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Nickel Iron Batteries for Twenty First Century Energy Storage

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Encell Technology -- Overview

- Founded 2006 – Venture-funded startup to develop scalable energy storage solutions
- Located in former GE/Gates/Energizer battery facility: Gainesville, FL
- Technical Team: Decades of battery experience and successful product launches
- Encell Technology NiFe Battery Applications:
 - Renewable energy storage
 - Hybrid micro grids
 - Utility Scale Load Leveling



Solar powered cell tower

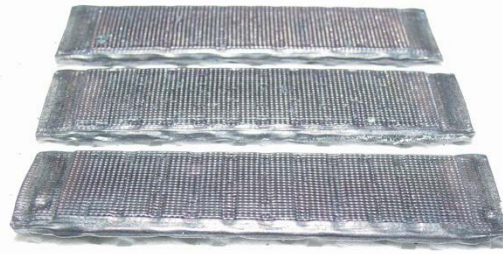
NiFe Battery History

The Edison nickel-iron (NiFe) battery is a storage battery with

- NiOOH cathode, Fe anode, KOH electrolyte,
- Active materials are held in perforated pockets,
- Extremely Abuse Tolerant (overcharge, overdischarge, and short-circuiting),
- Very long life - Can be continuously charged. Can last for more than 40 years.
- More than 1,000 full depth of discharge cycles
- 65% energy efficiency



Edison style batteries still in production



Steel pockets holding active material powder



Edison and Encell Comparison

Edison / Current Commercial NiFe Verses Encell's NiFe batteries

Cell Component	Edison/Current Commercial (Seiden, Taihang, Ukrimpex, Russian Battery Federation)		Encell	Advantages	IP
Positive Electrode	Structure	Exo-(Conductor, Containment)	Internal-Conductor, Sintered Containment	Higher - Power, Efficiency, Life Lower - Cost, Failures, Fade	
	Chemistry	Ni(OH) ₂ , Co Conductor Powder	Ni(OH) ₂ , Co Conductor, Zn Additive, Precipitated	Higher Capacity, Less Fade	
Negative Electrode	Structure	Exo-(Conductor, Containment)	Internal-Conductor, Chemically Fused Containment	Higher - Power, Efficiency, Life Lower - Cost, Failures, Fade	X
	Chemistry	Iron, Carbon Conductor	Iron, Nickel Conductor, Performance additives	Higher - Power, Capacity, Life, Efficiency Less - Fade, Defects, Gassing	X
Separator	Structure	Window Spacer	None-Woven Fabric; Extensive history in rechargeable alkaline industry	Higher - Power, More Robust Lower - Cost Required for no-maintenance	X
	Chemistry	PVC	Polypropylene	Higher - Life, Tolerance to abuse	X
Electrolyte		KOH	Non-KOH Proprietary	Higher - Capacity, Life, Temperature Range, Charge Retention, Efficiency	X
Cell Design		Historical Pocket Prismatic	Current Aircraft Starter Prismatic	Higher - Capacity, Tolerance to Physical Abuse Lower - Cost	

Encell NiFe Batteries

NiFe Advantages

- **BATTERY LIFE** - Longest cycle life battery chemistry known. No known failure mode of the active material. Edison batteries are functioning at initial capacity after 100 years.
- **OPERATING RANGE** – Outstanding high temperature performance. Better than NiMH, Lilon, NiCd, Lead Acid, and NiZn. Chemistry has excellent performance at 80° C.
- **ROBUSTNESS** - Most abuse tolerant of all battery chemistries. Tolerates extreme overcharge, deep discharge, extreme reversals, short circuits with no degradation. Electrode dimensional stability, no swelling for mechanical stress
- **EFFICIENCY** - Has potential to be the highest rate since the reaction kinetics are among the highest. Encell proprietary Fe electrode is the key
- **EXCELLENT SAFETY** - Safest: does not have a known thermal runaway, explosion, or burning failure mode. Also environmentally friendly since it does not use acid, or dangerous metals. Battery can be short circuited for handling
- **COST** – Cost equal to or below Lead Acid