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THE WAY TO CLEAN ENVIRONMENT
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Techno-economic Approach for Solar Energy Concept Onboard Marine Vehicles

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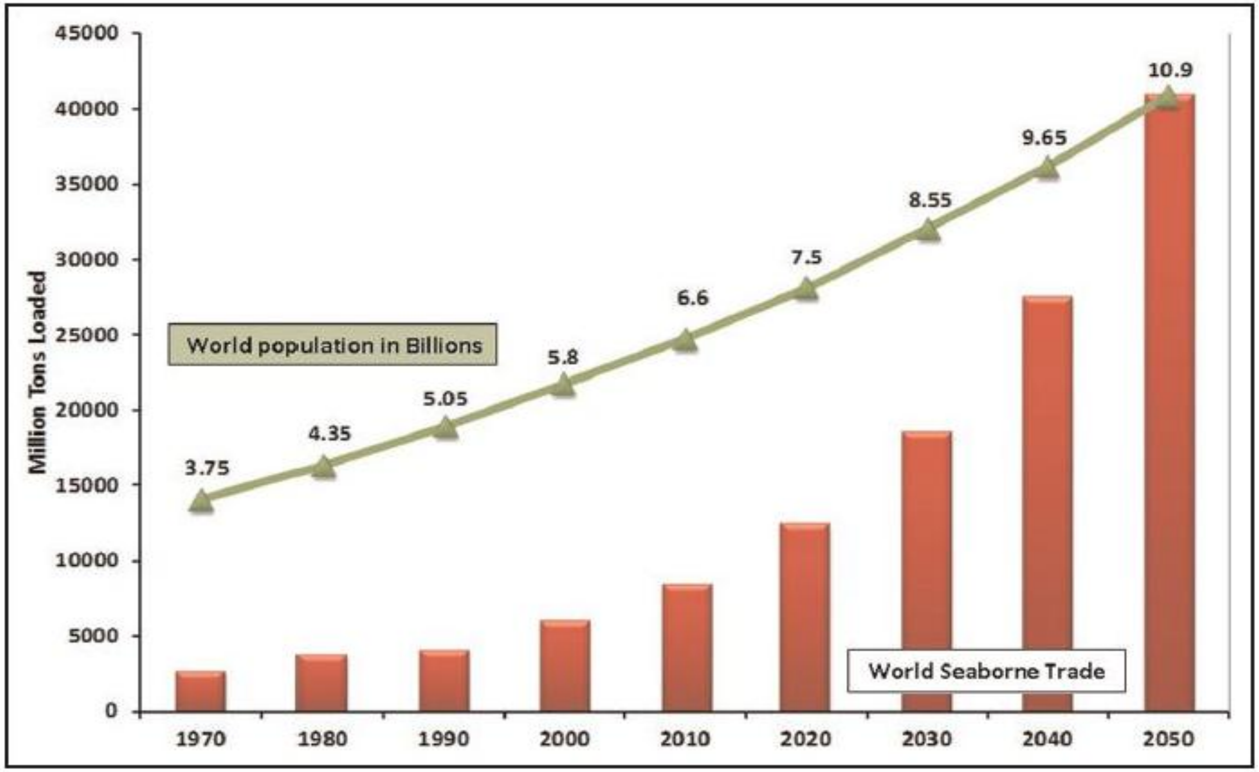
THE AIM OF THIS WORK

CONTENTS

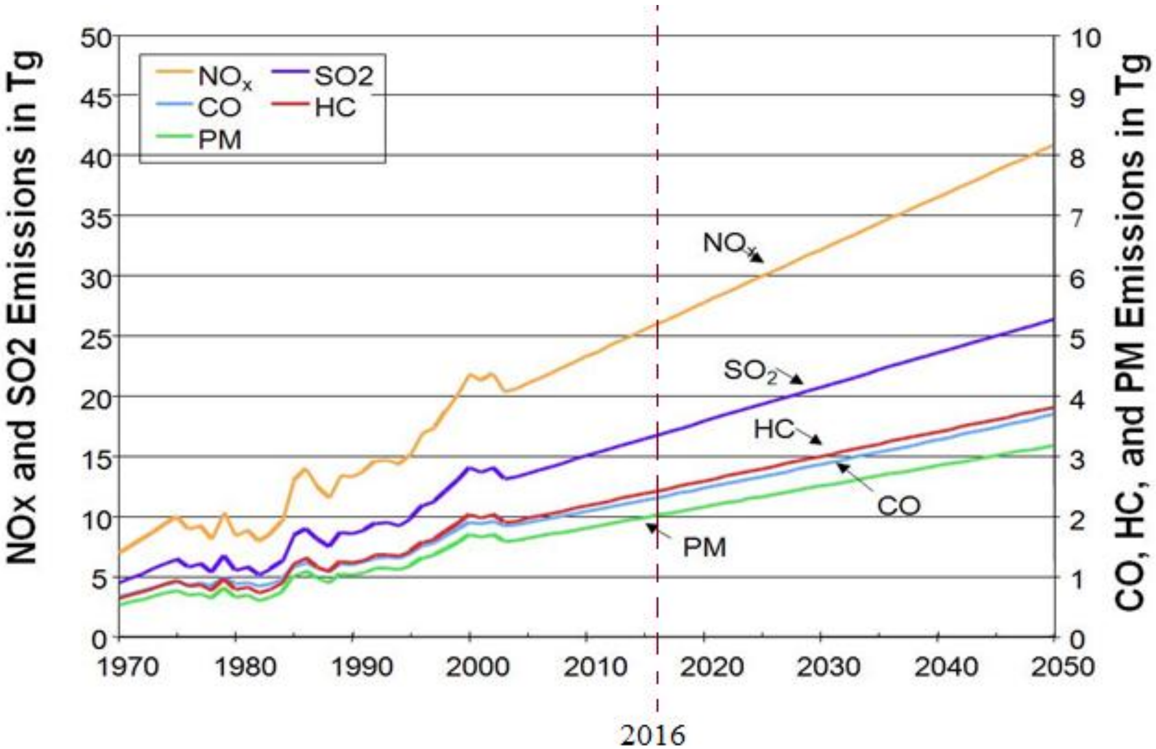
❖ Background

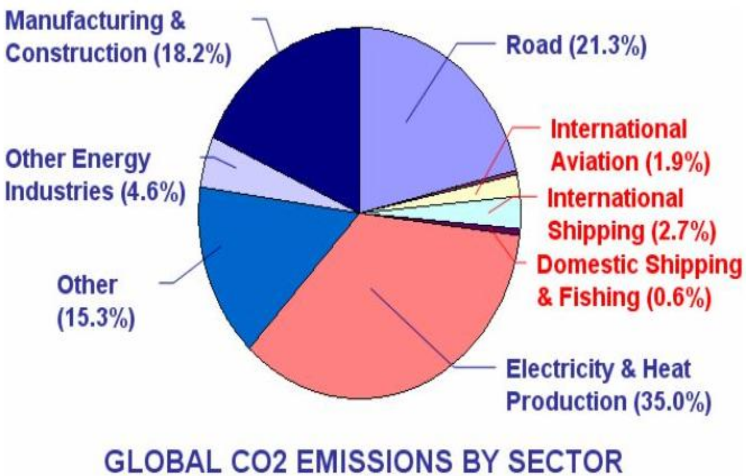
- Around 80% of global trade by volume is carried by sea
- Marine Fuel demand: 6.1% of global world oil demand
- Residual Marine Fuel demand: 49.5% of total global residual demand



Source: United Nations Conference on Trade and Development (UNCTAD). Review of maritime transport. New York;Geneva: UNCTAD, 2012.

