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GROUP

AHEAD OF THE TIDE

Subsea Power – Enabling AUT

AUT 2019 - 23 October 2019

Darren Burrowes
CTO/BlueZone Group

AGENDA

THE NEED

LITHIUM ION

FUEL CELL

ALUMINIUM

CONCLUSION

SUBSEA RESIDENT AUV – THE NEED

- Rapid advances in miniaturisation
- An All Electric future?
- Reduced Through-Life Cost

ENABLING TECHNOLGIES

- Navigation
- Communication
- **Connection**
- Energy

20-FT CONTAINER COMPARISON

	Energy	Power
Lithium-Ion	0.5MWh	30kW
Fuel Cell	0.6MWh	80kW
Aluminium-Air	10MWh	500kW

Saab Sabretooth

10kWh @ 3.3kW

Porsche Taycan

93.4kWh @ 270kW

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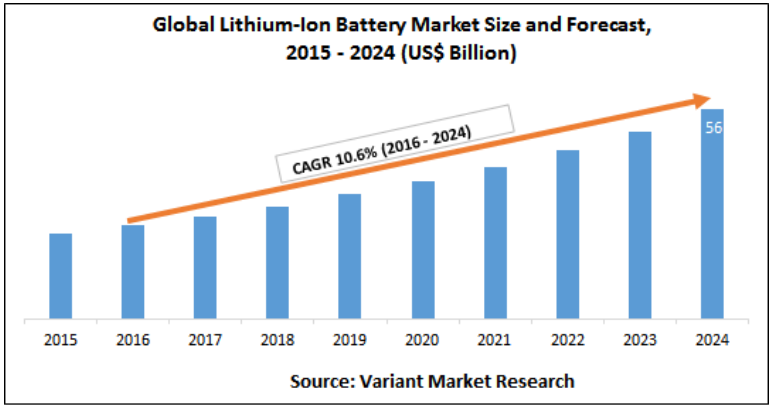
LITHIUM ION

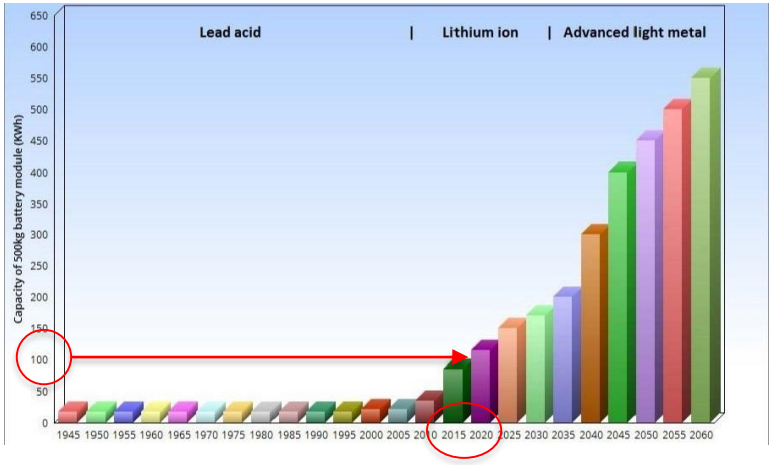
Lithium Ion Today

- Energy :100kWh Power: 30+kW
- Voltage range 14.4V to 400+V
- Currents up to ~100A
- Design life up to 30 years

Advanced Light Metal Future

- Improved lithium-ion technology,
- New battery chemistries
- Lithium-air, lithium-sulphur and sodium-ion





LITHIUM ION

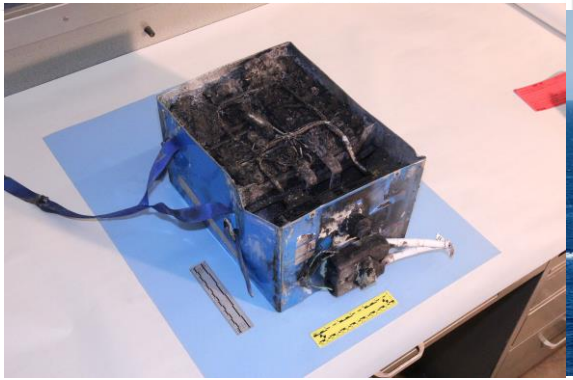
- Long-endurance lithium-ion batteries
- Australia's *Attack* Class submarines
- Safety issues

Japan Launches First Lithium-Ion Equipped *Soryu*-class Submarine

JS *Oryu* is the first Japanese disel-electric submarine to feature lithium-ion battery technology.

