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Numerical models of tidal lagoons

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Outline

- Models
  - 0D models
  - 2D/3D models
- Tidal range resource
- Optimisation
  - Energy
  - Economics
- Other considerations

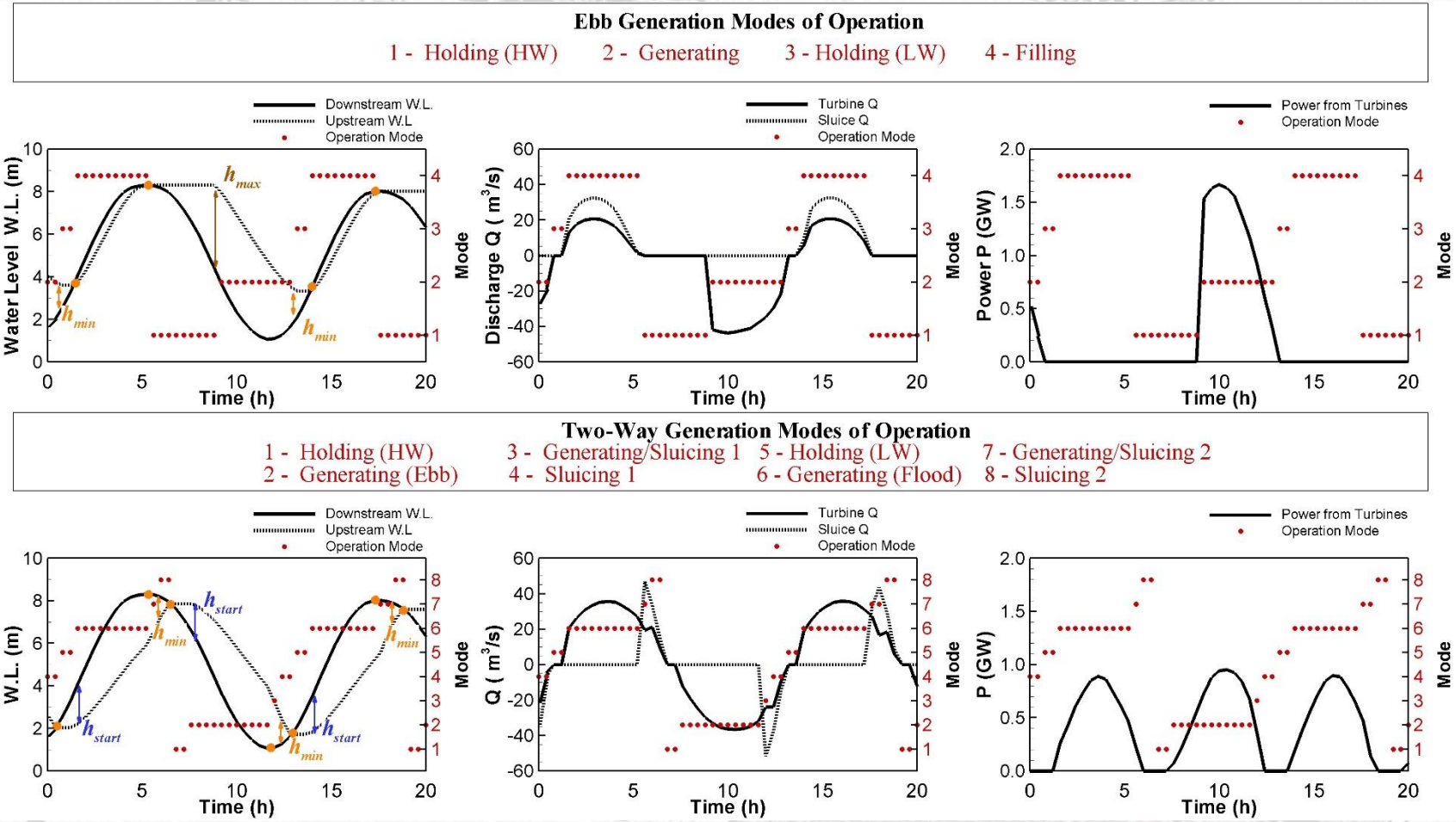
NRN-LCEE funded Lagoon workshop, Bangor University 17-18 May 2016