❖ STATISTICS OF SHIP EMISSIONS

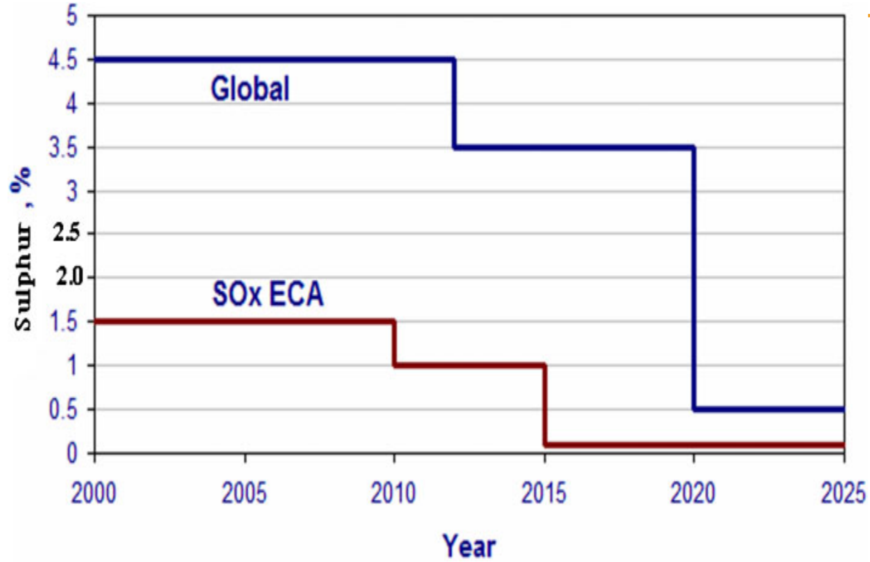


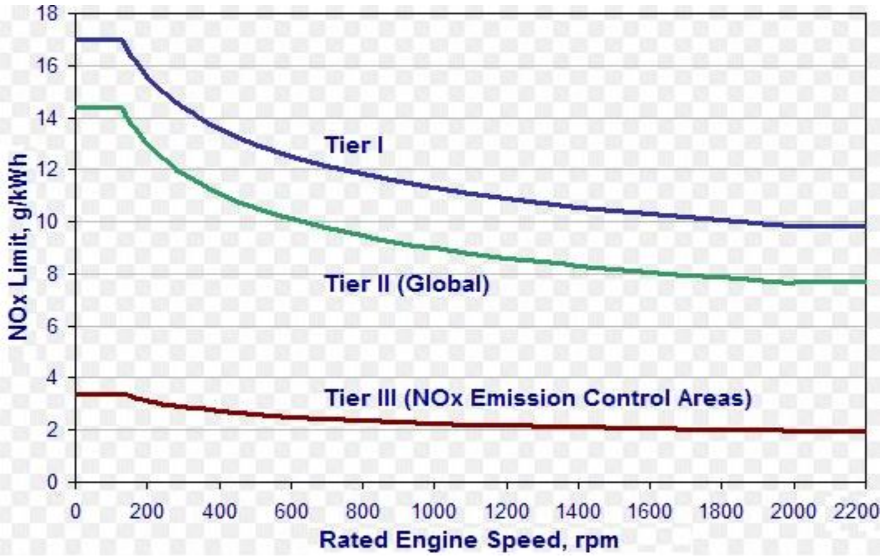


Ship responsible of

- **4-9% of global SO_2 emissions**
- **2.7 % of global CO_2 emissions**

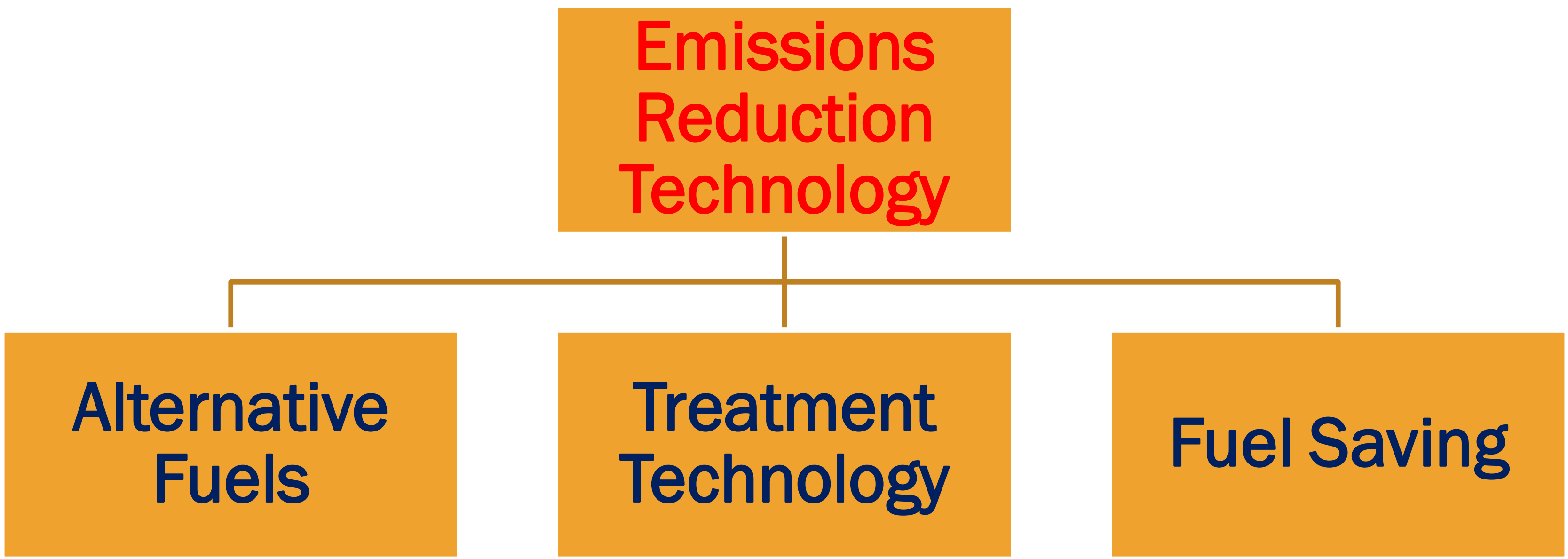
Emissions Regulations





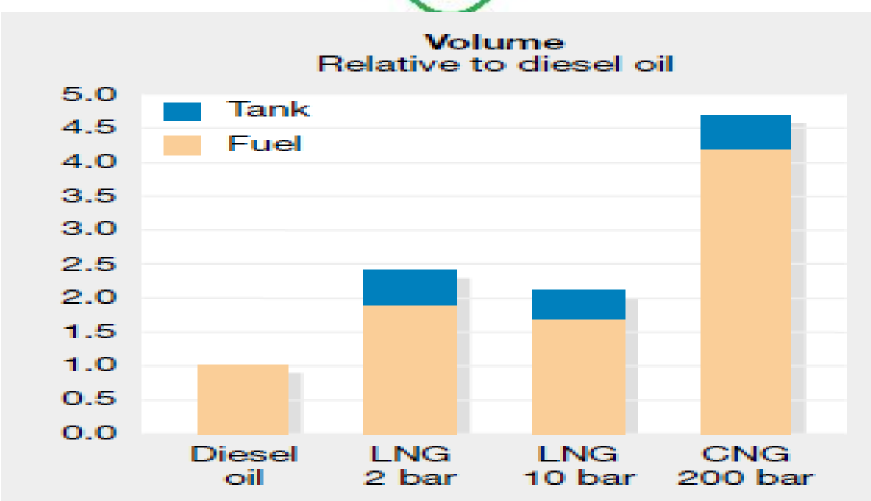
$$\text{EEDI} = \frac{P \times sfc \times C_F}{C \times V} \text{ gm } CO_2\text{/tonne mile}$$

