AZIPOD USER GROUP MEETING 2017

Batteries & Hybrids

Evaluating opportunities

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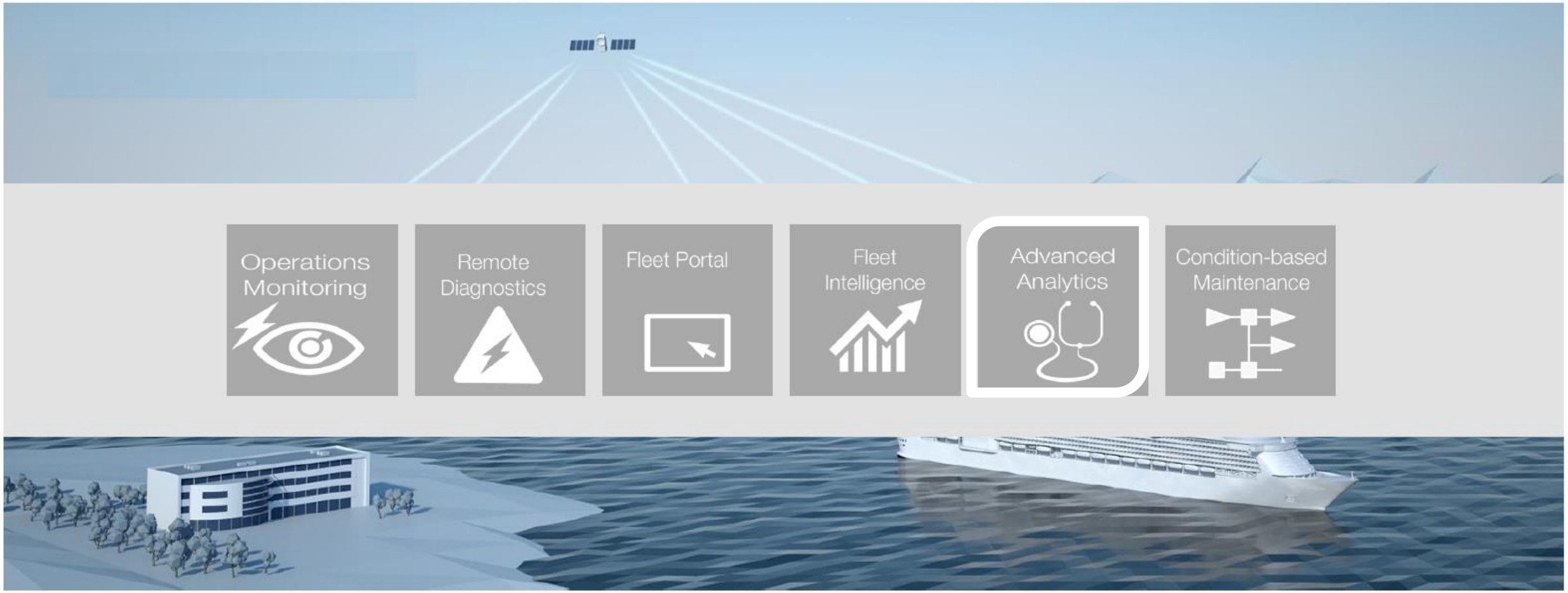
ABB MARINE - DIGITAL SERVICES

Collaborative Operations Solutions



Batteries and Hybrids

Potential Benefits

Concept

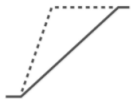
Simulation tool

Case studies

Potential Benefits with Energy Storage

Spinning reserve
Energy Storage system is connected and running, but not charging or discharging energy into the system. On loss of generating capacity it steps in to take the load for a predefined period of time.

Peak shaving
Energy Storage system absorbs load variations in the network so that engines only see the average load.



Enhanced Dynamic Performance
Energy Storage system absorbs sudden load changes and then ramps the change over on running engines.

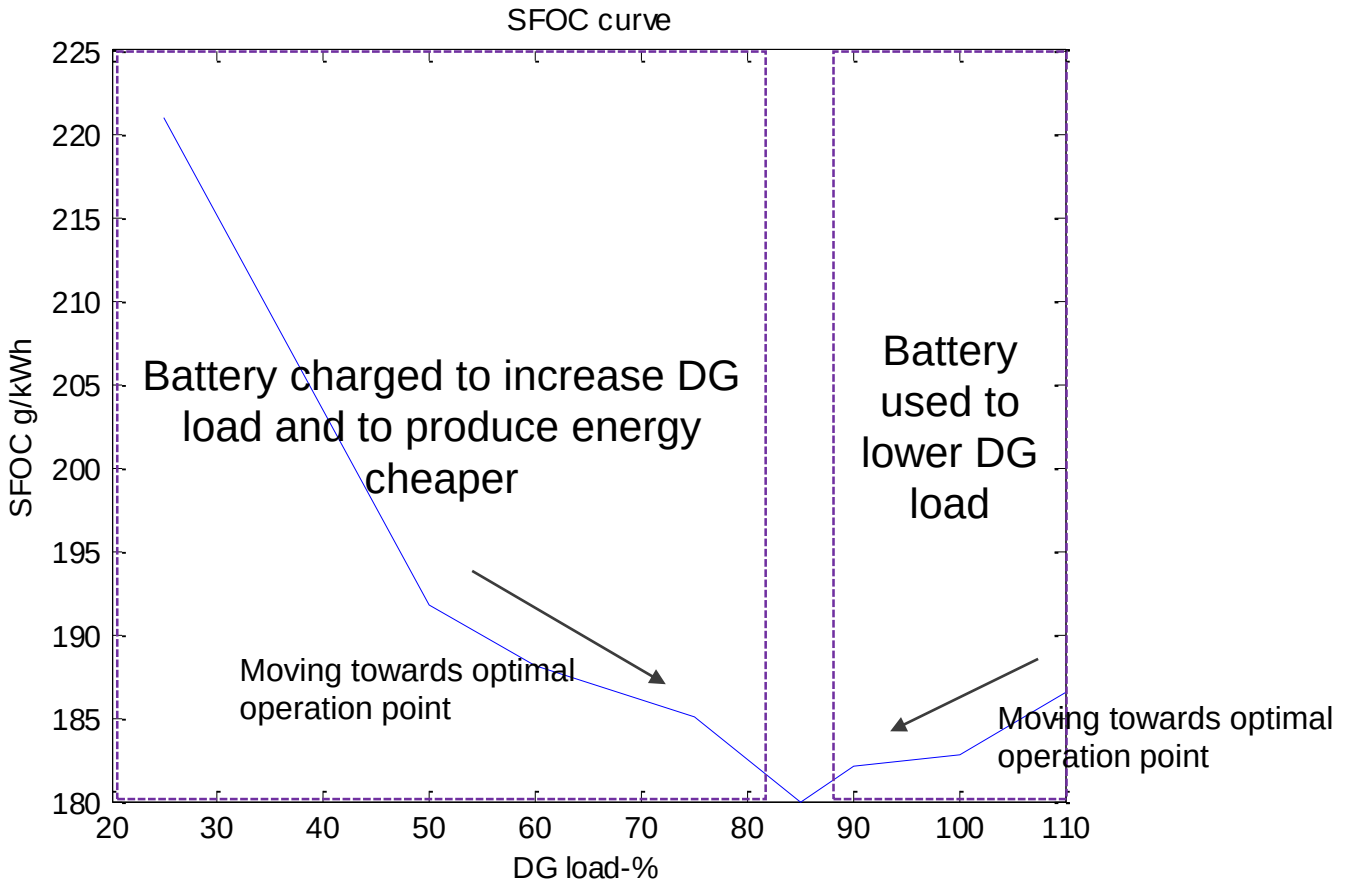
Strategic Loading
Energy Storage system interacts with the power system to optimize engine fuel efficiency.

