The Research Council of Norway

DNV·GL

KONGSBERG

NTNU AMOS
Centre for Autonomous Marine Operations and Systems

NTNU – Trondheim
Norwegian University of Science and Technology

Hybrid Power Plants

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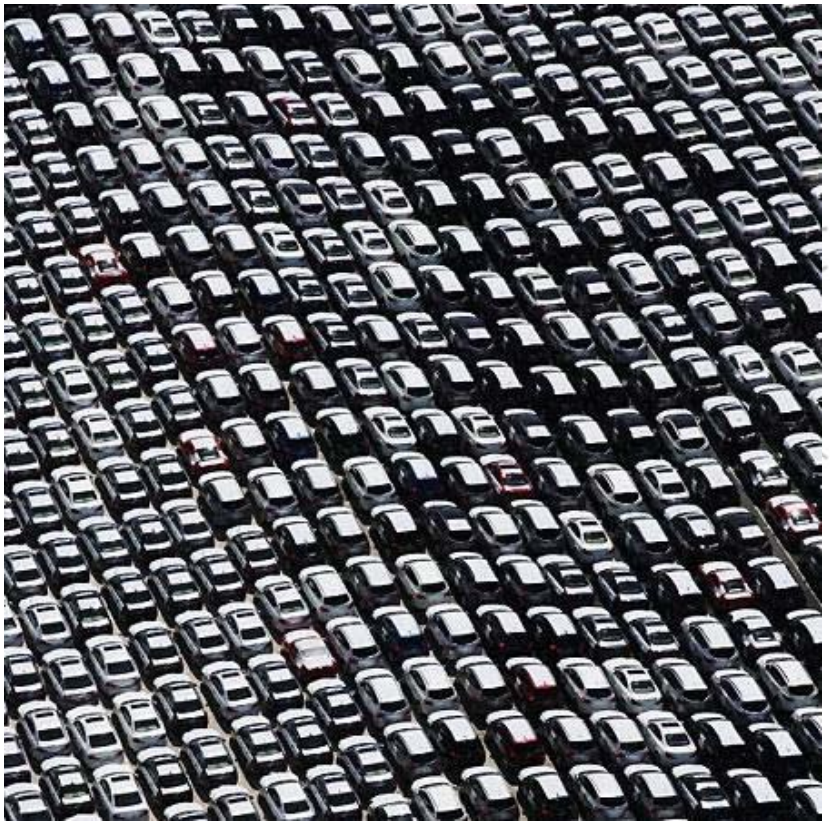
Gas emissions

