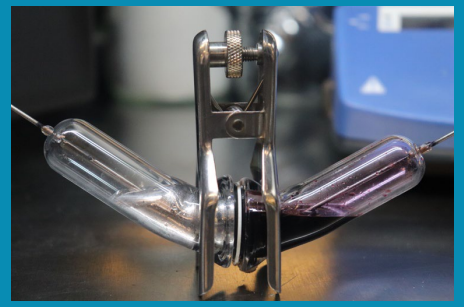
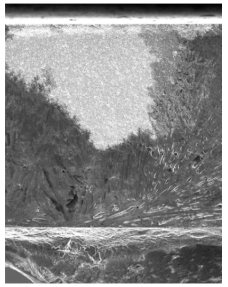
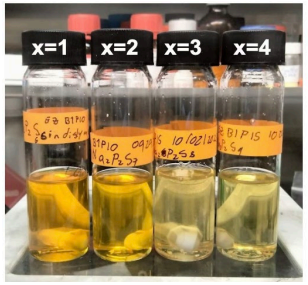
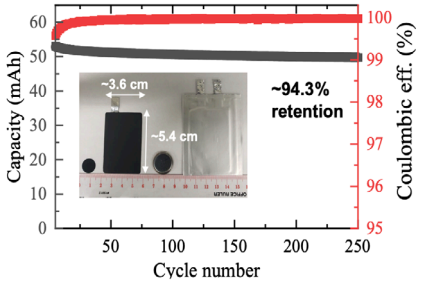
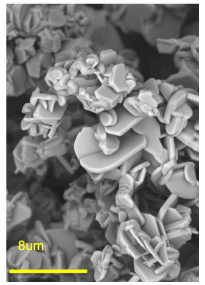
Sodium-Based Batteries











PRESENTED BY

Erik D. Spoerke, Ph.D.

Presentation ID: 400

DOE Office of Electricity Peer Review 2023
October 24-26, 2023

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Sodium Batteries Overview

Sodium (Na) is >1000X more abundant than Lithium – just in the Earth's crust

- 6th most abundant element in Earth's crust and 4th most abundant in the oceans
  - 93% of soda ash (Na_2CO_3) reserves are in the U.S. (Hirsh, et al. Adv. Energy. Mater., 2020, 10(32), 202001274.

Sodium Metal Anode (e.g., Molten Sodium)

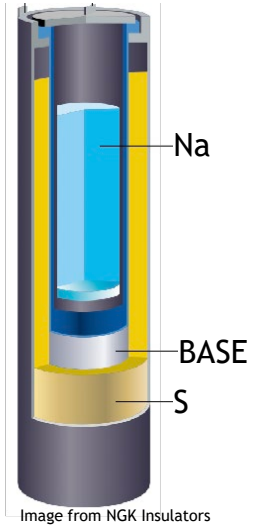


Image from NGK Insulators

"Mature" High-Temperature NaS and Na-$NiCl_2$ deployments support:

- Renewables Integration
- Grid Services
- Microgrids
- Behind-the-Meter Applications
- Select Mobility

BASF We create chemistry

NGK INSULATORS

FZSoNick

Emerging systems show promise

- Low-temperature molten salt
- Molten Na flow batteries
- Solid State Na batteries

