Solar Power – The Sustainable Solution for Marine Propulsion

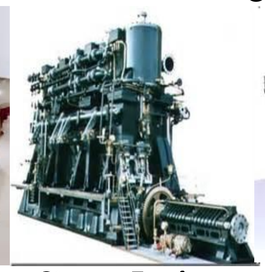
by C. Maheshwar

Historical Development of Marine Propulsion

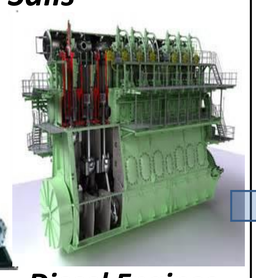
Oars

Sails

Screw Propellers



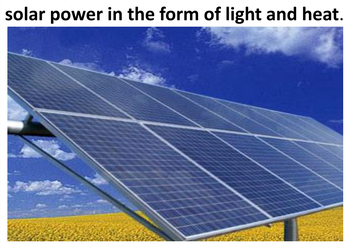
Steam Engines



Diesel Engines

Solar PV power for Ship propulsion

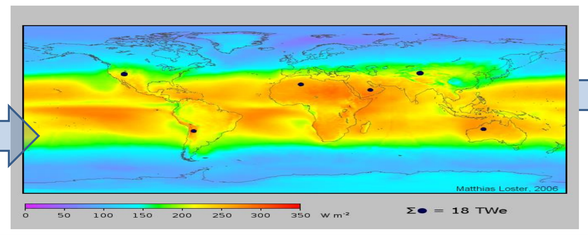
Actively pursued due to availability of abundant and unhindered solar power in the form of light and heat.



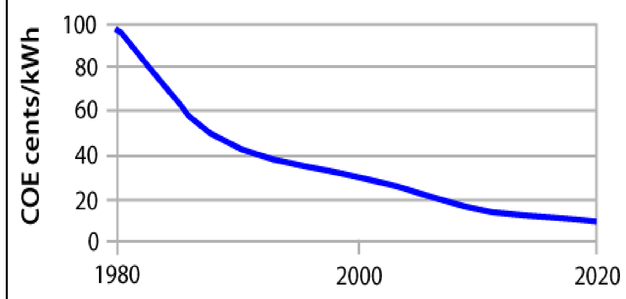
Why solar power?

- Depleting Fossil Fuels
- Growing Environmental Concerns
- Ever increasing Cost of Fossil Fuel
- More stringent enforcement of fuel quality regulations like SECA requirement

- Insolation: Measure of Available Solar Power in KWh/ m²/day
- Typical Insolation Values : 4KWh/m²/day in the North Europe to 6.5 KWh/m²/day in sunniest regions of US
- Sahara Desert: 8.3 KWh/m²/day



