Permanent Mission of Barbados to the United Nations

Stakeholder Forum
FOR A SUSTAINABLE FUTURE

The Role of Oceans as a Sustainable Resource That Can Contribute to the Global Energy Transition

An HLPF 2020 Side Event, hosted by the Permanent Mission of Barbados to the United Nations & Stakeholder Forum for a Sustainable Future

- **Hon. Kirk D. M. Humphrey, M.P., Minister of Maritime Affairs and the Blue Economy, Barbados**
- **H.E. Ambassador Lois Michele Young, Permanent Representative of Belize to the United Nations & Chair of AOSIS**
- **Under-Secretary-General Fekitamoeloa Katoa 'Utoikamanu, United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States**
- **Ambassador Peter Thomson, United Nations Secretary-General's Special Envoy for the Ocean**
- **Mr. Rémi Gruet, CEO of Ocean Energy Europe**
- **Professor Weili Cui of the State University of New York Maritime College**
- **Misters Rik van Hemmen, President, and Michael Raftery, Chief Technology Officer, Martin & Ottaway and SurfWEC LLC**
- **Respondent: Ahmed Abdel-Latif, Permanent Observer to the United Nations, IRENA**
- **Closing remarks by H.E. Ambassador H. Elizabeth Thompson, Permanent Representative of Barbados to the United Nations**

Moderated by Charles Nouhan, Chairman of Stakeholder Forum

www.un.int/barbados / Email: prun@foreign.gov.bb
www.stakeholderforum.org / Email: renewables@stakeholderforum.org
@stakeholders

17 PARTNERSHIPS FOR THE GOALS

Oceans powering the energy transition

Rémi Gruet, CEO, Ocean Energy Europe

Ocean Energy Europe

- 120 members
- Our Lead Partners:

DP ENERGY

enel Green Power

engie

RÉGION NORMANDIE

SCOTTISH DEVELOPMENT INTERNATIONAL

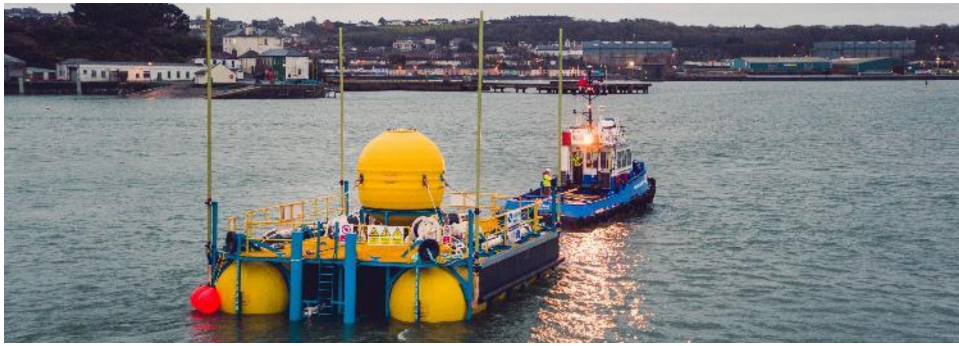
SEABASED

seai SUSTAINABLE ENERGY AUTHORITY OF IRELAND

SIMEC ATLANTIS ENERGY

Ocean energy – the next big thing in energy

- 400,000 EU jobs by 2050
  - maritime industries
  - coastal regions
- Flexible & predictable
  - Complements wind/solar
- Great potential
  - 100 GW in Europe
  - 10% of EU electricity
  - 94 Mio households
- 337 GW globally by 2050




This is a tidal farm…


ATLANTIS
AR1500 TURBINE
INDUSTRIAL FIGHTER


UNDERWATER HAZARD

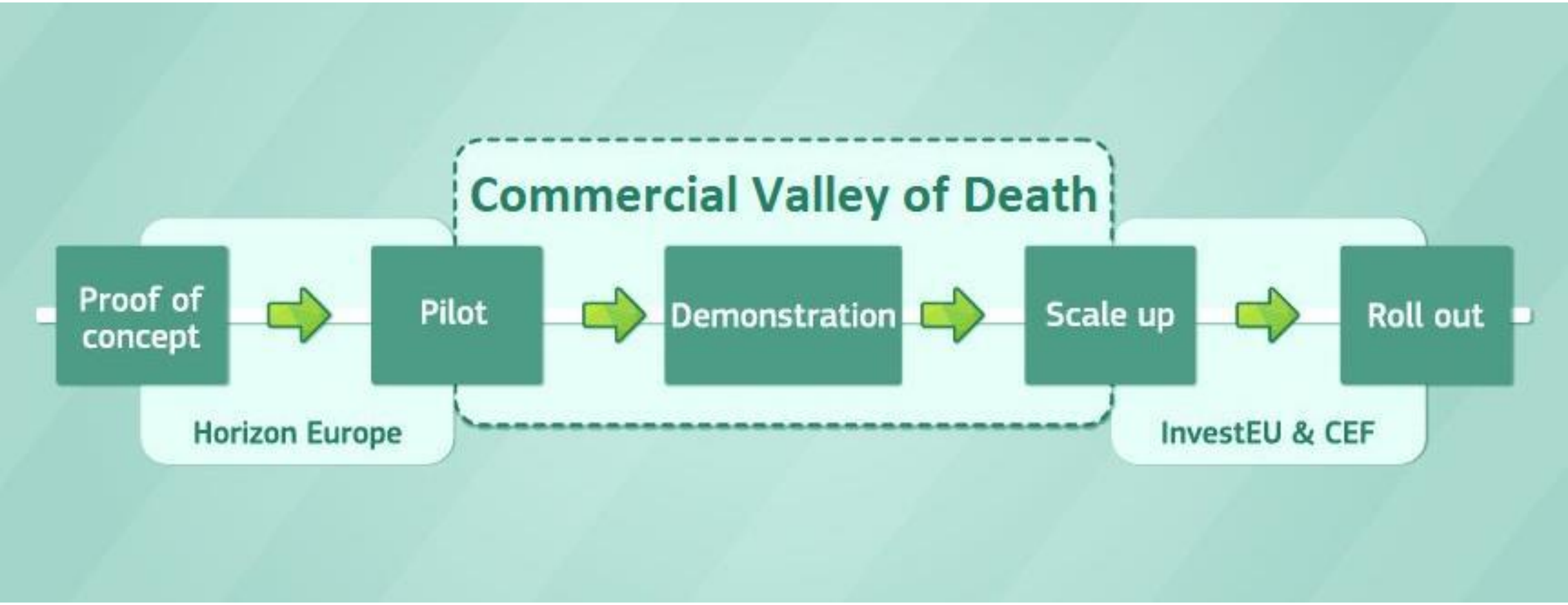

SUSTAINABLE
ENVIROTEK


LIFT HERE
CORPOWER
9707962
GREEN MARINE
WWW.GREENMAR

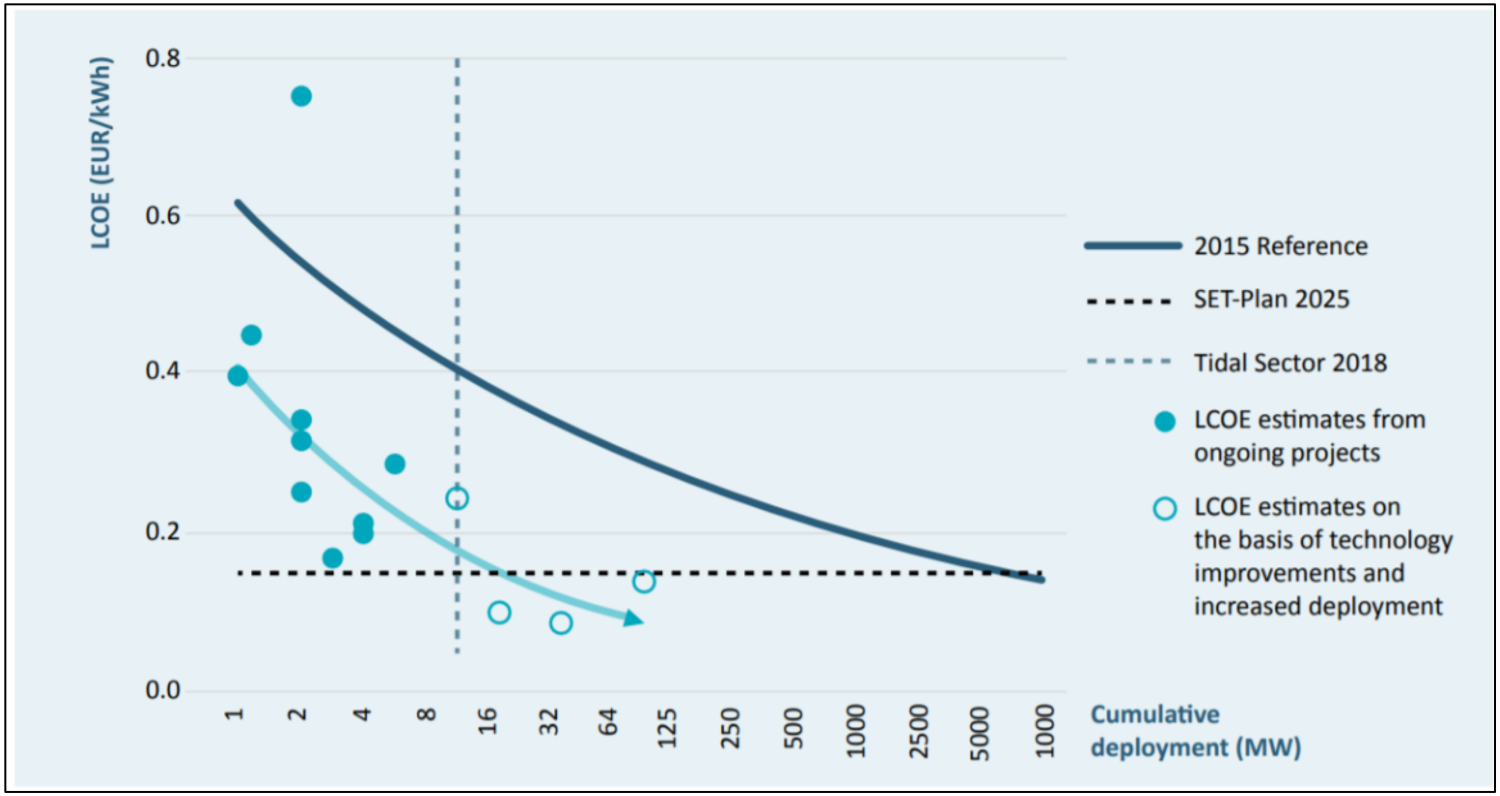

SIZE LOAD

Demo projects: Essential for new tech to reach the market

- Tidal - demo farms in the water - ready for scale-up
- Wave – full scale devices in the water - just behind

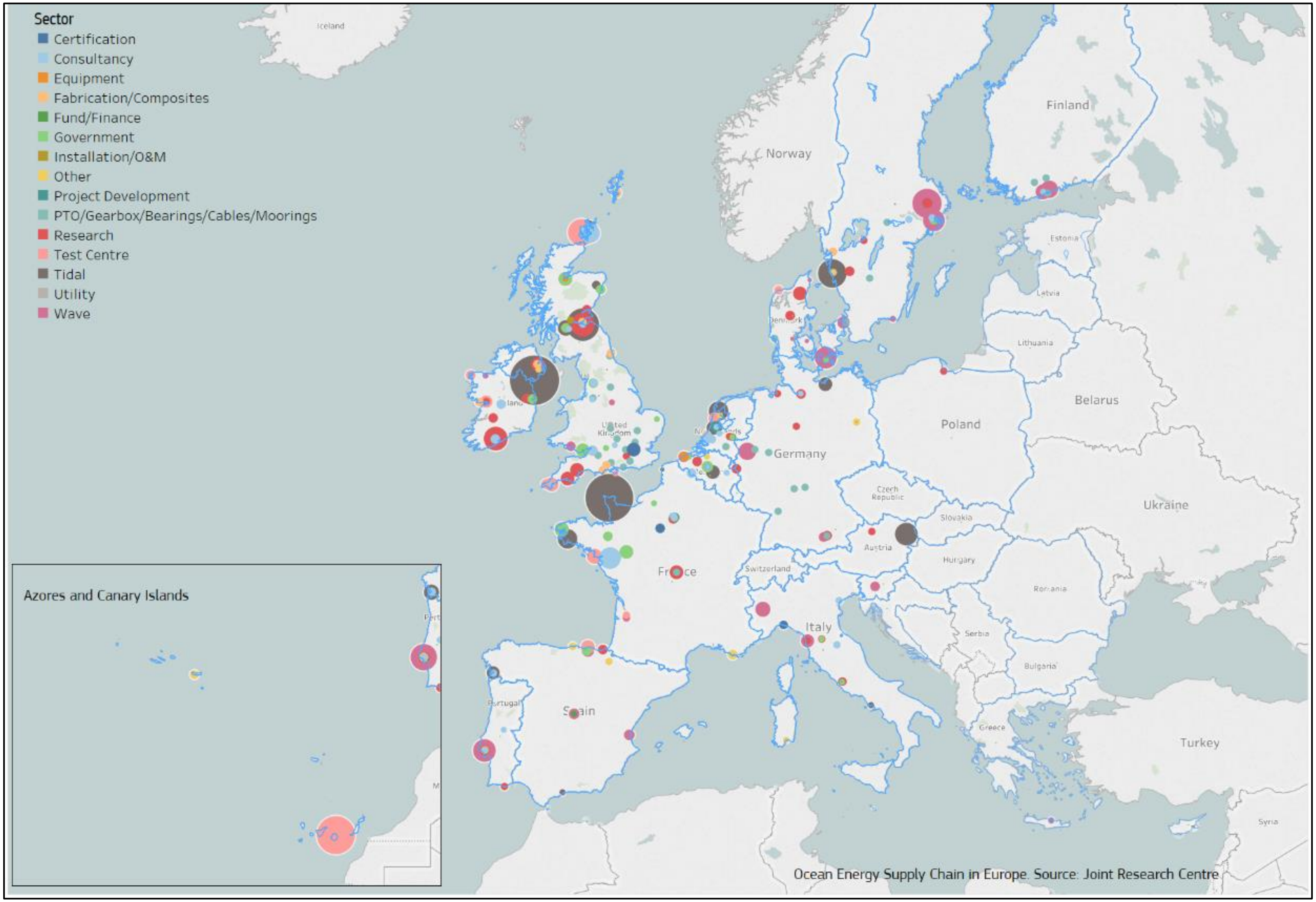


Demo projects deliver…
DRAMATIC COST REDUCTIONS



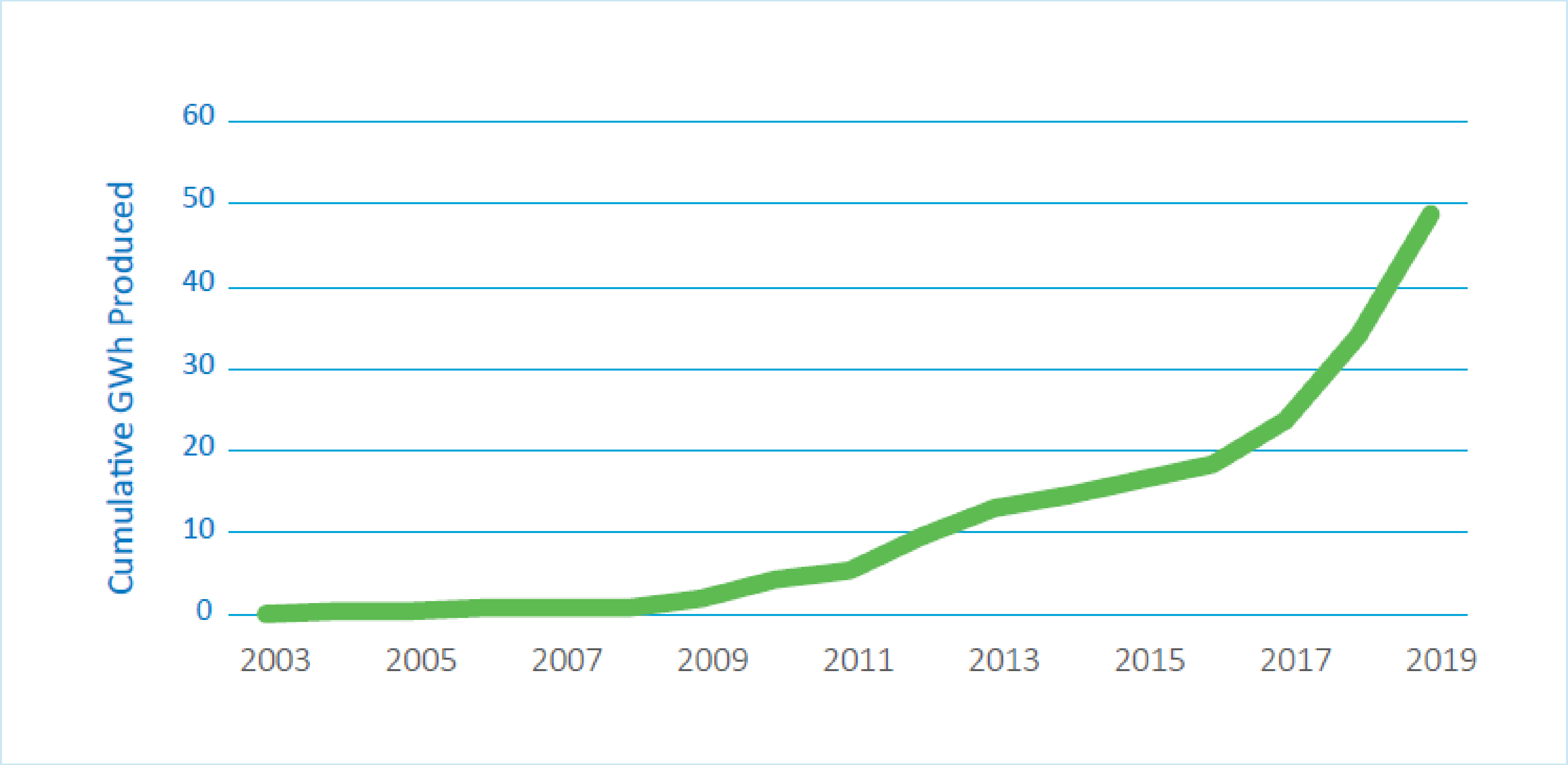
EC JRC: tidal costs reduced by >40% between 2015 - 2018

