IRENA

International Renewable Energy Agency

Ocean Energy Technologies an Enabler of Environamental and Economic Development of Small Island Development States (SIDS)

https://www.youtube.com/watch?v=SSZL6822YH8

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TU Delft, 23 October 2017

OVERVIEW

MANDATE

To promote the widespread adoption and sustainable use of **all forms of renewable energy** worldwide

OBJECTIVE

To serve as a **network hub**, an **advisory resource** and an **authoritative, unified, global voice** for renewable energy

SCOPE

All renewable energy sources produced in a **sustainable manner**

MEMBERSHIP

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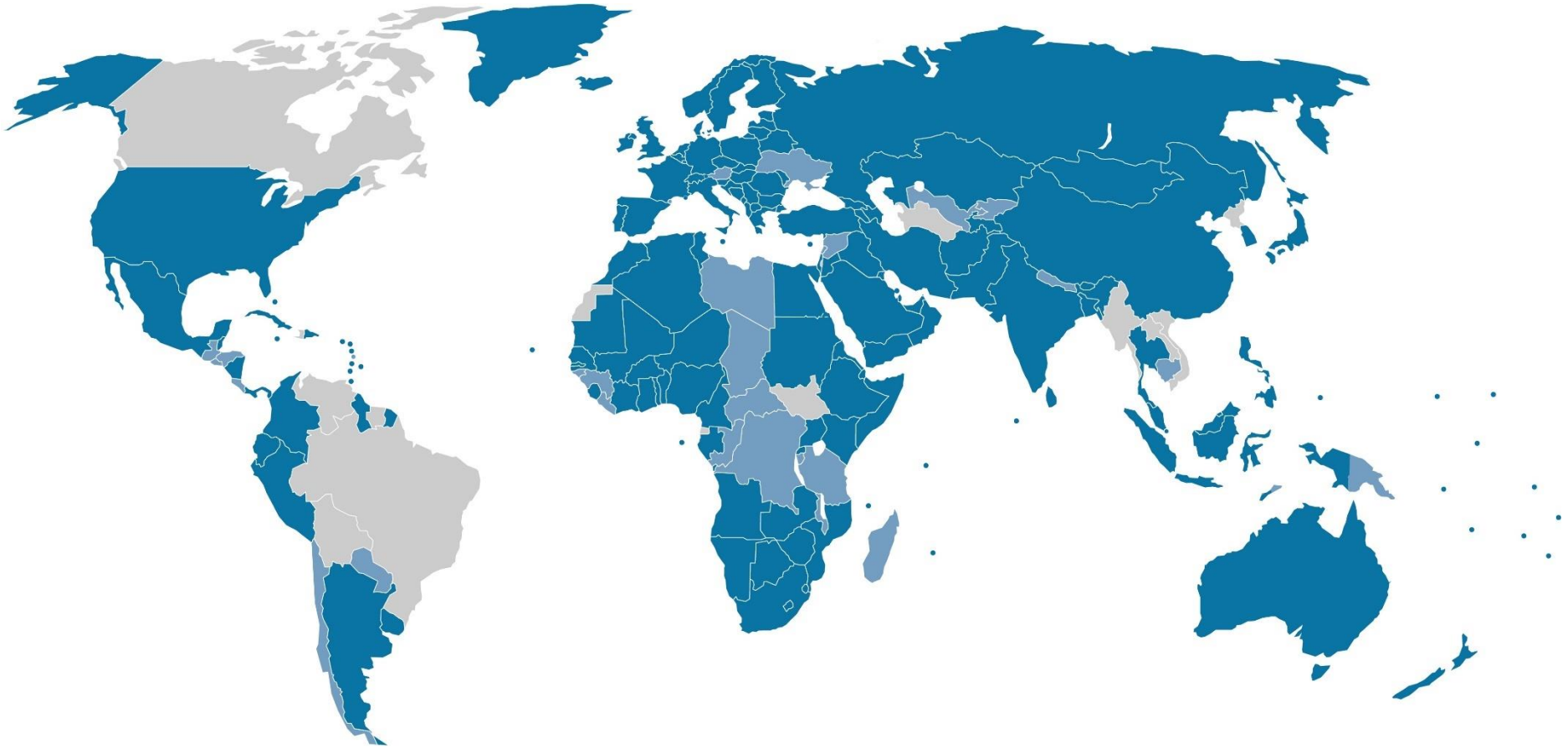


150 Members

30 States in Accession

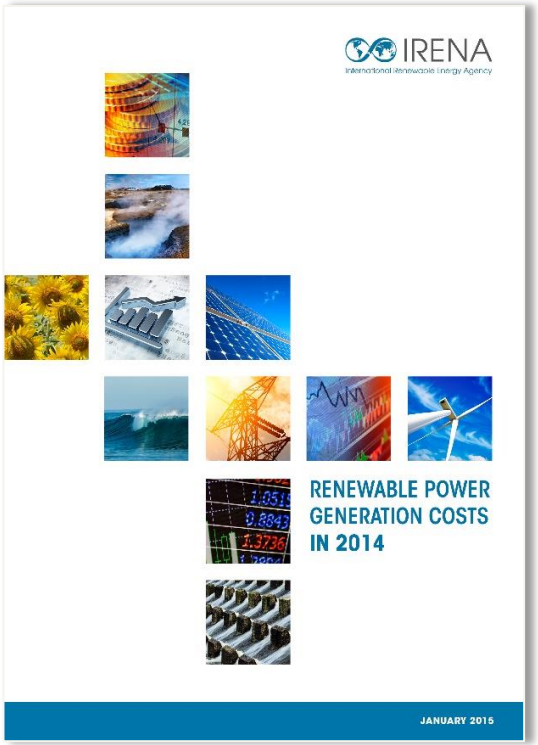
SIDS LIGHTHOUSES INITIATIVE

- Agenda of mobilising USD 500 million over next five years
- Joined by **34 Small Island Developing States (SIDS)** and 19 additional State and non-State partners
- Committed to transformation of **island energy systems**
- Enabling SIDS to:
  - Accelerate renewable energy development harness their **wealth of domestic resources**
  - Demonstrate leadership in **climate change mitigation**

COST ANALYSIS

- Provides accurate, up-to-date, **reliable and transparent data**
- Highlights **growing competitiveness** of renewables worldwide
- **IRENA Renewable Costing Alliance:**
  - Builds **data partnerships** with real-world projects
  - Database of 15,000 renewable energy power generation projects

IRENA COSTS
Renewable Energy Costs, Technologies and Markets

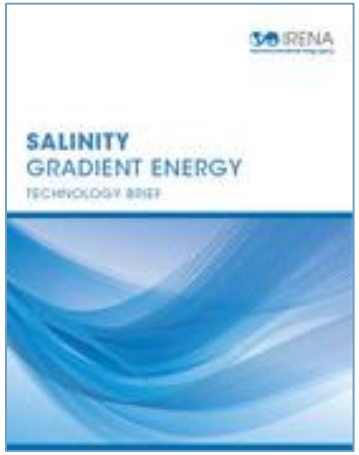


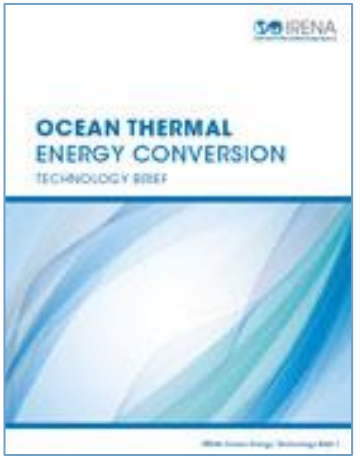
RENEWABLES READINESS ASSESSMENTS

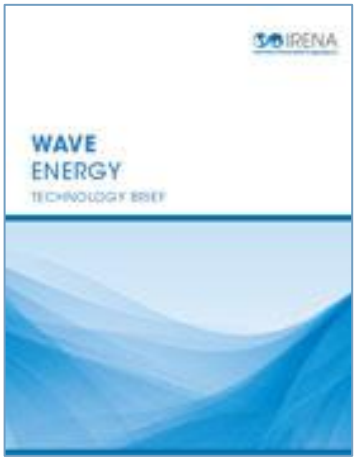
- Country-led, collaborative process to shape **national action plans**
- Identifies **effective policies** for renewable energy deployment
- Helps craft **investor-friendly regulations**
- Framework for future IRENA **engagement and advice**
- Undertaken by **22+ countries**

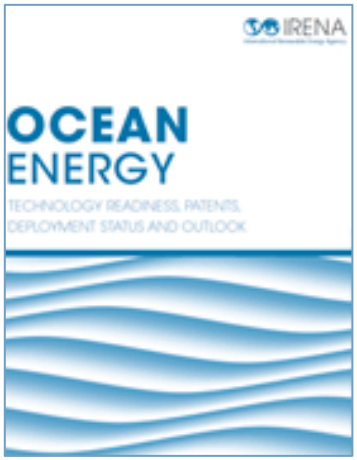
TECHNOLOGY BRIEFS

- Ocean Energy Technology Briefs 2014
- Ocean Energy Technology Readiness, Patents, Deployment Status and Outlook 2014









CONTENT

- Opportunities
- Sector Coupling
- Electricity Cost
- Challenges
- Standards
- Tidal Energy
- Wave Energy
- Ocean Thermal Energy Conversion (OTEC)
- Next Steps

OPPORTUNITIES (1)

Why should we look at renewable energy on islands?