Workshop paper

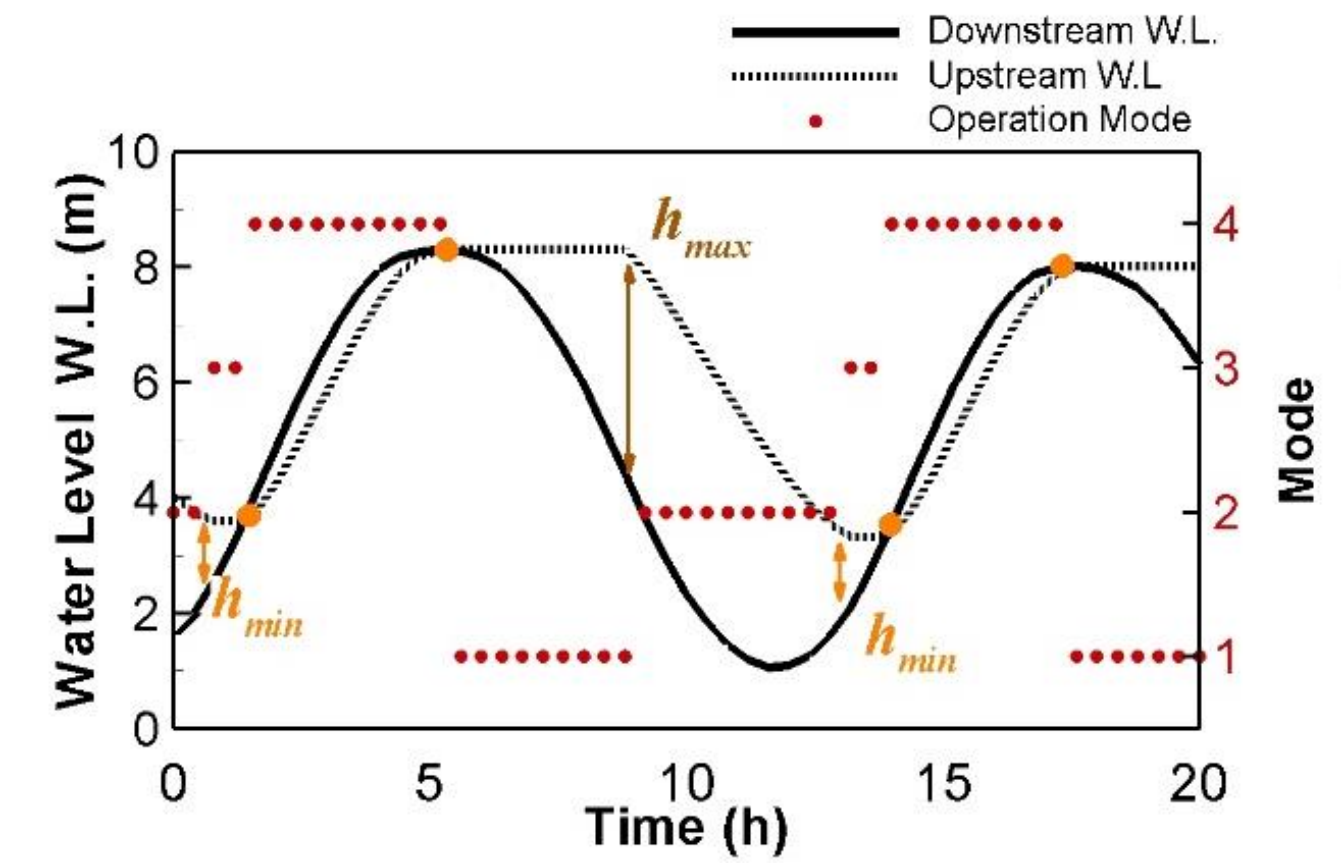
Neill, Robins, Angeloudis, Walkington, Ward, Masters, Lewis, Falconer, Piano, Avdis, Aggidis, Evans, Adcock, Piggott, Zidonis, Ahmadian. Tidal range energy resource and optimization – past perspectives and future challenges. *Renewable & Sustainable Energy Reviews* (in review).

[Bangor, Imperial, CSB Consilium, Swansea, Cardiff, Lancaster, Intertek, Oxford]