Demo projects deliver…
FIRST SUPPLY CHAINS



Demo projects deliver:
DATA + INVESTOR CONFIDENCE

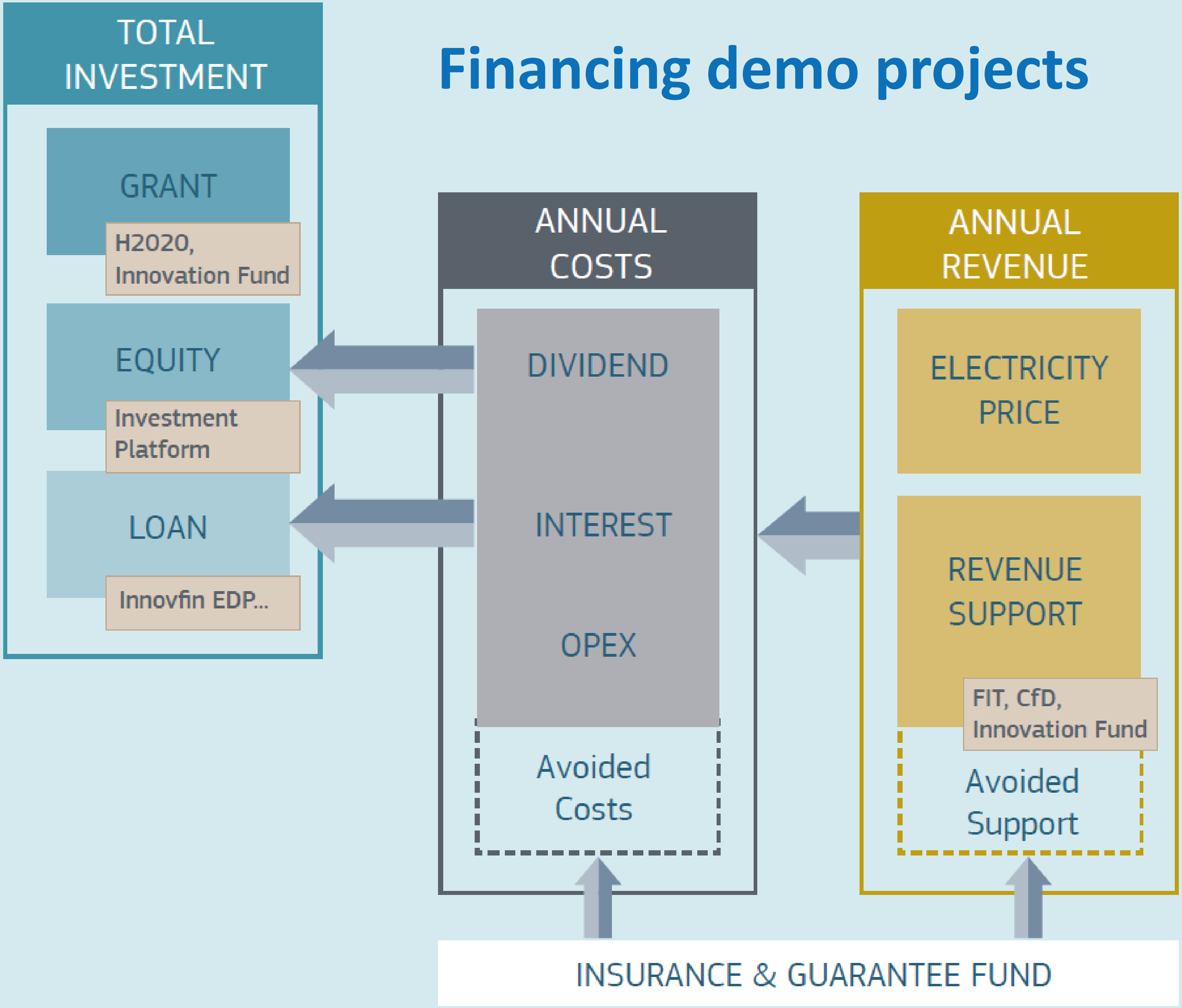
Ocean Energy Europe



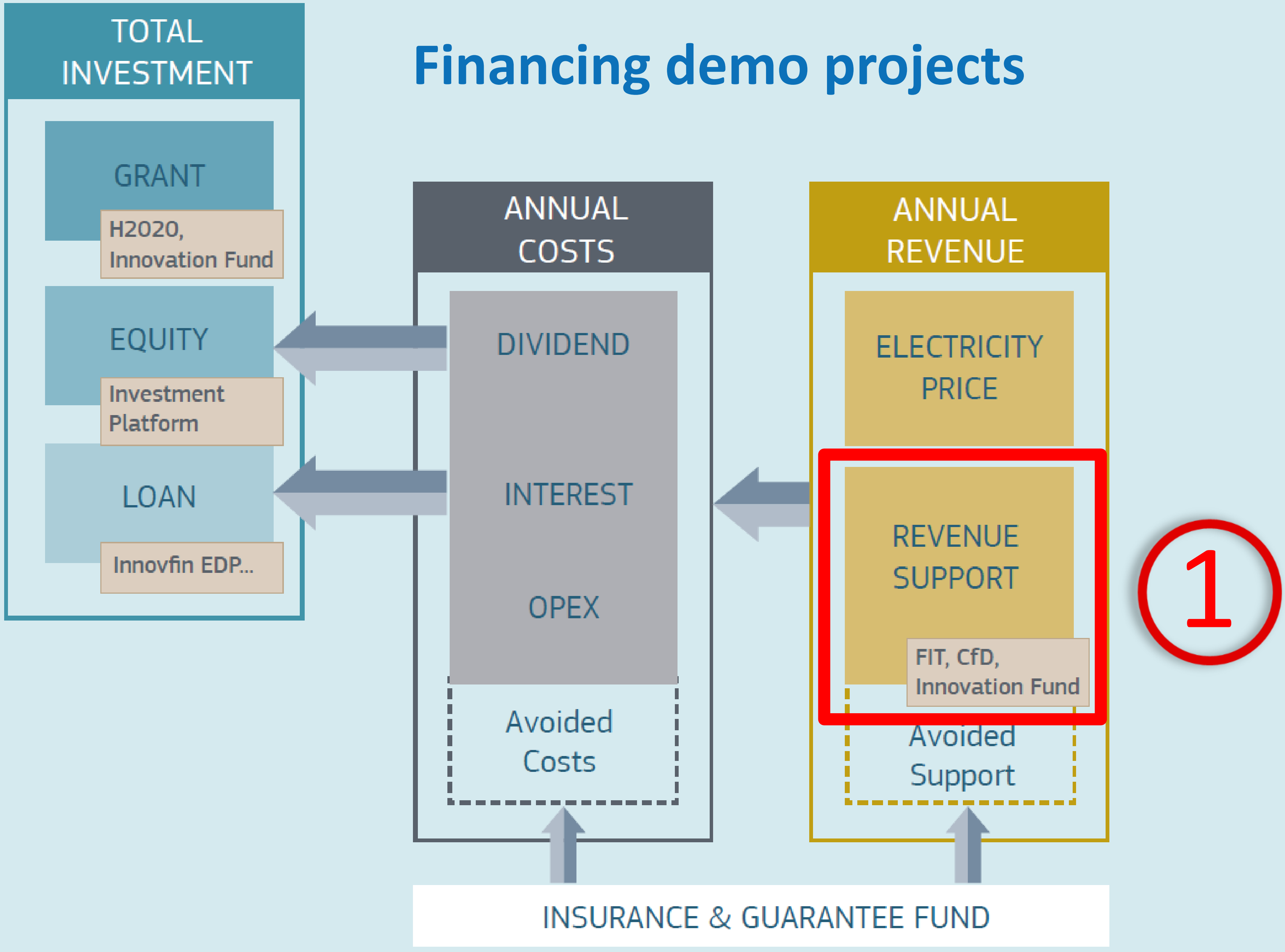
Cumulative GWh produced by tidal stream in Europe

Source: Ocean Energy Europe

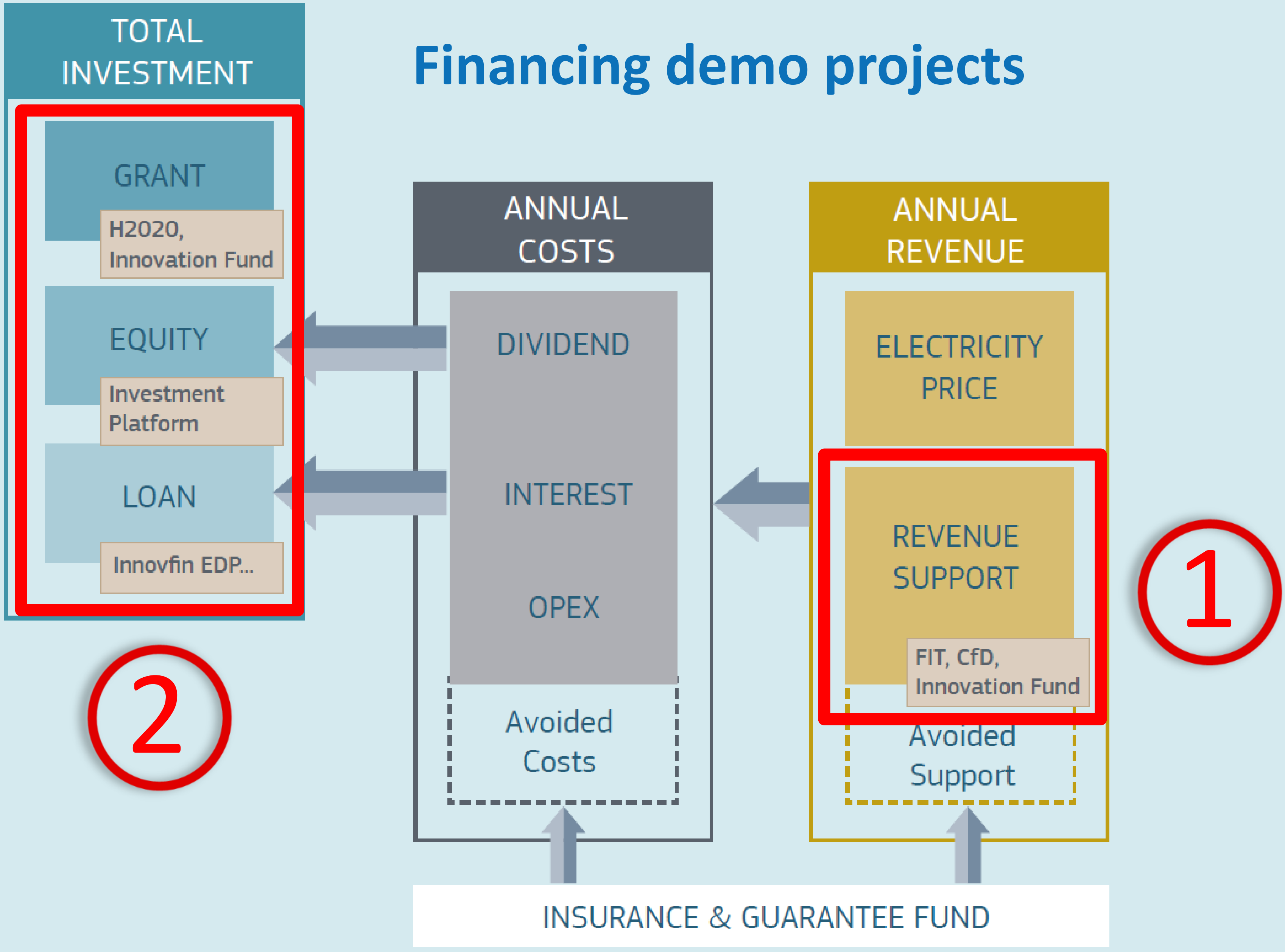
Financing demo projects



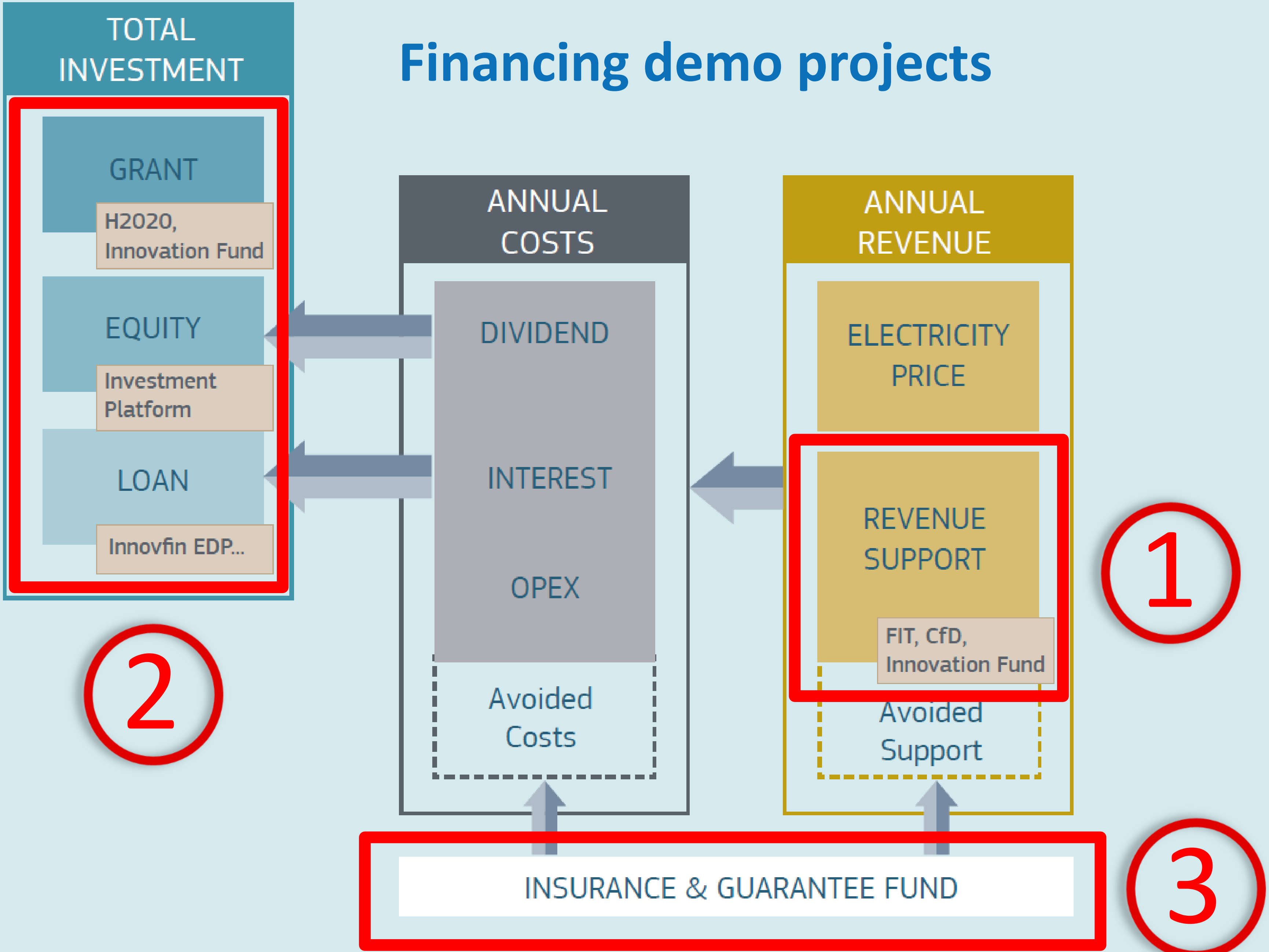
Financing demo projects



Financing demo projects

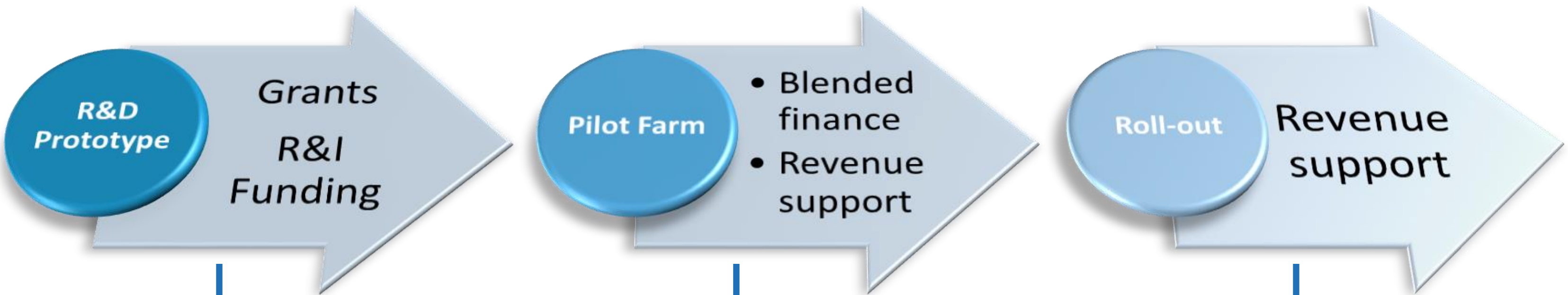


Financing demo projects



To Do List to benefit from industrial Ocean Energy

Ocean Energy Europe



Funnel for the most successful innovations

Help projects reach financial close

Deploy pre-commercial & commercial projects

Thank you!

