EMR'22
HES-SO Sion
June 2022

EMR'22 Summer School
"Energetic Macroscopic Representation"

« EMR-based simulation of electric-gas ship »

Fabian AMOROS, Walter LHOMME, Jean-Frédéric CHARPENTIER, Jean-Yves BILLARD, Benoit NOTTELLET

University of Lille, Naval Academy Research Institute, Segula Technologies, France

« INTRODUCTION »

Project : Retrofit a 50 years old Diesel Ship: The Sydney

Coalis

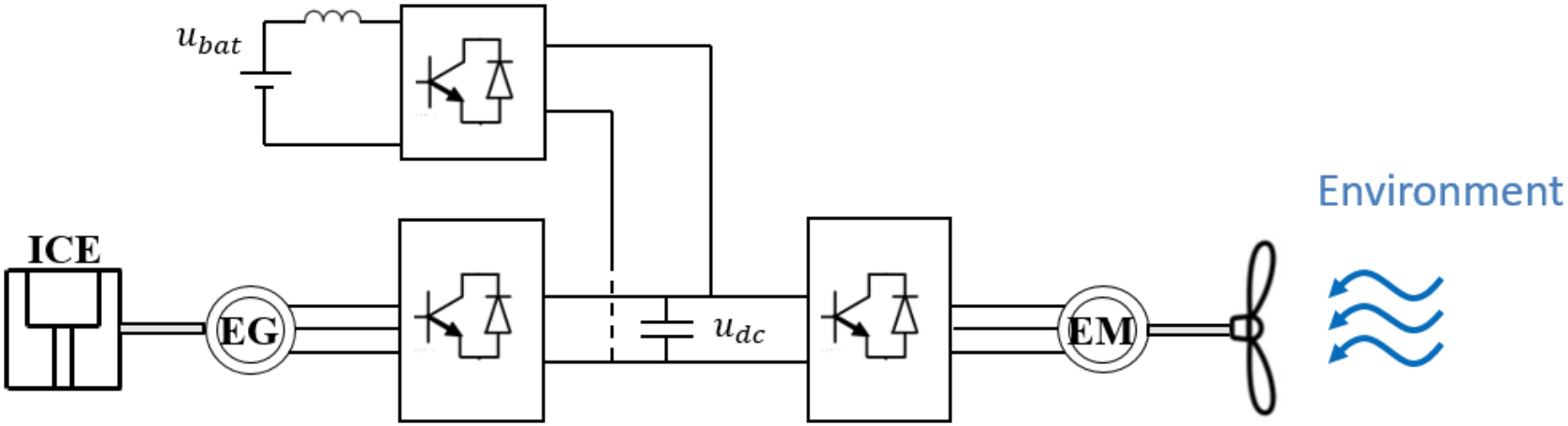
- Objectives
  - Show the feasibility of the hybrid retrofit process
  - Gas technology demonstrator

➢ The Simulator will be used to design the propulsion

- Outline -

1. Modelling
2. EMR of the System
3. Simulation Results
4. Conclusion

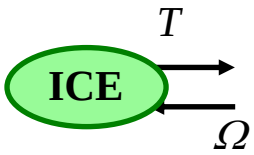
« MODELLING »

