DeepWind'2013 – 10th Deep Sea Offshore Wind R&D Conference, 24th – 25th January 2013, Trondheim, Norway

Methodology to study the life cycle cost of floating offshore wind farms

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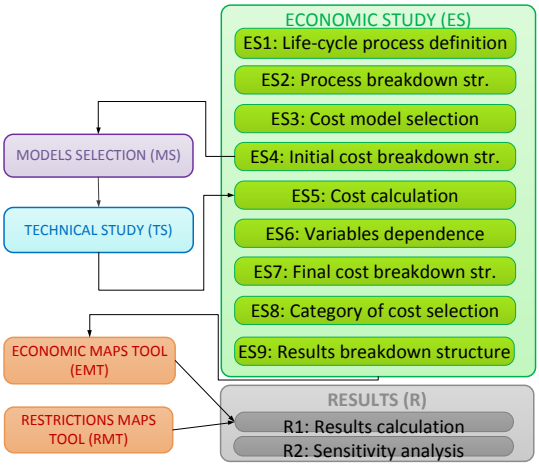
Abstract. The main objective of this paper is to determine a theoretical methodology process to study the life cycle cost of floating offshore wind farms. The principal purpose is adapting the LCC (Life-Cycle Cost Calculation) from several authors to the offshore wind energy world. In this sense, several general steps will be defined: life cycle definition, process breakdown structures, viability study and sensitivity study. Moreover, technical and economic issues and their relations will be considered. On the other hand, six life cycle phases needed to install a floating offshore wind farm will be defined: design and development, manufacturing, installation, exploitation and dismantling. They will be useful to define the majority of the steps in the process. This methodology could be considered in future works to calculate the real cost of constructing floating offshore wind farms.

