

# Offshore Platforms: Classification, Technologies, Architectures, and Applications

An Chen

School of Southampton Ocean Engineering Joint Institute, Harbin Engineering University, Harbin, China

Corresponding author: ac1e21@soton.ac.uk

**Abstract.** Offshore platforms deal with challenges brought by the marine environment, providing workplaces for oil production, wind energy, and marine research. Offshore platforms play important roles in the ocean development. Although there are still challenges such as stability, control, and sensing technology, offshore platforms hold the potential to further improve their performance and application value with the continuous progress in technology. This paper presents a summary of the present research status within the domain of offshore platform studies, introducing different types of offshore platforms from the perspectives of their applications and basic structures. In terms of technology, this paper presents the technical aspects and architectural framework of offshore platforms. Additionally, the applications of offshore platforms are discussed. Comprehensive analysis indicates that offshore platforms exhibit strong adaptability and stability in marine environments. With the advancement of technologies, the reliability and performance of offshore platform are expected to improve in practical scenarios. This paper may offer a reference for the research of offshore platforms.

**Keywords:** Offshore platforms; Oil drilling platforms; Marine resource; development; Sustainability.

## 1. Introduction

Offshore platforms are complex structures operating in the ocean, with functionalities such as energy production and scientific research. Offshore platforms deal with challenges brought by the marine environment, adapting to varying water depths and harsh working conditions through diverse structural designs and technological frameworks. Offshore platforms play pivotal roles in energy provision, environmental preservation, industries, and so on.

As mankind ventures further into the exploration of marine resources, notable advancements have been achieved in the evolution of offshore platforms. The functionalities continue to refine, and different support structures have been employed to enhance adaptability in diverse working environments.

The technological framework of offshore platforms mainly includes structural design, sensing and monitoring systems, and control systems. Relying on innovative structural design and stability control methods, platforms are capable of navigating the intricacies of the marine environment. Advanced sensing technology facilitates real-time monitoring of the marine environment and platform status.

Although offshore platforms are applied across various domains, there are still challenges such as stability, safety concerns, control, and sensing technology. With the continuous progress in technology, offshore platforms hold the potential to further improve their performance and application value.

This paper reviews related researches in the field of offshore platforms and reevaluates accomplishments, including technological frameworks and applications across various fields. The current development and applications of offshore platforms are introduced with their significance and advantages in marine resource development. The advancement of offshore platforms along with different support structures and related technologies are summarized. A detailed breakdown of the technological framework of offshore platforms is provided, covering structural design, sensing and monitoring systems, and control systems. Specific applications of offshore platforms, such as in oil

extraction and wind power generation, are exemplified. In addition, the potential of offshore platforms in future marine resource development is emphasized.

This paper could serve as a point of reference for the design and investigation of offshore platforms.

## **2. Classification of offshore platforms**

Offshore platforms, sizeable constructs housing drilling rigs, serve the purpose of exploring, extracting, storing, and refining crude oil and natural gas from beneath the ocean floor. While primarily employed in the oil sector, these platforms also find utility in diverse fields such as radio broadcasting, navigation aids, radar surveillance, space missions, and oceanic exploration[1]. In this section, the classification of offshore platforms will be described, and their functional purposes and deployment methods will be compared.

### **2.1. Classification based on functional purposes**

#### **2.1.1. Offshore oil drilling platforms**

The offshore oil drilling platform is a type of platform used for the exploration, extraction, and production of natural gas and crude oil from the seabed. These platforms are typically located on the ocean floor and utilize drilling equipment to extract oil and gas resources, followed by processing and storage activities. These platforms play a vital role in the oil industry and serve as a primary facility for petroleum production.

#### **2.1.2. Offshore wind farms**

Offshore wind farms are facilities used for harnessing wind energy to generate electricity in the ocean. These wind farms are typically located on the ocean surface, often far away from the coastline, and utilize the strong offshore winds to drive wind turbines for electrical power generation. A typical offshore wind farm typically consists of a substantial quantity of generators, corresponding to the installed megawatt capacity and spread across a distance of several kilometers[2].

#### **2.1.3. Offshore accommodation platforms**

Offshore accommodation platforms provide lodging for personnel working at sea in fields like oil and gas, offshore wind energy, and marine research. They offer comfortable living spaces, essential facilities, and support services for long-term work and living at sea, ensuring the well-being of workers.

