PHEE Annual Conference 2016
The future of engineering and Technology
Major Engineering Opportunities
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Tidal Energy: Prospect for the future ?

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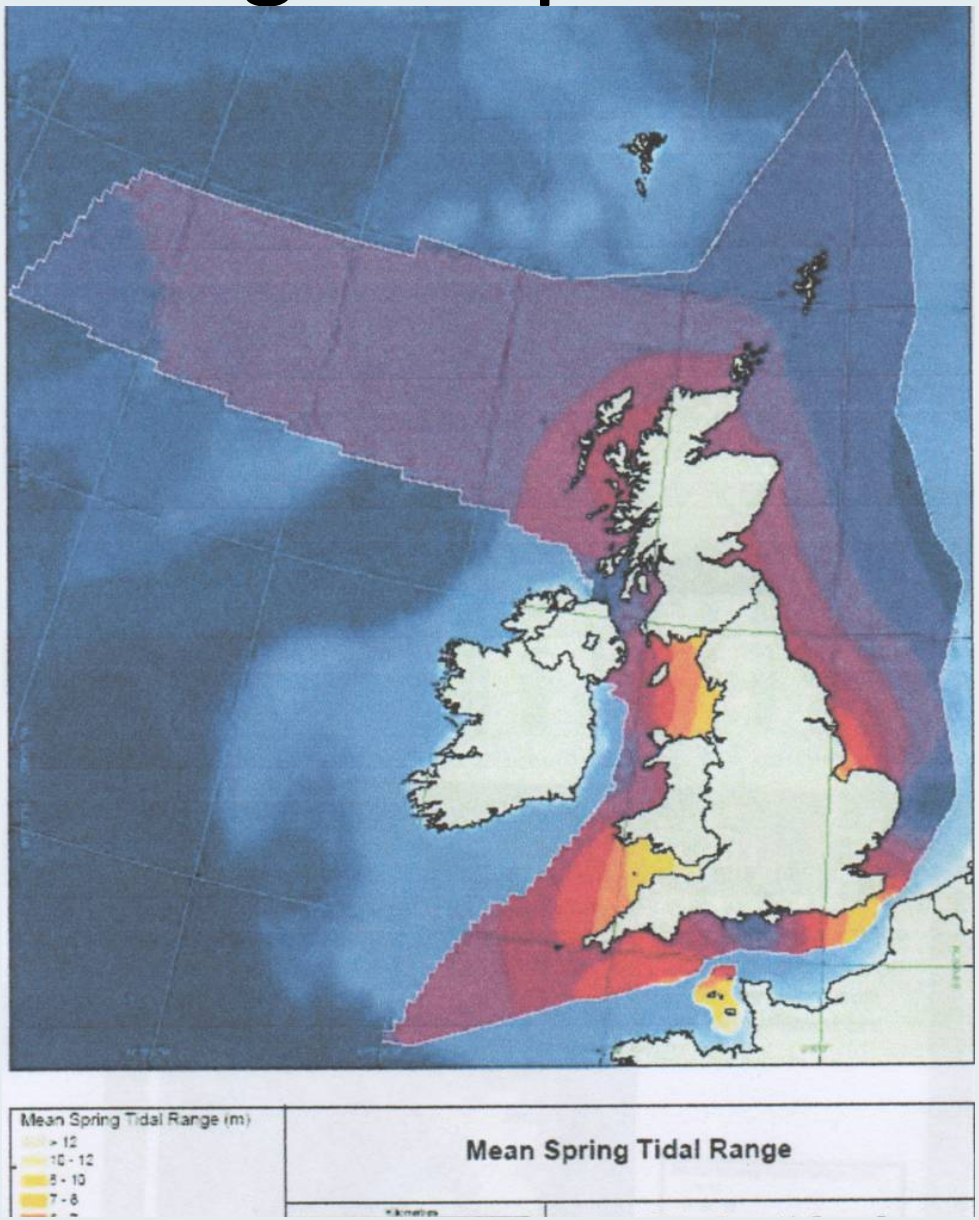
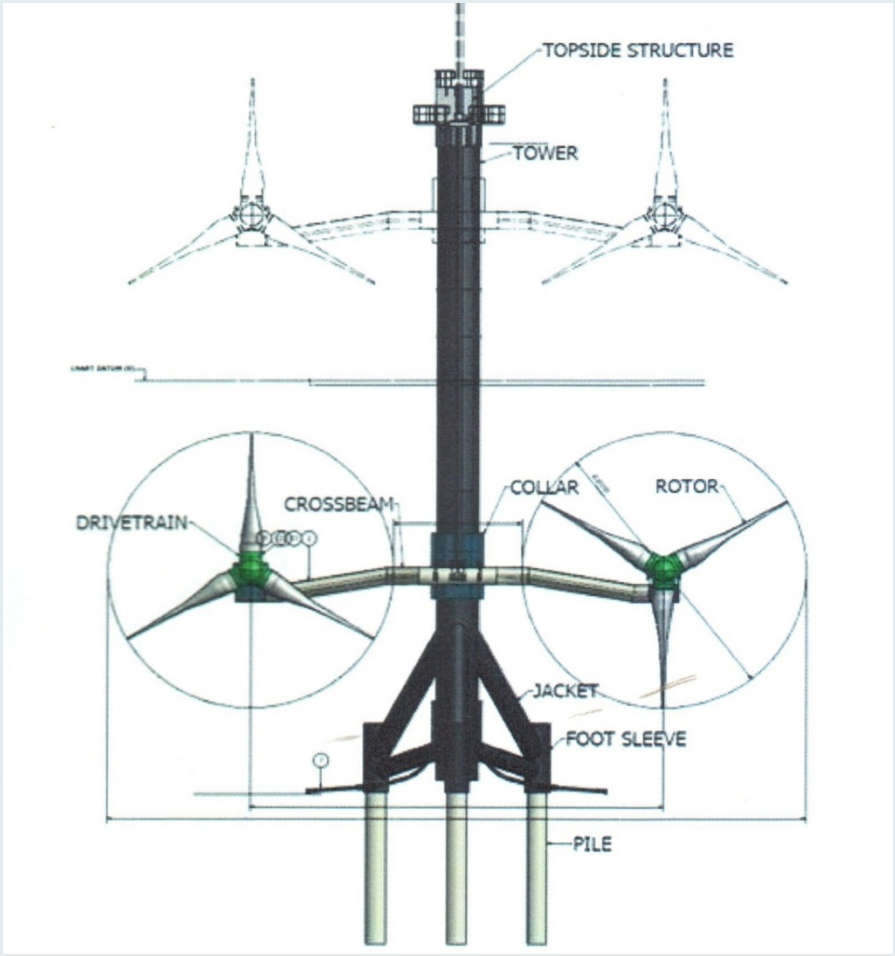
Tidal range map around UK



Ways of harnessing tidal energy

- Tidal stream
- Tidal barrages
- Tidal lagoons

Tidal stream device



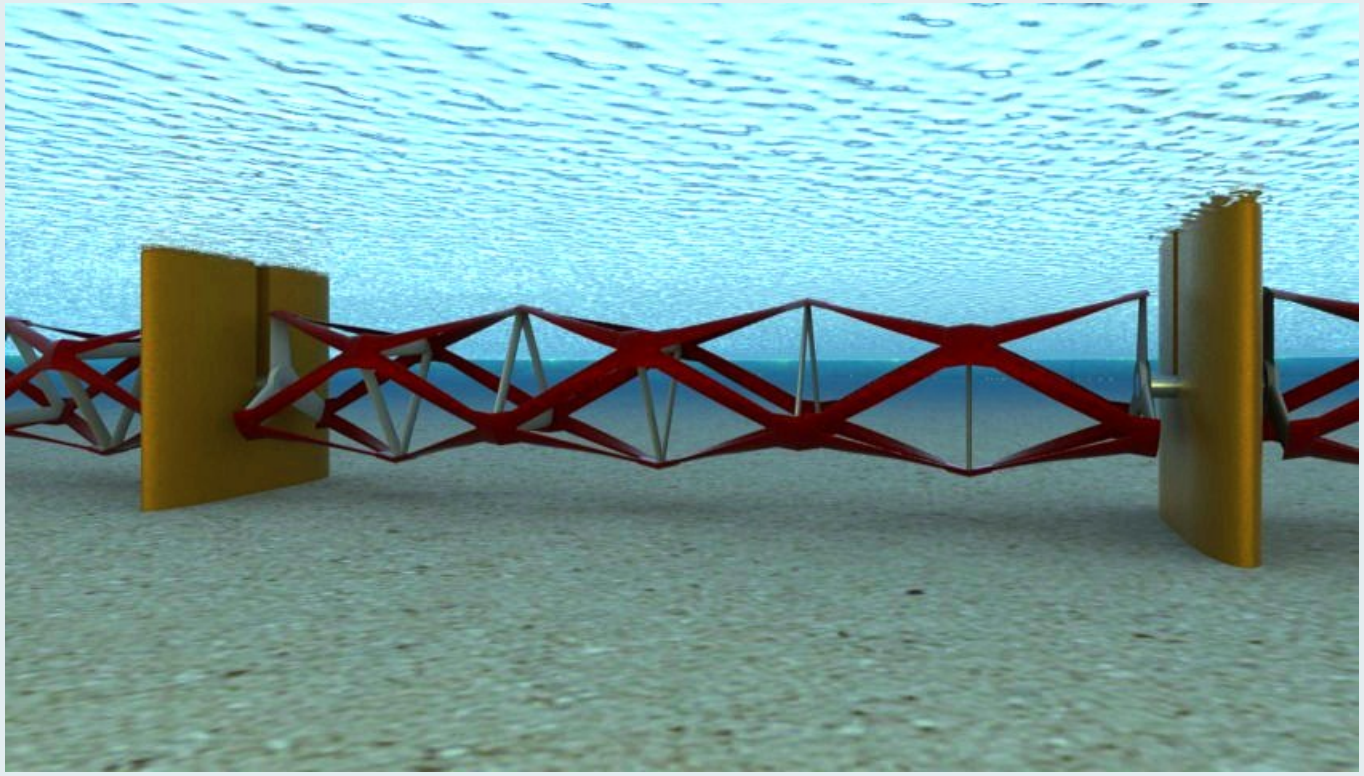
MCT Seagen 2MW device

Deltastream prototype device

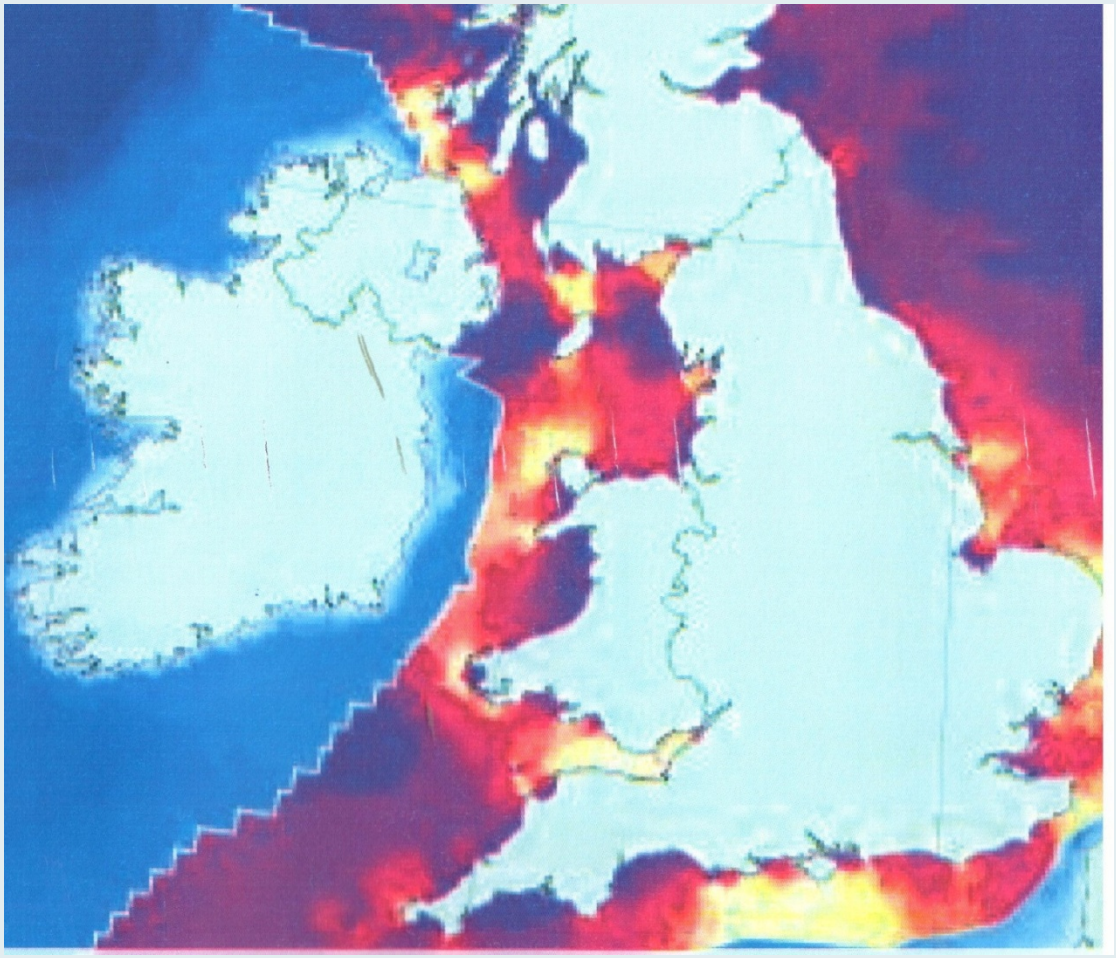
3 no 15m dia rotors gives 1.2 MW,
Needs minimum 25m depth at low tide
Awaiting installation in Ramsey sound.