@euoea

www.oceanenergy-europe.eu

Ocean Energy Europe

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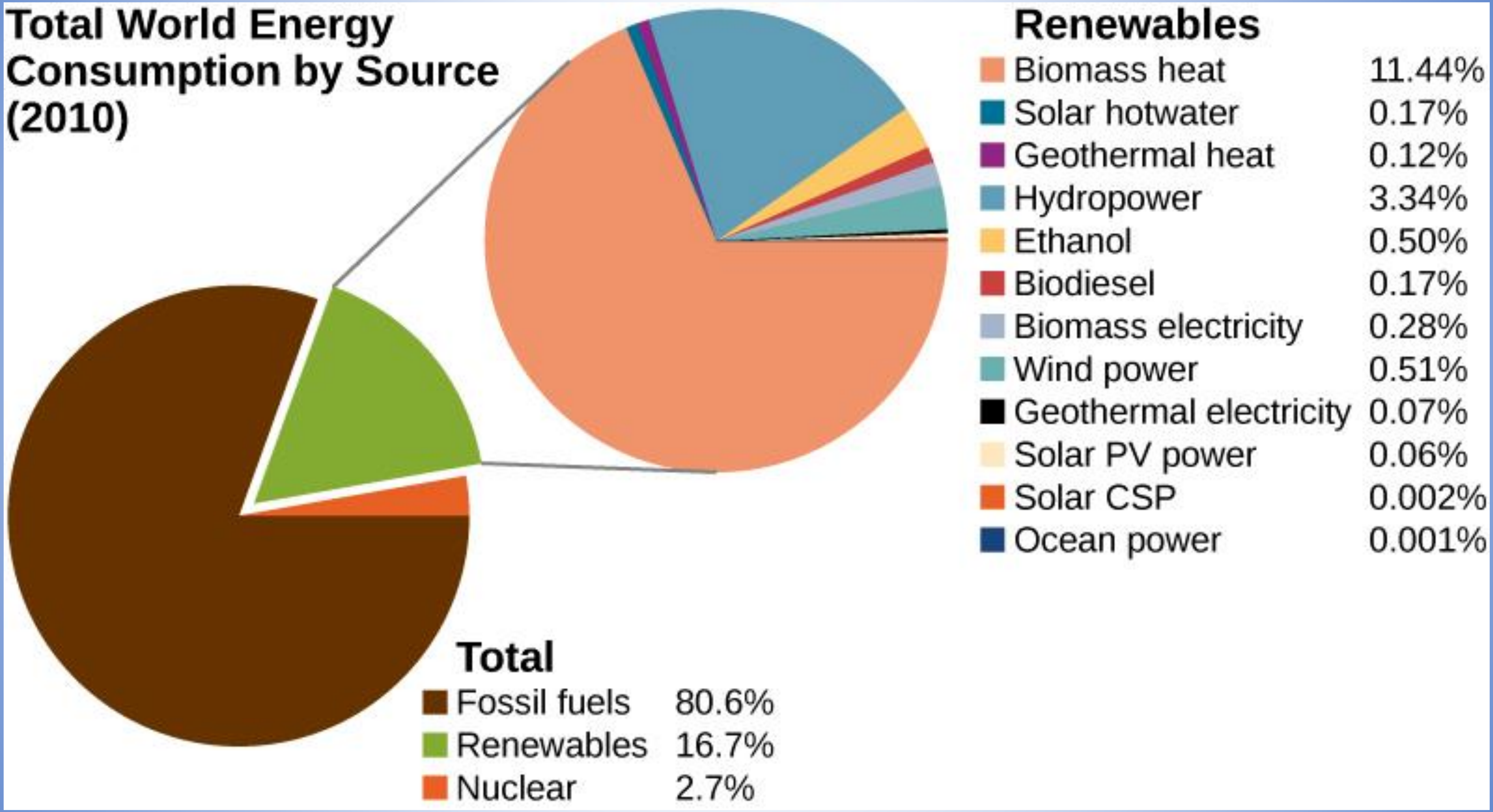
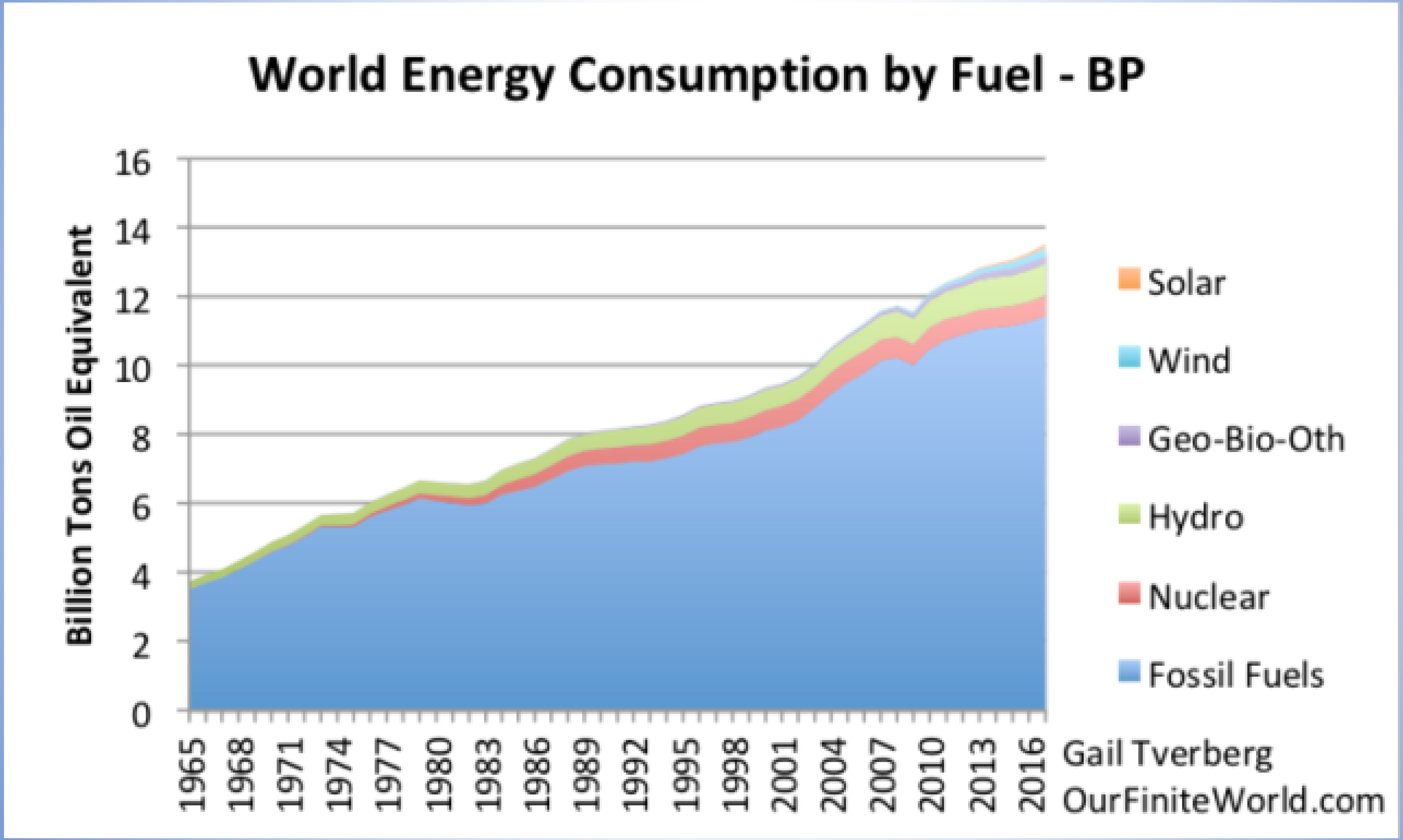
Global Partnership for Ocean Wave Energy Technology (GPOWET)

Presenter:
Weili Cui, PhD
Department of Mechanical Engineering
SUNY Maritime College

Recent Developments in Wave Energy Converters and Their Potential



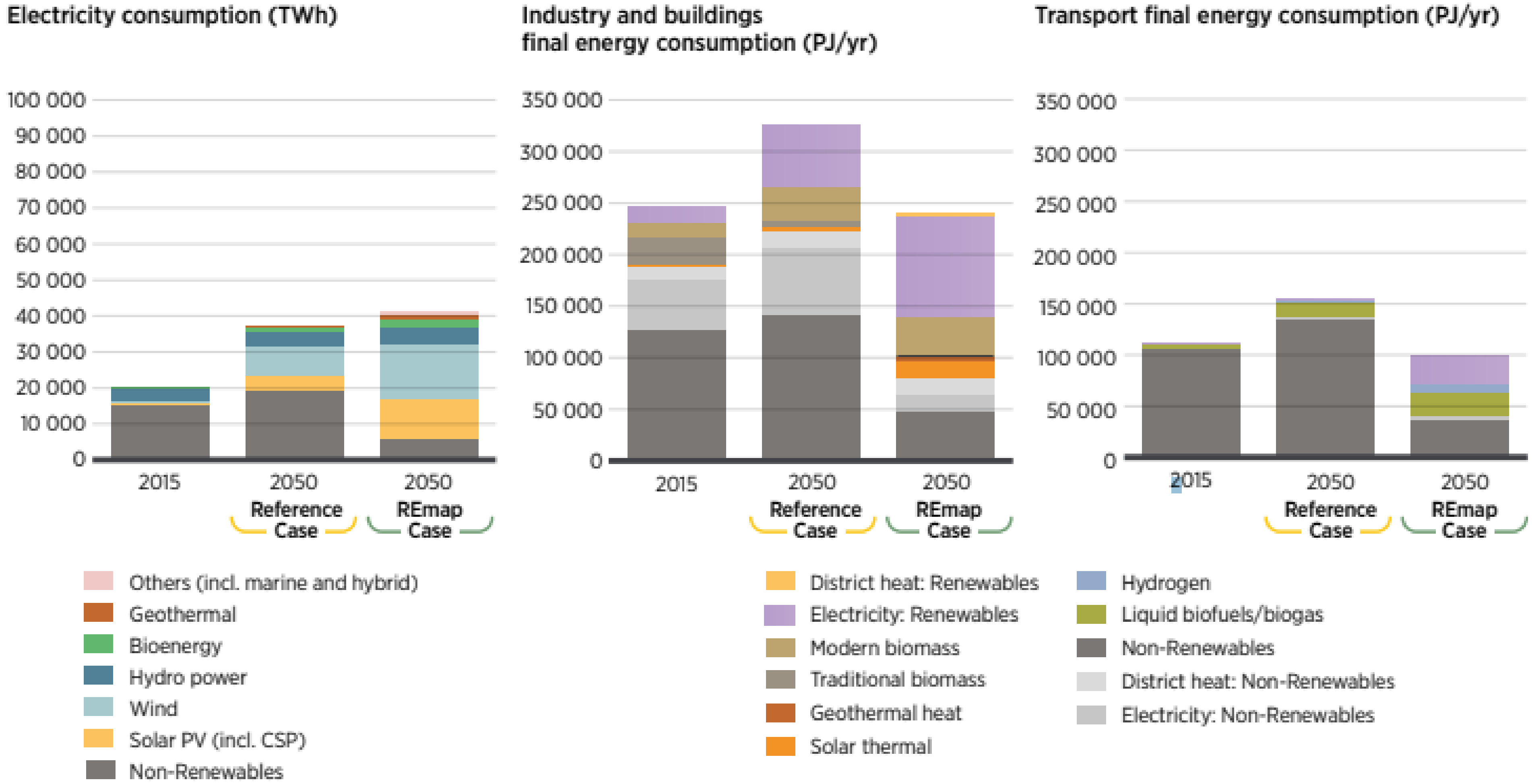
Fossil fuels provided 85% of energy supplies in 2017



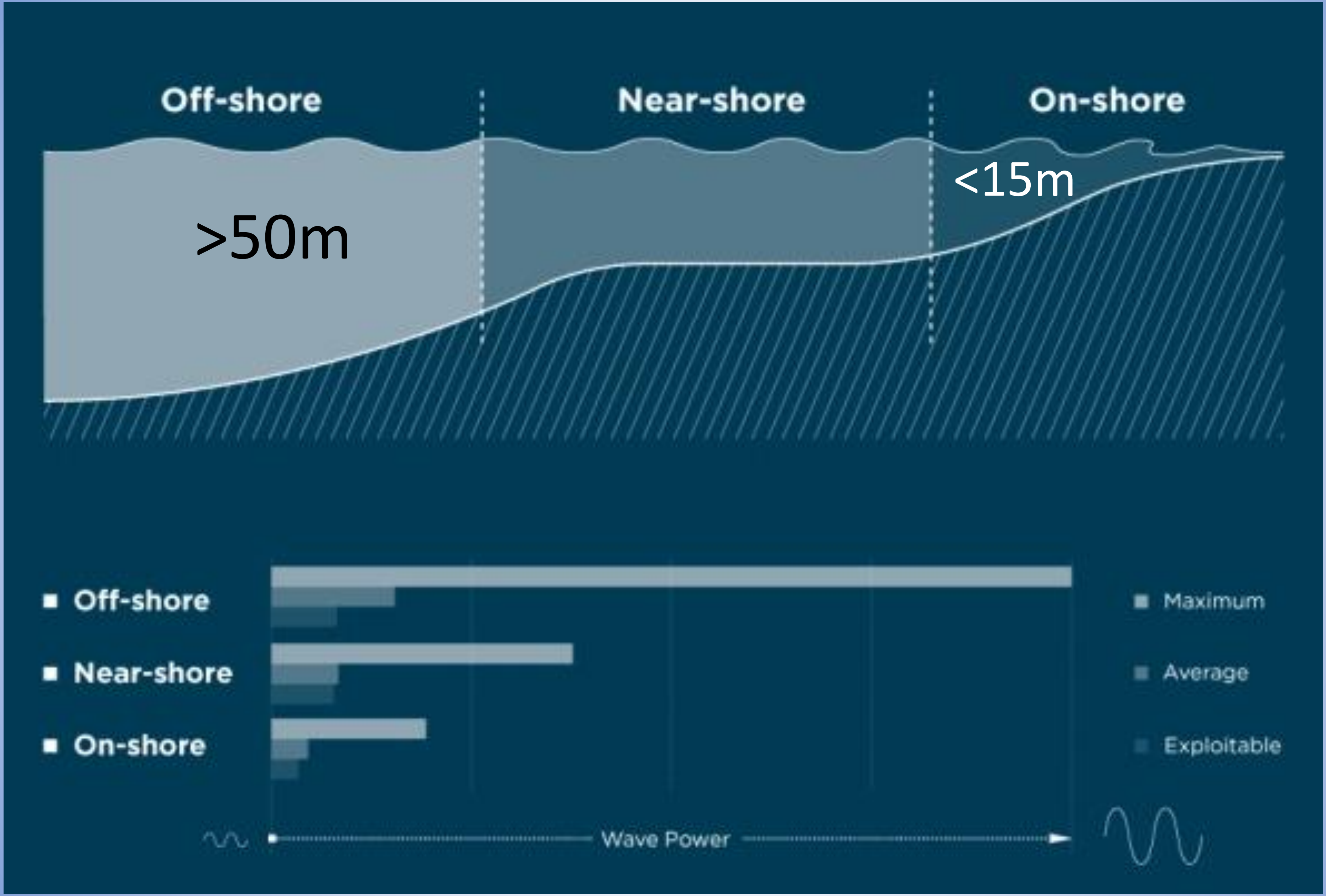
BP 2018 Statistical Review of World Energy 2018.

Figure 6. Renewable energy should be scaled up to meet power, heat and transport needs

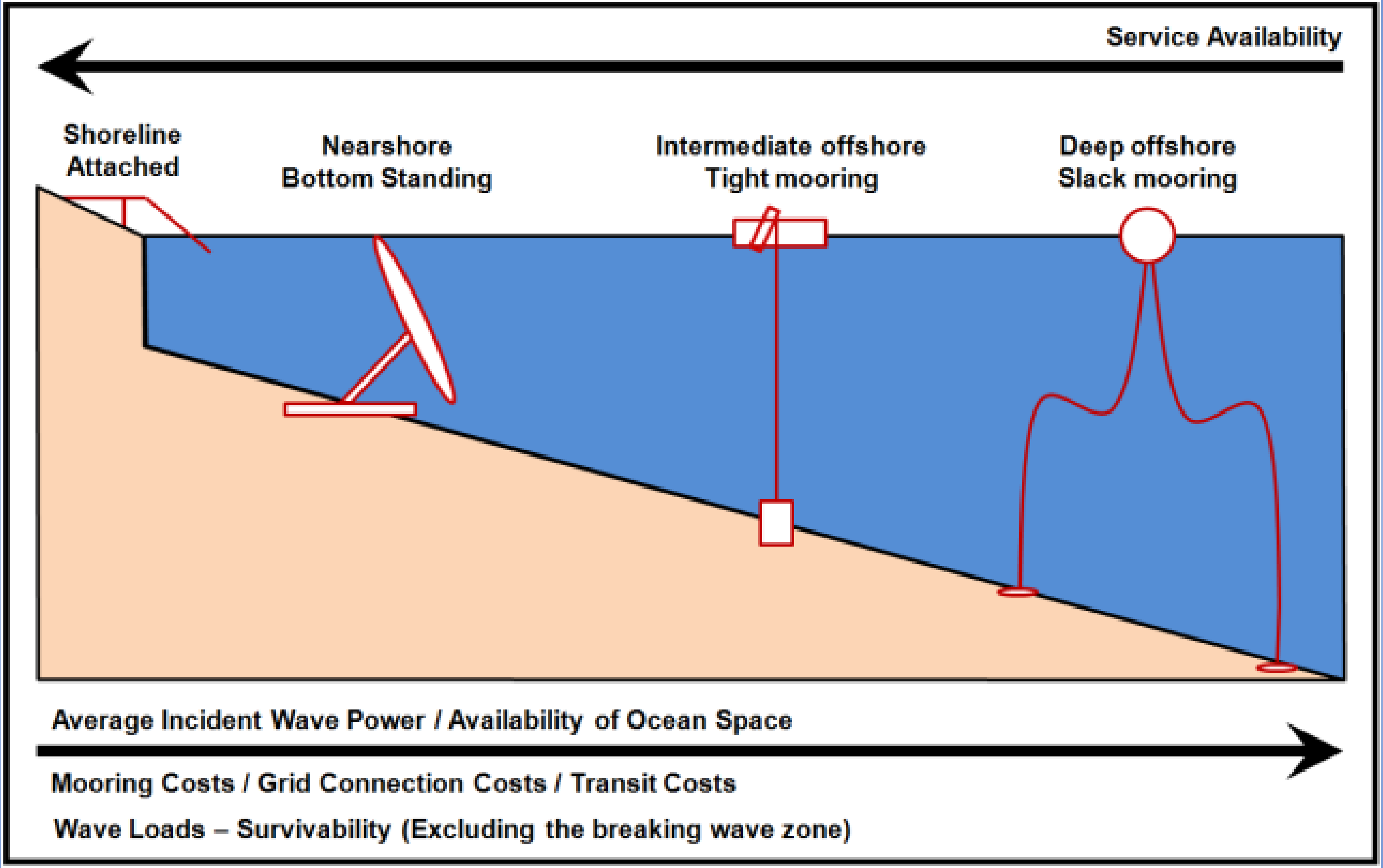
Use of renewable and fossil energy in electricity generation, buildings and industry, and transport - Reference and REmap cases, 2015-2050 (TWh/yr or PJ/yr)



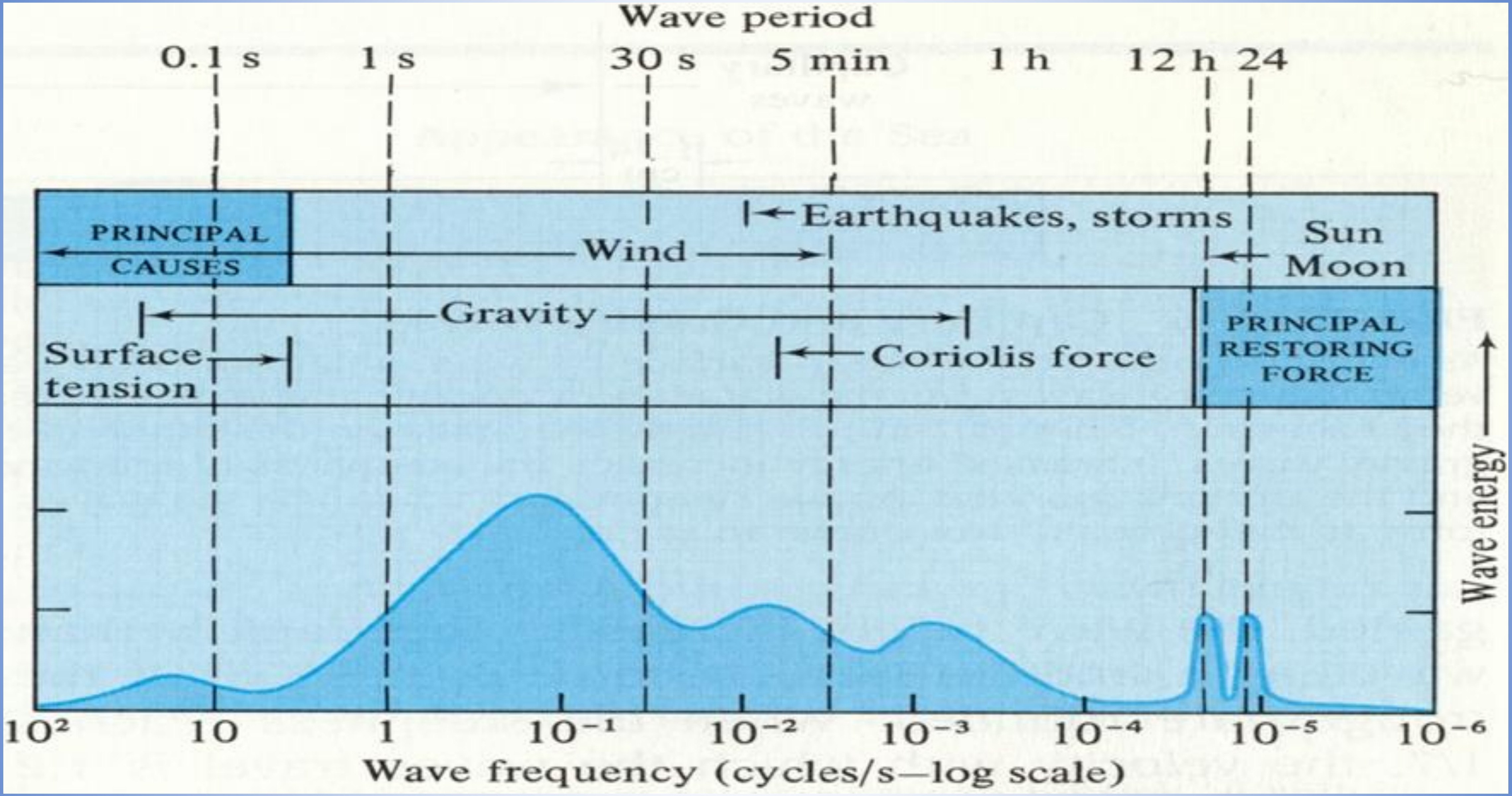
Note. Since 3.6 PJ equals 1 TWh, the axis for electricity consumption on the left is scaled to match the values of the other two figures, making comparison possible.



