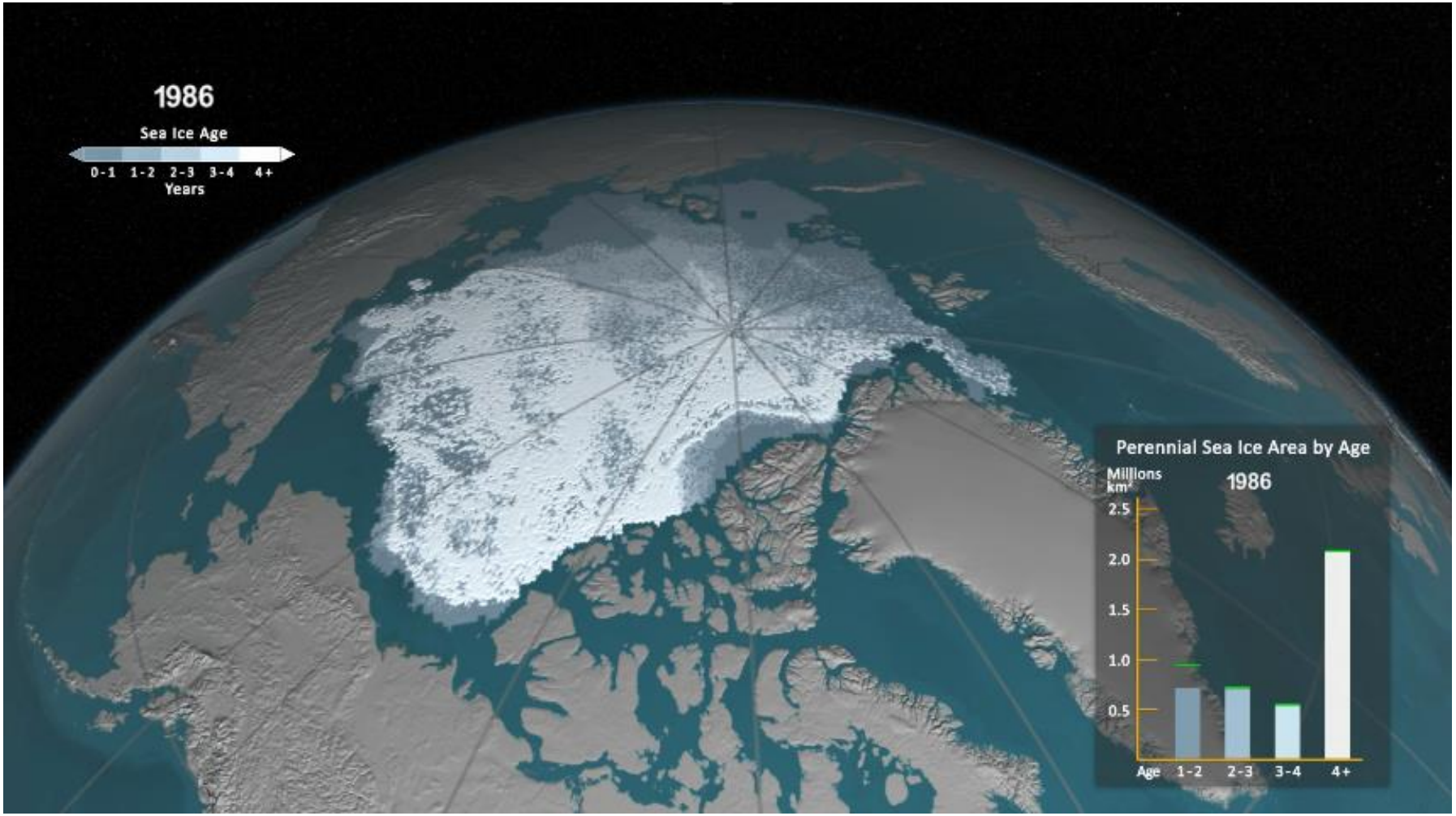
TON FIJEN – TLP TECHNICAL DIRECTOR

TIDAL LAGOONS, FROM SWANSEA TO FLEET LAGOONS

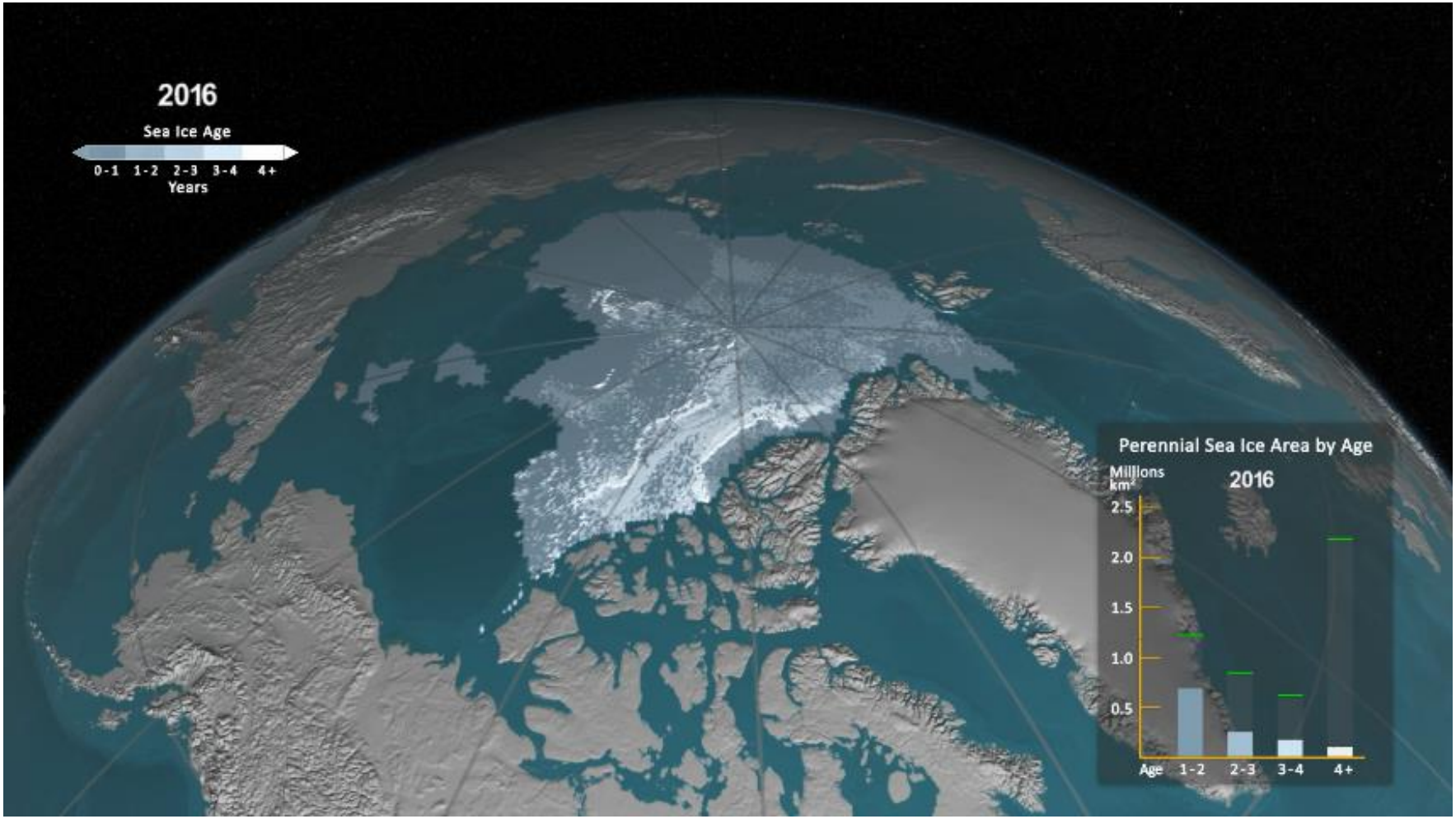
I-SEE seminar, 3 October 2017

TIDAL LAGOON POWER

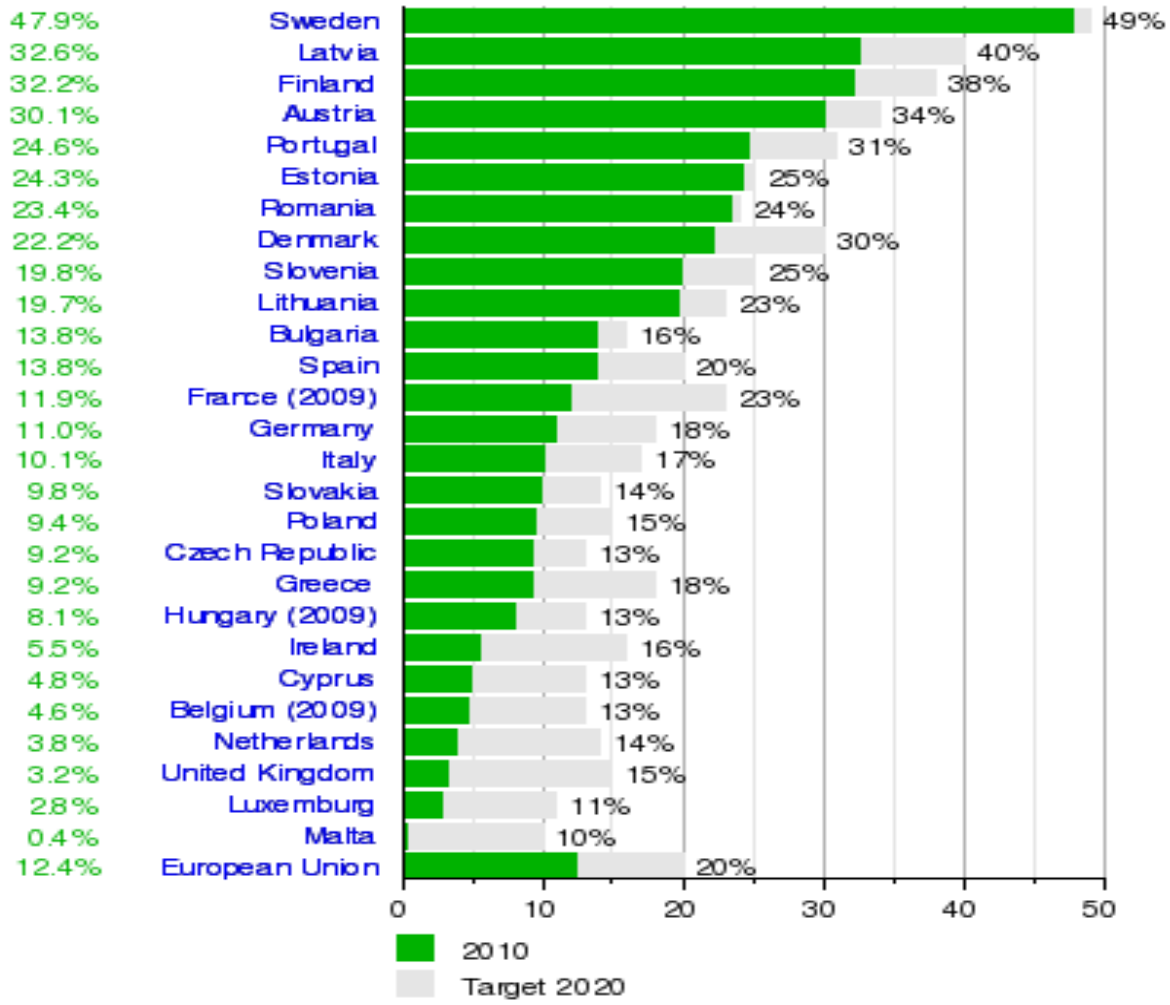
ARCTIC SEA: EXTENT & AGE 1986



ARCTIC SEA: EXTENT & AGE 2016

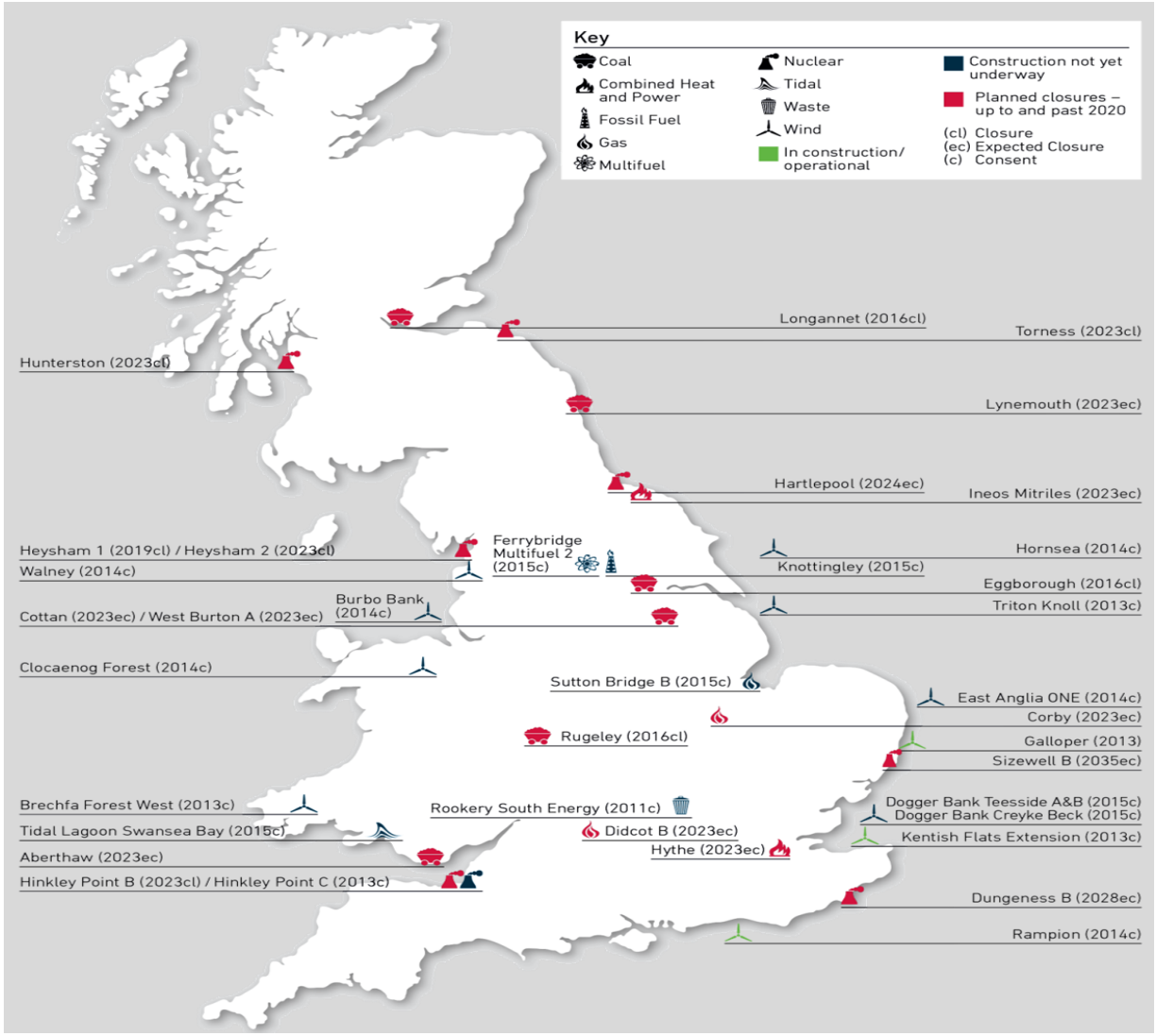


WHY DO WE WANT TO BUILD TIDAL LAGOONS?