Kepler prototype device

10m dia, 60m long, 6 MW



Tidal stream around UK



Tidal stream sites

Most sites would have expensive grid connection costs

Tidal stream sites theoretical output

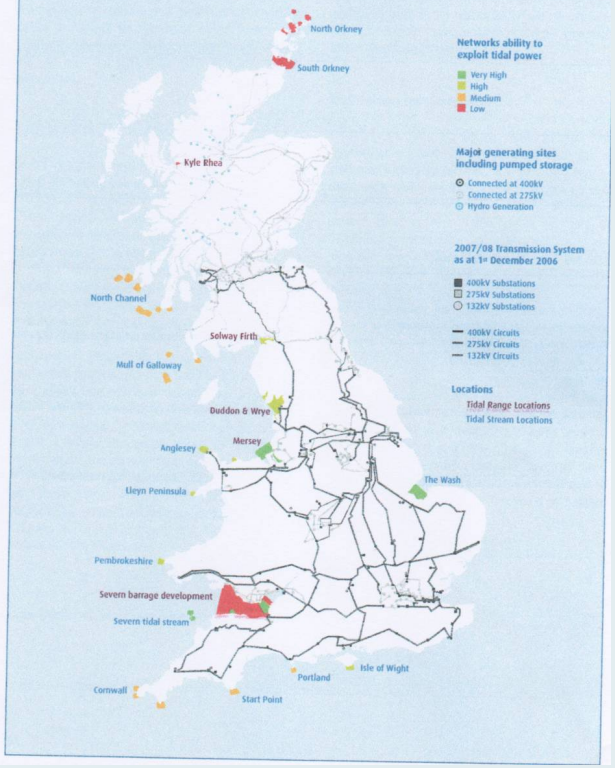
Site Name	Area	Resource (TWh/year)
Pentland Skerries	Pentland Firth	3.9
Strøma	Pentland Firth	2.8
Duncansby Head	Pentland Firth	2.0
Casquets	Alderney	1.7
South Ronaldsay	Pentland Firth	1.5
Hoy	Pentland Firth	1.4
Race of Alderney	Alderney	1.4
South Ronaldsay	Pentland Firth	1.1
Rathlin Island	North Channel	0.9
Mull of Galloway	North Channel	0.8

Electricity transmission network

also the owners of the transmissions system in England and Wales; in Scotland, the primary owners are ScottishPower Electricity Transmission Ltd and Scottish Hydro Electricity Transmission Ltd.

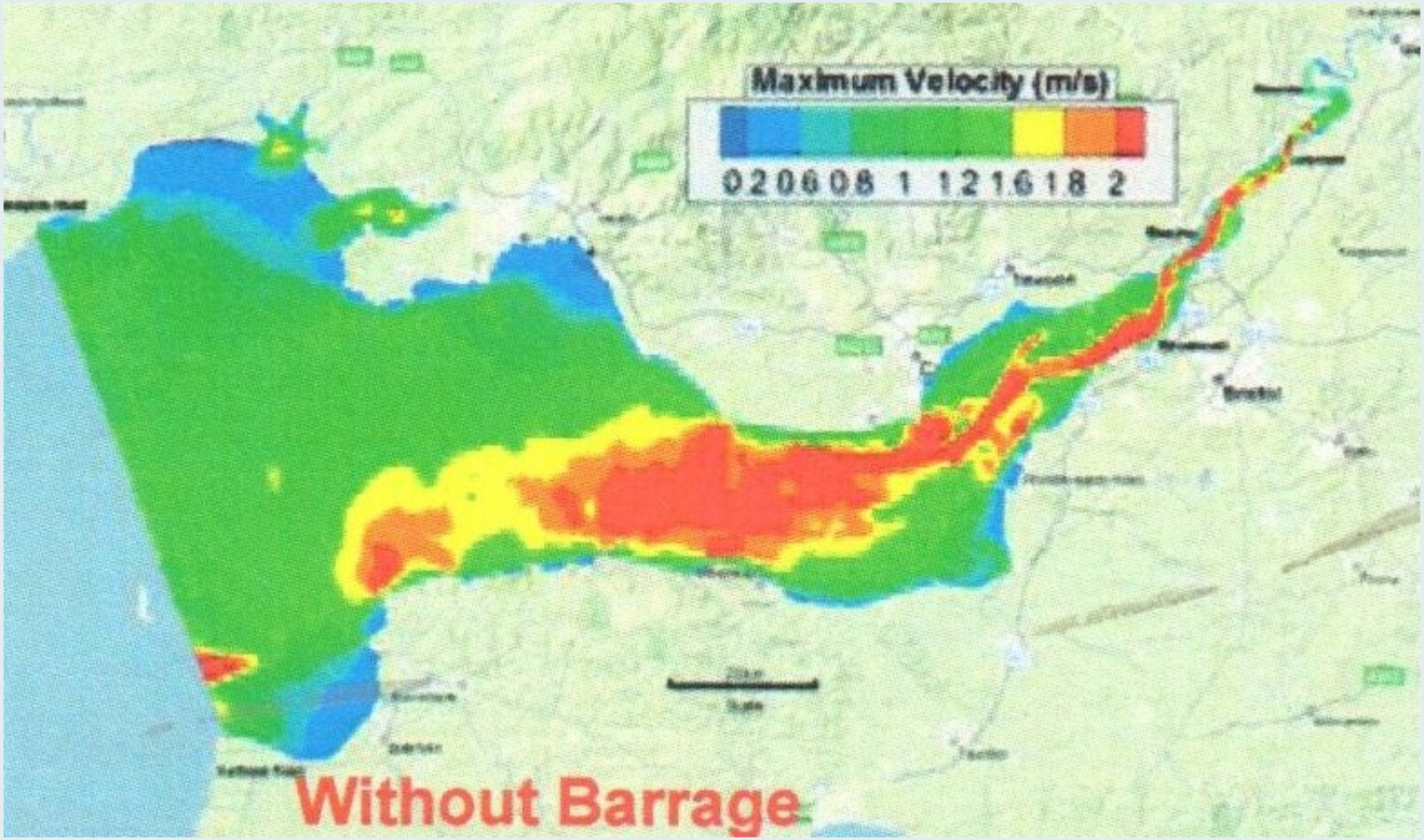
The transmission system feeds into the loca distribution system, which is managed by th 14 Distribution Network Operators (DNOs) on a regional basis.

Figure 6 **Electricity transmission network in Great Britain[12], showing grid constraints on tidal power.**

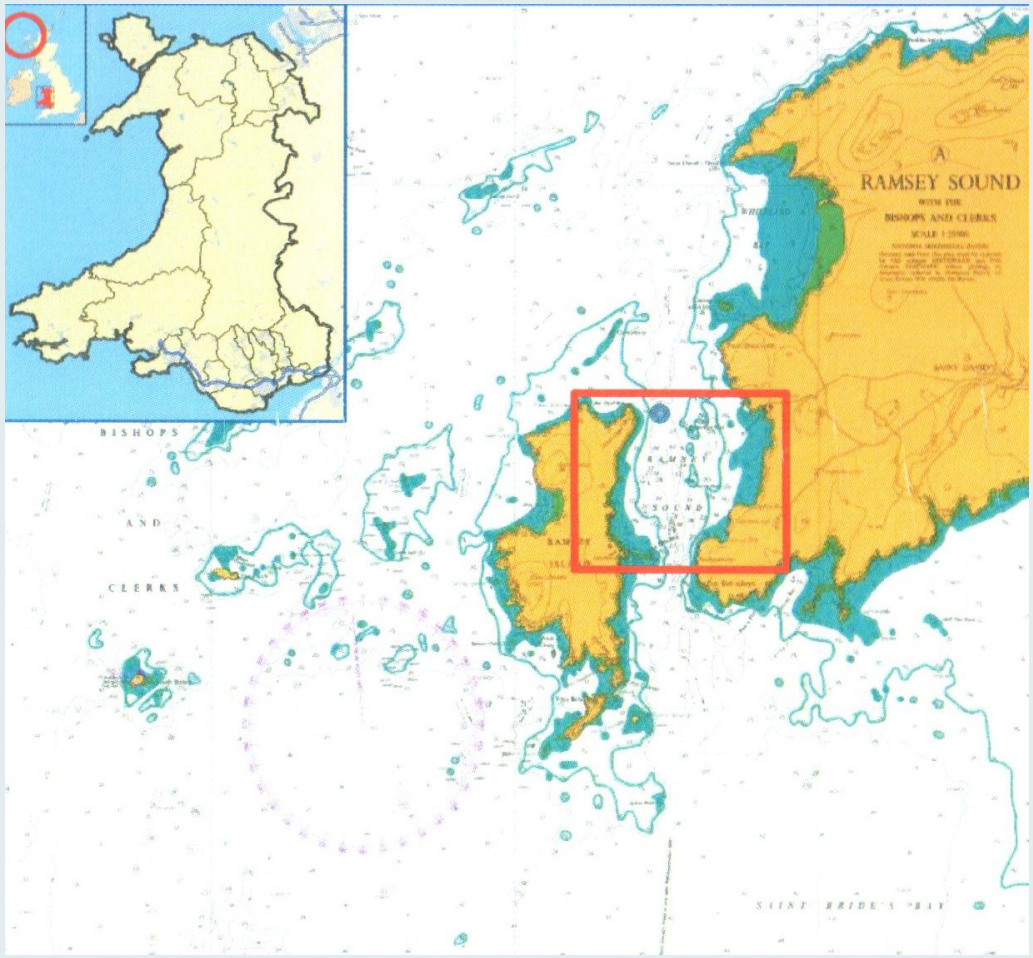


Potential areas for tidal stream

Total potential energy output 0.8TWh/year
But need to avoid navigational channels
depths generally less than the 30m required.



