KPIT

Sodium-ion Battery Technology

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Outline

- About KPIT
- Setting the Context
- Our Approach
- Technology
- Application Markets
- Roadmap
- Global Developments

KPIT OVERVIEW

KPIT At A Glance

12000+
Automobelievers

51
Patents

25
Innovation Awards

4%
of Revenue spent on R&D

Our Vision

Reimagining mobility *WITH* ***YOU*** for creation of a cleaner, smarter & safer world

KPIT is present where the mobility ecosystem is transforming

Americas

- Novi, MI
- Columbus, IN
- Bettendorf, IA
- Belo Horizonte, Brazil

Europe

- Munich
- Coventry
- Gothenburg
- Wolfsburg
- Dortmund
- Amsterdam
- Milan
- Stockholm

Asia

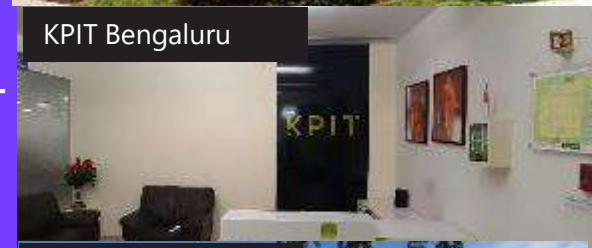
- Pune
- Bengaluru
- Singapore
- Bangkok
- Shanghai
- Tokyo
- Seoul

Key Customers

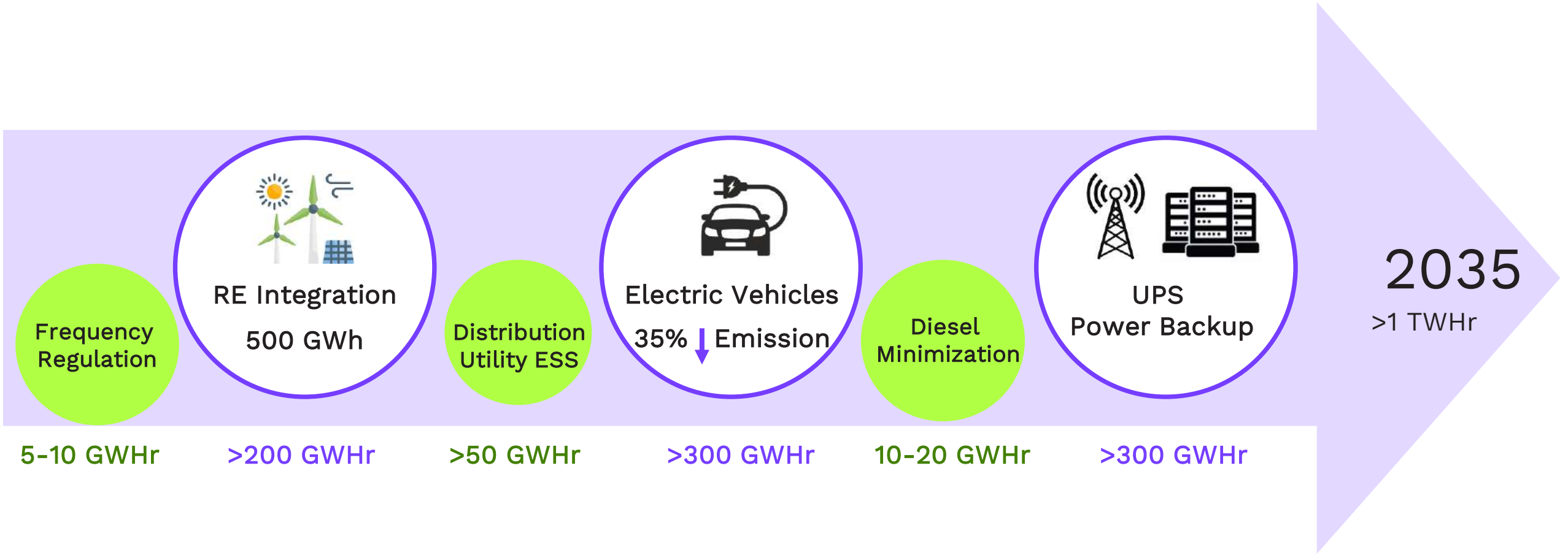
BMW, HONDA, FCA (Fiat Chrysler Automobiles), Volkswagen, Jaguar Land Rover, Volvo, Cummins, GM, TATA, Alexander Dennis, John Deere, Daimler, KOSTAL, HITACHI (Inspire the Next), Renault Nissan, Eaton, Continental, DENSO, MAGNA, Panasonic

We work with each of the top-10 global OEMS

Software Development Excellence Centers



Critical Role of Batteries in Clean Energy Transition



Access to low cost, durable and sustainable battery systems is very crucial to achieve the targeted market penetration

What do we mean by sustainable battery systems?

