



Synchronous Energy Storage

*Malta's 100MW Pumped Heat Electricity
Energy Storage*

June 15th, 2022

Thermal Long Duration Energy Storage typically offers two major value propositions

Energy shifting



Time horizon	Role of storage	Typical solution
Intraday	Balance variable daily generation with load	8-24 hours LDES
Multiday, multiweek	Support multi-day imbalances Absorb surplus generation to avoid grid congestion	24+ hours LDES
Seasonal duration	Support during seasonal imbalances Mitigate extreme weather events	Hydrogen

Grid services



Grid services offered by LDES

Synchronous Inertia

Fast frequency response (FFR)

Primary/secondary/tertiary reserve

Reactive power/voltage control

Short circuit level improvement

System restoration/ black start

Note: services are technology-specific

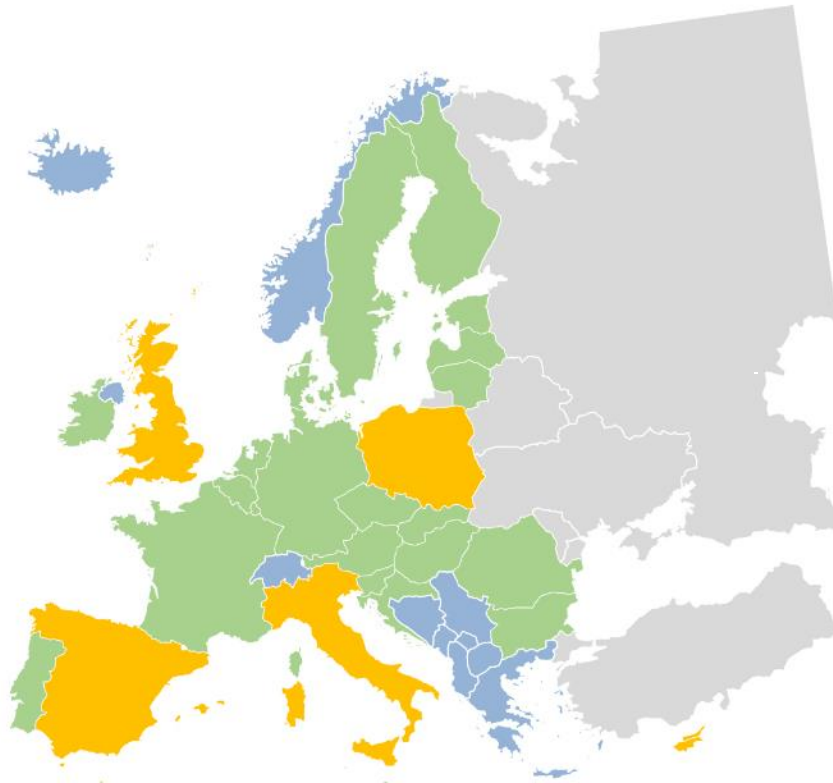
McKinsey
& Company

Source: Long Duration Energy Storage Council

European needs for synchronous storage

Interconnection
target 10% criteria
2020

Color code:
Below 10% threshold
Above 10% threshold
not considered



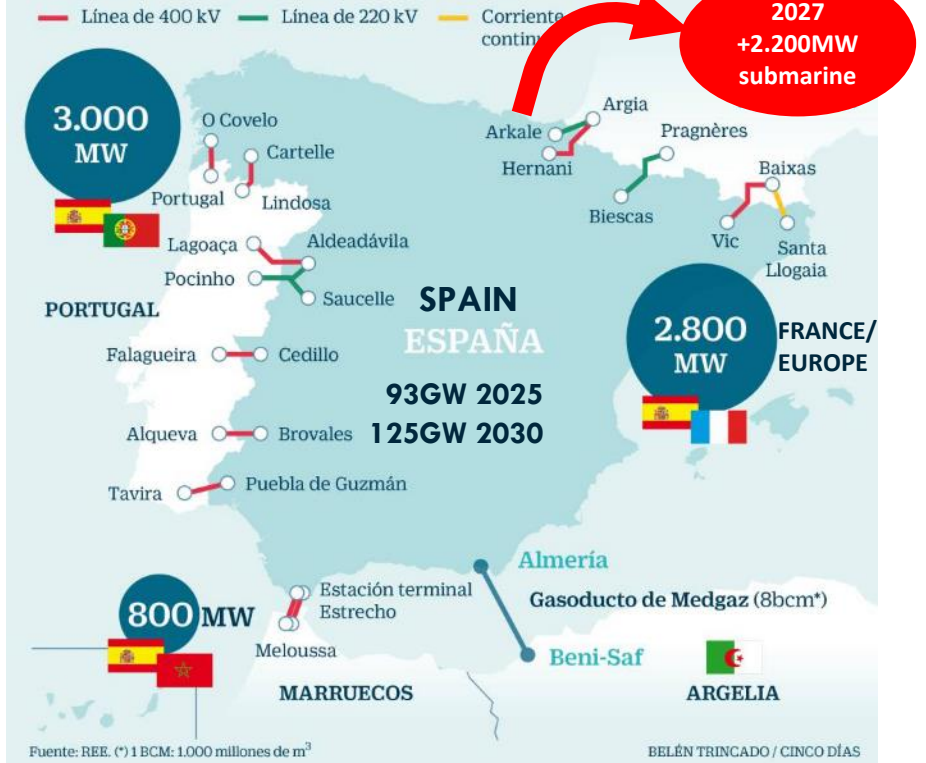
Fullfillment of the 10% interconnection target in 2020

https://eepublicdownloads.entsoe.eu/clean-documents/tyndp-documents/TYNDP2018/rgip_CSW_Full.pdf

Iberian Grid Interconnections 2020

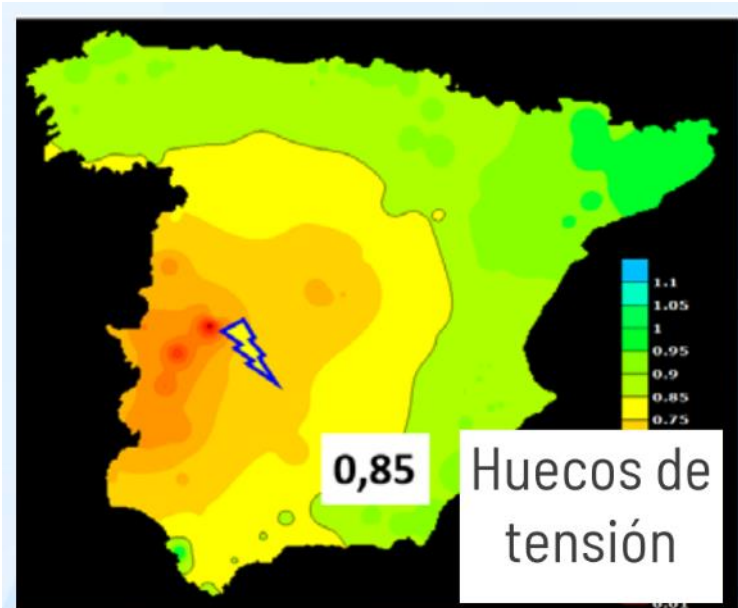
Interconexiones internacionales

Capacidad de intercambio comercial (MW)