Zero Emission Operation
Energy Storage system powers the system so that engines can be turned off. This enables things like zero-emissions in harbor.

Enhanced Ride Through
Same as spinning reserve, but on local level in a sub-system like a hotel network or a thruster.

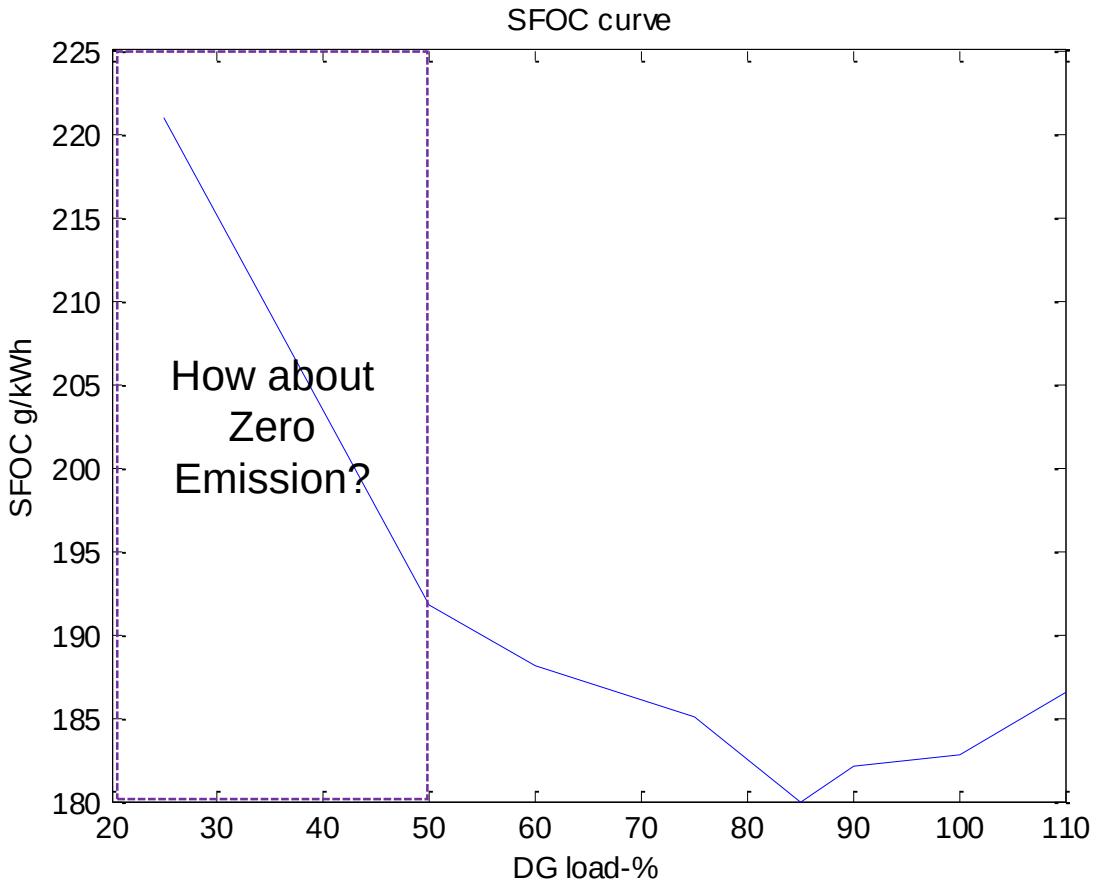
Energy Storage Analysis

Load balancing



Energy Storage Analysis

Load balancing



Energy versus power and life time

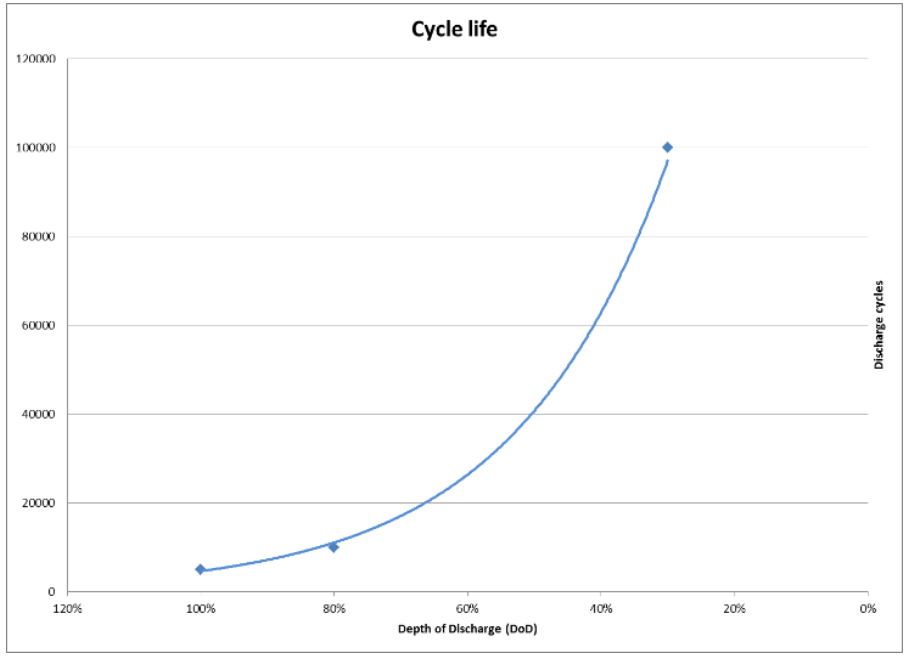
Things to consider

Industrial batteries have 3 vital attributes:

- Energy Density
- Power Density
- Number of Cycles (charges and discharges)

Li-Ion batteries have 16 times more energy content than a Lead Acid battery, and you get 10 times more power (W/kg) out