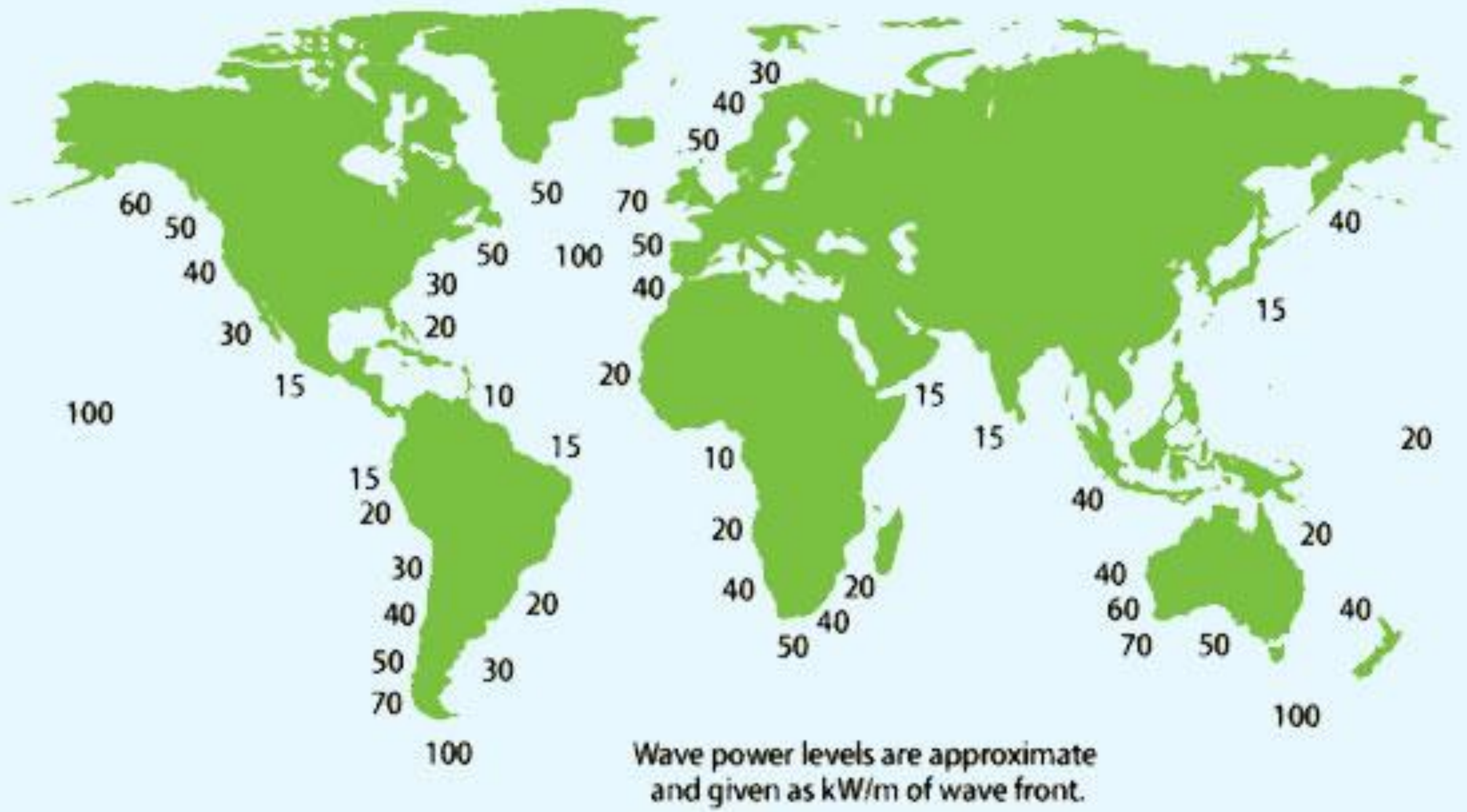
https://waveenergyconversiontamu15.weebly.com/theory-of-wave-energy--availability.html



https://waveenergyconversiontamu15.weebly.com/theory-of-wave-energy--availability.html



Ocean Energy Spectrum, **Thurman Harold V.,** “Introductory Oceanography” Sixth Edition, Macmillan, 1991



Source: T.W. Thorpe. "An Overview of Wave Energy Technologies: Status, Performance and Costs.'

Four Main Challenges of Generating Energy at Sea

1. Survivability
2. Energy capture efficiency
3. Transportability/operation and maintenance
4. Capital cost

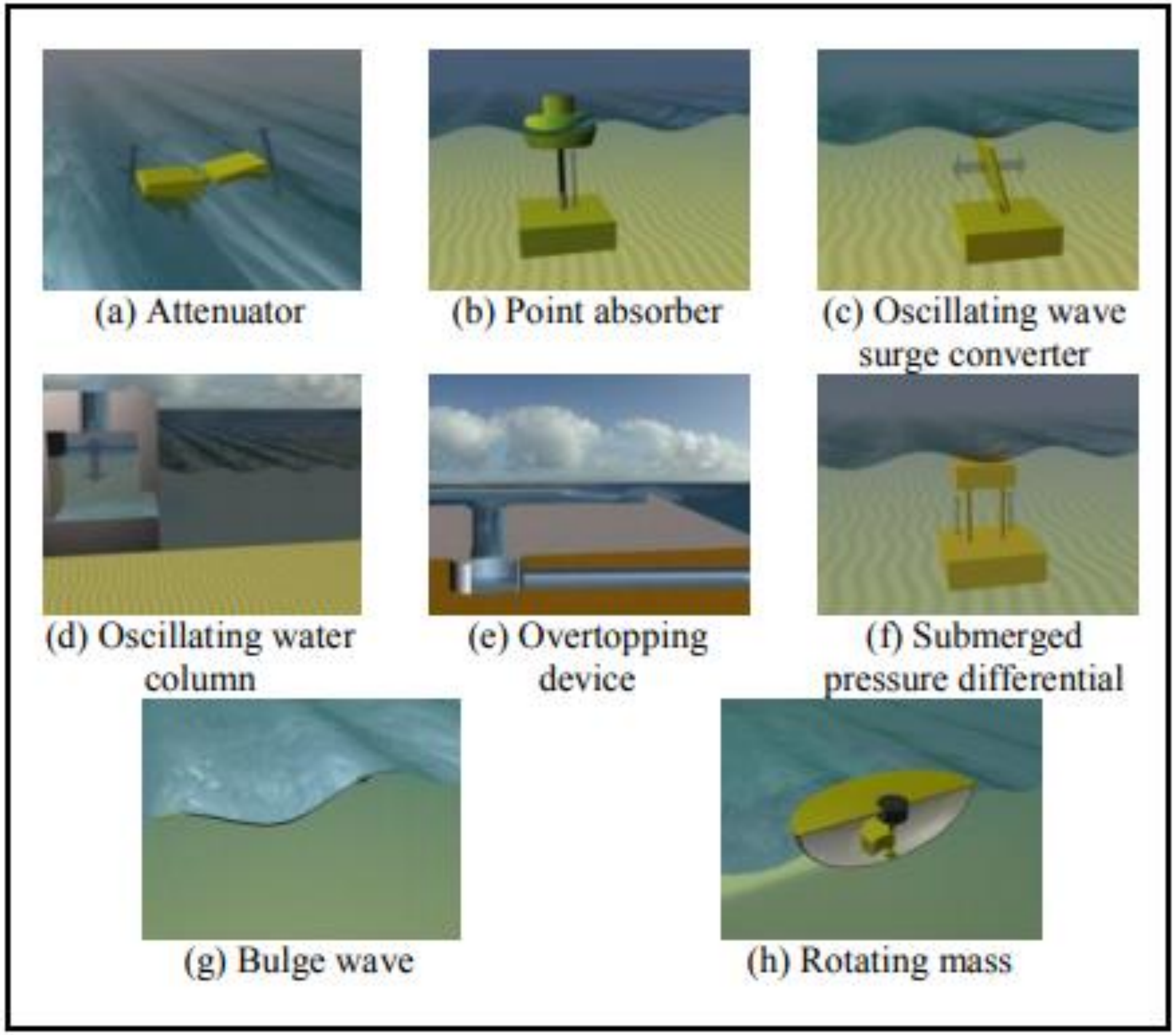
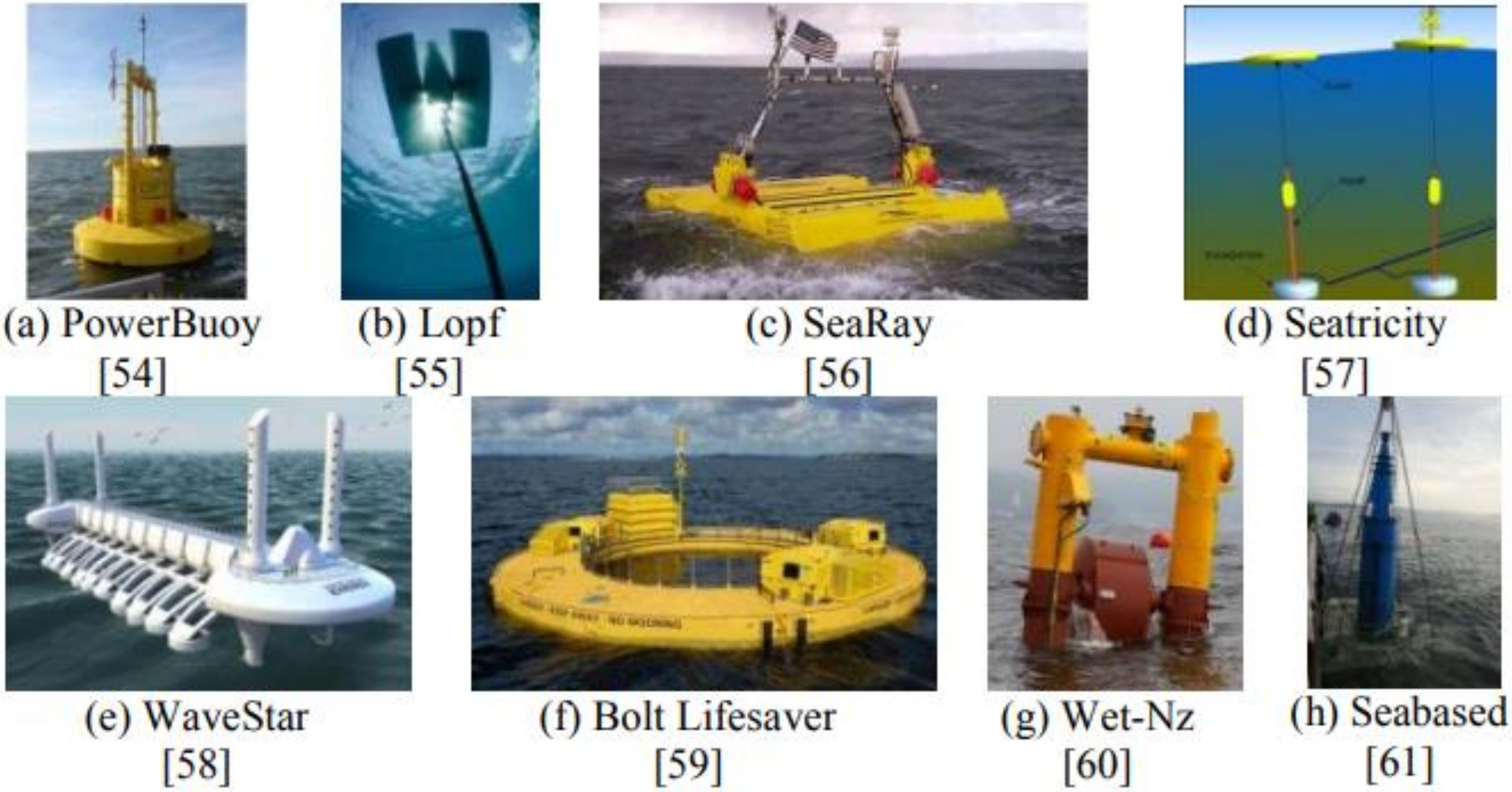


Fig. 1 Types of WECs [51]

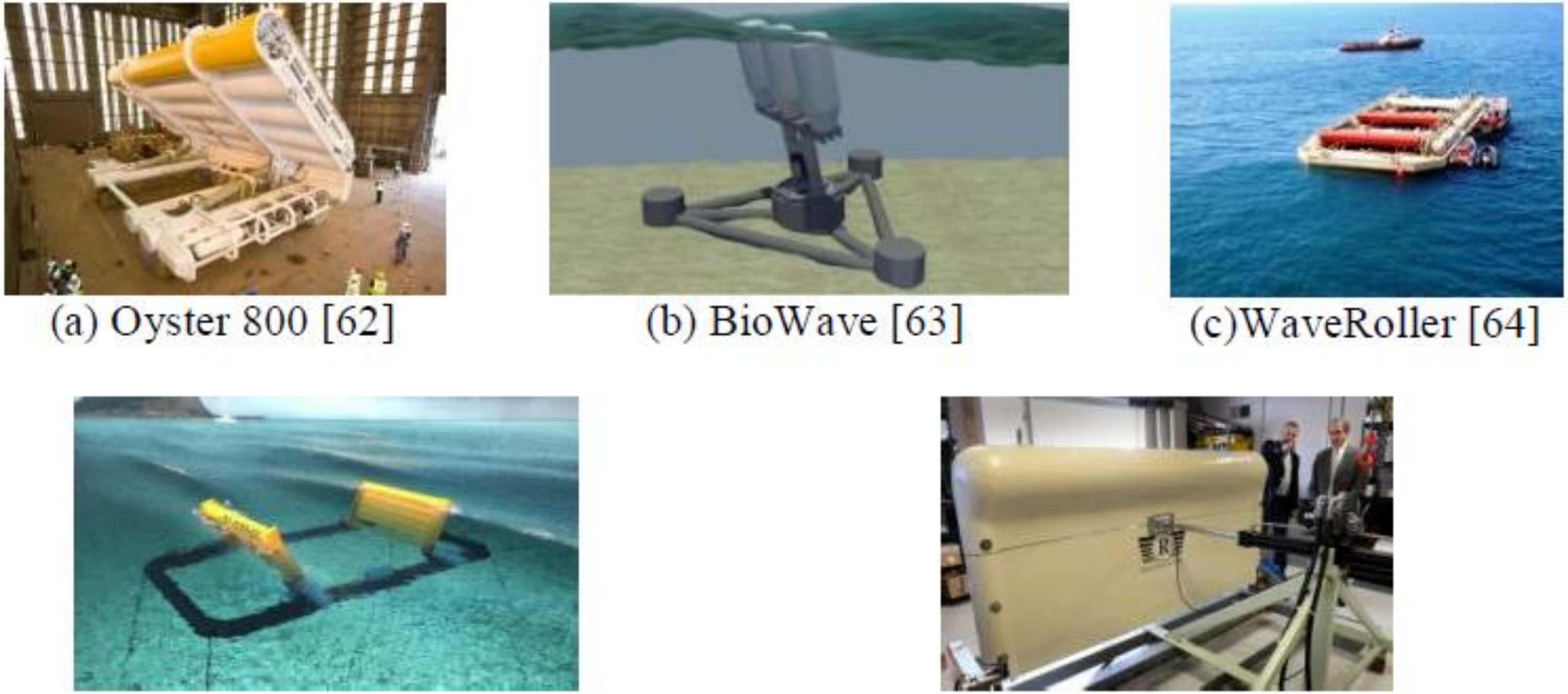
https://www.researchgate.net/publication/258221898

Point Absorber, Oscillating Wave Surge Converters & Oscillating Water Column Are the Most Promising



Selected examples of point absorber WECs

https://www.researchgate.net/publication/258221898



(a) Oyster 800 [62]

(b) BioWave [63]

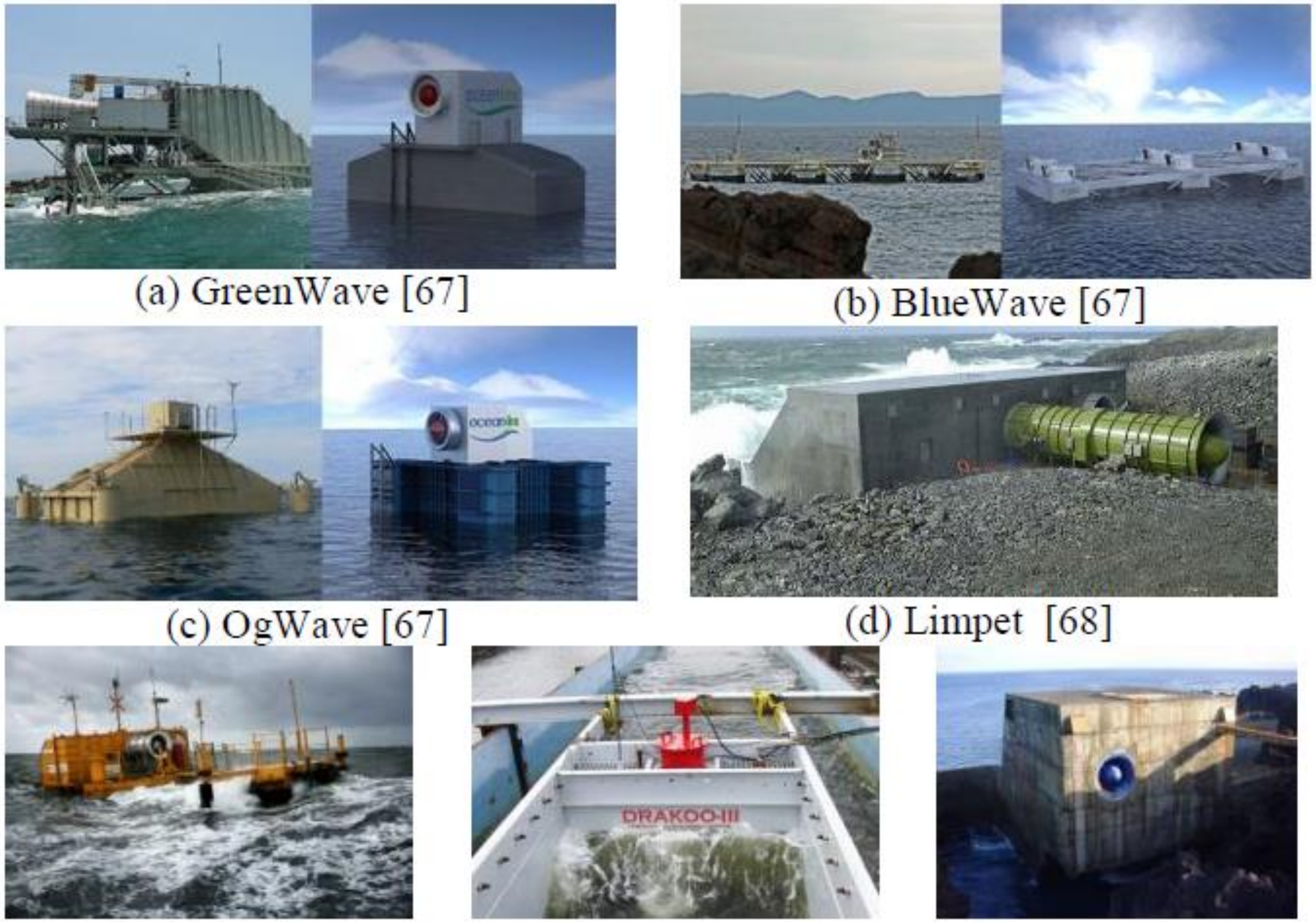
(c)WaveRoller [64]

