



Technology Presentation

www.offshoreenergystorage.com

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Non-Confidential
January 2025

FLASC: Summary



FLASC is addressing supply–demand mismatch for offshore wind



The **latest Open-Gas-Cycle** technology brings 10-30% of additional revenue to offshore wind farms



Cost-competitive with the cheapest land-based storage



Working with the world's leading wind developers and delivery partners



FLASC solution is prototyped, patented and received a statement of feasibility from DNV

European
Innovation
Council



► Supported by the EU's most prestigious funding scheme for disruptive high-impact innovation

- **Seeking partners to support bids for offshore wind farm projects**



The Problem

Supply-Demand mismatch is increasing with more installed offshore wind



- Offshore wind generation is intermittent and can only be used **when** there is immediate energy demand.



- When the onshore grid is constrained, offshore power cannot be delivered **where** it is needed and ends up being wasted.

Client-Specific Pain Points

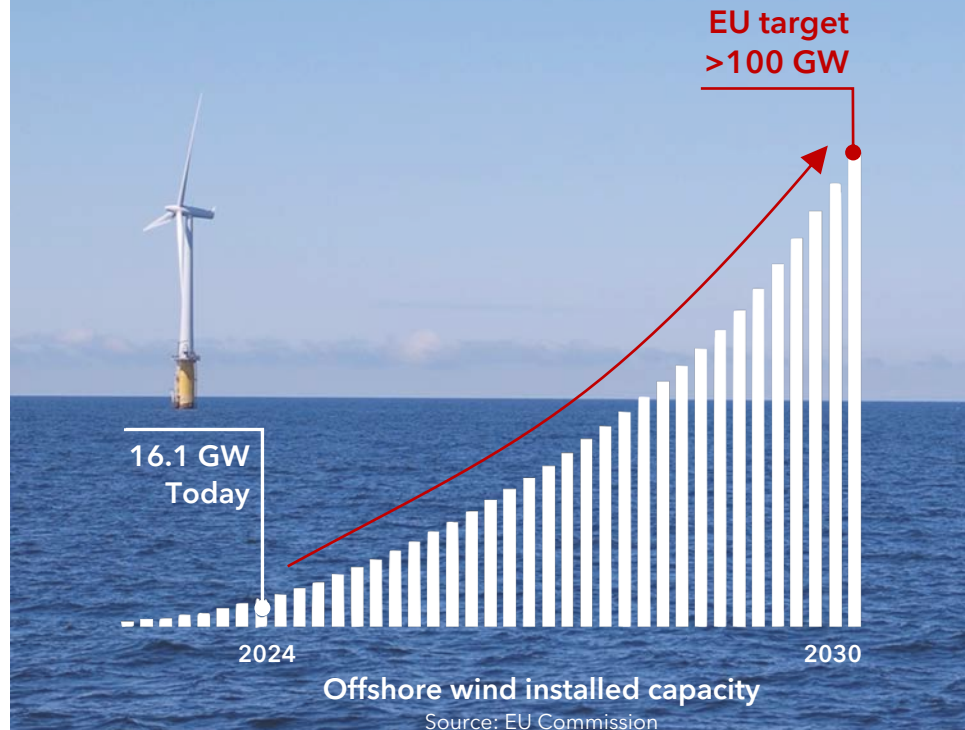


Offshore Wind
Developers

- Decreasing** offshore wind profitability
- Limiting** future wind farm deployments
- Compromising** clean energy transition

End Client

"The cost of matching UK electricity supply and demand in 2022 surpassed £4 billion, tripling since 2019 due to shrinking baseload and rising grid instability" - UK, NIA



FLASC Delivers an Offshore Energy Storage Solution

► Store Energy **where** it is produced

► Deliver it **when** needed

1 - Behind-the-Meter Optimisation

- Increase value of the wind farm output by delivering power when it is needed
- Support grid flexibility and stability
- Avoid additional grid and connection fees

2 - Offshore Multi-Use

- Increase the utilisation of the offshore space
- Share offshore logistics and grid infrastructure
- Interface with other technologies: green H₂, offshore PV, wave, existing subsea pipelines

3 - Minimum Impact at Landing Point

Wind farms connect to busy port areas or pristine coastlines making it challenging to install onshore energy storage

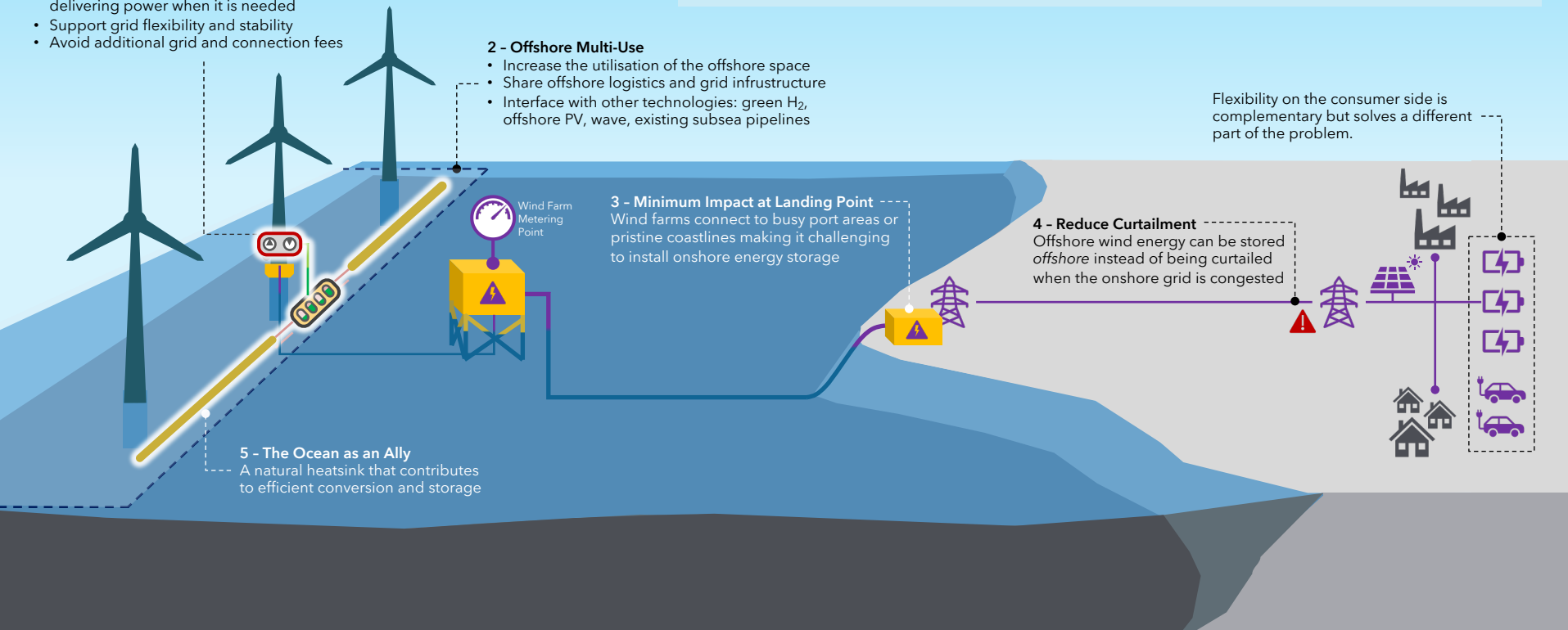
4 - Reduce Curtailment

Offshore wind energy can be stored *offshore* instead of being curtailed when the onshore grid is congested

Flexibility on the consumer side is complementary but solves a different part of the problem.

