



Patent Searching | Research and Analytics | Patent Filing | Prosecution | Litigation and E-Discovery | IP Valuation | Patent Portfolio | Landscape

Sample Landscape Study On Ocean Energy



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The power of the ocean: abundant clean energy

The ocean energy or marine energy resource is vast. The theoretical resource potential of ocean energy is more than sufficient to meet present and projected global electricity demands well into the future. Estimates for this potential range from 20 000 terawatt-hours (TWh) to 80 000 terawatt-hours (TWh) of electricity a year, which is 100% to 400% of current global demand for electricity. Furthermore, successful deployment of ocean energy technologies offers substantive opportunities and benefits, including:

- **Energy independence:** tapping into an indigenous resource
- **Decarbonisation:** delivering CO₂-free power
- **Job creation:** building a low-carbon industry, including providing employment opportunities for coastal and island communities
- **Complement to other renewables:** attractive in combination with other renewable energy options: e.g., improved predictability, decreased variability, spatial concentration, and socio-economic benefits.

Insight

Marine energy or ocean energy (also referred to as marine power , ocean power, or marine and hydrokinetic energy) refers to the energy carried by ocean waves, tides, salinity, and ocean temperature differences.

Forms of Ocean Energy

SALINITY GRADIENT

At the mouths of rivers where fresh water mixes with saltwater, energy associated with the salinity gradient can be harnessed using a pressure-retarded reverse osmosis process and associated conversion technologies

OCEAN THERMAL ENERGY

Thermal energy due to temperature gradient between sea surface and deep-water can be harnessed using different ocean thermal energy conversion (OTEC) processes.

OCEAN TIDAL ENERGY

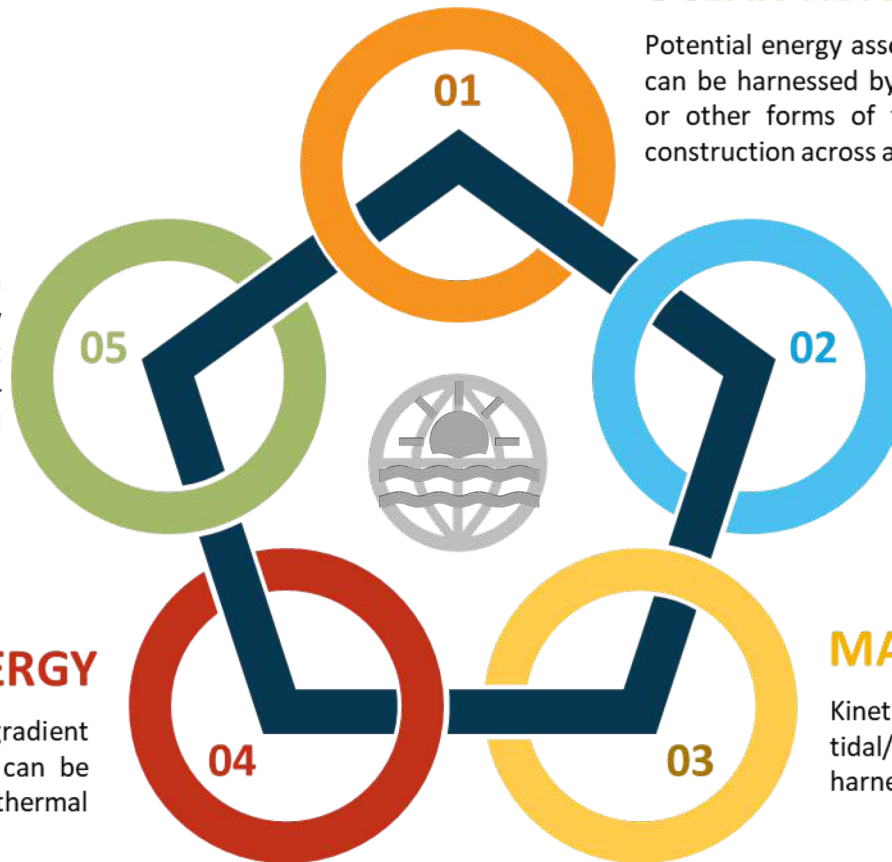
Potential energy associated with tides can be harnessed by building barrage or other forms of turbine equipped construction across an estuary.

OCEAN WAVE ENERGY

Energy associated with ocean waves can be harnessed using modular types of technologies.

MARINE CURRENT

Kinetic energy associated with tidal/marine currents can be harnessed using modular systems.



Insight

Ocean can produce two types of energy: thermal energy from the sun's heat, and mechanical energy from the tides and waves. Above are the few main sources of renewable Ocean energy.

Forms of Ocean Energy

WHAT IS TIDAL ENERGY?

Tidal streams are created by the constantly changing gravitational pull of the moon and sun on the world's oceans. Tides never stop, with water moving first one way, then the other, the world over. Tidal stream technologies capture the kinetic energy of the currents flowing in and out of the tidal areas. Since the relative positions of the sun and moon can be predicted with complete accuracy, so can the resultant tide. It is this predictability that makes tidal energy such a valuable resource.

The highest (spring) tidal ranges are generated when the sun, moon and earth are in line. Water flows in greater volumes when attracted by this combined gravitational pull. The lowest (neap) tidal ranges are generated when the sun, moon and earth describe a right angle. The split gravitational pull causes water to flow in lesser volumes.

Tidal stream resources are generally largest in areas where a good tidal range exists, and where the speed of the currents are amplified by the funnelling effect of the local coastline and seabed, for example, in narrow straits and inlets, around headlands, and in channels between islands

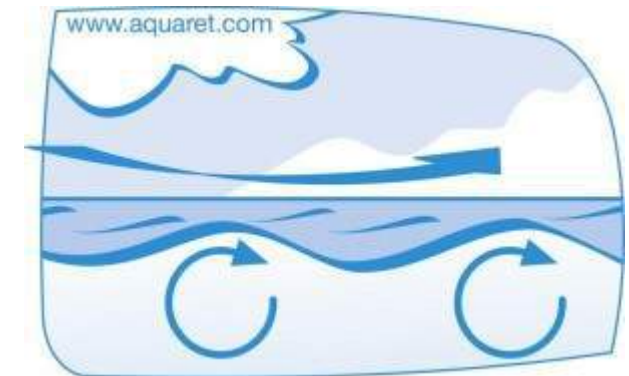


Forms of Ocean Energy

WHAT IS WAVE ENERGY?

Waves are formed by winds blowing over the surface of the sea. The size of the waves generated will depend upon the wind speed, its duration, and the distance of water over which it blows (the fetch), bathymetry of the seafloor (which can focus or disperse the energy of the waves) and currents. The resultant movement of water carries kinetic energy which can be harnessed by wave energy devices

The best wave resources occur in areas where strong winds have travelled over long distances. For this reason, the best wave resources in Europe occur along the western coasts which lie at the end of a long fetch (the Atlantic Ocean). Nearer the coastline, wave energy decreases due to friction with the seabed, therefore waves in deeper, well exposed waters offshore will have the greatest energy. There are many designs being pursued by developers to harness the power of waves.



Insight

Tidal and Wave Energy are two important and major sources of renewable Ocean energy.

Forms of Ocean Energy

WHAT IS OCEAN TEMPERATURE GRADIENT OR OTEC (OCEAN THERMAL ENERGY) ?

Ocean thermal energy conversion (OTEC) makes use of the temperature difference between the warm surface of the ocean and the colder layers underneath. Due to solar heating, the amount of energy available in the temperature gradient between hot and cold seawater can be substantially larger than the energy required pumping the cold seawater up from the lower layers of the ocean. The warm water from the surface is used to boil a working fluid (or, in open cycle systems, the seawater itself under low pressure), which is then run through a turbine and condensed using cold seawater pumped up from the depths.

