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Indigenous Sodium ion Battery:
An initiative toward self- reliant India

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Empowering Energy Independence

&

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Agenda & Context

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- Brief Introduction
- Challenges in Scaling Indian Battery Industry
- Why Sodium ion batteries?
- Innovations
- Technology Differentiation
- Case Study
- Sodium-ion battery Technology Status
- Conclusions

Battery and its types

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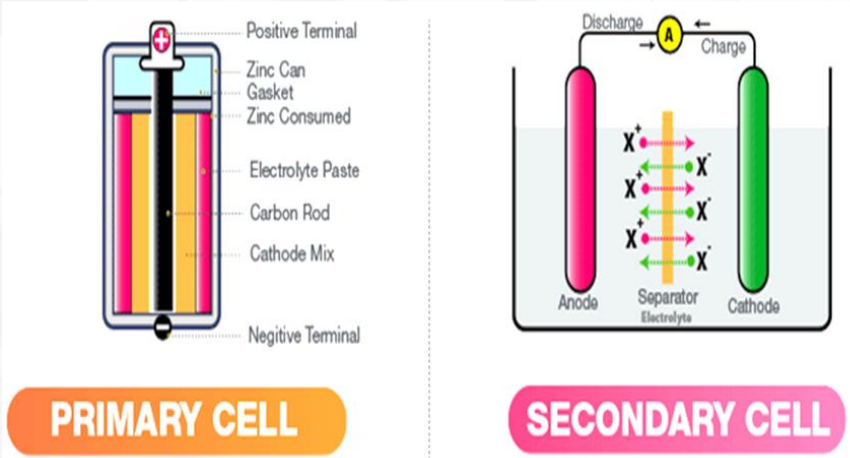
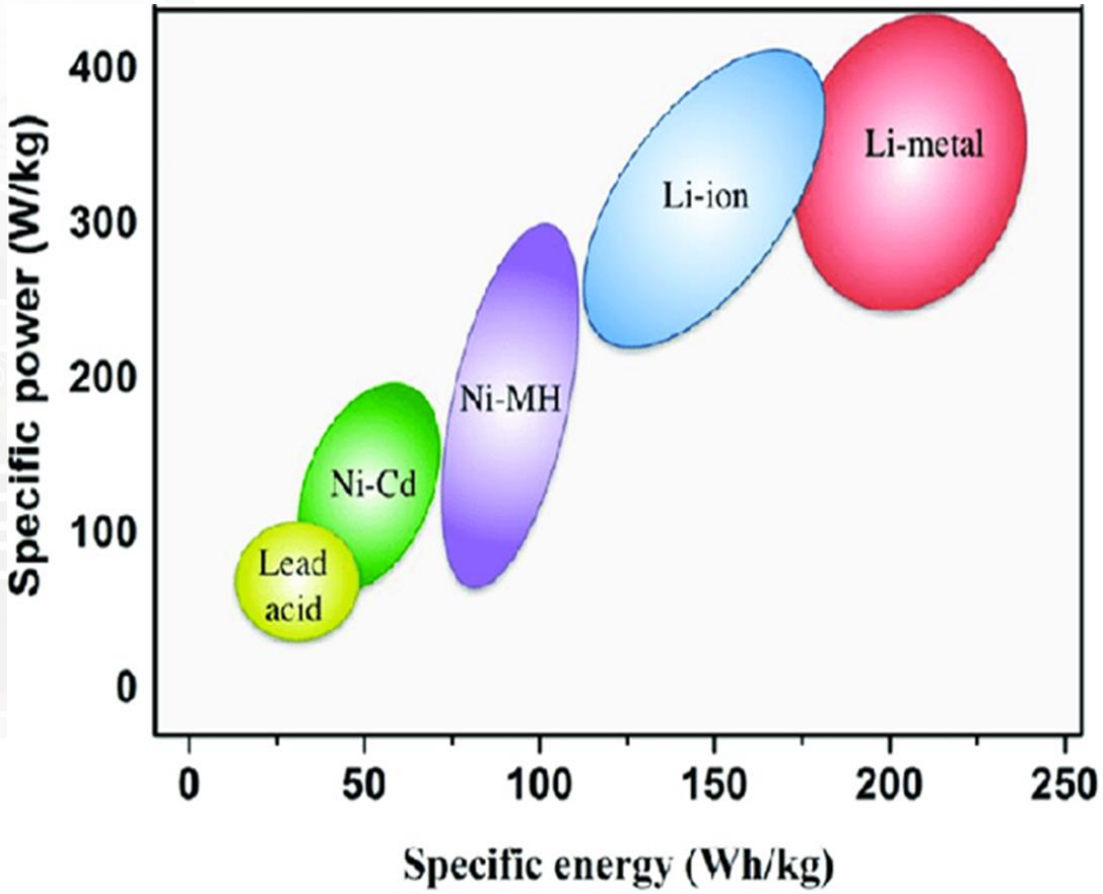
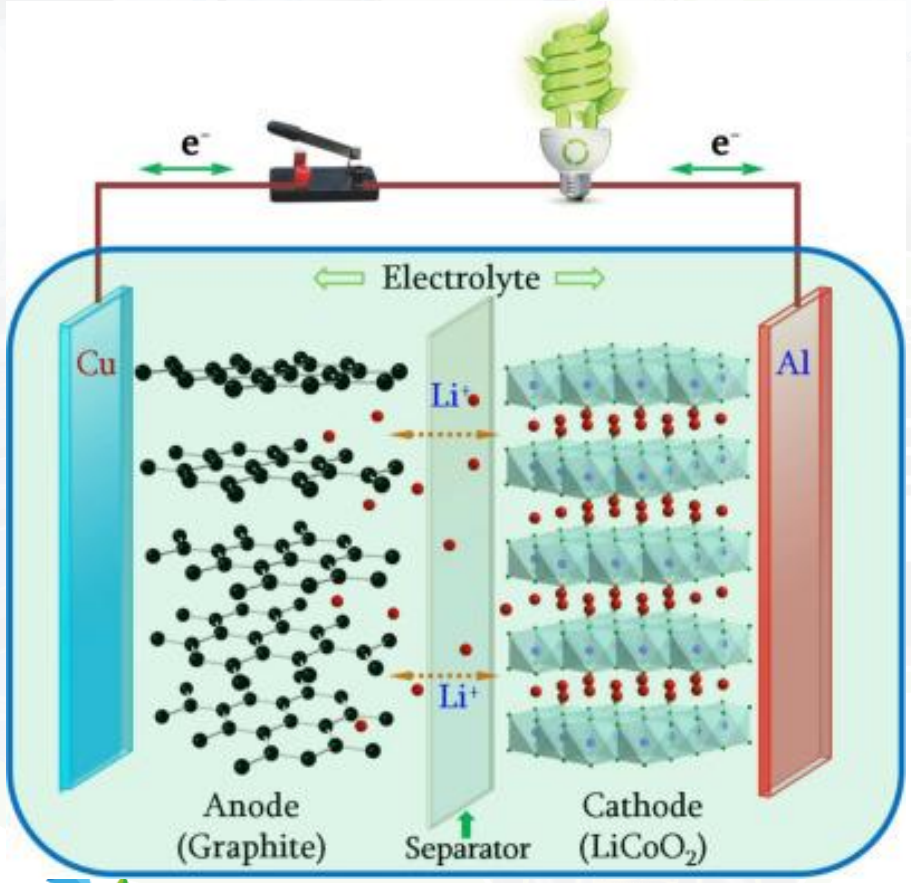
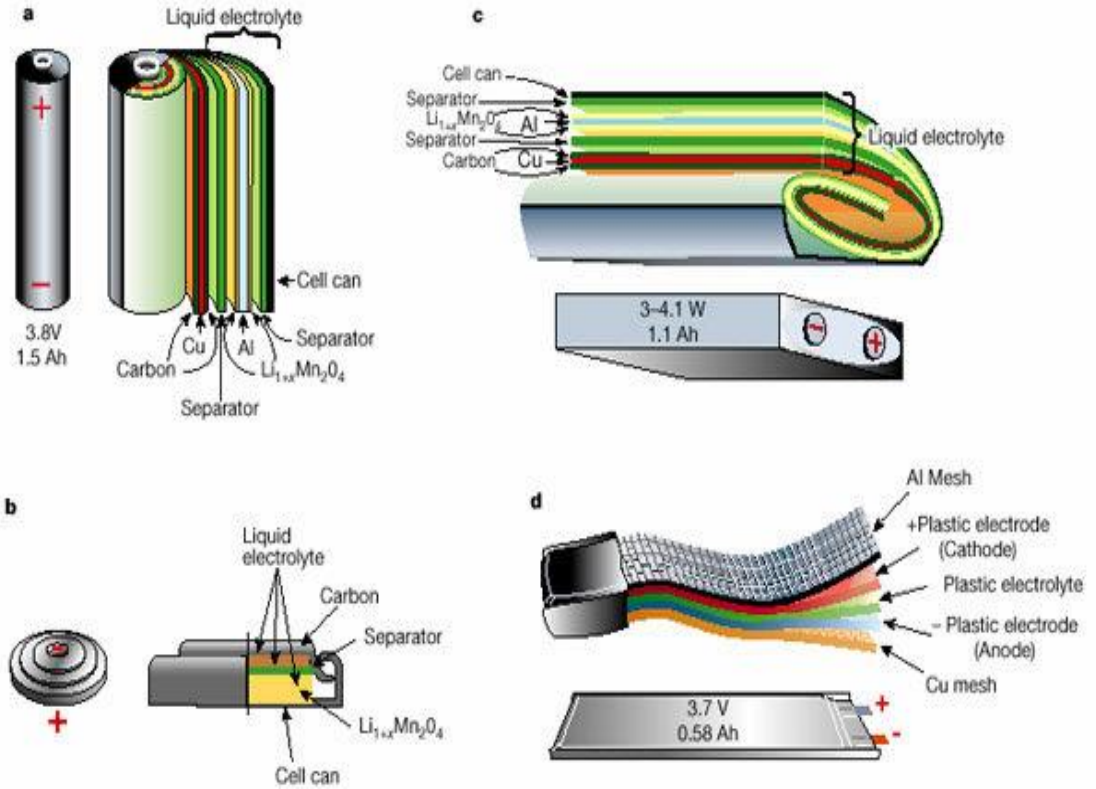


