Batteries for OBS Instrumentation

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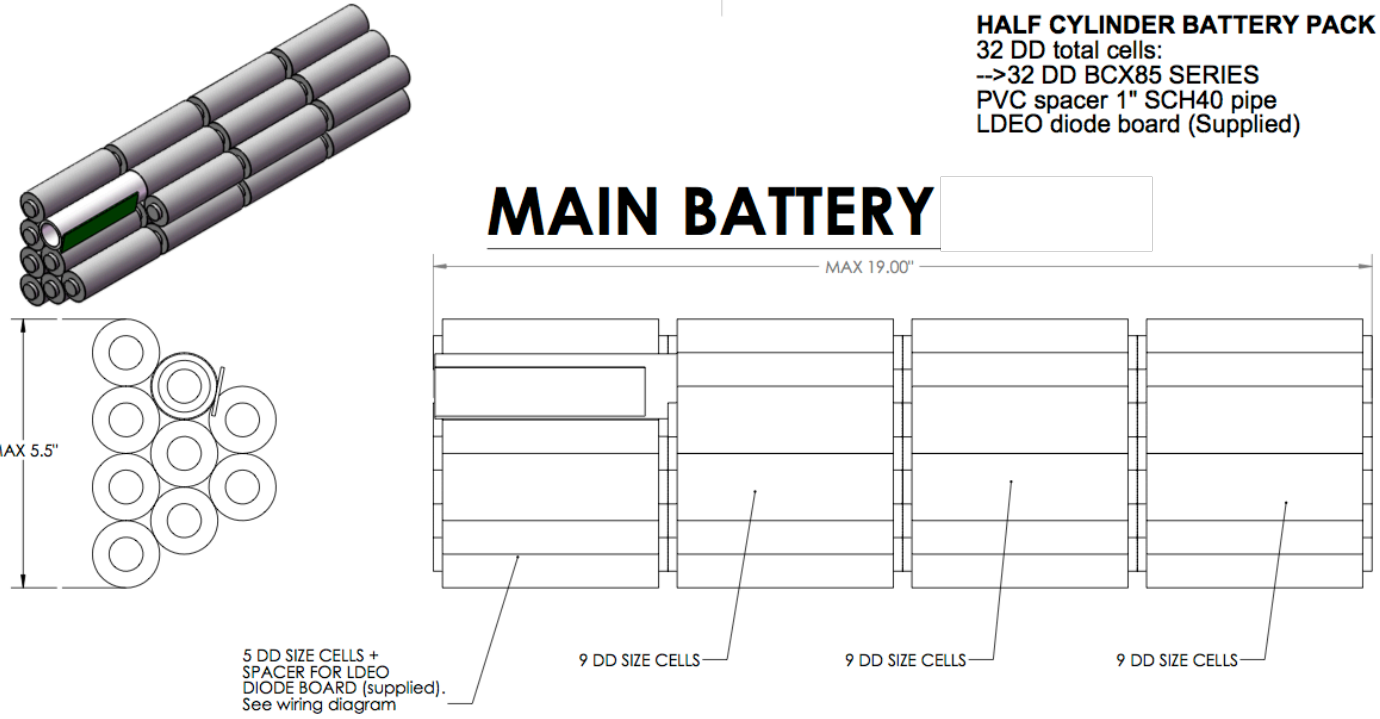
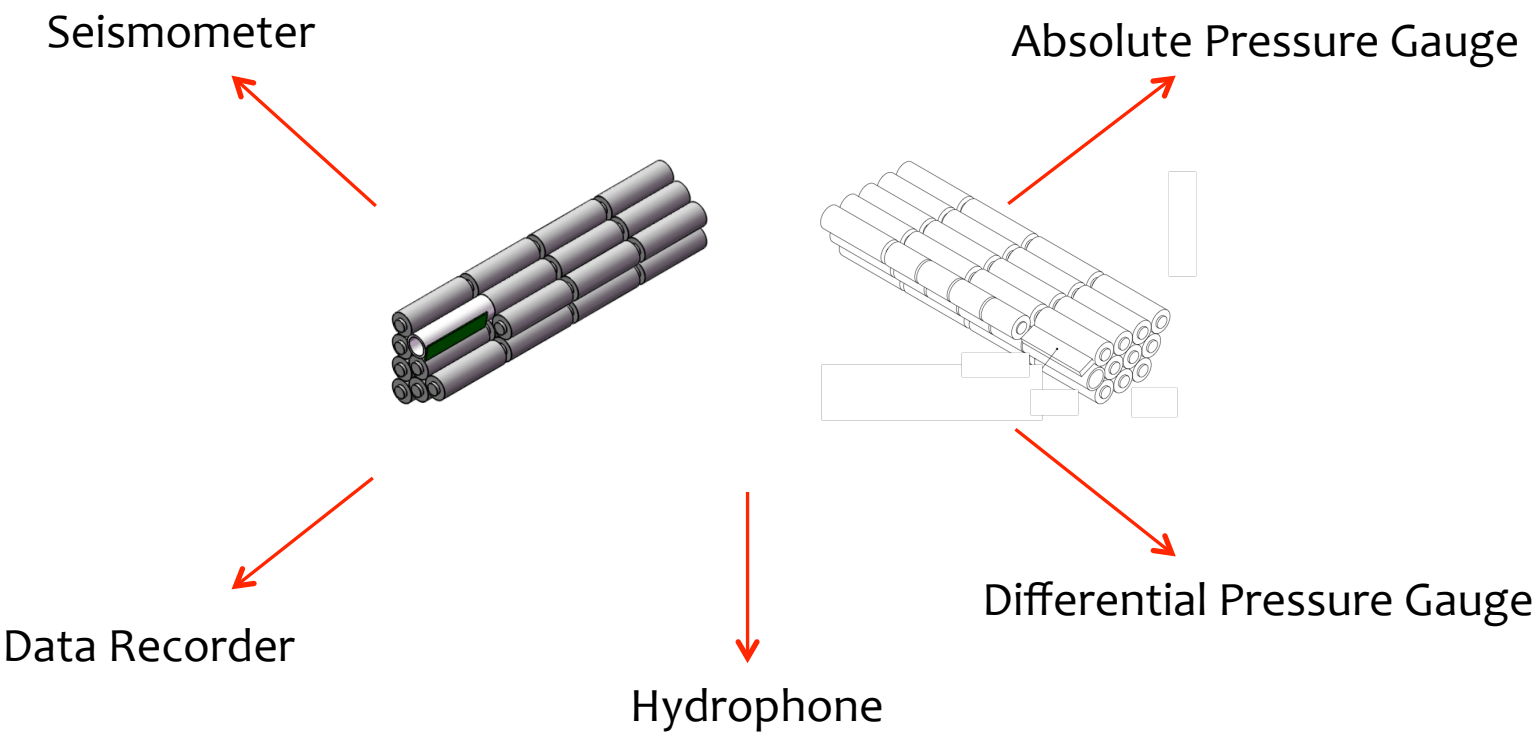
Our Current Battery Assembly