By Ankit Panda
October 05, 2018

Image Credit: Kawasaki



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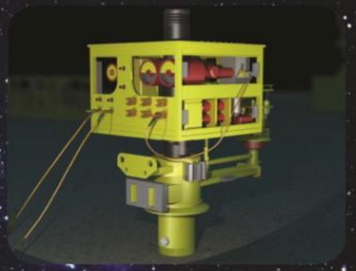
DEEP SPACE TO DEEP OCEAN

The Challenges

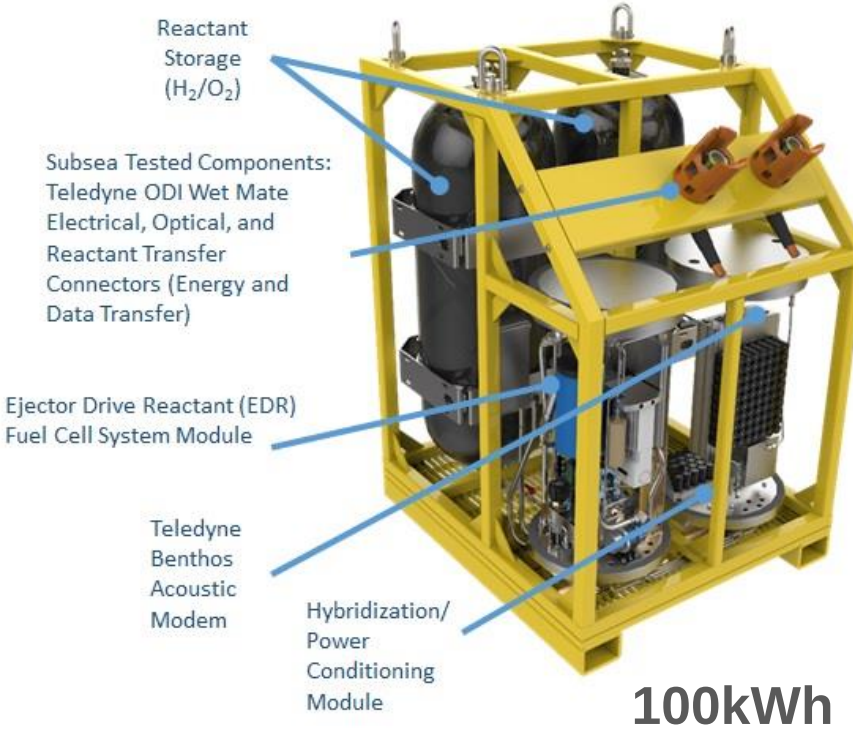
DEEP SPACE	DEEP WATER
Extreme temperatures	Extreme temperatures/pressures
Long lifetime	Long lifetime
Repair is not an option	Repair is impractical
Corrosive conditions	Corrosive conditions
Structural load	Structural load
Process chain traceability	Process chain traceability



