Technical Study

MSP as a tool to support Blue Growth

Roundtable discussion paper: Tidal & Wave Energy, 11/ 12 October 2017

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Author: Bodil Skousen & Diletta Zonta, Ecorys
European MSP Platform Consortium Contractors:

with Thetis, University of Liverpool, NIMRD, and Seascape Consultants

Tidal & Wave Energy

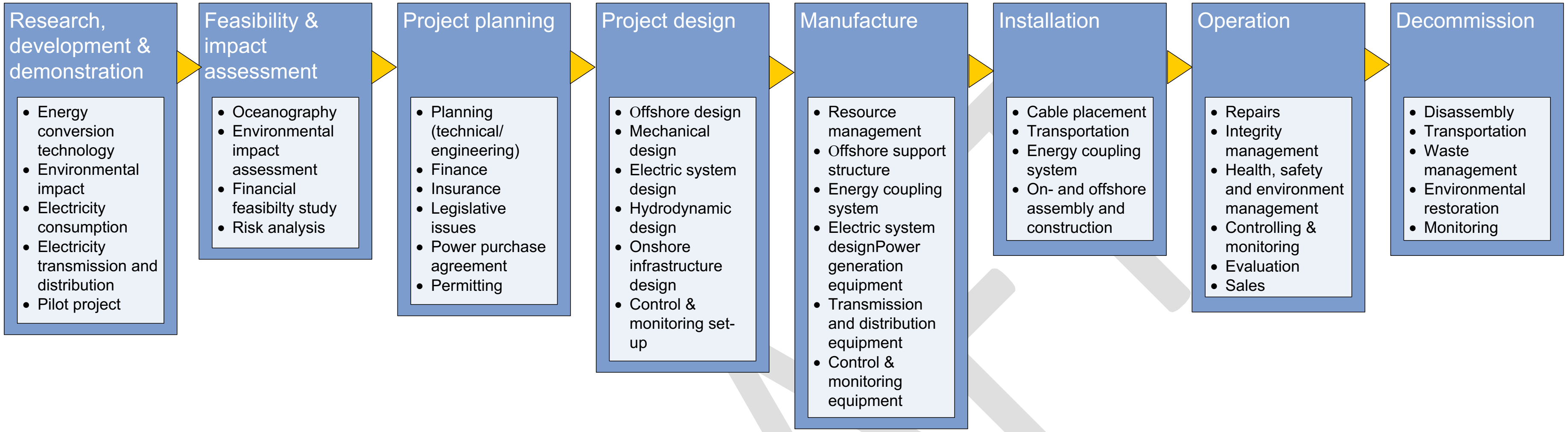
1 Introduction

Overall size of the sector and industry structure

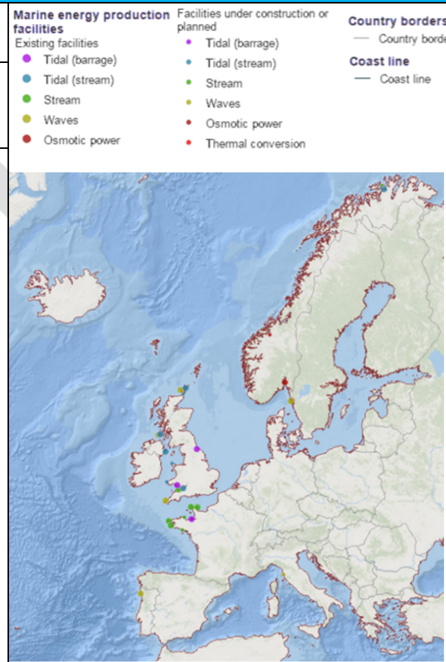
Mature ☐ Growing ☐ Emerging ☒

Tidal and wave energy are understood to be the main ocean energy technologies, others being salient gradient and OTEC[1,2]. Ocean energy technologies are all at different development stages: for the purpose of this factsheet, wave and tidal will be analyzed. Wave energy is dependent on wave height, speed, length and the density of the water, whereas tidal energy is generated by the difference in surface height in a dammed estuary, a bay or a lagoon[3] (tidal barrage) and the kinetic energy in the currents caused by the tides (tidal stream)[4]. Tidal and wave are the more developed segments of ocean energy, with tidal energy currently being more advanced. Some areas being close to launch full consenting procures for tidal stream projects, e.g. Wales. Early tidal applications focused on tidal barrage, but most developments are now focusing on tidal stream technology such as large tidal stream projects, e.g. Wales, were are getting close to launch full consenting procedures. A small number of tidal stream devices have been tested at sea in full-scale demonstrations (notably Scotland and France)[5].