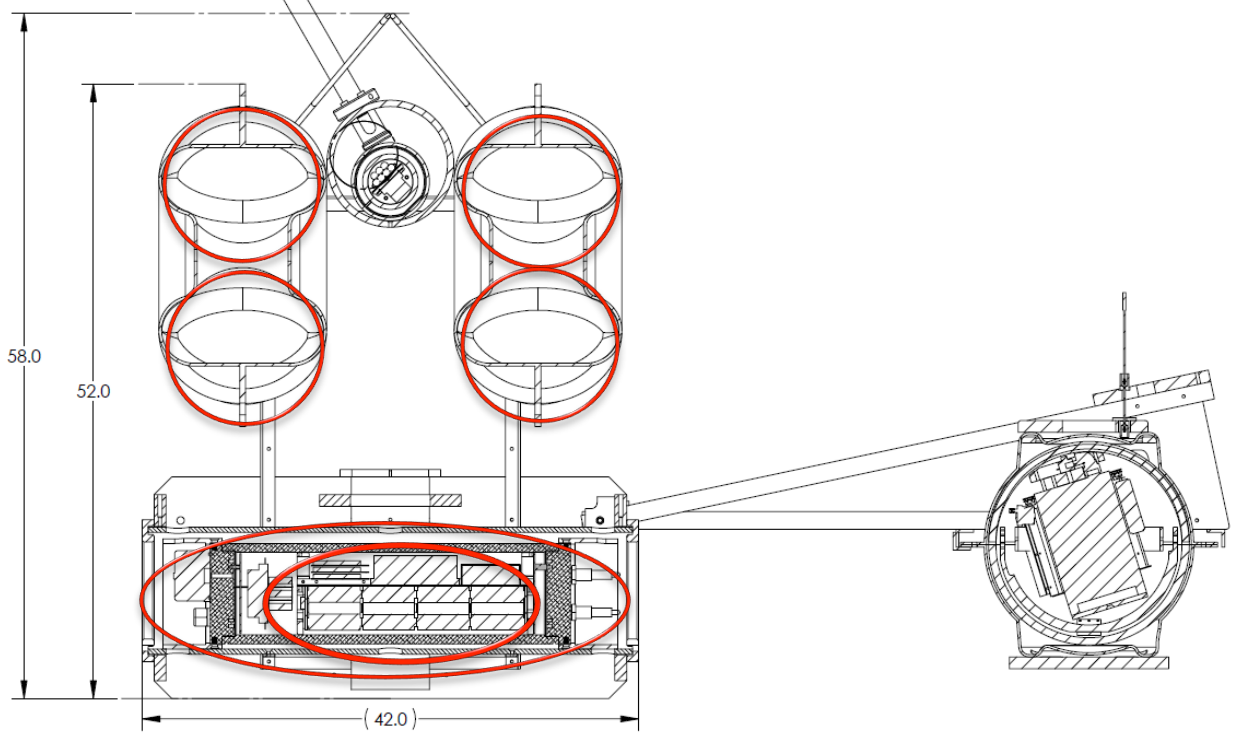


The Battery is a Central Piece to the OBS



The Key Role of the Battery

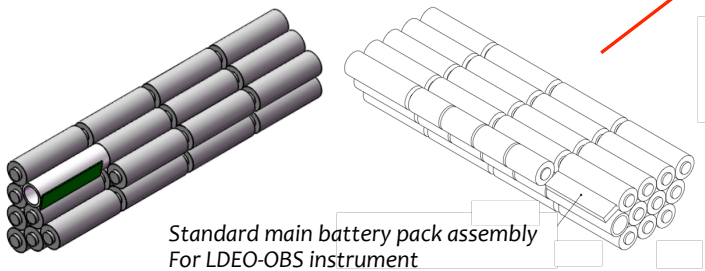
Size of Battery → **Size of Pressure Casing** → **Floatation Needed** → **Size & Shape of Frame**



A Few Considerations

Low Temperatures

Safety & Toxicity



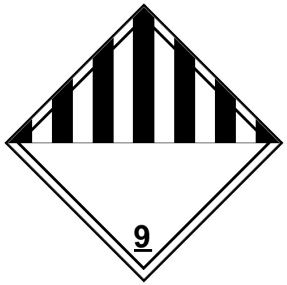
Standard main battery pack assembly
For LDEO-OBS instrument

High Pressure Environments

Long-Term Deployments

Safety of operation

Remnants of a battery pack after undergoing combustion



Options

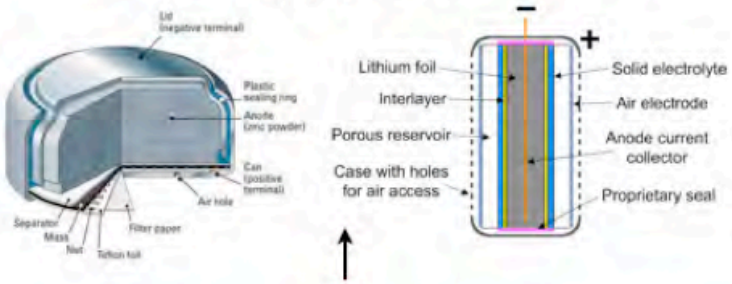
Batteries

Li/CF_x, $Li/SOCl_2$

self-contained

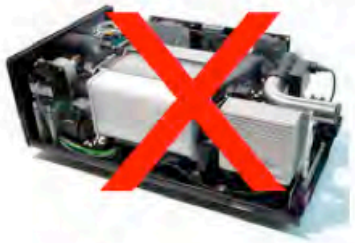
Semi-Fuel Cell

Zn/Air, Li/Air



Fuel Cell

PEM, DMFC, SOFC



fuel air

Increasing Energy density

In Seawater:

