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PETROVIETNAM LEVERAGING ITS TECHNOLOGY AND SERVICES INHERITED FROM OIL AND GAS OPERATION INTO THE CONSTRUCTION AND SUPPLY CHAIN OF OFFSHORE WIND POWER

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Summary

In the era of global integration, there is a clear shift from fossil fuels to renewable energies across nations. The investigation and utilization of renewable energy sources, especially offshore wind energy, emerge as a pivotal area for energy companies and corporations. The Vietnam Oil and Gas Group (Petrovietnam) is standing at the threshold of substantial opportunities and challenges in expanding its operational spectrum towards renewable energy with a particular focus on offshore wind power. This study analyzes Petrovietnam's inherent strengths and capabilities with the orientation and strategy to become a leader of the service supply chains for offshore wind power in Vietnam.

Key words: Offshore wind energy, offshore wind supply chain, oil field service, energy transition.

1. Introduction

The transition towards green and sustainable energy is an inevitable trend among nations worldwide. Alongside economic growth, Vietnam's demand for energy and electricity is projected to rapidly increase in the coming years. Concurrently, to ensure energy security, Vietnam is also developing an energy transition roadmap aimed at a "net zero" CO_2 emissions target by 2050. This strategic shift reflects the country's commitment to balancing economic development with environmental sustainability, positioning itself as an active participant in the global movement towards cleaner energy sources.

The Power Development Plan VIII clearly sets a direction for harnessing the full potential of offshore wind energy (around 600,000 MW) for power production. By 2030, it is projected that the capacity of offshore wind power to meet domestic electricity demand will be around 6,000 MW. This capacity will increase further and meet the target of 70,000 - 91,500 MW by 2050 if technologies foster rapidly and/or the cost of electricity and transmission reduce affordably. To achieve these goals, Vietnam needs to set up and develop a supply chain for the offshore wind energy industry.

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Based on the experience developing supply chain in European countries, oil and gas companies hold a distinct and clear advantage when diversifying into the offshore wind sector.

First, with decades of experience in offshore oil and gas projects, these companies have unique advantages in managing logistics, engineering, manufacturing, installation and even providing professional manpower for offshore wind farms.

Second, many of the essential techniques for transporting and installing offshore wind structures such as platforms and foundations are very similar to those used in the oil and gas industry.

Third, oil and gas companies have existing infrastructure, facilities, and equipment that can be conveniently upgraded to meet the needs of building wind farms [1].

Fourth, oil and gas companies normally have significant financial capacity, and, because of their internationally operational scale and expansive readiness, they have established local relationships in many global markets [2].

Facing significant opportunities and challenges in the energy transition, Petrovietnam is strategically positioning itself to become a leading energy and industrial group in Vietnam and Asia. Petrovietnam, with its array of competitive advantages, is well-equipped to engage in the offshore wind energy's (OWE) supply chains, leveraging its vast experience and existing facilities in offshore oil and gas. These strengths underpin Petrovietnam's goal to be a pivotal enterprise in Vietnam's OWE industry. To maximize its potential in OWE, Petrovietnam must swiftly adopt, integrate, and manage the advanced technologies in this sector. Considering the scarcity of OWE projects in Vietnam and Petrovietnam's limited experience in this area, it is essential to research OWE technologies to quickly seize technological expertise, integrate into the global value chain, and conquer the international market in this domain.

This research aims to analyze Petrovietnam's offshore wind technological and services supply chains capabilities, identify gaps that Petrovietnam must address to manage OWE construction technology, propose internal collaboration strategies for Petrovietnam to take the lead in the OWE market in Vietnam.

2. Overview of offshore wind supply chain

Wind energy is increasingly recognized as a pivotal solution in the near future for narrowing the gap towards achieving the global net-zero emissions target. The development of wind farm technology, particularly in the realm of offshore wind, has witnessed remarkable progress.

Recently, in line with the resolute commitments of various governments and the rapid global progress in offshore wind energy planning, many studies have been published on advanced technologies in OWE construction and operation.

Typical layout of a standard offshore wind farm project comprises wind turbines, offshore and onshore substations, array/export cable systems and transmission line as illustrated in Figure 1.

Within this framework, the overall components of an offshore wind power project generally include essential elements as follows.

2.1. Turbine system

A wind turbine system consists of a rotor, nacelle, tower, and foundation. Figure 2 shows a typical wind turbine with a monopile foundation.

