

Renewable Subsea Power

Technology Update

24th August 2022

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Opportunity Overview

Baker Hughes looking across industry at key technology and solution enablers in order to provide flexible power and communications systems, to provide integrated system solutions to key industry challenges:



Challenge

- Subsea tie-backs to existing assets, with minimal reconfiguration of host
- Umbilical remediation (e.g. loss)
- Long-offset field developments
- Carbon capture & storage



Enabling technologies

- Wind, Wave, Solar, Tidal power generators
- Subsea battery storage
- All electric subsea systems
- Over-the-horizon communications



Solution

- Locally generated renewable power
- Integrated subsea systems
- Security of energy supply
- Enabling decarbonization

Baker Hughes are collaborating in Renewable Subsea Power project with Mocean Energy, Verlume and the NZTC to prove a concept for Autonomous Renewable Subsea Power utilizing wave energy, subsea energy storage and remote communications to power all-electric SPS infrastructure.



Technology building blocks

Integrated system solution

Baker Hughes 



verlume

Baker Hughes 



Renewables for Subsea Power (RSP) Project

The Project:

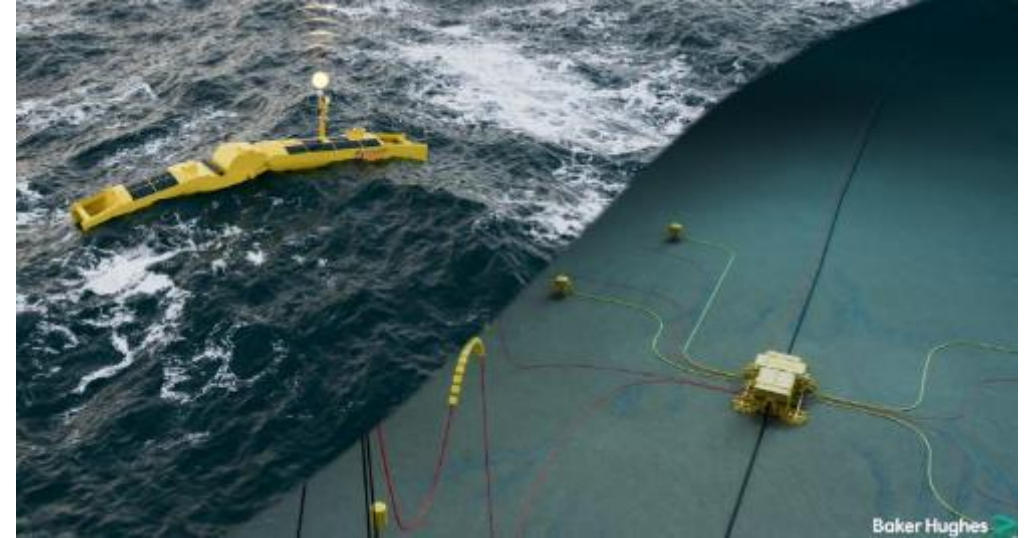
RSP is a collaborative project between Baker Hughes Mocean Energy, Verlume and the OGTC (NZTC)

The Objective:

To prove a concept Autonomous Renewable Subsea Power system utilizing wave energy, subsea energy storage and remote communications to power an all electric SPS infrastructure.

Project Status:

- Phase 1 – FEED and System Simulation/Bench Testing – successfully completed in 2021.
- Phase 2 (In process) – Building/commissioning subsea system in preparation for pilot offshore demonstration
- Phase 3 (Pending) – Deploy pilot offshore North Sea in Q3 22 for four month demonstration.
- **System (API) TRL 5 Feb 2023**

