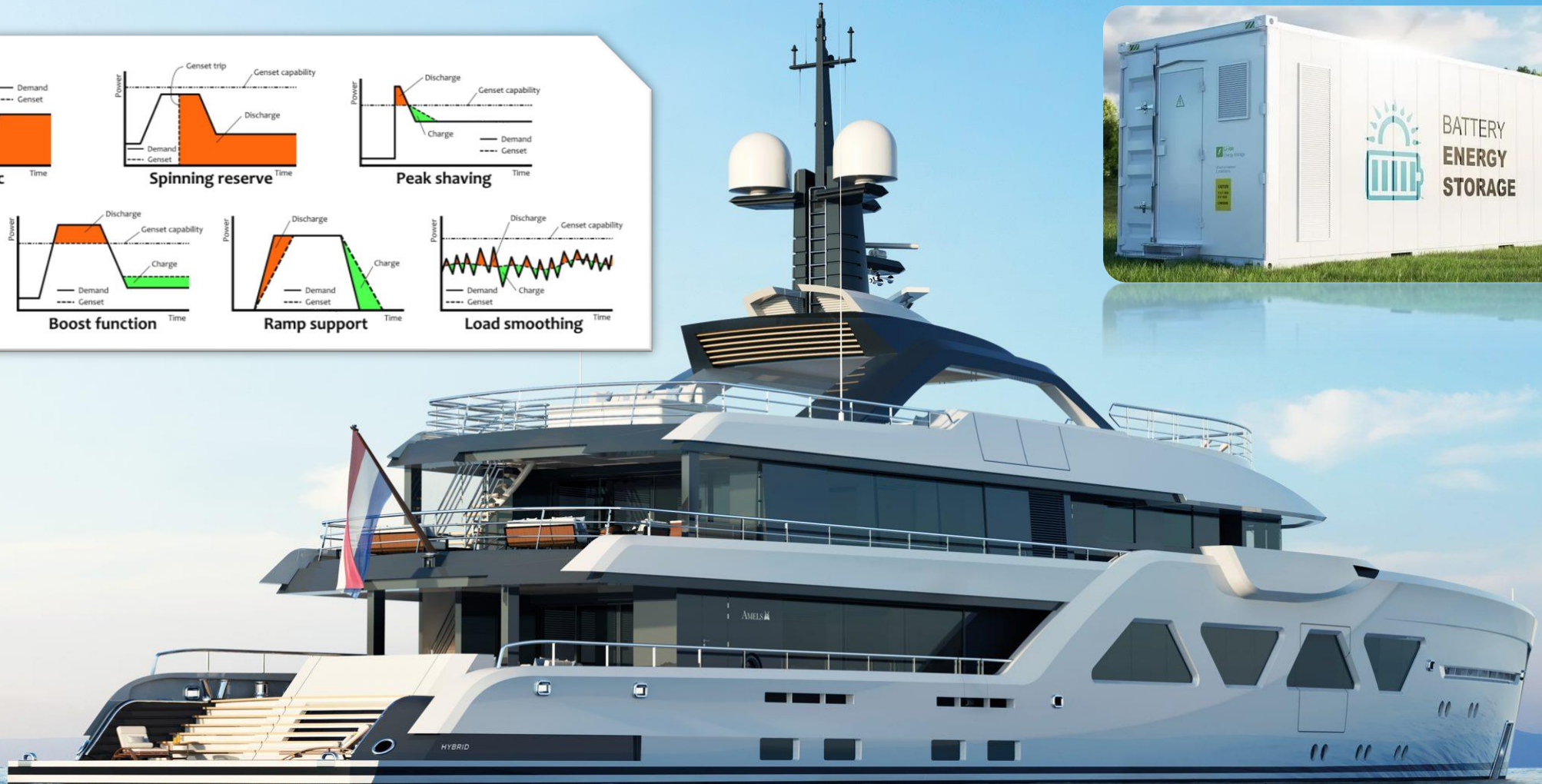
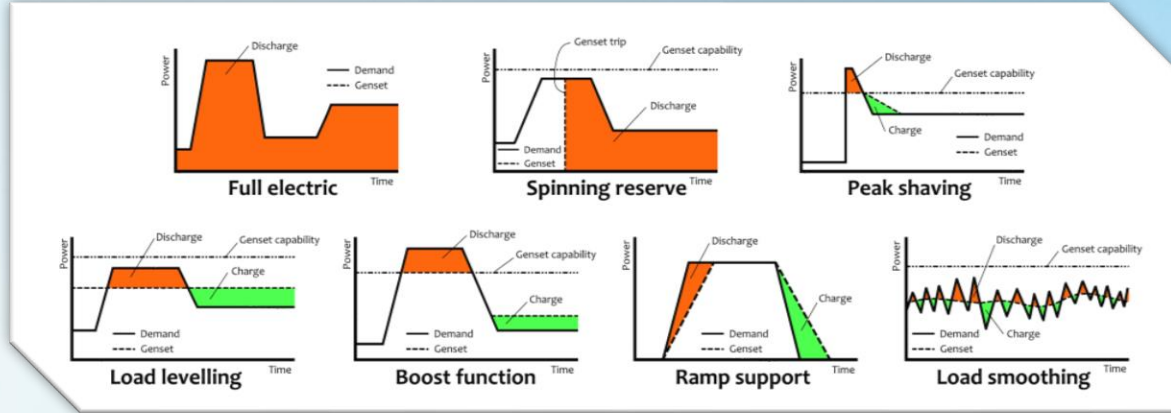


Battery Storage Systems



Introduction

Matthijs Mosselaar

Background: MSc. Electrical Power Engineering
Delft University of Technology

Occupation: (Electrical) Engineer

- Hybrid systems
- Technical Sales Support
- Modelling/Simulation
- Power Quality / EMC