Conventional electricity by fossil fuels
(heavy fuel oil or diesel generators)

Climate change ➡ Vulnerability

Dependency ➡ High cost of electricity

OPPORTUNITIES (2)

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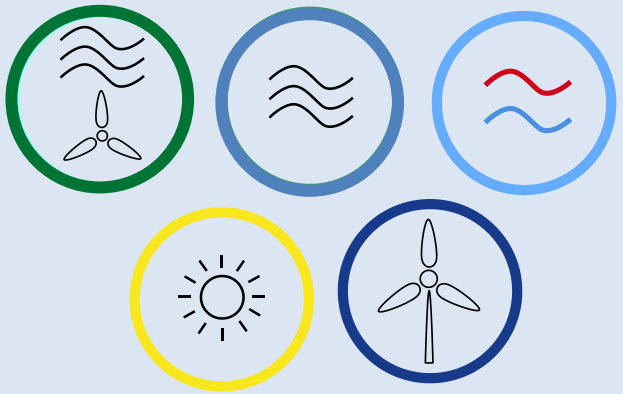
Global Theoretical Potential

Tidal Energy: 90 GW[1]

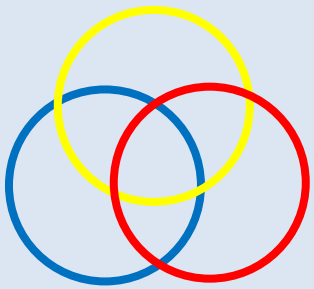
Wave Energy: 3.0 TW[2]

OTEC: 30 TW[3]

Diversity supply



Sector coupling



Restricted land area

[1] http://tidalenergytoday.com/2015/02/17/estimate-of-global-potential-tidal-resources/

[2] G. Mork, S. Barstow, A. Kabuth, M. Teresa Pontes, 2010. Assessing the Global Wave Energy Potential. *Proceedings of OMAE2010* Shanghai, China https://pdfs.semanticscholar.org/d7fd/7fc8b4ec97db3cec84648b3303e9f267b581.pdf

[3] K. Rajagopalan and G. Nihous, 2013. An Assessment of the Global Ocean Thermal Energy Conversion Resources with a High-Resolution Ocean General Circulation Model. http://hinmrec.hnei.hawaii.edu/wp-content/uploads/2010/01/Global-OTEC-Resources_2013.pdf

SECTOR COUPLING

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Desalination

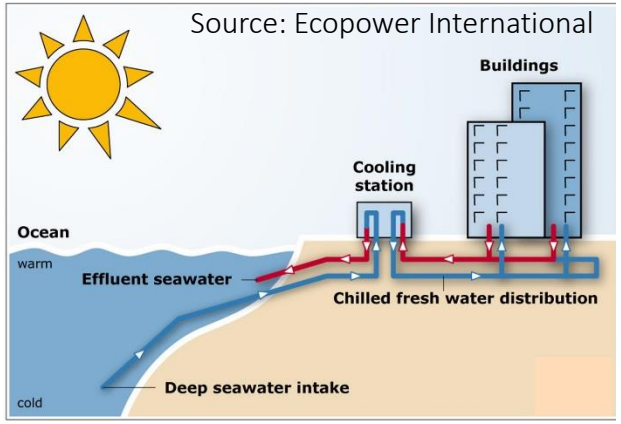
Device: Atmocean
wave energy converter
Method: reverse osmosis
Location: Chile
Time: 2015 (3 weeks demonstration project)

Source: Tidal Energy Today

SWAC
sea water air conditioning

Method: OTEC
Location: Bora Bora,
Intercontinental Resort and Thalasso Spa
Time: 2006

Source: Intercontinental Bora Bora



Source: Ecopower International

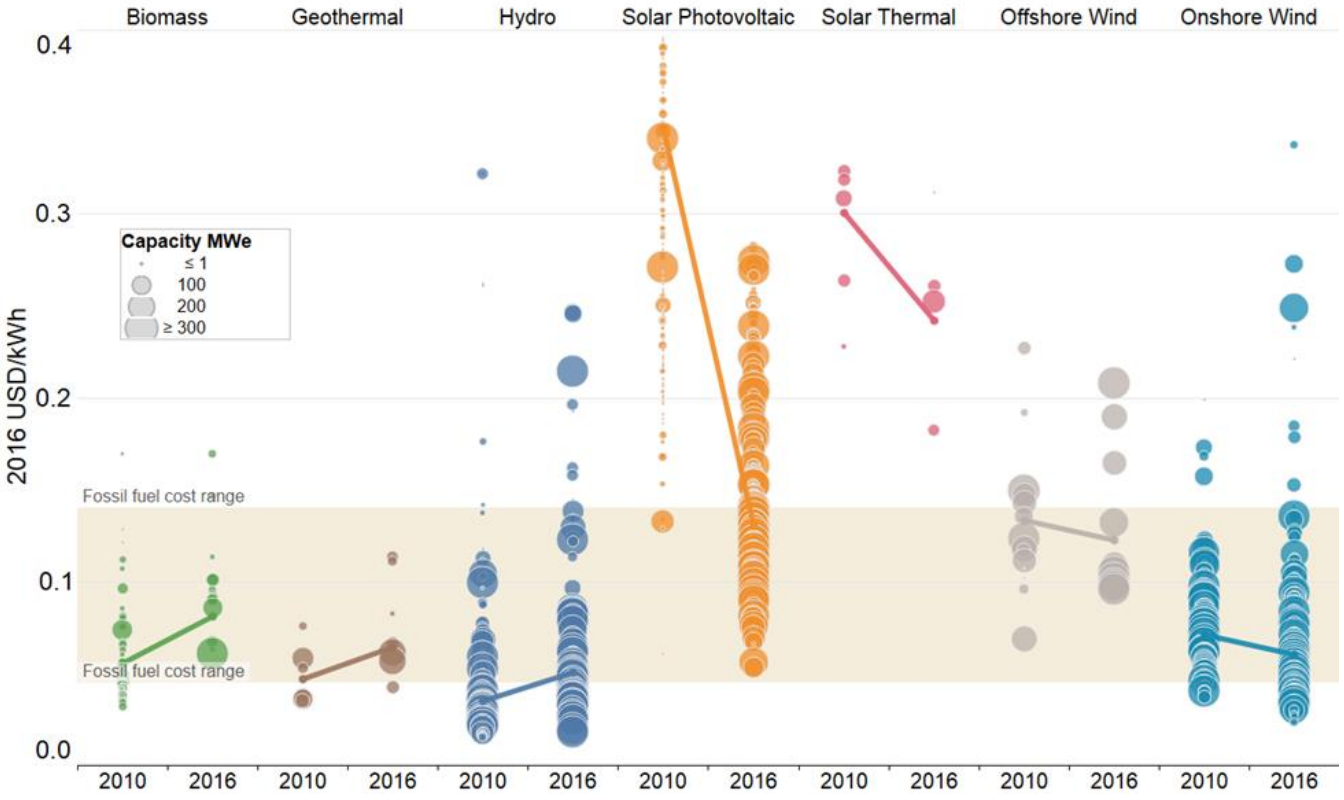
Aquaculture

Method: OTEC
Location: Kumejima, Japan
Time: 2013

Source: OTEC Okinawa

ELECTRICITY COST

Renewables: Highly competitive for new capacity



Each circle represents one project, centre of circle is LCOE value on Y axis, diameter is size of project. Year is the year commissioned.

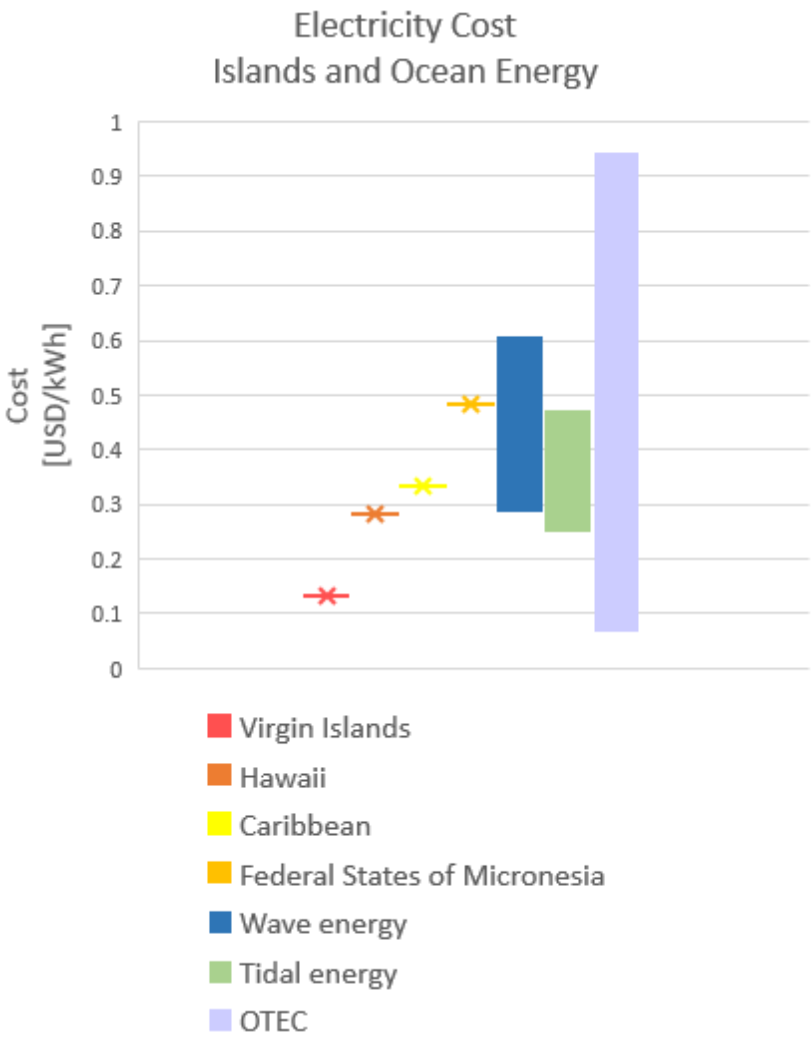
Traditional renewables highly competitive

Cost reductions for wind and solar, make them increasingly competitive

Cost rise for average hydro projects, geo & biomass data needs more work

ELECTRICITY COST

- Cost of electricity for residential use on islands, examples:
  - Virgin Islands 0.13 USD/kWh[1] ;
  - Hawaii 0.28 USD/kWh[2] ;
  - Caribbean average 0.33 USD/kWh [3];
  - Federal States of Micronesia 0.48 USD/kWh [4]



