The role of Tidal Stream Energy in Achieving the UK's Net Zero 2050 Goals

Dr. Daniil Hulak
Dr. Marko Aunedi
Brunel University of London

Brunel University of London

Outline

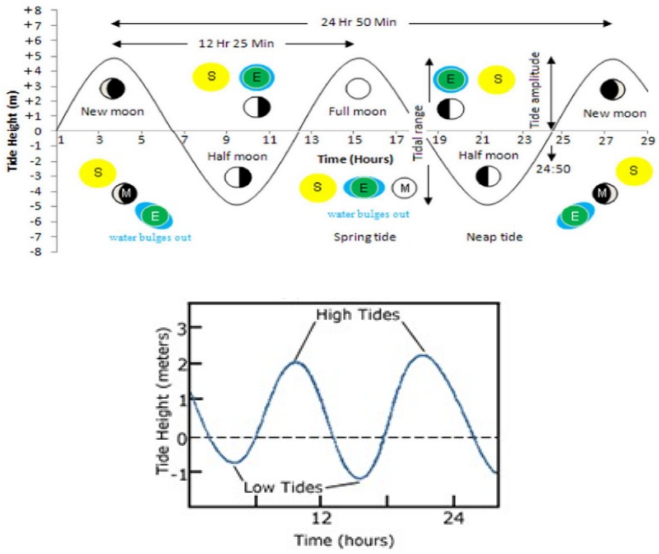
- Tidal stream overview
- Investigation of GIS-based tools for tidal resource allocation
- Assessment of tidal resources using reduced GB transmission grid model

Tidal stream technology basics

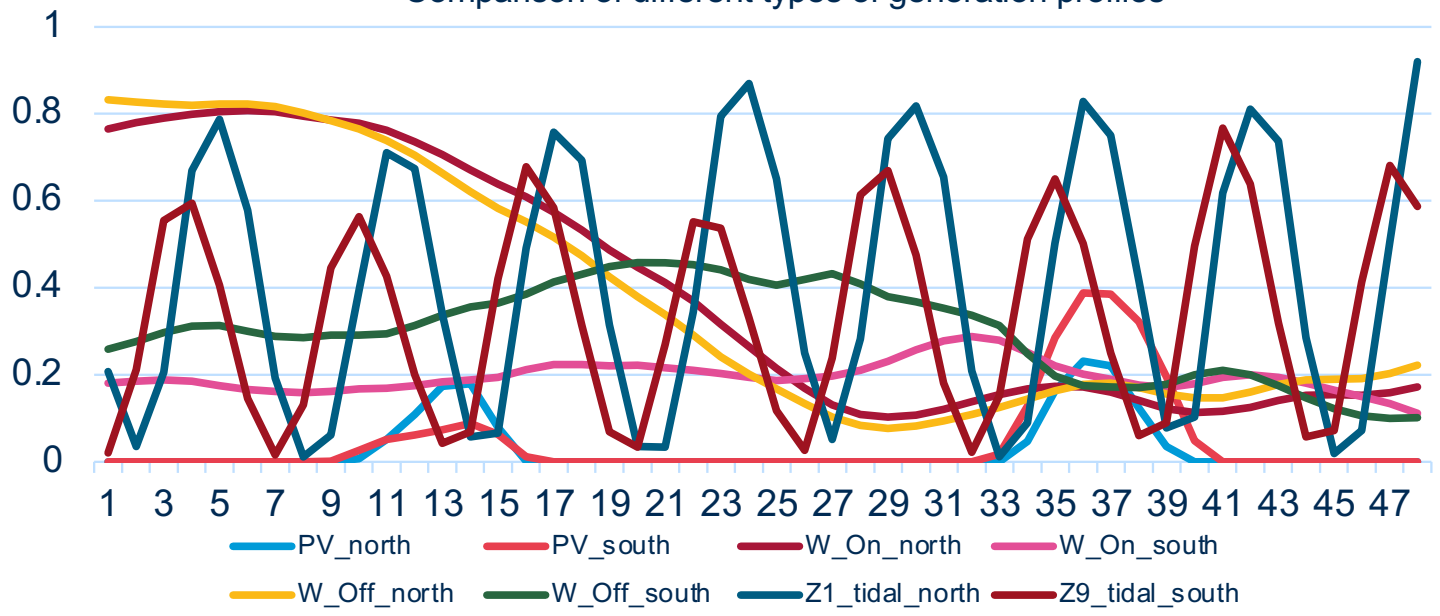
Brunel University of London

Examples of tidal stream generators

Tidal oscillations



Comparison of different types of generation profiles



Tidal energy in Future Energy Scenarios (FES) 2024

Brunel University of London

Project Name	Connection Site	MW Connected	MW Increase_Decreas	MW Total	MW Effective Date	Project Status	HOST TO	Plant Type
Menter Mon Morlais Anglesey Marine Er	Penrhos GSP	0	40	40	31/03/2028	Scoping	NGET	Tidal
Menter Mon Morlais Anglesey Marine Er	Penrhos GSP	0	20	60	31/03/2029	Scoping	NGET	Tidal
Menter Mon Morlais Anglesey Marine Er	Penrhos GSP	0	40	100	31/03/2030	Scoping	NGET	Tidal
Menter Mon Morlais Anglesey Marine Er	Penrhos GSP	0	80	180	31/03/2032	Scoping	NGET	Tidal
MeyGen Tidal	Gills Bay GSP	0	28	28	01/04/2027	Consents Approved	SHET	Tidal
MeyGen Tidal	Gills Bay GSP	0	43	71	01/04/2028	Consents Approved	SHET	Tidal
MeyGen Tidal	Gills Bay GSP	0	83	154	01/04/2028	Awaiting Consents	SHET	Tidal
MeyGen Tidal	Gills Bay GSP	0	83	237	01/04/2028	Awaiting Consents	SHET	Tidal
MeyGen Tidal	Gills Bay GSP	0	50	287	31/10/2030	Scoping	SHET	Tidal
Port of Mostyn	Connah's Quay 400kV Substation	0	210	210	01/04/2027	Scoping	NGET	Tidal