(d) Langlee [65]

(e) SurgeWEC [66]

Selected examples of oscillating wave surge converter WECs

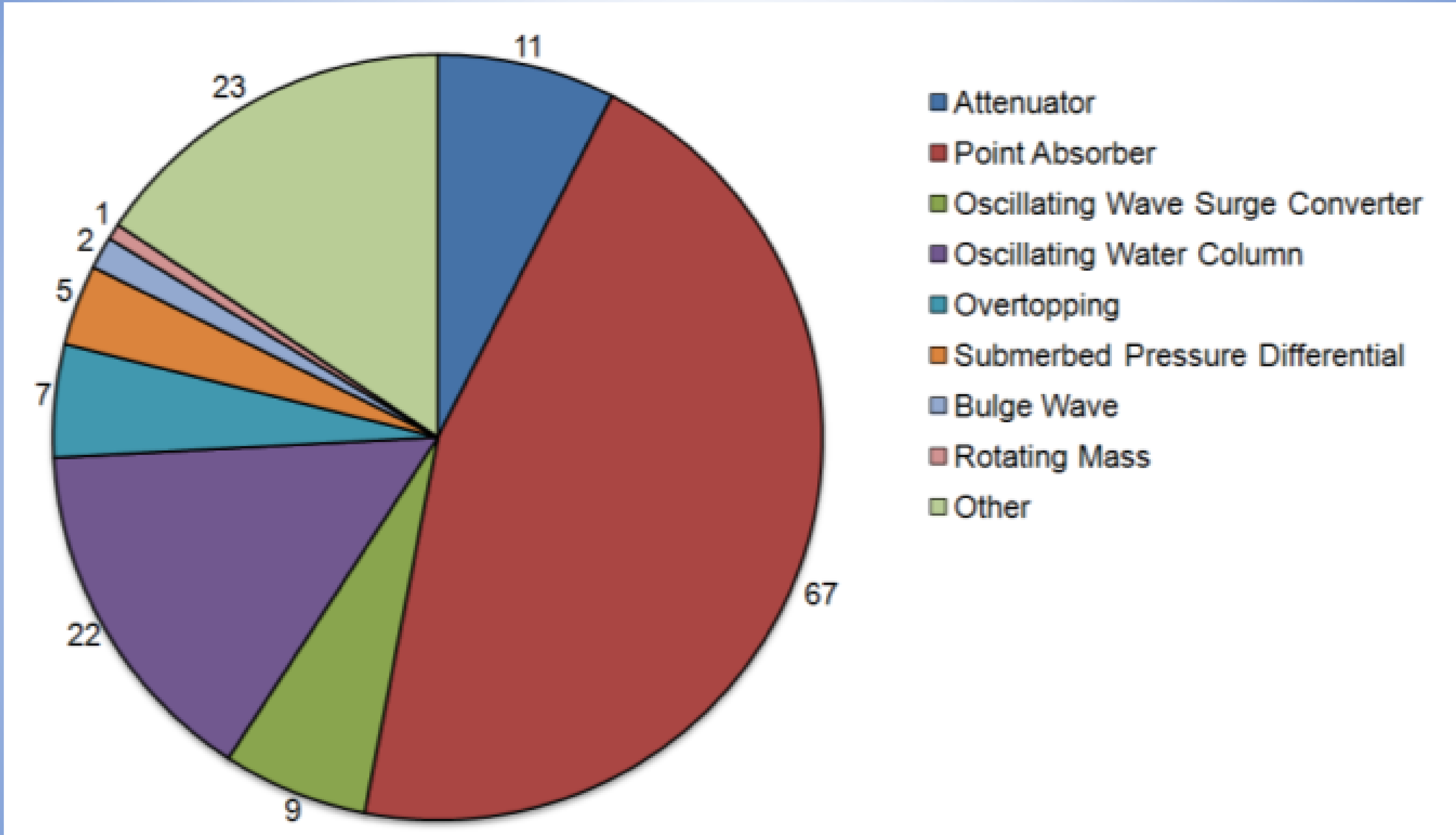
https://www.researchgate.net/publication/258221898



(a) GreenWave [67] (b) BlueWave [67]
(c) OgWave [67] (d) Limpet [68]
(e) OE buoy [69] (f) Drakoo [70] (g) Pico [71]

Selected examples of OWC WECs

https://www.researchgate.net/publication/258221898



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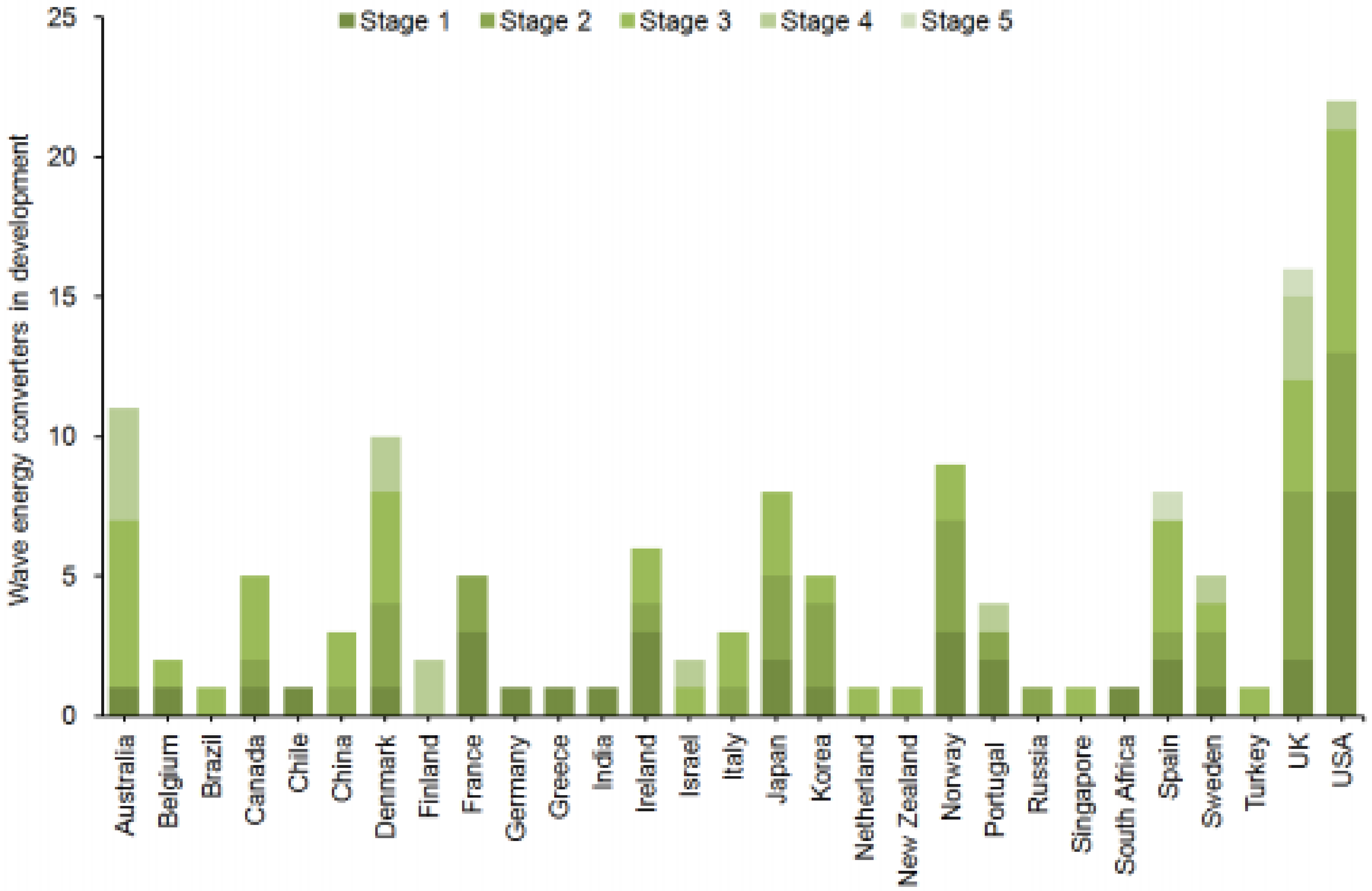
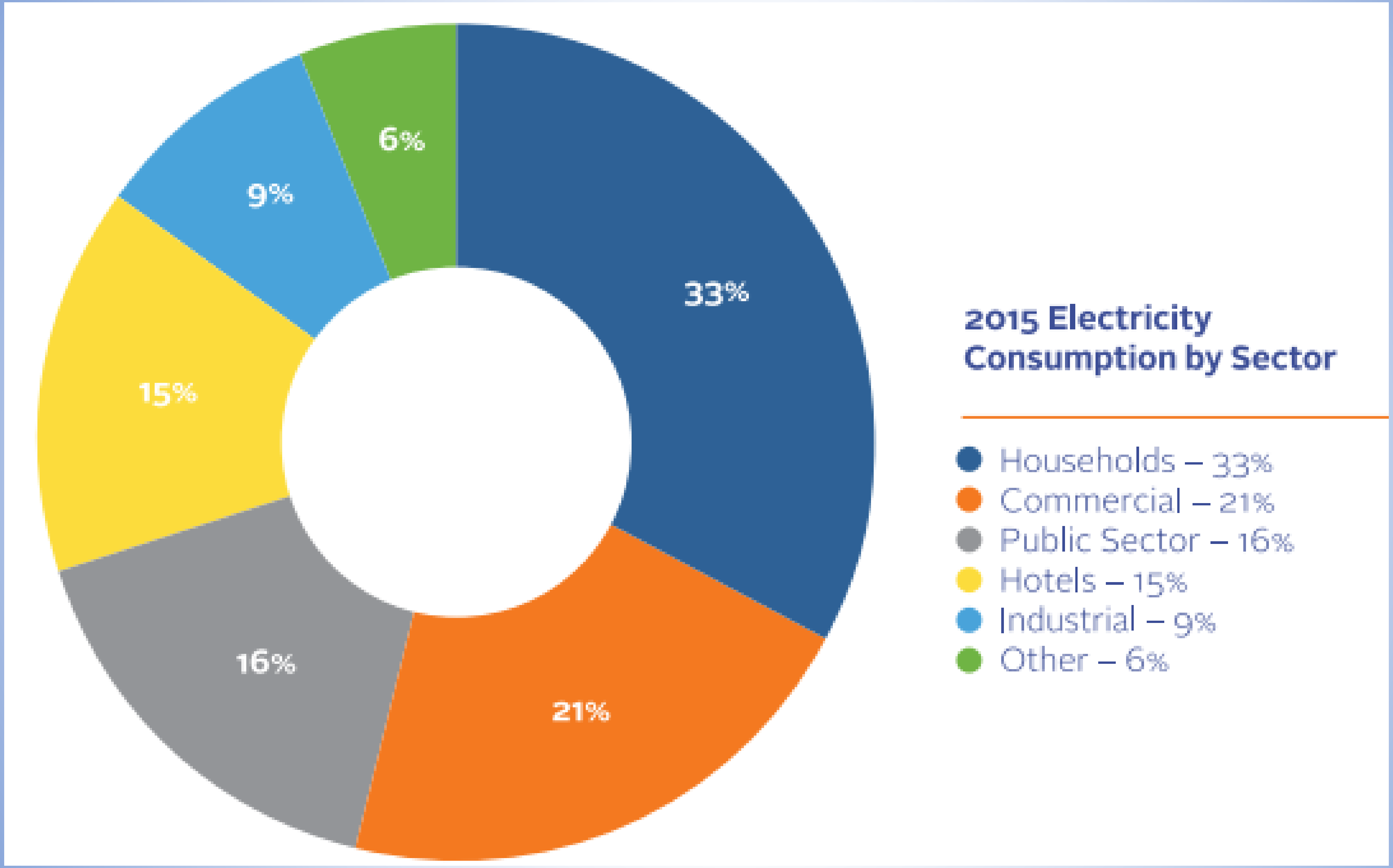


Fig. 18 Current R&D distribution worldwide (as of 03.02.2013)

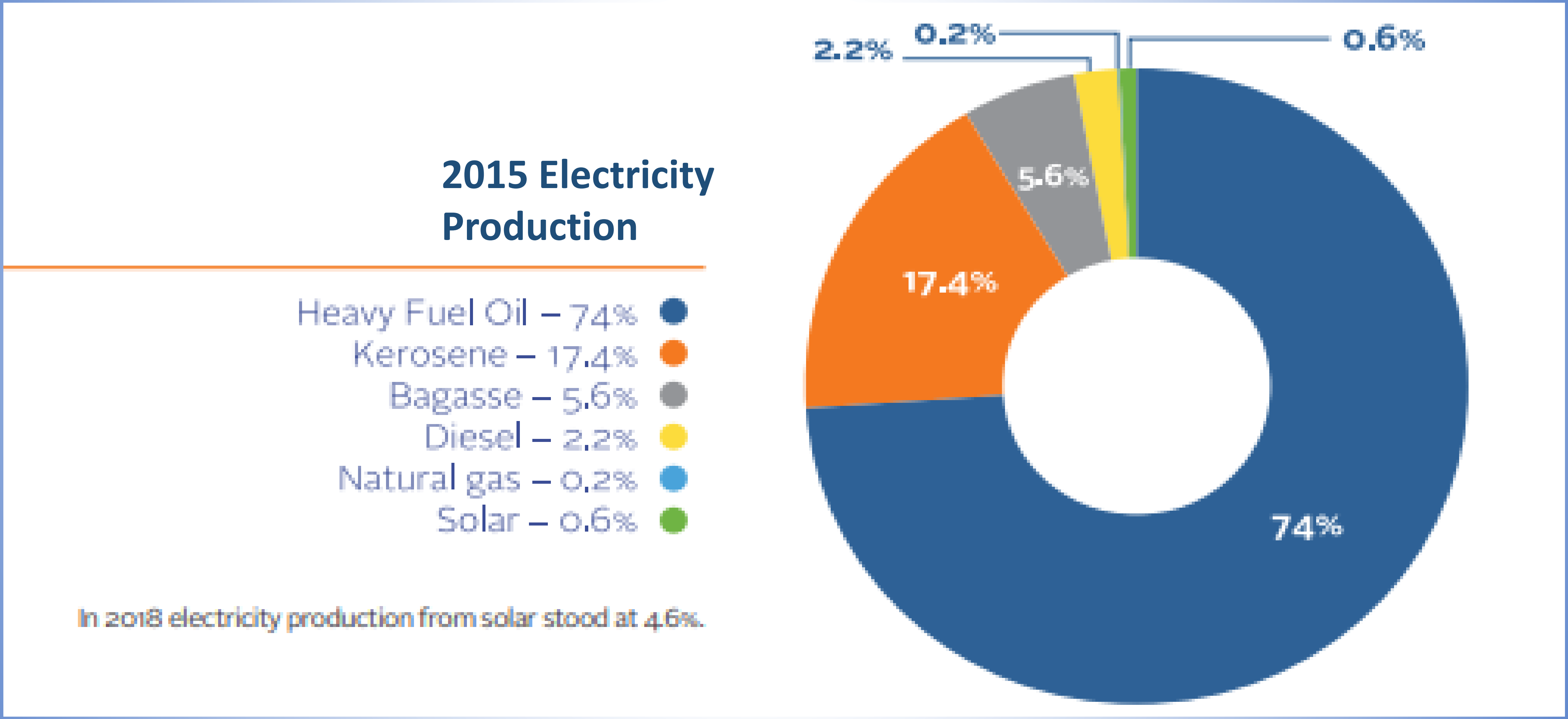
US & UK at the Frontline of Research & Development

Barbados Committed to Transit to 100% Renewable Energy by 2030



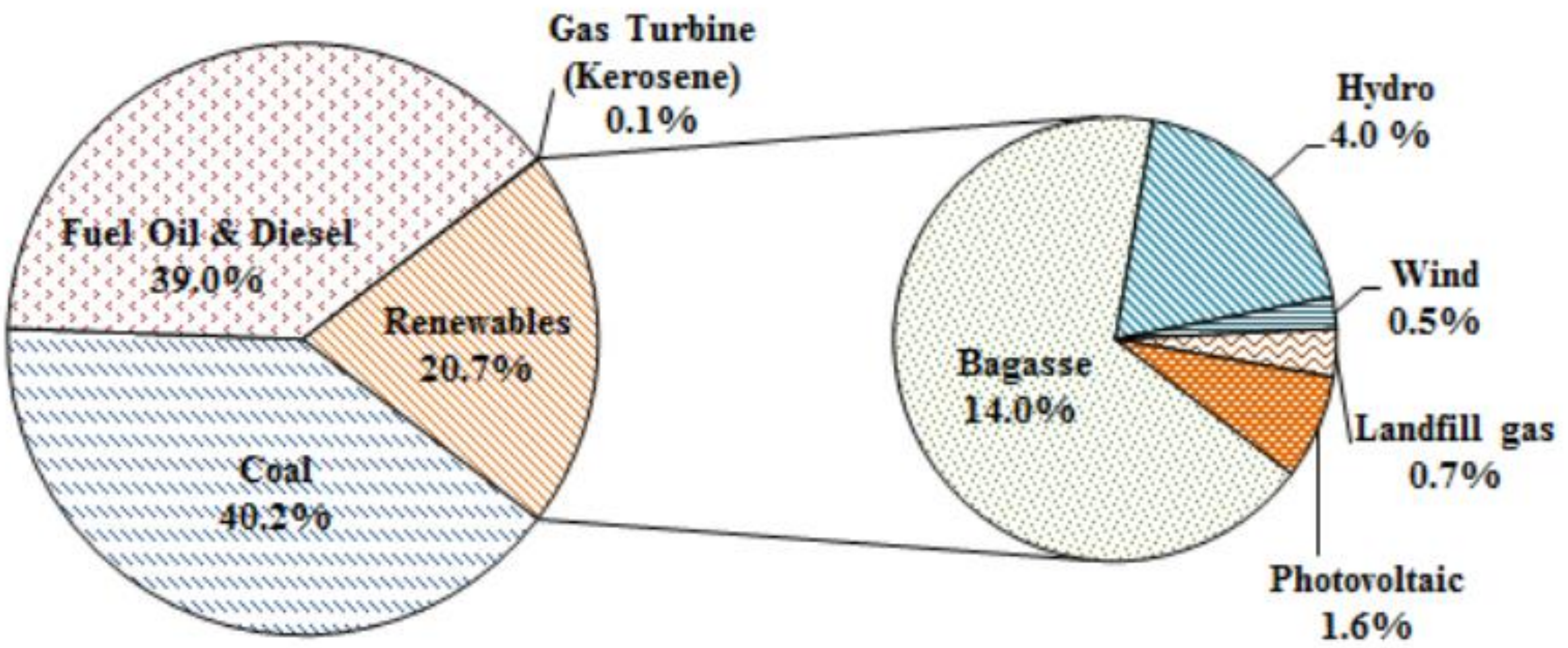
National Energy Policy for Barbados 2019 - 2030