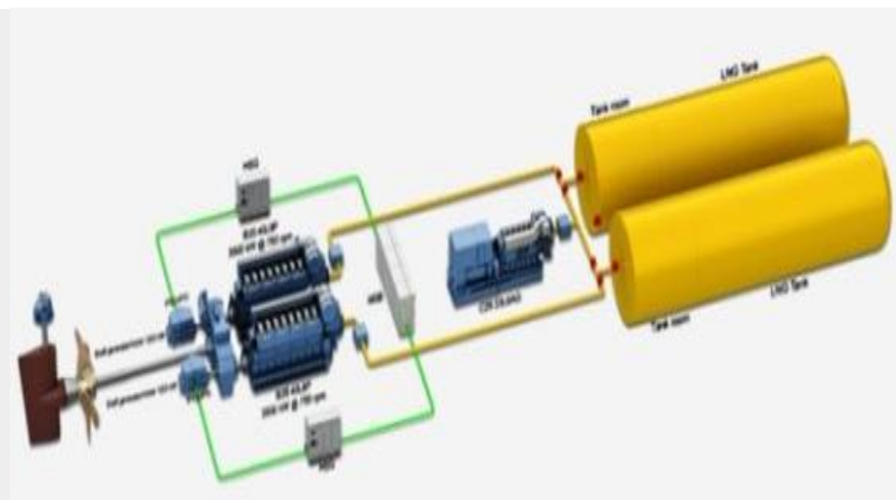
METHODS OF SHIPS EMISSION REDUCTION



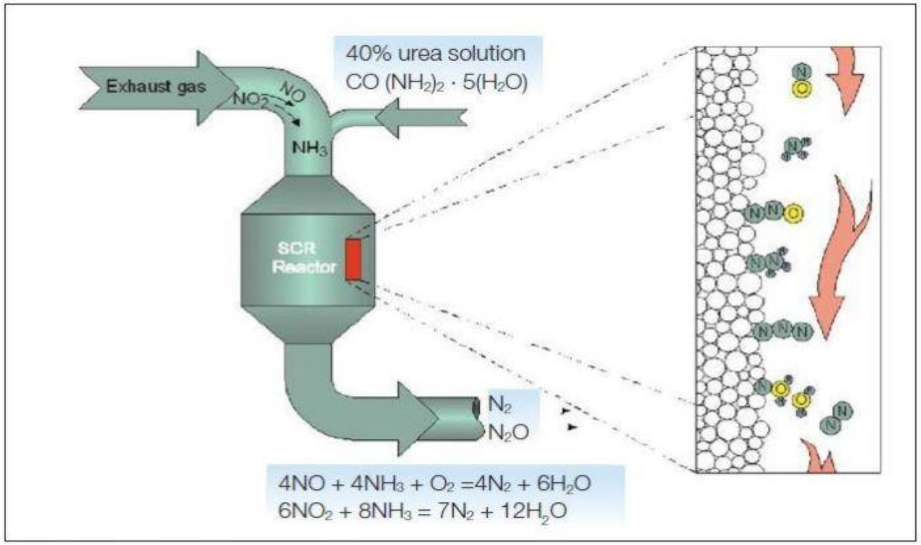
USING OF ALTERNATIVE FUELS

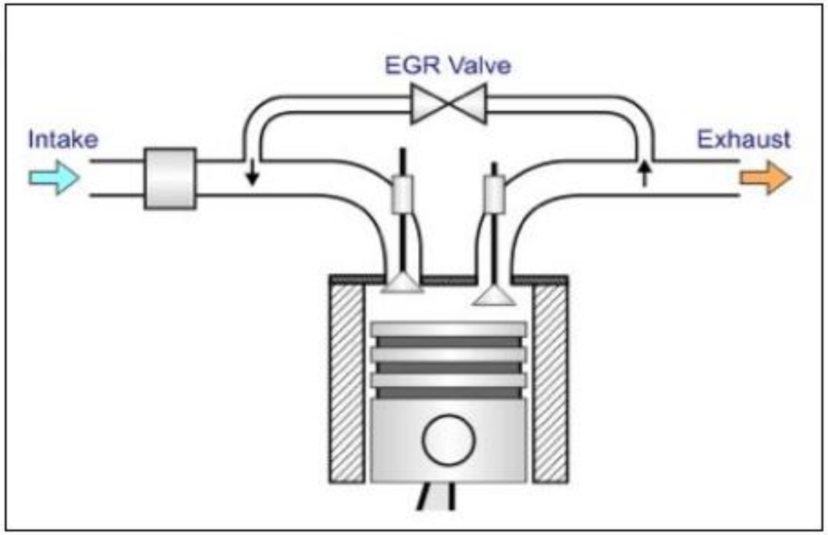
	LNG	Propane	Bio-diesel	Alcohol	F-T diesel	H_2
Renewability	Fairly good	Fairly good	Good	Very good	good	Excellent
Performance	Excellent	Very good	Very good	Good	Very good	Good
Cost	Excellent	Excellent	good	good	good	Fairly good
Adaptability	Excellent	Very good	Excellent	Good	excellent	Good
Availability	Very good	Very good	Very good	Very good	good	Excellent
Safety	Excellent	Very good	Excellent	Very good	excellent	Fairly good
Environmental Impact	Excellent	Very good	good	good	Very good	Excellent