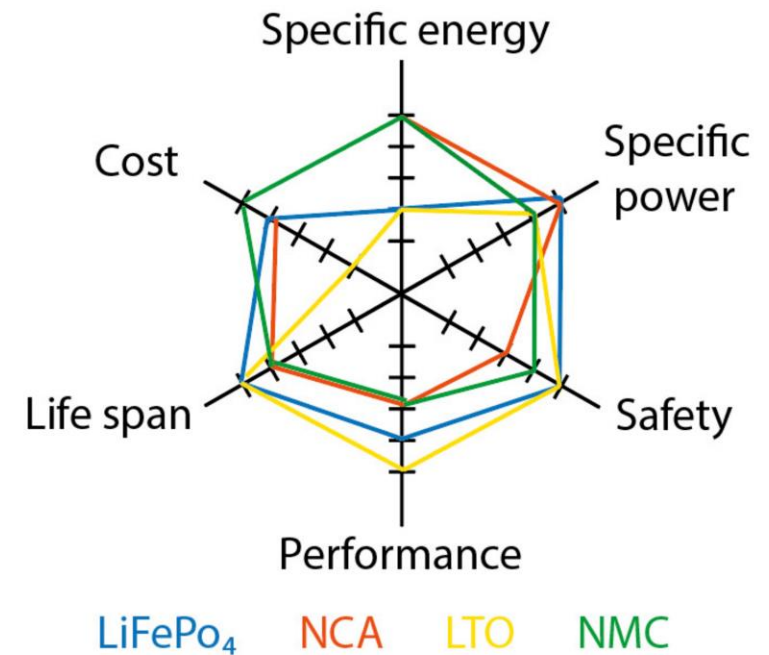


Battery specifications

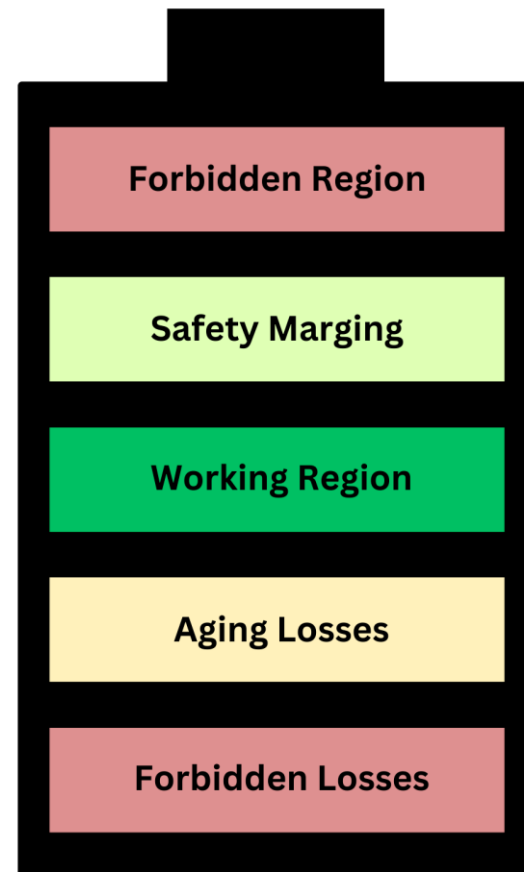
- High power
- High energy
- Chemistry
- Ageing

$$\text{C-rate} = \frac{\text{power (kW)}}{\text{energy (kWh)}}$$

C-rate < 0,8: high energy
C-rate > 0,8: high power

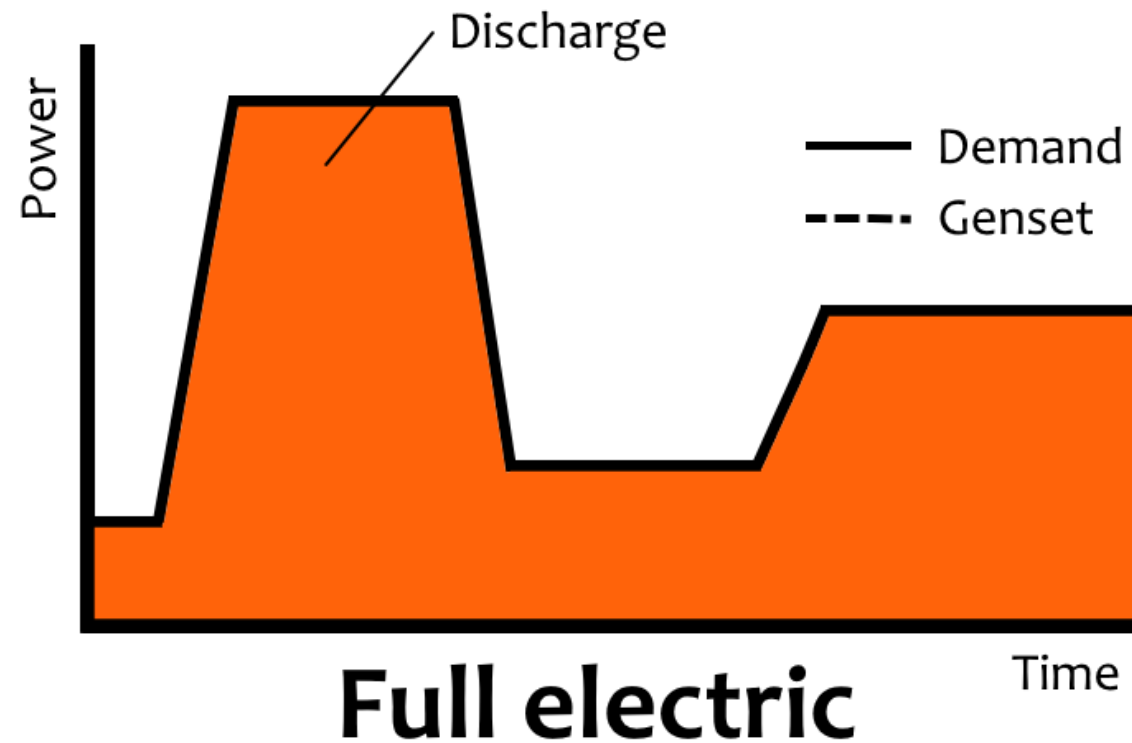


Battery specifications



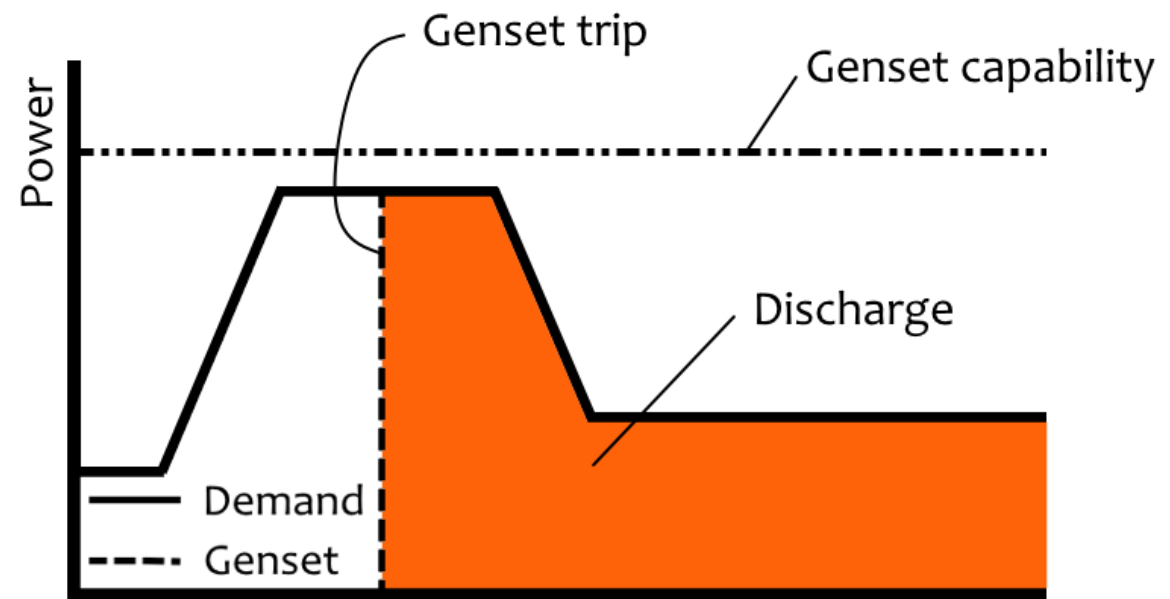
Full electric

- How much power?
- For how long?
- How many times?



