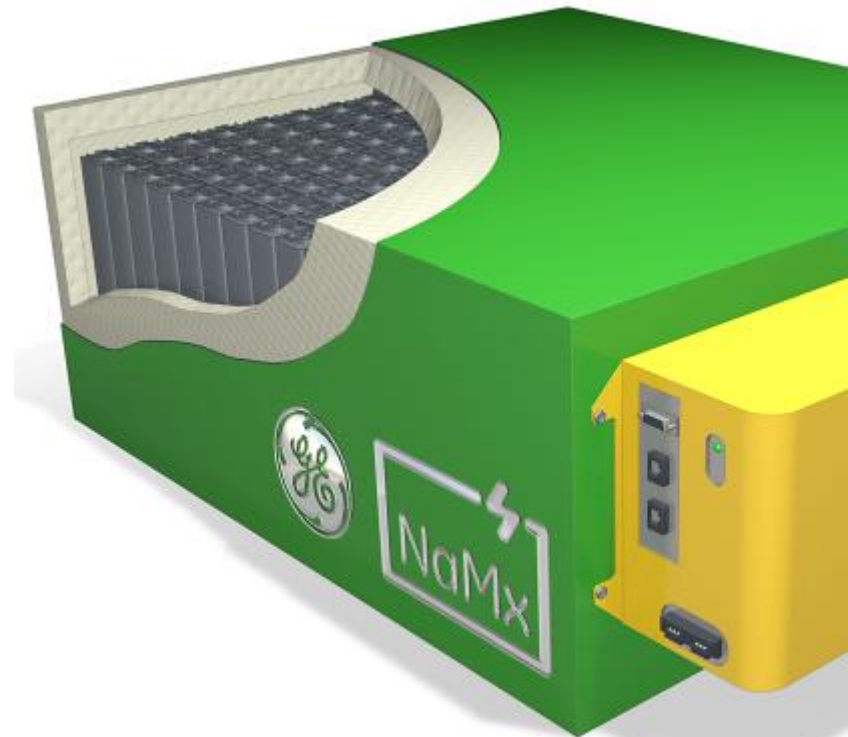


Sodium Nickel Energy Storage Technology for Rail and Public Transportation

Matthew Maroon
Senior Product Manager
GE Energy Storage



Overview

1. History of Sodium-Nickel Batteries
2. History of GE Energy Storage
3. Technology Background
4. Applications for Sodium-Nickel

History of Sodium-Nickel Chemistry

Original application = British Rail in the 1970s



History of GE Energy Storage

GET Hybridization
Program Launch
2001



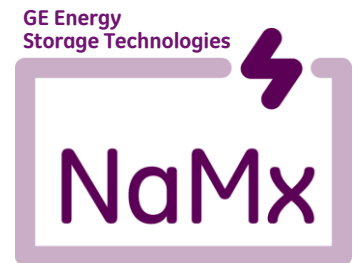
Battery Chemistry
Evaluation
2002 - 2006