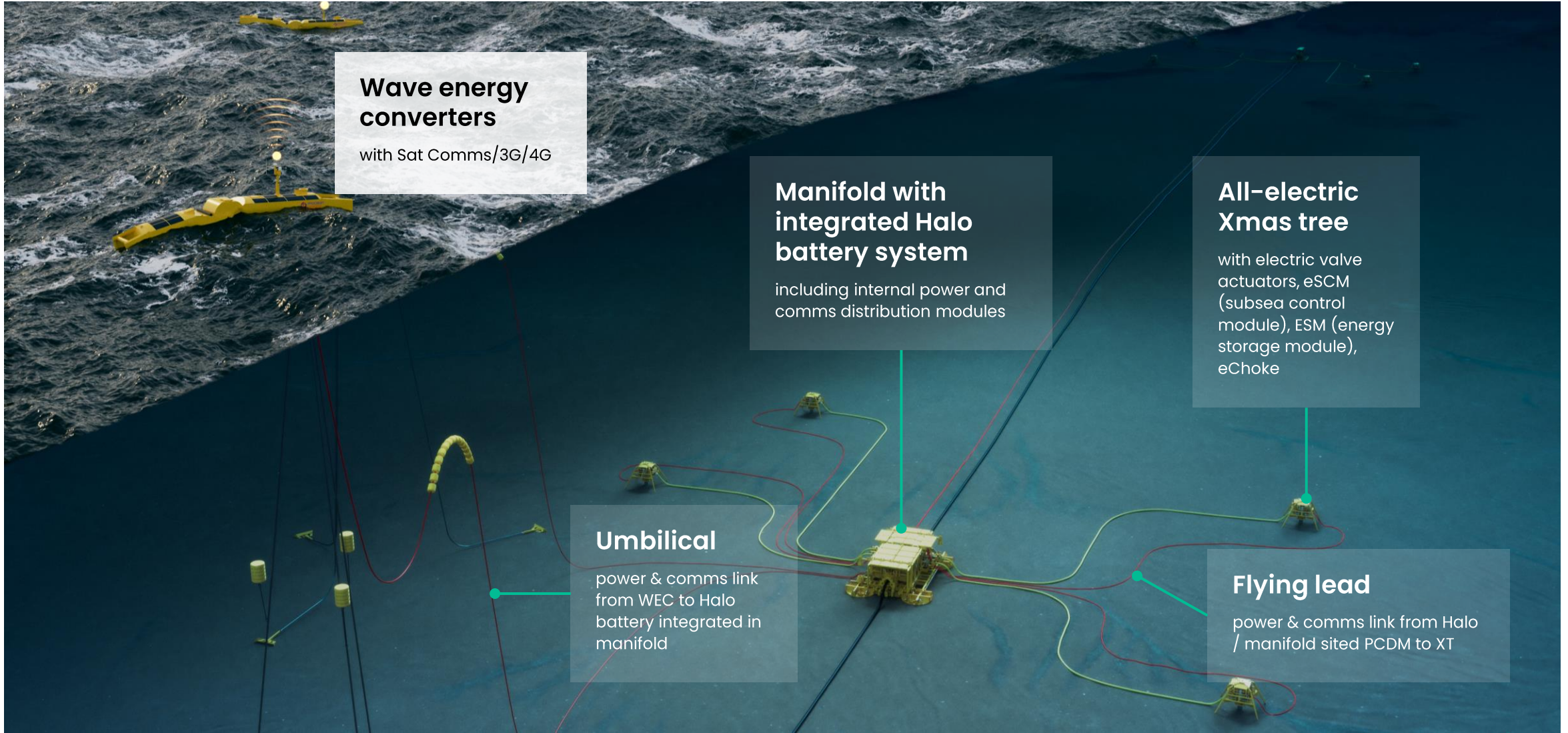


Verlume Halo
Battery Storage
Modules



Mocean Energy
– Wave Energy
Converter
(WEC)





Renewable Subsea Power Project (RSP) – An application of wave energy

Wave Energy Converter (Mocean Energy)

- Typical 10Kw
- 21m, 60 tons, direct drive vernier hybrid motor, 3 line catenary mooring
- Design life 25-years, maintenance 5-years



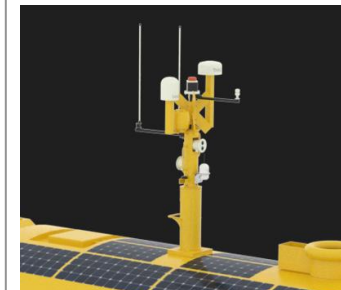
Energy Storage Module (Verlume)

- Li-ion battery system w/ fully integrated energy management system
- Typically 1MWh module – 15 off battery enclosures
- 7.8m c 2.9m x 3.2m
- Weight 45 tons
- Peak power 9kW



