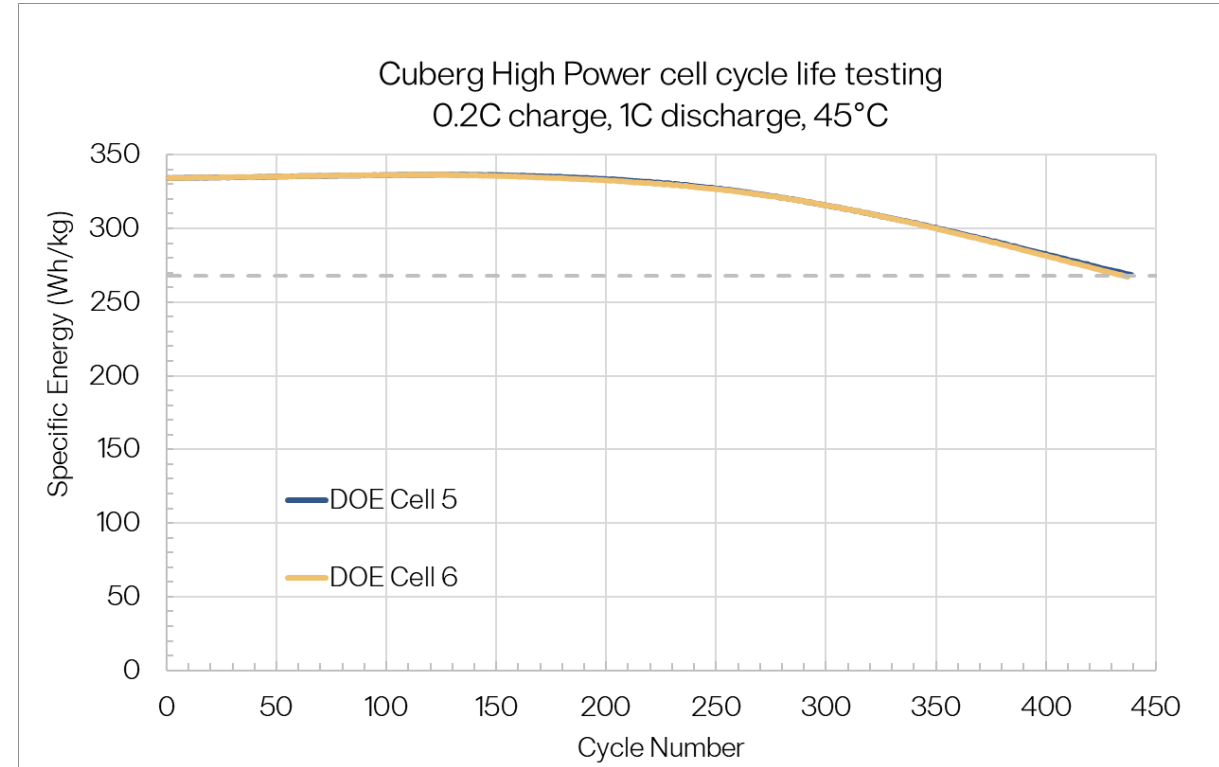
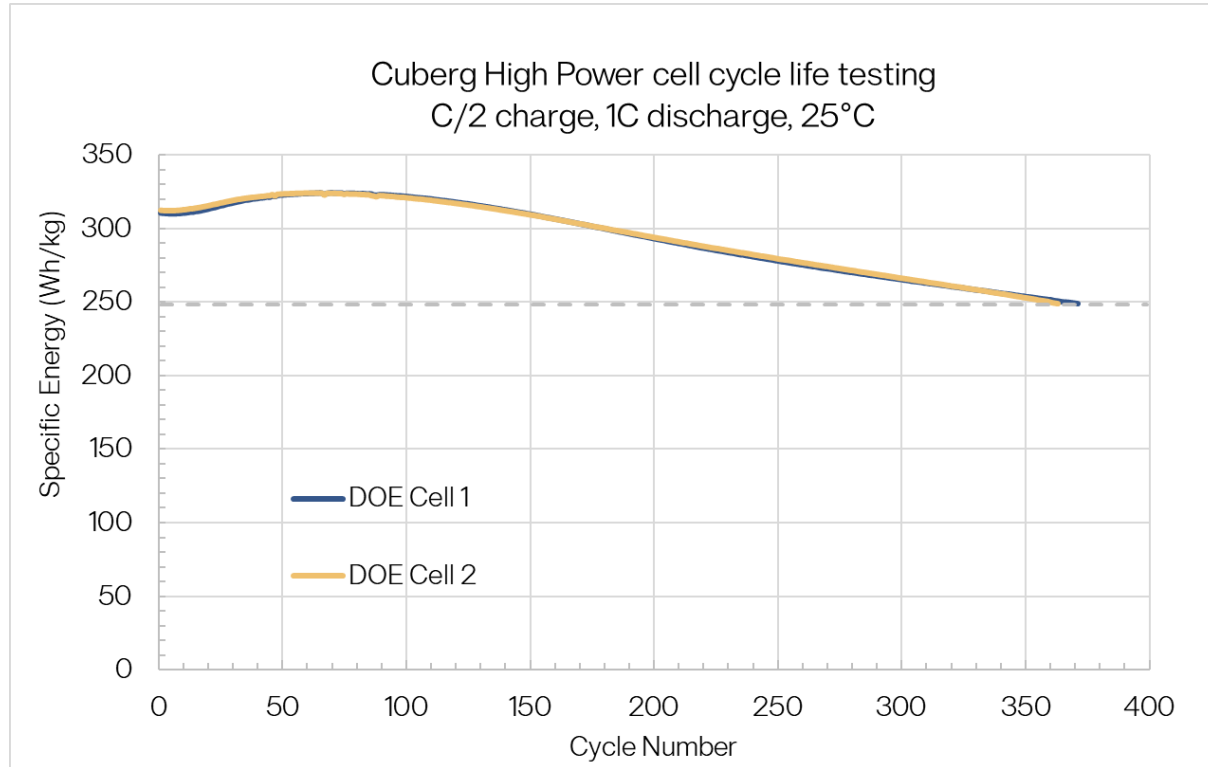
# Cuberg cells: Ideally suited for high performance applications

