



**SIMEC ATLANTIS
ENERGY**

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AR Series Turbine Development

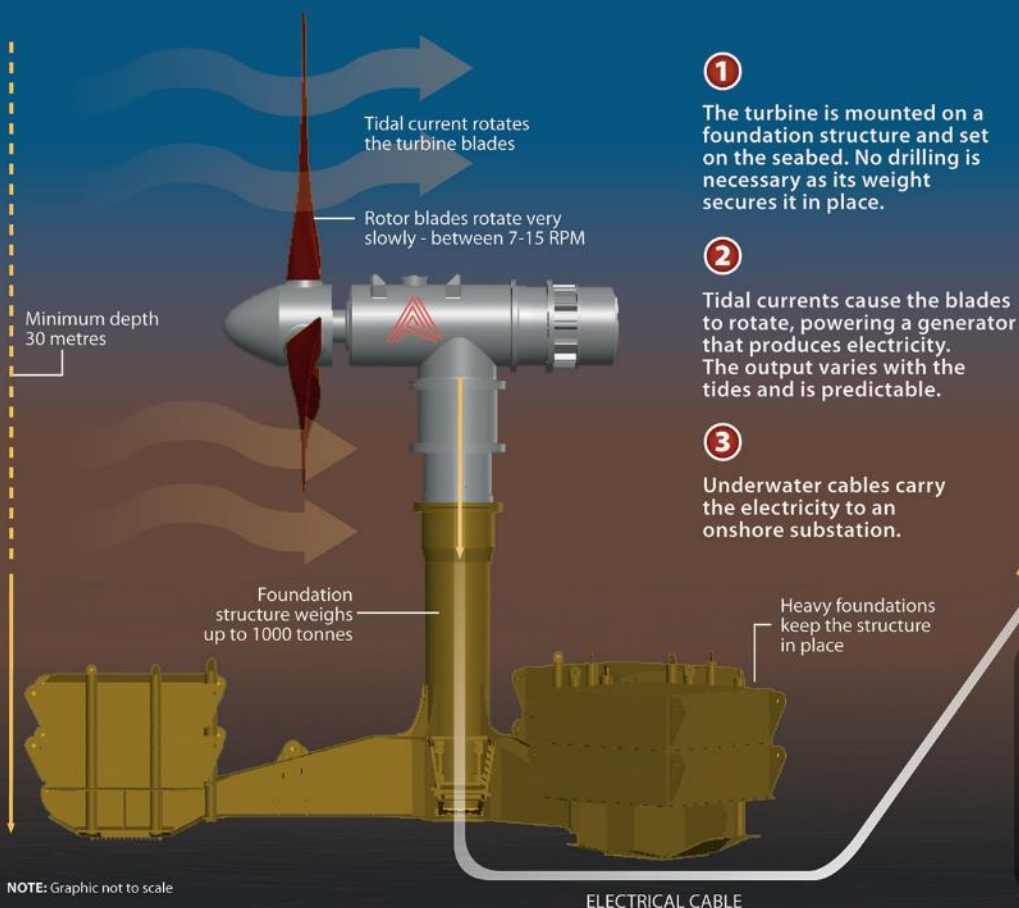
Fraser Johnson

O&M Manager MeyGen Tidal Array

September 2020

Tidal power

Tidal power is a predictable source of clean energy generation, making use of mature technologies developed by the oil & gas and wind industries over the past two decades.



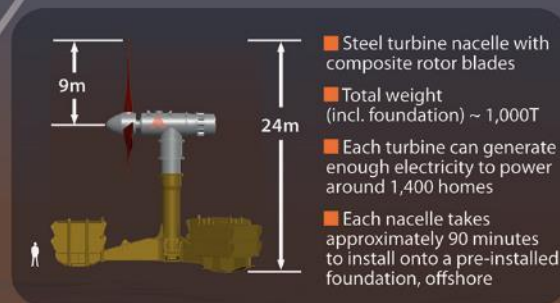
NOTE: Graphic not to scale

ELECTRICAL CABLE

Why underwater?