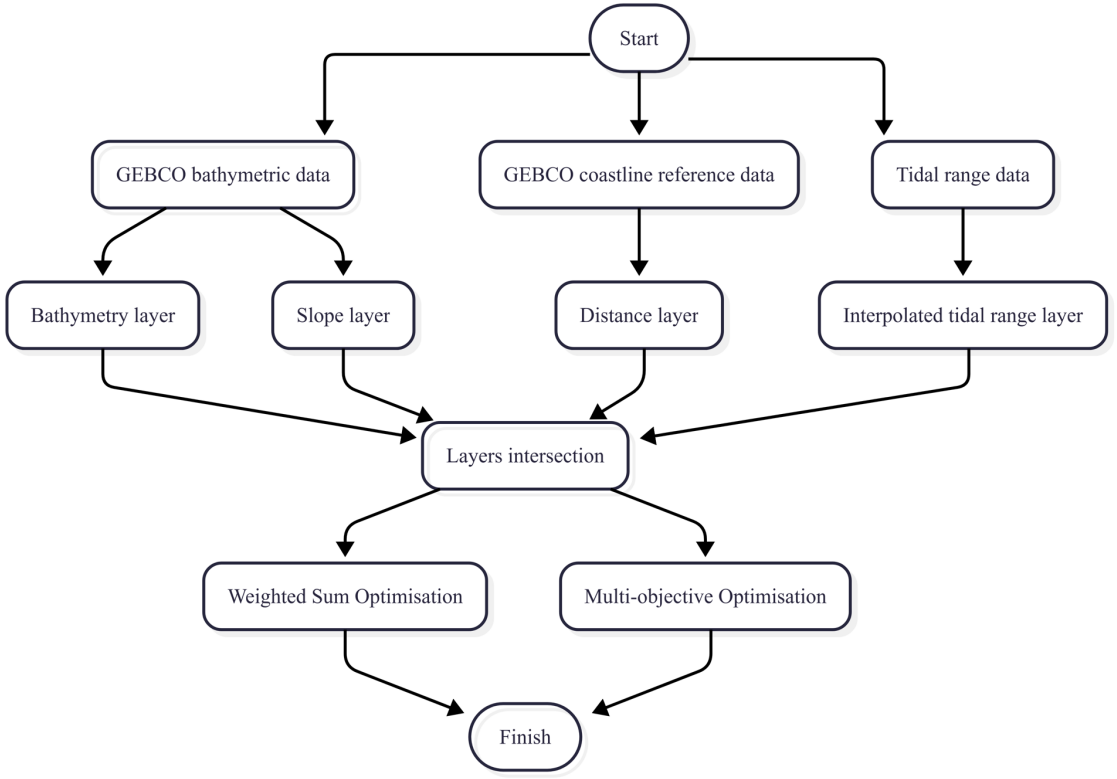
- Overall new capacity in 2030: 667 MW
- No clear distinction between tidal stream and tidal range
- Existing UK tidal projects that received CfD:
  - AR4 – 41 MW, £211/MWh
  - AR5 – 53 MW, £198/MWh
  - AR6 – 28 MW, £172/MWh

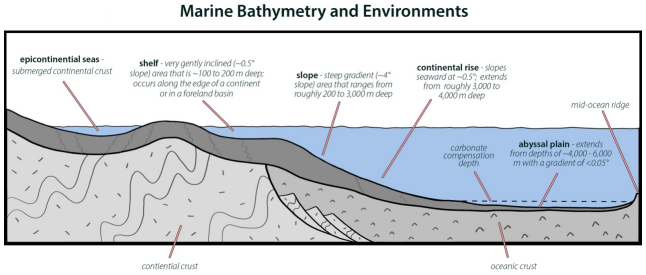
General approach to tidal resource assessment, assumptions and data

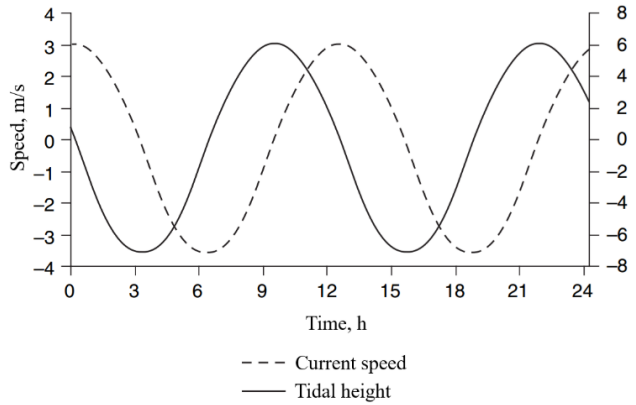
- Focus on tidal stream projects assessment (lower cost and less environmental impact)
- Built bathymetry grid maps + tidal heights map
- Optimal depth for tidal stream assumed at 35-45 m (based on Korte at al., 2024 for Germany) and at velocities of more than 2.5 m/s (Lewis at al., 2015 for Irish Sea)
- There is a correlation/link between tidal height and tidal currents