Share of renewable energies in gross final energy consumption in EU-27 countries in 2010 (in %). UK 5.2% in 2013.

THE UK ENERGY GAP



Source: Bircham Dyson Bell LLP, 'The Energy Crunch' 2016

UK POWER MARKET BACKDROP

Electrification demand (transport, heat, etc.)	**20GW**
+	
Going offline (coal etc.)	**25GW**
=	
Total new capacity needed	**45GW**
−	
Consented capacity (nuclear, tidal, wind, etc.)	**18GW**
−	
Interconnectors (not yet consented)	**7GW**
=	
THE POWER DEFICIT	**20GW**

SOME UK STATISTICS

- UK electricity consumption 320 TWh in 2015
- Renewable installed capacity: 19.5 GW in 2013 (Mainly wind).
- Renewables 15 % of electricity generation (2013), or 54 TWh.
- Swansea and Cardiff Tidal Lagoons, can provide 6 TWh or about 2 % of UK demand.
- 6 potential Tidal Lagoons can provide about 8 to 9 % of UK electricity demand.

1. Building Tidal lagoon Swansea Bay

SWANSEA LAGOON

SWANSEA BAY TIDAL LAGOON - OVERVIEW

- Wall Length: 9.5 km
- Area: 11.5 km
- Installed Capacity: 320 MW
- Daily Generating Time: 14 Hours
- Annual output(net): 540 GWh
- Annual CO2 Savings: 236,000 t
- Design Life: 120 Years
- Height of Wall: 5-20m
- Wall Above Low Water: 12m
- Wall Above High Water: 3.5m
- Tidal Range Neaps: 4.1m
- Tidal Range Springs: 8.5m

ENERGY MODELLING

0D Model – Typical output

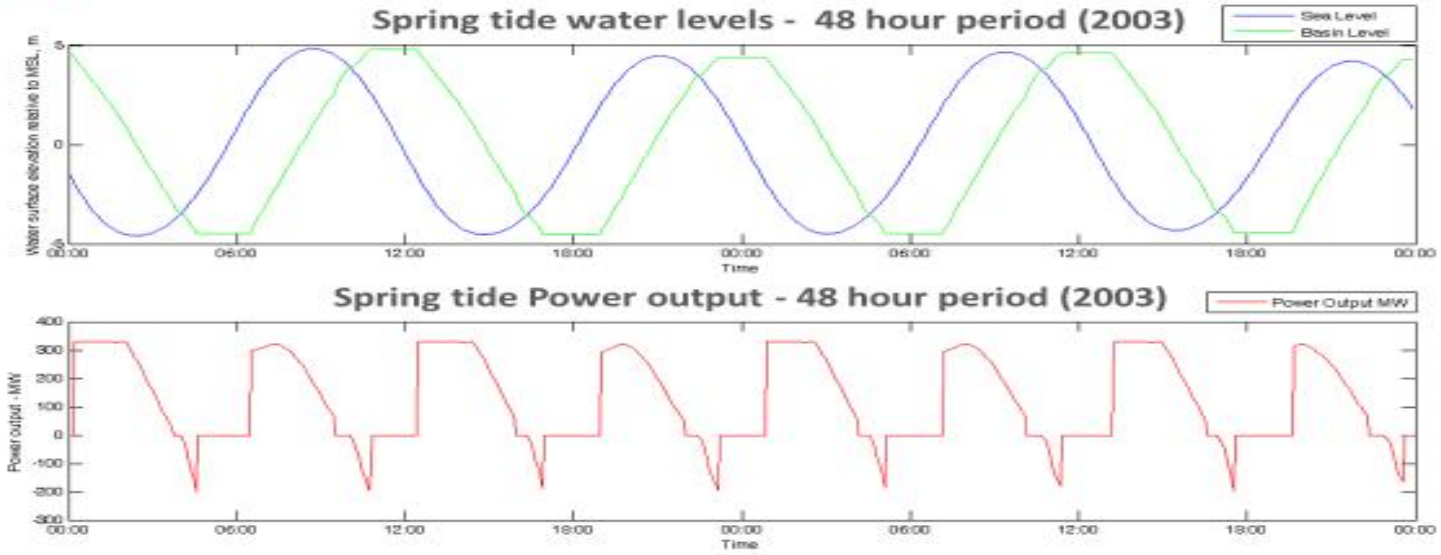


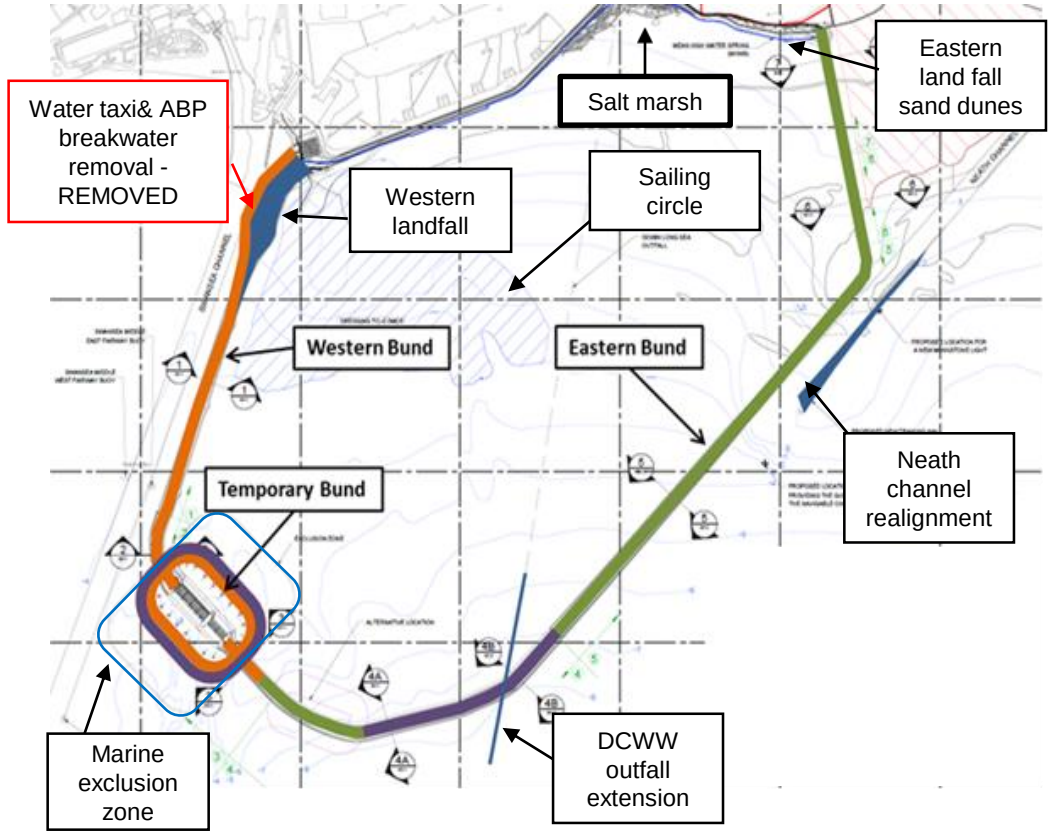
Figure 1 B (Mitigation pumping)

MULTI – FUNCTIONAL INFRASTRUCTURE

SCOPE OF WORKS – CONTRACT

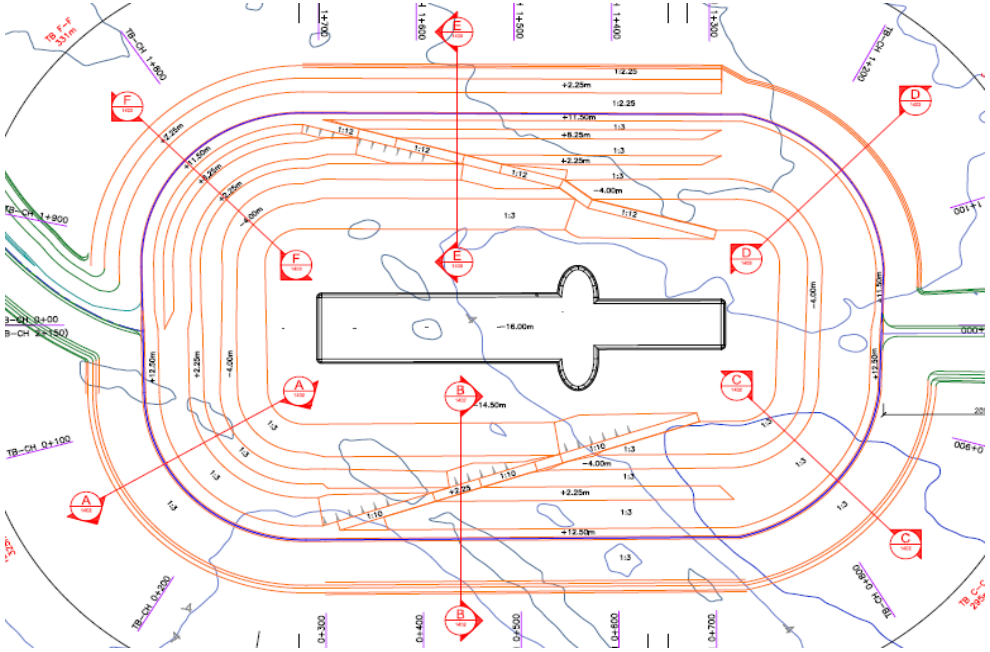
- Turbines –JV of General Electric & Andritz Hydro
- Marine Works - to be retendered
- Civil Works – Laing O'Rourke
- Ancillary Works – Alun Griffiths
- O&M Packages have been tendered

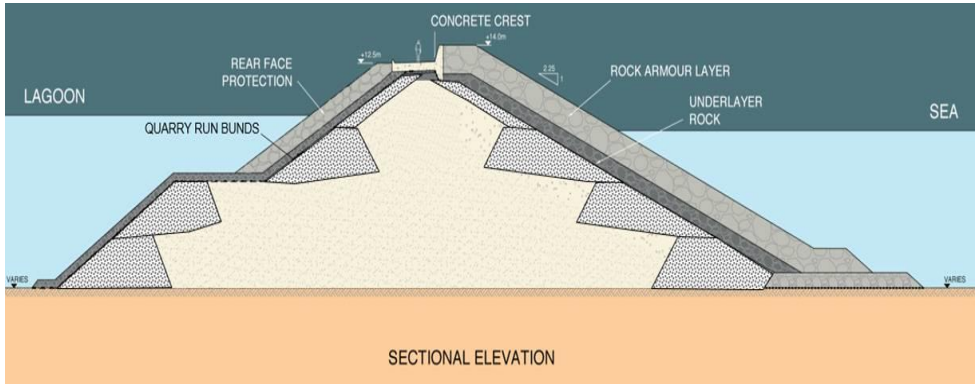
- 9.5km of Permanent bund wall
- 2km of temporary bund wall
- Approx. 8M m3 of dredging and fill
- 4M t of rock supply(grading up to 10t)
- 250.000 m3 of concrete



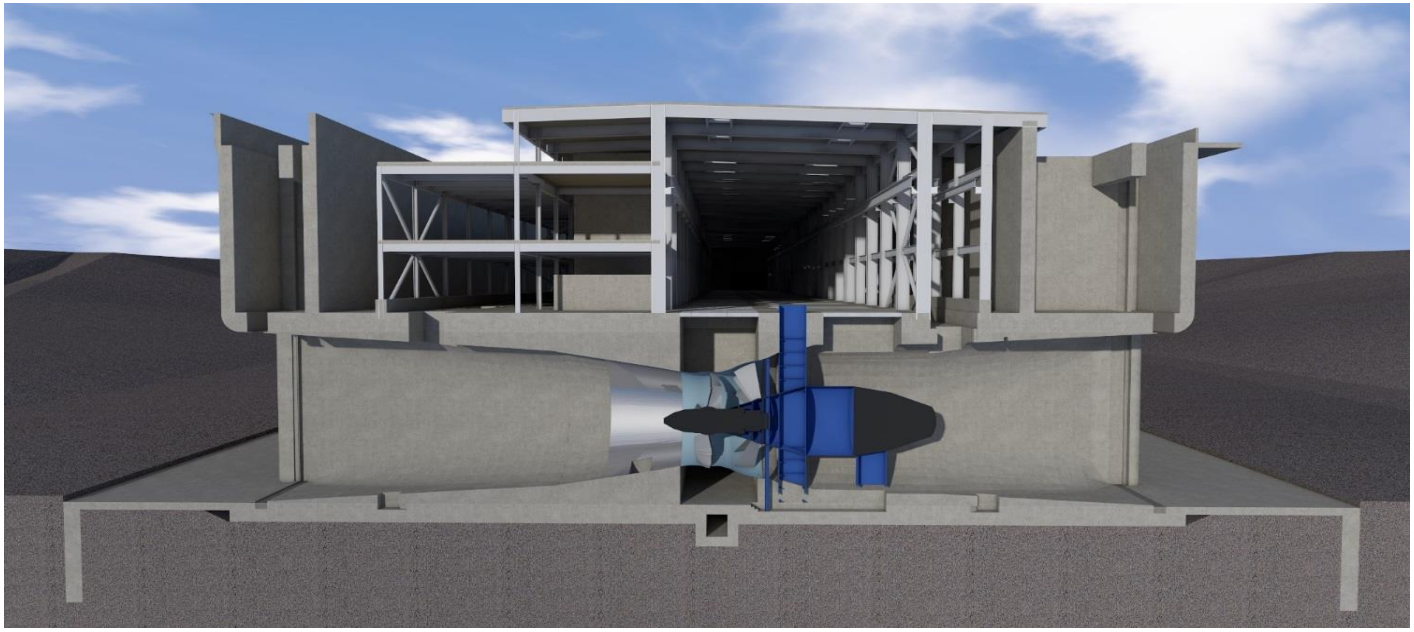
BUND WALL STRUCTURE – OUTLINE DESIGN

- Sand/sediments dredged from within lagoon
- Internal bunds can be done with gravel, geo-containers or quarry run
- Design validated in physical model tests with waves up to Hs 5m

