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Energy from the sea: an action agenda for deploying offshore renewables worldwide

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&
Francisco Boshell – IRENA Analyst

G20 Collateral Event
21 May 2021

Opening Remarks

Roland Roesch

Importance of G20 supporting Offshore Renewables

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Population

60%
of the global population

Economy

80%
of global GDP

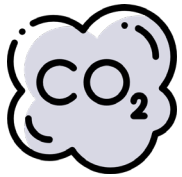
Trade

75%
of global exports

Energy

4/5
of the global energy demand

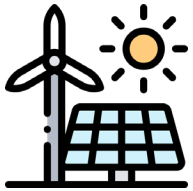
Emissions



79%
of the global carbon emissions

Renewable Energy

General



81%
of the global installed renewable generation capacity

Potential

75%
of the global 2010 - 2030 renewable deployment potential

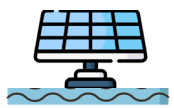
Offshore wind

99.3%
of the global installed capacity

Ocean Energy

100%
of the global installed capacity

Floating PV



N/A
(However plenty deployed projects are in G20 countries)

Contributions of offshore renewables to the Blue Economy and the Energy Transition

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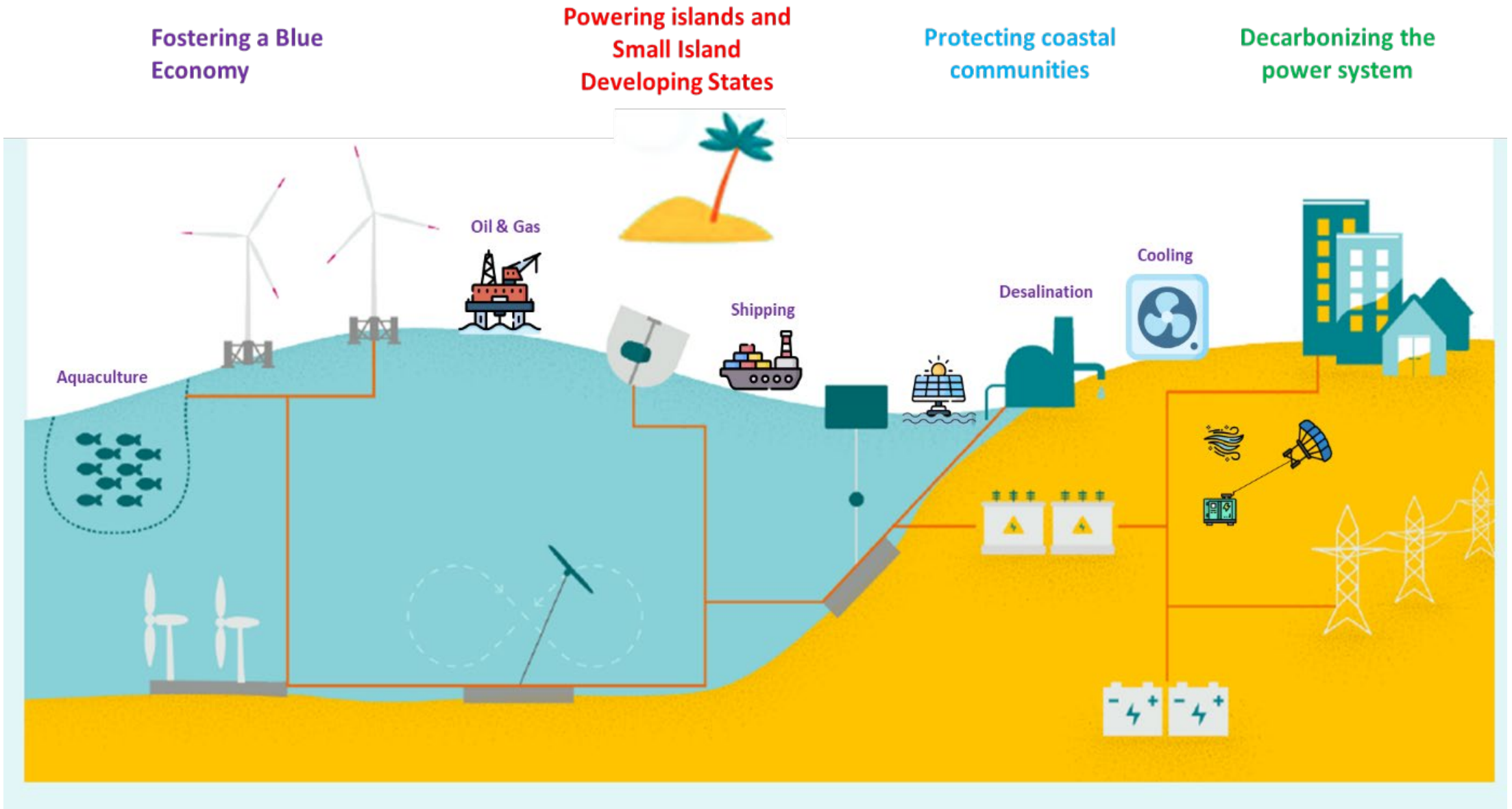
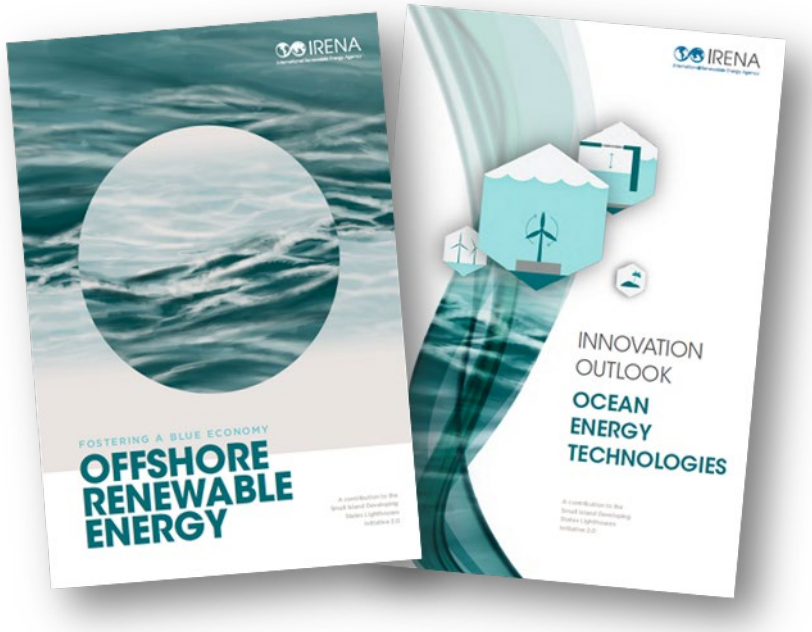