[1] Ocean Energy Forum, Ocean Energy Strategic Roadmap Building Ocean Energy for Europe, 2016
[2] In some countries (e.g. France, Spain, Portugal), (floating) offshore win is also considered as ocean energy. However these will be treated in the factsheet on 'Offshore wind'
[3] DG MARE, Energy sectors and the implementation of the Maritime Spatial Planning Directive, 2015, 11
[4] Ecorys et al., Blue Growth – Scenarios and drivers for Sustainable Growth from the Oceans, Seas and Coasts, 2012
[5] Ocean Energy: Technology Information Sheet https://setis.ec.europa.eu/related-jrc-activities/jrc-setis-reports/ocean-energy-technology-information-sheet



Value chain for tidal and wave energy. Source: Ecorys et al., 2012

Time horizons			Spatial characteristics			
Seasonal	No		Place based	Yes	Requiring specific spatial conditions	[6] **Figure 1: Wave and tidal locations in**
Planning horizon	2050		Linear			
Development time	2-3 years	Development of individual projects	Distance to shore and water depth	Wave : o Shoreline devices: fixed to or embedded in the shoreline o Near-shore devices: deployed at 20-25m. water depth at distances up to 500m. from the shore; o Offshore devices: deployed in powerful wave resources in water depths over 25m. Tidal stream: usually deployed in water depths of 15m. and over, while resources can also be found at shallower depths ; Tidal barrage: deployed near-shore in resource-intensive areas, across a bay or river		
	15-30[7] years	Horizon still unknown due to limited certainty on future conditions and future technological development	Moving			
Lifetime of installation	5/10 years	Up until now, testing devices are put in the water for short periods of time (< 1 year). Industrial roll-out would require much longer time spans (5-10 years).	Land Sea interaction	Yes & No	Yes due to grid connectivity and maintenance and No as what concerns to installations	

[6] Source: European Atlas of the Seas
[7] IFP Energies nouvelles (IFPEN) School

2 Relevance

General

Main locations of tidal stream resource in Europe include in areas around Scotland, including the Orkney Islands, off the coast of Northern Ireland, off the coast of Normandy and Brittany and between the Greek islands Korfu and Paxi and the Greek mainland, Spain the Netherlands and Denmark[8]. Main locations for wave energy resources are the Atlantic Ocean (United Kingdom, Ireland, Spain, Portugal and France) and the North Sea (Denmark)[9].

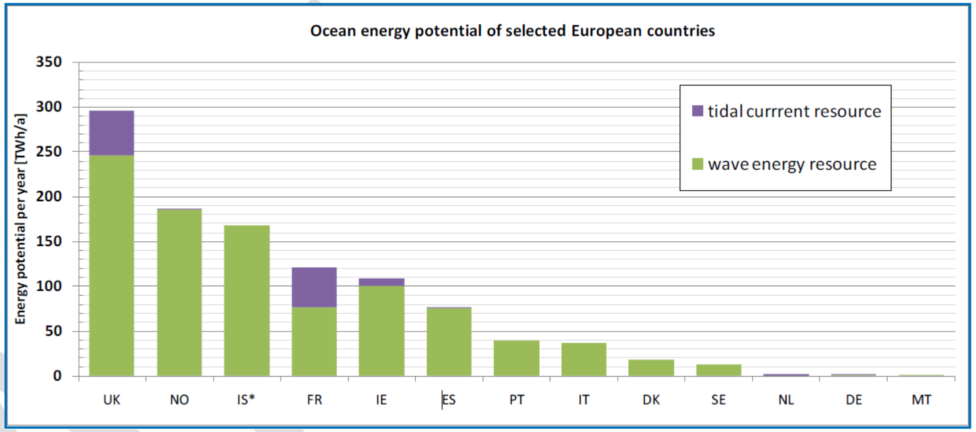
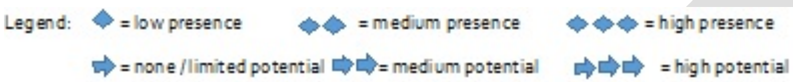


