VRAQUIUS2.0

FEDNAV

1 Intro

2 Different technologies

3 Scenarios

4 Results

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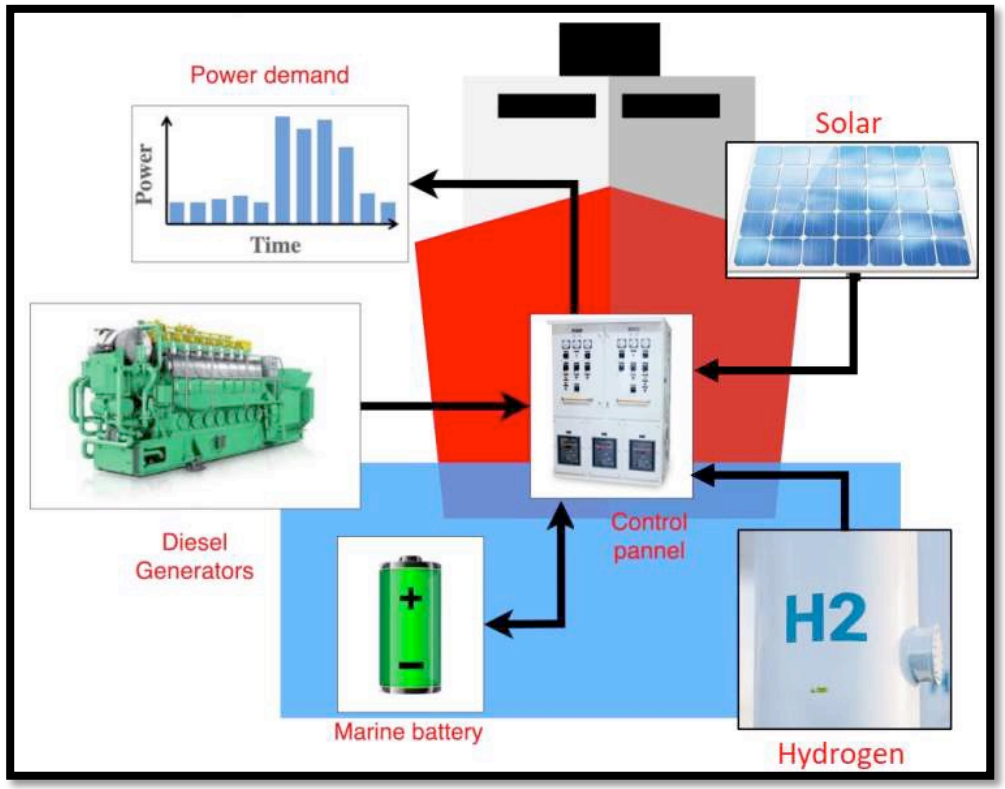
1

- Context
- Our goal
- Architecture of a micro-grid for a bulk carrier

Why are we doing this?

- Renewable energy
- Storage system
- Regulations

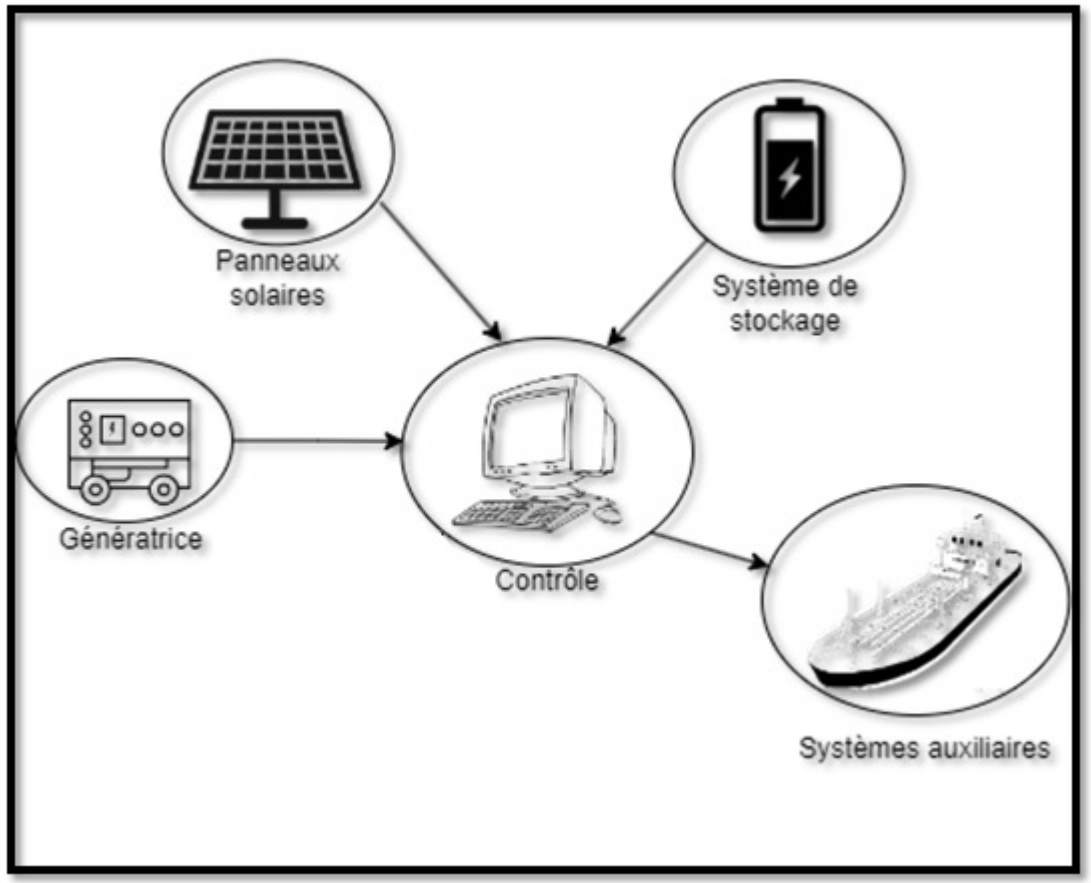
INTERNATIONAL MARITIME ORGANIZATION



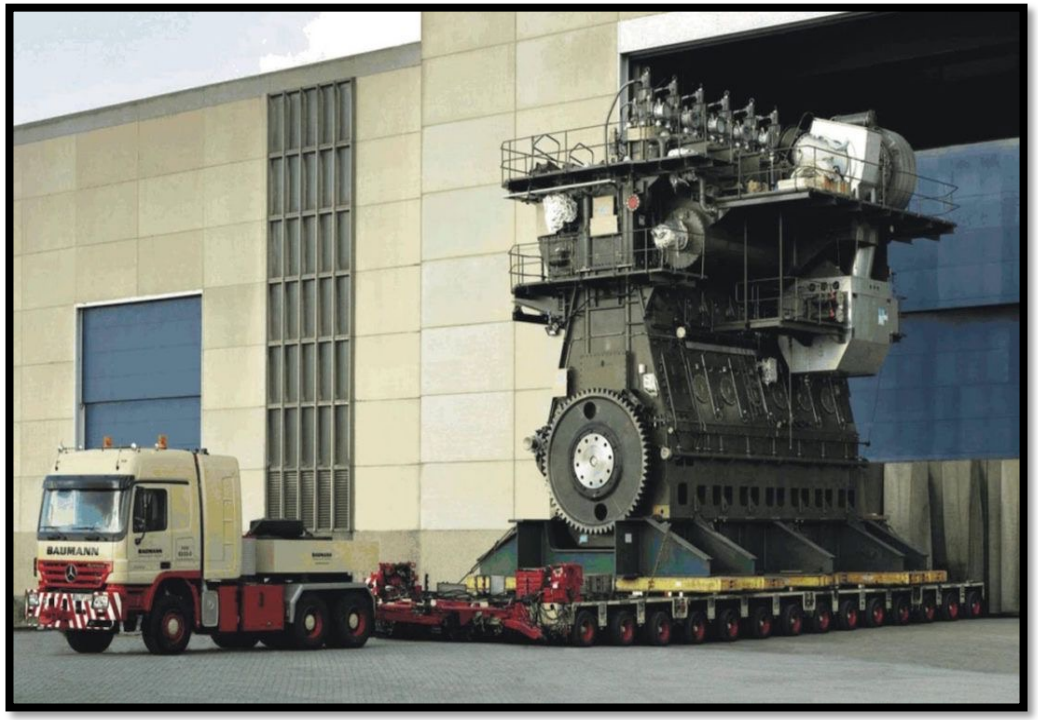
Solution?

Micro-grid!