5 - The Ocean as an Ally

A natural heatsink that contributes to efficient conversion and storage



The Technology: Open-Gas Cycle HPES

FLASC is the first utility-scale energy storage solution tailored for co-location in offshore wind farms.

It enables wind developers to store energy **where** it is produced and deliver it **when** needed, improving the wind farm economics.

The **Open-Gas Cycle** technology embodies the latest developments in **performance** and **energy density**

- **Charging Mode:** A motor and hydraulic pump drive a reciprocating liquid piston array to compress air into a pre-charged container
- **Discharging Mode:** The air expands through the reciprocating liquid pistons which drive the hydraulic system in reverse to produce electricity

Key Technical Advantages:

1. No seawater inside the system
2. Significantly increased energy density
3. Use of efficient positive-displacement pumps



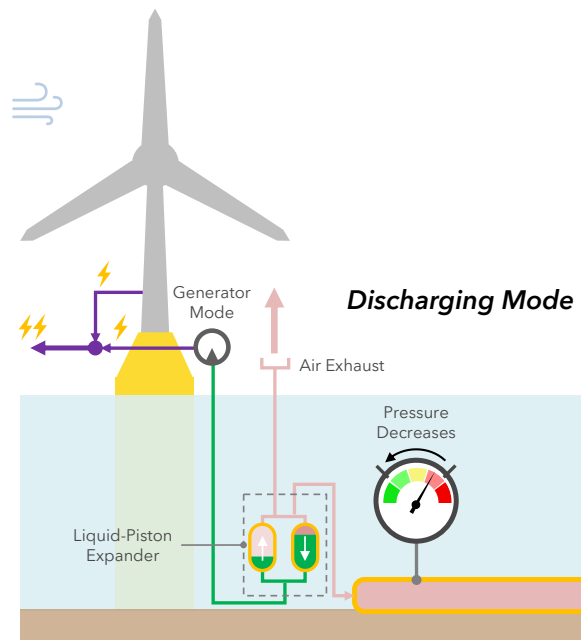
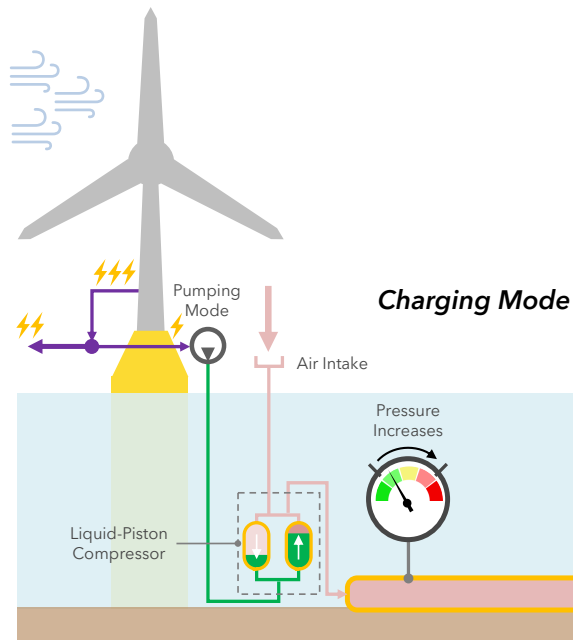
Pneumatic Pre-Charging:

- Minimises fatigue and increases energy density resulting in a Levelised Cost of Storage **competitive with onshore systems**



The Ocean as a Natural Heatsink:

- Enables an isothermal process with **70-75% round-trip efficiency** without complex thermal storage or heat exchangers



Built on Proven Innovation

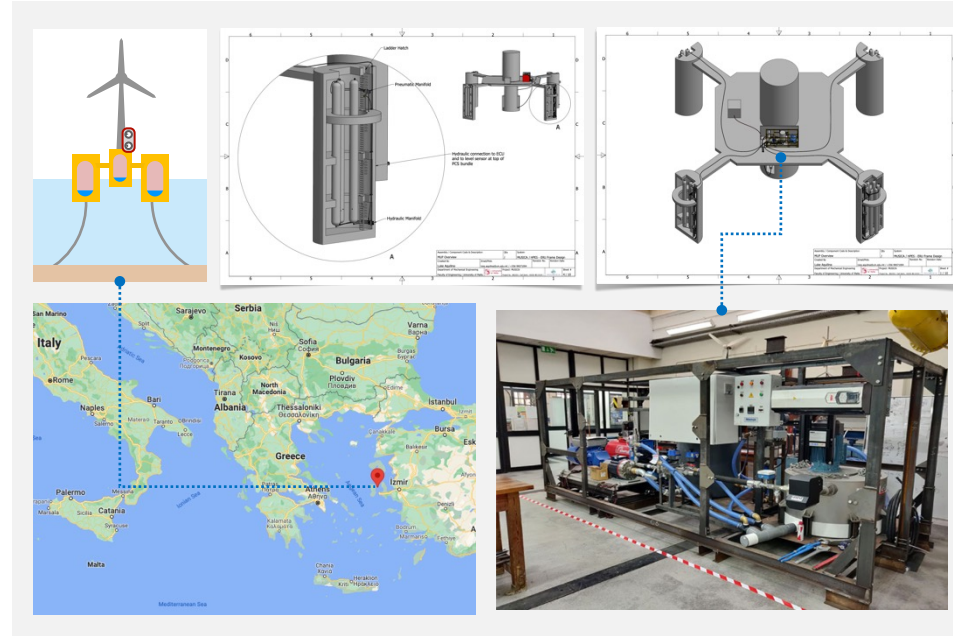
- Demonstration projects already using the **FLASC Liquid-Piston Technology**



▲ Proof-of-Concept Prototype (2017-19)

Grand Harbour, Malta

- Validating the liquid-piston technology and use of the ocean as a natural heatsink to achieve an isothermal process.
- Isothermal Efficiency of 96% achieved across 15 months of marine testing.^[1]