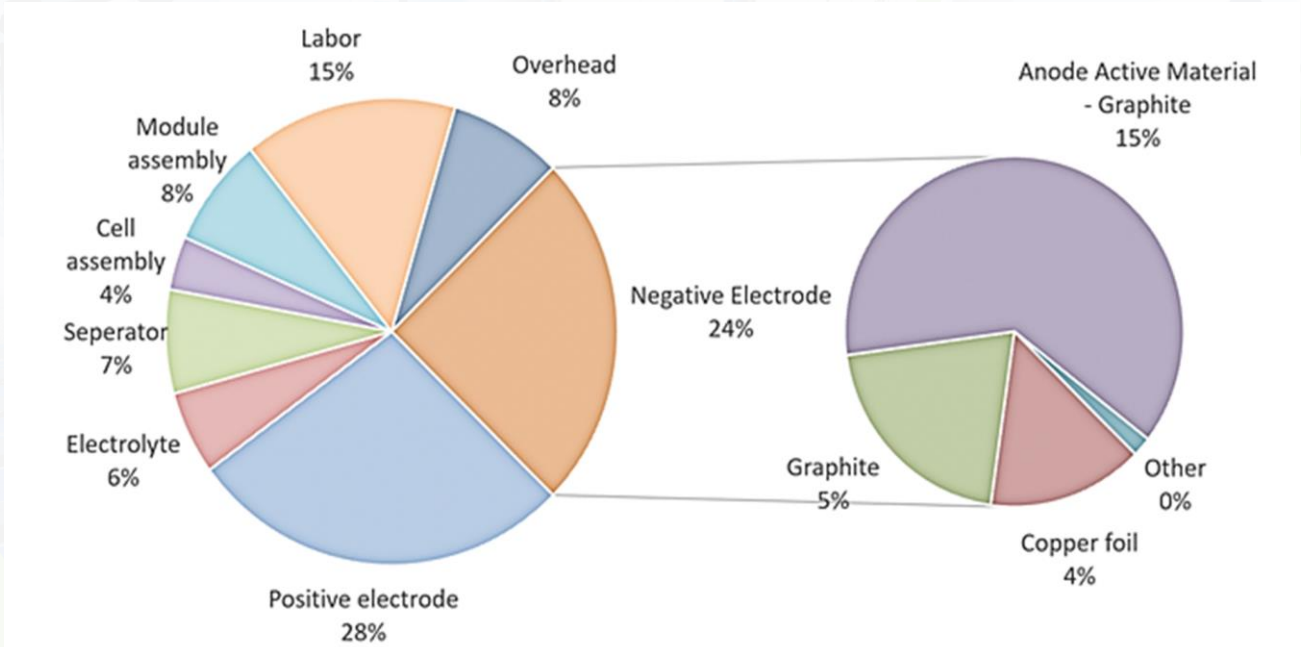


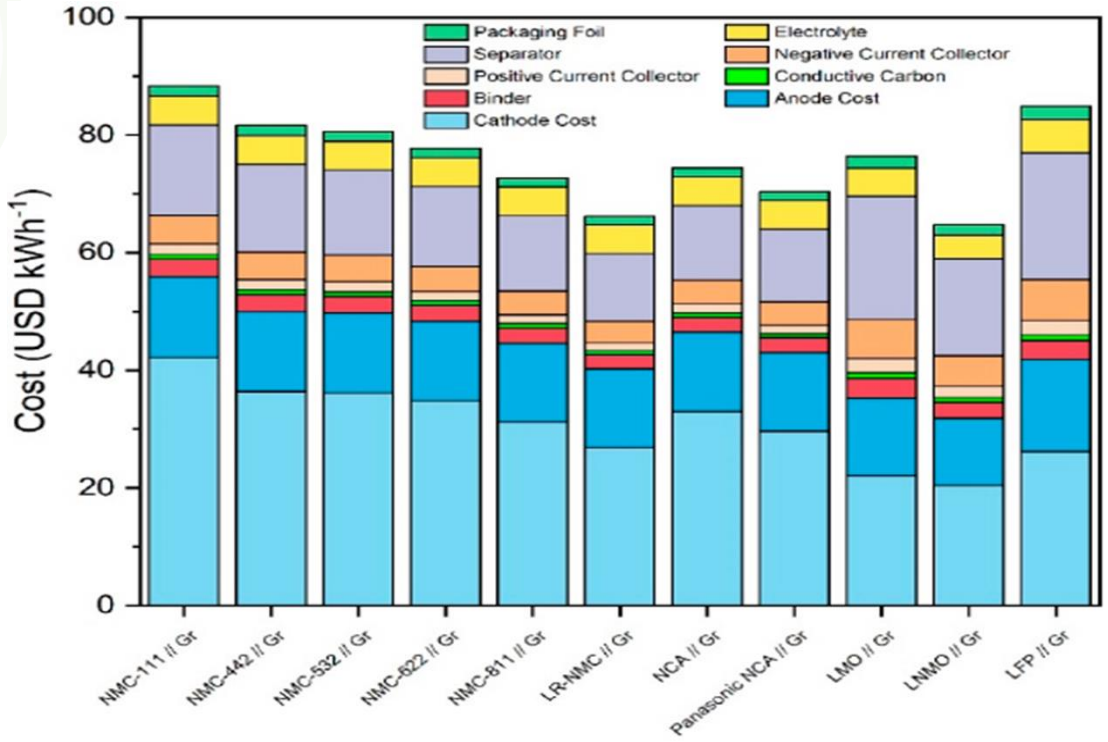
Li-ion batteries and different available sizes