WHAT IS SALINITY GRADIENT ?

Salinity gradient energy or blue energy is one of the high potential energy sources that is placed in renewable energy's list. The salinity gradient energy can be one of the important sources of the renewable energy to electricity generation for global electrical demand in future. When saline and fresh water mixes the Gibbs free energy is released. This energy could be used for generation of electrical power. Salinity gradient power makes use of the potential energy available when saltwater and fresh water mix.

Ocean Energy Technologies

1

Wave Energy Converters

Full-scale prototypes being tested. Many leading WEC designs have remained at this stage for some time

2

Tidal Stream

Leading developers testing individual prototypes in locations representative of potential commercial sites, generating grid-connected electricity. Demonstration in arrays still lacking

3

Tidal Range

Most mature of the ocean energy technologies, with a proven track record stretching back to the 1960s but limited deployment to date

4

OTEC

A few test facilities (mostly pilot-scale) trailed, but no long-term operation

5

Deep Ocean Current

Very few active concepts being developed; laboratory-scale tank testing has occurred

6

Salinity Gradient

A handful of university-based research projects have been conducted, as well as small-scale system operation

Insight

The focus of this study is to analyze technologies, such as 'Wave Energy Converters', 'Tidal Stream', etc., as they have created a hype in the domain and are closest to see commercial launches.

Notable Tidal Power Projects

Swansea Bay Tidal Lagoon, United Kingdom – 240MW

The 240MW Swansea Bay Tidal Lagoon project, to be built at Swansea Bay in the UK, is one of world's biggest tidal power project.

The planning application for the £850m (\$1.4bn) project was approved in March 2013.

The plant will be located at a site with average tidal range of 8.5m and will involve the construction of a 9.5km-long sea wall or breakwater facility to create a lagoon cordoning off 11.5km² of sea. The plant will use reversible bulb turbines to generate power as water passes in and out of the lagoon with the rise and fall of tides.

The ground breaking for the tidal power project is scheduled for 2015 while full commissioning is expected in 2018. The tidal lagoon, with an estimated annual power generation capacity 400GWh, will power over 120,000 homes for 120 years



Insight

The Swansea Bay tidal lagoon project in the UK and the MeyGen tidal array project in Scotland stand out among the few large-scale tidal power projects currently under development.

Notable Tidal Power Projects

MeyGen Tidal Energy Project, Scotland – 86MW

MeyGen Tidal Energy Project located in the Inner Sound of the Pentland Firth off the north coast of Caithness, Scotland, is currently the world's biggest underwater tidal turbine power project under development.

The tidal array project received offshore planning consent for its 86MW first phase development from the Scottish Government towards the end of 2013. The second phase development of the project is expected to raise the total installed capacity to 398MW by 2020.

The MyGen project was initiated in 2006 by the Scottish company MeyGen, a joint venture between the tidal technology company Atlantis Resources and Morgan Stanley. Atlantis Resources acquired full ownership of the tidal array project in December 2013. Construction is expected to start for a demonstration array involving up to six AR1000 single-rotor tidal turbines in 2014 with final commissioning expected in 2015. The first 1MW prototype of the 22.5m tall AR1000 tidal turbine with 18m rotor diameter was deployed at the European Marine Energy Centre in 2011.



Insight

The Swansea Bay tidal lagoon project in the UK and the MeyGen tidal array project in Scotland stand out among the few large-scale tidal power projects currently under development.

Notable Wave Energy Project

Pelamis, World's First Commercial Wave Energy Project, Agucadoura

Pelamis Wave Power's Agucadoura Wave Farm is the world's first commercial wave energy project located five kilometre off the Agucadoura coast in Portugal. The farm started delivering 2.25MW produced by three Pelamis generators in September 2008.

Pelamis Wave Power, earlier known as Ocean Power Delivery (OPD) supplied the first three Pelamis P-750 "advanced wave energy conversion technology" machines. Another 28 machines were planned as a part of phase 2 to generate 22.5MW for state-run power company Energias de Portugal.

The first three generators, however, had to be towed back to the port after four months of commissioning because of technical problems. The global financial crunch of 2008 made financing of the re-installation of the generators even more difficult. The wave farm has since then been shut down.

The order for the initial phase was worth €8.2m, funded by a Portuguese consortium led by Enersis. The project was expected to bring power ashore at Agucadoura, and provide electricity to 1,500 homes using the national state run electricity grid system.

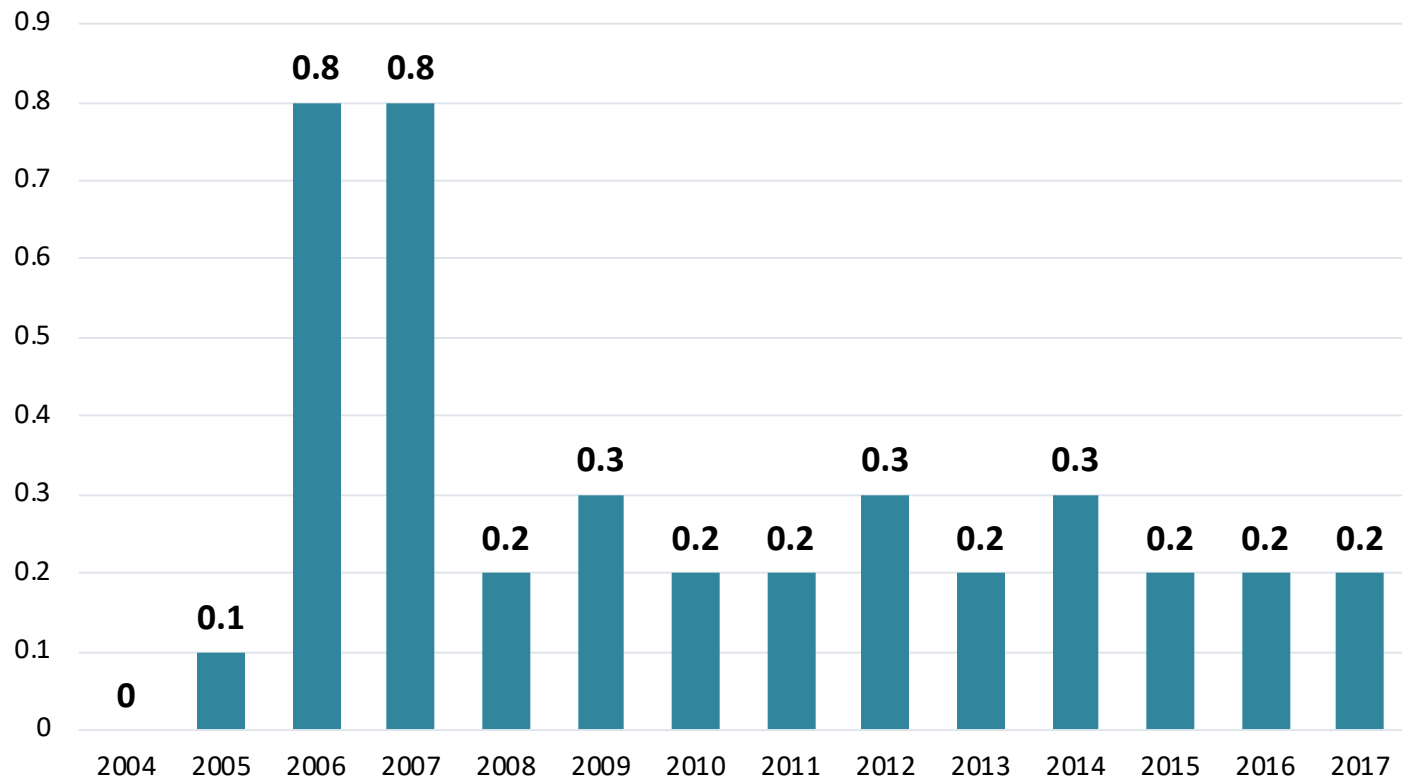


Insight

On completion of both the phases, the project was expected to meet the average electricity demand of more than 15,000 Portuguese households.