## Key Specifications (at 25 deg C)

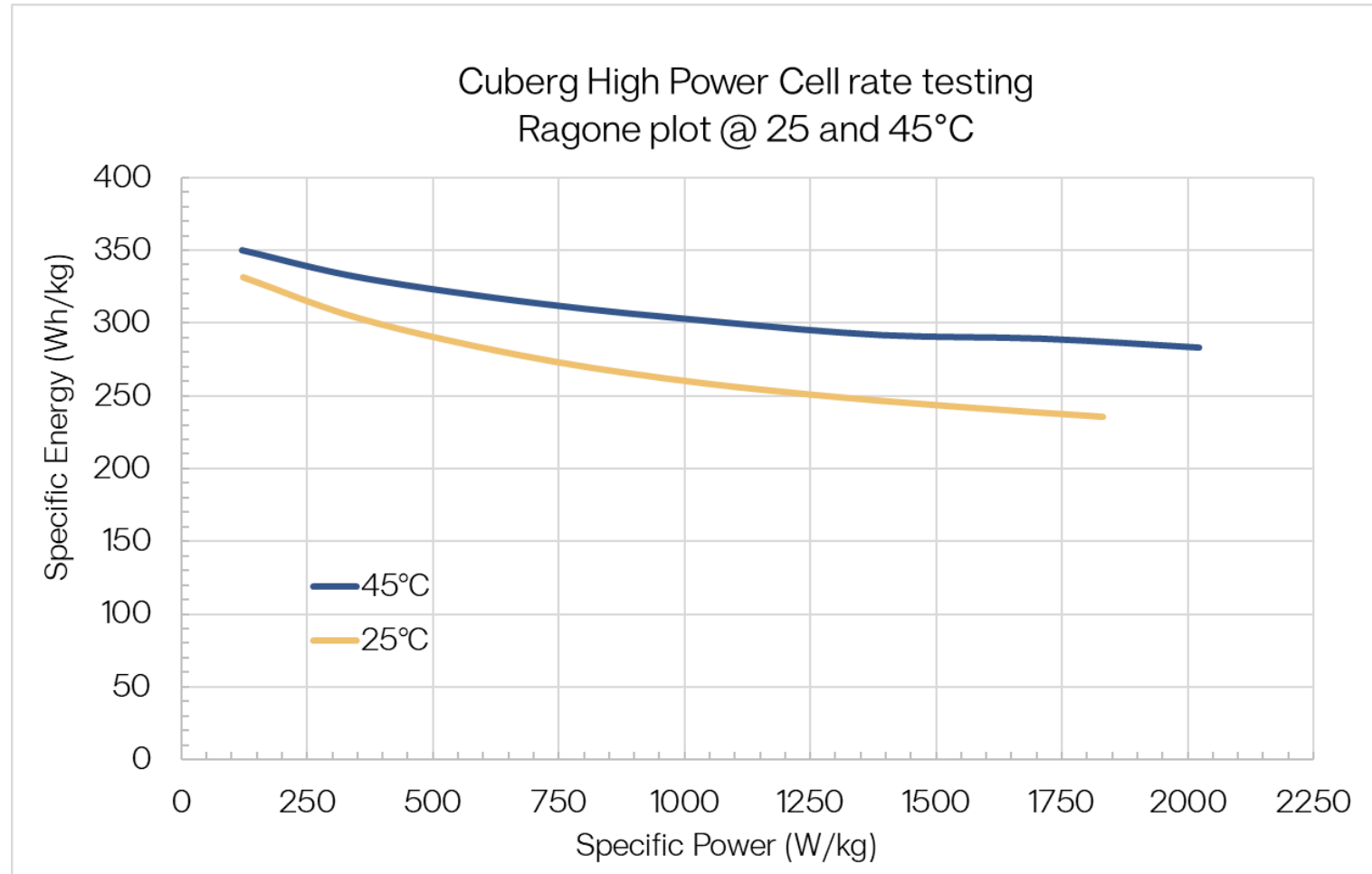
Cell Energy	19.4	Wh
Cell Capacity	5.1	Ah
Nominal Discharge Voltage	3.8	V
Max. Constant Discharge Current	40	A
Max. Constant Charge Current	5	A
Nominal Energy Density	660	Wh L <sup>-1</sup>
Nominal Specific Energy	370	Wh kg <sup>-1</sup>
Cycle Life (>80% initial capacity)	370+	cycles



