LH2 Tanker Design Based on WIT Operating Model and CAPEX as Competitive Advantage

Presented by:
Geoffrey Uttmark, TransTech Marine Co./ShipShares LLC

Est. 1979

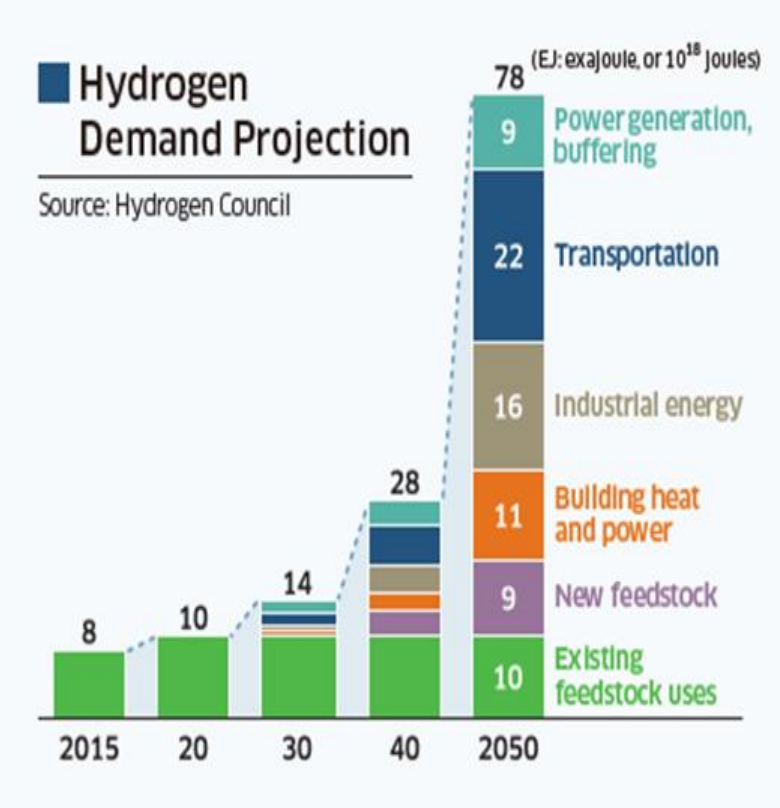
Est. 1979
ShipShares.com

Roland Capital
航士高资本

Take-Aways

1. “Hydrogen economy” could produce demand for 1,000 LH2Ts (liquid-hydrogen tankers) over 25 years.
2. Lake Ontario could become the global low-cost producer of “green hydrogen”.
3. WIT (warehouse-in-transit) can replace JIT in both bulk and liner trades.
4. Smaller ships can derive more of their propulsive power from wind than can larger ships, enabling use of wind for prime mover in some circumstances.
5. Hybrid WIT-LH2T using fuel-cell / battery bank to power Flettner rotors / retractable thrusters is technically viable.
6. LH2T Funding: “Green” finance can mitigate LH2T CAPEX.
7. LH2Ts represent opportunity for US commercial shipyards.

Hydrogen Economy



"…energy economists predict in year 2050 55 million tonnes of hydrogen, or 8 EJ, will be traded and transported by sea. .."

"… This represents 10 percent of a forecast demand that could exceed 550 million MTs …"

NB: 1 EJ = 7 MT H2

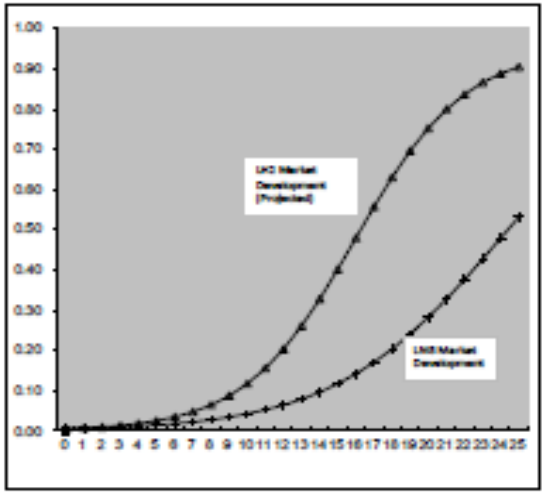
Hydrogen Economy

PROJECTED DEVELOPMENT OF LH2 TRADE VS. ACTUAL DEVELOPMENT OF LNG TRADE
One Ship Replacement Cycle