Economic Value

Tide, Wave and Ocean Energy Investment in USD billion



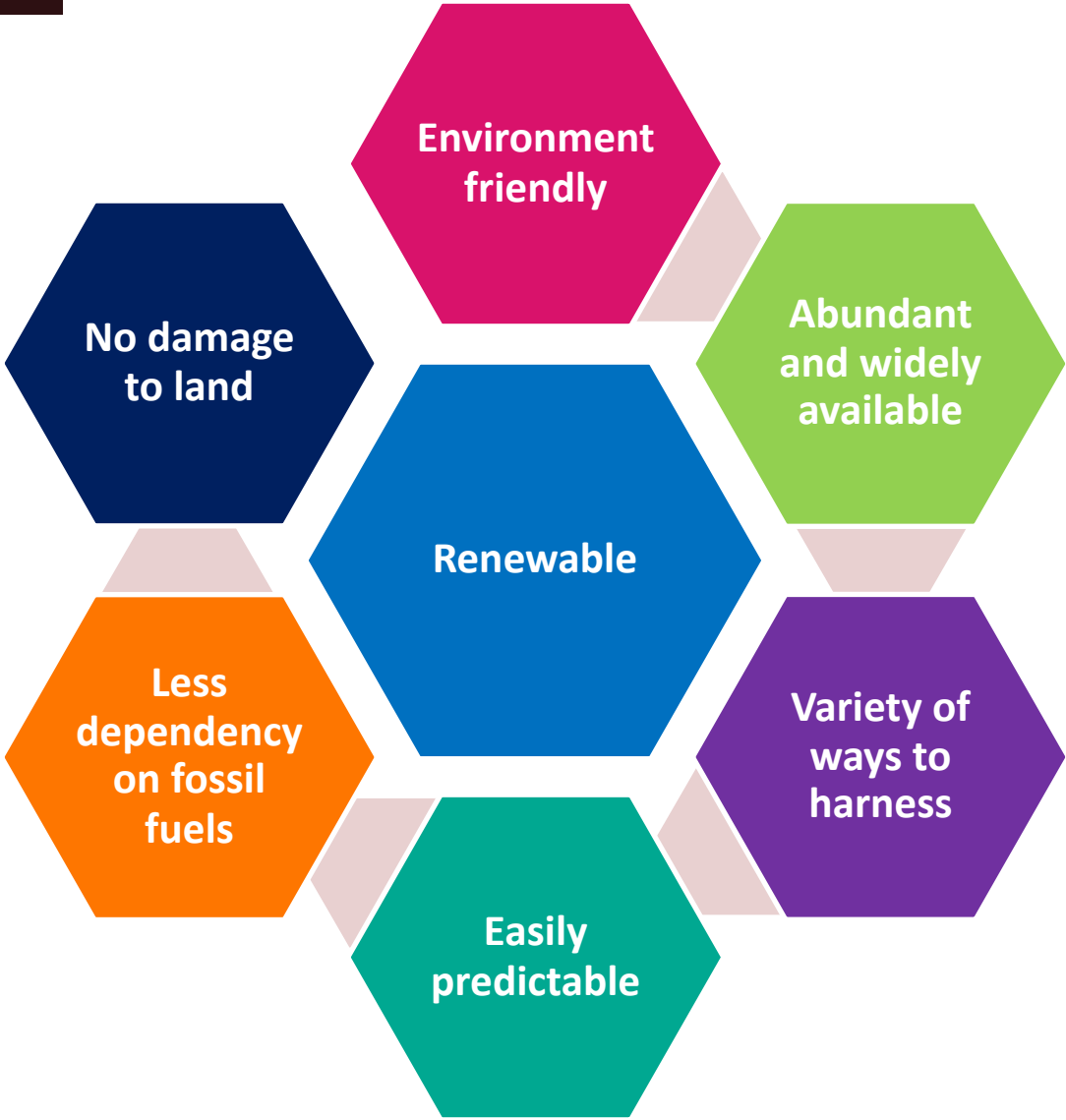
\$900 Bn

Estimated global market potential for wave and tidal energy by 2050

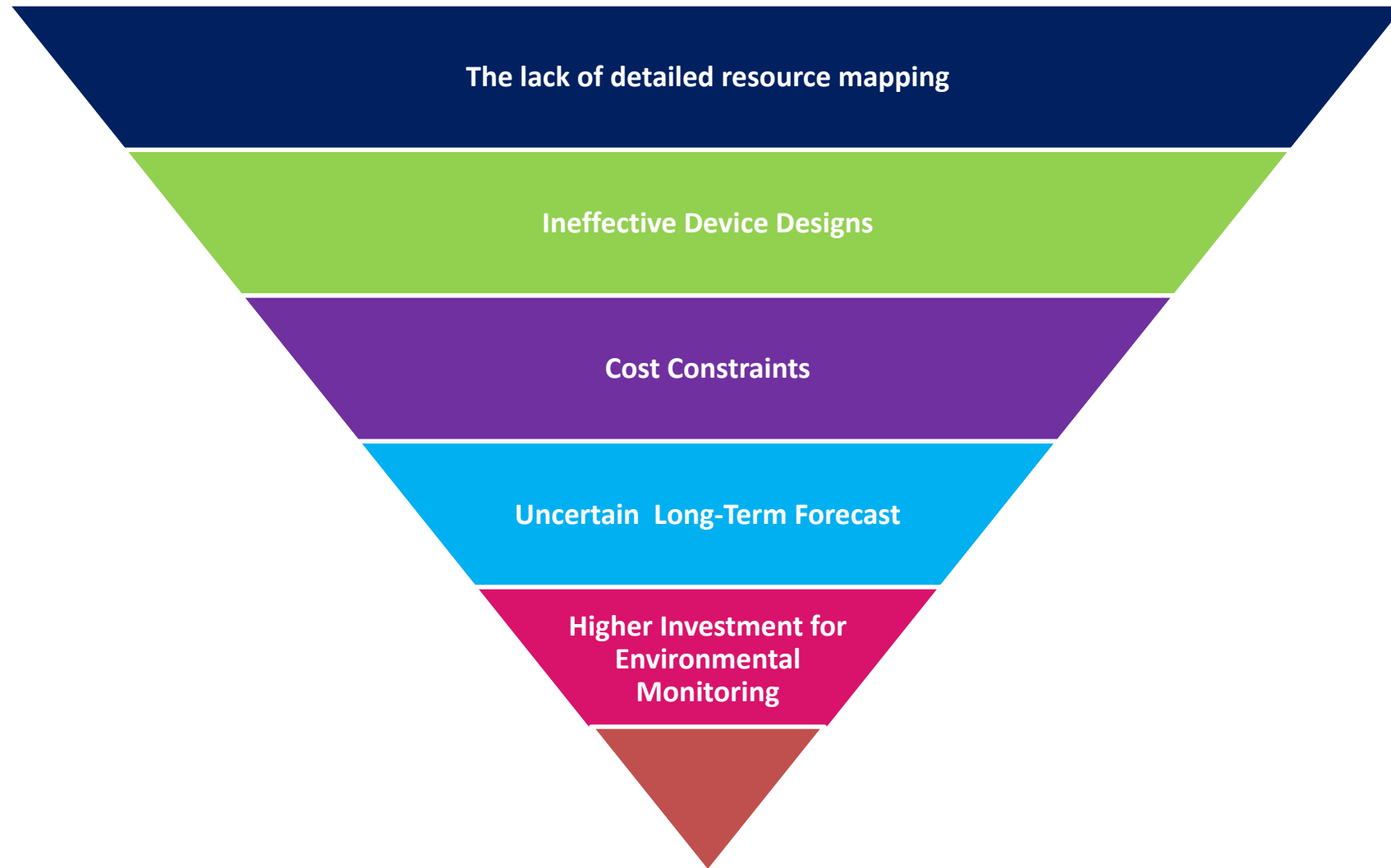
Insight

Economic opportunities
A recent market research report forecasts that the value of the global tidal and wave energy market will reach \$11.3 billion in 2024

Ocean Energy: Merits



Ocean Energy: Demerits



Objectives Summary

The landscape study:

- Focuses on patents and patents applications pertaining to the technology “Ocean Energy”.
- Limits to the patents and patents applications granted/published up until the first week of May, 2019.
- Focuses on two major ocean energy technologies viz. ‘Tidal Stream Turbines’ and ‘Wave Energy Converters’.
- Helps understanding the major patent holders, geographical distribution of patents, technologies classification, etc.
- Analyses patent application filing/publication/grant trends over the years, top assignees, and patent classifications among others.