Beta Acquisition &
NaMx Development
2007 - 2008



Business
Launch
2009

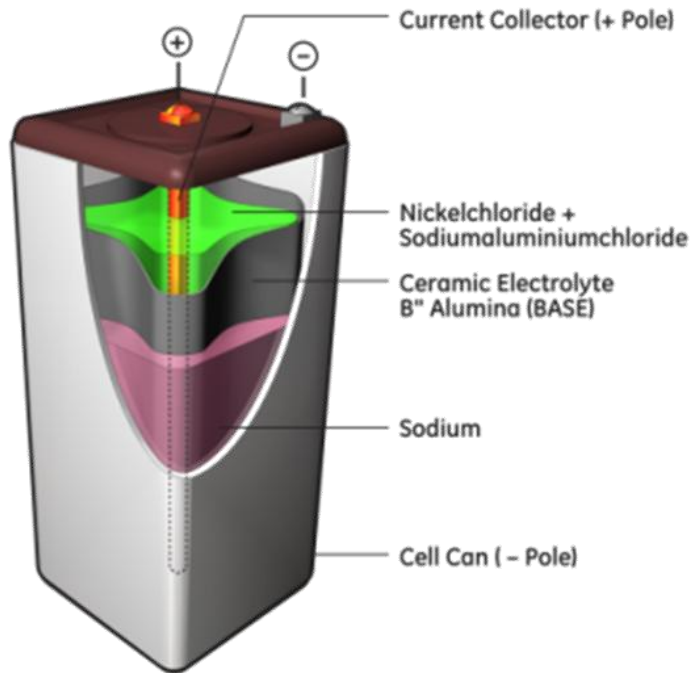


Production Launch
2010-present

- 220,000 ft² manufacturing facility
- Schenectady, NY
- 250+ employees
- 1+ GWh production at full capacity

Durathon Sodium Nickel

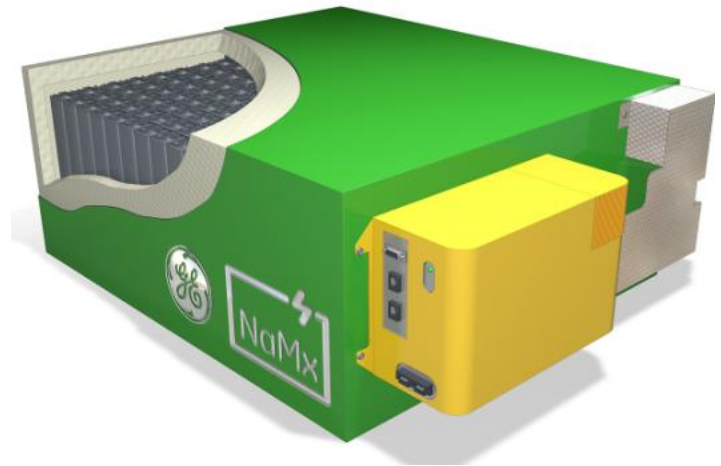
Cell



OCV \approx 2.58V



Battery Module (Includes Management System)



Energy or Power Modules in
48V, 300 V, 480V

Durathon Advantages

Long Life

3,500+ cycles @ 80% DoD
10 years cycle life
Indefinite shelf life



Maintenance

No maintenance
Remote monitoring



Extreme Temp

No de-rating at extreme
temperatures
(-40°C to +65°C)



Reliability

Overcharge prevention
Parallel design
Cells in a string fail short



High Energy

95+ Wh/kg
150+ Wh/L



Eco-Friendly

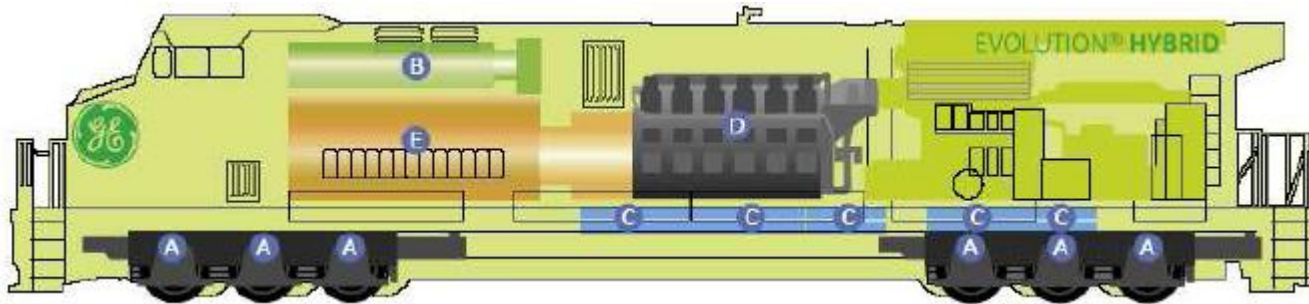
99% recyclable
Non - toxic
No hazardous materials

Electrified Motive Applications

	Auxiliary Power	Electric Hybrid	Full Electric
Electrification	Least		→ Most
Battery Strategy	Move aux loads off engine	Downsize engine, augment motive power needs	All power demands
Benefits	Most conventional drivetrain, least incremental cost	Fuel and emission savings, no range or time limitations	Most fuel and emission savings, least maintenance
Limitations	Least fuel and emission savings	Most compromise	Limited range and time usage
Examples	GE Hybrid Evo loco, On-Highway Trucks	Mild HEV, PHEV	Forklift, Full EV, Off-Catenary Rail