IRENA's support to G20 on Offshore Renewables

What is meant by offshore renewables

- Offshore wind – bottom fixed and floating
- Floating PV
- Marine technologies
- Increasing attention for offshore hydrogen islands



Today's event

- **Objective:** collect insights from experts to support G20 Action Agenda for offshore renewable energy

IRENA's Report for G20 Energy Ministerial Meeting

- July 23rd - release of report at G20 Energy Ministerial Meeting

IRENA Collaborative Framework Ocean Energy & Offshore Renewables

Aim:

- Agency to proactively function as a global network hub
- Facilitate **government peer-to-peer collaboration** and exchange of knowledge

In brief:

- Collaborative Framework on Ocean Energy/Offshore Renewables covers:
  - Offshore and floating wind technology; **ocean energy technologies**; and Floating solar photovoltaic.
- Co-facilitated by the **Kingdom of Tonga and Italy**
- **40 member countries** engaged + industry associations
- Suggested areas of work include exchange of good practices on: Marine spatial planning; Foster collaborative R&D programmes; Coupling of offshore renewables with power-to-X technologies; and Grid interconnection for offshore generation

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Status and Outlook for Offshore Renewables

Francisco Boshell

Offshore Wind Market

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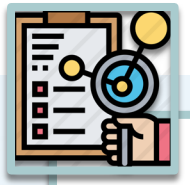


Market status

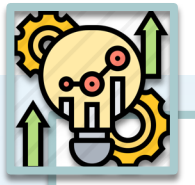
- Global installed capacity in 2020: **34 GW**
- Growth between 2019 and 2020: **18%**
- Leading region: Europe **90%** of global capacity
- New markets: China half of new additions in 2020 **(3 GW China)**
- Global floating wind capacity: **30 MW**
- Capacity factor: Hywind **> 50%**

Outlook in 1.5oC Scenario

- Global capacity: **380 GW** in 2030 and **2,000 GW** in 2050
- Floating **~ 30 GW** in 2030 and **~ 300 GW** 2050
- Needed annual installations: **~ 70 GW** per year
- Needed annual investments: **~ 150** to **200 USD billions** per year

Competitiveness

- **Fixed foundations**:
  - 2019 Global average: **USD 0.115/kWh**
  - 2023 outlook based on auction data: **USD 0.05 – 0.10/kWh**
- **Floating foundations**:
  - 2019 Global average: **USD 0.160/kWh**
  - 2024 outlook based on auction data: average **USD 0.13/kWh**



Recent Developments

- EU Offshore strategy **~ 300 GW** in 2050
- Japan: **45 GW** by 2040
- India: **30 GW** in 2030
- China plan for a **50 GW** wind farm by 2030 in Fujian province
- Korea plan for a **6 GW** floating wind farm by 2030
- USA: Vineyard Wind **800 MW** project

Ocean Energy Market

Market status

- Global installed capacity 2020: **535 MW**
- Tidal range dominates capacity but technology trend shifts towards **tidal stream** and **wave energy**
- Leading region: **31** countries with projects in pipeline, mostly in EU

Outlook in 1.5oC Scenario

- Global capacity: **70 GW** by 2030 and more than **350 GW** by 2050
- Needed annual installations: **~ 12 GW** per year
- Needed annual investments: **~ 35** to **45 USD billions** per year

Competitiveness

- Tidal: **USD 0.20-0.45/kWh**
- Wave: **USD 0.30-0.55/kWh**
- 2030: **USD 0.11/kWh**

Recent Developments

- **12** countries pursuing **tidal** and **wave energy**
- Canada grid-connected tidal stream project of **9 MW**
- The European Commission targets at least **40 GW** by 2050.
- Emerging markets include **China**, **Japan** and **Republic of Korea**.
- The world's largest tidal stream turbine **2 MW** operational in Scotland.

Floating PV Market

Market status

- Global installed capacity 2020: **2.6 GW**
- 339 projects in **35** countries
- Accelerated growth in last 3 years – **1.5 GW** additional capacity

Outlook in 1.5oC Scenario

- future demand driven by **Asian countries**
  - India plans **1 GW**
  - Korea plans **2.7 GW** in the Yellow Sea

Competitiveness

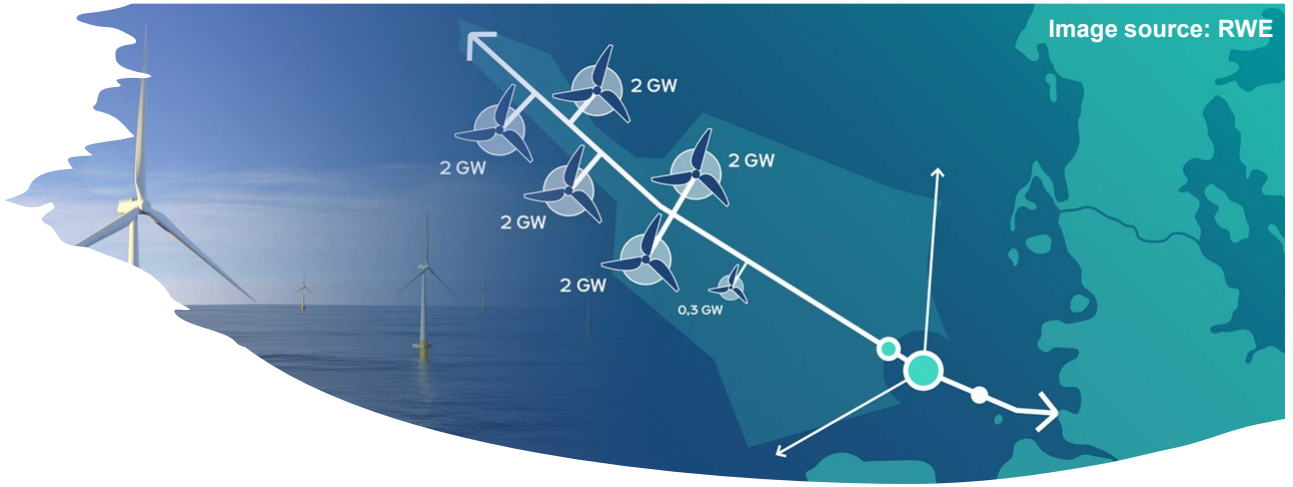
- 2020 estimated: **USD 0.354/kWh**

Recent Developments

- The largest plant globally is located in **China** with **150 MW**
- **Ghana** has installed **5 MW** in 2020
- **Netherlands** has a **27.4 MW** plant
- **Singapore** plans **50 MW**

