



CryoVault Energy LLC

*Storing Air.
Powering Tomorrow.*

Clean · Long-Duration · Scalable

TECHNOLOGY DOCUMENTS

PROCESS
FLOW
DIAGRAM

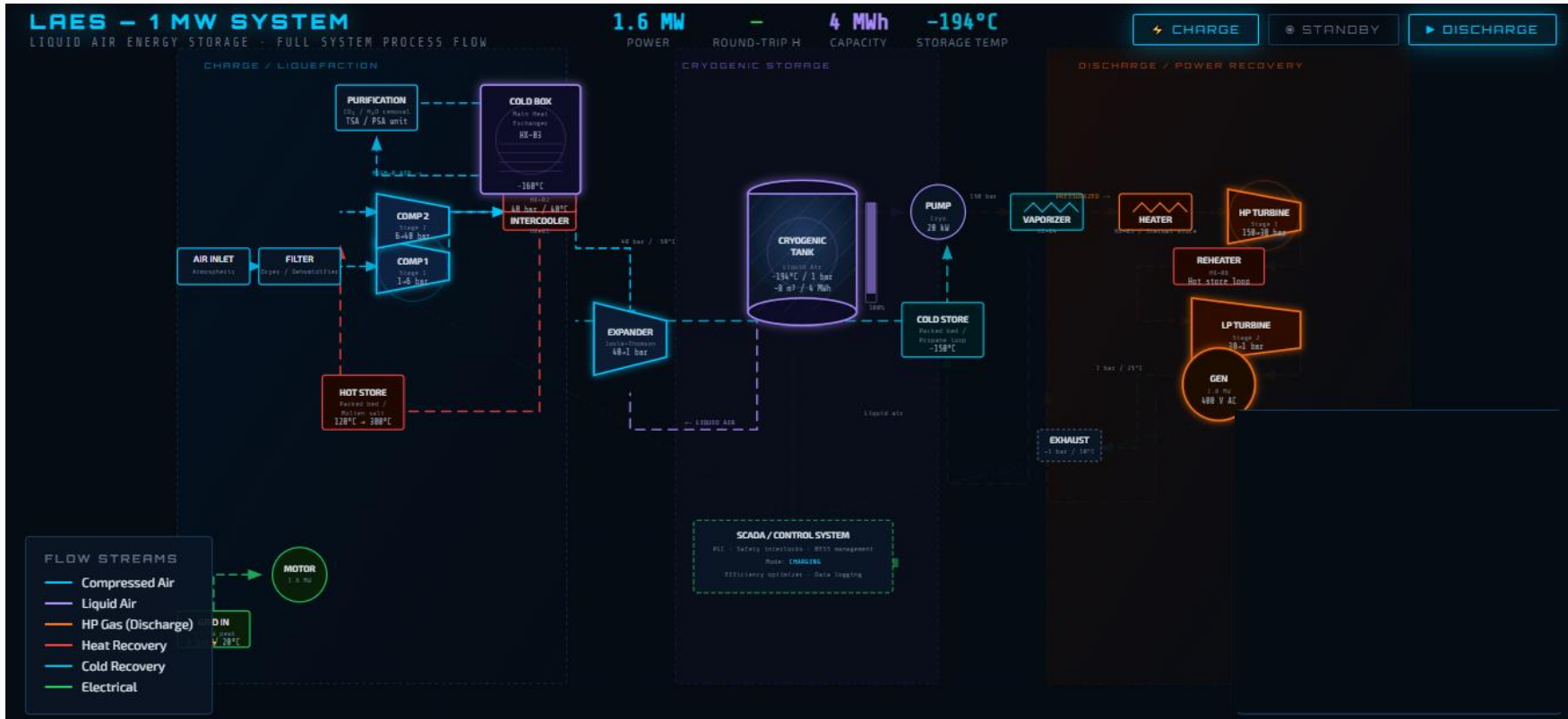
3D MODEL

EQUIPMENT
LIST

**(Simplified PFD / 3D / Equipment List – Proprietary
Details Omitted)**

Process Flow Diagram (Preliminary)