Batteries that

Are based on earth abundant raw materials

- The materials are geographically uniformly distributed
- Mining and extraction of materials is not/less energy intensive

Are manufactured with processes that are not energy intensive

- Environmental conditions, Use of benign solvents
- Fast/energy efficient/high-yield processes

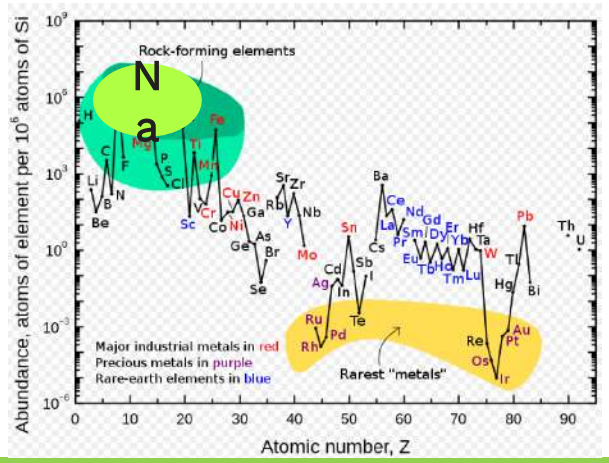
Are designed and developed precisely for the market where they are to be used

- Homegrown solutions: Access to core knowhow
- Tunability for diverse requirements

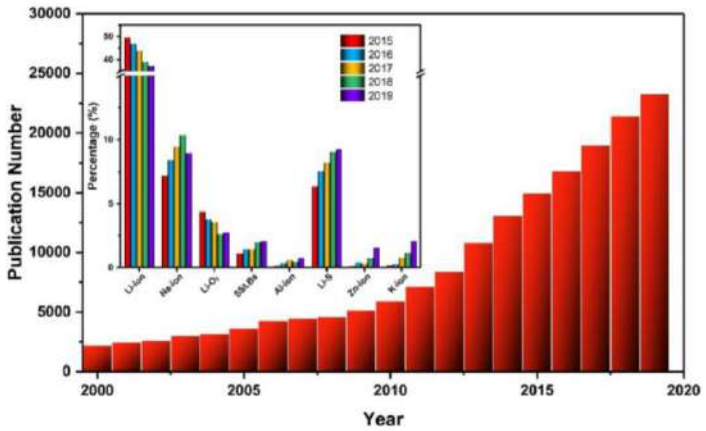
Have a strong local supply chain

- National energy security
- Minimized carbon footprint of transportation

Why Sodium-ion Chemistry?



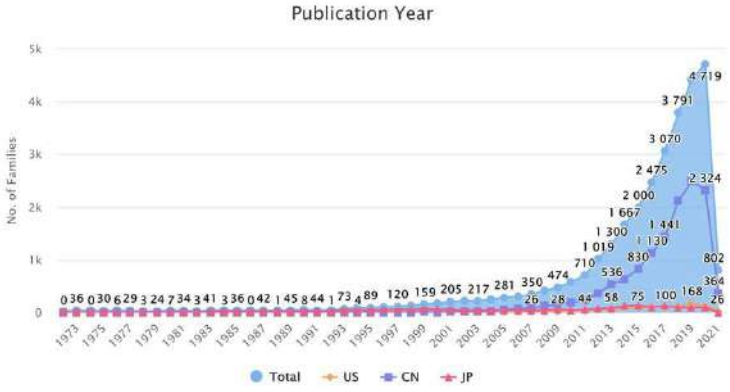
Abundance of elements in Earths Crust



Research Publication Trends

	Sodium	Lithium
Potential (V *vs.* S.H.E.)	−2.70	−3.04
Cation radii (Å)	0.97	0.68
Price (US$ per ton)	250–300	5800
Atomic weight (g)	23	6.9
Capacity (mA h g^{-1})	1160	3860