0D modelling – various operating strategies



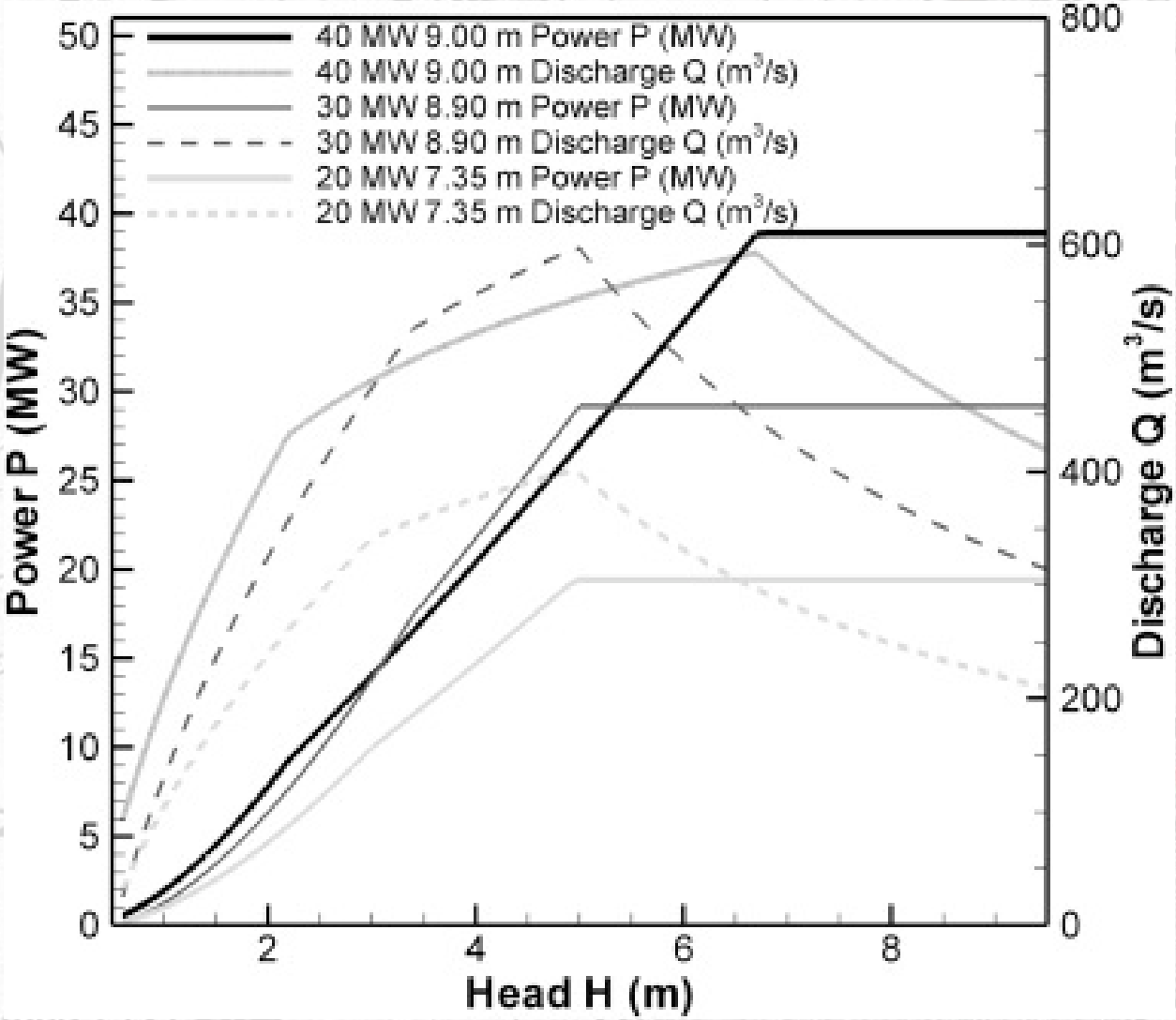
Ebb generation



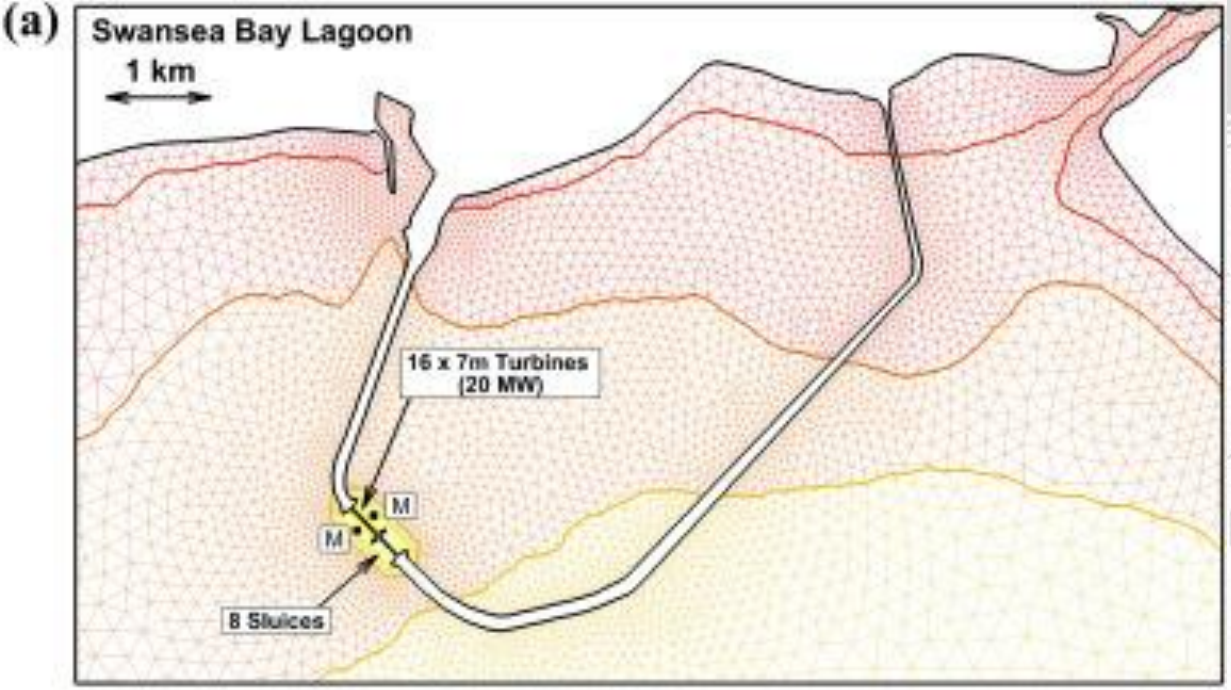
Ebb Generation Modes of Operation

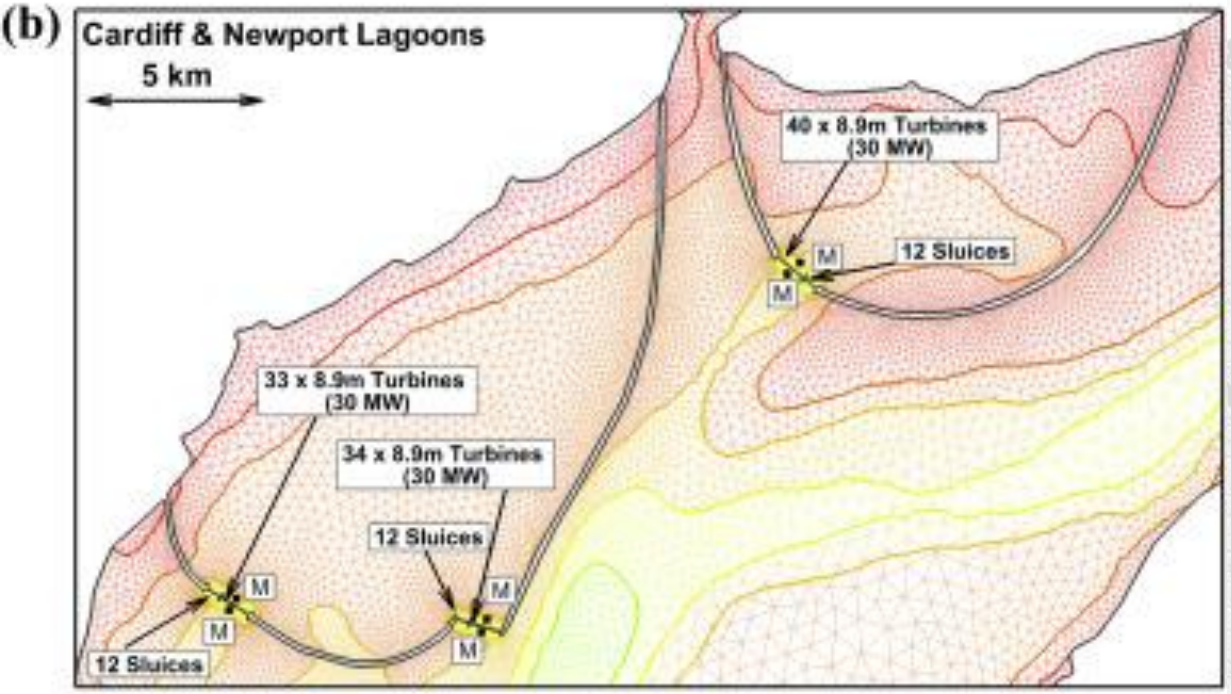
1 - Holding (HW) 2 - Generating 3 - Holding (LW) 4 - Filling