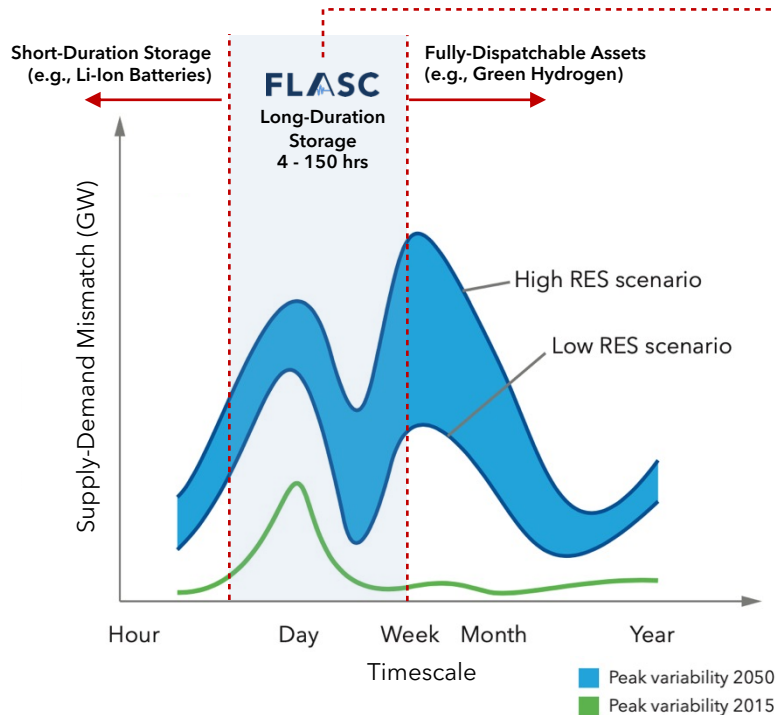
▲ Floating Wind Demo (2020-25)

Oinousses, Greece

- Liquid-piston integration into a floating wind turbine hull, interface with other technologies on the multi-use platform that will cater for small-island applications.
- Fabrication of the Energy Conversion Unit is complete, including full controls, grid connection and commissioning tests.^[2]

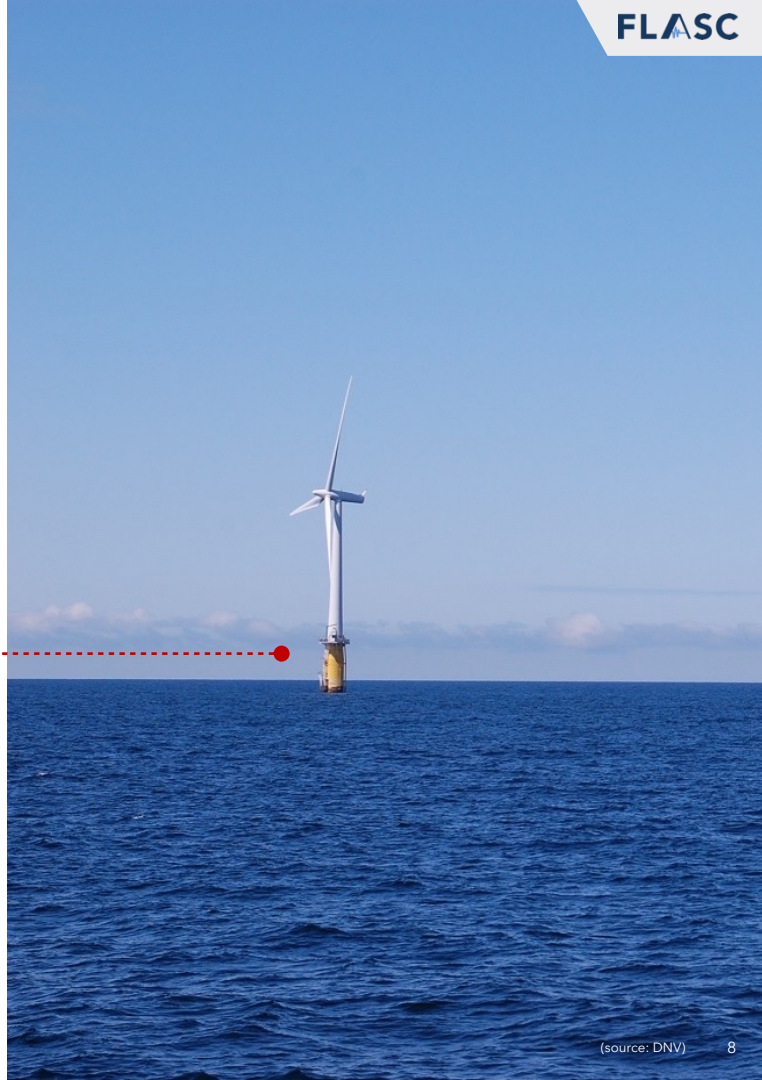
Offshore Wind needs Long-Duration Energy Storage

FLASC is in the sweet-spot to provide crucial intra-day storage for supporting offshore wind integration. It also complements short-duration batteries and green hydrogen.