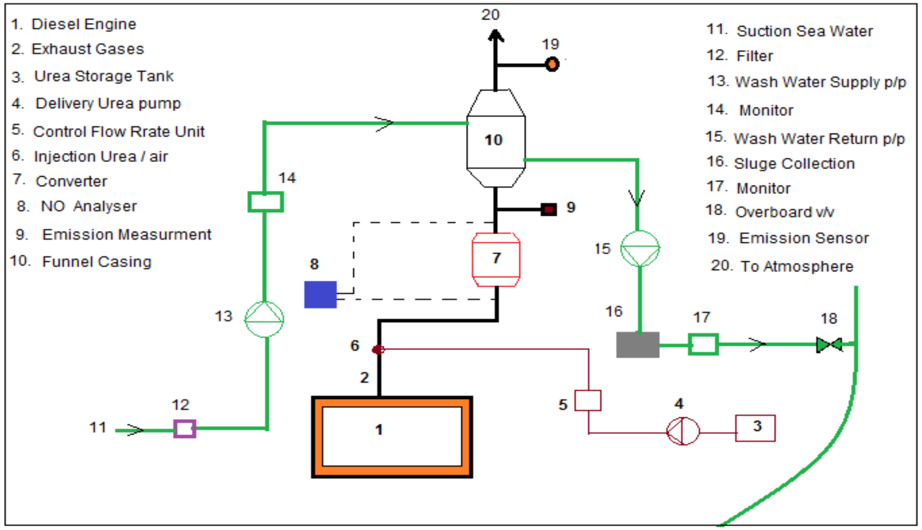


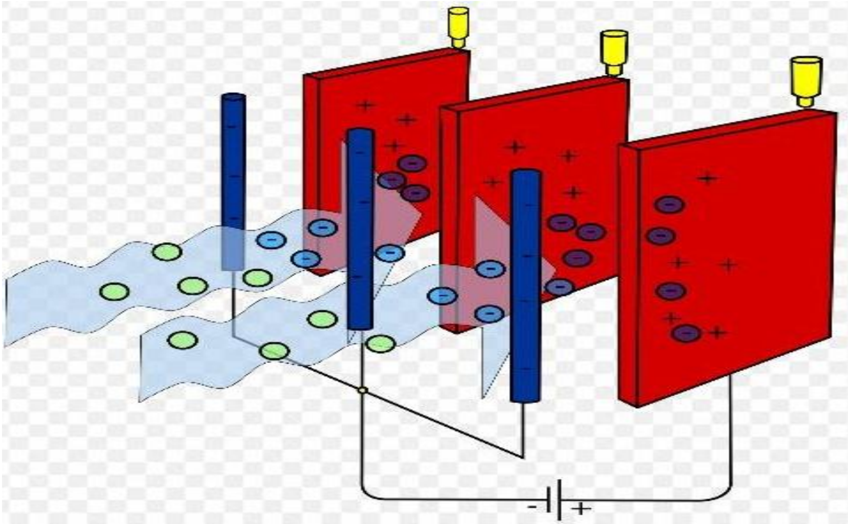


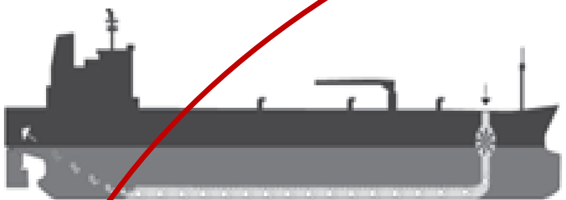
USING TRETMENT TECHNOLOGY ONBOARD SHIP

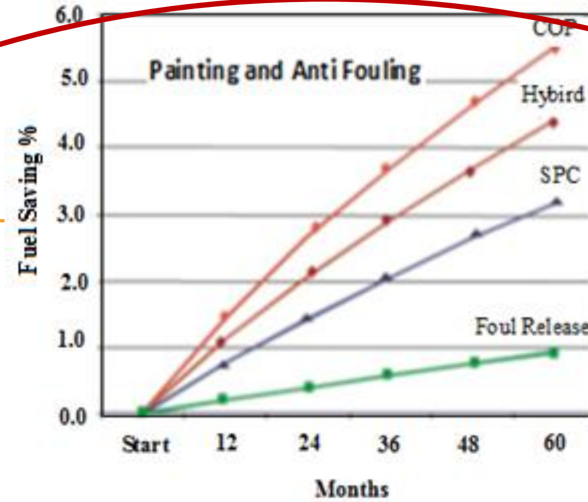


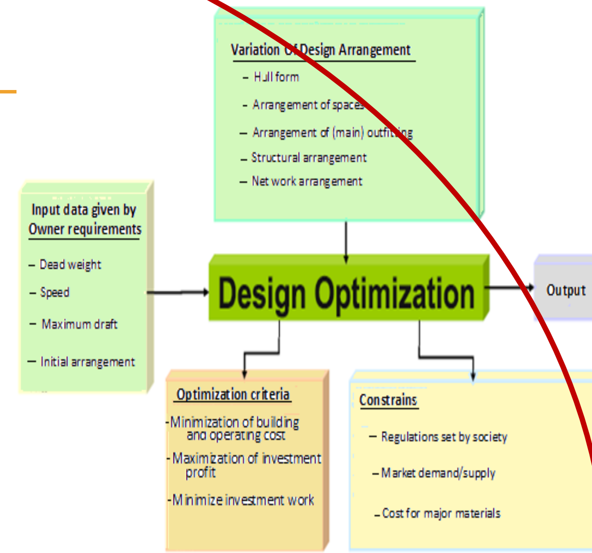






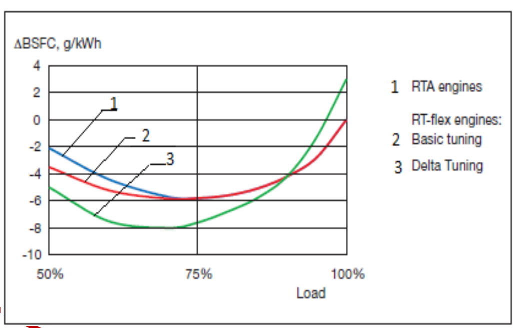


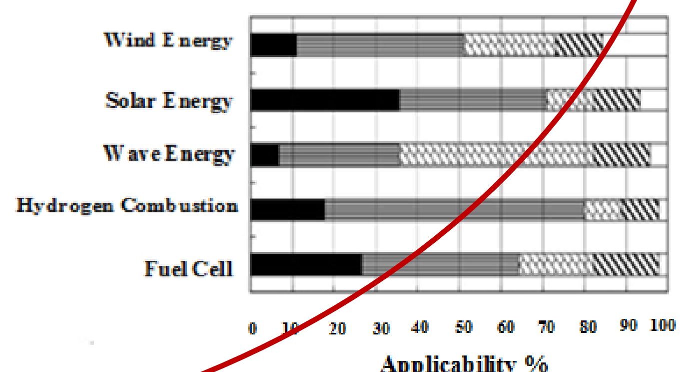




Fuel Saving Strategies Onboard Ships

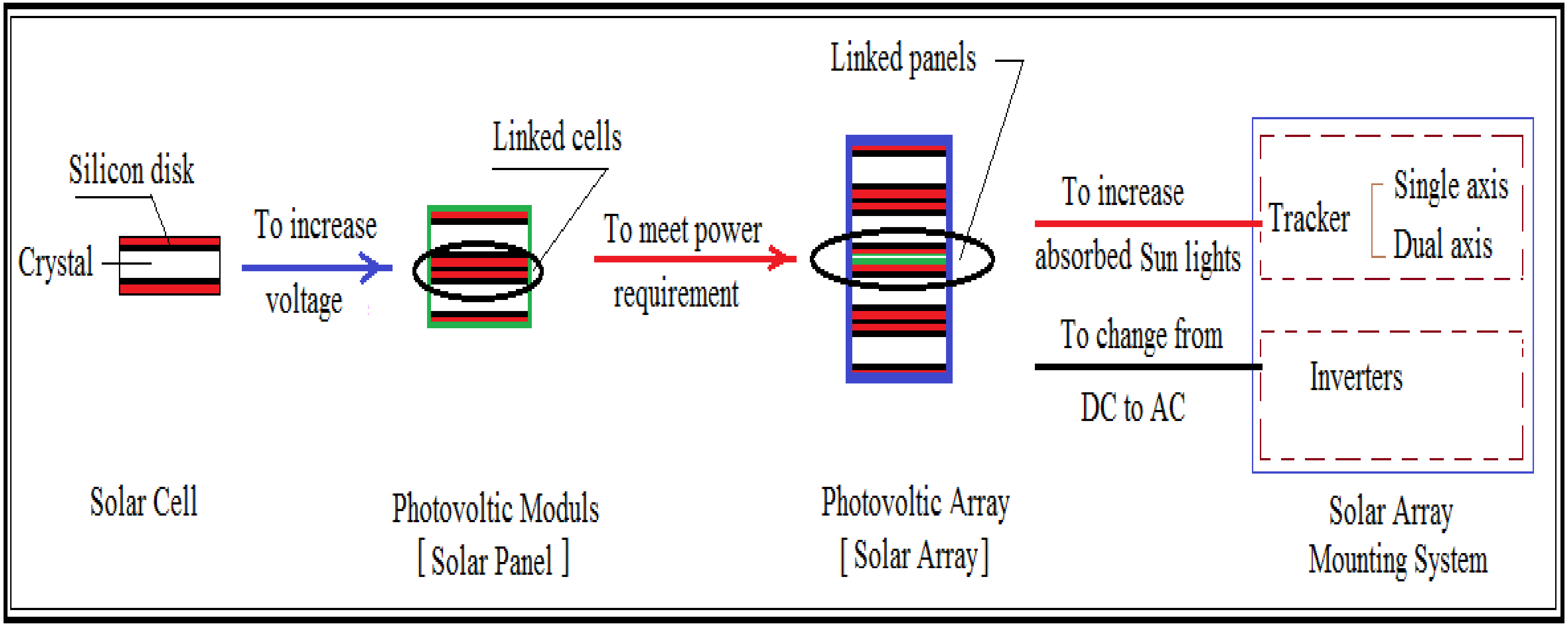
- Ship Resistance Reduction
- Energy Conservation Management
- Shore- Side Power
- Engines Performance Improvement
- Utilization Renewable Energy



