

# **Past and Present Use of Electric Ships in the Energy Industry**

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# Introduction and Purpose

- A wide range of ships type are used in the energy sector from basic tank ships to extremely complex industrial vessel such as dynamically positioned deep water drilling vessel and include other vessel such as offshore crane-ships, pipe-laying vessels, icebreaking supply vessels, and semisubmersible drilling units.
- The main purpose of this paper is to describe how, from a naval architect's point of view, electric propulsion has been used on numerous occasions to solve a particular design challenge, and to illustrate that there exists a significant knowledge base on the design, construction and operation of electric ships.

# History

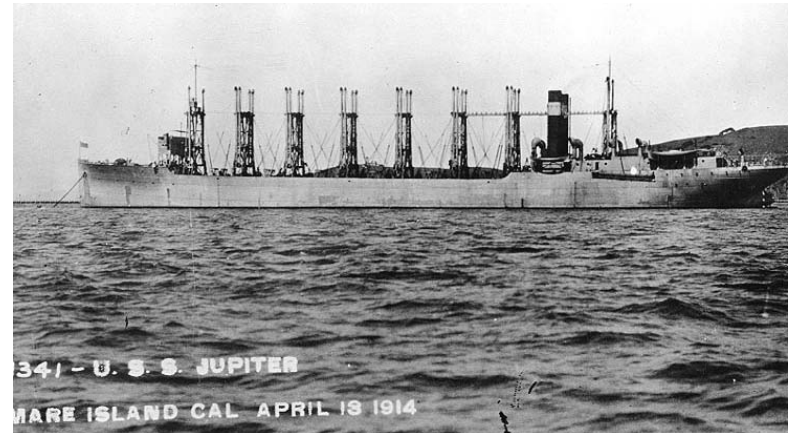
- Nikola Tesla was an early proponent of electric propulsion for ships. He wrote in the *New York Herald*, in February 25, 1917:
- *“The ideal simplicity of the induction motor, its perfect reversibility and other unique qualities render it eminently suitable for ship propulsion, and ever since I brought my system of power transmission to the attention of the profession through the American Institute of Electrical Engineers I have vigorously insisted on its application for that purpose.”*

# Tesla's View of Early 20<sup>th</sup> Century Marine Propulsion

- *“The present turbines are extremely unsuitable for ship propulsion. They offer a striking example of an antiquated invention of small value elevated to a position of extraordinary commercial utility through profound research and astonishing mechanical skill.”*

# The Early Years

- One of the first electric ships in the US was a naval vessel which could be said to belong to the energy sector. The ship was a naval collier named the *Juniper*. This ship, built in 1913, was equipped with a 6,600 hp plant and related equipment.
- Captain Q. B. Newman, chief of engineering, for the USCG, was responsible for a major step forward in marine electrical propulsion systems when he used synchronous motors to drive the propellers more efficiently than the induction motors used by the Navy at the time.
- Synchronous drives were installed in the cutters *Tampa*, *Haida*, *Mojave*, and *Modoc*, which were put into service in 1921.



*Naval Collier "Jupiter"*



*USCGC "Modoc" WP G 46*



# The T-2 Tanker Story



*SS "Huntington Hills" T-2 Tanker*



*SS Esso Glasgow - 1944-1971.*

- There were 481 of T-2 steam turbo electric tankers.
- These ships were 523 feet 6 inches long, 68 feet beam.
- Deadweight was 16,613 tons and they displaced about 21,880 tons.
- Propulsion consisted of a steam turbine generator connected to a propulsion motor directly connected to the propeller, obviating the need for a large main reduction gear.
- The turbo-electric propulsion system delivered 6,000 shaft horsepower, giving a top speed of about 15 knots
- The principal reason to use electric propulsion was to eliminate the need for large gearboxes, the manufacturing capability for which was limited.
- Many of these tanker had long post war service