Fuel ≈ 75,000
CO_2 ≈ 75,000
NO_x ≈ 2,000,000
PM ≈ 2,500,000

Fuel ≈ 6,000
CO_2 ≈ 6,000
NO_x ≈ 70,000
PM ≈ 100,000

Fuel ≈ 400
CO_2 ≈ 400
NO_x ≈ 7,000
PM ≈ 12,000



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Gas emissions

Annual Nox emissions from shipping in Bergen

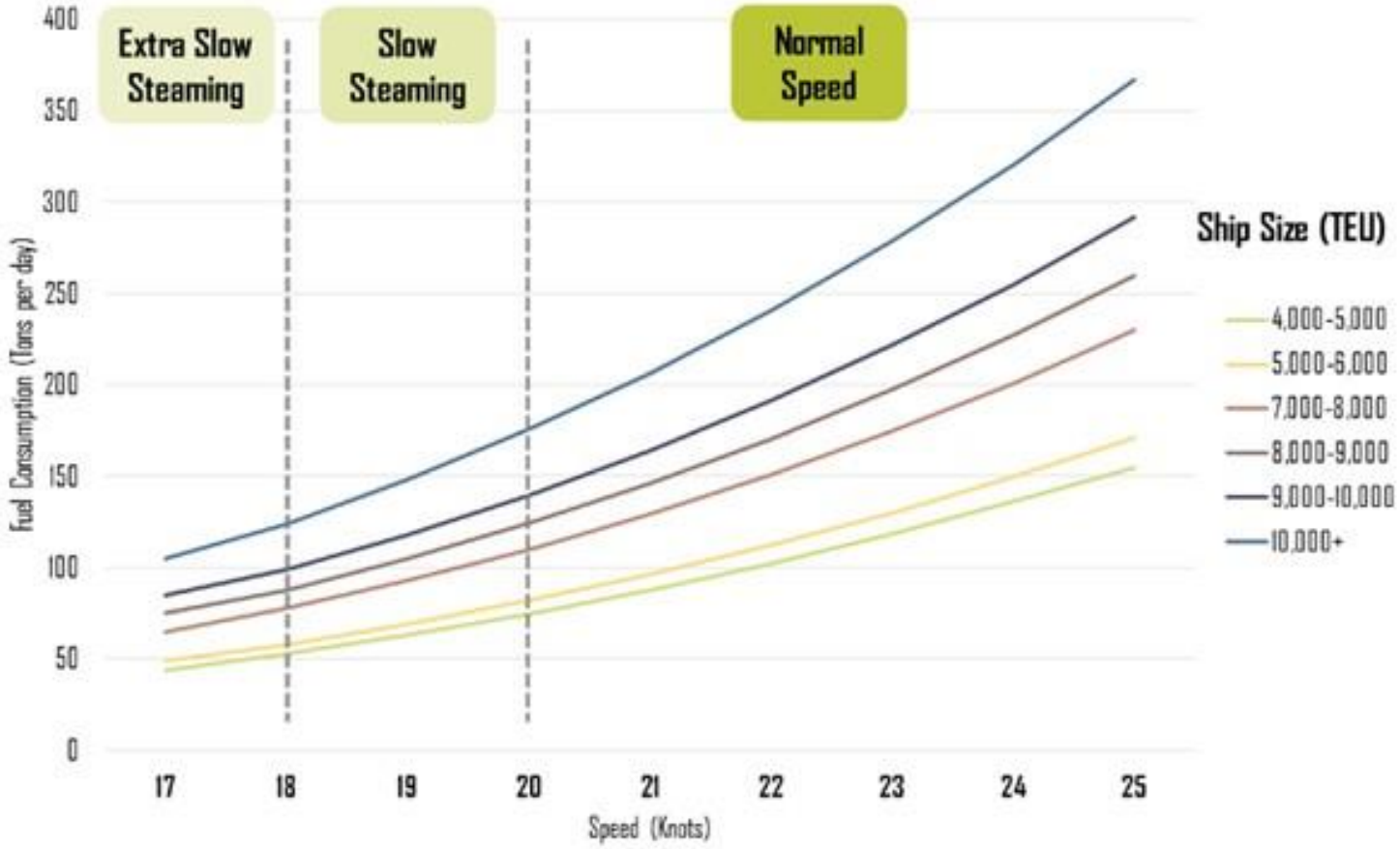
≈

Annual Nox emissions from 250 000 cars driving 7500 km in Bergen

Bergen has approximately 100,000 registered cars


NORWEGIAN SPIRIT

Fuel cost



For example, the ship “The Norwegian spirit”
consumes ≈ 4200L of diesel per hour (in transit)
That means that it can cost up to US$20 000 000.00

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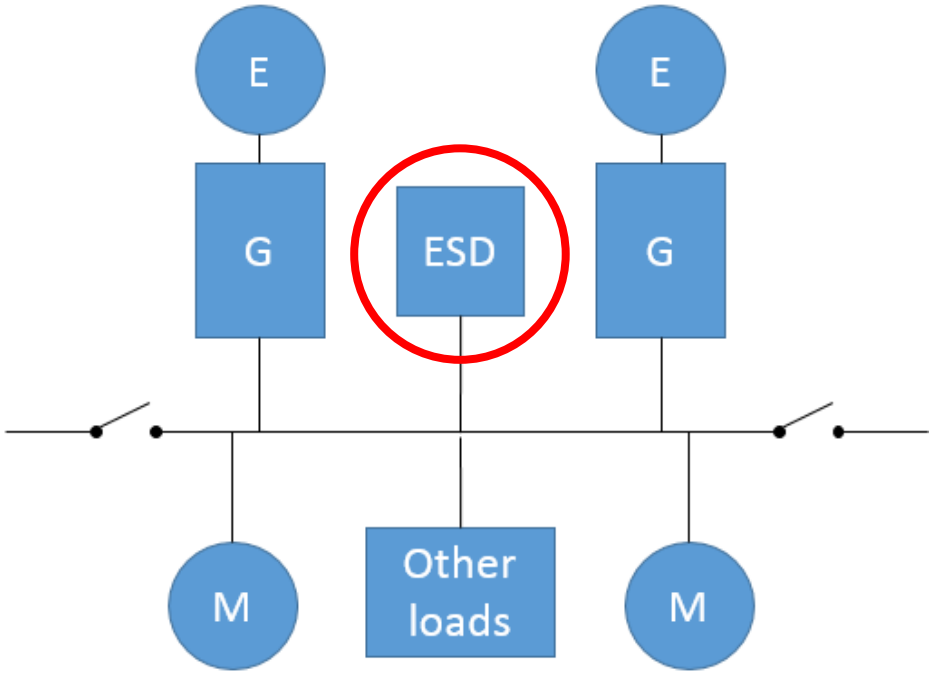
Source: DNV-GL

Hybrid power plants

What is a hybrid power plant?



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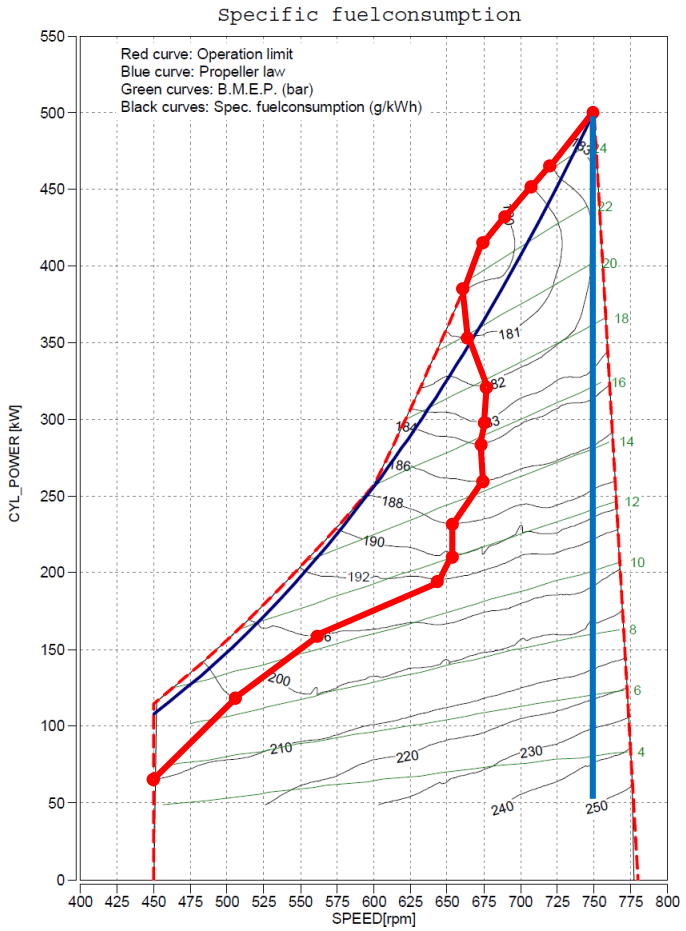
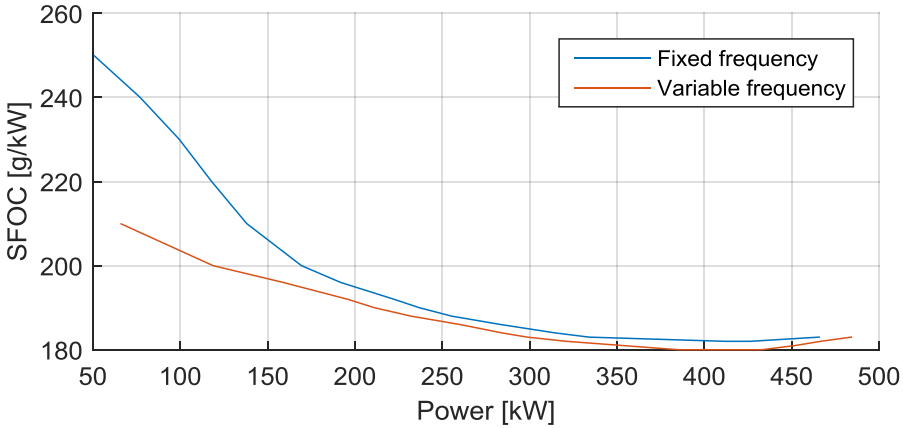
Generator-set fuel consumption