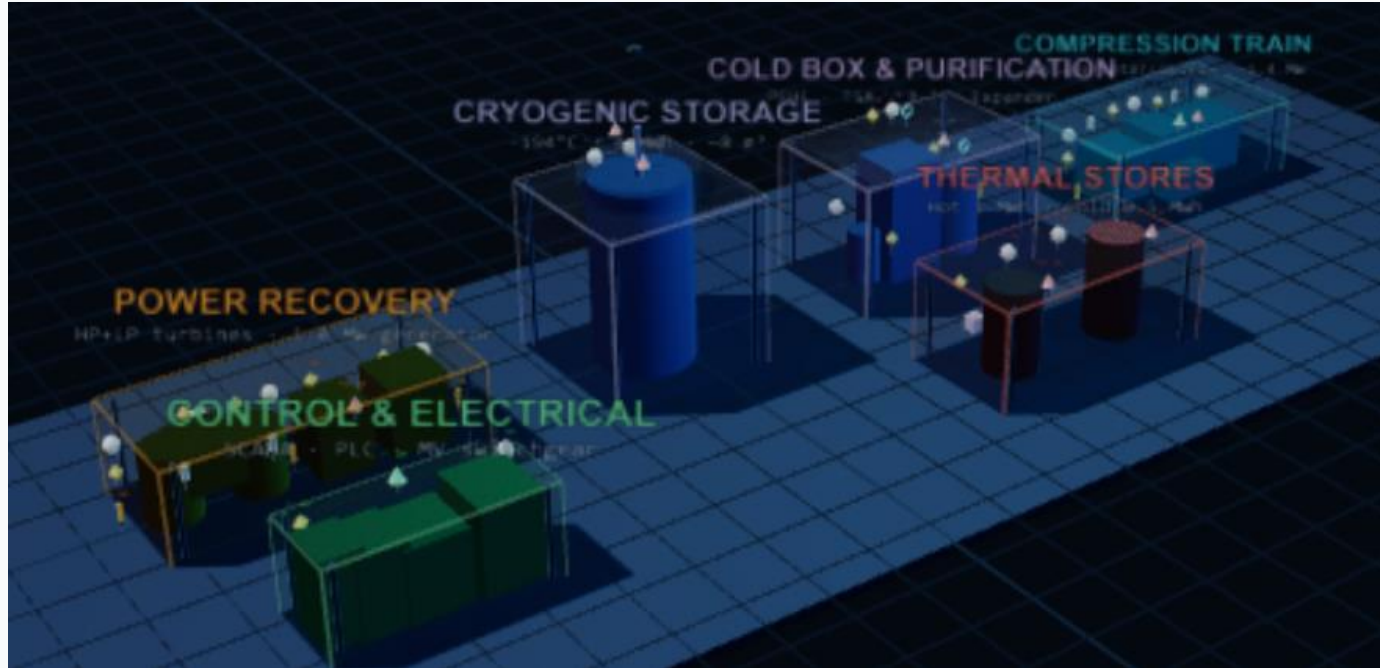
Conceptual PFD. Equipment specifications, control strategies, and integration details are not fully disclosed.



3D Model (Preliminary)



System configuration is modular and may be adapted based on site conditions and application (data centers, peaker plants, utilities)



NOTES

- Not to scale. Configuration represents a conceptual architecture for a ~1 MW / ~4 MWh system
- System design leverages commercially available compressors, cryogenic storage, and turbomachinery
- Thermal storage loops (hot/cold) shown schematically; implementation may vary based on heat recovery strategy.
- Piping, Instruments, Control philosophy and dispatch strategy not shown

Equipment List (1 MW)



Indicative equipment list shown for illustration; detailed specifications and integration information are not disclosed