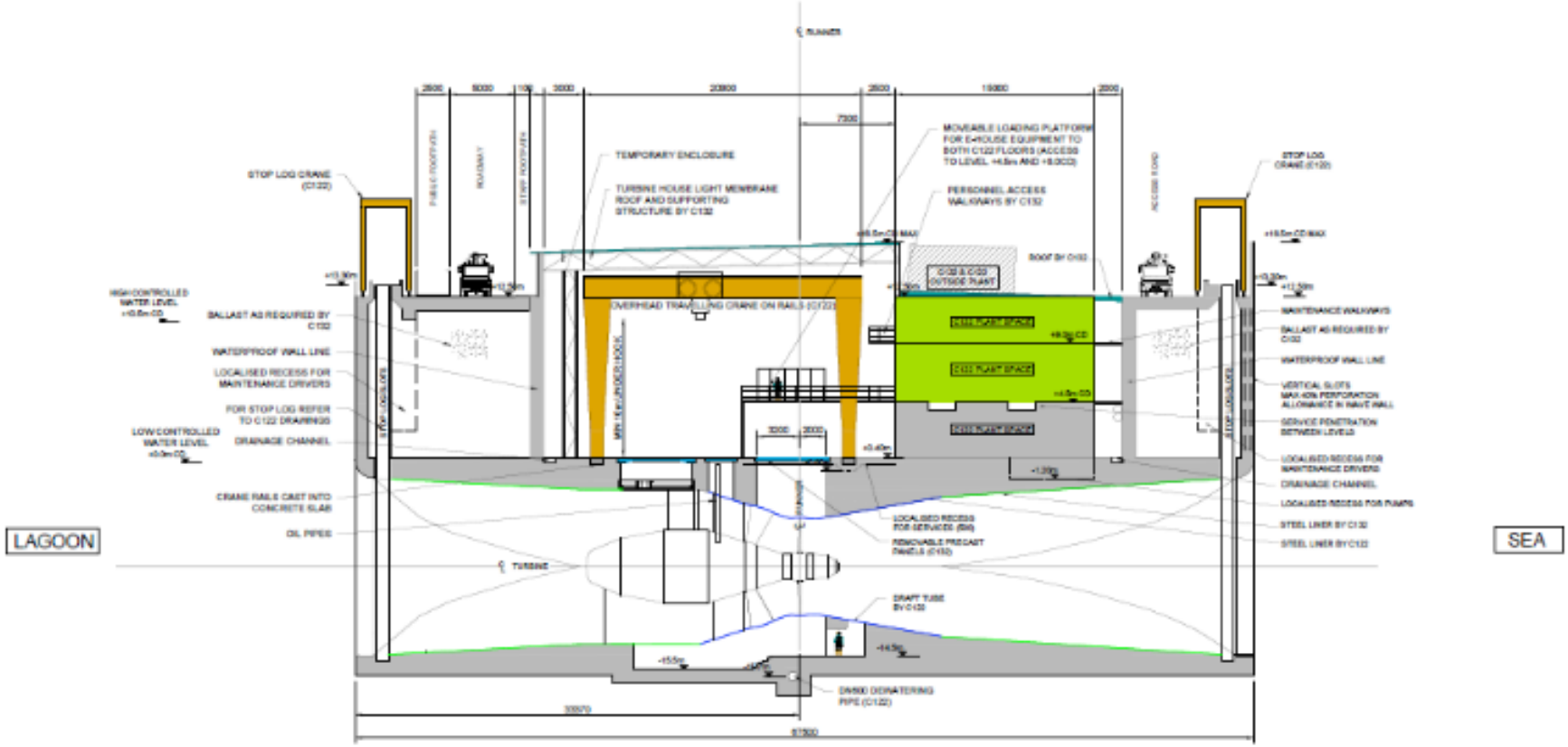




TURBINE HOUSING

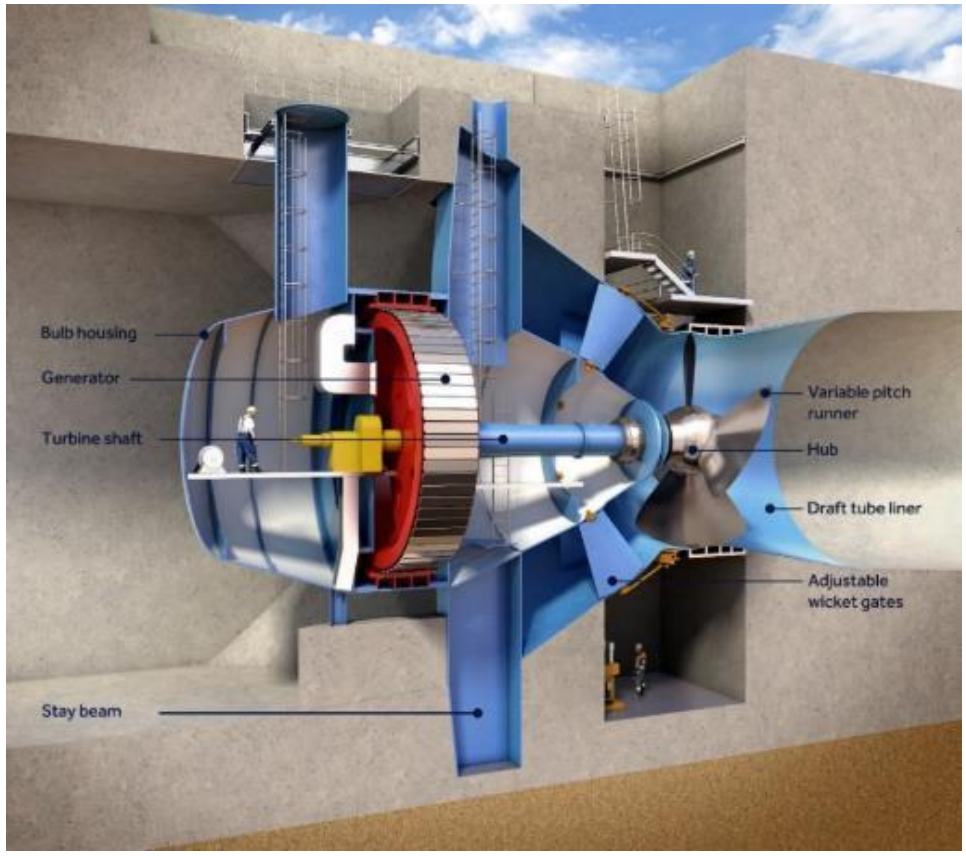


TURBINE HOUSE CONFIGURATION



- We've introduced a modular construction concept using to install containerised rooms which house the M&E plant (shown green) which can be mass produced off-site (scalable for other lagoons etc.)

LOW HEAD KAPLAN BULB TURBINE – 7.2M RUNNER

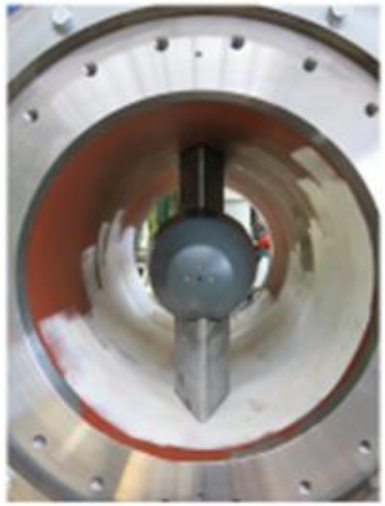


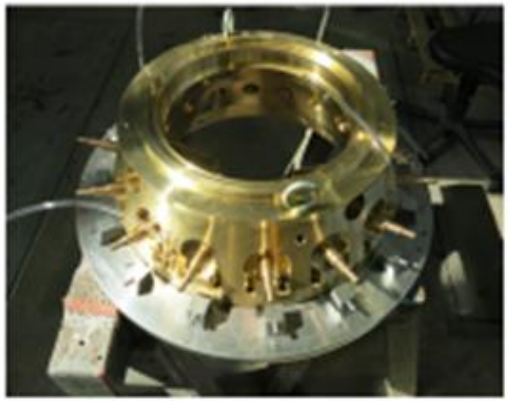
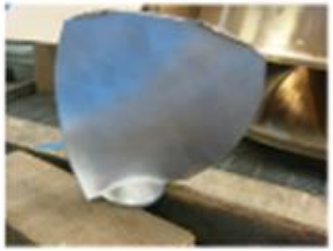
- Our preferred contractor (Andritz Hydro) has supplied 455 similar design bulb turbines around the world with an installed capacity over 10GW.

DISTRUBUTOR AND RUNNER INSTALLATION

BULB NOSE INSTALLATION

IEC60193 HOMOLOGOUS MODEL TESTING-GUARANTEED PERFORMANCE

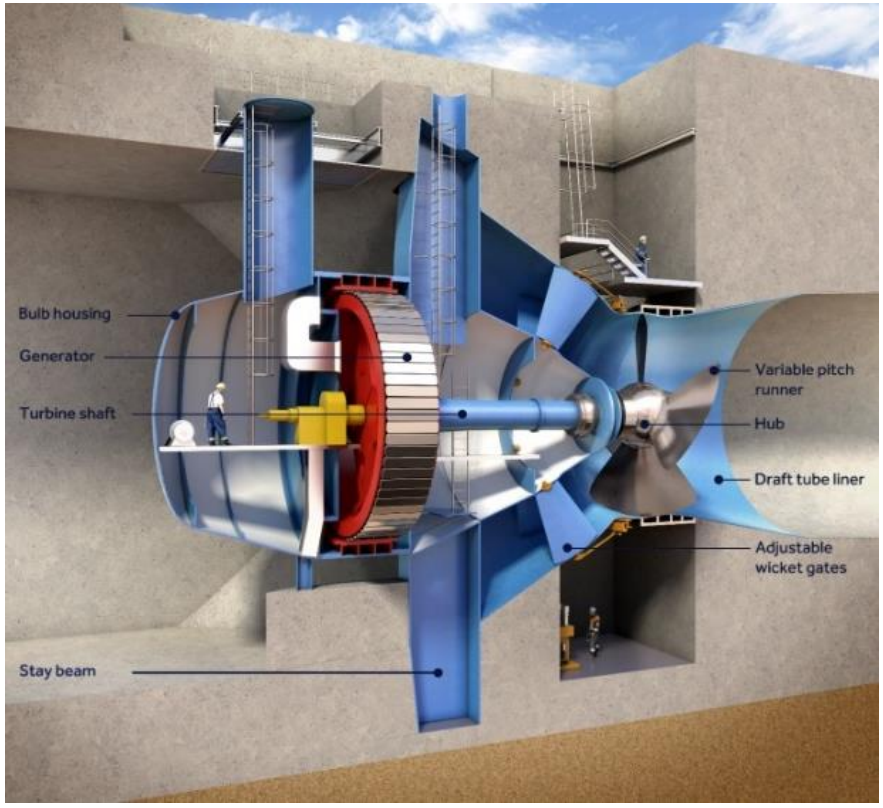


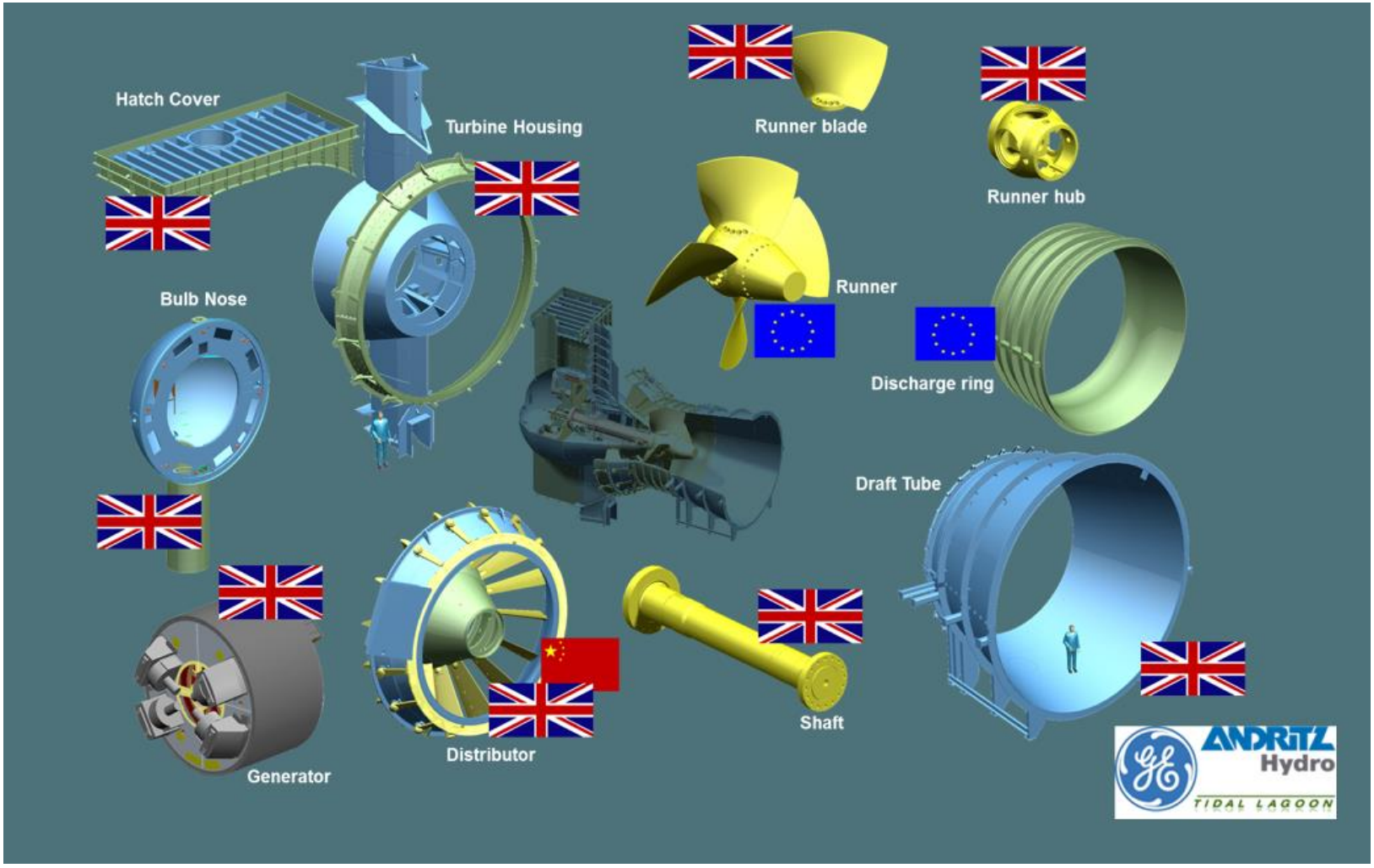

LA RANCE TIDAL POWER STATION – 50TH ANNIVERSARY

A UK SUPPLY CHAIN

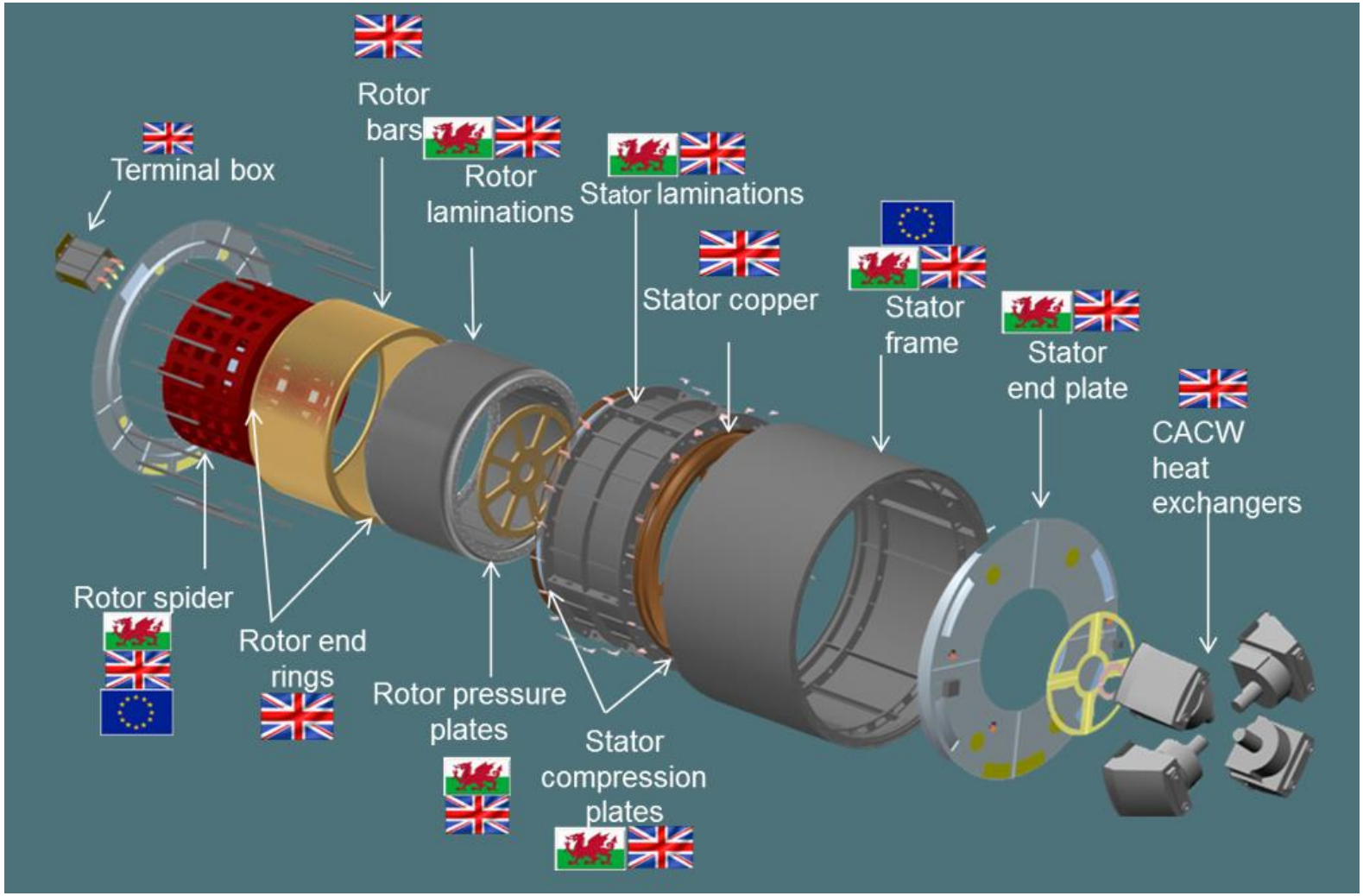
Realising a 50% Welsh, 65% UK content aim



