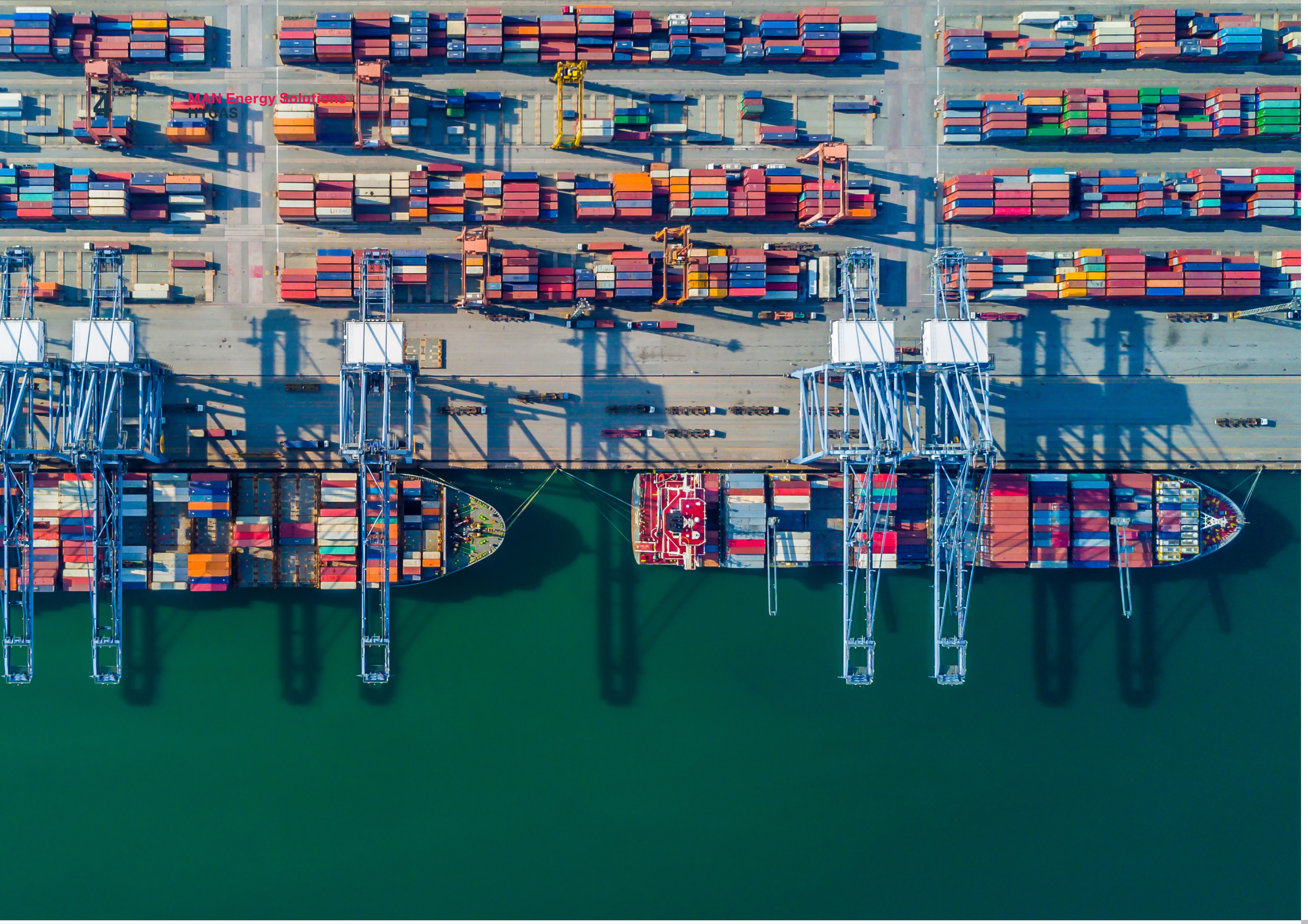

Acknowledgement

This brochure is based on a joint study by MAN Energy Solutions, DNV GL and CORVUS Energy. The brochure comprises key results from a paper submitted to the 2019 CIMAC Congress. The project partners are grateful for the support received from Neptun Ship Design, for letting them make use of the TOPAZ 1,700 ship design as basis for this study.