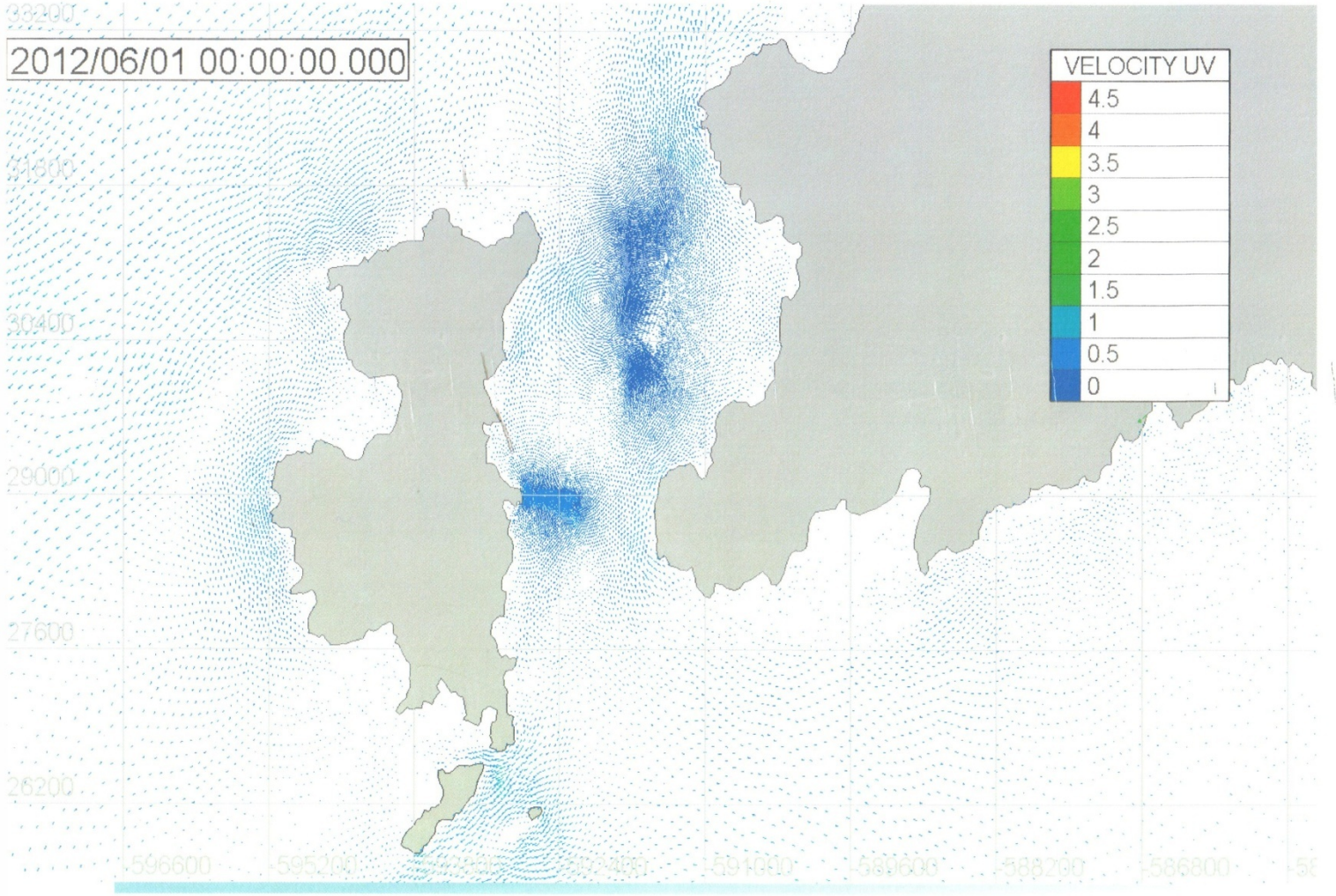
Ramsey Sound tidal stream site



Case Study – Ramsey Sound, Pembrokeshire: Spatially-Varying Velocities

Intertek

Valued Quality. Delivered.



Ramsey Sound

Only 2% of the area of the Sound is suitable

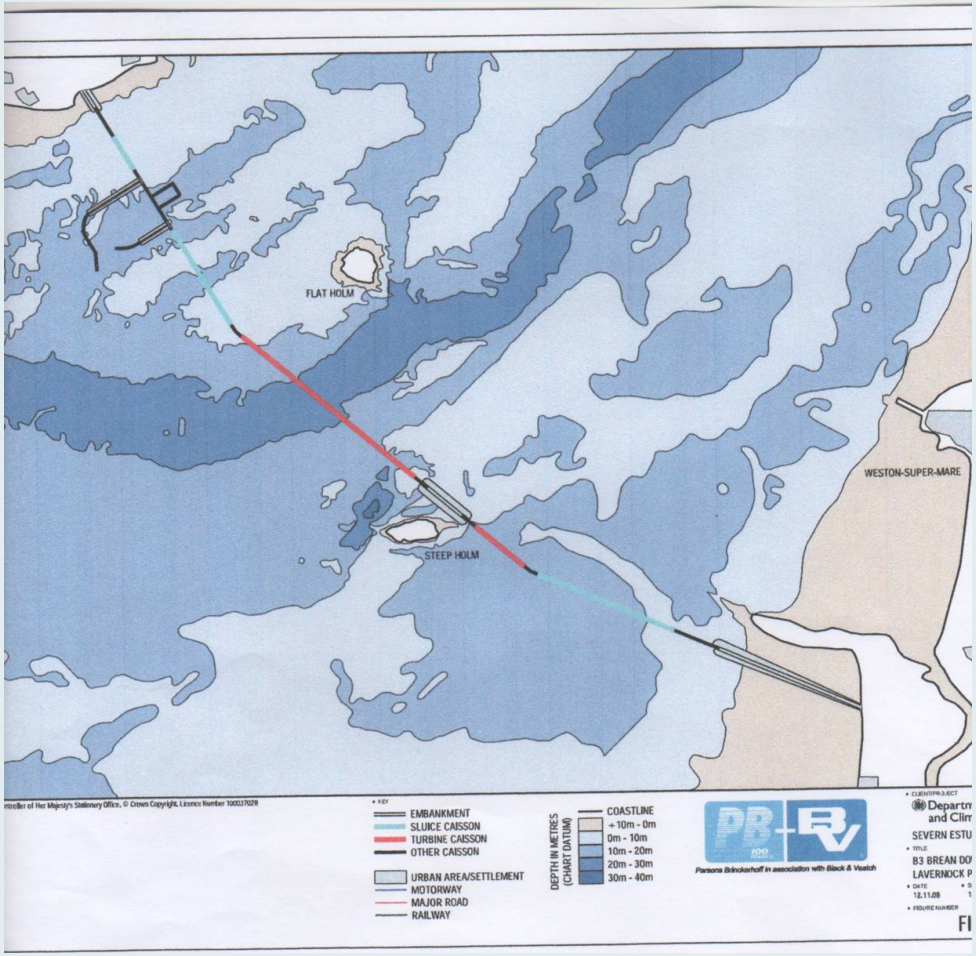
- Turbines like clean, uniform flow
- Turbulence is ; difficult to quantify /

Tidal barrages

Carew Mill Pembrokeshire, 16th century corn grinding

Severn Barrage

Cardiff-Weston line, 6,000 MW, 16TWh/year, cost £25bn



2-dimensional analysis

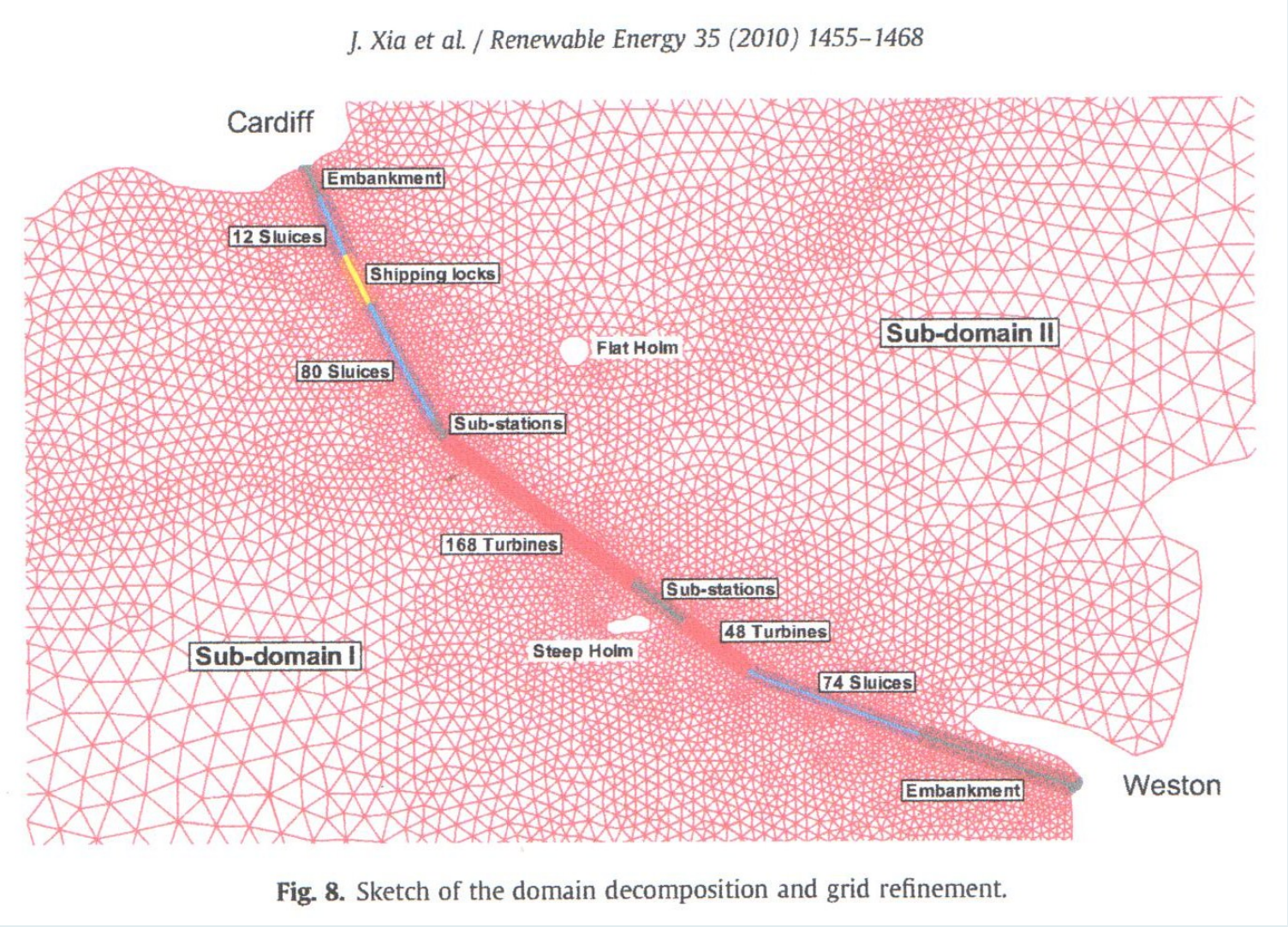
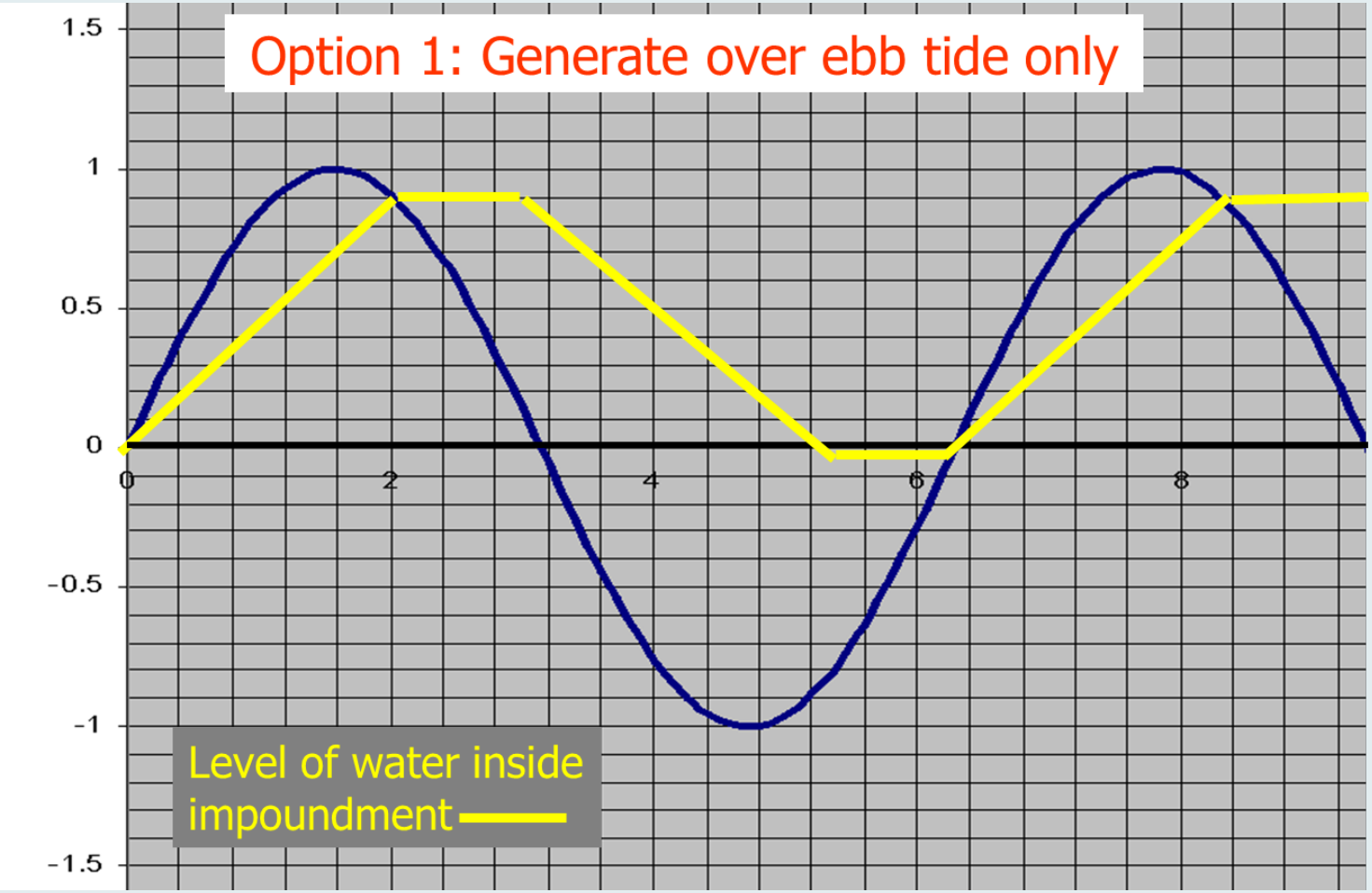
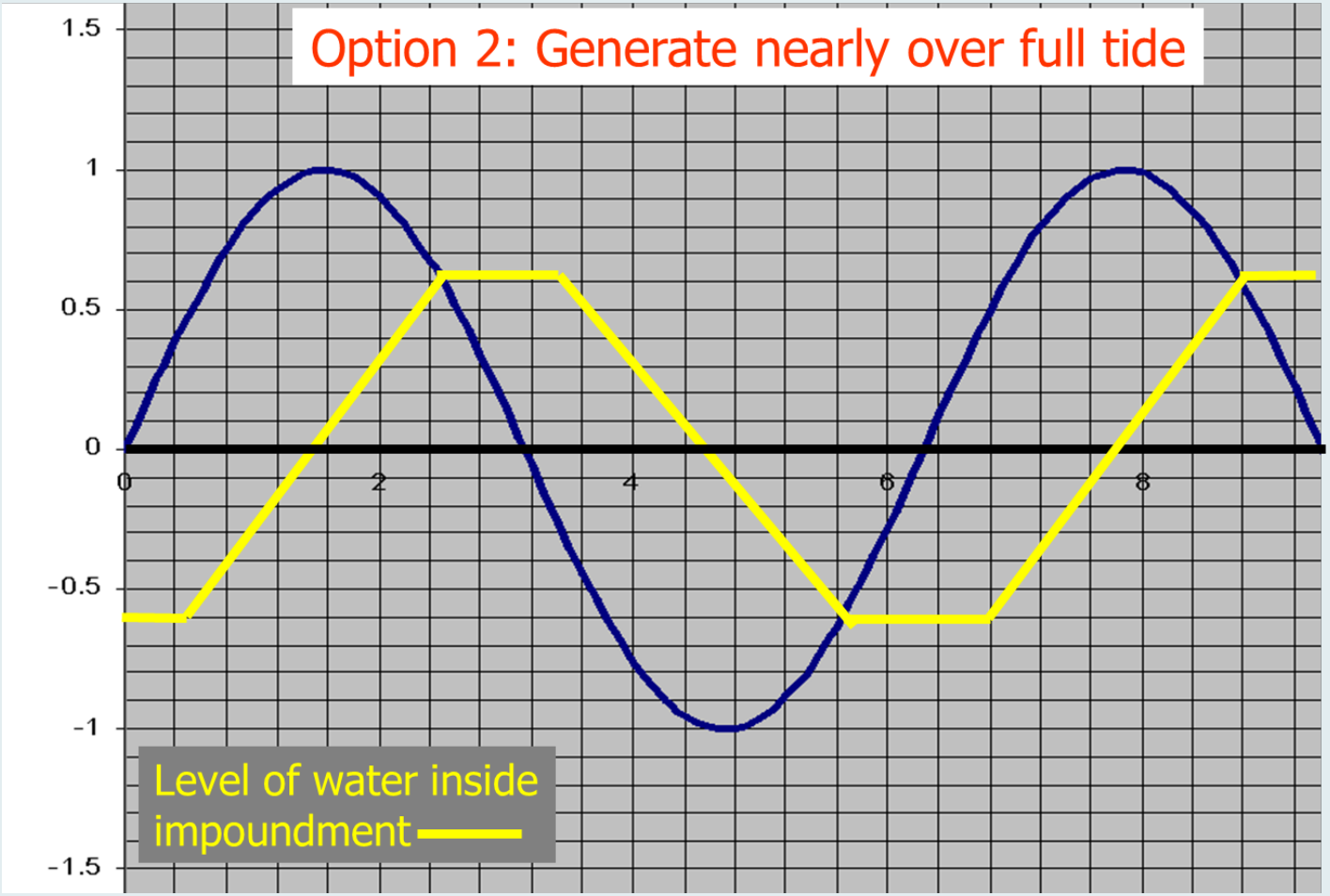