Figure 2 Tidal current and wave potential in Europe. *Source: Fraunhofer IWES, Lessons learnt on Ocean Energy, 2017, p. 9*



Status in each Sea Basin (Table 1 [10])

Sea Basin	Presence	Potential	Comments
Atlantic	◆◆◆	➔➔➔	Considerable activity, both tidal and wave potential
Baltic Sea	◆	➔	Minor activity, mostly testing potential
Black Sea	-	➔	No activity and very limited potential
East Med	◆	➔	Some tidal activity (Greece), limited potential

[8] Ecorys, Lessons Learnt on Ocean Energy Development, 2017, 13
[9] Ecorys, Lessons Learnt on Ocean Energy Development, 2017, 21
[10] Table based on expert judgment and assessment of the sources quoted throughout the document.

North Sea	◆◆	➡➡	Some activity, tidal and wave potential
West Med	◆	➡	No activity, limited potential

Status in each EU Country (Table 2[11])

Sea Basin	Country	Presence	Potential	Comments
Atlantic	Ireland	◆◆	➡	Wave deployed in Bernera
Atlantic	Portugal	◆◆	➡	Wave deployed in Peniche
Atlantic / North Sea	United Kingdom	◆◆◆	➡➡	Tidal and wave deployed in Scotland and Wales: Meygen Pentland Firth, Shetland Tidal Array, Wello CEFOW project, European Marine Energy Centre
Atlantic / West Med	France	◆◆◆	➡➡	Large scale tidal in pre-commercial in Paimpol Bréhat, Fromveur and Ushant island in Brittany, and Raz Blanchard in Normandie
Atlantic / West Med	Spain	◆◆	➡	Wave prototypes The Cantabria Coastal and Ocean Basin, Canal de Experiencias Hidrodinámicas de el Pardo, Canal de Ensayos Hidrodinámicos, Canal d'Investigació I Experimentació Marítima
Baltic Sea	Sweden	◆	➡	Wave prototypes in Smogen
Baltic Sea / North Sea	Denmark	◆	➡	Wave prototypes in Hanstholm
Baltic Sea / North Sea	Germany	◆	➡	No plans
East Med / West Med	Italy	◆	➡	ENEL Green Power, Sicily and Western Sardinia
North Sea	Netherlands	◆◆	➡	Tidal technology deployed Tocardo Eastern Scheldt barrier, Zeeland

[11] Table based on expert judgment and assessment of the sources quoted throughout the document. **Note: No information was found for the status at the following countries: Estonia; Finland; Latvia; Lithuania; Poland; Bulgaria; Romania; Croatia; Cyprus; Greece; Slovenia; Belgium; Malta.**

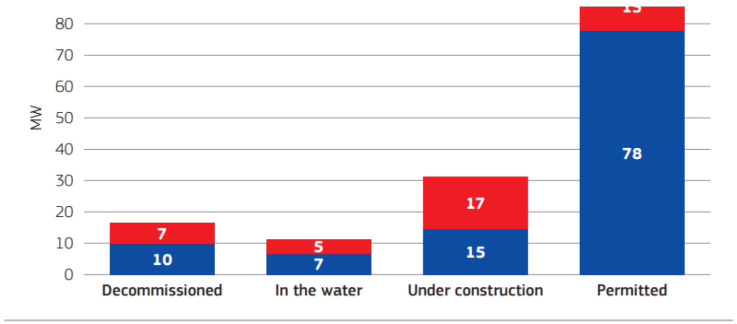
3 Status and evolution Analysis

Current Status

The first experimental wave energy devices were deployed at sea in the late 1990s, however subsequent development has been sluggish and the wave sector in particular has suffered from policy fluctuations and some project closures, which affected investors' confidence. Over the past years, 13 wave energy devices of 100 kW or larger have been deployed at sea with a total capacity of almost 5 MW. Out of these, 10 were deployed over the past 3 years. Most of these devices are experimental or down-scaled versions of the final concept[12]. However, positive development dynamics show that,in EU, "6 further projects totalling 17MW are under construction, including a multi-megawatt device" (Ocean Energy Europe)[13]. At the same time, "Further 15MW of wave energy capacity are already permitted" (Ocean Energy Europe)[14].