GEBCO_2024,15 arc-second interval grid in TIFF format

Framework for tidal resource assessment

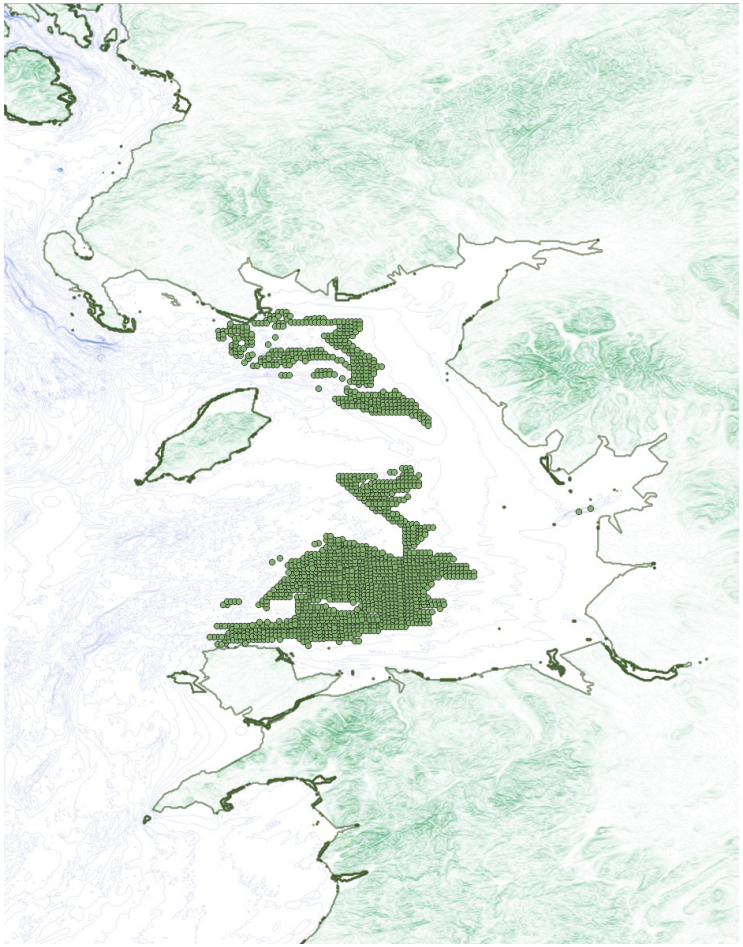


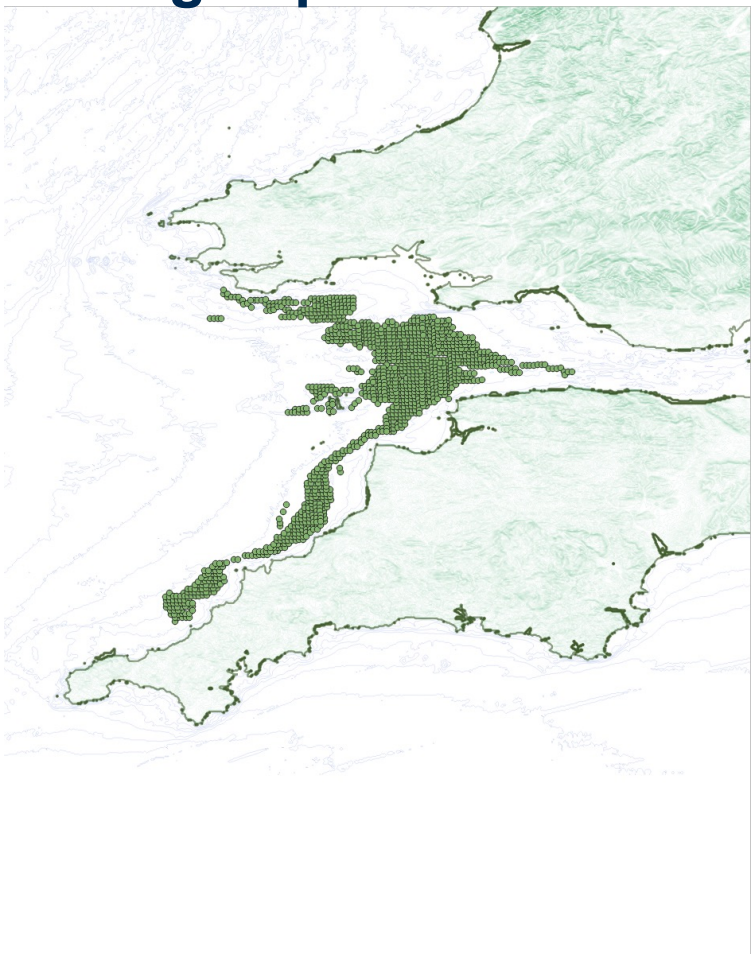




35 m > depth > 45 m
Slope ---> min
Distance to the shore ---> min
Height range ---> max, range > 5 m