[1] https://www.eia.gov/state/print.php?sid=VQ
[2] https://www.hawaiianelectric.com/my-account/rates-and-regulations/average-price-of-electricity
[3] http://www.nrel.gov/docs/fy15osti/62691.pdf
[4] http://www.nrel.gov/docs/fy15osti/64294.pdf

CHALLENGES

- Technology
- Economic
- Social
- Environment
  (impact largely unknown)
- Infrastructure

Source: Ocean Energy Technology Readiness, Patents, Deployment Status and Outlook 2014, IRENA

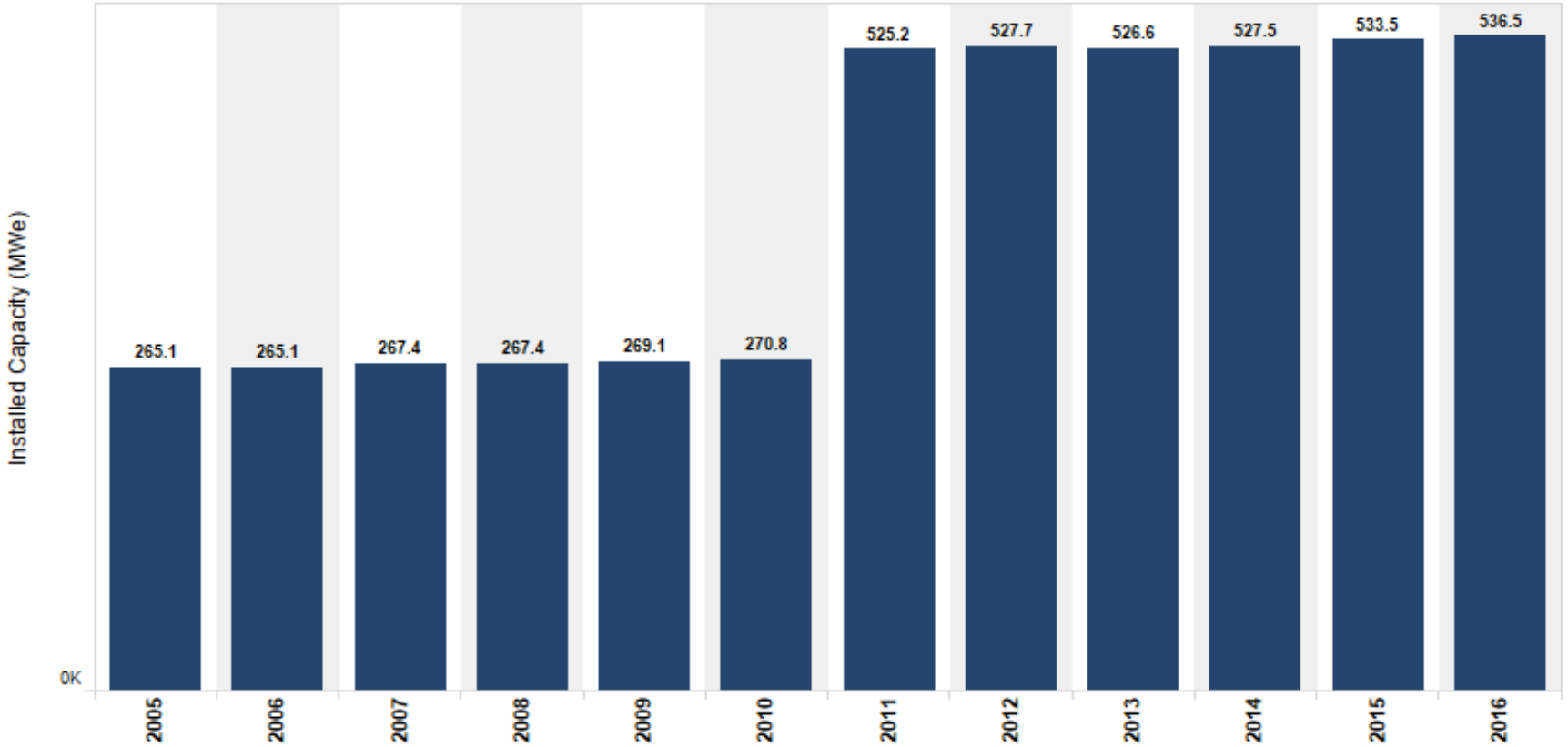
STANDARDS

» IEC-TC 114 Marine Energy – Wave, tidal and other water current converters system definition, performance measurement of wave tidal and water current energy converters, resource assessment requirements, design and survivability, safety requirements, power quality, manufacturing and factory testing, evaluating and mitigation of environmental impacts

Number	Name
IEC TS 62600 – 1:2011	Part 1: Terminology
IEC TS 62600 – 2:2016	Part 2: Design requirements for marine energy systems
IEC TS 62600 – 10:2015	Part 10: Assessment of mooring system for marine energy converters (MECs)
IEC TS 62600 – 100:2012	Part 100: Electricity producing wave converters – Power performance assessment
IEC TS 62600 – 101:2015	Part 101: Wave energy resource assessment and characterization
IEC TS 62600 – 102:2016	Part 102: Wave energy converter power performance assessment at a second location using measured assessment data
IEC TS 62600 – 200:2013	Part 200: Electricity producing tidal energy converters – Power performance assessment
IEC TS 62600 – 201:2015	Part 201: Tidal energy resource assessment and characterization

OCEAN ENERGY INSTALLED CAPACITY

Cumulative Installed Capacity Ocean Energy

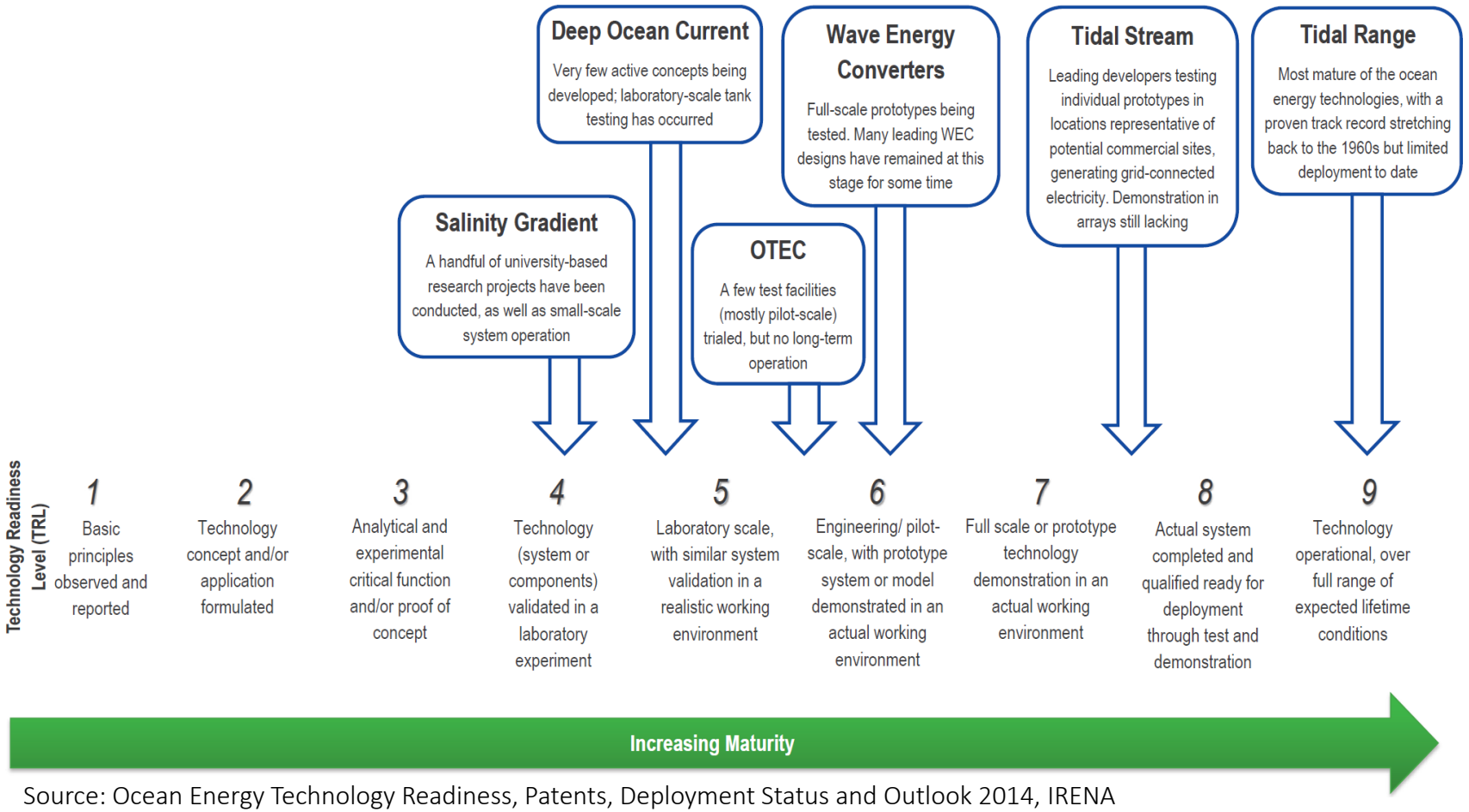


The highest share (> 90%) of installed ocean energy capacity is tidal range energy, with the 240 MW plant in France in 1966 and 254 MW in South Korea in 2011. The latter is clearly shown in this graph.