Input Variables:		LNG Trade		LH2 Trade	
Initial Market Penetration:		0%		0%	
Projected Penetration:		95%		95%	
Growth Constant:		22%		33%	
Fitting Constant:	x =	192.88	Calc.	192.88	Calc.

Market Penetration as Function of Time:

Time Years	LH2T Fleet Growth Rate	LNG Fleet Growth Rate	Available Market Penetration (Pct.)
0	0.005	0.005	
1	0.006	0.007	
2	0.008	0.009	
3	0.009	0.013	
4	0.012	0.018	
5	0.015	0.025	
6	0.018	0.034	
7	0.022	0.047	
8	0.028	0.064	
9	0.034	0.087	
10	0.042	0.117	
11	0.052	0.155	
12	0.064	0.203	
13	0.079	0.261	
14	0.098	0.328	
15	0.117	0.401	
16	0.142	0.479	
17	0.170	0.557	
18	0.203	0.630	
19	0.240	0.696	
20	0.282	0.753	
21	0.328	0.799	
22	0.376	0.837	
23	0.427	0.866	
24	0.479	0.888	
25	0.531	0.904	



Lake Ontario Green Hydrogen

"RECORD-SETTING HIGH WATER LEVELS IN THE GREAT LAKES" PADEP 7/21/2020

"NIAGARA POWER COSTS HALF A CENT A KILOWATT-HOUR TO PRODUCE, COMPARED WITH 7 CENTS AT OIL-BURNING PLANTS AND MORE THAN 20 CENTS AT NEWER NUCLEAR POWER PLANTS."

NEW YORK TIMES OCTOBER 8, 1984

NB: THE FIGURES DIFFER TODAY BUT IN APPROXIMATELY THE SAME RATIOS.

WIT (warehouse-in-transit) Can Replace JIT

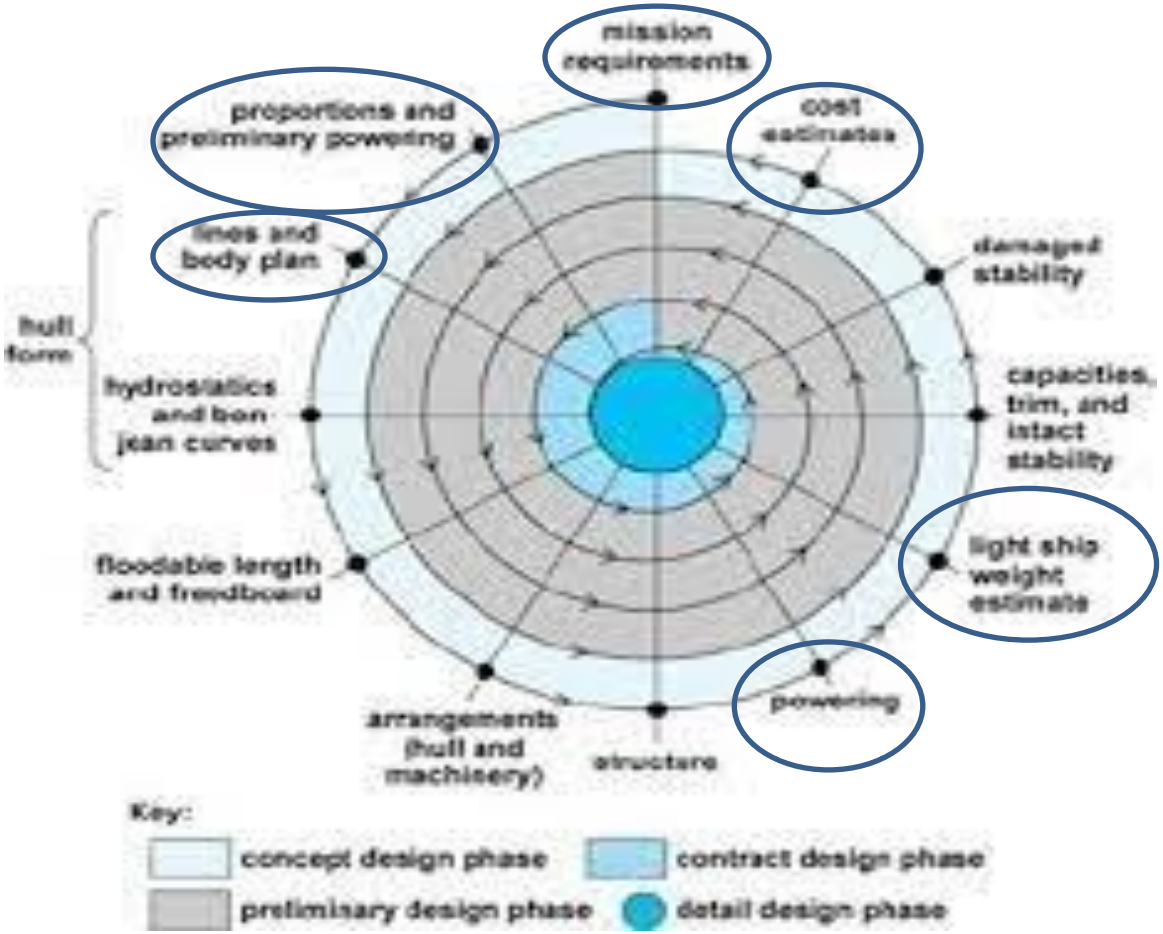
JIT (Just-In-Time) driven by:

- High interest rates (inventory carrying cost)
- Low bunker prices
- Environmental unawareness

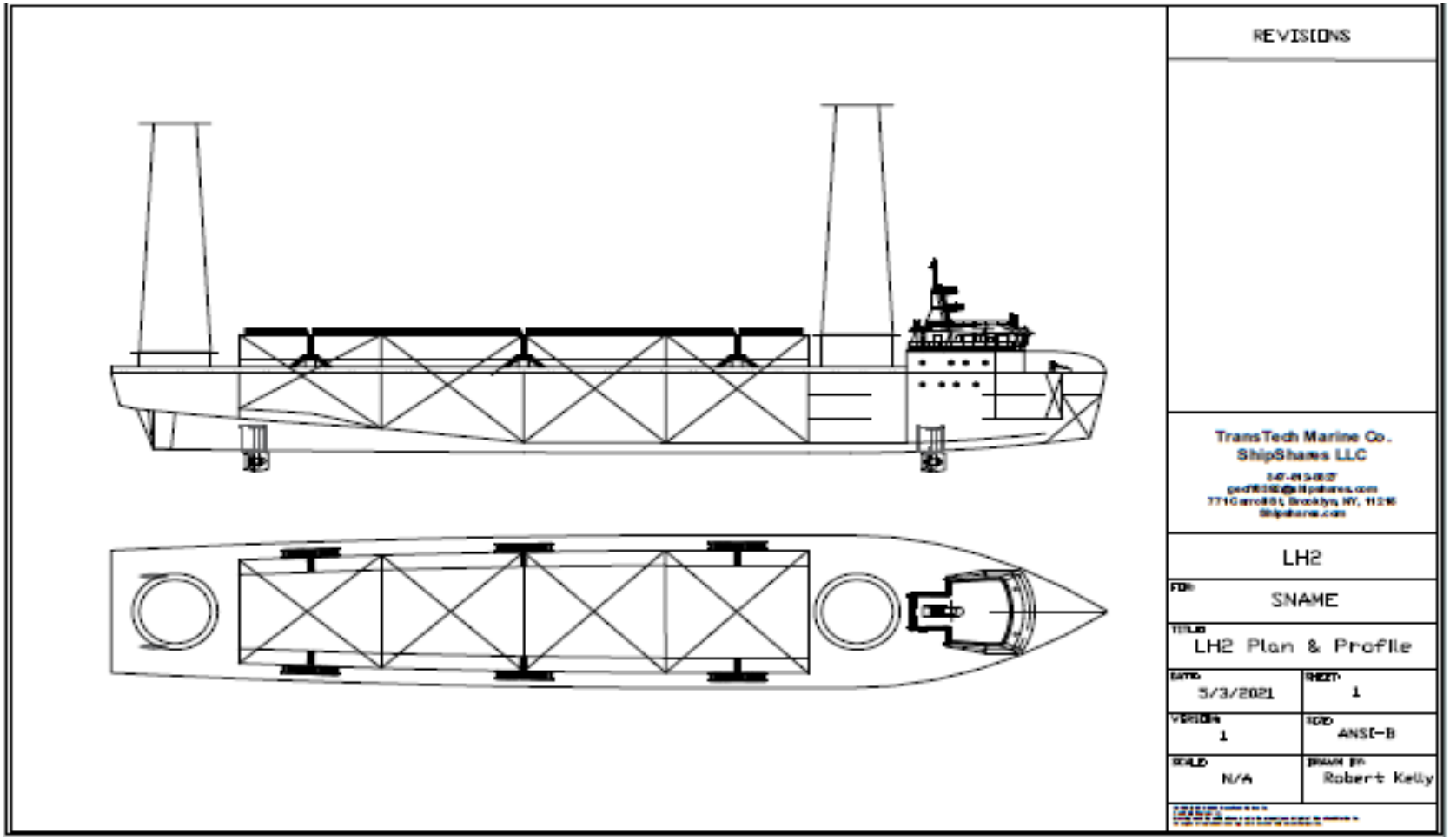
WIT driven by:

- Many small ships equal fewer Large ones.
- Slower speed enables “greener” propulsion (Environmental Awareness)
- Expansion and diversification of the global shipbuilding base will increase competition, and series production to drive down vessel first cost.
- Increased number of ship operators will moderate freight rates.
- Strength in numbers inherently creates resilience.

Hybrid WIT-LH2T



Hybrid WIT-LH2T

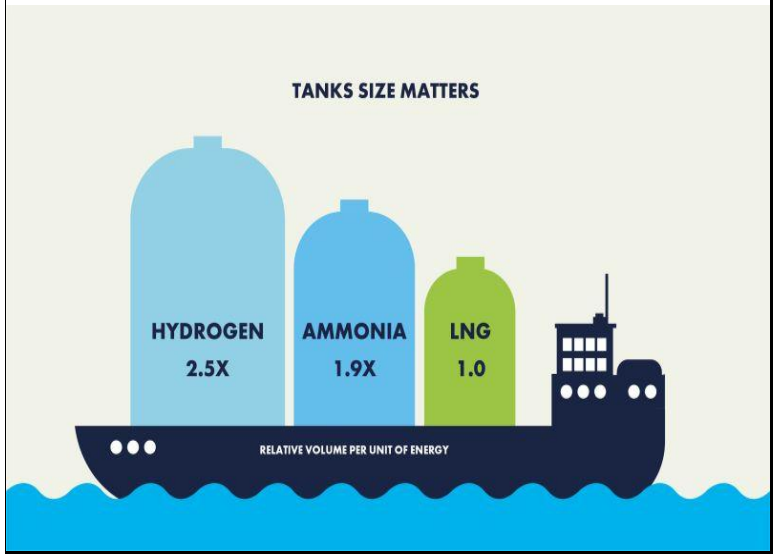


Hybrid WIT-LH2T

Physical Properties of LNG and LH2

	LNG	LH2	MDO (for ref.)	
Boiling point	-162	-253	145 - 370	°C (at 1 bar)
Density	453	71	830	kg/m3
Gravimetric density (Specific energy)	54	120	46	MJ/kg (LHV)
Volumetric density (Energy density)	22.2	8.5	38.6	MJ/L (LHV)
Flame velocity	40	250	87	cm/s
Ignition range	4 - 16	4 to 75	NA	% in air by volume
Autoignition temperature	530	571	169	°C
Minimum Ignition Energy (MIE)	0.28	0.02	20	mJ (mini-joules)