Micro-grid


Panneaux solaires
Système de stockage
Génératrice
Contrôle
Systèmes auxiliaires

Power sources



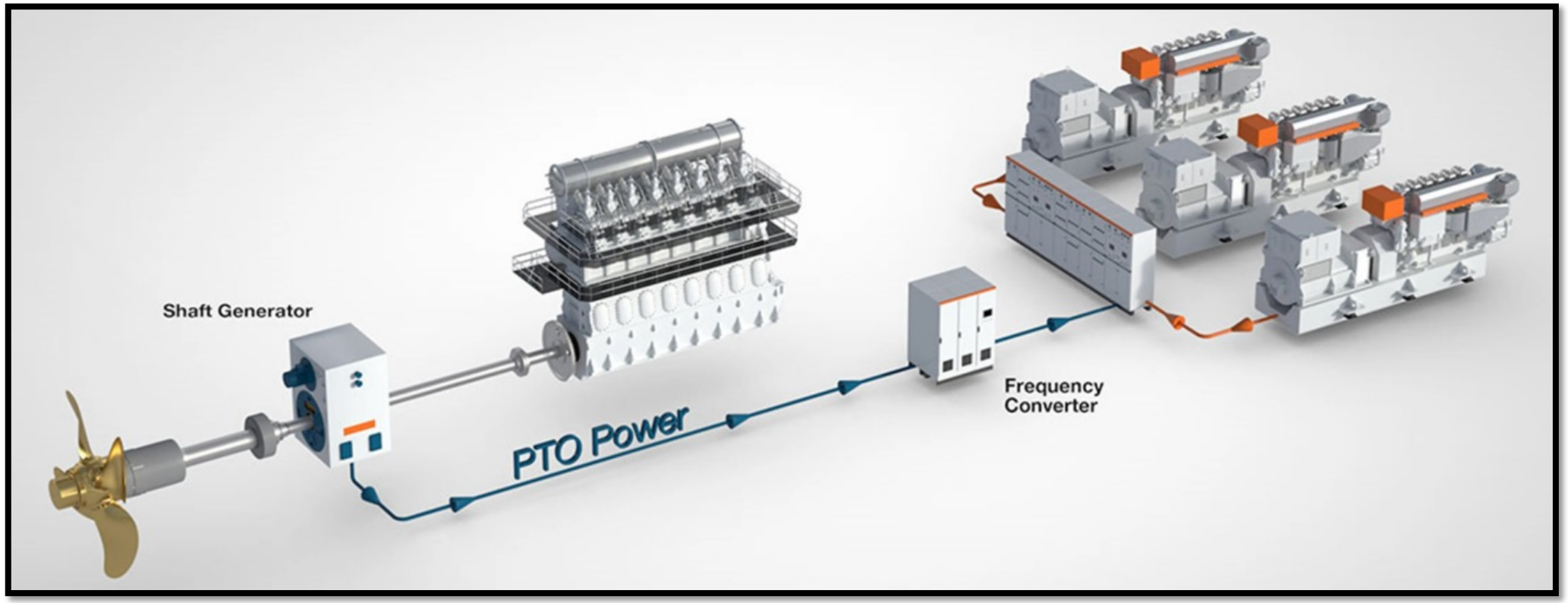
Main engine
(Propulsion)

Generators
(Auxiliary load)

2

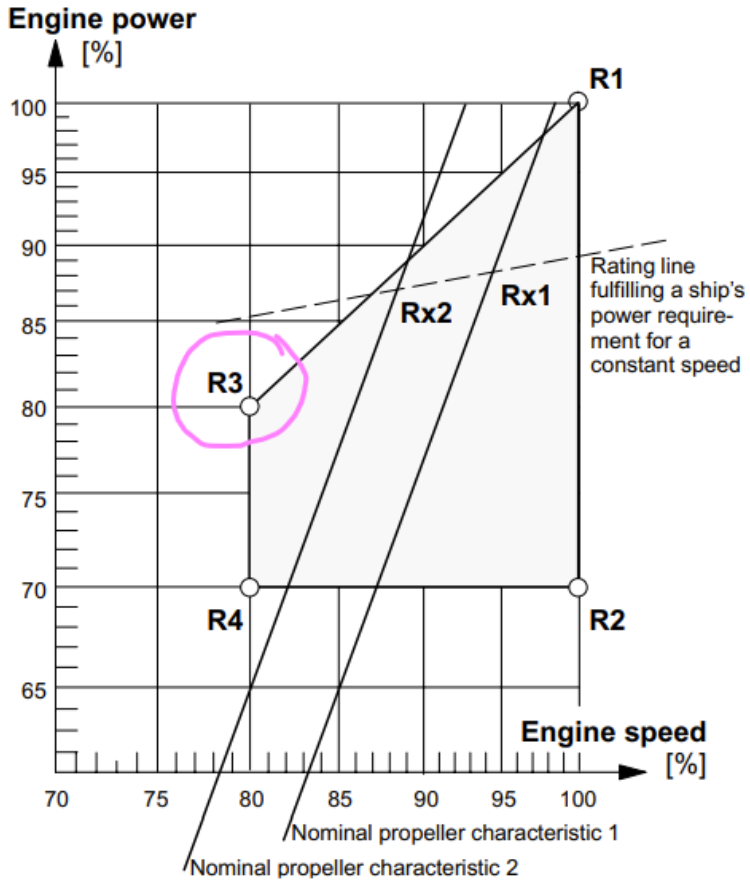
- Different technologies
  - Shaft Generator
  - Solar panel
  - Batteries

Shaft Generator



Shaft Generator – PTO layout limit

- Operation in R3 (Zone 3);
- ~ 80% engine power and 80% engine speed;
- $\sim 92.8\ rpm.$
- $PTO = 9{,}53\%(7000kW) = \mathbf{667,1kW}$;

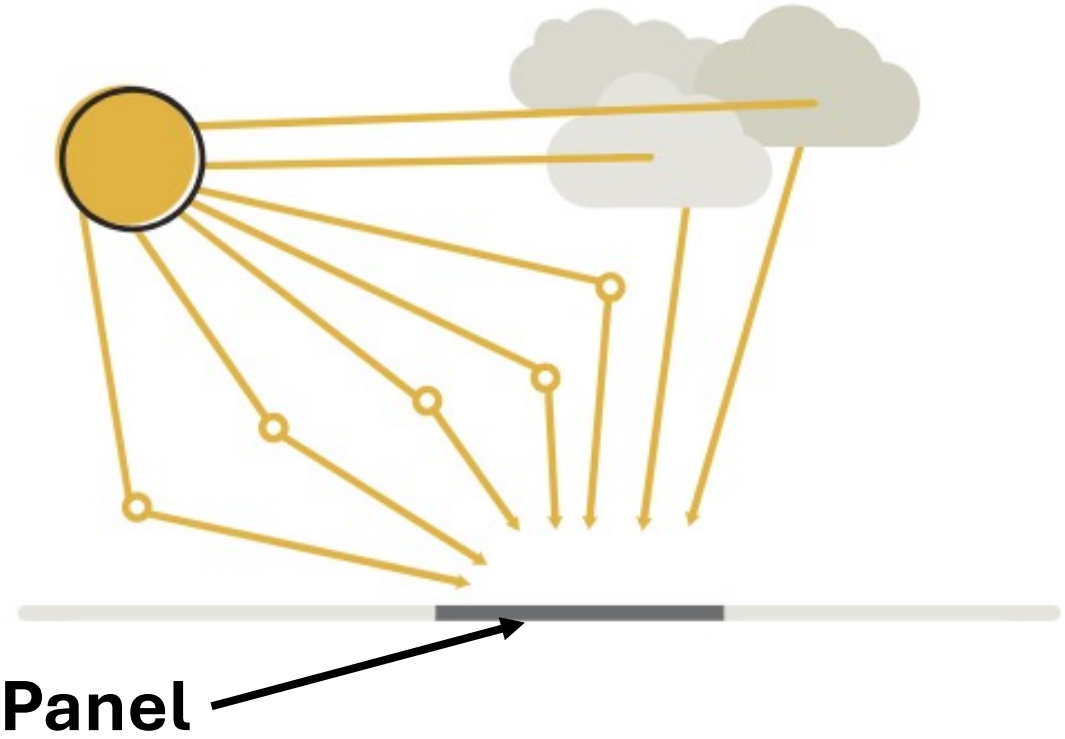


Wartsila%20Marine%20Installation%20Manual%20MIM%20RTA48T.pdf

Solar Panels

Characteristics of simulated PV

- Each panel has 420 W.
- Fixed PVs.
- Direct and diffuse horizontal plane with the atmosphere (**PV angle = 0°**).
- Energy efficiency ≈ 40%
- Radiation and temperature are average data.