Spinning reserve

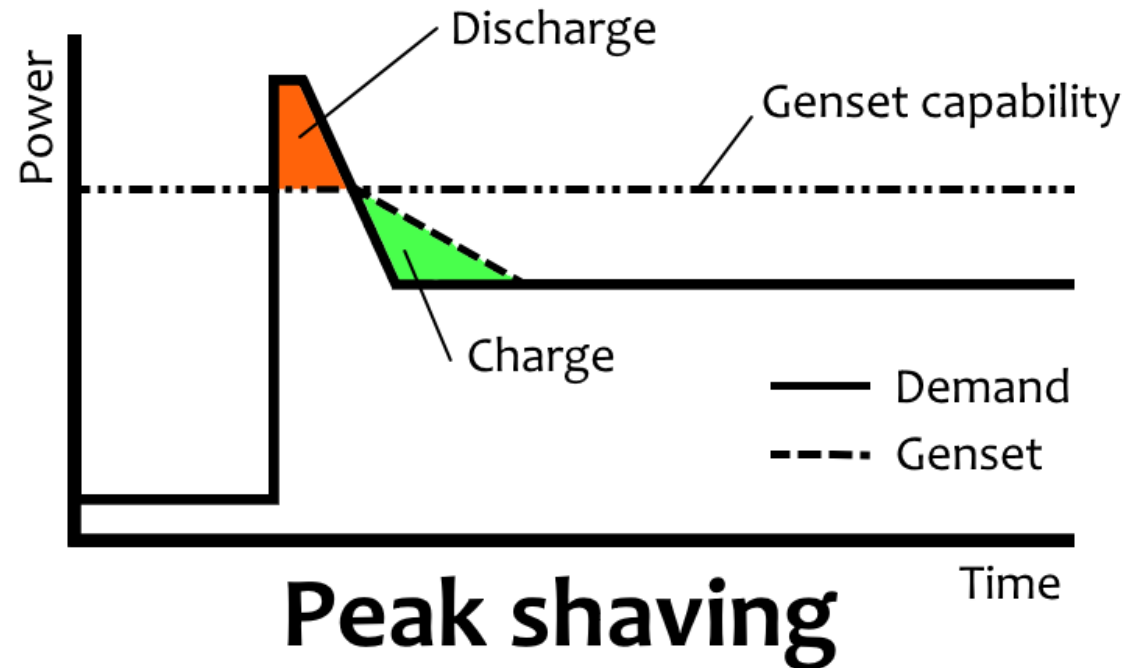
- How much power?
- For how long?
- How many times?
- Other applications at the same time?



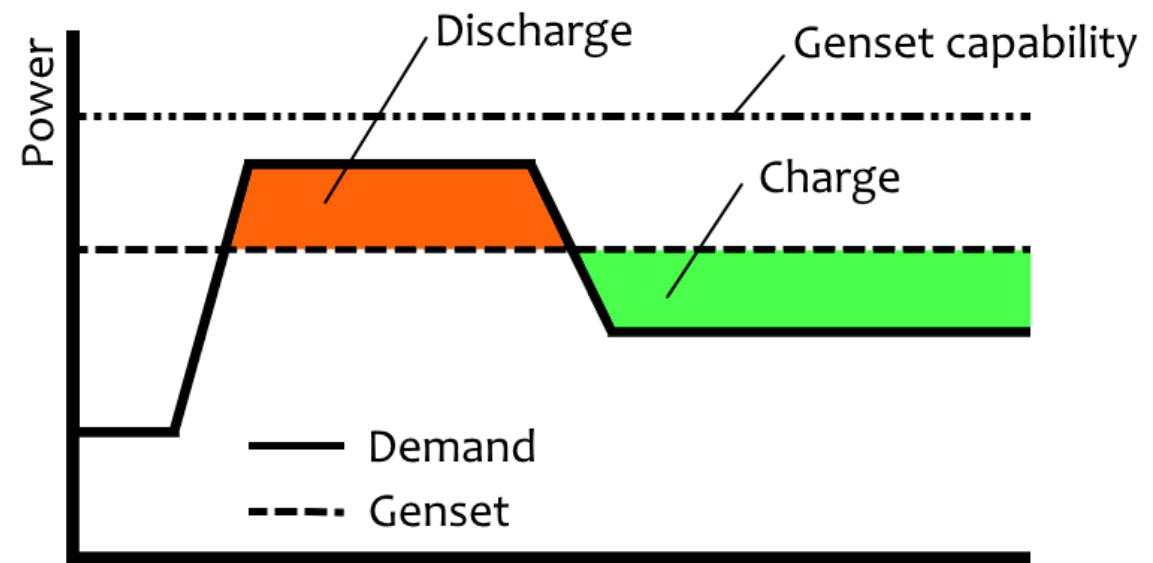
Spinning reserve Time

Peak shaving

- How much power?
- For how long?
- How many times?

