



Design parameters independent on the type of platform in floating offshore wind farms

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Abstract. The main developments in offshore wind power are focused on wind turbines with foundations on seabed. However, there exist important limitations for installing these structures in places with high depth within short distance from the coast.

This means that the progress of offshore wind energy around the world is tied to the development of safety and low cost floating platforms for renewable energy offshore devices [1].

Therefore, the first aim of this paper is to know which alternatives exist for a floating offshore wind farm establishment and design parameters are independent or dependent of platform configuration. In order to evaluate each alternative, the request inversion for each configuration has been analyzed.

From this point of view, the conclusion is that a string configuration for the electrical network is better than a star configuration. Moreover, an accommodation platform cannot be established due to the fact that it would increase the costs considerably. With regard to maintenance, it would be better to have a proper vessel only if the number of trips is more than three.

Key words

Offshore, energy, floating, wind, turbine.

1. Introduction

In the current energy crisis, it has become increasingly important to define new forms of energy production. About 71% of the surface is covered by water, thus

offshore energy farms should be necessary to cover the future electrical needs.

In relation to this, Galicia, a region located in the north west of Spain, can become one of the most important areas using floating offshore to obtain wind power, since it is already available in the onshore market.

Nowadays, one of the main constraints of this type of energy is its high cost.

From the analysis of the costs of each phase of the lifecycle of floating offshore wind farms, the main cost variables can be obtained. This analysis becomes the way to define new configurations to reduce the cost of developing new wind farms in the future.

2. Variables

In order to analyze the economical effects of the design parameter, they have been separated into two groups:

- **Level 1 Variables (L1V):** those that are dependent on the general features of the park.
- **Level 2 Variables (L2V):** those that are dependent on configuration alternatives of the farm.

This paper will be focused on the Level 2 Variables.

3. Level 2 Variables

Level 2 Variables are defined as those dependent on configuration alternatives of a floating offshore wind farm.

In addition to this, two types of Level 2 Variables will be defined:

- **Level 2.a Variables:** those independent on the type of floating platform.
- **Level 2.b Variables:** those dependent on the type of platform [2].

This paper will explain only Level 2.a variables.

4. Level 2.a Variables

Level 2.a Variables are defined as those which, being dependent on the configuration options of the farm, are independent on the type of platform chosen.

Through the study of the whole lifecycle of the process of a floating offshore wind farm four types of Level 2.a Variables have been defined:

- **Farm Configuration:** depending on the type of electrical network.
- **Installation:** in relation with the type of vessel used for transport and installation of the floating platform.
- **Maintenance:** taking into account the required level of exigency.
- **Accommodation:** it is necessary to know if an accommodation platform is required or not.

Each one of them will now be analyzed separately.

5. Farm Configuration

There are two basic types of electrical connection settings [3]:

- **String connection.**
- **Star connection.**

There are also two types of string connection, as shown in Fig. 1 and Fig. 2:

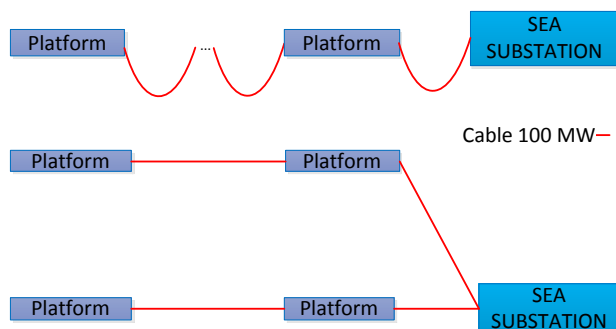


Fig. 1. Type 1 String connection.

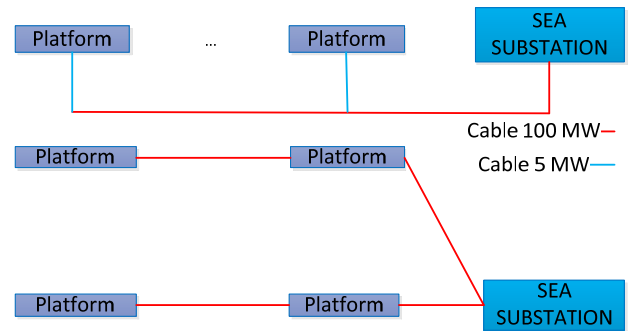


Fig. 2. Type 2 String connection.