Space saving, no visual pollution

An underwater turbine with 9 metre blades can generate the same power as an onshore wind turbine with 30 metre blades. Low environmental impact with slow rotor speeds.



More predictable

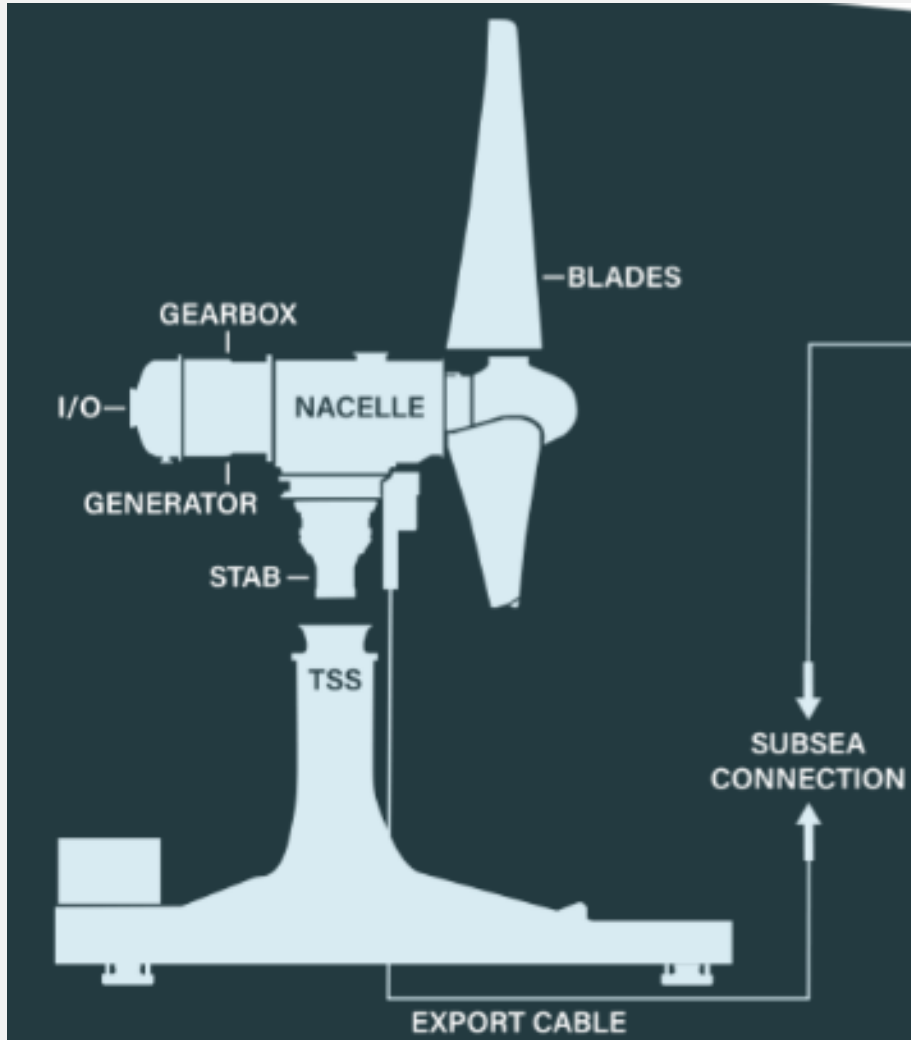
Unlike wind and solar energy, tidal energy is predictable as tidal currents can be accurately forecast years in advance. This makes for a more reliable source of electricity generation.

Large untapped resources

Water covers about 70% of the world's surface and every continent has potential sites for harnessing the power of tidal currents.