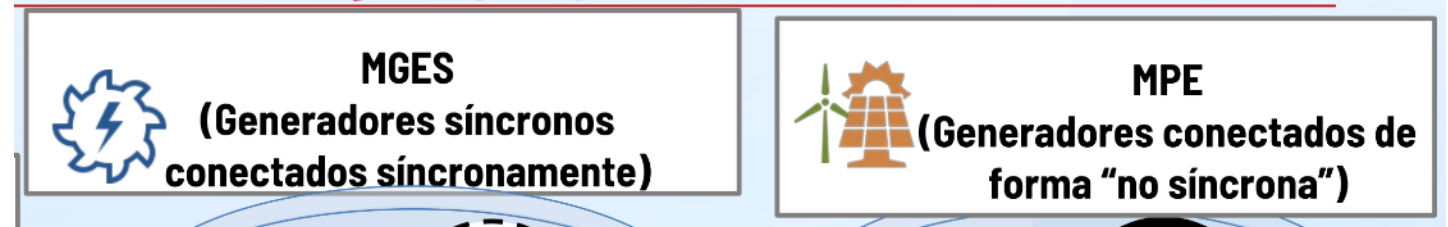
https://cincodias.elpais.com/cincodias/2017/07/10/companias/1499700974_956333.html

15GW new synchronous generation open in Spanish Grid



Almost 15.000MW excess capacity available for synchronous generators like Malta PHES

https://www.ree.es/sites/default/files/01_ACTIVIDADES/Documentos/AccesoRd/Presentacion_SG_CG_10Sept20.pdf



Dirección General de Operación

Fecha de publicación: 1 de julio de 2021

Información sobre capacidad de acceso [MW] disponible y ocupada en los nudos de la red de transporte

Nombre y tensión del nudo	Comunidad Autónoma	POSIBLE CONEXIÓN		CRITERIO DE POTENCIA DE CORTOCIRCUITOS (MW)				CRITERIO ESTÁTICO				CRITERIO DINÁMICO				SITUACIÓN NUDO						CAPACIDAD DE ACCESO DISPONIBLE A LA RED DE TRANSPORTE		
		Posición en la red de transporte	Posición en la red de distribución	Capacidad de acceso nodal	Binutos	Margen no ocupado	Capacidad de acceso nodal	Zona con capacidad compartida a la que pertenece el nudo	Margen no ocupado	Capacidad de acceso nodal	Zona con capacidad compartida a la que pertenece el nudo	Limitación interna por configuración del nudo	Margen no ocupado	Capacidad de acceso otorgada MGES	Capacidad de acceso otorgada MPE	Capacidad de acceso admitida solicitud y pendiente resolver MGES	Capacidad de acceso admitida solicitud y pendiente resolver MPE	Capacidad no disponible MGES a la red de transporte	Capacidad no disponible MPE a la red de transporte	MOTIVO capacidad no disponible	Criterio limitante MGES	Capacidad de acceso disponible para MGES [MW]	Criterio limitante MPE	Capacidad de acceso disponible para MPE [MW]
SAUCELLE 220	Castilla y León	✓	✓	878	878	497	226	906	226	906	226	0	635	257	14	0	0	226	226	Concurso por resolución SEE	E_Nudo	0	E_Zona	0
SAX 400	Comunidad Valenciana	✓	✓	1.595	973	2.529	1.987	803	803	281	0	635	257	0	542	0	0	281	281	Concurso por resolución SEE	D_Nudo	0	D_Zona	0
SEGORBE 220	Comunidad Valenciana	✓	✓																		E_Nudo	0	E_Zona	0
SEGOVIA 400	Castilla y León	✓	✓																		D_Nudo	0	D_Zona	0
SENTMENAT 400	Cataluña	✓	✓																		D_Nudo	0	D_Zona	0
LA SERNA 400	Navarra	✓	✓																		D_Nudo	0	D_Zona	0
LA SERNA 220	Navarra	✓	✓																		D_Nudo	0	D_Zona	0
SESVILES 66	Balnearios	✓	✓																		WSCR	0	WSCR	0
SEVUE 220	Aragón	✓	✓																		E_Nudo	144	E_Zona	144
SIONGASIA 220	Galicia	✓	✓																		E_Nudo	0	E_Zona	0
SIOENOR 220	Pais Vasco	✓	✓																		E_Nudo	0	E_Zona	0
SIO 220	Asturias	✓	✓																		E_Nudo	0	E_Zona	0
SILLEDA 400	Galicia	✓	✓																		E_Nudo	0	E_Zona	0
SIMANCAS 220	Madrid	✓	✓																		E_Nudo	0	E_Zona	0
SOMBRAS 220	Galicia	✓	✓																		WSCR	0	WSCR	0
SOLLER 66	Balnearios	✓	✓																		WSCR	0	WSCR	0
SOLORZANO 400	Cantabria	✓	✓																		WSCR	0	WSCR	0
SOLORZANO 220	Cantabria	✓	✓																		WSCR	100	WSCR	100
SON MOX 220	Balnearios	✓	✓																		D_Nudo	0	D_Zona	0
SON MOX 66	Balnearios	✓	✓																		WSCR	0	WSCR	0
SON OMS 66	Balnearios	✓	✓																		E_Nudo	0	E_Zona	0
SON OLANCHO 66	Balnearios	✓	✓																		E_Nudo	0	E_Zona	0
SON PARDO 66	Balnearios	✓	✓																		E_Nudo	0	E_Zona	0
SON REUS 220	Balnearios	✓	✓																		E_Zona	0	E_Zona	0
SON REUS 66	Balnearios	✓	✓																		E_Zona	0	E_Zona	0
SOTO DE RIBERA 400	Asturias	✓	✓																		E_Zona	0	E_Zona	0
SOTO DE RIBERA 220	Asturias	✓	✓																		WSCR	0	WSCR	0
SUBIRATIS 220	Cataluña	✓	✓																		E_Nudo	0	E_Zona	0
SUBIRATIS 220	Galicia	✓	✓																		WSCR	424	WSCR	424
T. RESTANAR 220	Madrid	✓	✓																		E_Nudo	0	E_Zona	0
TABARA 400	Castilla y León	✓	✓																		D_Nudo	0	D_Zona	0
TABERNAS 400	Andalucía	✓	✓																		D_Nudo	0	D_Zona	0
TABERNAS 220	Andalucía	✓	✓																		WSCR	0	WSCR	0
TABERNAS 220	Cataluña	✓	✓																		E_Zona	0	E_Zona	0
TABIELLA 220	Asturias	✓	✓																		WSCR	940	WSCR	940
TABILERO 66	Canarias	✓	✓																		D_Nudo	24	D_Nudo	24
TACORONTE 66	Canarias	✓	✓																		D_Nudo	0	D_Nudo	0
TAFALLA 220	Navarra	✓	✓																		E_Zona	0	E_Zona	0
TAGORO 66	Canarias	✓	✓	110	34	167	EN SEC	0	0	0	0	0	0	0	75	0	0	0	0		E_Zona	0	E_Zona	0