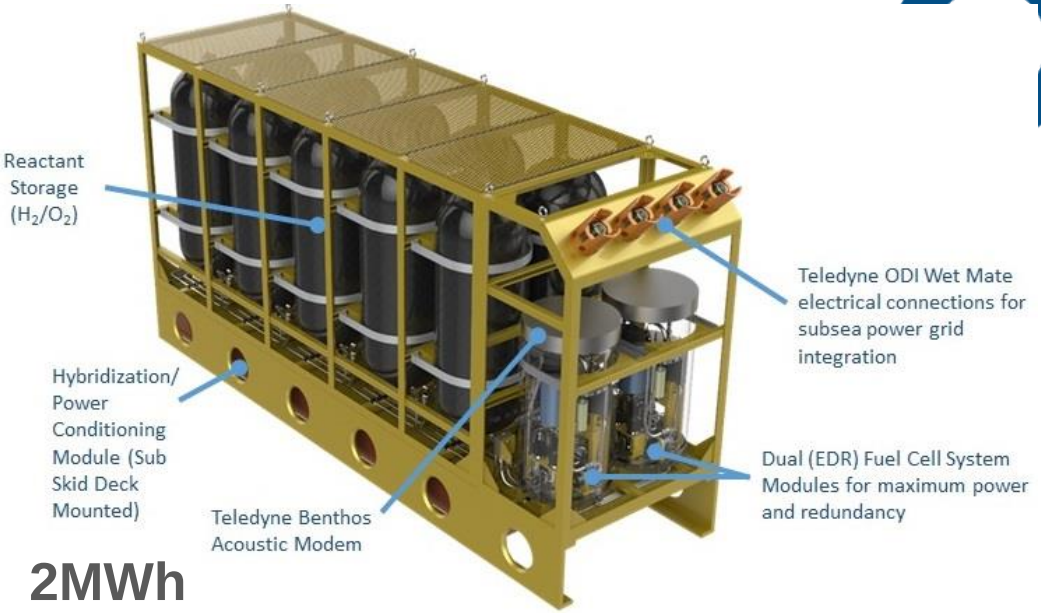



SUBSEA POWER NODE

- 1.5x1.4x1.4 skid at 810kg
- Long life >10,000 hours
- Reactant storage agnostic
- Compressed-gas
- TRL 9 commercially refillable



