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

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
- Offshore wind
  - 99.3% of the global installed capacity
- Ocean Energy
  - 100% of the global installed capacity
- Potential
  - 75% of the global 2010 - 2030 renewable deployment potential
- Floating PV
  - N/A (However plenty deployed projects are in G20 countries)
Contributions of offshore renewables to the Blue Economy and the Energy Transition

- Fostering a Blue Economy
- Powering islands and Small Island Developing States
- Protecting coastal communities
- Decarbonizing the power system
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

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

Aim:
- Agency to proactively function as a global network hub
- Facilitate government peer-to-peer collaboration and exchange of knowledge
Status and Outlook for Offshore Renewables

Francisco Boshell
Offshore Wind Market

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 1.5°C 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 1.5°C 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 1.5°C 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)

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

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

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 (GBP 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

<table>
<thead>
<tr>
<th>Country</th>
<th>Wind capacity [GW] (total / offshore)</th>
<th>Date of auctions</th>
<th>Capacity awarded (all rounds) [GW]</th>
<th>Wind farms awarded</th>
<th>Average bid (Capacity-weighted)</th>
<th>Minimum bid</th>
<th>Sided</th>
<th>Duration (years)</th>
<th>Grid costs in bid</th>
<th>Site costs in bid</th>
<th>Inflation adjustment</th>
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<td>€84  ($50,162,500)</td>
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<td>2015–19</td>
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- Land lease paid for by the wind farm in the latest tender round
- 16-20 years, with 16 years for latest wind farms
- Renewable obligation certificate scheme mirroring NL auction results
- Financial cap on total investment

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

Fixed offshore wind

<table>
<thead>
<tr>
<th>Technology</th>
<th>Example</th>
<th>Application</th>
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</thead>
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<tr>
<td>Conventional</td>
<td>Vestas 15 MW wind turbine will start production 2024</td>
<td>Islands and small Island states</td>
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<tr>
<td>Trend</td>
<td>NorthH2 offshore wind – hydrogen production project with 200 MW electrolyzer capacity in the Netherlands</td>
<td>Industrial and local consumption</td>
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<td></td>
<td>Norway's Hywind Tampen 88 MW floating offshore farm</td>
<td>Oil &amp; Gas, Cooling</td>
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<tr>
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<td>Denmark's two artificial offshore wind islands with a 12 GW total capacity</td>
<td>Shipping, Blue economy activities, Aquaculture</td>
</tr>
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<td>Skypower100 airborne wind system in Germany with a capacity of 100 kW</td>
<td>Desalination</td>
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</table>
Recommendations for a G20 Offshore Renewables Action Agenda

G20 strengths to push an Offshore RE Global Agenda

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

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www.flickr.com/photos/irenaimages
www.youtube.com/user/irenaorg
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 today's 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
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
• 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)**

- **Wave**: 2.31 MW
- **OTEC**: 0.23 MW
- **Salinity Gradient**: 0.05 MW
- **Tidal stream**: 10.60 MW

**Figure S2: Total ocean energy deployment (MW)**

- **Tidal barrage**: 521.5 MW
- **Others**: 13.2 MW

Source: IRENA ocean energy database

Outlook Ocean Energy markets

Current pipeline of projects

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

**Market outlook (1.5°C scenario)**
- 2030 – 70 GW
- 2050 – 350 GW

**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

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Aim:
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- Facilitate government peer-to-peer collaboration and exchange of knowledge
Unlocking OE potential

**Key Recommendations**

<table>
<thead>
<tr>
<th>Technology:</th>
<th>Policy:</th>
<th>Infrastructure:</th>
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</thead>
<tbody>
<tr>
<td>Technology convergence and standardization</td>
<td>Premium price MWh</td>
<td>Availability of Networks</td>
</tr>
<tr>
<td>Conduct resource assessment campaigns</td>
<td>Promote innovative business models</td>
<td>Engage and inform the emerging supply chain</td>
</tr>
<tr>
<td>Support test centres</td>
<td>Compensate additional services (regulation)</td>
<td>Synergies with other RE technologies – firm generation</td>
</tr>
<tr>
<td>Capital grant funding for R&amp;D</td>
<td>Innovative financial structures</td>
<td></td>
</tr>
</tbody>
</table>

**Environmental and Social:**
- Improve access to baseline data
- Consult and engage the public

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.

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8. Leverage synergies between renewables and energy efficiency.


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.

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

OTEC technical potential in the Caribbean

<table>
<thead>
<tr>
<th>Country</th>
<th>Maximum Technically Exploitable Resource (MW)</th>
<th>OTEC</th>
<th>Total</th>
<th>Average electrical demand (MW)</th>
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<td>Floating offshore wind - deep sea: 1 178</td>
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<td>The Bahamas</td>
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Source: Johnston, 2019

Innovative Business Model 1: Offshore renewables powering a Blue Economy

Source: IRENA (2020), Innovation Outlook: Ocean Energy Technologies
Example: Tidal energy + solar PV & wind for green hydrogen production (floating wind explored)

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

<table>
<thead>
<tr>
<th>Developer</th>
<th>POWER</th>
<th>DESALINATION</th>
<th>COOLING(SWAC)</th>
<th>OIL AND GAS</th>
<th>AQUACULTURE</th>
<th>SHIPPING/PORTS</th>
<th>AUV CHARGING</th>
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**Note:** SWAC = seawater air conditioning; AUV = autonomous underwater vehicle

**Source:** IRENA (2020), Innovation Outlook: Ocean Energy Technologies
## Hybrid electricity generating systems

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

<table>
<thead>
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### Table 7: Projects coupling ocean energy with other renewable energy sources (continued)

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**Note:** WEC = wave energy converter  
**Source:** IRENA, ocean energy database