Fig. 8. Sketch of the domain decomposition and grid refinement.

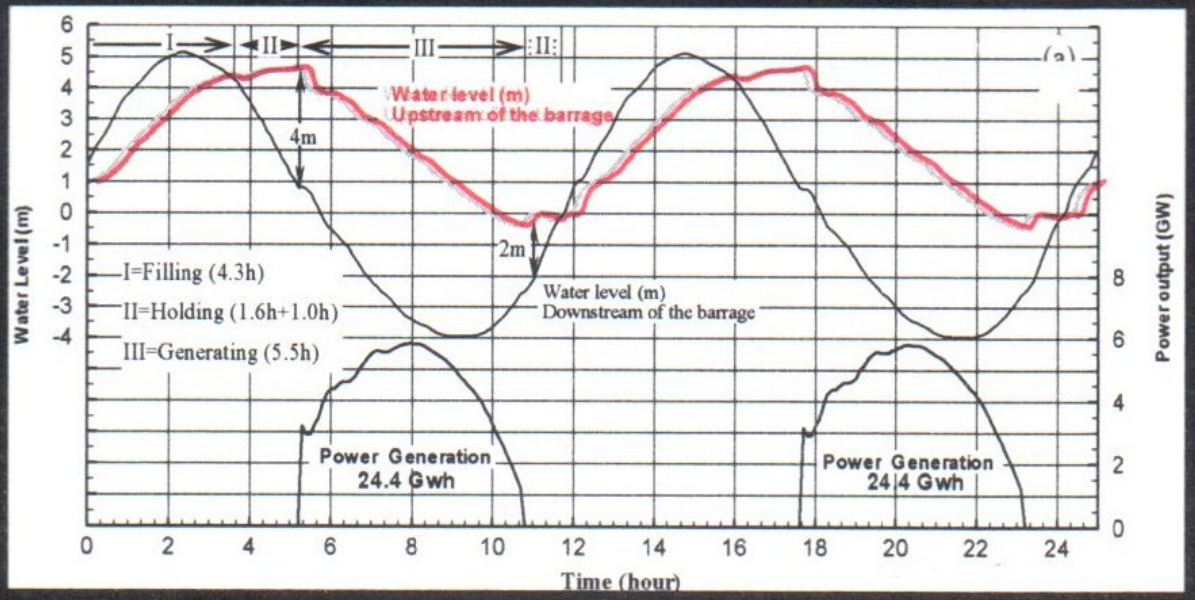
Modes of operation
Ebb generation.