Executive Summary

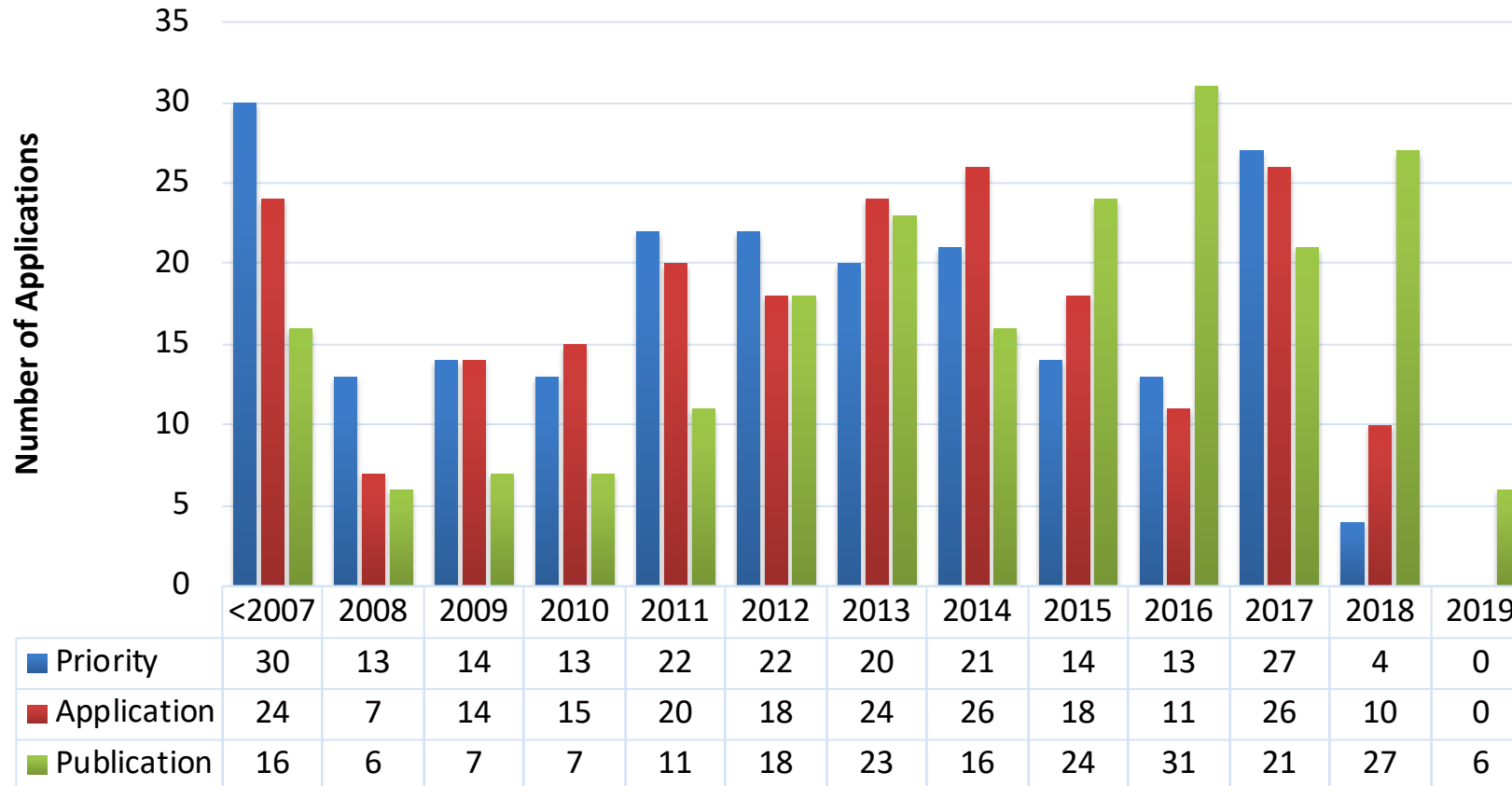
- After analysis, **213** relevant patent families were picked as relevant from a pack of **1311** patent families.
- Notably, Individual Inventors dominate research in the technology, wherein **95** patents/applications are assigned to said individual inventors. Corporate Entities, on the other hand, has **36** patents/applications.
- Among corporate entities, '**AW Energy**' has **(7 nos.)** patents or pending patent applications and emerges out as the leading patent assignee followed by **Alstom Hydro (5 nos.)**. **GE** and **Sabella** too hold significant patent portfolio **(3nos.)** patents/applications each.
- Universities too have significant number of patent filings, **(21 nos.)** patents/applications
- Last four years, there is a surge in patent publication, wherein 2016 has reported/witnessed maximum publications **(31 nos.)**.
- Inventors from China, particularly, **Chen Zi** and **Chen Yongyuan** are the leading innovators. Not to forget **Järvinen Arvo** and **Lazaris Spyros** as they has also contributed significantly

Patent Literature Analysis: Assumptions

- Report provides patent literature analysis for the emerging technology *Viz.* “Hydrokinetic Energy”.
- The patent search started with the identification of relevant search terms or keywords and patent classification codes.
- The study was primarily carried out using Questel-Orbit, a popular database for patent literature that has patent coverage for more than 95 jurisdictions around the world.
- All analysis has been performed on unique patent families (one publication per family).
- The formulated search queries were focussed to retrieve patent literature pertaining to the “Tidal/Ocean/Wave Energy/Tidal Stream Turbines/Wave Energy Converters.

Graphical and Analytical Representation

1. Priority, Filing, Publication Year Based Trend Analysis



Note: There may be higher number of application for the years 2015-2018, attributed to non-published patent applications.

Insight

The above graph demonstrates priority, filing, and publication trends over the years.