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D2366664EN-Printed in Germany
GGKM-AUG-0421

Maritime HYCAS

MAN Energy Solutions
Future in the making

Joint study to explore new cost-effective applications of hybrid power generation on larger ocean-going cargo ships

The goal of this study is to explore new cost-effective applications of hybrid power generation on larger ocean-going cargo ships.

Background

Increased scrutiny is being put on shipping to reduce its environmental damaging emissions. To address this, the IMO has adopted an initial strategy aimed at reducing total GHG emissions from international shipping by at least 50% within 2050. The question to ship operators however remains; is it possible to reduce GHG emissions whilst staying profitable? Many studies suggest yes, and one of the more promising measures, are hybrid power solutions.

Vssel type selection

Hybrid power systems often achieve significant efficiency gains and emission reductions in operation modes in which a ship's power demand fluctuates, for example when major energy consumers, such as cranes or thrusters, are utilized. This typically happens in connection with port visits. A review of historical AIS data showed that container feeders are a ship type meeting this requirement, and thereby potentially being a good case for hybridization.

Searching for a suitable, representative container vessel design for the study, the consortium found the TOPAZ 1,700 TEU vessel by Neptun Ship Design GmbH to be a good match in terms of size and topology.

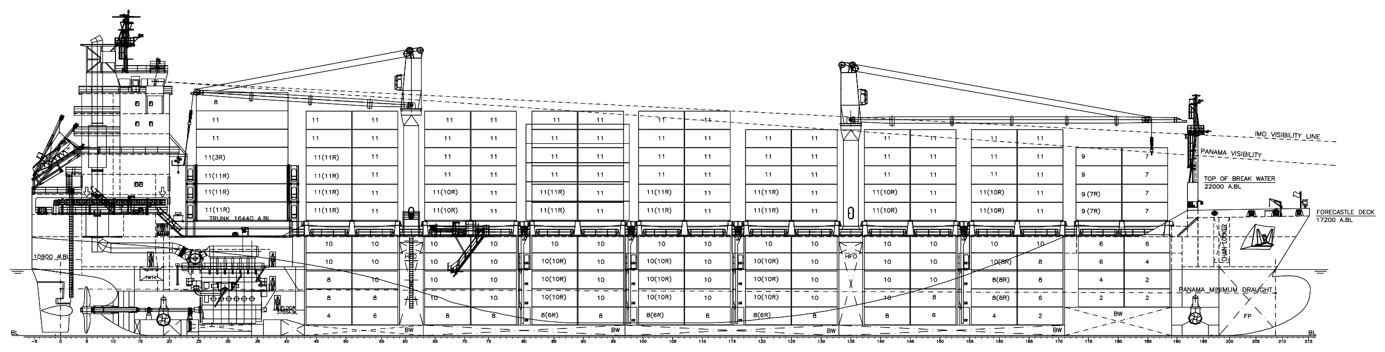

Figure 1: General arrangement of the selected 1,700 TEU Container feeder

6S60ME-C10.5 / 4x6L21/31

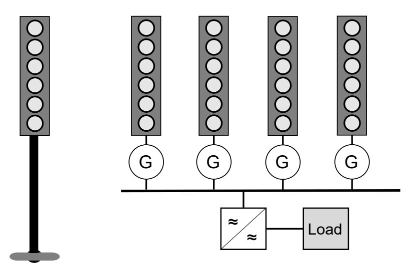

Figure 2: Simplified machinery topology

Reference ship

Length overall:	169.99 m
Breadth:	28.1 m
Design draft:	8.5 m
Design speed:	19 knots
Main engine:	MAN 6S60ME-C10.5 @ 11,280 kW
Diesel-gensets (DG): 1,254 kWe	4 x MAN 6L21/31 @ 1,254 kWe
Cranes:	2 @ 530 kW
Bow thruster:	950 kW
Reefer capacity:	250

Table 1: Main particulars of the Topaz 1,700

Operational profile

AIS data analytics was utilized to generate a representative vessel operational profile for a container feeder operating on a north European trade (figure 3). Further modelling was carried out to estimate both the propulsion and electric power demand for the given operation modes, and create an artificial time-based load profile as shown in figure 4.

