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# Offshore wind power - the new trend for economic development and security of island sovereignty

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ABSTRACT

*Climate change is a serious global challenge. Vietnam is one of the developing countries, heavily affected by the impact of climate change. At COP26, Vietnam made strong commitments with 150 countries around the world to commit to bringing net emissions to "zero" by the middle of the century. Together more than 100 countries have joined the Leaders' Glassow Declaration on Forests and Land Use; together with 48 countries participating in the Global Declaration on the transition of coal power to clean energy; together with 150 countries participating in the Alliance for Action 2 for Safe Adaptation, etc. Resolution No. 55-NQ/TW of the Politburo on orientations of Vietnam's national energy development strategy to 2030, with a vision to In 2045, the development of the energy industry in general and the electricity industry, in particular, was assessed as follows: "Investment in the construction of electricity supply infrastructure has a strong development, which is an important condition for ensuring supply security. electrical response. Bringing electricity from the national grid to almost every part of the country, including remote, border, and island areas. Vietnam is a nascent offshore wind market, with abundant wind resources and growth fundamentals, becoming the leading offshore wind market in Southeast Asia. Therefore, the development of supportive policies and breakthrough mechanisms to develop power source projects and a roadmap to build a power grid for power transmission offshore wind is identified as a strategic renewable energy source. In the long term, associated with the implementation of Vietnam's maritime strategy is a top priority. This paper presents the current situation of the offshore wind power industry and the application opportunities of fixed turbine foundation technology in the future in Vietnam.*



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## 1. Introduction

The global offshore wind power market has had an annual growth rate of 24% per year since 2013, with a total wind power capacity of 29.1 GW, representing 5% of the global wind power capacity by the end of 2019 (Joyce et al., 2020). Europe was the largest market at the end of 2019, accounting for 75% of total global offshore wind projects (REN21, 2020). However, offshore wind power installations in Asia has been increased with the prevalent position of China, followed by Taiwan, Vietnam, Japan, and South Korea (Figure 1). The offshore wind power capacity in North America was only 30 MW as of 2019 and will accelerate in the coming years. The top five offshore wind markets are the UK, Germany, China, Denmark, and Belgium (GWEC, 2019).

In Asia, Japan built Asia's first offshore wind power project with two V47-660kW turbine units in 2003. However, the Asian offshore wind market was not ready to take off until 2014, when the Chinese central government announced the National Offshore Wind Development Plan (2014-2016). In 2017, China surpassed the annual installation milestone of 1 GW and overtook the UK to become the world's leading market for new installations in 2018 (GWEC, 2020).

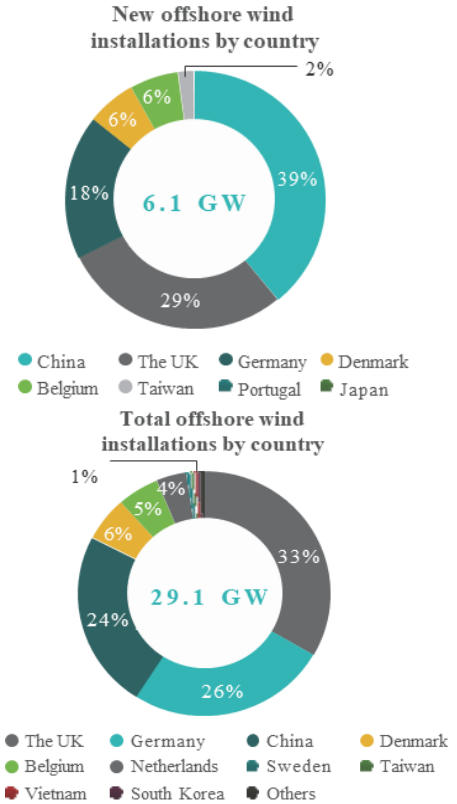


*Figure 1. Offshore wind power capacity growth in 2019 (Global Offshore Wind Report 2020).*

GWEC Market Intelligence (Joyce et al., 2020) predicted that China will continue to dominate the Asian offshore wind market in the first half of this decade, with a market share of more than 70%. Taiwan is expected to be the largest overseas market in Asia after China of new facilities during the same period.