Batteries

	Acid/Lead	Nickel/Cadmium	Nickel/ hybrid metal	Lithium - Ion
Storage (Wh/kg)	↑	↓	↓	↑↑↑
Life cycle	600 cycles	2000 cycles	2000 to 3000 cycles	3000 cycles
Price	↓↓	↑	↑	↑↑↑

Batteries

- 1 MWh
- Dimensions :
  - 6,1m x 2,44m x 2,9m
- Immediate power

3

- Studied sea route
- Scenarios

Antwerp → Baie-Comeau

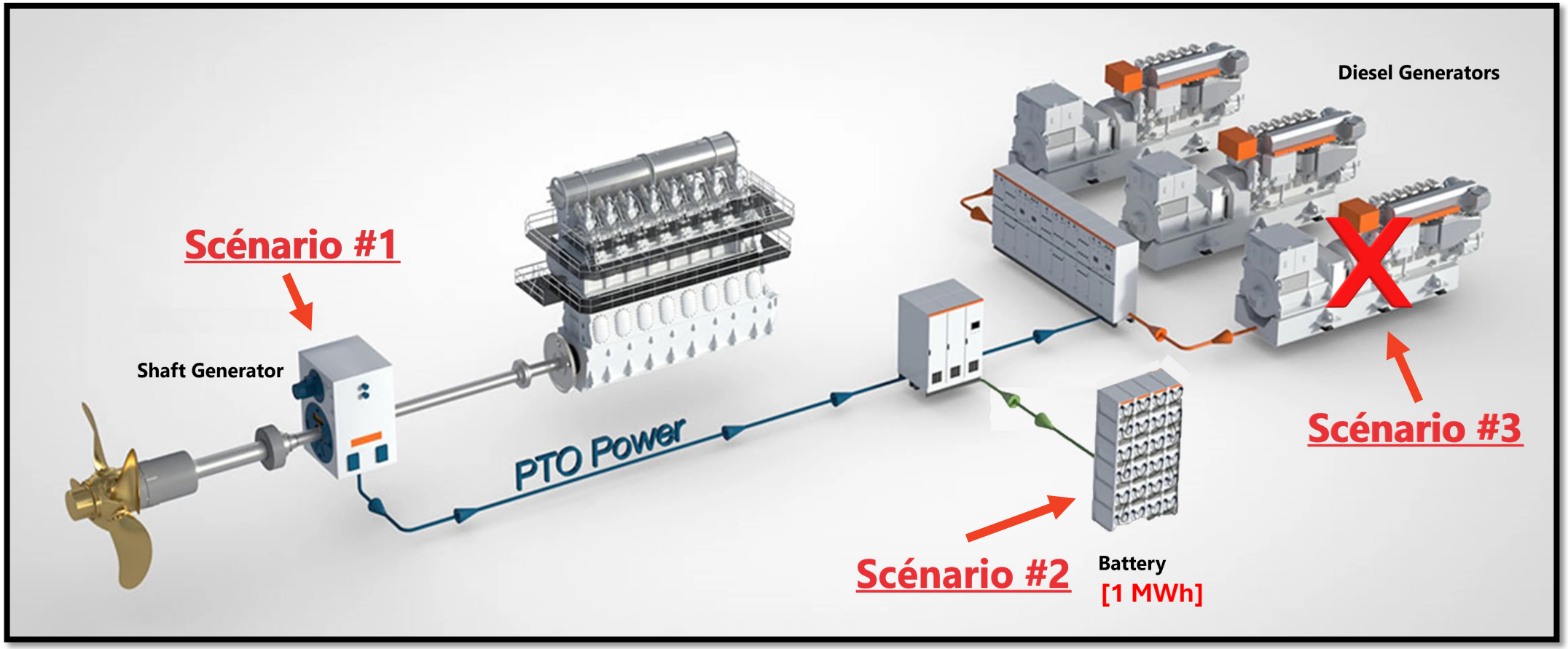
4

Scenarios

- #1 
- #2   
- #3     

Shaft Generator Battery Remove third generator

Scenarios


Diesel Generators
Scénario #1
Shaft Generator
PTO Power
X
Scénario #3
Scénario #2
Battery
[1 MWh]

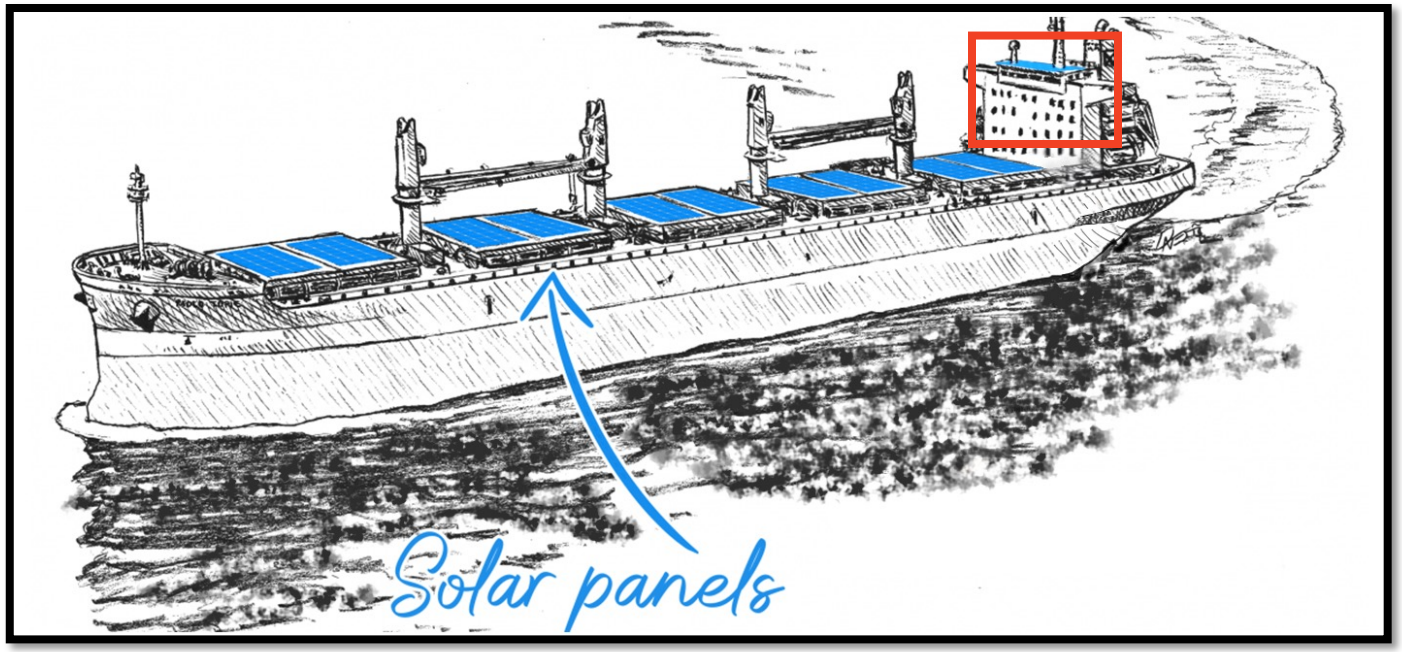
Scenario #4

Composition of the scenario

- Shaft generator
- Battery
- **Solar panels**

Solar panels

- 17 at sea (fixed on the bridge's roof)
- 17 at port (fixed on the bridge's roof)
- Footprint based on Federal Baltic



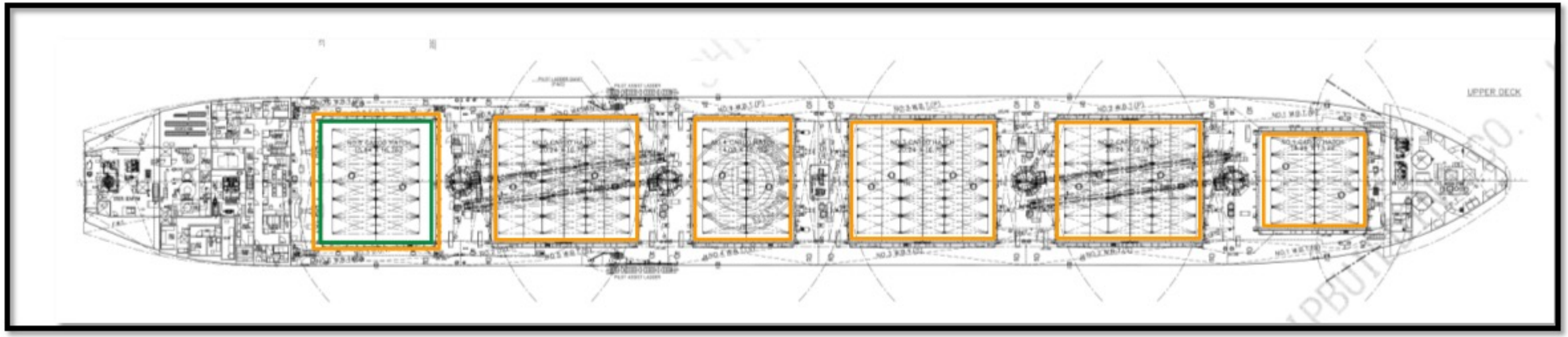
Scenario #5

Composition of the scenario

- Shaft generator
- Battery
- **Solar panels**

Solar panels

- 161 at sea (with a PVs container)
- 17 at port (fixed on the bridge's roof)
- Footprint based on Federal Baltic