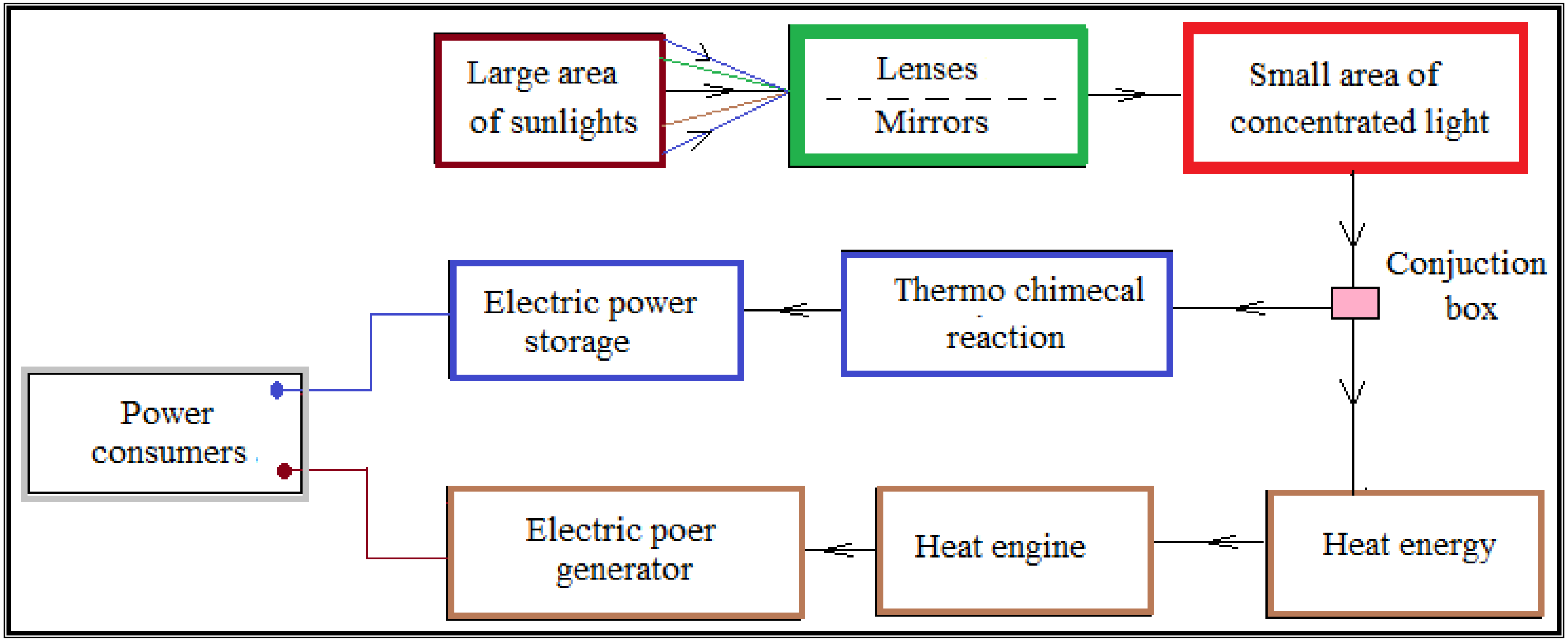


Solar Energy for Ship

Manufacture and production processes of solar power energy for ships



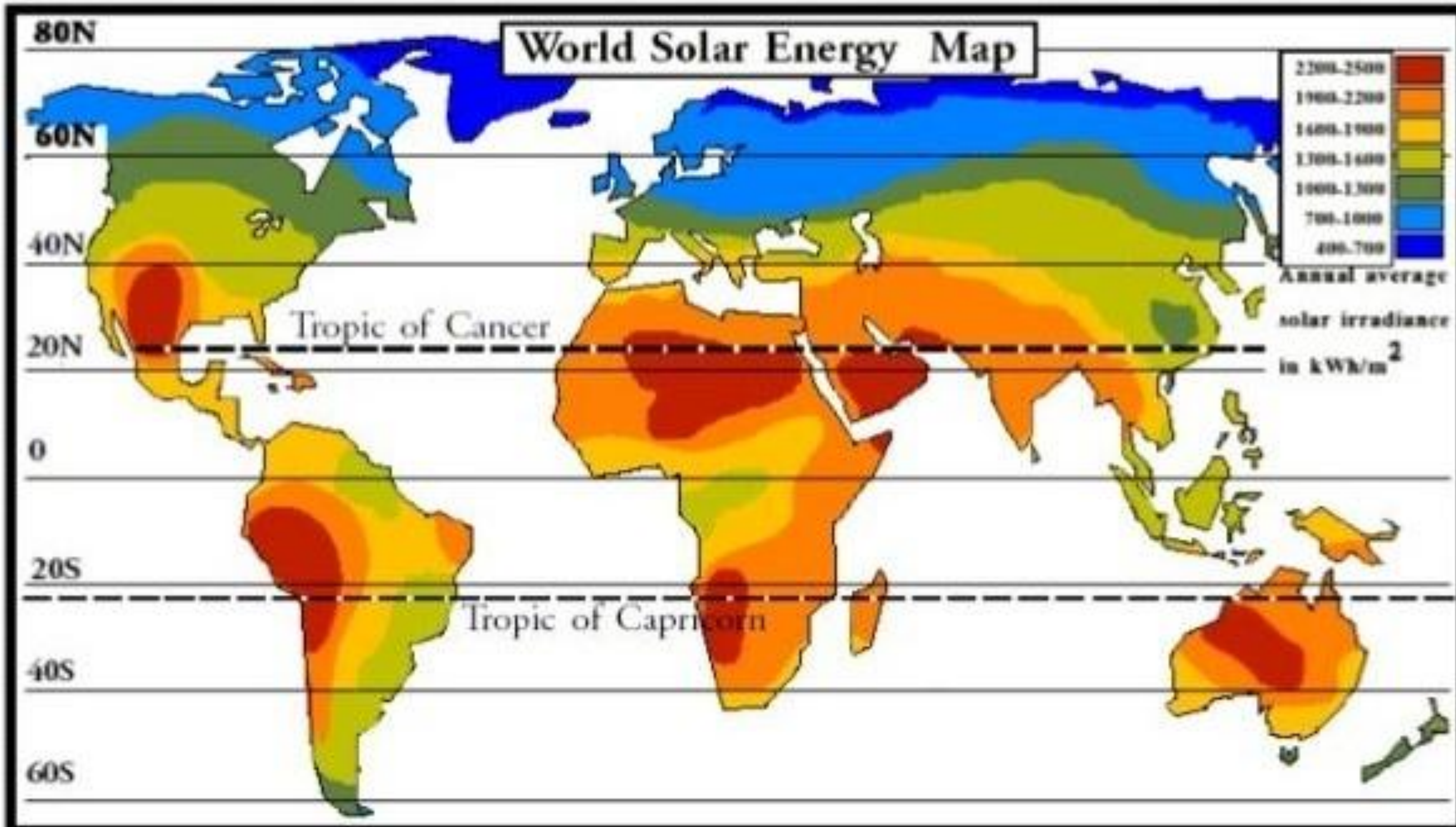
Solar PV Production Process



Solar Thermal Production Process

Factors affecting Applying of Solar Energy Onboard Ships

i-*Solar radiation distribution*



The long-term average of the annual sum of radiation worldwide is in the range from 700 to 2700 kW.hr/m^2 and the daily sum is in the range from 2.0 to 7.5 kW.hr/m^2 (Paulescu et al., 2012).

ii-Solar Sun-exposed deck area

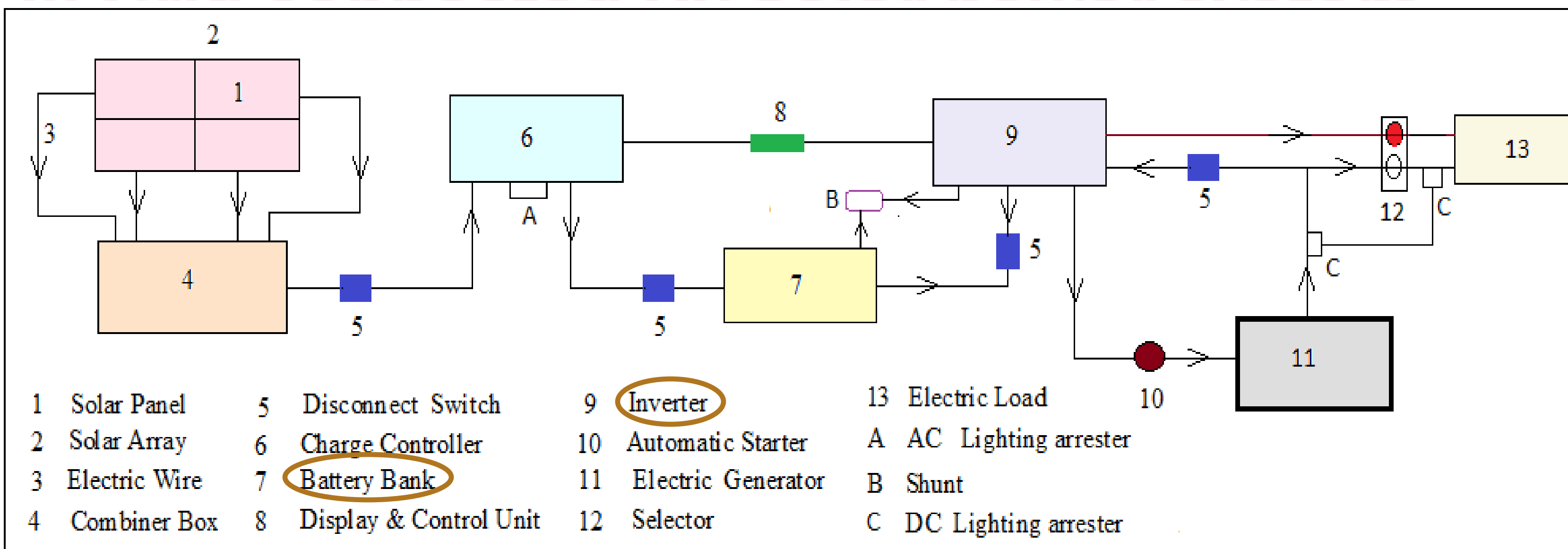
$$Amount\ of\ Solar\ Energy = ASE * P.A * \mu$$