METHODOLOGY

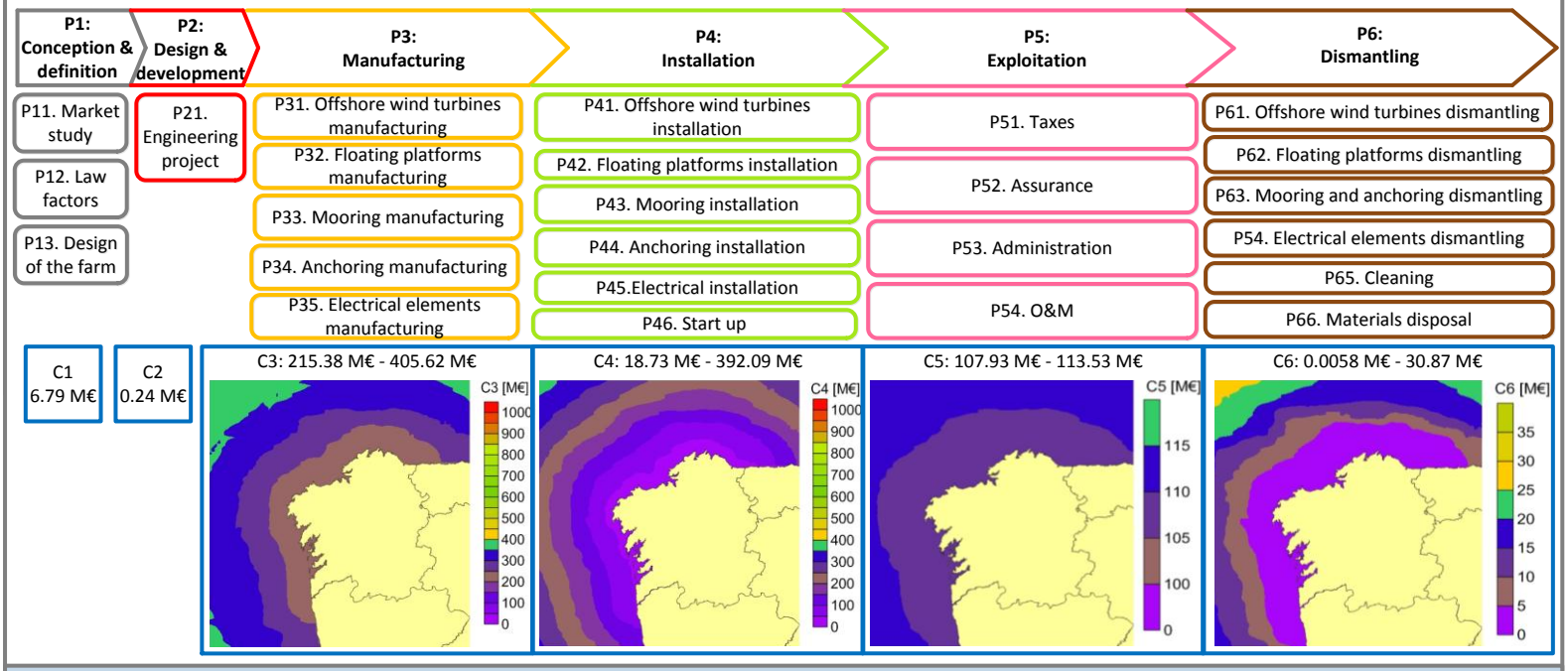


- **Economic study (ES)**: it is of utter importance in the methodology because it helps to define each of the costs involved the development of floating offshore wind farms. In fact, this article will only develop the ES step.
- **Life-cycle process definition (ES1)**: Life-cycle process has been defined modifying the recommendations of IEC 60300-3-3:2004 because this normative is focused more in a product than in a process. Therefore, the main phases of the life-cycle of a floating offshore wind farm are 6.
- **Process breakdown structure (ES2)**: it determines which are the main stages and sub-stages of the process.
- **Cost model selection (ES3)**: IEC 60300-3-3:2004 proposes several models to calculate the life-cycle cost. However, the present study will only take into account the model based on the life-cycle phases.
- **Initial cost breakdown structure (CBS) (ES4) and cost calculation (ES5)**: they are based on the disaggregation of the main costs of life-cycle: C1, C2, C3, C4, C5 and C6.

CASE OF STUDY

- Floating offshore semisubmersible platform.
- No cohesive soil.
- There is no accommodation platform.
- Synthetic fiber is the mooring material.
- Plate anchor.
- HVDC Electrical chain configuration.
- Wind turbine tower will be assembled onshore.
- Dismantling considered will be "tree falls".
- Preventive maintenance carry out with a helicopter.
- Mooring and anchoring installation are developed with an Anchor Handling Vehicle (AHV).
- Substation installation is developed with a cargo barge and a heavy lift vessel.
- Floating platform will be installed taking into account a tug boat, because draft of semisubmersible platform considered is less than shipyard draft.
- Floating offshore substation.
- Port and shipyard located in Ferrol, A Coruña (North West of Spain), close to an area of good offshore wind resource.

RESULTS

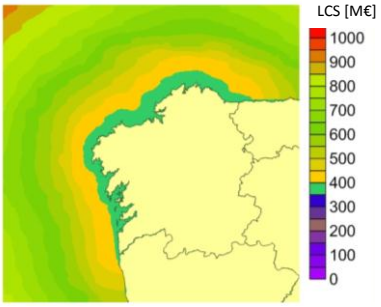


$$LCS_{FOWF} = C1+C2+C3+C4+C5+C6$$

CONCLUSIONS

Main dependences

- **Wind Turbines**: number, power, cost per MW, mass, diameter.
- **Floating platforms**: mass, cost in shipyard (steel, direct labor, direct materials, no direct activities (management, amortization of the machines, etc.).
- **Climate**: height and period of waves, wind speed at anemometer height, wind parameters (shape and scale).
- **Location**: depth, distances (to shore, to port, to shipyard).
- **Anchoring and mooring**: weight, cost per kilogram, number of mooring lines.
- **Electrical systems**: cost per section of electrical cable, number of electrical cables, grid and cable voltages.
- **Installation**: number, speed and fleet of vessels used in installation phase.
- **O&M**: failure probability.



LCS_{FOWF}
365.50 M€ - 945.62 M€

- Methodology LCS_{FOWF} has been established.
- Development of the Economical Study
- Phases Economical Study
- Definition of the life-cycle phases
- Most important costs: manufacturing and installation
- Calculation of the costs for an specific location

References:

- Fabrycky WJ, Blanchard BS. Life-cycle Cost and Economic Analysis. Prentice Hall; 1991.
- Castro-Santos L, Ferreño González S, Martínez López A, Diaz-Casas V. Design parameters independent on the type of platform in floating offshore wind farms. RE&PQJ 2012;10:1-5.