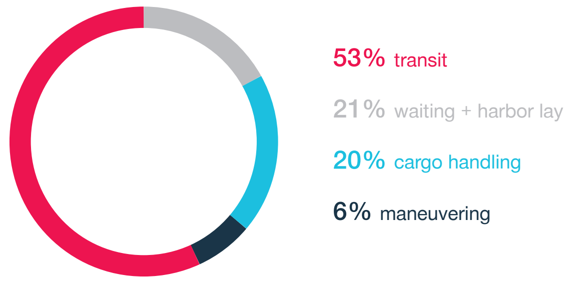

Figure 4: Time spent in different operating modes

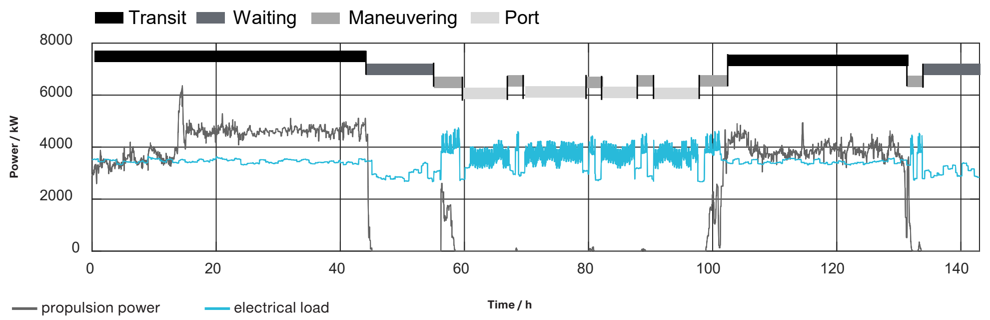

Figure 3: Representative propulsion and electrical load profile for the case with 250 reefers

The results of the study are presented in the form of two scenarios

1. A new built hybrid vessel in 2020 using current battery technology, where a battery is applied for peak shaving and spinning reserve for the Diesel Gensets.
2. A new built hybrid vessel in 2030 where batteries are applied for zero-emission maneuvering in and out of ports.

Scenario 2020

Simulations showed that a battery size of 500 kWh could replace one genset. The resulting engine topology is shown in figure 5. For a container ship, the total number of reefers on board and the power they demand, will have a significant impact on the electrical load and thereby on the potential benefits of hybridization. The 'spinning reserve' capability achieved by installing atteries can provide substantial savings in cases where startup of additional gensets can be avoided or delayed.

Figure 6, with 150 reefers active, shows that the battery is also able to cover peaks during waiting and port stay. It is then possible to run just one genset at a high optimum load point, instead of two.

In the case where no reefers are active (figure 7), at least one genset is running during port stay in the conventional as well as in the hybrid case. Hence, most of the savings are attributed to the on board cranes during cargo operation and the thruster during maneuvering.