The tidal segment has developed faster in recent years, thanks to convergence of technology and involvement of large industrial players and utility companies. By the end of 2016, 21 tidal turbines totaling 13 MW were deployed in European waters. Additionally, construction is ongoing on 20 turbines adding up to 12 MW[15].

Figure 3 Deployed tidal stream and wave capacity, capacity under construction and permitted capacity (MW) in Europe in June 2016



Source: Ocean Energy Forum, Ocean Energy Strategic Roadmap Building Ocean Energy for Europe, 2016, p. 17

Drivers

- ✓ Global climate change, renewable energy targets, sustainable development goals
- ✓ EU support, especially related to R&D and testing (FP7, Horizon 2020) and ERDF (smart specialization energy)
- ✓ Selected Member State and national and regional policy support and planning (notably Scotland, France (Normandy, Brittany), Wales)
- ✓ High (theoretical) resource potential of wave and to less extent tidal energy

12 Ocean Energy Europe, Ocean energy project spotlight – investing in tidal and wave energy, 2017, p. 4
13 Ibid.
14 Ibid.
15 Ibid.

✓ High public acceptance/favorable public opinion: Depending on the location, public acceptability of ocean energy projects is more positive than towards conventional offshore wind and offshore oil and gas operations.

Barriers & Bottlenecks

Note: *Direct spatial implications* would be those which already hold a spatial characteristic (i.e displacements, re-routings, etc.); *Indirect spatial implications* would be those which might occur or not depending if we solve the barrier/bottleneck or not (i.e. efficiency improvements might bring more efficient developments and less new developments might be needed in the future which would create less spatial implications in terms of less space required)

Barriers & Bottlenecks	Direct spatial implications	Indirect spatial implications	Comments
Public acceptance		■	Citizens and stakeholders in regions with strong fishery or tourism sectors tend to be more reluctant to embrace the same marine energy project as it can compete for space with such activities[16].
Robustness of technology		■	Some elements of tidal still need to be demonstrated over long periods of operation, as current installation procedures are sub-optimal in terms of safety, practicality and costs. Wave core technologies have not converged and stabilized yet[17].
Research and innovation support		■	The involvement of the right expertise and the research funding incentives are considered barriers, where there might be a tendency for developers to work in isolation and difficulty to involve the right technical expertise, leading to the design of sub-optimal solutions. Currently EU devoted 68% of the funds being directed to technology development[18].
Grid connection	■		The integration in the general energy market is considered a challenge. This is partly due to transmission issues and the lack of storing surplus electricity[19]. There can be lack of secured access to grid connection or no grid available in the nearby onshore areas for

[16] Ecorys, Lessons Learnt on Ocean Energy Development, 2017, p. 33
[17] Ocean Energy: Technology Information Sheet: https://setis.ec.europa.eu/system/files/Technology_Information_Sheet_Ocean_Energy.pdf
[18] Research themes financed by EU funding in 2011 according to T.D. Corsatea, D. Magagna. Overview of European innovation activities in marine energy technology. Publications Office of the European Union, Luxembourg (2013),10.2790/99213
[19] DG MARE, Energy sectors and the implementation of the Maritime Spatial Planning Directive, 2015, p. 9