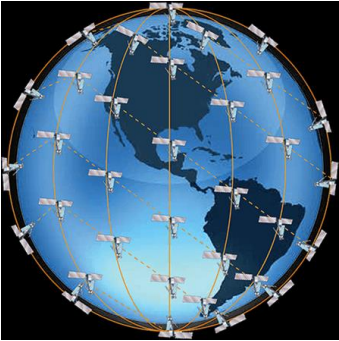
Remote Communications

- Thales VesseLINK (Iridium Cetrus) – global coverage for marine communications / maritime satcomms
- Secondary system: Sailor 250 Fleet-broadband (Inmarsat)
- Network capable 634kbps up and 1000 kbps down
- 4G dependant of coverage – Tampnet UKCS



Summary Options Remote Communications

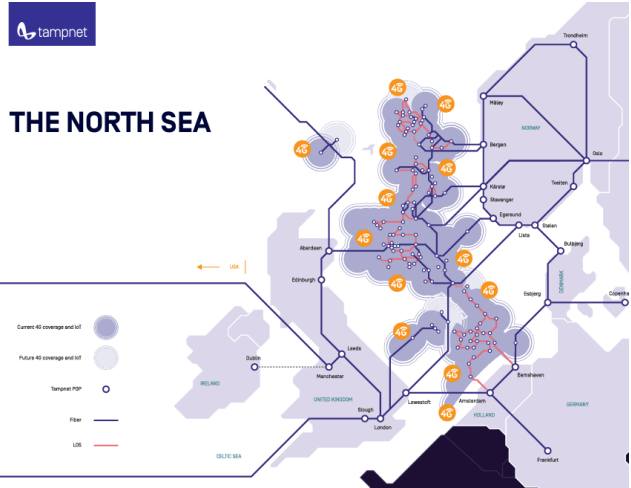
Satellite
~300kbps



Radio
~40-100kbps



3G/4G
~7.2mbps



CCS system design

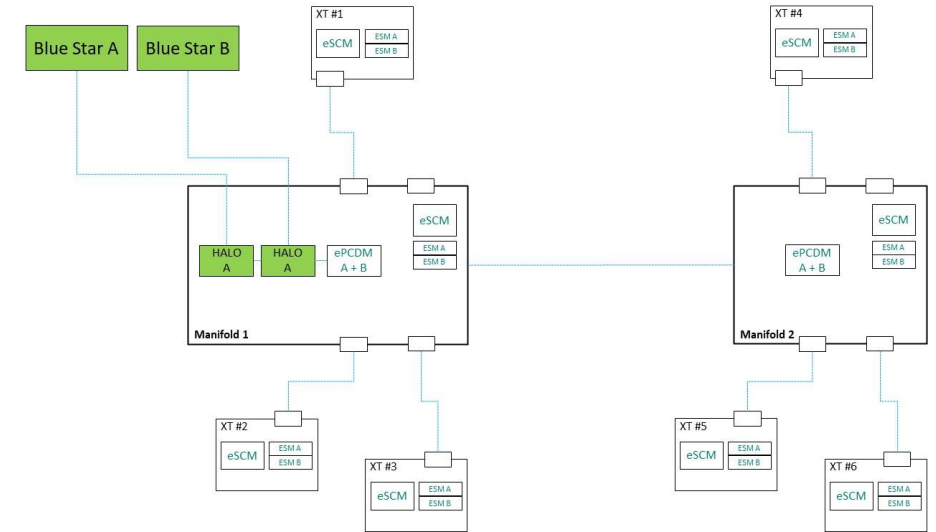
Reference case for assessment—carbon capture & storage development scenario in north sea

System description / design drivers

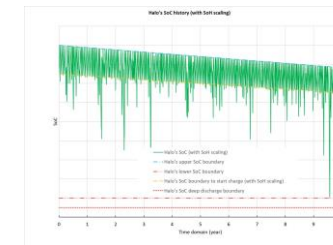
- Long-offset / shallow-water carbon capture & storage
- Simple architecture – 2 manifolds with 6 CO₂ injection wells
- No chemicals required
- All-electric subsea controls
- Integrated controls distribution

Solution development

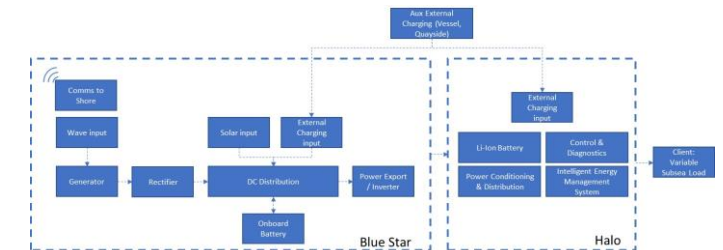
- Challenge to provide alternative to power cable from shore → reduced CO₂ emissions; reduced CAPEX; installation flexibility
- Local power generation via WEC with subsea storage in Halo battery
- Sized for power demand from subsea system with dual redundancy in WECs and Halo batteries
- Communications to shore via 3G/4G or Satellite