Upcoming developments

50 GW Offshore wind in Fujian province, China (**2030**)



10 GW Aquaventus **offshore wind** and **green hydrogen** project, Germany (**2035**)

2.1 GW Floating solar PV at Saemangeum Seawall, Republic of Korea (**2025**)

9MW tidal array in Nova Scotia, Canada (**2021**)

Different policy instruments – different results

- **Feed-in-tariffs, feed-in-premiums, auctions - CfD, PPAs**
  - EU Offshore wind auctions
  - China feed-in-tariff for tidal energy of USD 0.39/kWh
  - Canada feed-in-tariffs for tidal energy
  -
- **Provide public capital investment support**
  - Welsh Government (UK) provides USD 1.7 million (GPB 1.2 million) for a tidal energy project off North Wales
  - Korea plans to invest USD 43 billion for an 8.2 GW offshore wind power plant.

Auction design for Offshore Wind varies and has an impact on results

Country	Wind capacity [GW] (total / offshore) [38]	Date of auctions	Capacity awarded (all rounds) [GW]	Wind farms awarded	Average bid (Capacity-weighted)	Minimum bid	Sided	Duration (years)	Grid costs in bid	Site costs in bid	Inflation adjustment
Denmark	5.7 / 1.3	2005–16	2.2	7	€84 (DKK625)	€50 (DKK372)	2	12	×	✓	×
UK	21.0 / 8.2	2015–19	9.8	11	€65 (£57)	€46 (£40)	2	15	✓	✓	✓
Netherlands	4.5 / 1.1	2016–19	3.0	5	€32	€0	1	15	×	×[a]	×
Germany	59.3 / 6.4	2017–18	2.7	10	€19	€0	1	20	×	✓	×
Belgium	3.4 / 1.2	n/a[b]	2.3	10	€104	€79	1	16[c]	×[d]	×	×

[a] Land lease paid for by the wind farm in the latest tender round

[b] Renewable obligation certificate scheme mirroring NL auction results

[c] 16-20 years, with 16 years for latest wind farms

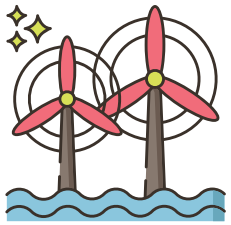
[d] Financial cap on total investment

Source: Jansen et al (2020) Offshore wind competitiveness in mature markets without subsidy

Innovative trends

Technology

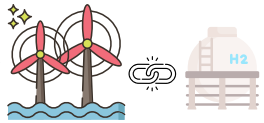
Conventional



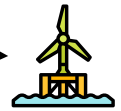
Fixed offshore wind

Trend

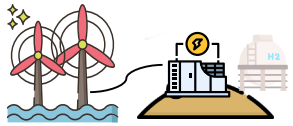
Larger turbines and deeper waters



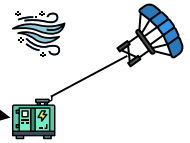
Generation of green hydrogen



Floating foundations



Artificial Islands



Airborne wind energy systems

Example

Vestas **15 MW** wind turbine will start production 2024

NorthH2 offshore wind – hydrogen production project with **200 MW** electrolyzer capacity in the Netherlands

Norway's Hywind Tampen **88 MW** floating offshore farm

Denmark's two artificial offshore wind islands with a **12 GW** total capacity

Skypower100 airborne wind system in Germany with a capacity of **100 kW**

Application

Conventional

Industrial and local consumption

Trend

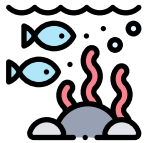
Islands and small Island states

Oil & Gas

Cooling

Shipping

Blue economy activities



Aquaculture

Desalination

Recommendations for a G20 Offshore Renewables Action Agenda

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G20 strengths to push an Offshore RE Global Agenda

- **Acknowledge** the key role of offshore renewables at G20 ministerial level.
- G20 to **cooperate** with IRENA's Collaborative Framework to **collect** and disseminate key data on Offshore Renewables.
- **Promote** G20 countries to include offshore renewables in national energy and climate policies -e.g. NDCs.
- **Support** increase public investments in RD&D for all offshore renewable technologies.
- **Design** and **implement** joint RD&D projects at commercial scale
- **Promote** public-private partnerships for innovative offshore renewables like offshore wind-to-hydrogen generation units.
- **Identify** and **promote** innovative financing mechanisms for offshore renewable technologies within the "Finance Track" of the G20.

Thank you

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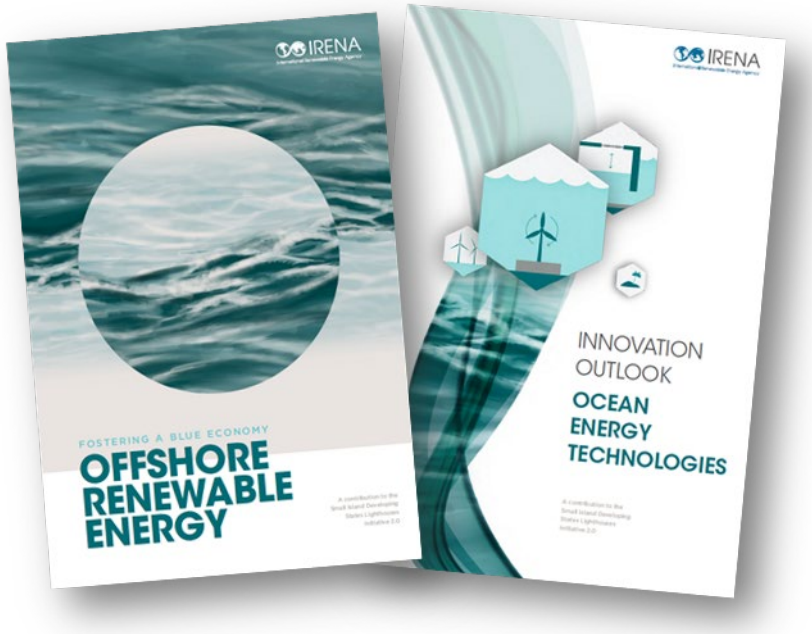
Backup slides

IRENA's support to G20 on Offshore Renewables

What is meant by offshore renewables

- Offshore wind – bottom fixed and floating
- Floating PV
- Marine technologies
  - Tidal range
  - Tidal stream
  - Wave technologies
- Increasing attention for offshore hydrogen islands

