Danfoss Drive Solutions for Marine Hybrid & Electrification

Dong-Yeong Ryu, Leader of DPD API Marine Electrification
Dong-Yeong Ryu (DY), 류동영

Education: Naval Architech/Mechatronic with Master Degree

1992 – 1996: 2 years of overseas experiences and 2 years as engineers in Chemical company
1996 – 2010: Sales manager, ABB Korea Marine & Offshore
2010 – 2022: Two positions in Danfoss Korea
2023 – current: Sales Leader of API Marine Electrification, Danfoss Drives

Personal Ambitions and Goals for future:
Hybridization and electrification of all ships

Hobby: Table tennis and golf
Danfoss at a glance

Worldwide sales in more than 100 countries

Three strong business segments with leading positions
- Power Solutions
- Climate Solutions
- Power Electronics and Drives

Leading technology partner for our customers who want to decarbonize through energy efficiency, machine productivity, low emissions, and electrification

+42,000 Employees worldwide. People are the foundation of our business

Well on the way towards carbon-neutral global operations by 2030

97 Factories in more than 20 countries

1933 Long track record within innovation and engineering founded by Mad Claussen in 1933
Global Marine Market

<table>
<thead>
<tr>
<th>Study Period:</th>
<th>2018-2027</th>
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<tbody>
<tr>
<td>Base Year:</td>
<td>2021</td>
</tr>
<tr>
<td>Fastest Growing Market:</td>
<td>Asia Pacific</td>
</tr>
<tr>
<td>Largest Market:</td>
<td>Asia Pacific</td>
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<tr>
<td>CAGR:</td>
<td>4.84%</td>
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</table>

**The shipbuilding market:**

Value 2021 = USD 133 Billion
E. Value 2027 = USD 176 Billion

**CAGR = 4.84%**

Retrofit Market: > 15 years old
Global Electric Ship Market

The Global Electric ship market:

Value 2021 = USD 4.7 Billion
E. Value 2027 = USD 16.2 Billion
CAGR = 14.9%

Main Drives:
• Rise in conversion of propulsion system in passenger vessels / Tugboats etc.
• Increasing sea borne trade across globe and growing maritime tourism industry

<table>
<thead>
<tr>
<th></th>
<th>2023</th>
<th>2024</th>
<th>2025</th>
<th>2026</th>
<th>2027</th>
<th>2028</th>
<th>2029</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growing with Market</td>
<td>100</td>
<td>115</td>
<td>132</td>
<td>152</td>
<td>175</td>
<td>201</td>
<td>231</td>
<td>265</td>
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<tr>
<td>Outperform market</td>
<td>100</td>
<td>120</td>
<td>144</td>
<td>173</td>
<td>208</td>
<td>250</td>
<td>300</td>
<td>360</td>
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</table>
Global Shaft Generator Market based on HSD Engine Order Book

- HSD Engine Order Book shows the trend of shaft generator demand
- The demand of shaft generator is increasing and continue to increase according to IMO regulation Phase 3-5
Which application (target application) and how can the electric energy be saved?
Hybrid Power Generation

Clean air thanks to less emissions

New-build or retrofitted battery energy storage gives the vessel
• Better dynamics
• Performance optimization
• Ability to stop engines
• Downsizable main engine
• Stable average power from main engine and dynamic peaks from battery

The result is less fuel consumption and less emissions

Typical fuel savings: 20-30%
Hybrid Power Generation & Hybrid Propulsion

Save up to 30% on fuel consumption

- Variable speed shaft generator/motor with PTO/PTI (Power Take Out, Power Take In), Boost, and Take Me to Harbor function
- Common DC bus optimizes power conversion
- Floating voltage/frequency auxiliary generators ensure maximum efficiency
- Micro grid converters produce clean AC power
- Battery energy storage peak shaving system allows smaller and more efficient engines. Typical fuel savings: 20-30%
Basic Engineering of Electric & Hybrid Propulsion System

**Required basic engineering?**

- “Harmonic mitigation” “short circuit current” “generator dimensioning X”d, power factor (how much reactive power?)