# Cuberg cells: Independently validated performance



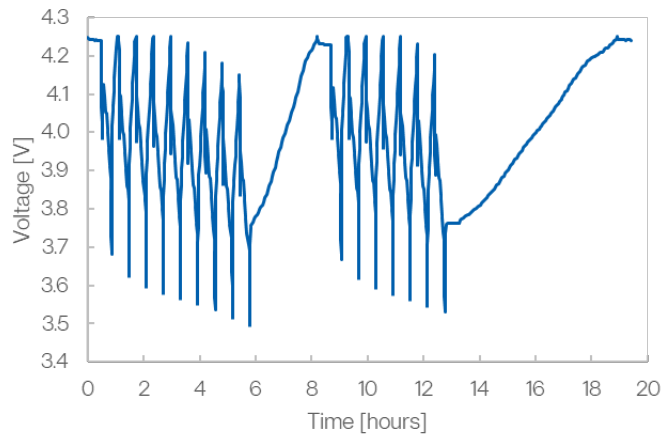
# Cuberg cells: Independently validated performance



# Cuberg cells: Profile testing - eVTOL

## + Simulated air taxi use case

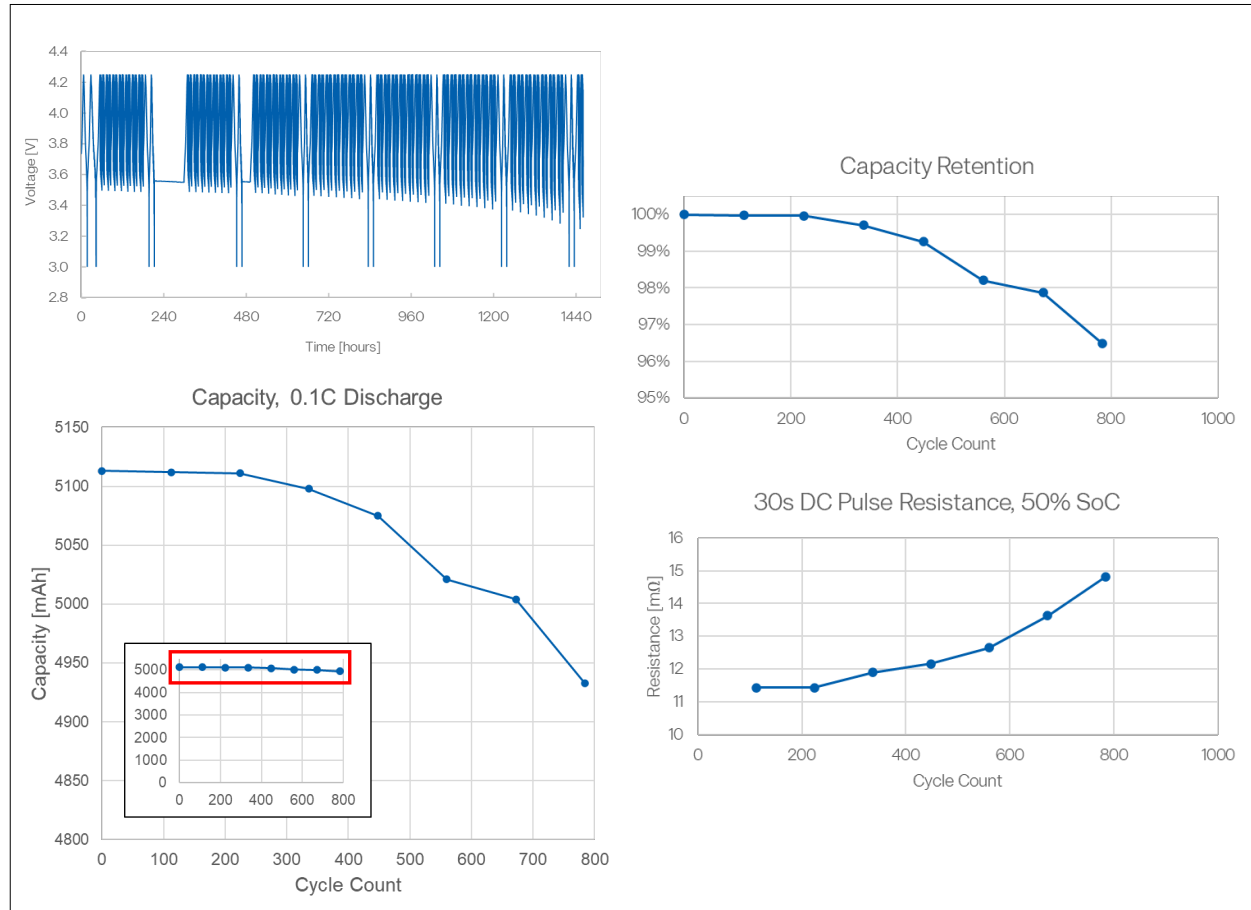
- + Multiple flights/day
- + Fast charging at stops during loading/unloading
- + Midday/overnight charges