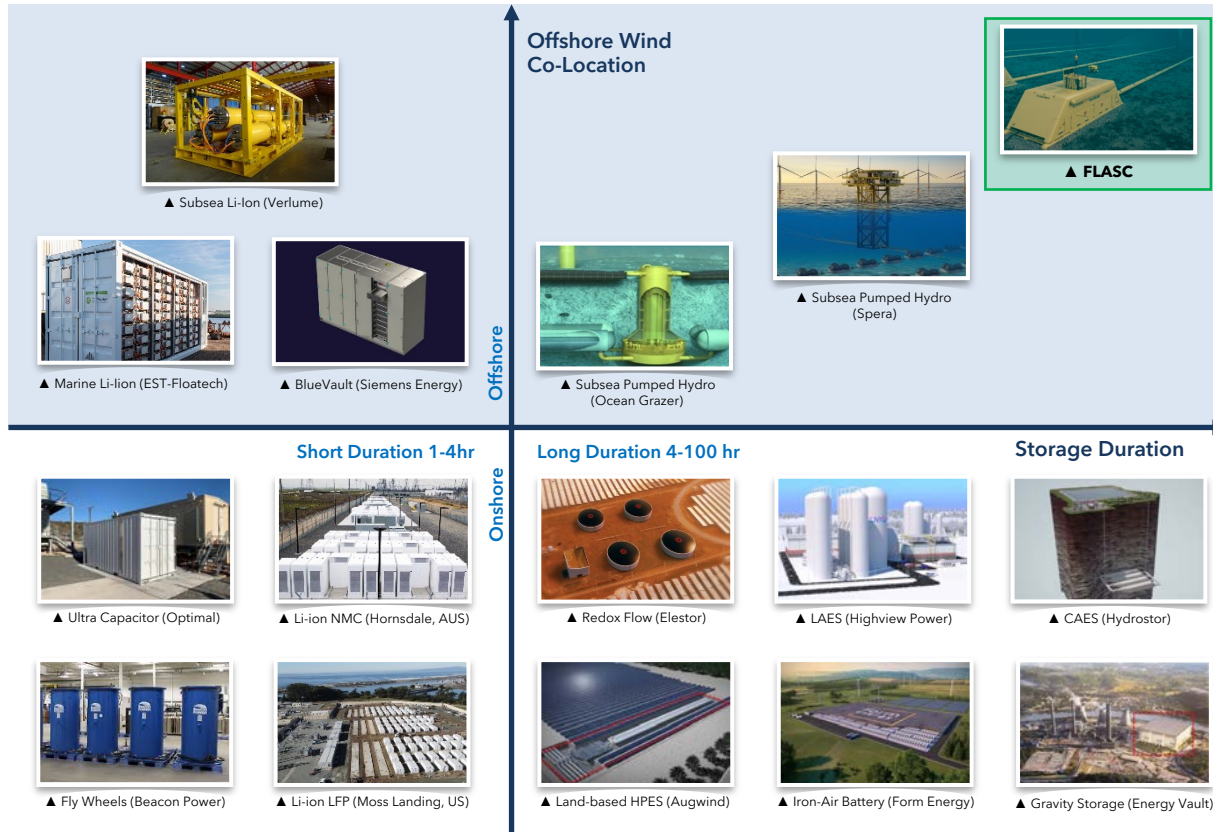


Peak variability of residual load at different time scales
in a European electricity grid in 2015 and expected in 2050

(source: DNV)

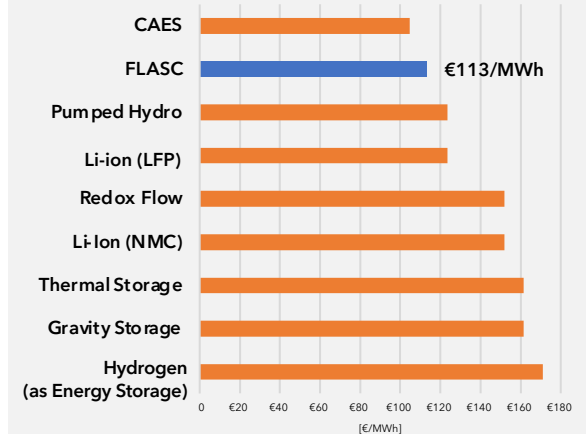


The Winning Solution for Offshore Renewables



- FLASC is uniquely positioned to address temporal and spatial mismatch in offshore wind applications
- Energy density up to x100 greater than existing offshore solutions
- **Levelised cost that is competitive with the cheapest land-based storage**

2030 Levelised Cost of Storage (LCOS)^[1]



[1] 2022 Grid Energy Storage Technology Cost and Performance Assessment (US Dept of Energy) (+100MW / 10-hr Duration)

The Product: Fully-Integrated Offshore Energy Storage Hardware

$$\text{FLASC} = \underbrace{\text{ECU} + \text{LPM}}_{\text{Power [kW]}} + \underbrace{\text{PCS}}_{\text{Capacity [kWh]}}$$

Can be sized independently to achieve durations of **4 to 100 hours**

Main Features:

- Scalability: **>100 MWh**
- Long Lifetime: **+30 years**
- Roundtrip Efficiency: **70-75%**
- No flammability risks or chemical hazards
- Robust global supply-chain
- Modular design for all applications

ECU: Energy Conversion Unit

- Electrical interface with variable-speed motor/generator
- Rotating equipment located topside to minimise OPEX
- **Modular topside unit** [2.5MW in a 40' Container]

LPM: Liquid-Piston Module

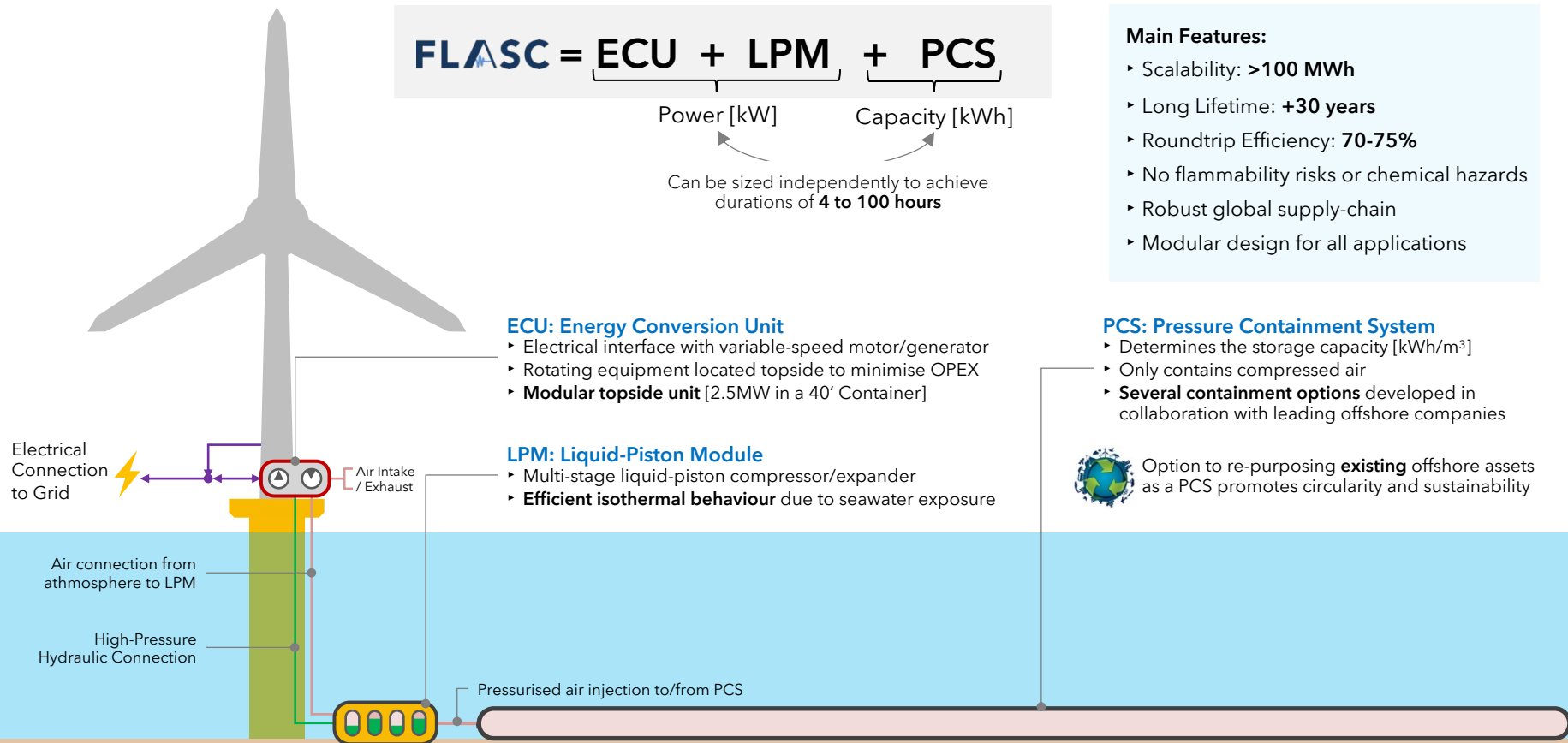
- Multi-stage liquid-piston compressor/expander
- **Efficient isothermal behaviour** due to seawater exposure