Subsea system block diagram—simplified



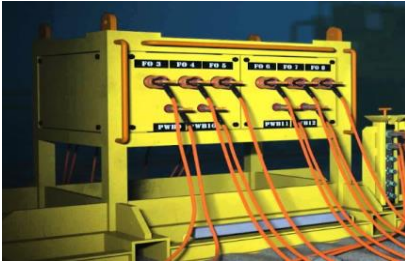
Halo—state of change (yrs)



Blue Star / Halo block diagram—simplified

Autonomous Renewable Subsea Power Application

Umbilical Remediation



- Re-enable failed assets with electrical umbilical failures (Assumes hydraulics still in tact)
- Energy Security
- Simple Transparent link remote SatCom/4G
- Works with existing controls architecture

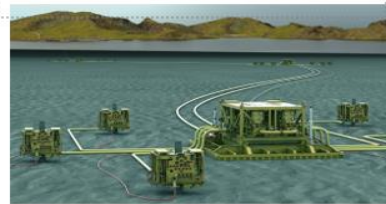
AUV Residency



- Charging and data transfer
- Routine fly-by inspections
- Piloted tasks
- Chemical delivery (future)

Brownfield Expansion

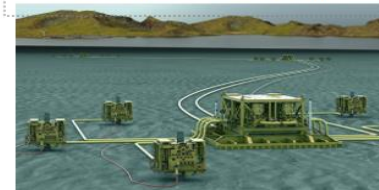
All Electric Subsea System



- Enable in-fill/stranded asset wells
- Minimal impact on host infrastructure control system
- Simple Transparent link remote SatCom/4G

CCS

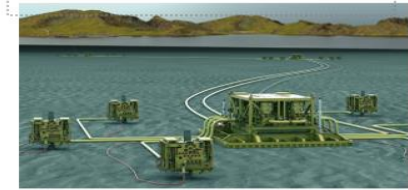
All Electric Subsea System



- Designed for Simplified Controls Architecture (electric controls)
- Alternate to DCFO from shore
- Remotely powered system (Energy Security)
- Green Power Generation (No GHG)

Long Offset

All Electric Subsea System



- Enable Long Offset wells
- Remove need for Hydraulic umbilical (employ remote chem injection subsea)
- Minimal impact on host infrastructure control system
- Simple Transparent link remote SatCom/4G

Mocean Energy – Blue Star 10

Mocean are adapting the engineering design of the Blue X prototype into their first product, the Blue Star 10 wave energy converter.

BST 10 available for commercial applications 2024



Power: 10 kW rated power; 4 – 9 kW average annual power production depending on site.



Battery storage: 150 kWh on board battery storage; expandable with subsea batteries.



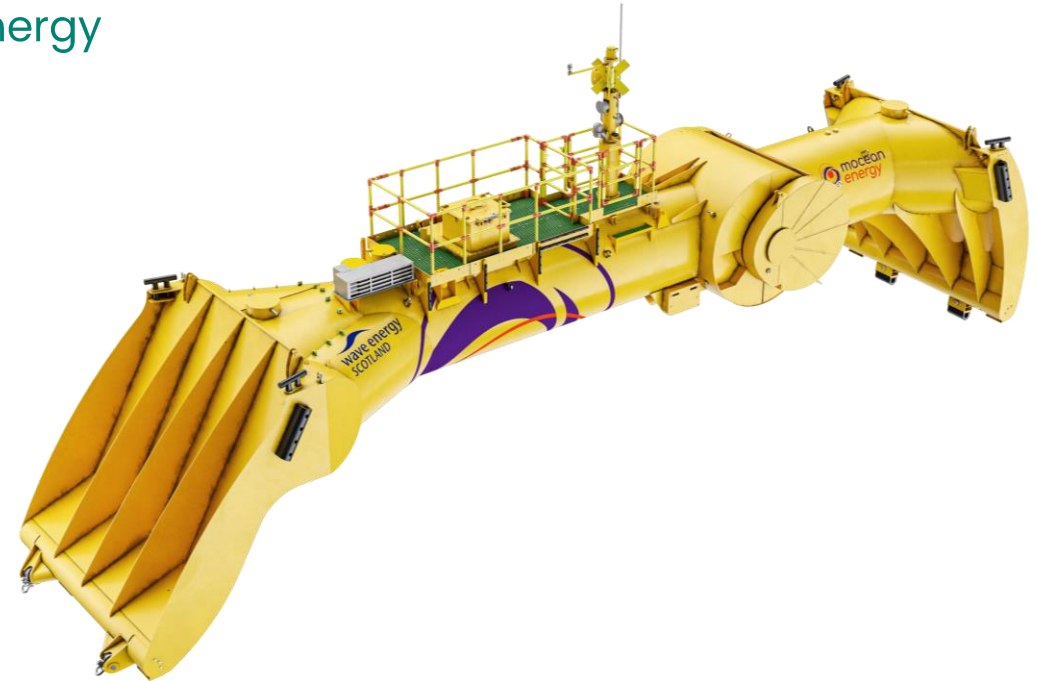
Communications: control system and mast support a variety of wireless comms systems.