- Need pressure housing
- Energy density reduced by 50%
- Need to add bouyancy

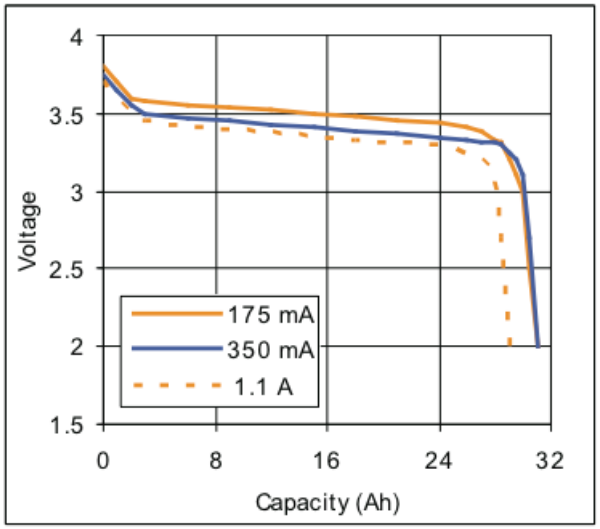
- Fuel cells make little sense for OBS instruments

What batteries are we using in our instruments?

* DD Lithium primary cells
* Lithium Bromine Chloride

Technical Overview

Open Circuit Voltage (25°C)	3.9 V
Rated Discharge Current	350 mA
Rated Capacity	30 Ah
Maximum Continuous Current	3.0 A
Cell Diameter	33.5 mm (1.32 in.)
Cell Length	111.5 mm (4.39 in.)
Cell Weight	216 g
Lithium Weight	10.2 g
Safety Fuse	4.0 A
Self Discharge	3% per year at 25°C
Operating Temperature	-55°C to +85°C
	-67°F to +185°F



Capacity vs. discharge rate at four different temperatures

Lithium Bromine Chloride Cell. Electrochem. Clarence, NY

Can We Use Recheargables?

* Waste reduction
* Lower cost

Battery type	Lead-acid	Ni-Cd	Ni-MH	Lithium-ion
Energy density[a] (W/kg)	30-50	45 – 80	60-120	110-160
Power density[b]	180	150	250 – 1000	1800
Nominal voltage	2V	1.25V	1.25V	3.6V
Overcharge tolerance	High	Moderate	Low	Very low
Self-discharge	Low	Moderate	High	Very low
Operating temperature	-20-60°C	-40-60°C	-20-60°C	-20-60°C
Cycle life[c]	200-300	1500	300-500	500-1000

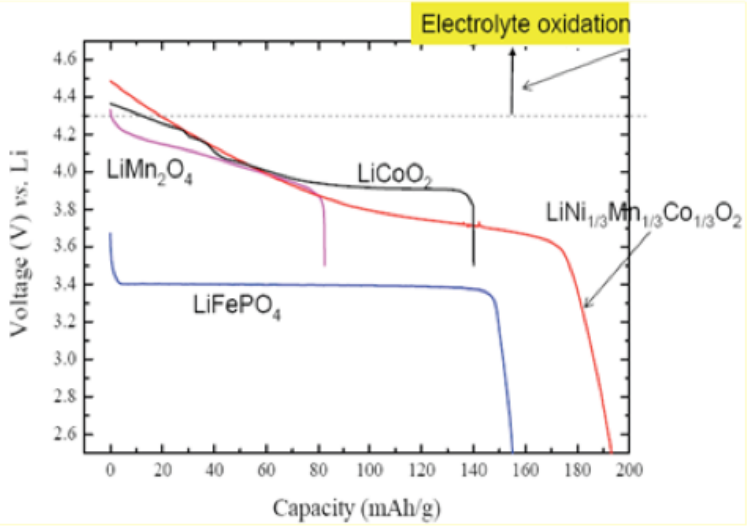
X. Chen, W. Shen, et al. *An Overview of Lithium-ion Batteries for Electric Vehicles. IPEC, IEEE 2012*

Li-ion Rechargeable Batteries

Cathode Material Types	EVs Battery Packs Manufacturers
Lithium Cobalt Oxide (LCO)	Panasonic, Telsa
Lithium Manganese Oxide (LMO)	AESC, EnerDel, GS Yuasa, Hitachi, LG Chem, Toshiba
Lithium Iron Phosphate (LFP)	A123, BYD, GS Yuasa, Lishen, Valence
Lithium (Nickel-Manganese-Cobalt) Oxide (NMC)	Hitachi, LG Chem, Samsung