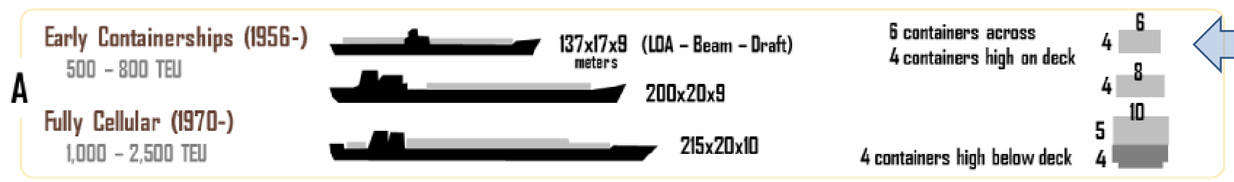
PV Cost of Energy



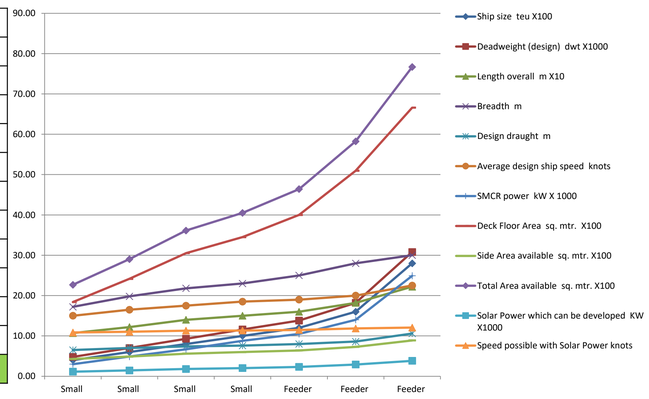
Cost of Solar PV Power

- 5,500 US$ per KW for a 23 KW grid connected solar PV system
- 7,500 US$ per KW for a stand alone smaller system
- The bigger the system, the lower the cost.
- Moore's Law can be rewritten for Cost of Solar PV energy. It can be stated that the Cost of Solar PV power will halve every decade.
- Though presently the cost of power generation from fossil fuel (15 ct/Kwh) is less than solar PV power, it is predicted that in the near future, with the increasing acceptance of solar PV energy on land, the cost of PV panels would certainly fall sufficiently enough to compete and eventually win over the fossil fuel.

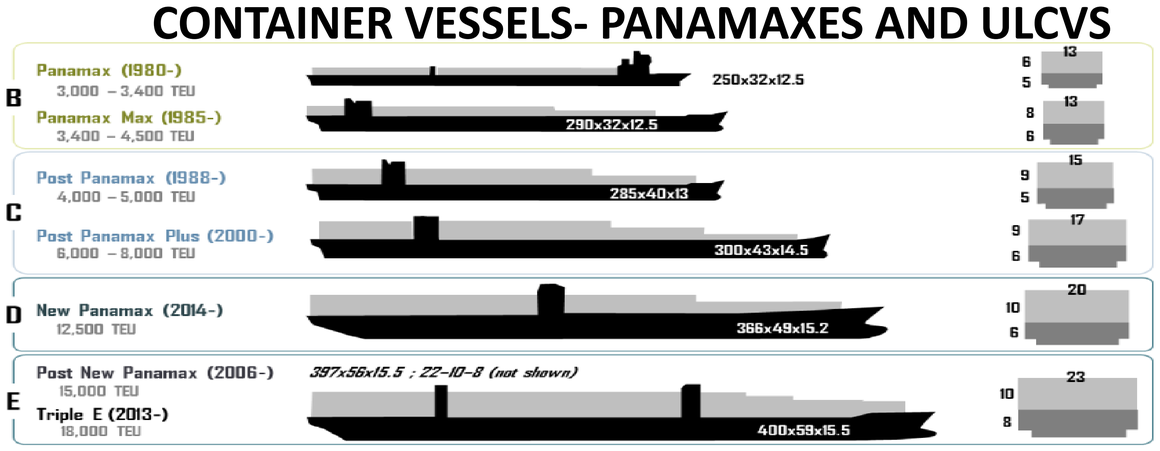
CONTAINER VESSELS- SMALL CRAFTS AND FEEDERS



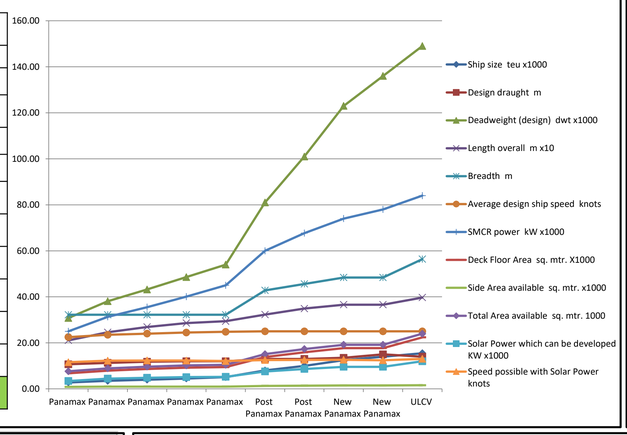
Container ship class		Small	Small	Small	Small	Feeder	Feeder	Feeder
Ship size	teu	400	600	800	1,000	1,200	1,600	2,800
Design draught	m	6.5	7	7.4	7.6	8	8.6	10.6
Deadweight (design)	dwt	4,800	7,000	9,300	11,600	13,800	18,200	30,800
Length overall	m	107	122	140	150	160	182	222
Breadth	m	17.2	19.8	21.8	23	25	28	30
Average design ship speed	knots	15	16.5	17.5	18.5	19	20	22.5
SMCR power	kW	3,000	4,870	6,700	8,800	10,500	14,000	24,900
Deck Floor Area	sq. mtr.	1,840	2,415	3,052	3,450	4,000	5,096	6,660
Side Area available	sq. mtr.	428	488	560	600	640	728	888
Total Area available	sq. mtr.	2,268	2,903	3,612	4,050	4,640	5,824	7,668
Solar Power which can be developed	KW	1,134	1,451	1,806	2,025	2,320	2,912	3,834
Speed possible with Solar Power	knots	10.85	11.02	11.30	11.34	11.49	11.85	12.06