Average Solar Energy

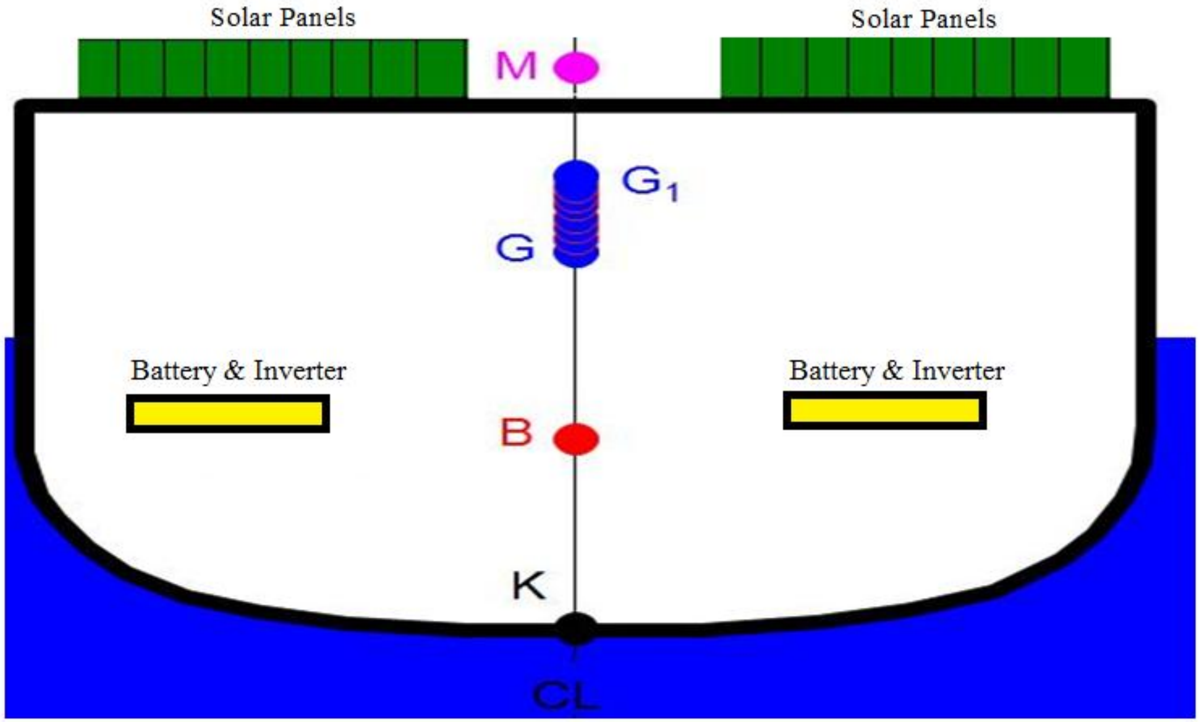
Solar Panel Area

solar panel efficiency

iii-Grid-connected PV solar power system



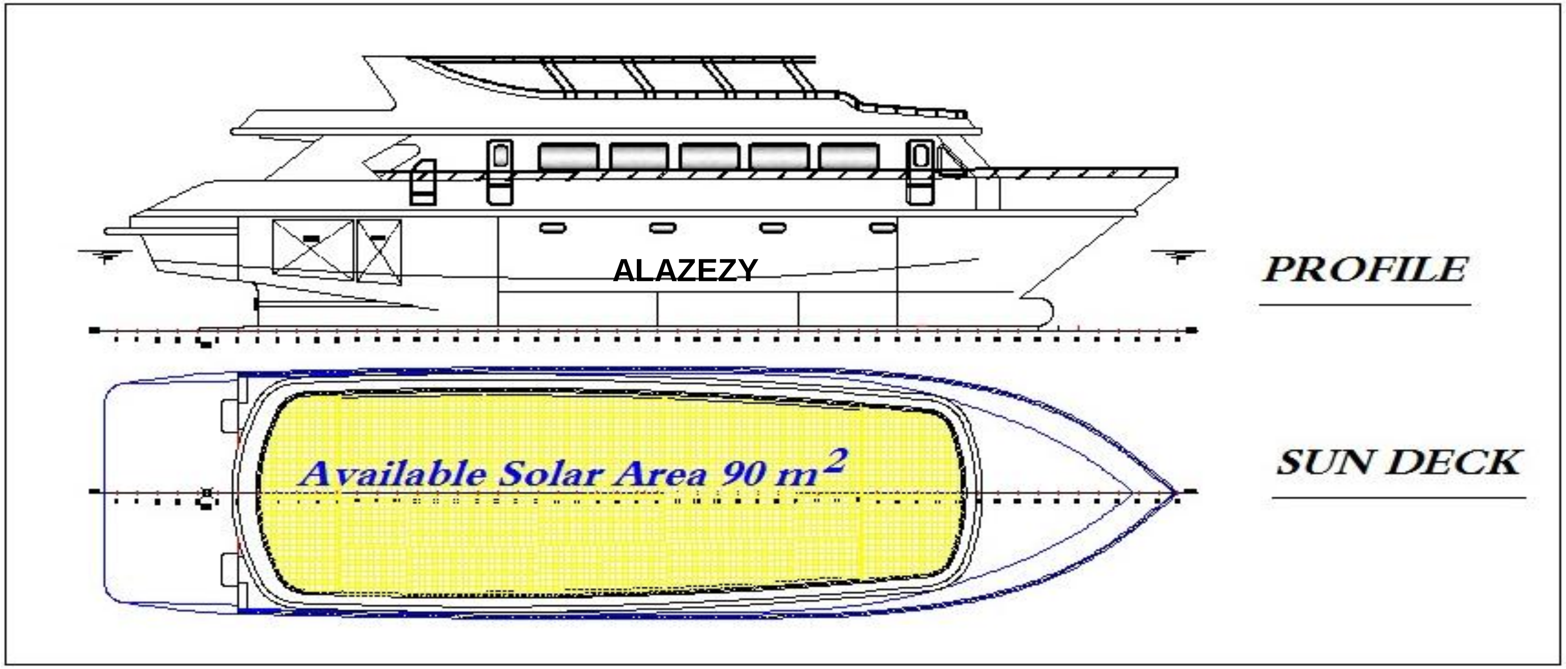
iv-Impact of the weight of solar energy system on ship stability



$$Lost\ of\ Ship\ Stbility = \frac{\Delta * KG \pm \sum m * kg}{\Delta + \sum m} - KG$$

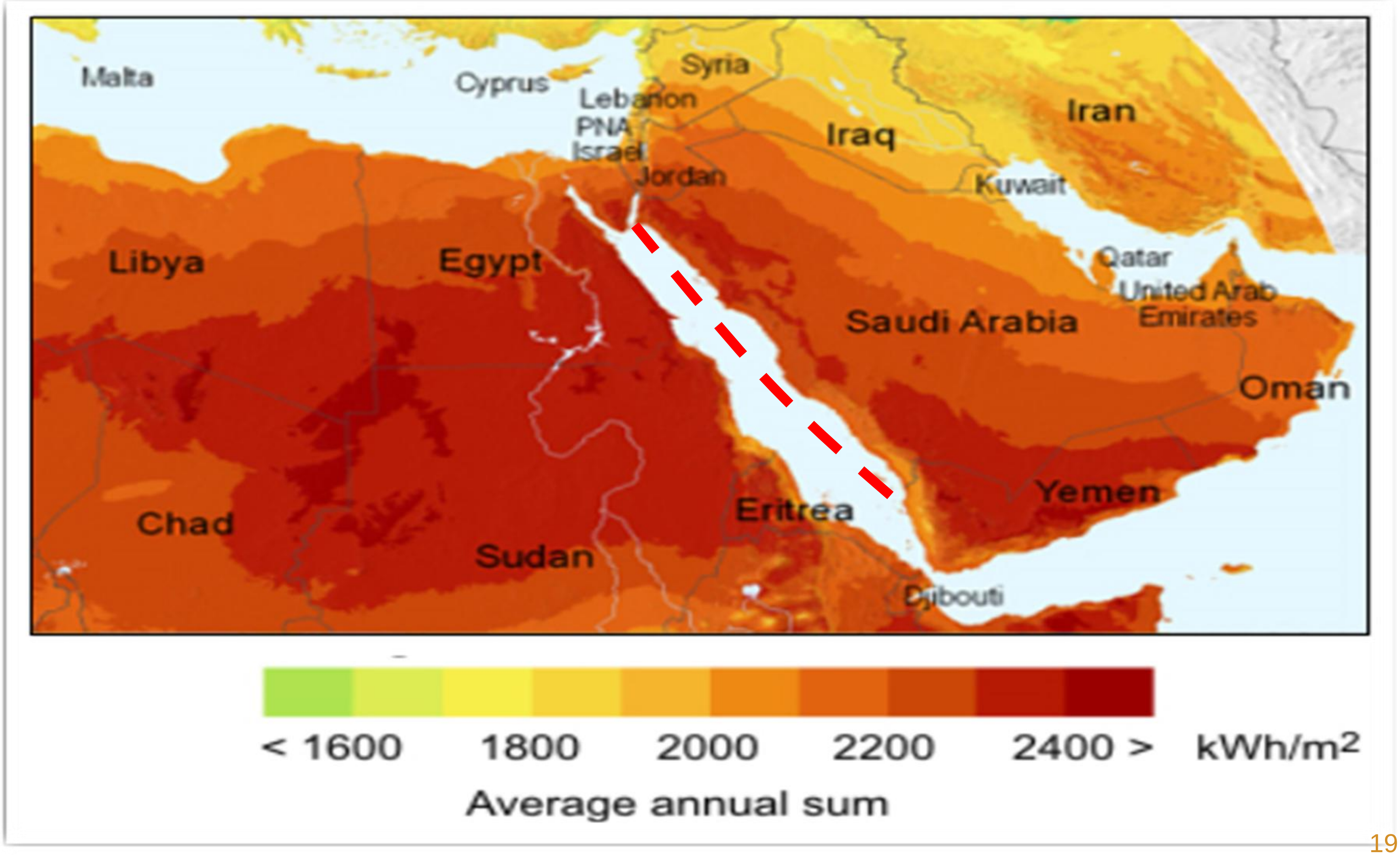
vi- Power Density

NUMERICAL CASE STUDY : ALAZEZY RESEARCH VESSEL



Ship Type	Research Boat
Maximum speed	14 knots
Transit speed (medium load)	12 knots
Length overall	43.1 m
Beam	9.5 m
Draft at full load	3.2 m
Depth	3.8 m
Main generator	2 x Cumins QSM11 D(M) – 2 x 291 kW
Average electrical power required during the cruise	11 kWh
Average electrical power required during the berthing	5 kWh
Area available for solar array installation (Aav)	90 m^2
Average time exposed to the Sun	8 hrs