Modes of operation
Ebb and flood generation

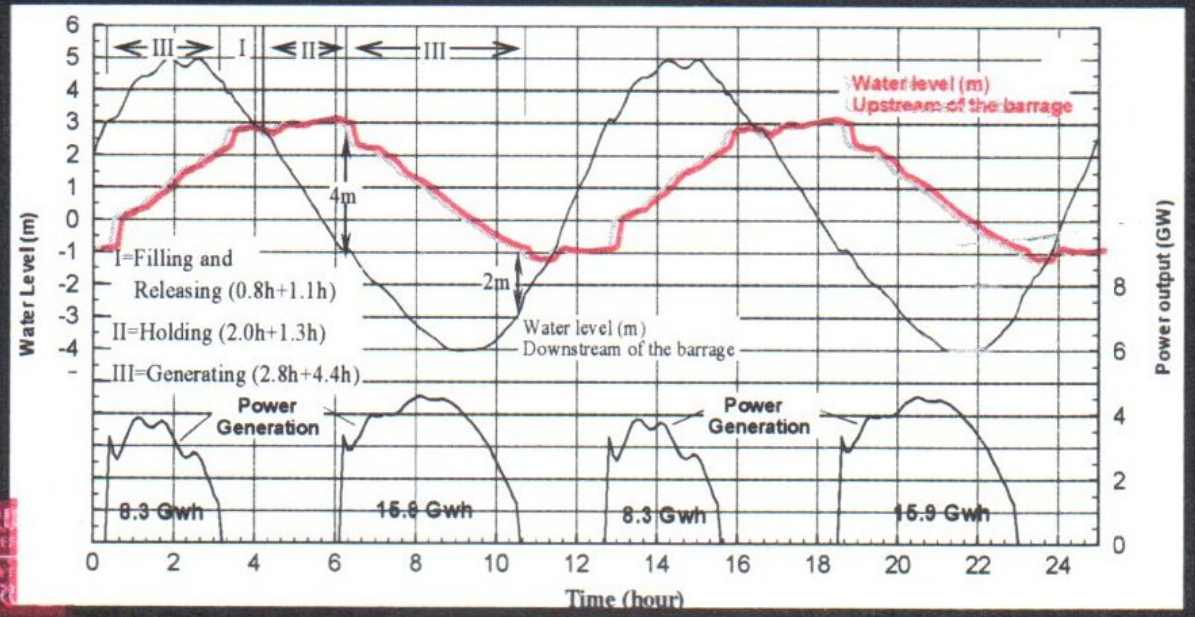


Water levels and Power Output



Ebb Only

- 48.8 GWh/24.8h
- 5.2 m mean tide
- High tide 4.6 m
- Power for 11h



Two-Way

- 48.4 GWh/24.8h
- 4.4 m mean tide
- High tide 3.2 m
- Power for 15h

Mitigation pumping

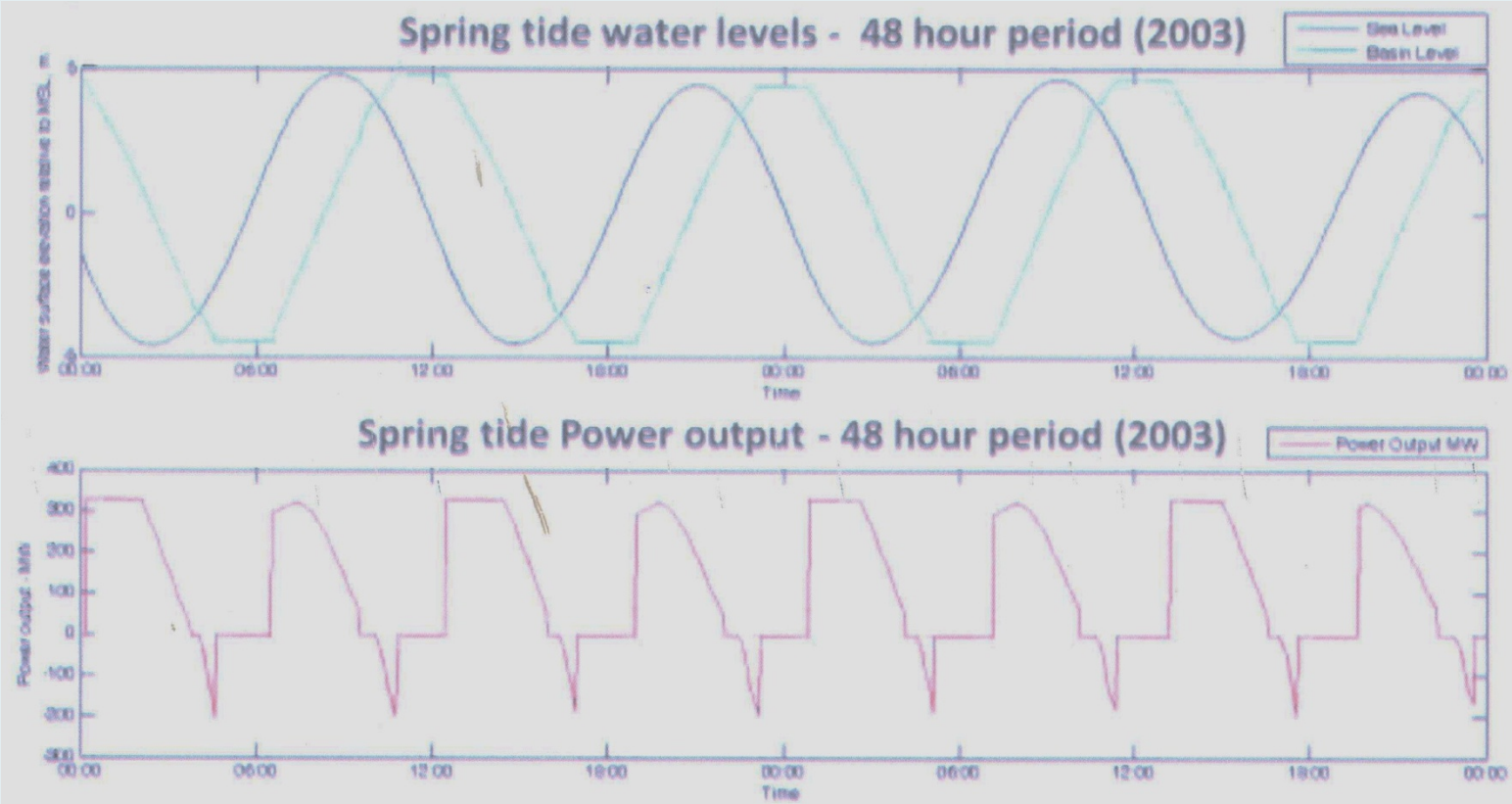
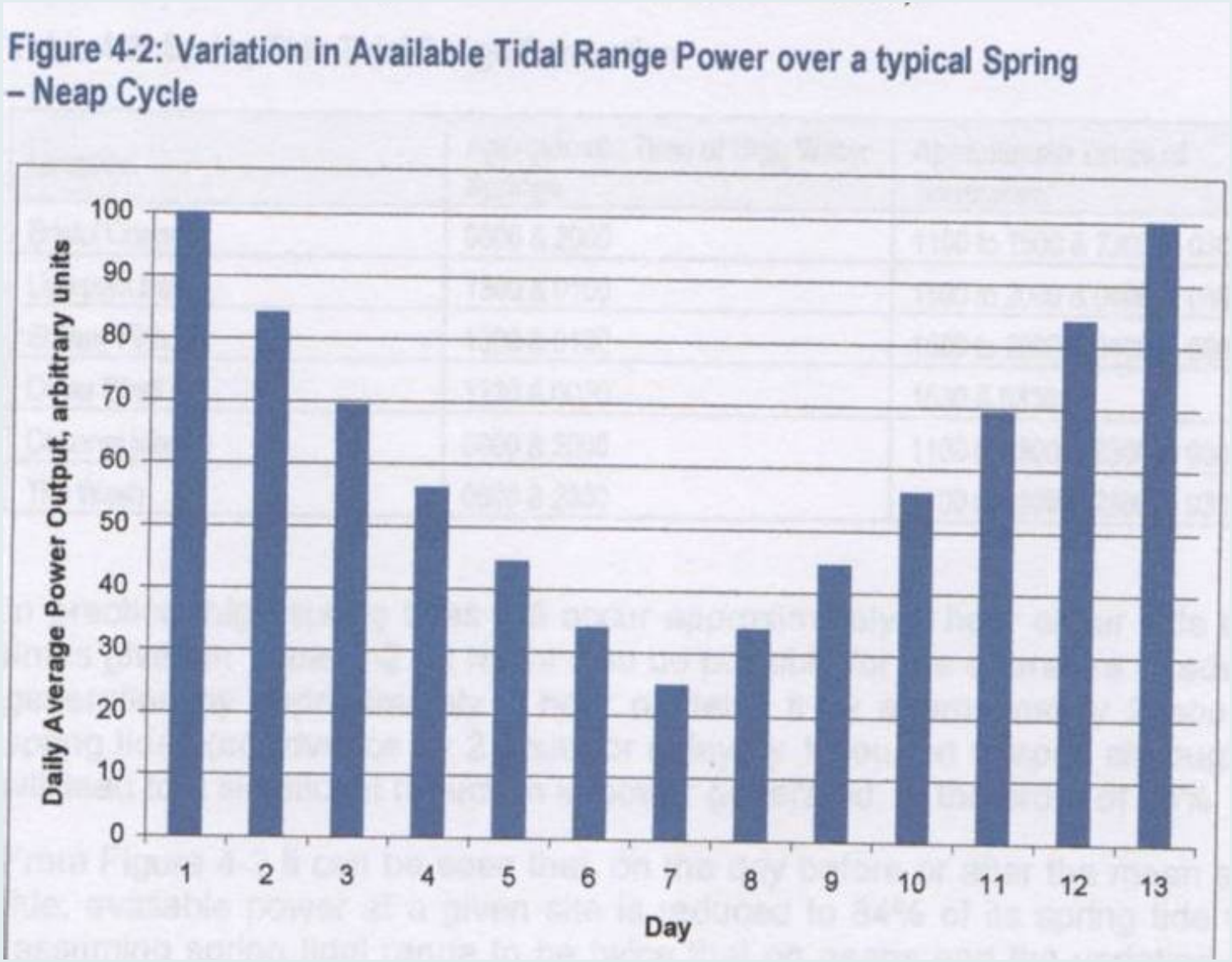


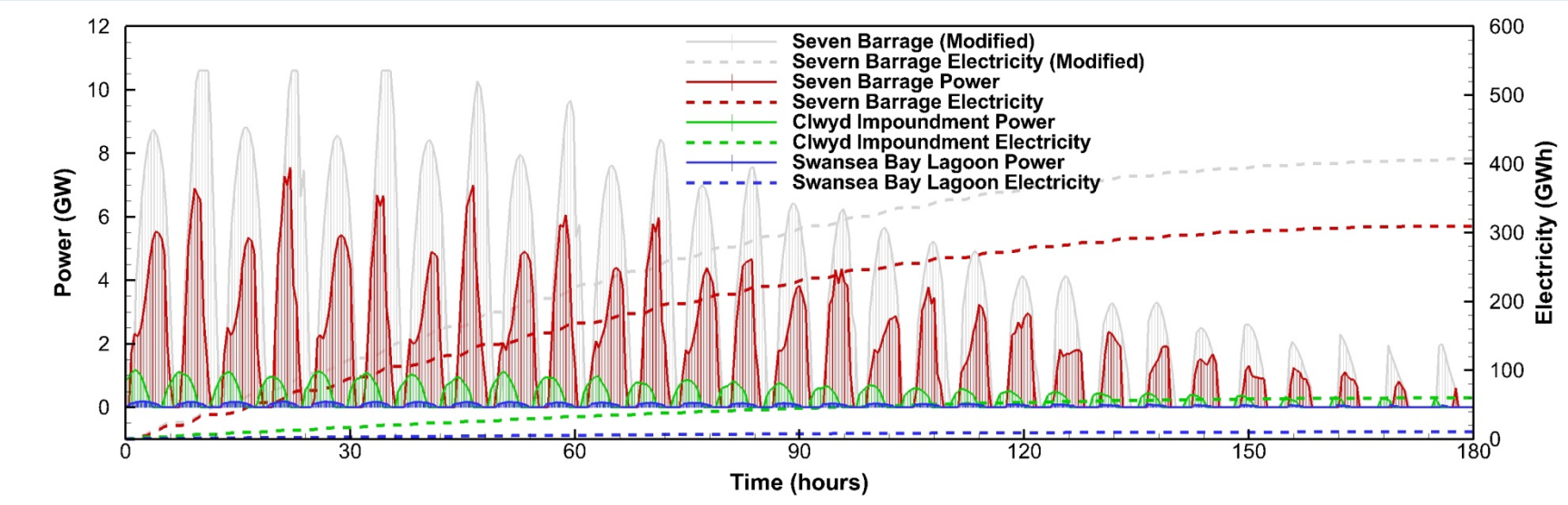
Figure 1 B (Mitigation pumping)

Figure 4-2: Variation in Available Tidal Range Power over a typical Spring – Neap Cycle

