Energy management framework in a zero emissions port

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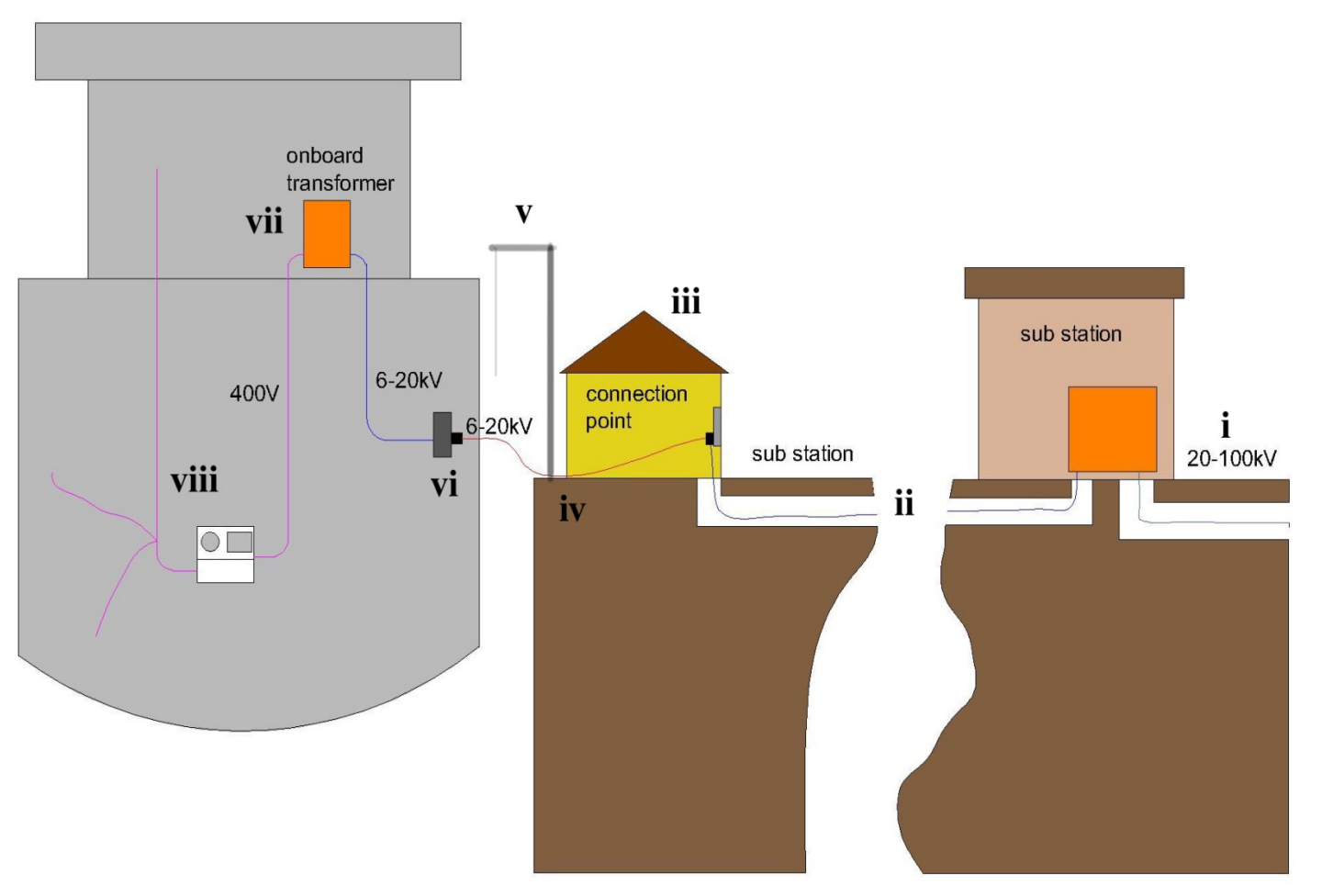
Outlines

- Introduction
- Ship's Shore connection
- The concept of zero emissions port
- Energy demand from ships
- PSO (Particle Swarm Organization) algorithm
- Application to port's grid energy management
- Conclusions

Introduction

- Cold ironing = connection of all ship's electrical distribution systems with shore's connection during ship's port berthing .
- Traditionally during maintenance periods or in shipyards dry docking.
- New ship's emission control in port rules requiring electrical energy from shore.