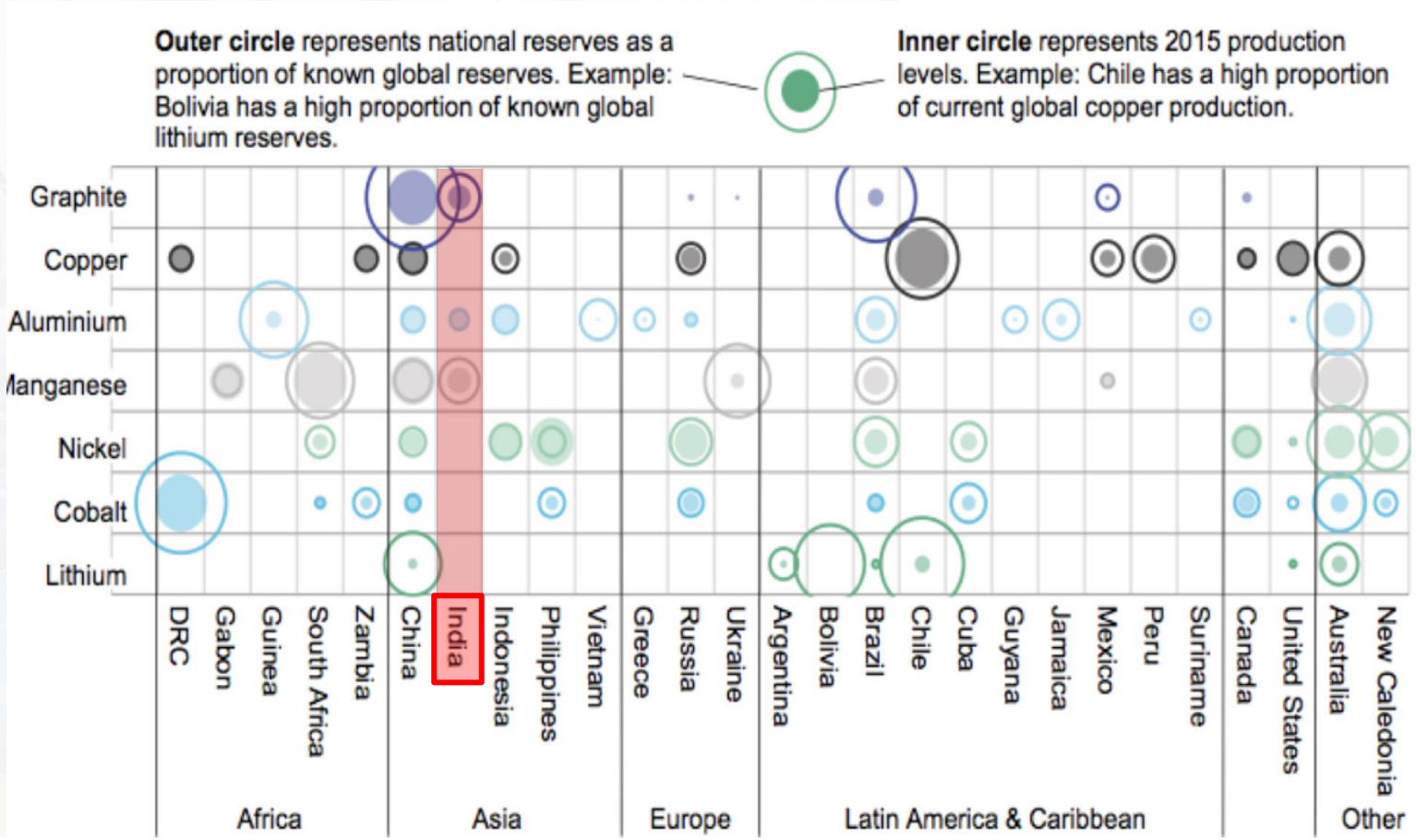


Component Wise Distribution





Challenges in scaling Indian Battery Industry



Note: Area of outer rings represent national reserves as a proportion of known global reserves, shaded circle represents 2015 production in that country x 20 as a proportion of known global reserves.

Reserves of Critical Materials for Nickel-manganese-Cobalt Lithium-ion Batteries in Selected Countries-

Niti Aayog

Why Sodium-ion Battery?

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- **High battery performance at low cost**
- **Simple Battery Design**
- **Uses low cost, earth abundant materials**
- **Highly safe and do not spread fire**
- **Sustainable & eco-friendly**
- **Infinite resources and worldwide availability**

Applications

- Electric Two & Three Wheelers
- Solar & Wind Grid
- UPS & Inverter Batteries
- SLI Batteries
- Small Applications like Toys, Emergency Lights etc.

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Innovation 1

Bio/Agri-Waste

Hard Carbon

Sodium Ion Batteries

- Indi Energy achieved world's highest capacity in Hard Carbon for Sodium ion batteries (SIBs) made using bio/agricultural waste. Technology patented by Indi Energy (both Indian and International).

	TMAX China	Indi Energy Hard Carbon
Manufacturing Price per Kg	-	Rs. 8,500
Selling price per Kg	Rs. 25,000 - 40,000	Rs. 14,000 - 16,000

- Only company in India currently working in supplying low cost, high quality Hard Carbon for SIBs. Currently running Pilot plant in IIT Roorkee.
- The innovation can simultaneously reduce air pollution issues and increase income for Indian farmers.

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Innovation 2

Sodium precursors

Sodium-ion cathode

- Indi Energy Sodium ion cathode uses earth abundant materials.
- No use of lithium, cobalt or nickel.
- High charge/discharge rate capable cathode material.
- Technology patented by Indi Energy.

