

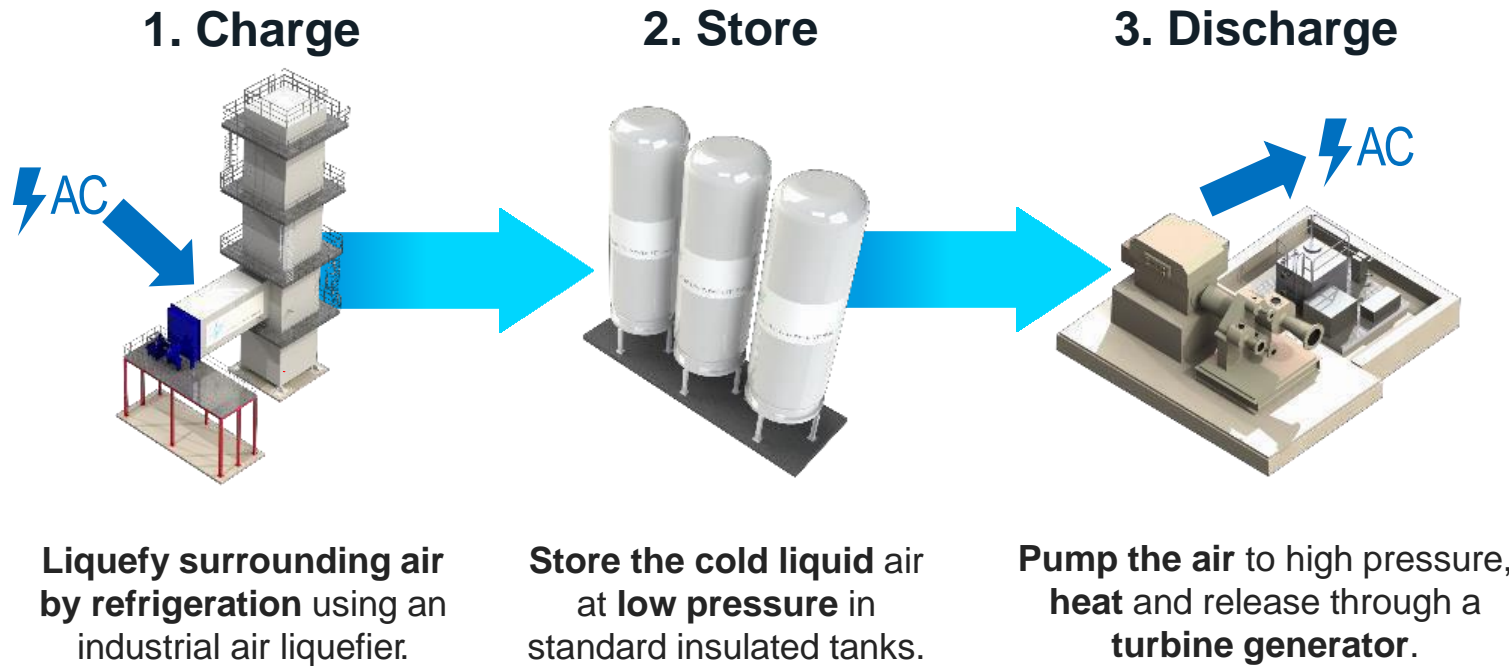


Liquid Air Energy Storage
Highview's Technology



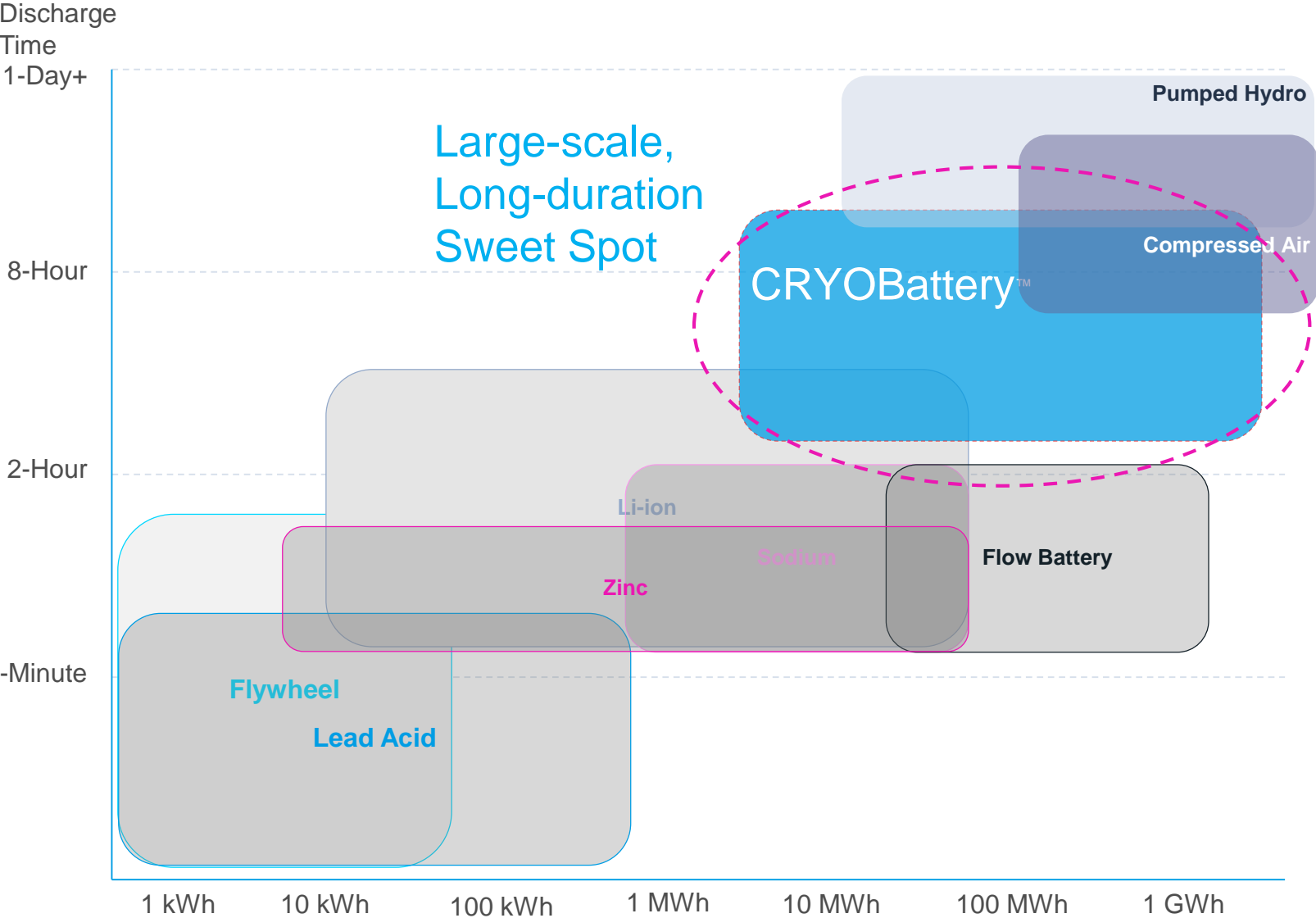
CryoBattery: Technology Overview

The processes used in the CryoBattery system are well known in the O&G sector and air separation industry and both sectors have a long history and a well-developed supply chain.



The three components can be **sized independently** to achieve the most cost-effective solution

Optimal Technology for Large-Scale, Long-Duration Storage



Services Supported by CRYOBattery™

- Wholesale market
25-200+ MWh
3-10 hours
- Transmission
25-200+ MWh
3-8 hours
- Large Scale Renewables
50-500+ MWh
4-12 hours

CRYOBattery™ Cost and Performance Leader for Long-Duration Storage



	Chemical	Mechanical		
	Li-Ion	CRYOBattery™	Pumped Hydro	Compressed Air Storage
Size (MW)	• 0–100+	• 25 – 500+	• 25-1 GW+	• 150+
Duration	• Mins -Hours	• Hours - Days	• Hours - Days	• Hours - Days
Cost Outlook	+++	++	-	-
Lifetime (years)	• Medium	• Long	• Long	• Long
Degradation	• Yes	• No	• No	• No
Efficiency	• 85%+	• 60%+	• 70%+	• 50%+
Deployment Time	• 3-9 months	• 1-2 years	• 4+ years	• 2+ years
Pros & Cons	<ul style="list-style-type: none"> ✓ Rapid deployment ✓ Standard & repeatable ✗ High degradation 	<ul style="list-style-type: none"> ✓ Location ✓ Standard & repeatable ✓ Low risk of site rejection 	<ul style="list-style-type: none"> ✗ Location ✗ Site-specific design ✗ High risk of site rejection 	<ul style="list-style-type: none"> ✗ Location ✗ Expensive ✗ High risk of site rejection