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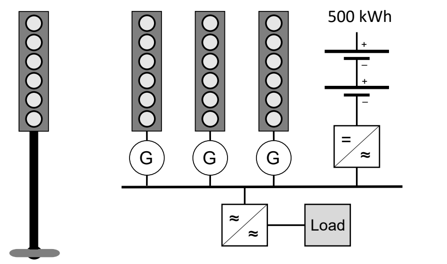

Figure 5: Possible simplified topology of a hybrid propulsion train

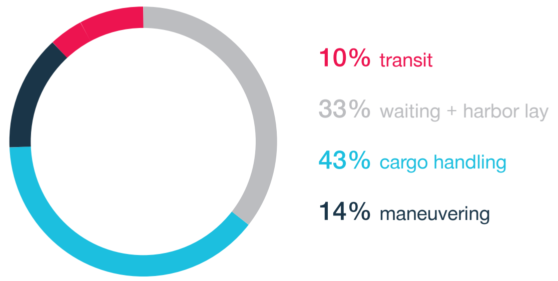

Figure 6: OPEX saving from Diesel Gensets in different operating modes (with 150 reefers active)

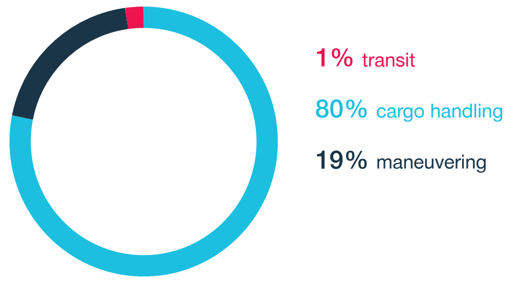

Figure 7: OPEX saving from Diesel Gensets in different operating modes (no reefers active)

Using a discount rate of 10% and an inflation rate of 2%, and further applying a battery price of 500$/kWh and an MGO fuel cost of 750$/t, the net present value (NPV) for different reefer loads are found in table 2. All cases presented show saving potential and positive NPV, and with short payback time.

Reference ship

Reefer power kW/reefer	No reefer	Fuel saving %	Run time saving %	NPV k$	Payback y
	0	2,2	29,5	341	2
3.4	50	1,2	21,4	180	3
	150	1,2	20,5	338	2
	250	0,7	0,7	229	3

Table 2: Results of a battery hybrid system with 500 kWh battery versus a conventional machinery configuration. Reefer power at 3.4 kW.

Scenario 2030

For a zero-emission port entry/exit application, the size of the battery is solely determined by the power de- mand and duration of maneuvering. For this reason, a total installed apacity of 11 MWh was needed. The resulting engine topology is shown in figure 8.

The zero-emission mode looks economically viable only if battery system costs are lower than today, fuel prices are higher, and incentive schemes or stricter emission regulations are in place, all of which may well be the case by 2030. However, assuming that by 2030, fuel costs would be 1000 $/t and battery costs are at 400 $/kWh, the NPV would become positive, as seen in figure 9.

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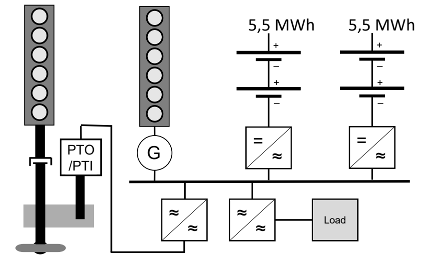

Figure 8: Possible simplified topology of a hybrid propulsion train ready for zero-emission operation

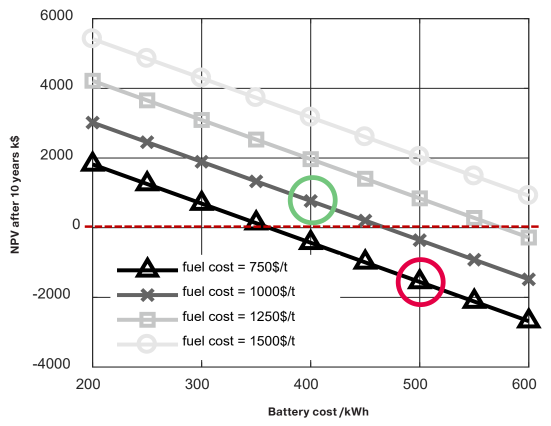

Figure 9: Development of NPV in dependence of battery cost and fuel cost for zero emission mode