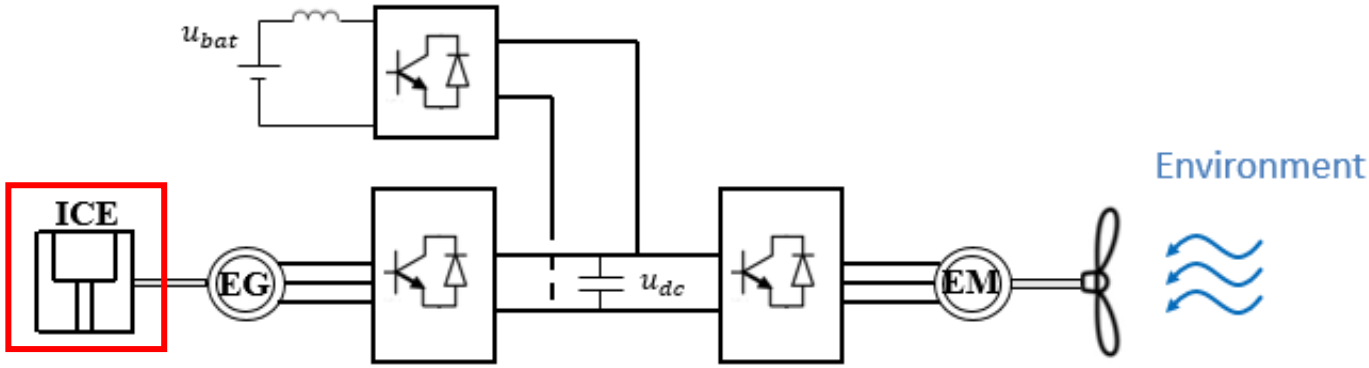


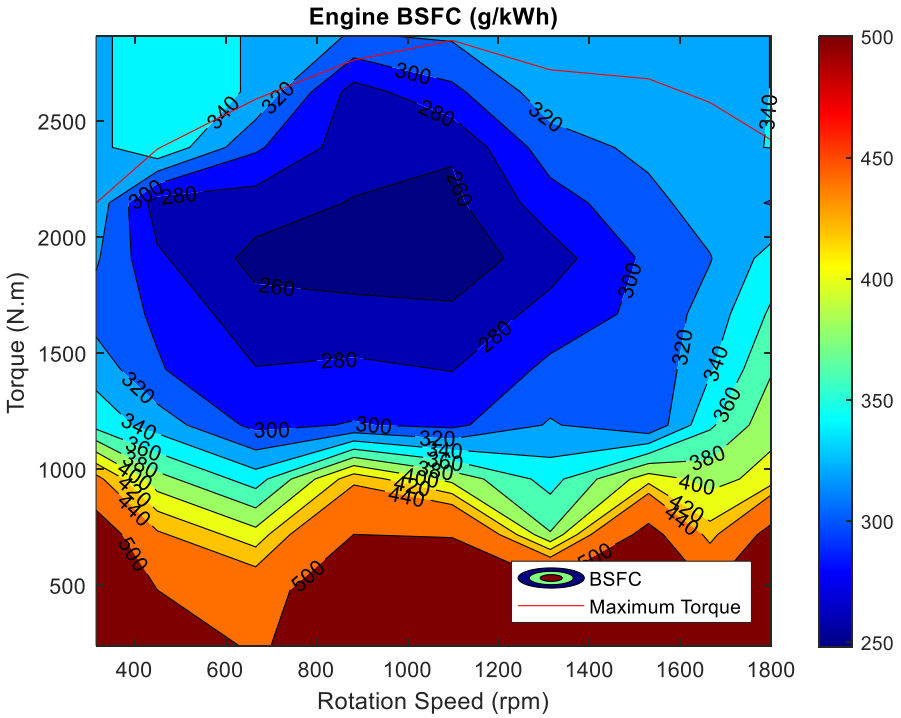
Architecture of the Hybrid vessels

EMR-based simulation of electric-gas ship

- Modellling -





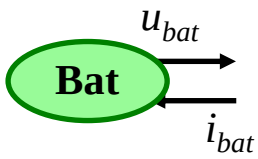


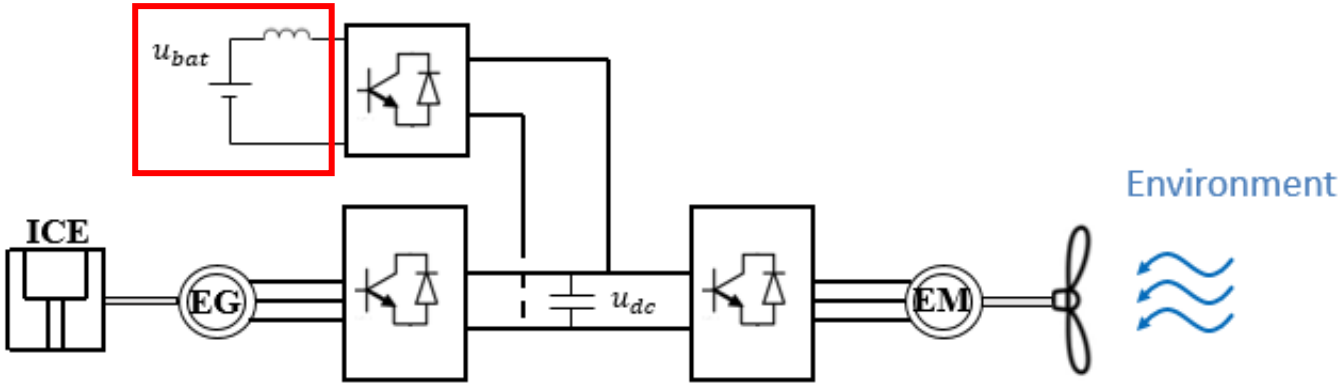
Internal Combustion Engine

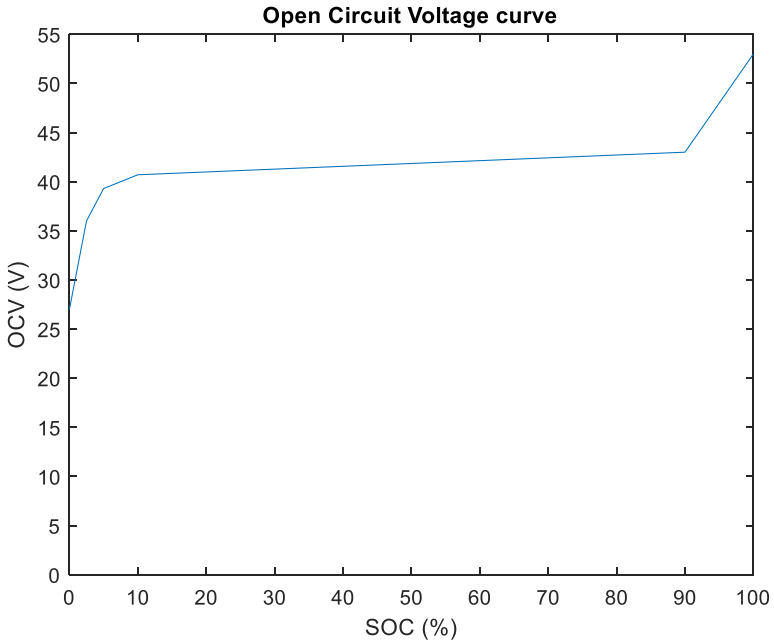
- Brake-Specific Fuel Consumption

EMR-based simulation of electric-gas ship

- Modellling -

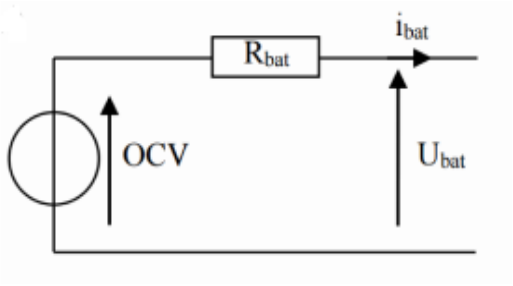


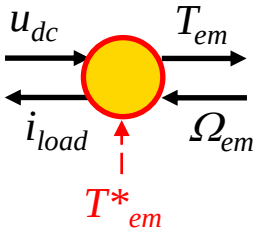


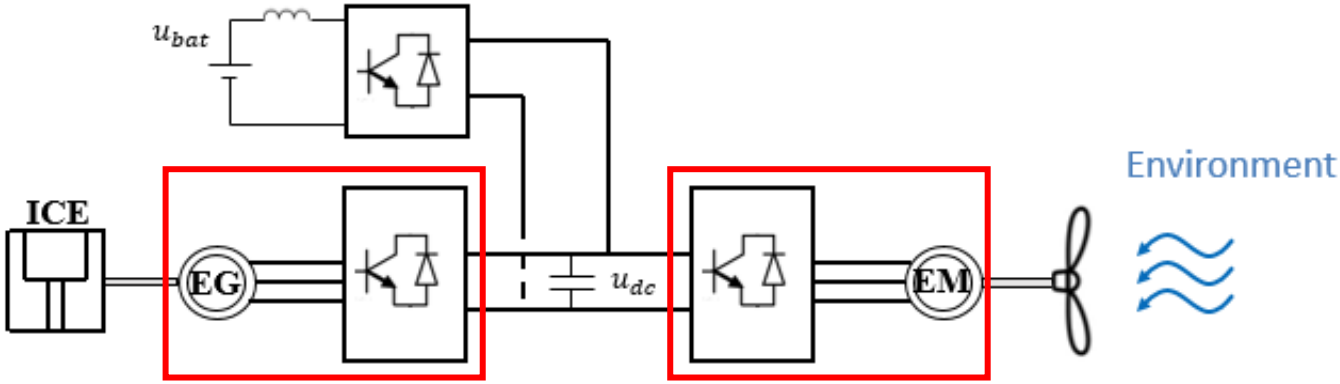


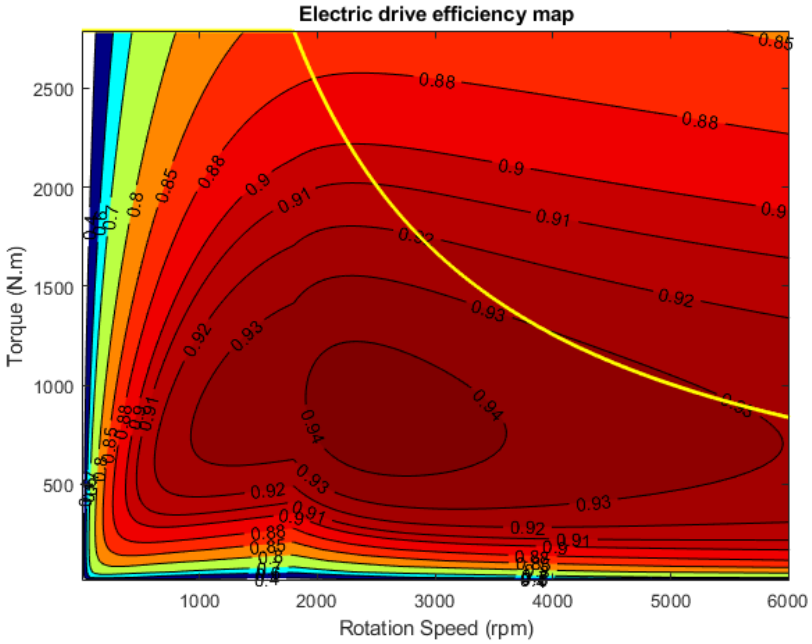