However, the scale will be expanded in 2025, at that time more utility-scale offshore wind power projects will be connected in Japan, Korea, and Vietnam. GWEC Market Intelligence (Joyce et al., 2020) forecasts that China's market share in this region is likely to drop to 58% by 2025 and will continue to decline as foreign projects expand into new markets with high resource potentials, such as India and the Philippines, by the end of this decade. The average annual growth rate in Asia will be 1.7% in the first half of this decade but it is likely to accelerate to 8.4% in the second half. The top five markets in this region this decade will be China (52 GW), Taiwan (10.5 GW), South Korea (7.9 GW), Japan (7.4 GW), and Vietnam (5.2 GW) (GWEC, 2020).

## 2 Potential and orientation of offshore wind power development in Vietnam

National electricity development planning of Vietnam for the period 2011 - 2020 with a view to 2030 determines the target of 800 MW for onshore and offshore wind power by 2020 and 6 GW by 2030. The estimation was based on the technical potential in Vietnam with a coastline of more than 3,300 km and average wind speeds of 8÷9 m/s in the South and on the offshore wind resource of 475 GW identified by the World Bank Group (ESMAP, 2019). The offshore wind market in Vietnam is expected to reach around 2.0 GW by 2025 and 5.2 GW by 2030 (Ben, 2020).

Thang Long Wind super project with a capacity of 3,400 MW and an investment of 11.9 billion USD is the largest wind power plant project in Vietnam that has been proposed off the coast of Mui Ke Ga, Binh Thuan Province by Enterprize Energy Group and other partners. At the Vietnam Energy Summit 2020 on July 22, 2020, in Hanoi, Enterprize Energy signed a Memorandum of

Understanding (MOU) to provide equipment and services for the Project with the domestic contractor consortium between Vietsovpetro and PVC-MS.

Following the project of Enterprize Energy Group, Copenhagen Infrastructure Partner Group (ICP) of Denmark and Binh Thuan Province signed a Memorandum of Understanding on the development of an offshore wind power project in La Gan with a capacity of up to 3.5 GW on July 23, 2020. La Gan project is one of the largest-scale offshore wind power projects in Vietnam, which can enhance the country's position in the field of renewable energy in the region and the world. With an expected capacity of 3.5 GW, La Gan will provide an opportunity to access the most modern and advanced wind power technology in the world. This project also supports transforming Vietnam into a country with an electrical system with a high integrated rate of renewable energy and low carbon emissions in accordance with Resolution 36-NQ/TW of the Politburo dated January 22, 2018, on the strategy for sustainable development of the marine economy.

Offshore wind plays an important role in Vietnam's clean energy transition, bringing in domestic and foreign investment, creating domestic and sustainable jobs, reducing carbon, and making Vietnam an energy leader in Southeast Asia.

## 3. Resource, technical and economic benefits of power offshore wind

Using different approaches, Nguyen and Du (2020) concluded that the wind power potential in Vietnam is very abundant. In the South Central and Northern seas, the average annual wind speed at 100 m altitude is 9÷10 m/s, the power factor (IEC 61400-12-1, 2017) is greater than 50%, and the annual energy density is greater than 50 GWh/km$^2$. Each sea area around Phu Quy island (Binh Thuan province) or Bach Long Vi island (Quang Ninh province) can provide up to 38 GW of offshore wind installation capacity with a power factor greater than 60%. In the southern region, the offshore wind power project in Bac Lieu with a capacity of 100 MW has been operated, providing about 300 million kWh/year and will reach 1,000 MW or 3 billion kWh/year by 2025. In particular, the offshore wind power project of Thang Long (Binh Thuan) with a capacity of 3.4 GW is in the process of a feasibility study from 2019 and can be completed before 2030.