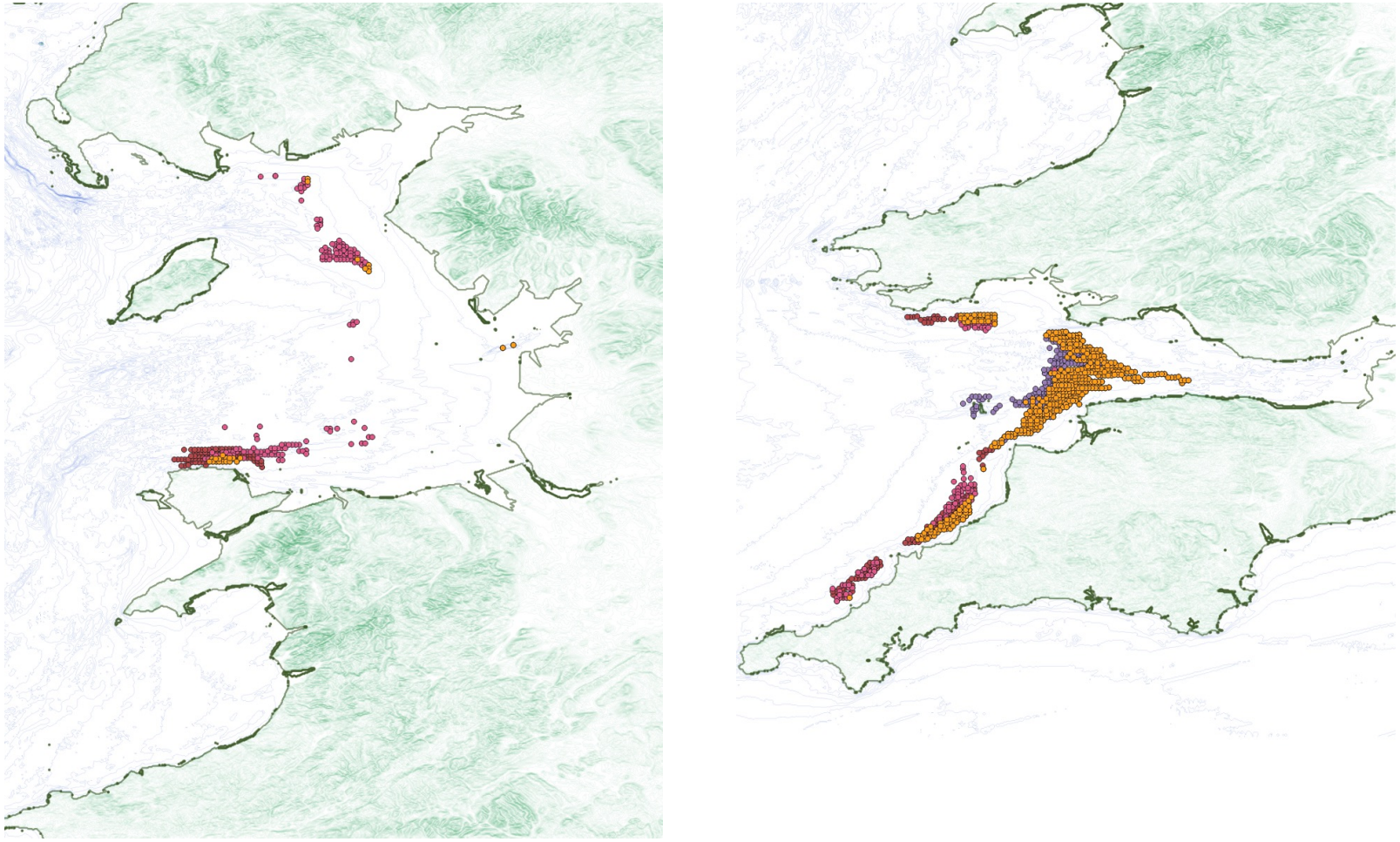
Results of the initial stage optimisation





35 m > depth > 45 m
Slope less than 1 degree
Distance to the shore less than 50 km
Height range > 5 m

Results of the optimisation

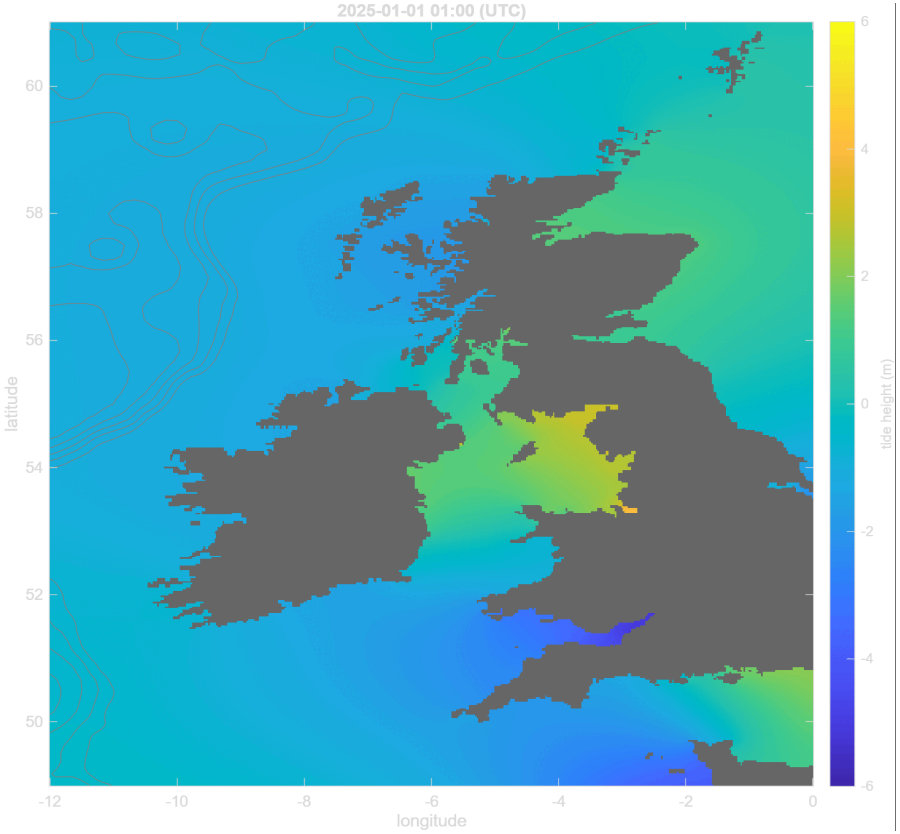


- Optimisation with coefficients 0.33-0.33-0.34
- Optimisation with coefficients 0.1-0.1-0.8 (slope priority)
- Optimisation with coefficients 0.1-0.8-0.1 - (height range priority)
- Optimisation with coefficients 0.8-0.1-0.1 (distance to shore priority)