Hill charts for various lagoons/turbines



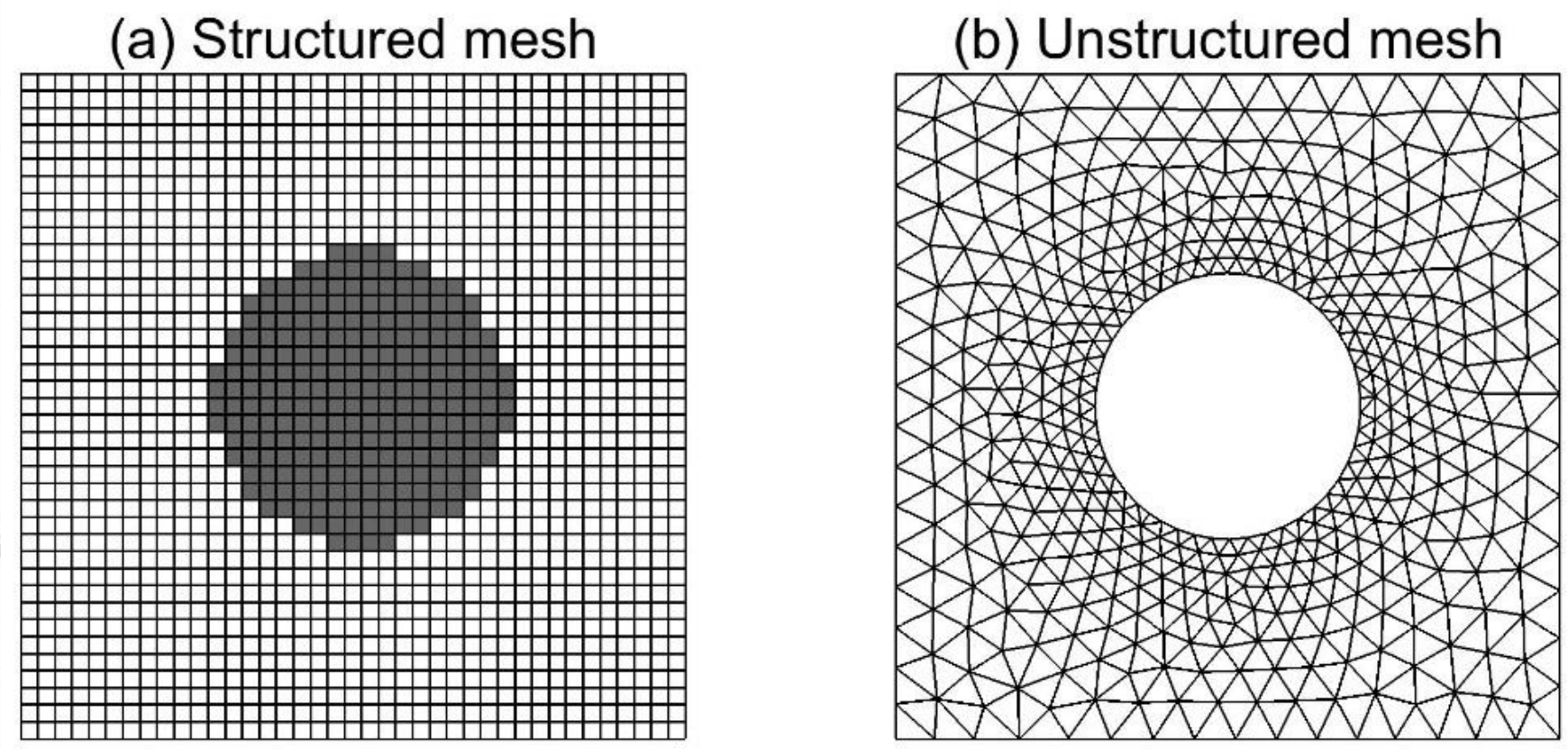
Angeloudis & Falconer (2017)





Angeloudis & Falconer (2017)