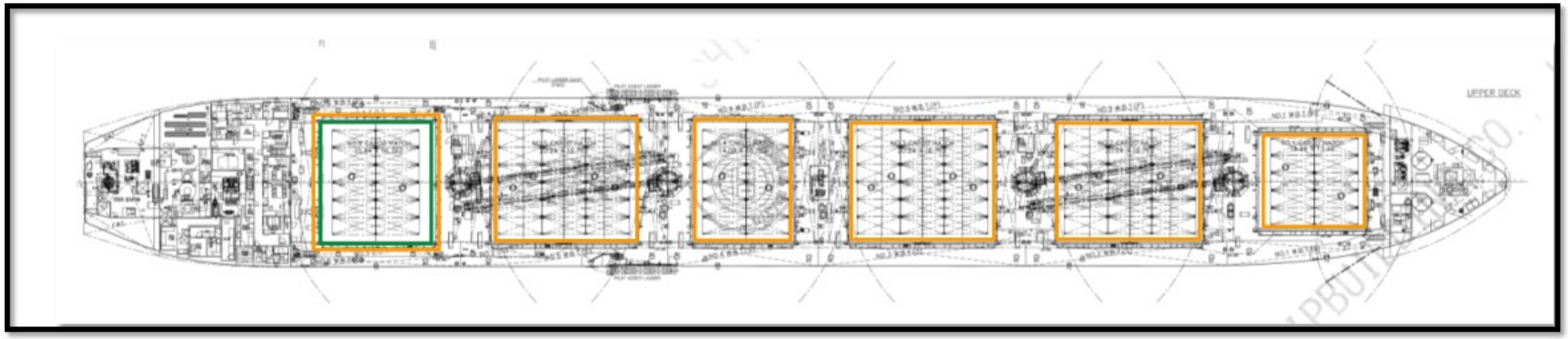
Scenario #6

Composition of the scenario

- Shaft generator
- Battery
- **Solar panels**

Solar panels

- 976 at sea (with a PVs container)
- 17 at port (fixed on the bridge's roof)
- Footprint based on Federal Baltic



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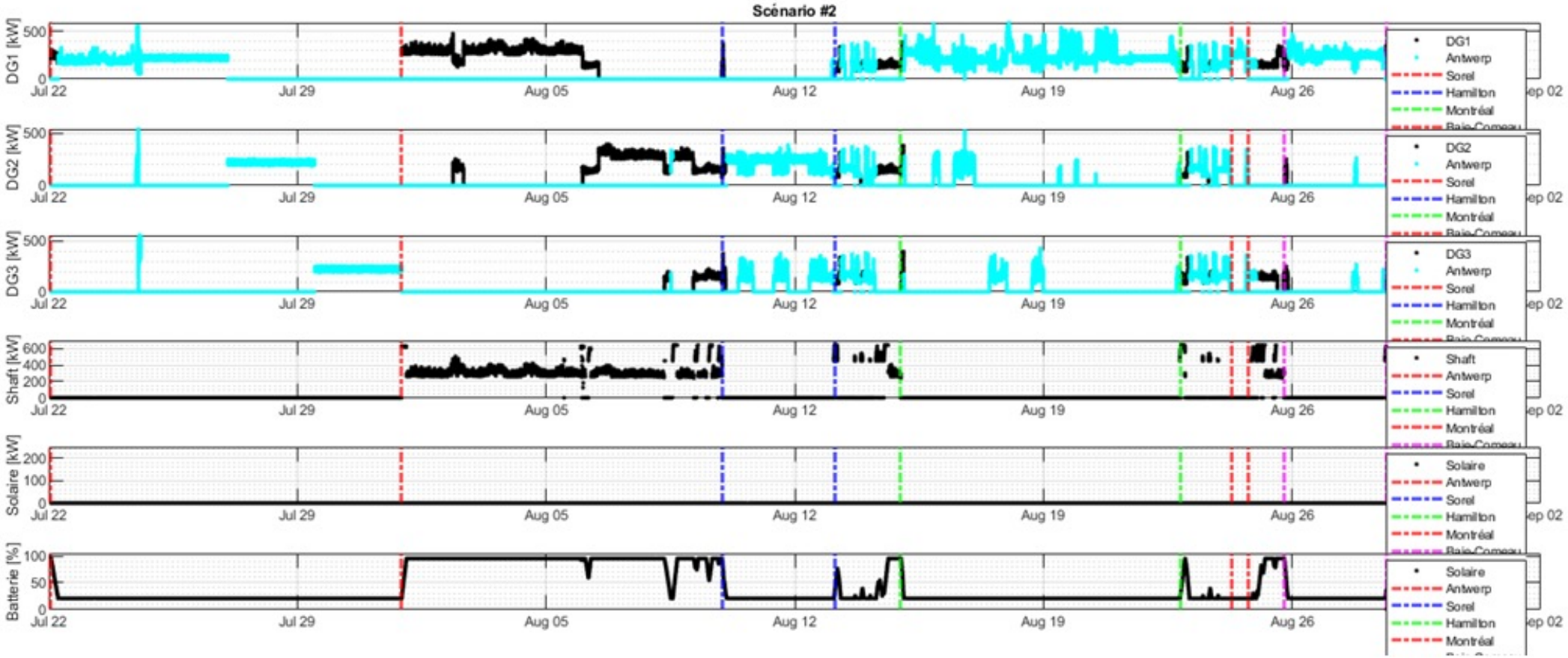
- Results
- Recommandations