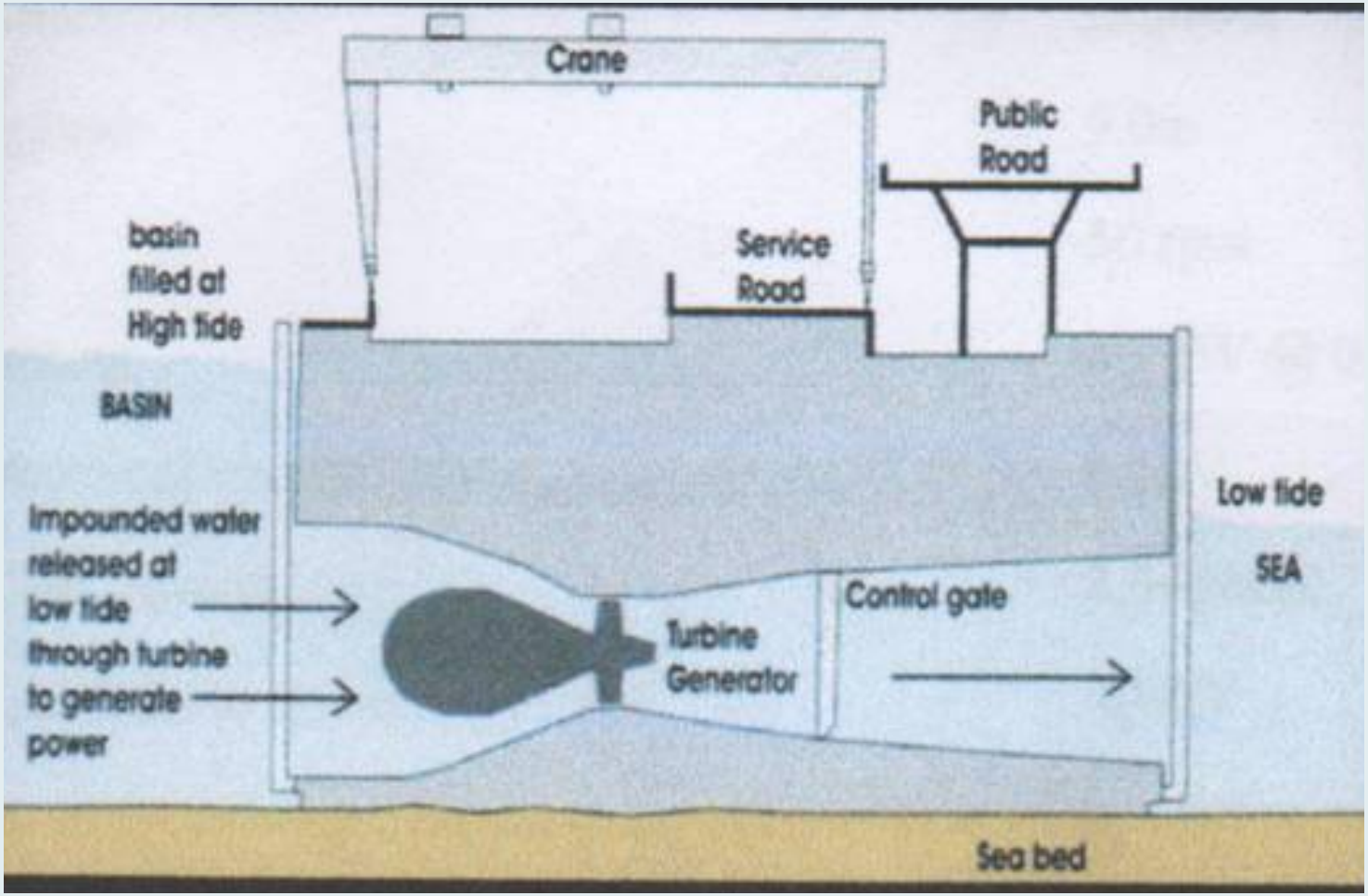


Power from a combination of schemes

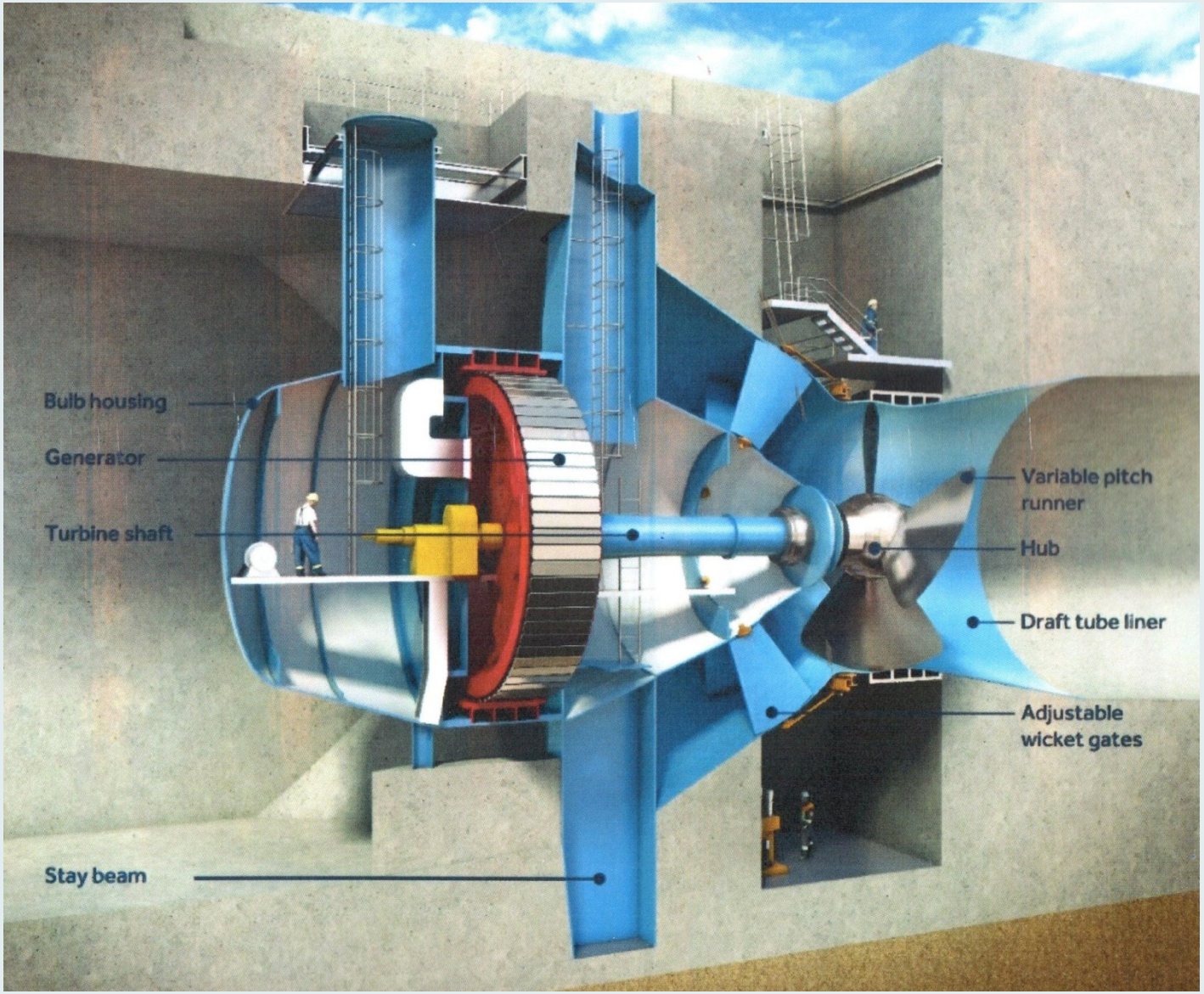
Severn barrage ebb/flood, Swansea, and Clwyd lagoons



Tidal Power generation

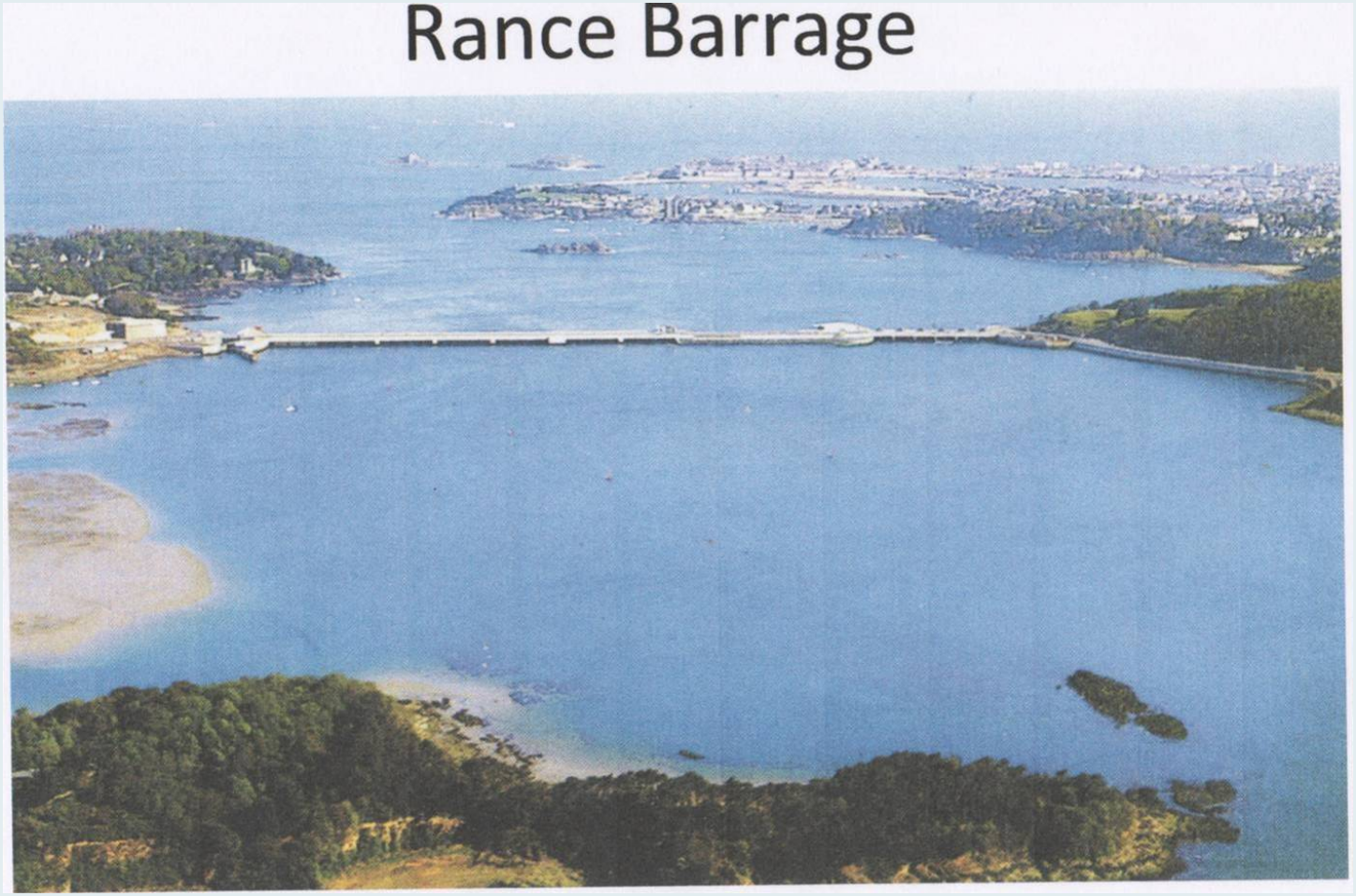


Double regulated bulb turbine



La Rance, Brittany

240 MW, Operating since 1966, cheapest electricity in Europe



La Rance tidal power scheme

- Minimal operational problems/maintenance
- Tourist attraction
- Road connection
- Unknown environmental impact

General issues for barrages

- Impedance of navigation
- Reduction of high tide at upstream ports
- Some loss of intertidal habitat
- Effect on sea bird feeding ground
- Some mortality of migratory fish
- High construction costs.
- Scale up factor