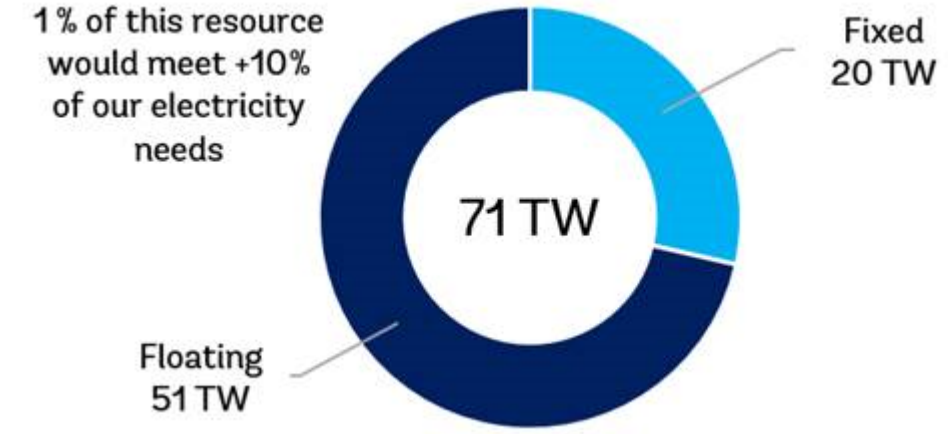


Report for G20 Energy Ministerial Meeting

- Support a **G20 Action Agenda** for global deployment of offshore renewables
- Identify **emerging innovations** in technology, policy and business models to **scale up offshore renewables**
- Timelines 2021:
  - **May 10th to May 23rd** – Review of DRAFT report by G20 WG
  - **May 27th** - G20 Side Event on Offshore Renewables
  - **July 23rd** - release of report at G20 Energy Ministerial Meeting

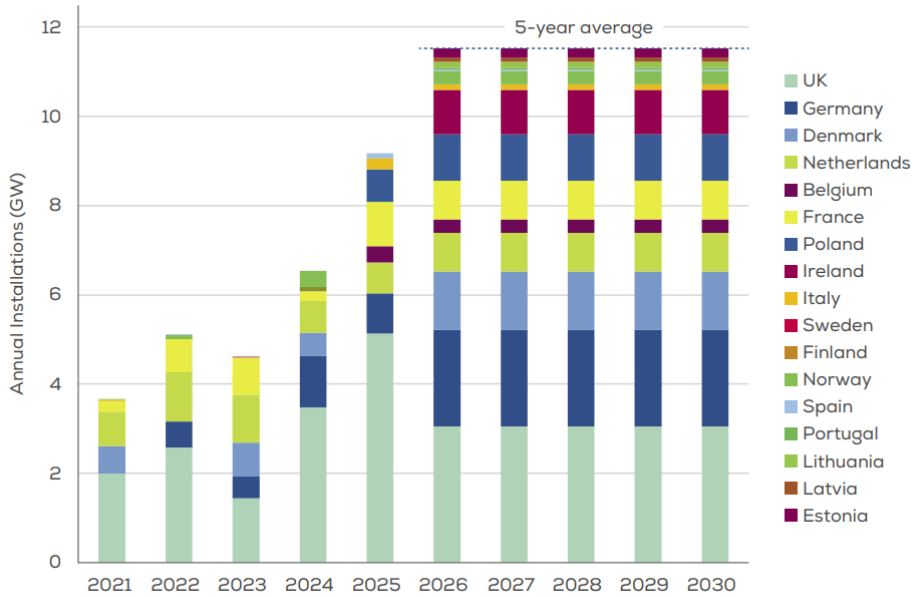
Offshore wind

- 34.4 GW installed end 2020, 6 GW added
- Cost continue to fall
  - Developers pay for leases in UK
- 71 000 GW potential
  - Ten times todays global power generation capacity
- IRENA World Energy Transitions 1.5C scenario: 2000 GW offshore wind by 2050, 7500 TWh production
  - Around 10% of total power generation in 2050
  - 70% of the technical potential is in deeper waters suited to floating wind
- So far around 30 MW floating wind installed, 13 announced projects in EU, Asia, US
  - Proven technology, high capacity factors
  - Cost need to be reduced further
- 5-30 GW floating wind by 2030, several 100 GW by 2050