General arrangement



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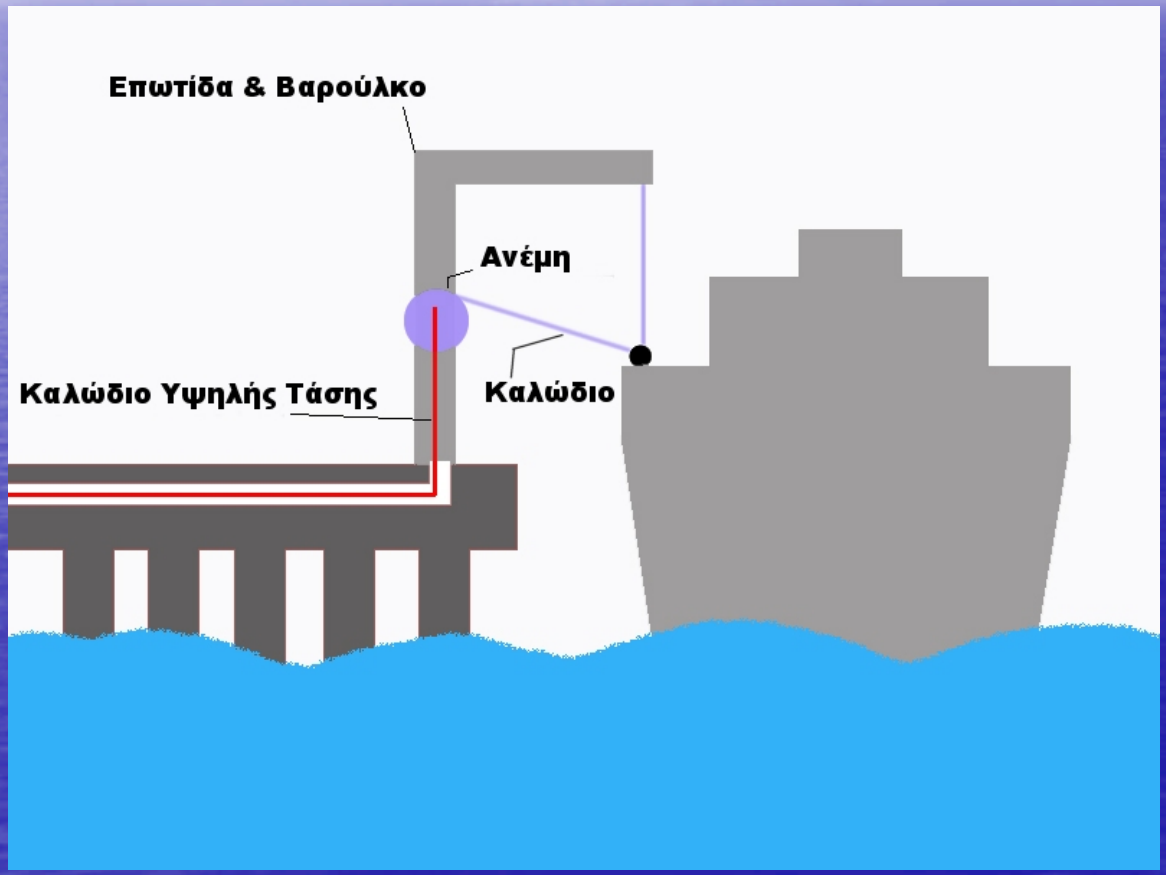
Practical problems

- Frequency
- Voltage (M/V on board)
- Safety during HV cables handling
- Several ship’s types - berthing procedures