			connection[20]. Moreover, grid connection to onshore grids cannot always absorb the electricity from wave energy production. R&D is looking at how to better integrate produced electricity into the general energy market as well as to tackling the issue of storing surplus electricity, which is a common challenge for the offshore renewable energy sector. These developments are expected to have spatial implications.
Variability of electricity production			This variability of production from wave and tidal devices might lead to issues such as grid congestion, weak grids, and voltage stability problems which is also related to technological development.
Cost-reduction, finance and profitability			As wave and tidal are still high capital-intensive sectors, securing investment is still considered as a challenge. The cost of the device, infrastructure and installation represent a high share of the kWh cost – resulting in a high LCOE compared to other renewable energy sources. At the level of single wave device demonstration, very high installation & maintenance costs occur.[21]
Critical mass			As the offer of wave and tidal sector is limited, the sector does not yet have sufficient market demand to support the generation of tailor-made solutions for each application or site that is needed – therefore they rely often on synergies with other sectors.
Insurance or warranties			Due to the limited overview available of predictable total costs and technological reliability, the sector has hardly any access to insurance or warranties[22].
Environmental impacts			The impact of wave and tidal energy devices on the environment is not completely understood, which may hinder project consent or delay the process of obtaining permits. A potential site and the complete marine ecosystem is by law required to be surveyed by seasonal observations. The efforts to perform these surveys are considered to be a financial risk since the outcome of such surveys can lead to the rejection of a marine energy project. Environmental impacts have been a barrier especially for tidal barrage technologies[23].

[20] Ocean Energy: Technology Information Sheet: https://setis.ec.europa.eu/system/files/Technology_Information_Sheet_Ocean_Energy.pdf
[21] Ecorys, Lessons Learnt on Ocean Energy Development, 2017, p. 36
[22] Ecorys, Lessons Learnt on Ocean Energy Development, 2017, p. 45
[23] Ecorys, Study on Lessons for Ocean Energy Development, 2017, p. 33

			However, some on-going developments appear to be promising and in position to secure environmental consenting, e.g. the Cardiff Lagoon Project[24]
Political support			There are different degrees of political support in Member States, with the EU Atlantic countries, where support appears to be more substantial. However some policy supports have been reducing in recent years at the level of Member States, as specific Feed-in Tariffs have been put in question and renewable energy policies become more technologically neutral.
Licensing and consenting			Uncertainty and inconsistency related to current consenting and licensing procedures and associated costs by complying with environmental protection regulation presents a barrier to the further progress of the sector[25].
Issuing of permits			Although wave and tidal energy developers may not face the same public opposition as on-shore and off-shore wind developers, obtaining a license to develop is a lengthy process, where securing all necessary permits can take time.

Policy & Management

EU EIA Directive; EU Habitats and Birds directive; EU SEA Directive; EU Renewable Energy Directive.

Trends

The ocean energy sector as a whole foresees to deliver larger-scale projects of up to 50MW by 2020 in preparation for wholesale market roll-out from 2025[26]. The ambition of the sector is to roll-out both wave and tidal energy over the next 35 years at such a scale that it could cover up to 10% of the European Union's energy demand[27]. However, in light of developments over the last 20 years, it is still too early to assess whether this ambition is realistic.

24 Tidal Lagoon Power, http://www.tidallagoonpower.com/projects/cardiff/
25 Ocean Energy Forum, Ocean energy strategic roadmap building ocean energy for Europe, 2016, p. 26
26 https://www.oceanenergy-europe.eu/en/communication/publications/industry-vision-paper-2013
27 Ocean Energy Europe, Ocean energy project spotlight – investing in tidal and wave energy, 2017

Unlike wave resources, tidal resources are not widely distributed but can only be found in few distinguished hot spots, limiting the overall availability of the resource as such, consequently reducing the attractiveness of exploiting it at large scale[28]. Only a few countries worldwide are actively engaged in the development of tidal stream industries and projects. Therefore, those succeeding will have substantial global export opportunities (e.g. in Asia).

4 Spatial Consequences of Future Trends

Implications

Wave and tidal technology are placement driven and depending on the resource potential in a given location. While areas with high potential for tidal energy have already been identified, the wave energy sector (despite its demand for space is expected to be limited to modest in the short-to medium-term) still entails potential for further development. The situation of the wave energy sector could drastically change in the longer term, once breakthroughs would be realized, leading to an upscaling and cost reduction in a way similar to offshore wind – with major spatial implications as a consequence (i.e the dimensions of a single wave turbine, which was installed as a generation test device in the port of Cartagena, Spain, are around 12m height, an 9.75m in width and length).