- + Diagnostic cycles run after each simulated week



Flight Cycle		
Flight Profile	Time [min]	Power [W]
	0.5	76
	20	19
	0.5	76
Rest	30 seconds	
Fast Charge	15 minutes	
Rest	30 seconds	

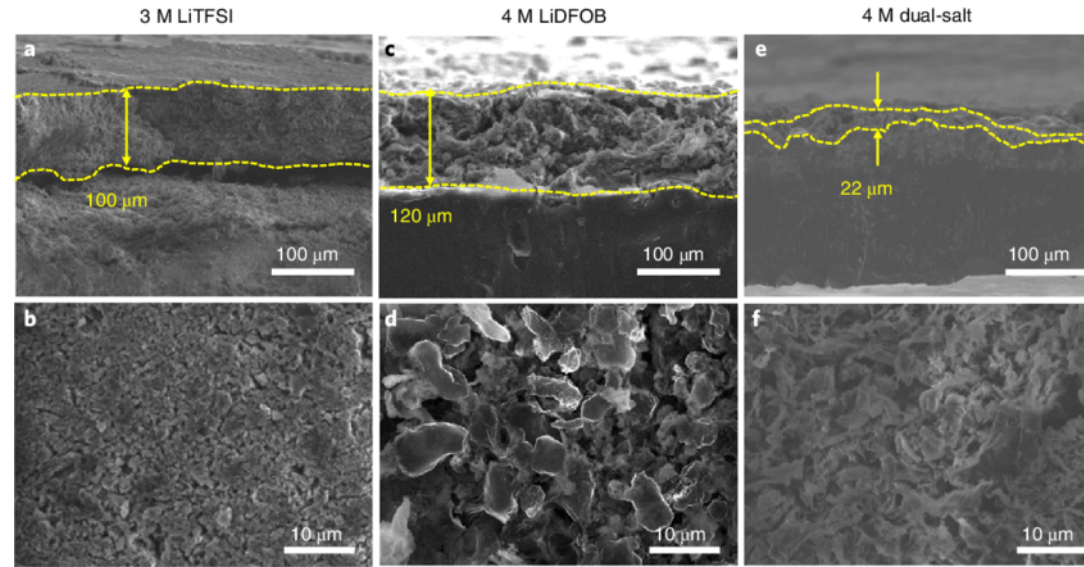
Charge Parameters			
Charge	Type	Current [A]	C-Rate
Fast	CCCV	7.4	1.45C
Midday	CC	1.28	0.25C
Overnight	CC	0.51	0.1C