Survivable and reliable: dives through waves to shed loads; redundancy; simple mechanical system.

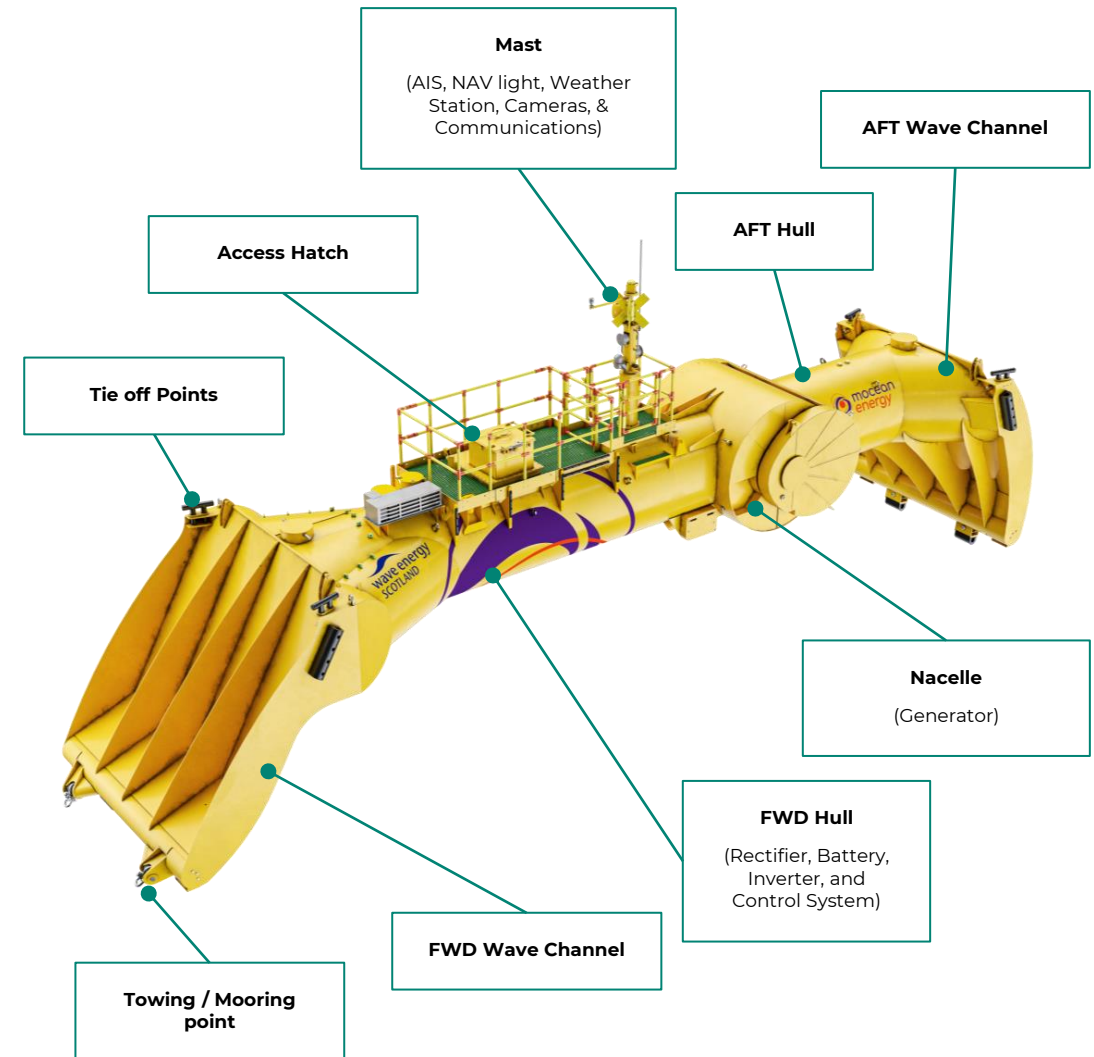


Low cost operations: installation with Multicats or AHV's; at-sea maintenance.



Mocean Energy – Blue Star 10

Outline Specification	
Dimensions	20m (L) x 5m (W) x 5m (H)
Weight	56 tonnes
Design Life	25 years
Communications	Satellite, Cellular, or Radio
Power Distribution	3-phase AC output from generator Rectified to feed nominal 800 VDC battery
Power Export	From 800 VDC to end-user required Adapted via on-board inverter and transformer
Power Delivery	Via umbilical
Moorings	3-line catenary (typical)
Directional Sensitivity	WEC can weathervane
Water Depth	50 – 3,000 m (mooring dependent)