Battery

- 0 level model



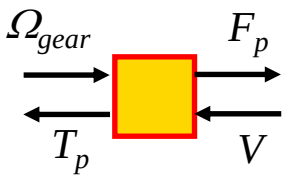


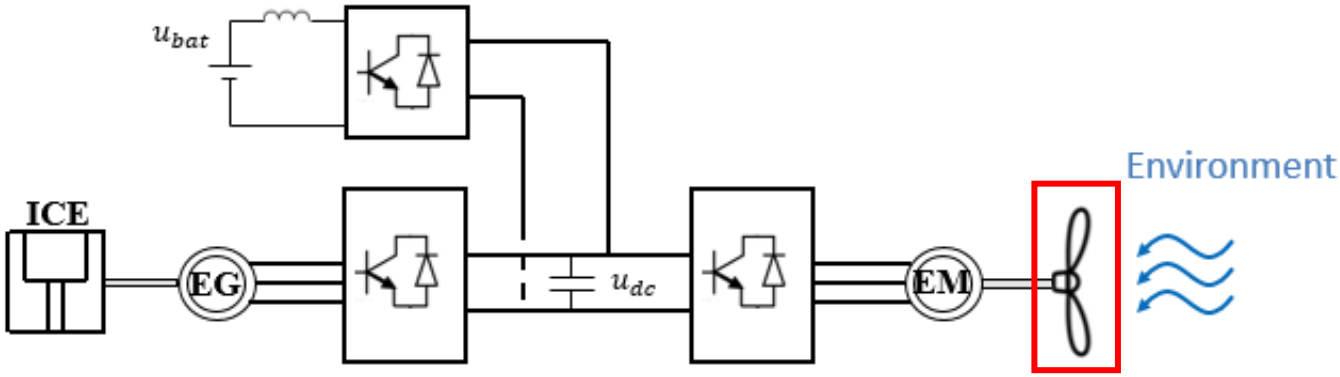


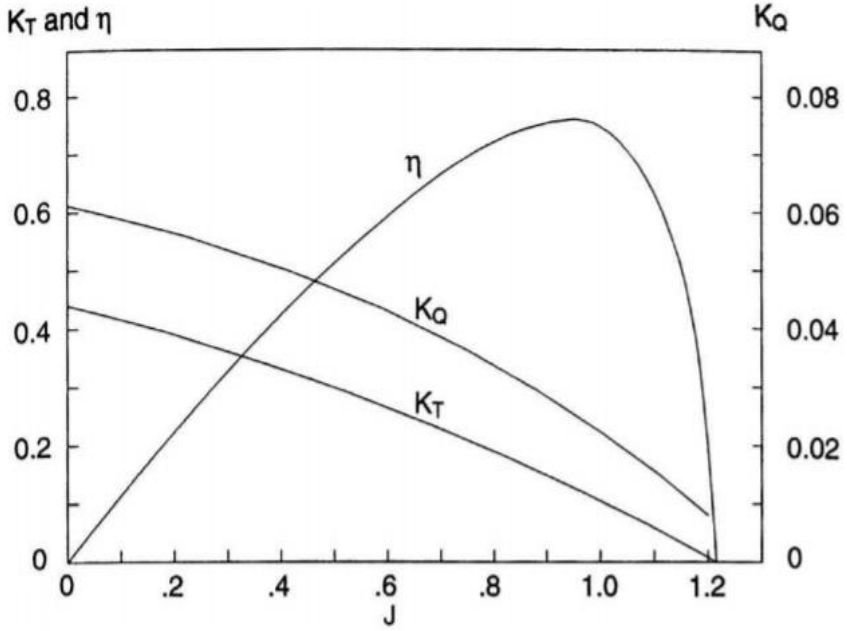


Electric machine + inverter

- Efficiency Map from
  - Experimental data
  - Model-based efficiency map





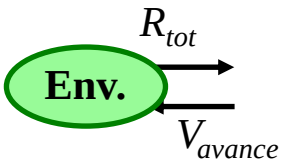


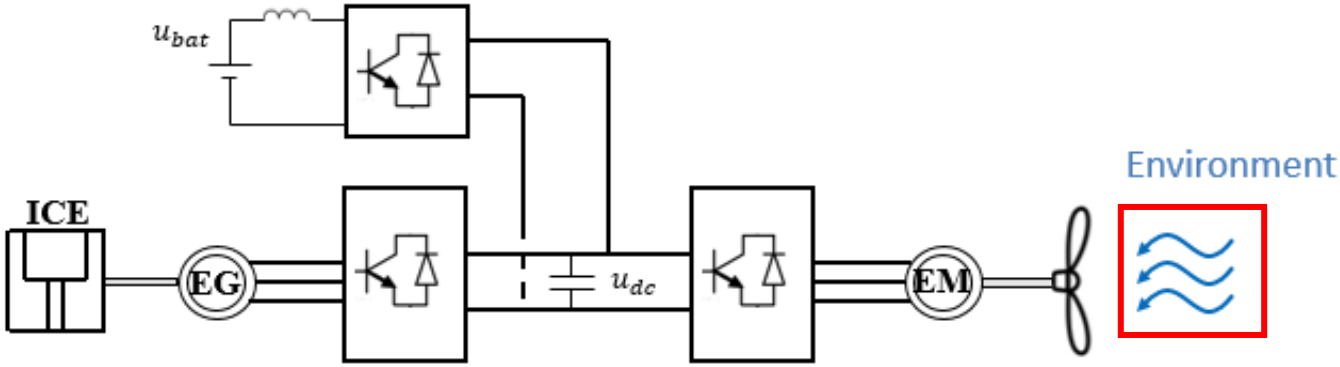
Propeller Empirical model

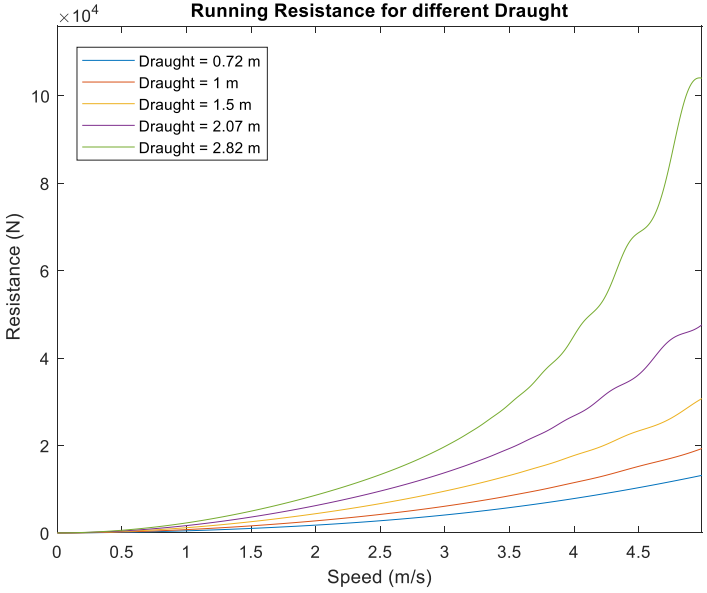
- $J = \frac{V_a}{n.D}$ *Advance parameter*
- K_T *Thrust coefficient*
- K_Q *Torque coefficient*
- $\eta = \frac{J}{2.\pi} . \frac{K_T}{K_Q}$ *Efficiency*