CAPACIDAD DE ACCESO DISPONIBLE A LA RED DE TRANSPORTE

Criterio limitante MGES

Capacidad de acceso disponible para MGES [MW]

Criterio Limitante MPE

Capacidad de acceso disponible para MPE [MW]

E_Nudo

0

WSCR

0

D_Nudo

0

WSCR

0

E_Nudo

0

WSCR

0

E_Nudo

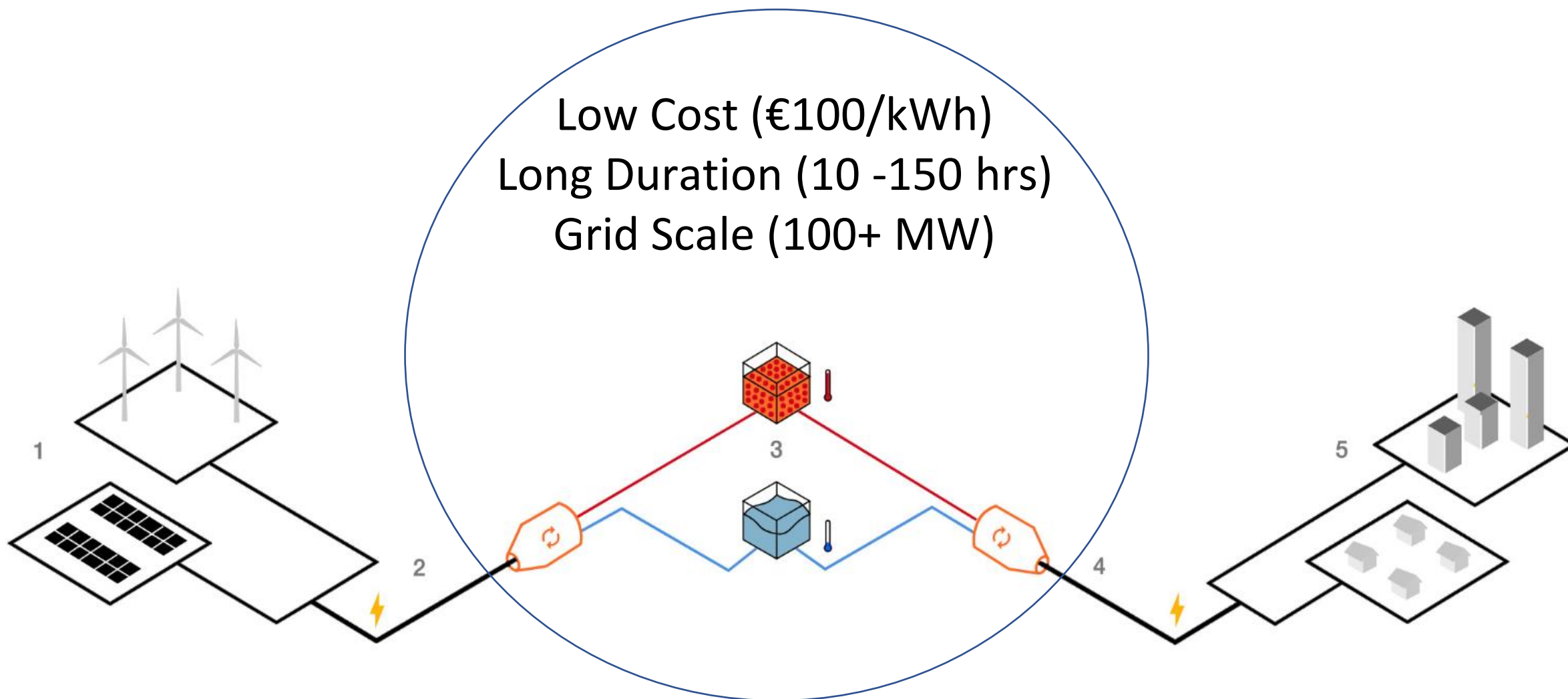
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WSCR

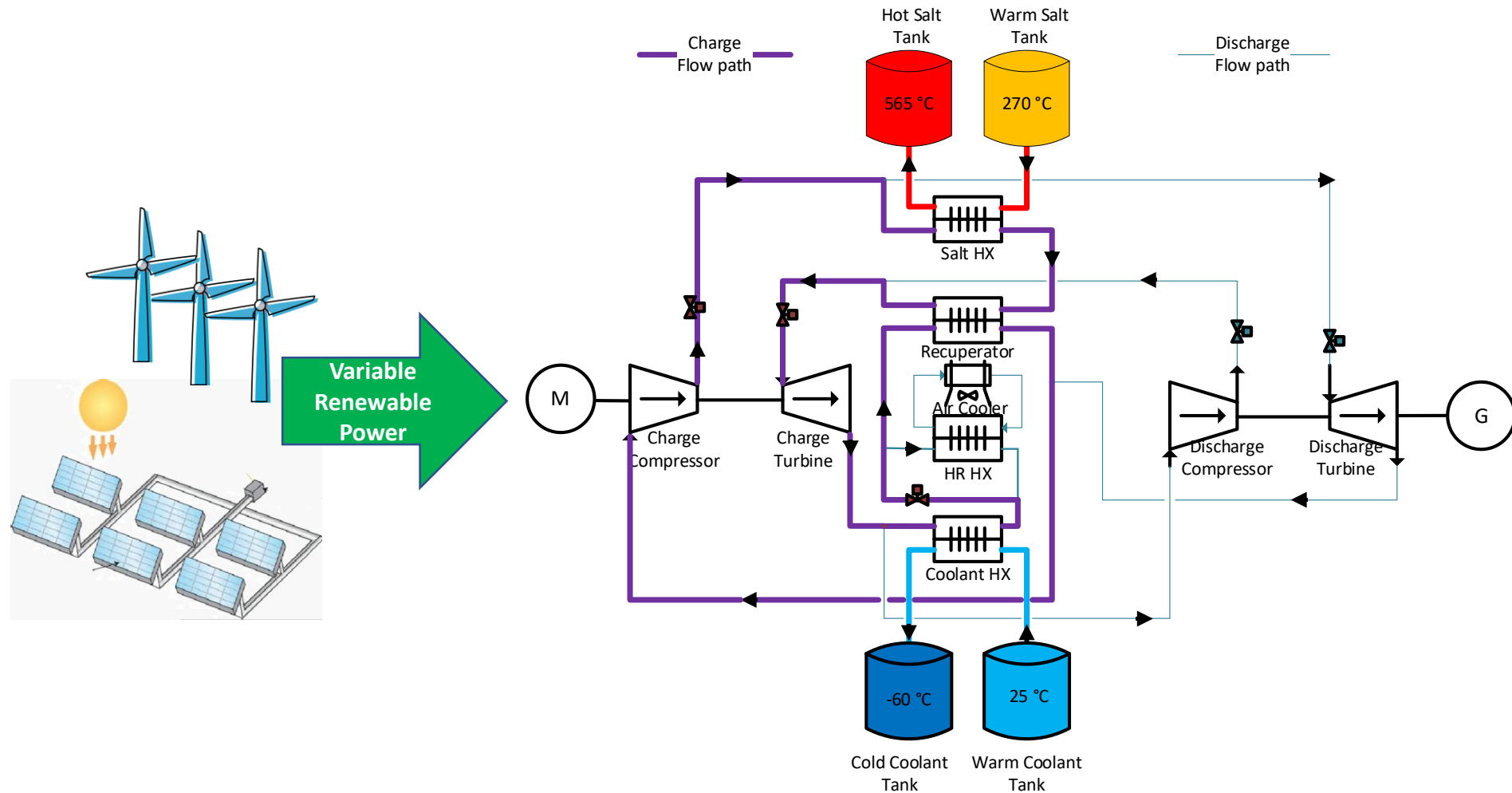
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https://www.ree.es/sites/default/files/12_CLIENTES/Documentos/Capacidad_de_acceso_a_RdT_ED_1sep21.pdf