PCS: Pressure Containment System

- Determines the storage capacity [kWh/m³]
- Only contains compressed air
- **Several containment options** developed in collaboration with leading offshore companies



Option to re-purposing **existing** offshore assets as a PCS promotes circularity and sustainability



ECU + LPM Configurations



ECU: Energy Conversion Unit

- Electrical to hydraulic power conversion at wind turbine level
- 40-ft container-sized module with 2.5MW of rated power

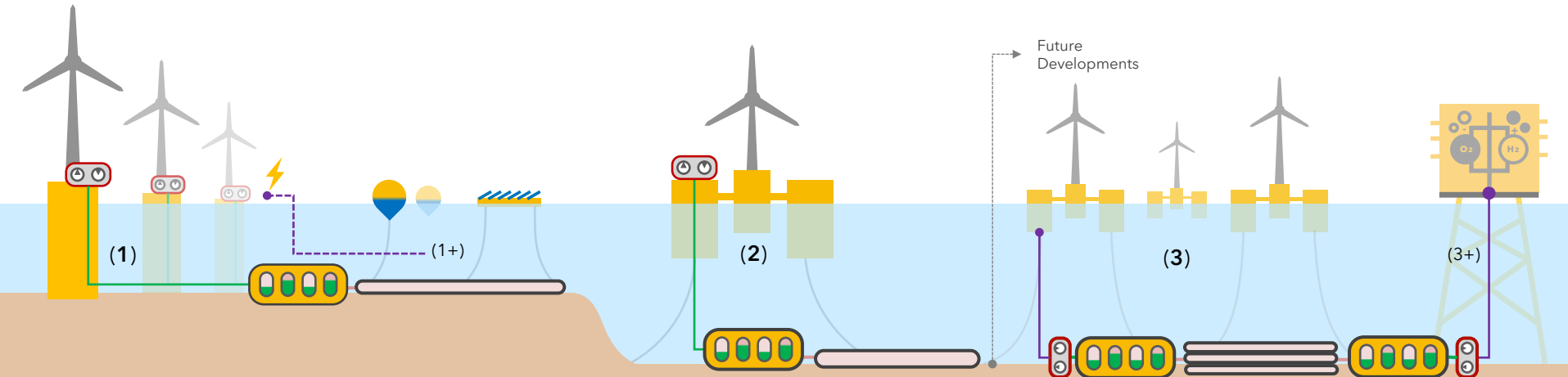


LPM: Liquid-Piston Module

- Hydraulic to pneumatic power conversion using liquid-pistons
- Subsea modules with up to 40MW of rated power

Equipment can be scaled as needed and optimised for different applications:

- (1) Several turbine-level ECUs hydraulically connected to centralised LPMs on the seabed
 - (1+) Electrical interface with other generation sources (e.g. wave, solar) also possible for multi-use applications
- (2) Floating wind applications currently supported with a topside ECU and hydraulic connection to the subsea LPM
- (3) Future developments will include fully-subsea ECU+LPM designs with direct electrical interface to topside
 - (3+) Specific configurations to support offshore Green Hydrogen production also being developed

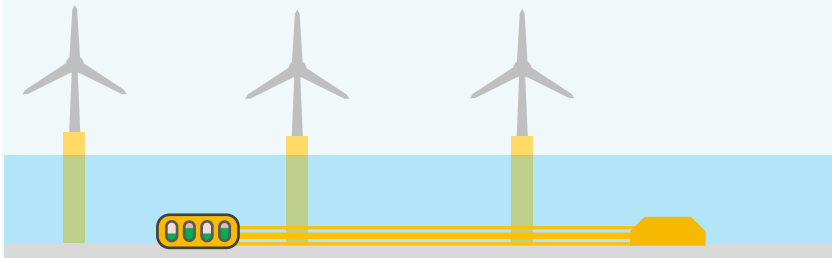


PCS Options

- ▶ A range of options developed as part of our long-standing collaboration with **subsea 7** a global leader in offshore project delivery across oil & gas and offshore wind development

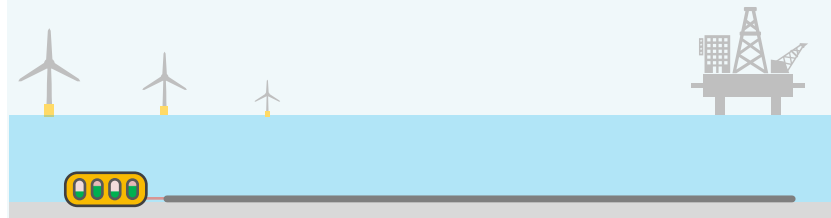
Subsea Bundle

- ▶ Fixed length of pipes bundled together to form a rigid towable structure
- ▶ Bundles of up to 7km can be fabricated onshore and towed into position
- ▶ Maximum OD ø1.5m with a storage capacity of up to 140MWh / bundle



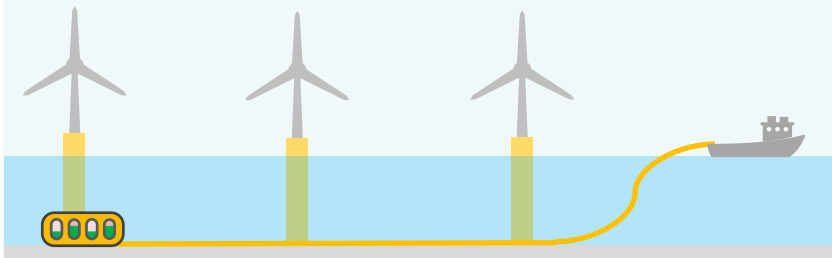
Re-Purpose Existing Pipes

- ▶ Offshore pipelines at end-of-life can be re-used for energy storage
- ▶ Pressure can be de-rated and optimised in line with pipeline residual life
- ▶ Additional cost-benefit by deferring abandonment cost



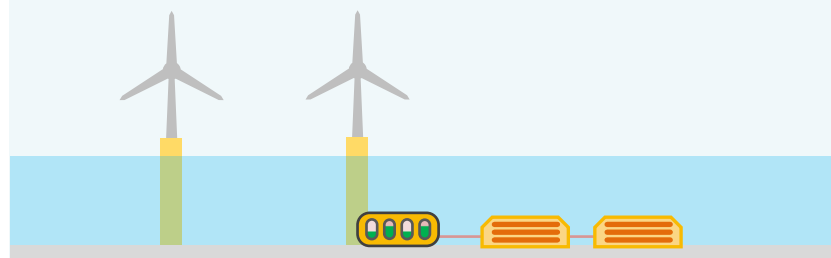
New Pipe

- ▶ Install a new length of pipe optimised for the application needs
- ▶ Diameter ranges from ø30" to ø42", reaching up to 14MWh/km
- ▶ Scalable to +1GWh of capacity for large wind farm applications