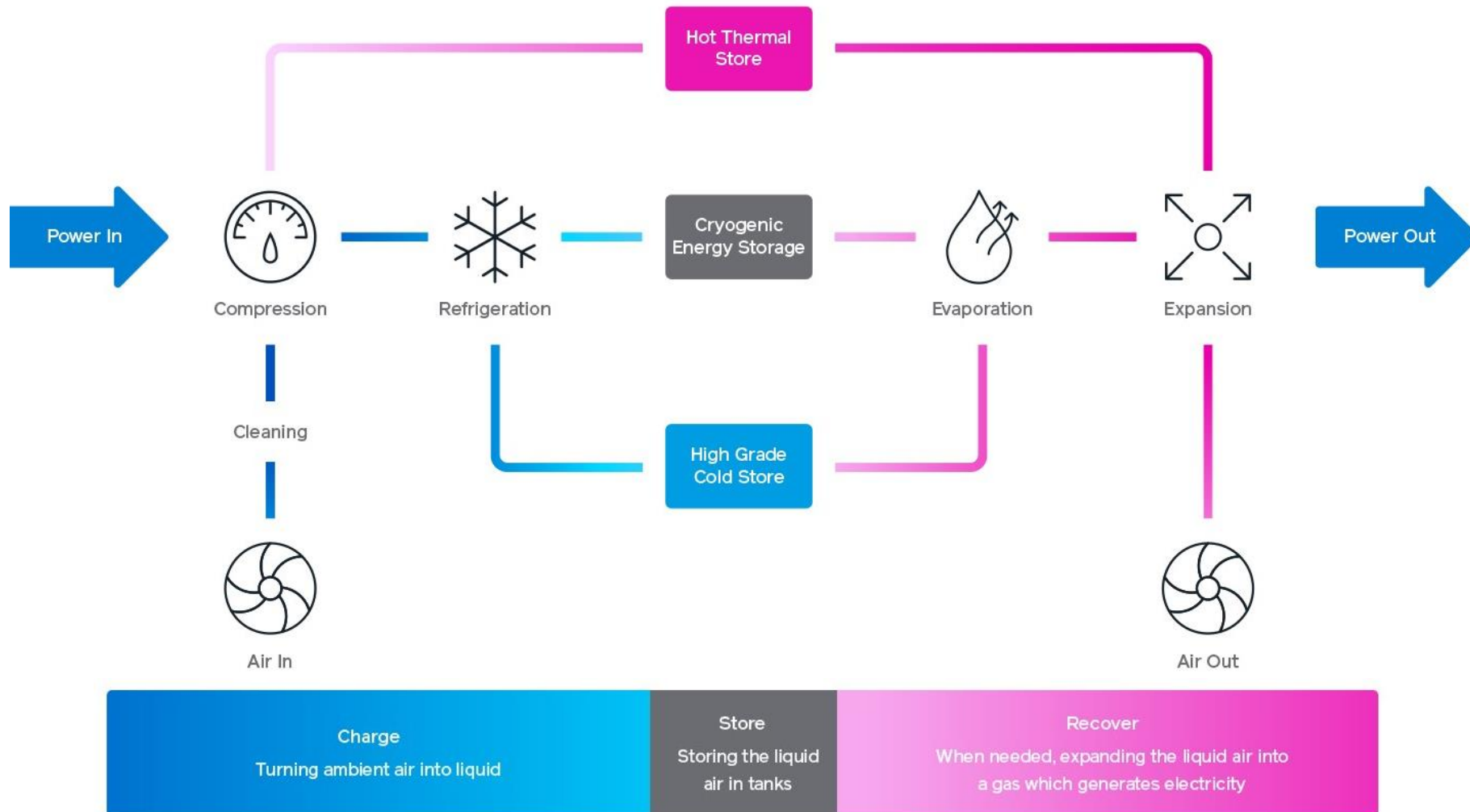
- Pumped hydro
 - dominant large-scale technology (over 90% share)
 - specific site
 - environmental conditions difficult to satisfy

- Li-ion winning market share due to its ease of delivery, BUT:
 - costs increase sharply with large-scale, long-duration applications
 - rapid degradation issues
 - commodity concerns
 - safety issues

- CRYOBattery™ wins on a cost *and* performance basis

Proven Technology

Efficient, Cost Competitive, and Simple Technology Based on Proven Industrial Processes