INLYTE ENERGY

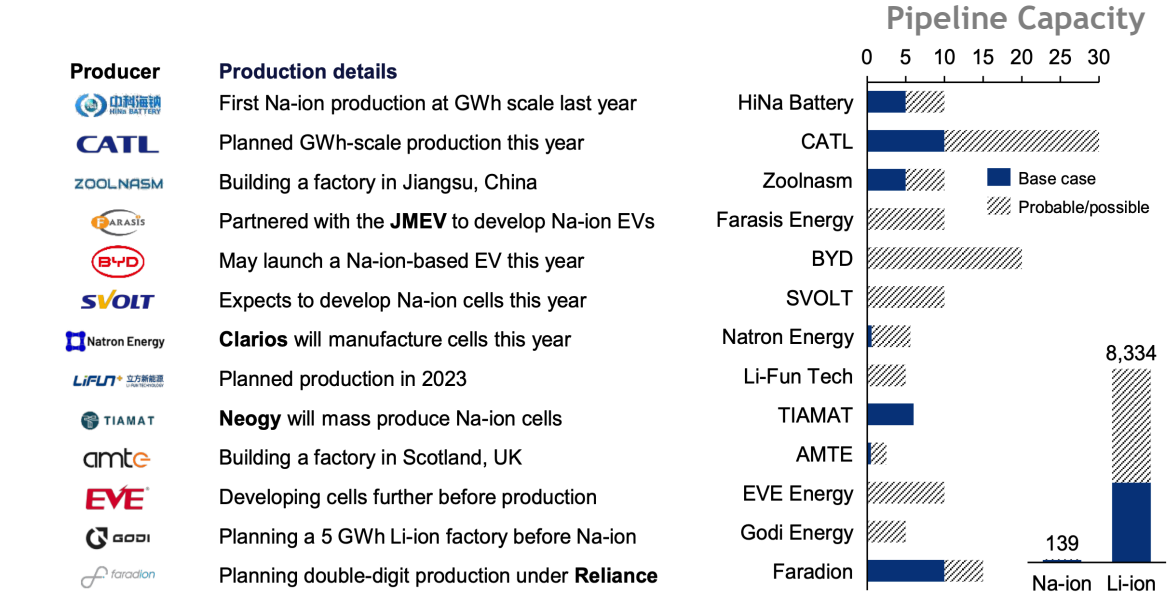
ENLIGHTEN®

LiNa Energy

ADENA POWER

Sodium Ion Batteries (NaIBs)

Producer	Production details
中科海钠 HINA BATTERY	First Na-ion production at GWh scale last year
CATL	Planned GWh-scale production this year
ZOOLNASM	Building a factory in Jiangsu, China
FARASIS	Partnered with the **JMEV** to develop Na-ion EVs
BYD	May launch a Na-ion-based EV this year
SVOLT	Expects to develop Na-ion cells this year
Natron Energy	**Clarios** will manufacture cells this year
LiFUN 立方新能源	Planned production in 2023
TIAMAT	**Neogy** will mass produce Na-ion cells
amte	Building a factory in Scotland, UK
EVE	Developing cells further before production
GODI	Planning a 5 GWh Li-ion factory before Na-ion
faradion	Planning double-digit production under **Reliance**



Immature technology/manufacturing has limited demonstrations and deployments. Significant NaIB manufacturing capacity is projected to 40-100 GWh by 2030.

Natron High-Power, High Cycle Life Prussian Blue NaIBs are used for "critical power applications.

Faradion NaIBs deployed for 10kW stationary-storage demonstrations.

Solstice: A Collaborative Approach to Na-Zn Batteries

SOLSTICE

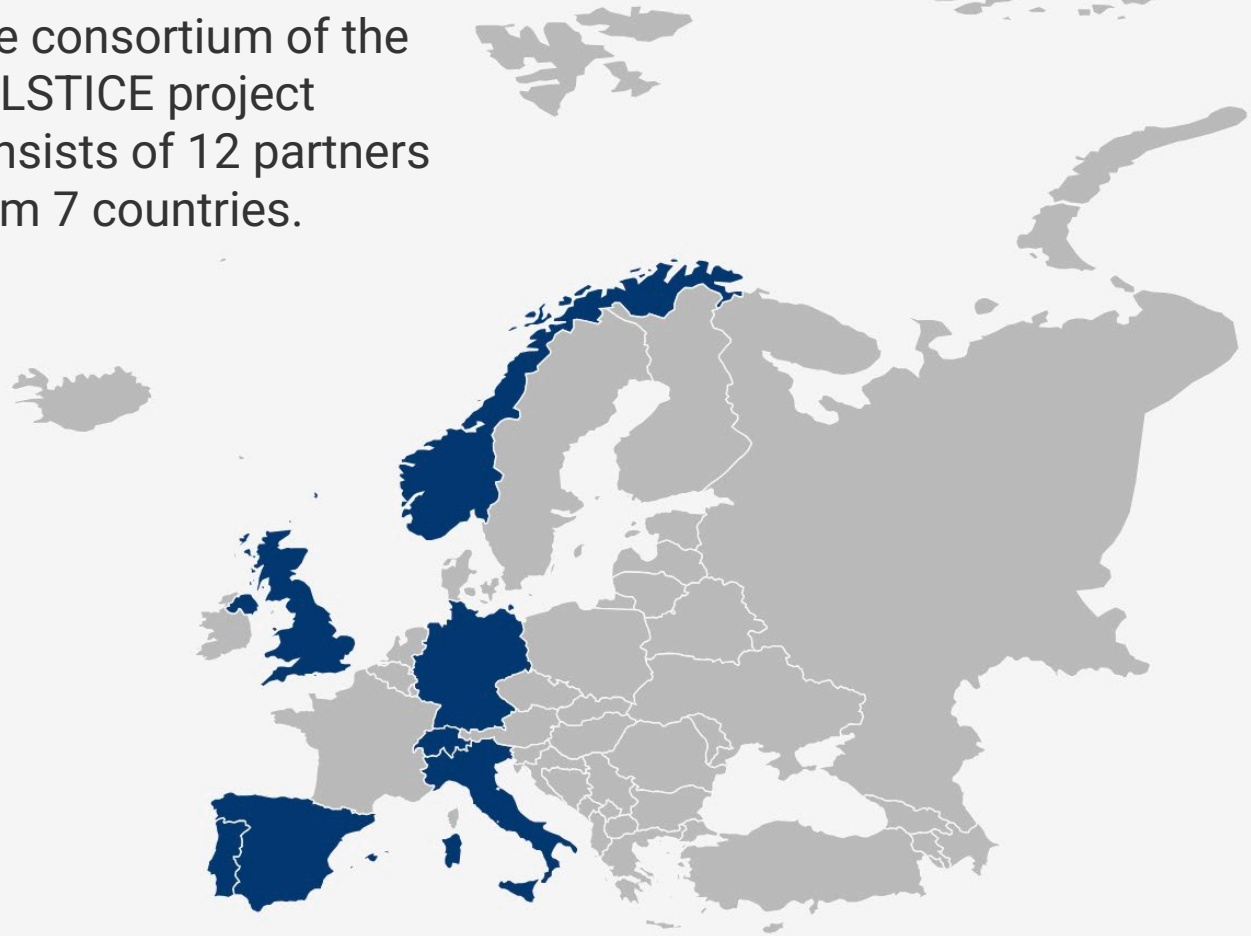
Sodium-Zinc molten salt batteries for low-cost stationary storage