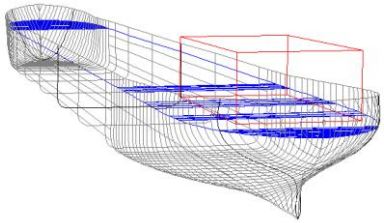
EMR-based simulation of electric-gas ship

- Modellling -









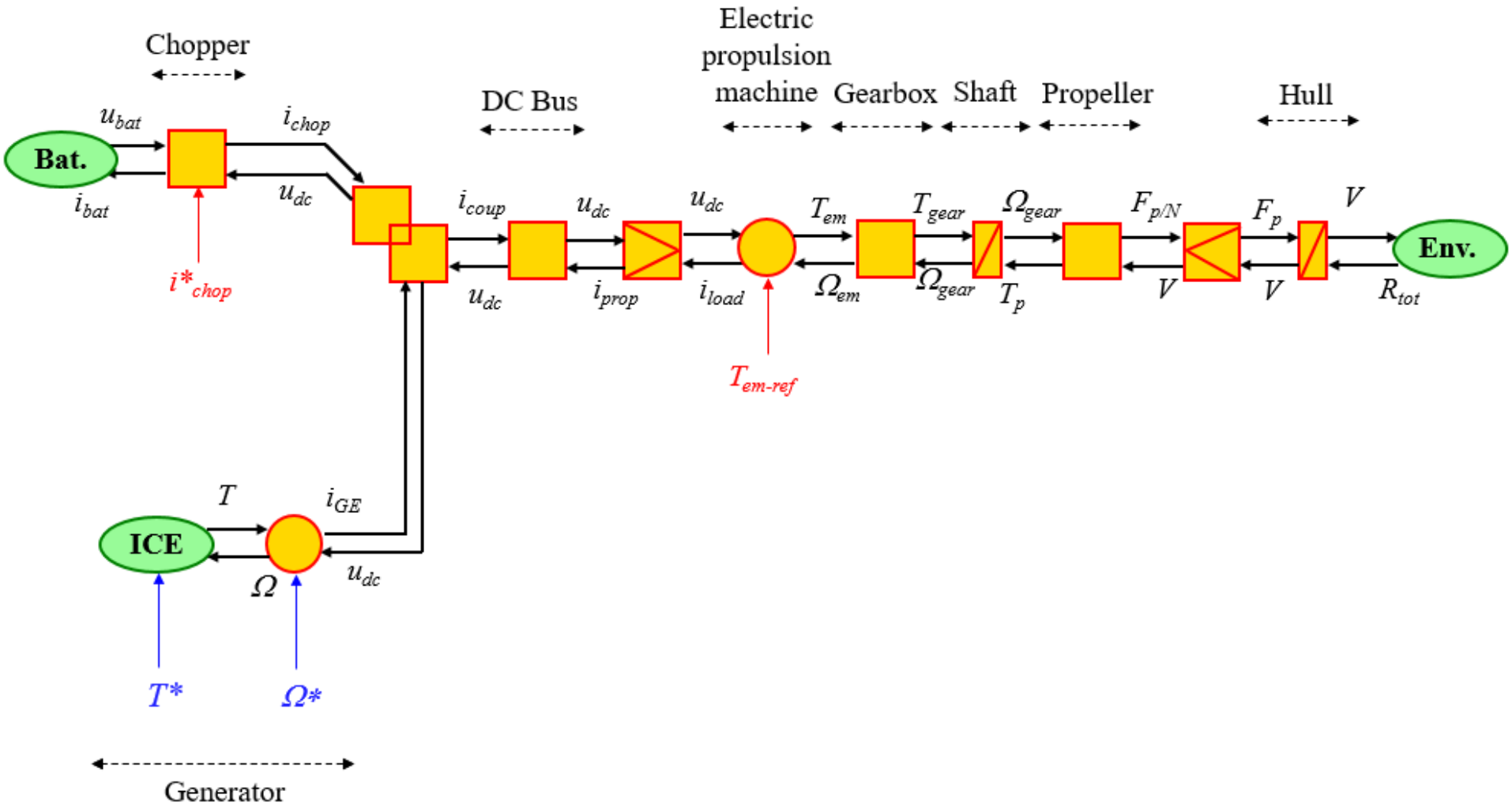
Environment

- Unaccurate empirical model
  - Typical 10 – 15 % error

« EMR OF THE SYSTEM »