+ 800+ cycles completed successfully



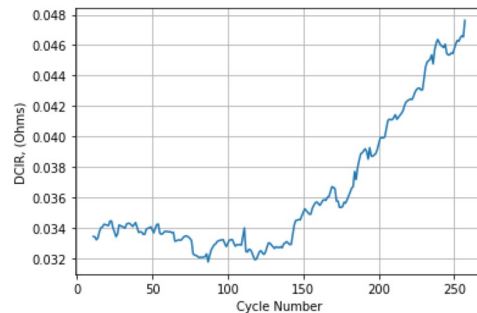


# Cuberg cells: Failure modes

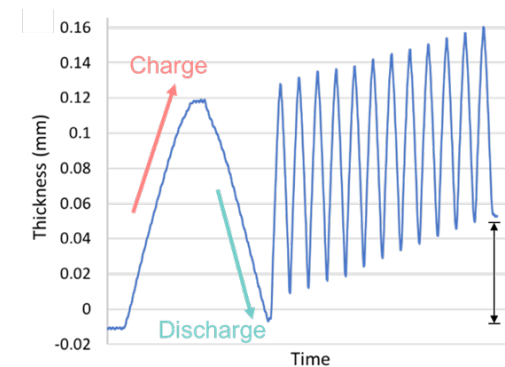
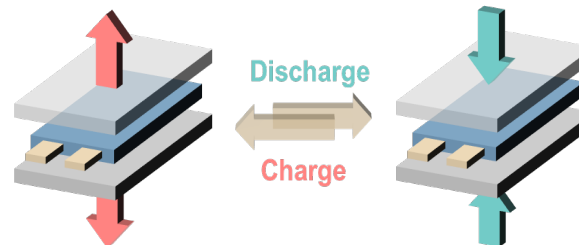


Jiao, Shuhong & Ren, Xiaodi & Cao, Ruiguo & Engelhard, Mark & Liu, Yuzi & Hu, Dehong & Mei, Donghai & Zheng, Jianming & Zhao, Wengao & Li, Qiuyan & Liu, Ning & Adams, Brian & Ma, Cheng & Liu, Jun & Zhang, Ji-Guang & Xu, Wu. (2018). Stable cycling of high-voltage lithium metal batteries in ether electrolytes. *Nat. Energy*. 3. 10.1038/s41560-018-0199-8.

Resistance increases as cell cycles

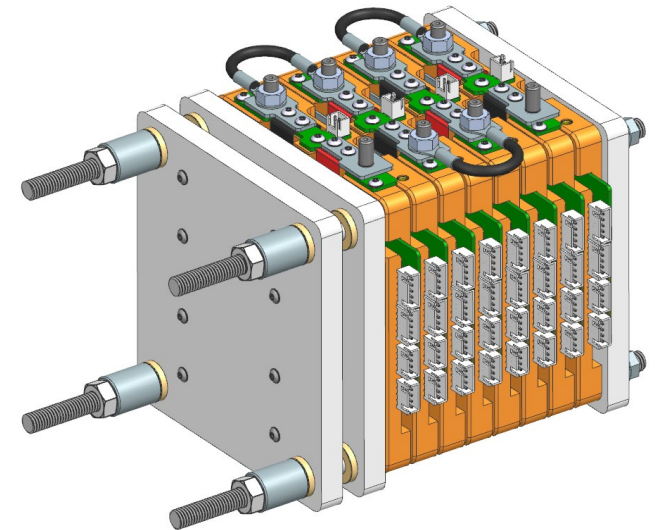


Resistance caused by thickness growth (Lower power, shorter cycle life)