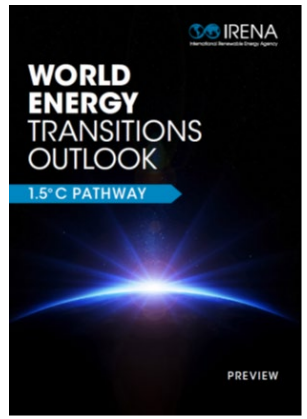


Source: World Bank, 2021

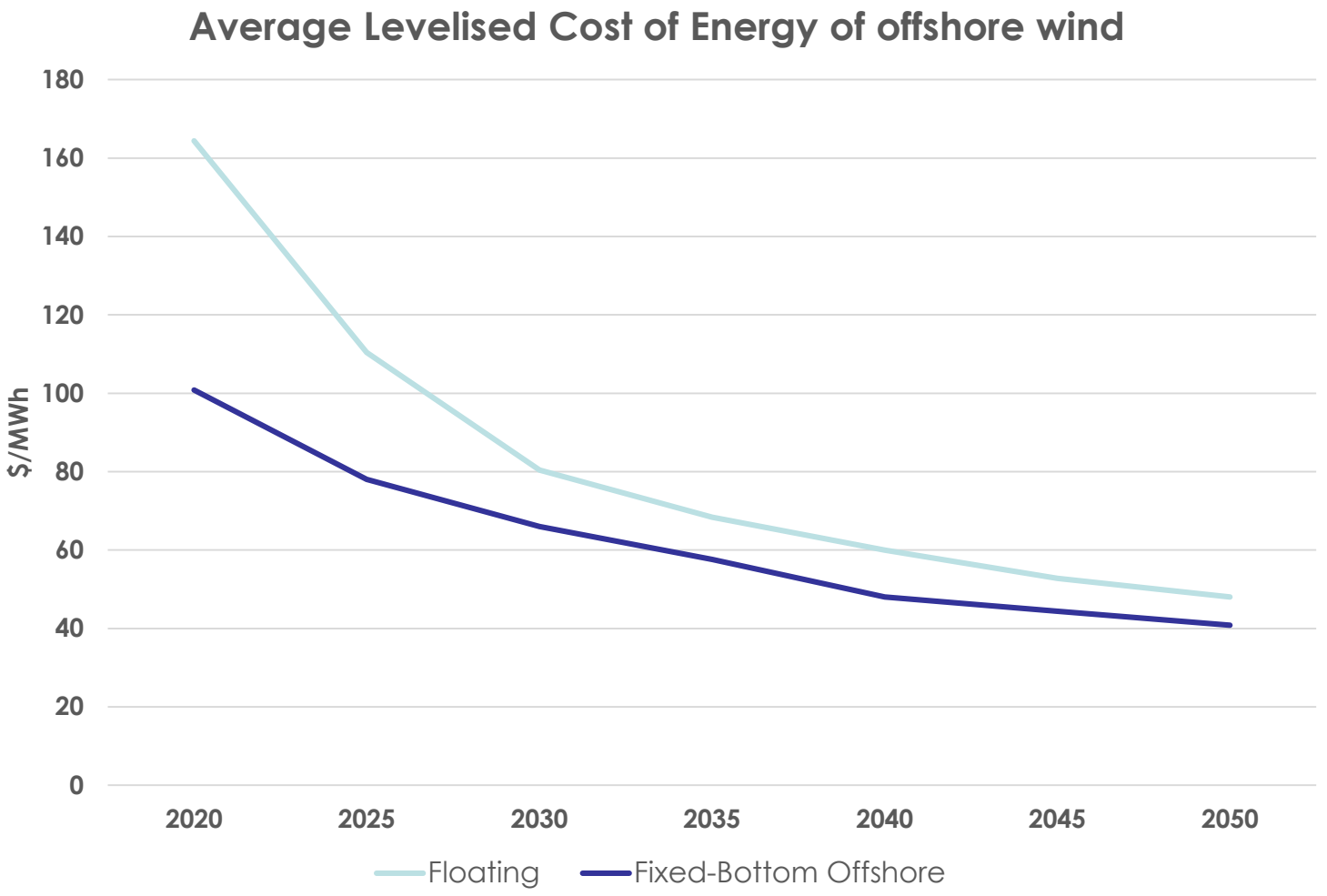
FIGURE 19
European Offshore Wind Outlook to 2030[13]



Source: WindEurope



Future wind energy costs drop significantly



Expected cost declines of 17%-35% by 2035 and 37%-49% by 2050

Source: IRENA, based on data from Lawrence Berkeley National Laboratory and DNV GL

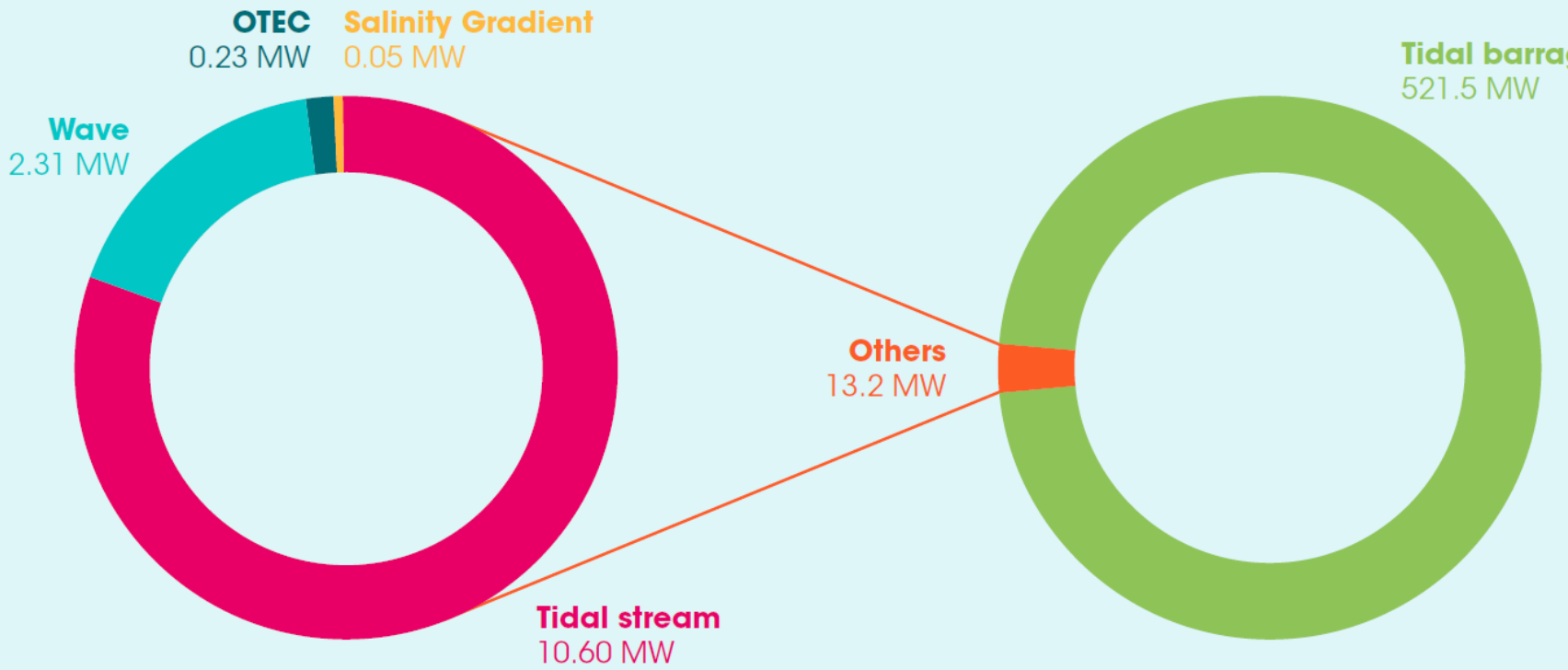
Floating solar PV

- Until the end of august 2020, a cumulative installed floating solar PV capacity was around 2.6 GW from active projects in more than 35 countries globally. The installed capacity has more than doubled since 2018 with 1.1 GW installed capacity.
- Currently, 338 floating solar PV projects are installed in 35 countries and are **mainly installed on freshwater artificial reservoirs.** Top 10 projects are in China, Japan and the Republic of Korea. The largest plant globally is located in China with 150 MW.
- The future demand for floating solar PV is expected to be driven by Asian countries. India plans a project of 1 GW, while the Republic of Korea plans one of 2.7 GW in the Yellow Sea. European countries are also aiming for several GW in coming years.