Case Study



Malta
Cyprus
Lebanon
PNA
Israel
Jordan
Syria
Iraq
Iran
Kuwait
Qatar
United Arab Emirates
Libya
Egypt
Saudi Arabia
Oman
Yemen
Eritrea
Chad
Sudan
Djibouti
< 1600
1800
2000
2200
2400 >
kWh/m2
Average annual sum

ECONOMIC ANALYSIS

Annual Average Cost of solar energy system

$$Annual\ Net\ Cost\ Savings = AAEPC - AAC$$

Annual Auxiliary Engine Power generation Cost

$$AAEPC = Fuel\ Cost + \sum Maintenance\ Cost + \sum Operating\ Cost$$

$$AAC = TUC \times CRF$$

$$CRF = \frac{i(1+i)^N}{(1+i)^N - 1}$$

$$TUC = SP_{CC} . N_m \left[1 + ins_{cp}\right] + \sum PG_a + \sum O\&M_c$$

Cost of one solar panel

$$Batteries\ cost = N_B * B_C$$

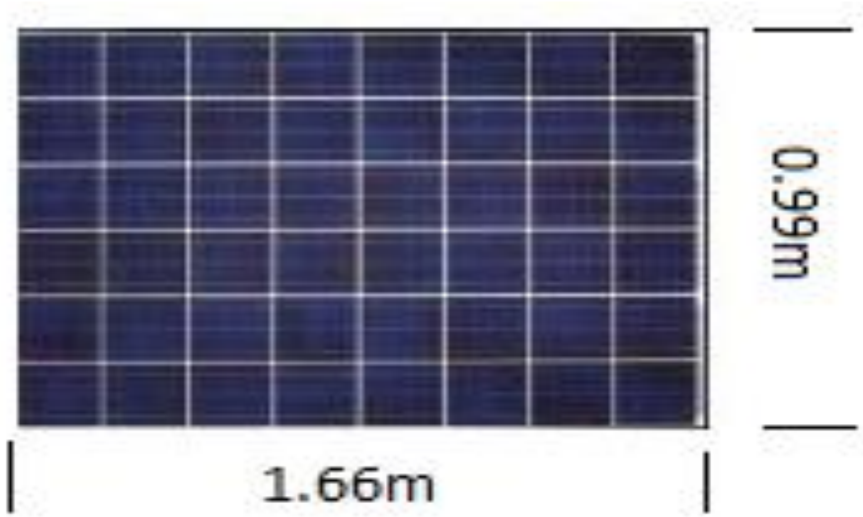
$$N_m = \frac{E_l * PSI * \mu_{pv}}{G_{av} * TCF * \mu_T * PV_{pp}}$$

$$N_m = \frac{A_{av}}{A_{SP}}$$

$$N_B = \frac{E * N_d}{V_B * B_{cap} * DoD}$$

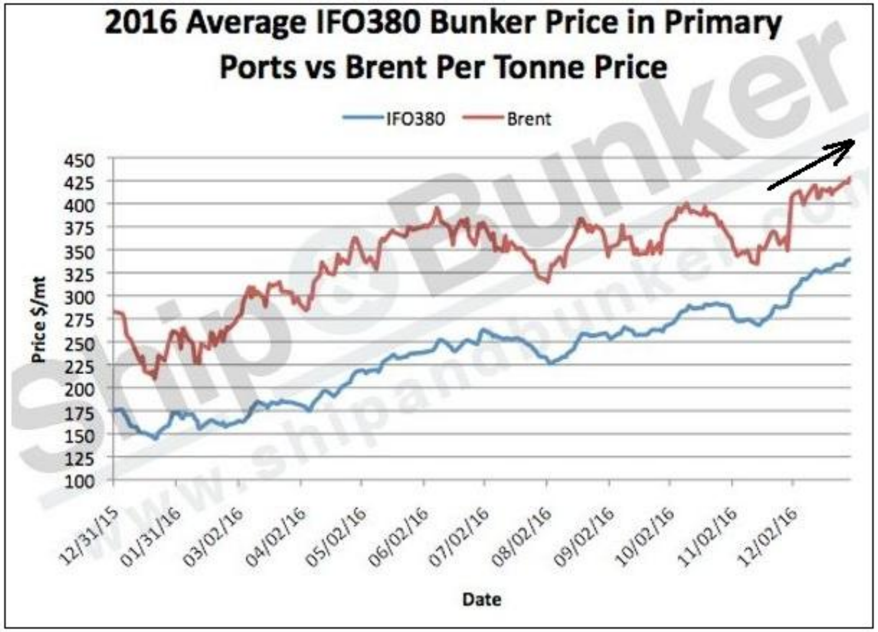
Model	KD260GX-LFB2
Size	166* 99* 4.6 cm
Weight	20 kg
Power rating (PV_{pp})	260 Watt
Open circuit voltage (V_{oc})	38.3 volt
Short circuit current (I_{sc})	9.09 Amps
Voltage at P_{max} (V_{mp})	31 volt
Current at P_{max} (I_{mp})	8.39 Amps
Solar panel cost	322 US$

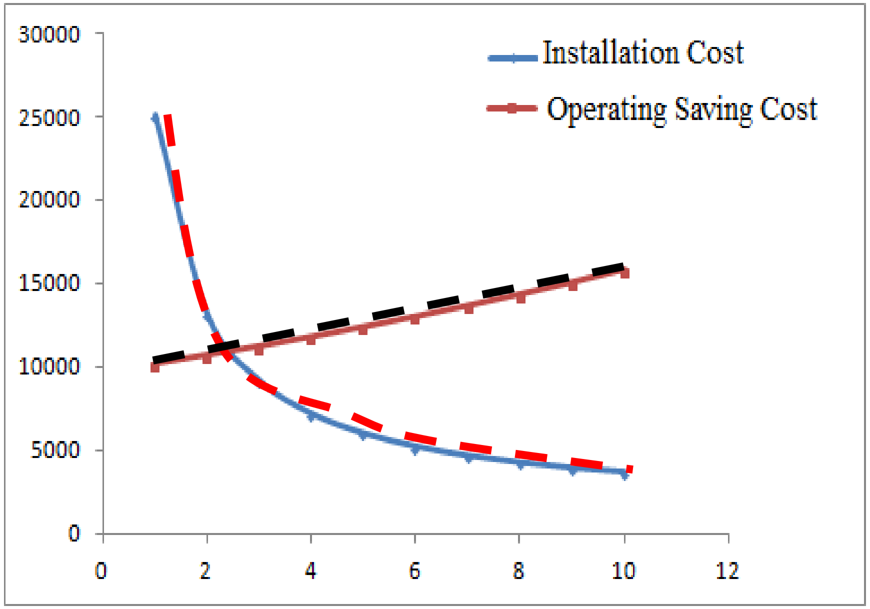
Item	Value
B_{cap}	300 Ah
N_d	2
DoD	0.8
V_B	12
M&O	0.5% of total cost
ins_{cp}	10%