2. Geographical Distribution of Patent Application Filings

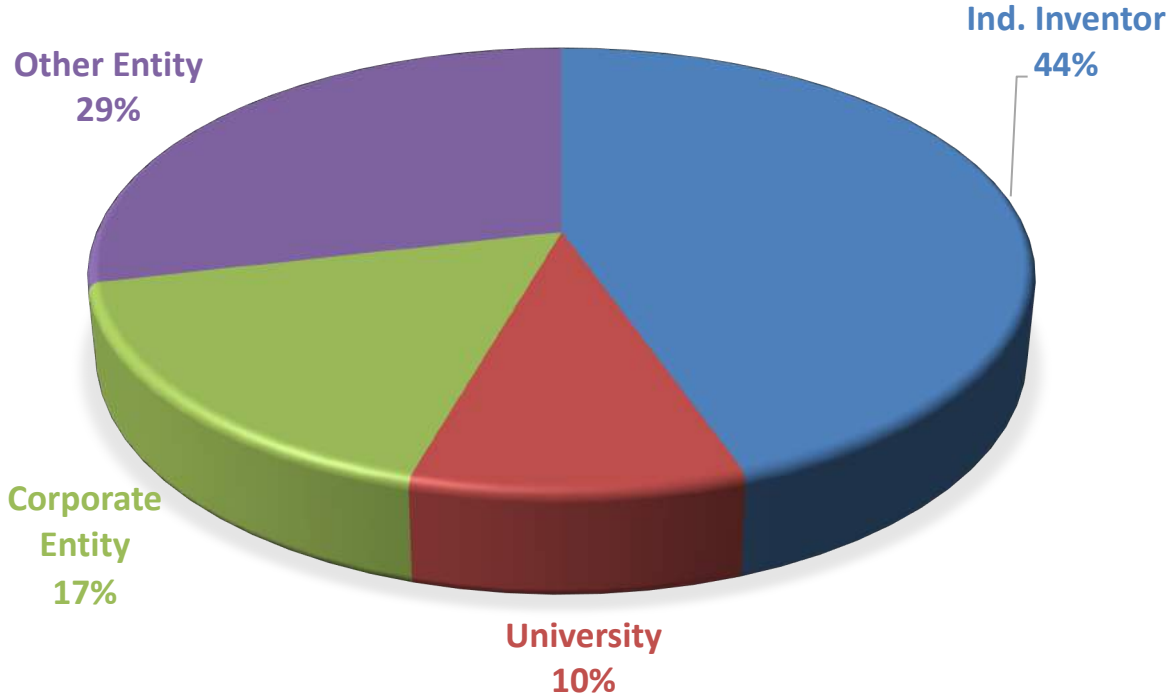
Priority Country	Priority Year												
	<2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Grand Total
FR	4	1	6	4	9	7	5	5	3	4	5		53
CN	3	1		1	3		5	2	4	4	17	4	44
US	9	4	5	4	4	8	2	2		2	1		41
AU	4		1	1	1	1					2		10
WO				2				2	2	1			7
GB				1	1	2		2					6
KR							1	1	4				6
TW		1			1		2		1	1			6
DE	2	1						2					5
EP		2	1		2								5
Others	8	3	1		1	4	5	5		1	2		30
Grand Total	30	13	14	13	22	22	20	21	14	13	27	4	213

Insight

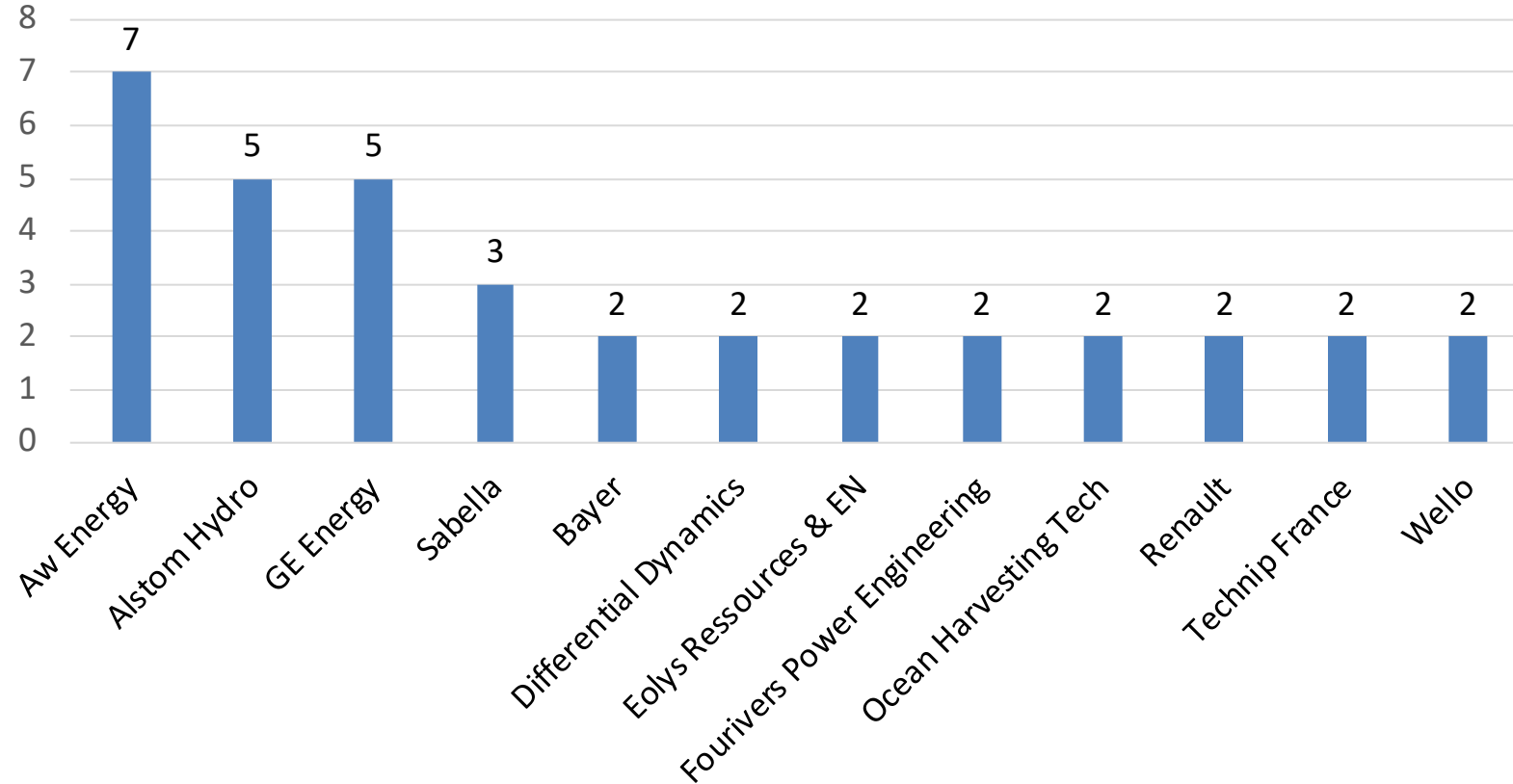
Geographical distribution demonstrates that maximum number of filing were originated in France followed by China and United States.

Note: There may be higher number of application for the years 2015-2018, attributed to non-published patent applications.