Specifications	LCO	LMO	LFP	NMC
Nominal voltage	3.90V	3.70V	3.40V	3.60-3.70V
Charge limit	4.20V	4.20V	3.60V	4.20V
Cycle life	500	500-1000	1000-2000	1000-2000
Operating temperature	Average	Average	Good	Good
Specific energy (Wh/kg)	155	100-120	160	200
Specific power	1C	10C, 40C	35C	10C
Thermal runaway (°C)	150	250	270	210
Safety	Poor	Average	Very good	Good
Cost	High	Low	Moderate	Moderate

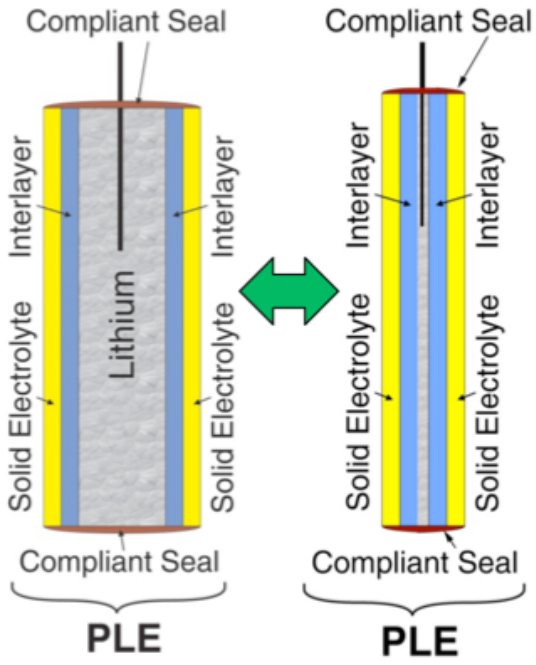
Performance comparison among commercially-viable lithium-ion batteries