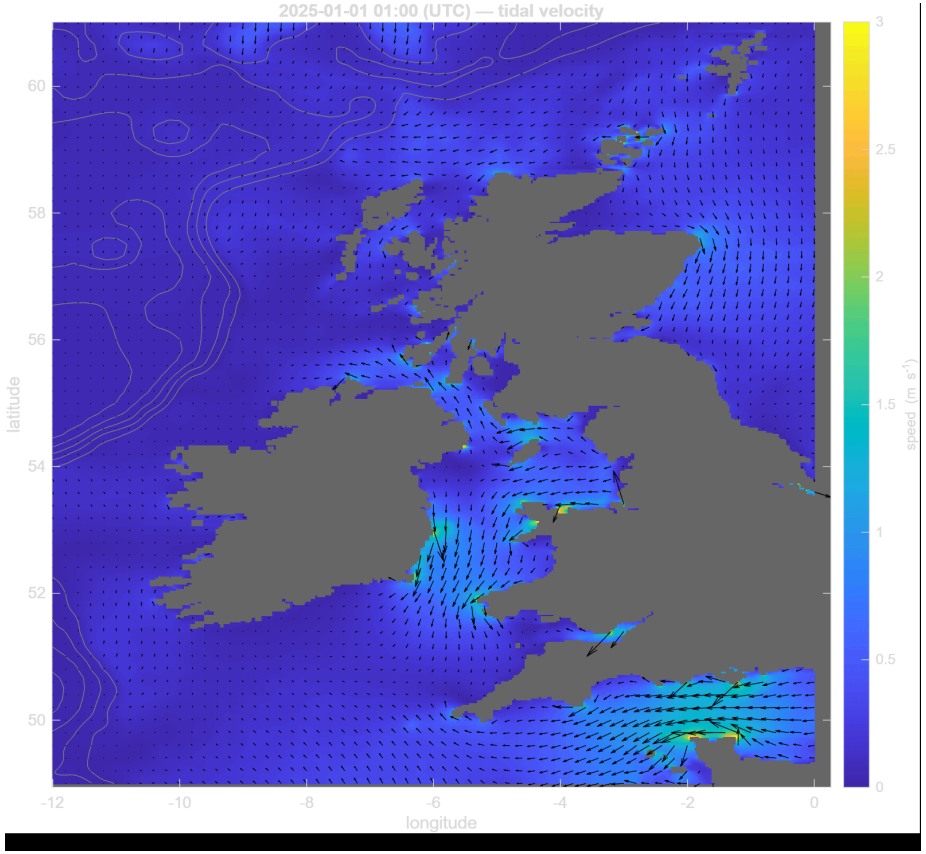
TPXO data for the research

Brunel University of London

Tidal range change



Tidal velocity change

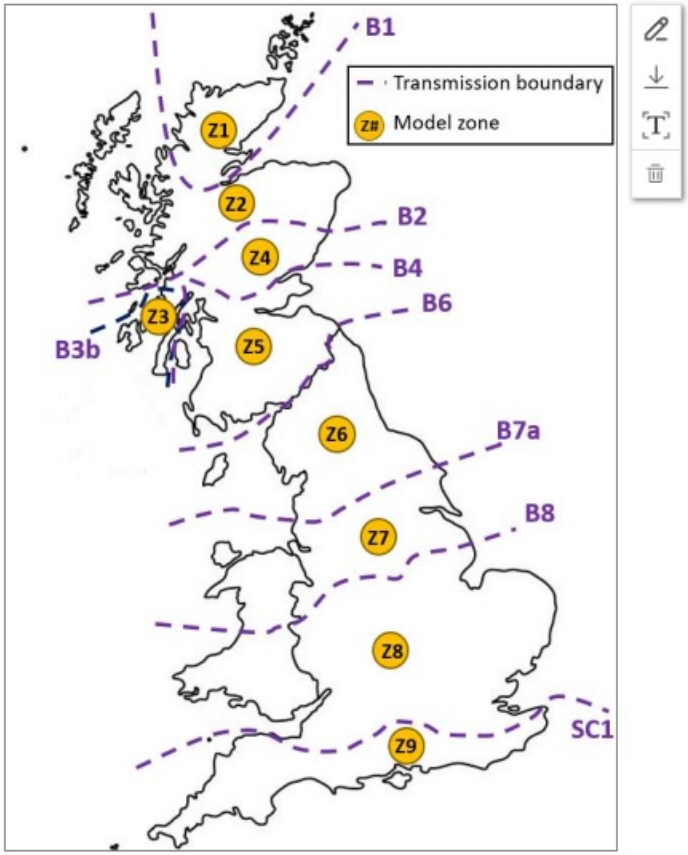


Power system simulation with tidal stream generators

Applied Energy
Volume 347, 1 October 2023, 121413

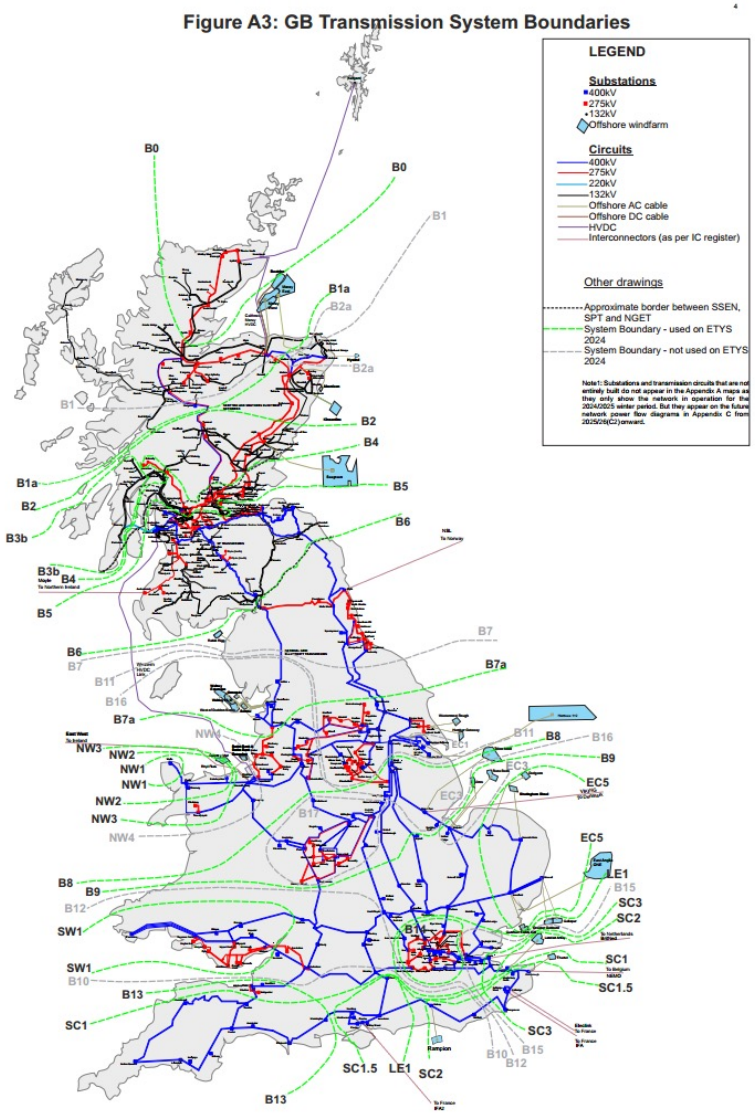
A modelling framework to quantify the power system benefits from ocean energy deployments