THE TURBINE MAIN COMPONENTS



THE GENERATOR



SWANSEA BAY PROJECT TIMELINE*

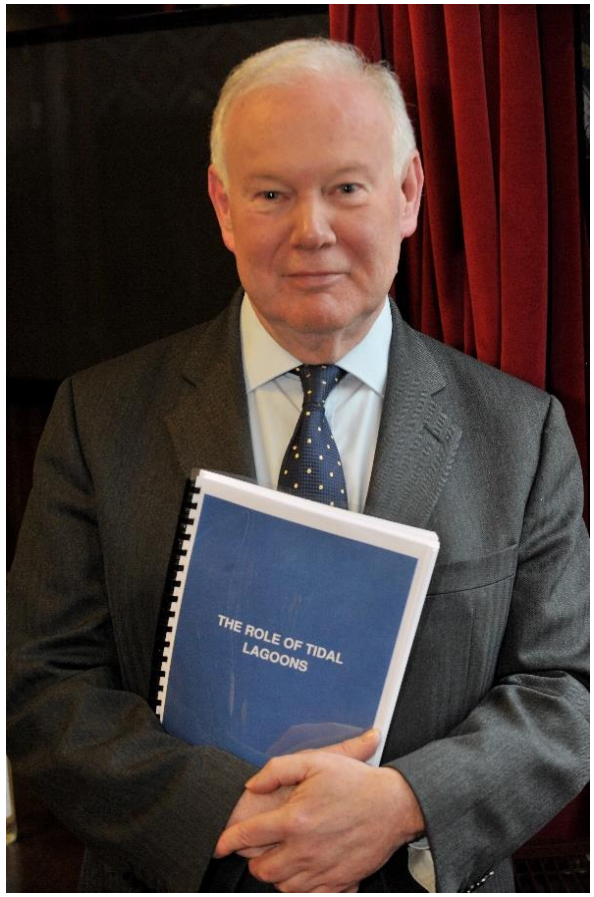
- DCO approval in June 2015
- Independent Hendry review: January 2017
- CfD and Marine licence: anticipated early 2018
- Start on site anticipated end 2018
- First power on 2022
- Construction period: 4 years

* Subject to receipt of all necessary permissions and achieving financial close

THE HENDRY REVIEW

Background

- Rt Hon Charles Hendry was appointed in May 2016 to assess the strategic case for tidal lagoons, and the role they could play in the UK's energy mix.
- Over a 6 month process, Charles Hendry and his Review Team visited Swansea, Cardiff, Newport, Liverpool, Bristol and Sheffield, speaking directly to those involved in, or affected by, tidal lagoon proposals. The Review received almost 200 responses to the Call for Evidence.
- On 12 January 2017, Charles Hendry published his final report and 30+ core recommendations of the Independent Review of Tidal Lagoons, including:
- *'I recommend that the Government now move to a timely 'final stage negotiation' to explore robust and satisfactory terms that might be acceptable to both the developer and the Government'.*
- Tidal lagoons can *'play a valuable and cost competitive role in the electricity system of the future'.*



A NO REGRETS POLICY

Moving ahead with a pathfinder lagoon at Swansea Bay *'as soon as is reasonably practicable'* is a *'no-regrets policy'*

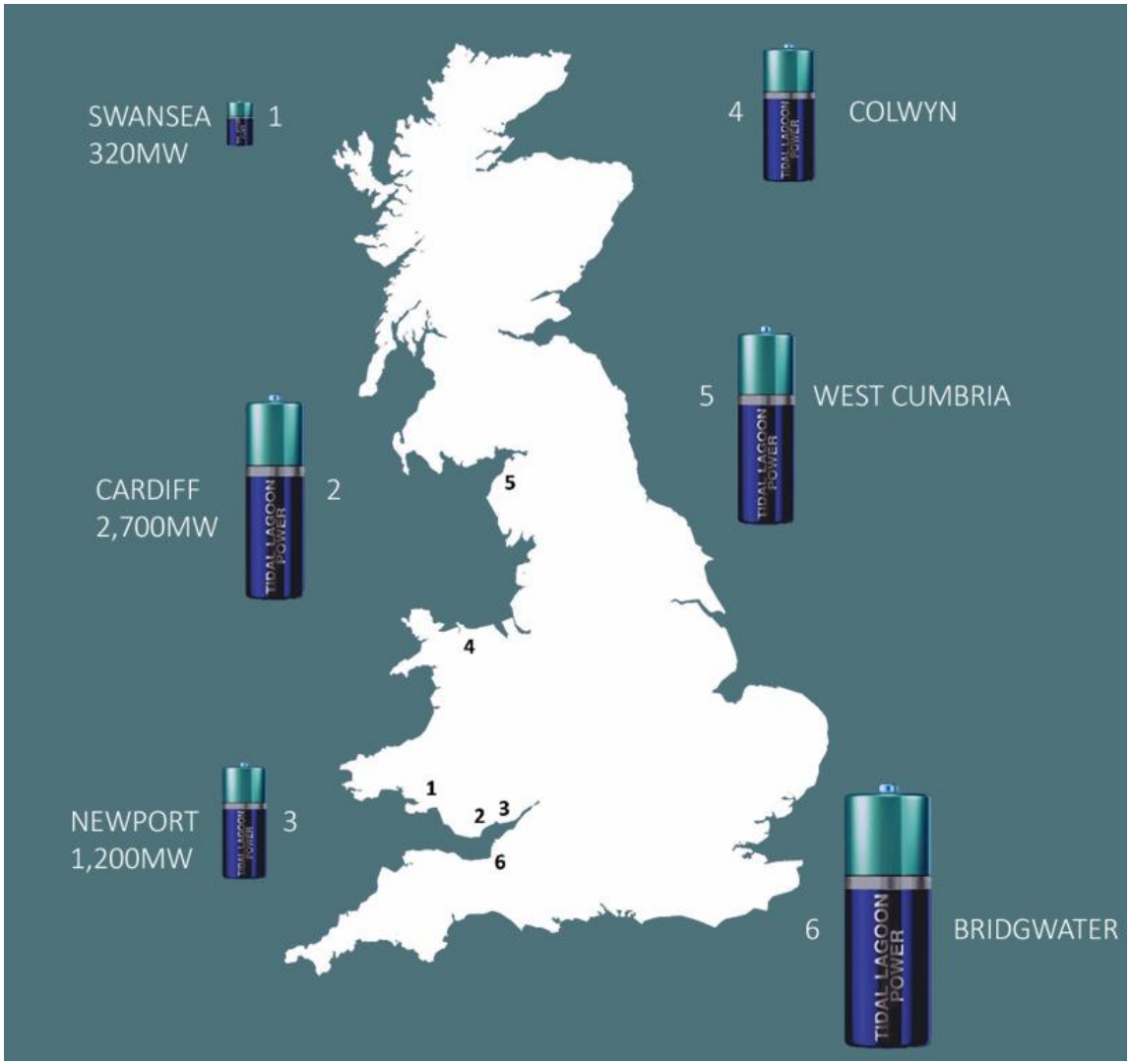
- At a cost of about 30p per household per year over the first 30 years, a pathfinder at Swansea Bay represents ***"an extremely modest amount to pay"*** to start a "***significant new industry".***

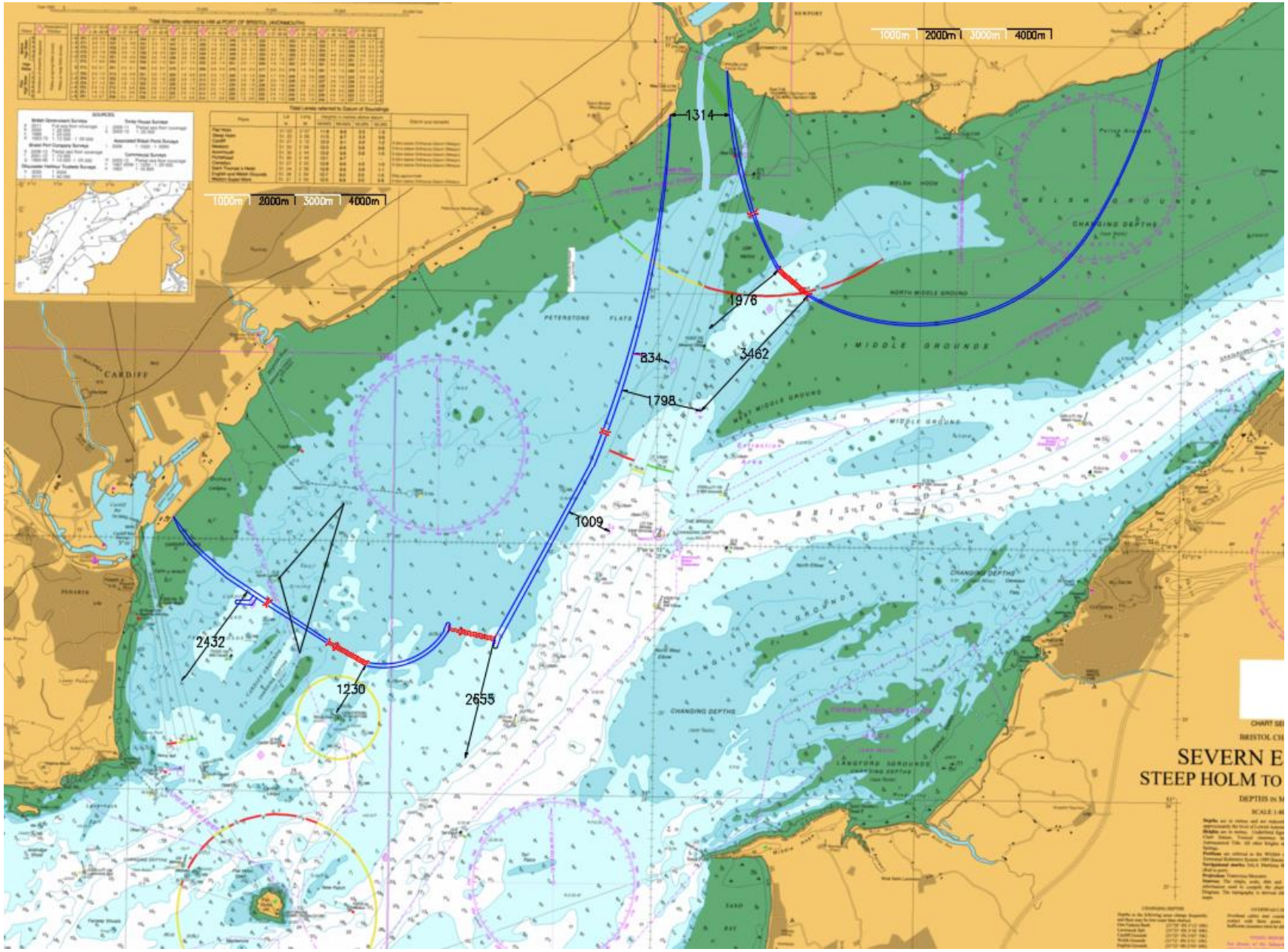
- For larger lagoons, potential impact on consumer bills is ***"attractive"*** (potentially less than 50p per household per year over 60 years), particularly when compared to nuclear projects over a long time period.

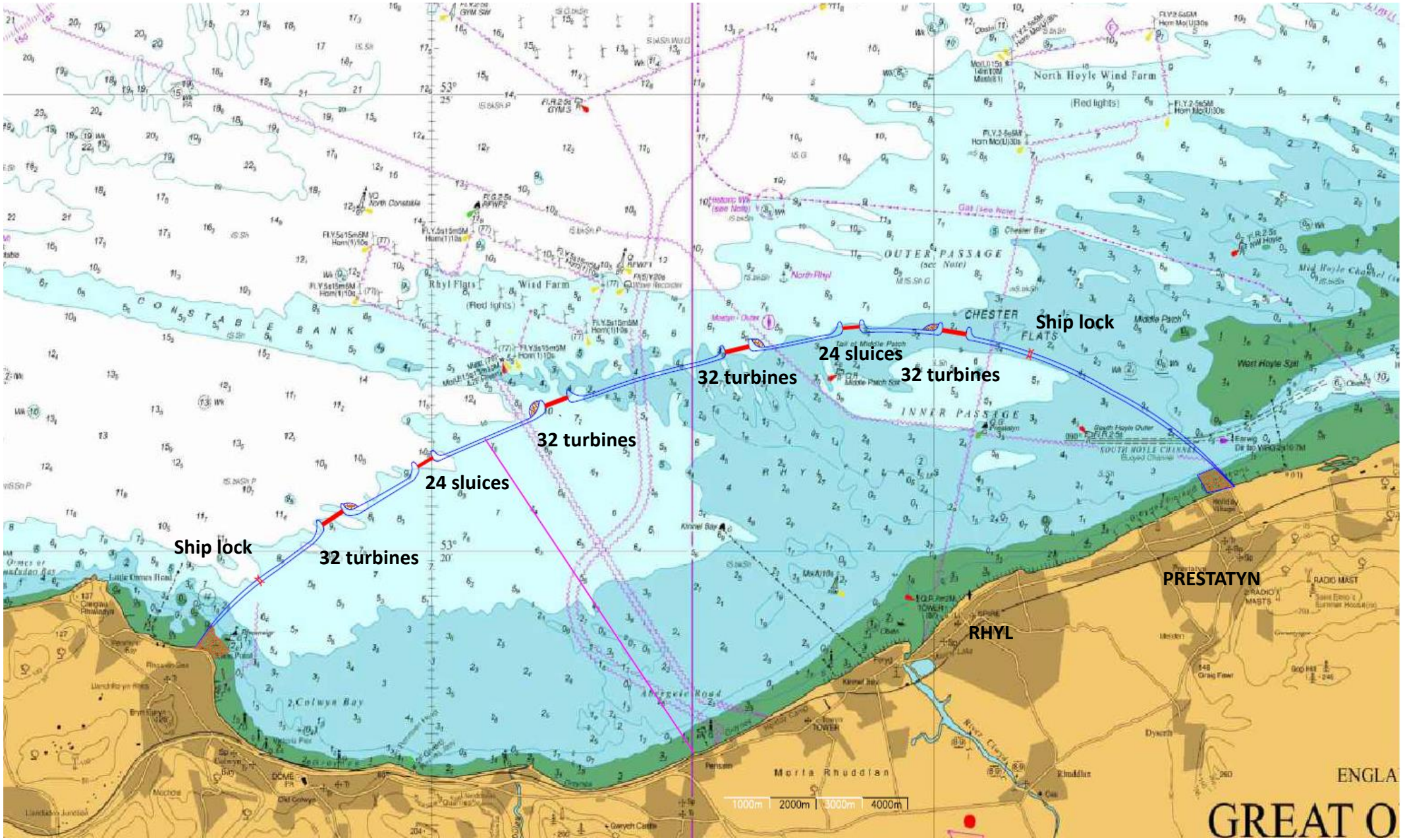
- *"During a 60-year period, a large scale tidal lagoon is* ***less expensive than offshore wind and significantly less expensive than nuclear'."*** Followed by 60 years of ***"subsidy free"*** power.