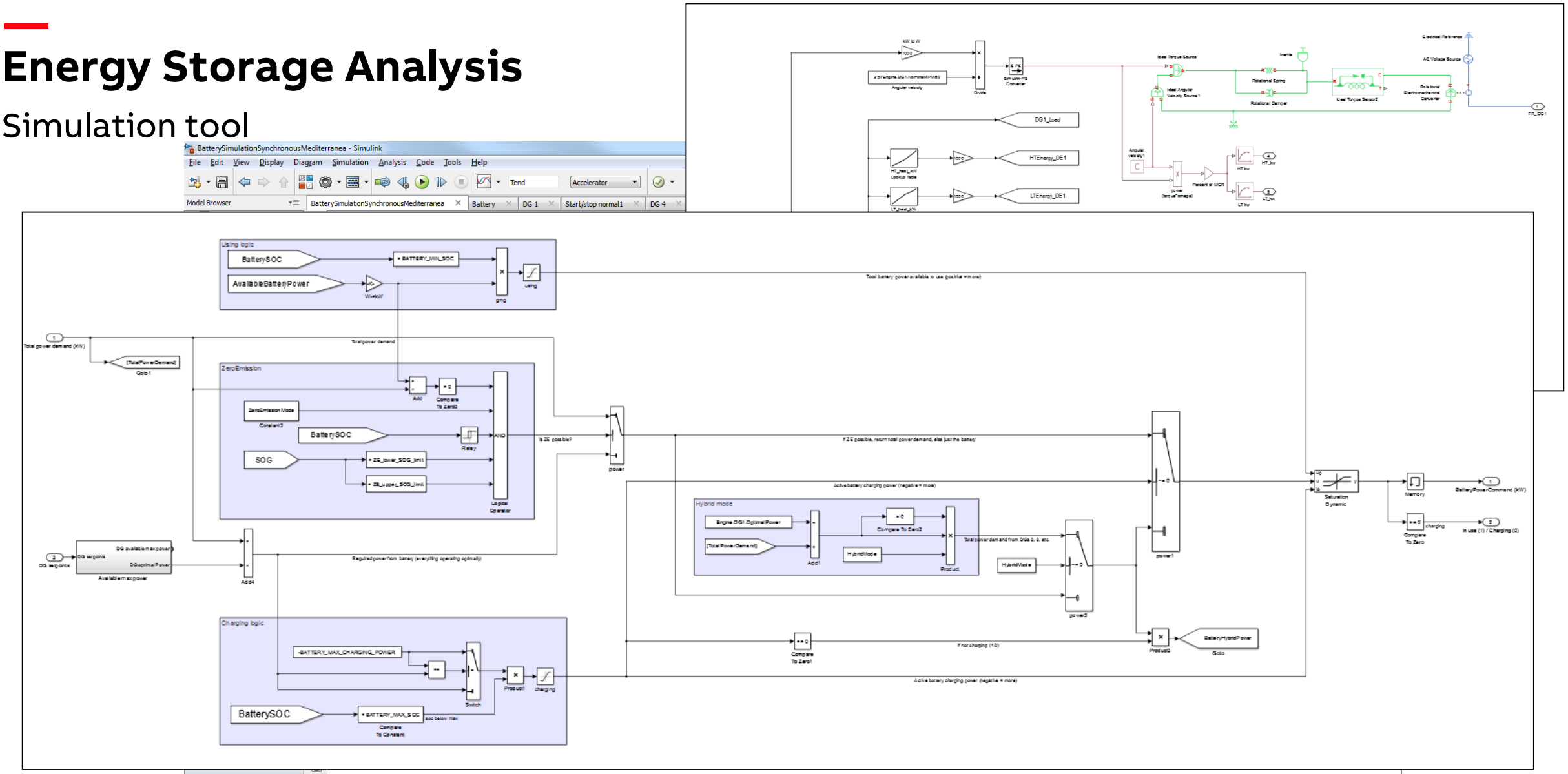
Cycle life versus
Depth of Discharge, DoD



LI-NCA, LI-NMC,
LI-LTO,
LI-LFP, LI-LMO

Energy Storage Analysis

Simulation tool



Energy Storage Analysis

Case Studies

Battery

- Size: 4MWh
- DoD: 60 %
- Maximum charge/discharge: 3 C

Control

- Zero Emission: 0.2 < SOG < 10 knots
- Hybrid Mode: If not ZE and power demand over optimal of smallest engine
- DG maximum load: 90 %
- New DGs won’t be started-up for battery charging

Energy Storage study

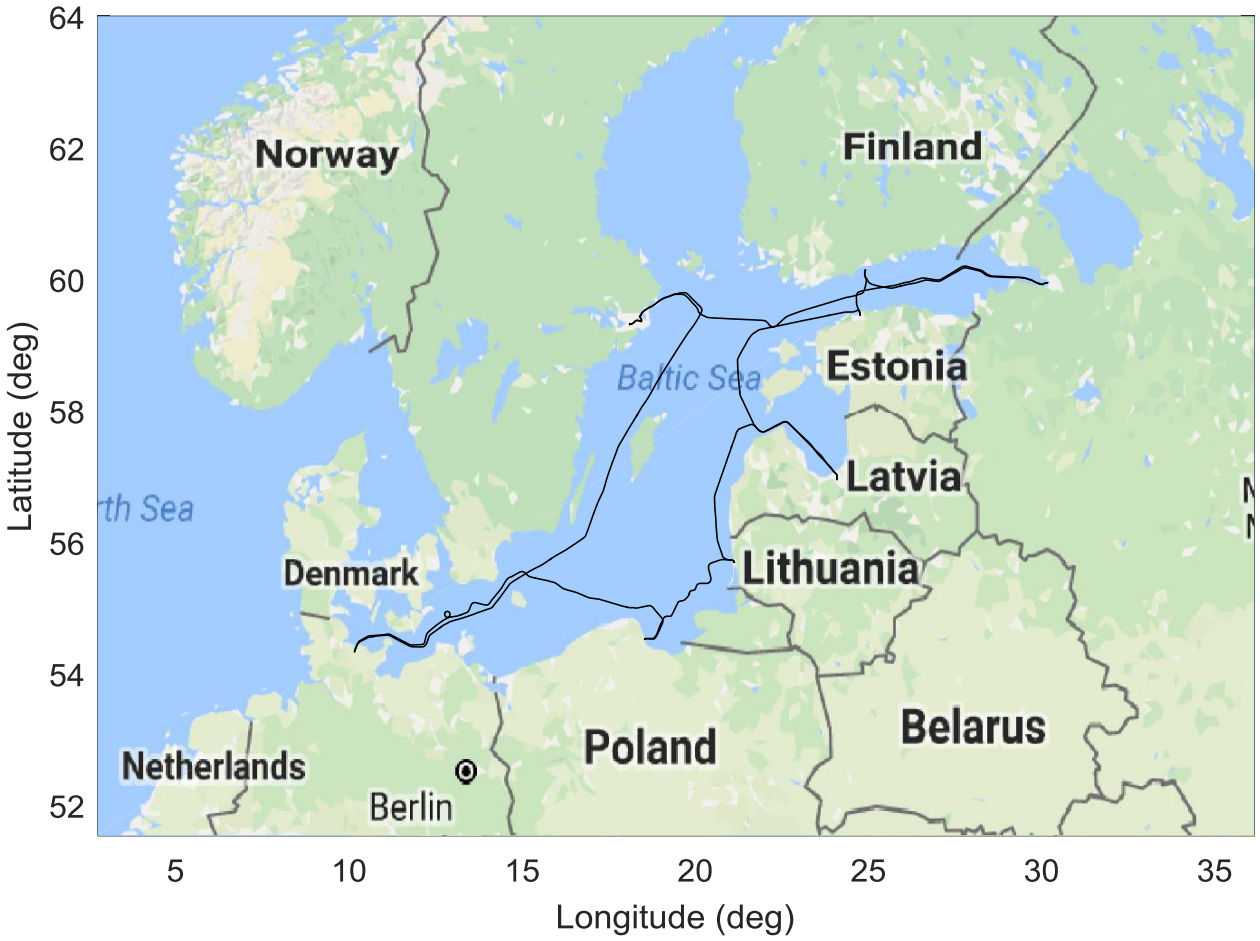
Results

Case	Vessel	Time period	Real fuel consumption	Savings when battery	Battery usage time	Cycles per year	ZE/Hybrid time**	Expected battery lifetime
ZE	Star Destroyer I	8.-15.5.2016	211.0 ton	6.6% (1.9%)	1883 min (27.7%)	834 (16)	269 min/ 0 min	14.4 years
ZE + hybrid	Star Destroyer I	8.-15.5.2016	211.0 ton	3.6% (3.3%)	5528 min (81.2%)	2700 (52)	110 min/ 1901 min	4.4 years
ZE + hybrid	Star Destroyer II	18.-22.5.2016	141.4 ton	2.33% (1.89%)	3126 min (80.7%)	1154 (11)	189 min/ 1392 min	10.4 years
ZE + hybrid	Death Star	3.-10.6.2016	406.1 ton	3.5% (3.5%)	6870min (68.1%)	521 (10)	60 min / 2819 min	23 years
ZE + hybrid	Death Star II	28.4.-8.5.2015	708.3 ton	4.4% (4.4%)	10200min (66.8%)	723 (27)	20 min / 4840 min	16.6 years

* Numbers are excluding port time (SOG < 0.1 knots)
** Longest period for ZE was 20 minutes