# Cuberg battery pack integration

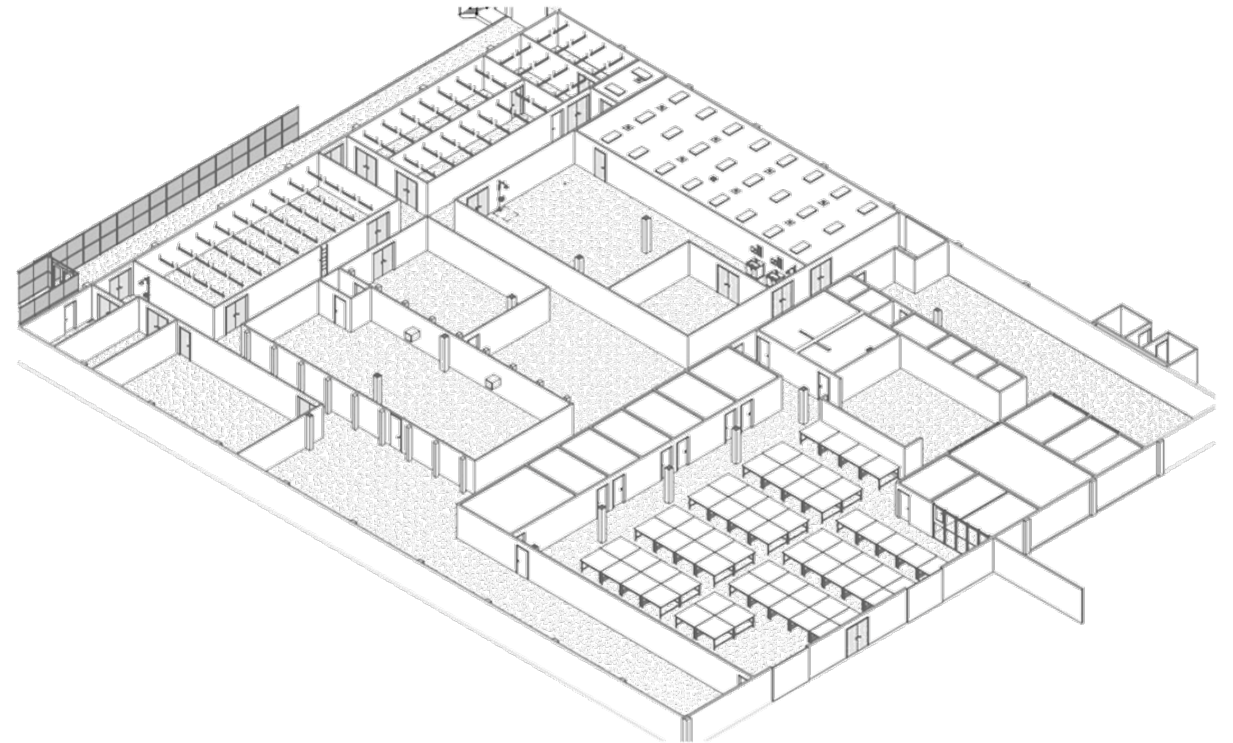
- + Partnering with expert battery pack integrators to design, build, and test modules for electric aviation applications
- + **Current development efforts:**
  - + Prototyping small modules (e.g. 4S2P)
  - + Performance and thermal testing to understand cell behavior in series/parallel
  - + Propagation testing to inform cell design decisions
  - + Cell characterization for BMS development (SOC/SOH estimation)
- + **Main technical challenges:**
  - + 40psi stack pressure while maintaining lightweight advantage of cells
  - + Prevent propagation to neighboring cells if one cell enters thermal runaway
- + **Goal:**
  - + >300 Wh/kg at module-level
  - + Meet DO-311A/EASA abuse tests



# Cuberg is rapidly expanding infrastructure

## + New 30,000 sq ft facility under construction

- + Production capacity of 1,000 cells per week by end of 2021, continuing to increase
- + Cycling channel capacity increasing to 2,000 by Q3 2021
- + Extensive in-house safety testing (50 cells/week)