Innovation 3

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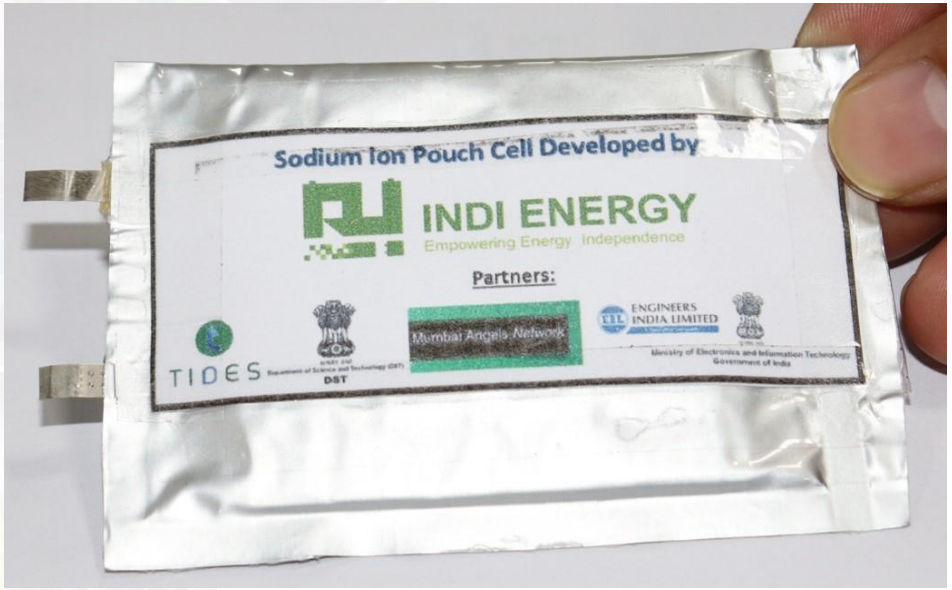
India's first company to indigenously develop Sodium ion Pouch Cell, made using locally available materials.



Sodium ion Pouch Cell

Specification:

- **3.2 V, 1000 mAh capacity.**
- **Cycle life tested: over 500 cycles with >80% capacity retention.**

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Technology Differentiation

For Battery Cell	Lead Acid Battery	Lithium Iron Phosphate Battery (LFP)	Indi Energy Sodium-ion battery
Cost Per kWh	Rs. 2,500 – 3,000/kWh	Rs. 10,000 – 11,000/kWh	Rs. 7,000 – 8,000/kWh
Energy Density	30 – 35 Wh/kg	120 – 140 Wh/kg	100 – 120 Wh/kg
Nominal Cell Voltage	2.1 V	3.2 V	3.2 V
Safety	Moderate	High	High
Materials	Toxic	Scarce	Earth - Abundant

Case Study

E-rickshaw battery

- 2 million E-rickshaws currently running in the country covering more than 80% market share of all EVs currently running in India.
- A typical E-Rickshaw battery of 4-5 kWh battery ratings costs around **Rs. 25,000-30,000.**
- **Currently uses poor performing Lead acid battery with life of only 6-12 months, use of toxic materials like Pb and charging time of 8-10 h.**
- **Li-ion batteries with life of around 2-3 years, charging time of 3-5 h, Heat dissipation issues and cost of around Rs. 65,000-70,000.**
- **The Sodium ion batteries would easily replace them with life of atleast 3 years, charging time of 3-5 h and estimated cost of around Rs. 45,000-50,000.**

Sodium ion Battery Technology Status

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Na+ Battery (SIB) Manufacturers Overview