### **2.2. Classification based on structure and deployment methods**

With the increasing demand for energy and ocean observations, there have been significant advancements in offshore platform technology. Some of these new platforms are built upon existing offshore oil and gas exploration platforms, incorporating various innovative offshore structural designs, ranging from fixed platforms to subsea support platforms. In this section, the structural characteristics of several typical offshore platforms will be presented.

#### **2.2.1. Fixed platforms**

Fixed platforms are offshore structures that are firmly attached to the seabed. They are commonly used in shallow water where the seabed is relatively stable and the water depth is not too great. These platforms consist of a rigid structure with vertical legs or piles that are driven into the seabed to provide stability[3]. In some concrete platform designs, the weight of the legs and the platform itself is substantial enough that they do not require physical anchoring to the seabed; they can simply rest on their own mass[4]. Fixed platforms are widely used for drilling and production operations in the oil industry. Their key features include stability, simplicity in design, and relatively low cost compared to other types of platforms.

### **2.2.2. Floating platforms**

Floating platforms are offshore structures that float on the water's surface, instead of being anchored to the seabed. They are used in deeper water where it is not feasible to build fixed platforms. Floating platforms come in various designs, including:

a. Floating Production Storage and Offloading (FPSO) vessels: These are floating facilities used for the production, storage, and offloading of oil and gas. They have processing equipment on board and can store large quantities of hydrocarbons[5].

b. Floating Production Units (FPU): Similar to FPSOs but without storage capacity, FPUs are used to process and produce oil and gas, with the hydrocarbons exported via pipelines to shore or other facilities[6].

c. Tension Leg Platforms (TLP): Tension Leg Platforms (TLP) consist of a buoyant platform tethered to the seabed by a series of tensioned tendons or vertical tethers. These tethers keep the platform in position, providing vertical stability while allowing the platform to move horizontally with the waves. TLPs are preferred for their ability to dampen motions in rough sea conditions and their suitability for drilling and production activities in deepwater regions.

Floating platforms offer the advantage of mobility, allowing them to be relocated as needed. However, they are generally more expensive to build and operate compared to fixed platforms[7].

### **2.2.3. Semi-submersible platforms**

Semi-submersible platforms are floating structures that use buoyancy and ballast to partially submerge themselves underwater, providing excellent stability in harsh sea conditions. They are commonly used for drilling and production operations in deepwater and challenging offshore areas.

### **2.2.4. Subsea support platforms**

Subsea support platforms, also known as subsea templates or manifolds, are installed on the seabed to connect multiple subsea wells. They act as hubs for gathering and distributing oil or gas from several wells nearby and are vital components of offshore production systems.

## **3. Technology architectures of offshore platforms**

### **3.1. Offshore Platform Technology**

With the development of human exploitation of ocean resources, the field of offshore platforms has made significant progress. Numerous research achievements have contributed to the development of more advanced and reliable offshore platforms.

One of the primary research areas in the offshore platform field is structural design and stability. To cope with harsh marine environments, researchers have proposed various innovative designs and structural technologies. Among them, multiple stability control methods have been applied to offshore platforms to ensure their stability in rough seas and strong winds.

Another essential research area is the sensing and monitoring systems of offshore platforms. Advanced sensing technology is developed to monitor the marine environment and platform status. Researchers have explored various sensors, including high-precision meteorological and oceanic sensors, structural health monitoring sensors, etc., to ensure that offshore platforms promptly grasp changes in the surrounding environment and take corresponding countermeasures. In addition, using advanced data processing and communication technology, offshore platforms can achieve real-time monitoring and remote operation, thereby improving platform safety and efficiency.

In addition to structural design and sensing monitoring, manufacturing and construction of offshore platforms are also critical research areas. Researchers have been committed to developing more efficient and sustainable manufacturing techniques to reduce platform construction costs and shorten construction periods. Among them, the use of advanced materials and manufacturing processes, as well as the adoption of automation and intelligent production methods, has been widely

explored. Furthermore, environmental protection is also a concern, and researchers have explored sustainable construction methods to reduce the impact on marine ecosystems.

Overall, these relevant researches contribute to the development of more advanced and reliable offshore platforms. However, there are still many challenges to be addressed, including improving the stability and safety of offshore platforms in extreme marine conditions, developing more advanced sensing and monitoring systems, and advancing sustainable manufacturing and construction techniques. Future research will continue to drive the technological development of offshore platforms, providing stronger support for energy development and scientific research in deepwater and complex marine environments.