The principal differences between them are the power of the cable used and the quantity of it. In Type 1, wind turbines are connected using only 100 MW cable. However, in Type 2 each wind turbine has its own 5 MW cable, which will be connected with the rest of platforms with a 100 MW line.

On the other hand, star connection can be of two basic types, depending on how the wiring has been joined, as shown in Fig. 3 and Fig. 4:

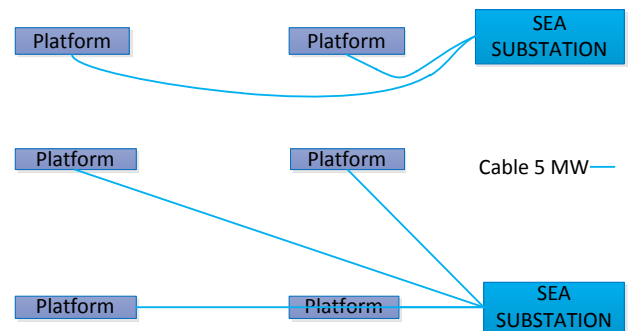


Fig. 3. Type 1 Star connection.

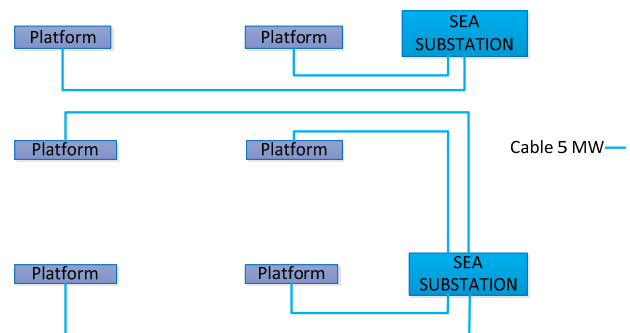


Fig. 4. Type 2 Star connection.

Firstly, it would be evident that connection with more power was more expensive. However, it will be also dependent on the quantity of cable used.

6. Installation

There are two basic types of installation:

- **Offshore installation.**
- **Onshore installation.**

Offshore installation can be carried out by jack – up vessels or by a combination of barge, tug and floating crane.

Regarding onshore installation, it can be done in two ways. The first one, only wind turbine is mounted onshore, so a port crane will be needed, and also a barge and a tug. However, in the second one, turbine and platform are assembled in a harbour or in a shipyard. For this second option, the barge will not be necessary.

7. Maintenance

As far as maintenance is concerned, this can be done in two ways [4]: onshore based or offshore based.

Furthermore, several maintenance levels will be taken into account [5]: minimal, basic, intermediate, high and exhaustive.

Thus, the possible types of maintenance are:

- **Onshore maintenance**, without permanent accommodation (minimal, basic, intermediate, high)
- **Offshore maintenance**, with permanent accommodation (exhaustive).

These alternatives are dependent on the number of maintenance trips needed per year: minimal maintenance supposes 1 trip, basic maintenance 2 trips, intermediate maintenance 3 trips, high maintenance 4 trips and exhaustive maintenance 5 or more trips.

8. Accommodation

Bearing accommodation in mind, two cases can be chosen:

- **There is accommodation**, with a platform designed for it.
- **There is no accommodation.**

9. Results

A. Farm configuration

Farm configuration depends on cable quantity, wind turbine diameter, number of wind turbines, shore distance, deepness and cable cost. In this case, the aim will be to reduce the amount of cable, which is the most important factor.

In Option 2 of the star configuration more cable will be needed than in Option 1, so it has been rejected.