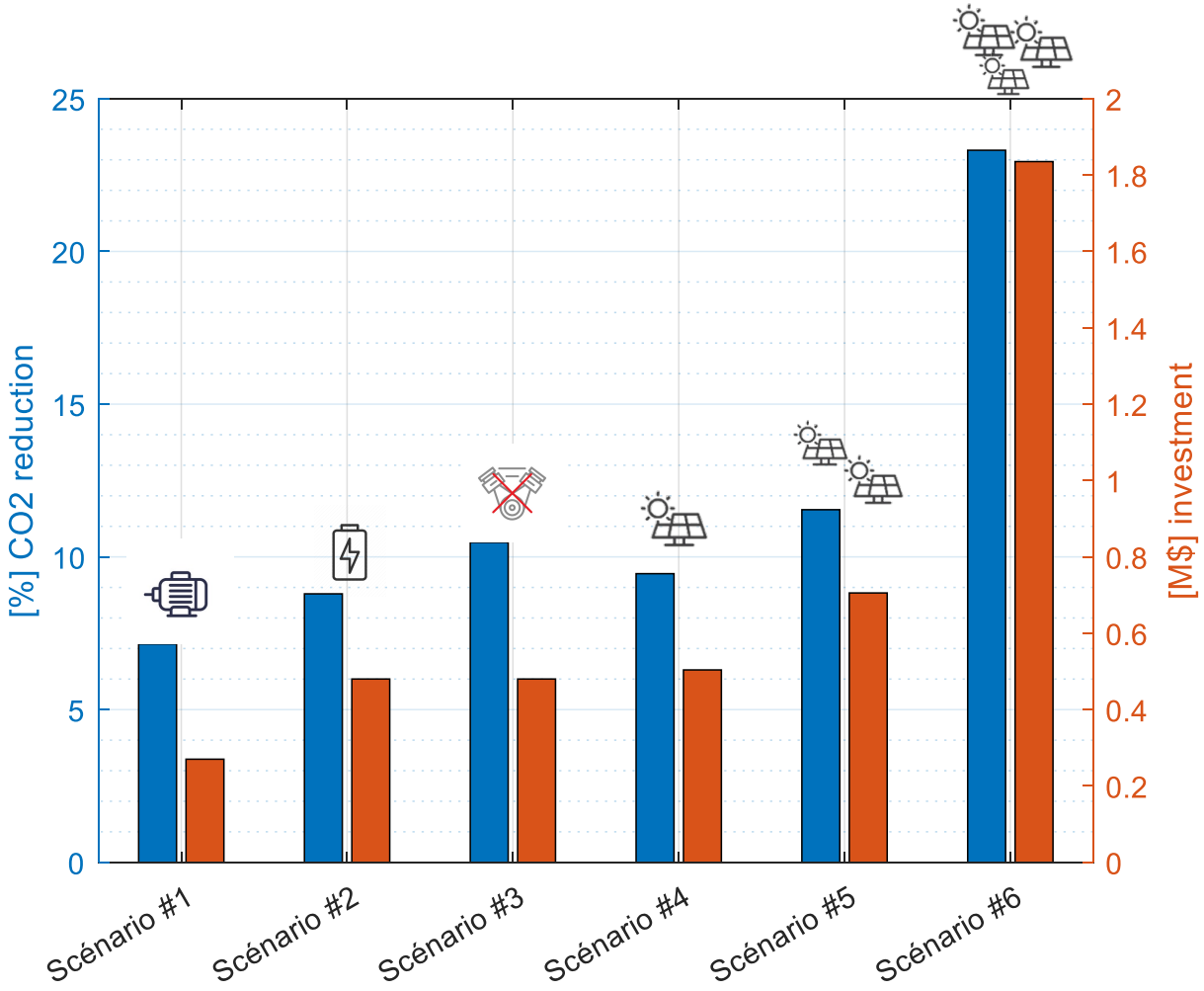
Consumption profile

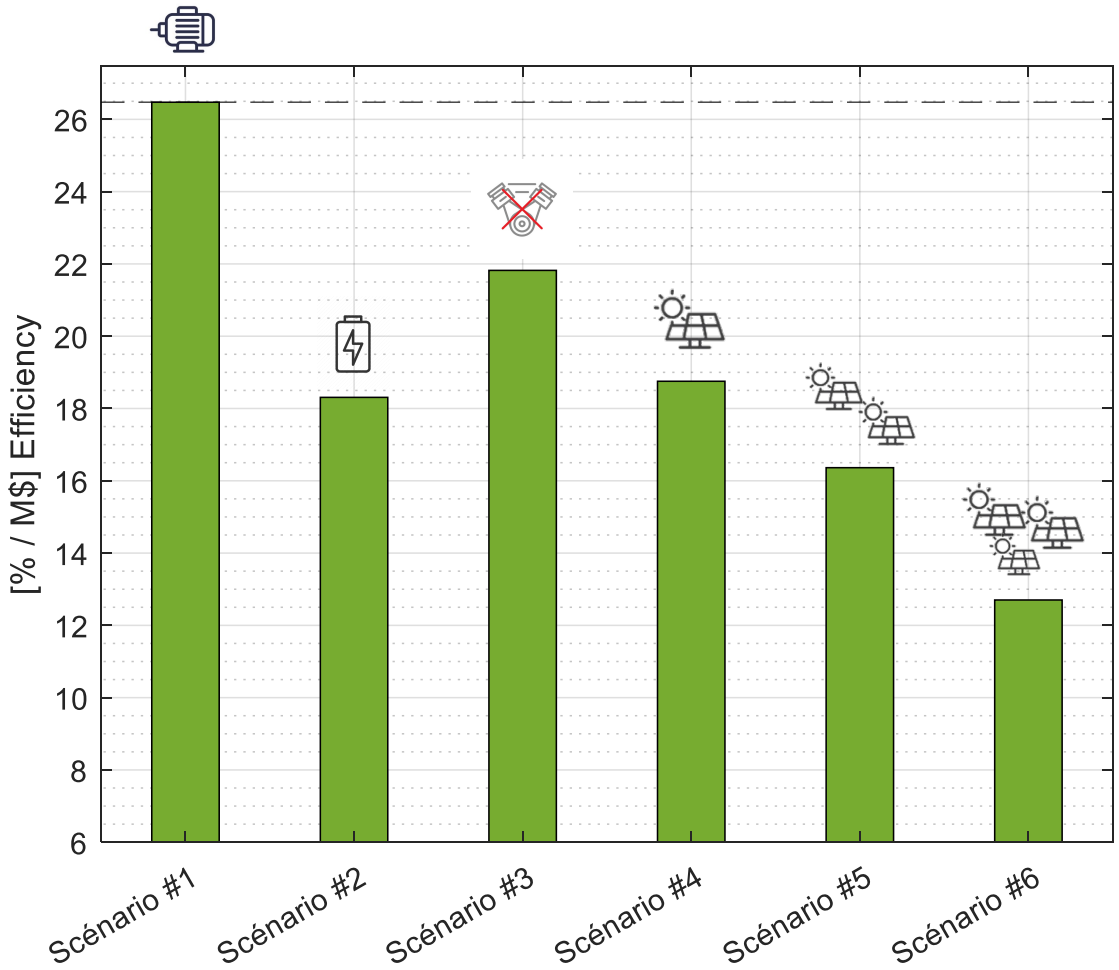


Costs

Note : Investments estimate were made using the cost of material/equipment only. Installation and maintenance were not taken into consideration.

Equipment	Estimate [k$]
Shaft generator	270
Battery [1 MWh]	200
Solar Panel (x1)	1.4
Inverter	10

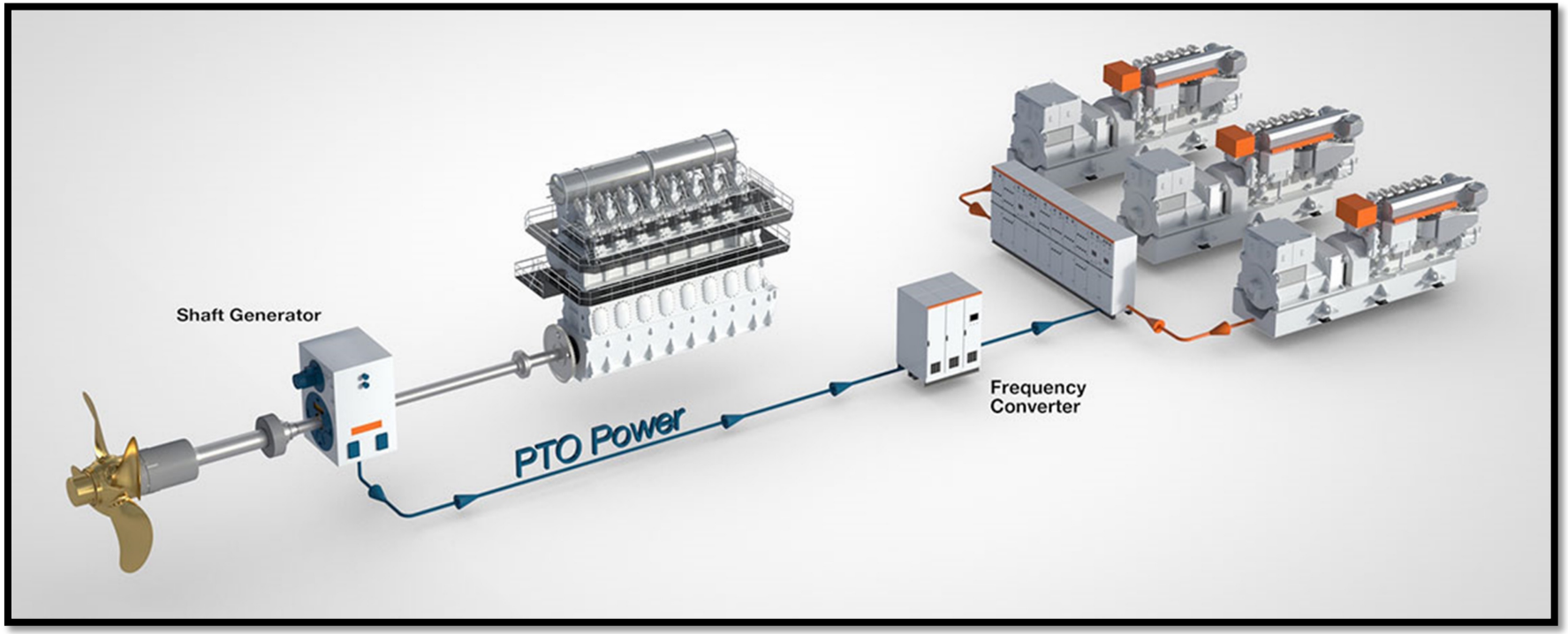




*Installation cost not taken into consideration

Recommandations

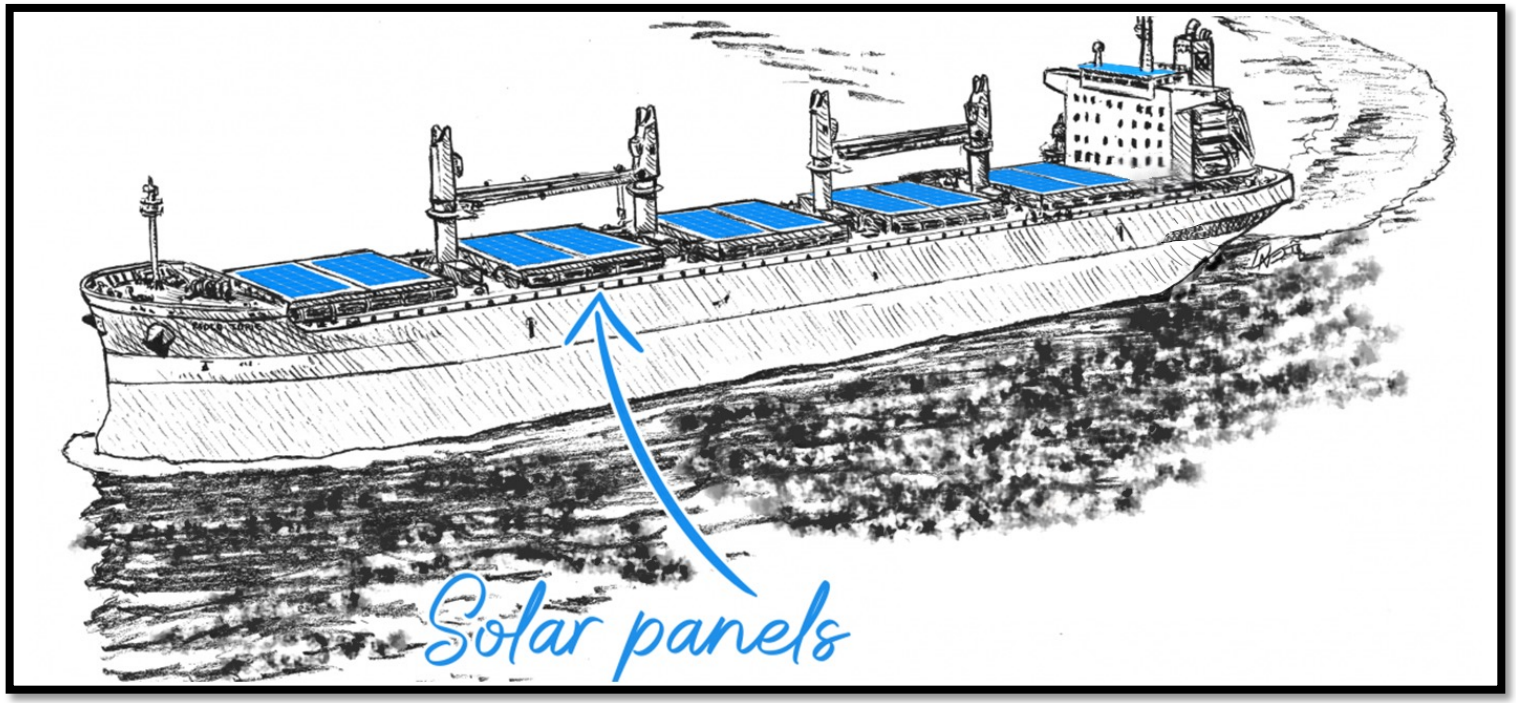
Scenario #1 : Shaft generator – The Best Money Ratio