2D modelling – structured v unstructured mesh

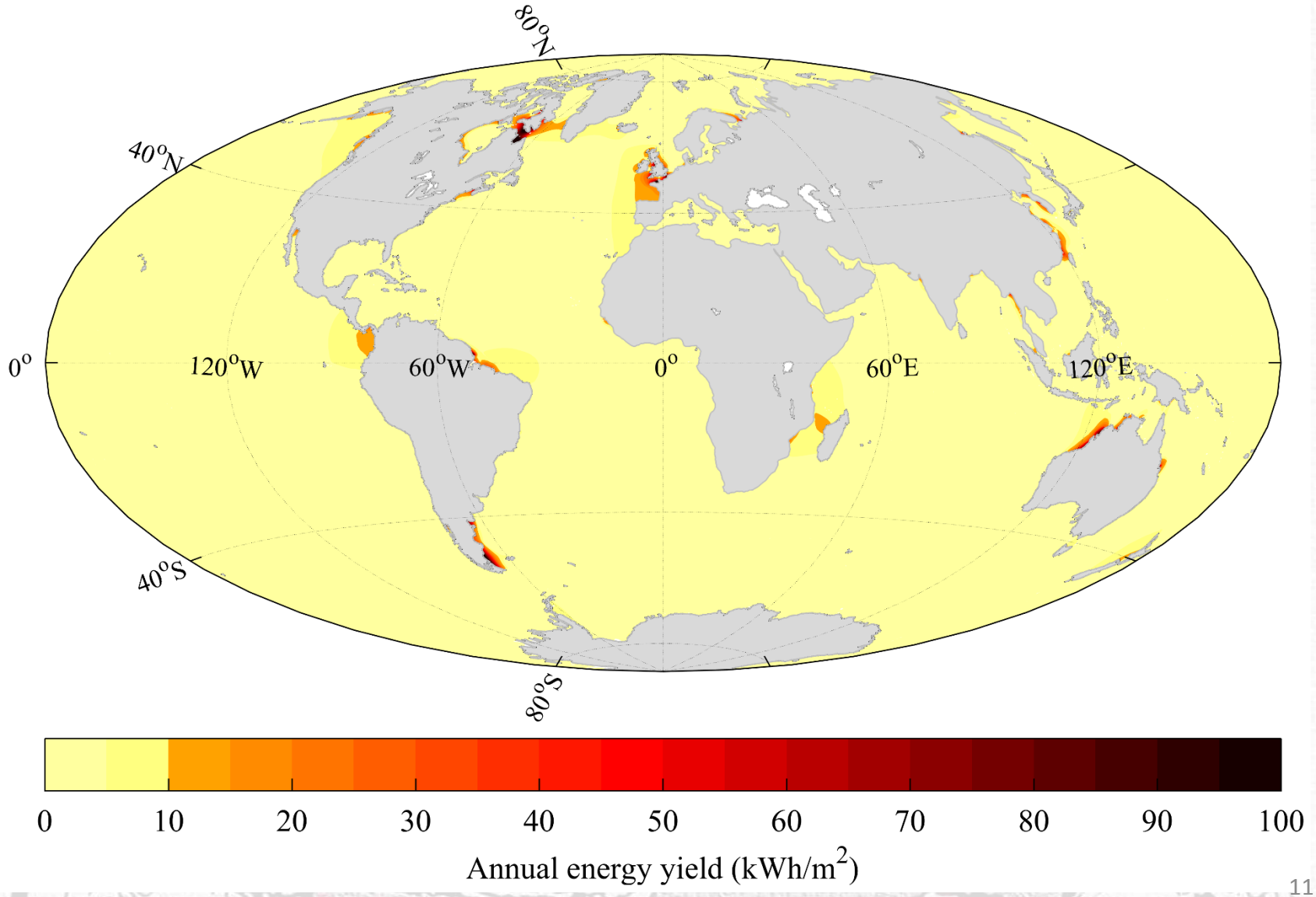


Annual energy predictions for various cases: 0D versus 2D studies

Case	Operation	Area (km^2)	Location	0D prediction (TWh/yr)	2D prediction (TWh/yr)	Hydrodynamic impact on power production (%)
Swansea Bay Lagoon	Two-way	11.6	Bristol Channel	0.53	0.49	6.8
Clwyd Impoundment	Two-way	125	North Wales	2.74	2.63	3.8
Severn barrage (HRC)	Two-way	573	Severn Estuary	25.01	22.05	38.9
Severn Barrage (STPG)	Ebb-only	573	Severn Estuary	23.03	15.77	31.5