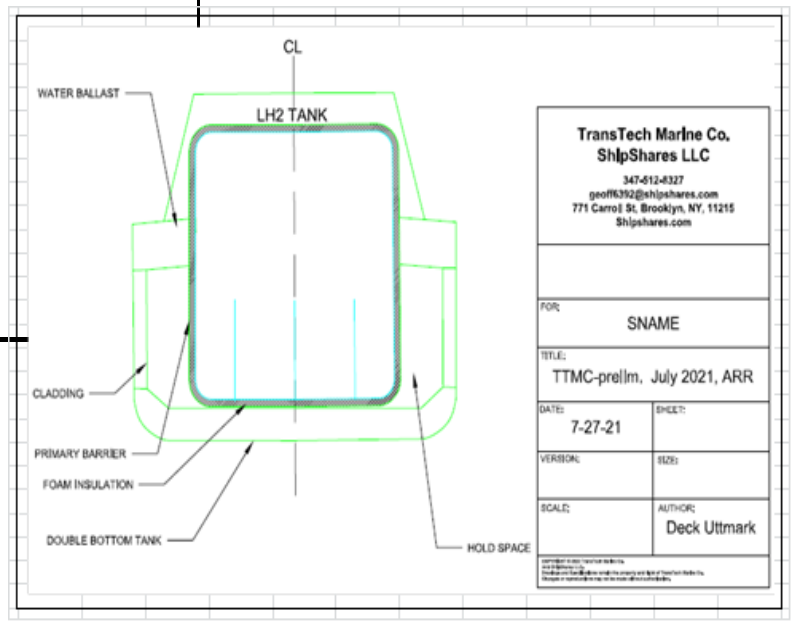
TTMC June 2021 ARR



Hybrid WIT-LH2T

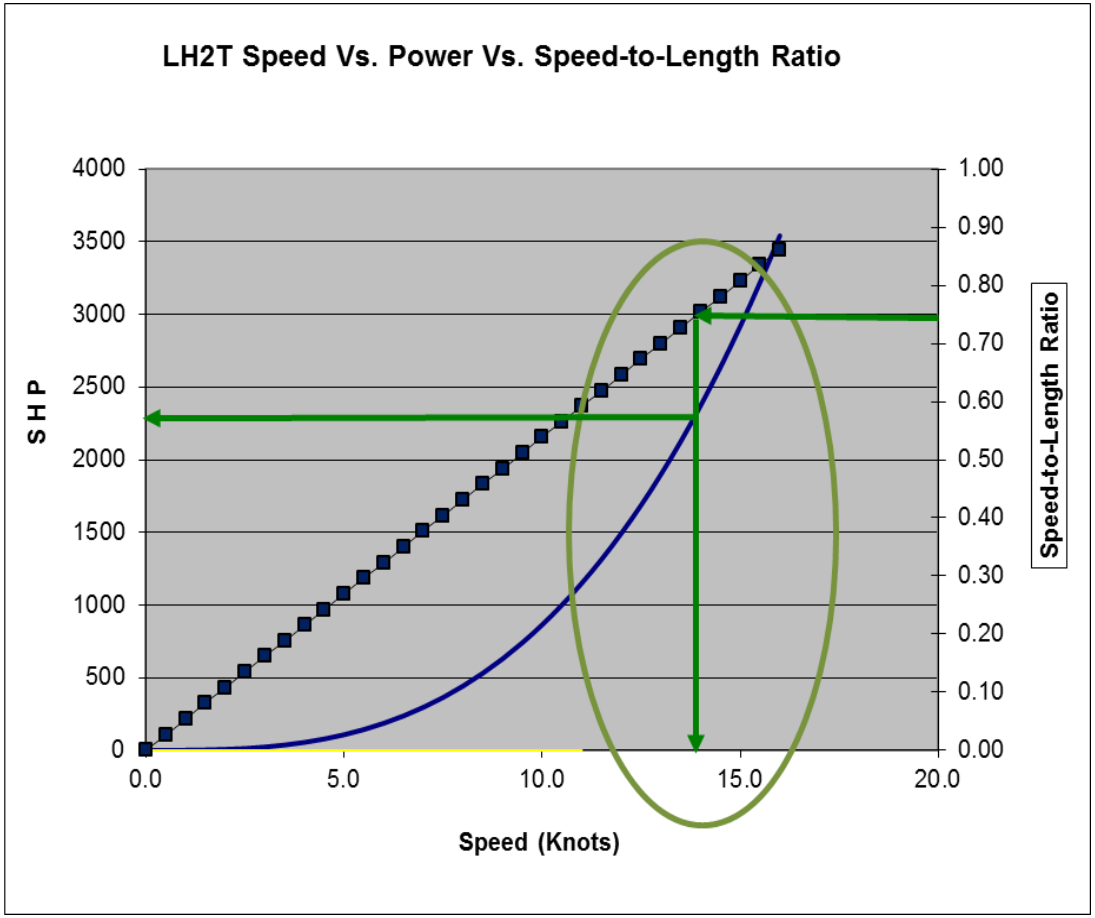
5,500 m3 Obround Liquefied Hydrogen Storage Tank Specification