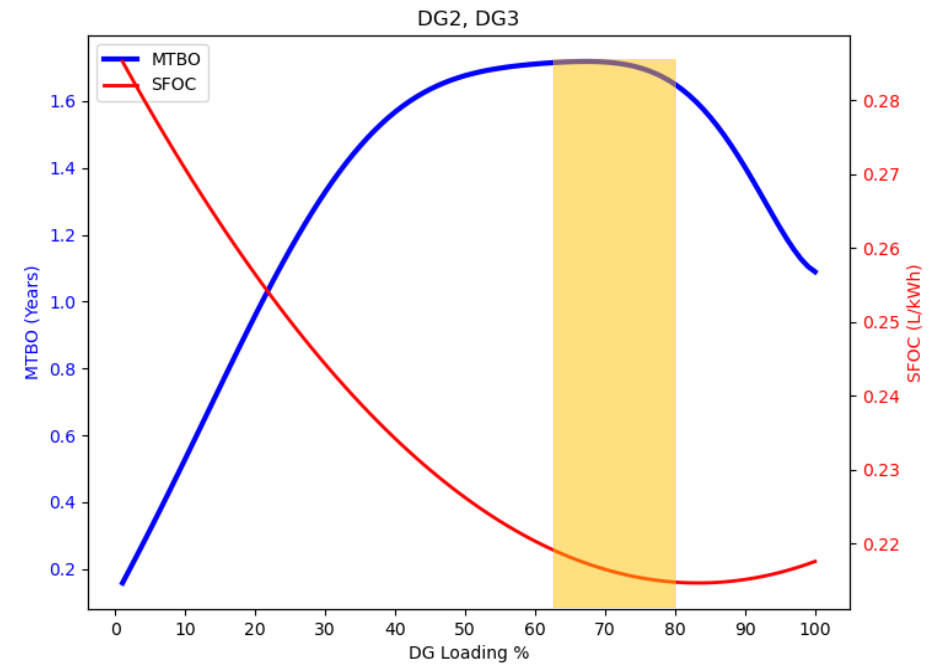
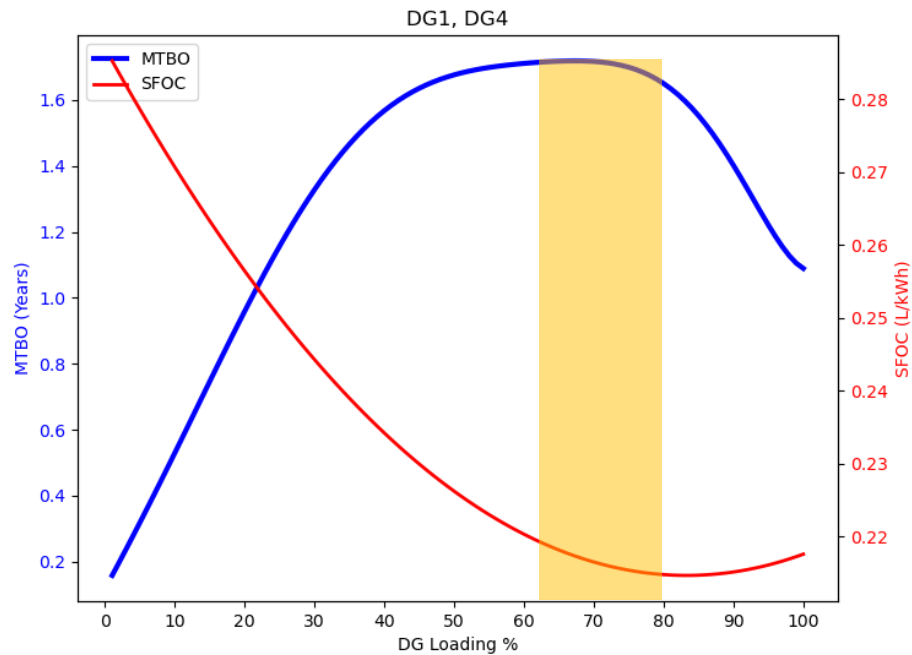


Load levelling



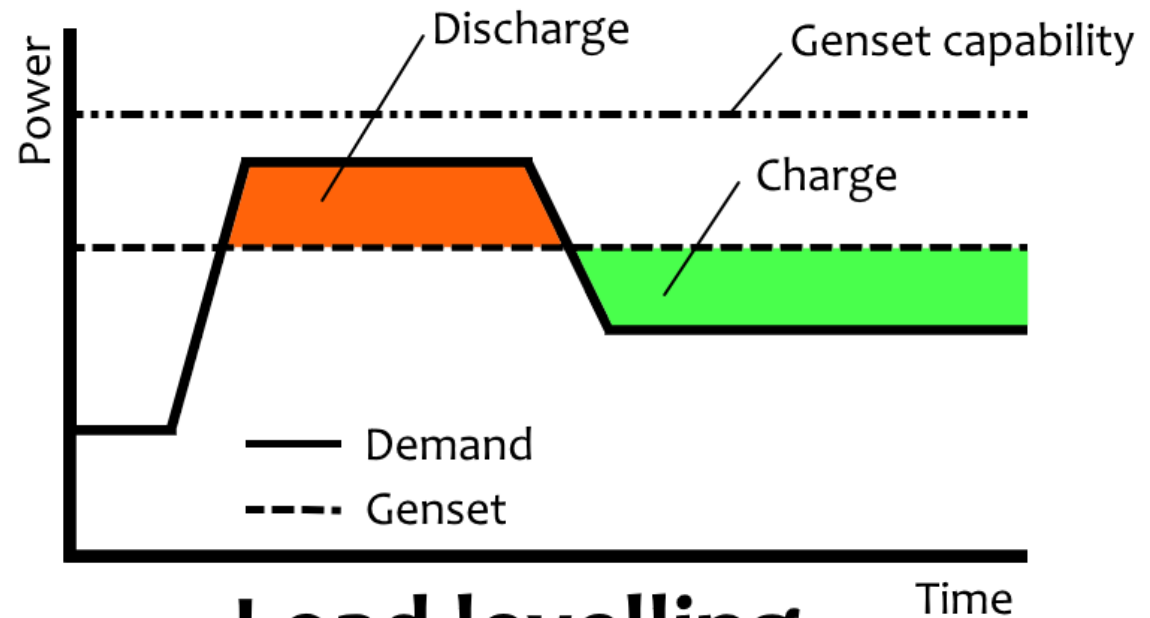
Load levelling

Load levelling



Load levelling

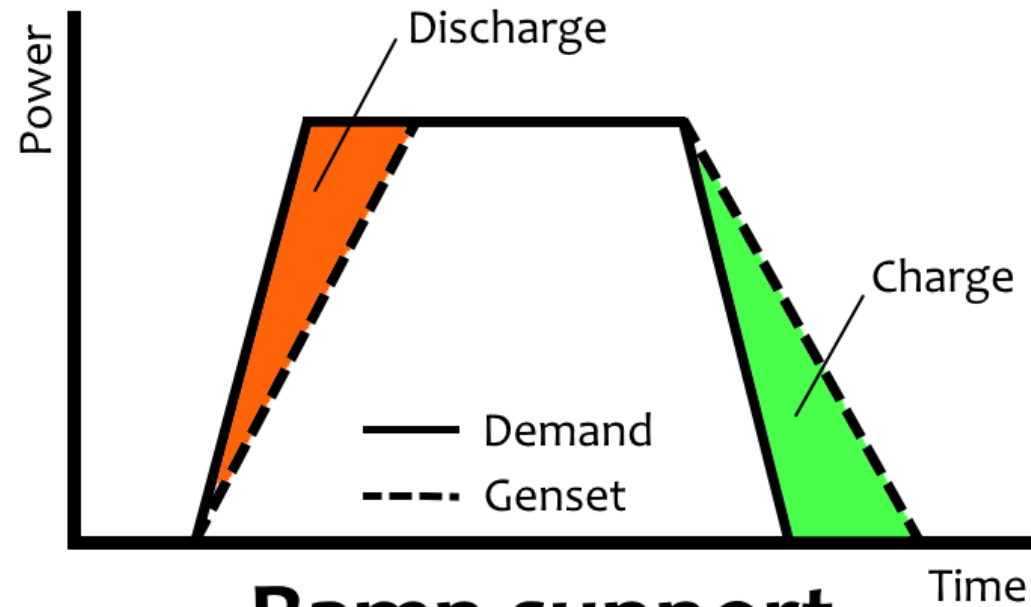
- How much power?
- For how long?
- How many times?



Load levelling

Ramp support

- How much power?
- For how long?
- How many times?



