Renewable Energy Use and Challenges
Promoting Offshore Wind Power Generation to Achieve Carbon Neutrality by 2050

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Chairperson and Representative Director, Toda Corporation
Co-chair, Japan Climate Leaders’ Partnership (JCLP)
Vice President, National General Contractors Association of Japan
Profile

Engaged in the construction industry for more than 40 years since joining

Currently belongs to the following organizations and focuses on the development of the construction industry and the realization of a carbon-neutral society.
- Co-Chair, Japan Climate Leaders' Partnership (JCLP)
- Vice-Chair, Eco-First Promotion Council
- Chairperson, Japan Construction Occupational Safety and Health Association
- Vice President, National General Contractors Association of Japan
- Chairperson, the Associated General Contractors of Tokyo

Engaged in floating offshore wind power generation business in 2007 and started commercial operation in 2015

→ Japan's first floating offshore wind power generation project started off the coast of the Goto Islands in Nagasaki Prefecture

Currently working towards the industrialization of floating offshore wind power
### Government Debt

#### General Government Debt: GDP ratio

- **Baseline (Model calculation)**

#### GDP ratio

It is important to know the total amount of debt in relation to the size of the country’s economy (GDP), which is the source of tax revenue.

**Japan's debt is more than twice GDP**

(Highest level among major developed countries)

- When public debt exceeds 90% of GDP, economic growth declines by 1%
- How to achieve 100% of GDP by 2060

#### Utilization of natural energy

- Can be one of the tools to improve government debt and economic growth

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**CHART: prepared from WORLD ECONOMIC OUTLOOK**

(https://www.imf.org/external/datamapper/GGXWDG_NGDP@WEO/OEMDC/ADVEC/JPN/GBR?year=2028&yaxis=lin)
Challenges for the Sustainable Development of Japan Economies

2. Decline in the Working Population and Tight Demand for Human Resources

### Demand for Human Resources for GX

- **The Demand for Human Resources of Japan to realize GX in 2030 (MRI Estimate)**

  - **Total**
  - **Increase demand for CM due to the decentralization of power generation facilities**
  - **Power Company Increase of 35,000**

### The Trend of Working Population

- **2020**
  - About 64 million
  - 40% reduction

- **2065**
  - About 40 million

**Countermeasures:**

- Improvement of work style, operational efficiency and productivity (by IT・DX etc.)
- Necessity for high productive industries that contribute to CN
- Necessity for shifting human resources across industries and companies

Source 1: Mitsubishi Research Institute (MRI) MRI estimates based on the energy supply-demand model and the "2015 Input-Output Table for Analyzing Next-Generation Energy Systems," Waseda University, Smart Society Technology Integration Research Organization, and Institute for Economic Analysis of Next-Generation Science and Technology

Japan Wind Resources and Energy Demand

Japan's wind resources have a potential of **about 1.8 times** its energy demand ➞ Improve the energy balance and establish energy security!
Mass Production and Installation of Offshore Wind Power in Japan

**NEAR SHORE (~60km)**
- **Shallow water**
  - 30 TWh
  - 84,539 units
  - Floating 10MW

- **Deep water**
  - 2,223 TWh
  - 1,141 units (10MW)
  - Fixed-base

**TOTAL POTENTIAL (~300km)**
- **Shallow water**
  - 43 TWh
  - 343,645 units
  - Floating 10MW

- **Deep water**
  - 9,031 TWh
  - 1,636 units (10MW)
  - Fixed-base

More than twice the total power consumption of Japan

More than 1.8 times primary energy of Japan (4.9 trillion kWh)

Floating offshore wind turbines are needed that can be mass-produced and installed

### [Types of Offshore Wind Turbines]

- **Mono-pile**
- **Gravity**
- **Jacket**
- **Berge**
- **Semi-sub**
- **Spar**

### Comparison of Shallow and Deep Water

<table>
<thead>
<tr>
<th>Water depth</th>
<th>Shallow water</th>
<th>Deep water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power generation potential (annual)</td>
<td>10 ~ 60 m</td>
<td>60 m or more</td>
</tr>
<tr>
<td>43TWh</td>
<td>9,031TWh</td>
<td></td>
</tr>
<tr>
<td>Equivalent number of 10MW machines that can be installed</td>
<td>1,636 pcs.</td>
<td>343,645 pcs.</td>
</tr>
</tbody>
</table>

Floating offshore wind power can be mass-produced, installed and it can be the main source of primary energy.

