AMERICAS LNG SUMMIT & EXHIBITION

October 19-21, 2025 | Lake Charles, USA

Technical Conference

AI based Autonomous LNG Carrier Solution: Results of on-board verification of AI-CHS Solution for 174K LNG carrier voyages

Sun Choi, Hyeonwon Jeong, Sungwon Lee, Youngjae Sung - HD Korea Shipbuilding and Offshore Engineering

Background & needs of AI based CHS

Root cause of generation of BOG (Boil-off Gas)

- Steady heat ingress : LNG remains at -163℃, resulting in a significant temperature difference from the surroundings
- Dynamic heat ingress : Increasing in kinetic energy due to sloshing

BOG management is required to control the cargo pressure in the LNG tank properly

BOG Handling criteria

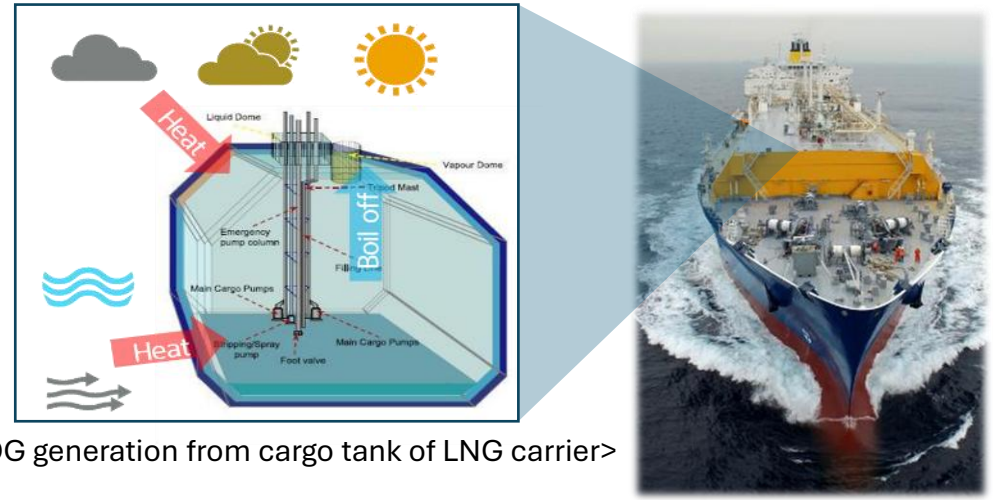
Best
Good
Worst

- **Highly economic**: Used as fuel for M/E (propulsion) and G/E (power generation)
- **Less economic**: Use of re-liquefaction equipment (high power consumption)
- **Worst economic**: Incineration in the GCU (Gas Combustion Unit)

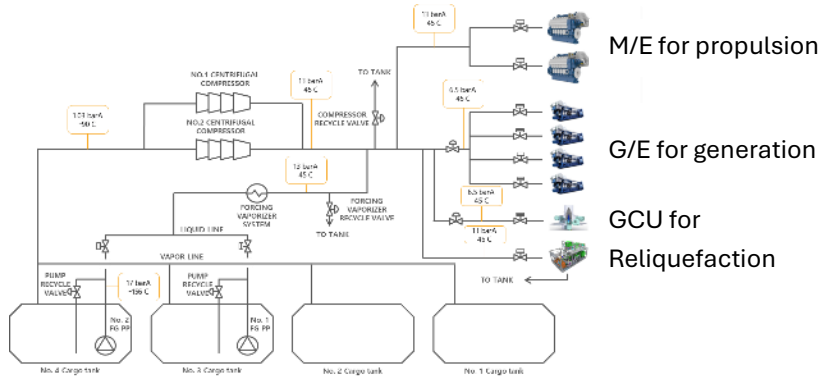
Optimization of CHS (Cargo Handling System) operation through BOG prediction based on the voyage route ***→ Establishment of Zero Waste BOG technology***

Key Benefits of Our Suggestion

- Assistance for inexperienced operators in economic voyage.
- Development of autonomous LNG carrier technology at IMO Level (Maritime Autonomous Surface Ships, MASS) 1~2.
- Economic operation considering the entire system: "Cargo tank – CHS – Engine."
- Minimization of additional LNG consumption (Our proposed concept: surplus fuel saving) for operating CHS



