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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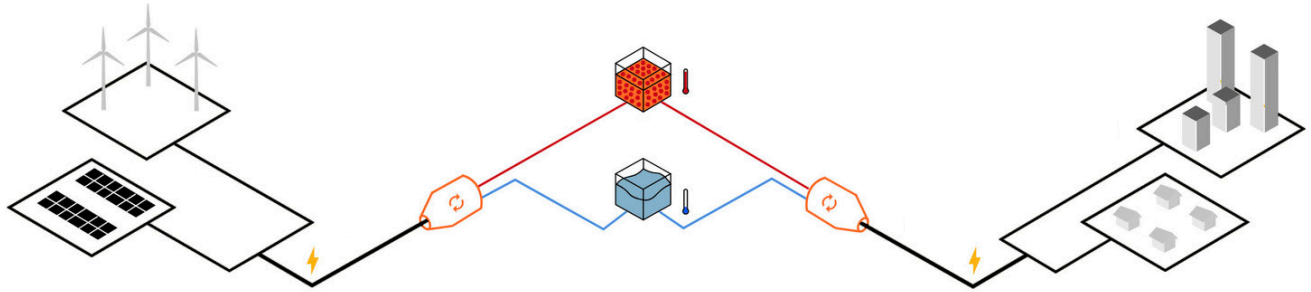
Malta is Long-Duration Energy Storage



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

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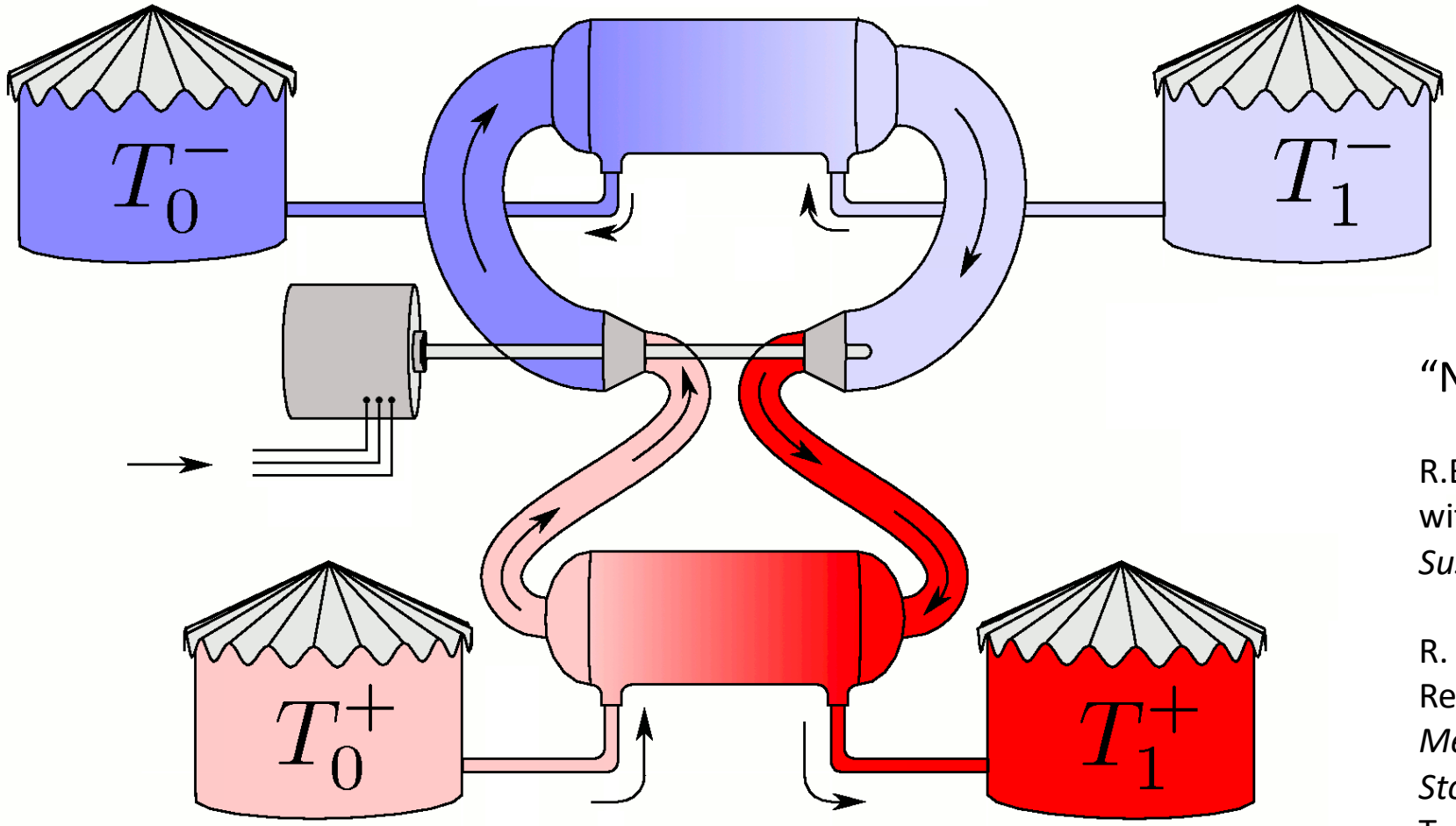
Malta PHES: Recuperated Air-loop Brayton-cycle Heat Pump/Heat Engine



"Necessary, Sufficient, and Doable"

R.B. Laughlin, "Pumped thermal grid storage with heat exchange," *Journal of Renewable and Sustainable Energy* 9, 044103 (2017)

R. B. Laughlin, "Mass Grid Storage With Reversible Brayton Engines," in *Thermal, Mechanical, and Hybrid Chemical Energy Storage Systems*, ed. by K. Brun, R. Dennis and T. Allison. London UK, Elsevier, 2021.