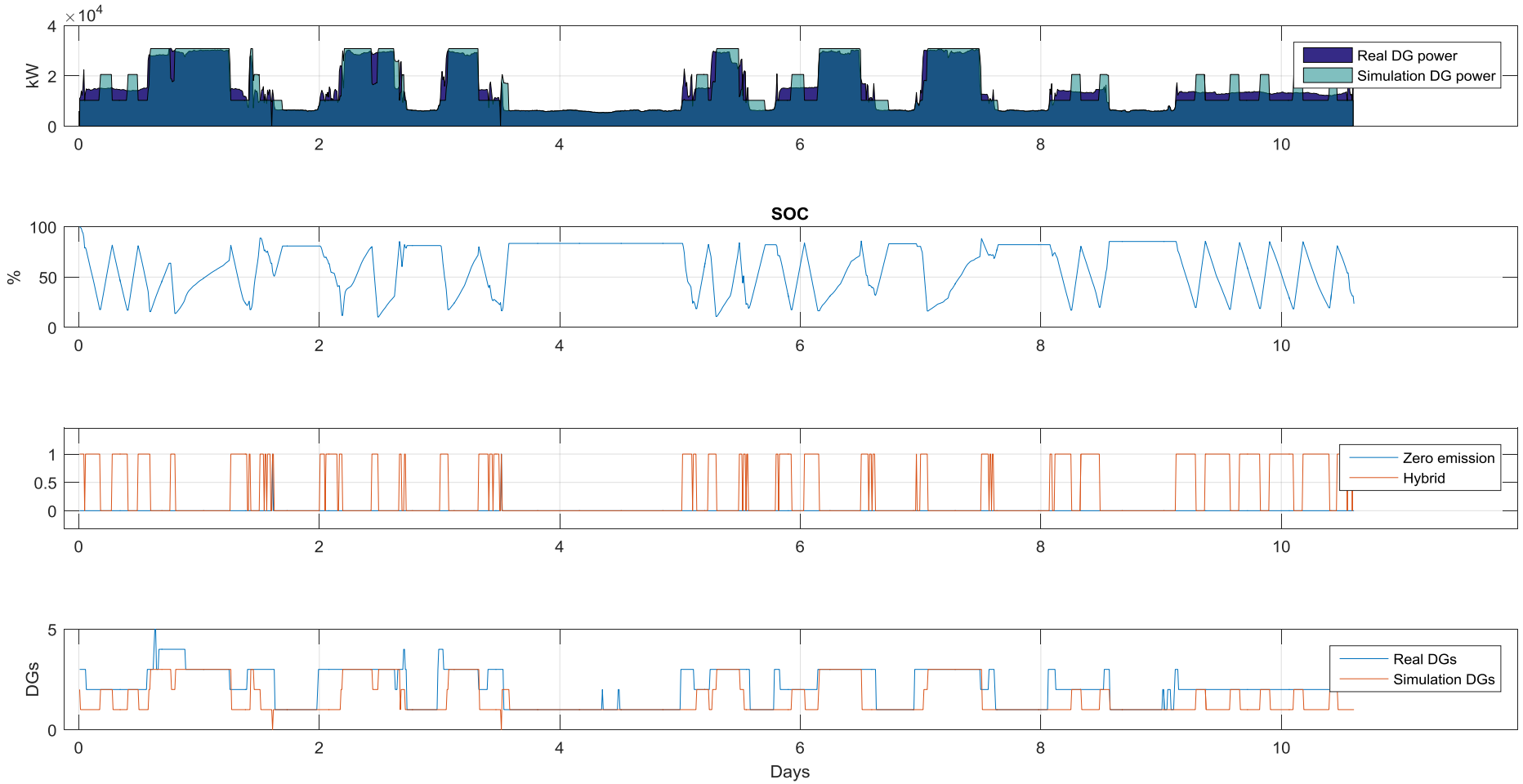
Death Star - Baltic Cruise

ZE + Hybrid



Death Star – Baltic Cruise

ZE + Hybrid



Death Star – Baltic Cruise

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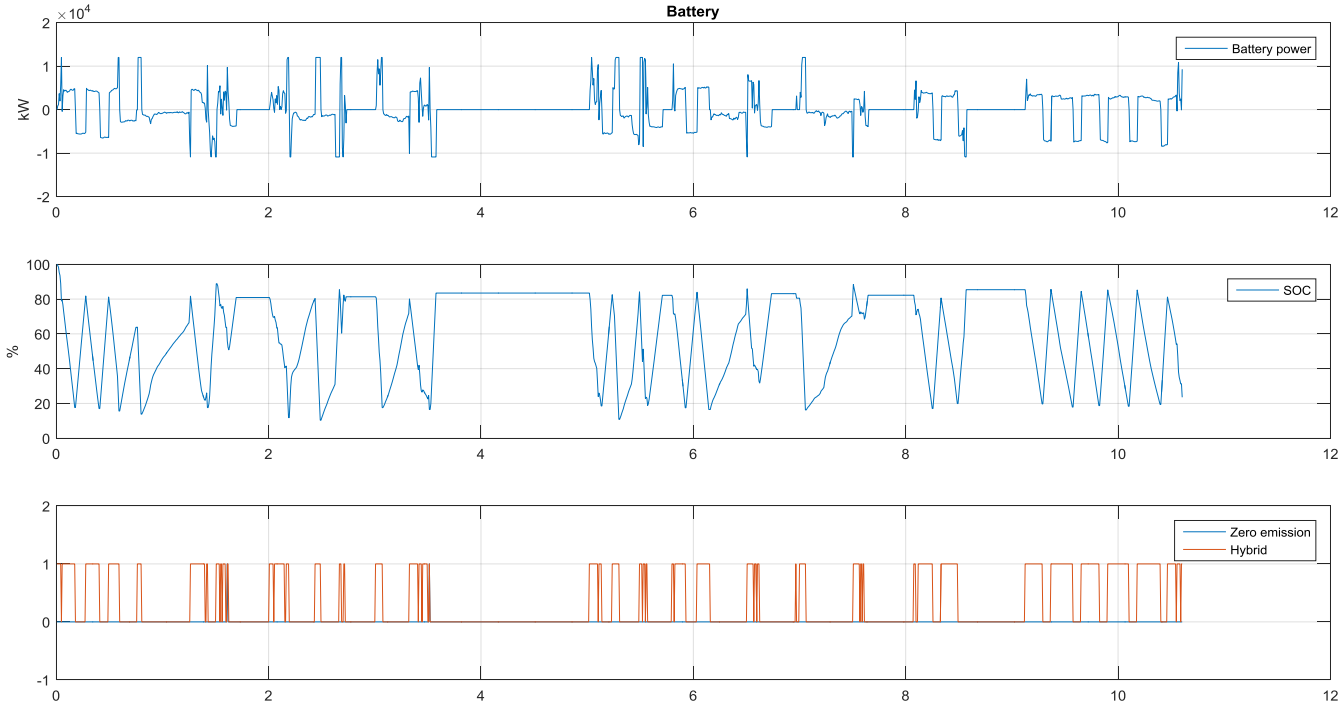
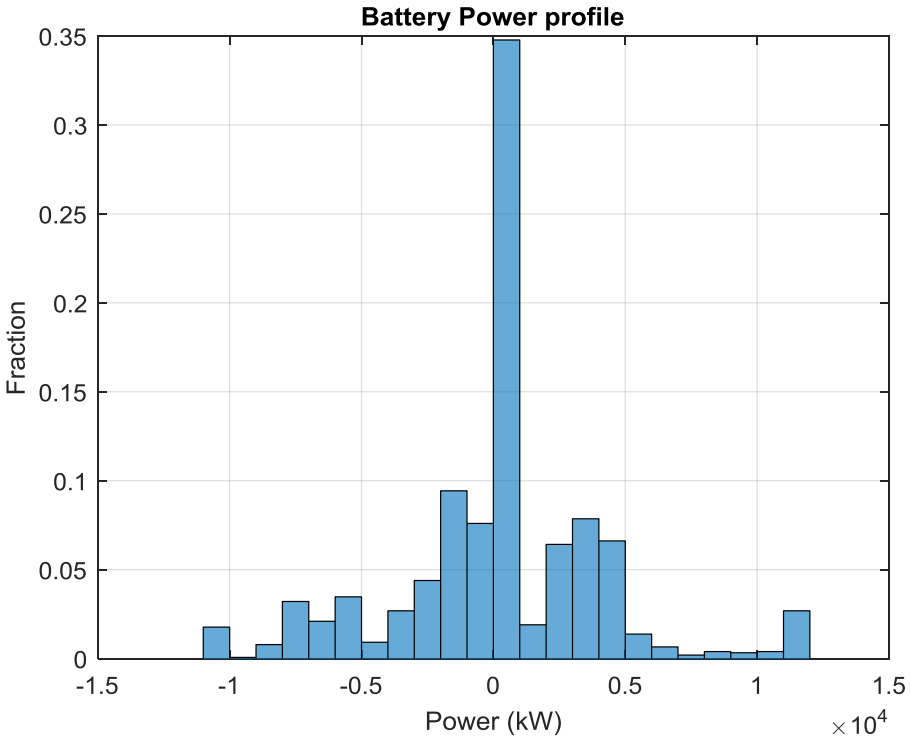
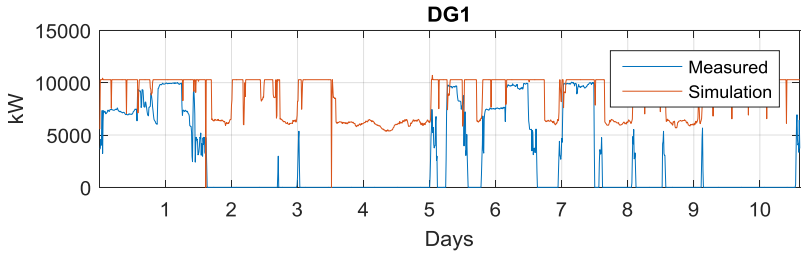
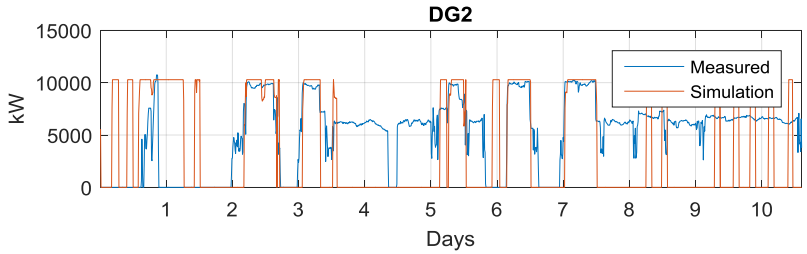