2. UK Fleet Lagoons

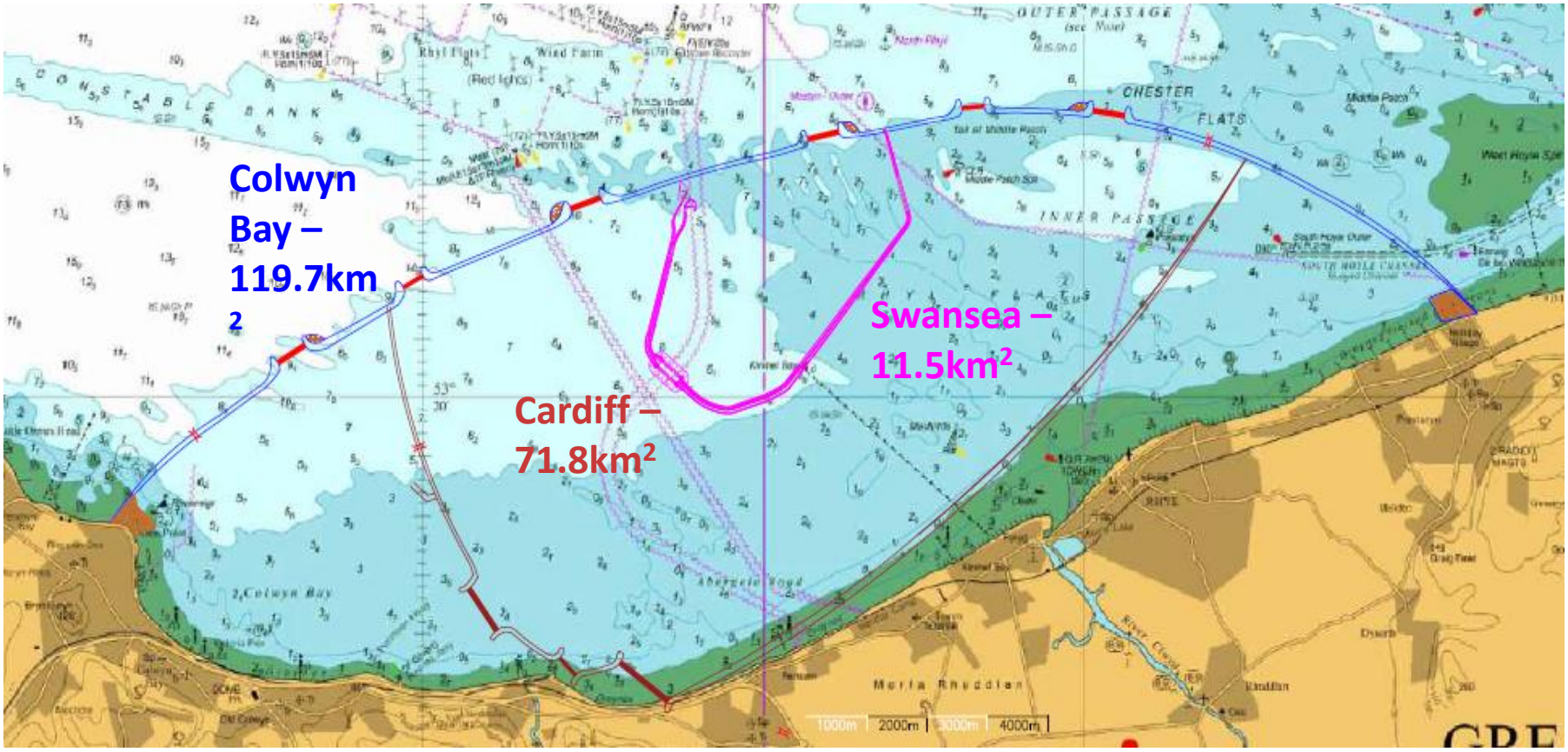
OUR GOAL TO DEVELOP AND OWN 8% OF UK GENERATION ASSESTS




1314
1976
834
3462
1798
1009
2432
1230
2655
CARDIFF
PENARTH
PETERSTONE FLATS
NORTH MIDDLE GROUND
MIDDLE GROUND
WEST MIDDLE GROUND
WELSH GROUND
BRISTOL DEEP
CHANGING DEPTHS
LANGFORD SHROUNDS
1000m 2000m 3000m 4000m
SEVERN E
STEEP HOLM TO


Ship lock
32 turbines
24 sluices
32 turbines
32 turbines
24 sluices
32 turbines
Ship lock
PRESTATYN
RHYL
North Hoyle Wind Farm
Rhyl Flats Wind Farm
CONSTABLE BANK
OUTER PASSAGE
INNER PASSAGE
CHESTER FLATS
Colwyn Bay
Morfa Rhuddlan
1000m
2000m
3000m
4000m

COMPARISON OF LAGOON SIZES

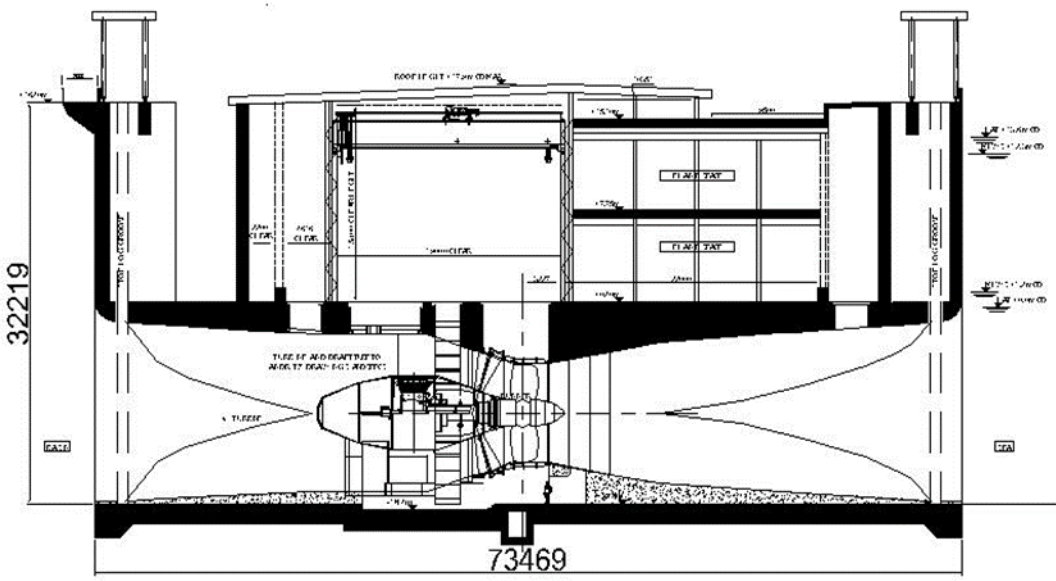


CARDIFF LAGOON: ENGINEERING STUDIES

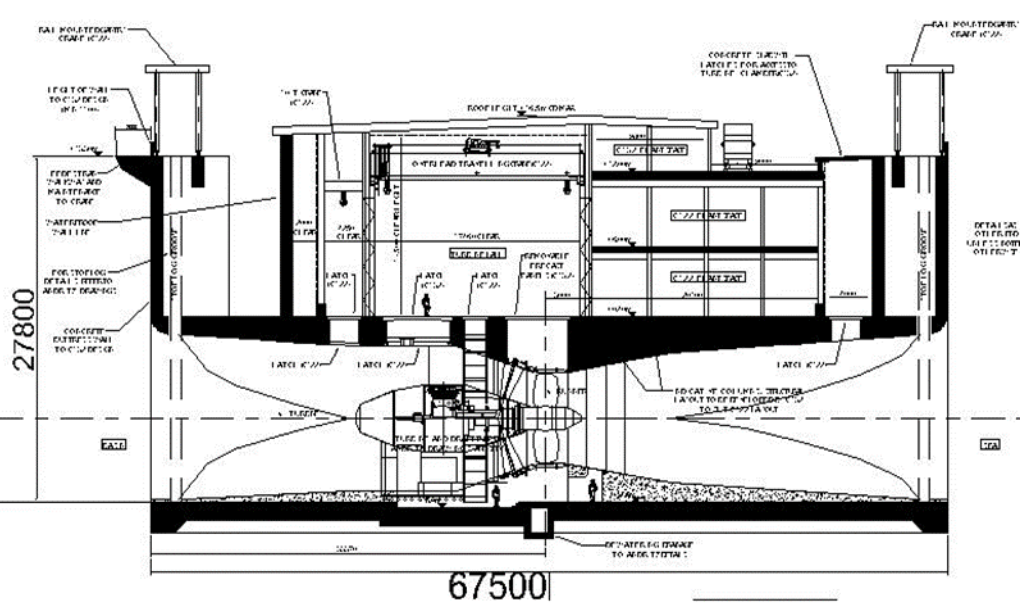
- Bathymetry and Geophysical surveys, and Lidar - Completed
- Geotechnical desk study - Completed
- Tender and submissions for Soil Investigation – Completed
- SI drilling work – Waiting for financial approval.
- Design wave study and JPA waves and levels – completed
- FEED design and Quantities – Ongoing work, in-house and Atkins
- Optimized lay-outs – Ongoing, in house
- Cost Estimates – ongoing, in house
- Sedimentation estimates and Maintenance Dredging – Desk top completed, finalising further work with ABPMer.
- Technical Methods to reduce sedimentation – ongoing, Atkins
- Caisson study – first phase finalised, HaskoningDHV
- Impact of lagoons on tides – ongoing, ABPMer and in house
- Impact on navigation – ongoing, ABPMer
- 2-D power output modelling – ongoing, in house
- Flooding and Flood risk assessment – JBA and HJA, ongoing.

CARDIFF POWERHOUSE DESIGN MODIFICATION

Cardiff

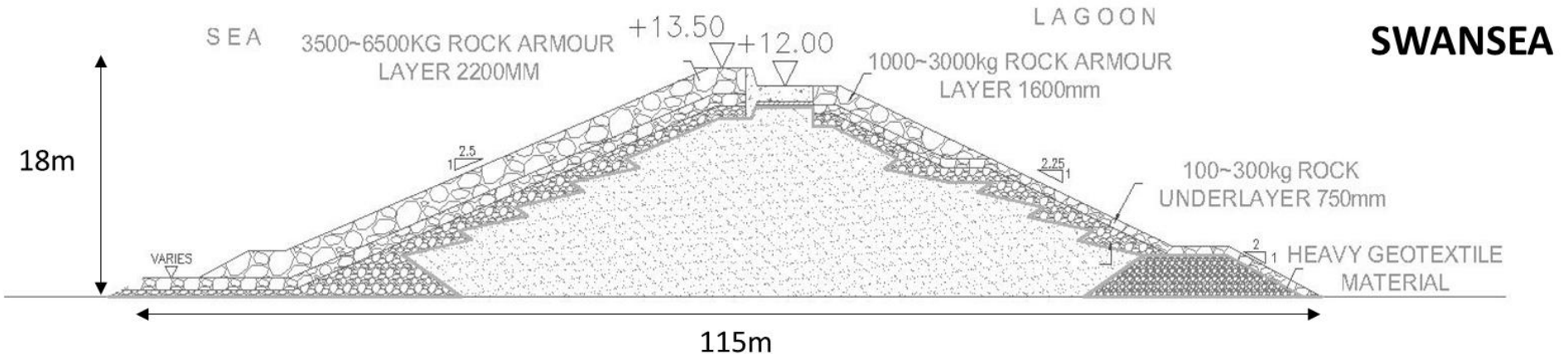


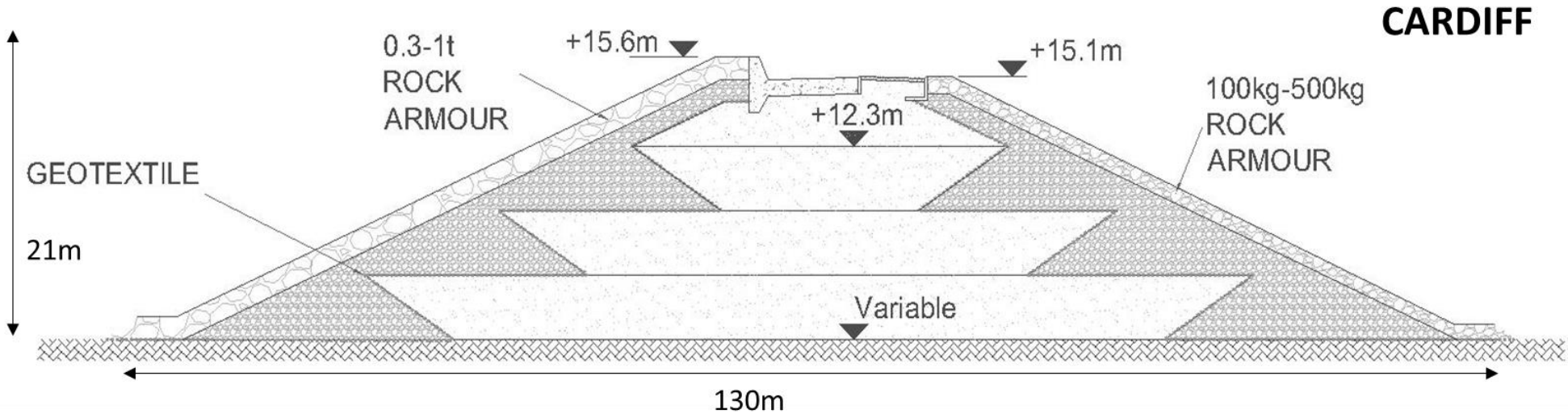
Swansea



- Turbine blocks are based on a scaled-up version of the Swansea design to accommodate a larger 8m turbine and increased tides