Electrical connection 1/2



Electrical connection 2/2

Implementation in International Ports

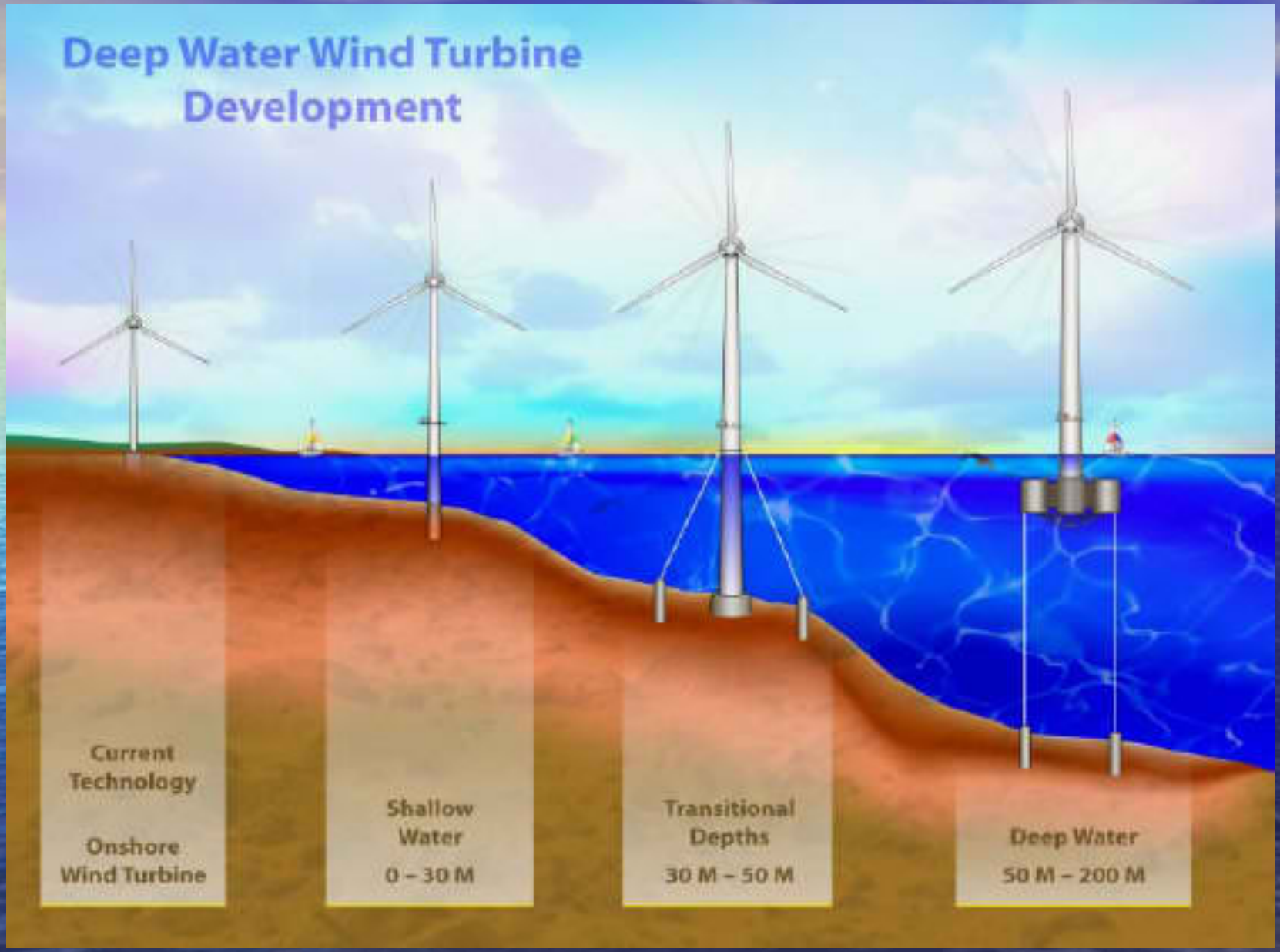
• Göteborg, Lübeck, Zeebrügge,	Ro/ro and/or
• Kotka, Kemi, Oulu	Ferries
• Juneau, Seattle	Cruise
• Antwerp	Container
• Port of Los Angeles	Container
• Port of Long Beach	Container
• San Fransisco, San Diego ...	