# Cuberg powers your future mobility challenge

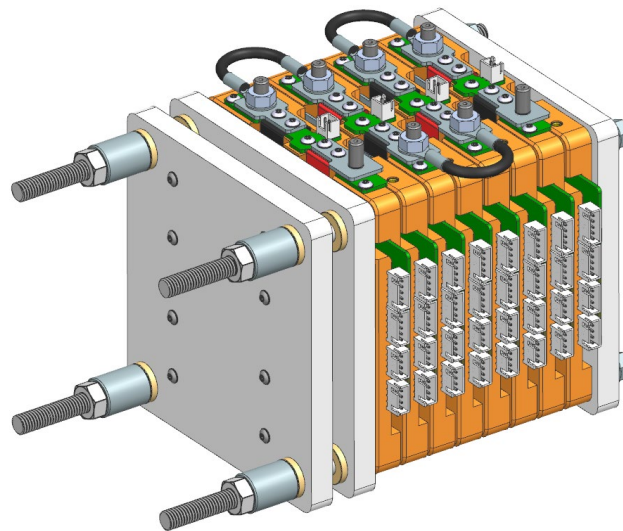
## Cuberg cells

- + 5 Ah cells available for testing today
- + Cuberg experts evaluate testing plans
- + In-house customer profile testing



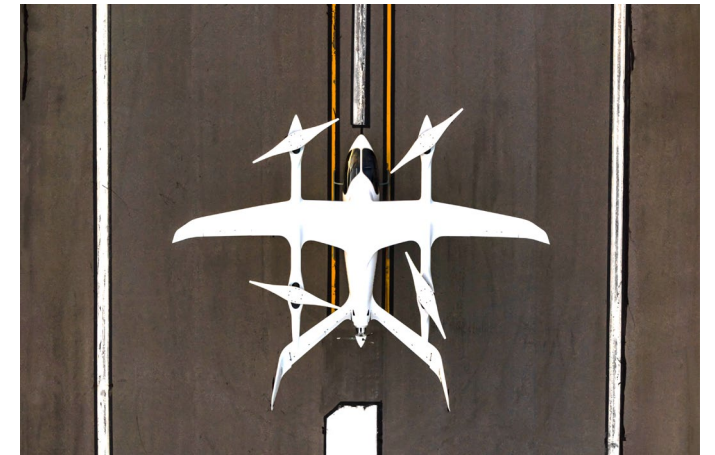
## Cuberg module/pack

- + Design and build module and pack solution
- + Custom cells to suit your application
- + Designed to meet certification requirements



## Next steps

- + What is your application?
- + What is your project timeline?
- + What kind of production volumes do you envision?







## Production Expertise

- + The Northvolt partnership provides the needed expertise to ensure successful production scale up of the Cuberg battery
- + Northvolt Ett
  - + 40+ GWh Gigafactory
  - + First SOP 2021

## World's greenest battery

- + CO2 free energy
- + Vertical integration allows for more efficient supply chain and traceability
- + Connected battery infrastructure offers real time monitoring of battery performance and health

## Battery systems

- + 100+ team developing energy storage systems
- + Applications in stationary energy systems, heavy equipment battery packs, etc.
- + \$200 million expansion announced 02/2021