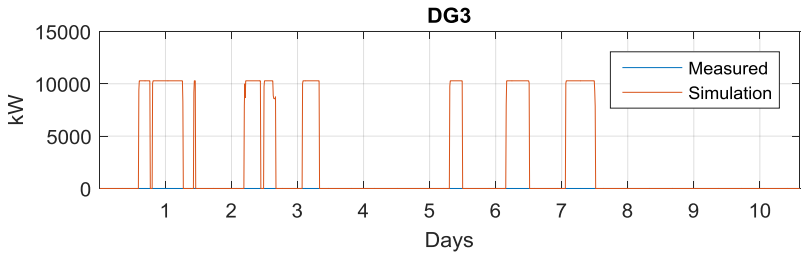


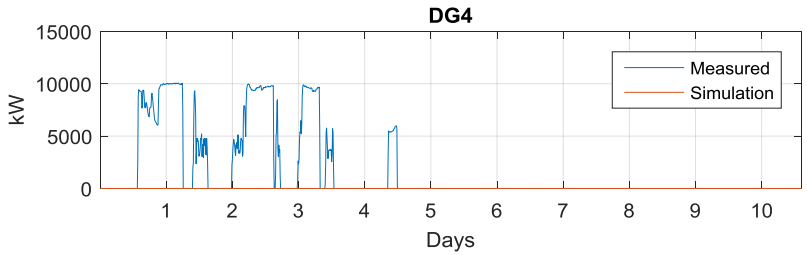
Death Star – Baltic Cruise

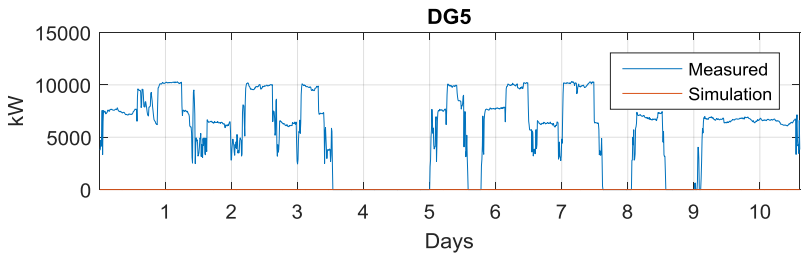
ZE + Hybrid

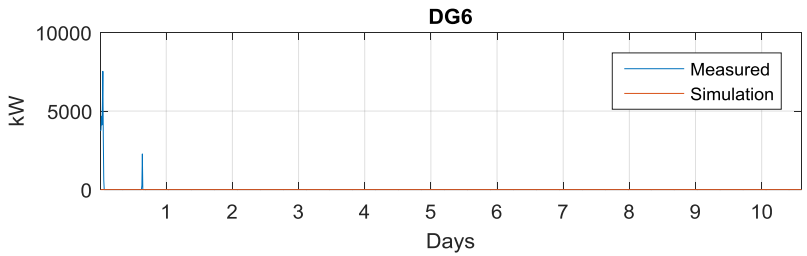






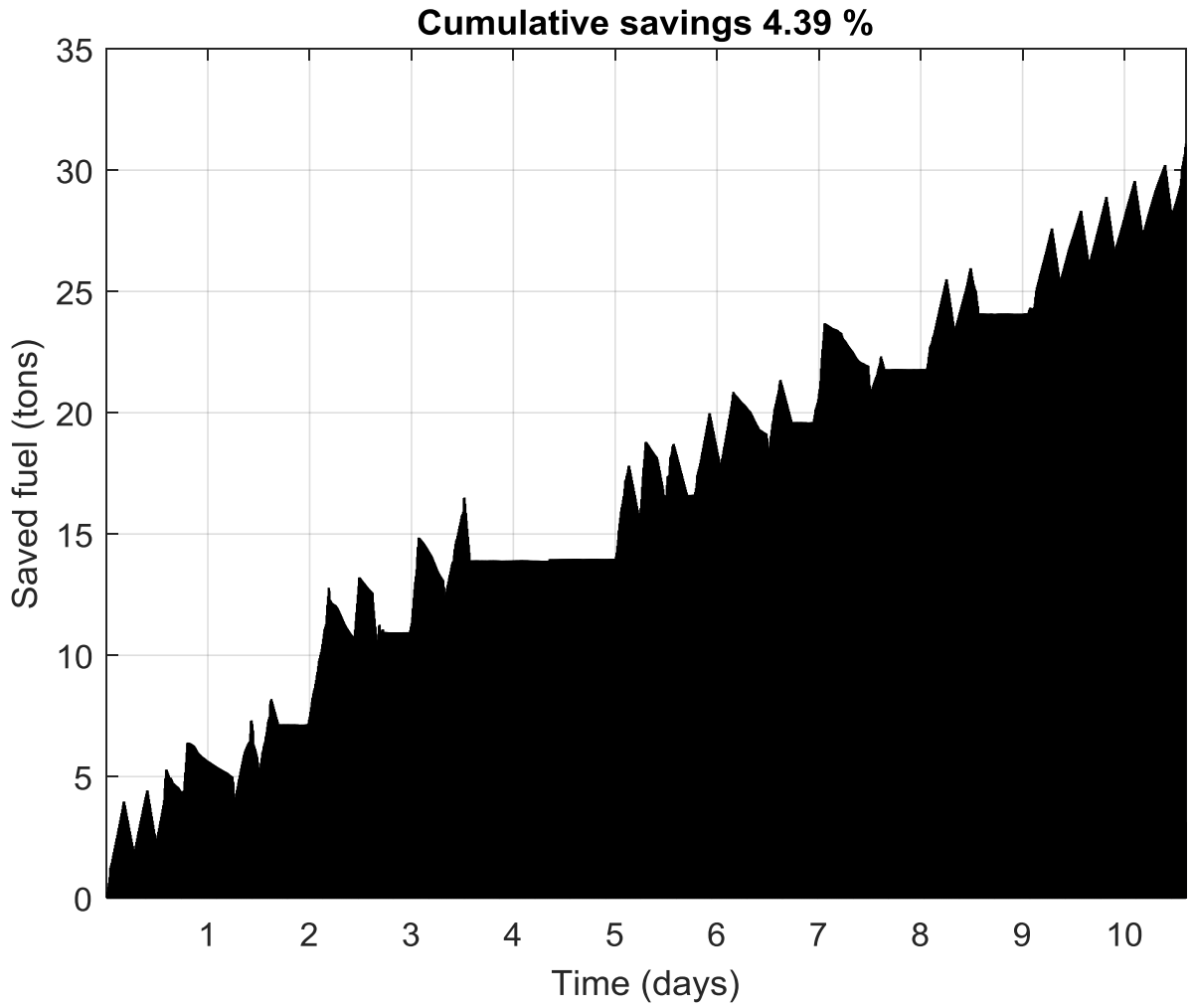