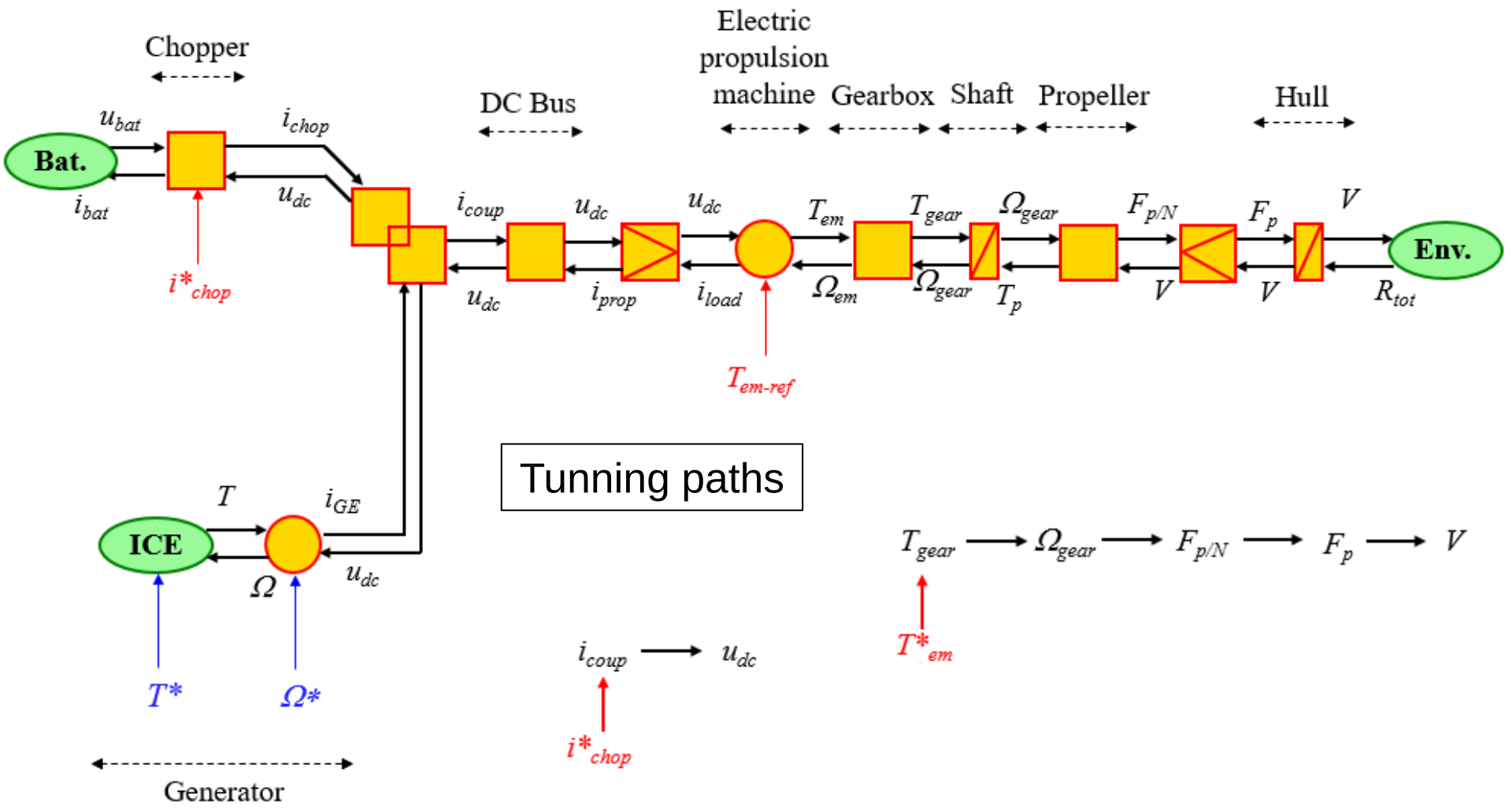
EMR-based simulation of electric-gas ship

- EMR of the System -



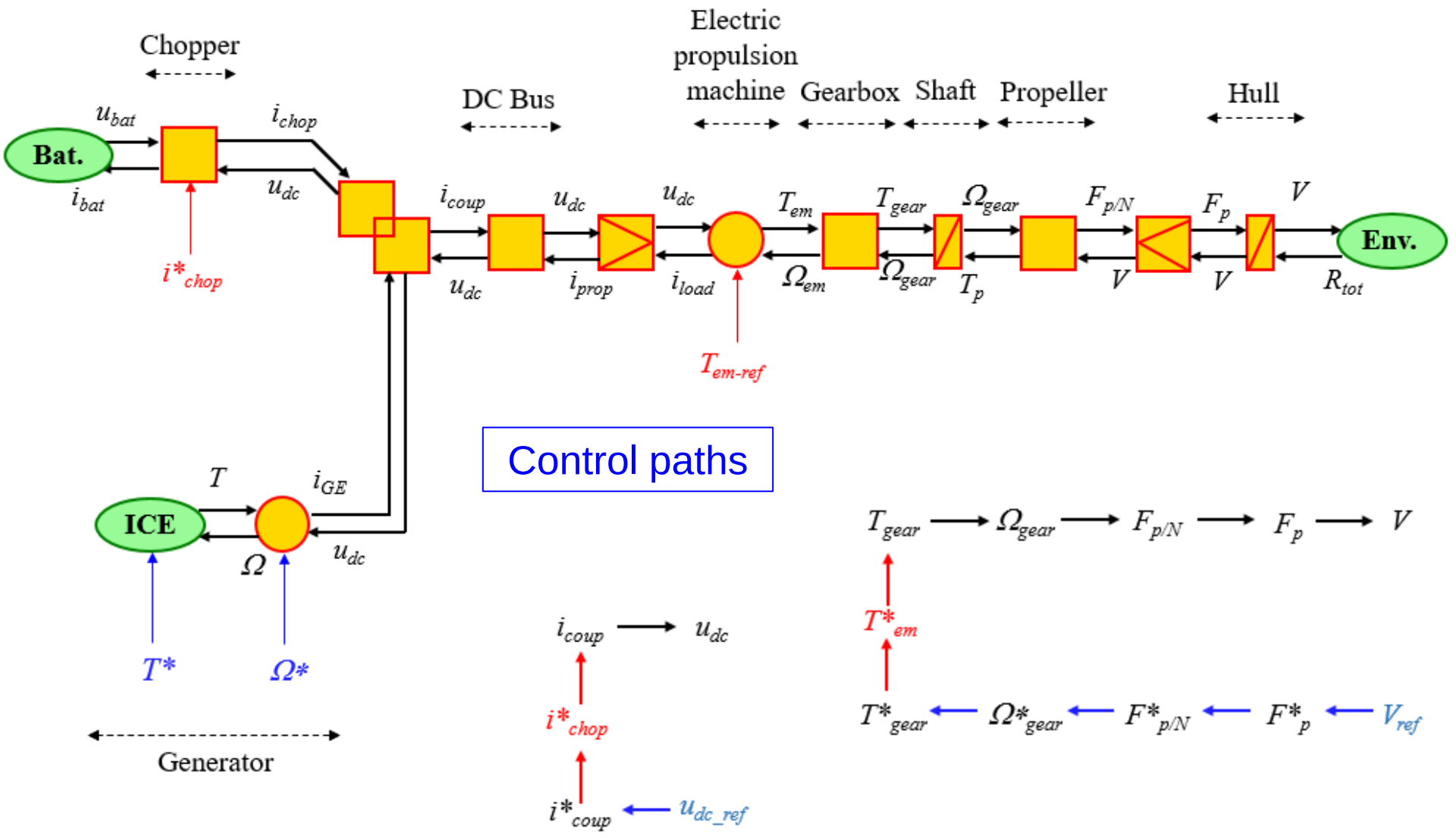
EMR-based simulation of electric-gas ship