Shona Pennock [a], Donald R. Noble [a], Yelena Vardanyan [b], Timur Delahaye [c], Henry Jeffrey [a]

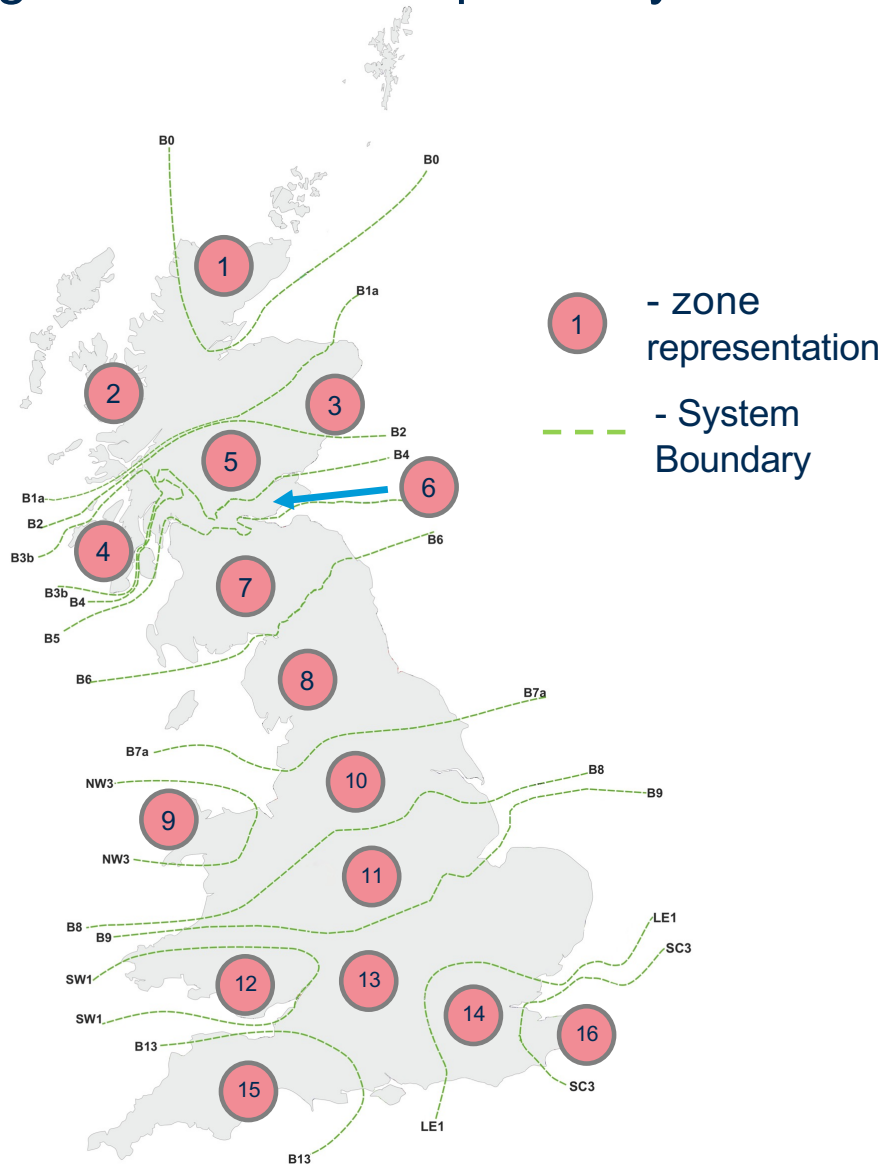


- Uses simplified network modelling (9 zones)
- Analysis integrates yearly generation and demand profiles, hourly dataset
- Uses open-source software PyPSA + Gurobi optimiser
- Contains a transparent and reproducible framework