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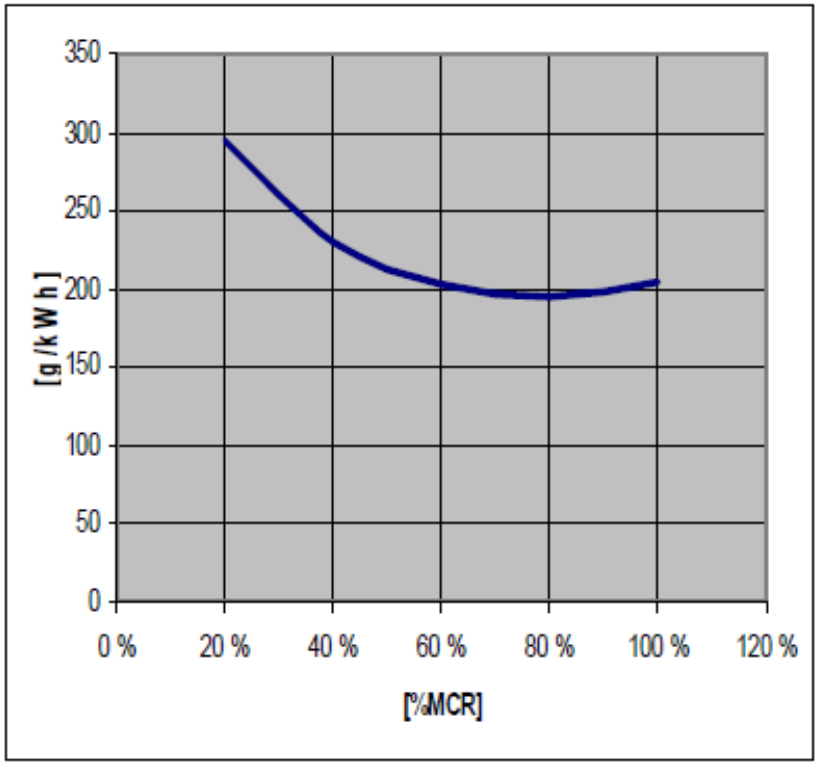
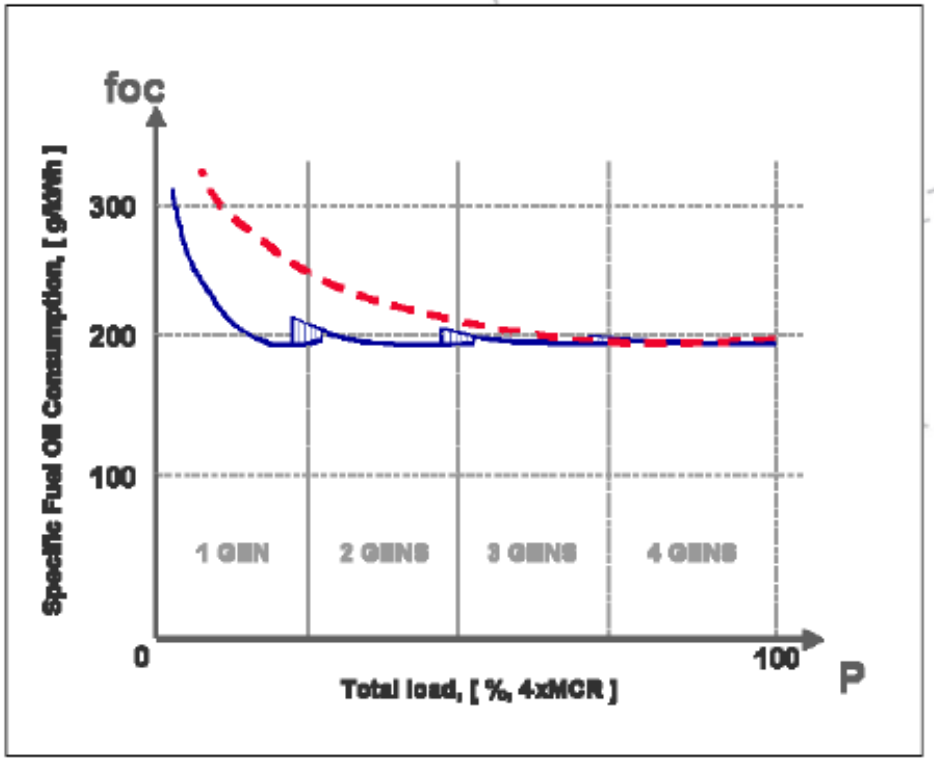
Prime Mover – Medium Speed Diesel Engine