- Turbine: The turbine assembly is often fabricated

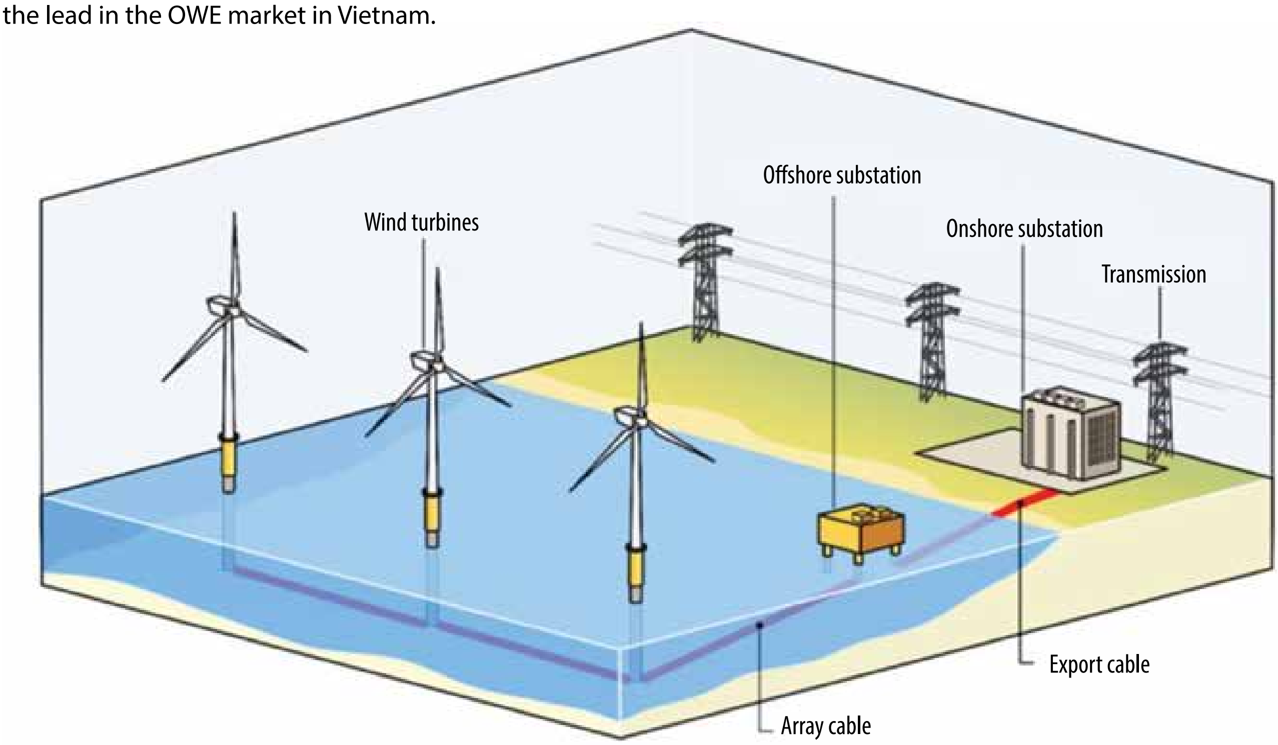

Figure 1. *Comprehensive layout of a prototypical offshore wind energy project [3].*

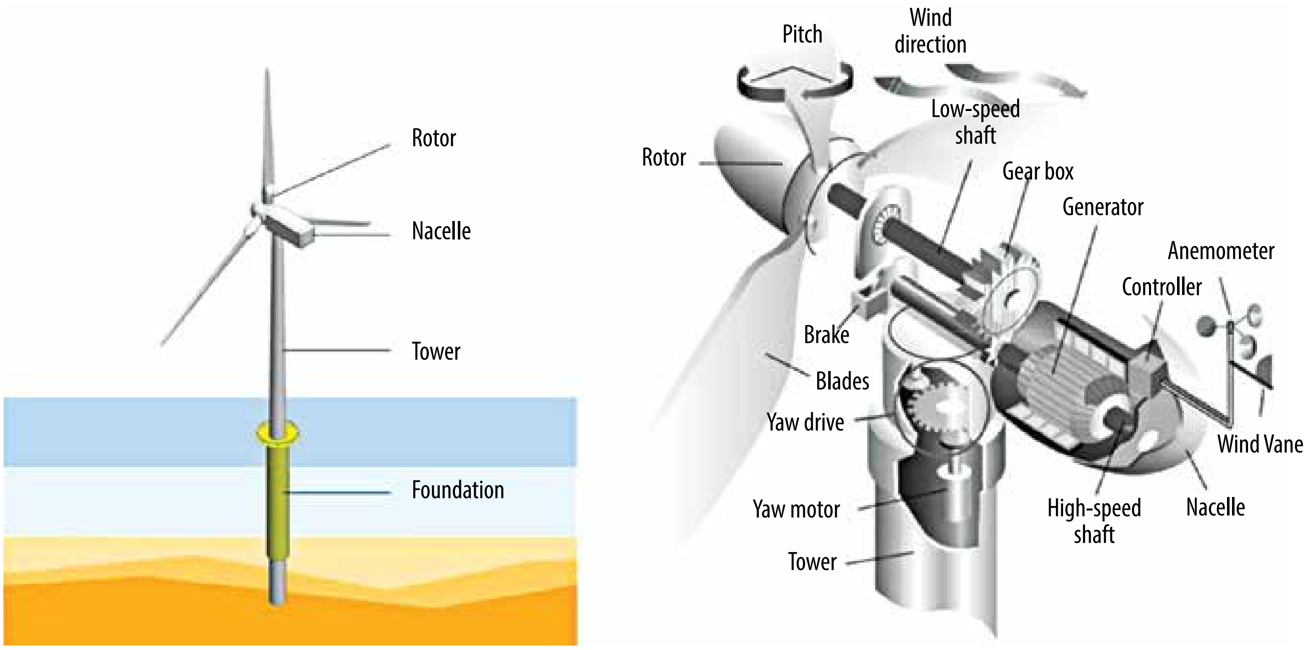

Figure 2. *Configuration of the wind turbine technology assembly [4].*

by specialized wind turbine manufacturers. Globally, there are approximately 35 offshore wind turbine manufactures, of which 10 are located in China and the remaining in Europe, Japan, the US, South Korea, and Taiwan. Contemporary wind turbines are progressively being substituted with rotary magnet arrays, propelled by the kinetic energy of the blade system. This streamlined design principle enables the generator to function at significantly low rotational speeds while yielding a substantial electric power output. Other intrinsic benefits include shortened maintenance intervals, enhanced longevity, and reduced noise emissions.