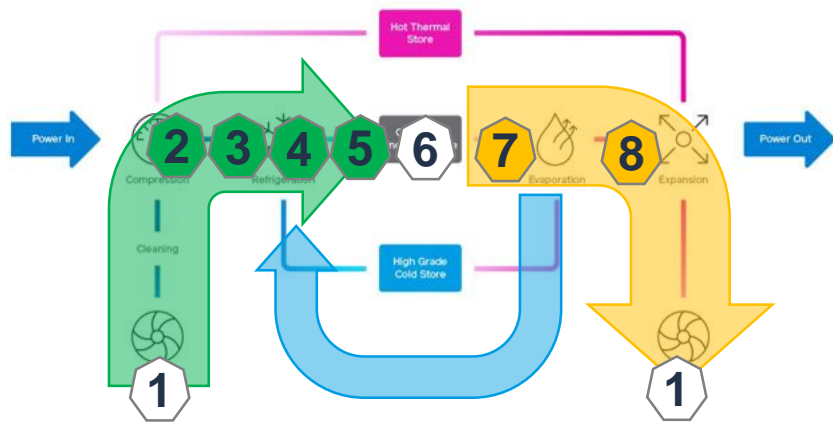


Leading Industrial Partners



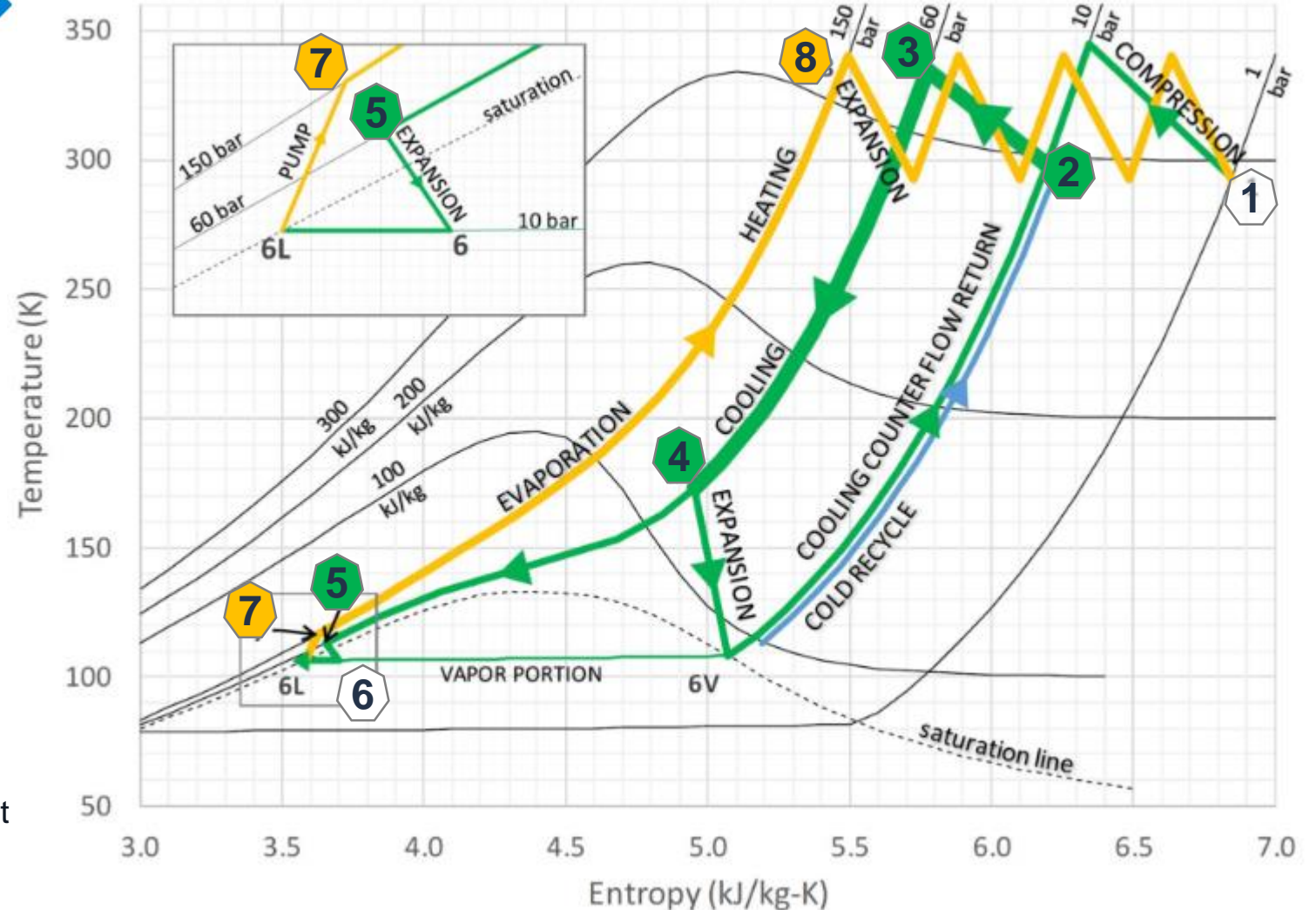
MAN Energy Solutions

CRYOBattery™ Cycle Technology



- 1-2** Adiabatic compression optimizes grade of heat captured
- 2-3** Air compressed to super-critical pressure for efficient liquefaction
- 3-5** Working fluid cooled utilizing proprietary COLD RECYCLE technology to more than double the liquefaction efficiency
- 6** Cryogenic liquid air stored in low pressure super insulated vessels