Ramp support

Operational profile

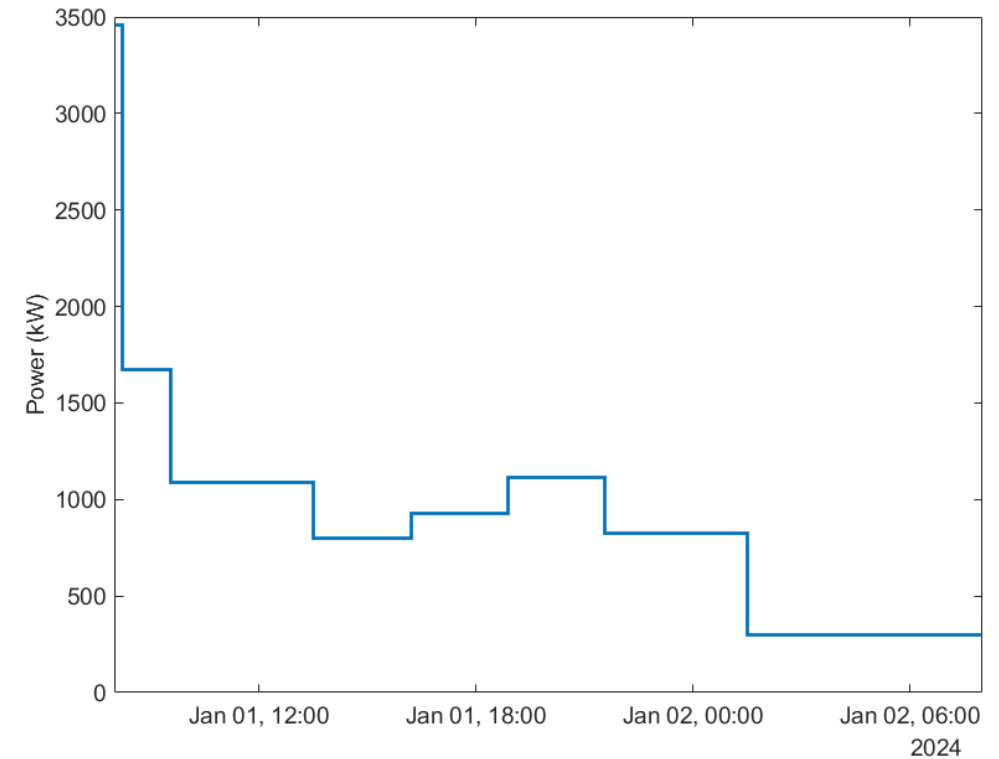
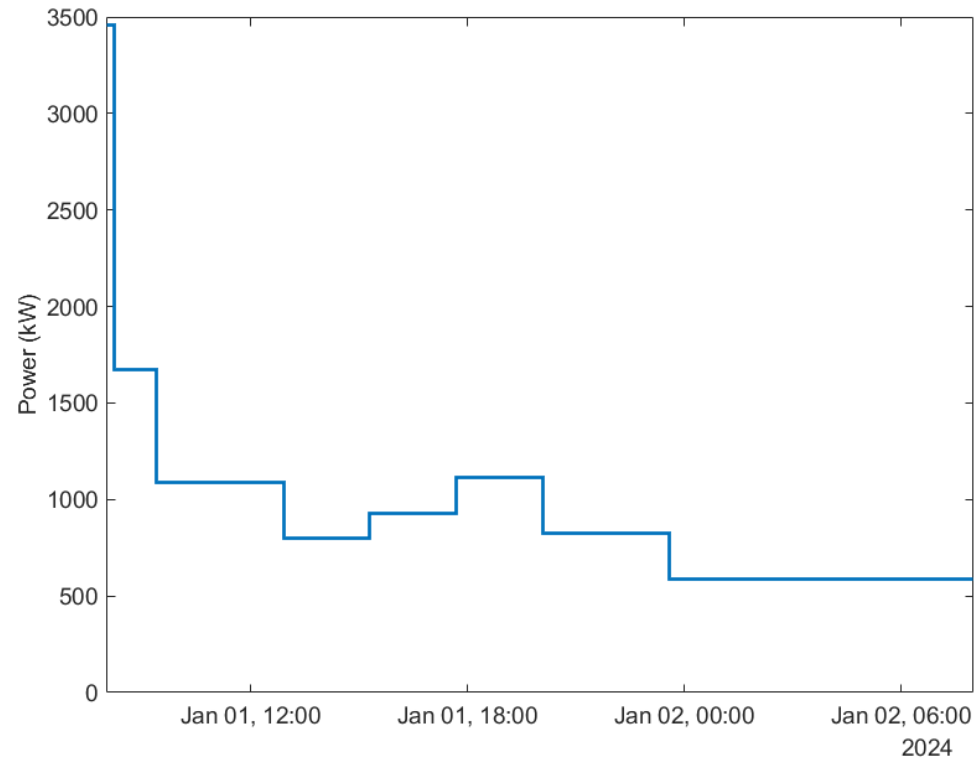
Less than ideal case

- Create operational based on operating mode power and time
- Example for an '80 percent full-electric vessel'

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	
Operating mode 1	0,21	0,21	0,21	0,21	0,21	0,21	0,24	0,21	0,21	0,21	0,21	0,21	0,21	0,24	3
Operating mode 2	1,19	1,19	1,19	1,19	1,19	1,19	1,34	1,19	1,19	1,19	1,19	1,19	1,19	1,34	17
Operating mode 3	3,51	3,51	3,51	3,51	3,51	3,51	3,94	3,51	3,51	3,51	3,51	3,51	3,51	3,94	50
Operating mode 4	2,39	2,39	2,39	2,39	2,39	2,39	2,68	2,39	2,39	2,39	2,39	2,39	2,39	2,68	34
Operating mode 5	2,39	2,39	2,39	2,39	2,39	2,39	2,68	2,39	2,39	2,39	2,39	2,39	2,39	2,68	34
Operating mode 6	2,39	2,39	2,39	2,39	2,39	2,39	2,68	2,39	2,39	2,39	2,39	2,39	2,39	2,68	34
Operating mode 7	3,51	3,51	3,51	3,51	3,51	3,51	3,94	3,51	3,51	3,51	3,51	3,51	3,51	3,94	50
Operating mode 8	8,42	8,42	8,42	8,42	8,42	8,42		8,42	8,42	8,42	8,42	8,42	8,42		101
Operating mode 9							6,5							6,5	13
	24	24	24	24	24	24	24	24	24	24	24	24	24	24	