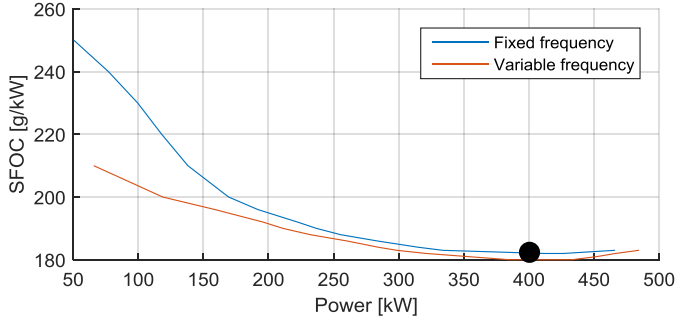


MCR: Main Continuous Rating

Multiple gensets: Redundancy

Configuration 1

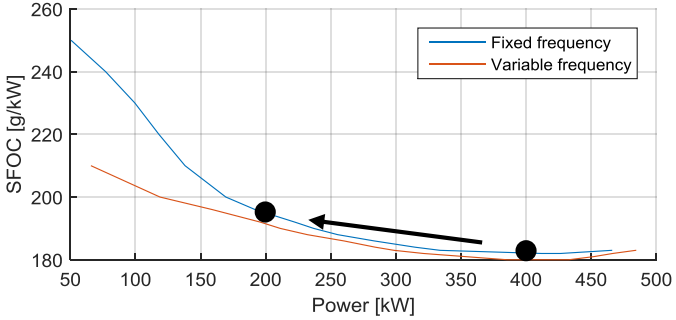
1x



- Power = 400kW
- Reduced SFOC (lower fuel consumption)
- No redundancy

Configuration 2

2x



- Power = 2*200kW
- Increased SFOC (higher fuel consumption)
- Redundancy

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Hybrid power plants

PROS:

- Reduced gas emissions (CO_2, NO_X, etc)
- Lower operational cost
- Increased safety and redundancy
- Compliance with new environmental rules and regulations

CONS:

- Increased complexity
- Higher initial cost
- Fire hazard
- Heating issues
- New technology, not yet stablished
- Few products available

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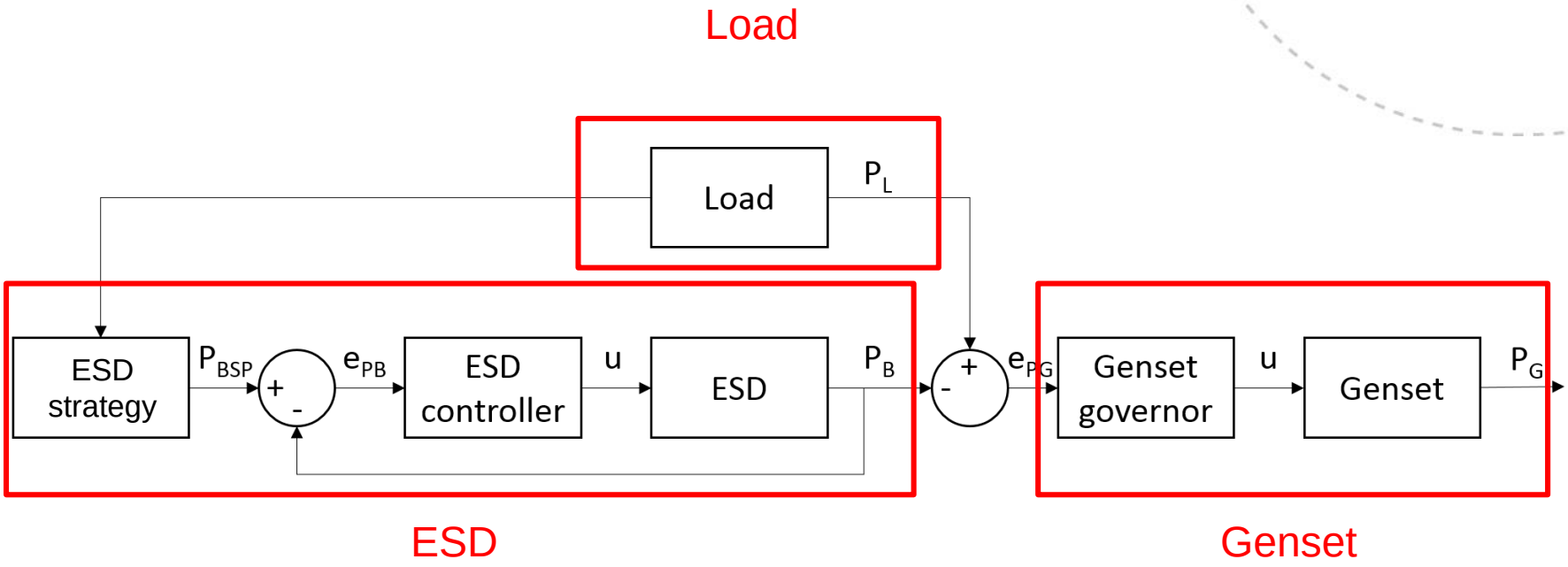