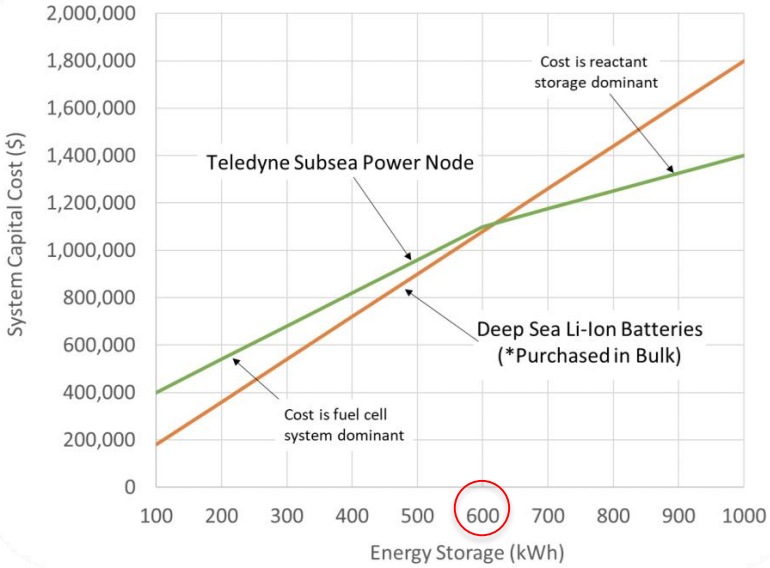
100kWh



2MWh

SUBSEA POWER NODE

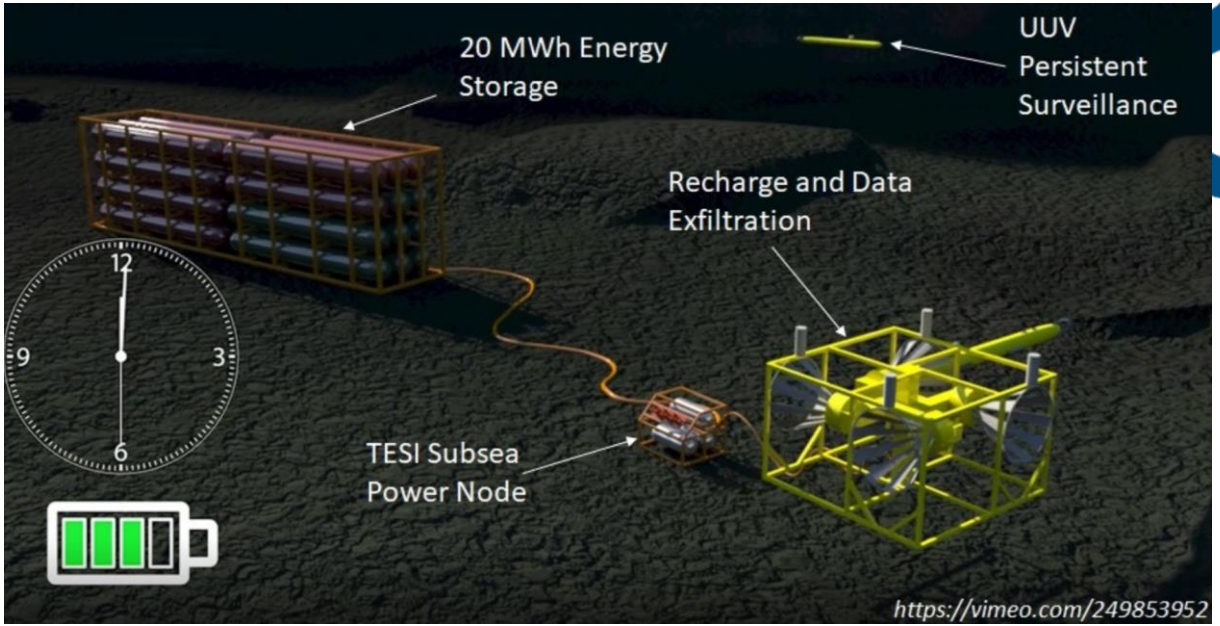
- Cost decrease for energy increase
- Lower capital cost for energy > 600 kWh
- Unfuelled fuel cell systems are not required to meet special safety regulations
- Can operate at very low temperatures and have freeze-thaw cycle capability
- No “shelf-life” - degradation is based on hours of operation not date of manufacture



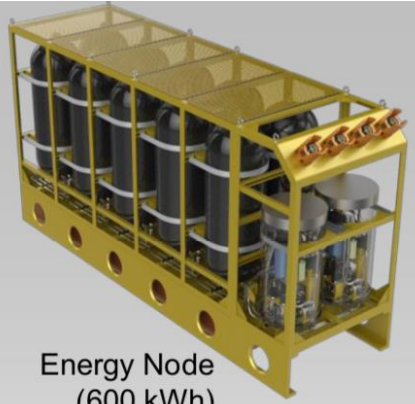
SUBSEA POWER NODE

Specifications

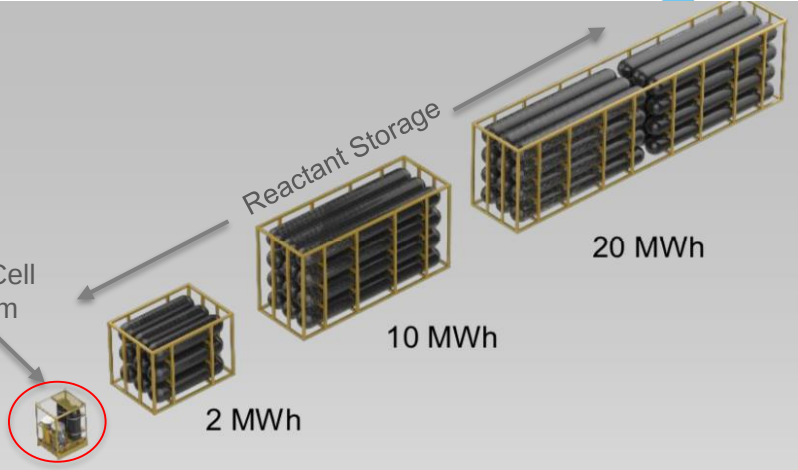
- Power: 16kW (Continuous)
- Voltage: 400 to 600 Vdc
- Grid balancing capable
- Mass Target: 3,370 kg
- Negative buoyant fuelled
- Positive buoyant empty
- Operating Depth: 3000m