CARDIFF PERMANENT BUND WALL MODIFICATION

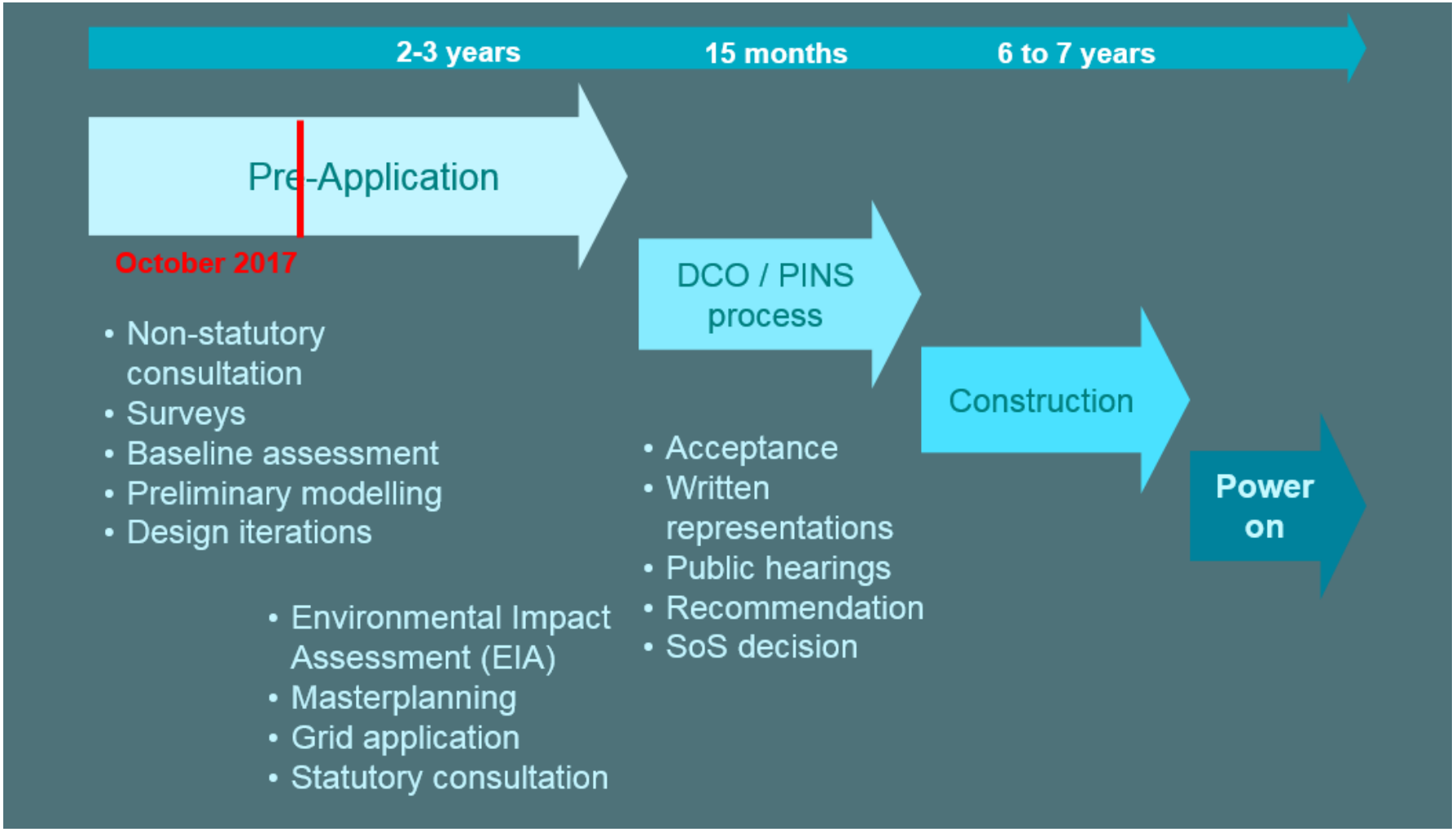




COMPARISON CARDIFF AND SWANSEA TIDAL LAGOONS

- Cardiff lagoon is 6x bigger, but the bund wall is only 2.2x the length of Swansea lagoon.
- 38% higher tides at Cardiff, therefore higher energy output.
- Water volume in lagoon, Swansea 70 million, Cardiff 810 million m3.
- Cardiff lagoon produces 9.6x more energy , but has only 5.6x the number of turbines and 3.1 x number of sluices than Swansea.
- Cardiff lower construction cost per GWh generation

CARDIFF PROGRAMME



3. Specialist Studies and Research

R&D FOCUS

- 2 D power output modelling.
- Effect of lagoons on reducing tides in Severn.
- What is best combination of lagoons ??
- More balanced power output, base load ?
- Housing structure, in-situ versus caisson construction.
- Reduce Loss of intertidal area.
- Compensation for lost intertidal habitat.
- Improve fish friendliness of turbines.
- Sedimentation, maintenance dredging.
- Hydraulic losses, vortices.
- Construction logistics.

HOW DO YOU CONSTRUCT AND INSTALL A CAISSON?

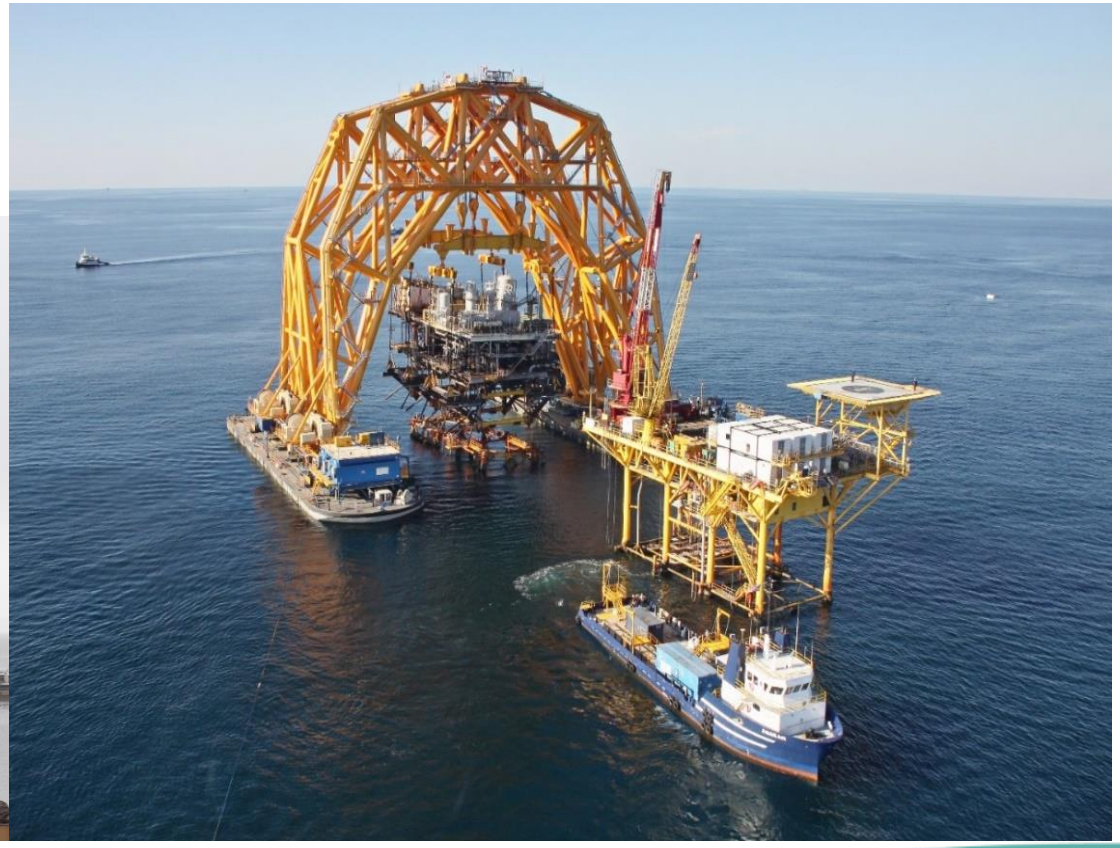
One option: Purpose built dry dock

HOW DO YOU CONSTRUCT AND INSTALL A CAISSON?

CAISSONS

Catamaran type placing gantries

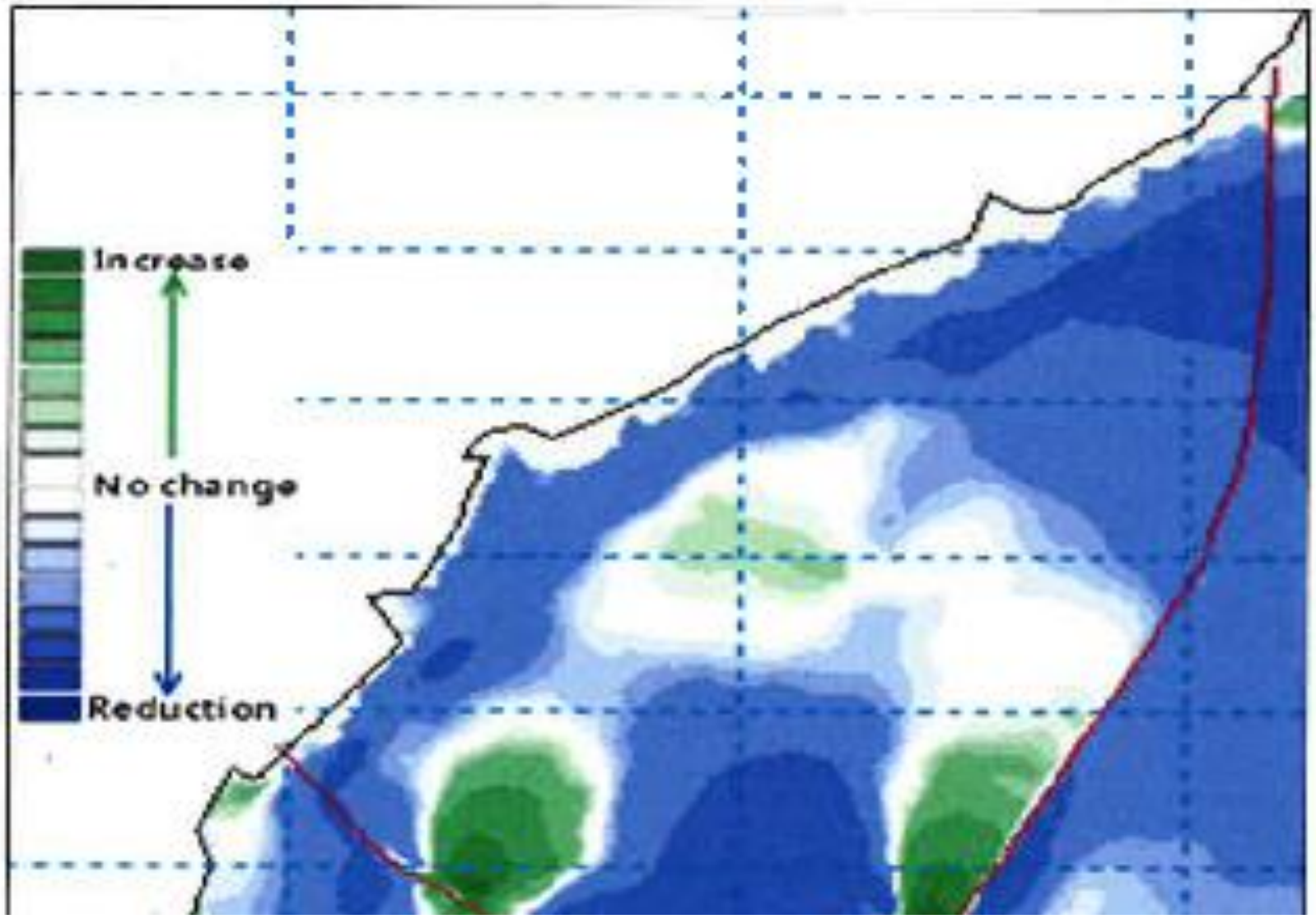
- Used to reduce draft and control placing of caissons



HOW DO YOU CONSTRUCT AND INSTALL A CAISSON?

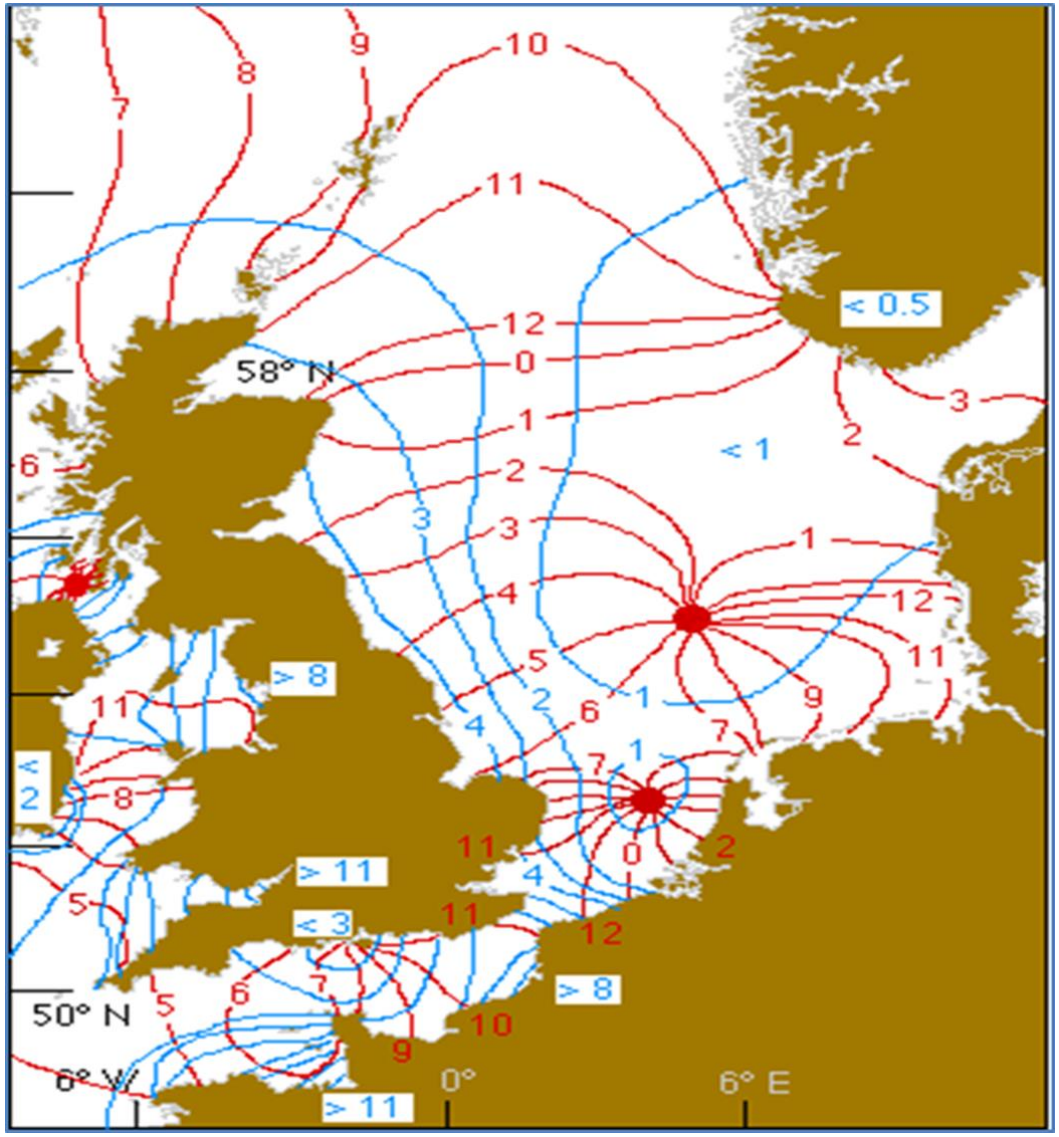
CARDIFF SEDIMENTATION

- Initial desk top study done.
- Assumed average SS of 250 ppm across the water column. Existing data and new data.
- Water exchange in and out of lagoon from 0-D model.
- Settling velocity depends on particle size. Limited info presently available. Average about 10 to 15 micron.
- Lagoon modelling to determine sedimentation areas, lower velocity and lower shear stress.