3. Trend Analysis: Entity Types



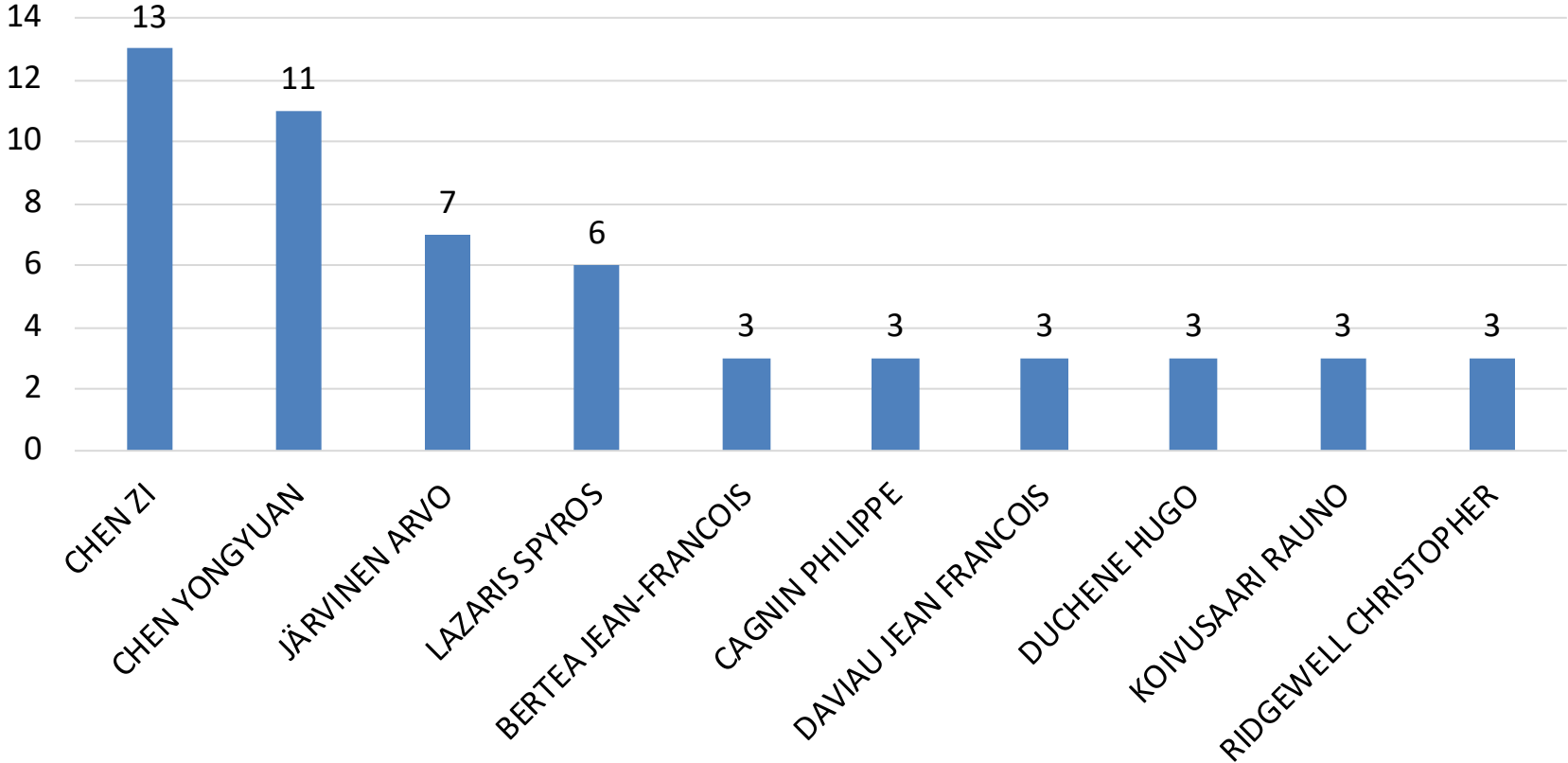
3.1 Trend Analysis: Corporate Entities



Insight

The above chart demonstrate trends for corporate entities, wherein AW Energy emerges as the leading patent applicant in Ocean energy technology followed by Alstom Hydro and GE Energy.

4. Trend Analysis: Inventors



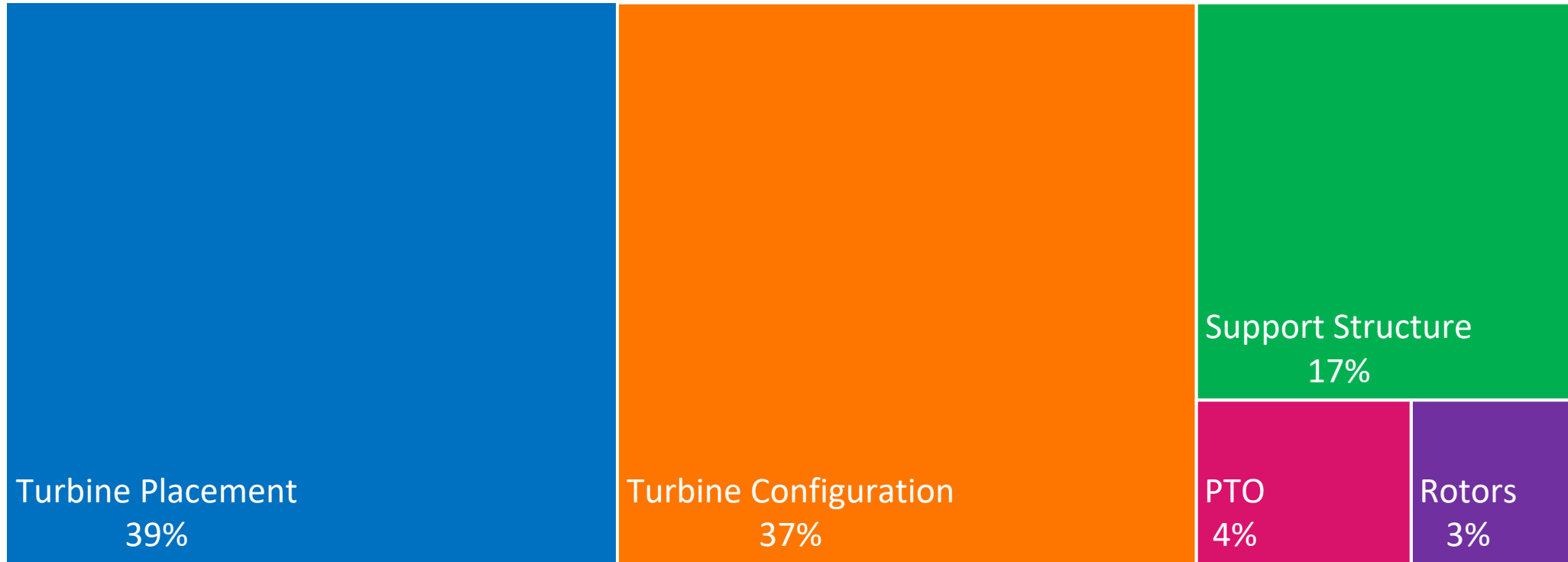
Insight

The above chart demonstrates trends for inventors, wherein 'Chen Zi' emerges out as the leading inventors in Ocean energy technology followed by Chen Yongyuan and Järvinen Arvo.