55 solar panels are needed

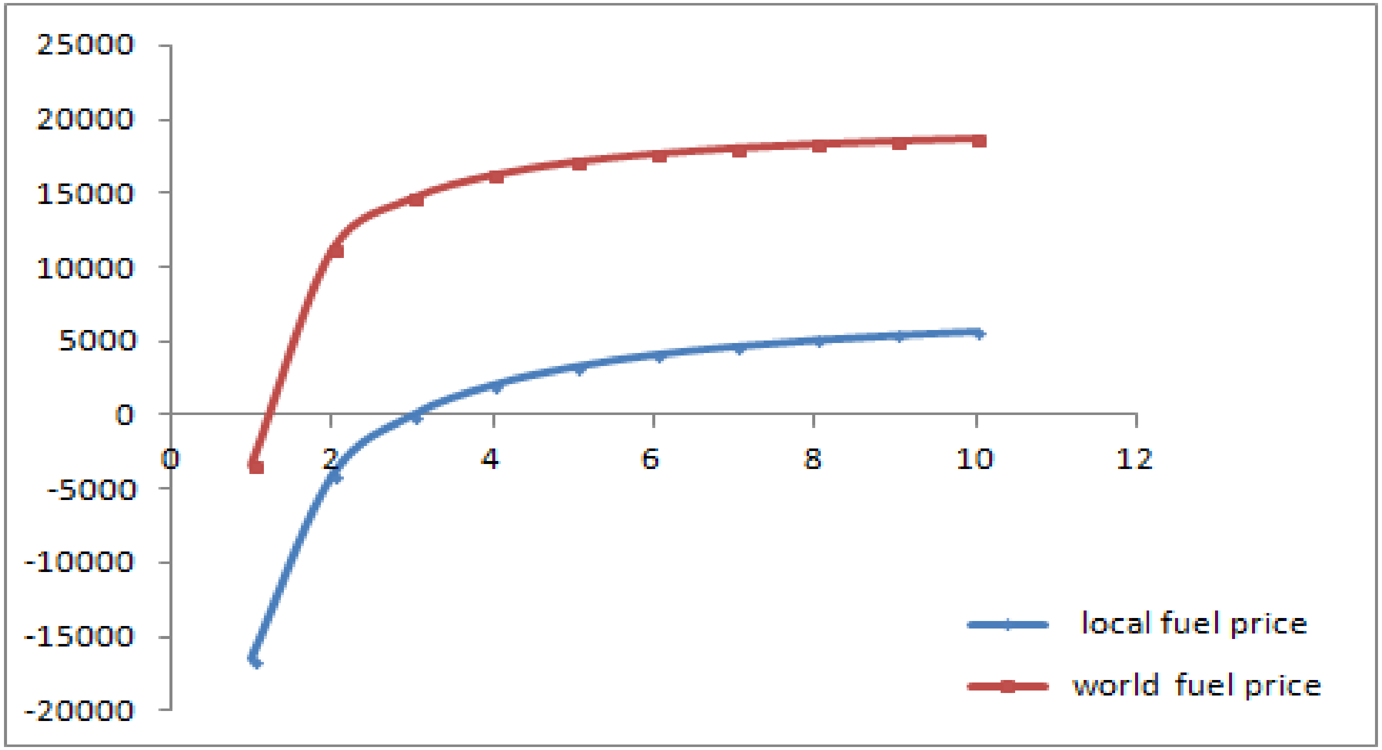
Economic Results





Installation and Operating Costs

The proposed system can provide the auxiliary engines and electric devices by : 84.57 % of the required electric auxiliary load during berthing, and 38.6 % of the required electric load during cruising.



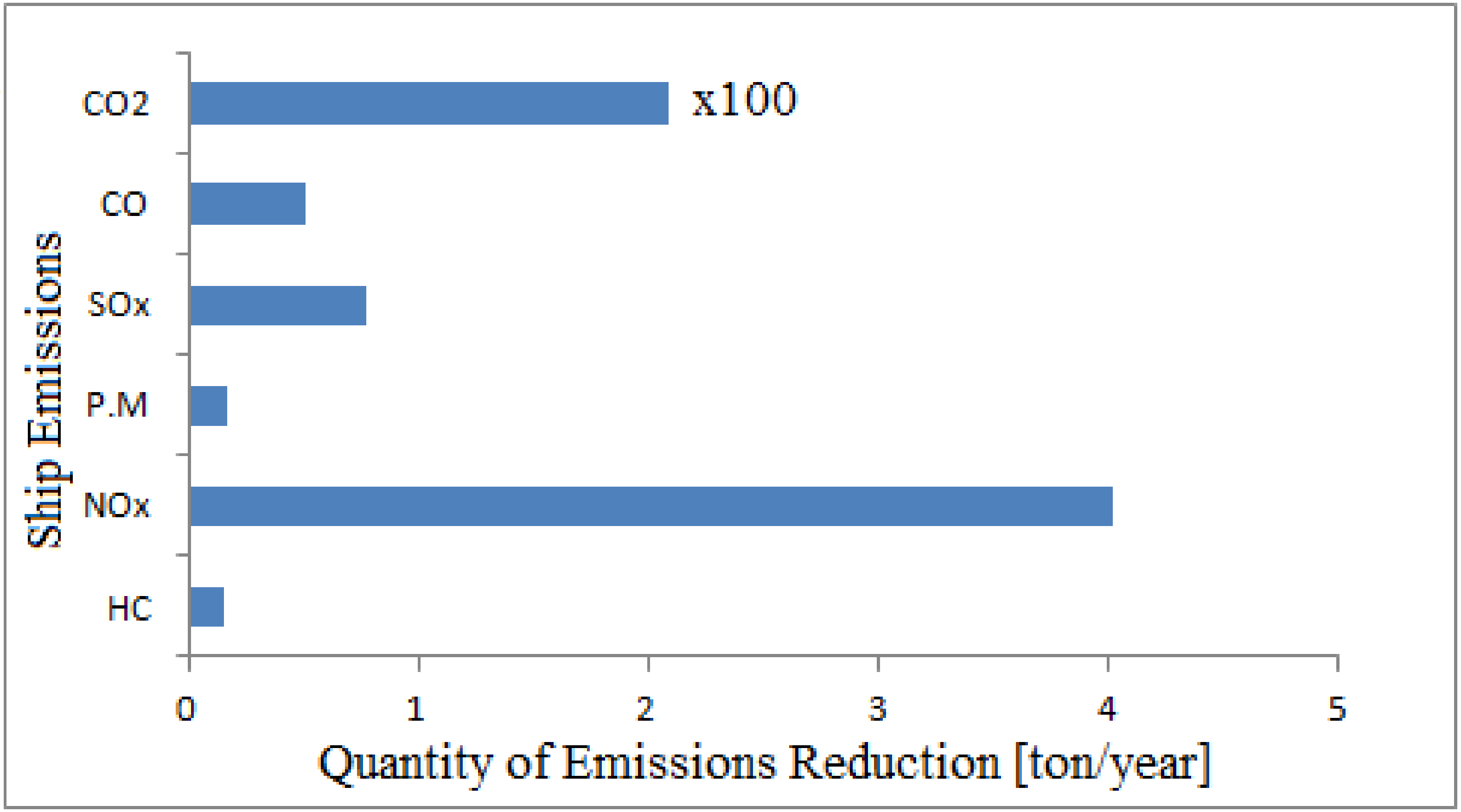
Various scenarios demonstrated in the economic analysis

ENVIROMENTAL ANALYSIS

$$ERQ = L_f \cdot E_f \cdot R_p \cdot P \cdot t_T$$

- ***(ERQ) emission reduction quantity ,***
- ***(L f) is load factor,***
- ***(Ef) is emission factor,***
- ***(R p) is emissions factor reduction* percentage due to applying solar energy**
- ***(P) engine power rating, and***
- ***(T t) ship sailing time.***

Emission Gases	CO_2	CO	NOx	PM_{10}	SOx	HC
Emission Factor (g/kW. h)	698	1.68	13.43	0.55	2.56	0.53



results showed that there is a possibility of achieving a total reduction in ship's emissions of about 215 tonnes per year.

CONCLUSION

- *Until now, there are some challenges that need to be overcome before integrating solar energy on a ship*
- *PV solar panel appears to be a more suitable solar power unit for small vessels.*
- *As a numerical study each square meter of the proposed solar system can achieve:*
  - *annual electric load saving by about 673kw*
  - *annual reduction of ship emissions by about 3.38 ton.*
- *Although the results are very small compared with the huge amount of power and emissions belong to marine vehicles , it still a step toward the green ships.*
- *Finally, despite the fluctuate of fuel prices at lower levels , the world concern regarding ship emissions will accelerate the process of using solar power concept on-board ships in the near future, especially with the new legislations issued by the International Maritime Organization.*

FUNDING

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Thank you for your Attention

Any Question ?

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