Modular Tanks

- ▶ Array of slender tanks suitable for smaller applications
- ▶ Standard subsea module designed for towable installation
- ▶ Scalable to +10MWh per module and can be combined for larger capacities



Typical FLASC configuration

- Co-located energy storage enables developers to improve business case of existing offshore consents
- Optimum Power/Storage requirements typically correspond to 5-10% of wind farm power with 4-hr duration

1GW Offshore Wind (72 x 14MW Turbines)

+ FLASC Energy Storage [80MW / 320 MWh]



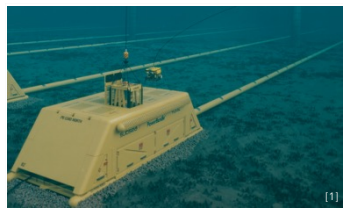
ECU: 8 wind turbines with
10MW installed topside
[4x2.5MW modules]



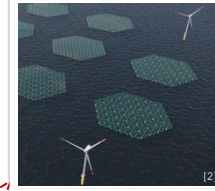
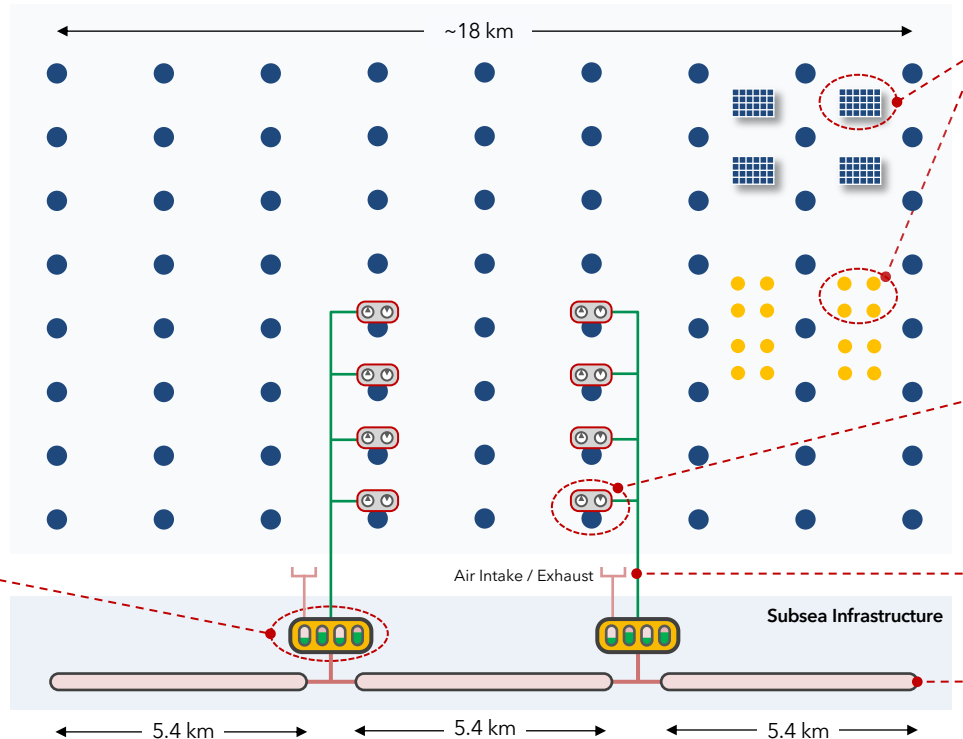
LPM: 2 x 40 MW subsea
units interfaced with
multiple ECUs



PCS: 3 x 5.4km bundles
with ϕ 1.5m storing a total
of 320MWh



▲ Subsea equipment based on established towable designs



▲ Can be co-located with other offshore renewables in multi-use applications



▲ 8 out of 72 Turbines fitted with extended deck for topside electrical equipment and hydraulics

High-pressure hydraulic connection between topside ECUs and subsea LPM

PCS storage installed subsea only occupies 1 wind farm row and caters for full energy storage requirements

Applications & Go-To-Market

Stage 1



Offshore Wind & Grid Support

FLASC enables offshore energy storage at scale, making possible the scale-up of offshore clean energy and its integration into the energy system.

Stage 2



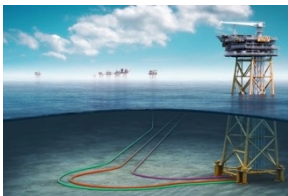
Offshore Hydrogen Production

FLASC enables a stable supply of power to the hydrogen electrolyser, improving efficiencies and prolonging the electrolyser lifetime (patent filed 2021).



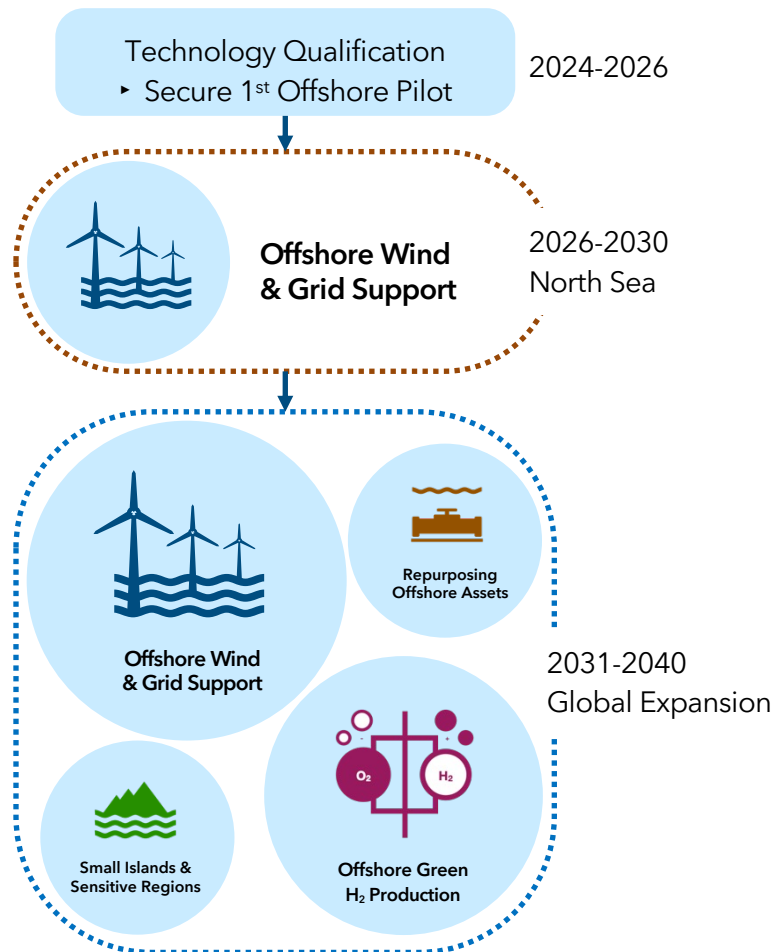
Small-Islands and Sensitive Regions

FLASC storage frees up precious land and provides flexibility as a sustainable and socially-positive solution.