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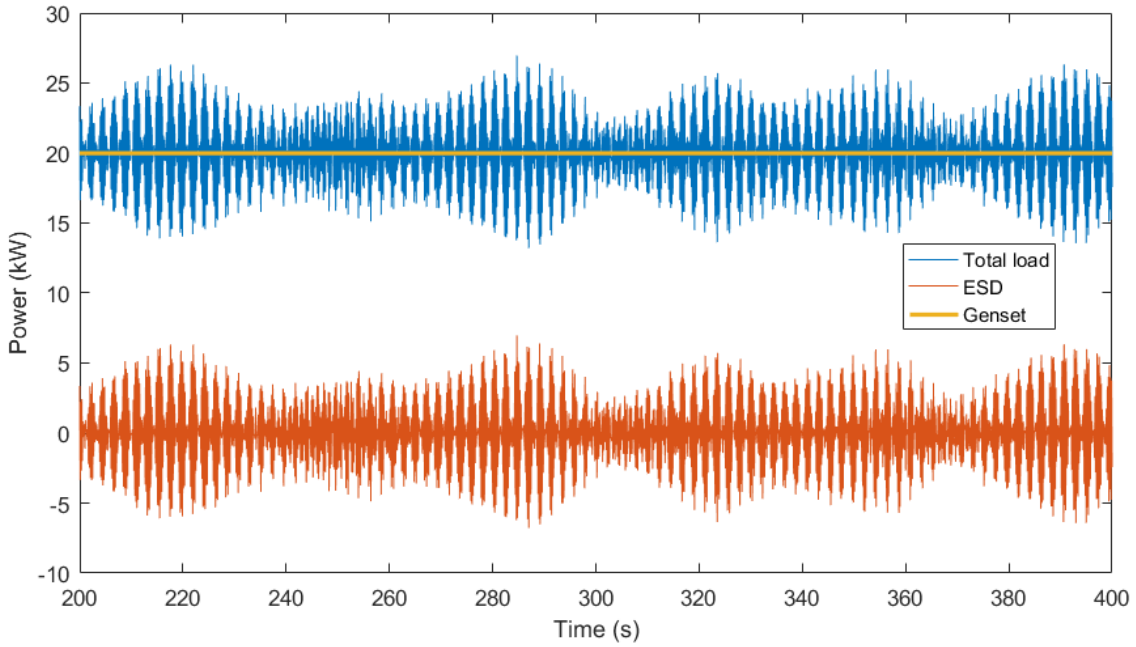
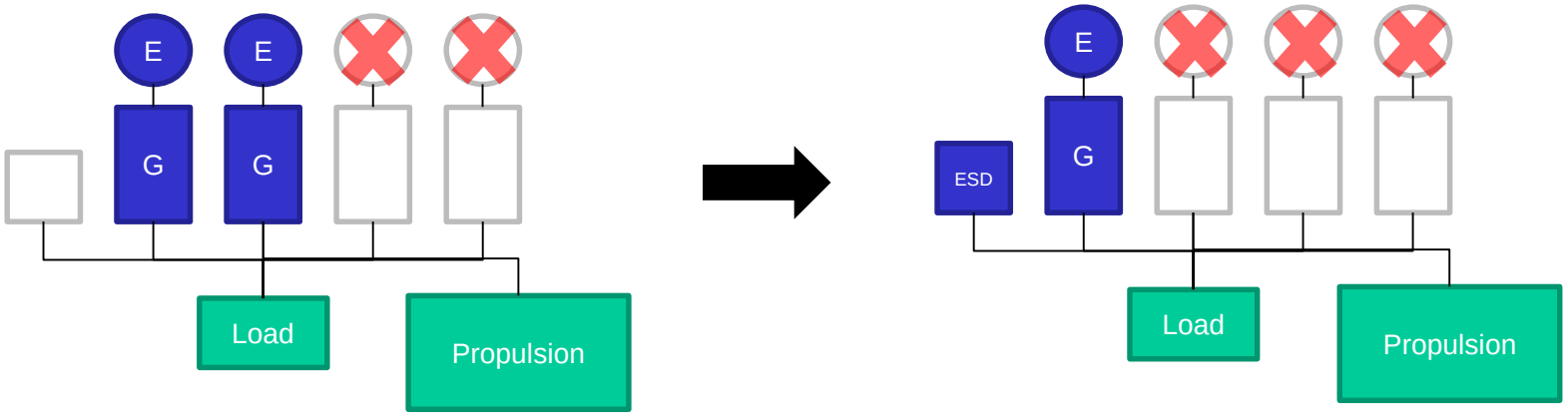
Hybrid system usages: Peak shaving

- Peak shaving removes the high frequency loads in the power bus, the engine is responsible by providing the average load.



Hybrid system usages: Spinning reserve

- An ESD can be used instead of a redundant genset, increasing an engine total loading, where it runs more efficiently.



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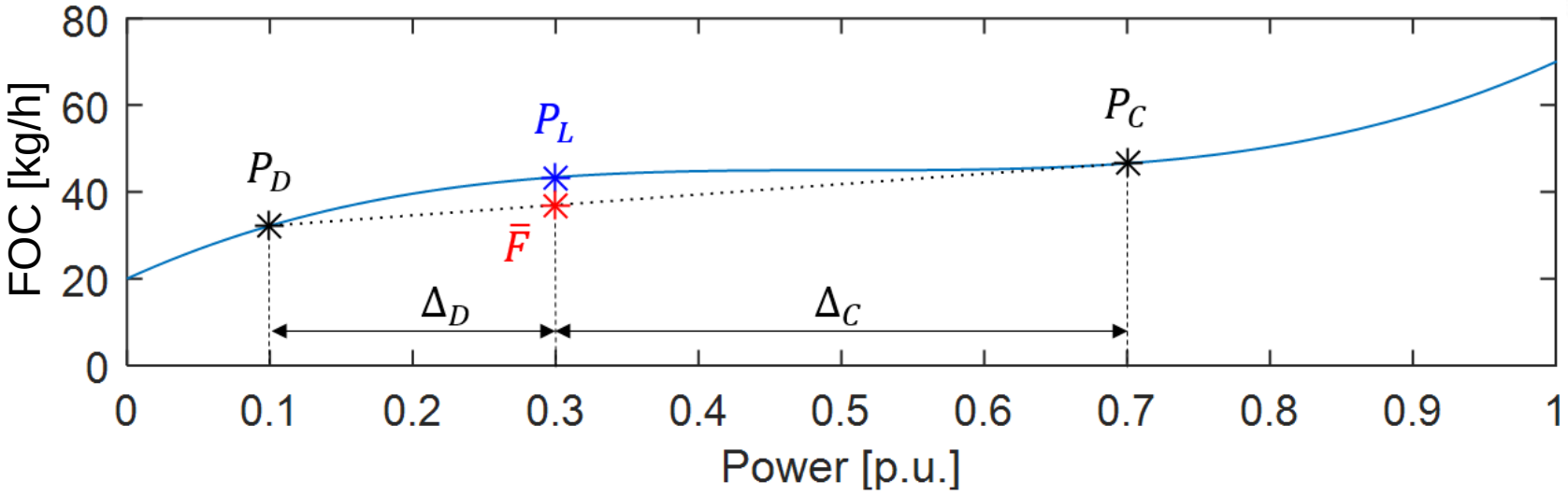
Hybrid system usages: Strategic loading

- Strategic loading goal is to charge the Energy Storage Device (ESD), reducing the Specific Fuel Oil Consumption (SFOC) and discharge it, cyclically.