- Blade: Approximately 60% of blades for the global wind industry are manufactured in-house by turbine producers, and this proportion is even higher for offshore wind. All blades used in renowned offshore wind turbines like Areva, Siemens, and Vestas are produced by the turbine manufacturers themselves. The materials commonly used for blade construction are plastics (polyester or epoxy) reinforced with glass fibres (FRP). However, in advanced technology, carbon fibres may become more prevalent due to its high strength and lightweight properties. To date, wind turbine blades have evolved to lengths over 110 meters, corresponding to a power generating capacity of up to 15 MW. The trend of manufacturing longer blades continues to rise, increasing the capacity of turbines.

- Towers: Offshore wind turbine towers are typically constructed from conical, rolled steel tubes, connected by flanged bolt joints in segments of about 30 - 40 meters. As turbines increase in size, the towers must also grow in dimensions and sectional divisions. The diameter of towers for 3 - 4 MW turbines is around 4 - 5 meters, while tower structures for 8 - 10 MW turbines can have a base diameter of up to 8 - 10 meters. These towers are assembled into complete wind towers either at ports or directly at the construction site, depending on the assembly strategy. To date, due to design, technology considerations, and technology, turbine towers are commonly produced by turbine manufacturers or through production partnerships with technology transfer from turbine to tower manufacturers.

- Foundation structure: Offshore base structures must endure high levels of dynamic loads and continuous fatigue stress. Featuring substantial steel thickness, these structures often employ cold-rolling methods. To counter fatigue loads and prevent cracking, the steel types used must meet stringent requirements and are sourced from specific companies (e.g., Tata, JFE, Nippon, etc.). Furthermore, the material thickness for the nodes of the foundation requires careful consideration. Offshore wind turbines are supported by either fixed foundations or floating foundations. Notably, floating foundations for offshore wind turbines enable stability in deeper waters (typically greater than 60 meters), at locations where fixed foundations are not feasible.

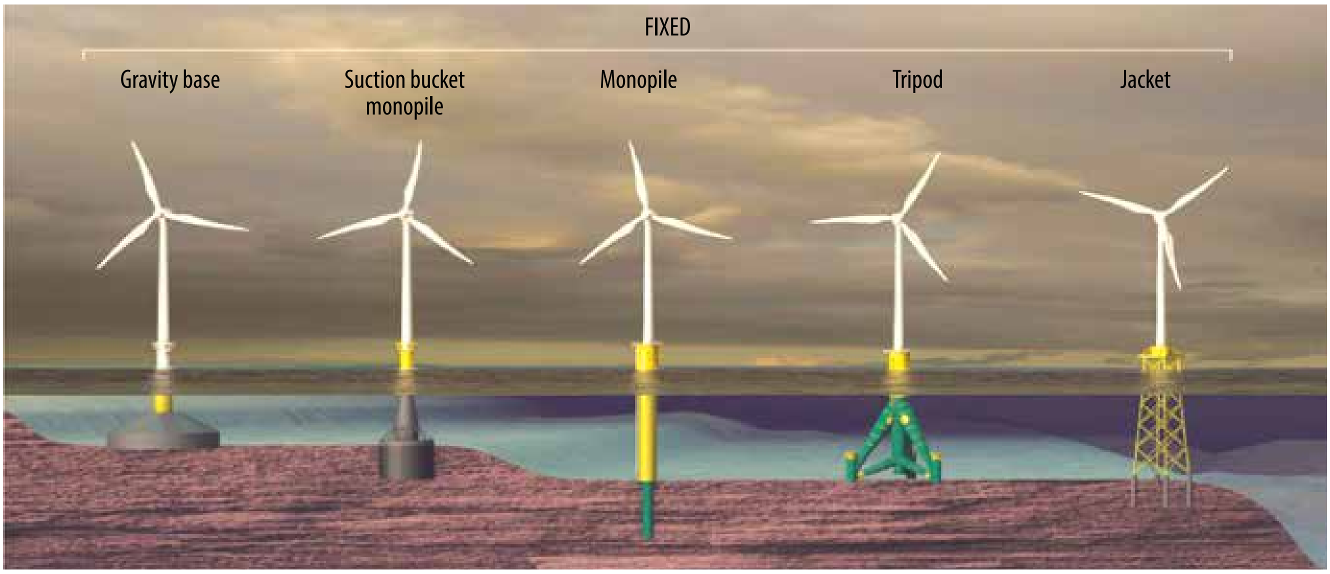

Figure 3. Types of fixed foundations [4].