- EMR of the System -



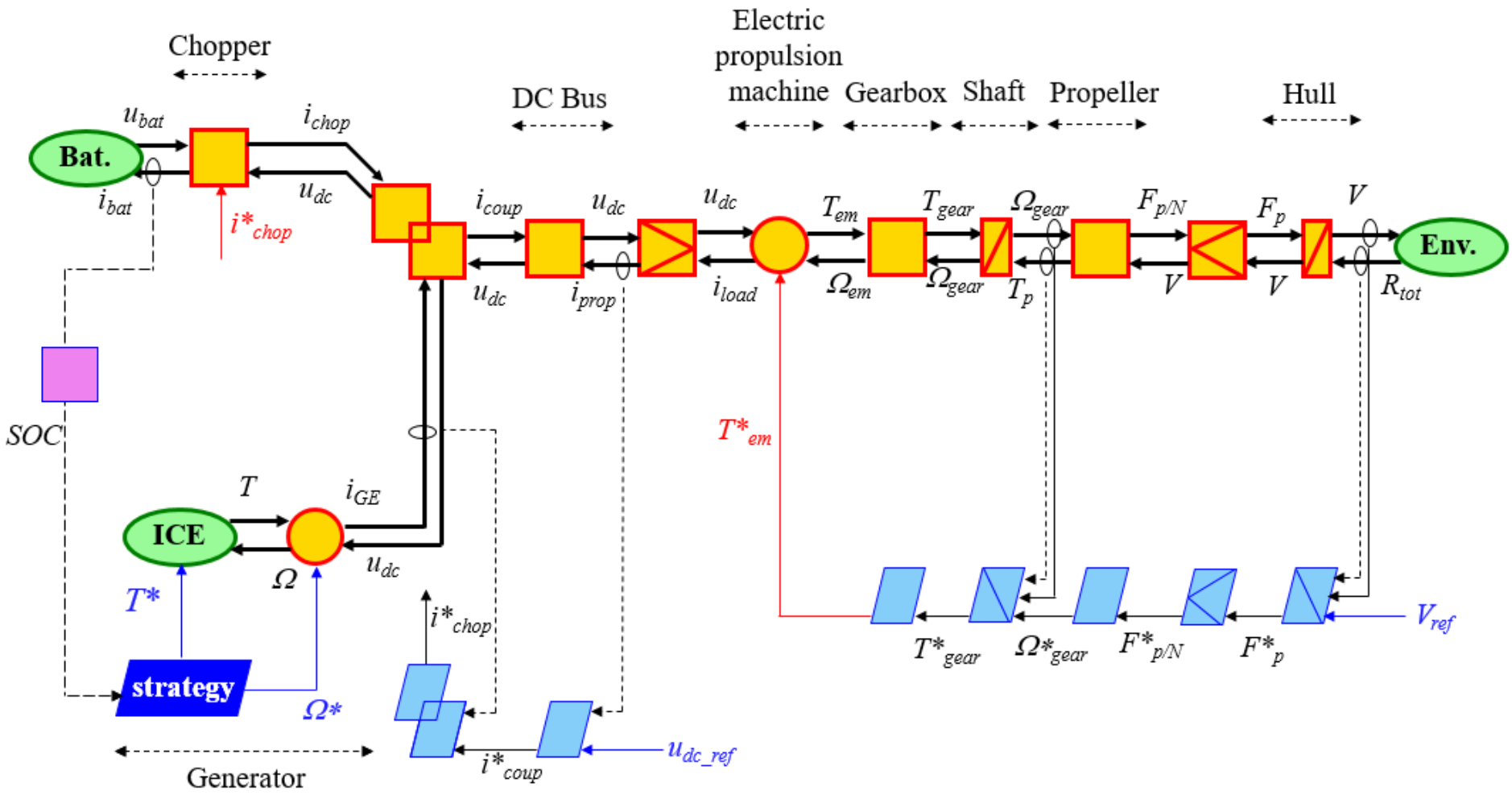
EMR-based simulation of electric-gas ship

- EMR of the System -

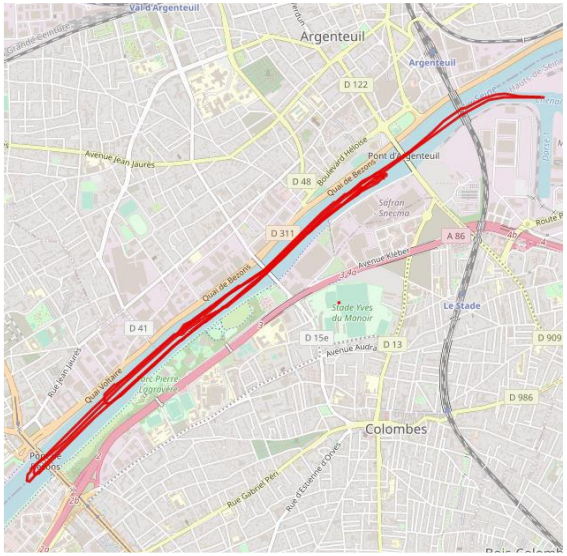


EMR-based simulation of electric-gas ship

- EMR of the System -

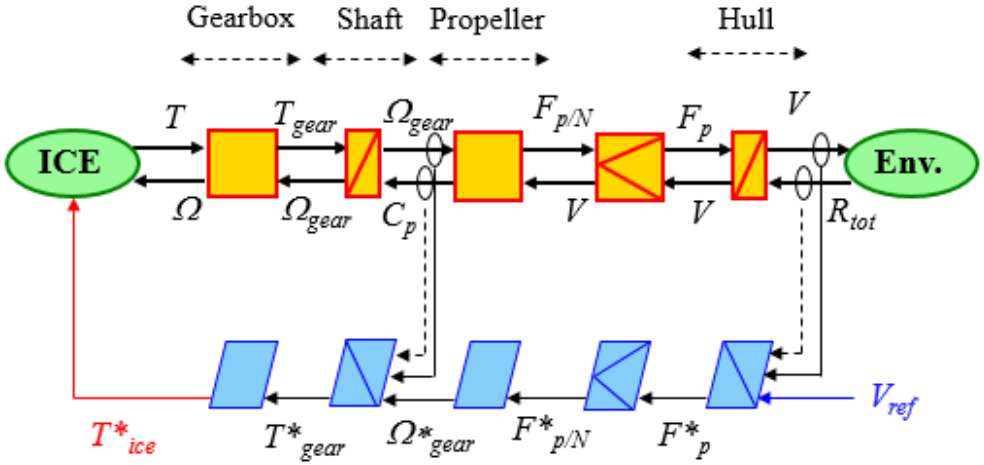


« SIMULATION RESULTS »