Example – DNV-GL Fellowship-III vessel

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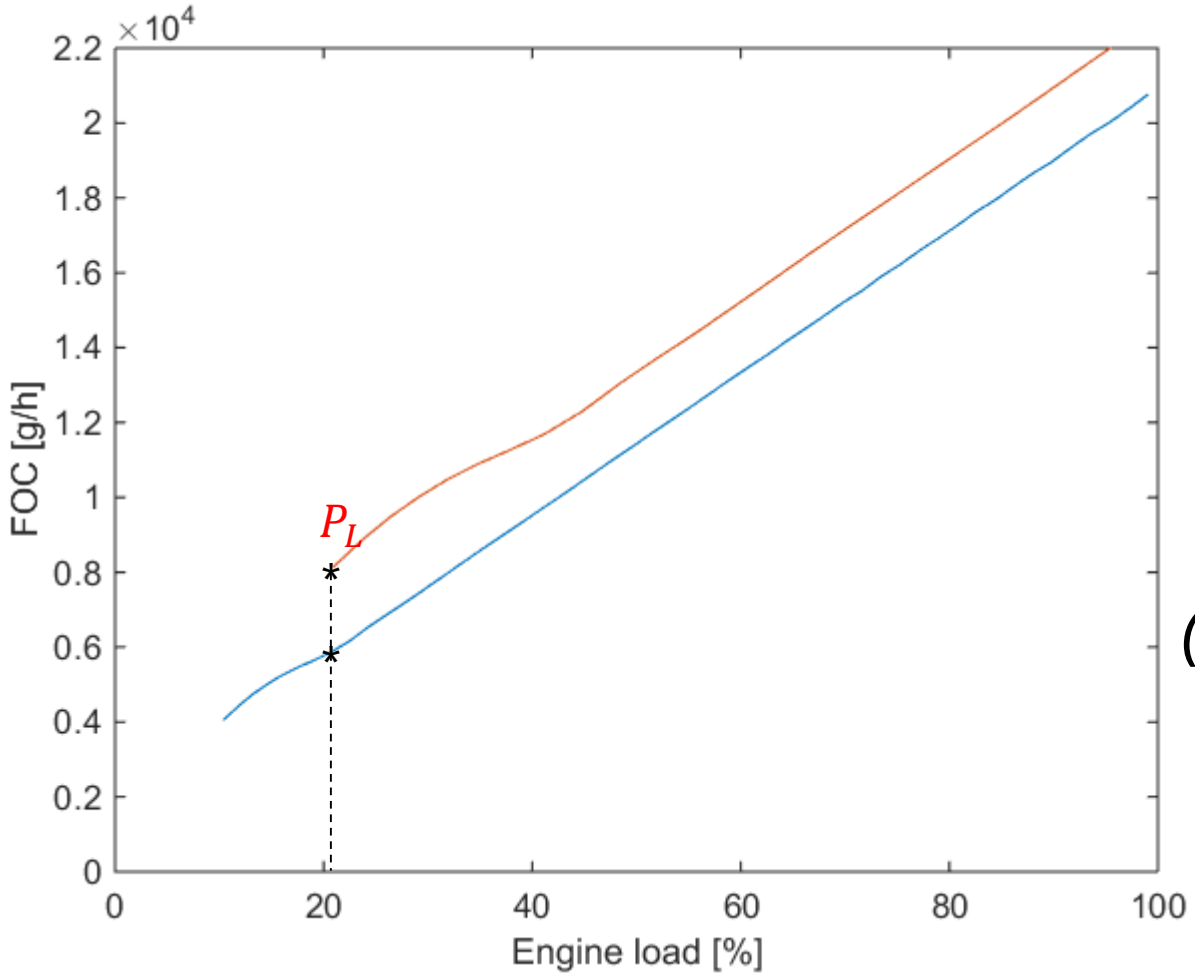
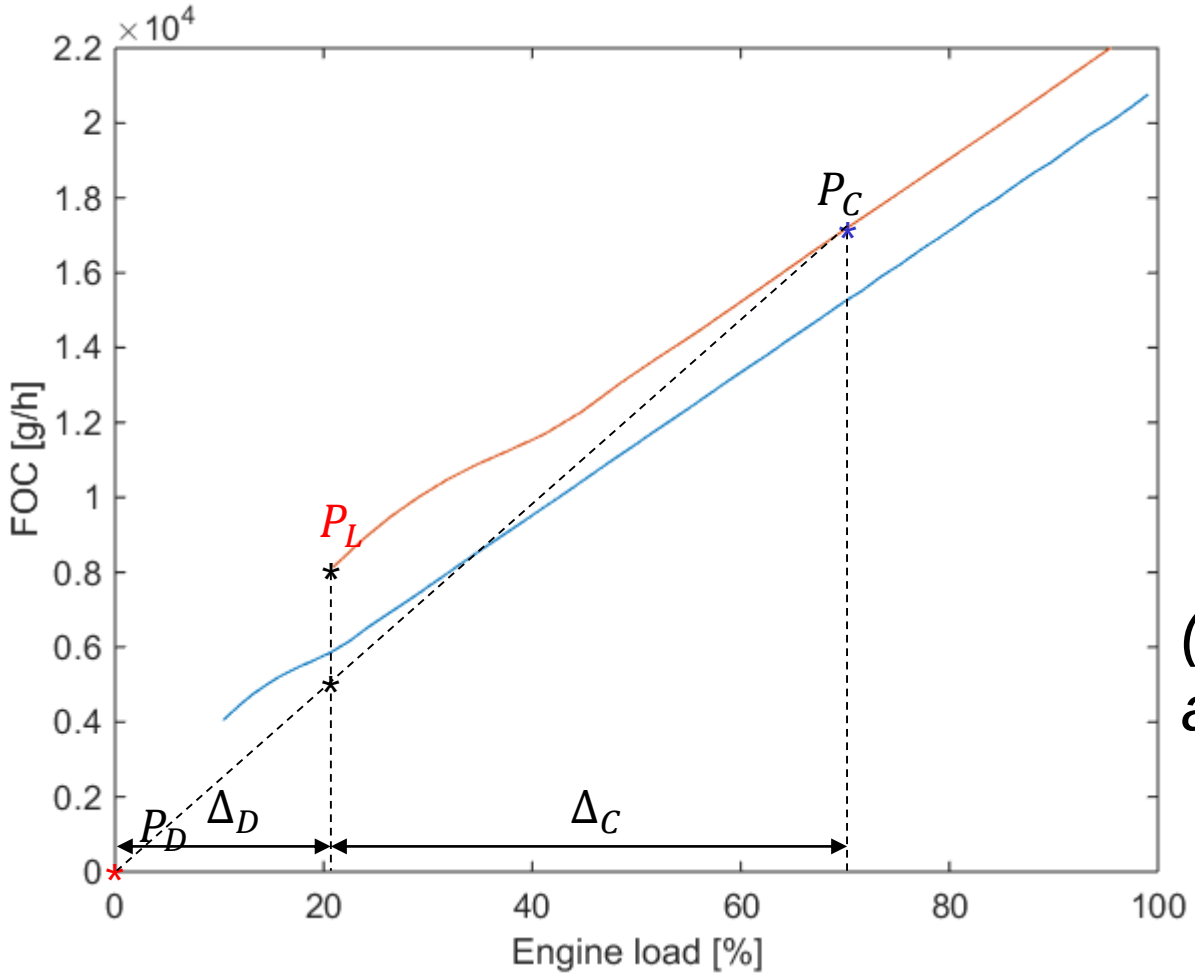