Status of ocean energy markets

Figure S1: Ocean energy deployment excluding tidal barrage (MW)

Figure S2: Total ocean energy deployment (MW)



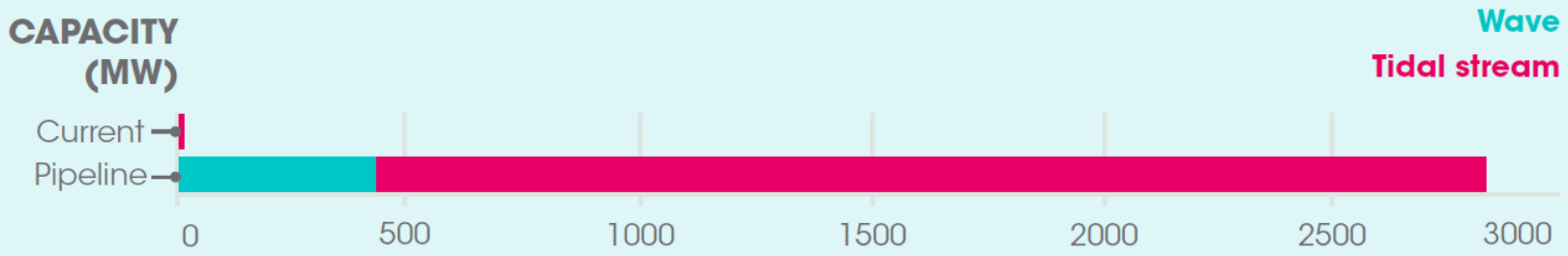
Source: *IRENA ocean energy database*

Source: IRENA (2020), Innovation Outlook: Ocean Energy

Outlook Ocean Energy markets

Current pipeline of projects

Figure S3: Active and projected tidal stream and wave capacity beyond 2020



Note: *While their capacity is too small to appear on this chart, additional projects are planned for the other ocean energy technologies beyond 2020. For example, a 2 MW ocean thermal energy conversion plant and a 1 MW salinity gradient energy plant are planned in the Netherlands (Johnson, 2019).*

Source: *IRENA ocean energy database*

Market outlook (1.5°C scenario)

- **2030 – 70 GW**
- **2050 – 350 GW**

Source: IRENA (2020), Innovation Outlook: Ocean Energy

IRENA Collaborative Framework Ocean Energy & Offshore Renewables

Aim:

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- Facilitate **government peer-to-peer collaboration** and exchange of knowledge

In brief:

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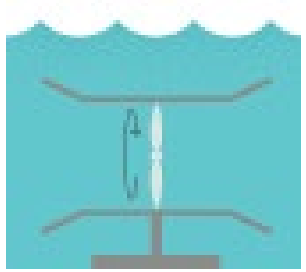
  - Offshore and floating wind technology; **ocean energy technologies**; and Floating solar photovoltaic.
- Co-facilitated by the **Kingdom of Tonga and Italy**
- **40 member countries** engaged + industry associations
- Suggested areas of work include exchange of good practices on: Marine spatial planning; Foster collaborative R&D programmes; Coupling of offshore renewables with power-to-X technologies; and Grid interconnection for offshore generation

Unlocking OE potential

Key Recommendations



Technology:

Technology convergence and standardization

Conduct resource assessment campaigns

Support test centres

Capital grant funding for R&D

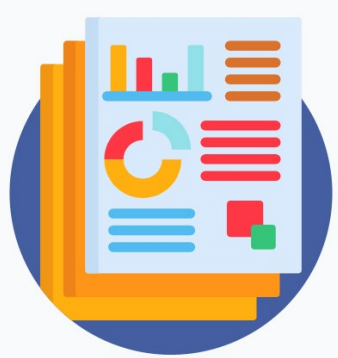
Policy:

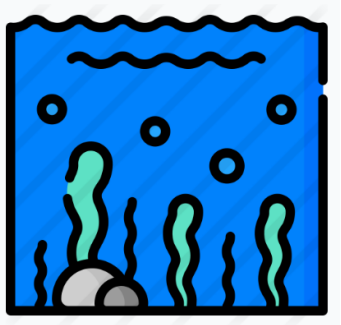
Premium price MWh

Promote innovative business models

Compensate additional services (regulation)

Innovative financial structures





Environmental and Social:

Improve access to baseline data

Consult and engage the public

Infrastructure:

Availability of Networks

Engage and inform the emerging supply chain

Synergies with other RE technologies – firm generation

Source: IRENA (2020), Innovation Outlook: Ocean Energy

Icons made by Freepik from www.flaticon.com

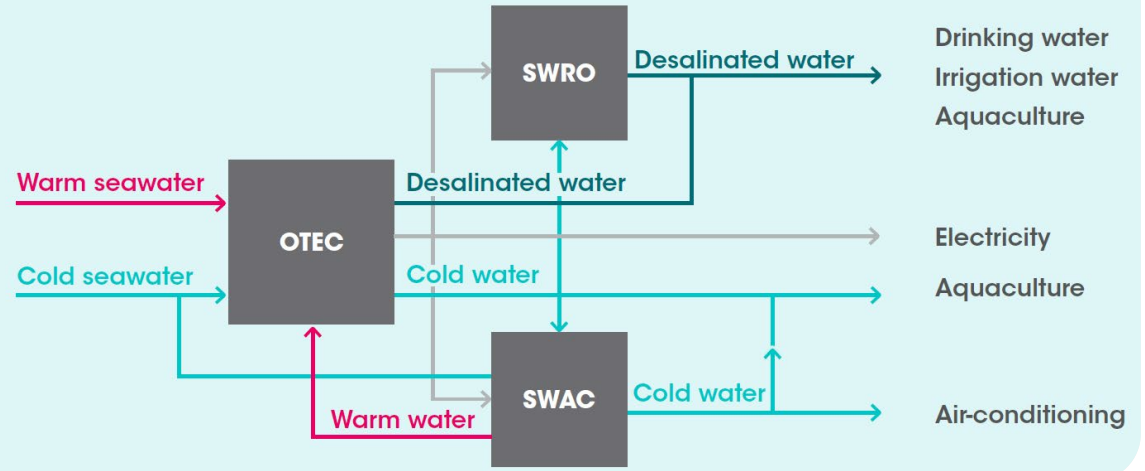
SIDS Lighthouses Priority Areas

1. Support SIDS in reviewing and implementing **NDCs**, with **technical assistance** and **capacity building**
2. Expand from assessment and planning to **implementing** effective, innovative solutions.
3. Promote **all renewable sources**, including geothermal and ocean energy, and step up work on wind and PV
4. Support the development of bankable projects, **access to finance** and co-operation with the **private sector**
5. Strengthen **institutional and human capacity** in all segments of the renewable energy value chain
6. Expand focus beyond power generation to include **transportation and other end-use sectors**
7. Expand focus beyond power generation to include **transportation and other end-use sectors**
8. Leverage synergies between renewables and **energy efficiency**
9. **Nexus** between RE and agriculture, food, health and water – to foster broad **socio-economic development: job creation**, **gender** equality and **women's empowerment** through renewables.
10. Link renewable energy uptake to climate resilience and more effective disaster recovery.
11. **Enhance collection and dissemination of statistics, supporting informed decision-making**
12. Reinforce and expand partner engagement, leveraging synergies with other SIDS initiatives
13. Boost renewable power deployment, aiming for a target of 5 GW of installed capacity in SIDS by 2023

