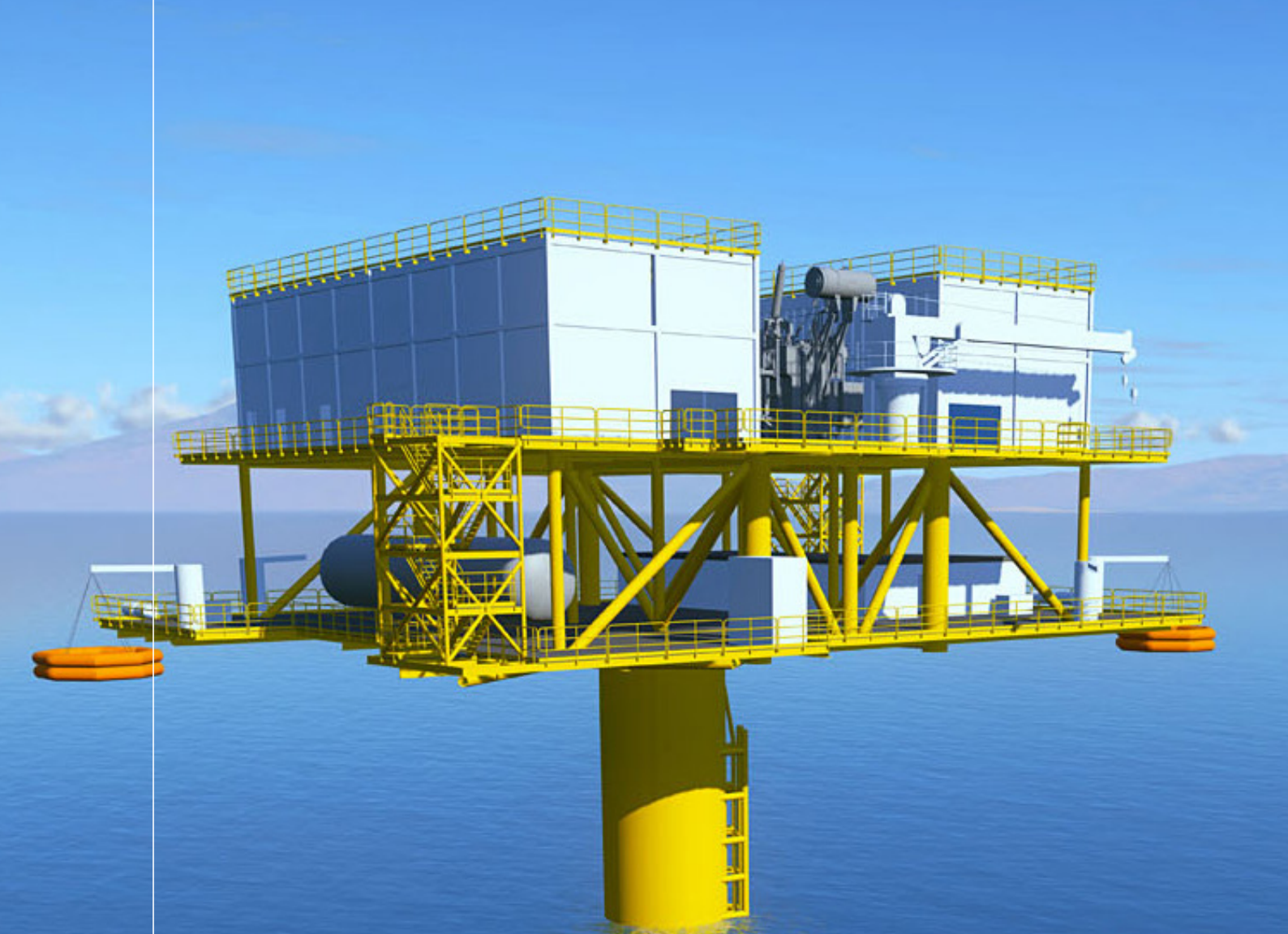
FLOATING SUBSTATION DESIGNS FOR OFFSHORE WIND APPLICATIONS

SAIPEM



INTRODUCTION

The floating offshore wind farms are becoming the more interesting and economic solution for sites with 60 m of water depth. While several designs for floating foundations for Wind Turbine Generators have been developed and patented, floating substations are representing the next step to have a complete solution for a floating wind farm applicable to a large panel of site conditions and characteristics.

A modular design approach for floating HVAC substations sized starting from 250 MW that can be scaled-up to 600 MW has been developed considering sea and environmental conditions as well as motion, acceleration and inclination restrictions dictated by the equipment onboard and by the inter array and export dynamic cables.