Statistic results show that the total technical potential of offshore wind power in Vietnam is more than 600 GW (ESMAP, 2019; Doan et al., 2019). To have further evaluation of the technical potential of offshore wind power, the Vietnam Energy Transition Initiative has conducted a study to analyze and simulate the possibility of connecting offshore wind power to the grid system by 2030 (Nguyen, 2020). The simulation results show that Vietnam can integrate about 10 GW of offshore wind power from 2023 to 2030 and the exploitation of this energy will play a significant role in the power structure of Vietnam in the next decade. According to the report for the first 6 months of 2020 of the Electricity Regulatory Authority of Vietnam (ERAV), the electricity supply source of Vietnam is mainly from coal (59%), hydropower (19%), oil and gas (17%) and renewable energy (5%) (ERAV, 2021). In accord with the draft Power Plan VIII, future electricity demand will be mainly satisfied by increasing the capacity of gas, wind, and solar power; meanwhile added proportions from large hydropower and coal will be decreased due to limited water and fund resources (MIT, 2021). With a high average power factor and low hourly variable power output, offshore wind becomes a "variable base load" technology. Therefore, focusing on the development of renewable energy, especially offshore wind power, will partly meet an increase in energy demand as well as enhance national energy security and improve the trade balance of Vietnam with other countries.

In terms of costs over the entire life cycle of offshore wind power plants, it can be seen that the technology investment rate tends to decrease, in addition, this technology is also supported through the fixed purchase price of electricity for renewable energy (Feed-in Tariff). Besides, it is easier to mobilize investment capital for electricity produced from renewable energy than to raise capital for electricity used in fossil fuels.

During a project life cycle, offshore wind power emits less $CO_2$ and other pollutants, it also uses less water and land than other power sources. Fossil fuels emit an average of 500 tons of $CO_2$ per GWh of electricity. Meanwhile, the wind

plant with a capacity of 1 GW emits less than 2.2 million tons of $CO_2$ per year to the power of fossil fuels. In addition, fossil fuels emit an average of 1.1 tons of sulfur dioxide ($SO_2$) and 0.7 tons of nitrogen oxides ($NO_x$) per each GWh of electricity produced. These gases are one of the facts of air pollutants that have a great impact on the environment and people's health.

In any case, offshore wind development can support solar power, which tends to produce more electricity in the summer and less in the winter. In addition, offshore wind power also contributes to ensuring energy security and using domestic resources with high potential. In addition, this power source also contributes to reducing $CO_2$ and other pollutant emissions and contributes to reducing investment in synchronous power generation sources such as gas or coal power plants (IEA, 2020).

## 4. Difficulties and challenges

Wind power is one of the potential industries and sustainable development in the future. However, the challenge will be encountered when implementing offshore wind power projects in Vietnam.

- Administrative procedures and legal barriers: At present, policies on investment procedures, power purchase and sale contracts/prices between the project investor and Vietnam Electricity Group (EVN) have not been fully promulgated. The timely support of the Government is crucial to the success of the project. At the same time, legal procedures need to be transparent, creating a specific mechanism for the development of this green energy industry.

- In terms of technology, reducing the cost of electricity production from offshore wind in Vietnam depends on the development and support of new technology, especially offshore wind turbines currently being designed for the region with a wind speed higher than the average wind speed in the offshore area of Vietnam. Therefore, to ensure economic efficiency, it is necessary to research and develop a suitable rotor for the average wind speed in Vietnam. In addition, to develop offshore wind power, technical solutions are needed to deal with specific extreme climate conditions such as tropical storms, or no wind. Moreover, if offshore wind power projects are deployed in Vietnam, innovative technology solutions in production, installation, and operation need to suit specific conditions, in order to increase reliability as well as reduce production costs.

- Incomplete data on geography, tides, and wind speed in regions: Currently, there is no high reliability, synchronization, and consistency of wind data in regions and regions of Vietnam. This leads to difficulties and biases in the initial evaluation (pre-feasibility) of a wind power project. Therefore, the Government should soon support relevant units to organize the implementation of research projects of high quality, scale, and applicability. Meanwhile, this is also the basis for creating Vietnamese standards for design, construction, and quality acceptance of a wind power project.

- In terms of development costs, the first offshore wind power project clusters will have higher costs, because this is the stage of both doing and learning from experience. The domestic supply chain has not yet been established in the first stage, so the construction time and cost may be higher than inexperienced markets. After implementing 2÷3 project clusters (1÷1.2 GW), it will be possible to lower the investment rate. According to the International Energy Organization (IEA), the global offshore wind power resource has the potential to reach 420,000 TWh annually (18 times higher than the current global demand). In 1991, the first offshore wind power project in Vindeby (Denmark) was built with 11 turbines with a total capacity of 5 MW at a depth of 4 m near the shore and was dismantled in 2017 after more than 25 years of operation. Recently, offshore wind projects have become much larger, up to several GW with larger turbines (up to 12 MW) and at great depths close to 200 m and more than 100 km offshore. Before 2016, the cost of producing one MWh of wind power was up to 200 USD, recently it has decreased to about 100 USD. In particular, a bidding project in the UK in 2019 costs only about 50 USD/MWh.