<BOG generation from cargo tank of LNG carrier>



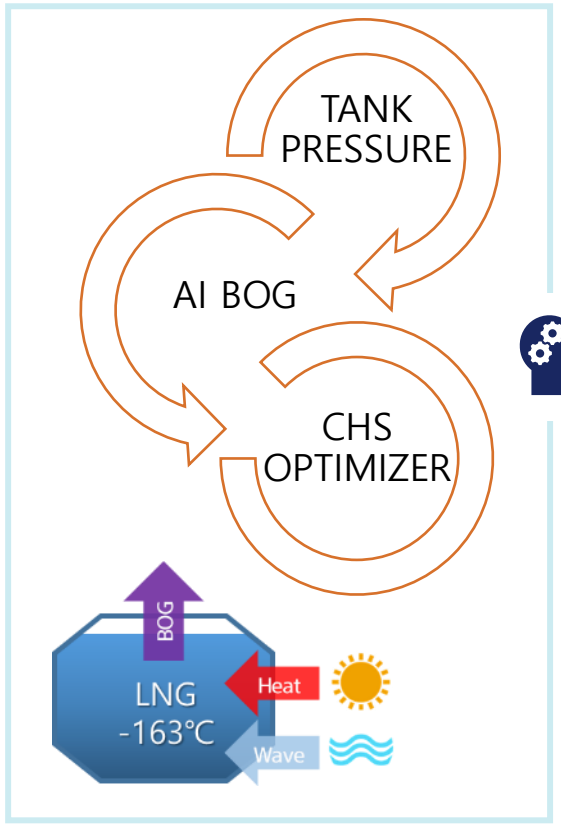
<Cargo Handling System (CHS) of LNG carrier>

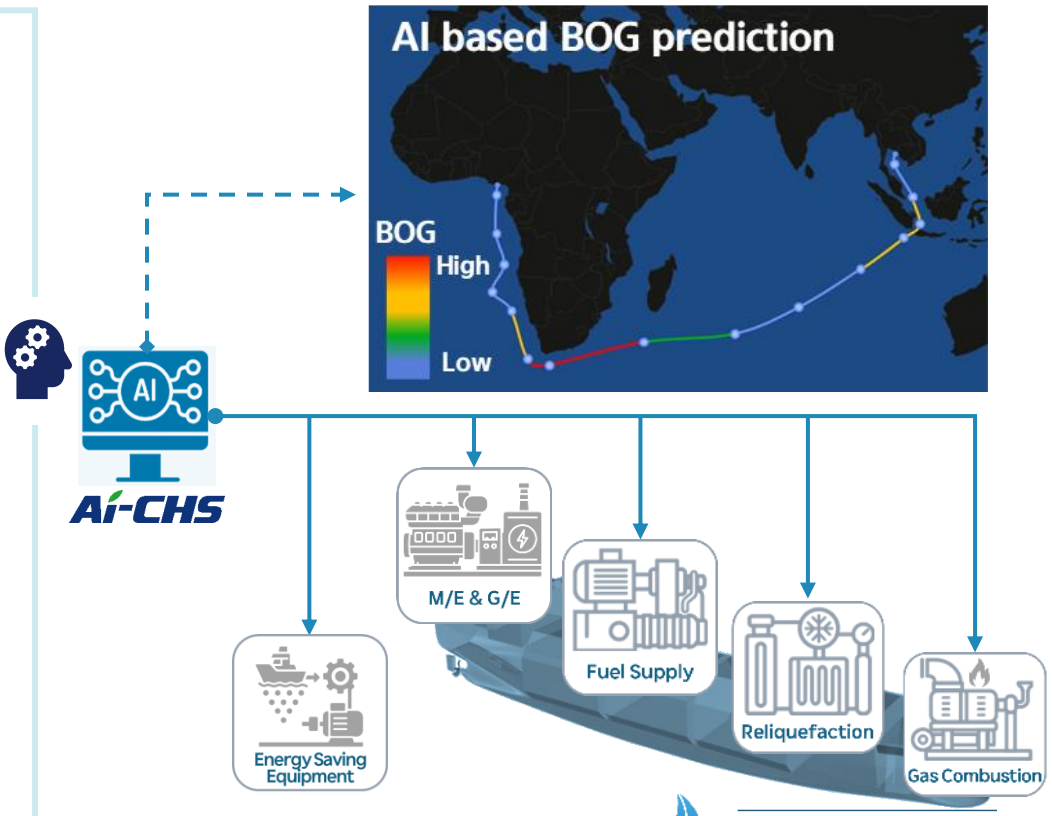
What is AI-CHS Solution?