UK power system based on ETYS 2024

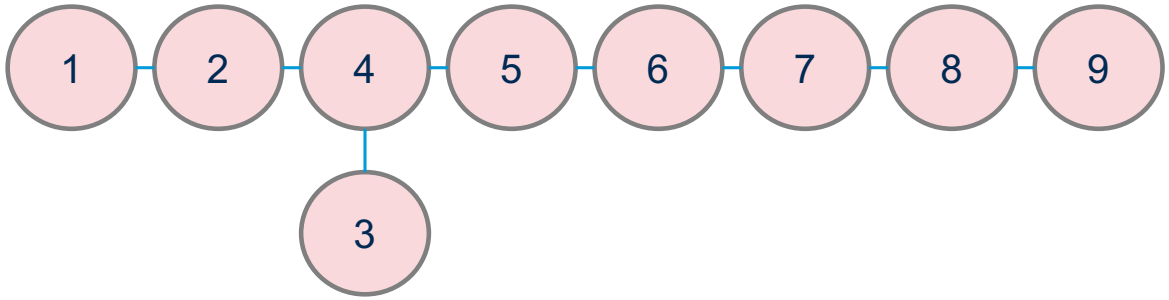


Aggregated 16-zone UK power system

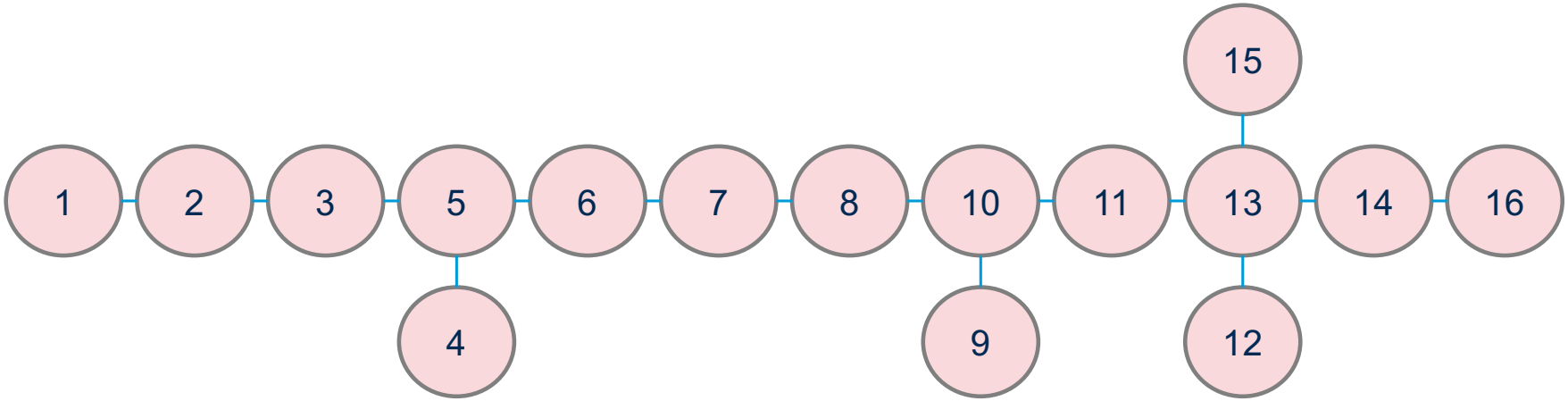


Enhanced granularity of transmission grid

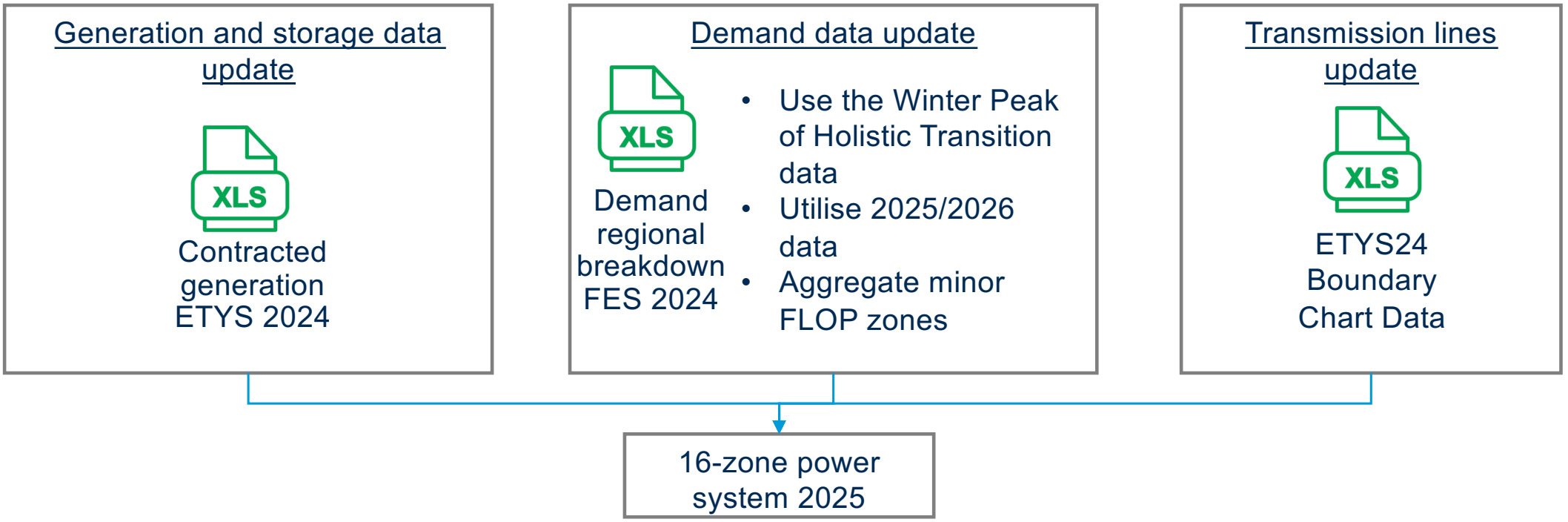
Previously applied approach



Proposed approach



16-zone reduced system representation



Power generation 2025, MW

GENERATOR TYPE	ZONE																TOTAL
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Biomass						55		681	150	1920			79	43			2928
CCGT			1180				20	141		7660	3957	3069	4824	5449	915	1527	28742
CHP							120	155		1268	226		158	30	129	36	2122
Coal																	0
Gas Reciprocating										70	20	21	64	750		100	1025
Hydro		475		168	230				49	30		50					1001
Nuclear							2270	3570					1230		1061		8131
OCGT										709	1624	339	915	140	146		3873
Oil & AGT													62				62
Pump Storage		300				440			2004								2744
PV			66		150		241	135		600	733	57	1130	470	140	400	4122
Thermal											35	21	186		57		299
Waste			40								50						90
Wind Offshore	100	1388	1045		1685	448	1080	5676	832	4237	824		4557	400		930	23202
Wind Onshore	1165	1450	160	349	297	43	6621			32		388					10505
TOTAL	1265	3613	2491	516	2362	986	10351	10358	3035	16525	7468	3945	13205	7282	2448	2993	88845

Demand 2025, MW

Zone	Demand, MW
1	85
2	345
3	446
4	71
5	404
6	894
7	2185
8	4060
9	282
10	11276
11	7836
12	2320
13	11011
14	13269
15	2981
16	517
TOTAL	57981

Storage 2025, MW

Zone	Storage
2	200
3	100
5	624
6	1031
7	2082
8	691
10	1756
11	562
12	250
13	1284
14	1051
15	407
16	499
Total	10538

Subtracted generation		Added generation		Coefficients applied
Zone	Capacity	Zone	Capacity	
Zone 1	100 MW onshore wind 1165 MW offshore wind	Zone 1	1643 MW tidal stream	Onshore wind = tidal stream Offshore wind = tidal stream * 1.325 PV = 0.3 * tidal stream
Zone 9	832 MW offshore wind	Zone 9	1102 MW tidal stream	