5. Trend Analysis: Technical

5.1 Focus of Inventions (Tidal Stream Turbines)

■ Turbine Placement ■ Turbine Configuration ■ Support Structure ■ Rotors ■ PTO

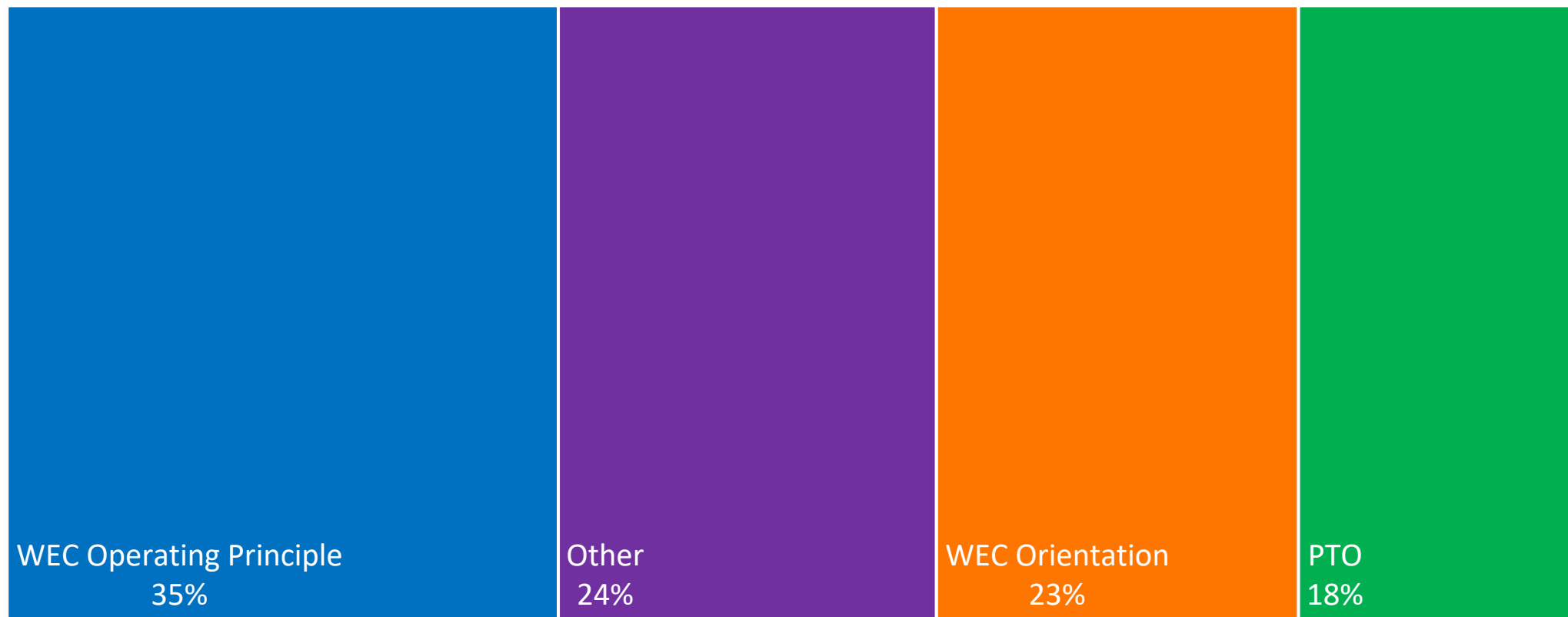


Insight

Large chunk of analysed patents/patent applications discusses innovations related to Turbine placement (39%) and Turbine configuration (37%) followed by Support structure (17%).

5.2 Focus of Inventions (WECs)

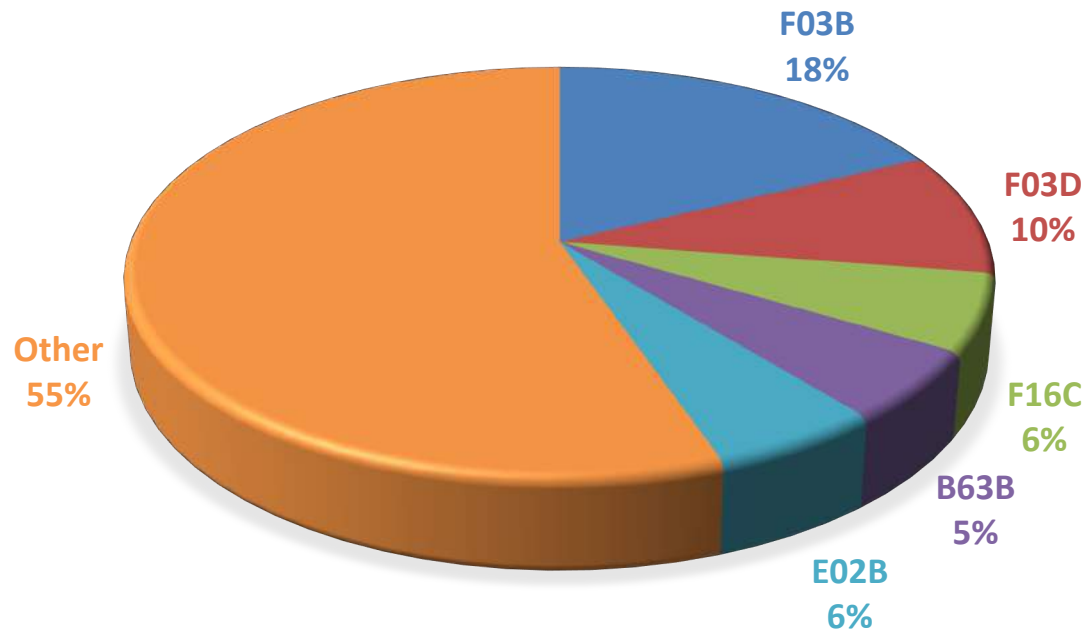
■ WEC Operating Principle ■ WEC Orientation ■ PTO ■ Other



Insight

Large chunk of analysed patents/patent applications discusses innovations related to WEC operating principle (35%) and WEC orientation (23%) followed by Power take-off (PTO) (16%).

6. IPCs Based Trend Analysis



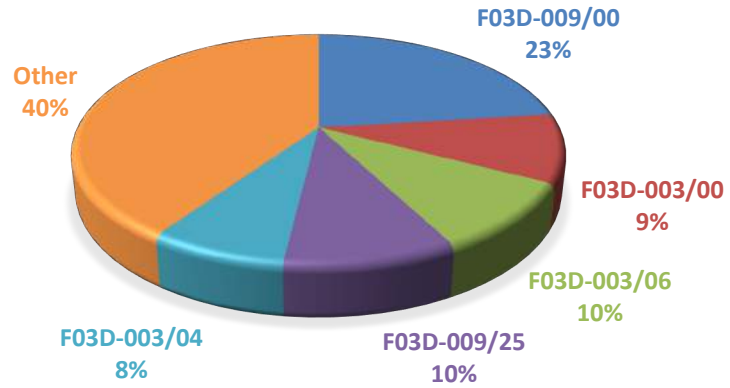
IPC	DEFINITION
F03B	MACHINES OR ENGINES FOR LIQUIDS
F03D	WIND MOTORS
F16C	SHAFTS; FLEXIBLE SHAFTS; MECHANICAL MEANS FOR TRANSMITTING MOVEMENT IN A FLEXIBLE SHEATHING; ELEMENTS OF CRANKSHAFT MECHANISMS; PIVOTS; PIVOTAL CONNECTIONS; ROTARY ENGINEERING ELEMENTS OTHER THAN GEARING, COUPLING, CLUTCH OR BRAKE ELEMENTS; BEARINGS
E02B	HYDRAULIC ENGINEERING
B63B	SHIPS OR OTHER WATERBORNE VESSELS; EQUIPMENT FOR SHIPPING

Insight

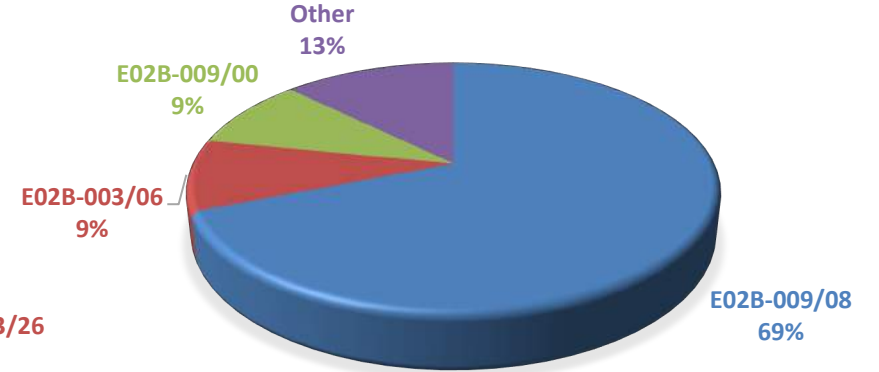
Large chunk of analysed patents/patent applications are assigned with patent class “F03B” and “F03D” followed by IPC “F16C”, “E02B” and “B63B”