Source: REsource IRENA

TECHNOLOGY READINESS LEVEL

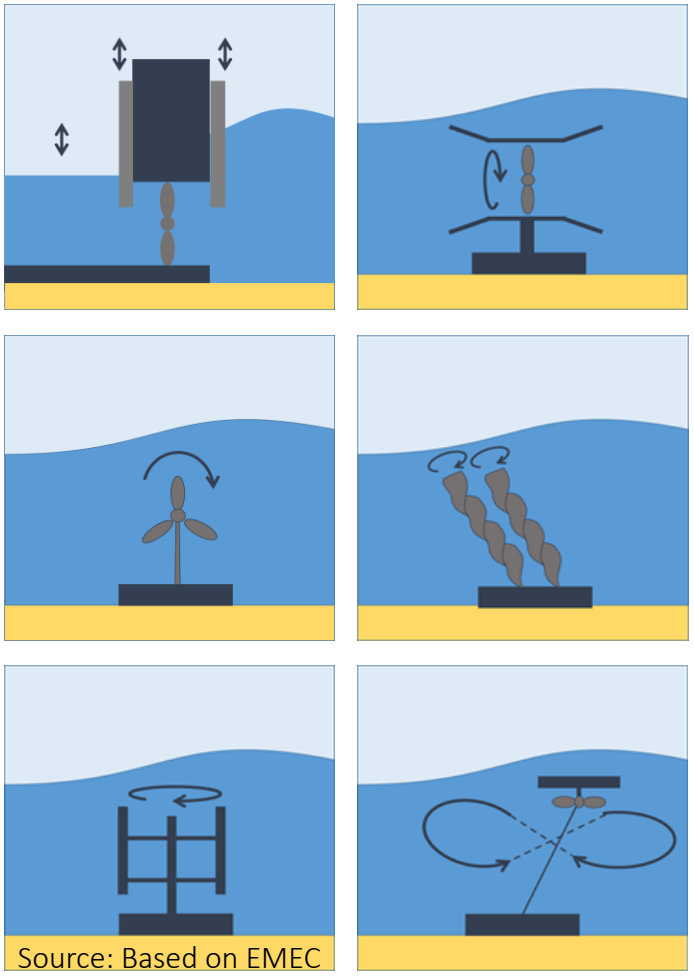
Diverse technologies to use ocean energy resources at different technology readiness levels (TRL)



Source: Ocean Energy Technology Readiness, Patents, Deployment Status and Outlook 2014, IRENA

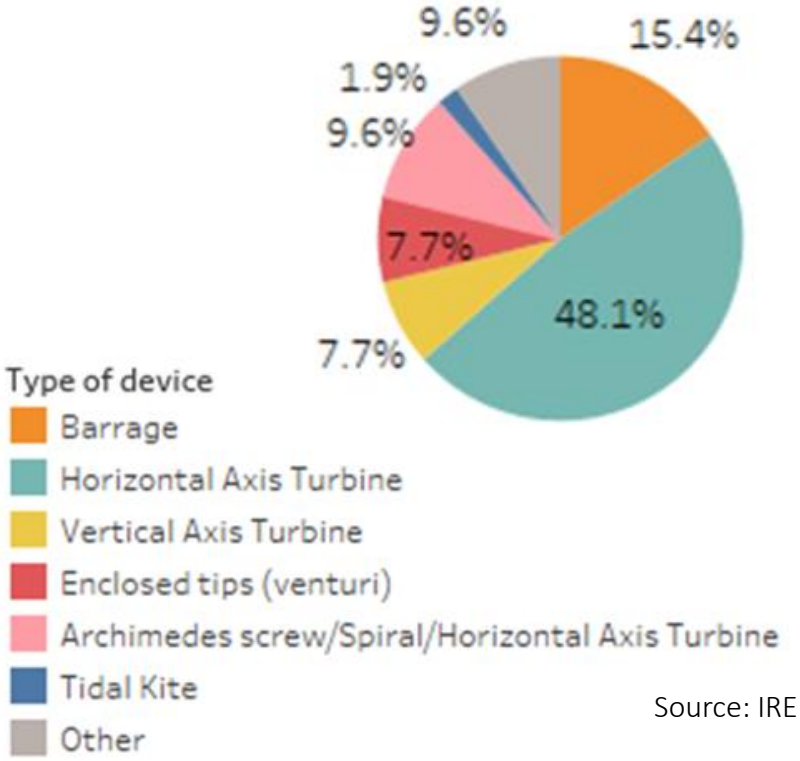
TIDAL ENERGY

Energy extraction	tidal current and tidal range
Cost range	0.25 - 0.47 USD/kWh[1]



Source: Based on EMEC

Percentage of number of tidal energy projects deployed up to June 2017 (48 projects)



Source: IRENA

[1] http://www.irena.org/DocumentDownloads/Publications/Tidal_Energy_V4_WEB.pdf

TIDAL ENERGY

Number of Tidal Energy Projects

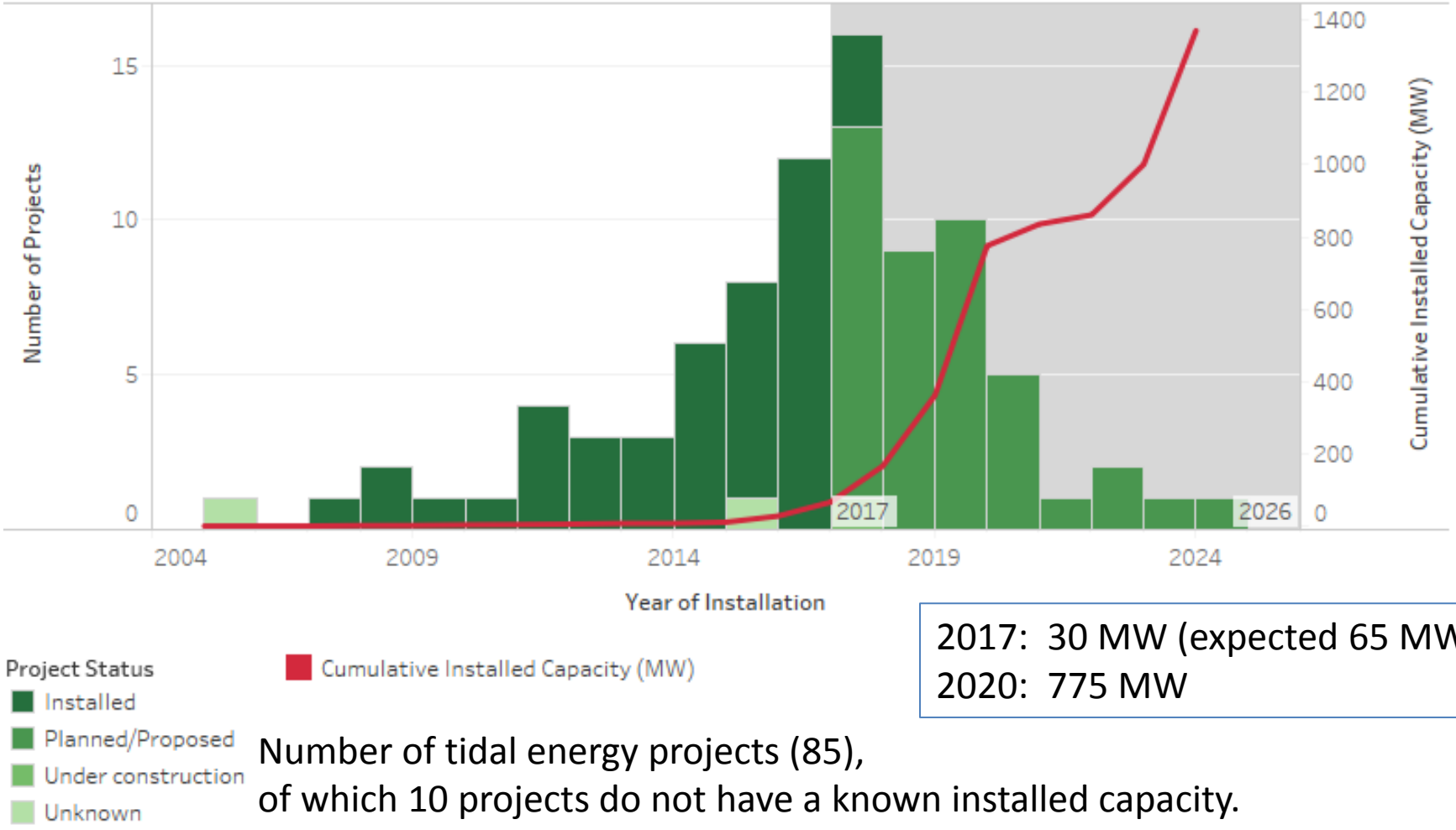
The Netherlands

Project: Eastern Scheldt Project - Tocardo T2
Capacity: 1.2 MW (5 turbines)
Location: Eastern Scheldt
Time: deployed 2015

Number of tidal energy projects that have been installed, are under construction or planned/proposed up to 2026 (87 projects), excluding tidal barrage (9 projects), unknown status (2 projects) and unknown year of installation (5 projects).