Each renewable energy source requires specific devices, which will have different spatial characteristics, which requires a relatively high preparation of consenting and licensing. Difficulties arise where insufficient expertise/evidence is available about strategic environmental impacts.

However, in general terms, the geographical proximity of ocean energy devices and the attendant onshore infrastructure would raise the potential spatial conflicts that may occur with other coastal uses. Especially for the tidal energy, this sector occurs mostly in shallow waters, where other marine uses may also occur (coastal fisheries, shipping, conservation…) and creating conflicts with those uses. Comprehensive Life Cycle Assessments of ocean energy arrays that would also include areas like fluctuation of power output, storage, or grid integration are still missing and for a number of individual WEC types, no Life Cycle Assessments are available so far. The inclusion of the need to provide WEC types LCAs could help minimizing MSP conflicts.

28 Ecorys, Study on Lessons for Ocean Energy Development, 2017, p. 31

Relations with other sectors

Wave and tidal are emerging sectors which rely heavily on other sectors for creating critical mass and synergies. Offshore wind (including floating wind), and pipelines and cables are the most obvious sectors, including for the shared use of infrastructure (e.g. vessels). The sector poses some spatial tensions vis-a-vis other maritime activities, notably fisheries and conservation being the most obvious ones. Commercial deployment of tidal and wave energy would have spatial implications requiring offshore space, although many synergies exist in terms of use of equipment, installations, infrastructure and skills base.

The matrix below indicates the potential tidal and wave compatibility (synergies and conflicts) with other marine sectors. Note: red = potential conflicts; green = potential synergies; grey = not applicable.

		Shipping & Ports	Tourism & Recreation	Oil & Gas Extraction	Pipelines & Cables	Fishing	Aquaculture	Offshore wind	Marine Aggregates	Conservation
Wave & tidal	Synergies									
	Conflicts/Risks								Potential	Tidal barrage

Wave energy and ports: As ocean energy projects begin to drive the development of additional harbor and port infrastructure, onshore facilities, and grid extensions will also be developed.

Wave and tidal energy and cables: Similarly, the ocean energy development will need from the development of the submarine cables sector as means to deliver the obtained energy to energy grids.

Wave and tidal energy and conservation: Future research in the area of environmental impacts should be focused on localized environmental impacts including e.g. electromagnetic field effects of subsea cables, flow alteration, sedimentation and habitat change of near generation devices.

Wave and tidal energy and offshore wind energy: Synergies may take place in terms of supply chain services, grid connection and development of storage, floating offshore wind, turbines. Research and technology development centers tend to be involved in both sectors.

Recommendations in MSP

(After the conference)

5 Resources / Actors / References

Actors

Name of Actor	Type of Actor	LINK	Short explanation
Ocean Energy Europe	EU Industry association	www.oceanenergy-europe.eu	Network of ocean energy professionals represents the interests of 115 organizations, including utilities, industrialists and research institutes.
Ocean Energy Forum (no longer active)	EU Stakeholder platform	https://www.oceanenergy-europe.eu/en/policies/ocean-energy-forum	Stakeholder platform established in 2014 by DG MARE to promote dialogue between all stakeholders (industry, Member States/regions, EC).
European Technology and Innovation (ETIP) Platform Oceans	EU Stakeholder platform	https://www.etipocean.eu	ETIP Ocean is a recognised advisory body to the European Commission, part of the EU's main Research and Innovation policy the Strategic Energy Technology Plan (SET-Plan). ETIP Ocean brings together around 250 experts from 150 organisations covering the entire European ocean energy sector.

Projects

Name	Type of Project	Duration	LINK	Short explanation
Numerous R&D projects	FP6, FP7, Horizon 2020	Typically 3-5 years		

FORESEA	INTERREG NW Europe	4 years		Cooperation of testing facilities in NW Europe
MeyGen				World largest tidal energy project under construction in Pentland Firth
Naval Energies			www.naval-energies.com	Commercial development of tidal energy, offshore wind energy and ocean thermal energy conversion (OTEC)
Scotrenewables			http://www.scotrenewables.com/	Development of floating tidal stream and run-of-river turbines

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