Manufacturers	Estab.	Collaboration / Investments /Announcements	Cell Energy De.(Wh/Kg)	Charge / dis-charge cycle	Mass Prod.	Website:
FARADION	2011, UK	-> Collab. (ESS) : Faradion's IP w/ AMTE 's design & manufacturing. ->2021, Faradion was **acquired by Reliance Industries** of India. -> **w/ IPLTech,** for SIB for **electric Commercial Vehicles** in India	155	3000 cycles	Giga-factory planned in India.	https://faradion.co.uk/
CATL	2011, China	-> CATL released the 1st SIB in July 2021 w/ energy density 160Wh/Kg. -> Next-generation sodium-ion battery energy density will >200Wh/kg. -> Plans to form a basic industrial chain by 2023.	160	Undisclosed	Production Capacity undisclosed.	https://www.catl.com/en/
Natron Energy	2012, USA	-> w/ Clarios : strategic agreement - production of large-scale SIB. -> Developing SIB for >10 years. Mass Manufacturing Q2, 2023.	20-30	50,000 cycles	0.6 GWh/yr in 2023	https://natron.energy/
中科海钠 HiNa BATTERY	2017, China	-> HUA YANG GROUP cooperated w/ HiNa BATTERY & Three Gorges Group to build cathode and anode production lines and SIB cell production lines.	145	4500 cycles	2022: 1 GWh/year Long Term : 5 GWh/yr.	https://www.hinabattery.com/
容百科技 RONBAY TECHNOLOGY	2014, China	-> In the process of technical R&D and production line construction of ferromanganese **Prussian white & layered oxide cathode** materials for SIB	Undisclosed	Undisclosed	Ton-level output in 2022	http://www.ronbaymat.com/
ZOOLNASM 众钠能源	2021, China	-> ZOOLNASH's product is a sodium iron sulfate battery, and its patented method for preparing high-performance cathode materials. -> Investment : Country Garden VC affiliated w/ major developer.	Undisclosed	Undisclosed	2023	http://www.zoolnasm.com/
钠创 NATRIUM	2018, China	-> R&D and production of cathode materials & electrolytes for SIB. -> Downstream customers include Honeycomb Energy, etc. -> App : ESS, electric 2W/3W, low-speed EVs	130-160	5000 cycles	Launch in 2022; 80,000mt of Cathode & Anode materials /year in 3-5 years.	http://natriumenergy.cn/
EVE	2014, China	-> 2022 : Cylindrical, ≥135Wh/kg, 10C Rate w/ 10m FC to 80% SOC, 2500 cycles. -> 2024 : SIB 140-160Wh/kg 6000+ cycles 50$/kWh, -> 2026 : SIB 140-160Wh/kg 10000+ cycles 30$/kWh.	135-160	2500-10,000 cycles	2023	https://www.evebattery.com/en
Tiamat Energy	2017, France	-> Tiamat designs, develops and manufactures SIB for mobility & ESS. -> Develop low-voltage systems for xEVs for electromobility from 2025.	90-120	5000 cycles	6 GWh/year by 2030.	http://www.tiamat-energy.com/
LiFUN	2013, China	-> Low-speed EVs, EV buses, stationary storage batteries for household use -> Presented the 1st consumer-grade SIB.	140	4000 cycles	2023	http://www.lifuntech.com/
Nippon Electric Glass	1944, Japan	-> Exhibit of All-Oxide All-Solid-State Sodium (Na) Ion Secondary Battery (2022)	Undisclosed	Undisclosed	2025	https://www.neg.co.jp/en/
BYD	2003, China	-> BYD to launch electric hatchbacks with new Sodium-ion batteries. -> New BYD Dolphin EV hatchback was recently spotted tested in Sydney	Undisclosed	Undisclosed	2023	BYD News

Indi Energy Sodium-ion battery & Hard Carbon

- **Energy Density: 100 – 120 Wh/kg**
- **Nominal Voltage: 3.2 V**
- **Safety: High**
- **Made from Agricultural waste and Earth – Abundant materials**
- **Hard Carbon Capacity: 300 mAh/g (upto 1.0 V) Cyclability: >1000 cycles at 1C with >80% capacity retention**

Challenges in scaling Sodium-ion Batteries globally

- **Supply of low cost, high quality Hard Carbon**
- **Supply of low cost, high rate capable Sodium ion cathode material**
- **Supply of low cost, high quality Sodium ion electrolyte**

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Achievements

Products:

Sodium ion Pouch Cell

Hard Carbon

Sodium-ion cathode

Incubated at

TIDES BUSINESS INCUBATOR

Indian Institute of Technology Roorkee

Supported by:

DST@ 1971-2021 Department of Science & Technology

EIL Engineers India Limited

Ministry of Electronics and Information Technology Government of India

Mumbai Angels Network

BIG Capital Group

Patents filed/granted

5 Indian Patents filed on various aspects of Sodium ion batteries, 1 (one) already granted by the Indian Patent office.

1 International Patent (PCT) filed.

Achievements

Indi Energy won the DRDO's Dare to Dream 3.0 contest under Startup Category in Oct 2022.

Indi Energy won the Best Startup Award under Energy sector in National Startup Awards 2022.

Indi Energy also won the Best Startup Award in the Startup Expo organised at IIT Roorkee in Nov 2022.

Thank You

For discussions/suggestions/queries email: **yogesh.sharma@ph.iitr.ac.in**