



Electrification Case Studies

Charging Station & FPSO Decarbonization

June 04, 2024

FER Forum – Trondheim

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Our Energy Transition Journey



Utilizing our Experience to Address The Energy Transition Needs



Decarbonization/Electrification

- Advance FPSO decarbonization
- FPSO electrification & eFPSO
- Power barge
- Offshore charging station

Alternative Fuels

- Green and blue Ammonia FPSO
- Alternative fuels transfer systems



Digital Solutions

- Develop innovative solutions
- Application for GHG emissions reduction

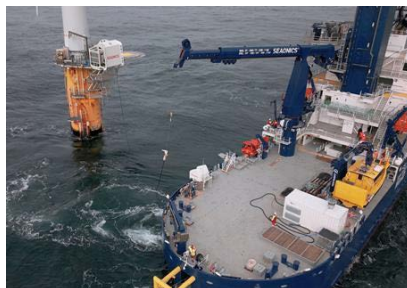
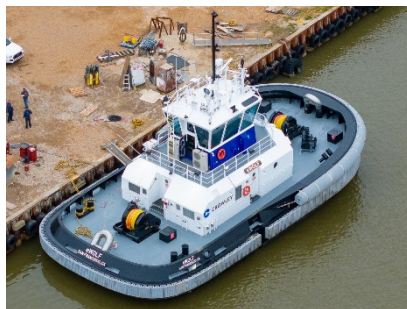
Floating Wind

- Semisubmersible and TLP designs for 15+ MW Turbines



Offshore Charging Station - Motive

Charging solution for electric/hybrid vessels supporting offshore wind farms



Power to ships outside of ports (cold ironing)





CALM Buoys

- Import/export terminals
- Unmanned operation
- Stationkeeping and weathervaning capability

Single Point Mooring Systems

- LV, MV, HV sliprings
- Large power supply
- Cable and power management

ELECTRIC CHARGING BUOY (ECB) CONCEPT & AiP

Electronically published by ABS Houston.
Reference T2457403, dated 06-OCT-2023.



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- SOFEC ECB targeted for electric / plug-in Hybrid Vessels

- Supports LV/MV/HV voltage levels
- Supports semi-autonomous operation
- Cable management/deployment
- IEC standards Compliant
- Employs SOFEC standard Buoy design
- Major equipment layout

- AiP Submittal Package

- Design Basis
- Block Diagrams
- GA's

- AiP obtained in October 2023

Task No.: T2457403 (5139776)
Approval in Principle (AiP):
Electric Buoy Concept

Attention: Andy Kolb, SOFEC, INC. (WCN 540593)

The document shown in the attached list are reviewed in accordance with the applicable requirements of the following:

- ABS Rules for Building and Classing Single Point Moorings, 2023
- ABS Rules for Building and Classing Marine Vessels, 2023
- ABS Guidance Notes on Review and Approval of Novel Concepts, 2017

The subject review has been focused on verifying compliance reflective of the details shown in the submitted document. We are pleased to advise that the submitted details were found to be in compliance with the applicable Rules listed above provided the List of Technical Findings and Approval Road Map are followed.

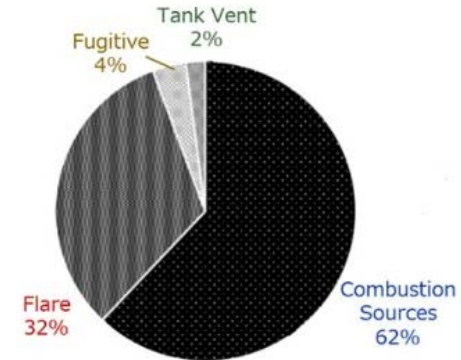
Please note that ABS Approval in Principle is granted based on the following conditions:

- 1) ABS review of the design is based on the details submitted in the document and our current scope of work is limited only to a design review for compliance in principle with the applicable requirements.
- 2) Regulations and Codes associated with flag administration and coastal state of intended area of operation will be subjected to the approval of the flag and coastal state.
- 3) Involvement of flag State, coastal State and/or port State Authorities will be critical and consultations with these parties should be addressed at the early design stage, and necessary authorization may also be required from the flag State, coastal State and/or port State Authority where the unit will operate.
- 4) Please note that through the AiP process, ABS seeks to identify major issues that may result in substantial change in direction in the project development, by evaluating the design approaches, Rules/ regulations/ requirements/ standards/ codes applied, and types of calculations presented. Comments that are raised during the AiP process focus on highlighting major issues only. Our review at this time in no way precludes any future amendments which may be deemed necessary due to submittal of additional information, clarification, drawing revisions during detailed engineering review for the subject design, or new requirements from IMO, Flag etc.
- 5) We have not performed the review on behalf of any Governmental Authority and all such reviews will have to be separately performed during detail design directly with them.
- 6) It is also to be noted that before the final class approval can be granted, the proposed design will need to be verified against the Rules, Guides, Regulations, Requirements and Standards applicable at the time that the contract for

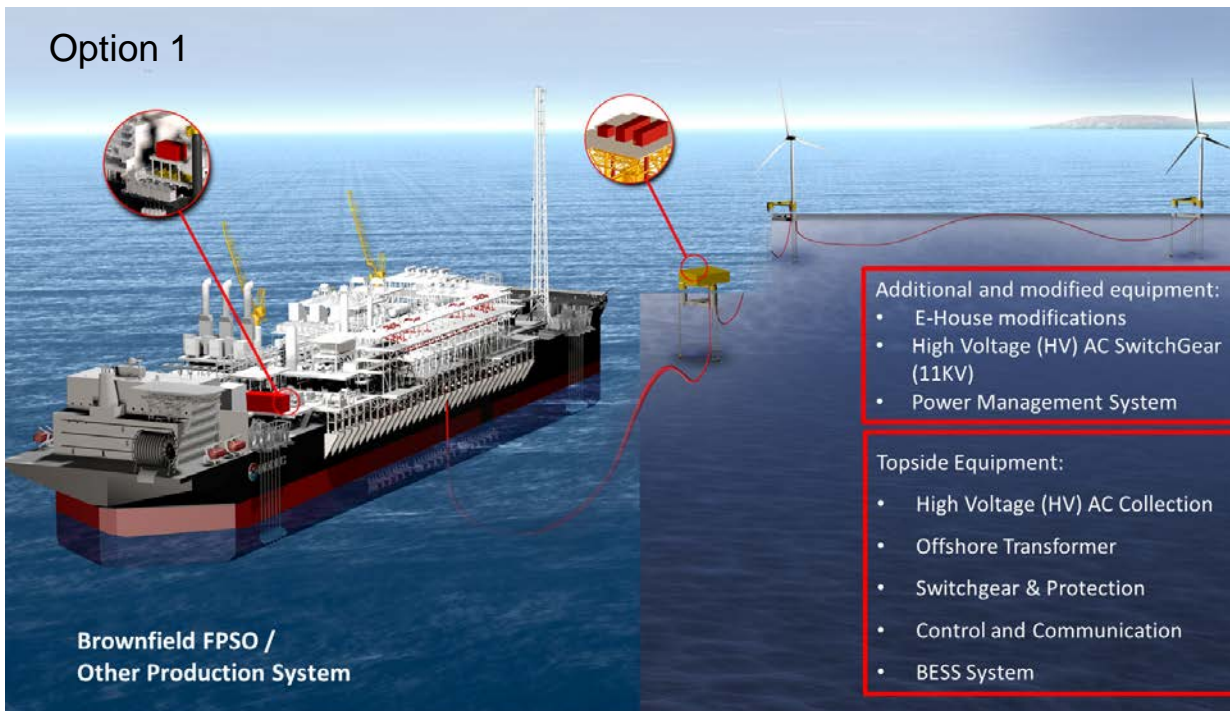
- **Electrical Slipping** – Electrical swivel that passes power from the geostationary connection to the rotational slide to allow Vessel to Weathervane
- **Cable / Umbilical** –
 - Permanent grid umbilical connection
 - Temporary cable connection between buoy and vessel
 - Connector – ensure a secure and watertight connection between all equipment
- **Cable management system** – for payout/pay in of the buoy charging cables to vessel
- **Telecommunication & Nav aids**
- **Safety & Earthing** – ensuring sufficient protective devices and proper earthing, especially when the vessel could be earthed differently than the buoy or incoming supply power
- **Stationkeeping Capability** – horizontal motions and weathervaning
- **Additional / Optional Modules:**
 - Solar Panel – for charging and small power
 - Battery Bank – for backup and independent power for the winch and buoy controls