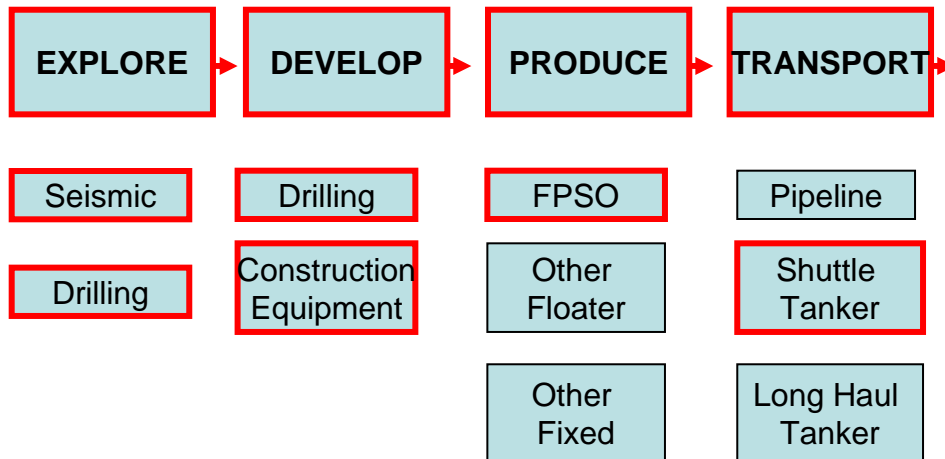
# Current Applications

- Electric propulsion is used in a variety of applications across the energy value chain, from exploration through development, production and transportation

# Marine Component - Oil & Gas Value Chain

From “in the Ground”

To “in the Tank”



Opportunity for Marine Electric Power Systems



# Areas where Electric Systems Provide Solutions

- **Cost of Propulsion Systems for OSVs** → • **Adapt readily available diesel-electric locomotive technology**
- **Need propulsion in submerged hulls of early generation of semisubmersible drilling units** → • **Use DE system with prime movers at deck level and propulsion motors in hulls**
- **Need capability to maintain station in 10,000 ft water depth while drilling** → • **Use DP system with multiple thrusters to give fast response position control**
- **Need efficient marine propulsion system which can burn either boil off LNG or HFO** → • **Use 4 stroke medium speed diesel generator sets driving electric propulsion motors**
- **Need to provide high power – high torque propulsion system for Arctic tankers** → • **Fit twin Azipod propulsion units driven by multiple diesel generators**

# Typical Applications - Exploration



**Dynamic Positioned  
Deepwater Drillship**

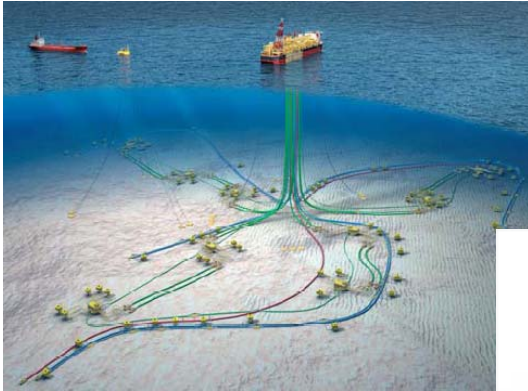


**Semi-submersible  
Drilling Unit**



**Heavy Duty Jack-Up  
Drilling Unit**

# Typical Application - Production



**FPSO – DE Power System**



**N.Sea FPSO GT Electric Power System**



**World's Largest FPSO – China  
Electric power exported to whole  
field complex**

# Typical Application - Transport



**2 x 10MW Azipods**



**Icebreaking Tanker  
Loading at Arctic Terminal**



**Icebreaker  
26,000hp D.E.  
Thrusters**



**DP-DE Shuttle Tanker**



**DFDE LNG Ship**

# Offshore Drilling

- Drilling for oil and gas offshore is a relatively new activity
- It started in the Gulf of Mexico something over 50 years ago in a few feet of water
- Today we explore for hydrocarbon resource world-wide in water depths exceeding 10,000ft

Current Status of World Drilling Fleet

<b>Drilling Units</b>	<b>In Service 2008</b>	<b>On Order 2008</b>	<b>% Increase in Fleet</b>
<b>Jack-Ups</b>	435	73	17%
<b>Semi-Subs</b>	176	52	30%
<b>Drillships</b>	42	44	105%
<b>Total</b>	653	169	26%



# Offshore Drilling Units – Jack-Ups

- Jack-ups are used in shallower water areas, typically with water depths less than 350 ft. Most units are 3 legged and can self-elevate the hull clear of the water surface once the unit has been floated into location.
- These units typically have 4 diesel generator sets installed which are used to run the rig elevating system, the onboard cranes, the drilling equipment, rotaries, hoisting gear, mud pumps etc and the normal hotel load for the crew of about 100+/-.



