South Korea offshore wind power overview

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South Korea offshore wind overview

First to complete true utility scale offshore project

South Korea offshore outlook, 2017-2027e

Offshore wind summary

- Offshore by YE/2017: 38MW
- Wind RPS system: Offshore REC weighting is 2.5:1
- Wind* target: 18GW by 2030 (13GW is offshore)
- Average shore distance: ~10km
- Average wind speed: 7.0m/s at 80m
- Average water depth: ~20m

Note: 1MWh generated from renewable energy = 1 REC
Offshore REC weighting decreases as project gets older
*Wind target includes both onshore and offshore wind

Source: MAKE
Despite favorable conditions for offshore wind development, South Korea is still subject to 3-4 typhoons every year during summer season.
South Korea offshore wind overview

Rich offshore wind resources in Southern regions

South Korea offshore wind map

DRIVERS

▪ Offshore wind is identified as a potential high technology manufacturing sector: Enables sector to receive national R&D support which govt. believes local companies can become world class

▪ Parts of local supply chain are already integrated with global offshore wind supply chain: Local cables, towers, forgings suppliers are already global offshore suppliers

BARRIERS

▪ No installation vessels in South Korea: There is no plans to import vessels from Europe and companies are actively looking for a local solution

▪ Difficult negotiations with local population: Particularly difficult with fishermen over high compensation

Source: MAKE. KIER
Key pipeline project is the 2.5GW Southwest project

Offshore pipeline by province

<table>
<thead>
<tr>
<th>Province</th>
<th>Planned (GW)</th>
<th>Under construction (GW)</th>
<th>Operational (GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Jeolla</td>
<td>4.4</td>
<td>2.8</td>
<td>1.7</td>
</tr>
<tr>
<td>North Jeolla</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Gyeongsang</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jeju</td>
<td>0.6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

National Southwest project

<table>
<thead>
<tr>
<th>Phase</th>
<th>Purpose</th>
<th>Demonstration</th>
<th>Build track record</th>
<th>Large scale deployment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td></td>
<td>By 2018</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase 2</td>
<td></td>
<td>By 2020</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase 3</td>
<td></td>
<td></td>
<td></td>
<td>2020+</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phase</th>
<th>Cost (USD)</th>
<th>Completion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>384 million</td>
<td>By 2018</td>
</tr>
<tr>
<td>Phase 2</td>
<td>1.8 billion</td>
<td>By 2020</td>
</tr>
<tr>
<td>Phase 3</td>
<td>8.9 billion</td>
<td>2020+</td>
</tr>
</tbody>
</table>

Source: MAKE, MOTIE, KOWP
South Korea offshore wind overview

Ambitious renewable energy targets for wind and solar

South Korea renewable energy capacity, 2017 and 2030 "RE 3020" vision

Targeting 17GW of new added wind power capacity by 2030 would require on average >1GW of new wind power capacity to be installed every year leveraging offshore wind.
South Korea offshore wind overview
Primary policy driver relies on forcing more RE on large IPPs

Renewable Portfolio Standard obligations

Requirements of S.Korea’s RPS system

- The Renewable Portfolio Standard (RPS) scheme requires any power producer with over 500MW of capacity to gradually increase their share of RE in their generation portfolio.

- Power producers receive one Renewable Energy Certificate (REC) for every 1MWh generated - though different RE sources have a higher weighting (e.g. multiplier).

- Failure to comply will result in penalty charge of 150% of average REC price though it can be deferred up to 3 years at maximum 20% of mandatory supply.

REC multiplier for wind power

<table>
<thead>
<tr>
<th>Energy</th>
<th>Onshore</th>
<th>Offshore &lt;5km</th>
<th>Offshore &gt;5km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>1</td>
<td>1.5</td>
<td>2</td>
</tr>
</tbody>
</table>

Note: Offshore refers to distance to grid connection

Source: MAKE, MOTIE

South Korea is the only market in Asia Pacific that relies on Renewable Portfolio Standard system instead of a FIT for offshore projects as a policy driver.
South Korea offshore wind overview

South Korean offshore wind costs need to drop significantly

South Korea LCOE offshore estimates

<table>
<thead>
<tr>
<th>Component</th>
<th>2015</th>
<th>2025e</th>
<th>2035e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbine</td>
<td>40</td>
<td>26</td>
<td>-26%</td>
</tr>
<tr>
<td>Grid</td>
<td>30</td>
<td>77</td>
<td>-77%</td>
</tr>
<tr>
<td>Foundation</td>
<td>20</td>
<td>41</td>
<td>-41%</td>
</tr>
<tr>
<td>Logistics &amp; installation</td>
<td>20</td>
<td>65</td>
<td>-65%</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>20</td>
<td>71</td>
<td>-71%</td>
</tr>
</tbody>
</table>

- Offshore cost estimates are still very high as they are extrapolated from demonstration units
- Given high cost of offshore LCOE, developers would much prefer a fixed guaranteed price rather than reliance on fluctuations in REC prices and electricity tariff
- Ideally, the government envisions offshore project costs to drop to around USD 3 million per MW in the long term once demonstration projects are completed to be a sustainable RE source

Expectations are that offshore LCOE in South Korea will drop by 40% by 2025 and 55% by end of 2035 with cost reductions gained from experience and economies of scale

Source: MAKE, MOTIE
South Korea offshore wind overview

Local turbine suppliers are anticipating offshore growth

- Longest track record in offshore wind in Korea with 33MW installed and 60MW under construction using its 3MW platform
- Acquired Hyundai Heavy Industries’ 5.5MW turbine that was designed with AMSC-Windtec

DOOSAN

- Parent company Hyosung Corp. is a major conglomerate in construction, heavy industries and machinery
- 5MW offshore prototype turbine was designed with Aerodyn
- Limited track record in wind (22MW) and has left onshore wind to focus on offshore wind

HYOSUNG

- Active in onshore wind but no track record in offshore wind
- Plans to upgrade latest 4.2MW model to 5MW with prototype planned for installation in 2018
- Looking at potential acquisition of Samsung’s 7MW turbine to increase competitiveness

UNISON

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- Looking at potential acquisition of Samsung’s 7MW turbine to increase competitiveness

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