AR Series design principals



- Mass <1 60Te
- To be installed and recovered using existing 250Te Offshore Construction vessels operating on DP
- Main body to provide the units structural integrity
- Modular design with bolted connections to simplify and minimise maintenance time
- Wet-mate connection for data and power with bespoke features to and installation and recovery to minimise time onsite

AR series design evolution



· AR1000

- July 2011
- 1MW
- 150Te
- Fixed pitch



· AR1500

- May 2018
- 1.5MW
- 150Te
- Variable pitch
- Yawing

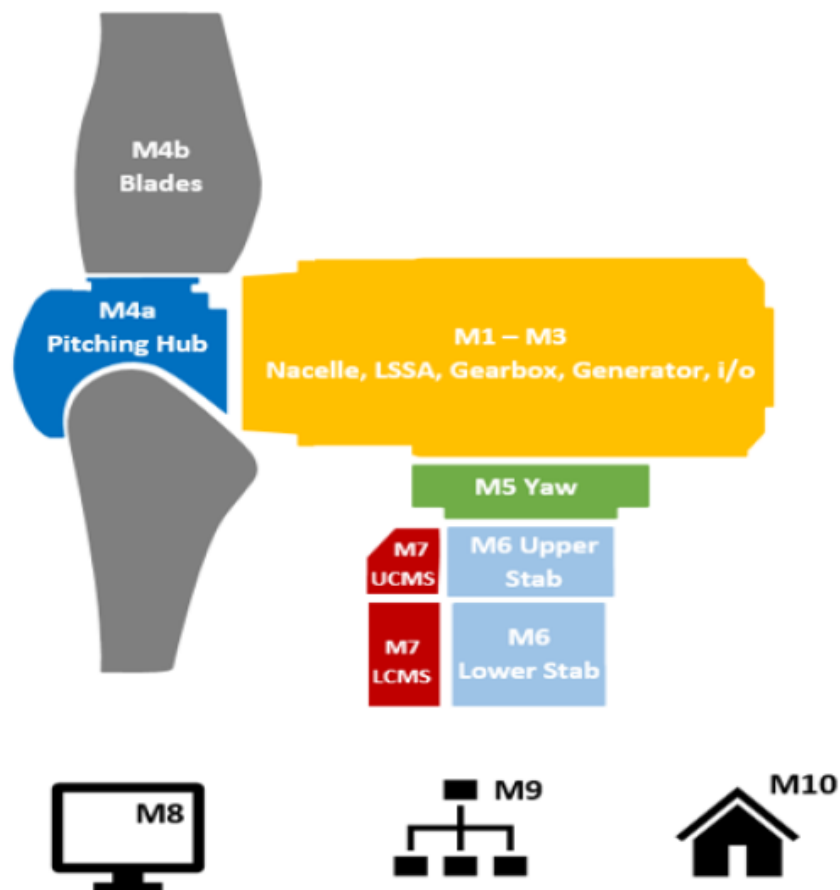
Andritz Hydro Hammerfest



- 3 x 1.5MW turbines
- Single unit design philosophy expecting design improvements from MeyGen operation
- MKII turbine in development
- Torque isolated design principal
- Similar to AR series, but with steel blades



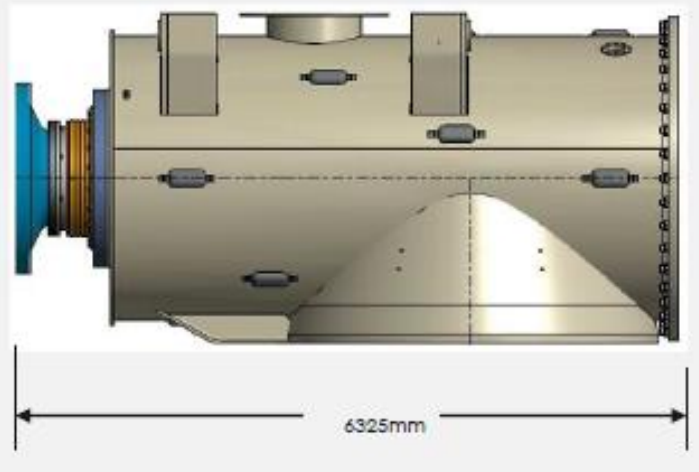
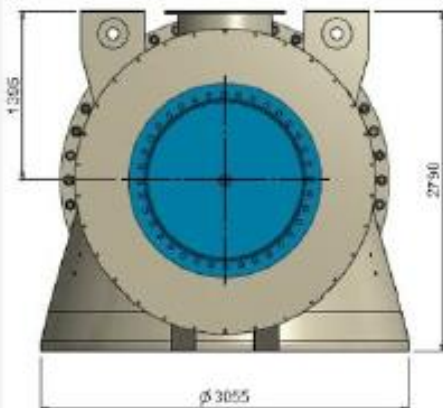
AR series modules