Basic Electrochemical Parameters



Patent Publication Trends

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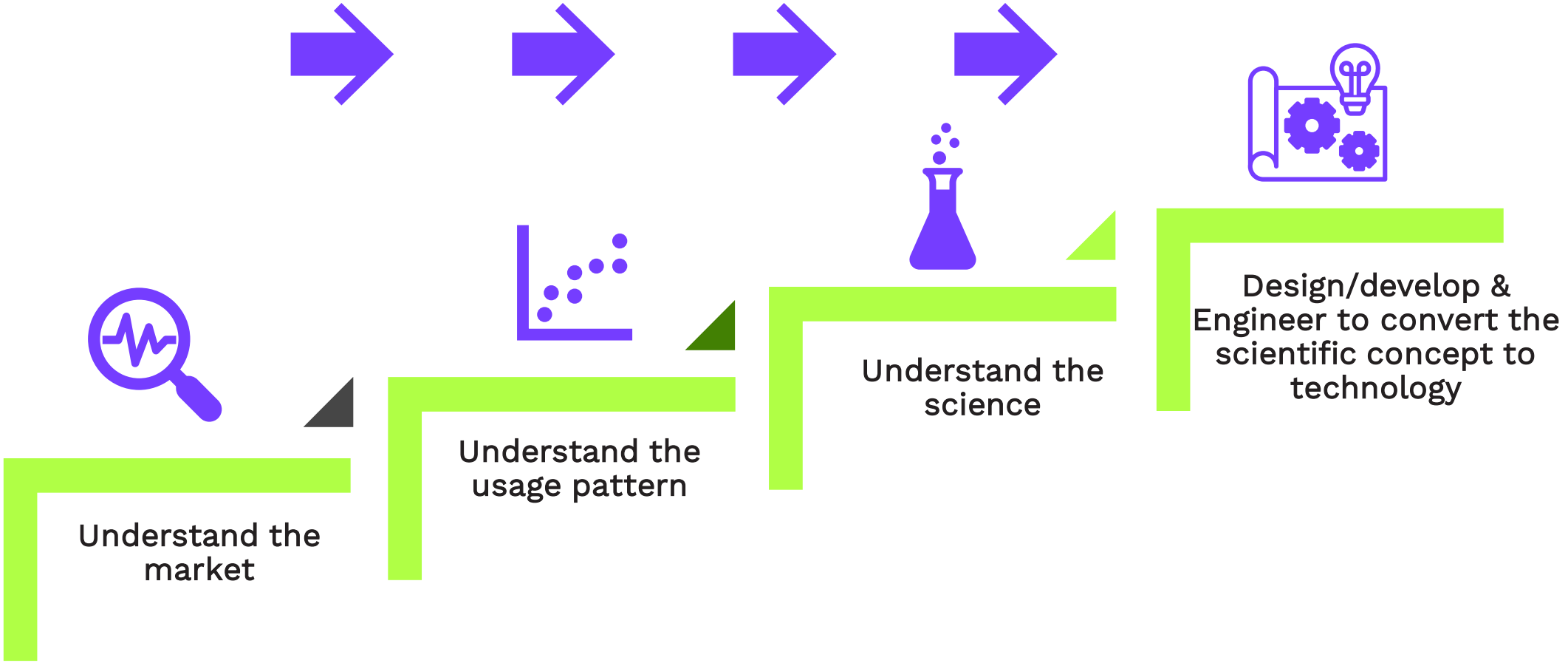
OUR APPROACH

Our Approach



Understand the market

Mobility

Micro-grid

Backup & Grid

Understanding the 3W Battery Market

- Market research across India: 15 cities, 300 E-3W owners, 15 Distributors, 5 OEMs
- 8.5% CAGR 2020-2030, Projected Market Value $295.4 Mn
- Growth Driver: Proliferation of Electric Rikshaws- L3 and L5
- Lead Acid → Li-ion

Understanding the Usage Pattern

- E-Rikshaw daily mileage: ~70 km
  CNG/Diesel daily mileage: >100 km
- Avg.no of halts/day : 6, Avg. time of halt: 15-20 mins
- Avg. CNG/Diesel Wait+filling time: 18-20 mins
- Charging time of Lead Acid/Li-ion: 2-4 Hrs

Understanding the Economics

- CNG/Diesel: Rs. 2.5/km, Electric: Rs. 1.3/Km
- Daily mileage of CNG/Diesel: ~100 km, Electric: ~70 km
- Daily income with CNG/Diesel: ~Rs. 1000, Profit: ~ Rs. 600
- Daily income with Electric: ~Rs. 800, Profit: ~ Rs. 650

