Outlook for Ocean Energy Development in Korea

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**Ocean Energy Development in Korea**

**Sihwa Lake Tidal Power Plant**
- Capacity of 254MW (25.4MW x 10)
- 8 Sluices
- Completed in 2011

**Jeju OWC Wave Power Pilot Plant**
- Capacity of 500kW (250kW x 2)
- Impulse turbine of 1.8m(dia.), 26 blades
- 37.0m(L) x 31.2m(B) x 27.5m(H)
- To be completed in 2015

**Uldolmok Tidal Current Power Pilot Plant**
- Capacity of 1,000kW (500kW x 2)
- Helical type Vertical Axis Turbine
- Completed in 2009

**Goseong OTEC/SWAC Pilot Plant**
- 20kW OTEC
- 60RT SWAC
Sihwa Lake Tidal Power Plant

- **History**
  - Completion of Sea Dyke of 12.7km in 1994
  - Severe Lake water pollution
  - Tidal Power Plant was proposed as a counter measure, based on the findings from national R&D
  - Construction: 2004 ~ 2011
  - Total Project Cost: USD 355 million

- **Effects of Sihwa Tidal Power Plant**
  - Improve water quality in Sihwa Lake and environmental recovery
  - Generate renewable clean energy
  - Enhancement of regional economy by forming waterfront and tourist attraction

- **Power Output in 2011.8~2014.12**

<table>
<thead>
<tr>
<th>Period</th>
<th>MWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011.08 ~ 2011.12</td>
<td>52,304</td>
</tr>
<tr>
<td>2012.01 ~ 2012.12</td>
<td>465,924</td>
</tr>
<tr>
<td>2013.01 ~ 2013.12</td>
<td>483,777</td>
</tr>
<tr>
<td>2014.01 ~ 2014.12</td>
<td>492,172</td>
</tr>
</tbody>
</table>
Workshop 3.3: Blue Economy Development: Where are we now? Where are we headed?

Sihwa Lake Tidal Power Plant

- Water Level Variations & Restored Tidal Flat
- Variation of ignition Loss in tidal flat
Tidal Current Power Generation System with active-control device

- **Medium Scale Model (1:5)**
  - Outdoor Experiment
    - 2013~2014 / Uldolmok Test Site
    - Rotor Dia. : 2.4m
    - Blade Active Pitch Control
    - Passive/Active Yawing by Rudder

- **Design of KS200**
  - 2014~2015
  - Based on Experimental Results

- **Fabrication of KS200**
  - 2015~2016

- **Installation**
  - 2016. 9 ~ 10
  - Near Uldolmok Test Site

- **Verification Test**
  - 2nd : 2018 ~ 2020
  - Performance Assessment
  - Environmental Impact Monitoring

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### KS200 (Korean Shark 200) Specification

<table>
<thead>
<tr>
<th>Component</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rotor</strong></td>
<td>Diameter: 12m, Swept Area: 113m², Rotor speed: 16 rpm, Power regulation: Active blade pitch regulation</td>
</tr>
<tr>
<td><strong>Yawing system</strong></td>
<td>Type: Rudder pitch control, Control type: Passive/Active</td>
</tr>
<tr>
<td><strong>Transmission system</strong></td>
<td>Type: Direct drive</td>
</tr>
<tr>
<td><strong>Mechanical brake</strong></td>
<td>Type: Hydraulically released</td>
</tr>
<tr>
<td><strong>Generator</strong></td>
<td>Type: Permanent Magnet Synchronous Generator (PMSG)</td>
</tr>
<tr>
<td>Rated power</td>
<td>225kW</td>
</tr>
<tr>
<td>Voltage</td>
<td>3e: 575 V_e</td>
</tr>
<tr>
<td>Cooling system</td>
<td>Direct to passing sea water</td>
</tr>
<tr>
<td><strong>Monitoring system</strong></td>
<td>SCADA system: Server-client, Remote control: Full turbine control</td>
</tr>
<tr>
<td><strong>Tower &amp; Substructure</strong></td>
<td>Type of tower: Cylindrical tubular steel, Type of substructure: Gravity type circular caisson, Hub height: 11m from seabed</td>
</tr>
<tr>
<td><strong>Operational data</strong></td>
<td>Cut-in current speed: 1m/s, Rated current speed: 2.3m/s</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>Platform &amp; Drive train: Less than 60 tons, Tower &amp; Substructure: Less than 700 tons</td>
</tr>
</tbody>
</table>
Hybrid-OTEC Power Plant (200kW, 2014)

- Combined operation with wood chip gasification power plant
- Using multiple heat sources

Substituted by Geothermal or Solar heat sources for SiDS
SWAC plant to reduce energy demand

- Cooling source can be acquired from
  1) direct heat exchanger by cold deep ocean water
  2) cold heat of evaporator of heat pump by use of seawater as a condensing heat source

- Test bed (100RT & 500RT) were established in 2014 and 2015
Workshop 3.3: Blue Economy Development: Where are we now? Where are we headed?

Technology Development

● Technology Readiness Levels

<table>
<thead>
<tr>
<th>Energy Resources</th>
<th>Europe</th>
<th>Korea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tidal Barrage</td>
<td>TRL 9</td>
<td>TRL 9</td>
</tr>
<tr>
<td>Tidal Current</td>
<td>TRL 8</td>
<td>TRL 6-7</td>
</tr>
<tr>
<td>Wave</td>
<td>TRL 8-9</td>
<td>TRL 5-6</td>
</tr>
<tr>
<td>OTEC/SWAC</td>
<td>TRL 8-9</td>
<td>TRL 5-6</td>
</tr>
</tbody>
</table>

● Technology Topics

1. Proving reliable operation
2. Device design: cost reduction and development of promising technologies
3. Enabling technologies (cabling and electrical connection)
4. Innovation: novel technologies, new components and subcomponents
5. Knowledge sharing

- Wave and Tidal Energy Strategic Technology Agenda. SI Ocean (2014)
Prospectives

● Wave and Tidal Energy in Europe
  ✓ 100GW of installed capacity by 2050
  ✓ Up to 260TWh Generation
  ✓ Power 66 million European homes
    ❖ Ocean Energy Europe (2014)

● Wave and Tidal Energy Worldwide
  ✓ Up to 337GW of installed capacity including Asia
  ✓ Good opportunity to industry

● Meygen Project in UK
  ✓ 398MW of installed capacity (269 turbines)
  ✓ Power supply for 175,000 Scottish households
  ✓ Commissioning of the 3 of 1.5MW Unit is scheduled for the end of 2016
  ✓ ANDRITZ HYDRO Hammerfest

● Tidal Current Energy in Korea
  ✓ The first pilot array of 10MW will be installed in 2020~2024
Technology for ocean energy development have been improved rapidly, and several machines for wave and tidal energy is at the pre-commercial stage.

By 2050, up to 337GW of wave and tidal energy could be installed around the world, which give an enormous opportunity to ocean energy industry in domestic waters and export markets.

From 2000, MOF of Korea has supported the long-term RDI&D program for the development of ocean energy technology, and has a plan to build the field test centers for wave and tidal current energy from 2017 and the first pilot array of tidal current energy by 2024, which could be the good opportunity to industry and forming supply chain.

For the successful industrialization, several barriers should be overcome, such as financial risks, technological reliability, environmental problems and grid-connection.