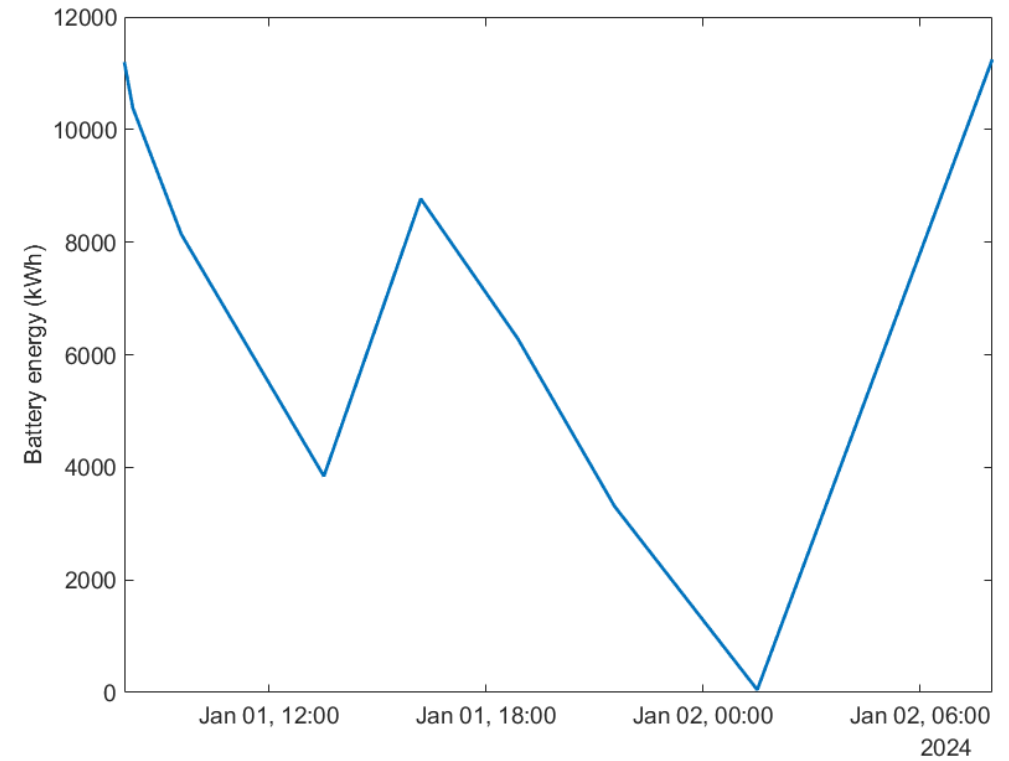
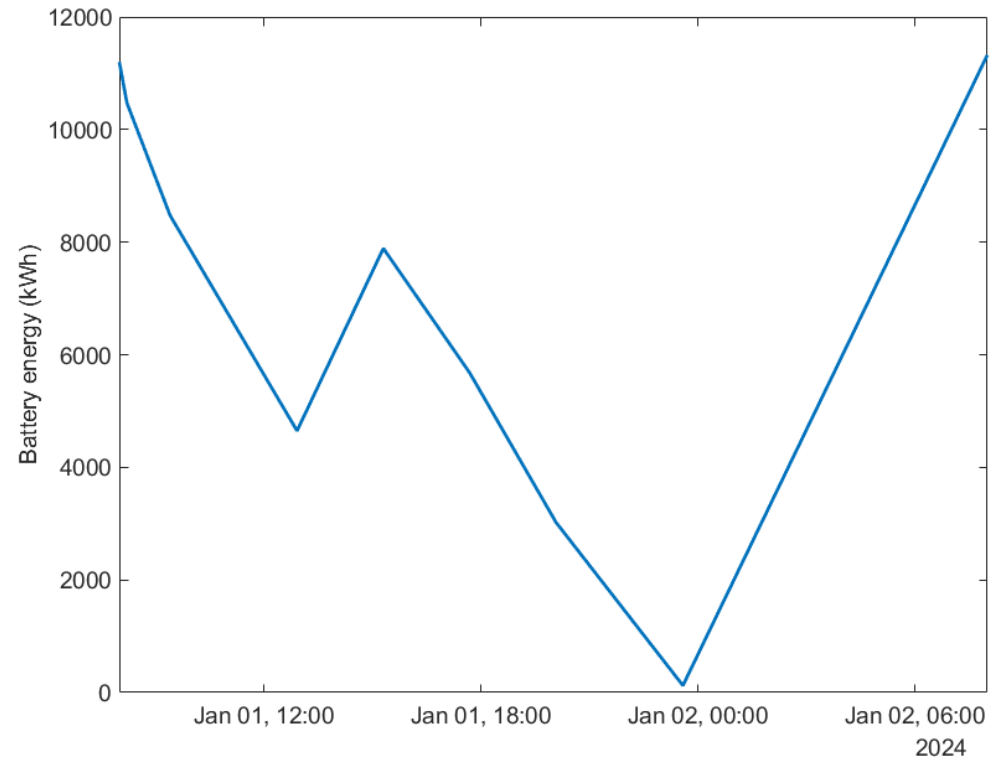
Operational profile