Land at risk of inundation

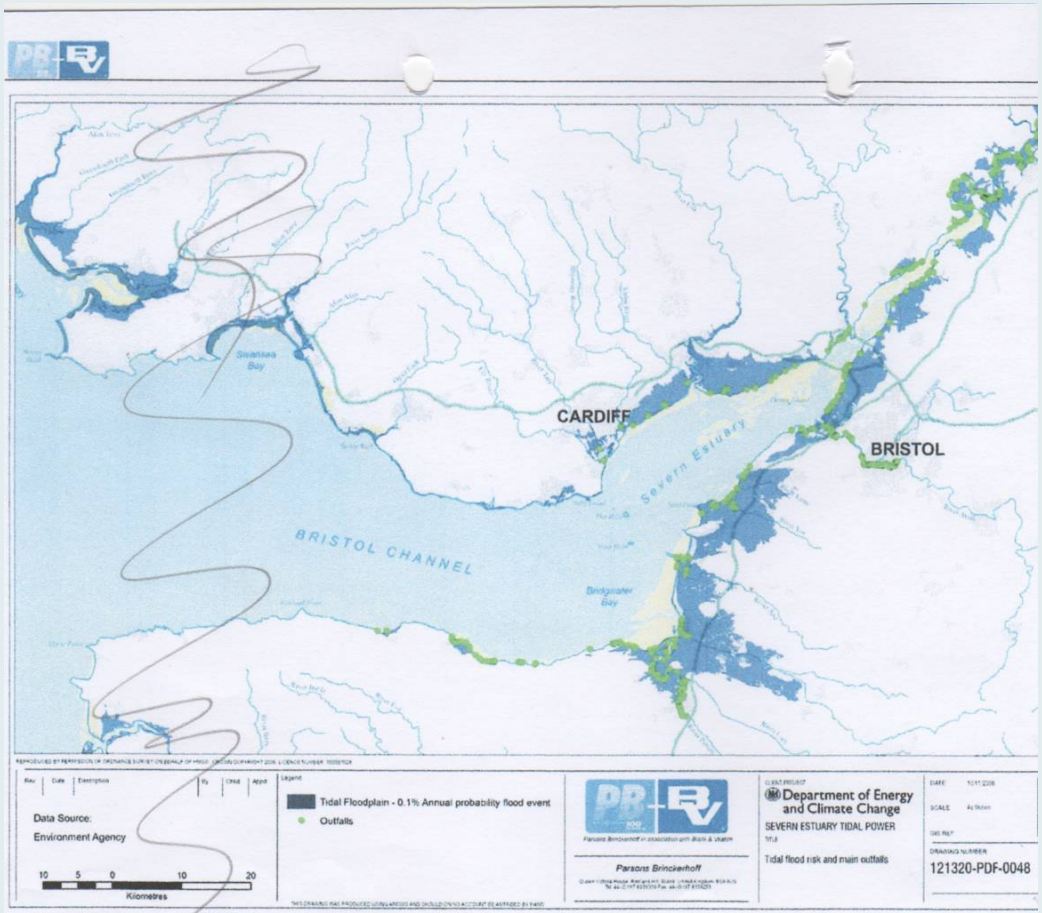


Figure 6.4 Tidal Floodplain

Potential tidal lagoons

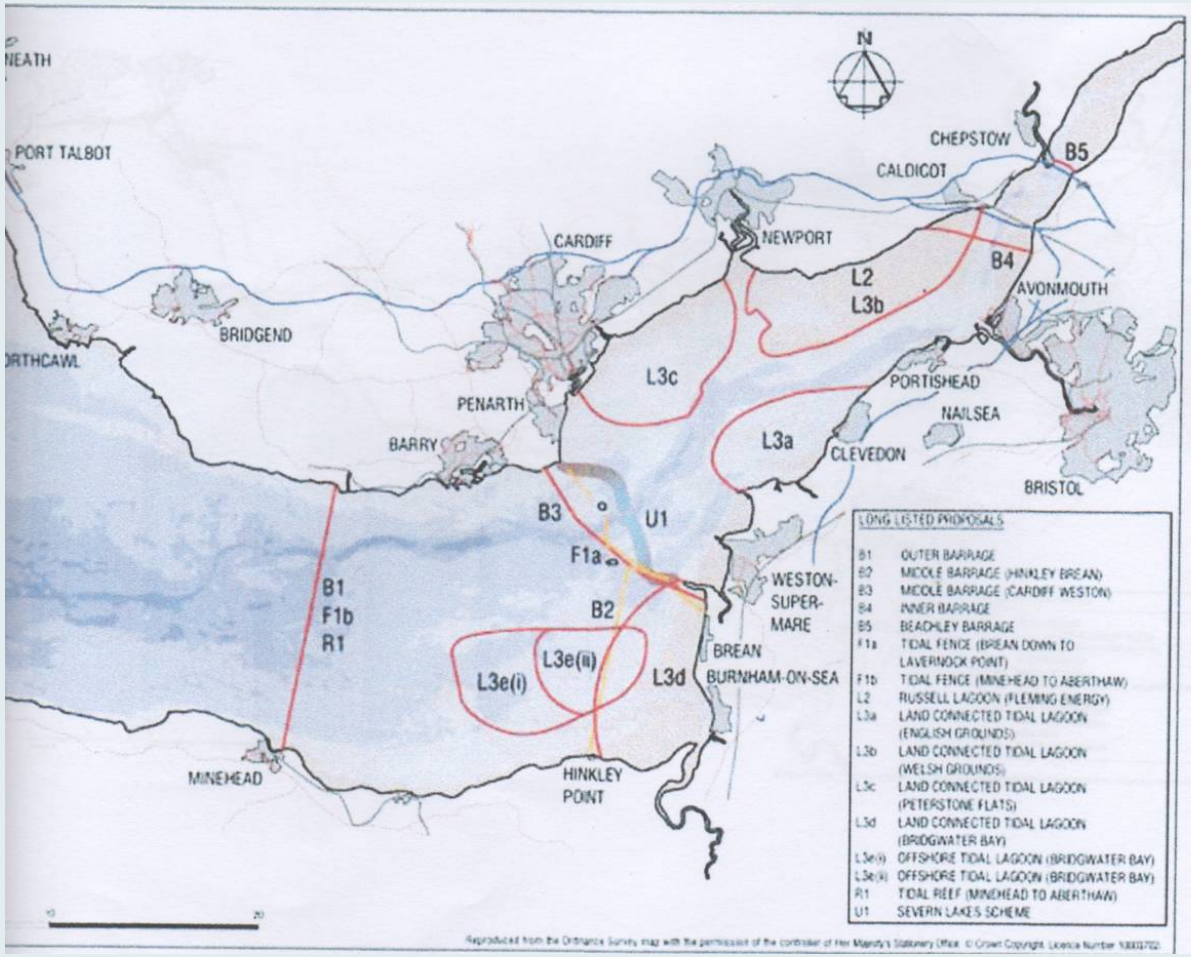


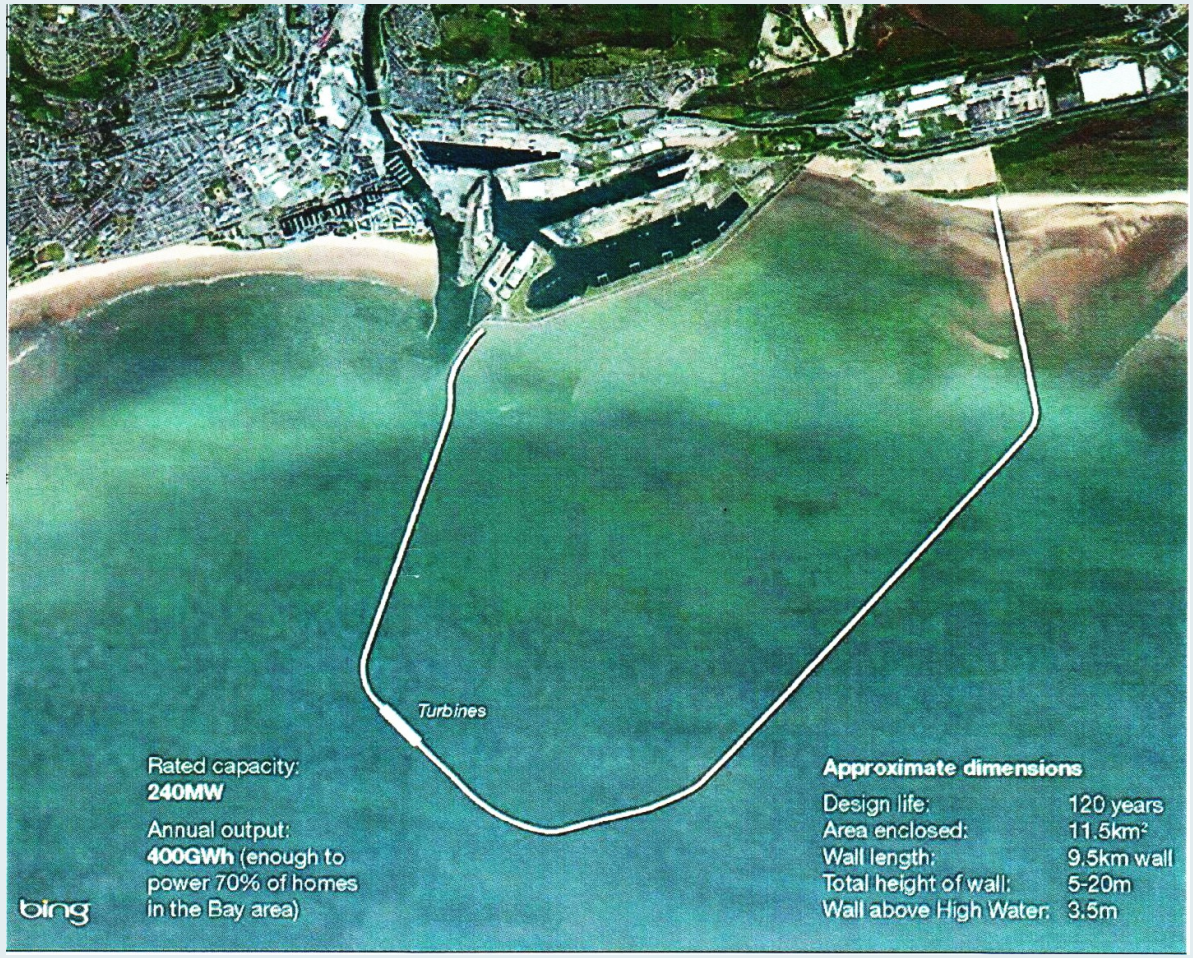
Figure 3: Map of the Bristol Channel and Severn Estuary showing the long-listed proposals' locations

Characteristics of tidal energy lagoons

- D shaped lagoon
- Long lagoon walls
- Can avoid navigation and port impact
- Less impact on migratory fish
- Greater risk of siltation.
- Generally higher unit cost.

Swansea Bay lagoon

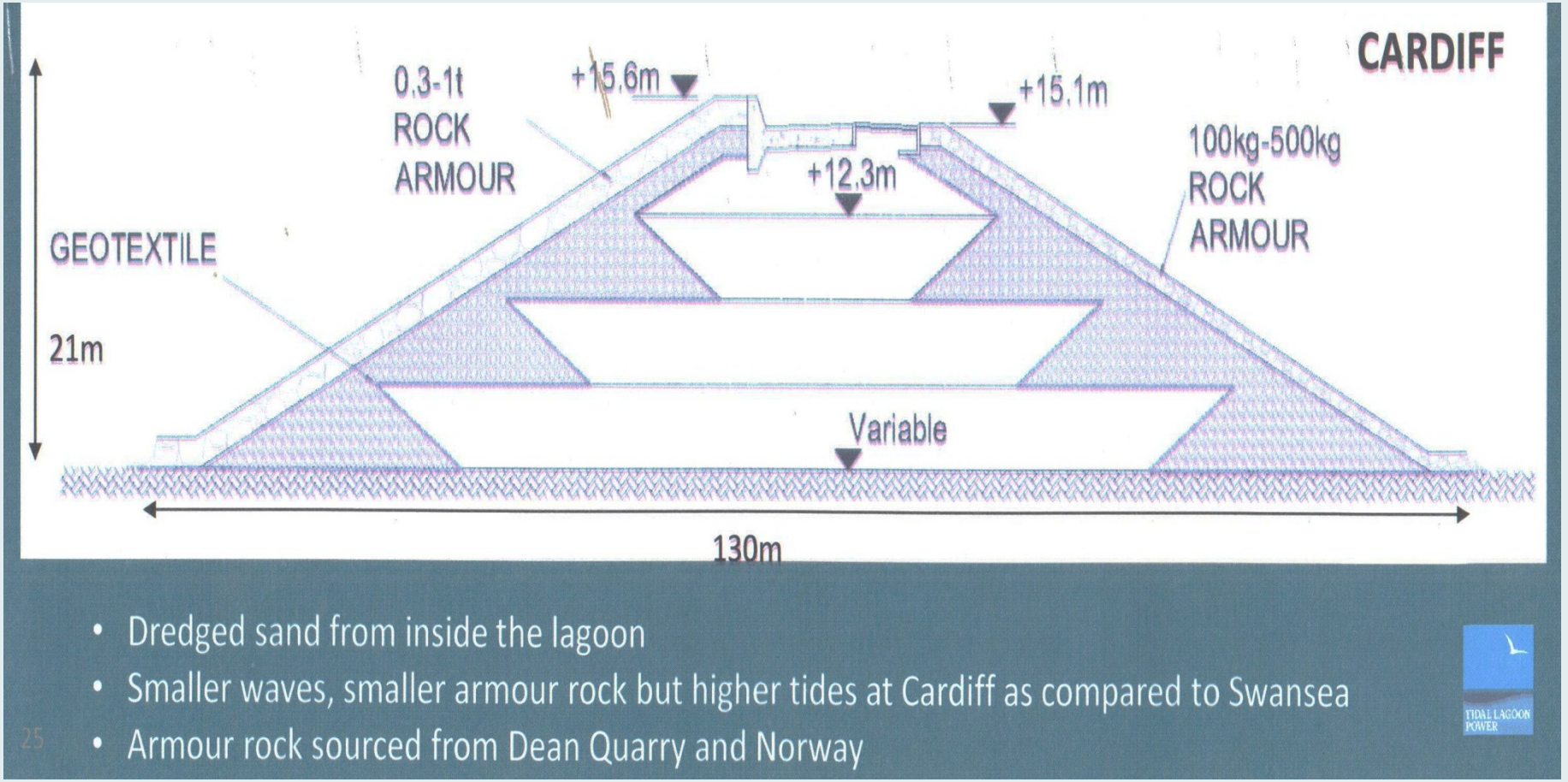
240 MW, 0.4TWh/year, cost £1bn, has planning permission, negotiating contract for difference.



Cardiff lagoon

2,700MW, 5.2TWh/year, under study.

Lagoon wall

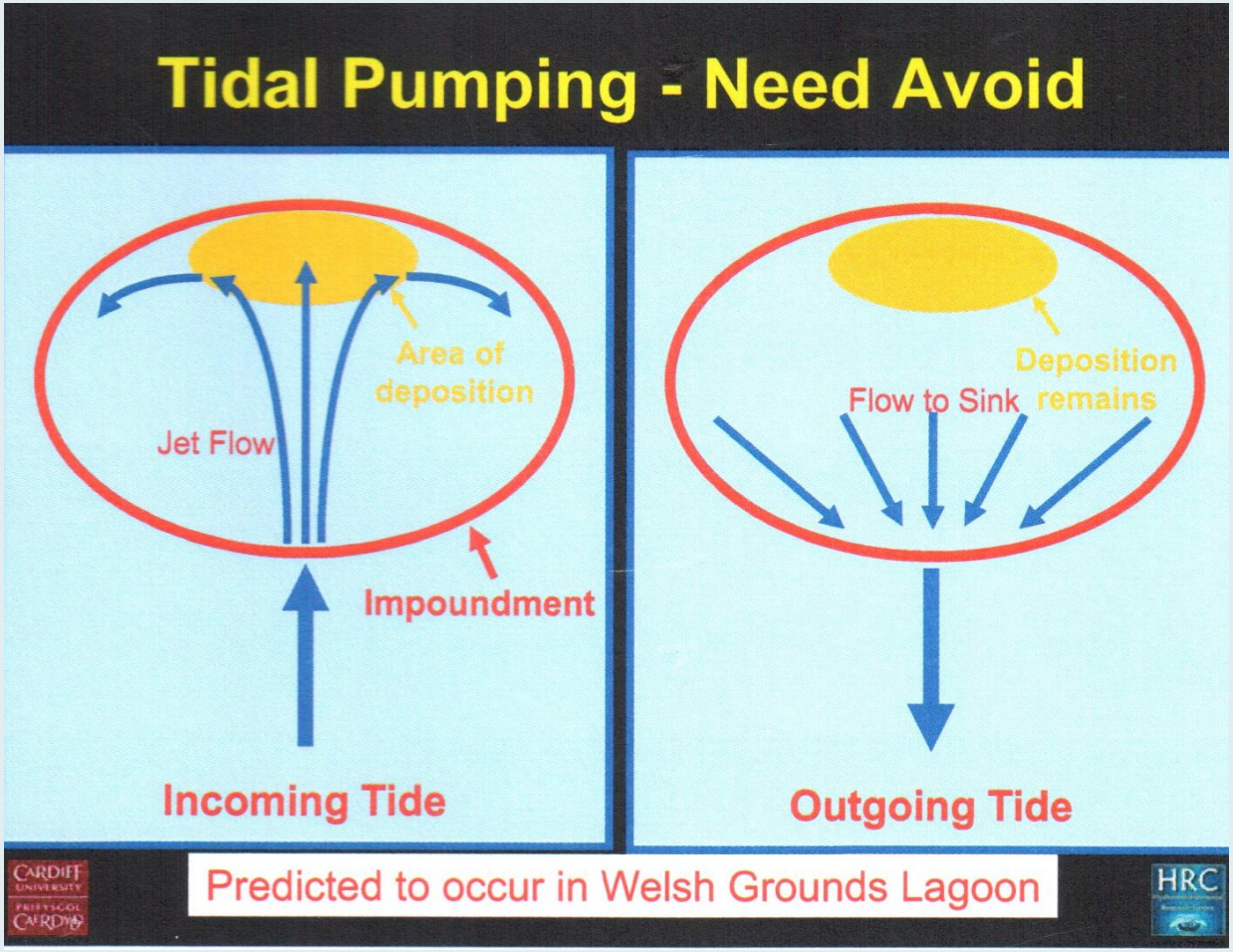


- Dredged sand from inside the lagoon
- Smaller waves, smaller armour rock but higher tides at Cardiff as compared to Swansea
- Armour rock sourced from Dean Quarry and Norway