Recommandations

Scenario #6 : Shaft generator, battery and maximal PV

- The most reduction of CO2



Thanks for the opportunity

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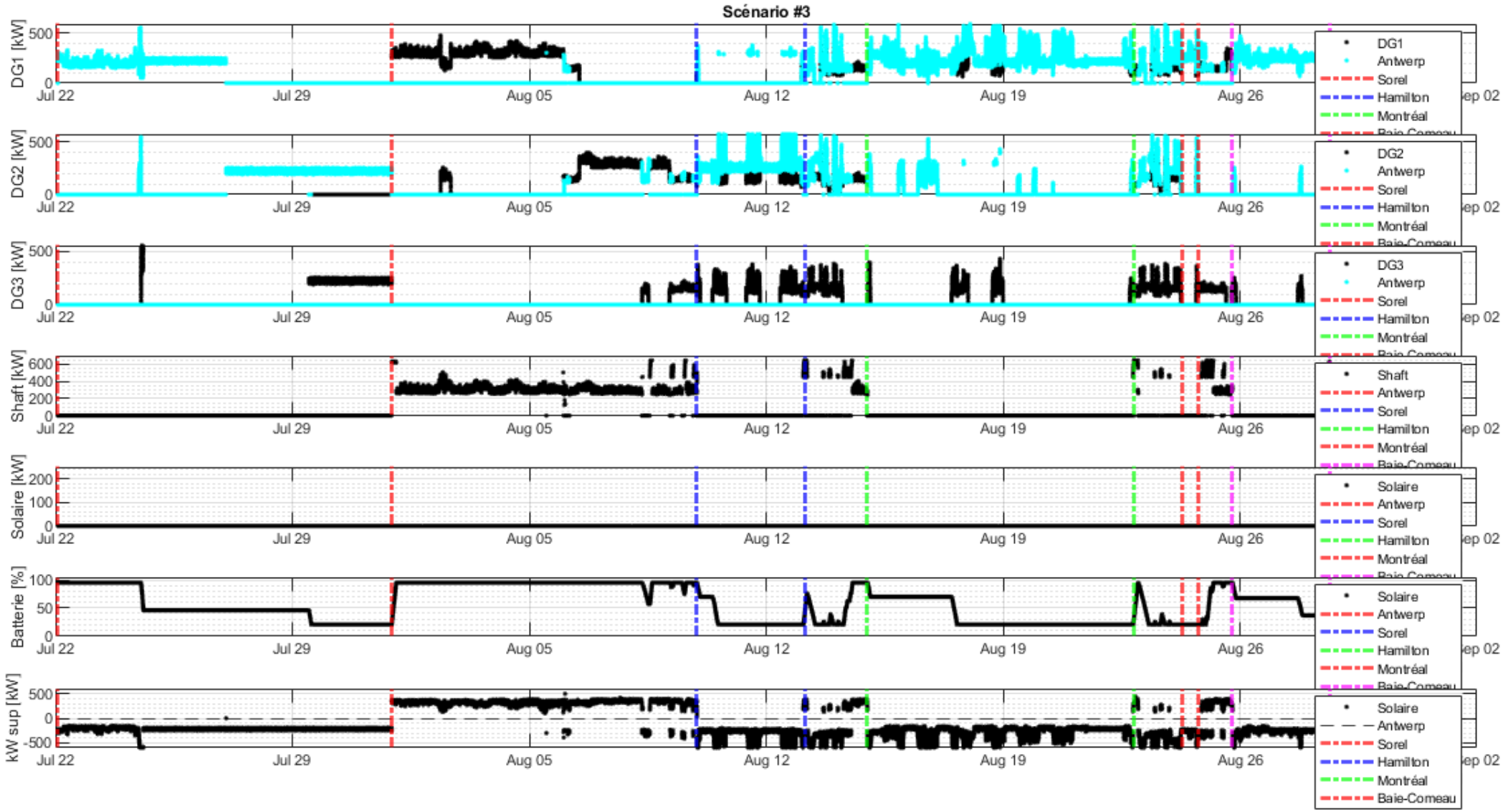
Appendix

Hypothesis

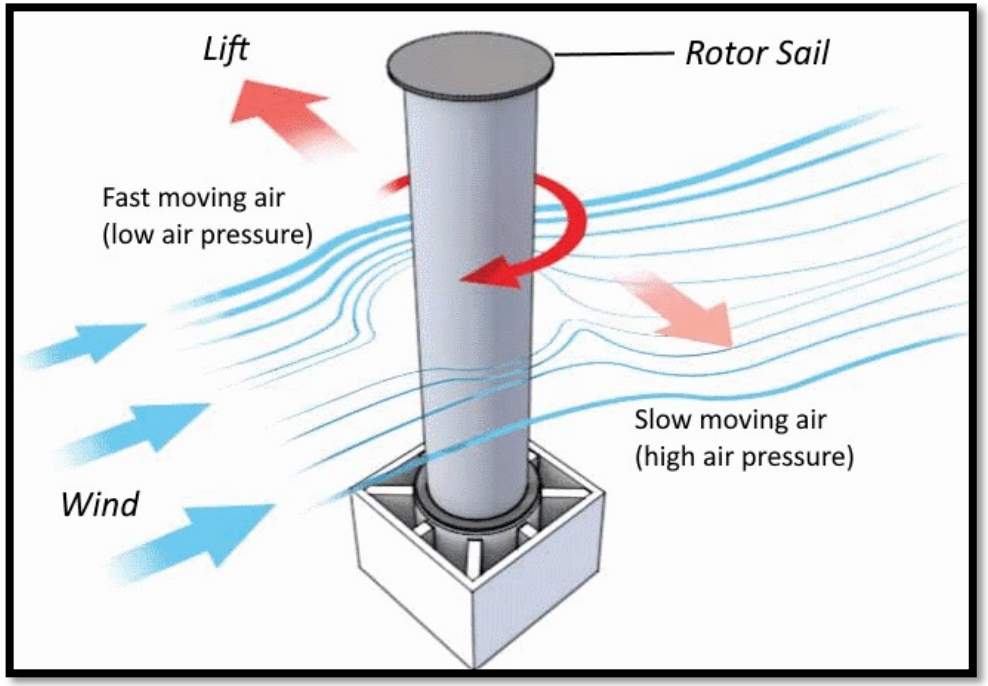
- Diesel was used for international and territorial waters (767.88 $/Ton) *https://www.oilmonster.com/bunker-fuel-prices*
- *Solar panel (1 600$ US/ PV)* 420 watt glass rigid marine solar panel with 24% efficient HJT solar cells

Scenario 3


Scénario #3
DG1 [kW]
DG2 [kW]
DG3 [kW]
Shaft [kW]
Solaire [kW]
Batterie [%]
kW sup [kW]
Jul 22
Jul 29
Aug 05
Aug 12
Aug 19
Aug 26
DG1
DG2
DG3
Shaft
Solaire
Antwerp
Sorel
Hamilton
Montréal
Baie-Comeau

Rotor Sail


ANEMOI
ANEMOI
ANEMOI


Lift
Rotor Sail
Fast moving air
(low air pressure)
Slow moving air
(high air pressure)
Wind