Barbados' Energy Dependence on Fossil Fuels



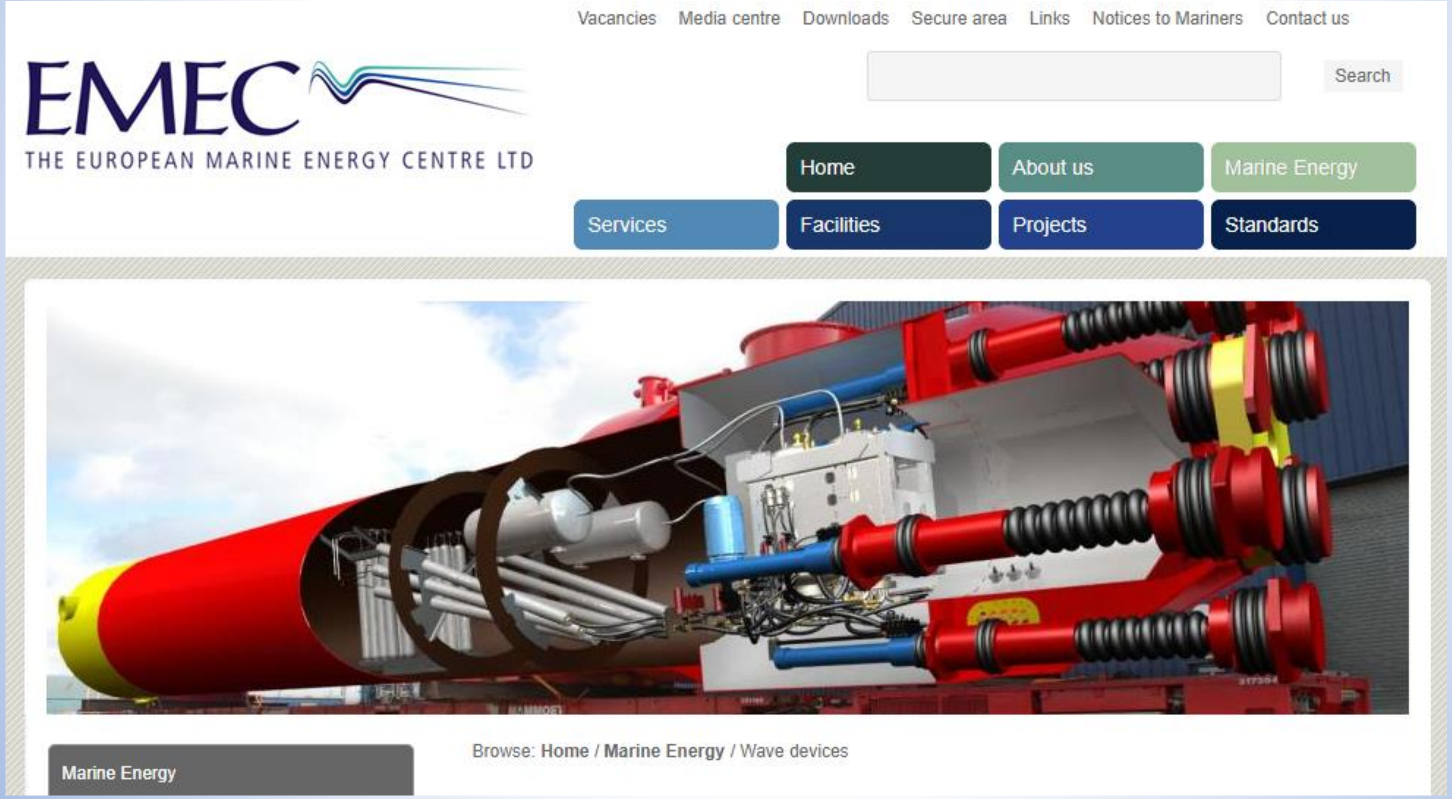
National Energy Policy for Barbados 2019 - 2030

Mauritius' Energy Dependence on Fossil Fuels



http://statsmauritius.govmu.org/English/Publications/Documents/2019/EI1454/Energy_Yr18.pdf

Wave Energy Conversion Sea Trials have been Ongoing at the European Marine Energy Centre (EMEC) for over 10 Years for Various Designs



http://www.emec.org.uk/marine-energy/wave-devices/

OPERA

Figure 17. The OPERA project improved IDOM's MARMOK-A-5 device.

The OPERA project, completed in 2019, validated and de-risked innovation in wave energy development and increased TRL by deploying a device in open-sea operating conditions and sharing the resulting data [17].

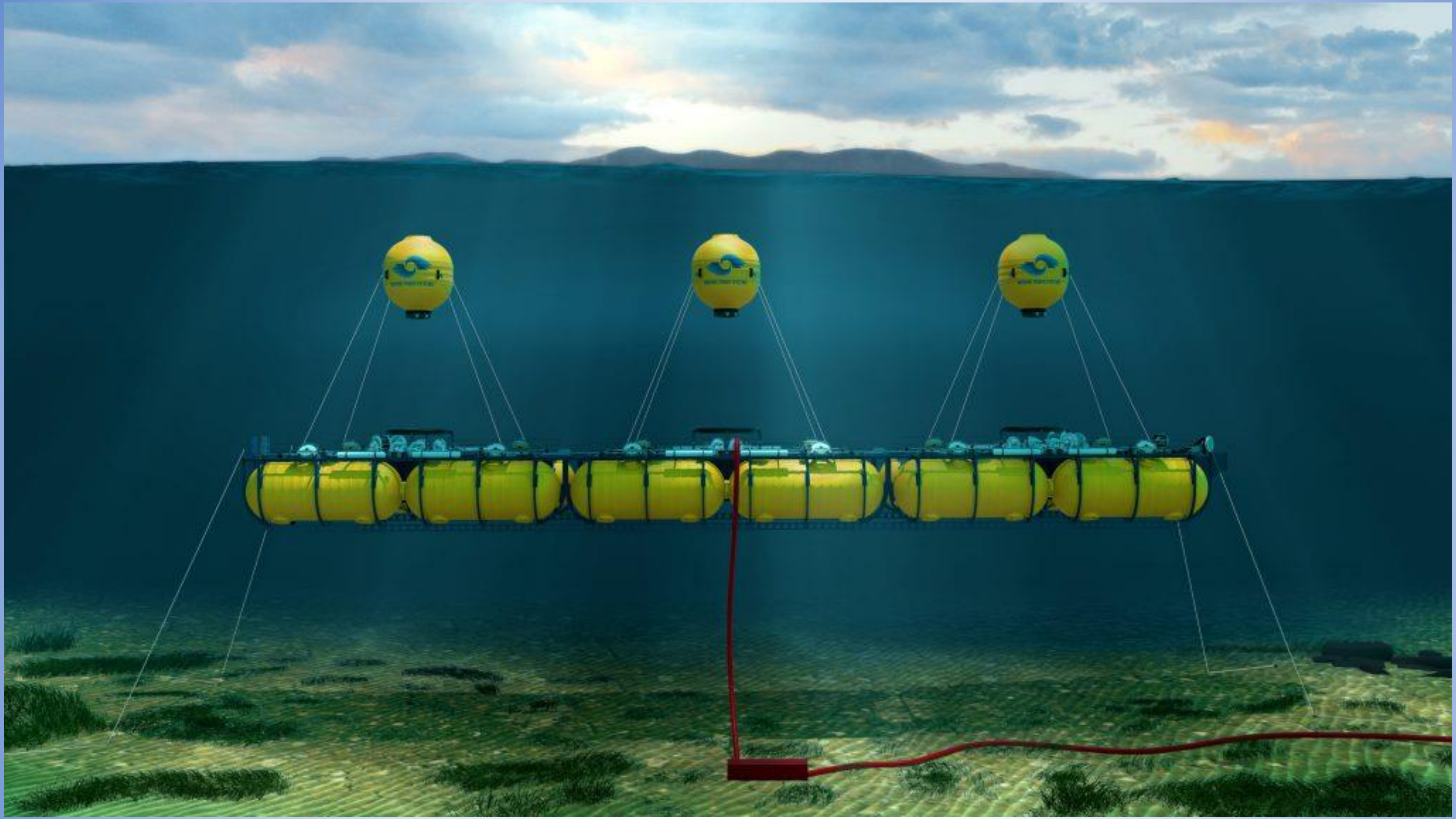
https://www.oceanenergy-europe.eu/wp-content/uploads/2020/05/ETIP-Ocean-SRIA.pdf

WAVEBOOST

Figure 16. CorPower Ocean's half-scale demonstration project at EMEC test site.

The WaveBoost project developed and validated an innovative PTO technology that improved reliability and performance of CorPower Ocean's point-absorber buoy [16].

https://www.oceanenergy-europe.eu/wp-content/uploads/2020/05/ETIP-Ocean-SRIA.pdf



Marine Power Systems unveils WaveSub wave energy device

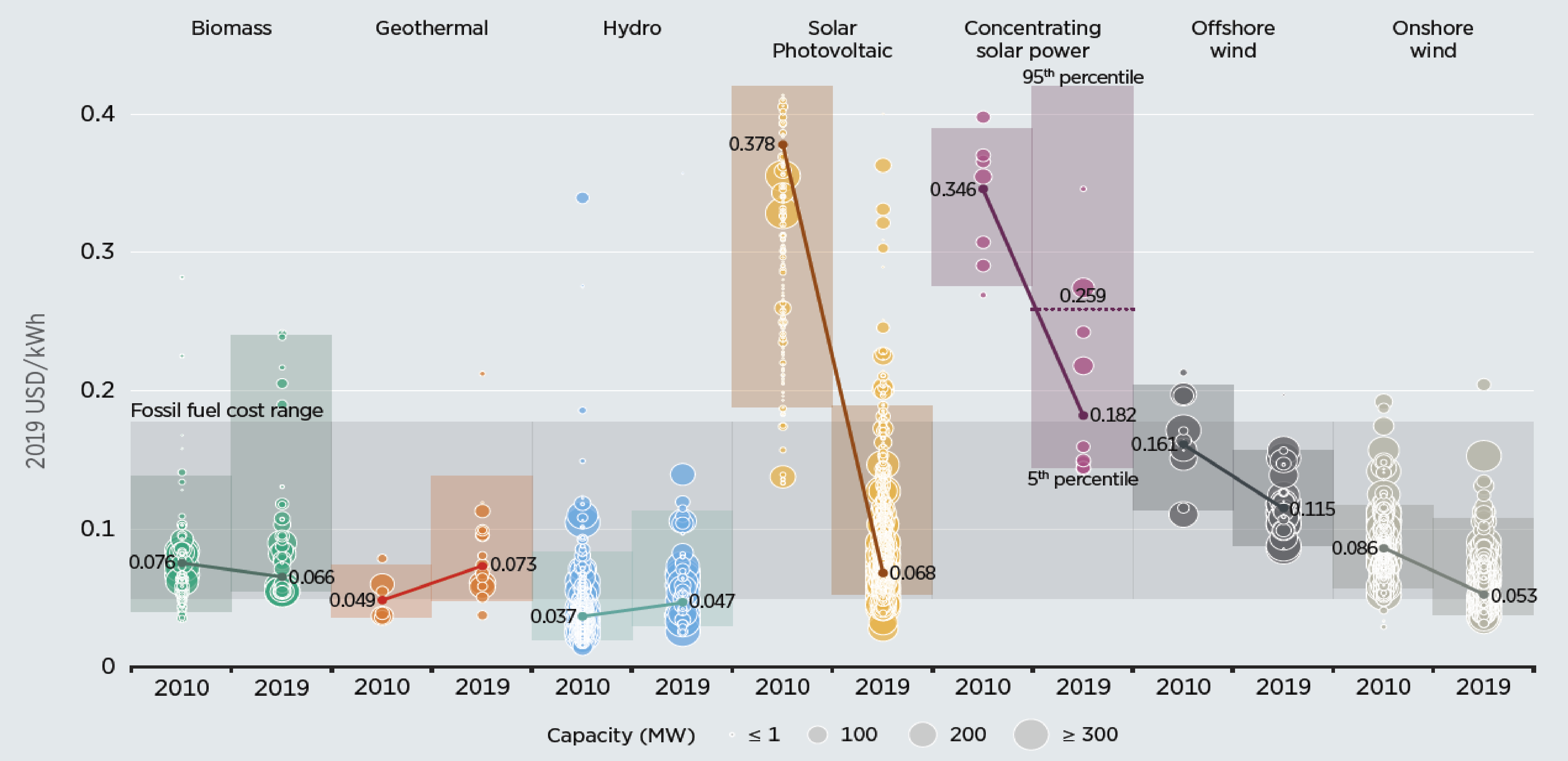
https://www.marinepowersystems.co.uk/marine-renewable-milestone-hit-as-uk-wavesub-unveiled-for-sea-based-testing/

Performance must be increased to a level where revenue justifies installation and maintenance.

Optimization of Shoaling/lensing/focusing variable-depth tension leg platforms and load control, where the energy storage on platforms is on the order of the megawatt-hour level and can be dispatched on demand, will take us further towards commercial viability.

https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2014/IRENA_Ocean_Energy_report_2014.pdf

Figure 1.2 Global LCOEs from newly commissioned utility-scale renewable power generation technologies, 2010-2019



Note: For CSP, the dashed bar in 2019 shows the weighted average value including projects in Israel.

Source: IRENA Renewable Cost Database.

Thank you

Dr. Weili Cui

Professor, SUNY Maritime College

wcui@sunymaritime.edu

Global Partnership for Ocean Wave Energy Technology (GPOWET)

Presenter:
Rik van Hemmen, President, Martin, Ottaway, van Hemmen & Dolan, Inc., and SurfWEC LLC

What is GPOWET?

The Global Partnership for Ocean Wave Energy Technology is a Group of Stakeholders Working Together to Advance the Development of Sustainable Energy Solutions

NGO – Stakeholder Forum

Industry – Solar, Wind, Tidal, Conventional Hydro, Currents, Waves, and Energy Storage Technologies

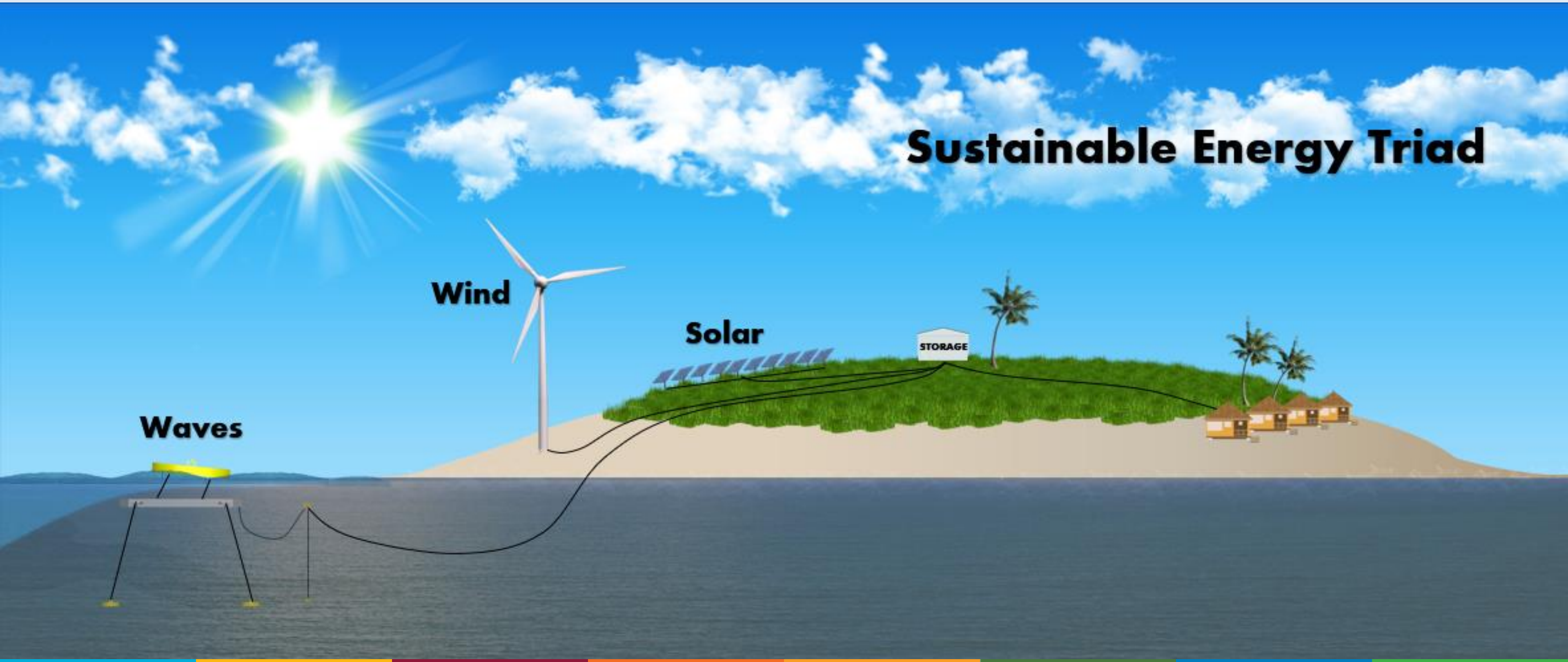
Research and Educational Institutions

Governments – we seek government partners to enable us to register as a sustainable development multi-stakeholder partnership on UNDESA’s Small Island Developing States Action Platform

This is a “Big Tent” Approach to with Extreme and Far-Reaching Impact

The Technologies are Here, We Need Optimization and Implementation

The partnership's goal: To deliver utility level power generation to support resilient societies and economies that can adapt to climate change



Implementation and Optimization Go Hand-in-Hand

If We Have a Lot of Electric and a Lot of Gasoline (petrol) Vehicles, We Are Not Going Anywhere