- **Use cases**
 - Operational needs and constraints
 - Consideration of all the different vessel sizes
 - Identifying plausible scenarios for vessel connecting and disconnecting and charging duration
- **Difference between grid supply power and vessel load power**
- **Standardization of parameters and interconnections**
 - Voltages: LV (400V – 1kV), HV (1kV – 35kV+)
 - Frequency: 50Hz vs 60Hz
 - AC vs DC
 - Connectors: Not standard
- **Power management between the vessel/buoy/grid**
- **Cable connections to the sliprings**
- **Battery technology: Evolving fast**

- **Motive**
 - More than 60% of FPSO CO₂ emission is from power generation
- **Solutions**
 - Increase of efficiency
 - Combined Cycle
 - CCS
 - Electrification
- **Electrification Options**
 - Offshore wind
 - Import power from shore or other sources
 - Green power from grid
 - Power barge
 -
- **Challenges with Wind as Power Source**
 - Space constraints (more critical for existing vessels)
 - Reliability and availability of electrical supply
 - Additional cost of equipment \$/CO₂
 - Still need the GTGs in case of non-availability of wind power or issues with battery storage



Option 1



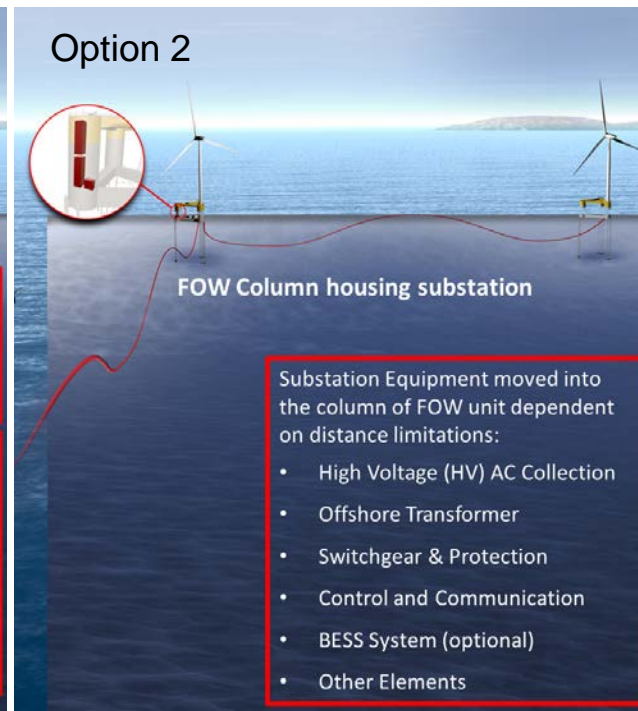
Additional and modified equipment:

- E-House modifications
- High Voltage (HV) AC SwitchGear (11KV)
- Power Management System

Topside Equipment:

- High Voltage (HV) AC Collection
- Offshore Transformer
- Switchgear & Protection
- Control and Communication
- BESS System

