Malta Pumped Heat Energy Storage

DOE Long Duration Energy Storage Workshop
“BIG” Energy Storage: Priorities and Pathways to Long-Duration Energy Storage

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Malta is Long-Duration Energy Storage

Malta’s grid-scale pumped heat energy storage system (PHES) is a low-cost, long-duration solution which will enable the global energy transition.

- **Long-Duration**: 8 - 24+ Hours
- **Grid-Scale**: 10 - 100 MW+
- **Low-Cost**: <$100/kWh
Malta PHES: Recuperated Air-loop Brayton-cycle Heat Pump/Heat Engine

“Necessary, Sufficient, and Doable”


Malta’s Competitive Advantage

• Long-Duration - 8 to 24+ hours
• Low-Cost - 100 MW systems projected to be < $100/kWh
• Long Useful Life - Over 30 years w/o capacity degradation
• Rotating Inertia - Malta provides inertia to the grid as fossil/nuclear plants retire
• Separation of Charge / Discharge Capacity and Duration - Power capacity determined by turbomachinery and heat exchangers, energy duration determined by hot / cold storage volumes
• Decoupling of Charge from Discharge - Prime movers for the charge / discharge cycles are on physically separate powertrains; allows design to be tailored to customer’s specific use case
• Availability of Waste Heat - Energy losses in Malta system are easily extracted for industrial applications (district heating, thermal desalination)

Key Characteristics – Malta vs. Li-Ion Battery

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Malta PHES</th>
<th>Li-Ion Battery</th>
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<tbody>
<tr>
<td>Roundtrip Efficiency (e- to e-)</td>
<td>55-65%</td>
<td>85%+</td>
</tr>
<tr>
<td>Roundtrip Efficiency (including thermal)</td>
<td>90%+</td>
<td>85%+</td>
</tr>
<tr>
<td>Duration</td>
<td>8-24+ hours</td>
<td>0-6 hours</td>
</tr>
<tr>
<td>Projected Installed Cost ($/kWh at 10 hrs)</td>
<td>$100-150</td>
<td>$170-250</td>
</tr>
<tr>
<td>Economies of Scale</td>
<td>Significant</td>
<td>Limited</td>
</tr>
<tr>
<td>Expected Useful Life (Years)</td>
<td>30+ years</td>
<td>10-15 years</td>
</tr>
<tr>
<td>Annual Degradation</td>
<td>None</td>
<td>2%</td>
</tr>
<tr>
<td>Ability to Decouple Charge-Discharge</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>OK to Operate at High Ambient Temps.</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Frequency Response</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Reactive Power</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Voltage Management</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Inertia</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Blackstart Capability</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>District Heat Applications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commodity Risk</td>
<td>None</td>
<td>Li/Co/Rh</td>
</tr>
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Project Description

- Vertically integrated utility
- Total generating capacity several GW with significant near-term coal retirement obligations
- Resource adequacy, renewables shifting

Commercial Highlights

- Vertical integration allows project to take advantage of all available system benefits
- Initial tolling agreement plus option to transfer asset at or after year 2 of operations
- Malta engaged (paid) to support contract rate case
- System benefits analysis in process; will determine annual project benefits to the utility
- Permitting consultant engaged
- Interconnection evaluation in process
- Contract negotiations and analysis underway

Schedule & Location

<table>
<thead>
<tr>
<th>Project Schedule</th>
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<tbody>
<tr>
<td>Site Control</td>
<td>Q1’2021</td>
</tr>
<tr>
<td>Revenue Agreement</td>
<td>Q3’2021</td>
</tr>
<tr>
<td>Notice to Proceed</td>
<td>Q2’2022</td>
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<tr>
<td>COD</td>
<td>Q1’2024</td>
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</tbody>
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World-Class Partners

• Malta’s ownership represents a unique balance of **bold visionaries** and **world-class execution experience**
  - Breakthrough Energy Ventures
  - Google

• The company recognizes the value of technical partnerships and has aligned itself with the best
  - Heat Exchangers – Alfa Laval
  - Turbomachinery – **upcoming press release**
  - Engineer – Proman

• Commercial partners present relationship-based channels to market, along with insights into use case effectiveness and customer value
  - Utility Customer – **upcoming press release**

https://www.maltainc.com/malta-raises-50-million
Gaps, Challenges, and R&D Opportunities

- What is the work that needs to be done?
  - Major Equipment Design/Modification
  - Control & Operability (system vs. component)
  - Assembly of Guarantees & Warranties
  - Project Finance (project equity and project debt)

- What are potential roadblocks?
  - Too many novel items within a system (uncertainty)
  - Technical risk
  - Financial risk
  - Is it necessary, sufficient, and doable?

Specific helpful DOE support and R&D areas

- Extracting Best Practice Learnings

- Specialized testing facilities
  - Ideal-gas Brayton Loop
  - Full-size Heat Exchanger test loop: at actual boundary conditions (e.g. air and salt at pressure, temp., full flow); performance, corrosion, fatigue, lifecycle

- Materials testing
  - Test data for creep-fatigue interactions at temperature and pressure (needed for ASME BPV certification)
  - Corrosion, specifically stress-corrosion cracking given materials interaction (salt to base metal) at pressure, temperature, and under dynamic flow conditions

- Civil/structural research
  - Implications of wet soil and non-dry-sand soil types on molten salt tank foundation design, thermal cycling, tank life
Thank You

- Long-Duration: 8 - 24+ Hours
- Grid-Scale: 10 - 100 MW+
- Low-Cost: <$100/kWh

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