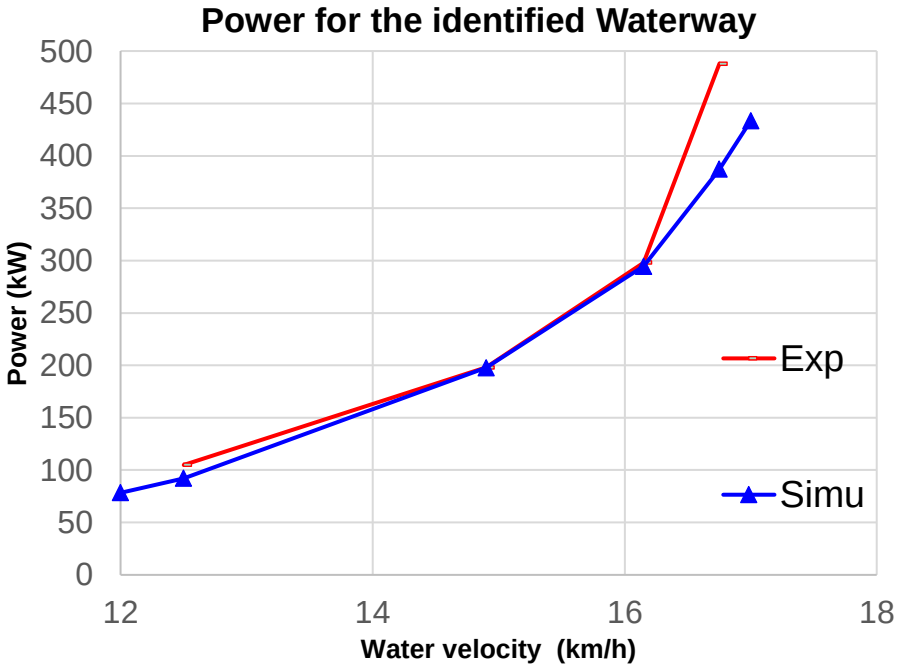


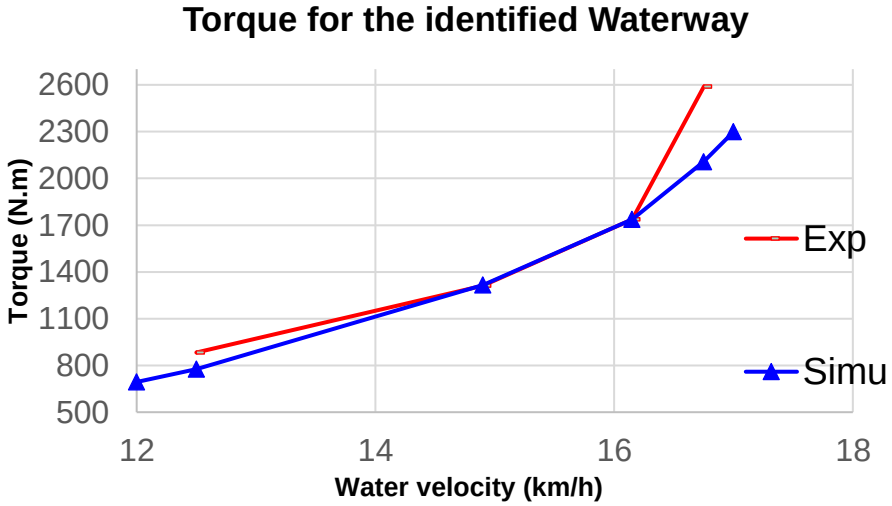
- On-board measurement on the Seine River
  - Upstream and downstream navigation at fixed engine rotation speed
  - Rotation Speed ; Power and Torque available

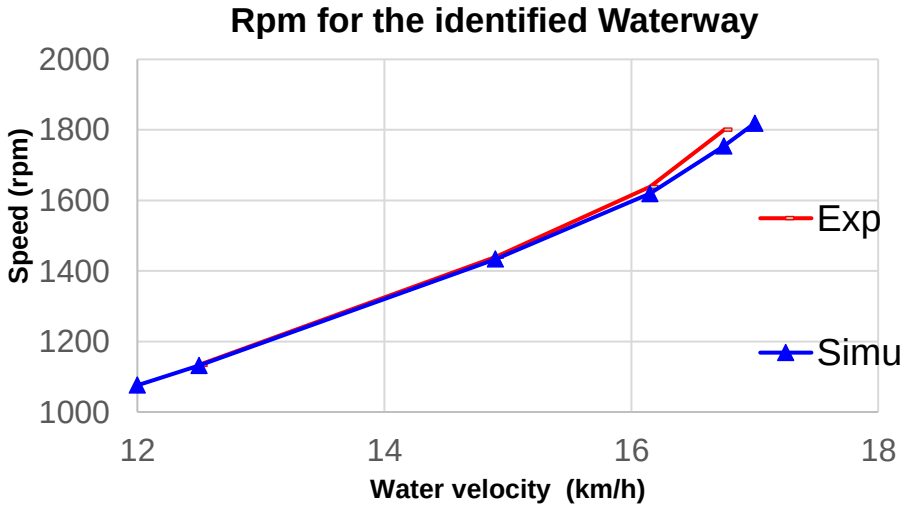
- Simulator Input
  - Design / Parameters of the vessels
  - Advance Speed step



EMR of the current thermic vessels – used for validation


Power for the identified Waterway
Power (kW)
500
450
400
350
300
250
200
150
100
50
0
12
14
16
18
Water velocity (km/h)
Exp
Simu


Torque for the identified Waterway
Torque (N.m)
2600
2300
2000
1700
1400
1100
800
500
12
14
16
18
Water velocity (km/h)
Exp
Simu


Rpm for the identified Waterway
Speed (rpm)
2000
1800
1600
1400
1200
1000
12
14
16
18
Water velocity (km/h)
Exp
Simu

« CONCLUSION »

- Conclusion -

- Dynamic validation on progress

- Implementation of a simulation tool using the PANDA approach (EMR)
  - Accurate enough for design purpose
  - Generic
    - ➢ For other ship application
    - ➢ For other generator technology
    - ➢ For other hybrid architecture

« BIOGRAPHIES »

EMR-based simulation of electric-gas ship

- Authors -

Fabian.amoros@segula.fr

F. Amoros
Segula Technologies
Naval Academy Research Institute
University of Lille, L2EP
PhD student in Electrical Engineering at Arts et Métiers, Paris
Research topics: Hybrid Ship, Naval Propulsion, Control & Design Optimization

Walter LHOMME
University of Lille, France
PhD (2007) and HdR (2020) in Electrical Engineering
Research topics: EMR, HIL simulation, EVs and HEVs,
Energy Storage Subsystem, Traction subsystems,

Jean-frederic.charpentier@ecole-navale.fr

JF Charpentier
Naval Academy Research Institute
Researcher
Research topics: electrical and e-hybrid naval propulsion,
marine renewable energy, electric machines and drives

Jean-yves.billard@ecole-navale.fr

Jean-yves BILLARD, Ecole navale, Research Institute

Researcher

Research topics: Energy efficiency of ships, Naval Propulsion, Naval hydrodynamics, Dynamic stability