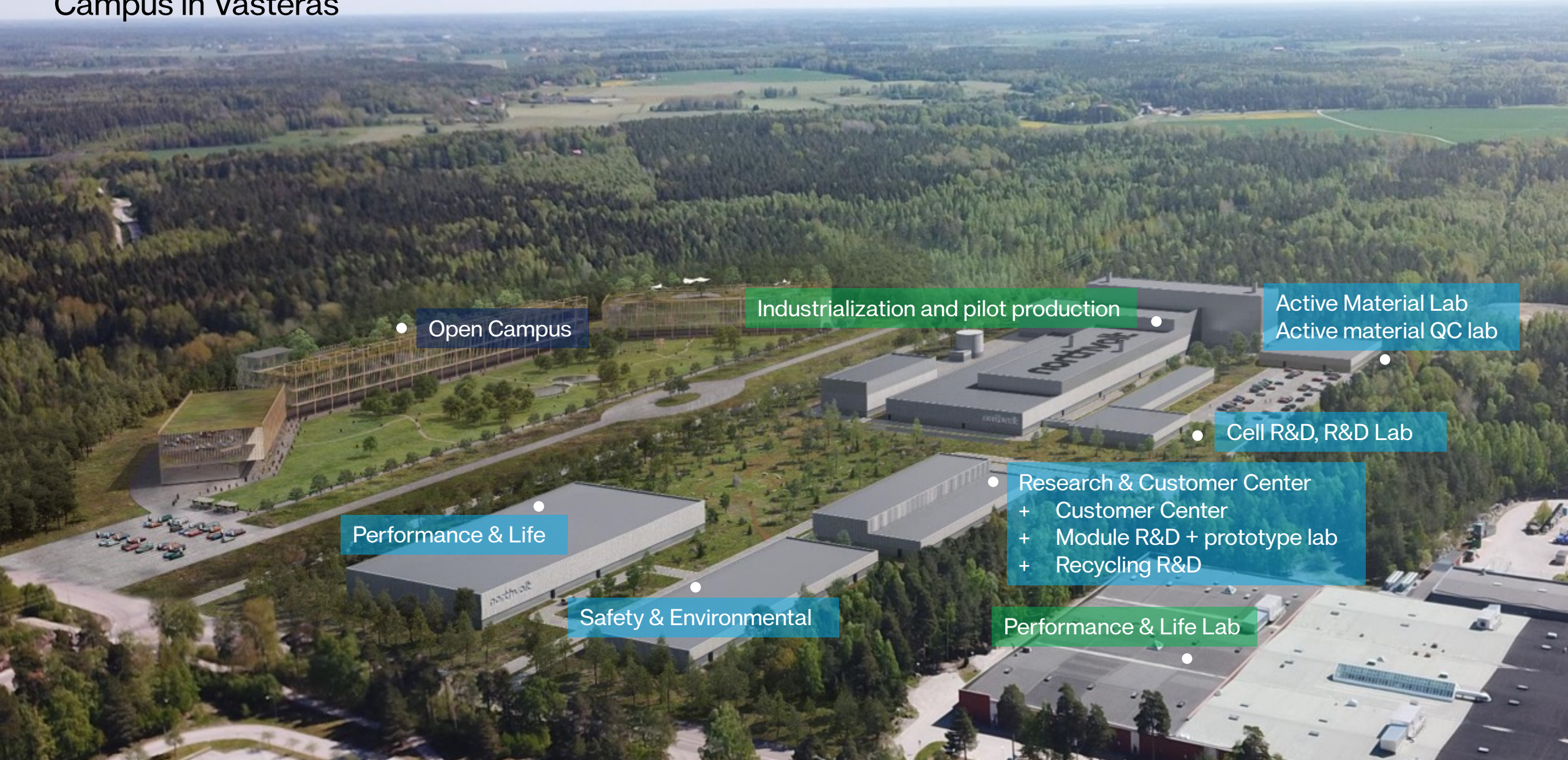
# Northvolt Labs – inbuild collaboration

Campus in Västerås

Labs 1.0

Labs 2.0

Labs 3.0



• Open Campus

Industrialization and pilot production

Active Material Lab  
Active material QC lab

• Cell R&D, R&D Lab

• Research & Customer Center  
+ Customer Center  
+ Module R&D + prototype lab  
+ Recycling R&D

• Performance & Life

• Safety & Environmental

• Performance & Life Lab



# Applied R&D for a clean energy future

## A passionate, diverse, and mission-oriented team

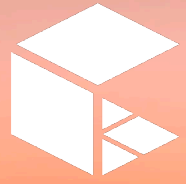
Are you passionate about making a positive impact through technology? We're looking for talented professionals who want to join a unique group of people in building a better world. We have an exciting opportunity to make a lasting impact in the battery industry, combining the agility and innovative culture of a Silicon Valley startup with the scale and capabilities of a world-class manufacturer. If you're interested in a position listed below, please don't hesitate to apply. If you don't see a position that matches your profile, you are welcome to apply under General Opportunity.

We hire great people from a wide variety of backgrounds and from all walks of life because it strengthens us as a company. If you share our values and our enthusiasm for building a better world, you will find a home at Cuberg.



## Open positions

<b>Process Engineer</b> Emeryville, California, United States.	<b>Production Technician</b> Emeryville, California, United States.	<b>Scientist</b> Emeryville, California, United States.
<b>Analytical Scientist</b> Emeryville, California, United States.	<b>Research Associate</b> Emeryville, California, United States.	<a href="#">View All</a>



**CUBERG**

Thank you

[www.cuberg.net](http://www.cuberg.net)