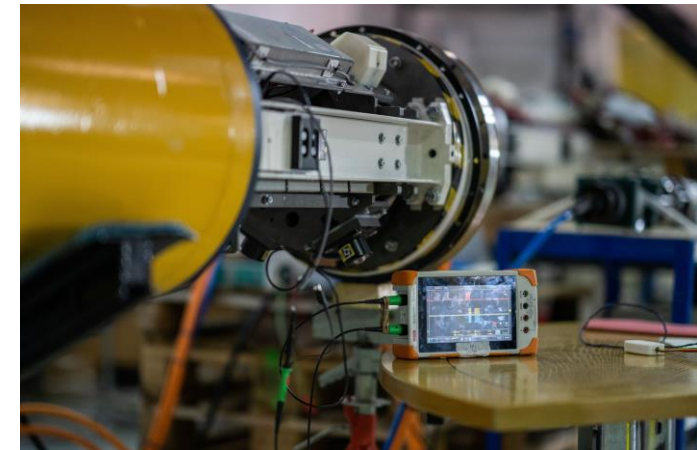
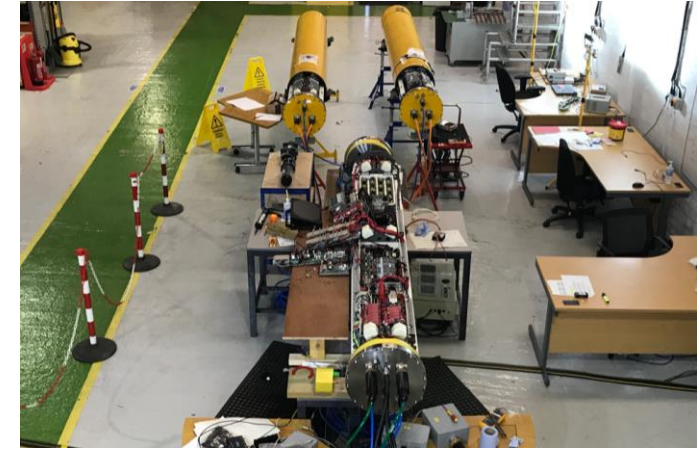
Blue X Commissioning

- + In 2021, funded through the Wave Energy Scotland, Mocean Energy, tested our Blue X device for 5 months at the European Marine Energy Centre in Orkney.
- + This testing provided invaluable lessons learned:
- + Power production: up to 5 kW sustained power and 30 kW instantaneous peak power.
- + Communications: 99.99% comms system uptime
- + Survivability: diving through waves to shed loads, equipment autonomously entering survival mode
- + Reliability: no major equipment failures.
- + Operations and maintenance: installation, removal, access as sea, battery charging, quick-turn-around removal and return to sea maintenance.