TIDAL ENERGY

Number of projects & Cumulative installed capacity

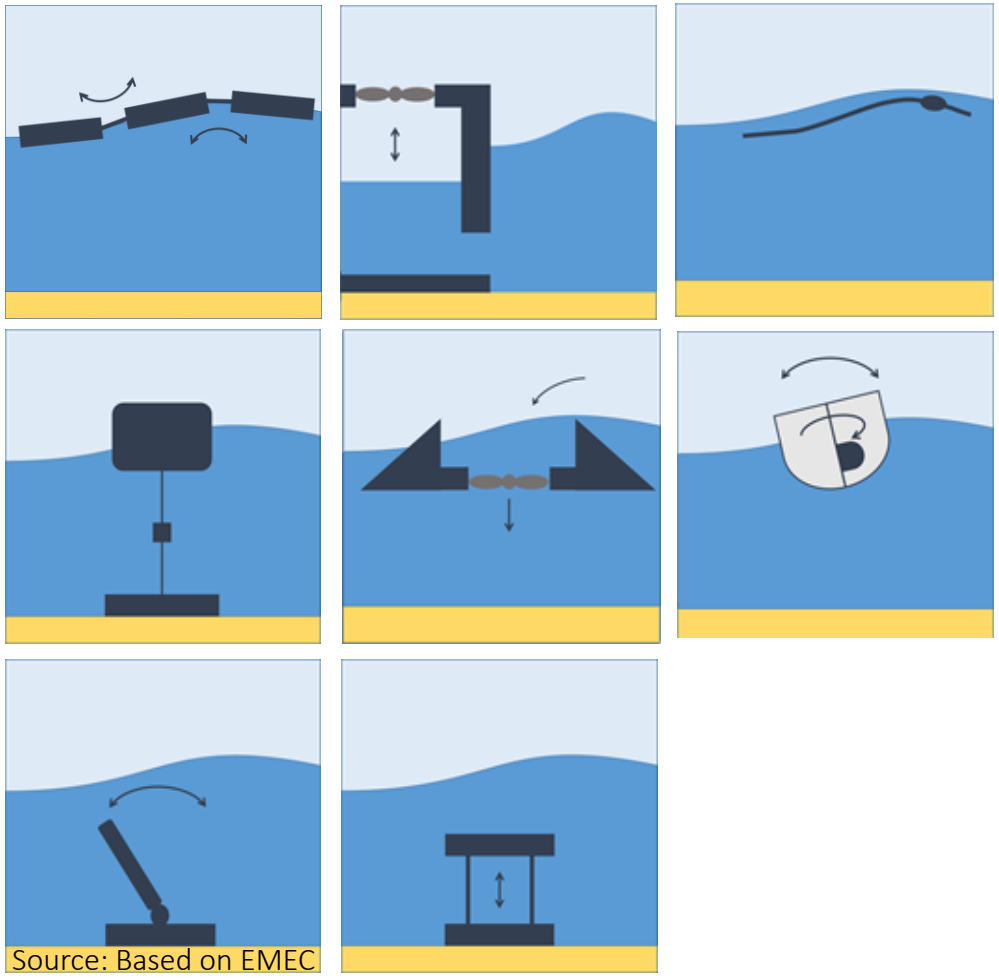


2017: 30 MW (expected 65 MW)
2020: 775 MW

Number of tidal energy projects (85),
of which 10 projects do not have a known installed capacity.
Tidal barrage projects are excluded.

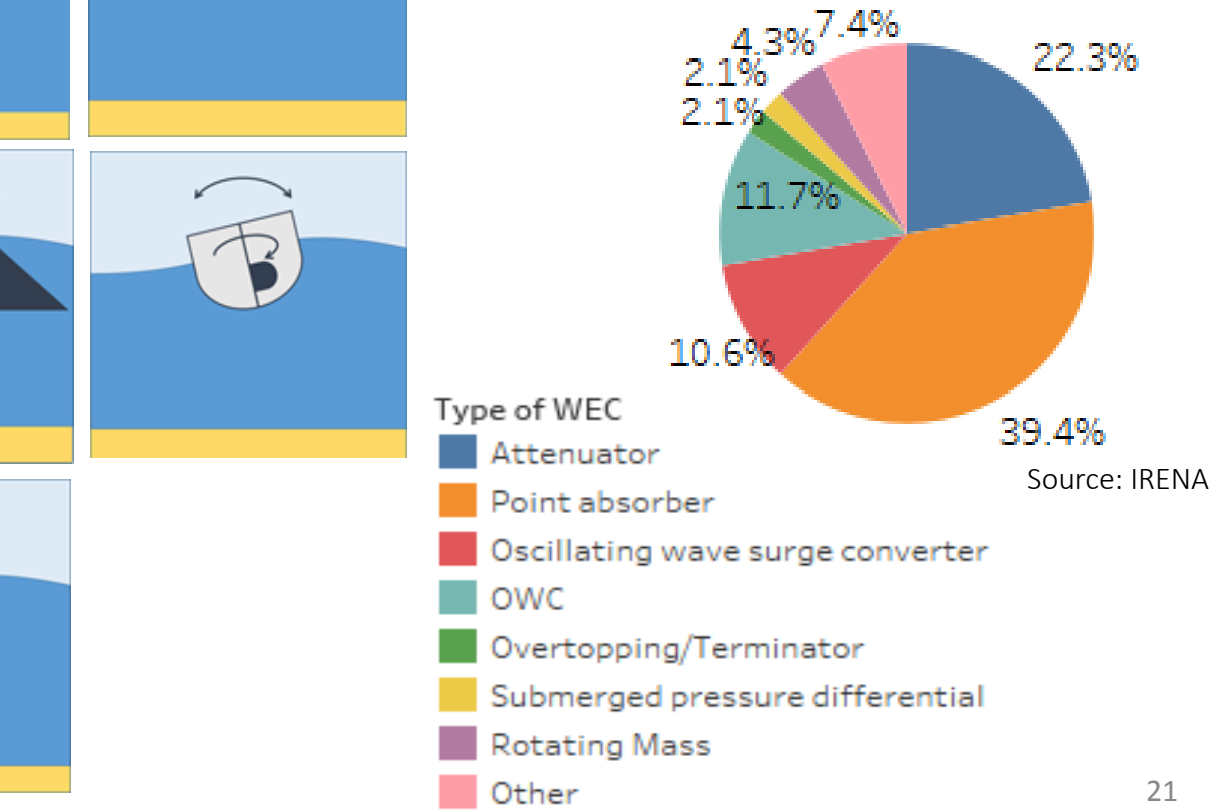
WAVE ENERGY

Energy extraction	Surge, sway and heave motion of the wave
Cost range	0.29 – 0.61 USD/kWh[1]



Source: Based on EMEC

Percentage of number of wave energy projects deployed up to June 2017 (94 projects)



Source: IRENA

[1] http://www.irena.org/DocumentDownloads/Publications/Wave-Energy_V4_web.pdf

WAVE ENERGY

Number of Wave Energy Projects

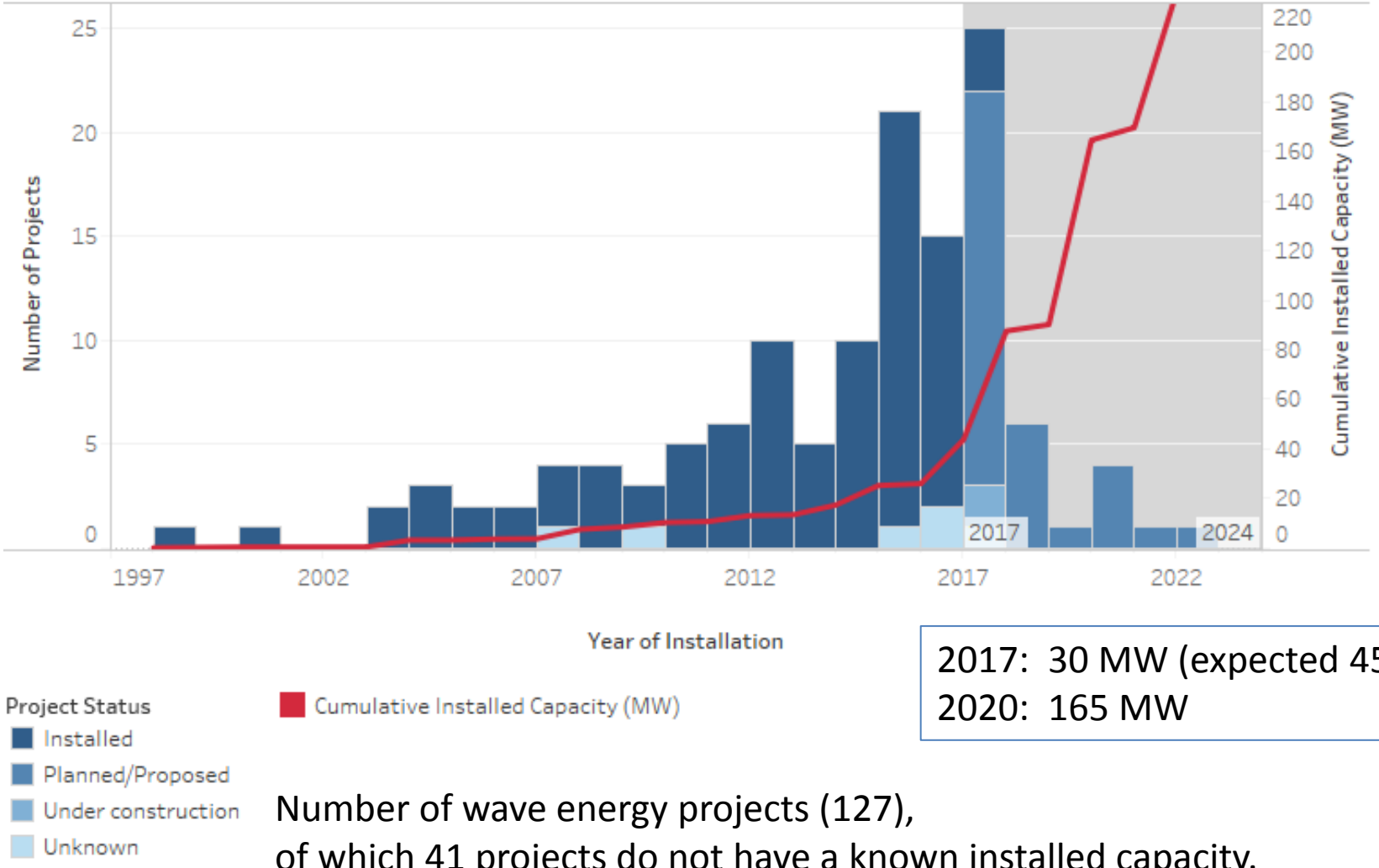
Australia

Project: Perth Project - CETO 5
Capacity: 720 kW (3 units)
Location: Garden Island
Time: 2015 - 2016

Number of wave energy projects that have been installed, are under construction or planned/proposed up to 2024 (122 projects), excluding the projects with unknown status (5 projects) and unknown year of installation (8 projects).