We Need to Build Complete Systems using Common Building Blocks Optimized for Each Location

Each Place is Different, but There Are Solutions for All Coastal and Island Nations

Remarkably, the Small Island Developing States (SIDS) Will Lead This Transformation Due to the Relatively Small Infrastructure Requirements as Compared to Large, Developed Nations, and the Developed Nations Will Follow

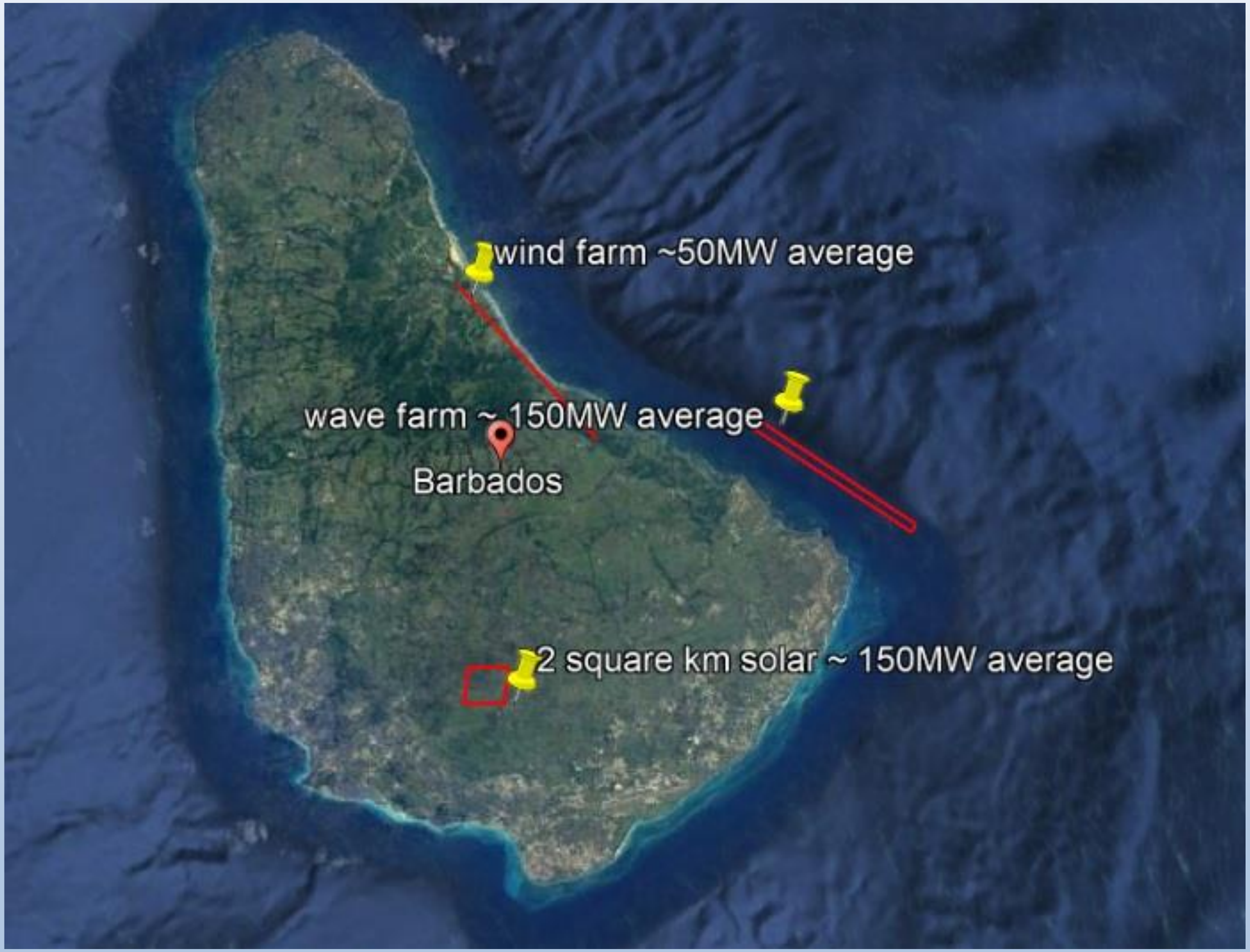
All the Energy and Power Infrastructure Requirements for a SIDS Nation Can Be in One Central Location in Many Cases

GPOWET Carry-On Benefits to SIDS & Coastal Countries

Improved Quality of Life on Land and Below Water
Economic growth/Sustainable transportation/Biodiversity

- Clean SIDS energy supply (Triad replaces fossil fuel use) (SDG7)
- Reduce outages (SurfWEC units operate safely in Hurricanes)
- Electrification of ground and marine transport systems (SDG11)
- Desalination of seawater (Storage Building – SDG6,15)
- Production of hydrogen (Storage Building SDG7,9,11,13,15)
- Wave-farms offer a healthy reef-like environment (SDG14)
- New skilled jobs and sustainable revenue streams (SDG8,11)

Renewable Triad Barbados Example



Wave Farm Power Projection Based on 60 – 6MW SurfWEC Units (90% of Time Availability)
Wind Farm Power Projection based on 30 – 5MW Wind Turbines (50% of Time Availability)
Solar Power Projection Based on 180,000 -250W Panels (30% of Time Availability)

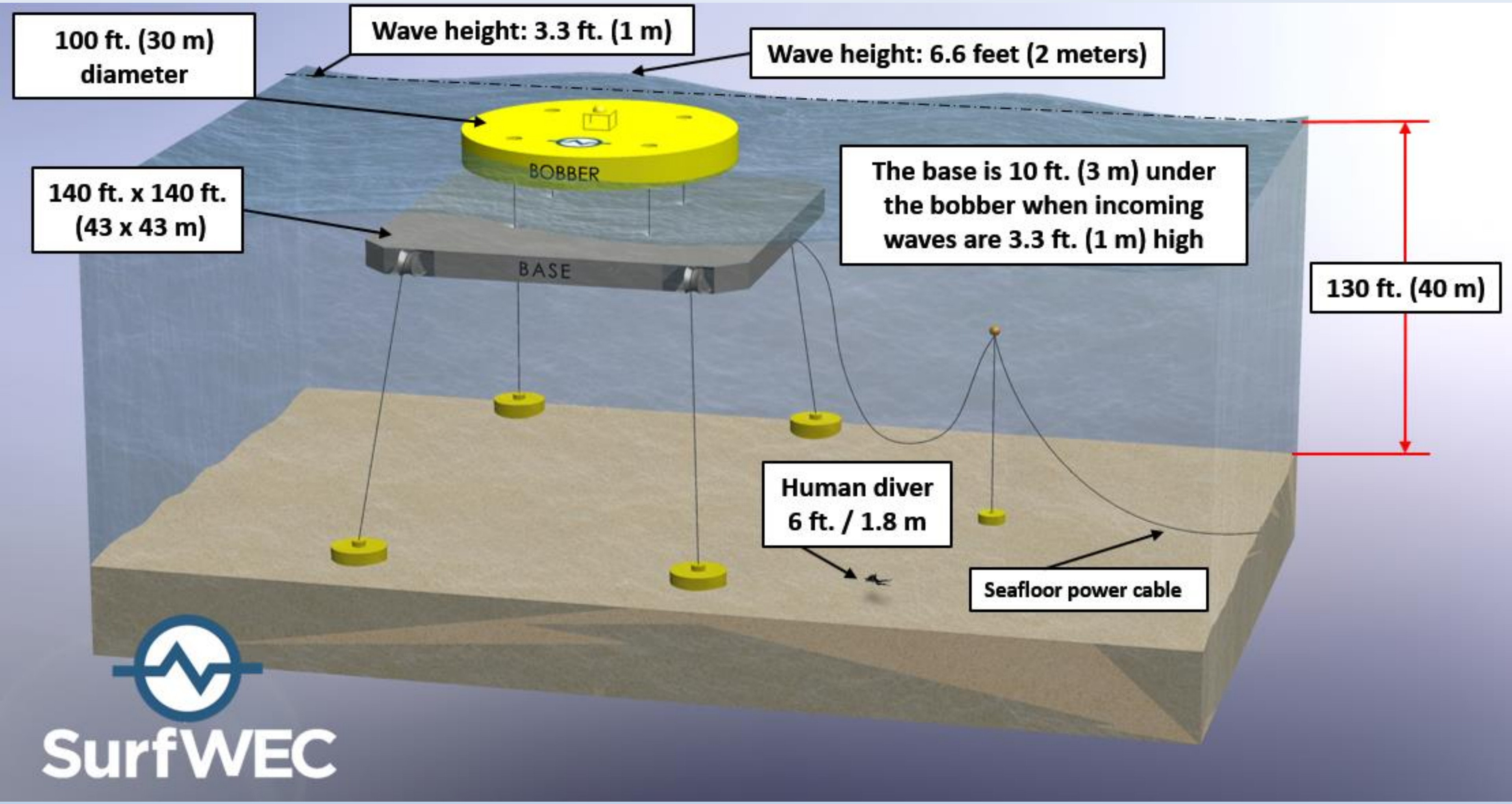
Global Partnership for Ocean Wave Energy Technology (GPOWET)

Presenter:

Michael Raftery, Chief Technology Officer, SurfWEC LLC & Inventor of the Surf-making Wave Energy Converter

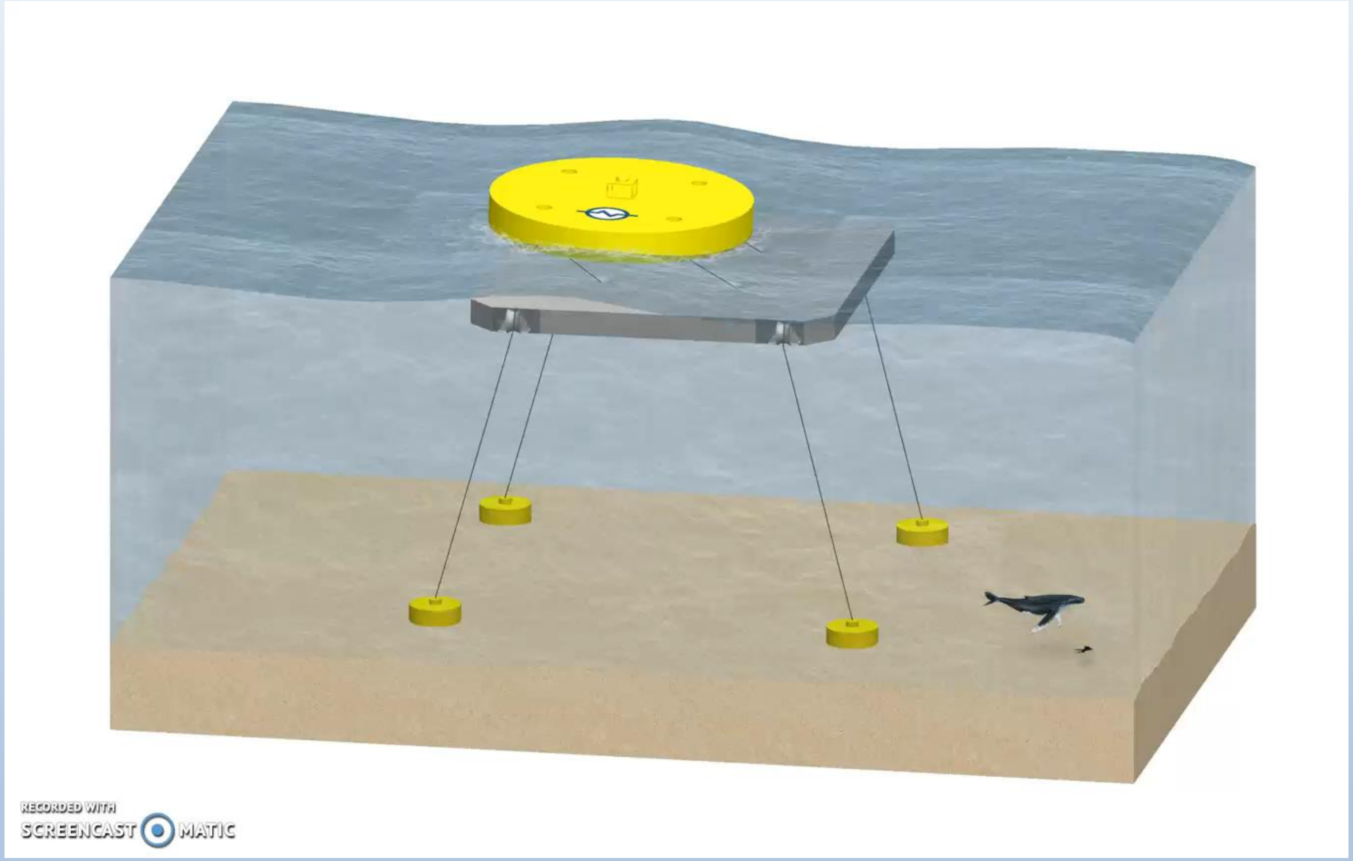
Surf-making Wave Energy Converter – SurfWEC

A new, patented addition to the global energy supply mix



Surf-making Wave Energy Converter – SurfWEC

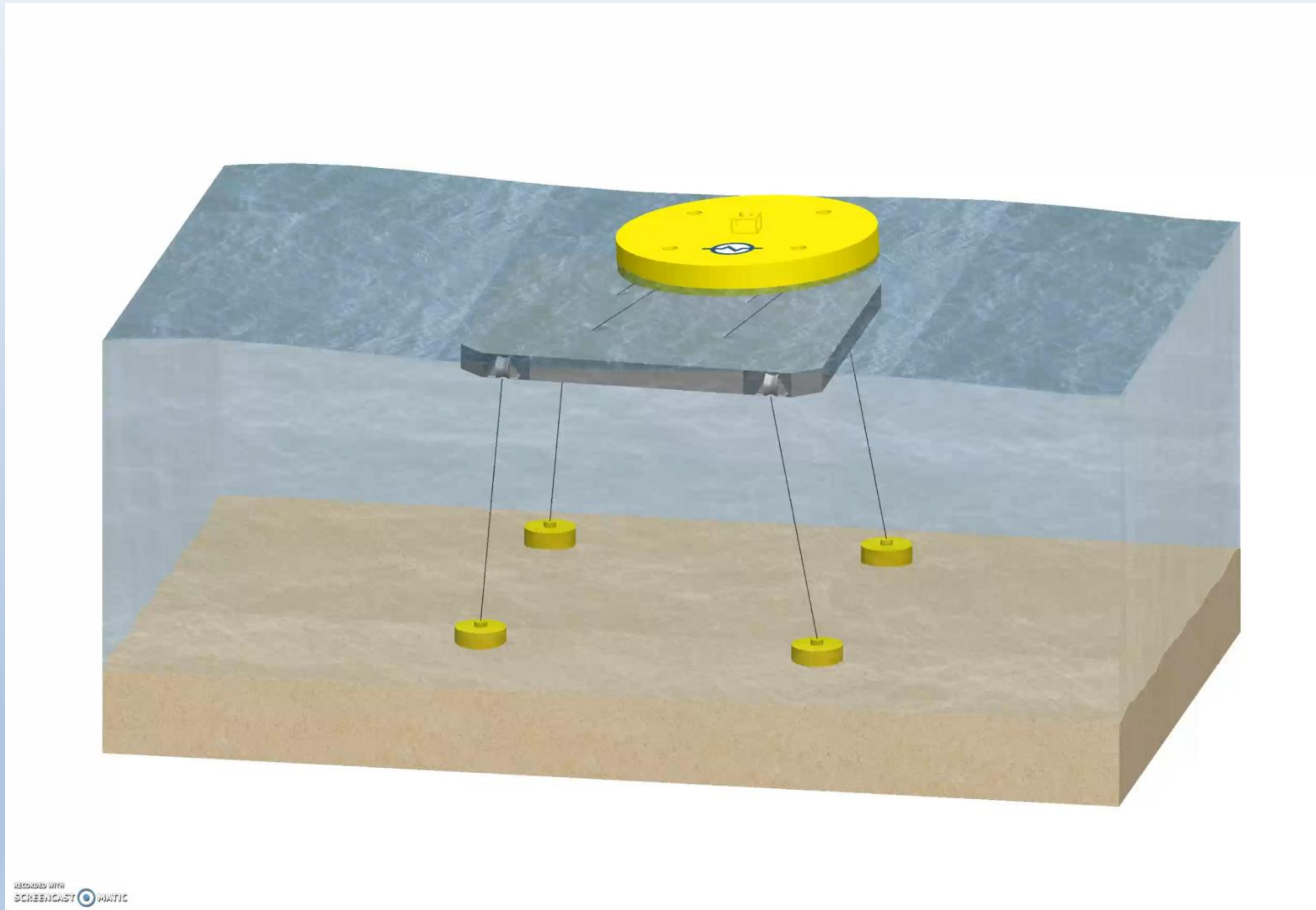
How it works



10,000+ Megawatt-hours of Electricity per Unit per Year for 41 of 44 AOSIS Members
(~8000 MWh/year - Mbirimbiri, Solomon Islands)
(~7000 MWh/year - Papua New Guinea)
(~4,000 MWh/year - Singapore [project site east of Kuala Lumpur])

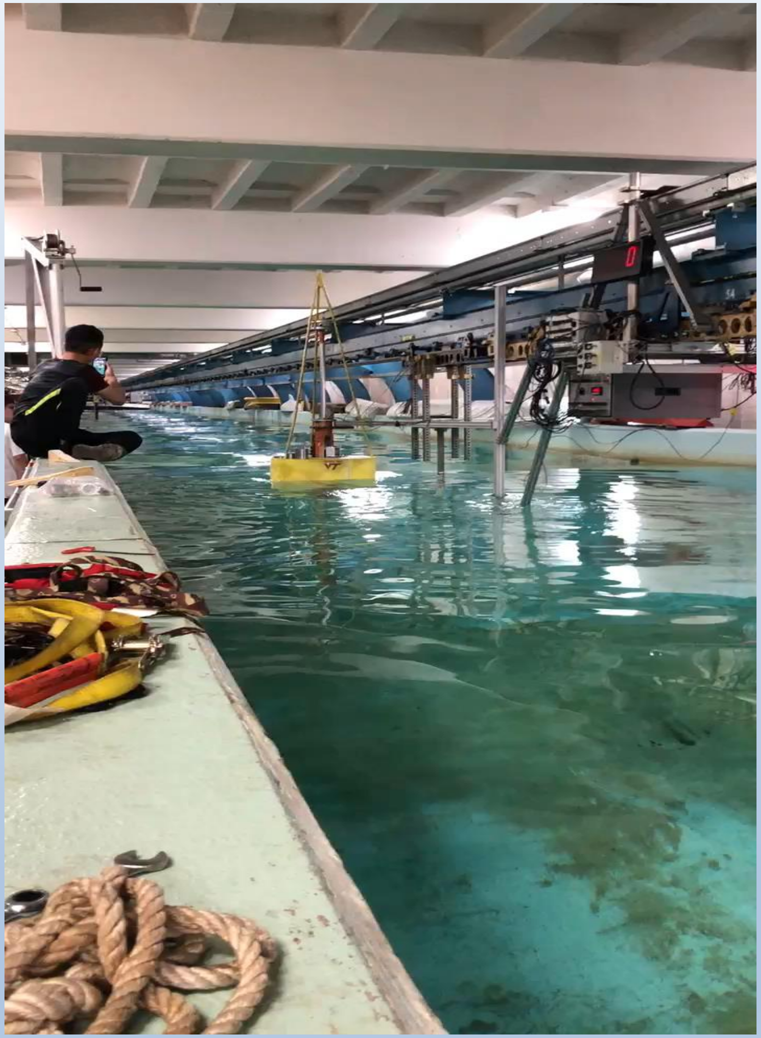
Surf-making Wave Energy Converter – SurfWEC

Disaster risk reduction: The Storm Avoidance Feature



When waves exceed 4 meters-high, platform automatically lowers to reduce wave loads.
Smart technology can 'learn' to optimize performance and avoid storms.