Short circuit current = apparent power (KVA) / (voltage x x”d)

- Decision for voltage, AC? Or DC grid? , harmonic mitigation (AFE, muti pulse?), generator, switchboard dimensioning, Drive dimensioning etc

- Dimensioning of ESS according to operation profile (Cycles?, Depth of Discharge?, etc)

- Interface between systems

- Optimised power management system
Shaft Generator Demo

- 0.75kW motor to simulate engine operation
- 24V Li-ion battery
- Codesys based operation panel
- 1800rpm, 120Hz 0.75kW PM motor (8pole) for shaft generator
- Pre-charging circuit
- Incremental encoder for closed loop control

Danfoss Drives Solution
Case Story 1 – KIOST Ocean Research Vessel

5900tons RV
K-Shipyard(Ex STX)
2014

1st Diesel electric propulsion system engineered locally in Korea

Customer : Hyundai HI

Scope of Supply
- Short Circuit calculation /THD
- Propulsion and Thruster Drives (2x 2.5MW, 1x2.33MW, 1.35MW)
- Interfacing with Automation and thruster controls etc

Key Winning Factors
- Listed in the vendors at concept design
- Local project management and Engineering
- Cooperation with local system integrators
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## Case Story 2 – Korea Coast Guard

| 3000tons | 2ships |
| 5000tons | 1ships |
| 2014 (K-Shipyard, HHI) |

1st KR Coast Guard Hybrid Propulsion ship project with Propulsion Motor Drives

**Customer:** HME

**Scope of Supply**
- 2 x 750kw Propulsion Drives (PTI)

**Key Winning factors**
- Local technical support
- Power Limitation functionality for fluctuating load
Case Story 3 – NIFS Research Vessel

1400tons RV
HK Shipyard
2014

1st KR NIFS Hybrid Propulsion ship project with PTI/PTO (motoring/generating)

Customer: STX Engine

Scope of Supply
- 2 x 500kw Shaft Generator/motor
- 2 x 500kw Grid Converters
- Isolation Transformers
- Interfacing with Automation/CPP propeller system

Key Winning factors
- Local project management and engineering
- Demo showing PTI/PTO functionalities

Generator

Grid converter

Drive

Converter

DIESEL
Case Story 4 – Fishery Petrol Vessel

900tons  3ships
1,900tons 5ships spec in 2020

1st KR Government Hybrid Propulsion ship project with battery under construction according to Green ship K Initiatives

1st local engineering and project management in Korea

Scope of Supply
- 2 x 500kw shaft generator/motor
- 2 x Grid converters and DC/DC converters
- 2 x Marine ESS (490 Kwh)
- Power Management System

Key Winning factors
- Local engineering & project management
- Locally made hybrid demos which verify local competency
- Proven references in Europe
Major References for GreenShip-K Initiatives from Danfoss Partners

References (2020-Current)

- 5 ships for 170T Purification ships
  - Application: 150kW Shaft generator with Li-Ion battery

- 2 x Hospital ships for Jeonlanam-do & Chungchungnam-do
  - Application: 250kW Electric propulsion with Li-Ion battery

- Bukhan-gang Tourist ship
  - Application: Pure electric propulsion with 2000kW Li-Ion battery

- 420T Car-ferry ship
  - Application: Pure electric propulsion with 2000kW Li-Ion battery

- Island Reaserch vessel
  - Application: 100kW Shaft generator with 200kW Li-Ion battery

- Chung-ju lake Figher-fighting vessel
  - Application: 100kW Shaft generator with Li-Ion battery

- 4 x 130T Harbor Naviator ships
  - Application: 150kW Shaft generator with Li-Ion battery

- DSME Shaft Generator for LPG/LNG, VLCC, Container (15+10 sets)

Zero emission

Zero emission
Key takeaway

1. Electric/hybrid ship market is increasing globally

2. Danfoss is willing to share system knowledges with customers

3. Hybrid Demo(test bench) is the Must to verify new emerging projects

4. Danfoss supports our partners & customers with feasibility study before making decision