CONTAINER VESSELS- PANAMAXES AND ULCVS



Container ship class		Panamax	Panamax	Panamax	Panamax	Panamax	Post Panamax	Post Panamax	New Panamax	New Panamax	ULCV
Ship size	teu	2,800	3,500	4,000	4,500	5,100	8,000	10,000	12,500	14,000	15,500
Design draught	m	10.7	11.3	11.8	12	12	13	13	13.5	15	14
Deadweight (design)	dwt	30,800	38,100	43,200	48,600	54,000	81,000	101,000	123,000	136,000	149,000
Length overall	m	211	246	269	286	294	323	349	366	366	397
Breadth	m	32.2	32.2	32.2	32.2	32.2	42.8	45.6	48.4	48.4	56.4
Average design ship speed	knots	22.5	23.5	24	24.5	24.8	25	25	25	25	25
SMCR power	kW	25,000	31,300	35,500	40,100	45,000	60,000	67,700	74,000	78,000	84,000
Deck Floor Area	sq. mtr.	6,794	7,921	8,662	9,209	9,467	13,824	15,914	17,714	17,714	22,390
Side Area available	sq. mtr.	844	984	984	984	984	1,292	1,396	1,464	1,464	1,588
Total Area available	sq. mtr.	7,638	8,905	9,646	10,193	10,451	15,116	17,310	19,178	19,178	23,978
Solar Power which can be developed	KW	3,412	4,451	4,823	5,097	5,226	7,558	8,655	9,589	9,589	11,989
Speed possible with Solar Power	knots	11.58	12.27	12.34	12.32	12.10	12.53	12.59	12.65	12.43	13.07



Calculation of Available Areas for Solar Panels

- Available Data: Design Draft; Scantling Draft; Design Deadweight; Scantling Deadweight; Breadth; Length Overall; Length Between Perpendiculars
- Deck Area= Length X Breadth
- Side Area= 2 X Freeboard X Length
- Freeboard = Depth – Design Draft
- Depth = Scantling Draft /0.85

Power Generated from Solar PV Energy on board?

Assumptions:

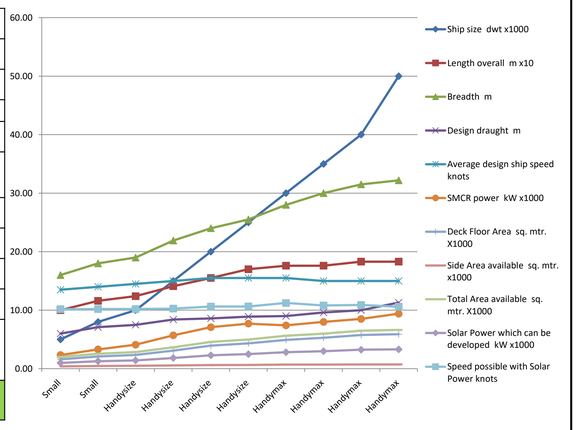
- Box structure
- Unhindered and continuous deck space and ship sides

Estimate:

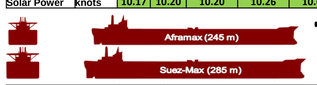
It is estimated that every Sq mtr of area can generate 0.5 KW of electric power using Solar PV Cells at about 15% efficiency.

