Subsea Power – Enabling AUT
AUT 2019 - 23 October 2019

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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 TECHNOLOGIES

• Navigation
• Communication
• Connection
• Energy
20-FT CONTAINER COMPARISON

<table>
<thead>
<tr>
<th></th>
<th>Energy</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithium-Ion</td>
<td>0.5MWh</td>
<td>30kW</td>
</tr>
<tr>
<td>Fuel Cell</td>
<td>0.6MWh</td>
<td>80kW</td>
</tr>
<tr>
<td>Aluminium-Air</td>
<td>10MWh</td>
<td>500kW</td>
</tr>
</tbody>
</table>

Saab Sabretooth
10kWh @ 3.3kW

Porsche Taycan
93.4kWh @ 270kW
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 diesel-electric submarine to feature lithium-ion battery technology.

By Ankit Panda
October 05, 2018

Image Credit: Kawasaki
AGENDA
THE NEED
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CONCLUSION
DEEP SPACE TO DEEP OCEAN

The Challenges

DEEP SPACE
- Extreme temperatures
- Long lifetime
- Repair is not an option
- Corrosive conditions
- Structural load
- Process chain traceability

DEEP WATER
- Extreme temperatures/pressures
- Long lifetime
- Repair is impractical
- Corrosive conditions
- Structural load
- 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
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
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
AGENDA
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MORE POWER ON THE SEABED

Source: Electric Power Research Institute
**Metal of Choice: Aluminium**

1. **Storing clean energy**
   - Mining Bauxite
     - Most abundant metal in earth’s crust
   - Charging
   - Alumina

2. **Transporting clean energy**
   - Discharging
   - Aluminum

3. **Discharging clean energy**
   - Recycling
     - 75% of all aluminum ever made is still in productive use
   - Applications
     - Fire retardant
     - Pharmaceutical
   - Aluminum hydroxide
**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

\[
4\text{Al} + 3\text{O}_2 + 6\text{H}_2\text{O} \rightarrow 4\text{Al(OH)}_3 + 2.71 \ \text{V}
\]

- 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
ALUMINIUM – WATER - SAFETY

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

Summary and Conclusions

<table>
<thead>
<tr>
<th>Test</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Temperature (71°C)*</td>
<td>No hazards observed</td>
</tr>
<tr>
<td>Low Temperature (-51°C)*</td>
<td>No hazards observed</td>
</tr>
<tr>
<td>Low Pressure (8.3 psia)*</td>
<td>No hazards observed</td>
</tr>
<tr>
<td>Near-vacuum (fraction of a psia)</td>
<td>No hazards observed</td>
</tr>
<tr>
<td>Activity Verification</td>
<td>Cell shown to be electrochemically active. No hazards observed during inadvertent short, but H₂ release rate not measured.</td>
</tr>
<tr>
<td>Fire Exposure</td>
<td>Minimal burning of non-metallic components. No significant heat release beyond exposure fire.</td>
</tr>
</tbody>
</table>

*Test specifications from MIL-STD-810G
CONCLUSION

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

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