- Currently, Europe has installed 20 GW of offshore wind power and has a supportive policy to quadruple (to 80 GW) by 2030. IEA forecasts that by 2040, global offshore wind power will have a development investment capital of about 1 trillion USD with an annual growth rate of installed

capacity of 13%. The countries/territories that will become offshore wind power development centers by 2040 are Denmark, Germany, Netherlands, Ireland, UK, USA, China, Japan, India, Korea, Taiwan (China), and Vietnam. The installed efficiency of offshore wind farms reaches 50%, nearly 20% higher than solar power and 30% higher than onshore wind power.

## 5. Orientation for research into offshore wind power fixed-bottom foundation technology in potential areas of Vietnam

Another research by the Danish energy agency (DEA) for the Ministry of Industry and Trade in 2020, detailed the technical potential according to a number of exclusion criteria such as Navigational flows; Conservation areas, banned from exploitation; Oil and gas exploitation fields; Distance to shore and seabed depth; Areas of severe storm winds, and earthquakes; Undersea cable. The results of the assessment of the technical potential of offshore wind power are about 162 GW. In which, the offshore wind power capacity with fixed-bottom foundation technology (seabed depth under 50 m) is about 132 GW and about 30 GW for floating technology (Danish Energy Agency, 2020).

According to the Map of Estimated Wind Engineering Potential for Fixed and Floating Offshore Winds in Vietnam in terms of installed electrical capacity in megawatts (MW) within 200 km of the coast provided on the initiative of The World Bank Group (WBG) on offshore wind is funded and guided by the Energy Sector Management Assistance Program (ESMAP). The methodology used to create this map is described in a WBG report published in October 2019 titled Wind Resource Data from the Global Wind Mapping (Figure 2).

The largest offshore wind power potential is in the South Central region, most of the potential can be built with fixed-bottom foundation technology. The Southwest region has offshore wind power potential but this area is very far from shore (nearly 100 km). The entire technical potential is included in the model to select the

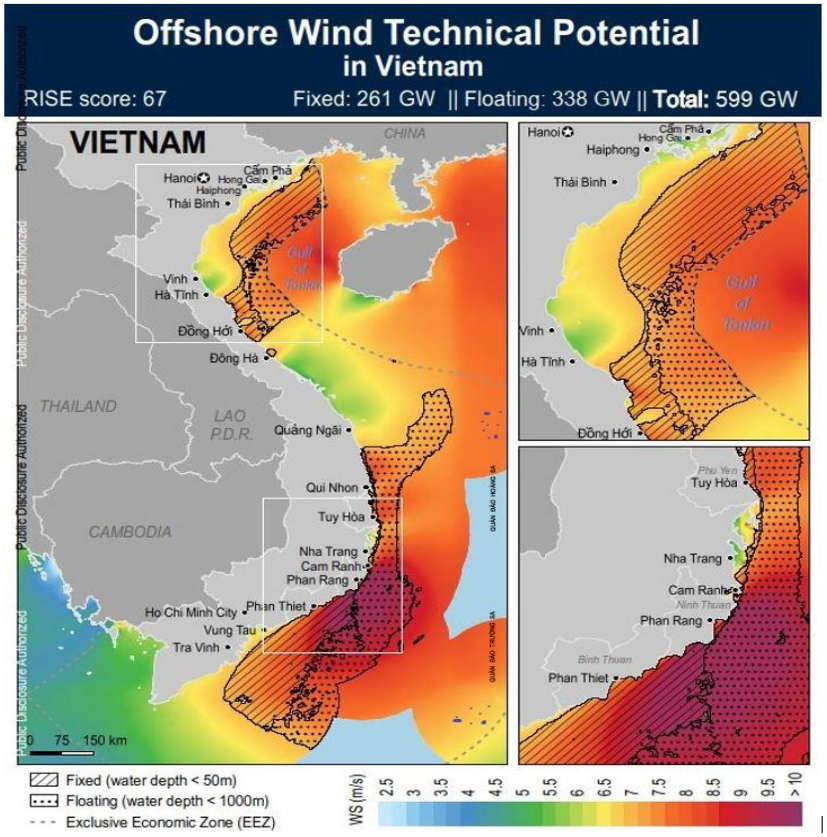


*Figure 2. Potential locations for the development of fixed bottom and floating bottom in the South (World Bank - Offshore Wind Technical Potential in Vietnam, March 2020).*