Build large-scale industries with high productivity and establish energy security

Source: IEA 2019
A World of Green Energy to Achieve CN in 2050

For a total of 1,000 GW, cover 53.6% of primary energy of Japan:
(1,000 GW = 2,628 TWh: capacity utilization rate = 30%)

Industry Scale: 18.4 trillion yen/y, 368 trillion / 20 years
(1,000GW・7yen/kWh)

Wind Farm Area

Wind power
Offshore fix-base
Onshore

Solar

Water

Geothermal

Others

Future design

Large Scale
Offshore Wind Farm

Wind Farm Area

Recover Ocean Plastic
Form Fish Reef

Floating Complex
Many Issues to be Solved

Challenges for Large Scale Floating Offshore Wind Power Project

▶ Acquisition, Development and Production of Wind Power Generators
▶ Offshore expansion of Wind Power
   → Floating complex (Installation of Mega Float)
▶ Formulation of Marine Spatial Planning
▶ Survey of EEZ
▶ Infrastructure Development (Power Grids and Ports)
▶ Fisheries Promotion and Biodiversity : Consideration for the Environment

Many Issues to be Solved
toward Achieving CN by 2050
Issue 1
Acquisition, Development and Production of Wind Turbines (Countermeasures)

Countermeasure 1
Developing, Manufacturing and Maintaining Wind Power Generators all over Japan

- Attracting domestic manufacturing bases for large parts such as blades, towers and nacelle assemblies—including licensed production
- Restructuring of domestic supply chains (expansion of exportable parts)
- Start design and development of wind power generators focusing on Japan’s EEZ
- Several years of development term and tens of billions of yen in development costs are required for formation building and mass production.
- Fix and declare medium- to long-term equipment introduction plans to increase the willingness of Japanese companies to participate
- Entering overseas markets with low-cost and high-quality energy by our own unique advanced technologies

Countermeasure 2
Procure overseas products until developing Japan Products

- Develop business scenarios that increase the sales motivation of global suppliers and procure immediate requirements
- Enhance local contents available to global suppliers
- Develop infrastructure environment for pre-assembly, commissioning, installation, and maintenance during transportation and on floating—reducing supply risk for global supplies
- Replace sequentially domestic wind turbines with high-performance and low cost
# Issue 1
## Acquisition, Development and Production of Wind Turbines (Larger Wind Turbines)

### Production Ended
- ~ 8MW

### Order Received
- 8 ~ 11 MW

### On orders
- 12 ~ 15 MW

### Under development 20MW

<table>
<thead>
<tr>
<th>Power (MW)</th>
<th>2.1</th>
<th>3.6</th>
<th>8.0</th>
<th>8.0</th>
<th>10.0</th>
<th>11.0</th>
<th>12.0 - 12.6</th>
<th>14.0 - 15.0</th>
<th>15.0</th>
<th>20.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maker</td>
<td>HITACHI</td>
<td>Siemens</td>
<td>Vestas</td>
<td>Siemens</td>
<td>Vestas</td>
<td>Siemens</td>
<td>GE</td>
<td>Siemens</td>
<td>Vestas</td>
<td>(predicted)</td>
</tr>
<tr>
<td>Model</td>
<td>HTW2.1-80</td>
<td>SWT3.6-120</td>
<td>V164-8.0</td>
<td>SG8-167</td>
<td>V174-10.0</td>
<td>SG11-200</td>
<td>Haliade-x</td>
<td>SG15-236</td>
<td>V236-15.0</td>
<td></td>
</tr>
<tr>
<td>Rotor Diameter (m)</td>
<td>80</td>
<td>120</td>
<td>164</td>
<td>167</td>
<td>174</td>
<td>200</td>
<td>222</td>
<td>222 ~ 236</td>
<td>236</td>
<td>340</td>
</tr>
<tr>
<td>Height (m)</td>
<td>110</td>
<td>150</td>
<td>194</td>
<td>197</td>
<td>204</td>
<td>230</td>
<td>252</td>
<td>252 ~ 266</td>
<td>266</td>
<td>370</td>
</tr>
<tr>
<td>Hub Height (m)</td>
<td>70</td>
<td>90</td>
<td>112</td>
<td>113.5</td>
<td>117</td>
<td>130</td>
<td>141</td>
<td>141 ~ 148</td>
<td>148</td>
<td>200</td>
</tr>
</tbody>
</table>

- Production Ended ~ 8MW
- Order Received 8 ~ 11 MW
- On orders 12 ~ 15 MW
- Under development 20MW

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### SANDAI Tower

- Height: 333 m
- Enlargement

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### TOKYO Tower

- Height: 333 m
- Enlargement

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### Model Comparison

- **HTW2.1-80**: 80 m, 110 m, 70 m
- **SWT3.6-120**: 120 m, 150 m, 90 m
- **V164-8.0**: 164 m, 194 m, 112 m
- **SG8-167**: 167 m, 197 m, 113.5 m
- **V174-10.0**: 174 m, 204 m, 117 m
- **SG11-200**: 200 m, 230 m, 130 m
- **Haliade-x**: 222 m, 252 m, 141 m
- **SG15-236**: 222 ~ 236 m, 252 ~ 266 m, 141 ~ 148 m
- **V236-15.0**: 236 m, 266 m, 148 m
- **(predicted)**: 340 m, 370 m, 200 m
Issue 2
Offshore Expansion of Wind Power: Idea of Floating Complex

[List of issues]
- ① Acquisition, development and production of wind turbines
- ② Offshore expansion of wind power
- ③ Formulation of Marine Spatial Planning

Floating complex
(Installation of Mega-Floats)