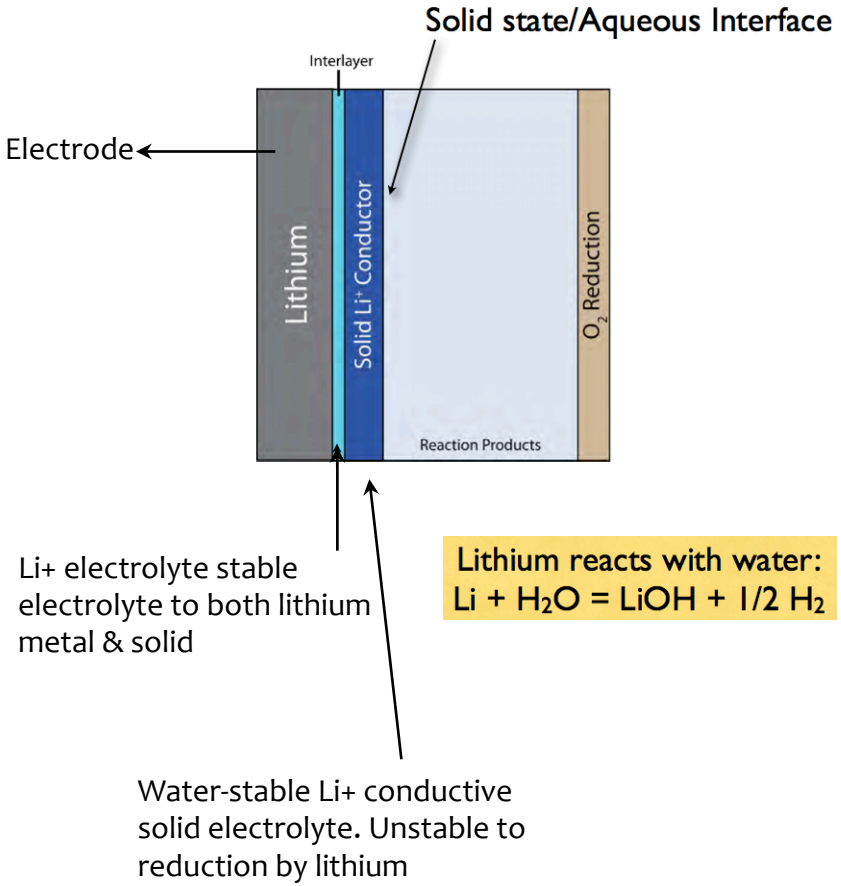


Voltage versus capacity of various lithium-ion batteries

X. Chen, W. Shen, et al. *An Overview of Lithium-ion Batteries for Electric Vehicles. IPEC, IEEE 2012*

The Protected-Electrode Battery: Li-Air Li-Seawater





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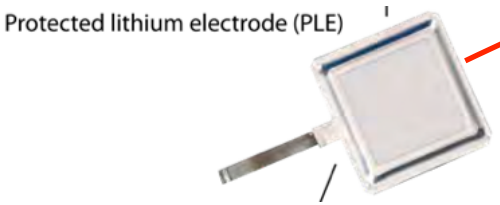

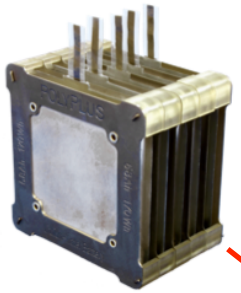

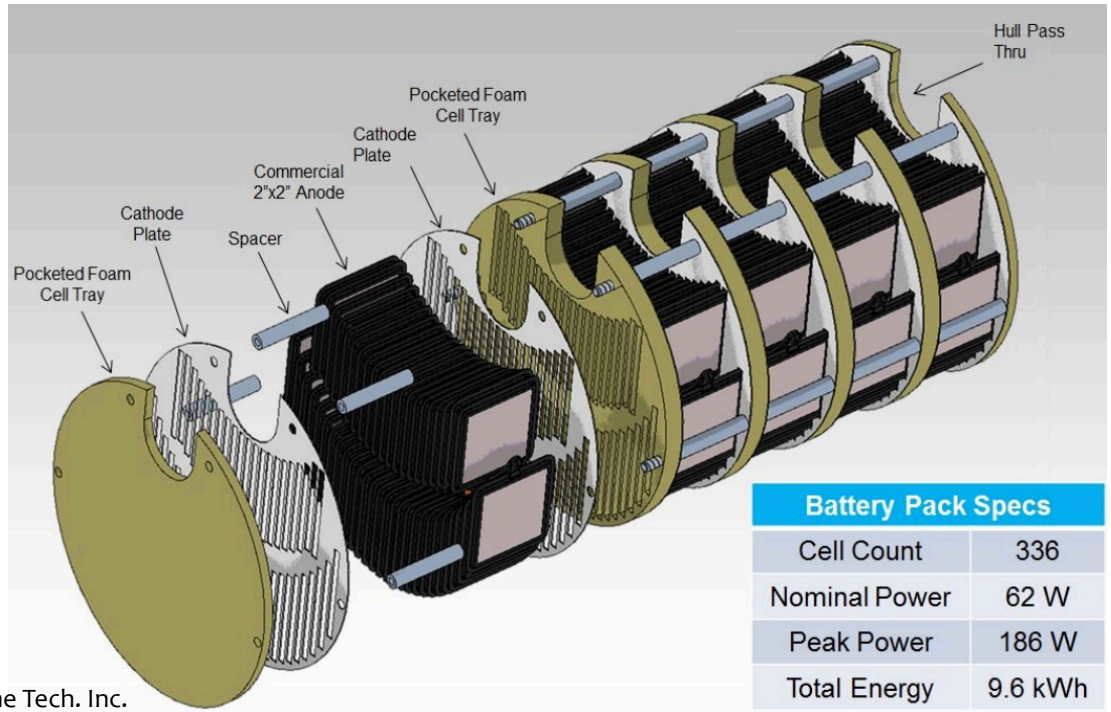

Battery Pack Specs	
Cell Count	336
Nominal Power	62 W
Peak Power	186 W
Total Energy	9.6 kWh