Major Pain Points

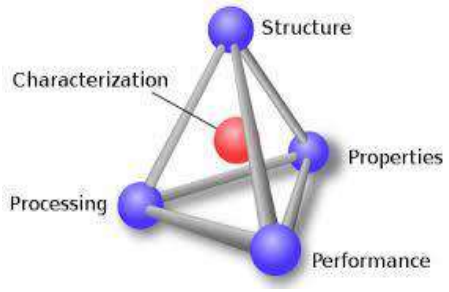
- High upfront cost of Li-ion battery pack
- Low payload with large battery pack
- Slow charging time
- Cycle Life (Without cooling)

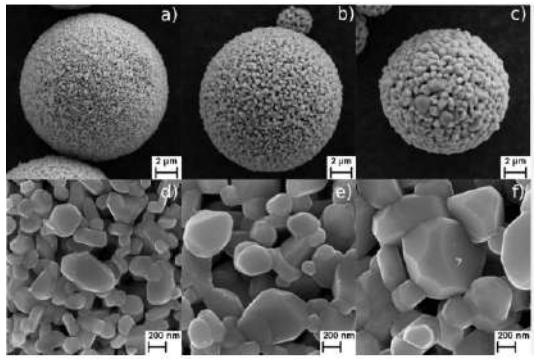
Target Performance Characteristics

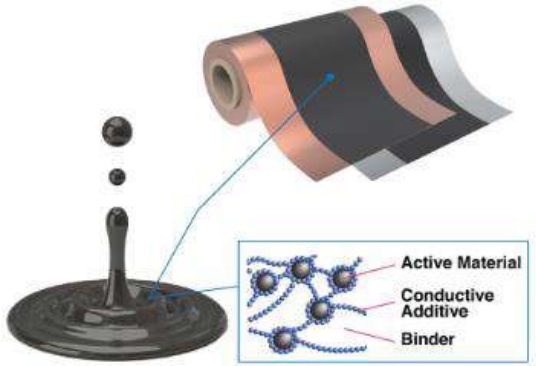
Markets	Key Considerations
2W	Slow Charging, Daily range, Cycle life, Weight/Volume, Cost, Safety, Thermal Management
3W	
Light Commercial Vehicles	
Intra-city Bus	
Power Back up	Cost, Power density, Cycle life, Thermal management, Volume
Grid Storage-FTM	Very long cycle life, Cost

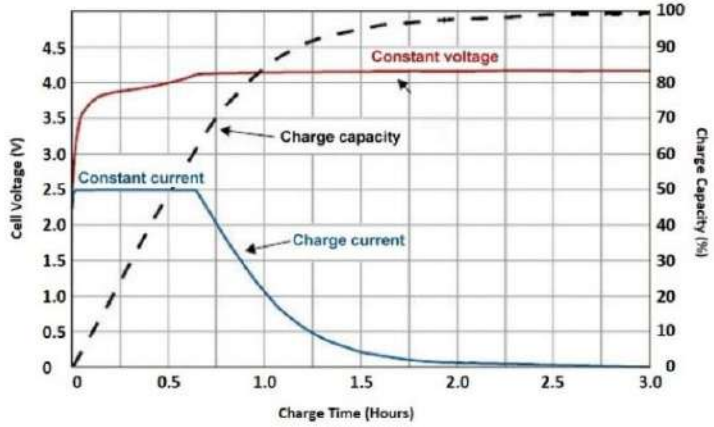
Battery Science - Technology

- Extensive collaborative research with IISER-Pune-Dr. Satish Ogale & team
- Developed Core Team having strong foundation of Materials Science, Engineering and Battery Electrochemistry









Coin Cell | Higher Capacity Cell | Cells →Pack → Application

Charter → Feasibility → Design → Verify → Prototype → Validate → Pilot Mfg. → Field Trial