Rotor Sail

Hydrogen

- Limited space
- Method to create hydrogen is not 100% green everywhere

Shaft Generator – PTO layout limit

Table 2

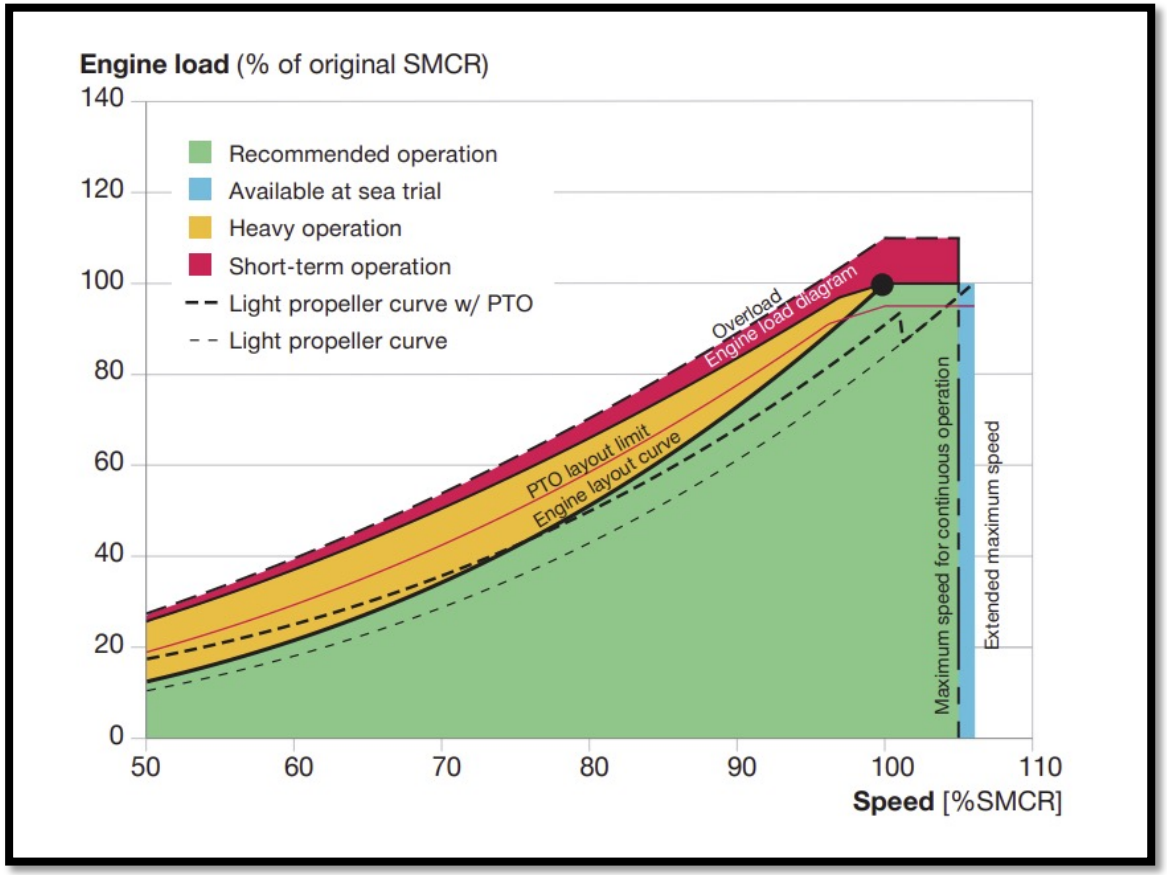
RPM [% SMCR]	$PTO_{layout\ limit}$ [% SMCR]
60 – 96.2	100 × (rel. rpm [%] / 100%)$^{2.4}$
96.2 – 100	95 × (rel. rpm [%] / 100%)
>100	95

$$PTO_{layout,lim} = 100 \cdot \left(\frac{rel.rpm[\%]}{100\%}\right)^{2.4}$$

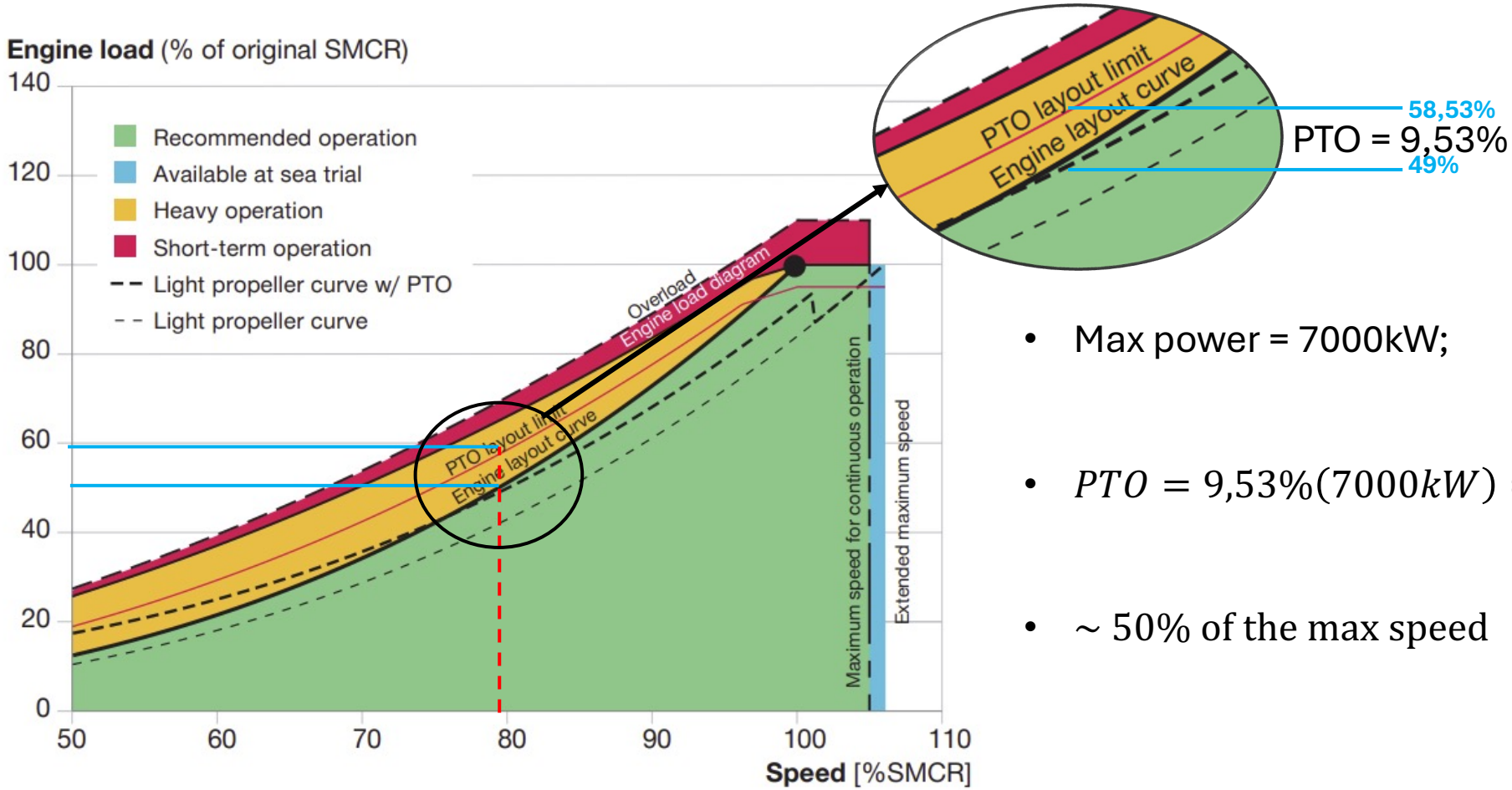
$$PTO_{layout,lim} = 100 \cdot \left(\frac{80\%}{100\%}\right)^{2.4} = \mathbf{58,53\%}$$

https://www.man-es.com/docs/default-source/marine/tools/5510-0003-03ppr.pdf?sfvrsn=b570e4e5_14

Shaft Generator

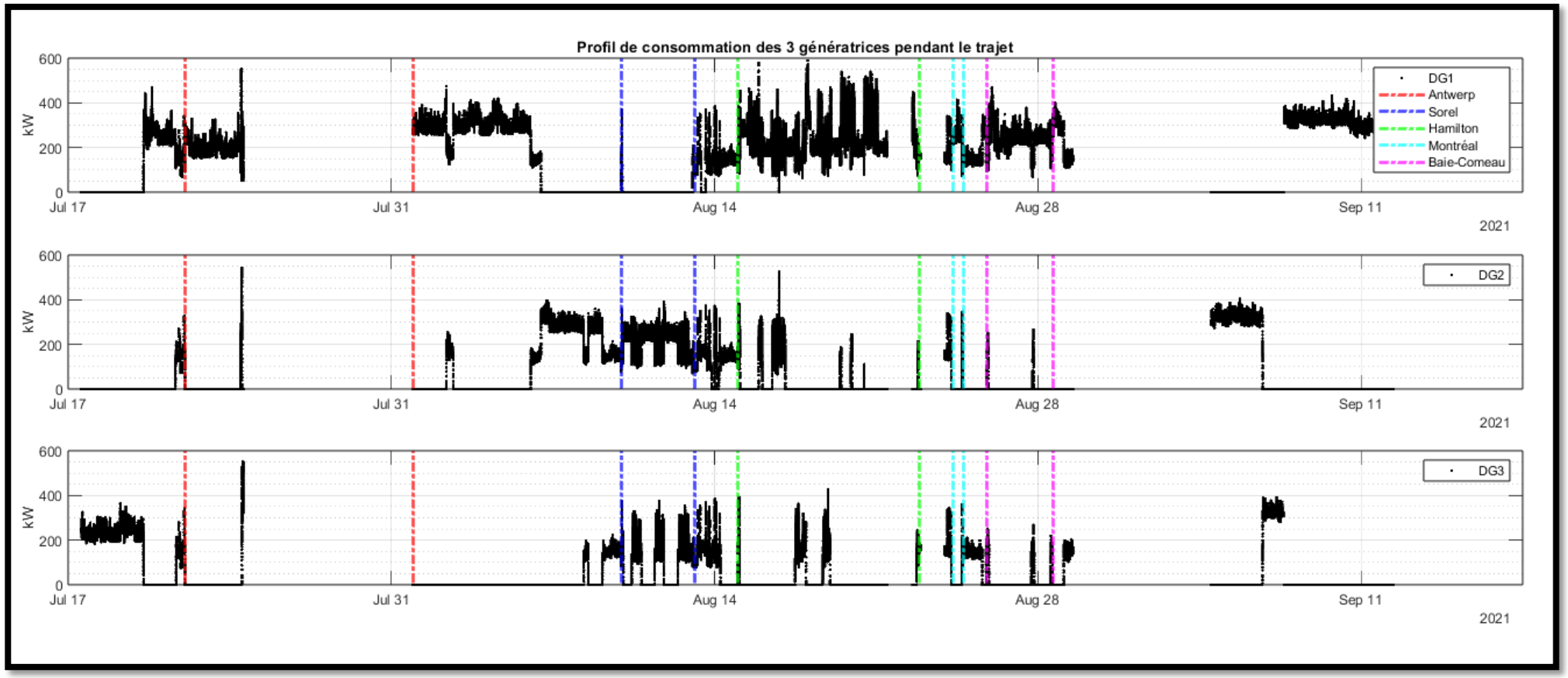


Shaft Generator – PTO layout limit



- Max power = 7000kW;
- $PTO = 9{,}53\%(7000kW) = \mathbf{667{,}1}\boldsymbol{kW}$;
- $\sim 50\%$ of the max speed