- 7-1** Stream efficiently pumped to pressure and super-heated using dual grade thermal heat from compression (1-3)

TS Diagram of Process



CRYOBattery™ Standardised Product

Highview's CryoBattery standardised product is a modular technology which delivers a solution which is cost competitive and configurable whilst maintaining optimum level of performance and flexibility.

Charging Module:

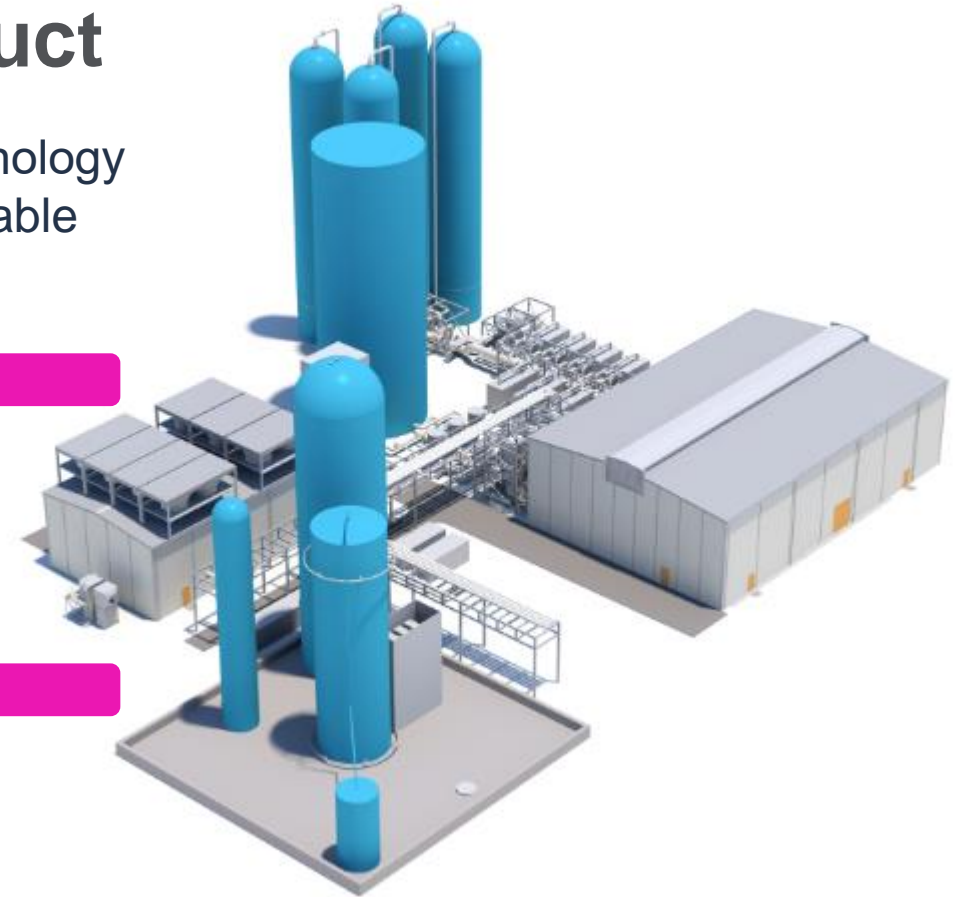
- State of art adiabatic CES technology
- 25MW (net) compressor drive train
- Start-up cold 5 minutes
- 2440 tonne/day peak output, peak energy charging rate of 15MWh/h