SMALL TANKERS

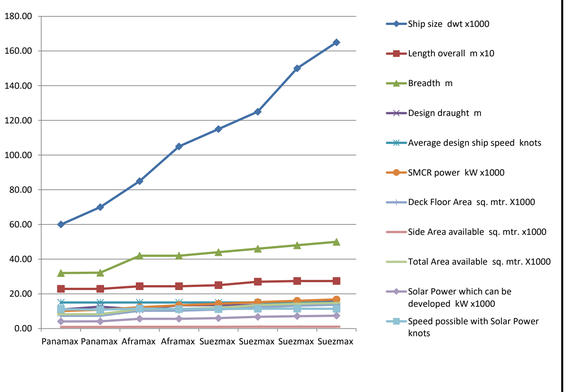
Tanker		Small	Small	Handysize	Handysize	Handysize	Handysize	Handymax	Handymax	Handymax	Handymax
Ship size	dwt	5,000	8,000	10,000	15,000	20,000	25,000	30,000	35,000	40,000	50,000
Length overall	m	100	116	124	141	155	170	176	176	183	183
Breadth	m	16	18	19	21.9	24	25.5	28	30	31.5	32.2
Design draught	m	6	7.1	7.5	8.4	8.6	8.9	9	9.6	10	11.3
Average design ship speed	knots	13.5	14	14.5	15	15.5	15.5	15.5	15	15	15
SMCR power	kW	2,340	3,300	4,100	5,700	7,100	7,700	7,400	8,000	8,500	9,400
Deck Floor Area	sq. mtr.	1600	2088	2356	3088	3953	4335	4928	5280	5765	5893
Side Area available	sq. mtr.	400	464	496	564	620	644	704	704	732	732
Total Area available	sq. mtr.	2000	2552	2852	3652	4573	4979	5632	5984	6497	6625
Solar Power which can be developed	kW	1000	1276	1426	1826	2287	2490	2816	2992	3249	3312
Speed possible with Solar Power	knots	10.17	10.20	10.20	10.26	10.63	10.64	11.23	10.81	10.89	10.59



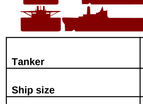
TANKERS-PANAMAXES AND SUEZMAXES



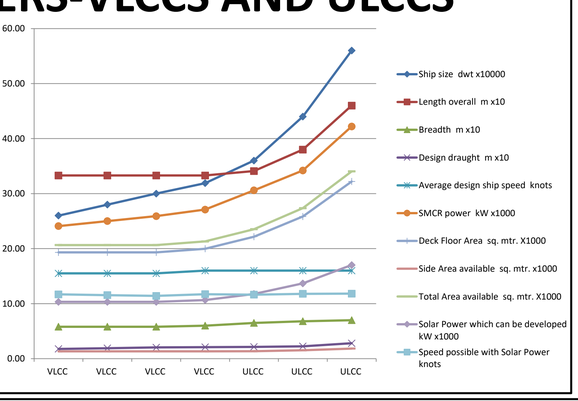
Tanker		Panamax	Panamax	Aframax	Aframax	Suezmax	Suezmax	Suezmax	Suezmax
Ship size	dwt	60,000	70,000	85,000	105,000	115,000	125,000	150,000	165,000
Length overall	m	228.6	228.6	244	244	250	270	274	274
Breadth	m	32	32.2	42	42	44	46	48	50
Design draught	m	11	12.6	11	13.4	13.5	13.5	14.8	15.6
Average design ship speed	knots	15	15	15	15	15	15	15	15
SMCR power	kW	10,100	10,800	12,300	13,400	14,300	15,200	16,000	16,800
Deck Floor Area	sq. mtr.	7315	7360	10248	10248	11000	12420	13152	13,700
Side Area available	sq. mtr.	914	914	976	976	1000	1080	1096	1,096
Total Area available	sq. mtr.	8229	8275	11224	11224	12000	13500	14248	14,756
Solar Power which can be developed	kW	4115	4138	5612	5612	6000	6750	7124	7,398
Speed possible with Solar Power	knots	11.12	10.89	11.54	11.22	11.22	11.44	11.45	11.41



TANKERS-VLCCS AND ULCCS



Tanker		VLCC	VLCC	VLCC	VLCC	ULCC	ULCC	ULCC
Ship size	dwt	260,000	280,000	300,000	319,000	360,000	440,000	560,000
Length overall	m	333	333	333	333	341	380	460
Breadth	m	58	58	58	60	65	68	70
Design draught	m	17.7	19	20.4	21	21.4	22.5	22.8
Average design ship speed	knots	15.5	15.5	15.5	16	16	16	16
SMCR power	kW	24,100	25,000	25,900	27,100	30,600	34,200	42,200
Deck Floor Area	sq. mtr.	19,314	19,314	19,314	19980	22165	25840	32200
Side Area available	sq. mtr.	1,332	1,332	1,332	1332	1364	1520	1840
Total Area available	sq. mtr.	20,646	20,646	20,646	21312	23529	27360	34040
Solar Power which can be developed	kW	10,323	10,323	10,323	10656	11765	13680	17020
Speed possible with Solar Power	knots	11.68	11.54	11.41	11.72	11.63	11.79	11.82