For each envelope of conditions applied, including topside weight, COG and footprint as well as the environmental conditions, the design of the floater allows to meet the recommended substation's equipment limitations in terms of motions, accelerations, and inclinations.

OBJECTIVES

This brochure illustrates a comparison of different designs for floating foundations applied to a range of offshore substations sizes potentially installed in severe environmental conditions and how each design is satisfying the motion and fatigue limitations of topside and equipment therein installed.

The objective is to identify the potential of the different floaters investigated to accommodate a floating HVAC substation. Focus is brought to the floating foundation aspect of floating substation, which is only one of the technological bricks required. One of the main technical challenge to be tackled by the industry for floating offshore substation (FOSS) is the design of the dynamic HV cables. Even if not addressed specifically here, a special attention has been made on the floating foundation designs to limit motions and therefore dynamic loads on the inter-array cables.

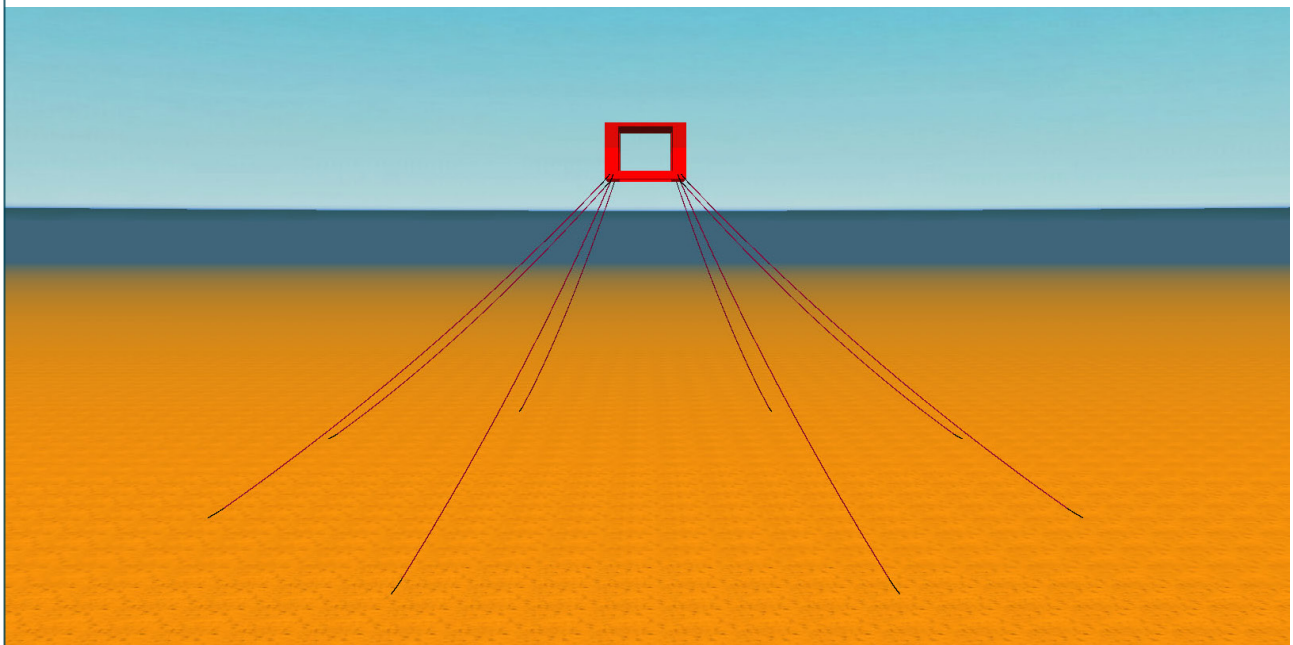
METHOD

Saipem made a design comparison for a large HVAC substation topside of 500 MW for a weight around 3,700 t.

Barges and semi-submersible floating foundations design were initially considered and compared through a qualitative evaluation:

Motion response is important for a floating substation, due to topside equipment and export cable. The semi-submersible floater is being preferred, focus is brought to 2 semi-submersible foundations designs with either 3 columns or 4 columns, connected with pontoons (shipyard flat-panels construction) and fitted with a double deck:

CRITERIA	BARGE FLOATER	SEMI – SUBMERSIBLE FLOATER
DECK AREA	LARGE DECK AREA	MEDIUM DECK AREA
MOTION BEHAVIOR	EXCESSIVE PITCH IN EXTREME WAVE LARGE MOTION RESPONSE	LIMITED SENSITIVITY TO WAVES SMALL MOTION RESPONSE
WEIGHT	HEAVY	LESS HEAVY
AIR GAP	LOW	HIGH
MOORING	HIGH LOADS	MODERATE LOADS
TOPSIDE WEIGHT SENSITIVE	NOT SENSITIVE	MORE SENSITIVE