Re-Purposing Offshore Assets

Existing offshore assets such as pipelines and platforms can be repurposed into an offshore energy storage system using the FLASC technology.



FLASC for Offshore Wind & Grid Support



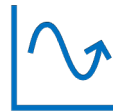
- ▶ Evaluation of Offshore Wind Business Cases with Siemens Energy
- ▶ Case study on 26 UK offshore wind farms presented at *WindEurope 2024*^[1]

Download the Full Presentation 

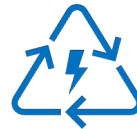
- ▶ Co-locating FLASC with UK offshore wind farms corresponds to an **IRR of 18%**
- ▶ Based on 2021-22 markets, FLASC would add **€300m/yr** to UK wind revenues
- ▶ Value add increases significantly to 2030 as wind penetration increases.
- ▶ Co-located energy storage being incentivised in recent subsidy schemes.



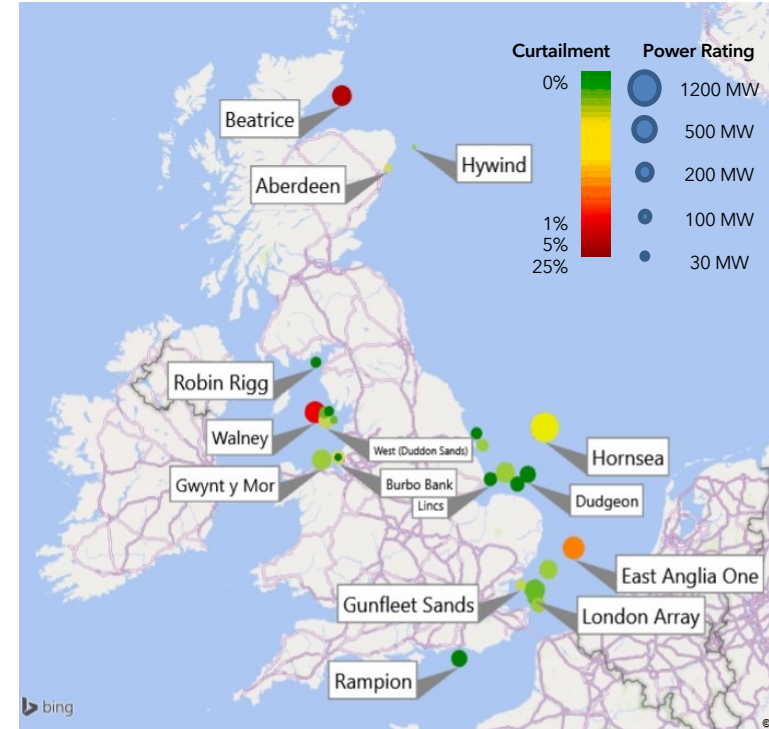
Adds at least 10% more value to existing UK offshore wind farms



Enables participation in balancing markets by hedging against volatility



Offshore wind can become an active provider of grid flexibility



[1] Singuran et al. (FLASC / Siemens Energy) "Clean energy when the wind is not blowing: evaluating business cases for co-located offshore energy storage across 26 UK offshore wind farms". *WindEurope 2024*

FLASC for Offshore Green Hydrogen Production

► Current Challenges:



► Commercial: green H₂ is expensive, needs cheap green electricity and high utilization rates.



► Technical: electrolyzers need fast response for intermittent power input, lifetime suffers with high on/off cycling, complex infrastructure.

► FLASC Value Proposition:

Combined intra-day storage solution for offshore Green H₂ (patent pending):

- Increase H₂ production for same wind farm power rating,
- Reduce in cost of produced H₂ (€/Nm³) making it **up to 20% cheaper**
- Improve electrolyser lifetime with a **+50% reduction in on/off cycling**

These benefits increase in lower wind climates (e.g. Mediterranean, Western Australia)

FLASC is active in studies and consortia working on Green Hydrogen:

1. Wind4H2[1] was an early feasibility study to evaluate integration of FLASC HPES with offshore green hydrogen production
2. HydroGenEration[2] in 2022 evaluated optimisation of hydrogen production specifically in lower wind climates, such as the Central Mediterranean.

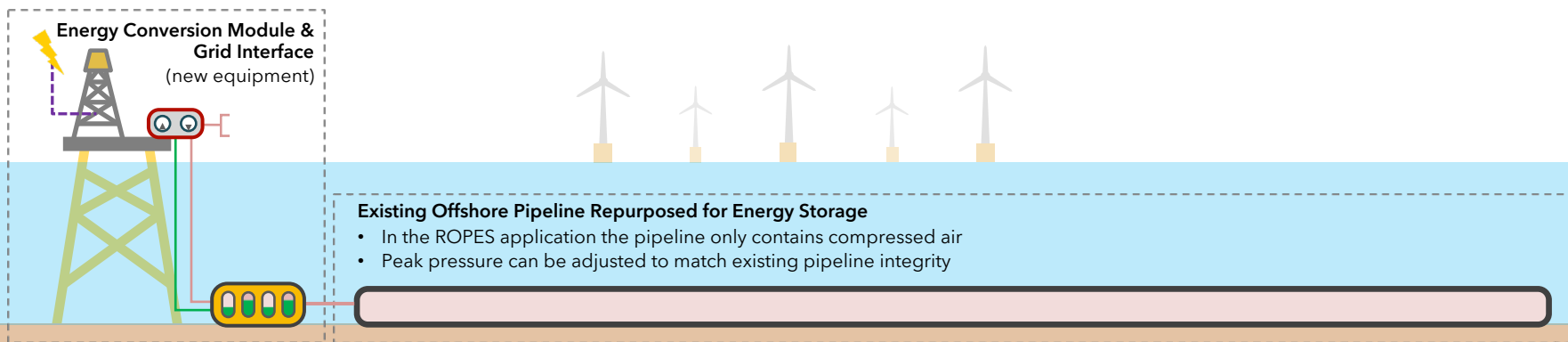


FLASC for ROPES: Re-Purposing Offshore Pipelines for Energy Storage

- ▶ There is a significant drive to re-purpose existing offshore assets to support the accelerating energy transition
- ▶ Not all pipelines are suitable for hydrogen transmission or carbon capture due to topology, material constraints and structural integrity
- ▶ FLASC HPES can be applied to existing pipelines converting them into a utility-scale energy storage system which represents one of the cheapest energy storage systems available
- ▶ **In most cases the re-purposing cost is offset by deferring the abandonment cost of the pipeline**