Less than ideal case



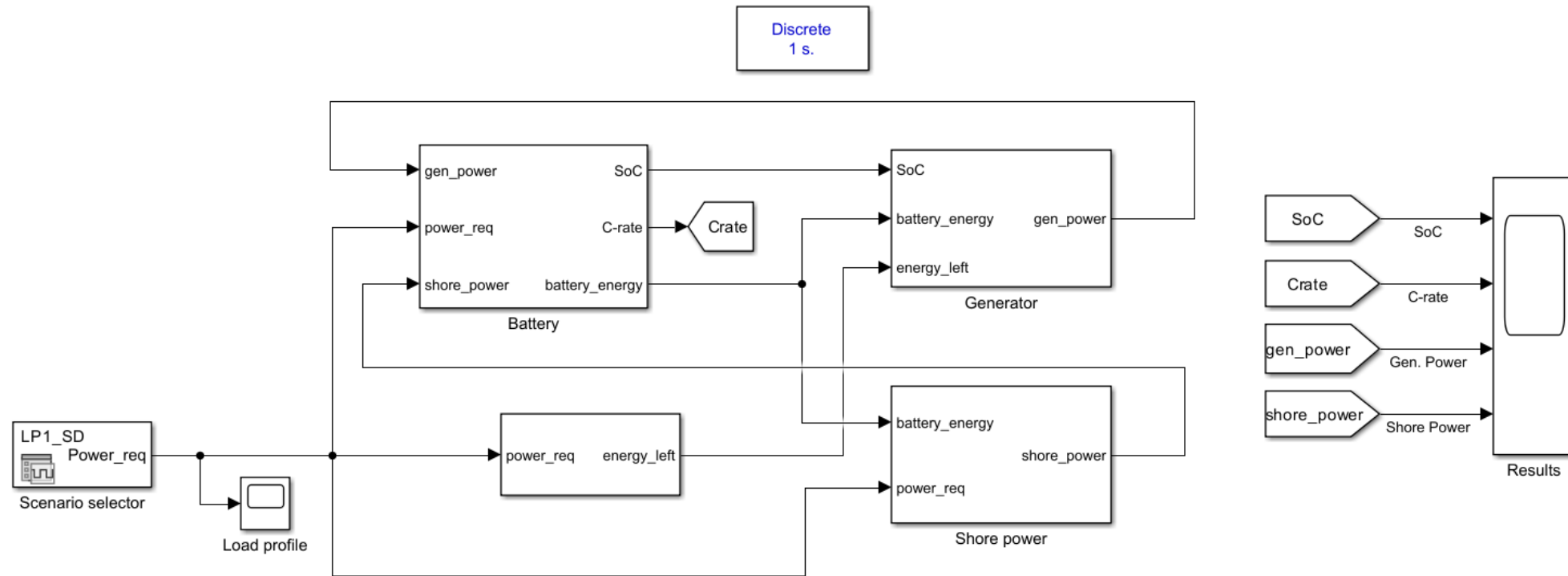
Battery energy

Simulation of operational profile



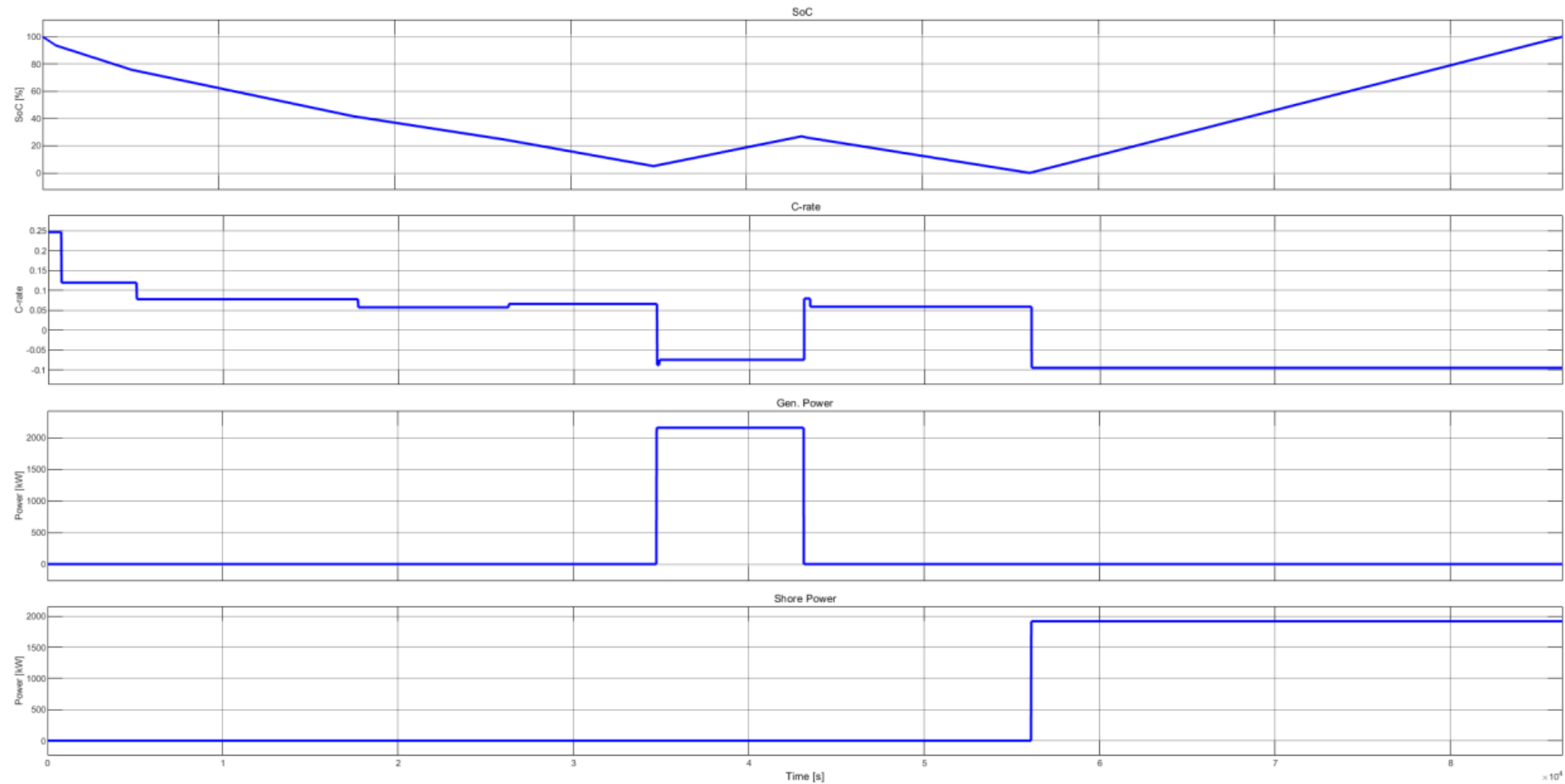
Operational profile

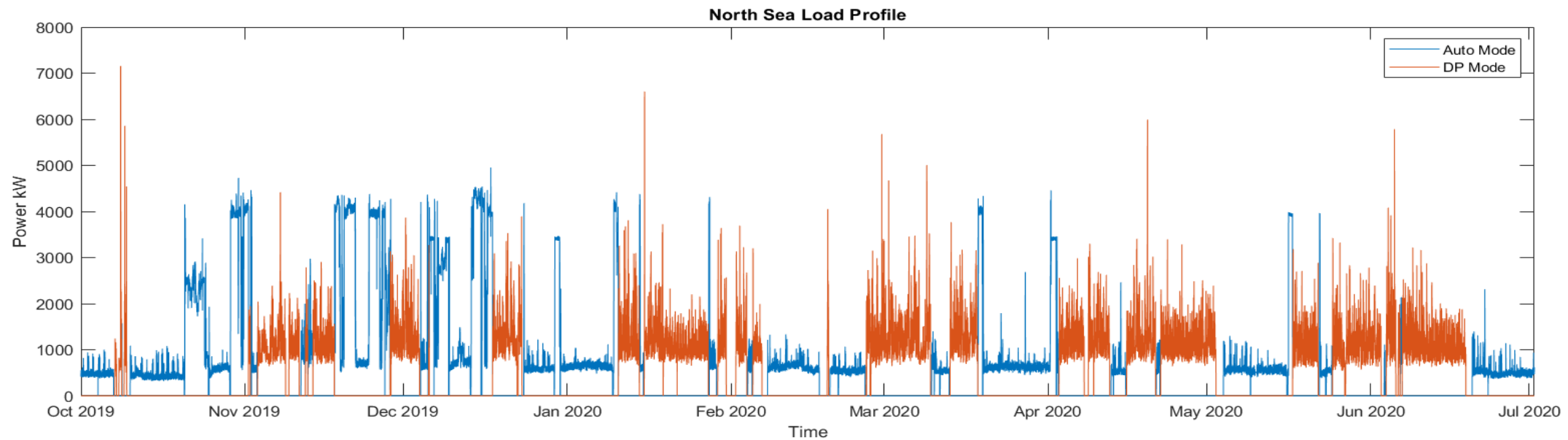
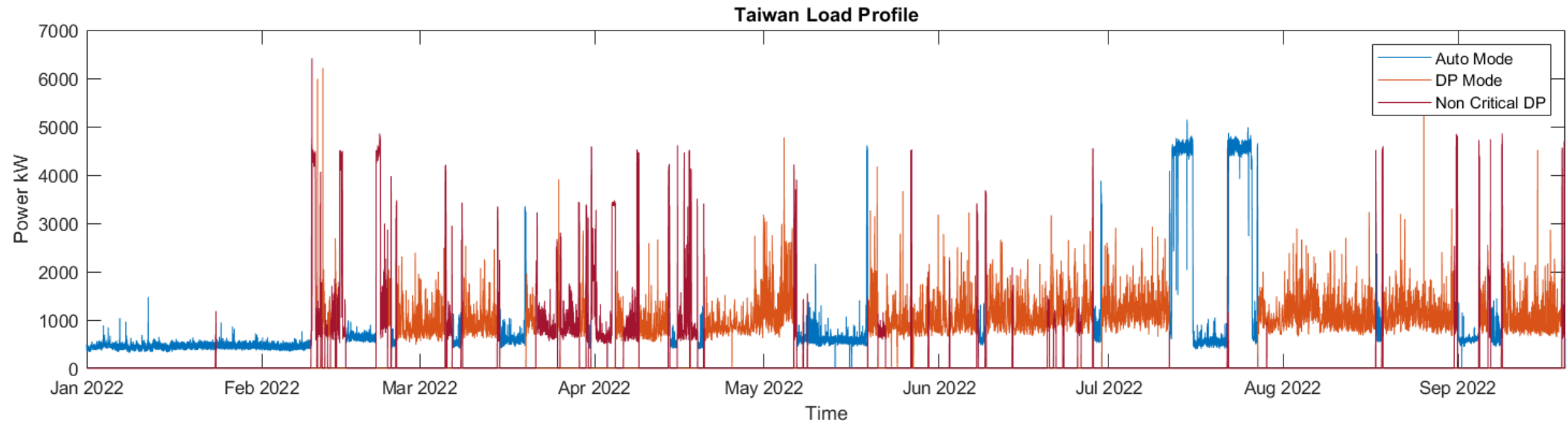
Simulation of operational profile