WAVE ENERGY

Number of projects & Cumulative installed capacity



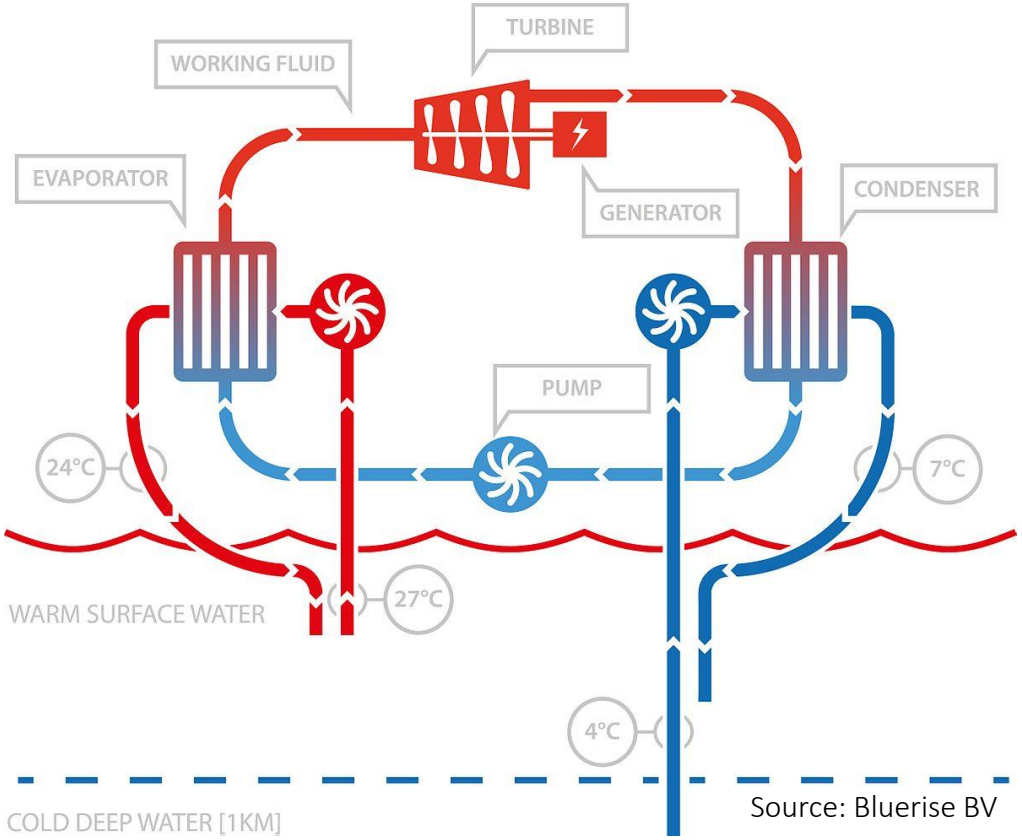
2017: 30 MW (expected 45 MW)
2020: 165 MW

Number of wave energy projects (127),
of which 41 projects do not have a known installed capacity.

OTEC

Energy extraction	Thermal gradient
Example project	Example project: NEMO (DCNS; Akuo Energy)
Cost range	0.07 – 0.94 USD/kWh[1] (depending on plant size)

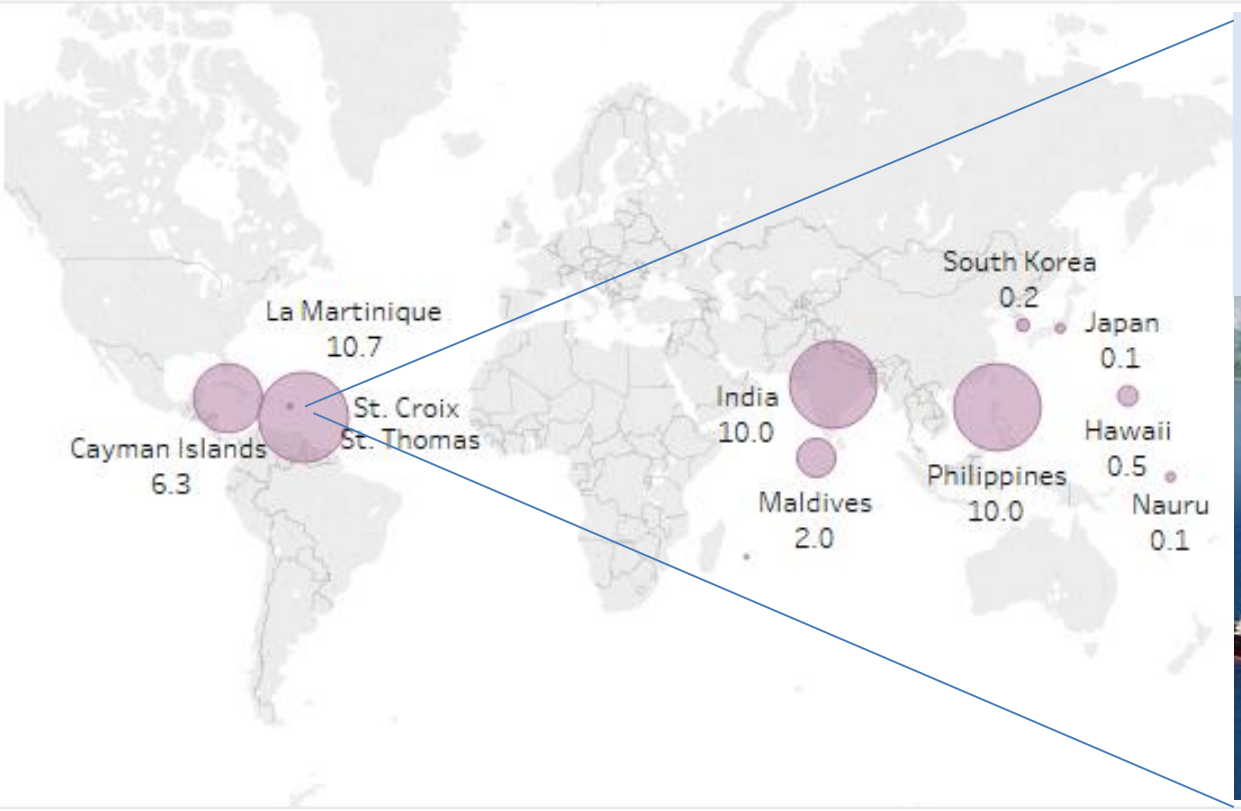

Source: OTEC Okinawa



Source: Bluerise BV

[1] http://www.irena.org/DocumentDownloads/Publications/Ocean_Thermal_Energy_V4_web.pdf

Installed Capacity OTEC



La Martinique

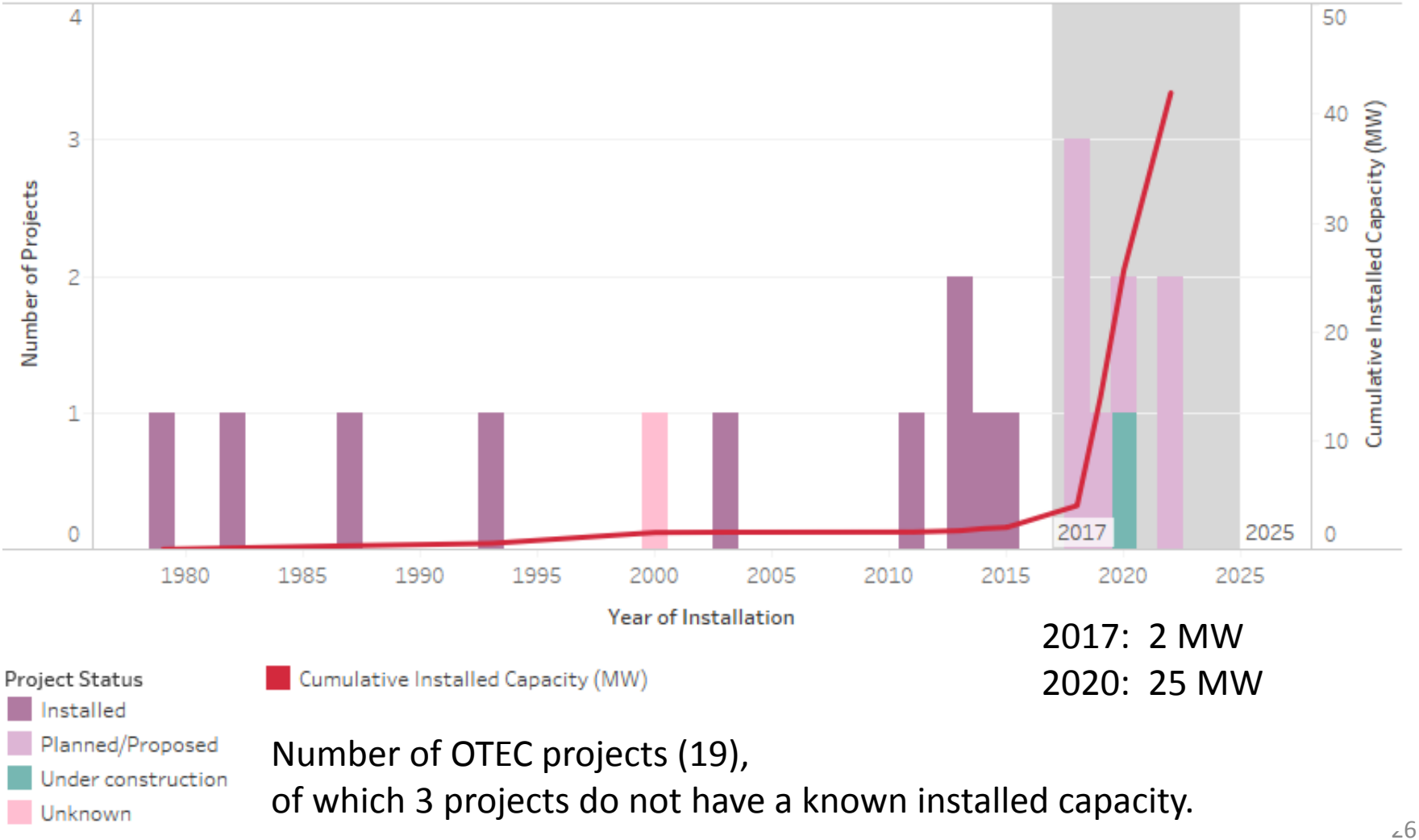
Project: NEMO
Capacity: 10.7 MW
Location: La Martinique
Time: scheduled deployment 2020

Source: DCNS and Akuo Energy

Installed Capacity of OTEC projects that have been installed, are under construction and planned/proposed up to 2025 (19 projects), excluding the projects of which the status is unknown (5 projects), and of which the year of installation is unknown (12 projects).