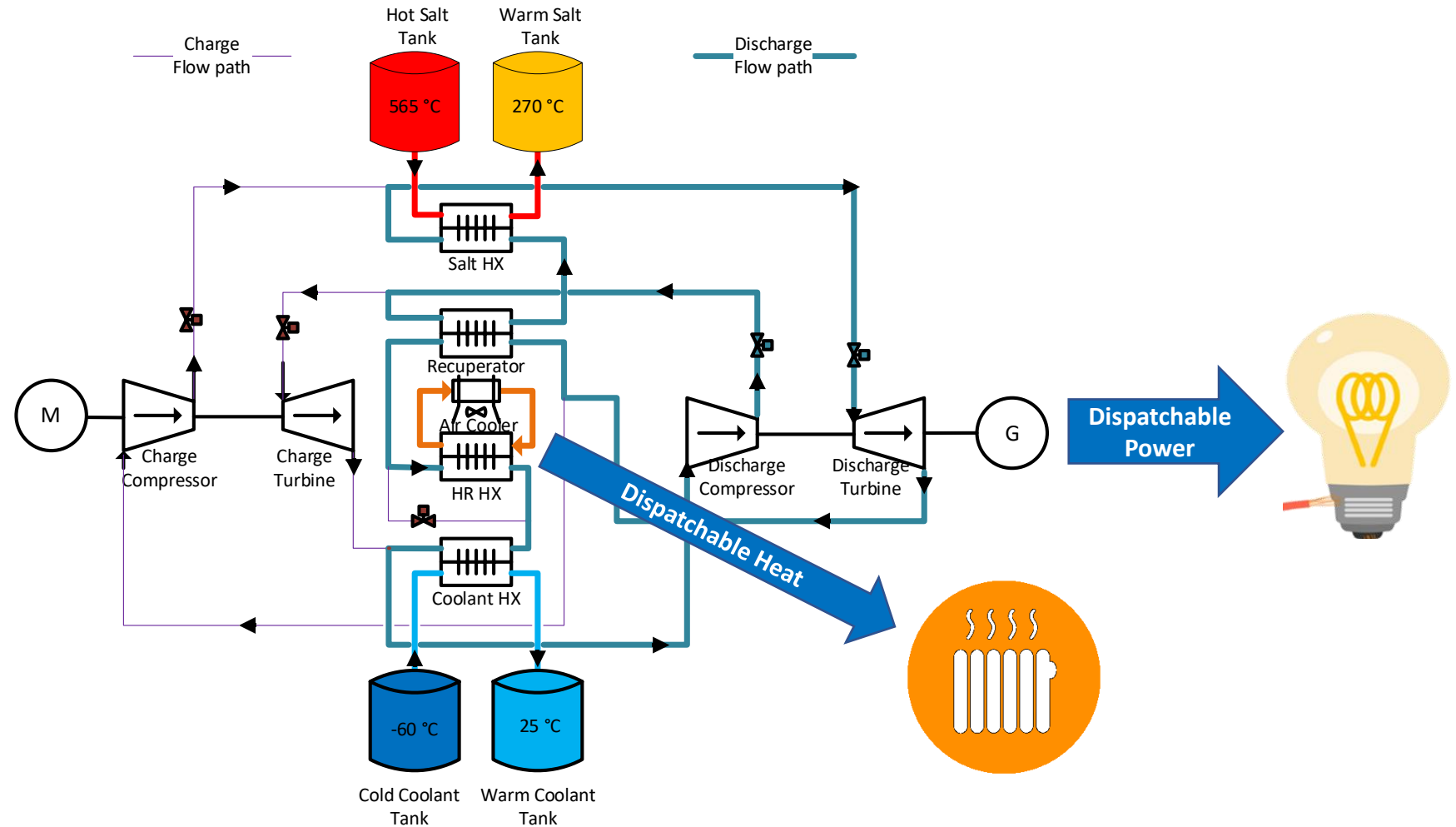
Breakthrough Grid-Scale Energy Storage



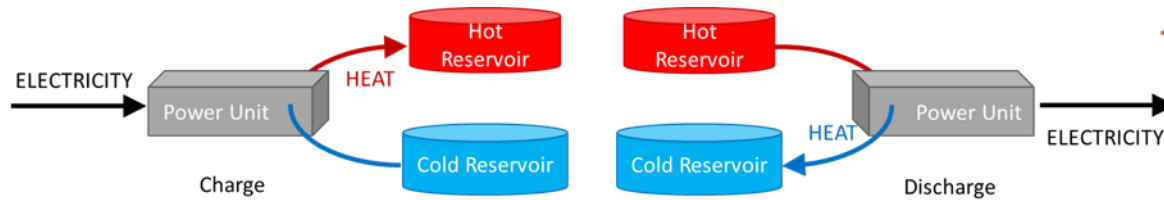
Malta Electricity Charging Cycle



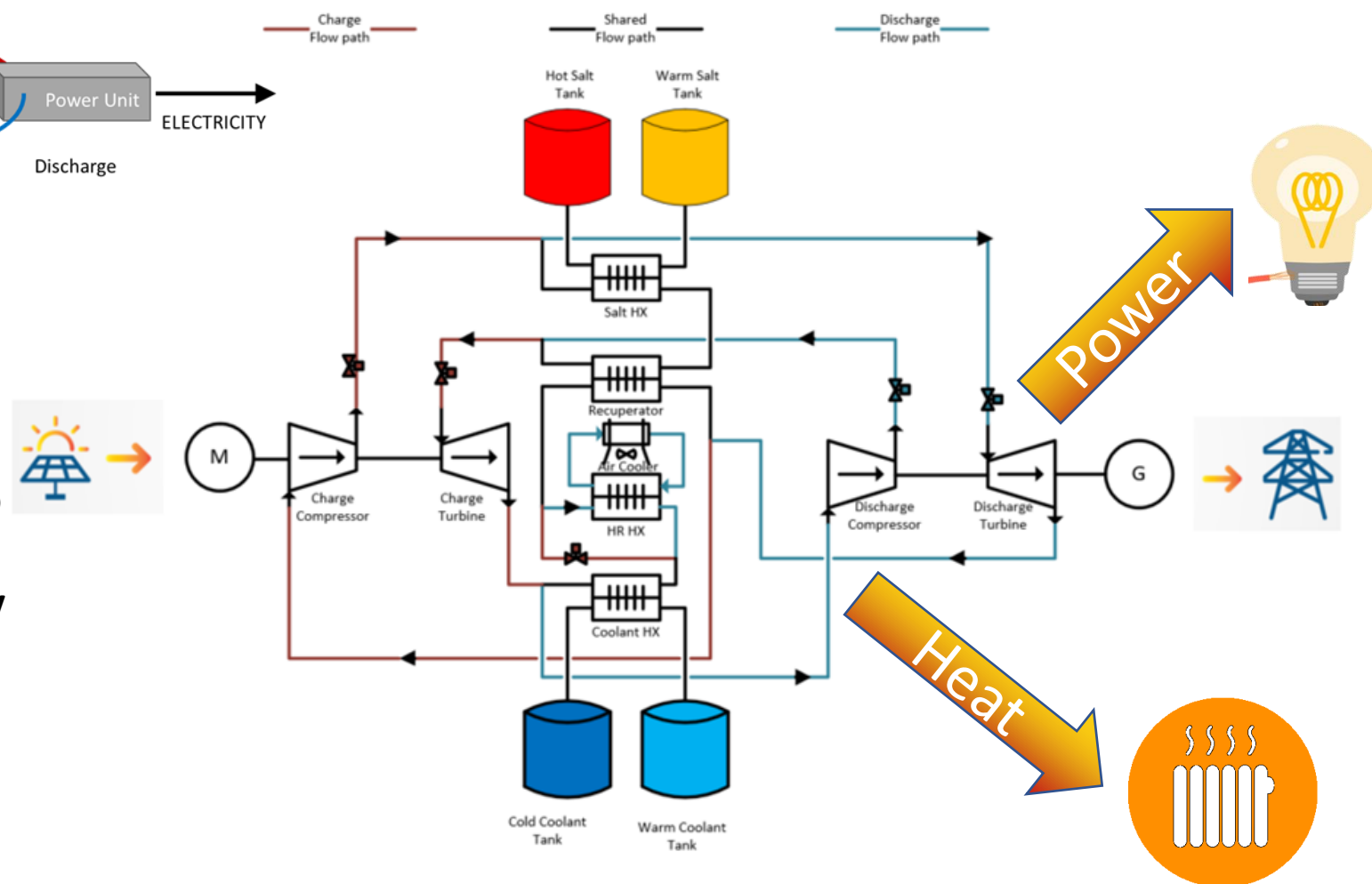
Malta Electricity and Heat Discharging Cycle



Malta PHES storage for delivering power and heat



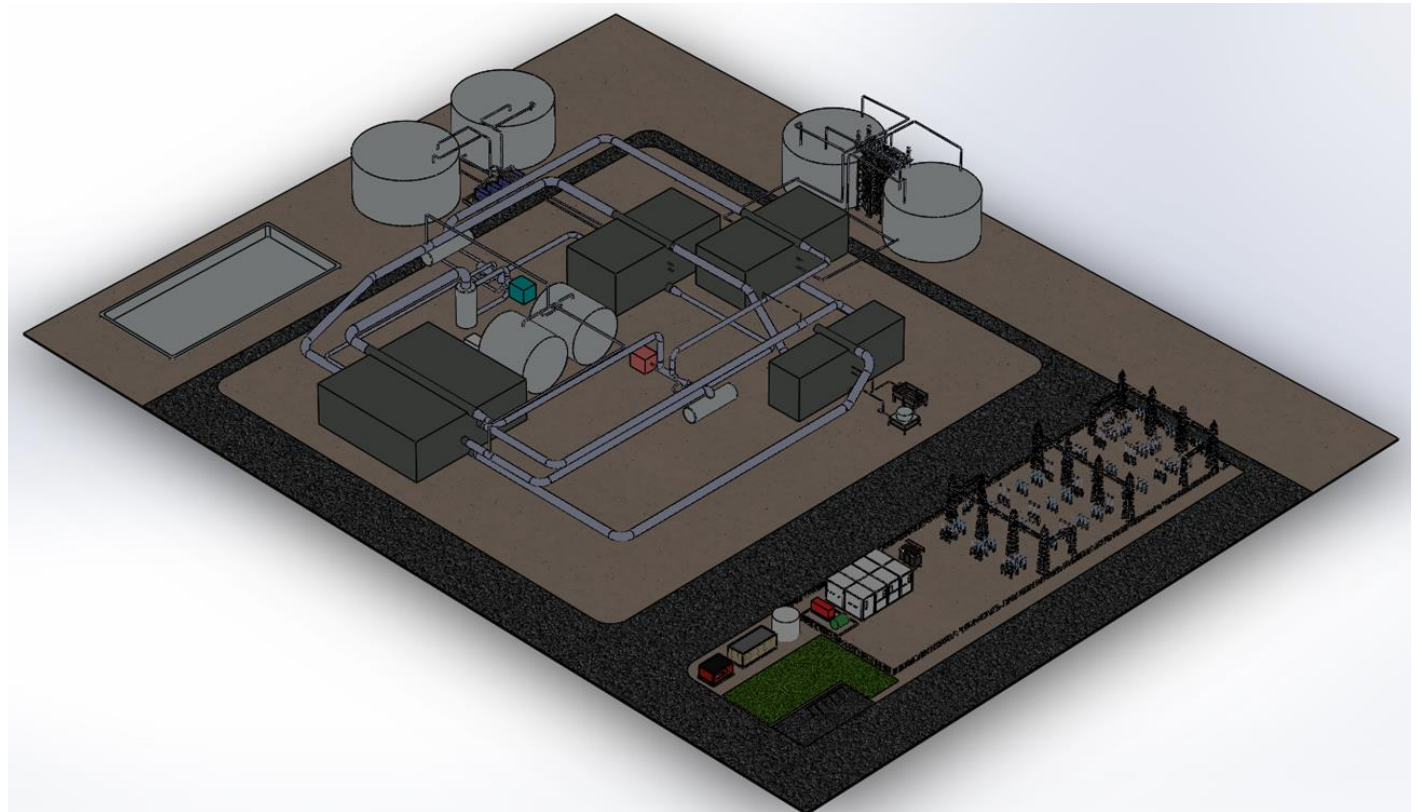
- **Long-Duration** - 4 to 24+ hours
- **Low-Cost** - 100 MW systems < €200/kWh short term down to 100€/kWh mid term
- **Long Useful Life** - Over 25 years w/o storage capacity degradation
- **Rotating Inertia** - Malta provides inertia to the grid as fossil/nuclear plants retire
- **Separation of Charge / Discharge Capacity and Duration**
- **Ideal for Trading by Decoupling of Charge from Discharge**
- **Presence of Waste Heat**