No One Size Fits all Solution

Durathon and GE Transportation



Concept

On-board Energy Storage can yield savings per loco of:

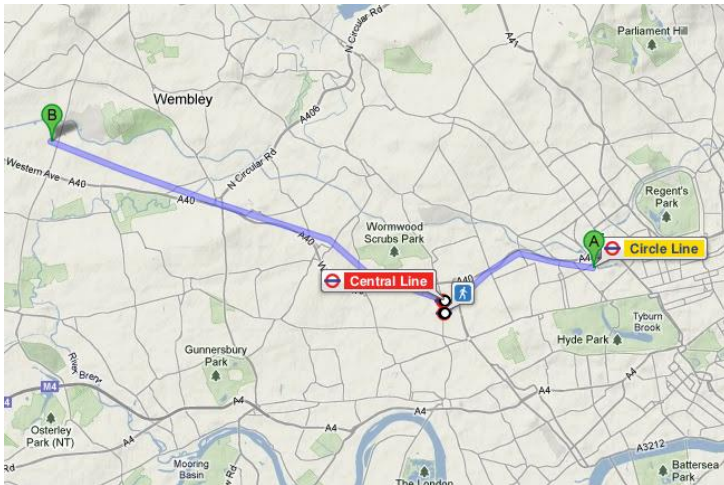
- 32,000 gallons fuel
- 357 tons CO₂
- 3.68 tons Nox