CRYOVault ENERGY - FEL 1 (1 MW) - EQUIPMENT LIST

Tag	Module	Equipment	Rating	Standard	Status	Critical Note
C-001 / C-002	Compression Train	Stage 1 Air Compressor	-- kW shaft / x→ x	ISO 1217 / API 619	IFI	Oil-free
HX-01	Compression Train	Intercooler Heat Exchanger	-kW / x°C outlet	ASME VIII / PED	IFI	Heat recovery to hot thermal store —critical for RTE
HX-01 / HX-02	Compression Train	Inter / After Heat Exchanger	-kW / x°C outlet	ASME VIII / PED	IFI	Heat recovery to hot thermal store —critical for RTE
M-001	Compression Train	Compressor Motor & VFD Drive	x kW / 400 V / IE3	IEC 60034	IFI	VFD
AF-001	Compression Train	Suction Air Filter / Dryer	-XX°C PDP / <1µm	ISO 8573-1	IFI	REDACTED
E-001	Cold Box & Purification	Main PFHE (Cold Box HEX)	-XX MW cold / XX°C	ALPEMA / ASME VIII	IFI	Brazed aluminium
AD-001	Cold Box & Purification	TSA Air Purification Unit	CO ₂ <1 ppm / H ₂ O <	ISO 7183	IFI	<1 ppm CO ₂
TV-001	Cold Box & Purification	Turbo-Expander	REDACTED	API 617	IFI	Cold production unit
XV-203	Cold Box & Purification	J-T Expansion Valve	Cryogenic needle	PED 2014/68/EU	IFI	Cryogenic rated
TK-001	Cryogenic Storage	Liquid Air Storage Tank	REDACTED	EN 13458 / PED Cat.I	IFI	Vacuum jacket integrity critical
P-001 / P-002	Cryogenic Storage	Cryogenic Pump (Duty)	REDACTED	API 610 / EN 13371	IFI	NPSHa must exceed NPSHr by ≥1.5 m —check tank geometry carefully
PSV-301/302	Cryogenic Storage	Primary Tank Relief Valve	1.5 bar set / full fire d	EN ISO 4126 / API 520	IFI	PSV required (primary + secondary) —PED Category IV mandatory
K-001 / K-002	Power Recovery	HP / LP Expansion Turbine	REDACTED	API 612 / ISO 10439	IFI	Overspeed trip hardwired SIL-2 —loss of load during discharge is design case
HX-05	Power Recovery	HP Superheater (Hot Store →HP)	REDACTED	ASME VIII / PED	IFI	
HX-06	Power Recovery	Reheater (Hot Store →LP)	REDACTED	ASME VIII / PED	IFI	
HX-04	Power Recovery	Vaporiser Heat Exchanger	REDACTED	ASME VIII / ALPEMA	IFI	Cold exergy from vaporisation recycled to cold store —critical for RTE
GB-001	Power Recovery	Gearbox	Speed matching to	API 677 / ISO 6336	IFI	Confirm gear ratio with turbine and generator suppliers jointly
G-001	Power Recovery	Synchronous Generator	REDACTED	IEC 60034 / BS 5000-	IFI	
TK-002/003	Thermal Stores	Hot / Cold Thermal Store Vessel	REDACTED	EN 13445 / ASME VIII	IFI	Cold store recovery adds -XX% RTE —cryogenic carrier fluid selection critical
HX-07	Thermal Stores	Hot Store Charge HX	REDACTED	ASME VIII	IFI	Two units: one for intercooler, one for aftercooler thermal recovery circuit
PU-501	Thermal Stores	Hot Store Circulation Pump	REDACTED	ISO 5199	IFI	Thermal oil —verify compatibility with hot store media and max temperature
PLC-001	Control & Electrical	Safety PLC / ESD System	SIL-2 / IEC 61511	IEC 61511 / IEC 61508	IFI	SIL-2 required
SCADA	Control & Electrical	SCADA & HMI System	OPC-UA + Modbus	IEC 62443	IFI	Cybersecurity assessment required for grid-connected plant (NIS regulations)
TX-001	Control & Electrical	Step-Up Transformer	1.25 MVA / 400V →	IEC 60076	IFI	
SW-001	Control & Electrical	MV Switchgear (11 kV)	1.25 MVA / 11 kV / 2	IEC 62271-200	IFI	DNO approval required for grid connection

CryoVault LAES - Interoperability



CryoVault LAES is designed from the ground up to integrate with the full BTM ecosystem via open, non-proprietary protocols.

1

UTILITY SIGNALS

OpenADR 2.0 and IEEE 2030.5 receive demand response and TOU dispatch signals directly from grid operators — ERCOT, CAISO, PJM.

2

EMS & GRID EDGE ASSETS

Modbus TCP and REST APIs connect CryoVault to leading EMS/DERMS platforms, smart meters, solar inverters.

3

PLANT & CLOUD

OPC-UA feeds instrument tags to the SCADA historian. MQTT/HTTPS streams performance data to cloud analytics in real time.

Value stacking — enabled simultaneously via open protocols

Demand charge reduction

\$15–35 / kW / mo

TOU energy arbitrage

Off-peak → on-peak

Ancillary services

DR · FFR · reserves

Waste heat boost

RTE 50% → 70%+

Phase 1 status — architecture defined, integration in progress

Protocols selected and documented. EMS vendor outreach underway.