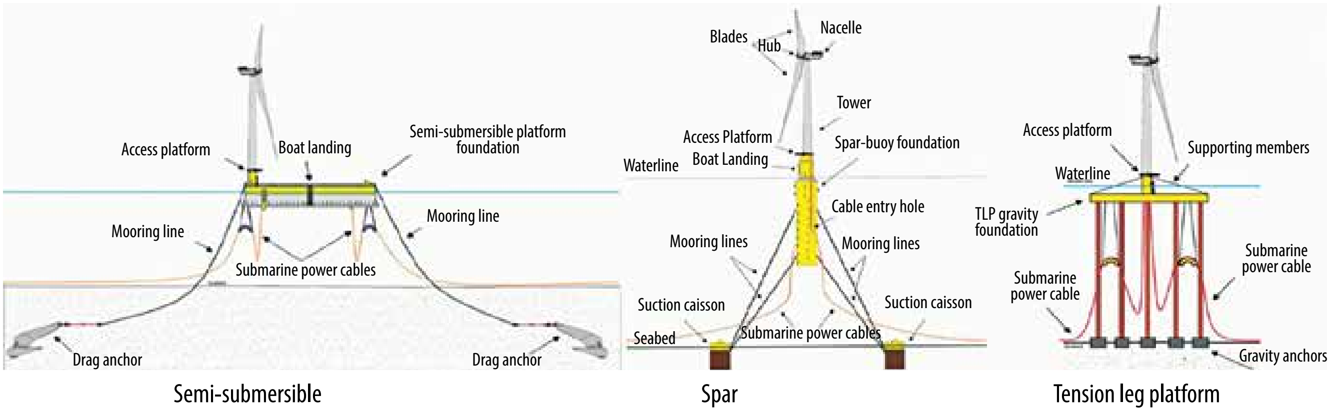

Figure 4. Types of floating foundations [6].

There are several types of foundations that are classified subject to water depth, geological and economic conditions. Different types of fixed foundation and floating foundation are shown in Figures 3 and 4.

2.2. Array cable

The turbine towers within the wind farm are interconnected via submarine array cables, most commonly to a centralized offshore transformer station, servicing varying numbers of turbine units and spanning distances of up to 50 kilometers. These offshore transformer stations are interconnected and their voltage is stepped up for transmission to the mainland via export cables. Depending on factors such as distance and turbine layout, the transformer station may utilize either high voltage alternating current (HVAC) or high voltage direct current (HVDC) transmission systems. HVDC systems, while more costly, offer superior transmission capacity and reduced power losses. The subterranean cables typically utilize cross-linked polyethylene (XLPE) composition, featuring tri-core arrangements with conductors made of copper or aluminum, and are insulated and positioned cohesively. These cores are collectively encased within a steel armoring, further enveloped by an external protective layer. Integral to these cores is an optical fibre cable, facilitating communication for remote monitoring and control functions.

2.3. Substation

- Offshore substation: This critical facility is used for voltage amplification, transitioning from the operational voltage of the interconnected array cables to the higher voltage of export cables. It is equipped with sophisticated switchgear for seamless connection or disconnection in contingency scenarios. Constituents of this station include high-capacity transformers, reactors, advanced switchgear, control apparatus, comprehensive fire suppression systems, and essential auxiliary mechanisms. These elements are purposefully placed within a robust topside structure anchored on a sturdy foundation. The

Figure 5. *Types of offshore wind power cables [7].*

project's magnitude dictates the number of substations, with larger projects necessitating multiple offshore substations. Engineered to withstand the rigors of the marine environment, these substations are meticulously designed for enhanced endurance and corrosion resistance. To mitigate the risks posed by the maritime environment, the electrical components are securely enclosed within either multiple protective containers or a singular, hermetically sealed mega-container.

- Onshore substation: This integral component is tasked with assimilating electrical energy from the export cables, amplifying the voltage to match transmission standards, and forging a nexus between the offshore wind farm and the national electricity grid. Advanced switchgear facilitates seamless connectivity and disconnection, ensuring operational integrity during malfunctions. Technologically, these terrestrial substations for offshore wind farms mirror their onshore counterparts in sophistication and functionality.

The standard process in the wind energy industry typically consists of the following steps:

- Project development phase (including surveying, designing, permitting, financing) includes:

+ Wind resource survey;

+ Environmental survey;

+ Geophysical, geotechnical, geological, topographical, and oceanographic survey;

+ Environmental impact assessment report preparation;

+ Conceptual design (pre-feasibility study report);

+ Basic design (feasibility study report);

+ Technical design;

+ Detailed design and EPC (engineering, procurement, and construction) tendering;

- Manufacture, supply phase;

Figure 6. *Offshore substation of ABB [8].*

Table 1. *Main service supply chains and segments in OWE*

Supply chain	Items
Project development and management	Project development consulting (permitting)
	Project management
	Wind measurement
	Marine surveying
	Design consulting
Manufacturing and supplying turbines, generators, blades, and tower	Turbine (nacelles, yaw, hub, pitch, generator, gearbox, ...)
	Blades
	Tower
	Auxiliary equipment
Manufacturing and supplying balance of plant (BOP) components	Electrical cables
	Transformer systems and electrical equipment
	Foundation and base structure
	Offshore substation
	Ancillary components
Transportation, installation, connection, and testing	Port and logistics services
	Vessel and barge services
	Foundation and base installation
	Turbine installation
	Offshore substation (OSS) installation
	Subsea cable laying
	Grid connection and commissioning
Operation, maintenance, and marine services	Operational services
	Inspection and maintenance services
	Vessel and operational support services
	Port and logistics services
Decommissioning	Port and logistics services
	Decommissioning services
	Waste management

- Transportation and installation phase;
- Operation and maintenance phase, including technical support;
- Decommissioning and dismantling phase.