Module	Component
M1	Nacelle main body
M2	Gearbox and Generator
M3	Electrical system & distributed I/O
M4a	VPS
M4b	Blades
M5	YDS
M6	Stabs
M7	Connection Management System
M8	Control System and Software
M9	Subsea Hub
M10	Onshore Electrical Infrastructure
M11	Tooling, Installation and Transport Frames

AR – Nacelle (M1)

- Fabricated structure
- 3m x 4m x 5m long
- Cast lower section
- Fabricated top section
- ~20Te



AR1500 Gearbox and Generator & LSS

- Low Speed Shaft
 - Forged
 - Seal and bearing pre-assembled to shaft before delivery
 - Inserted into Nacelle
 - ~17Te
- Gearbox and Generator
 - AR1500 uses permanent magnet
 - ~32Te



AR – Stab (M6)

Provides a connection between the turbine and the turbine support structure.

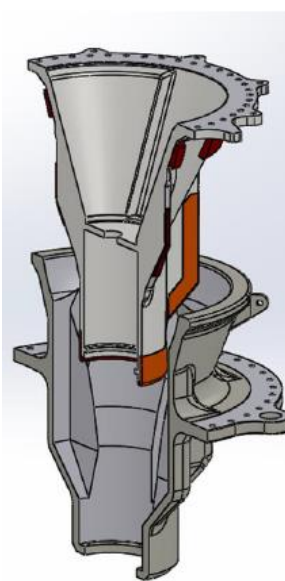
All loads and moments reacted by upper and lower bearings.

Cast steel construction

~10Te per unit

Inconel clad mating surfaces on lower stab to ensure 25 year life

Welded to turbine support structure



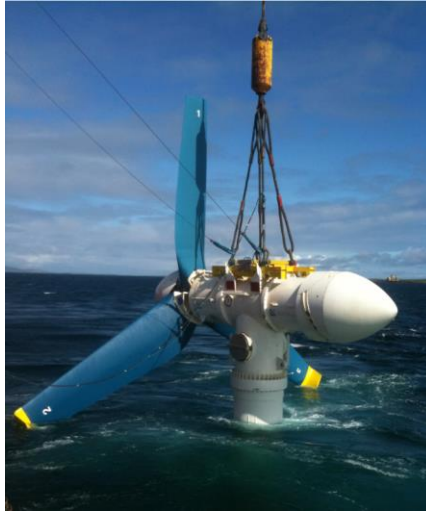
AR - VPS

- VPS options have been tried in development:
 - Hydraulic
 - Lead Screw
 - Electro-mechanical
- Cost reduction is going to demand independent pitch control
- Electro-mechanical looks like the more effective option with regards to cost and reliability
- Cast hub with pintle connections for ease of removal for maintenance
- Total weight ~30Te



AR Blades

- 2014
 - 8m long
 - GRP
- Destined for Japan on the Goto demonstrator

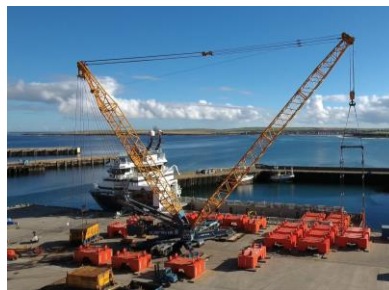


AR Series

- 2020
 - Carbon GRP
 - ~8m long
- Design development for a 26m rotor diameter with ~12m blades