*Large Jack-Up Unit – Legging-Off at Construction Yard*

# Offshore Drilling Units – Semis

- Although the concept of using semisubmersible units to provide stable platforms in deep water has been around for several decades it was not until the 1960s that serious application was made for offshore drilling. Some odd-ball shapes and sizes emerged but by the early 1970s the configuration had large settled on having two main submerged pontoon hulls which were connected to the upper deck structure by a number of vertical tubular legs.
- Early units such as the Aker H-3 unit had somewhat traditional propulsion motor–shaft–propeller-rudder arrangements, but more recent units are fully dynamic positioned, DP, with multiple electro-mechanical thruster units providing both propulsion and position capability.



*Aker H3 Self  
Propeller  
Semisubmersible  
Drilling Unit –  
1970, upgraded  
1990s*



*Sedco Express  
Modern  
Semisubmersible  
With efficient  
drilling systems*

# Offshore Drilling Units – Drillships

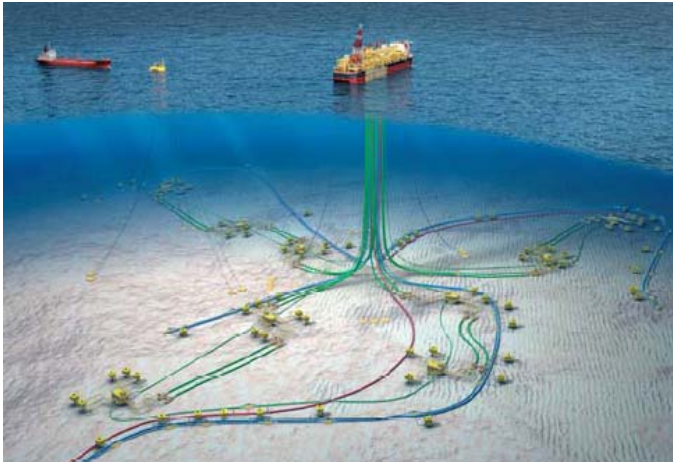
- While drillships do not have quite as high performance as semi-submersibles in the areas of minimizing motions in rough water, they provide two very important attributes which the semi does not have, namely relatively high transit speeds, which allow them to be deployed world-wide and high payload to deadweight which minimizes the need of resupply during drilling operation.
- The current generation of deepwater drill ships typically has about 35 MW of diesel generator capacity installed, with multiple prime-movers, often with varying numbers of cylinders to permit selection of optimum efficiency over a wide range of power

*Deepwater Pathfinder*, one of the first deepwater drillships -1998



Recent Deepwater drillship leaving Korean shipyard

# Floating Production Systems



*Dalia Field FPSO – 3 x 24MW dual fuel generators*



*FPSO "Schiehallion"*

*2 x LM6000 GT generators*

- Floating production system have become common in the offshore production industry over the past 2 decades for remote areas and for areas where the water depth makes construction of bottom founded facilities unfeasible.
- The most common of these facilities is the Floating Production Storage and Offloading, FPSO, unit. These units are either new-build hulls or conversions of large tankers and have major oil and gas production facilities installed on deck. They are connected to sub-sea wells by flexible risers and usually discharge to shuttle tankers for transport to refineries on-shore.



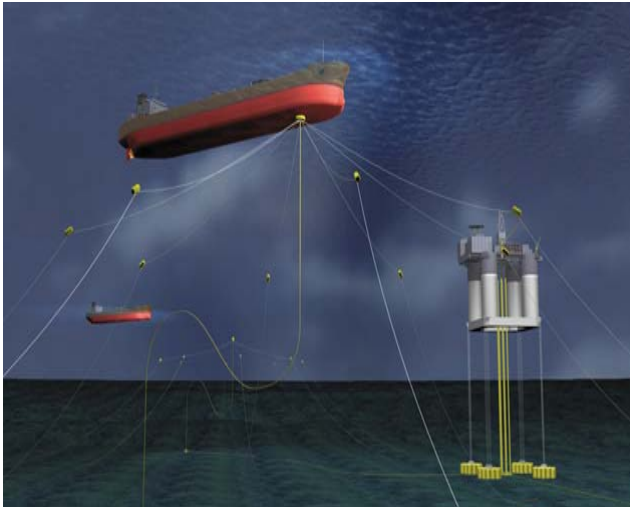
# Icebreaking Ships

- In 2008 the first of three large icebreaking tankers was delivered from Samsung Heavy Industries. These ships are equipped with two 10MW Azipod tractor propulsors and are designed to break approx. 5 ft of ice on a continuous basis. At 92,000 tons displacement these are the world's largest Arctic icebreaking ships.
- The electric drive system on these tankers allow them to operate independent of assisting icebreakers for year round navigation in northern Russian water, breaking up to 1.5m of ice continuously