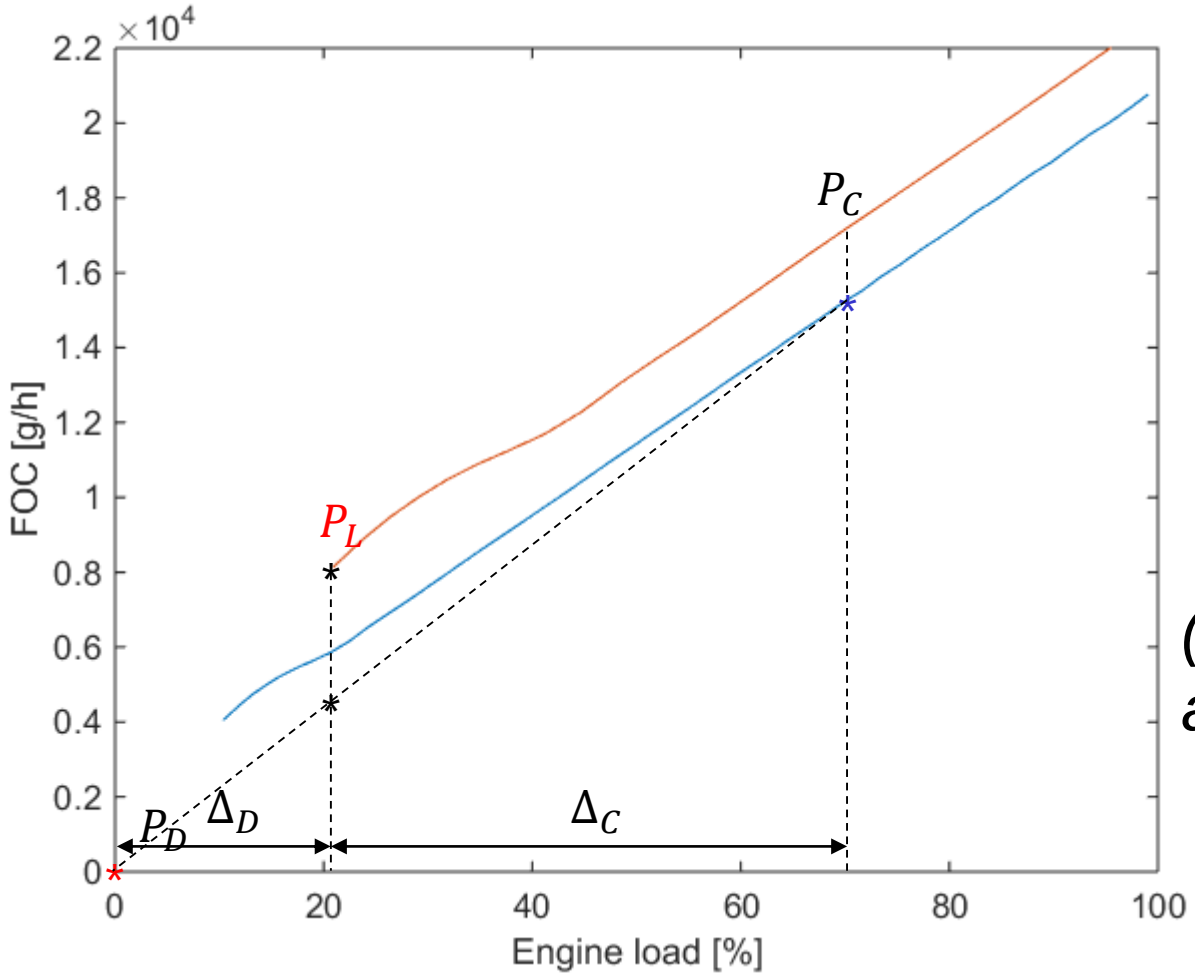
$Reduction$:
$Fuel = 28\%$
$Emissions = 30\%$
(Spinning reserve)

Example – DNV-GL Fellowship-III vessel



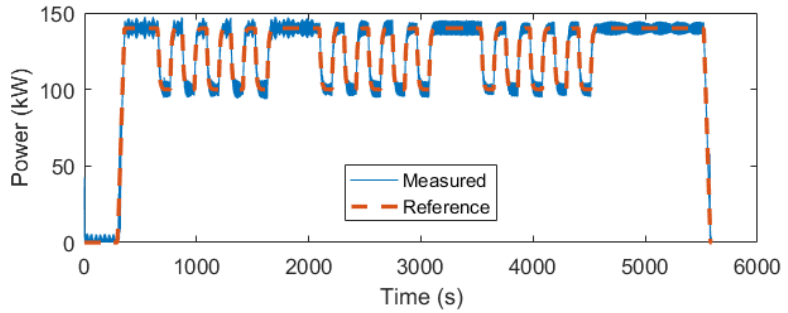
$Reduction$:
$Fuel = 38\%$
$Emissions = 46\%$
(Spinning reserve and strat. loading)