STPG=Severn Tidal Power Group; HRC=Hydro-environmental Research Centre, Cardiff

Global resource assessment

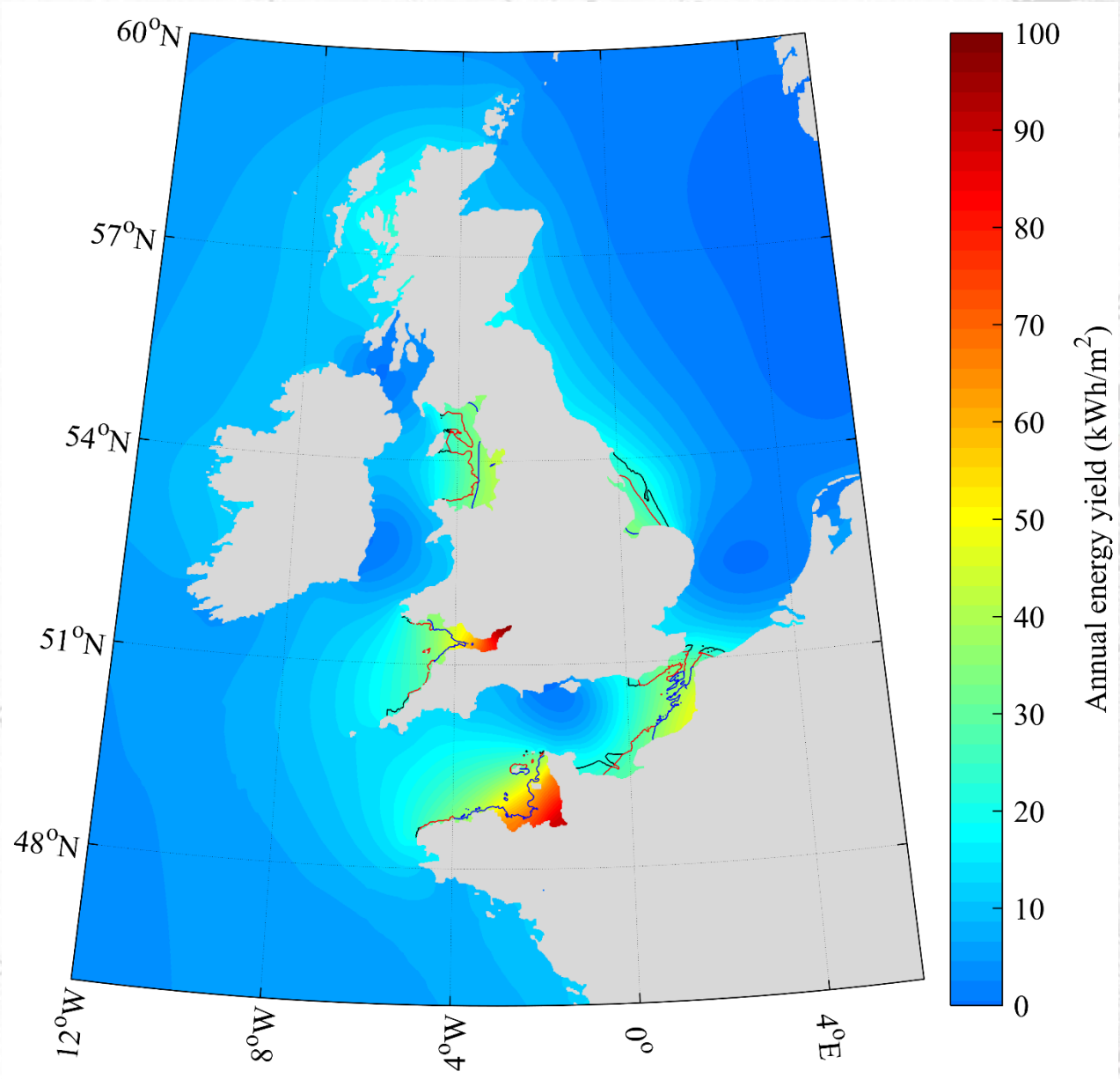


Annual potential yield (top 6 sites*)

Country	Annual PE (TWh)	% of global resouce
Australia	1760	30
Canada (Fundy)	1357	23
UK	734	13
France	732	13
US (Alaska) (partial sea ice)	619	11
Brazil	298	5