benoit.nottellet@segula.fr>

Benoit NOTTELLET, Segula Technologies

Head of R&I on naval activity

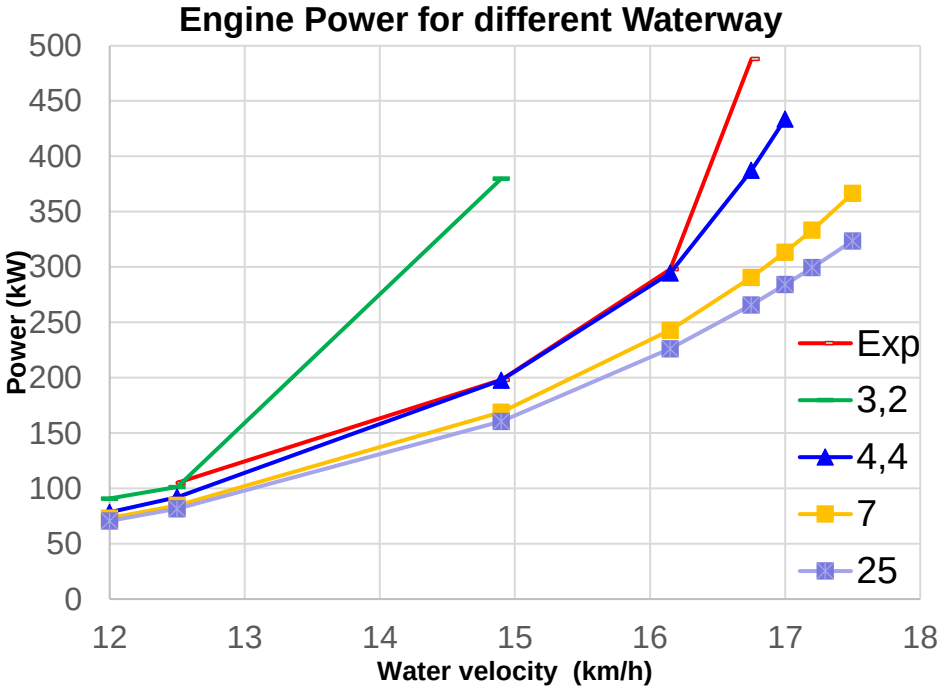
Research topics: Energy efficiency of ships, Naval Propulsion, Alternative energy for sips, loading optimization

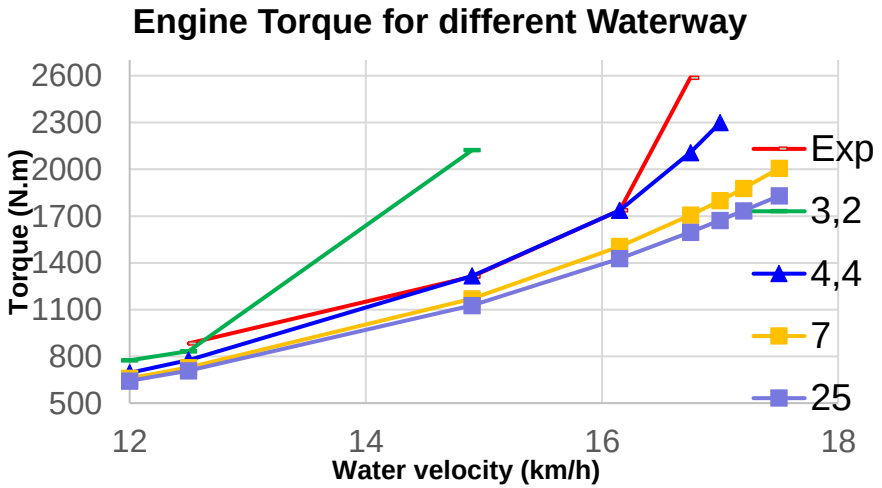
Thank you for your attention !

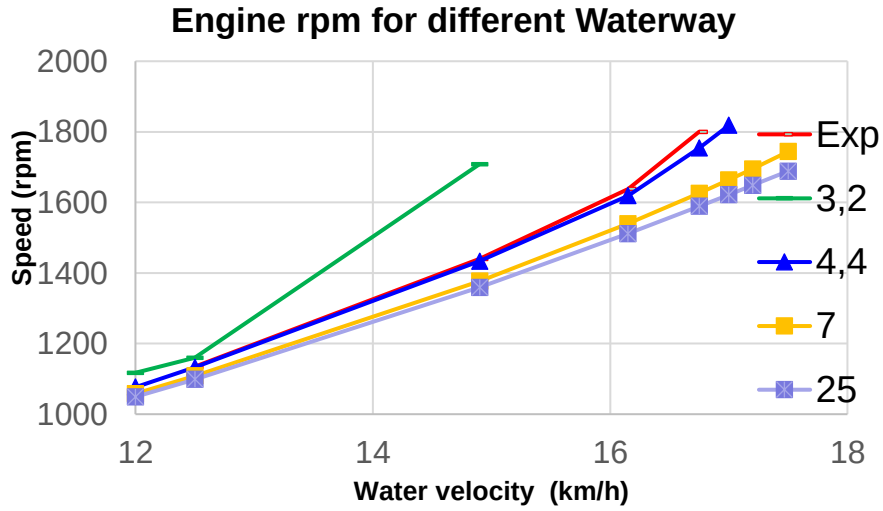
« Appendix »

EMR-based simulation of electric-gas ship

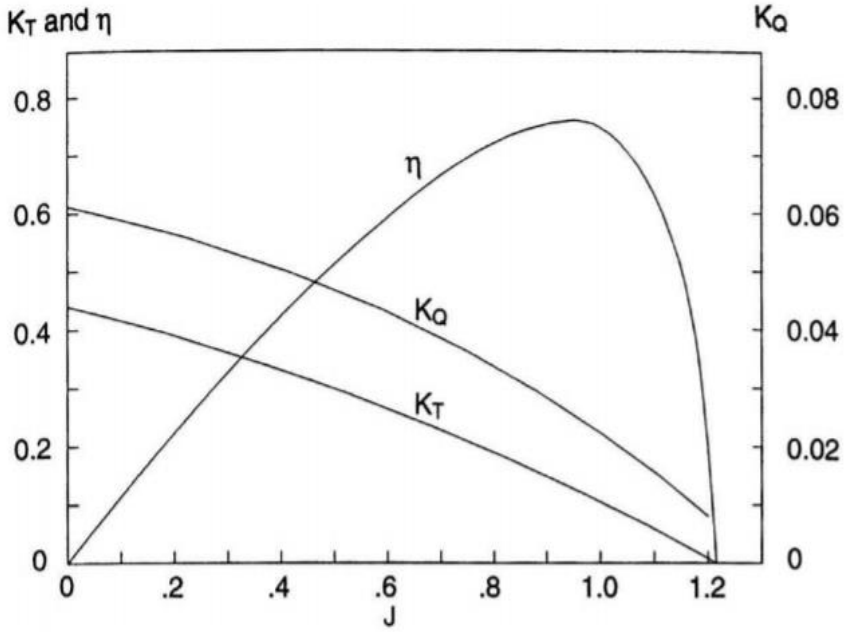
- Simulation Results for Different Waterway -





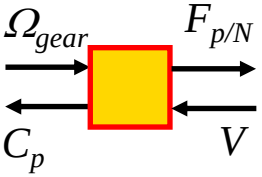


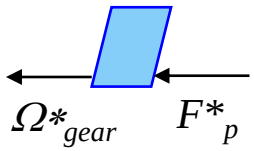
- Simulation Results for Different Waterway -



Propeller Empirical model

- $J = \frac{V_a}{n.D}$ *Advance parameter*
- K_T *Thrust coefficient*
- K_Q *Torque coefficient*
- $\eta = \frac{J}{2.\pi}.\frac{K_T}{K_Q}$ *Efficiency*





$$F_p = \rho.n^2.D^4.K_T \qquad (n \text{ rps})$$

$$C_p = \rho.n^2.D^5.K_Q$$

$$\eta = \frac{F_p.V}{2.\pi.n.C_p} = \frac{K_T}{K_Q}.\frac{J}{2.\pi}$$