Use of Floating Complex

- **Manufacturing and Maintenance Base for Floating Offshore Wind Turbines**
  Set up manufacturing and maintenance base in offshore wind setting area

- **Mooring Base**
  - For fuel cell ships and hydrogen ships etc.
  - Power supply station for sailing ships (like a gas station at sea)

- **Seawater Purification Base – Environmental Preservation**
  - Use of shellfish such as farmed oysters, scallops, pearl oyster and others
    (Aproximately 400 liters of seawater is filtered per day by one oyster)

- **Hydrogen Production and Storage Plants**
  - Electrolysis of seawater by generated electricity – green hydrogen
  - Storage of generated hydrogen and oxygen

- **Marine Surveillance and Defense Systems**
  - Restrict on ships of other countries that sailing territorial waters and contiguous zones
How can we proceed with discussions and “agree” on how to use the sea in a way that everyone can follow in the future? What should we pay attention to in this process? The "Marine Spatial Plan" [1] provides a standard path to follow.

- **Designate area for Offshore Wind Farms and Floating Complex**
  - For offshore wind power to be established as an industry, predictability in planning is important.
  - Designation of large areas requires prior agreement on how the area will be used.
  - Designation of sea areas on a project-by-project basis does not allow for predictability, and there is a risk of backtracking.

- **Creation of MSP**
  - Requires open, all-participating consensus.
  - It takes a long time to make MSP with agreement of many stakeholders (in 10-year increments).
  - We need to start right now and investigation on the current situation is going on.

- **Continuous Review of MSP**
  - It must be continuously reviewed in accordance with changes in social conditions even if a plan has been created once.
    
    ex) The ban of fishing in wind farm area ➡ prohibit only windmill perimeter

- **Establishment of Special Offshore Wind Zone**
  - To promote GX, it’s necessary to build large-scale offshore wind farms without waiting for the establishment of MSP
    
    ⇒ Need to establish special offshore wind farm zones in parallel with the preparation of the MSP

[Reference] [1] Guidelines for the Consensus Building Process on Ocean Use
Ocean Alliance – University of Tokyo
https://www.oa.u-tokyo.ac.jp/program/images/cbm.guideline.pdf

MDA Situational Indication Linkages (MSIL) https://www.msil.go.jp/msil/Htm/TopWindow.html

[List of issues]

1. Acquisition, development and production of wind turbines
2. Offshore expansion of wind power
3. Formulation of Marine Spatial Planning (MSP)
Example in EU ※Data presented by Isabella at a conference organized by the Renewable Energy Foundation

Demonstration of Floating Offshore Power Generation

1/100 scale Two-dimensional tank experiment (Kyoto University)

1/20 scale Deep-sea tank experiment (Maritime Research Institute of Technology and Safety)

1/10 scale field experiment (Sasebo City, Nagasaki Prefecture)

Entrusted Ministry of the Environment Demonstration Project (Off the coast of Kabashima, Goto City)

Small-scale testing equipment installed (1/2 scale, 100kW)

demonstration model installed (2000kW)

Semi-submersible spud barge (Float Raiser) multifunctional ship completed

Designated as promotion zone wind farm business operator (16.8MW)

Proceeding construction
Toda Corporation's Approach (Proprietary Technology: Hybrid Spar Features)

- **Simple Structure**
  - Contributes to standardization, Mass Production and low cost
- **Can be built on quays with low ground bearing capacity**
  - The weight per unit area is reduced by lying on its side
- **Stability**
  - Reduces the influence of waves and wind direction
- **Low-Cost Design**
  - Using comparatively cheap concrete and steel. Utilize the mechanical properties of each
- **Construction at Local Companies**
  - Steel parts are made by ironworks and shipyards in Nagasaki
  - Concrete parts are made by company in Goto City by standardizing structure

**Q1. What is the scale of wind turbine?**
2,000 kW (enough for about 1,800 households)

**Q2. What do you do with the generated electricity?**
- Connected to the power system of Kyushu Electric Power and supply to residents of Fukue Island and Goto City.

**Q3. How many tons does one windmill weigh?**
- About 3,500 ton. (Stable by ballast material (about 1,400 ton) inside the main body

**Q4. Will the windmill collapse? What to do for a typhoon?**
- Like “Roly-Poly Toy”, it is designed to get up and return to its original state whenever.
  - When a typhoon come and exceed the predetermined wind speed, it parry the wind by stopping the rotation of rotor.
Subject & Solution

R&D

---------Offshore Wind System Integration

- Wind turbine local factory & Supply chain
- Larger size, mass production, and lower cost of floating structure
- Surveys of wind and sea conditions in the EEZ
- Surveys on possible installation areas and mooring methods in the EEZ
- Development of power grid conversion to fuel, storage and transportation
- Development of floating manufacturing plants and maintenance bases
- Energy management in remote islands
- Measures for biodiversity and environment, utilization of marine space

Workshops and Collaborative research

Work on for industrializing offshore wind power with various corporation, research institutes and universities
Joint Research Chair for Offshore Wind System Integration

The future of Japan pioneered by the sea. Challenging energy that has not yet been seen.