*Excluding Hudson Bay

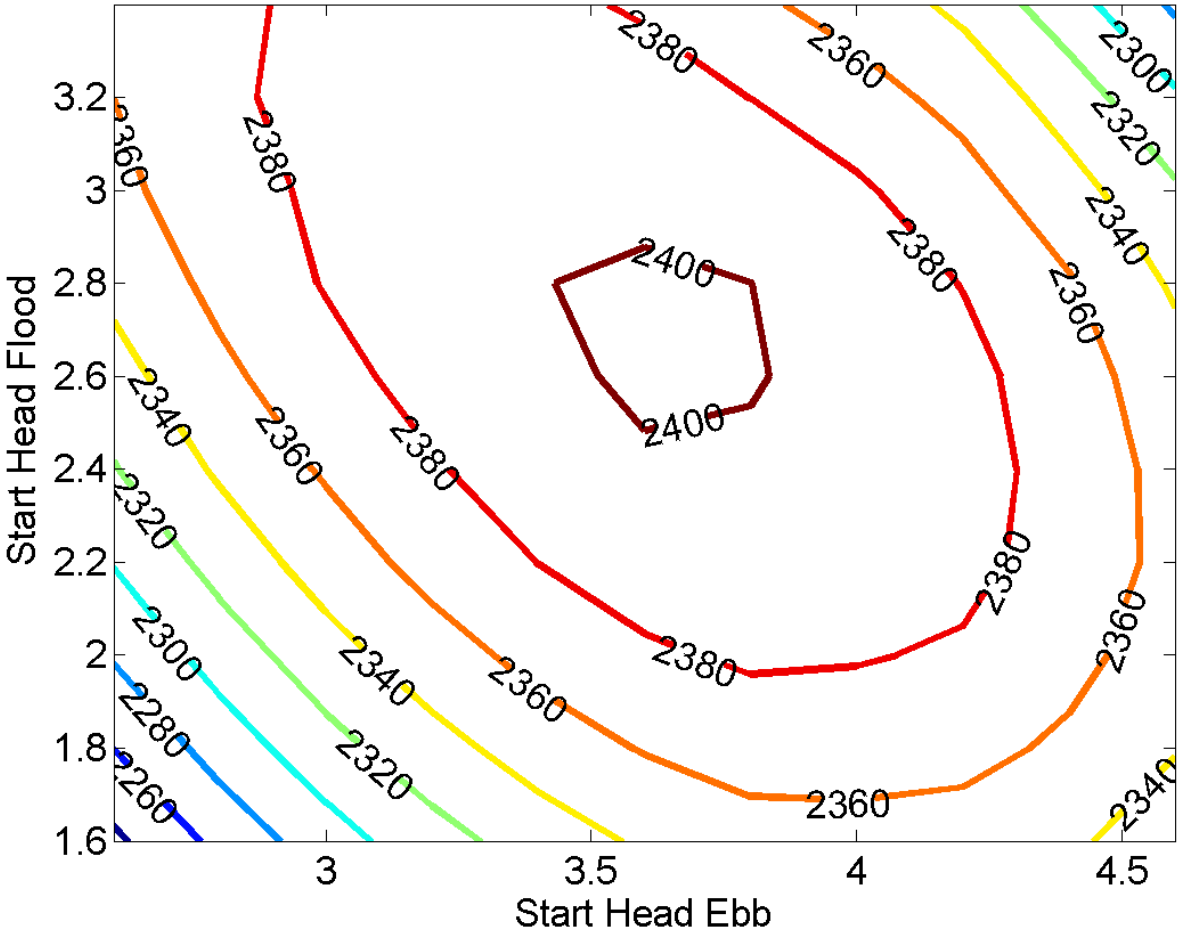
UK tidal range resource



Model resolution ~ 1 km

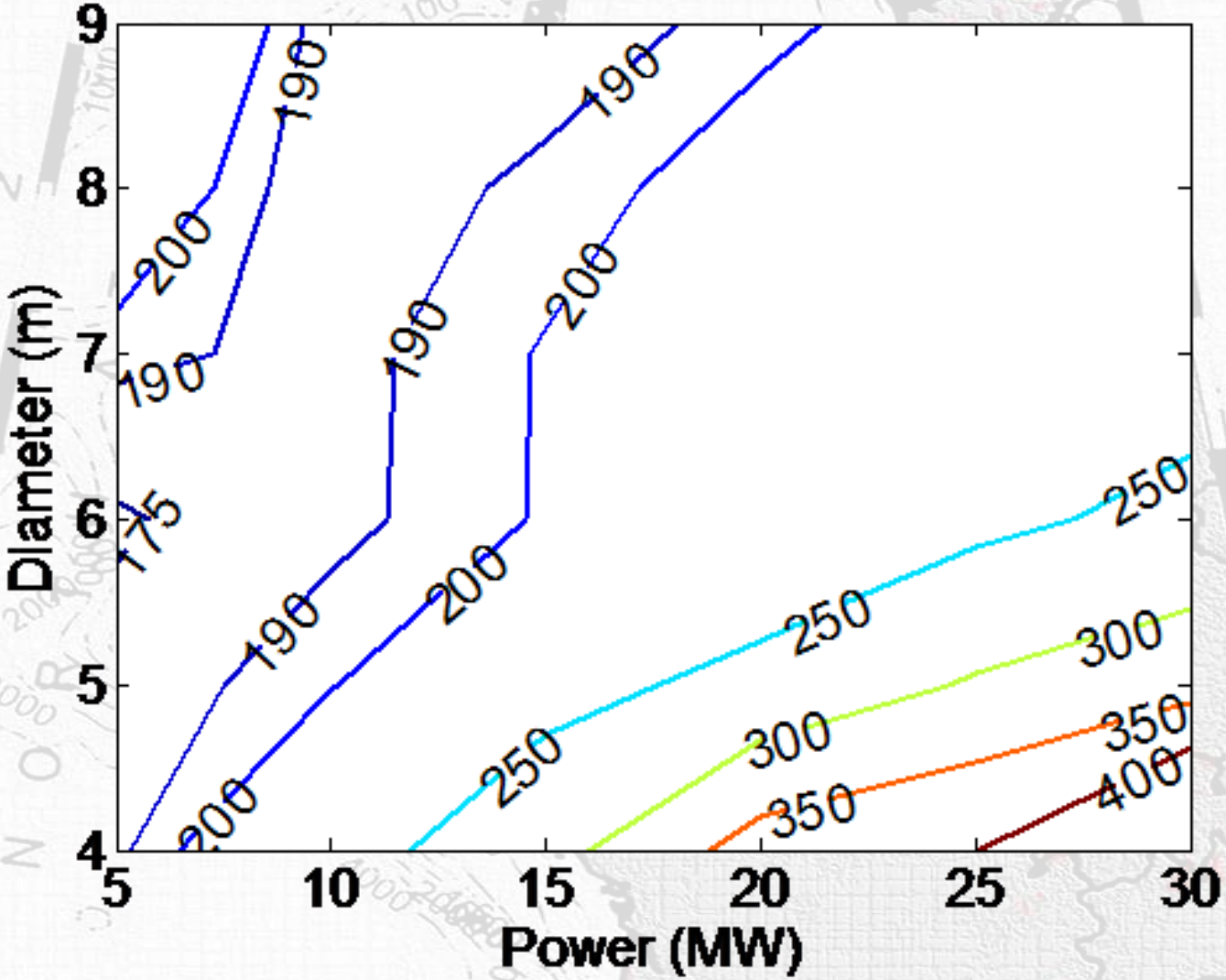
Contour lines –
Water depth < 30m and:
Blue > 84 kW/m²
Red > 60 kW/m²
Black > 50 kW/m²

Energy optimization



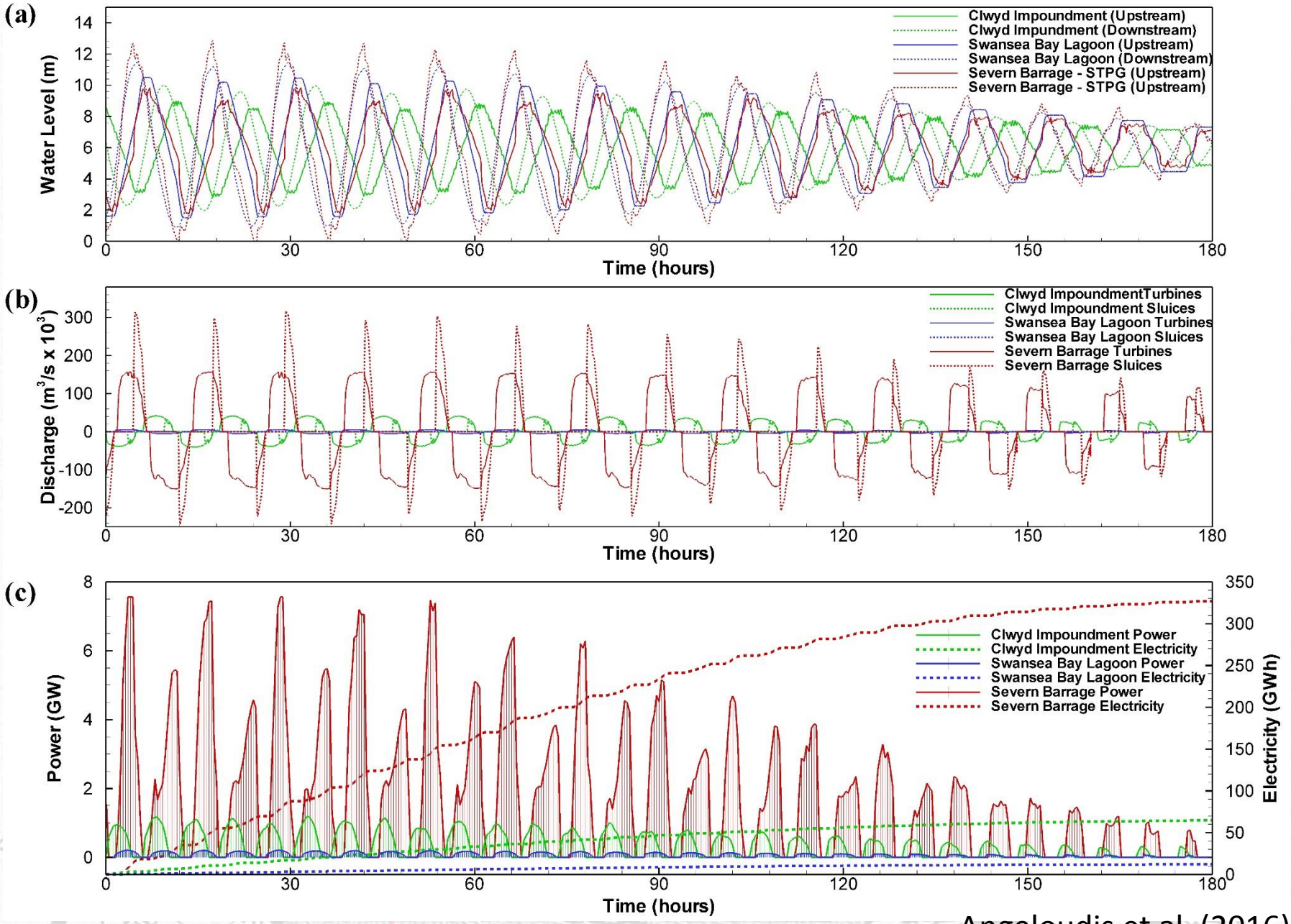
Energy yield (GWh) estimated using a 0D modelling approach