Basic concept of AI-CHS Solution

INPUT → MODEL → OUTPUT

1. **WEATHER FORECAST**
   - Sea Condition
2. **VOYAGE PLAN**
   - ETA, ETD, Route, Port Data
3. **TARGET TANK PRESSURE**
   - Current → Target
4. **CHS EQUIPMENT DATA**



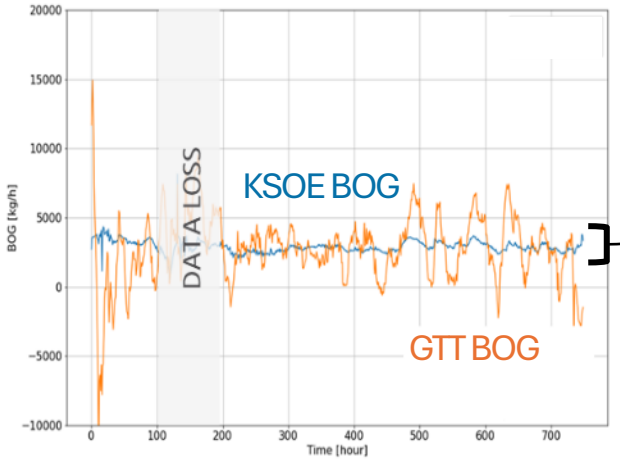


Technical concept of AI-CHS Solution (1)

Technical concept of AI-CHS Solution

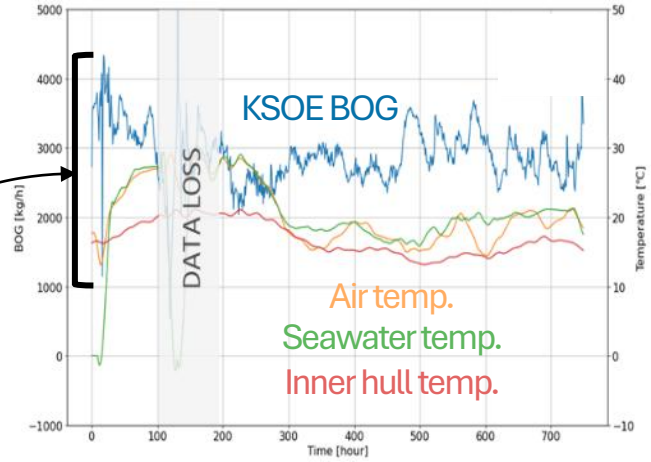
Boil off rate (Cargo heat ingress) = Heat transfer from Atm. (Steady state) + Kinetic energy due to external force = sloshing (Dynamic)

[GTT BOR Equation vs KSOE BOR equation]



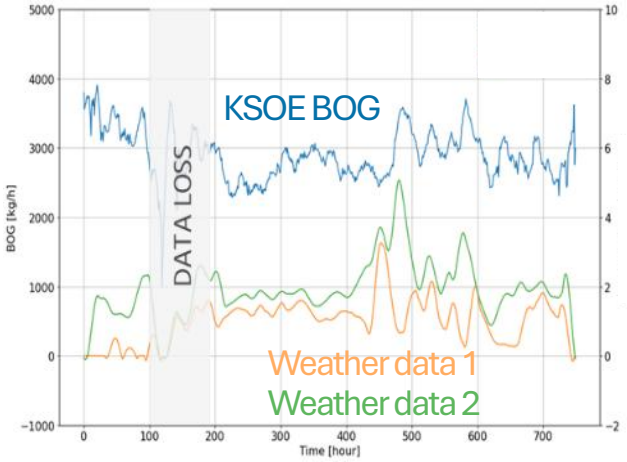
Conversion of a voyage-scale formular (GTT) to an hourly-scale formula (KSOE)

[BOG vs Temperature]



Correlation between **BOG and ambient temperature** is **weak**

[BOG vs other weather data]