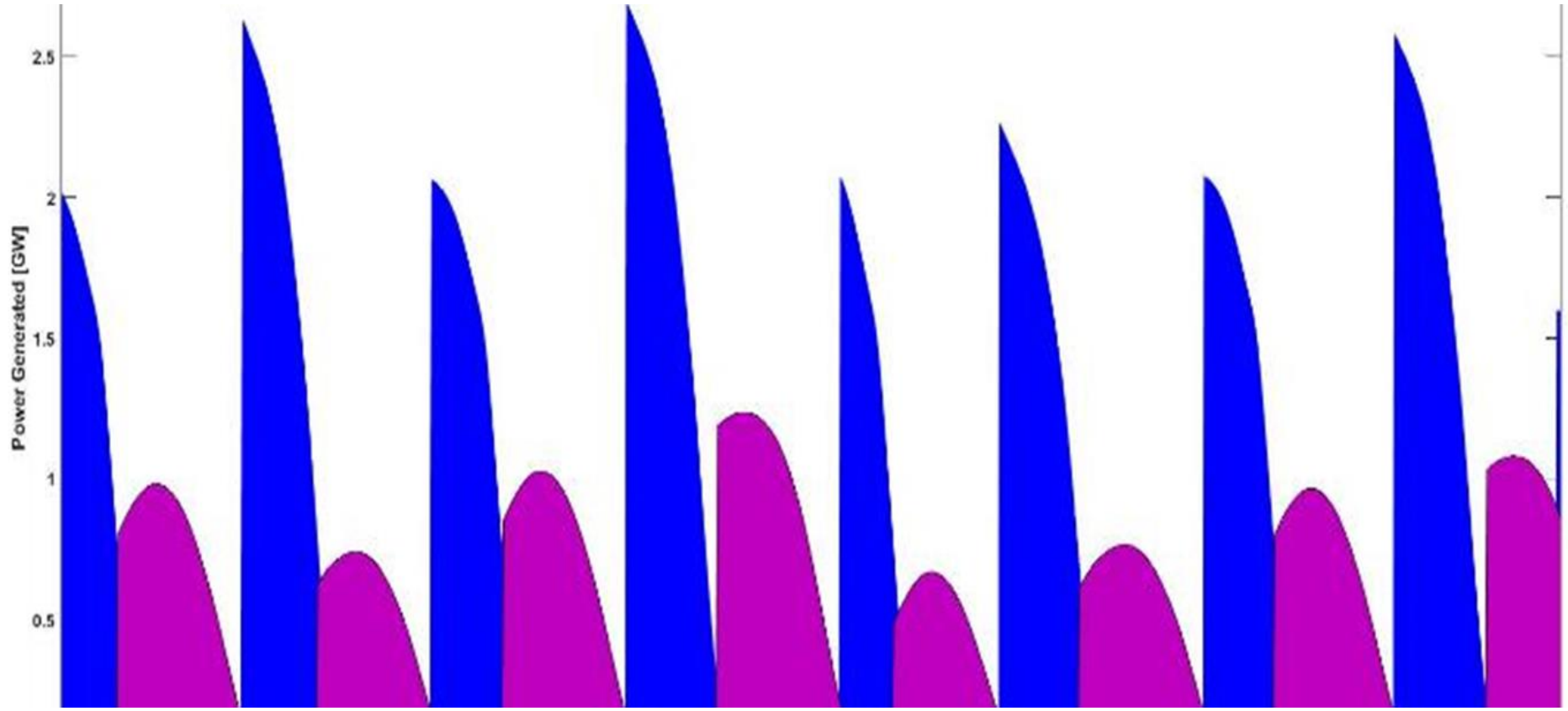


- Annual volume of deposition: about 4 – 10 million m3.
- Needs to be removed by maintenance dredging.