Discharge Module:

- Advanced dual thermal temperature reheat technology
- 50MW 4 stage axial turbine, clutch coupled synchronous generator
- Rapid <10sec full load performance

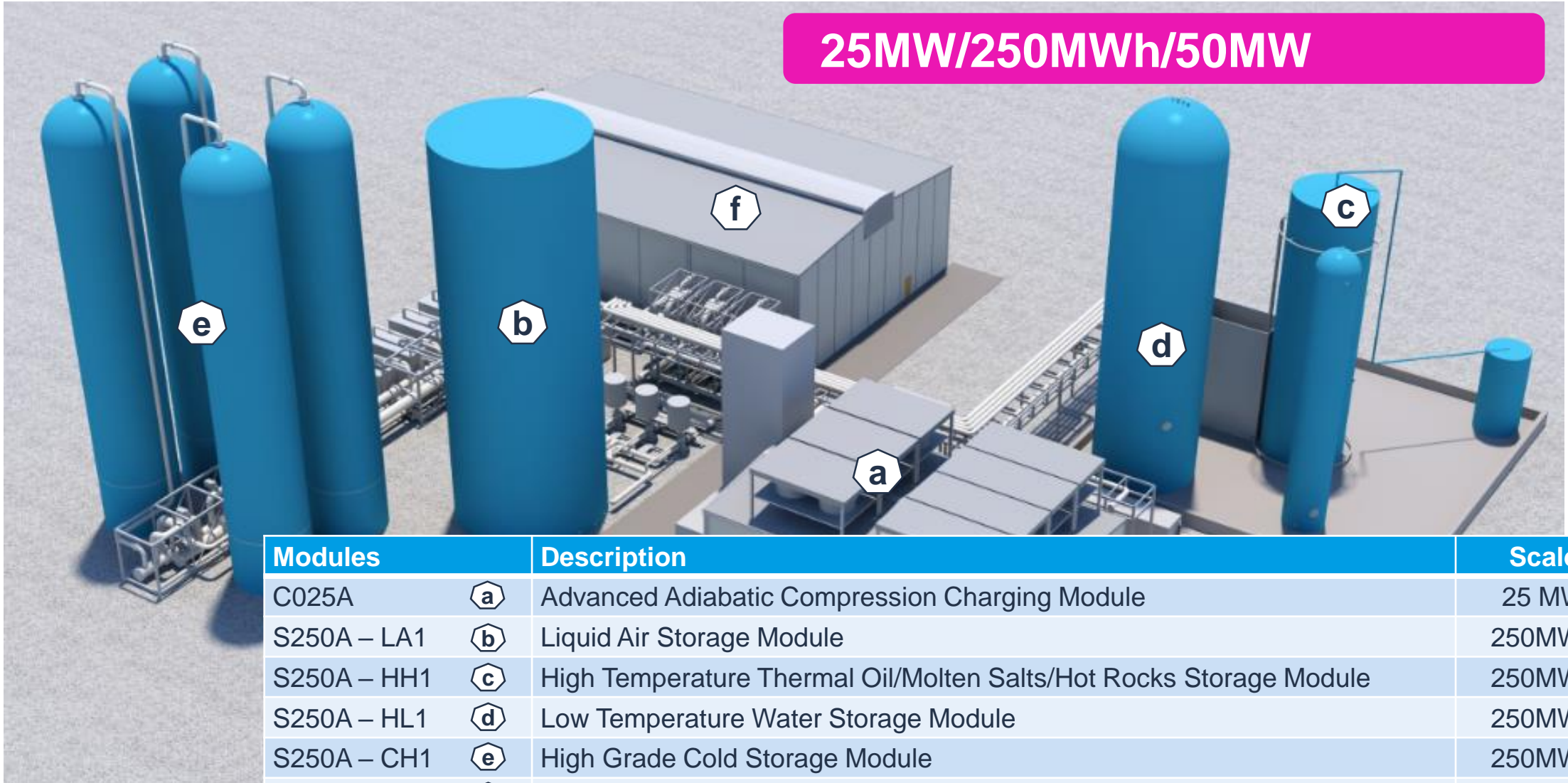
Proprietary BLU™ core controller system:







The system embodies the sum of Highview's market leading knowledge and expertise into a complete facility management system which seamlessly integrates the control of all components to provide an optimised energy storage facility performance, managing the balance between flexibility, efficiency and response.