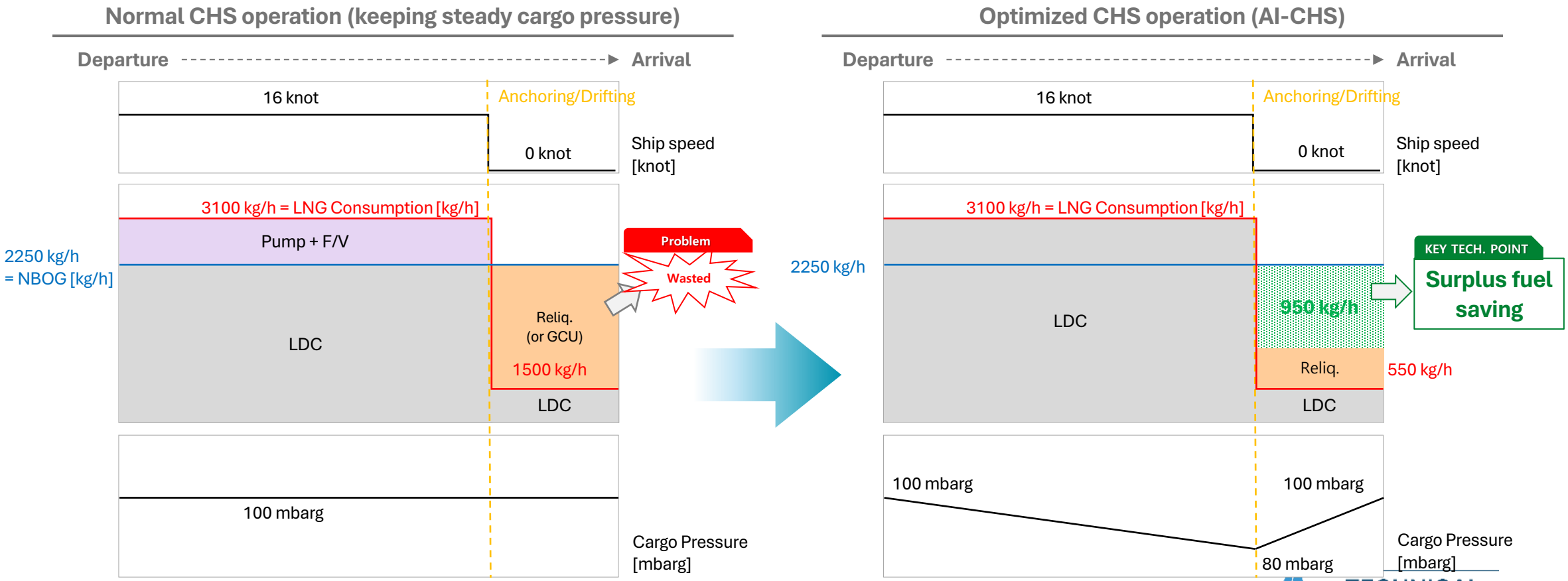


Correlation between **BOG and other weather data** is **strong**

Method	Purpose	Target condition	Parameter	BOR range	Correlation	ETC
Typical BOR Equation	BOR guarantee	**1 voyage**, Laden	Ambient Temp., Cargo/Insulation Temp., Pressure	- 4000 kg/h ~ + 4000 kg/h . (large fluctuation)	No Corr.	
KSOE Real-time BOR Equation	Real-time BOR evaluation	**1 hour**, Laden / Ballast		around 2000 kg/h (small fluctuation)	Temp. << WD1, WD2	Patented

Technical concept of AI-CHS Solution (2)

LNG Carrier cargo operating fuel saving concept (= surplus fuel saving)