Design development was made considering the following environmental conditions and assumptions driving the hull design:
→ The design development of the semi-submersible has been based on typical met ocean data as can be found outside South-Korean coastline, but the concept can be designed for worldwide operation
→ ~3,700 t OSS topside

For the topside design, Saipem is currently proposing a horizontal open deck concept, which presents the following advantages:
→ Minimize the need for structural support, thus reducing structural weight
→ Layout optimization through lowering COG of main heaviest equipment
→ Low COG results in increased stability and better motion response of the floater
→ Natural cooling of some equipment, not located in enclosed structure/ building

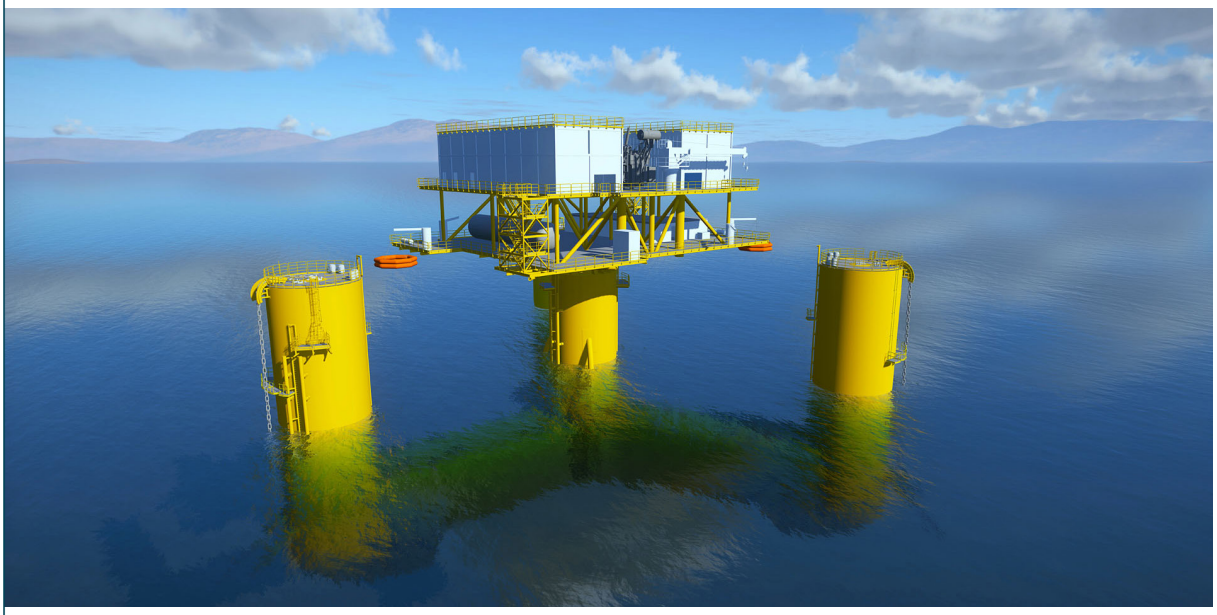
RESULTS

The comparative study is favorable to the 4-leg semisubmersible floating foundation:

Lower lightweight and material cost for similar metacentric height & stability for identical draught and freeboard

Larger deck area for the 4-leg semi

Square footprint more suitable to accommodate rectangular-base-substation



Another possible approach for the design of the floating foundation is to apply the WTG foundation design to the substation, thus providing a repeatable and scalable design for the entire wind farm. To that purpose, Saipem proprietary Star 1 and Hexafloat wind turbine floating foundation designs can be considered to support substations, focusing for the illustrations below on a rather smaller topside of approximately 350 MW capacity and 1,700 t weight.

CURRENT STUDIES

Saipem is currently applying its expertise on floating substations to those developing markets like Mediterranean Sea, US West Coast, Far East. Technical feasibility studies are ongoing for floating substations size in the range from 250 MW up to 1,2 GW.

Saipem can support its clients towards the design optimization of floating substations suiting specific project and site condition needs.

Saipem has received a “Statement of feasibility” by DNV for its conceptual study of a 600 MW floating substation, which is also pending patent.

TAKEAWAY

Saipem has evaluated the potential of different floating foundations and topside facilities architectures. For the selected designs, the structural arrangement will pursue simplicity and cost-effectiveness and rely, where possible, on simple and standardized fabrication methods such as flat panel production and automatic/robotic welding of shell plating, girders, and stiffeners.

The floating substation can satisfy the need of a completely floating wind farms which can make commercially viable the development of areas with great floating offshore wind potential but with water depth not allowing the installation of a substation on a fixed foundation.

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