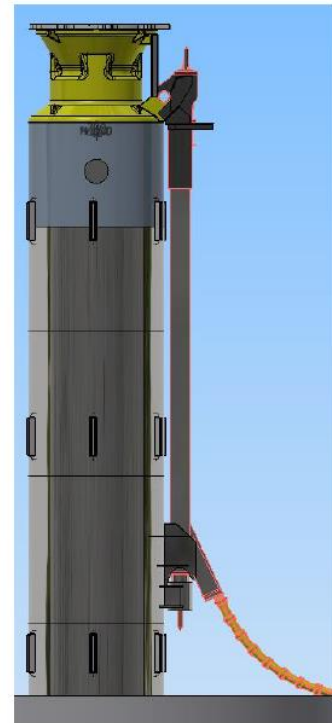
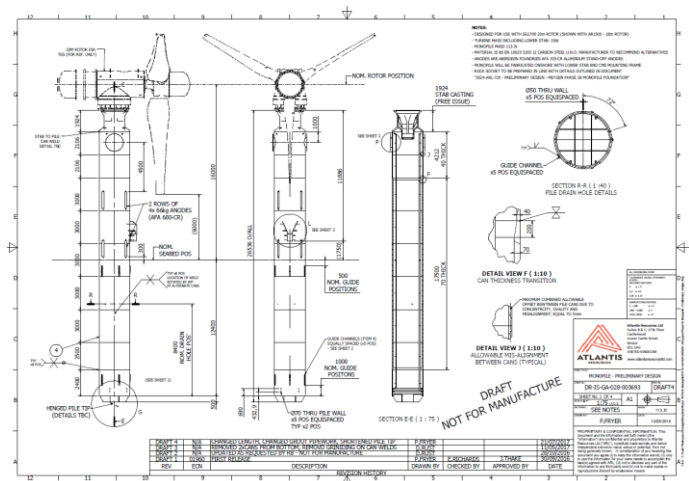


Foundations - Gravity



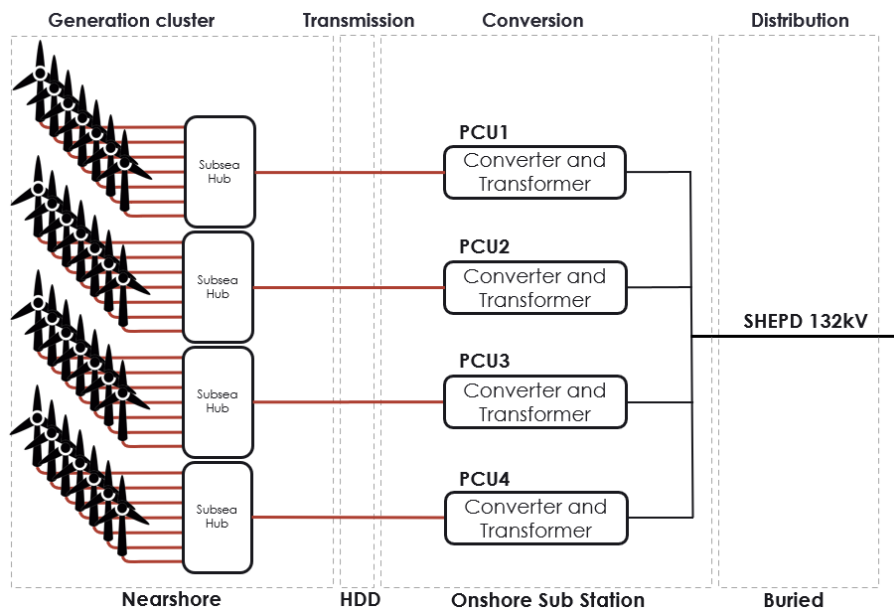
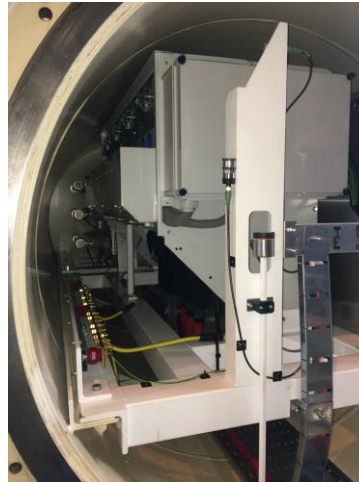
Foundations - Monopile