Port of Los Angeles

Port of Long Beach

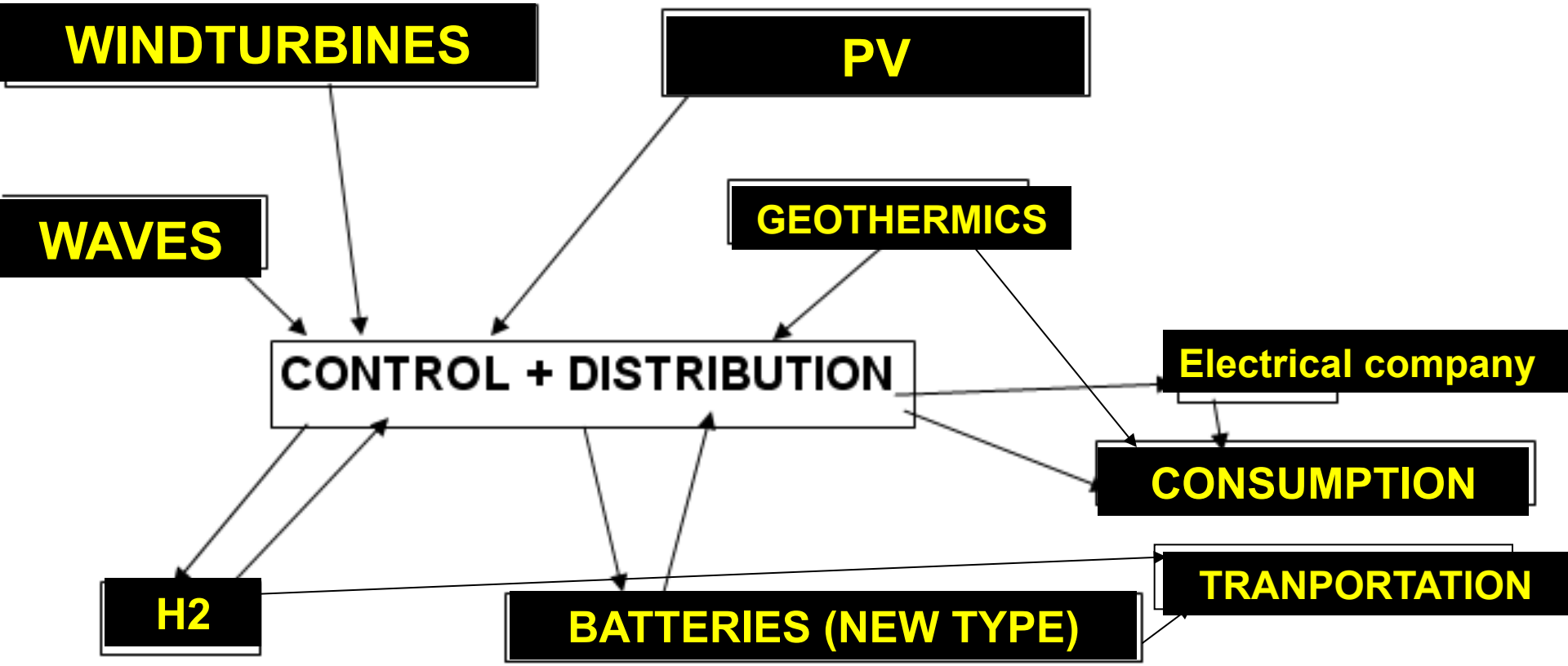
On-board Cable Connection

Gothenburg

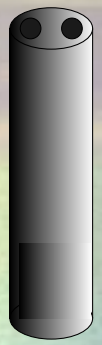

Deep Water Wind Turbine Development
Current Technology
Onshore Wind Turbine
Shallow Water
0 – 30 M
Transitional Depths
30 M – 50 M
Deep Water
50 M – 200 M