Our Technology

Key Highlights of Our Technology

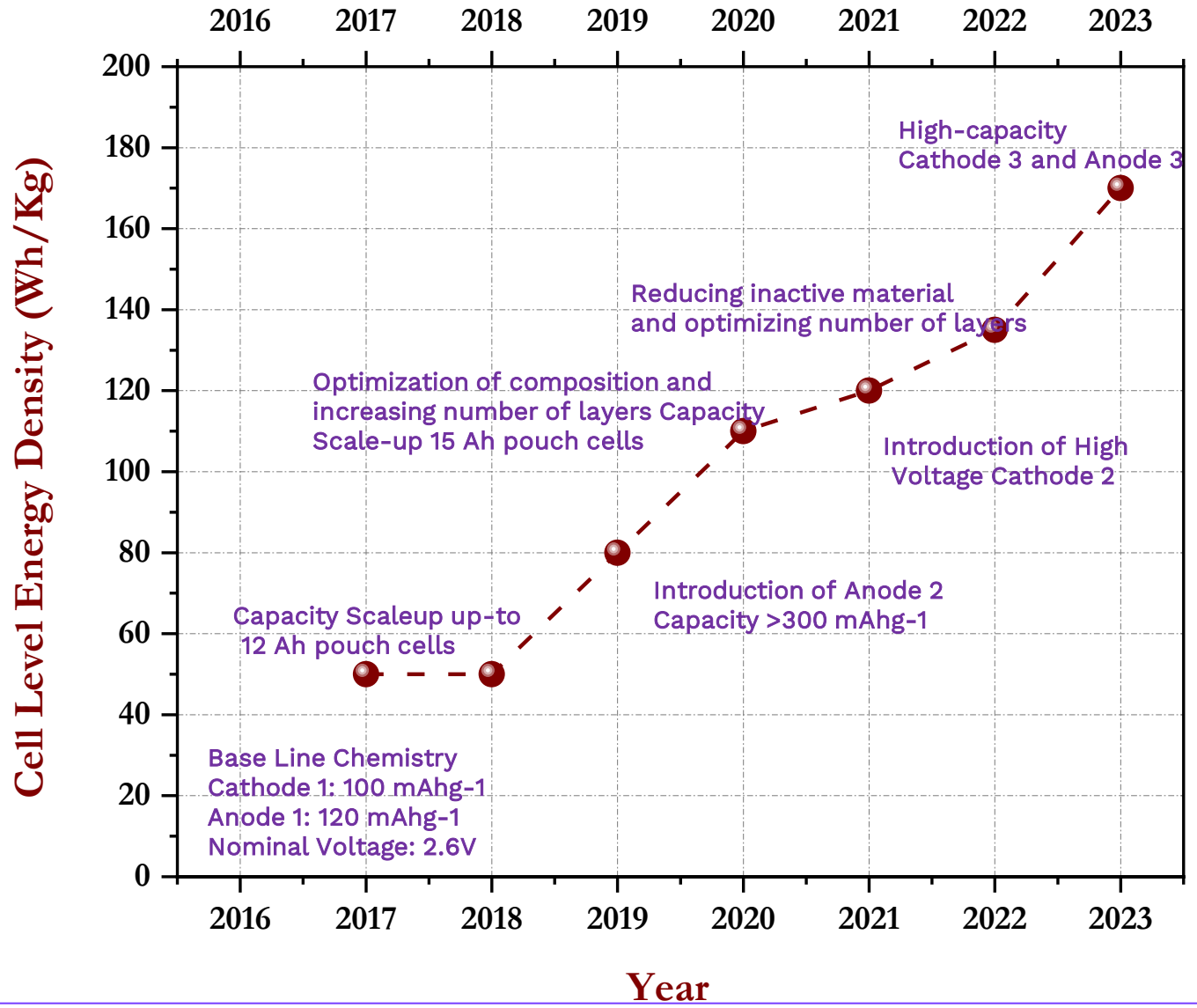
- Non-toxic, abundantly available raw materials
- Low energy intensive extraction of all raw materials
- Customizable Cell Design tailored for specific cell performance as per application
- Fits all formats: Pouch, Cylindrical, Prismatic
- Uses Existing Li-ion manufacturing infrastructure
- Plug & Play with existing modules & packs
- Syncs with existing Battery Management System
- Multiple variants with distinct characteristics

Technology Variants

Robust cell electrochemistry delivering long cycle life, 3000-6000 based on operating conditions

Technology Variant	Energy Density (Whr/kg)	Key Highlights
KP001	100	>80% charging in 15 mins, High Safety against over charge/discharge, Ability to store and transport at 0V
KP002	130	High Voltage, Lower IR, Better Power density
KP003	170-200	Low-Cost Anode/Cathode than KP001/2, Superior round-trip energy efficiency
KP004	50	>80% charging 6 mins, High Power density, Very long cycle life, Self-cooling capability, Ability to store and transport at 0V

Energy Density Progress



Cost Benefits

Materials	Na-ion Vs Li-ion ($/kg)
Cathode	50%
Electrolyte	60%
Current Collector	20%

Variant	Estimated Cell Cost ($/KWhr)
KP001	120
KP002	90
KP003	70

- >40% lower cost of raw material
- Uses same passive materials as of Li-ion
- Made on same manufacturing lines as Li-ion
- >30% lower LCOS for Stationary applications
- >30% lower upfront cost for Mobility applications
- >20% lower LCOS for Mobility applications