Generators capacity profile



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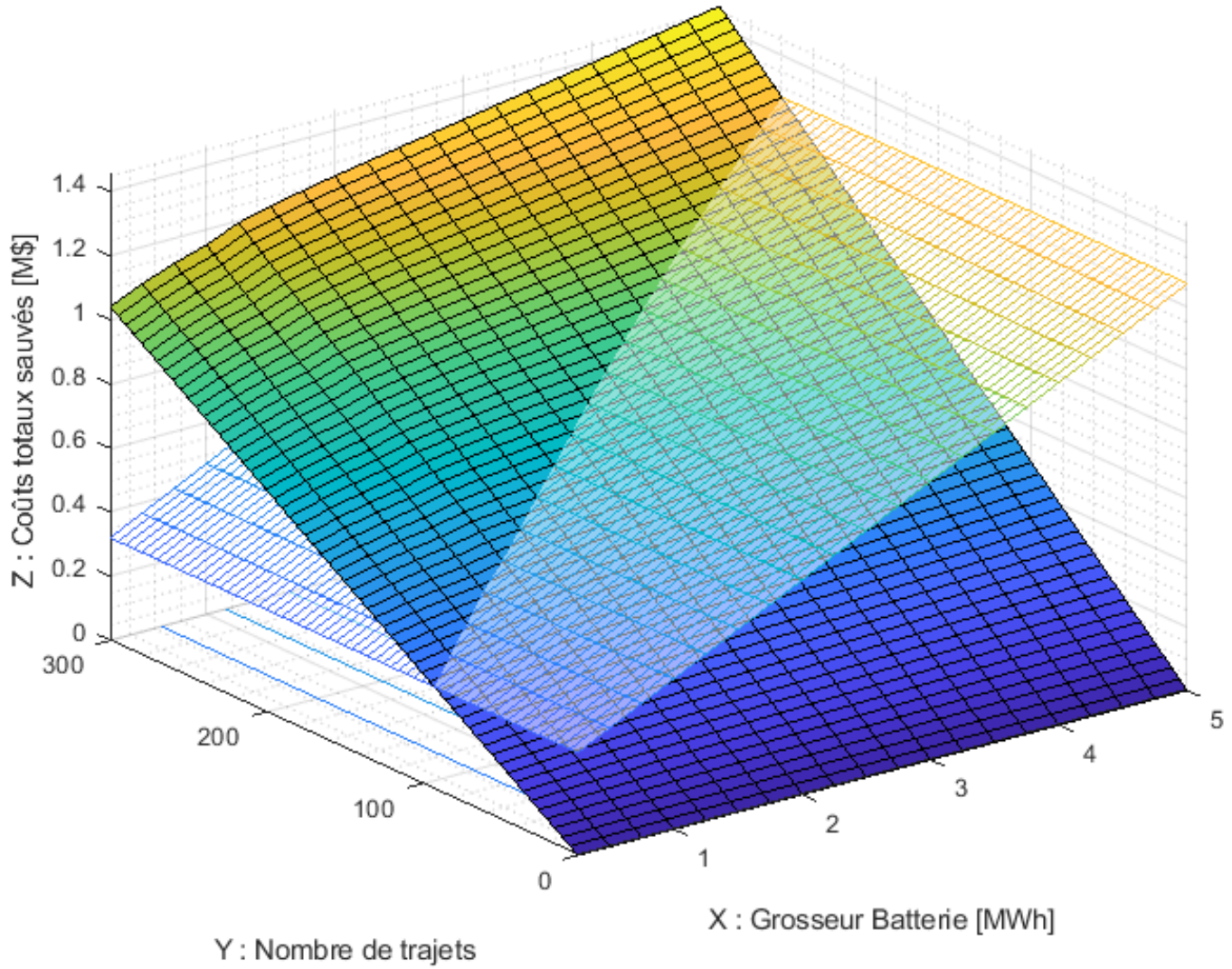
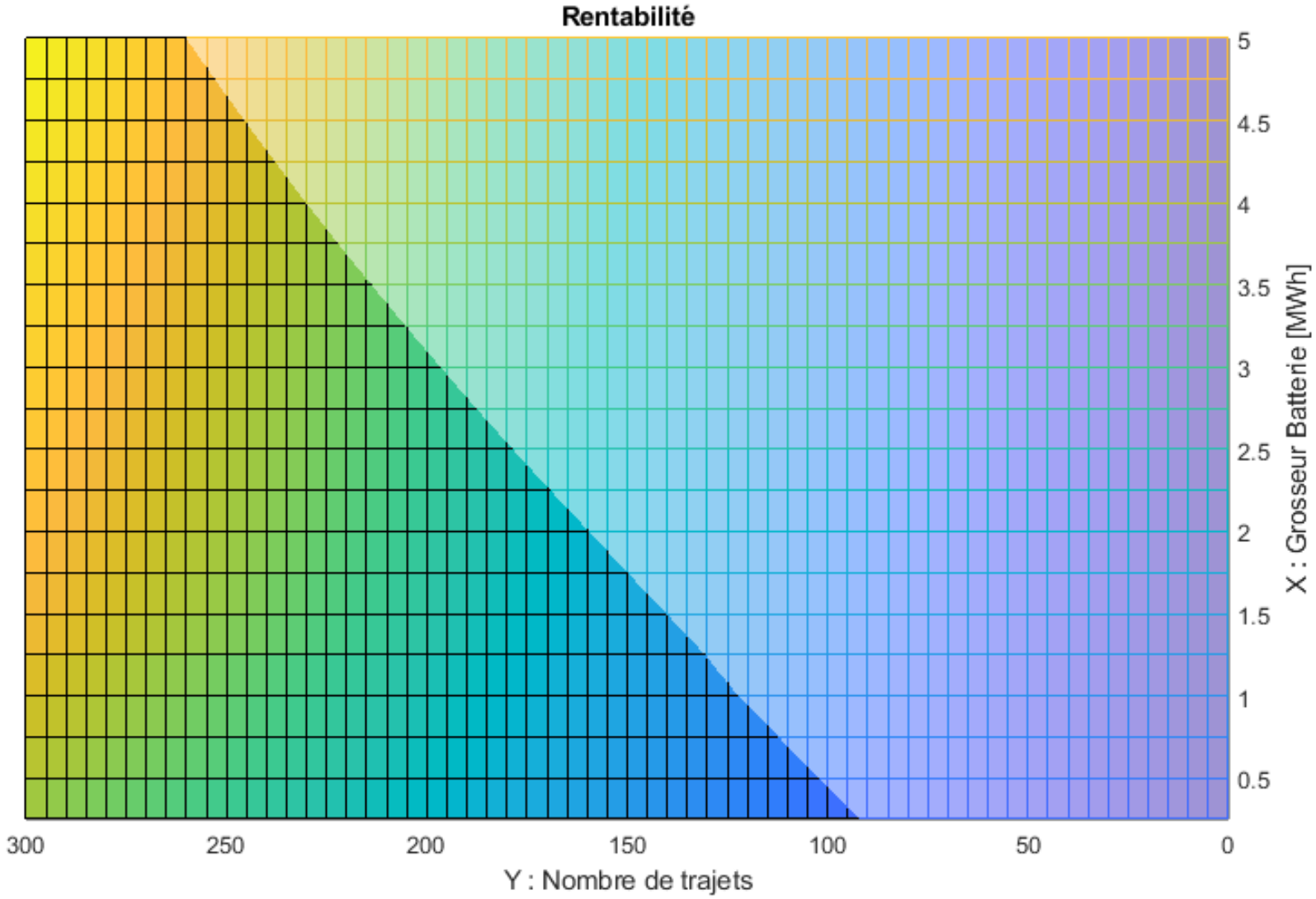

Z : Coûts totaux sauvés [M$]
1.4
1.2
1
0.8
0.6
0.4
0.2
0
300
200
100
0
Y : Nombre de trajets
1
2
3
4
5
X : Grosseur Batterie [MWh]


Rentabilité
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
X : Grosseur Batterie [MWh]
300
250
200
150
100
50
0
Y : Nombre de trajets