FLASC, Subsea7 and Xodus have evaluated several case studies:

- **UK, the North Sea: 330 MWh**
 - Pipeline Geometry: $\varnothing 36'' \times 153\text{km}$
 - Peak Storage Pressure: 44 bar
 - Application: Grid Integration of Offshore Wind
- **Western Australia: 280 MWh**
 - Pipeline Geometry: $\varnothing 30'' \times 55\text{ km}$
 - Peak Storage Pressure: 160 bar
 - Application: Decarbonization of Oil & Gas



Traction

7
LoIs

- Wind developers with confirmed interest to deploy FLASC systems in their projects.
- Representing an installed capacity of **+1GWh** by 2030

4
MoUs

- FLASC was included in **2 North Sea offshore wind farm tenders** since 2020
- Ongoing discussions for upcoming tender participation

x3

- World-leading delivery partners and suppliers ready to support our growth

+€1m

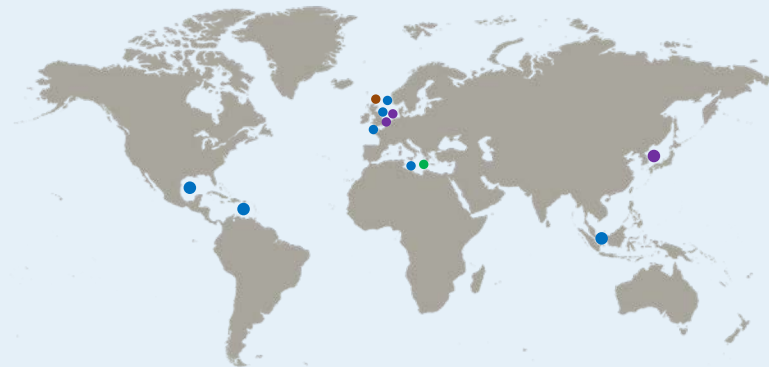
- Already generated from early revenues

+60

- NDAs established across our value chain including early commercial leads

5
Regions

- Technology versatility and established delivery partners enable a global reach



● Demo Project Deployment

● MoUs / Project Bids

● FEED Studies

● Feasibility Studies

Incentives for North Sea Offshore Energy Storage by 2030

Offshore Energy Storage

€1.0 – 1.9bn Market
(2.7 to 5.4 GWh capacity)



Gesteld dat deze 100GW 50/50 wordt opgewekt door zon-op-land en wind-op-zee.

- Voor 50GW jaargemiddeld zonvermogen is nodig: 7.140 km². Nederland heeft een oppervlak van 41.000 km². Dit is 17% van het landoppervlak.
- Voor 50GW jaargemiddeld wind-op-zeevermogen is nodig: 22.300 km². De Nederlands Exclusieve Economische Zone heeft een oppervlak van 58.000 km². Dit is 38% van de EEZ.

"22,300 km² of offshore space is needed for the 50GW target"

Source: Rijksoverheid 07-06-2023 [[LINK](#)]



"When looking at the development of offshore wind energy, I take into account the balance between the energy transition, food transition and nature transition in the North Sea. In this context <...> investigating how we can best shape multi-use in offshore wind farms.*

**Multi-use of offshore wind farms is permitted in accordance with the North Sea Programme 2022-2027 for: aquaculture, passive fishing, nature restoration and development and other forms of renewable energy generation and storage (such as offshore solar energy and batteries)"*

Page 5 of the Letter DGKE-DRE / 55305796 to Parliament regarding permit procedure offshore wind energy IJmuiden Ver Gamma and Nederwiek I (4 GW)

Source: Rijksoverheid 06-2024 [[LINK](#)]

Development Milestones

2017

Proof-of-Concept
[TRL5]

2018

International Patents
Granted

2019

DNV Statement
of Feasibility



▲ **Patents Granted:** Europe, US,
China and Japan



2020-23

Floating Wind
Demo [TRL7]
H2020 BG-05-2019

► Grid-connected ECU system to be deployed
offshore on a floating wind turbine.

2024-26

Technology
Qualification
[TRL8]

► Onshore qualification and grid-compliance as
the only remaining step before market entry

EIC Accelerator

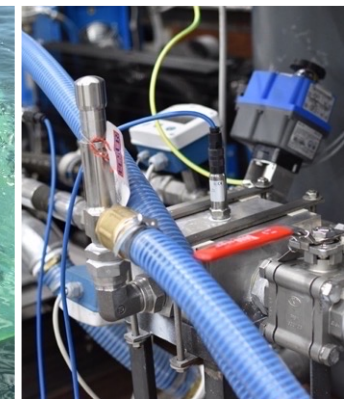
2026

Secure 1st
Offshore Project

► x7 Wind Developers have declared their interest to
deploy FLASC in their wind farms after qualification

2027-30

► Roll-out FLASC systems across North Sea wind farms: 30 units by 2030



European
Innovation
Council



Interreg
Vlaanderen-Nederland



Gefinancierd door
de Europese Unie



Horizon2020
European Union Funding
for Research & Innovation



Rijksoverheid voor Ondernemen
Nederland



Department for
Energy Security
& Net Zero



EUROPEAN
INVENTOR
AWARD 2024
Nominee Research Category

PowerUp!
by EIT InnoEnergy



FLASC - Company profile

- First movers in offshore energy storage since 2015
- **10 FTEs:** technical founders, a team of engineers and a business developer
- Network of seasoned advisers across offshore, energy and finance



- **Spin-Off from the University of Malta**
Established in The Netherlands in 2020, with exclusive access to all related IP and know-how



- **Part of the Buccaneer Delft Accelerator**
In the heart of the offshore energy sector, with access to an extensive partner network



- **Collaborating with Subsea7 since 2020**
Jointly developing solutions for offshore energy storage based on FLASC's HPES technology

- **Extensive track-record in securing and managing grant-funded projects across national and EU jurisdictions.**



Opportunities for Collaboration

- **Seeking partners to support bids for offshore wind farm projects**
- Strategic Partnerships / Collaborations
- Concept & Feasibility Studies

FLASC brings:

- ✓ **Experience from multiple wind farm bids on system integration**
- ✓ **Innovative solution built on proven technology**
- ✓ **Credible EPCI partners for project delivery**

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FLASC B.V. is a spin-off from the University of Malta, established in The Netherlands with registration number: 76566404.

The company is part of the Buccaneer Delft energy & offshore accelerator.

"FLASC's solution is an innovative technology with significant potential, offering a competitive and more sustainable alternative to Li-ion battery farms."

The collaboration with FLASC will allow us to leverage Subsea 7's world-class technical expertise in the development of offshore subsea solutions to accelerate the deployment of utility scale, low maintenance, storage solutions."

Thomas Sunde
VP Strategy and Technology, Subsea 7

Peer-Reviewed Literature

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