Option 2



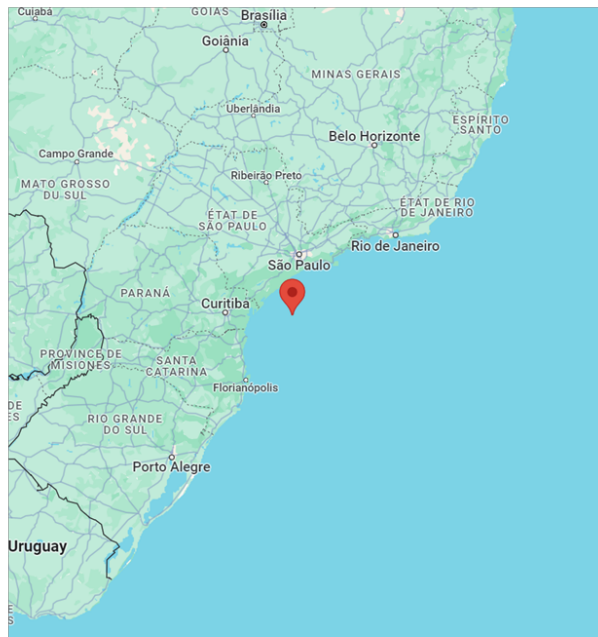
Substation Equipment moved into the column of FOW unit dependent on distance limitations:

- High Voltage (HV) AC Collection
- Offshore Transformer
- Switchgear & Protection
- Control and Communication
- BESS System (optional)
- Other Elements

Case Study: Model Parameters

Location specific: wind and sun hourly averages in the model

Average wind speed at hub height : 9m/s



GT system

Gas Turbine system	
GT Capacity (MWp)	28
GT efficiency	37%
Natural Gas energy content (MJ/m3)	39

FOWT + PV+ BESS System

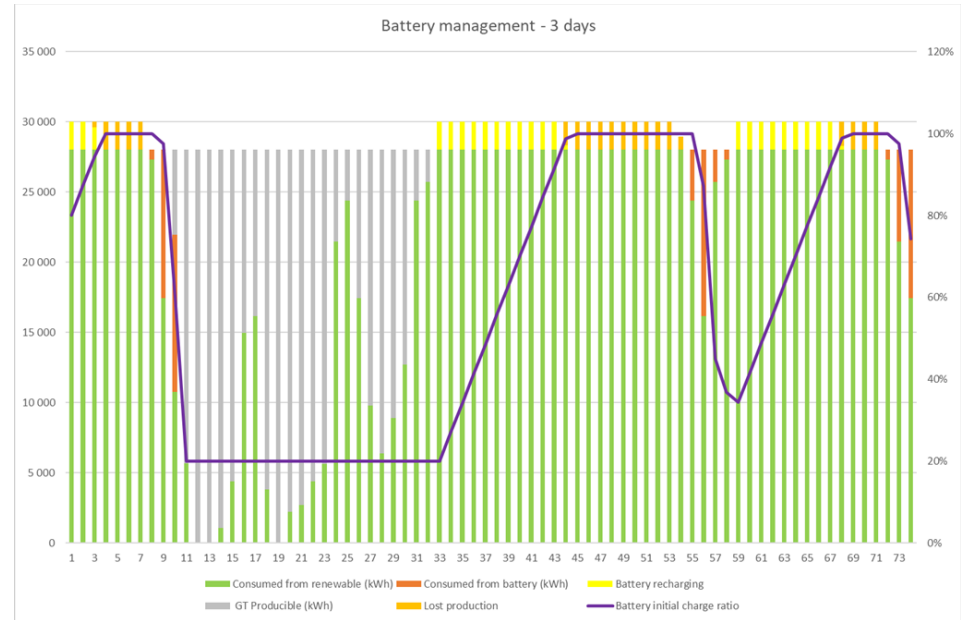
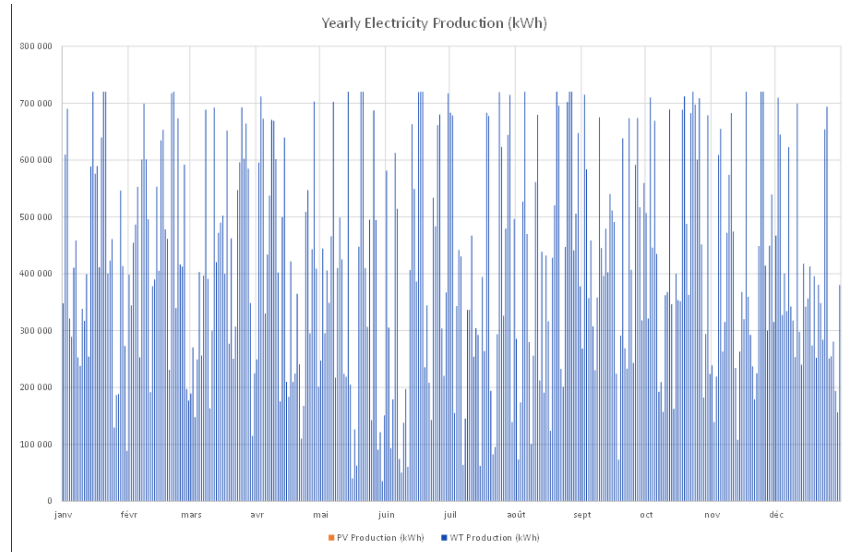
Wind Turbine system	
WT size (MW)	15
Number of turbines	2
WT total power (MW)	30
Hub height	150 meters
WT Total Producibile (MWh)	150 378
WT full power annual equivalent hours	5 013 hrs
WT Capacity factor	57,2%