Economic optimization



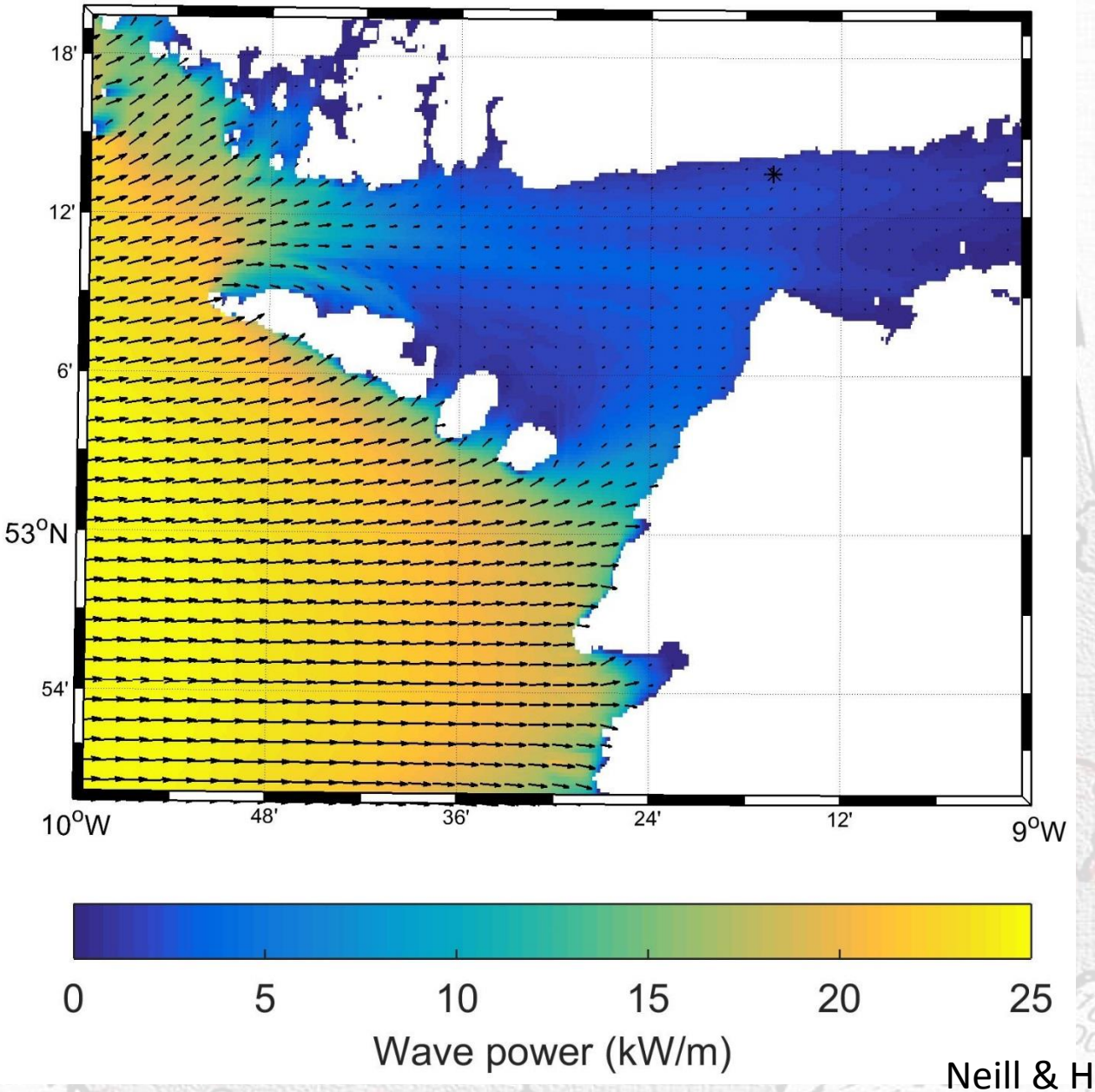
LCoE (£/MWh) for varying turbine design

Multiple lagoon operation



Angeloudis et al. (2016)

Wave modelling & coastal processes



Neill & Hashemi (2017)

Other considerations (resource and optimization)

- Long timescale change (SLR)
  - Generally a 1-3% increase in resource over the 21st century (Bangor paper in prep.)
- Storm surge influence on resource (Lewis et al. 2017)
- Storage
- Multiple lagoon interaction
- Potential for insights from 3D models
- Coupled models (e.g. wave-tide-atmosphere-sediments)

Lewis, M., Angeloudis, A., Robins, P., Evans, P. S. and Neill, S. (2017) Influence of storm surge on tidal range energy. *Energy* 122, 25-36.