Power Node
(100 kWh)



Energy Node
(600 kWh)



		2019	2020	2023
Application	**Power Range**	**Subsea Power Node (100 kWh)***	**Energy Node (600 kWh)***	**40' Class Container (20 MWh)***
ROV	1 to 2 kW	Months of operation	18 Months of operation	Years of operation
21" UUV Recharge Dock	1 to 5 kW	8 recharge cycles (800 km of traverse)	48 recharge cycles (4,800 km of traverse)	Years of operation
Chemical Injection System	3 to 6 kW	Month of operation	6 Months of operation	5 years of operation
Hydraulic Pressure Unit	4 to 80 kW**	Month of operation	4 Months of operation	1-2 years of operation

- ✓ Subsea operations with minimal ship support
- ✓ UAV surveying and mapping with persistent monitoring
- ✓ Enables both surface and subsea communication and broadcast
- ✓ Subsea micro-grid back-up power and stabilization
- ✓ Data can be transmitted to the node and either tethered to the surface or stored for retrieval during node recovery

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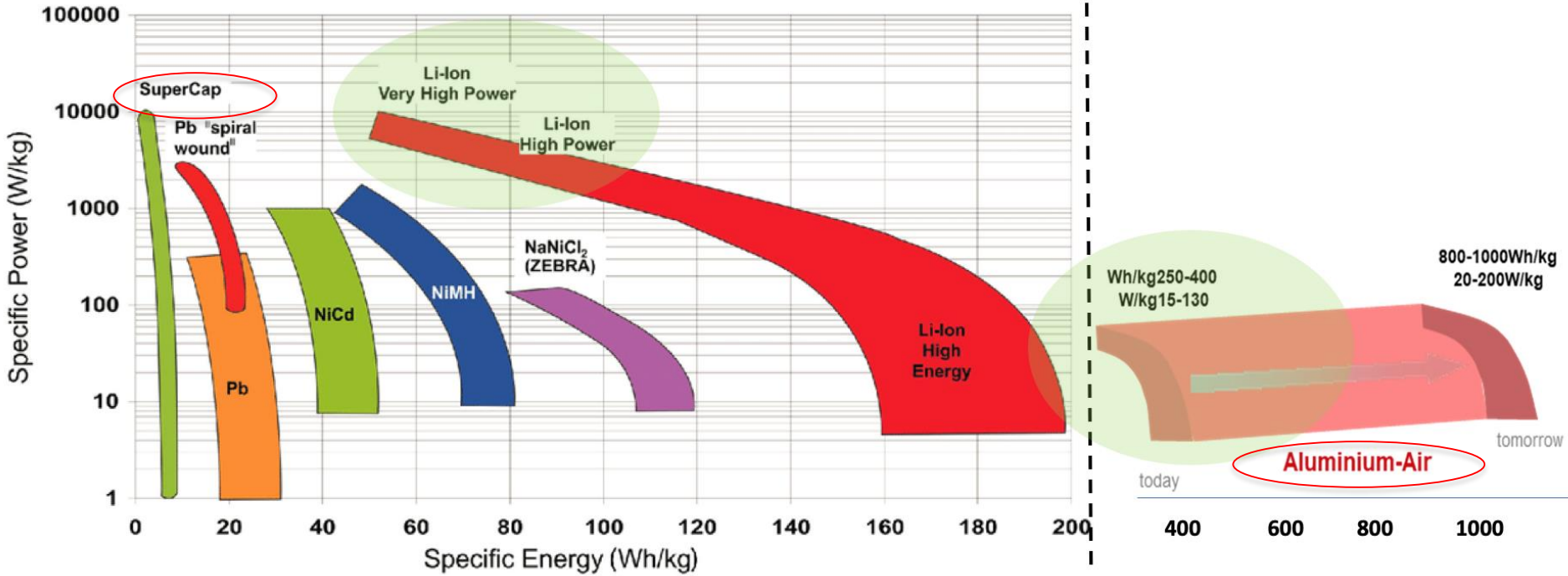
MORE POWER ON THE SEABED