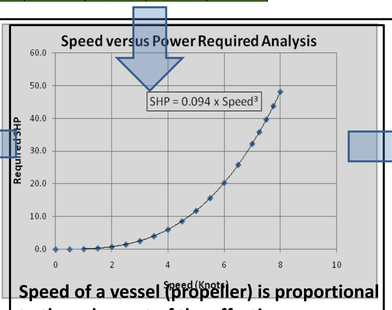


Case 1 - Small Container Vessel: For a small container vessel of 400 teu capacity with design speed of 15 knots with SCMR power of 3,000 KW, if we are able to generate 1134 KW from solar PV panels fitted on the deck and the shipsides, the speed can be over 10 knots, all other conditions being constant.

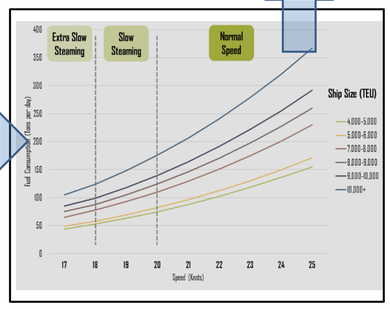
Case 2 – Largest Possible Container Vessel (future design): For a large container vessel of 18,000 teu with a design speed of 25 knots with a SCMR power of 91,500 KW, we will be able to generate 12,684 KW from solar PV panels fitted on the deck and the shipsides, the speed can be over 12.5 knots, all other conditions being constant.

Case 3 - Small Tanker: For a small tanker of 5,000 dwt with design speed of 14 knots with SCMR power of 2,340 KW if we are able to generate 1000 KW from solar PV panels fitted on the deck and the shipsides, the speed can be over 10 knots, all other conditions being constant.

Case 4 – Large sized Tanker (ULCC): For a large tanker of 560,000 dwt with a design speed of 16 knots with a SCMR power of 42,200 KW, we will be able to generate 17,020 KW from solar PV panels fitted on the deck and the shipside, the speed can be over 12 knots, all other conditions being constant.



Speed of a vessel (propeller) is proportional to the cube root of the effective power available at the shaft



Slow Speed Operation of Ships

- The present cost concerns and environmental concerns are forcing the shipping industry to adopt the new concepts of slow steaming of the vessels.
- At slower speeds, the fuel consumption and the emission of the engines are much lower than at high speeds.
- All the new yard deliveries of the vessels are being equipped with slower speed engines with lower fuel consumption and emissions.
- Even older vessels are retrofitting their engines with slow speed components.
- With solar PV panels used for power generation, vessels can be run at 50-75% of maximum speed, the figure varying from the type of the ship and size of the ship.
- Running ships at 50-75% maximum speed is perfectly acceptable in these days making Solar PV panels as the preferred means of main propulsion and power generation on merchant vessels.

Maintenance of Solar Panels.

There is no maintenance required for the panels other than regular surface cleaning

Power generation in night and cloudy conditions: Till the technology permits generation and storage of additional power during sunny periods and release during non sunny periods, the present day Diesel engines could continue to be used for propulsion power during night and cloudy conditions.

Power for propulsion during rough weather conditions: Before the onset of rough weather, propulsion power could be changed over to Diesel Engines and switched power to Solar PV power when conditions clear.

Regulatory Regime

The merchant marine industry is overburdened by the innumerable new regulations to control global warming, SOx emissions, NOx emissions, special areas, etc. The ship staff is working overtime to comprehend and to ensure compliance, but inevitably they get into trouble with the authorities. By the time, one has ensured compliance with one regulation, a new one is already in place forcing designers to go back to the drawing board. It is time to think out of the box and look for a different solution.

Economical Operation of Ships

Fuel constitutes about 50% of the operational cost of a ship. If we are able to dispense with diesel engines and the associated fuel storage systems, it would be much more economical to run ships than it is today with fossil fuels. We also save on the deadweight and volumetric cargo space giving us more cargo carrying capacity. Also there is a substantial saving on manning costs.

Undoubtedly, Solar power is the marine fuel of the future and perhaps offers an out of the box solution to the problems facing the marine industry and the world at large

The Road Travelled So Far - Auriga Leader & Turanor PlanetSolar

The car carrier equipped with the new solar power system

A small step for Man, but a giant leap for Mankind.