SOLSTICE will develop two types of Na-Zn cells sharing the same basic chemistry:

1. An all-liquid Na-Zn cell that operates at about 600 °C

2. A solid electrolyte Na-Zn cell akin to a classical ZEBRA® cell with a working temperature of ca. 300 °C and using a Na-β“-alumina ceramic as ion conductor

The consortium of the SOLSTICE project consists of 12 partners from 7 countries.



Broader Collaboration Around Sodium with NAATBatt!

Sodium Battery Committee

This committee studies developments in the emerging field of rechargeable sodium-based batteries. The committee will follow scientific developments in sodium battery chemistry and architecture and the use of sodium-based batteries in stationary and mobile commercial applications. The use of sodium as a viable alternative or supplement to lithium and lead in battery systems will be examined and discussed.

Current chairs: Erik Spoerke, Sandia National Laboratories; Jack Pouchet, Natron

JOIN THIS COMMITTEE

https://events.naatbatt.org/

https://naatbatt.org/join-a-committee/

Opportunities for Sodium Batteries

	R&D Technical Innovations	Non-Technical Advances
Flight Paths Listening Session (NaS, NaMH, SSSB, NaIBs)	• Cathodes • Electrolytes • Power Electronics/Integration • Manufacturing Advances • Lower Temperature	• Battery Ecosystem Development (Supply Chain, Manufacturing, End of Life, Workforce) • Education (Public Relations for Na Batteries) • Na-Specific Codes, Standards, Requirements, and Validation (not force-fit to Li-ion) • Demonstrations/Testing/Validation Resources • Lifecycle Analyses
Framework Study (NaIBs only)	• Cathodes • Electrolytes • In-Operations Materials R&D • Anodes • Controllers/Battery Management Systems	• High-Volume Manufacturing • Multi-Scale Demonstration Projects • Lifecycle Analyses

Storage Innovations 2030
https://www.energy.gov/oe/storage-innovations-2030

A Preview of What's to Come

Time	Session Topic	Presenter	Organization	Presentation ID
8:50 – 8:55am	Sodium-Based Batteries	Erik Spoerke	Sandia National Laboratories	400
8:55 – 9:10am	Low Temperature Molten Sodium Batteries	Leo Small	Sandia National Laboratories	401
9:10 – 9:20am	Shorting in Solid Electrolytes for Long Duration Sodium Batteries	Ryan Hill and Y-T Cheng	University of Kentucky	402
9:20 – 9:35am	Intermediate Temperature Sodium Battery Technologies	Guosheng Li	Pacific Northwest National Laboratory	403
9:35 – 9:50am	Nonaqueous Sodium-Based Catholytes for Redox Flow Batteries	Ethan Self	Oak Ridge National Laboratory	404
9:50 – 10:05am	Sodium Ion Batteries	Xiaolin Li	Pacific Northwest National Laboratory	405
10:05 – 10:20am	Scalable Method to Produce Sodium Manganese Nickel Iron Oxide Cathode Active Material	Kris Pupek	Argonne National Laboratory	406
10:20 –	Q&A			

Please Don't Miss the Posters!

Sodium Batteries

Title	Author	Title
Sodium Solid Electrolyte Battery Development	Neil Kidner	Adena Power
Towards Sustainable High-Performance Sodium- Ion Battery Cathodes	Marcos Lucero	Pacific Northwest National Laboratory
Molten Salt Speciation Affects Electrochemistry and Battery Cycling: Raman Spectroscopy and Modeling Analysis	Stephen Percival	Sandia National Laboratories
Current State of NaSICON for Molten Sodium Batteries	Amanda Peretti	Sandia National Laboratories
Low Temperature Molten Sodium Batteries	Leo Small	Sandia National Laboratories
Unlocking the NaCl-AlCl3 Phase Diagram for Low-Cost, Long-Duration Energy Storage	Mark Weller	Pacific Northwest National Laboratory