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Strategies for the development of offshore wind technology for far-east countries – A point of view from patent analysis

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ABSTRACT

In this research we explored the development of offshore wind technology through the evaluation of patents granted by the United States Patent and Trademark Office (USPTO) and the European Patent Office (EPO). On establishing the landscape of offshore wind patents, the key trends of technical development were identified from the leading countries. Rather than a wind turbine itself, technologies related to engineering vessels, floating foundations, turbine installations, integration of multiple technologies, towers and mooring systems have been identified as the top priorities for development; they occupied around 59% of granted patents selected from USPTO and EPO. The cost decrease, improvement of equipment transport and improvement of installation are the most common targets to be achieved; they occupied 45% and 50% of the granted patents selected from USPTO and EPO, respectively. The trends of installing a wholly assembled wind turbine with specially designed support and transport systems have been observed in sectors of vessels and turbine installations; there are many patents of which the aim was to integrate other renewable technologies within an offshore wind-turbine platform to share the costs of production and construction. Although, since 2007, there are increasing numbers of patents related to floating foundations, no obvious tendency of a specific type of floating foundation and mooring system has been observed. With an increasing number of overlapping patents between USPTO and EPO after 2013, the functions of those technologies mentioned above become similar. Based on the observation from the portfolio of patents from the leading countries and the current status of development in far-east countries, specialized development strategies for far-east countries are proposed in this research.

Contents

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1. Introduction

The production of electric power from offshore wind has shown an explosive growth in northern European countries in recent years [1], as shown in Fig. 1. By the end of 2014, the accumulated capacity of wind power attained 370 GW [2]. The leading countries for this accumulated installed capacity are China, USA, Germany, Spain and India in sequence. Among the cumulative installed capacity 370 GW, 8.5 GW was contributed from offshore wind power (OWP) within 14 countries; more than 94% (8.045 GW) of offshore wind capacity was located in 11 countries within Europe. The other three countries with offshore wind installed are China, Japan and South Korea, among which China has the most capacity (660 MW installed). Most turbine manufacturers in the world are in China, Denmark, France, Germany, India, Spain, USA and Japan [2]. The top ten manufacturers of wind turbines in the 2014 annual market are listed in Table 1. Those manufacturers with greater than 5% market share are Vestas, Siemens, Goldwind, GE, Enercon, and Suzlon Group. From this distribution of turbine manufacturers, developing countries such as China and India have successfully shared more than one quarter of the market through the local market advantages. However, about 88% of newly installed offshore wind turbines in 2014 occurred in Europe, and they were shared by two major European companies, namely Siemens and MHI-Vestas as shown in Table 2 [1]. The installed capacities and market share by manufacturer both show that the developments of offshore wind technology (OWT) of far-east countries are still in their early stages.

Although most technologies used for offshore turbines are derived from the land-based ones, the cost of OWP is still much greater than land-based ones. The dramatic cost increase is mainly derived from the support structures, installation process, electrical infrastructures, and operation and maintenance, which are specially designed or required to overcome the harsh conditions in offshore environments [3]. To minimize the cost, large R&D efforts have been devoted to develop varieties of solutions, such as increasing the generation capacity of turbines or decreasing turbine weight, which are helpful to reduce the installation cost per MW and minimize the requirement of heavy-duty engineering vessels, respectively; improving monitor and control systems, which can improve the output performance, safety issues, and the operation cost through a better control of rotor pitch and power regulation; improving availability of maintenance or the reliability of turbines, especially the gear box, yawing system, power converter, transformer, and generator itself, which can reduce the downtime loss and the maintenance cost; application of HV–DC transmission, which can reduce the transmission loss and cost under long distance application; new concepts of support structure (i.e., floating foundations) and construction methods, which could reduce the material used, installation time, requirement of special engineering vessels, etc. These trends are observed in several literature reviews [3–8]. Besides, Rodrigues et al. [8] also pointed out the technology development issues in some Asia countries, such as the seabed conditions for support structure, natural disasters (i.e., typhoons, earthquakes, and tsunamis), lack of engineering vessels, etc., which may be a further challenge to the OWP cost. However, the materials used for analysis in existing literatures focused mainly on academic literature, business reports, books and internet resources, whereas little literature that explores the development of offshore wind technologies from the point of view of patents was found.

In this research, we explored the development of OWT through the evaluation of patents granted by USPTO and EPO. By the establishment of this patent map, the key trends of development of OWT have been deduced and developmental strategies of OWT for far-east countries are proposed.

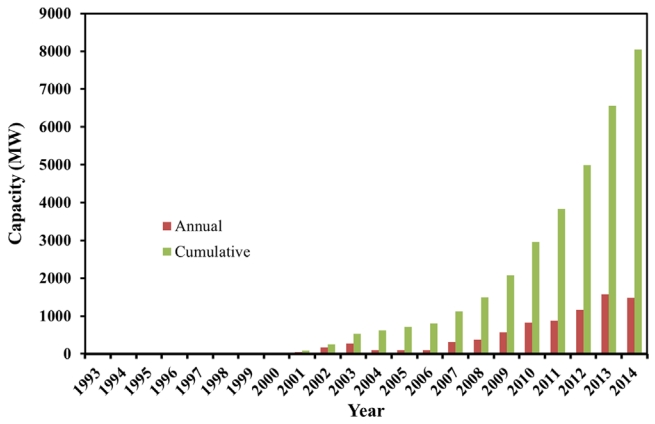

Fig. 1. Trend of installation of offshore wind-power capacity in Europe.
Data source: EWEA [1].

Table 1
Share of 2014 annual installations by wind turbine manufacturer
Data source: REN21 [1].

Rank	Manufacturer (country)	Market share (%)
1	Vestas (Denmark)	11.6
2	Siemens (Germany)	9.5
3	Goldwind (China)	9.0
4	GE Wind (U.S.)	8.7
5	Enercon (Germany)	7.3
6	Suzlon Group (India)	5.5
7	United Power (China)	4.8
8	Gamesa (Spain)	4.5
9	Mingyang (China)	3.9
10	Envision (China)	3.7
	Others	31.7

Table 2
Share of 2014 annual installations by offshore wind turbine manufacturers.
Data source: EWEA [2].

Manufacturer (country)	Market share (%)
Siemens (Germany)	86.2
MHI Vestas (Denmark)	9.5
Areva (French)	3.0
Senvion (India)	0.8
Samsung (Korea)	0.5