Zone 12	57 MW PV 388 MW onshore wind	Zone 15	447 MW tidal stream	
Zone 15	140 MW PV			

Preliminary simulation results

Generators outputs, price and CO2 emissions assessment

Generator type	SC0, TWh	Tidal, TWh	Dif, TWh	Price £/MWh	SC0, mln £	Tidal, mln £	Dif, mln £	CO2, t/MWh	SC0, mln t	Tidal, mln t	Dif, mln t
Biomass	22.05	22.04	-0.01	35	771.60	771.29	-0.3		0	0	0
CCGT	72.45	71.39	-1.05	113	8186.41	8067.43	-119.0	0.36	26.08	25.70	-0.38
CHP	0.00	0.00	0.00	182	0.00	0.00	0.0	0.51	0	0	0
Gas	0.02	0.01	-0.01	175	3.26	1.81	-1.4		0	0	0
Hydroelectric	4.04	3.90	-0.14	60	242.31	234.18	-8.1		0	0	0
Interconnector (BrittNed, Nemo…	0.00	0.00	0.00	250	0.00	0.00	0.0		0	0	0
Interconnector (EWICK)	0.00	0.00	0.00	250	0.00	0.00	0.0		0	0	0
Interconnector (IFA2)	0.00	0.00	0.00	250	0.00	0.00	0.0		0	0	0
Interconnector (Moyle)	0.00	0.00	0.00	250	0.00	0.00	0.0		0	0	0
Interconnector (NSL)	0.00	0.00	0.00	250	0.00	0.00	0.0		0	0	0
Interconnector (Viking Link)	0.00	0.00	0.00	250	0.00	0.00	0.0		0	0	0
Nuclear	57.89	57.81	-0.09	7	405.25	404.64	-0.6		0	0	0
OCGT	0.05	0.02	-0.03	175	9.14	3.47	-5.7	0.45	0.02	0.01	-0.01
Offshore Wind	105.10	101.07	-4.04	0	0.00	0.00	0.0		0	0	0
Oil and AGT	0.00	0.00	0.00	215	0.00	0.00	0.0		0	0	0
Onshore Wind	35.89	30.18	-5.70	0	0.00	0.00	0.0		0	0	0
Solar PV	4.49	4.28	-0.21	0	0.00	0.00	0.0		0	0	0
Thermal	1.23	1.23	0.01	60	73.54	74.01	0.5		0	0	0
Tidal Stream	0.00	11.23	11.23	0	0.00	0.00	0.0		0	0	0
Waste	0.56	0.55	0.00	60	33.51	33.23	-0.3		0	0	0
Grand Total	303.76	303.72	-0.03	X	9725.02	9590.06	-135.0		26.10	25.71	-0.39

Curtailment assessment

Generator type	Difference between scenarios, TWh
Biomass	0.01
CCGT	1.05
Gas	0.01
Hydroelectric	0.14
Nuclear	0.09
OCGT	0.03
Offshore Wind	-0.50
Onshore Wind	-0.26
Solar PV	-0.01
Thermal	-0.01

SC0 – initial scenario without changes in the system
Tidal – scenario with tidal stream generators substitution


Brunel
University
of London