6.1 IPC Sub Class Distribution

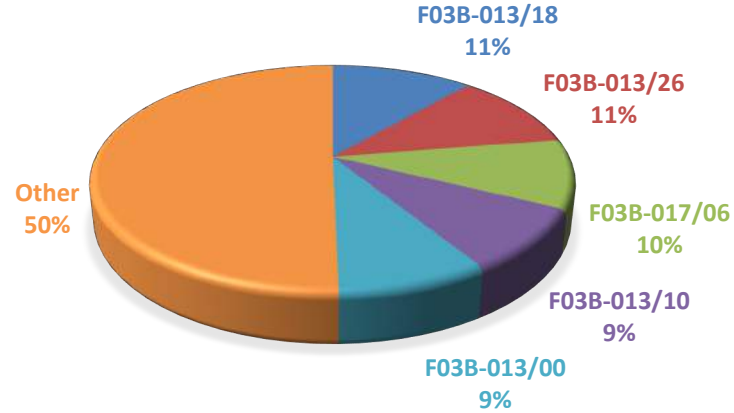
F03D, SUB SECTIONS



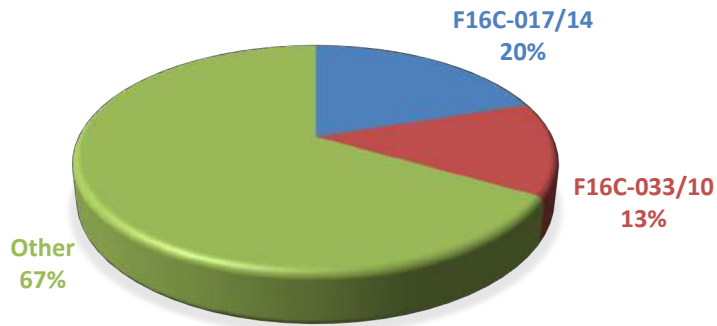
E02B, SUB SECTIONS



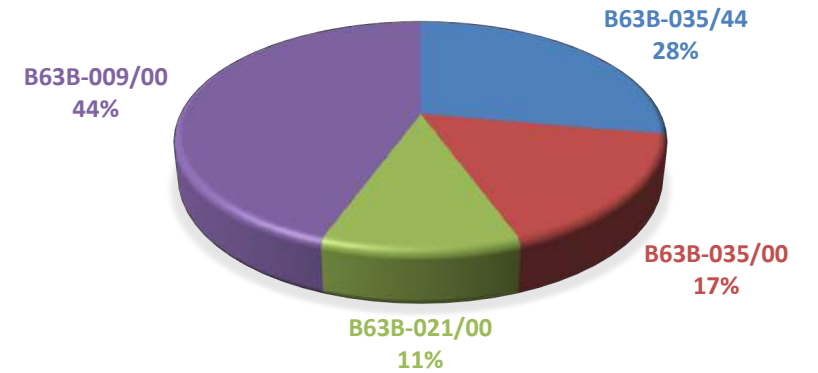
F03B, SUB SECTIONS



F16C, SUB SECTIONS



B63B, SUB SECTIONS



7. Conclusion

- Ocean energy has the potential to play significant role in the realm of renewable energy sources. The ocean energy resources are vast – with an estimated theoretical potential that can meet more than current and projected electricity demand.
- Accordingly, it has been verified that researchers, such as corporates, individual inventor, universities, etc. are investing their time and money for the research and development in this field.
- Notably, Individual Inventors are dominating the research in this domain, wherein 95 patents/applications are assigned to said individual inventors.
- Corporate Entities, on the other hand, are lagging the individual patent application filers.
- Among corporate entities, 'AW Energy' has maximum patents or pending patent applications.
- Patent filing activity has seen a surge in recent years and surely go up in the years to come.

APPENDIX 1: Sources

- [1] <https://www.ucsusa.org/clean-energy/renewable-energy/how-hydrokinetic-energy-works>
- [2] <https://www.energy.gov/eere/water/marine-and-hydrokinetic-energy-research-development>
- [3] <http://www.hydroquebec.com/sustainable-development/documentation-center/hydrokinetic-power.html>
- [4] <http://www.alternative-energy-tutorials.com/energy-articles/hydrokinetic-energy.html>
- [5] <https://www.sciencedirect.com/science/article/pii/S1364032115015725>
- [6] <https://www.sciencedirect.com/science/article/pii/S1364032114008624>
- [7] <http://energy-alaska.wikidot.com/hydrokinetic>
- [8] <http://me1065.wikidot.com/hydro-kinetic-power>
- [9] http://www.coastalwiki.org/wiki/Wave_energy_converters
- [10] <https://www.youtube.com/watch?v=VkTRcTyDSyk>
- [11] <https://www.irena.org/ocean>
- [12] [https://www.dutchmarineenergy.com/about-us/downloads/15%20-%20IRENA Ocean Energy report 2014.pdf](https://www.dutchmarineenergy.com/about-us/downloads/15%20-%20IRENA_Ocean_Energy_report_2014.pdf)
- [13] https://link.springer.com/chapter/10.1007/978-3-319-39889-1_8
- [14] <http://www.emec.org.uk/marine-energy/>
- [15] <https://irena.org/publications/2018/May/Renewable-Energy-and-Jobs-Annual-Review-2018>
- [16] <http://www.aquaret.com/index.html>
- [17] <https://www.power-technology.com/features/featuretidal-giants-the-worlds-five-biggest-tidal-power-plants-4211218/>
- [18] <https://www.power-technology.com/projects/pelamis/>
- [19] <https://www.presentationgo.com/>
- [20] https://www.conserve-energy-future.com/advantages_disadvantages_waveenergy.php

APPENDIX 2: IPC Sub-class Definitions

IPC SUB-CLASS	DEFINITIONS
F03B	MACHINES OR ENGINES FOR LIQUIDS
F03B-003/12	Blades; Blade-carrying rotors
F03B-011/00	Parts or details not provided for in, or of interest apart from, the preceding groups
F03B-013/00	Adaptations of machines or engines for special use; Combinations of machines or engines with driving or driven apparatus
F03B-013/10	Submerged units incorporating electric generators or motors
F03B-013/12	characterised by using wave or tide energy
F03B-013/14	using wave energy
F03B-013/18	where the other member, i.e. rem is fixed, at least at one point, with respect to the sea bed or shore

APPENDIX 2: IPC Sub-class Definitions

IPC SUB-CLASS	DEFINITIONS
F03B-013/22	using the flow of water resulting from wave movements to drive a motor or turbine
F03B-013/26	using tide energy
F03B-017/06	using liquid flow with predominantly kinetic energy conversion, e.g. of swinging-flap type , "run-of-river", "ultra-low head"
F03D	WIND MOTORS
F03D-003/00	Wind motors with rotation axis substantially perpendicular to the air flow entering the rotor
F03D-003/04	having stationary wind-guiding means, e.g. with shrouds or channels
F03D-003/06	Rotors

APPENDIX 2: IPC Sub-class Definitions

IPC SUB-CLASS	DEFINITIONS
F03D-009/00	Adaptations of wind motors for special use; Combinations of wind motors with apparatus driven thereby; Wind motors specially adapted for installation in particular locations (hybrid wind-photovoltaic energy systems for the generation of electric power
F03D-009/25	the apparatus being an electrical generator
F16C	SHAFTS; FLEXIBLE SHAFTS; ELEMENTS OR CRANKSHAFT MECHANISMS; ROTARY BODIES OTHER THAN GEARING ELEMENTS; BEARINGS
F16C-017/14	specially adapted for operating in water
F16C-033/10	Construction relative to lubrication
B63B	SHIPS OR OTHER WATERBORNE VESSELS; EQUIPMENT FOR SHIPPING
B63B-035/00	Vessels or like floating structures adapted for special purposes

APPENDIX 2: IPC Sub-class Definitions

IPC SUB-CLASS	DEFINITIONS
B63B-035/44	Floating buildings, stores, drilling platforms, or workshops, e.g. carrying water-oil separating devices
B63B-009/00	Methods of designing, building, maintaining, converting, refitting, repairing, or determining properties of vessels, not otherwise provided for
B63B-021/00	Tying-up; Shifting, towing, or pushing equipment; Anchoring
E02B-003/06	Moles; Piers; Quay walls; Groynes; Breakwaters Wave dissipating walls; Quay equipment
E02B-009/00	Water-power plants; Layout, construction or equipment, methods of, or apparatus for, making same
E02B-009/08	Tide or wave power plants

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