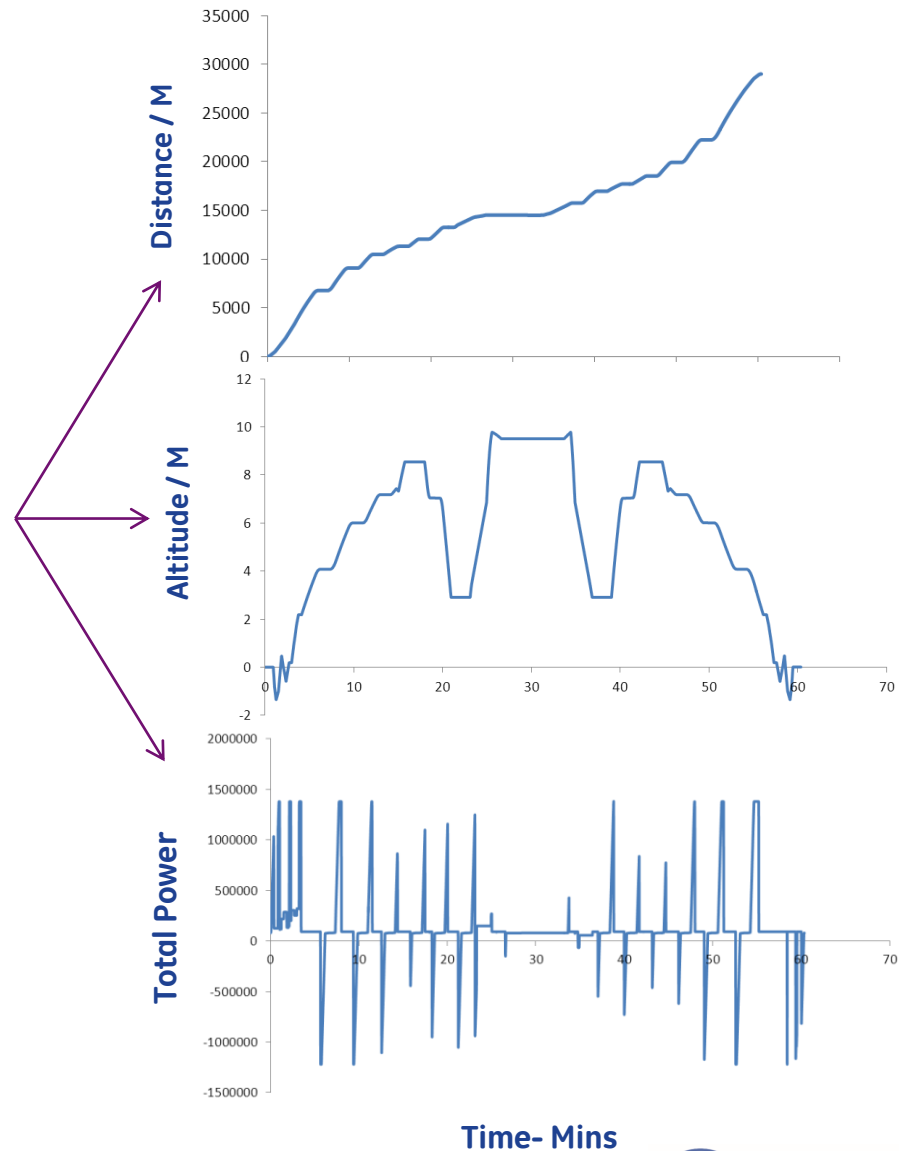
Demo Launch - 2007

Model Example

Application in London Paddington to Greenford



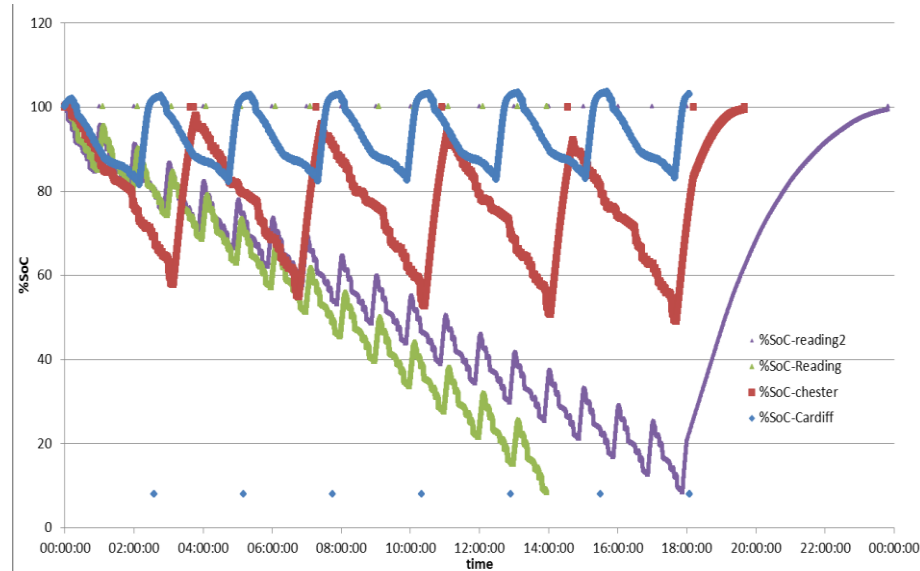
Route Map



Input Data for Battery Power Modeling

Model Example

Proprietary Durathon Electrochemical Model



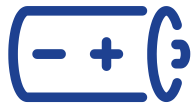
State of Charge versus Time

Very quick and iterative modeling –
pick the right application and the right technology

State of Marketplace

From battery supplier point of view

Technology



DoD vs. Cycle Life

Calendar Life

Energy Density

Specific Energy

Supply Constraints

Economics



Cost of Fuel / Batteries

Hybrid Drivetrain Cost

Financing

ROI Expectations

Regulatory



CO₂ Emission Caps

Local Regulations
(Ports, Cities, etc.)

Solving one of the three is not enough.

Technology Challenges



Cycle Life

- One cycle per day for 10 years daily use



Depth of Discharge Window, Wh/kg, Wh/L

- Minimizes weight / volume of batteries



Temperature Robustness

- Consistent performance from MN to FL



Reliability

- Six-Sigma+ reliability

GE Energy Storage – Markets

Actively pursuing high-energy requirements, long cycle life, temperature variable applications:

- Hybrid locomotives
- Off-catenary light rail
- High-speed commuter rail
- Electric Busses and Fleet Vehicles
- Industrial Motive applications

Thank you.

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imagination at work