The cheapest option of all is the string configuration Option 1, as is shown in Table I. In fact, Option 2 string configuration rising up to 3.6 M€ more than the chosen option because, although there is 5 MW cable and its cost is less than 100 MW cable, the quantity of cable used is higher. On the other hand, Option 1 star configuration is 4.4 M€ more expensive than the option chosen because the quantity of cable is so high that it does not compensate its costs.

Table I. – Farm configuration costs

Farm configuration	Cost (M€)
String configuration 1	57.8
String configuration 2	61.5
Star configuration 1	62.3
Star configuration 2	Rejected

B. Installation

Secondly, it is necessary to know what type of installation is the most favourable, which will be dependent on the vessel cost.

The choice of jack – up is discarded because its costs are higher than have a vessel only for wind turbines, as said the study of the CDTI (Industrial Technological Development Centre) [6].

So, after having compared several costs, the cheapest installation, both of wind turbines and platforms, is the Option 2 onshore installation, which eliminates the use of a barge. Option 2 offshore installation supposes 39.8 M€ more in costs that the option chosen, mainly due to the enormous cost of specialized floating cranes. Option 1 onshore has a slightly higher cost that the option chosen, only exceeds 772,5 € but they are in the same range, as Table II shows:

Table II. – Installation costs

Installation	Cost (M€)
Offshore 1	Rejected
Offshore 2	43.1
Onshore 1	3.3
Onshore 2	2.5

C. Maintenance

Maintenance will depend on the number of trips with this purpose: more trips imply more cost.

Having a proper ship for maintenance means a greater cost if maintenance is minimal (M), basic (B) or intermediate (I). However, if the maintenance is high (H) or exhaustive (E) the fact of having your own ship will be beneficial.

Therefore, the conclusion is that it is better to have your own ship if you are going to carry out 3 or more maintenance trips, as Table III shows:

Table III. – Maintenance costs

Maintenance	Cost (M€)				
	M	B	I	H	E
Proper ship	63	63.4	63.9	64.4	65
No proper ship	46.6	54.7	62.8	70.9	78.2

D. Accommodation

The costs will be higher if there is an accommodation platform, because, in this case, it is necessary to add the maintenance cost, manufacturing costs and installation costs of the platform for this purpose.

10. Conclusion

After having examined all the possible options regarding a floating wind farm configuration, the best ones are the following:

- Option 1 string configuration.
- Option 2 onshore installation.
- Maintenance with a proper ship for 3 trips onwards.
- There is no accommodation.

On the other hand, the elaboration of this study allows us to know what will be the main variables in the implementation of a floating offshore wind farm. Thus, its cost, which represents bottleneck threat in this sector, can be determined.

This study was carried out for a preliminary analysis of a set of options, future works will be focused in increase the details of each variable.

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References

- [1] Rodríguez, R., Gorrochategui, I., Vidal, C., Guanche, R., Cañizal, J., Fraguera, J. A., et al. (2011). Anchoring Systems for Marine Renewable Energies Offshore Platforms. OCEANS 2011 IEEE. Santander (Spain).
- [2] Ferreño Gonzalez, S., Castro Santos, L., Díaz Casas, V., Fraguera Formoso, J. A. (2011). Estudio, caracterización y comparación de tipologías de plataformas para soporte de aerogeneradores en alta mar. 50º Congreso de Ingeniería Naval e Industria Marítima (pp. 1-39). Cádiz.
- [3] Schachner, J. (2004). Power connections of offshore wind farms.
- [4] Offshore: Maintenance and Repair. Available at: Repower Corporation <http://www.repower.de/en/wind-power-solutions/operation/service/offshore-maintenance/oms/>

[5] Couñago Lorenzo, B., Barturen Antépara, R. (2011). Parque eólico marino flotante. Madrid.

[6] CDTI (Centro para el Desarrollo Tecnológico Industrial. Construcciones Navales del Norte) “El mar y las energías renovables. La aportación de la Ingeniería Naval y Oceánica. Proyecto Eolia”, in Jornadas Técnicas de Ingeniería Naval, 2010.