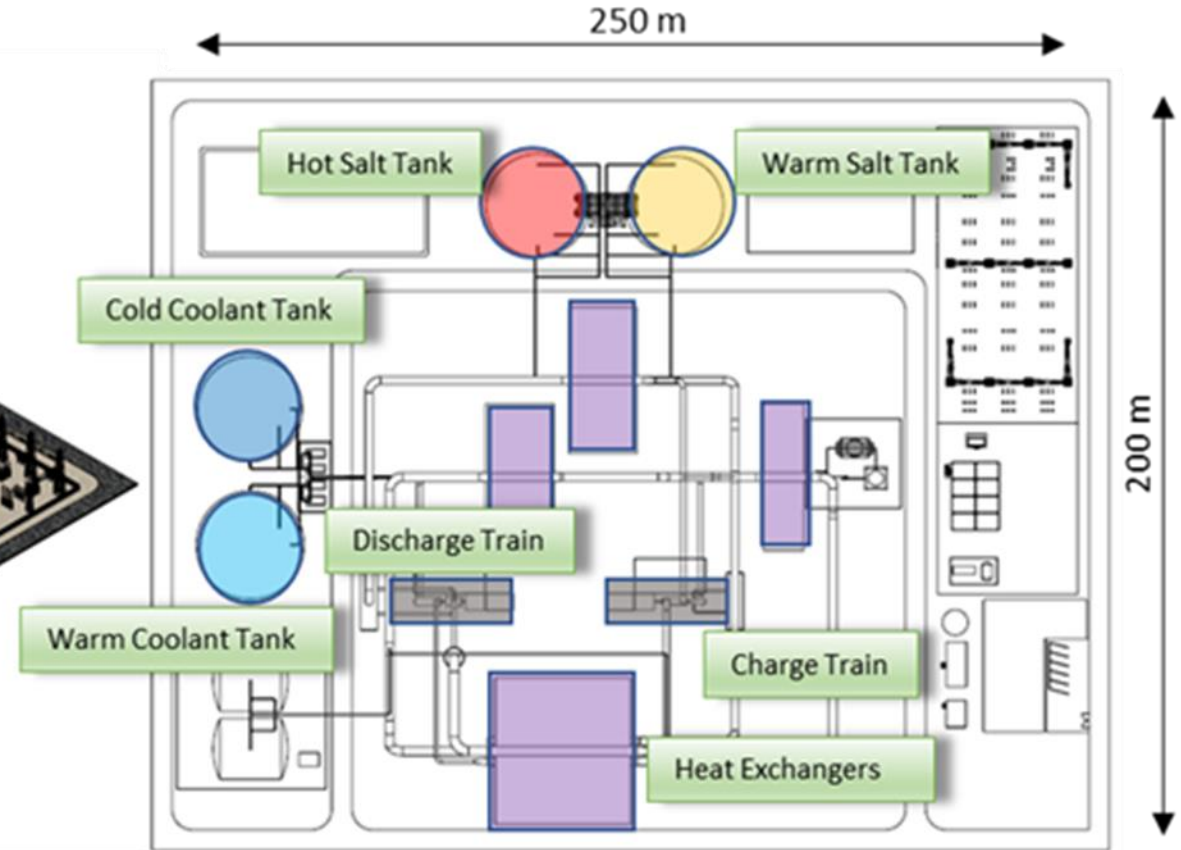
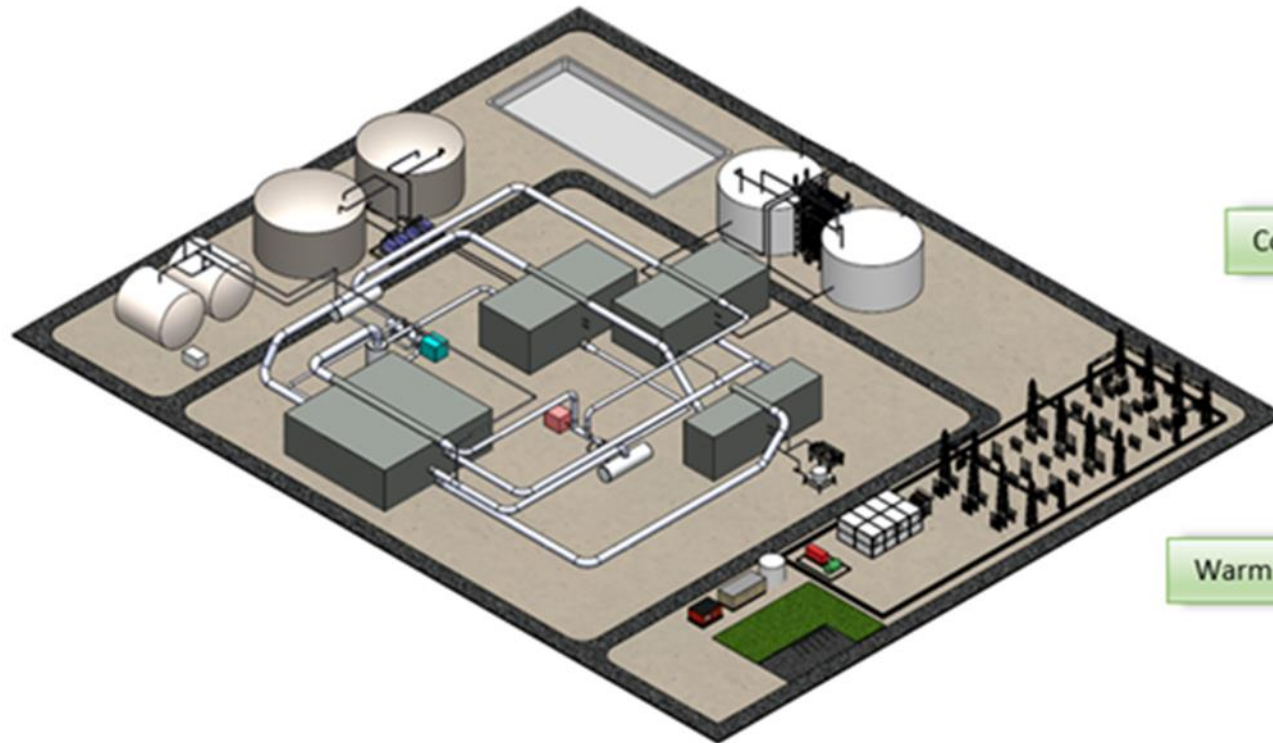
Proven Sub-Systems - Safe & Reliable