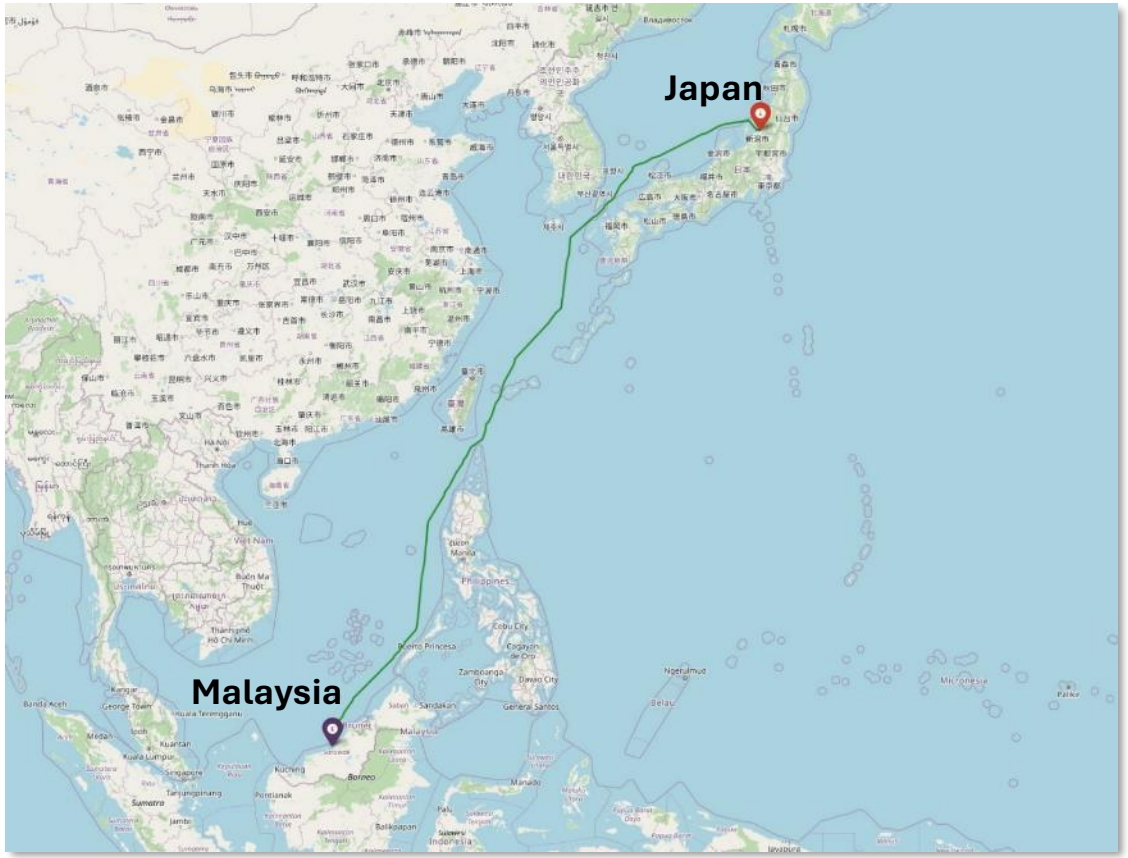


On-board verification of AI-CHS Solution for 174K LNGC

On-board verification overview

- Vessel: 174K LNG Carrier
- Loading: Malaysia
- Discharging: Japan
- Voyage distance: 2,720 nm
- Duration: 258.4 hours
- Loaded cargo volume: 154,809 m^3

<174K LNGC for on-board verification>



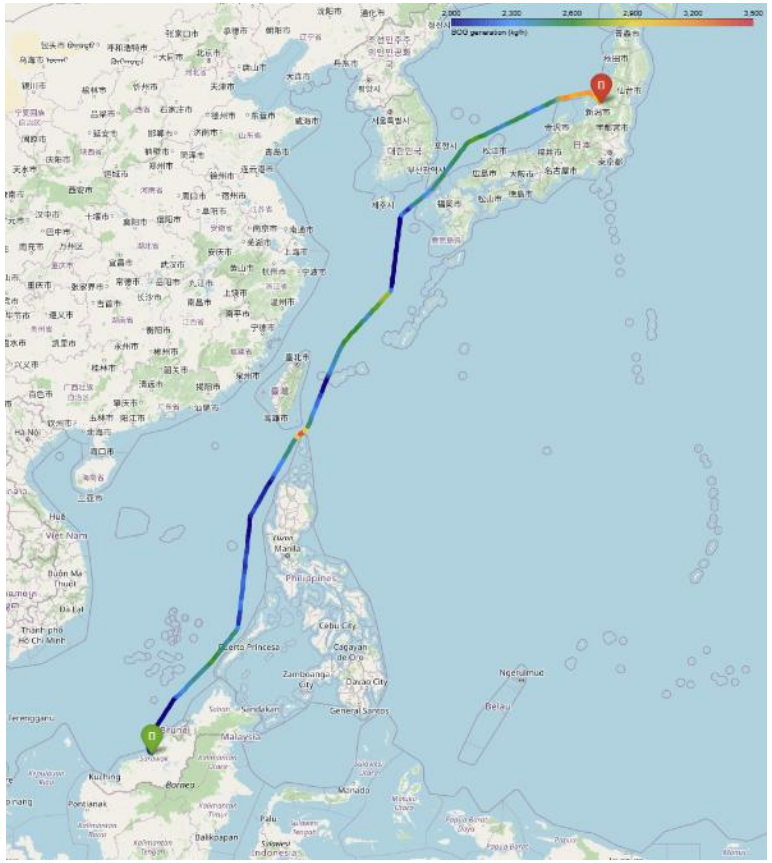
<Voyage route sailed during on-board verification>