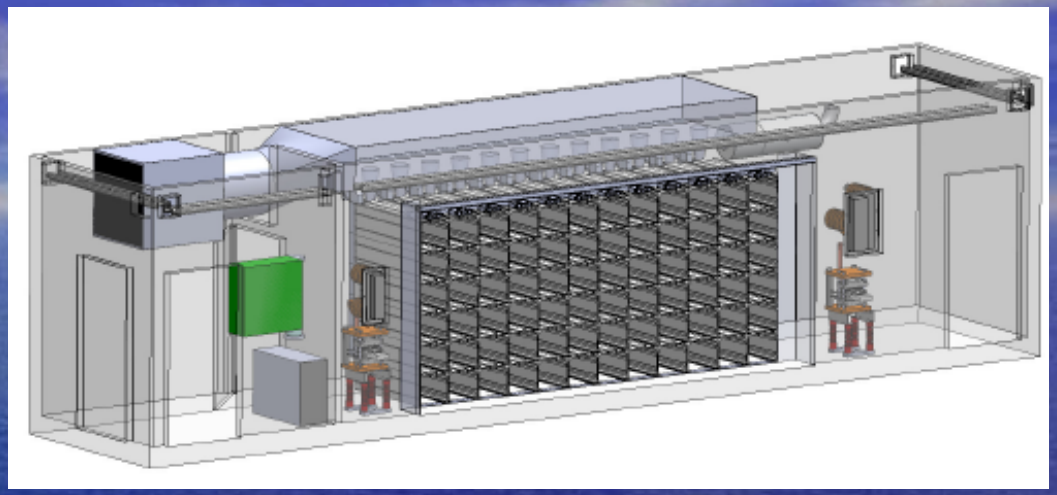
Wave energy
Pelamis & LIMPET

SMART GRID IN PORT



Solutions



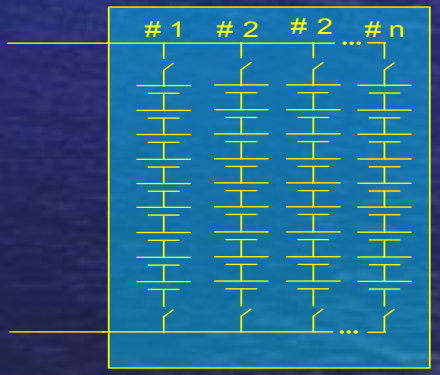


Cell

Module

Room

String



Storage

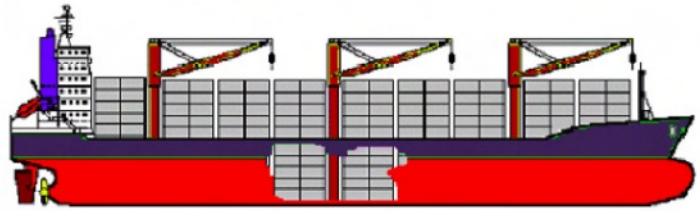
ABB SVC Light with Energy Storage 5-50MW

Intelligent grid

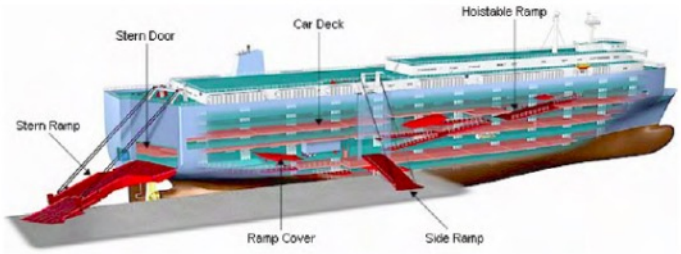
- Available systems
  - Floating windturbines
  - Photovoltaic s
  - Wave energy
- New batteries
- Control systems
- Load's control
- Grid's stability
- RES penetration
- Energy saving