- **Commercially-proven sub-systems** and equipment
- **Safe & reliable** operation
- **Low-cost option** based on intrinsic cost advantages
- Ability to **decouple power (MW) from energy (MWh)**
- **Flexible charge-to-discharge** ratio enables location- and application-specific solutions
- Malta projects “**look like**” **CCPP assets to the grid** (dispatchable, inertia)

100 MW Reference Plant Rendering



Malta M100 3D View and Footprint



Malta storage 100MW discharge output for 10 hours

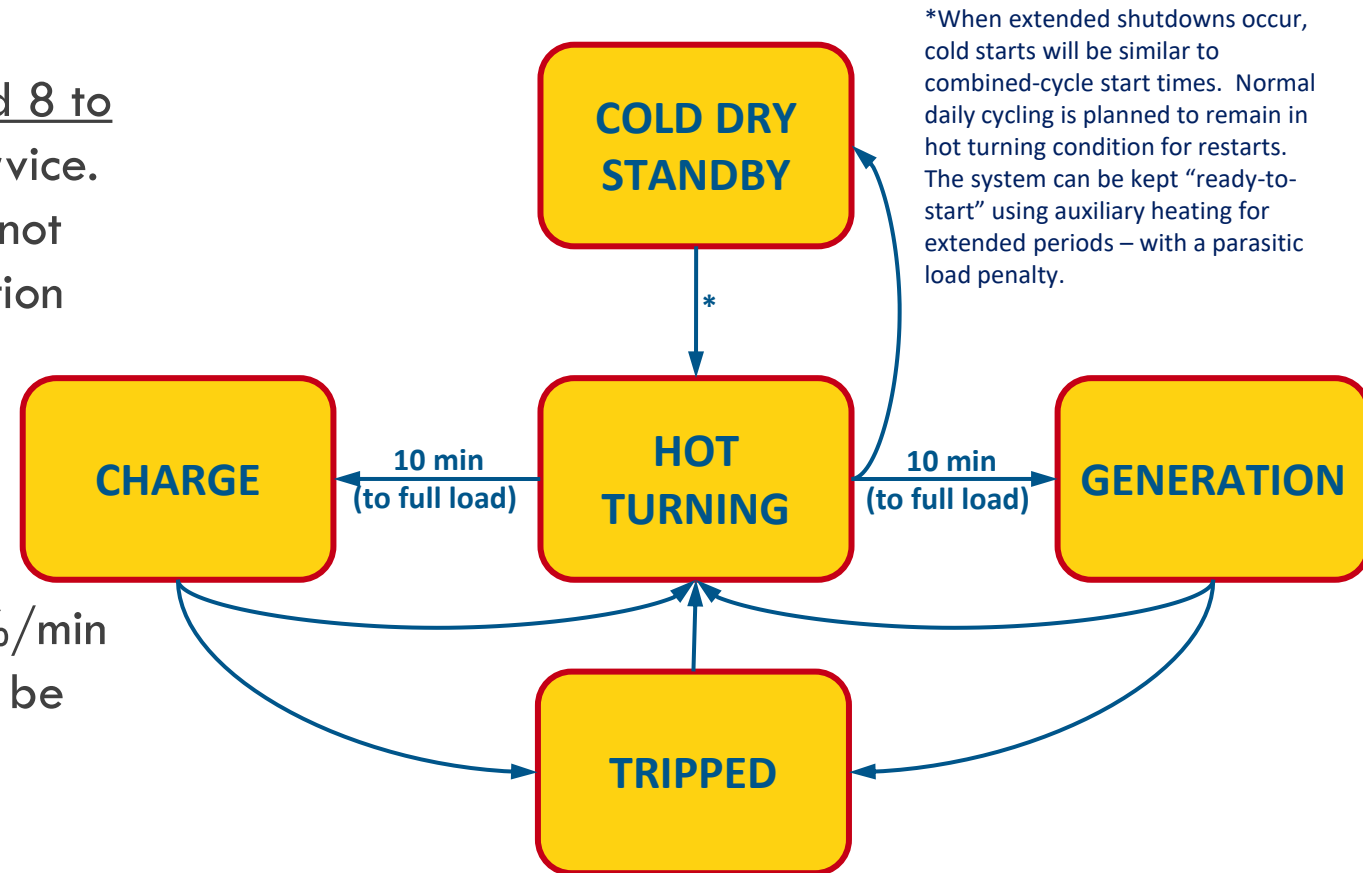


Malta M100 Pumped Heat Electricity Storage System

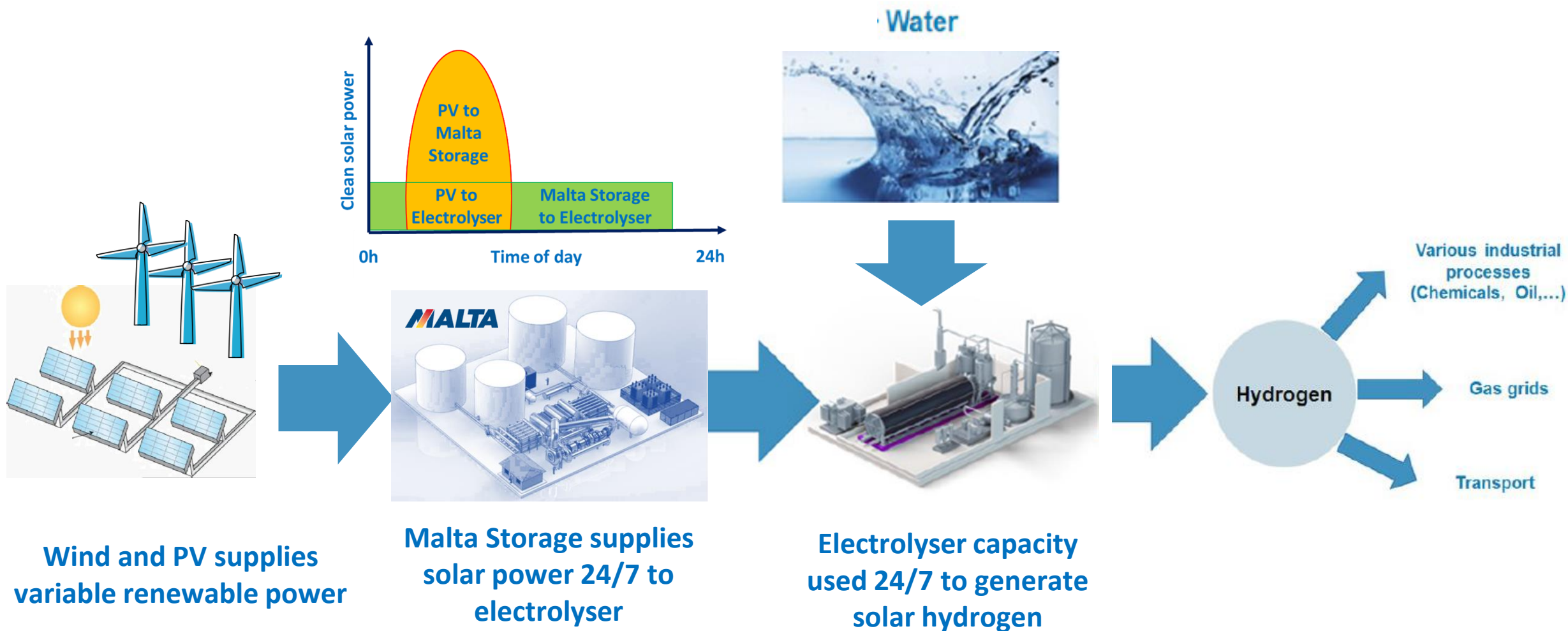
Rated discharge power	100 MWe
Rated charge power	200 MWe
Charge to discharge duration ratio	1:1
Discharge capacity	10-24+ hours
Electric storage capacity	1000-2400 MWhe
Footprint	5-7 hectares
Minimum load (charge and discharge)	27% of rated power
Overall net system efficiency (input-output)	55-60%
Heat loss per day with system fully charged	<1%
Asset lifespan	25+ years
Hot start up time	<10 minutes