development possibility, the data are simulated according to the 26 surveyed technical potential locations (each site has a scale of 1000÷11000 MW).

Offshore wind power projects with seabed depth of fewer than 20 m are in the Southwest region and offshore wind power projects with seabed depth of over 20 m are in the South Central region (Vietnam Offshore Wind Country Screening and Site Selection - C2Wind - Denmark - 2020; Danish Energy Agency, 2020).

Different from onshore wind power projects, offshore wind power projects require higher and stricter requirements in terms of structure, especially the base structure for wind power poles. Because these structures must be located deep below sea level and subject to harsher working conditions than wind power poles working onshore.

Regarding the offshore wind power foundation technology, there are currently 2 types of foundation technologies that can be applied: fixed-bottom foundation (single pile, tripod pile, jacket pile), floating foundation (pillar foundation, vertical anchor foundation, barge). In which, the fixed-bottom foundation technology is usually applied to water areas with a depth of fewer than 50 m as in Binh Thuan offshore (Figure 3a). The floating foundation type currently has only one active project in 2017 (Hywind Scotland developed by Equinor 30 MW), the rest are at the registration, research, and development stage. Floating foundation technology can be strongly developed in the future when reducing costs, which is appropriate for offshore areas with a water depth of more than 50 m as in Ninh Thuan offshore (Figure 3b), high wind speed, and a stable wind regime.

In Vietnam, offshore wind power projects are all at the project development stage, no projects have been built yet (excluding nearshore wind power projects). However, with the fact that wind power projects have been deployed onshore and nearshore, the development trend for offshore wind turbines in Vietnam will keep pace with the world, or at least similar to China. The latest commercial capacity scales of the famous wind turbine manufacturers mentioned above have been used in Vietnam (3÷5 MW) in onshore and nearshore projects. Therefore, the appearance of offshore wind turbines with a large capacity of 8÷15 MW, with a blade diameter of ≥200 m in the period to 2025 will be the trend. OEM manufacturers will consider placing the wind point in Vietnam and make appropriate adjustments to make it the most technically effective - economic and environmentally friendly.