Example 1 - OTEC coupled with cooling and water desalination in islands

OTEC: electricity (kWh) + other revenues

Figure 38: Ways of coupling OTEC, desalination, cooling and aquaculture



OTEC technical potential in the Caribbean

Country	Maximum Technically Exploitable Resource (MW)					Average electrical demand (MW)
	Fixed offshore wind	Floating offshore wind – conventional	Floating offshore wind – deep sea	OTEC	Total	
Antigua & Barbuda	4 935	1 477	11 718	100	18.230	38
The Bahamas	10 955	6 321	16 723	220	34 219	220
Barbados	0	112	7 063	140	7 315	104
Grenada	2 618	476	7 196	110	10 400	25
Jamaica	1 211	1848	9 709	180	12 948	498
Saint Kitts & Nevis	399	196	9 135	40	9 770	24
Saint Lucia	105	224	4 025	90	4 444	46
Saint Vincent & the Grenadines	3 227	385	3 017	70	6 699	17
Trinidad & Tobago	16 597	12 460	4 963	50	34 070	1 064
Total	**40 047**	**23 499**	**73 549**	**1 000**	**138 095**	**2 036**

Source: *Johnston, 2019*

Source: IRENA (2020), Innovation Outlook: Ocean Energy

Innovative Business Model 1: Offshore renewables powering a Blue Economy

Cooling

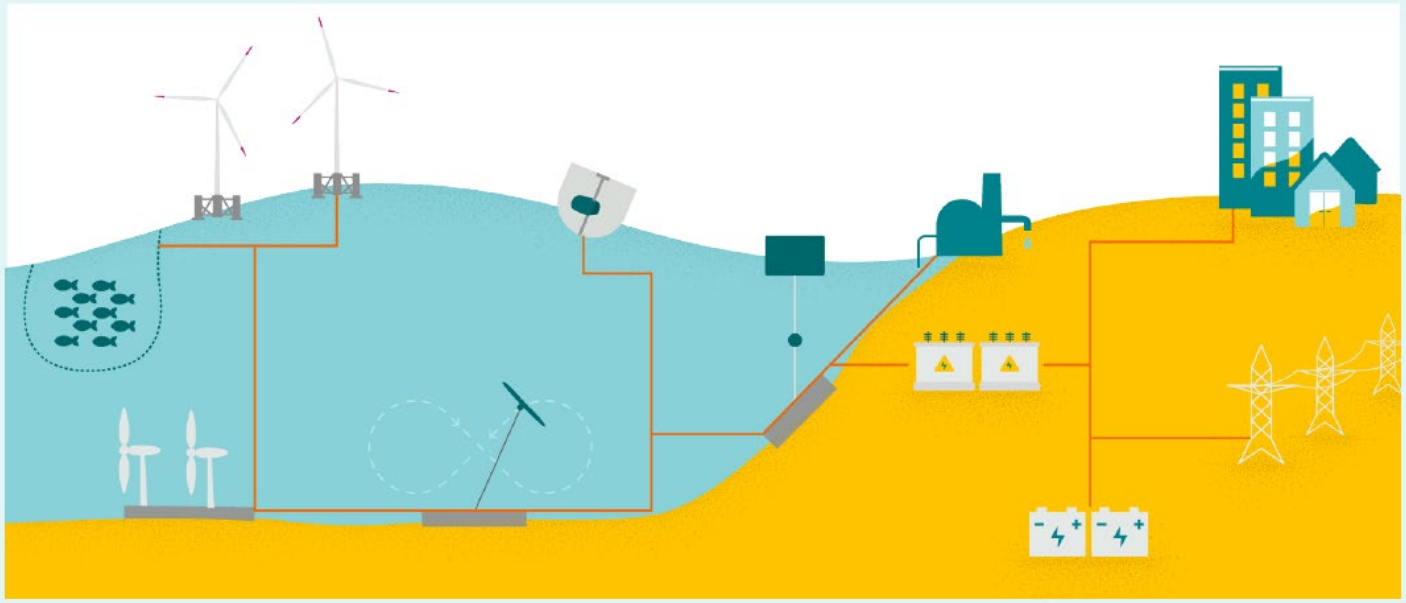
Shipping

Aquaculture

Offshore O&G

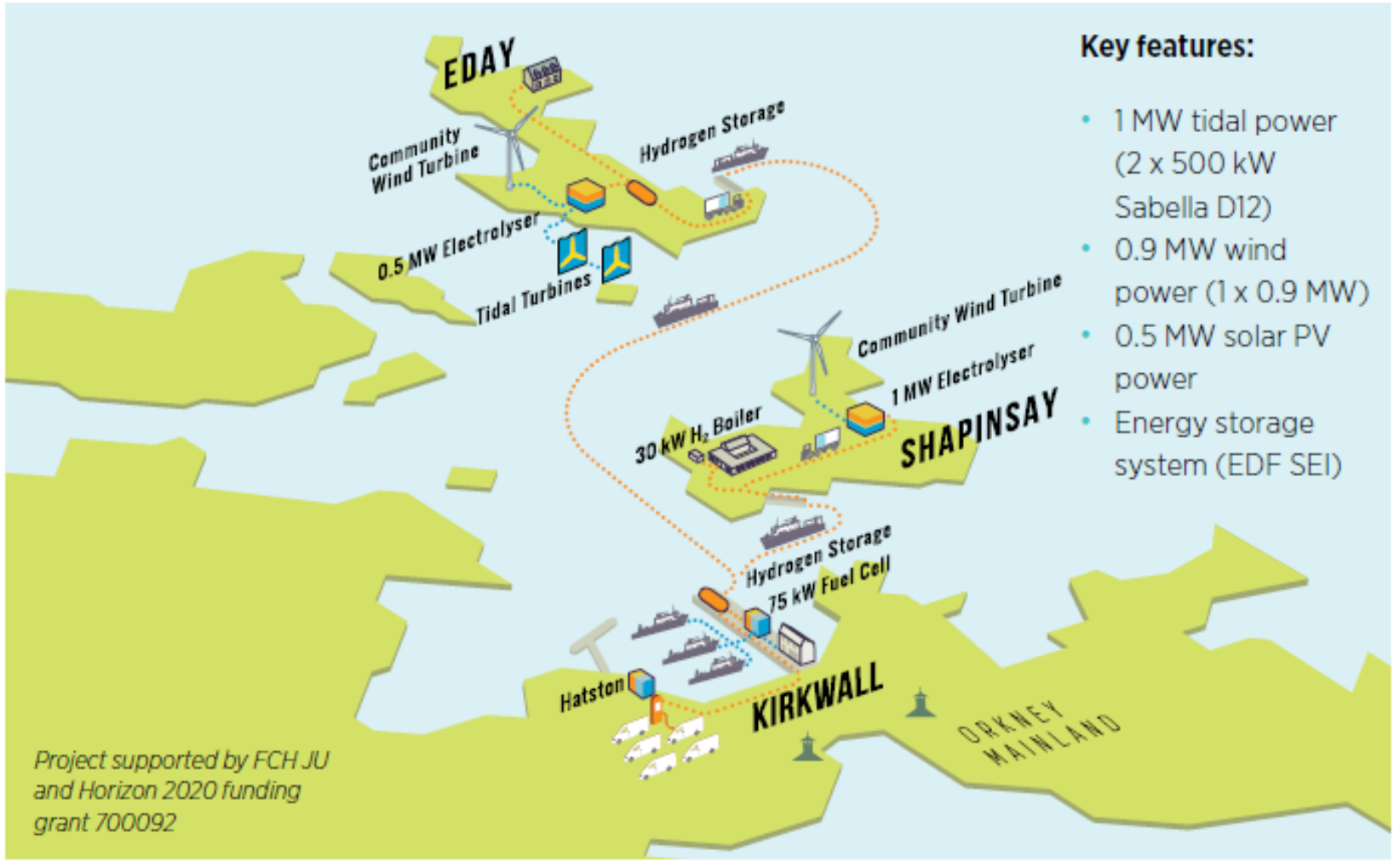
Desalination

Figure 33: Ocean energy coupled with other renewable energy sources to power the blue economy



Source: IRENA (2020), Innovation Outlook: Ocean Energy Technologies

Example: Tidal energy + solar PV & wind for green hydrogen production (floating wind explored)



BIG HIT project in Orkney

Image source: BIG HIT Orkney

Source: IRENA (2020), Innovation Outlook: Ocean Energy Technologies

Ocean energy and blue economy

Table 8: Examples of ocean energy developers focusing on powering the blue economy

	POWER	DESALINATION	COOLING (SWAC)	OIL AND GAS	AQUACULTURE	SHIPPING/PORTS	AUV CHARGING	Developer
Wave	✓				✓			SINN Power
								AWS Ocean Energy
								WavEC
								Albatern
								Aqua Power Technologies
								GIEC
								Japanese Consortium
Tidal	✓				✓			Sustainable Marine Energy
Wave	✓			✓	✓			Ocean Harvesting
Wave	✓			✓				Wave for Energy
								Hann-Ocean
								Floating Power Plant
Wave	✓			✓			✓	Ocean Power Technologies
Wave	✓	✓						Resolute Marine Energy
								Carnegie Clean Energy
								Wavepiston