Results of BOG prediction by AI

BOG prediction results

- AI-predicted BOG generation was compared with the amount of BOG actually consumed on-board during the voyage, since the direct measurement of BOG generated in the tanks are not possible. ***Difference: 2.23%***
- Predicted BOG:
  AI-predicted amount of BOG generated in the cargo tanks
- Actual BOG:
  LNG/BOG consumed by M/E and G/E + Reliquefied BOG + Accumulated BOG

<Comparison of BOG consumption during voyage and predicted BOG by AI>

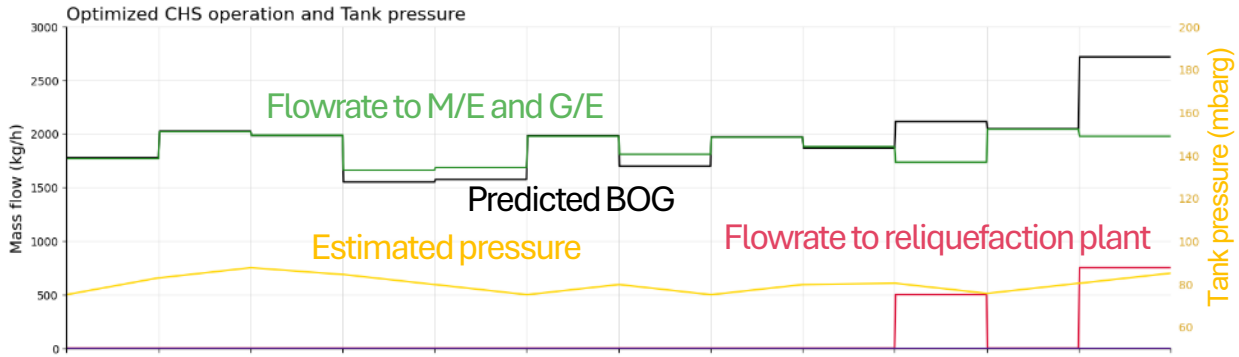


<Voyage route sailed during on-board verification>

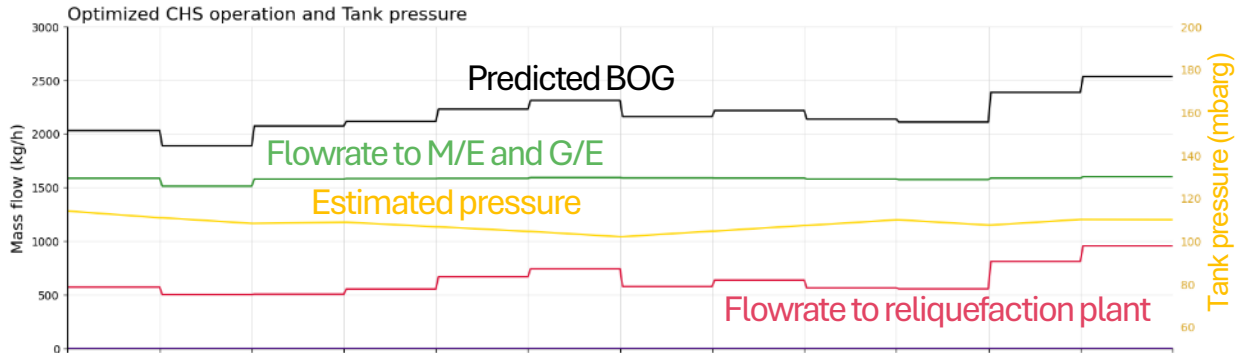
Results of CHS optimization

CHS operation optimization results

- CHS guidance generated after receiving the voyage route and plan is delivered to the Captain
- Operated as close as possible to the initial CHS operation guidance
- Operated as close as possible to the re-issued CHS operation guidance after reflecting the subsequent voyage schedule changes



<Initial CHS operation guidance>



<CHS operation guidance in latter part of voyage>

Conclusion

» **HD provides Customized, Integrated and Reliable solutions for Decarbonization Era with uncertainties and rapid changes**

Customized

Incomparable R&D Capability

1,750+ employees for R&D

Tailor made cutting-edge solutions
for various market demand

Integrated

Seamless Integrated Solution

A to Z Hull form, M/E, G/E, CHS, Automation, ESDs, etc.

Comprehensive solutions
for optimal performance

Reliable

Extensive Shipbuilding Experience

171 for LNGC

Proven track records
for successful construction (Delivery)

- As of July, 2024

TOTAL SOLUTION PROVIDER
FOR A SUSTAINABLE FUTURE

HD HYUNDAI