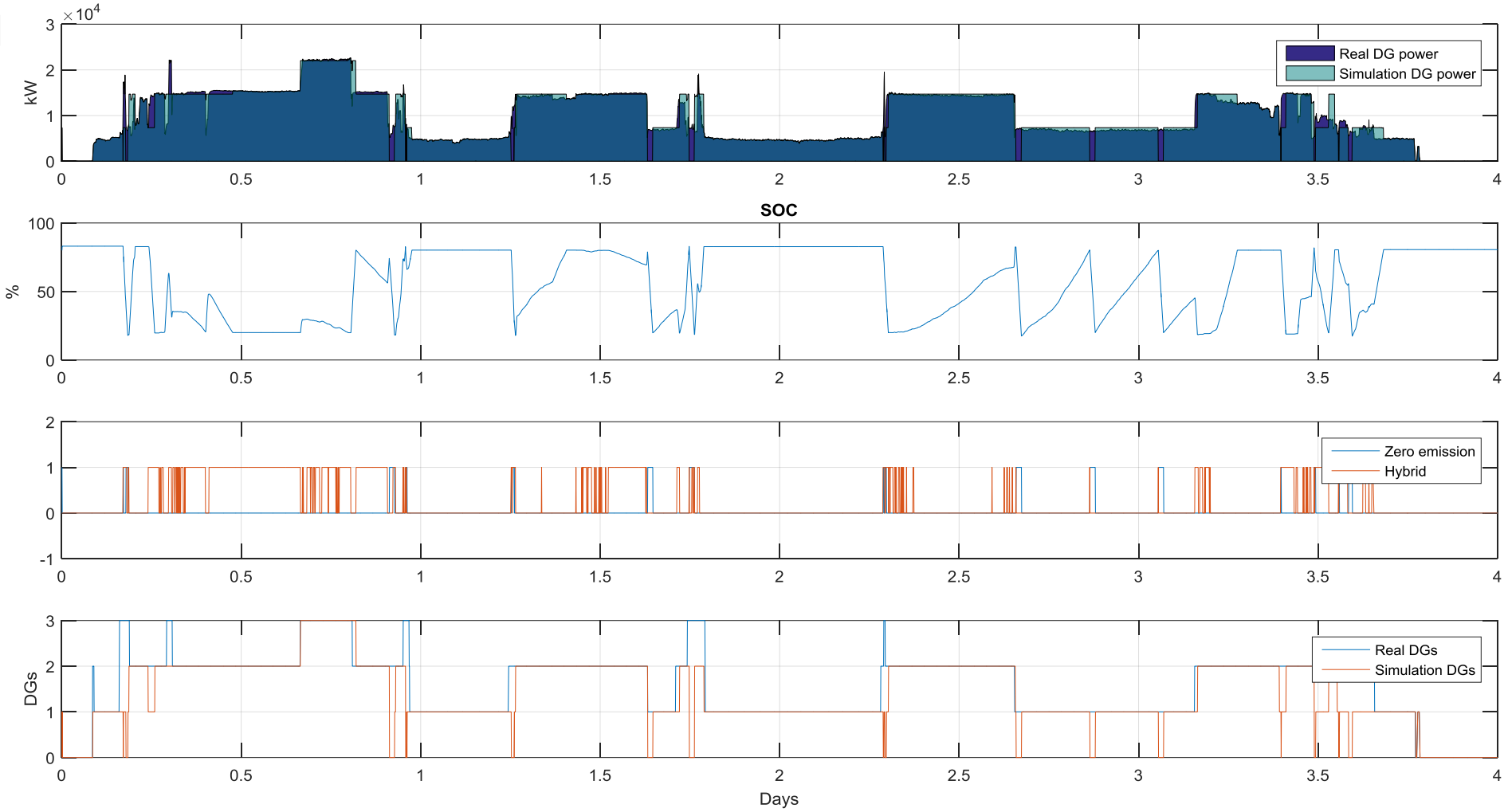
Death Star – Baltic Cruise

ZE + Hybrid



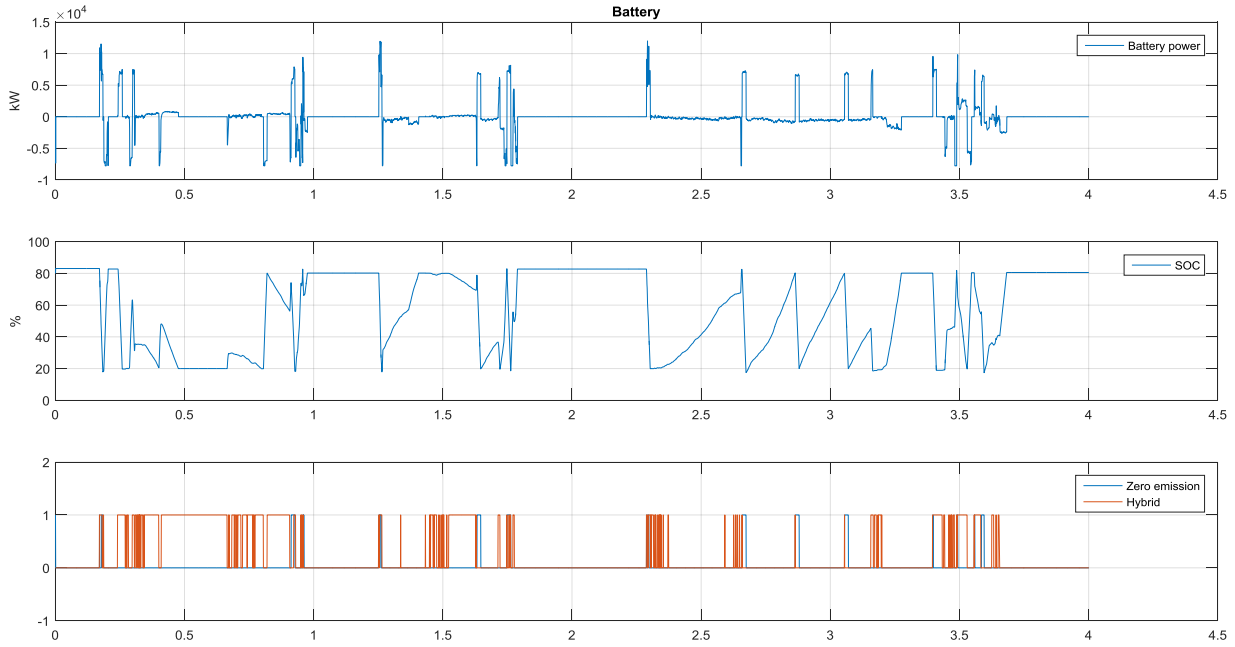
Star Destroyer II

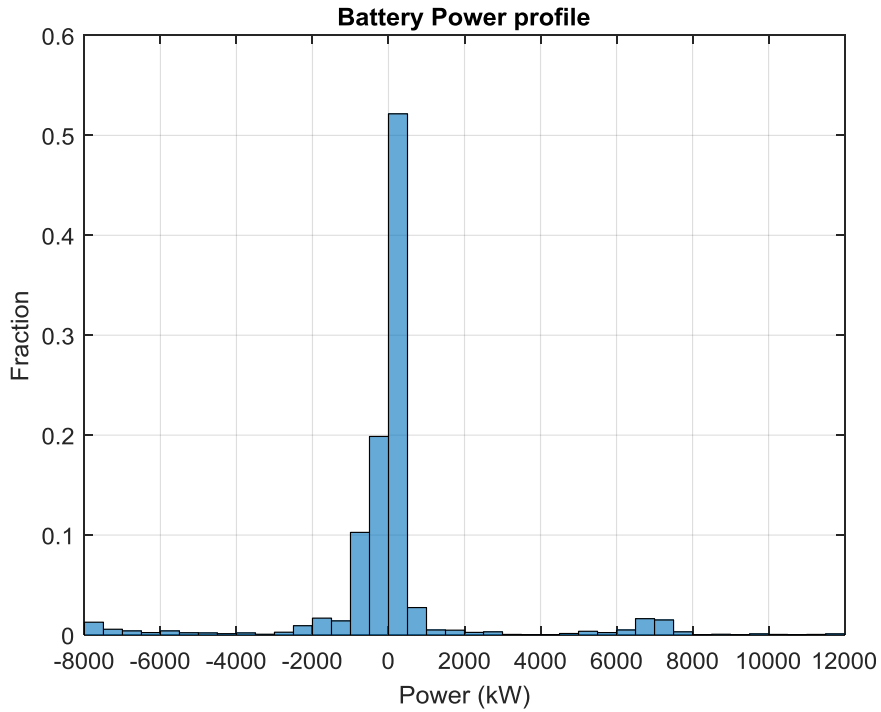
ZE + Hybrid



Star Destroyer II

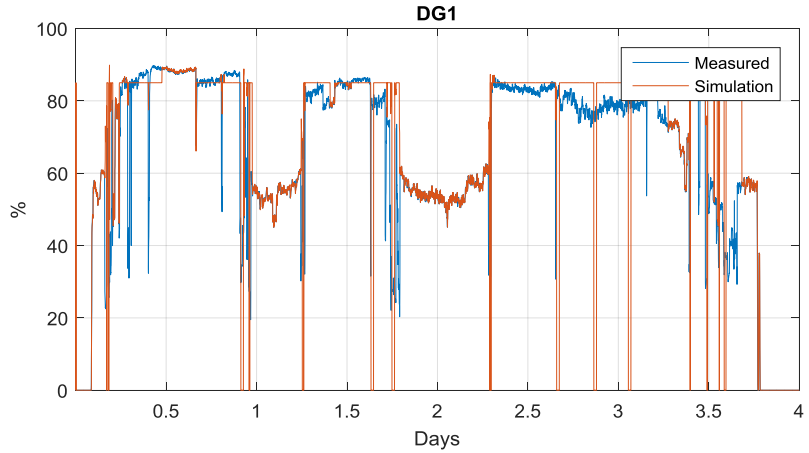
ZE + Hybrid

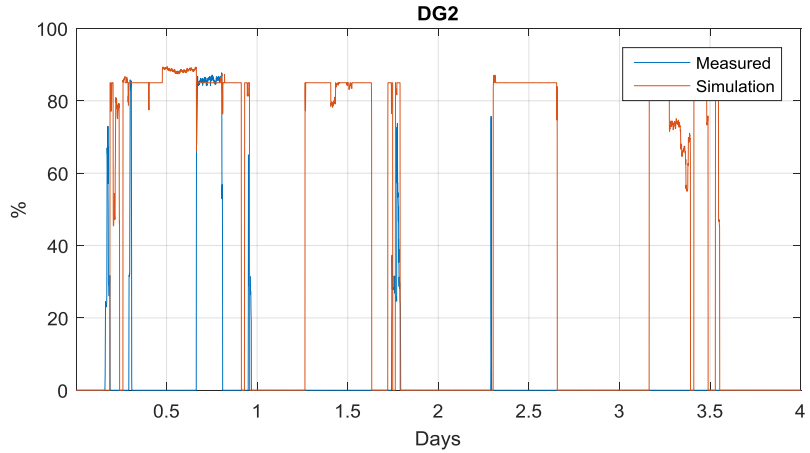