The Protected-Electrode Battery: Li-Air Li-Seawater

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Self Discharge	3% per year at 25°C
Operating Temperature	-55°C to +85°C
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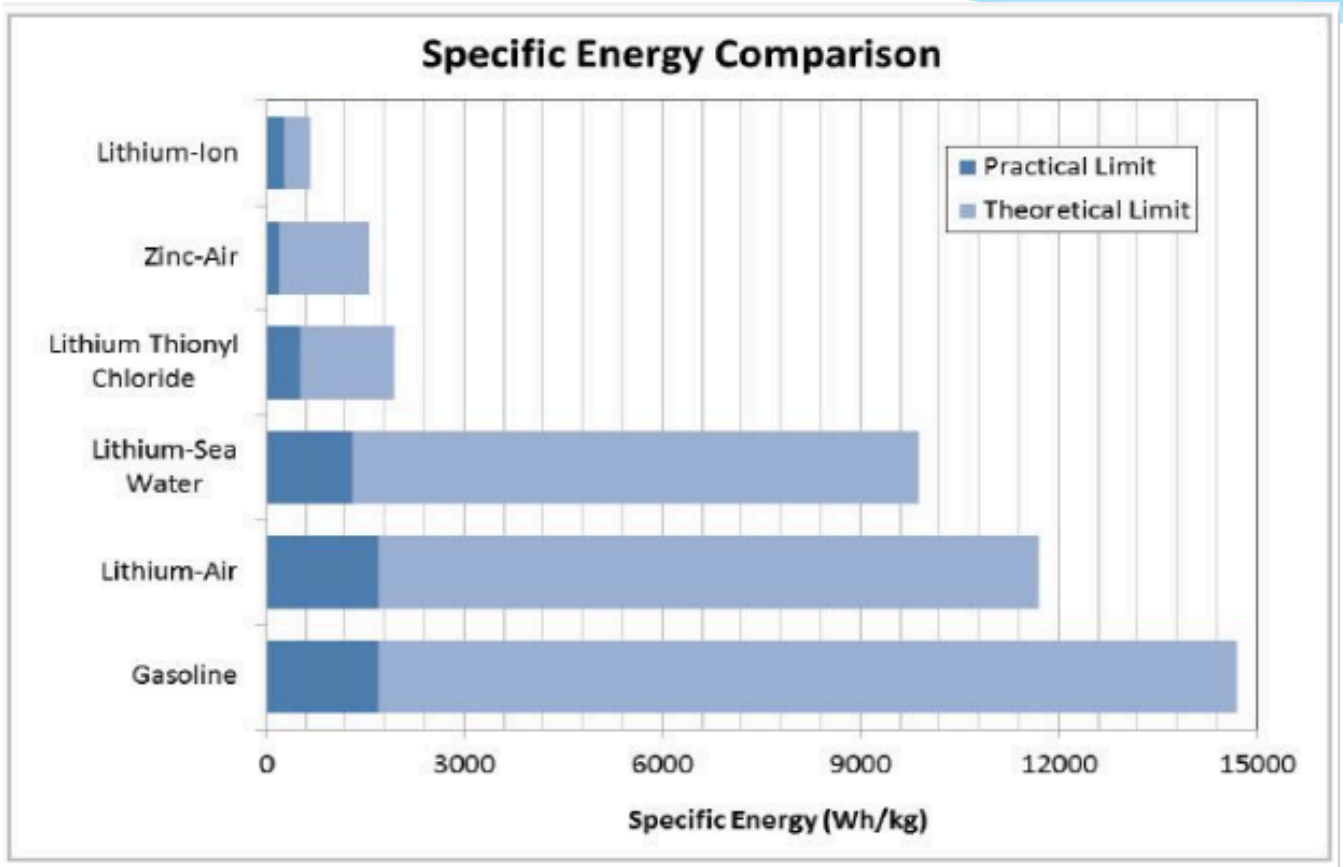
Performance Characteristics*

	Type I	Type II
Open Circuit Voltage	3.5 V	3 V
Nominal Voltage	3 V	2.5 V
Continuous Current Density	0.3 mA/cm	3 mA/cm
Nominal Cell Capacity	10 Ah	10 Ah
Specific Energy	**>1300 Wh/kg**	**400 Wh/kg**
Energy density	700 Wh/L	>600 Wh/L
Tested Mech. Pressure Tolerance	10,000 psi (6,500 m)	
Projected Shelf Life	>10 years	
Self-Discharge (prior/during use)	0%	

In Summary:


Specific Energy Comparison
Lithium-Ion
Zinc-Air
Lithium Thionyl Chloride
Lithium-Sea Water
Lithium-Air
Gasoline
Practical Limit
Theoretical Limit
0
3000
6000
9000
12000
15000
Specific Energy (Wh/kg)