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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-

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

Project 1

Project Description

Customer & Application

- 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

Project Progress

- 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

Project Schedule

Site Control	**Q1'2021**
Revenue Agreement	**Q3'2021**
Notice to Proceed	**Q2'2022**
COD	**Q1'2024**

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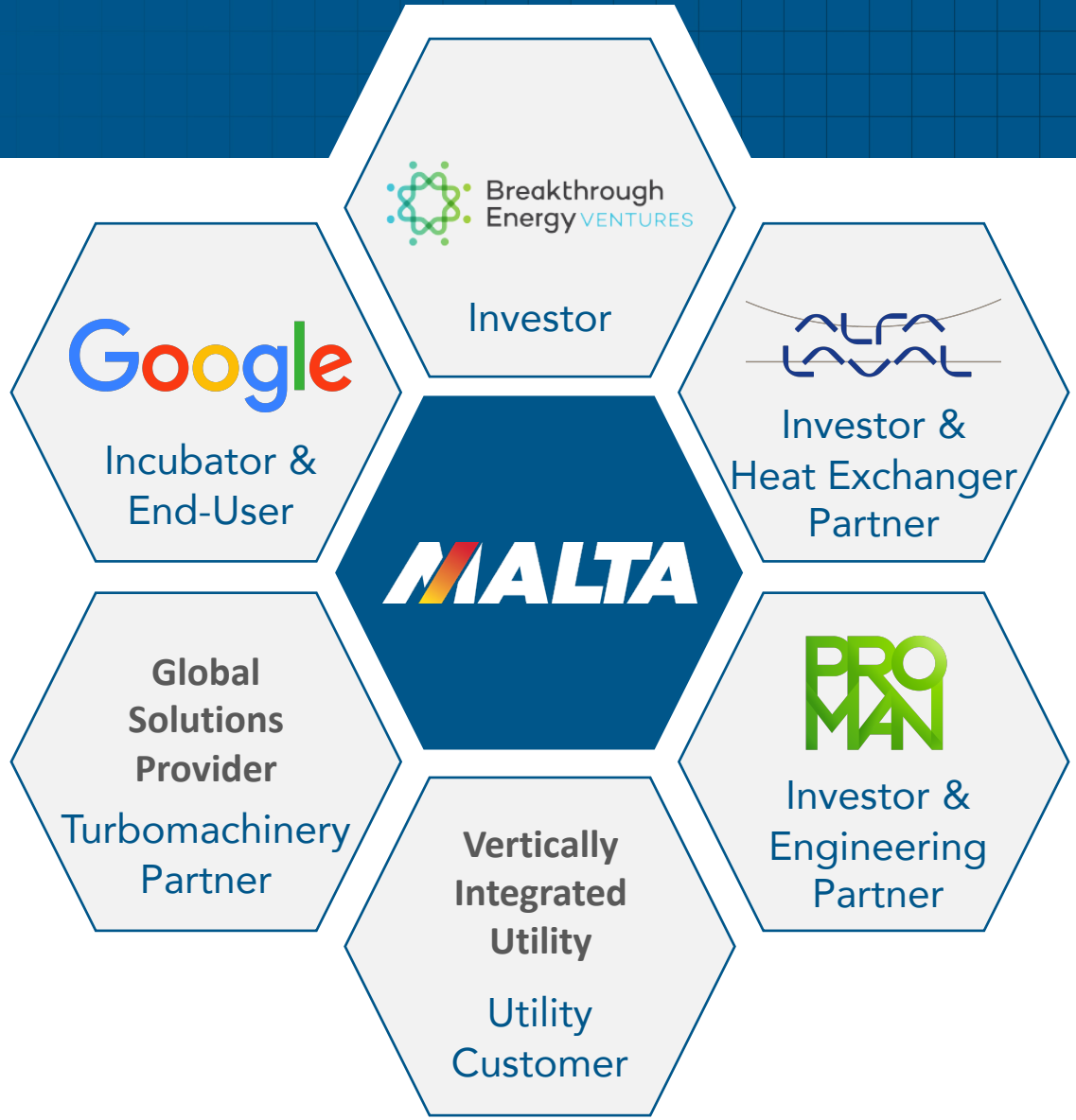
World-Class Partners

- 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
  - E.g. Mark Mehos et al. Concentrating Solar Power Best Practices Study. Technical Report NREL/TP-5500-75763 June 2020
- 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

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Thank You

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