Tank type	IMO independent double-shell obround storage tank
Number of LH2 tanks	2
Nominal per tank LH2 capacity	5,500 m3 (approx. 730 t), incl. 10% margin for internals
Tank Material	lithium aluminum alloy or … carbon fiber reinforced composite cryotank
Tank Dimensions (each of 2 tanks)	Obround 34' W x 44' H' x 140' L
Tank Pressure & Temp.	75 psi (0.5 Mpa) at -424 F (-253 C)
Tank Insulation	Vacuum-sealed multi-layered thermal insulation
Tank Covers	Double insulated GRP panels
BOR	0.5% < BOR0 < 1.0% / day
BO Management	Use BO to supply FCs
LH2 discharge methodgen	discharge pump + self-actuating control



Hybrid WIT-LH2T

Vs	EHP	SHP	SL Ratio
0.0	0	0	0.00
0.5	0	0	0.03
1.0	1	1	0.05
1.5	2	3	0.08
2.0	4	7	0.11
2.5	9	14	0.13
3.0	15	23	0.16
3.5	24	37	0.19
4.0	36	55	0.22
4.5	51	79	0.24
5.0	70	108	0.27
5.5	94	144	0.30
6.0	121	187	0.32
6.5	154	238	0.35
7.0	193	297	0.38
7.5	237	365	0.40
8.0	288	443	0.43
8.5	345	531	0.46
9.0	410	630	0.48
9.5	482	741	0.51
10.0	562	865	0.54
10.5	651	1001	0.57
11.0	748	1151	0.59
11.5	855	1315	0.62
12.0	971	1494	0.65
12.5	1098	1689	0.67
13.0	1235	1900	0.70
13.5	1383	2128	0.73
14.0	1543	2373	0.75
14.5	1714	2637	0.78
15.0	1897	2919	0.81
15.5	2093	3221	0.83
16.0	2303	3542	0.86



Hybrid-WIT LH2T

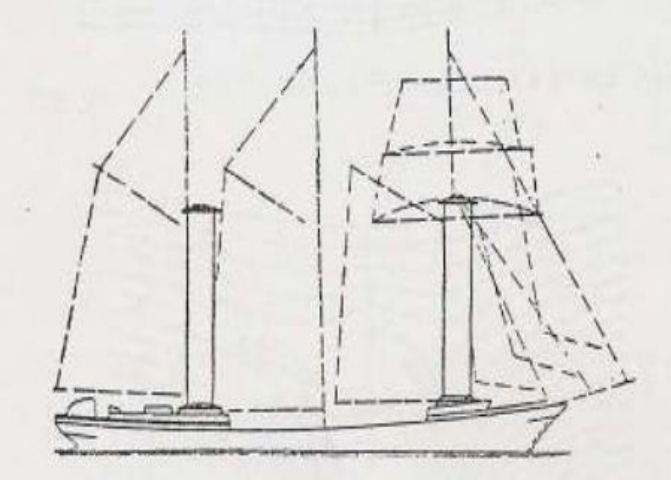
Comparison of Five Rotor Ships to Rotor-LH2T