In this context, the scopes of 6 service supply chains are described in Table 1.

3. Methodological approach and Petrovietnam's competency

By gathering data on existing facilities capabilities and the quality of human resources from the oil and gas service company of Petrovietnam, this study aims to analyze the degree of similarity and identify gaps that need to be addressed to master offshore wind power construction technology. The research involved collecting information from more than 20 service companies and major design and construction corporations within Petrovietnam, focusing on facility capabilities and human resources. This data then informed the identification of strategic steps towards achieving technological proficiency in the offshore wind power construction sector.

Within the aforementioned six service supply chains, Petrovietnam is identified to possess competitive advantages in services where it already has experience in the oil and gas sector. These services include project development/project management, surveying and design; fabrication of fixed/floating foundations and towers; transportation, service and installation; operational maintenance; port and marine support services for decommissioning.

In terms of facility and labor capabilities, Petrovietnam shows considerable similarity in supporting the supply chain services for offshore wind energy construction (OWEC).

- Regarding capabilities such as port and logistics services, vessels/barges, service ships and marine equipment, Petrovietnam can fully utilize these to supply transportation, construction support, and operations & maintenance (O&M) for offshore wind farms.

- For other facility equipment serving design and installation, Petrovietnam needs to upgrade to meet stricter requirements in the wind energy sector.

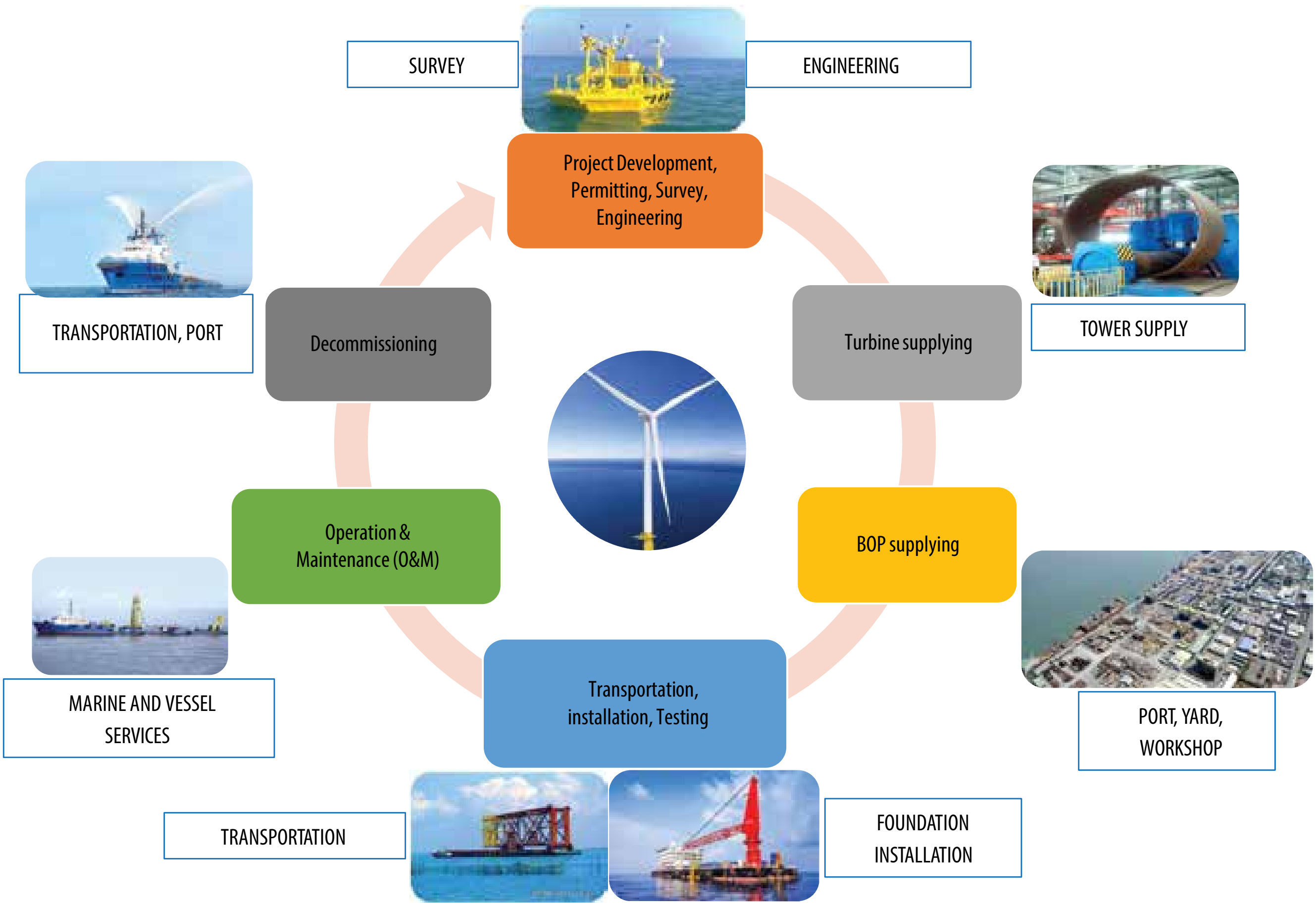

Figure 7. The supply chains of OWE and the strengths services of Petrovietnam.