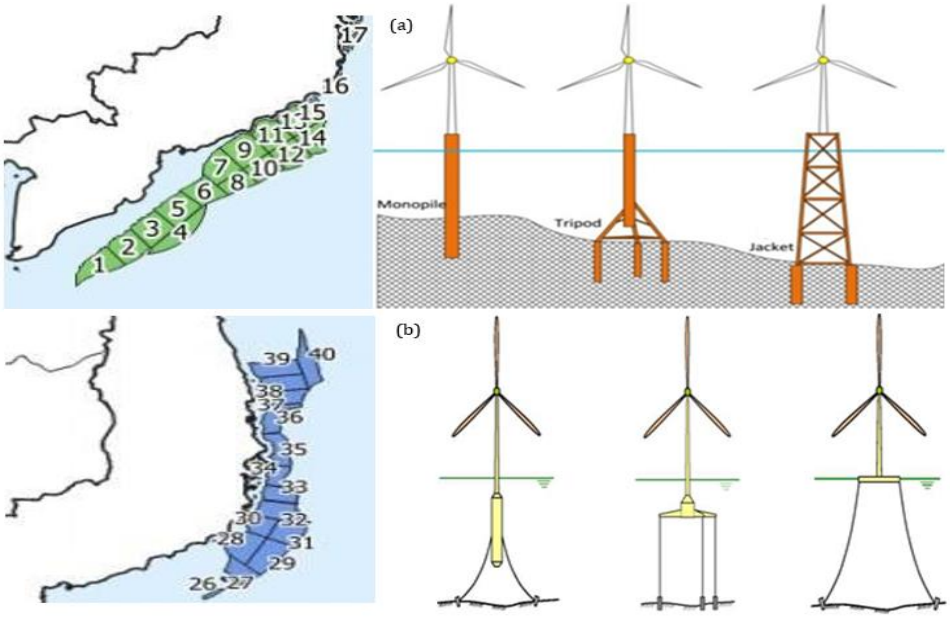


*Figure 3. Potential locations for the development of fixed bottom and floating bottom in the South (World Bank - Offshore Wind Technical Potential in Vietnam, March 2020).*
*(a) Fixed bottom turbines - Binh Thuan province area; (b) Floating Turbines - Ninh Thuan Province.*

## 6. Conclusion

Offshore wind energy resources are the most invested and developed new energy source in the world in today's world and will be the "eyes of God" to help strengthen the protection of national security and sovereignty at sea.

With the great policies of the Party and State, such as Resolution 55 and Resolution 36 on the development of marine renewable energy, offshore wind power, wave energy, tides, and ocean currents. When the EVFTA agreement between Vietnam and the EU comes into effect, large capital sources and offshore wind power technology from the EU will easily participate in offshore wind power development in Vietnam. This will be an opportunity for Vietnam to have the potential to take the lead in ASEAN, become a major offshore wind power center in the world, promote supporting industries and marine services, and export electricity in the future. offshore wind to the ASEAN region and surrounding areas.

However, to do this, the State needs to have national policies on offshore wind power. The State should soon develop a national strategy for offshore wind power development; There is a marine spatial plan for offshore wind power development in Vietnam in association with the National Strategy on Marine Wind Energy Development to 2030, with a vision for 2045.

Within the scope of the research, the author recommends that the authorities need to devise a central strategy for effective offshore wind development by identifying and removing barriers and setting ambitious goals to attract the offshore wind industry. suppliers, investors and promote competition, specifically as follows:

*(1) General Policy*

- Set clear, ambitious, and long-term goals for offshore wind integration.
- Identifying and zoning offshore wind power areas through marine spatial planning; consider performing environmental impact assessments and other site studies.
- Define a 'real' offshore wind site with a minimum shore-to-shore distance of 6 nautical miles (~11 km), primarily to avoid negative landscape impacts, conflicts with nearshore activities, and make it easier to reach consensus.
- Develop simplified and transparent licensing procedures
- Develop and issue a payment strategy for offshore wind power (FIT subsidy mechanism compared to bidding) including the terms of a viable PPA for loans.
- Integrate international best practices for wind farm design and certification.

*(2) Time and transition from the FIT price*

- The first true offshore wind power projects in Vietnam will not achieve COD until 2026 or later. Therefore, a new FIT tariff for offshore wind should be applied now to support the initial phase of 4÷5 GW of grid connection, before the implementation of the bidding mechanism.
- During the transition period before the expiration of the new FIT rates for the initial 4÷5 GW of offshore wind projects, a plan to arrange the transition from the new FIT to the tender should be clearly implemented and public announcement.
- Before bidding is applied, the financing feasibility of the existing PPA needs to be improved to attract foreign investment for the development of offshore wind power projects due to the large scale of investment.

*(3) Support processes and policies*

- Sufficient time must be given to prepare the procurement policy: A minimum of two years' notice should be given to key industry stakeholders of any significant change in approach.
- The government should incorporate an open and systematic consultation process when formulating future offshore wind power policies.
- Full transparency is required throughout the policy development process for offshore wind, such as the publication of objectives, draft regulations and procedures for comment.

*(4) Procurement plan*

- When announced, the tender needs to be large enough, e.g. 2÷3 GW per allocation, to accommodate strong interest in the offshore wind sector in Vietnam.
- Further research is needed on single-stage procurement compared to two-stage procurement in Vietnam.
- The design of the bidding session should

distinguish between mature technology and poor technology.

An efficient and streamlined licensing process is required for timely project delivery. Governments need to prepare for the purchase of offshore wind power with a "one-stop-shop", which will be responsible for overall coordination of licensing activities, or more clearly divide the responsibility for approval of permits within agencies. state agency.

**Author contributions**

Tram Thi Doan - methodology, writing original draft; Quang Van Tran - methodology, writing - review & editing, supervision.

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