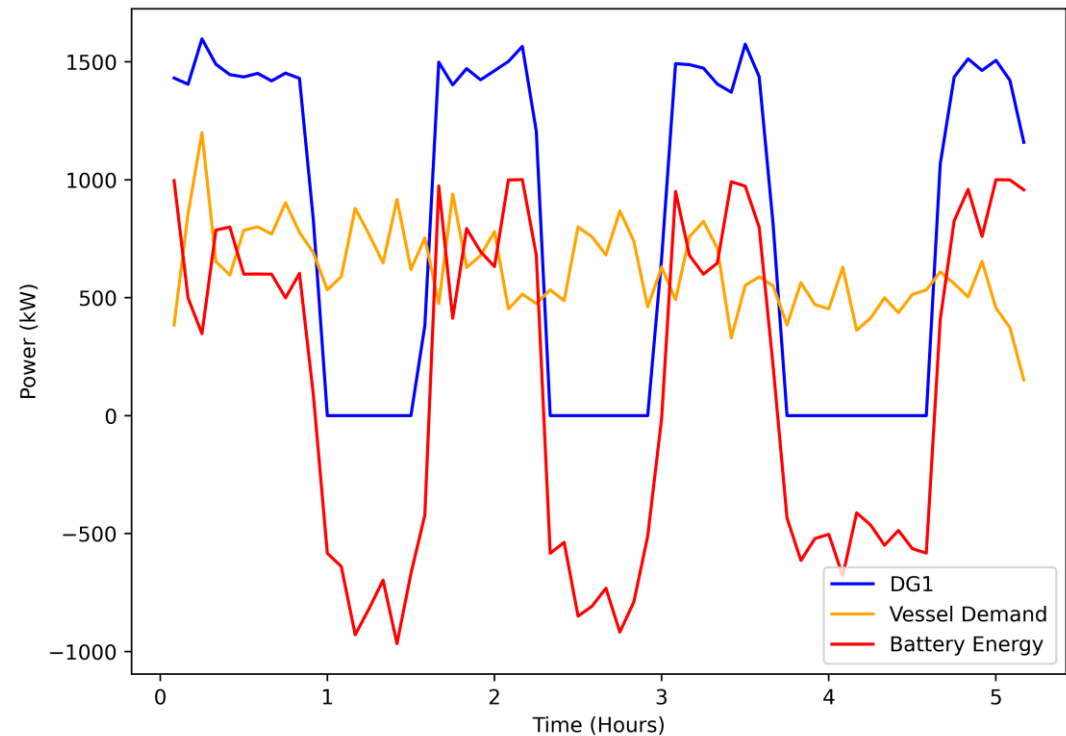
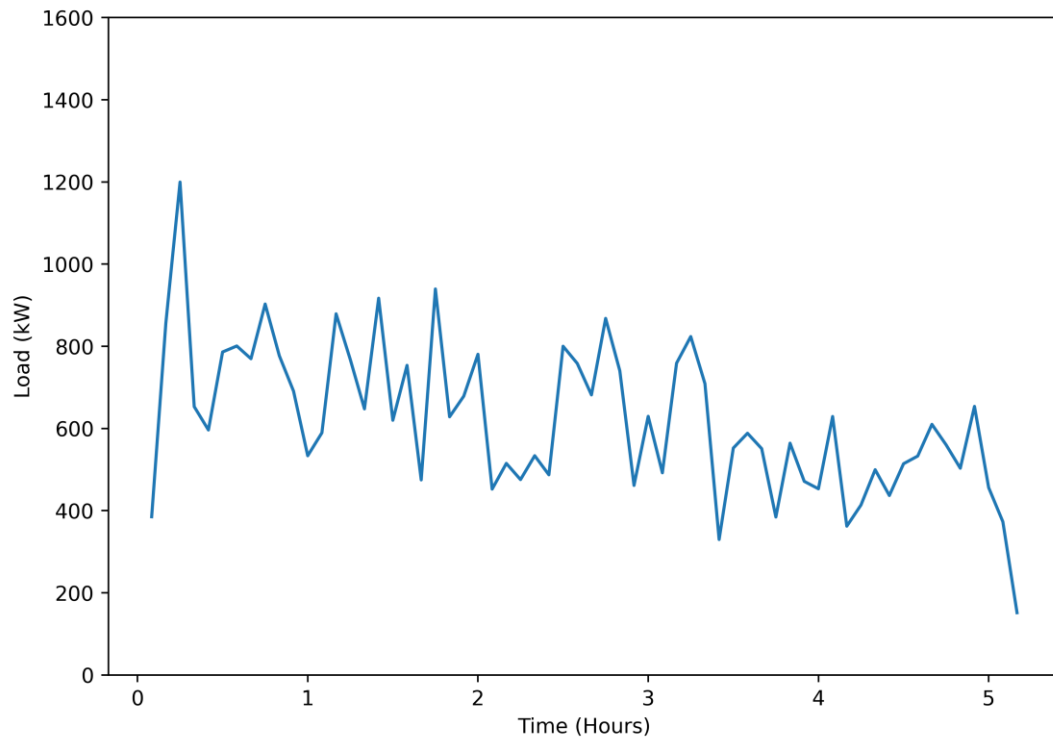
Operational profile

Simulation of operational profile





Simulation based on measurement data



Thank you!



WeConnect.