Table 2. *Analysis of Petrovietnam's capability to participate in the offshore wind energy service supply chain*

Supply chain phase	Similar activities	Distinctive activities
Project development and management	Offshore project management capabilities; Collection and assessment of data on natural conditions and marine environment; Geophysical and geological data interpretation equipment; Marine service infrastructure, equipment capabilities.	Wind potential survey and evaluation capabilities; Wind farm planning capabilities, calculation and optimization of offshore wind farm power.
Survey	OWE natural and marine environmental survey; Marine environmental research and survey.	Need for specialized research and training in data interpretation; Wind capacity interpretation equipment and software.
Design	Design of jacket, foundation and pile structures; Mechanical fabrication design; Piping design; Electrical and control, instrumentation design for auxiliary components.	Wind turbine system design; Electrical system, subsea cable, and transformer design; Design of floating, semi-submersible, and tension-leg foundations.
Supply of turbine equipment and components	Experience in procurement for oil and gas, industry, and power plants; Expertise and high standards in fabrication, supply, and assembly of turbine components/parts.	Expertise and high standards in fabrication, supply, and assembly of turbine components/parts.
Manufacturing and supplying balance of plant (BOP) components	Mechanical fabrication capabilities (including structures like flanges, electrical technology systems, etc.); Infrastructure of workshops, systems for cutting and bending metal, welding machines, etc.	High precision and high-technology component manufacturing; Requirements workshop equipment with larger area (>20 ha), advanced manufacturing technology for the mechanical and control, high capacity and precision in the steel fabrication; Lifting and fabrication equipment: Cranes, welding machines, cutting machines, sheet rolling machines, transport vehicles, painting workshops...
Port and logistics services	Manufacturing warehouses and yards; Ports.	Expanded open-air and closed warehouses, workshop, yards for mass production lines; Seaports require additional investment in transport and lifting equipment, expansion and dredging of channels to accommodate heavy-lift construction vessels when needed.
Vessel and barge services	Vessel and barge service capabilities.	N/A
Transportation and installation of turbines	International standards, experience for transportation in construction.	Purchase or lease of heavy-lift vessels and barges for turbine installation (HLV, JLV); Crane vessels/barges with self-elevating capabilities higher than oil and gas service standards; Specialized support vessels and services tailored to offshore wind energy requirements; Expert in wind turbine assembly operations.
Transportation, installation/dismantling of offshore foundations, piles, substations	Capacity for offshore transportation of piles and substation transformers.	Construction technology for large foundations; High-capacity crane/ heavy-lift vessel for transportation and installation to minimize the marine movement.
Subsea cable laying	Subsea cable laying capability.	Cable storage vessel; trenching, cable laying equipment; cable towing and alignment devices; cable protection.
Interconnection and performance testing	Connection and testing capability for foundation.	Connection capability for electrical system, turbine generator.
Port O&M facilities; service vessels and equipment	Yard and service vessels capability.	N/A

- In terms of wind turbine design and supply of components and equipment, Petrovietnam currently lacks the capability to meet these demands.

Analysis reveals that activities involving core turbine technology require distinct competencies compared to offshore oil and gas projects; however, the remaining services supporting construction, operation, and maintenance are fundamentally similar and can be developed from the capabilities in oil and gas services.

Given the significant market potential for offshore wind service supply [9] and the analogous capabilities between oil and gas services and offshore wind power services, Petrovietnam can supply its services into the offshore wind power chain. Table 2 shows the offshore wind supply chain phases and comparable services of Petrovietnam.

To assess the capacity of Petrovietnam's units to partake in the offshore wind energy supply chain, we collected data on the requisite capabilities and the current capacity of the evaluated units for a comparative analysis across several dimensions. These include (1) Existing capabilities and capacities; (2) Ability to adapt or transition from the oil and gas sector; (3) Investment potential, encompassing scale and market entry timing; (4) Competitive ability. Figure 8 in the article presents the results of this comprehensive evaluation, offering insights

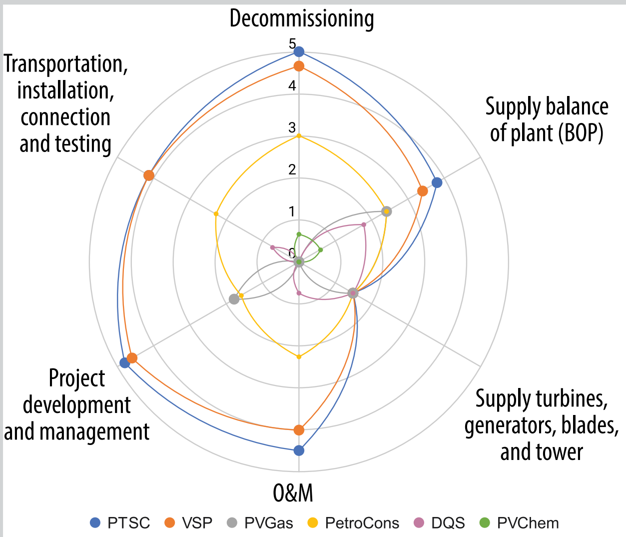

Figure 8. *Assessment of the capabilities of Petrovietnam in the offshore wind power supply chain.*