# Shuttle Tankers



- These ships typically work in conjunction with FPSOs or similar offshore production facilities. They normally have to maintain station offshore using dynamic positioning systems and have a fairly short cycle time. A typical cycle might be as follows:
  - Load – 16 hours
  - Sail to discharge port – 24 hours
  - Offload – 16 hours
  - Sail to load point – 24 hours
- The DP tanker "*Randgrid*" shown below is a good example of a modern shuttle tanker. She is a single screw diesel electric ship with 3 bow thrusters and 2 stern thrusters and a high-lift rudder.
- The "*Randgrid*" was the first vessel to be fitted with a submerged turret loading system which allows for the transfer of cargo through a special turret buoy which is picked up when the tanker arrives on station and dropped back to about 40m below the sea surface when the tanker is loaded.

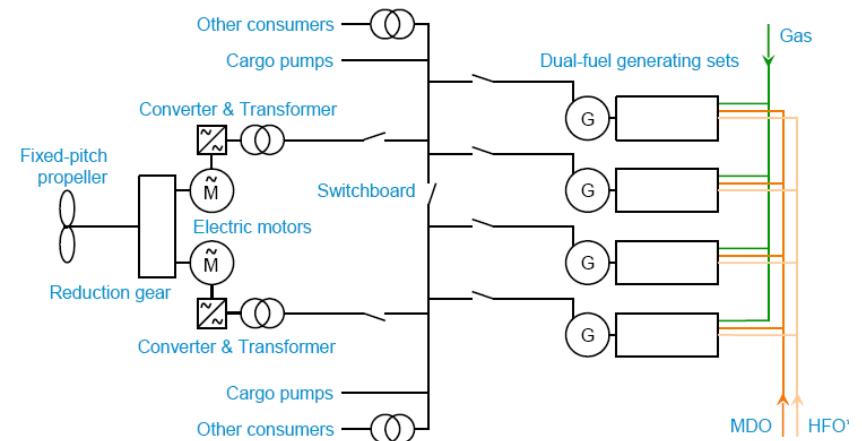
# LNG Ships

- Traditional LNG ships have had steam turbine plant installed and have used the boil of gas, BOG as a fuel source for the boilers along with heavy fuel as required.
- In recent years medium speed diesel engine technology has been advanced so that these units can now run on dual fuels – gas or liquid.
- The schematic shows a typical arrangement for a DFDE ship with 4 diesel generator sets, feeding two motors connected to a single propeller through a gearbox. Depending on the service it is possible to use prime movers of different size to optimize performance



*DFDE LNG Carrier “British Emerald”*

Dual-fuel-electric machinery



# Green Issues

- The issue of air emissions from marine activities has risen very fast on the environment agenda in the past few years and this is another area where electric propulsion can be of benefit by matching prime mover power to applied load in the most efficient way possible.
- For example, a traditional steam turbine LNG vessel would burn 90 tons of HFO and 90 tons of LNG BOG per day producing about 530t of CO<sub>2</sub> and 7 tons of SO<sub>x</sub>, while a new ship equipped with DFDE plant will burn 140 tons of low sulfur fuel per day producing 386 tons of CO<sub>2</sub> and almost no SO<sub>x</sub>.. These translate into reduction of approximately 36,000 tons of CO<sub>2</sub> and 1700 tons of SO<sub>x</sub> per annum.

# Conclusions

- The main purpose of this paper has been to demonstrate that there have been many possibilities to apply electric plant in the energy sector for a wide variety of reasons.
- Sound experience has been gained with both diesel-electric plant and gas-turbine electric plant and ongoing refinements continue in the areas of ship arrangements, power management, cost reduction, and operational flexibility
- The use of electric plant has been increasing in recent years, particularly in areas such as deep-water drilling units, shuttle tankers, offshore supply vessels and other ships which require significant power for other than propulsion service.
- As this use has increased so has the experience level with design and operation of such systems and today in the energy sector we have available mature electric systems which are robust and have high availability.