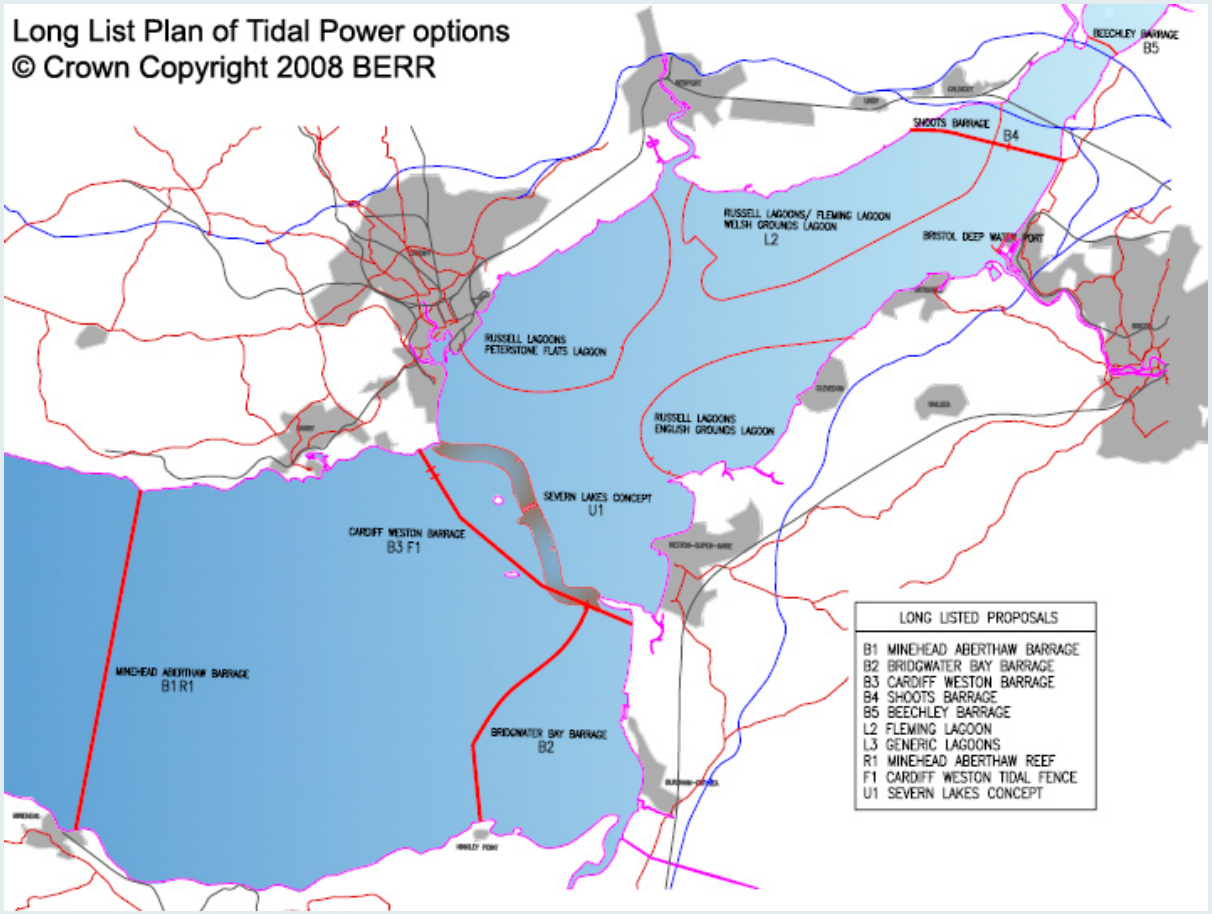
TIDAL LAGOON POWER

Tidal pumping sedimentation

Cardiff lagoon 4-10Mm3/year



Lagoons v barrage

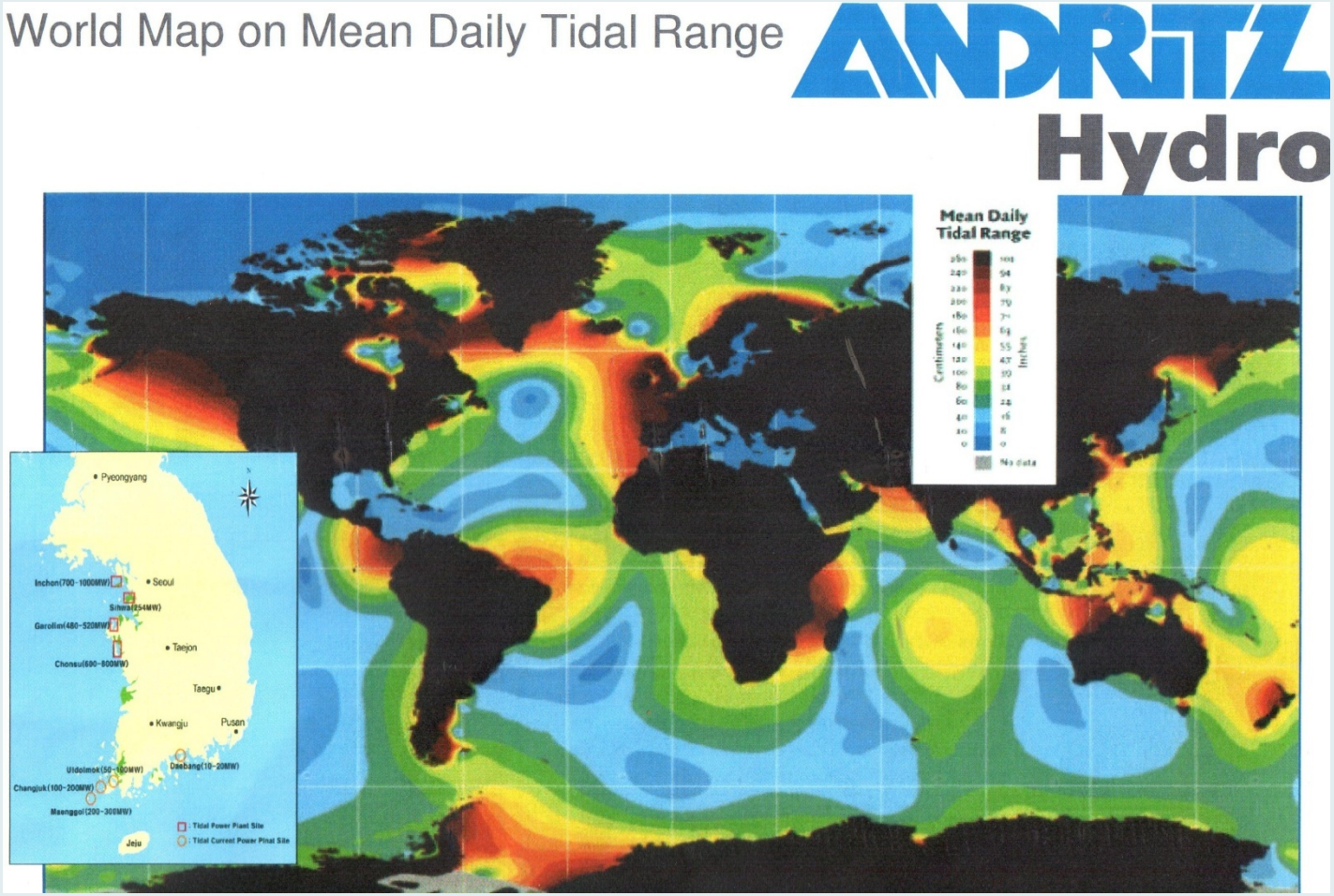


Power and energy output estimates

Note. The estimates are from different sources with different assumptions.

Scheme	Power GW	Energy TWh/year	Capital cost £bn
La Rance barrage	0.24		Built 1960s
Swansea Bay lagoon	0.32	0.54	1
Bridgewater Bay lagoon	3.6	6.2	12
North Wales lagoons	2.4	3	
Cardiff lagoon	2.7	5.1	7
Newport lagoon	1.2	2.3	
Cardiff-Bristol barrage	8.6	15.6	23

Overseas opportunities



Conclusions of tidal energy

- Tidal stream small energy output
- Tidal range could provide about 7% of UK energy need
- Tidal range uses proven technology
- Predictable power about 14 hours a day
- Power gap 2-3 hours each tide, but overlapping schemes can reduce effect .
- Significant environmental impacts.
- Protects from sea level rise/storm surge, coastal flooding.
- Similar cost to offshore wind, but tidal is predictable.
- Long asset life but need to future proof.

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Tidal Energy: Prospects for the future

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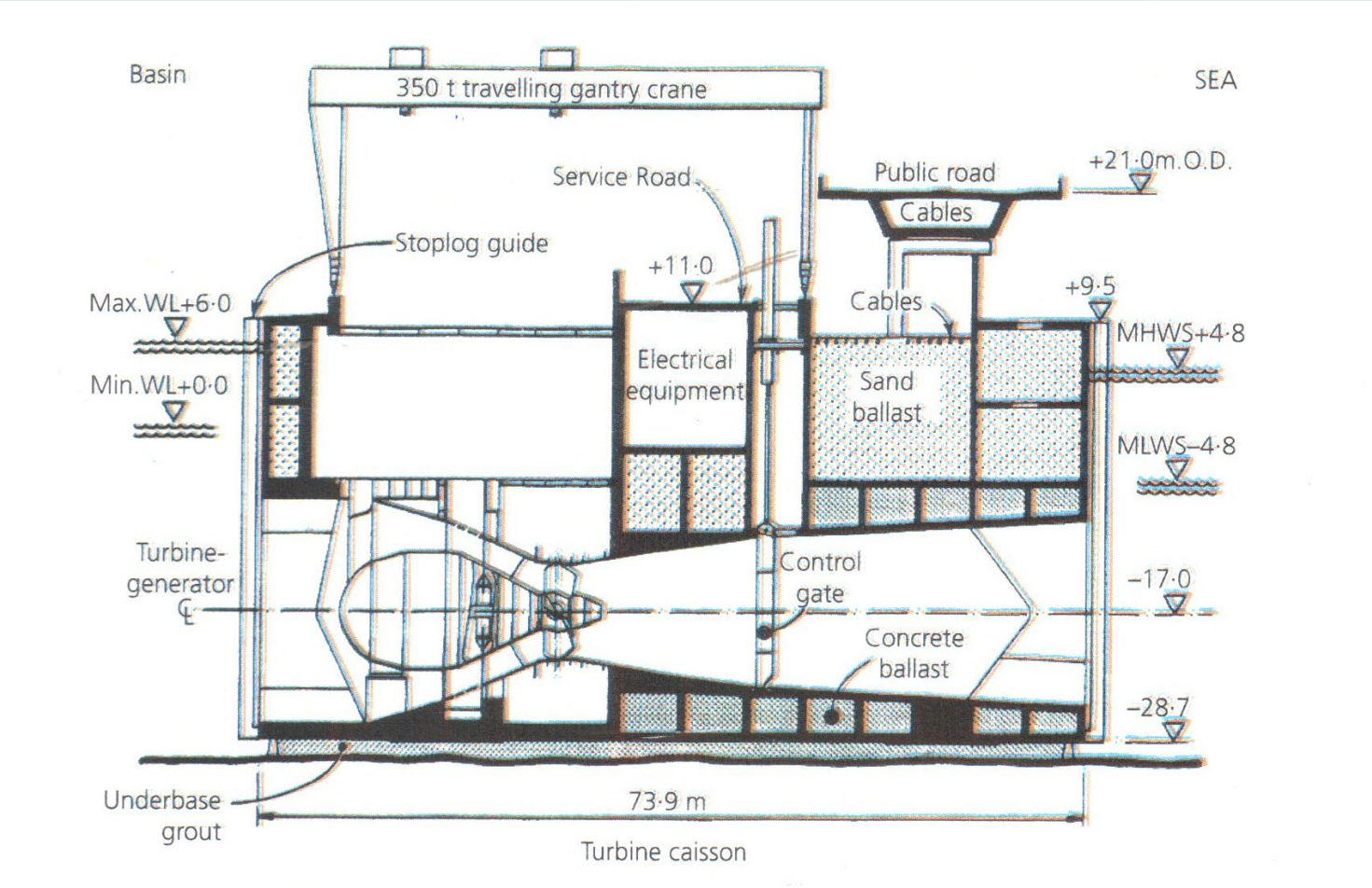
Turbine cross section



North Wales lagoons

4 hours out of phase with the Severn

Potential energy output 3TWh/yr

Decreasing carbon emissions to 2050 could double electricity demand

Typical Energy Scenario to achieve 80% reduction in carbon emissions