OTEC

Number of projects & Cumulative installed capacity



2017: 2 MW
2020: 25 MW

Number of OTEC projects (19),
of which 3 projects do not have a known installed capacity.

FUNDING for OCEAN ENERGY

- NER300
  "Financing instrument managed jointly by the European Commission, European Investment Bank and Member States." [1]

- FORESEA (Funding Ocean Renewable Energy through Strategic European Action)
  "Help bring ocean energy technologies to the market by providing access to North-West Europe's world-leading network of test centres." [2]

- OCEANERA-NET
  "Coordinate funding programmes between European countries and regions to support research and innovation in the ocean energy sector." [3]

- Horizon 2020 - TP Ocean

- Abu Dhabi Fund for Development (ADFD)

[1] http://www.ner300.com/
[2] http://www.nweurope.eu/projects/project-search/funding-ocean-renewable-energy-through-strategic-european-action/
[3] http://oceaneranet.eu/

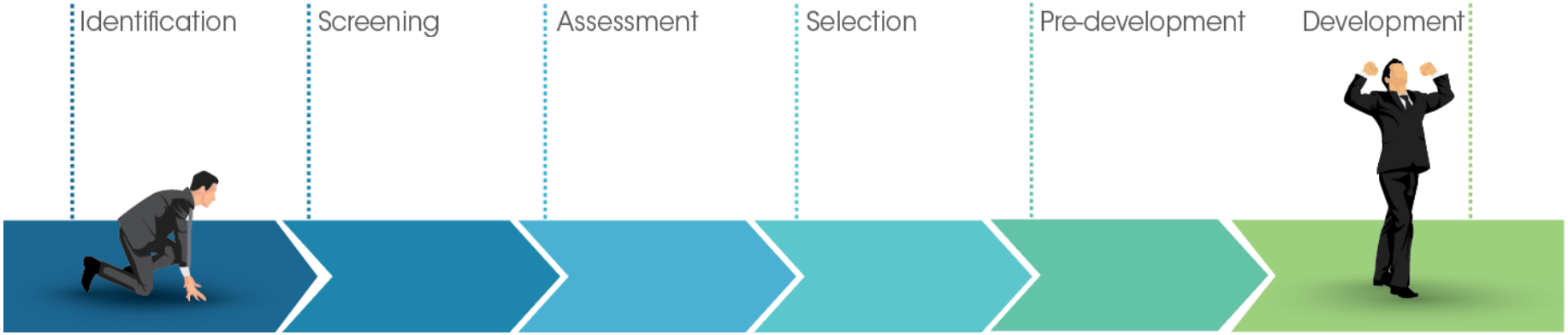
PROJECT NAVIGATOR

The challenge of RET projects

- Failing to prove project bankability to funding institutions
- Insufficient knowledge on project proposal development
  - Higher project development costs
  - Higher risk of project failure

Objectives

- Increase the bankability of projects by:
  - Strengthening the project development base
  - Enhancing the quality of project proposals
  - Reducing costs and mitigating risks through proper planning and efficient use of funds
  - Facilitating effective implementation



CLIMATE CHANGE ACTION

Unlocking financing for RE projects

IRENA's ON-GOING WORK

- Document Technology Development from the last three years
- Assess ocean energy market potential for Caribbean islands
- Develop tailor-made project development guidelines for ocean energy projects

- **Would you like to engage?**

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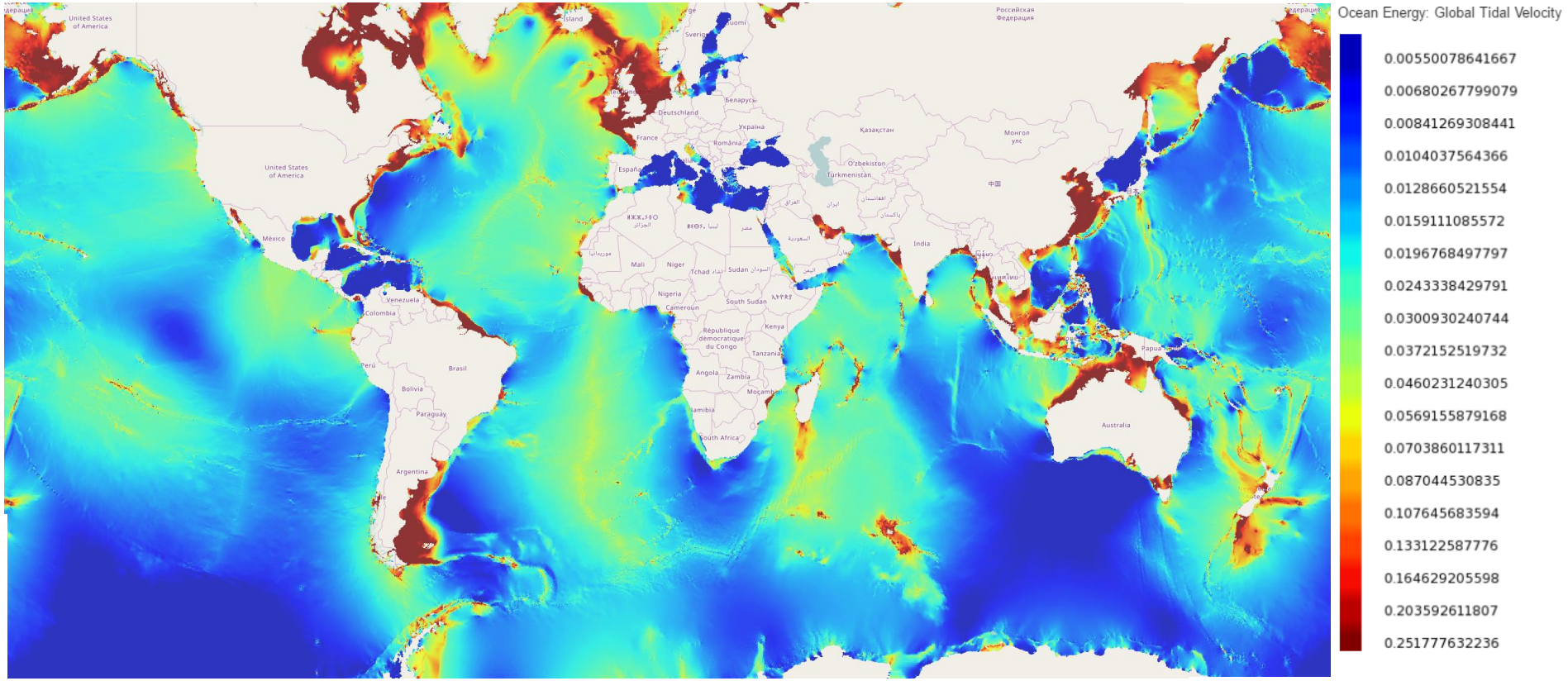
www.youtube.com/user/irenaorg