- Diameter 2.5m to 3.3m
- 25m length
- Wall thickness 60 to 80mm

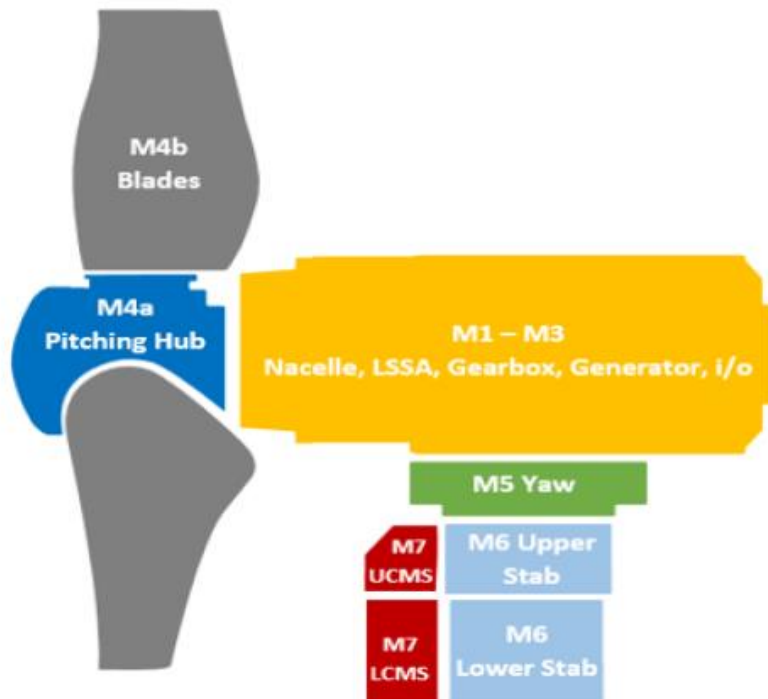


Subsea Hub (M9)

- Array scale development
- Dry-space housing offshore switch gear and step up transformers
- Wet-mate interconnection to the collector cables routed to each turbine
- 100m design depth
- 25 year design life



AR series supply chain opportunities



Module	Component	Supply Chain opportunities
M1	Nacelle Main Body	Steel casting
M4a	Variable Pitch System	Steel casting and additional components
M4b	Blades	Carbon GRP
M5	Yaw Drive System	Steel casting or fabrication and additional components
M6	Stabs	Steel casting
M9	Subsea Hub	Steel casting or fabrication and additional components
	Monopile Foundation	Steel fabrication and additional components