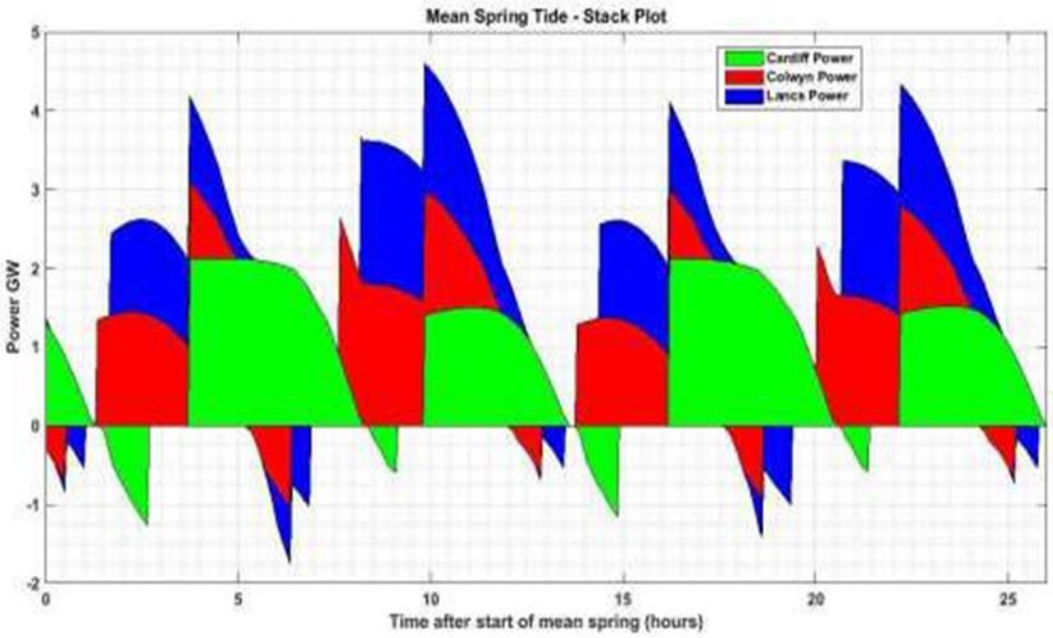
HIGH TIDES AND PHASING

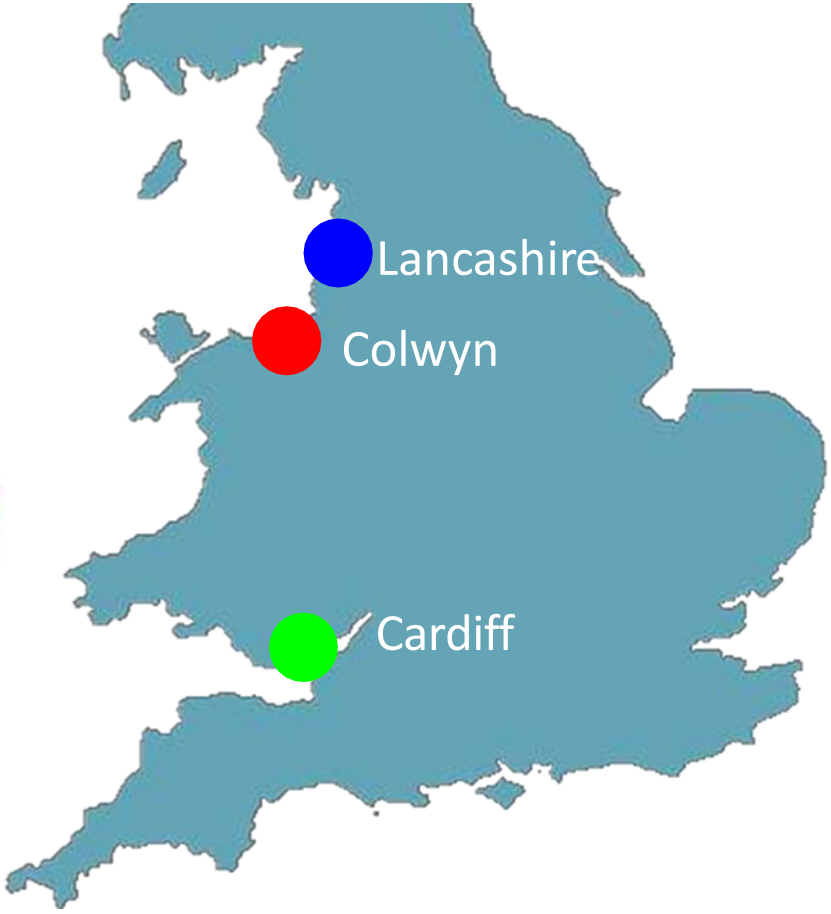


POWER OUTPUT 2 LAGOONS, SPRING TIDE

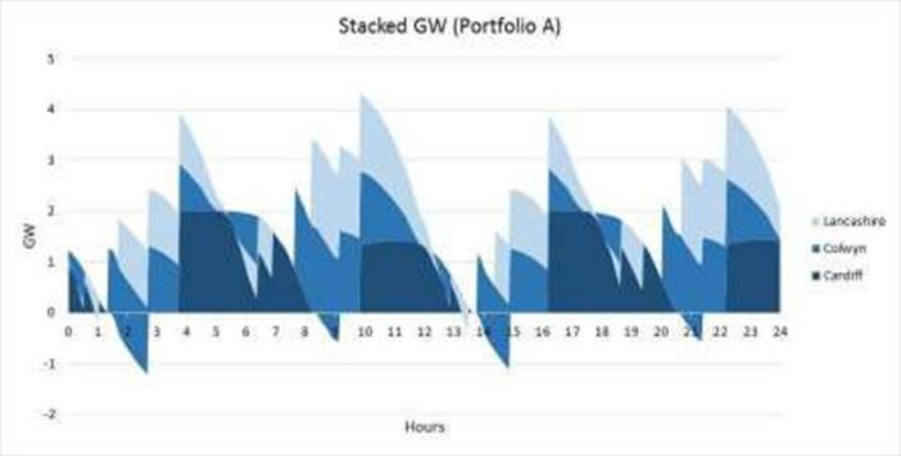


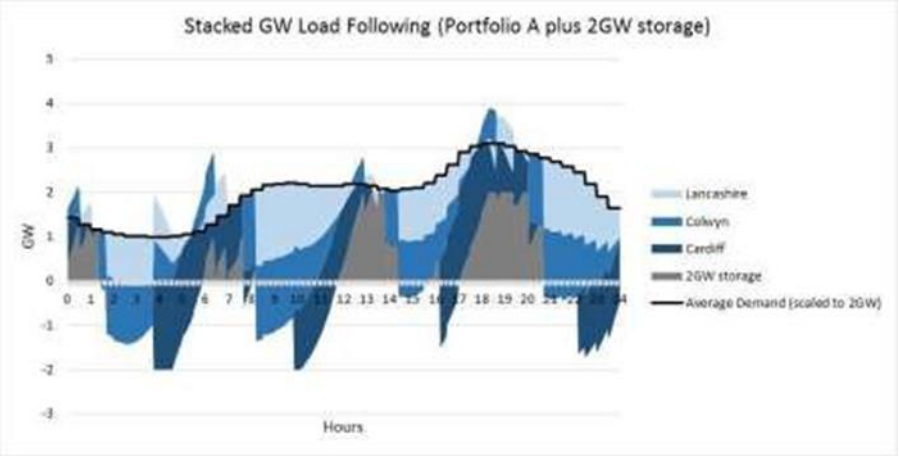
PORTFOLIO A: COMPLEMENTARY PROFILES

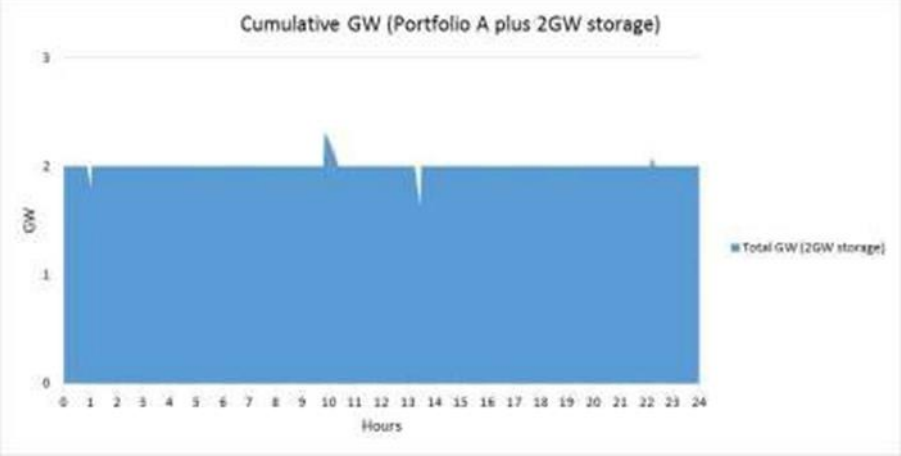


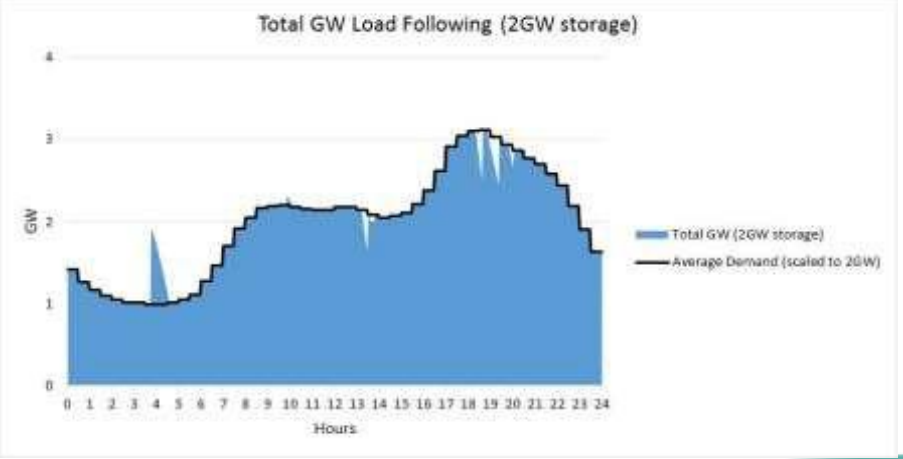


PORTFOLIO A: OPTIMISATION WITH STORAGE

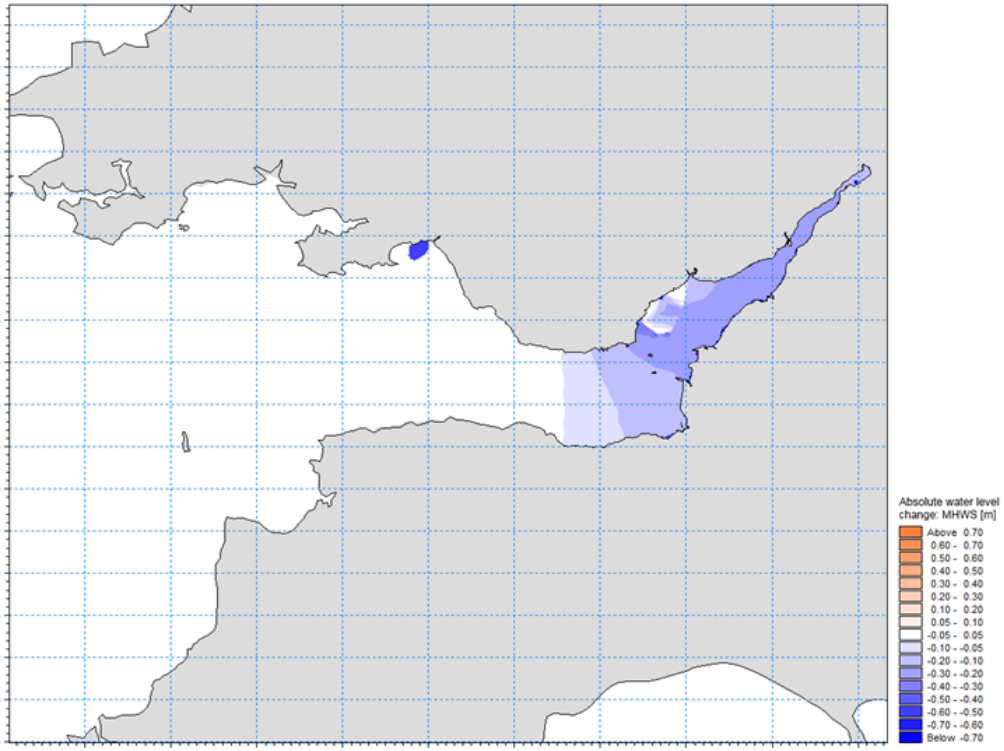


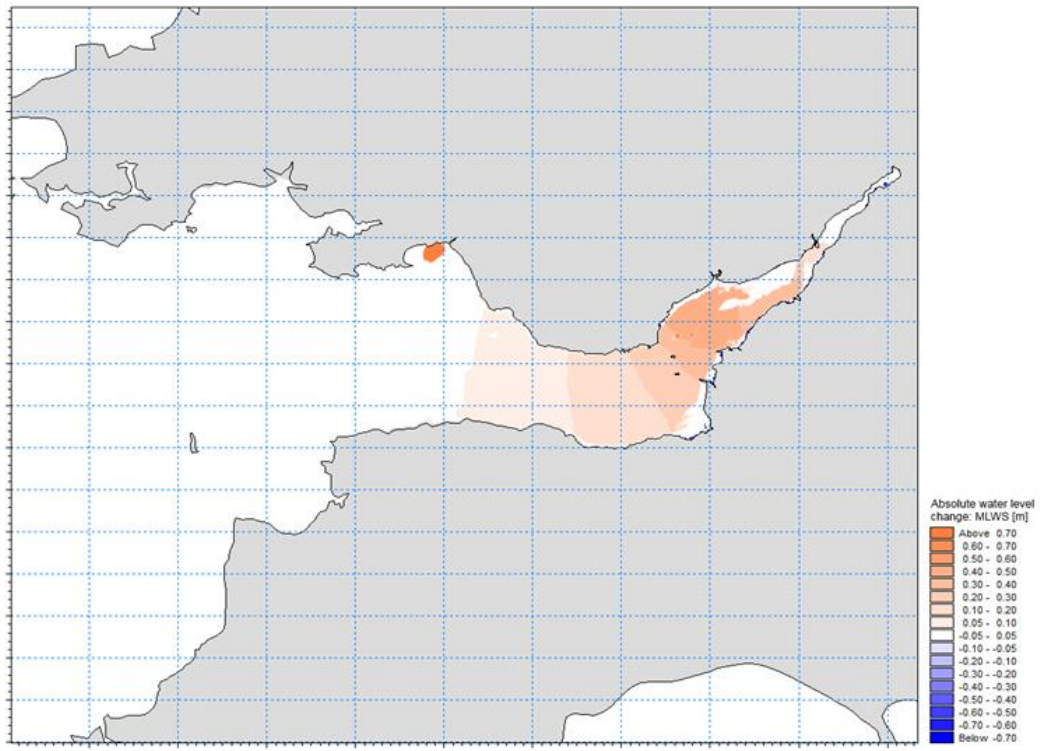






IMPACTS OF LAGOONS ON REDUCING HIGH TIDES AND INCREASING LOW TIDES.





HOW ARE WE ADDRESSING ENVIRONMENTAL ISSUES FOR THE CARDIFF LAGOON?

- Steering Group – NRW, EA, NE, MMO, PINS
- Expert Topic Groups
  - Coastal Processes
    - Modelling Work Plan
    - Water Quality
    - Flooding
    - Data Plan
      - Primary Data
      - Previous Studies
- Coastal Birds
- Fish
- Marine mammals
- Subtidal and intertidal habitats
- HRA/Compensation
- WFD

FUTURE LAGOONS IN THE SEVERN ESTUARY

Can lagoons be developed in the Severn?

- **Yes they can:**
- Positive attributes of the Severn will not be compromised by lagoons.
- EU's Head of Nature, in 2015, said that such development would be acceptable if the right approach to the Habitats Directive is adopted and **sufficient, high quality compensation is delivered**.
- An absolute presumption against development in European sites does not exist in the Habitats Directive. Rather an assessment process and compensatory strategy is in place.

ECOSYSTEMS ENHANCEMENT PROGRAMME

Vision: to have enhanced biodiversity, through a targeted nature conservation programme, alongside the generation of large-scale clean energy by 2030.

Aims:

1. Have a 'net positive' effect on biodiversity conservation.
2. Address the compensation and ecosystem-scale mitigation requirements TLP anticipate will arise from tidal lagoon development.
3. Foster innovative and collaborative partnerships to deliver conservation action in the UK, EU and globally.

EEP PROJECTS

Wetland habitat creation – fresh and salt water:

Work underway includes stakeholder engagement, engineering concept design, coastal process modelling, EIA scoping and surveys, and other feasibility studies.

Migratory fish and river habitat enhancement:

Projects and measures to improve the migration, spawning and escapement for key fish species. Includes 'catchment to coast' initiatives.

Subtidal habitat enhancement:

Measures to reduce existing pressures on subtidal habitats, potentially including new designation.

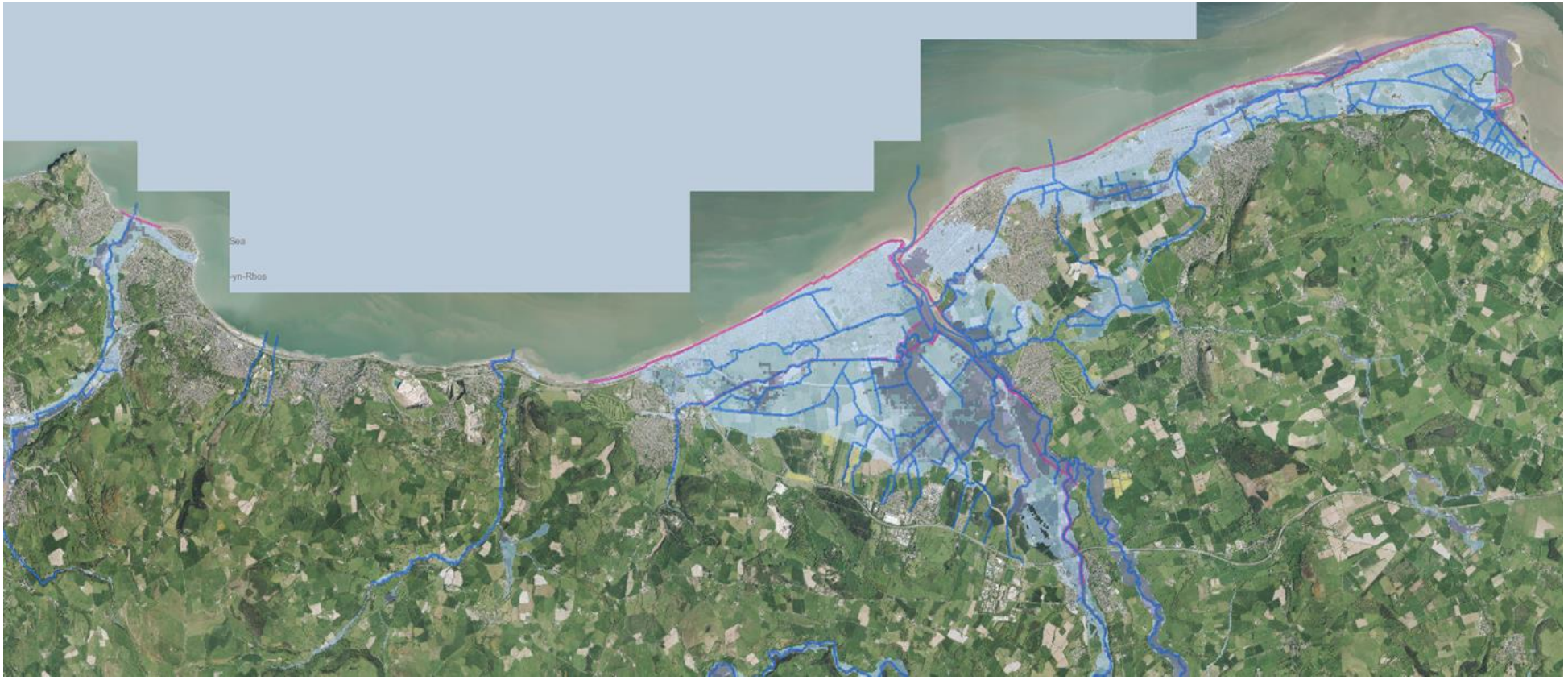
Wider measures:

Opportunities to improve and conserve biodiversity without a direct link to lagoon. Targeted local enhancement at main project sites and European-scale biodiversity conservation.

4. Colwyn Bay Flood Protection

COLWYN BAY FLOOD RISK AREAS-TIDAL DOMINATED:

Flood reaching 2 km inland , max water depth 1.8 m



TIDAL LAGOONS- FLOOD PROTECTION

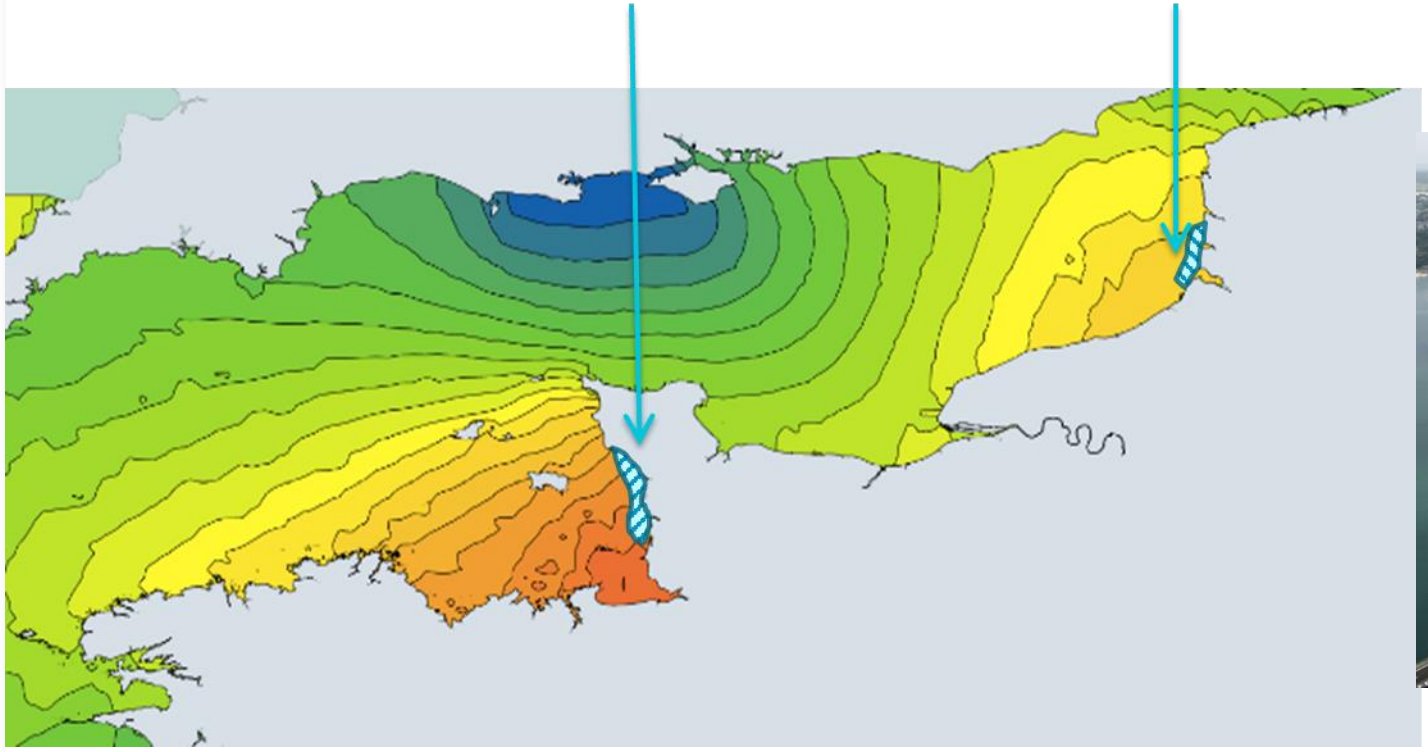
5. International Lagoons: France

NORTHERN FRANCE TIDAL RANGE

Two regions with right conditions for tidal lagoons – large tidal range and shallow waters:

Western Cotentin Peninsula (Normandie region)

Baie de la Somme



FRANCE

Potential:

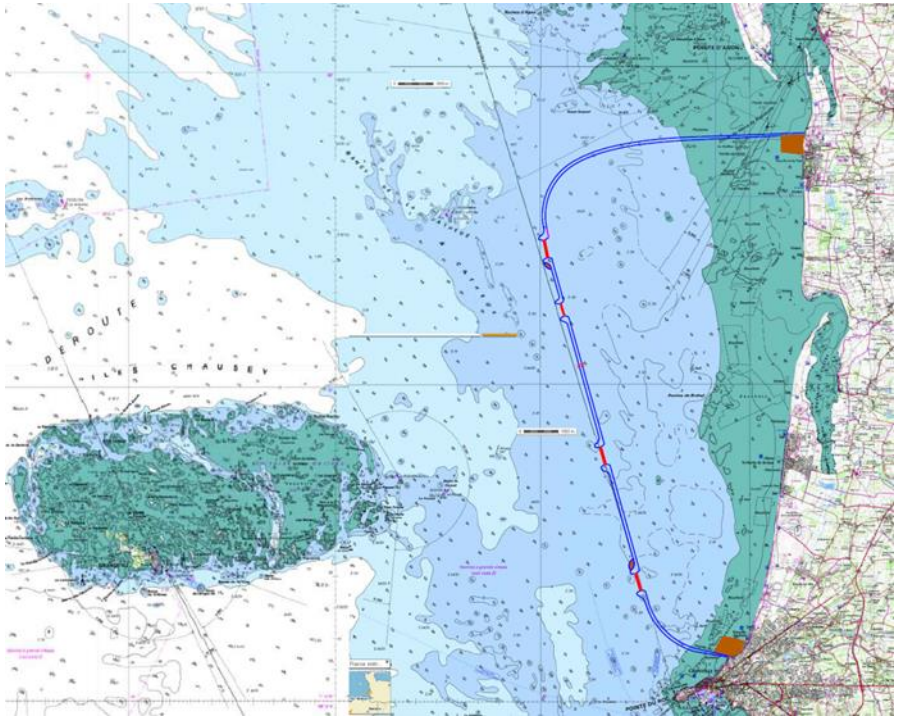
- Up to 14GW of potential capacity

Status:

- Initial meetings with key stakeholders
- Legal, planning and political research initiated

Next steps:

- Develop strategy around coastal protection law
- Put tidal lagoons on the energy roadmap
- Develop power management model for French market



Example layout: Hauteville Tidal Lagoon – 3.15 GW, Normandy, France

Thank you