- Examples
  - Ydriada , Green island

Container ship

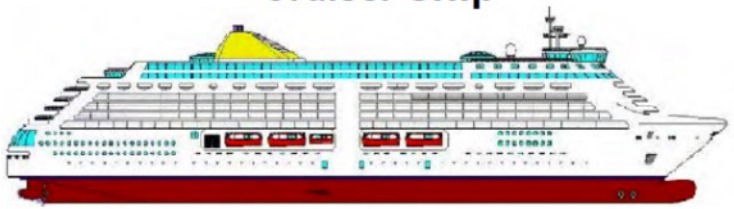


Ro/Ro- / Vehicle ship



Oil and Product Tanker

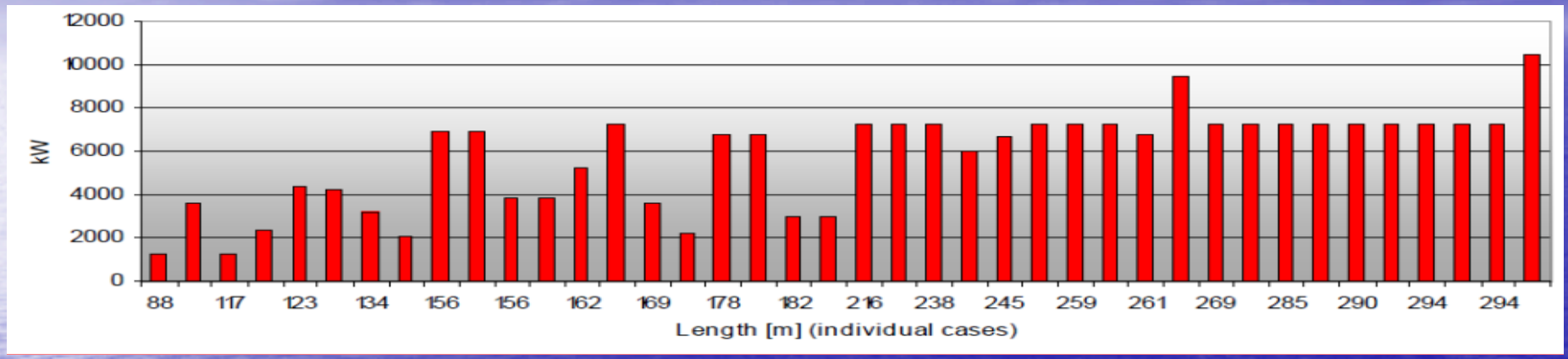
Cruiser ship

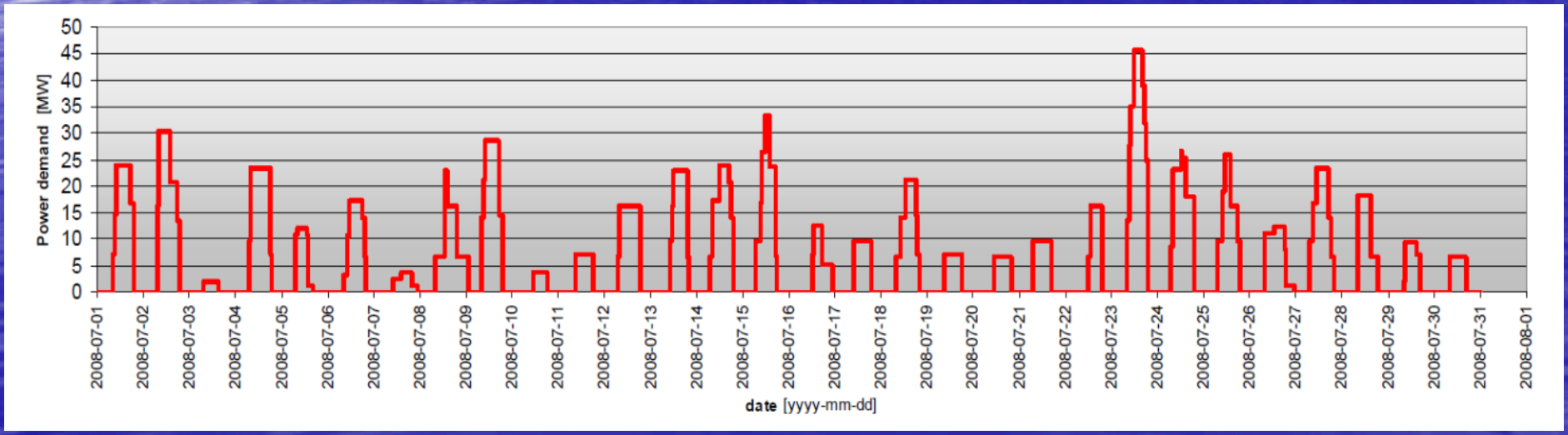


Summary of Power Demand

	Average Power Demand	Peak Power Demand	Peak Power Demand for 95 % of the vessels
Container vessels (< 140 m)	170 kW	1 000 kW	800 kW
Container vessels (> 140 m)	1 200 kW	8 000 kW	5 000 kW
Container vessels (total)	800 kW	8 000 kW	4 000 kW
Ro/Ro- and Vehicle vessels	1 500 kW	2 000 kW	1 800 kW
Oil- and Product tankers	1 400 kW	2 700 kW	2 500 kW
Cruise ships (< 200 m)	4 100 kW	7 300 kW	6 700 kW
Cruise ships (> 200 m)	7 500 kW	11 000 kW	9 500 kW
Cruise ships (total)	5 800 kW	11 000 kW	7 300 kW

Cruise ship average power consumption – Port of Tallinn cruise ship demand





Introduction

- Particle Swarm Optimization(PSO)
  - Proposed by James Kennedy & Russell Eberhart in 1995
  - Inspired by social behavior of birds and fishes
  - Combines self-experience with social experience

Concept

- Uses a number of particles that constitute a swarm moving around in the search space looking for the best solution.

- Each particle in search space adjusts its "flying" according to its own flying experience as well as the flying experience of other particles