Motion is Critical for Electricity Production

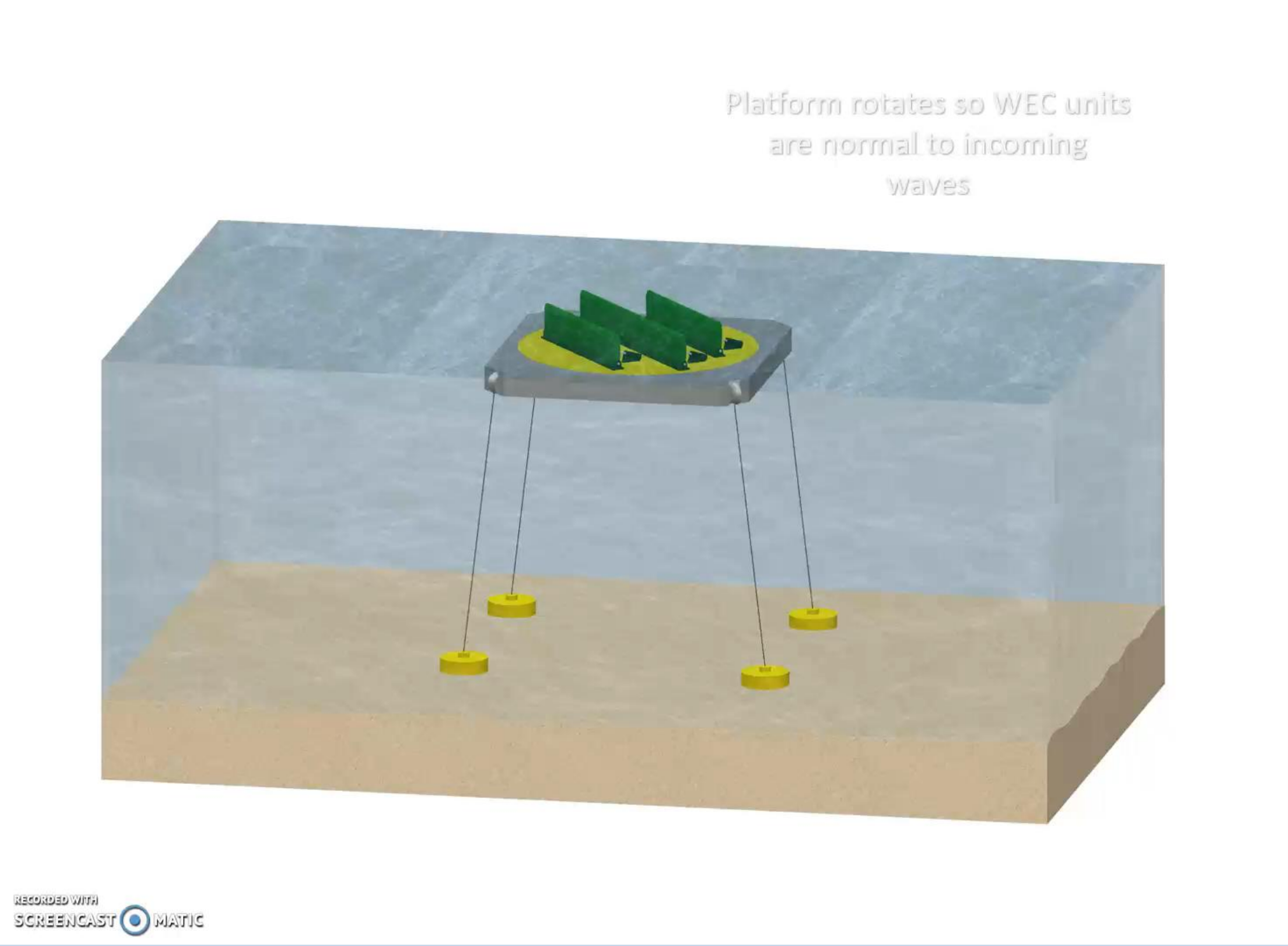


The submerged base creates a surf wave which causes the float with the same displacement to oscillate 3 to 4 times farther per wave in the same wave conditions than without the submerged base

3x Motion = 9x Electricity Production

4x Motion = 16x Electricity Production

Alternative Configuration – Shoaling Platform with Flapper Devices for use in Wave Climates with Annual Average Wave Periods of 5 Seconds (40 meter wavelength) or less, 6” (0.15m) – Diameter-Turret-Shaft Rotates Flapper Platform on Rollers, Flappers can be Replaced with Tidal Turbines



The Difference Between Nameplate Capacity and Average Electricity Production

The Nameplate Capacity for a Solar, Wind, Tidal, Current, or Wave Farm is the Maximum Power that Farm Can Produce in Any Condition at Any Time

The Actual Electricity Produced Varies From Location to Location and with the Resource Availability at Any Moment in Time

Tidal is Unique as it is Very Predictable

For Each Location, There Are Various Mixes That Are Optimal

With Regard to SurfWEC, We Have Been Running Projections of the Average Electricity Supply that Can Be Produced at Each of the 44 AOSIS Nations from the Available Wave Power Resource Since February 2020, as recommended by Mr. Sai Navoti, Chief of the SIDS Unit at UNDESA

There Are Differences That Will Help Us Determine Which Nations Are **Best for Early Implementation** and Which Nations Will **Benefit More From Development** in Other Locations

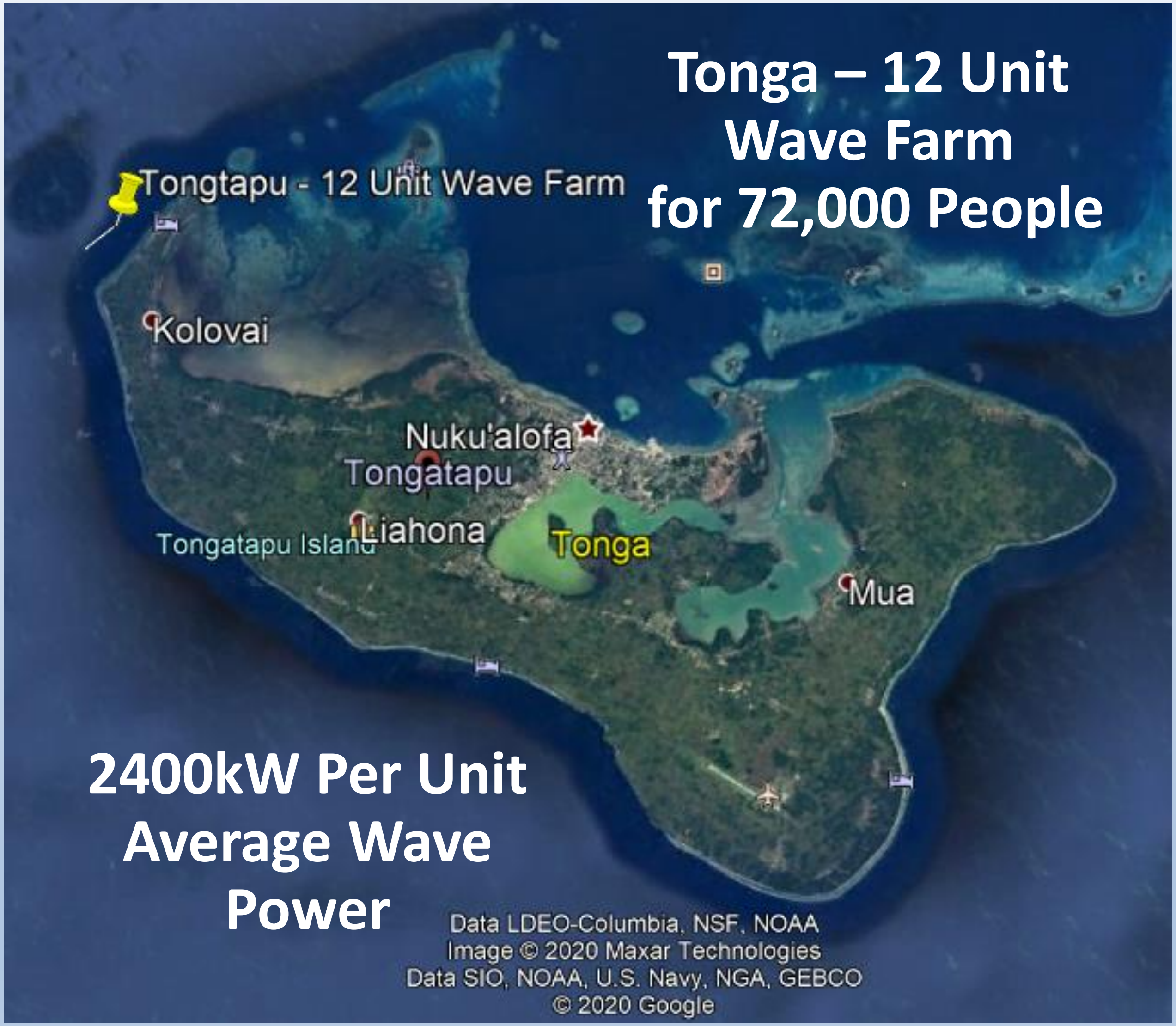
Projected Average Electricity Production in kilowatts per SurfWEC Unit for 44 AOSIS Nations from February 2020 to July 2020 based on Numerical Model

American Samoa: 2210
Antigua & Barbuda: 2119
Bahamas (Eleuthera): 1844
Bahamas (Nassau): 1237
Barbados (Ragged Point): 2416
Belize (Rocky Point): 2014
Cape Verde (Ponta Preta): 2360
Comoros Island: 2350
Cook Islands: 2908
Cuba: 1603
Dominican Republic: 1976
Fiji (Savu): 2434
Grenada (South West): 2216
Guam: 1991
Guinea (Bissau): 2136
Guyana: 1843
Haiti (South): 1553
Jamaica (Port Antonio North): 1537
Jamaica (Kingston South): 2026
Kiribati (Naa): 2155
Kosrae (Micronesia): 1918
Maldives (Male Region): 1557
Marshall Islands (Majuro): 2041
Martinique (North East):2219
Mauritius (North): 2836
Mauritius (South East): 3448
Nauru: 1829
Netherlands Antilles (North): 2084
Palau (Koror): 1456
Papua New Guinea: 790
Papua New Guinea (New Ireland): 979
Puerto Rico (North): 1962
Puerto Rico (South): 1827
Saint Kitts Nevis: 2203
Saint Lucia: 2131
Saint Vincent: 2402
Samoa (Apia): 2115
Sao Tome Principe (South): 2008
Seychelles (Victoria Islands): 2234
Singapore (Tiomen Island): 432
Solomon Islands (Mbirimbiri): 974
Solomon Islands (Santa Isabel): 1515
Suriname:2312
Timor: 1266
Tonga (Nuku): 2491
Tonga (West): 2575
Trinidad & Tobago: 2193
Tuvalu (West Vaitupu): 2132
US Virgin Islands: 2168
Vanuatu: 2002

Proposed Wave Farm Project for Barbados

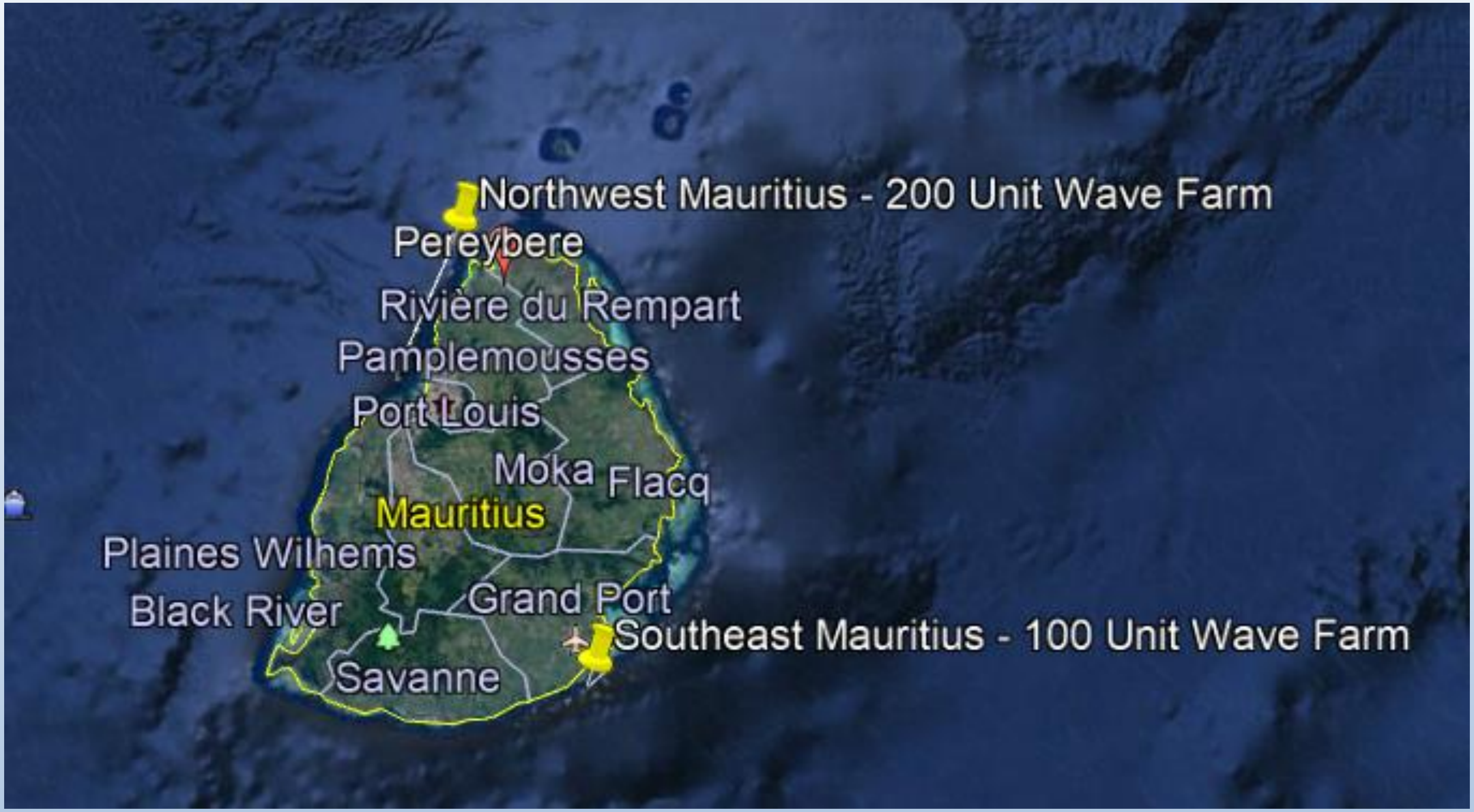
75 x 2400kW = 180 megawatts average electricity from wave power ~$750 million project

Proposed Wave Farm Project for Tonga



12 x 2400kW = 28 megawatts average electricity from wave power ~$120 million project

Proposed Wave Farm Projects for Mauritius



"Northwest": 200 x 2800kW = 560 megawatts average electricity from wave power
"Southeast": 100 x 3400kW = 340 megawatts average electricity from wave power
Total Average Wave Power for Mauritius Feb-July 2020 based on Numerical Model 900MW (7.88 billion kWh/year) for 1.3 million people with 894MW of installed electricity capacity (2016) https://theodora.com/wfbcurrent/mauritius/mauritius_energy.html
~ $3 billion project

The Economics of SurfWEC (US dollars)

Capital Expenditure (CAPEX)
$15 million for 1-6MW prototype unit, within 5km of shore, connected to grid
$9 million per unit at the 100 units production level

Operating Expenditure (OPEX)
Prototype: $300K/year with 5-year major overhaul cycle
100 unit production level: $200K/unit per year with 5-year major overhaul cycle

Revenue per unit per year from electricity sales
Barbados average: 20,000 MWh[1]/year x $208[2]/MWh = **$4.16 million/year**
Project paid off in less than 10 years, reduced electricity rates follow
Fiji: 20,000 MWh/year x $470[3]/MWh = **$9.4 million/year**
Solomon Islands: 13,000 MWh/year x $990[3]/MWh = **$12.8 million/year**

Headline: SurfWEC is projected to produce up to two times more electricity than a similar investment in off-shore wind, per project unit area, based on increased performance and availability over existing wave energy conversion technologies.

[1] *A MWh is 1,000 kilowatt-hours (kWh)*
[2] *REC for Solar in Barbados National Energy Policy, page 40, expanded past 500kW systems*
[3] *Electricity rates from: https://www.nrel.gov*

Development Timeline

Scale Model for Project Nation Wave Climate - Wave Tank Test, Delivery to Project Site, then Sea Trial

- Build; wave tank tests; followed by 6-12 months sea trial
  - 1-2 years: 2021 Order of Magnitude Budget: $1M US

Prototype (full scale)

- Build, followed by 1 year sea trial
  - 3-5 years: 2024 Order of Magnitude Budget: $15M US

Multiple unit expansion

- 2025 onwards

Commercial Deployment – 100's of units to utility-scale

- 2026 onwards

Thank you

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Permanent Mission of Barbados to the United Nations

Stakeholder Forum FOR A SUSTAINABLE FUTURE

Thank you for joining us.

The Role of Oceans as a Sustainable Resource That Can Contribute to the Global Energy Transition

An HLPF 2020 Side Event, hosted by the Permanent Mission of Barbados to the United Nations & Stakeholder Forum for a Sustainable Future

- **Hon. Kirk D. M. Humphrey, M.P., Minister of Maritime Affairs and the Blue Economy, Barbados**
- **H.E. Ambassador Lois Michele Young, Permanent Representative of Belize to the United Nations & Chair of AOSIS**
- **Under-Secretary-General Fekitamoeloa Katoa 'Utoikamanu, United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States**
- **Ambassador Peter Thomson, United Nations Secretary-General's Special Envoy for the Ocean**
- **Mr. Rémi Gruet, CEO of Ocean Energy Europe**
- **Professor Weili Cui of SUNY Maritime College**
- **Misters Rik van Hemmen, President, and Michael Raftery, Chief Technology Officer, Martin & Ottaway and SurfWEC LLC**
- **Respondent: Ahmed Abdel-Latif, Permanent Observer to the United Nations, IRENA**
- **Closing remarks by H.E. Ambassador H. Elizabeth Thompson, Permanent Representative of Barbados to the United Nations**

Moderated by Charles Nouhan, Chairman of Stakeholder Forum

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17 PARTNERSHIPS FOR THE GOALS