Extra slides

TIDAL ENERGY

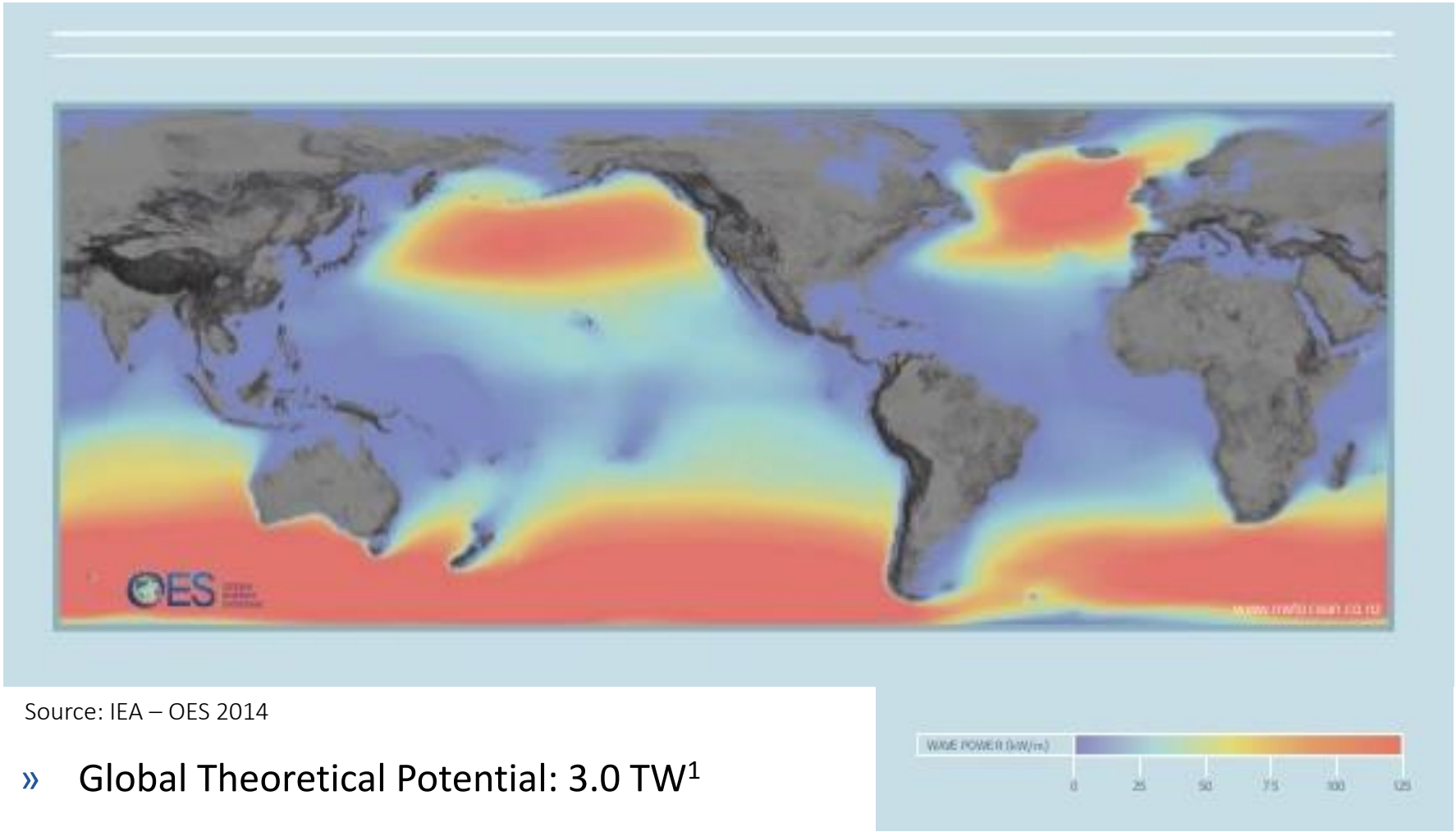
» Global Theoretical Potential: 90 GW



Source: Global Atlas IRENA

[1] http://tidalenergytoday.com/2015/02/17/estimate-of-global-potential-tidal-resources/

WAVE ENERGY

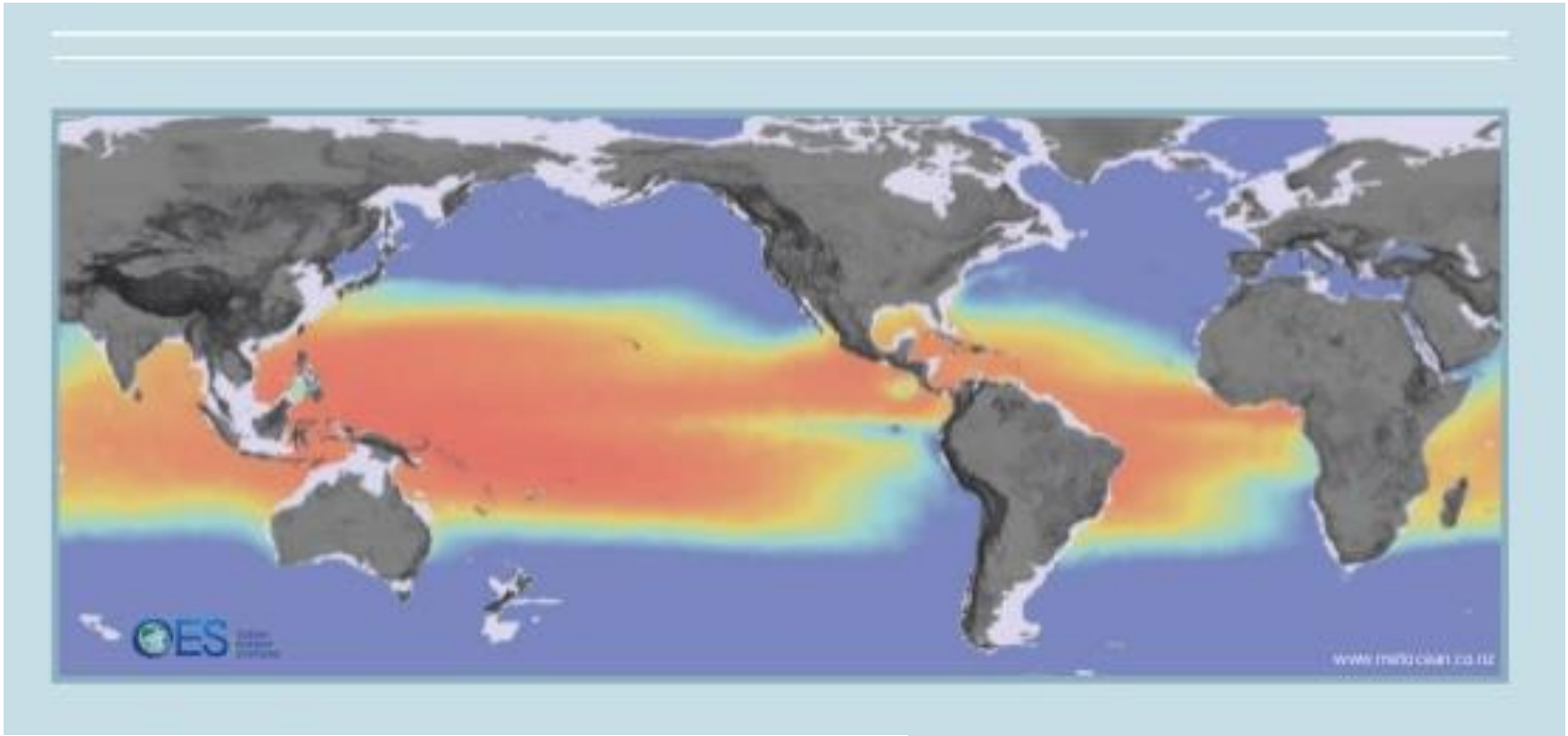


Source: IEA – OES 2014

» Global Theoretical Potential: 3.0 TW[1]

[1] G. Mork, S. Barstow, A. Kabuth, M. Teresa Pontes, 2010. Assessing the Global Wave Energy Potential. *Proceedings of OMAE2010* Shanghai, China https://pdfs.semanticscholar.org/d7fd/7fc8b4ec97db3cec84648b3303e9f267b581.pdf

OTEC



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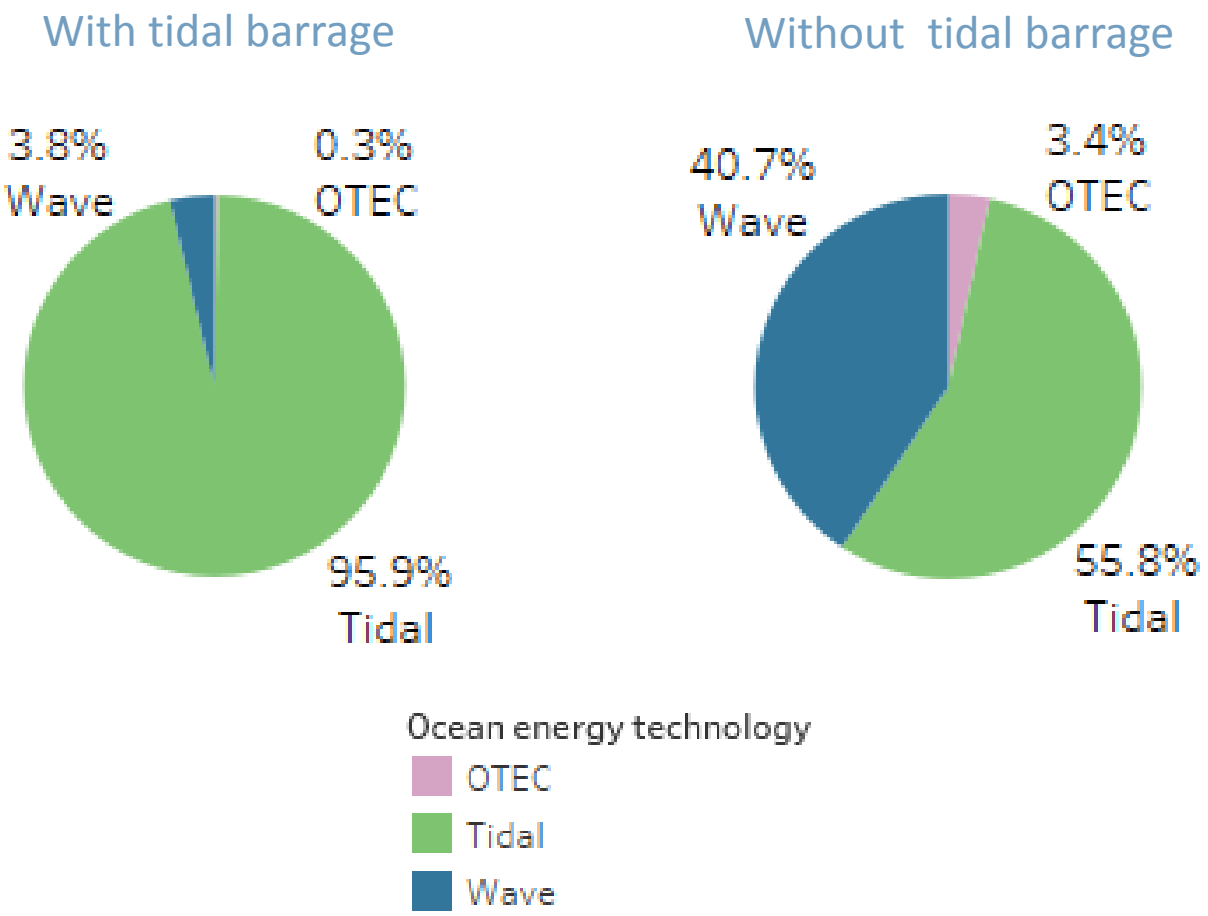
[1] K. Rajagopalan and G. Nihous, 2013. An Assessment of the Global Ocean Thermal Energy Conversion Resources with a High-Resolution Ocean General Circulation Model. http://hinmrec.hnei.hawaii.edu/wp-content/uploads/2010/01/Global-OTEC-Resources_2013.pdf

TECHNOLOGIES

Market share ocean energy technologies 2017



Source: IRENA