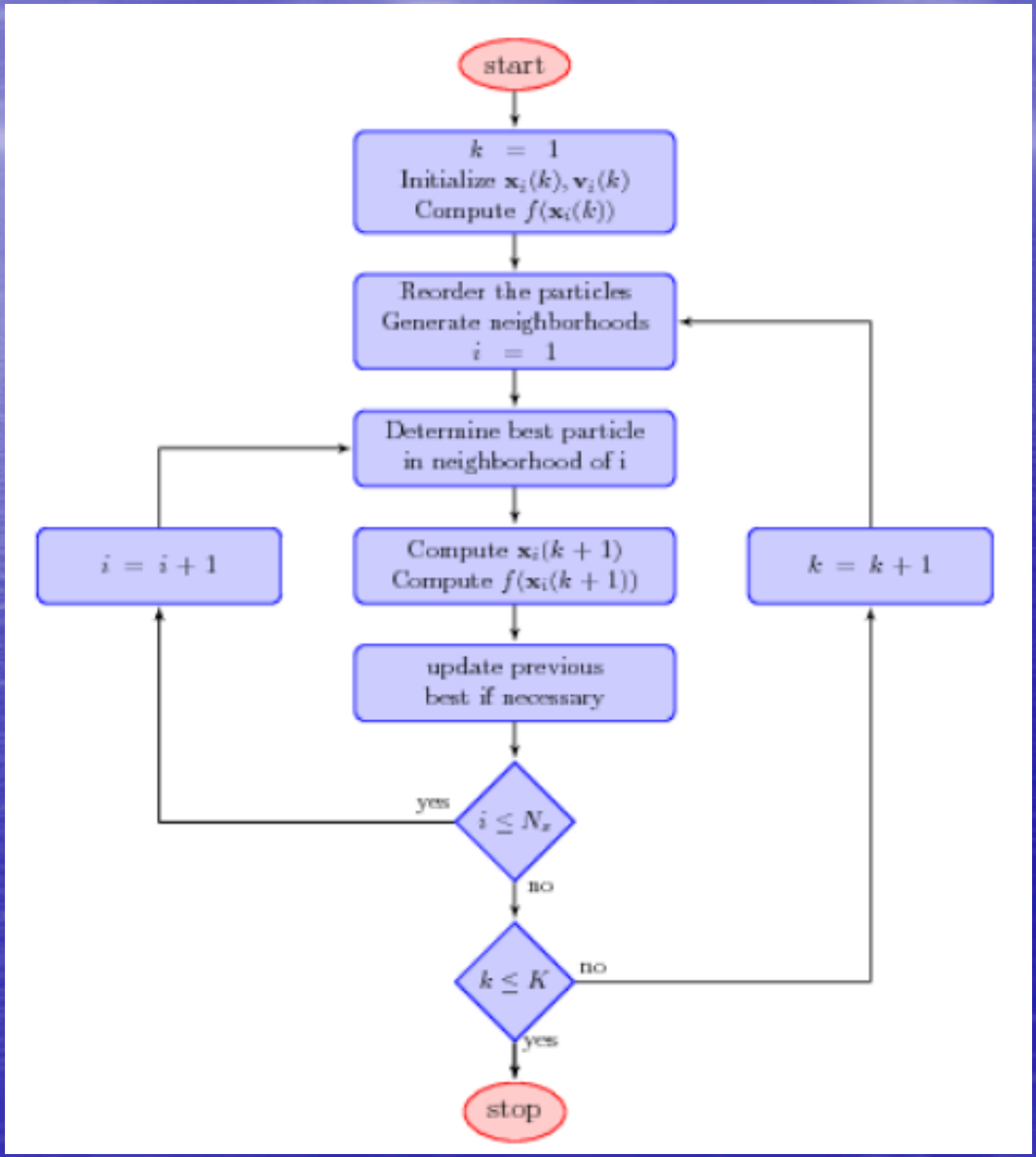
Particle Swarm Optimization

- Swarm: a set of particles (S)
- Particle: a potential solution
  - Position: $\mathbf{x}_i = (x_{i,1}, x_{i,2}, \ldots, x_{i,n}) \in \Re^n$
  - Velocity: $\mathbf{v}_i = (v_{i,1}, v_{i,2}, \ldots, v_{i,n}) \in \Re^n$
- Each particle maintains
  - Individual best position (PBest)
- Swarm maintains its global best (GBest)