Cold Start-up time	<2 hours

Efficient Mode Switching – Modeled After Industry

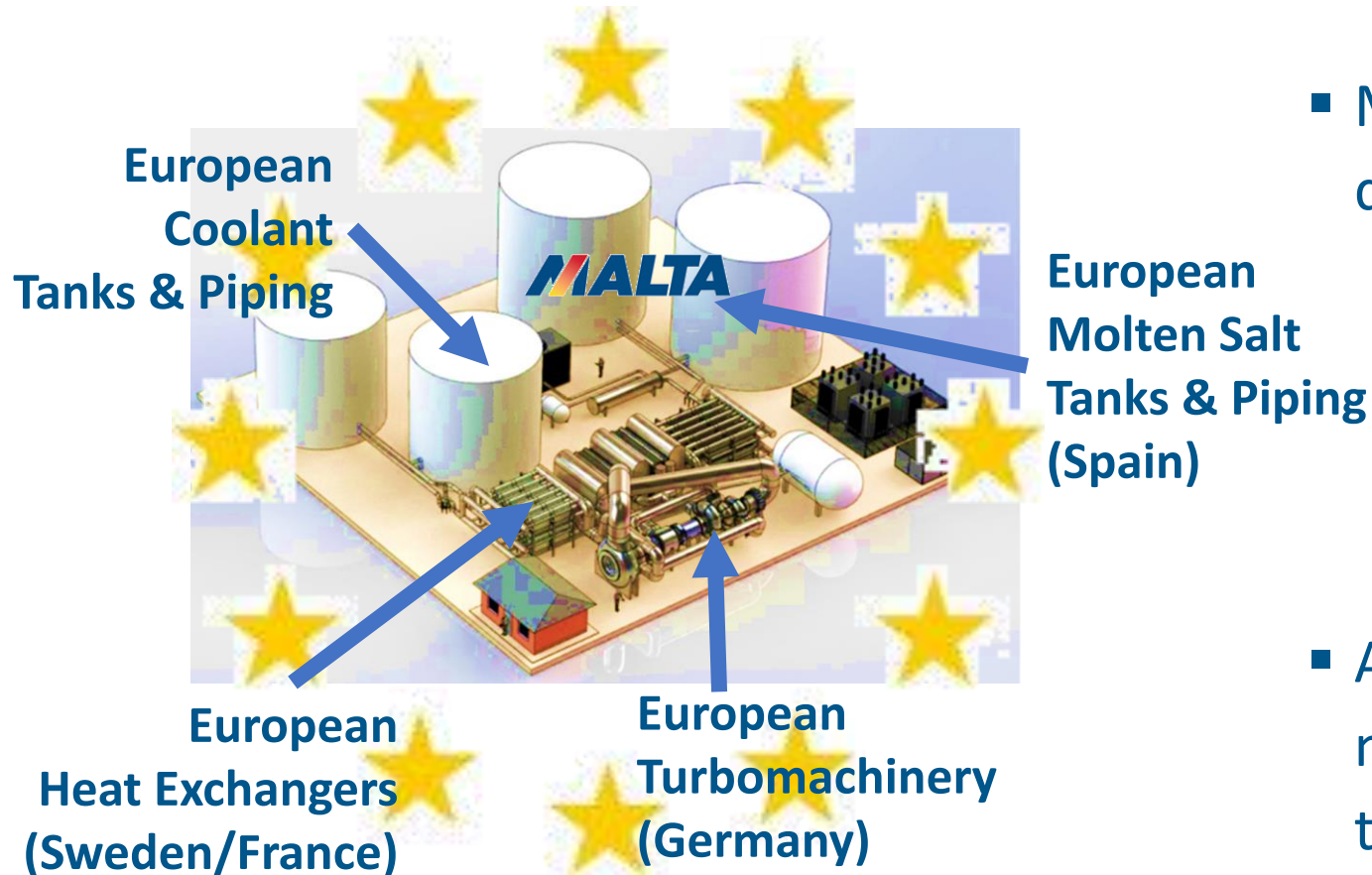
- The Malta design is modeled after typical simple-cycle gas turbine performance.
- Gas turbines start times range from around 8 to 15 minutes to minimum load in peaking service. Combined cycle plants are often slower if not dry-stacked, largely due to steam generation system limitations.
- Ramp rates range from 50%/min to 100%/min on gas turbines while Malta is targeting to be competitive in the 25%/min range.



Malta storage for 24/7 green hydrogen production



Malta M100: European sourcing creates European jobs



- Malta M100 will create the following direct jobs:
 - Planning & Construction: 230 person years over 12 months
 - Operation: 25 person years per year over 30 operating years
- Additional jobs will be created for the manufacturing of the heat exchangers, turbo-machinery, and other key components

Thank You



Long-Duration

8 - 24+ Hours



Grid-Scale

10 - 100 MW+



Low-Cost

<€100/kWh