### **3.2. Technical Architecture of offshore platform**

The technical architecture of an offshore platform requires the integration of various components to ensure its stable operation and effective functionality. Here is a detailed overview of the main technical architecture of offshore platforms.

#### **3.2.1. Structural Design and Stability Components**

The structural design of an offshore platform is a critical and primary step. Researchers use advanced design techniques and structural analysis to select the appropriate structure, ensuring that the platform can withstand the challenges posed by the marine environment. Different structural designs can deal with various sea conditions. For floating platforms, common structural configurations can be categorized into three main types: ballast, mooring lines, and buoyancy[8].

#### **3.2.2. Sensing and Monitoring System Components**

Offshore platforms need advanced sensing and monitoring systems to gain real-time awareness of the marine environment and platform status. High-precision meteorological and oceanic sensors are used to monitor sea conditions, climate, and marine ecosystems. Structural health monitoring sensors are employed to detect the structural integrity of the platform and identify potential issues[9].

#### **3.2.3. Control System Components**

The control system is the core of the offshore platform, responsible for managing and regulating the platform's operations. The motion control system is used for smooth movement and positioning six degrees of freedom based on hydrodynamic analysis[10]. Additionally, the platform also requires a safety control system to ensure that appropriate measures can be taken to safeguard personnel and equipment in emergency situations.

As a complex offshore artificial structure, in addition to structural design and stability components, sensing and monitoring system components, and control system components, there may also be components and technologies related to the following aspects. The specific architecture will depend on the platform's purpose, scale, and environmental requirements.

Energy supply: This involves generators, solar panels, and wind turbines to provide power.

Water management: Including water supply equipment and sewage treatment systems.

Communication: Satellite communication, radar, and radio systems for connectivity.

Safety measures: Fire and leak detectors, emergency evacuation systems.

Operational equipment: Cranes, drilling tools, and production facilities.

Emergency systems: Fire suppression, evacuation equipment, safety signage.

Transportation: Ship or helicopter access for material and personnel transport.

## **4. Applications of offshore platforms**

Due to its significance in marine resource development, offshore platforms have undergone extensive research and development. The structural design of offshore platforms enables them to cope with the dynamic marine environment, withstand waves and winds, adapt to varying water depths, and facilitate resource extraction or data collection in challenging sea conditions where traditional

vessels may struggle to operate effectively. As a result, offshore platforms have found widespread applications across various domains, primarily encompassing the following aspects.

#### **4.1. Oil and gas exploration and production**

Offshore platforms play a crucial role in the oil and gas sector. They are used for the extraction and production of oil and gas resources from the seabed. A typical oil production platform remains in place throughout the entire lifecycle of the platform or project (usually 20-30 years), providing production-related facilities including drilling platforms, production platforms, storage tanks, and pipelines[11]. These are examples of offshore platforms used for oil extraction, including the South Pars Oil Field in Iran, the Cantarell Field in Mexico, the Brent Field in the North Sea, the pre-salt fields in Brazil, and the Gulf of Mexico oil fields in the United States. Offshore platforms provide a stable source of energy supply and promote the development of related industrial chains.

#### **4.2. Wind power generation**

Offshore wind power platforms are a significant aspect of renewable energy. They harness the wind energy from the ocean, converting it into electricity through wind turbines[8]. Projects like the London Array and Horns Rev serve as examples of offshore wind farms, while the Hywind and WiConnect represent floating platform technologies for generating wind power in deep waters. Offshore wind power has the potential to become a major source of clean energy, helping to reduce greenhouse gas emissions and lower the carbon footprint of energy production.

#### **4.3. Marine resource development**

Offshore platforms are also used for the development of marine resources, such as ocean minerals, coral reefs, and seabed sediments. These platforms can provide research, sampling, and development facilities, aiding in the exploration and utilization of valuable resources in the ocean.

### **5. Conclusion**

Offshore platforms are complex structures designed for exploration, extraction, and processing of oil, gas, and other resources from the seabed. These platforms are vital in various sectors including oil production, wind energy, and marine research. They serve as hubs for energy generation, scientific studies, and industrial operations. This article presents a comprehensive overview of offshore platforms, their classifications, technological architectures, and applications. Advancements in technology, such as improving stability in extreme conditions, refining sensing systems, and enhancing sustainable construction methods, have enabled these platforms to thrive in challenging marine environments. Ongoing research will continue to upgrade their development, enhancing their capabilities and extending their applications across diverse sectors.

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