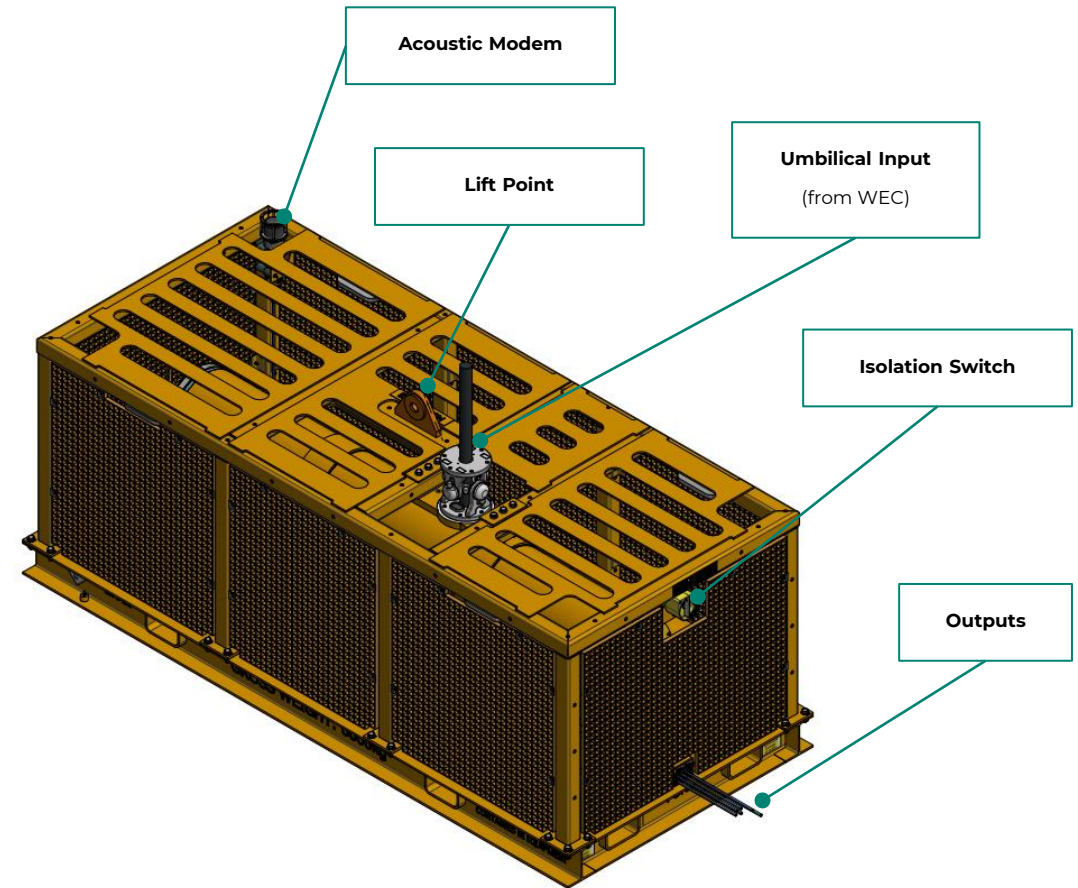
Verlume Halo – Intelligent Subsea Battery Storage

- + Modular and scalable **seabed battery** architecture with fully integrated, power generator agnostic Intelligent Energy Management System (IEMS).
- + Designed for integration with Marine Renewable Energy Converters to subsea payloads.
- + State-of-the-art **Lithium-ion battery technology** maximises energy density and system operating efficiency.
- + Energy capacity and power output **scalable and configurable to suit end user requirements**.
- + Developed initially as a replacement power supply for subsea O&G wells suffering from electrical supply failures.
- + **Adaptable for a range of applications**, e.g. new tiebacks, long step-outs, CCUS injection wells, subsea resident robotics and more.



Verlume Halo – Intelligent Subsea Battery Storage

Outline Specification	
Energy Storage Medium	Lithium-ion Batteries (chemistry and format adaptable, NMC / LFP base case)
Nominal Battery Capacity	5kWh – 10MWh+
Specific Output Condition	0 – 700V DC / AC (50 – 400 Hz) (Fully customizable, multiple outputs)
Charge Input	Trickle and fast charging options: - Agnostic renewable energy interface - Downline or umbilical redundancy options
Structure Type	Gravity foundation (standalone) or integrated package.
Water Depth	1500m standard 3000m maximum