All major OEMS, Cell manufacturers project Sodium-ion to reach 50-80$/Kwhr, once production starts at the equivalent scale of Lithium-ion

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Global Developments

A completely new ecosystem for Sodium-ion batteries & their material manufacturing is emerging across the globe

- More than 10 companies have announced/shown interest in Sodium-ion battery commercialization
- Most of the companies are from China, 3 from EU, 1 from UK, 1 from USA
- Production to start in 2023-24
- All have different chemistries with energy density ranging from 50 to 160 Whr/kg
- Applications range from Micro cars, Grid storage and Data Center back-up

EV REPORT

Sodium-ion batteries are real in China. BYD to build 30 GWh sodium battery plant

Reading Time: 2 minutes – Jiri Opletal | November 20, 2023 | 0

BYD's Seagull Starts At Just $11,300 And Has Sodium-Ion Battery

CATL's First Sodium-ion Battery to Power Chery EV Models

2023-04-16

Future Sodium Ion Batteries Could Be Ten Times Cheaper for Energy Storage

September 1, 2023 by Brian Wang

The first generation sodium ion are a bit cheaper than LFP but the volumes will not be worldchanging. However, the second generation sodium ion could reach $40 per kWh. Iron LFP batteries could get to $50/kWh with really high volume and efficiency at the cell level. The future low price of sodium ion would make for insanely cheap fixed storage products like the Tesla Megapack and Powerwalls.

Northvolt develops state-of-the-art sodium-ion battery validated at 160 Wh/kg

21 November, 2023

The Chinese government plans to promote high-quality development of its sodium-ion battery industry during 2021-25, the period of the country's 14th five-year economic plan.

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APPLICATIONS

Mobility

Micro-grid

Energy Storage

Backup & Grid

Marine

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Use Cases

Electric 2-Wheelers

Usage Pattern	Personal	Cargo
Average drive distance/day	< 50 km	>120 km
Practical range	60 to 120 km	<80 km
Running hours	2 to 3 hrs	> 8 hrs
Charging time	4 to 6 hrs	4 to 6 hrs
Battery capacity	2 to 4 kWh	2.5 to 3.5 kWh
Pain points	• High cost of battery • Longer charging time • Safety concerns with battery	

Electric 3-Wheelers

Usage Pattern	Passenger	Cargo
Average drive distance/day	> 120 km	>150 km
Practical range	70 to 100 km	80 to 100 km
Running hours	8 to 10 hrs	12 to 16 hrs
Charging time	4 to 6 hrs	4 to 6 hrs
Battery capacity	4 to 8 kWh	4 to 8 kWh
Pain points	• **High cost of battery** • **Reduced earnings/day** • **Longer charging time** • **Safety concerns with battery**	

Electric Cabs and LCVs

Usage Pattern	Cab	LCV
Average drive distance/day	> 300 km	>200 km
Practical range	100 to 200 km	80 to 120 km
Running hours	8 to 10 hrs	12 to 16 hrs
Charging time	2 to 8 hrs	2 to 6 hrs
Battery capacity	17 to 24 kWh	20 to 65 kWh
Pain points	• **Compromised payload (150 to 300 kg)** • **High cost of battery,** • **Longer charging time** • **Safety concerns with battery**	

1.8ton

8.5ton

Na-ion Battery Advantage

Drop-in replacement to Lead/Li-ion battery

30% lower cost

3 times Longer life

Hypercharge 80% in 15 min.

Downsize battery to reduce upfront cost → **Increased payload for Cargo**

Safest Chemistry

1.8ton

Electric Bus

Usage Pattern	Within City Transport
Average drive distance/day	200 to 250 km
Practical range	< 200 km
Running hours	12 to 16 hrs
Charging time	4 to 6 hrs
Battery capacity	180 to 350 kWh
Pain points	• Compromised Seating capacity • High Upfront cost due to battery • Longer charging time • High energy consumption due to battery wt.

Electric Bus: Na-ion Battery Advantage

- Hypercharge 80% in 15 min
- Downsize battery by 70%
- Upfront cost reduction by 60%
- Increase seating capacity by >10 seats
- Safest Chemistry

Stationary Storage : Na-ion Battery Advantage

- Smart Power management
- 30% lower cost compared to Li-ion Battery
- Wide operating Temperatures
- Long life
- Safest Chemistry

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THANK YOU!