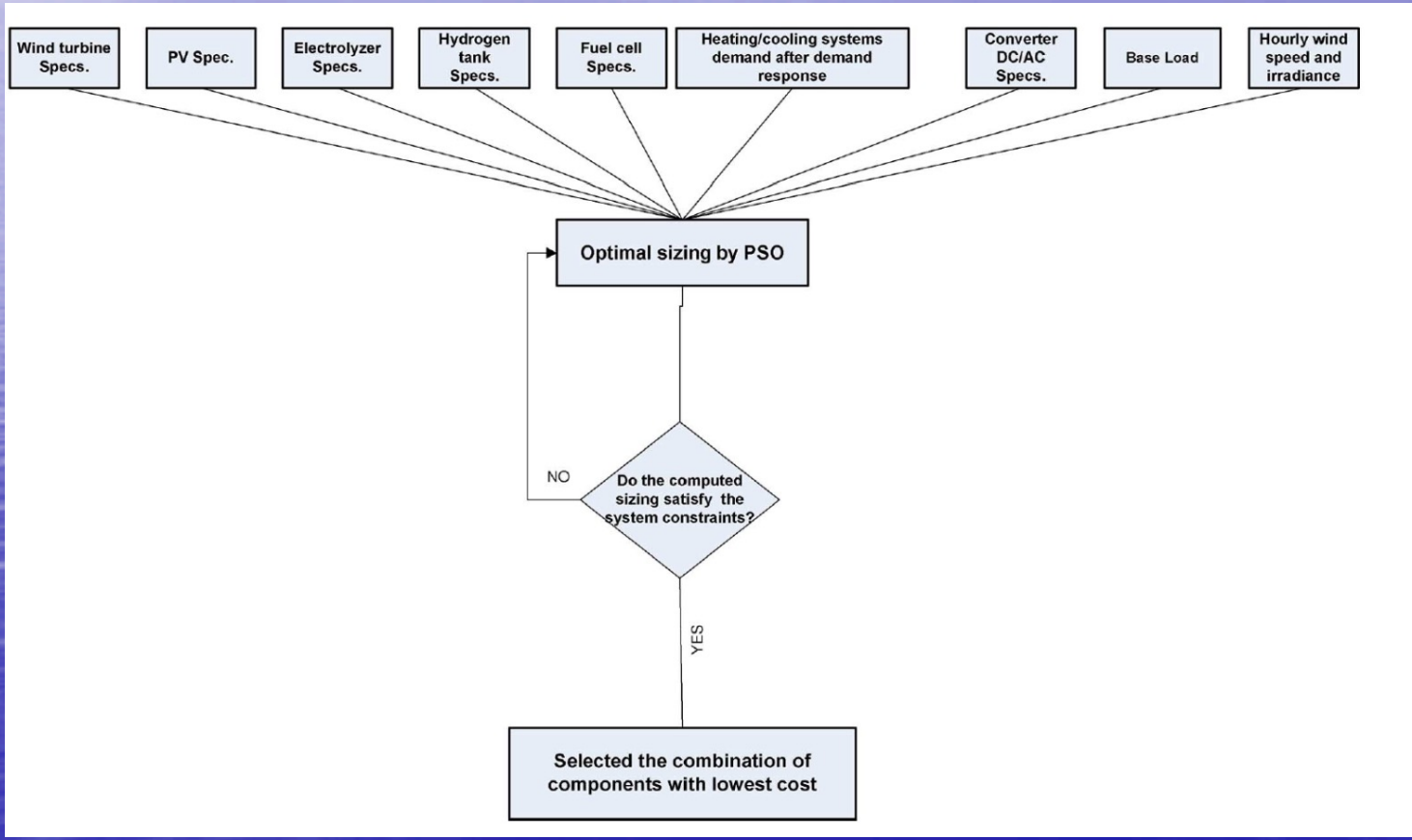
PSO Algorithm

- Basic algorithm of PSO
  1. Initialize the swarm form the solution space
  2. Evaluate the fitness of each particle
  3. Update individual and global bests
  4. Update velocity and position of each particle
  5. Go to step2, and repeat until termination condition

PSO flowchart



Flowchart of proposed optimisation methodology



ΕΝΕΡΓΕΙΑΚΗ ΑΚΑΔΗΜΙΑ

ΦΩΤΟΒΟΛΤΑΪΚΑ

ΚΛΕΙΣΤΟ ΥΔΡΟΠΟΝΙΚΟ ΘΕΡΜΟΚΗΠΙΟ +ΓΕΩΘΕΡΜΙΑ

ΥΒΡΙΔΙΚΑ ΚΑΪΚΙΑ

ΑΥΤΟΚΙΝΗΤΑ Η2 και ΗΛΕΚΤΡΙΚΑ

ΚΥΜΑΤΙΚΗ ΕΝΕΡΓΕΙΑ

ΤΟΥΡΙΣΤΙΚΟ ΤΑΧΥΠΛΟΟ ΚΙΝΟΥΜΕΝΟ ΜΕ ΑΠΕ

Conclusions

- Gold ironing
- Smart grids for cold ironing
- RES at sea
- Smart RES management using PSO
- In future Smart meters, M2M, Smart Grid

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Thank you for your attention

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