Photovoltaic system	
PV output (MWp)	0
Bifacial energy increase	10%
PV Total Producibile (MWh)	17
PV full power annual equivalent hours	1 728 hrs
PV Capacity factor	19,7%

Energy need	
Day start	8
Day finish	19
Night Constant nominal power (MW)	28
Day Constant nominal power (MW)	28
Annual energy need (MWh)	245 952
Cover ratio	61,1%

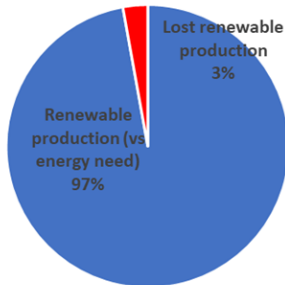
Battery system	
Battery capacity (kWh)	28 000
Battery capacity (hours)	1,0
Battery limit	20%
Charging limit	100%
Intial level	80%
Battery type	Lithium-ion
Energy density (Wh/Kg)	300
Volume density (L/Kg)	0,5
Weight (Tonnes)	93
Volume (m3)	47

Case Study: Wind Turbine and FPSO Energy Management

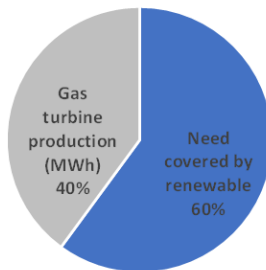


Case Study: Global Results

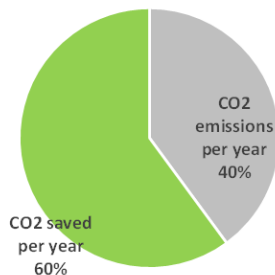
Curtailment



Renewable vs gas



CO2 emissions



Analysis

Total Renewable Power (MW)	30
Total Renewable Produced (MWh)	150 395
Total energy need (MWh)	245 952
Renewable production (vs energy need)	61%
Need covered by renewable	147 727
<i>Directly from renewable (MWh)</i>	<i>144 086</i>
<i>Consumed from battery (MWh)</i>	<i>3 641</i>
Renewable consumption	60%
Lost renewable production (MWh)	2 678
Lost renewable production	2%
Gas turbine production (MWh)	98 225
Gas turbine shut down ratio	42,1%
Total amount of natural gas needed (m3)	24 505 176
CO2 emissions per year	58 000 tons
Total amount of emitted CO2 (tons) per day	159 tons
CO2 saved per year	87 235 tons
Total amount of saved CO2 (tons) per day	239 tons

sofec

Thank You!



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External Turret: 28



Internal Disconnectable Turret: 6



Internal Permanent Turret: 5



Spread Moored: 21



Tower Yoke: 6*



CALM / SALM: 53 / 18