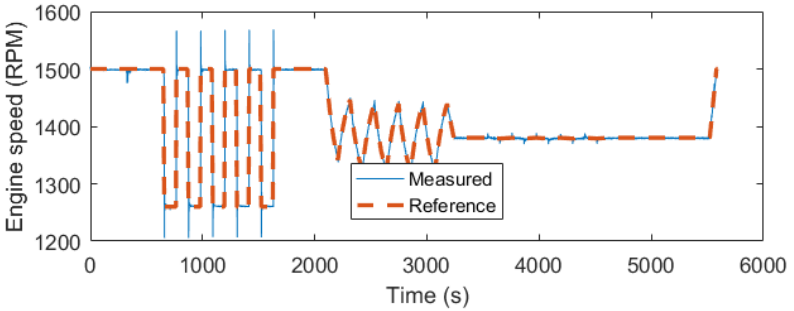
Example – DNV-GL Fellowship-III vessel

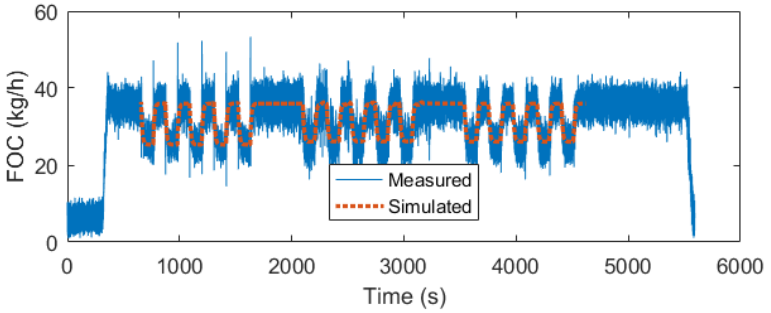


$Reduction$:
$Fuel = 45\%$
$Emissions = 54\%$
(Spinning reserve and strat. loading)

Model validation in the hybrid laboratory







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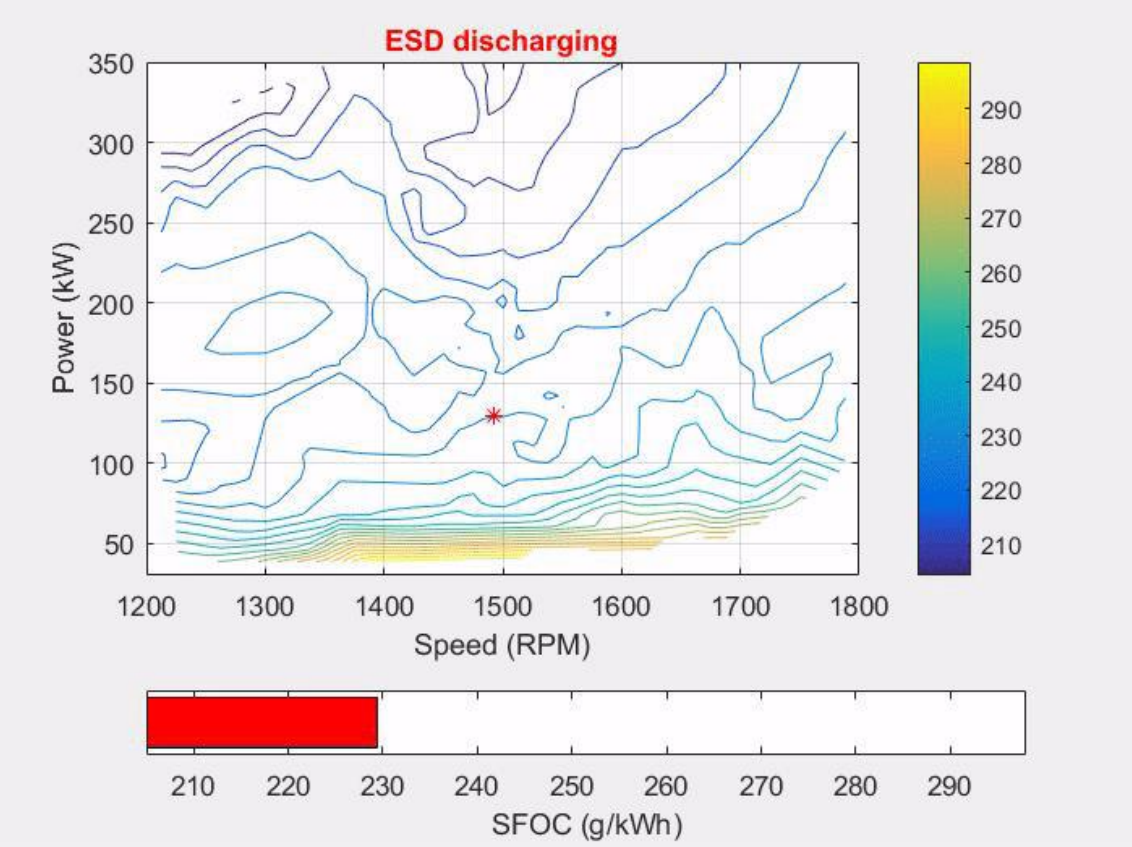
Specific Fuel Oil Consumption Function of Power and Speed



RED means that the ESD is being discharged, decreasing the total load and increasing the SFOC

Green means that the ESD is being charged, increasing the total load and decreasing the SFOC

Even though the SFOC is increased by discharging the ESD, the total fuel consumption should be lowered.

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Why use hybrid power plants?

Hybrid power plant benefits

- Smarter
  - Reduce fuel consumption
- Safer
  - Increase the redundancy and reduce the likely of blackouts
- Greener
  - Reduce emissions

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Thanks for your attention

Questions?

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