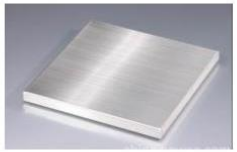


Source: Electric Power Research Institute

METAL OF CHOICE ALUMINIUM

2. Transporting clean energy

1. Storing clean energy



Aluminum

Discharging

Aluminum hydroxide

Alumina

Charging

3. Discharging clean energy

Mining Bauxite
Most abundant metal in earth's crust

Recycling
75% of all aluminum ever made is still in productive use

Applications
Fire retardant
Pharmaceutical

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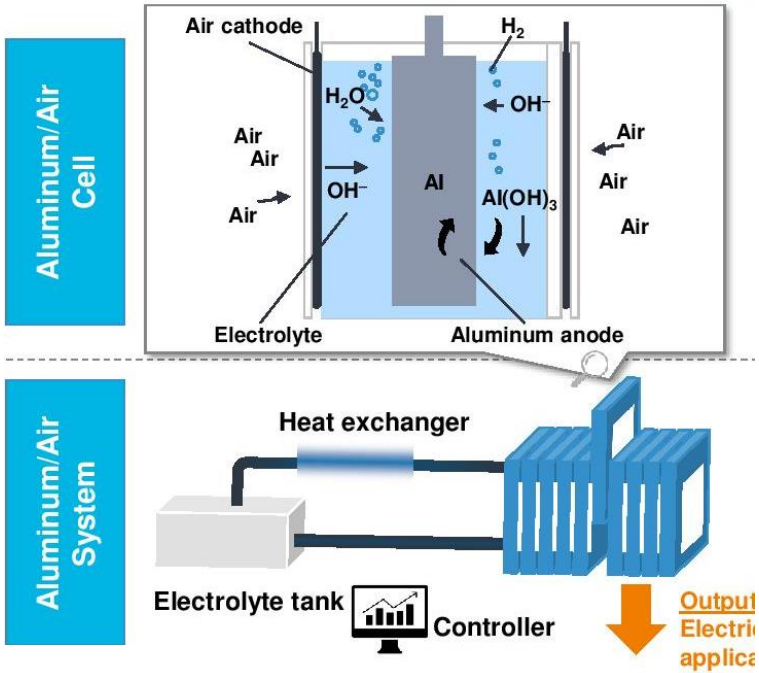
ALUMINIUM – AIR BATTERY



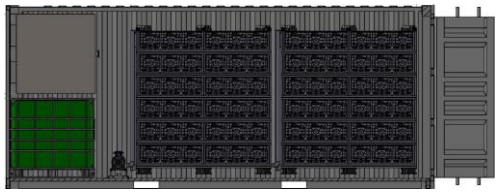
- Air-Cathode separates Oxygen from air and catalyst allows reaction with water
- Aluminum Hydroxide Al(OH)3 is produced at the anode generating heat and electricity

4Al + 3O2 + 6H2O → 4Al(OH)3 + 2.71 V

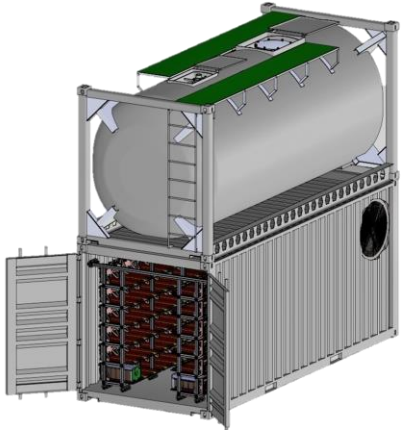
- Aqueous-electrolyte is continuously circulating in cells:
  - Flushing out by-products
  - Regulating heat