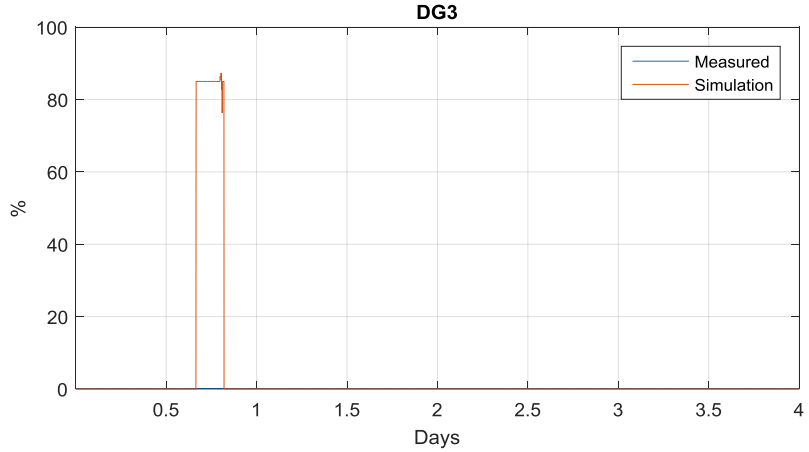


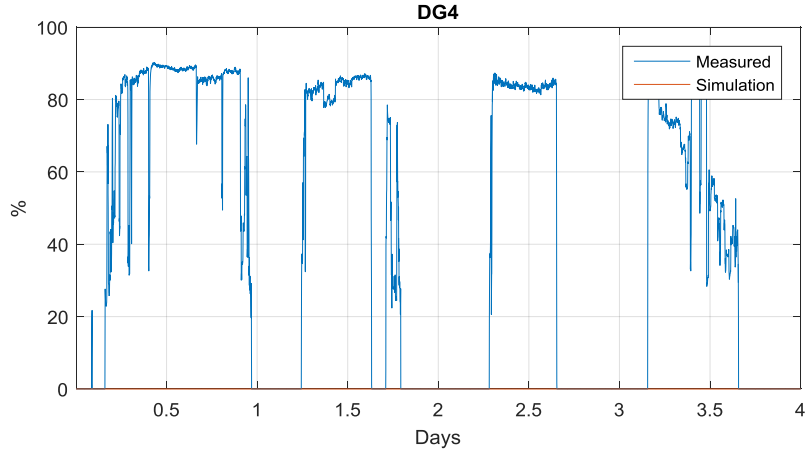
Star Destroyer II

ZE + Hybrid



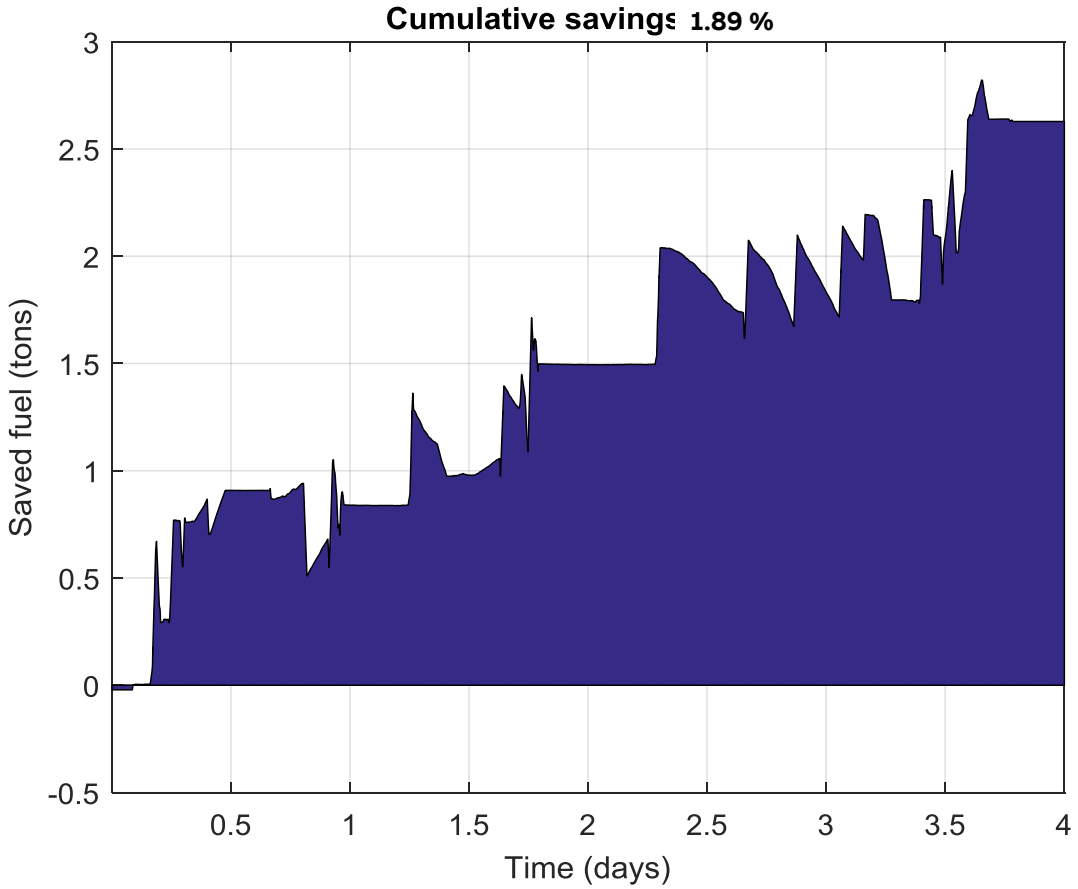






Star Destroyer II

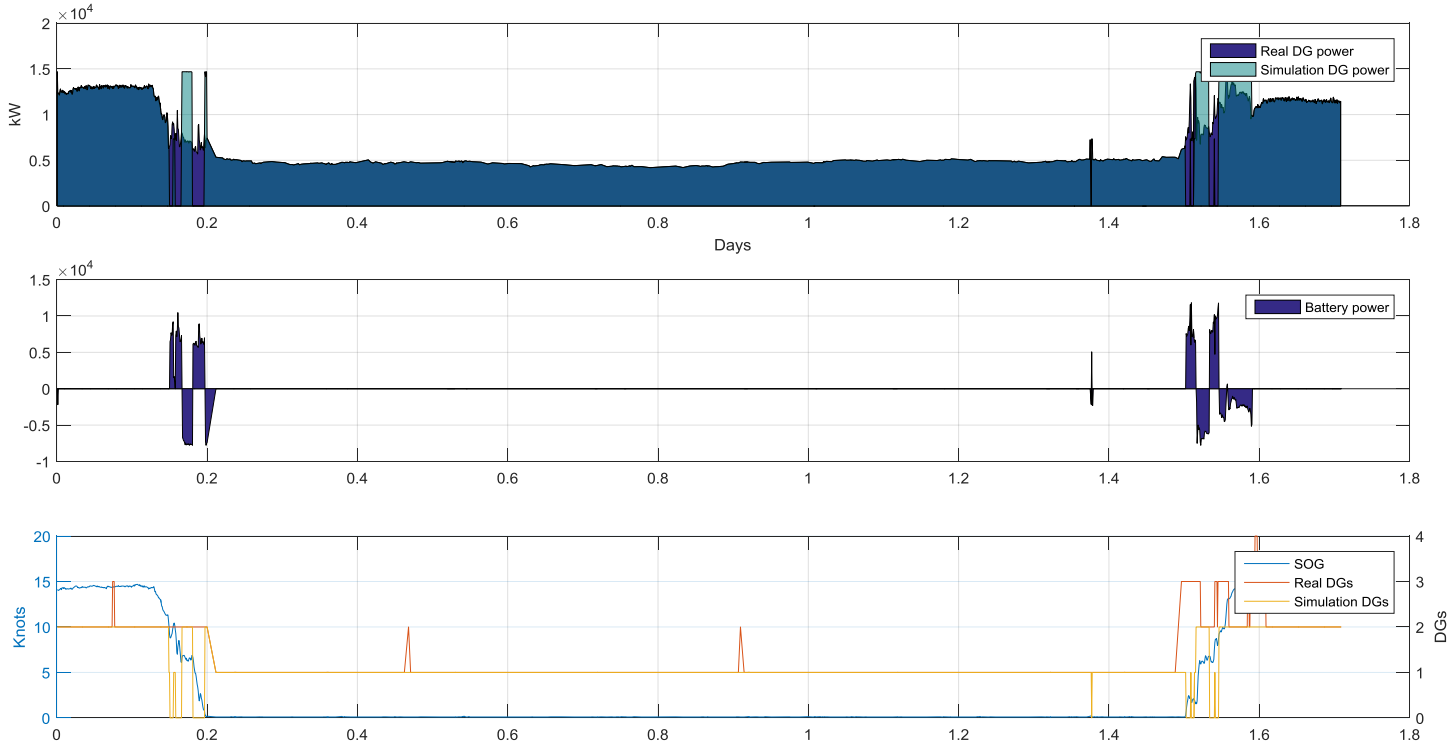
ZE + Hybrid



Energy Storage study

Star Destroyer II – Port Arrival & Departure

Total fuel consumption	26.0 tons
Fuel savings	4.6 % (16.3 %**)
Battery usage time	201 minutes (20.5 %)



* Numbers are excluding port time
** Battery power ≠ 0

Energy Storage study

Star Destroyer II – Port Arrival & Departure