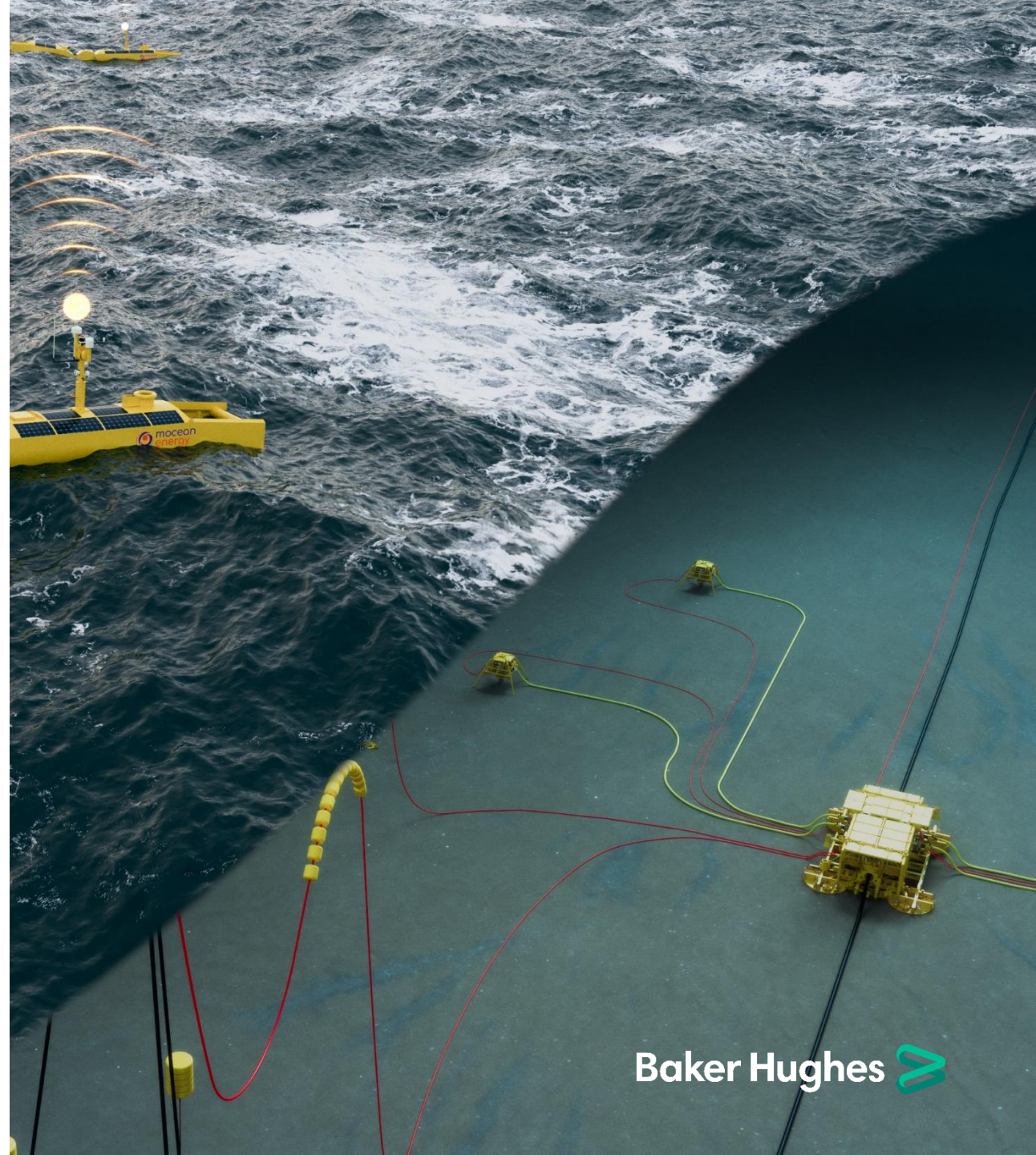


Halo: example configuration (as-built)



Conclusion / takeaway

1. CCS type application suitability
2. System sized for CCS reference case – 2 x WECs + 2 x Halo
3. Benefits through direct integration of renewable power
4. Summary of key design outcomes
5. Expected cost reductions relative to current systems
6. Technology readiness / upcoming system testing



Baker Hughes – Agnostic Autonomous Power and Communications Systems

Value Proposition

Flexible and scalable networks which deliver power and data to and from offshore facilities and fields.

- Complimenting Oil and Gas decarbonisation via
 - Power from shore (HV AC)
 - Offshore floating wind (HV AC)
 - Remote Power generation and Communications for (LV AC)
 - Subsea tieback
 - Long Offset
 - CCS applications
 - Umbilical remediation
 - AUV residency