AL – AIR CONTAINERISED CONFIGURATIONS

1X20’ container
5760 *kWh*
Integral electrolyte tank
(requires 5 reloads)



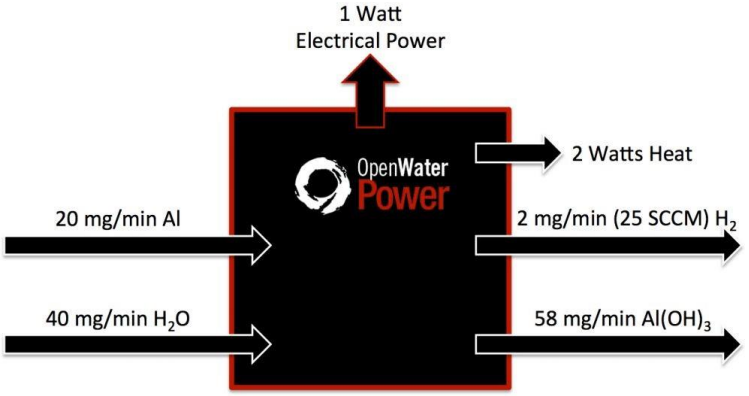
1X20’ container
7200 *kWh*
1X20’ electrolyte
tank container

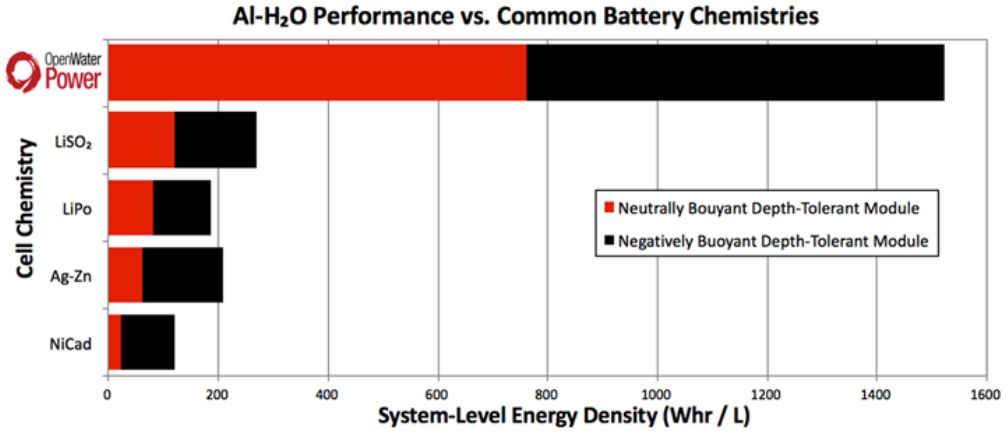


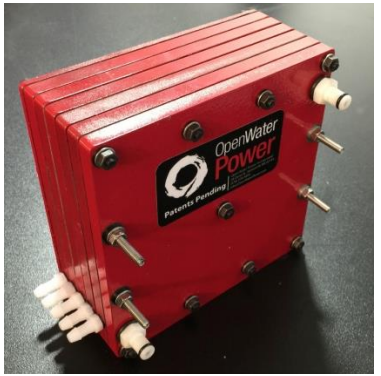
1X20’ container
10,000 *kWh*
Electrolyte produced
onboard utilizing heat
emitted from the chemical
reaction

ALUMINIUM - WATER

- Ten-fold increase in energy density
- Inherently safer
- Chemically inert prior to activation