CRYOBattery™ Standardised Product

25MW/250MWh/50MW



Modules		Description	Scale
C025A		Advanced Adiabatic Compression Charging Module	25 MW
S250A – LA1		Liquid Air Storage Module	250MWh
S250A – HH1		High Temperature Thermal Oil/Molten Salts/Hot Rocks Storage Module	250MWh
S250A – HL1		Low Temperature Water Storage Module	250MWh
S250A – CH1		High Grade Cold Storage Module	250MWh
D050A		Dual Temperature Axial Discharge Module	50MW

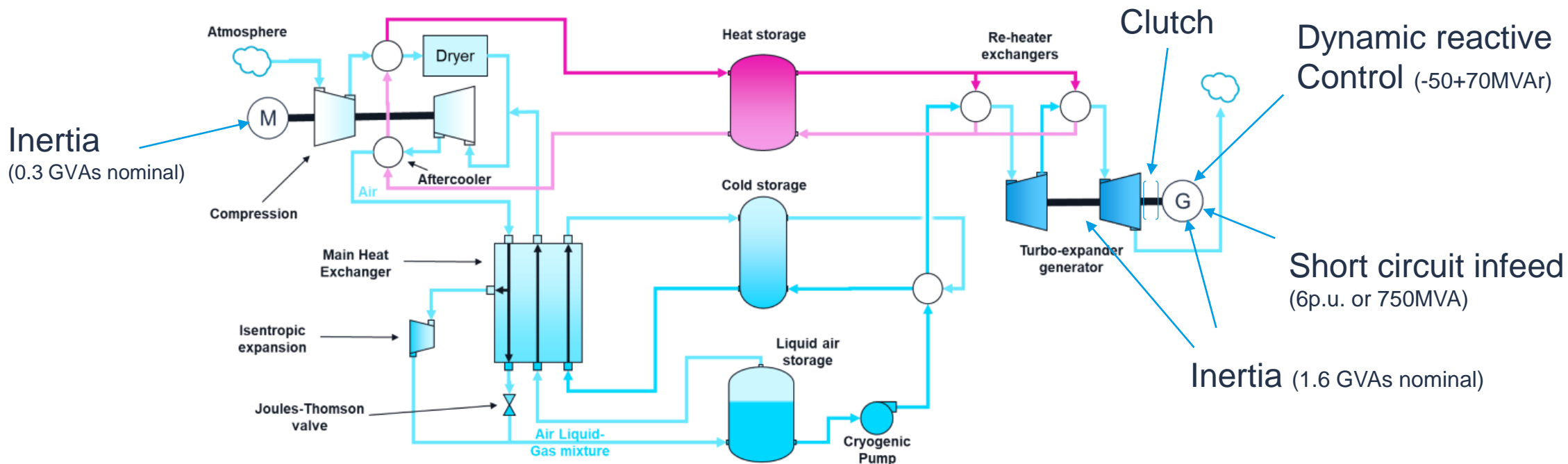
Proprietary BLU™ Core Controller Technology

Software features:

- Integrated control of all components
- SpinGen control in both wet (clutched) and dry (de-clutched) generator mode for enhanced start-up. Start-up times <10sec wet (clutched) and <20sec dry (de-clutched).
- Synchronous compensation mode
- Optimised cryo-pump fast cool and remain cool features
- Cryogenic vessel dynamic pressure control system
- Liquefier dynamic efficiency compensation control
- Transitional energy capture feature
- Embedded load control providing;
 - *turbine overspeed protection*
 - *increased turbine speed control stability*
 - *rapid profile following*
- Liquefier fast cool and remain cool features (<5min start-up)
- Hybridised technology capable
- Data acquisition
- 24/7 scheduling capability

Hidden Benefits of the CRYOBattery™

and other similar mechanical storage systems



Inertia
(0.3 GVAs nominal)

Dynamic reactive
Control (-50+70MVar)

Short circuit infeed
(6p.u. or 750MVA)

Inertia (1.6 GVAs nominal)

- Inertia
- Reactive
- Short circuit infeed

System Stability

System configuration:
 Charge 25MW
 Discharge 50MW (generator sized at 125MVA)
 Storage 250MWh