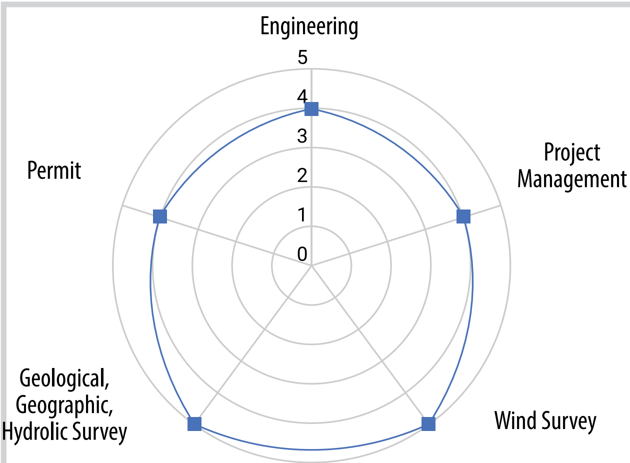

Figure 9. *Petrovietnam's capability in project development and management in offshore wind.*

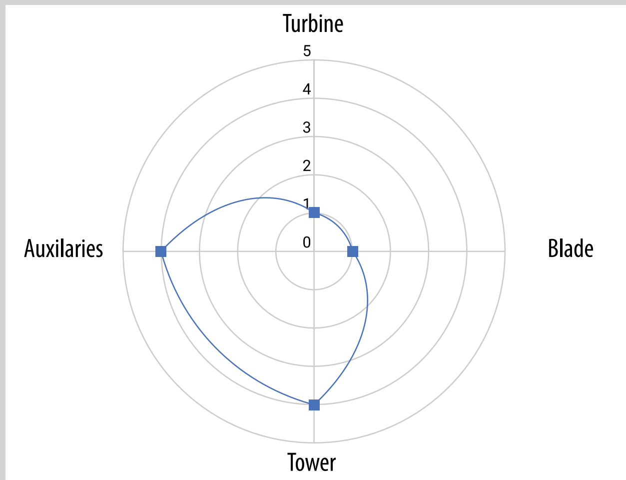

Figure 10. *Petrovietnam's capability in manufacturing and supplying turbines, generators, blades, and tower.*

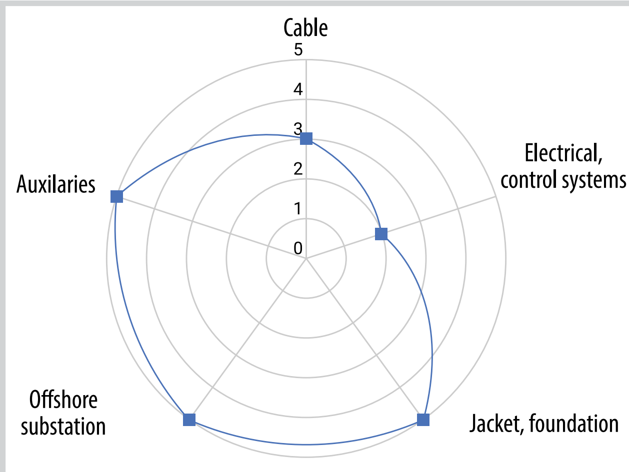

Figure 11. *Petrovietnam's capability in manufacturing and supplying balance of plant.*

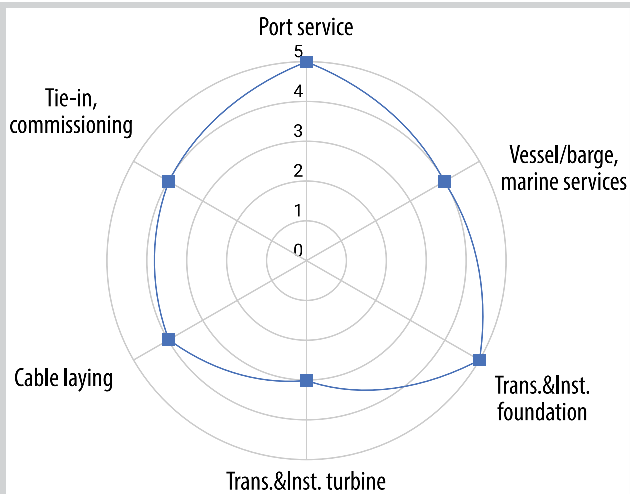

Figure 12. *Petrovietnam's capability in transportation, installation, connection, and testing.*

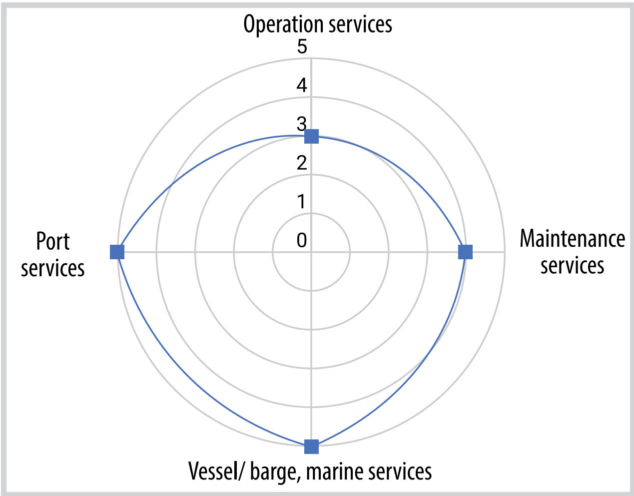

Figure 13. *Petrovietnam's capability in operation, maintenance, and marine services.*

Note: Rating on a scale from 1 to 5 reflecting the level of market entry opportunity, ranging from low to high.