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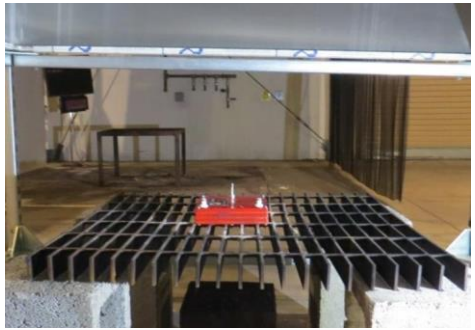
ALUMINIUM – WATER - SAFETY

- Does not generate hazards when exposed to extreme storage temperatures, low pressures, or fires



NAVSEA WARFARE CENTERS Carderock — Summary and Conclusions

Test	Description
High Temperature (71°C)*	No hazards observed
Low Temperature (-51°C)*	No hazards observed
Low Pressure (8.3 psia)*	No hazards observed
Near-vacuum (fraction of a psia)	No hazards observed
Activity Verification	Cell shown to be electrochemically active. No hazards observed during inadvertent short, but H_2 release rate not measured.
Fire Exposure	Minimal burning of non-metallic components. No significant heat release beyond exposure fire.

*Test specifications from MIL-STD-810G

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- Need: Subsea resident AUV & All-electric field
- Rapid technology development in energy storage
- Subsea applications coming soon

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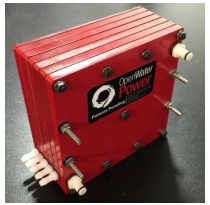

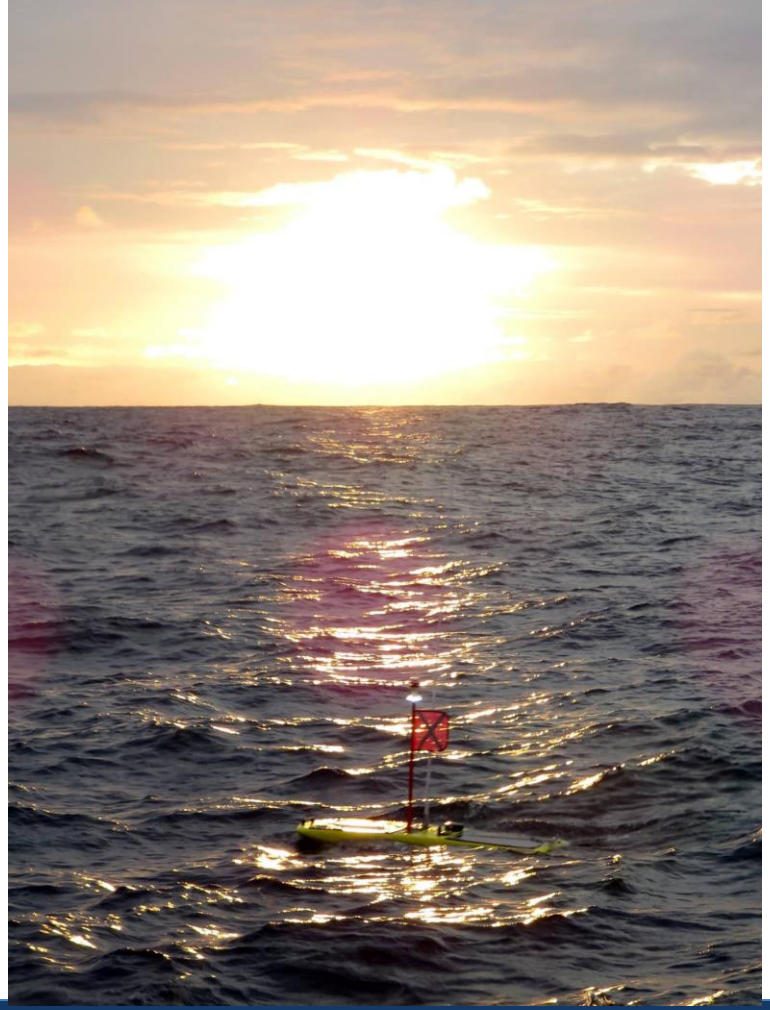

Thank you

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