								GIEC
Wave		✓						Atmocean
								NRELUS National Renewable Energy Laboratory

	POWER	DESALINATION	COOLING (SWAC)	OIL AND GAS	AQUACULTURE	SHIPPING/PORTS	AUV CHARGING	Developer
Tidal	✓					✓		EMEC (through hydrogen)
OTEC	✓	✓						NIOT OWC
OTEC	✓		✓					Makai
OTEC	✓	✓	✓					Bardot Ocean
								Bluerise
OTEC	✓	✓	✓		✓			Bretagne Ocean Power
Other						✓		GEPS Techno

Note: *SWAC = seawater air conditioning; AUV = autonomous underwater vehicle*

Source: *IRENA ocean energy database*

Source: IRENA (2020), Innovation Outlook: Ocean Energy Technologies

Hybrid electricity generating systems

Table 7: Projects coupling ocean energy with other renewable energy sources

	SOLAR	WIND	FLOATING WIND	PUMPED HYDRO	STORAGE	MICROGRID	HYDROGEN	Examples	Country	Status
Tidal		✓					✓	BIG HIT / Surf 'n' Turf	Scotland	In operation
Tidal					✓			Bluemull Sound Shetland	Scotland	In operation
Tidal	✓				✓			San Antonio	Philippines	Research
Tidal	✓	✓			✓	✓		PHARES Ushant Island	France	Planning
Tidal				✓				KIOST	Republic of Korea	R&D
Wave	✓	✓			✓	✓		King Island	Australia	Planning
Tidal					✓	✓		KIOST	Republic of Korea	R&D
								Dent Island	Canada	Test completed
Wave	✓				✓	✓		Garden Island	Australia	Planning
								KIOST	Republic of Korea	R&D
Wave			✓					Canary Islands	Spain	Research
								Bombora and MEECE	Wales	Research
Salinity							✓	REDstack	Netherlands	Planning
Wave	✓							GEPS Techno		Full-scale testing
								Eco Wave Power		Installed (Gibraltar and Israel)
								Wave for Energy		WEC full-scale testing completed
								GIEC		Open-sea testing completed
Wave	✓				✓			Ocean Power Technologies		Full-scale deployment announced
Wave	✓	✓						SINN Power		WEC prototype testing completed
Wave			✓					Floating Power Plant		Previous model testing completed
		✓						Marine Power Systems		WEC 1:4 scale testing completed
								Seabased		WEC tested, wave-wind resource assessment conducted
								Havkraft		WEC full-scale testing completed
Wave					✓			BOLT Lifesaver		Small-scale testing completed
Tidal					✓		✓	HydroWing (Tocardo Turbine)		Patenting

Note: *WEC = wave energy converter*

Source: *IRENA ocean energy database*

Source: IRENA (2020), Innovation Outlook: Ocean Energy Technologies