SAE – Development activities

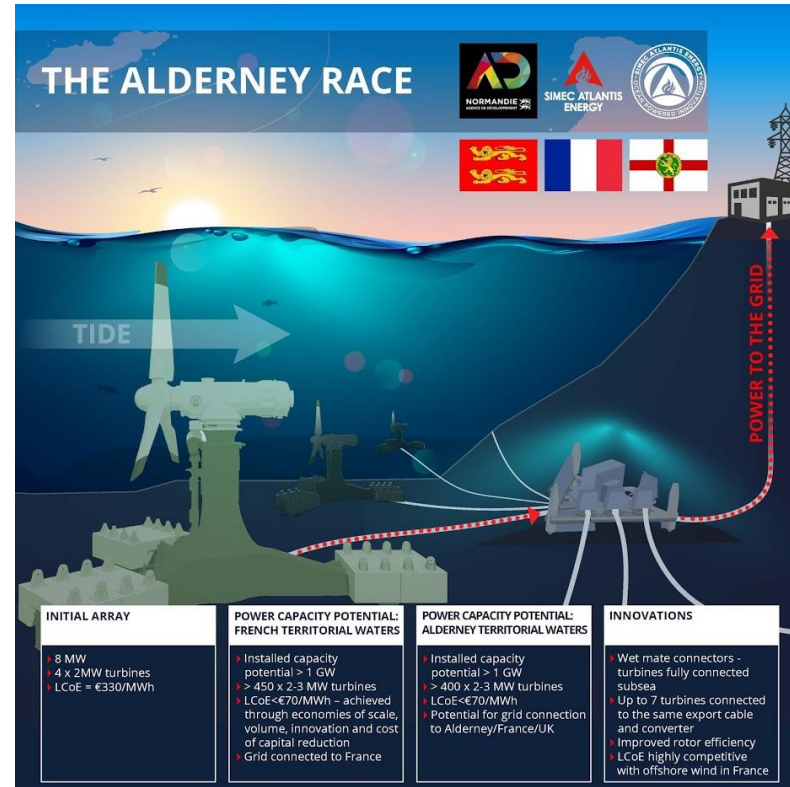
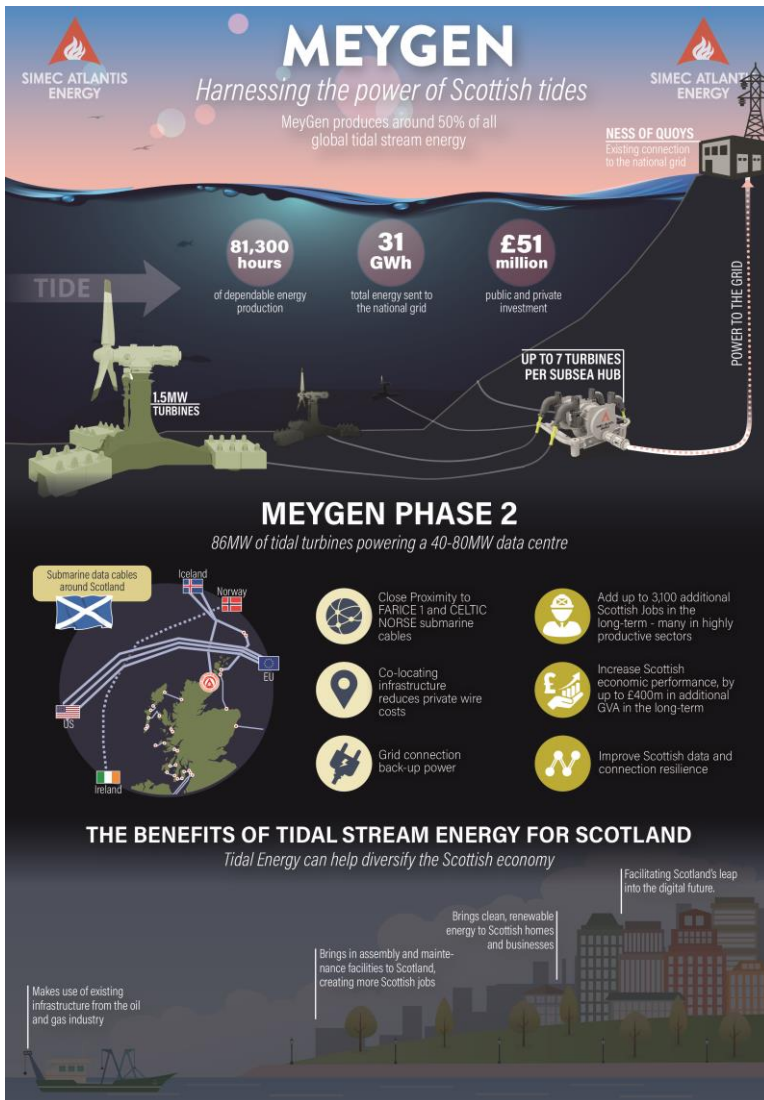
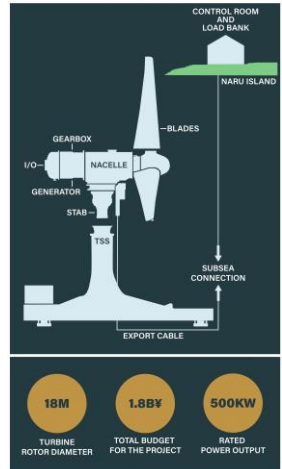
THE GOTO TIDAL POWER PROJECT

ATLANTIS OPERATIONS JAPAN
GODO KAISHA
AOJ
A SIMEC Atlantis Company

五島潮流発電実用化プロジェクト



PILOT AR500





**SIMEC ATLANTIS
ENERGY**

4th floor, Edinburgh Quay 2, 139 Fountain Bridge,
Edinburgh, EH3 9QG
fraser.johnson@meygen.com