Figure 14. *OWE project in a fabrication yard of a subsidiary of Petrovietnam.*

into Petrovietnam's readiness to effectively engage in the offshore wind energy sector.

Capitalizing on the strengths of each unit and utilizing existing facilities, Petrovietnam aims to master offshore wind power construction technology and dominate key service supply chain: development; manufacturing balance of plant (BOP) components, supplying towers, conducting; surveys and design; handling transportation, installation and commissioning, as well as operations and maintenance (Figures 9 - 13).

5. Conclusions

The oil and gas service industry exhibits notable parallels with offshore wind energy services, especially in domains such as project management, offshore construction engineering, and adherence to safety and environmental protocols. This parallelism unveils substantial opportunities for Petrovietnam in transition to the renewable energy sector. With a robust base and extensive experience in the oil and gas industry, Petrovietnam is strategically positioned not only to capitalize on its inherent competitive advantages but also to spearhead the integration and advancement of innovative technologies, especially in fabrication and construction, thereby enhancing its competitiveness in the offshore wind energy market.

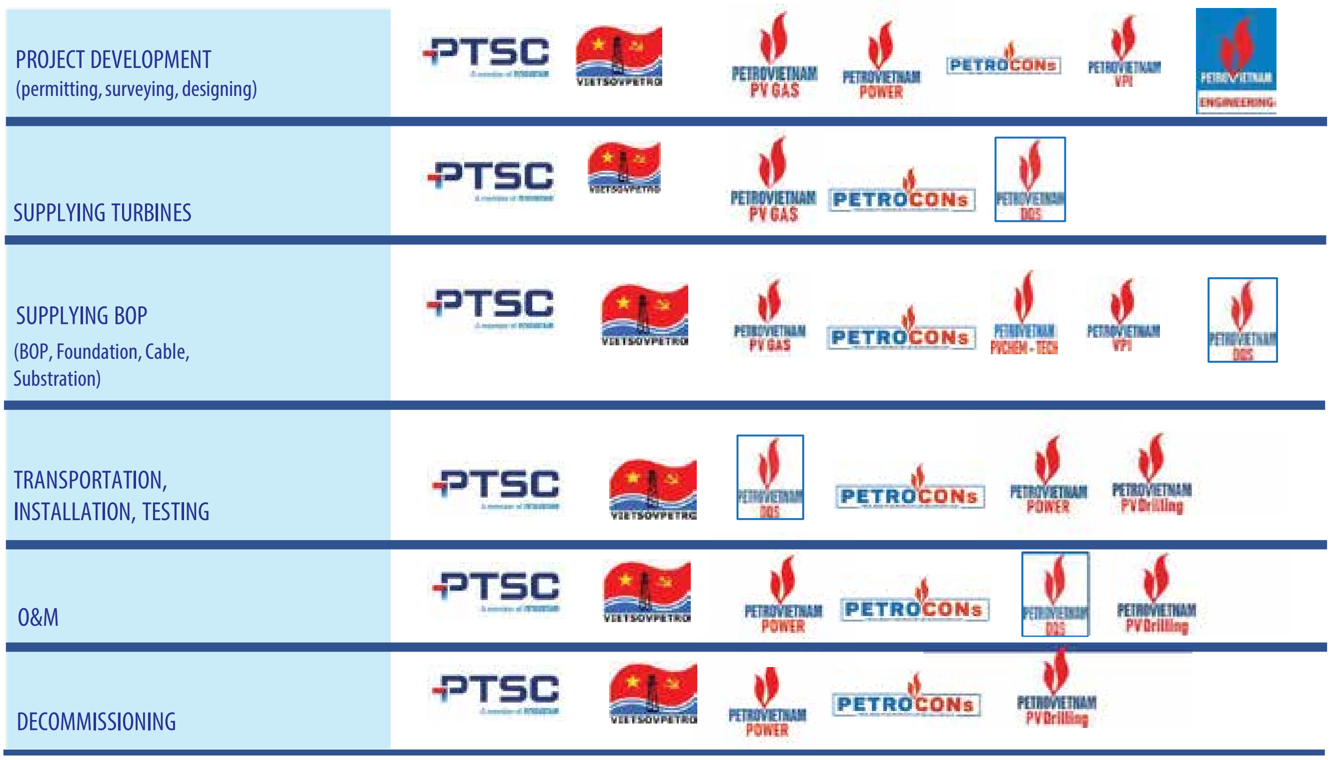

Figure 15. *Proposal for Petrovietnam's subsidiaries in the OWE's supply chain.*

Petrovietnam is progressively investing in and developing technology, facilities, and a team of highly skilled professionals for the offshore wind power sector, aiming not only to ensure a strong market presence but also to become a pioneer in this field in Vietnam. The goal is to emerge as a leading enterprise with mastery in technology, initially in project planning, design, construction, operation, maintenance, and dismantling within the offshore wind energy supply chain. This strategic shift is not only intended to meet the increasing energy demand but also to contribute to global sustainable development objectives.

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