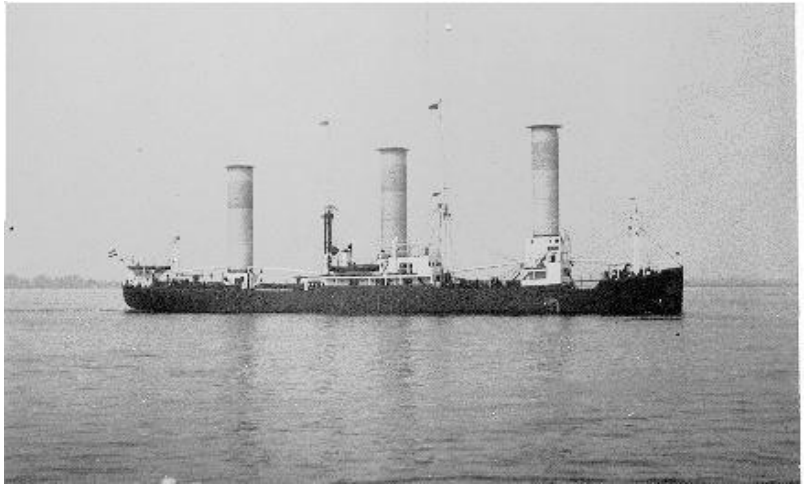
	<--- 1920s - 1930s --->		<---------- 2007 - Present ---------->			Dawning
	Buckau	***Barbara***	***E-Ship1***	***Fehn Pollux***	***Sea Zhoushan***	**LH2T**
Length (Ft)	155.8	293.0	427.8	294.4	1115.5	350.0
Beam (Ft)	28.5	43.0	74.2	43.2	203	60.0
Draft (Ft)	12.5	17.7	27.5	19.4	72	15.0
Displacement (LT)	680	4780	15779	4550	350,000	5080
Service speed (kts)	8.0	10.5	16.5	11.0	13.0	14.0
Mechanical propulsion (kW)	118	2 x 389	2 x 3500	900	33000	2500
SHP at Vs (HP)	158	1043	9387	1207	44253	2373
Mechanical thrust (Lb-f)	6441	32358	185270	35731	1108565	55199
Marine screw propellers	1	2	2	1	1	2
Number of rotors	2	3	4	1	5	2
Weight per rotor + fdn.(tons)	6.5	12.5	17.7	16.5	18.1	22.0
Length of the rotor (Ft)	51.0	55.8	88.6	59.0	78.7	80
Diameter (Ft)	9.2	13.1	13.1	9.8	13.1	20
Maximum velocity (rpms)	125	160	160	240	180	140
Material	Steel	Lautel	Steel	FRP	Steel	TBD
Rotor electric motor (kW)	10	30	0*	74	50	200
Thrust per rotor in 20 MPH wind (Lb-f)	6638	17874	28400	27789	28425	40507
Total thrust (Lb -f all rotors)	13276	53622	113600	27789	142125	81014
Rotor thrust / Mechanical thrust	**2.06**	**1.66**	**0.61**	**0.78**	**0.13**	**1.47**
DLR = Disp. LT / (.01 x LWL Ft)^3	194	205	217	208	260	128
SLR = Vs Kts /(LWL ^ 0.5)	0.64	0.61	0.80	0.64	0.40	0.75
ESA / D = Diam x Span x 8 / Vdisp. ^ .667	9.04	5.76	5.50	1.57	0.77	8.06

*Rotors aboard E-Ship1 are not driven by electric motors; rather, exhaust gases from diesel engine prime movers generate steam in boilers which are connected to a turbinethat drives the rotors.

TTMC June 2021 ARR

Hybrid WIT-LH2T



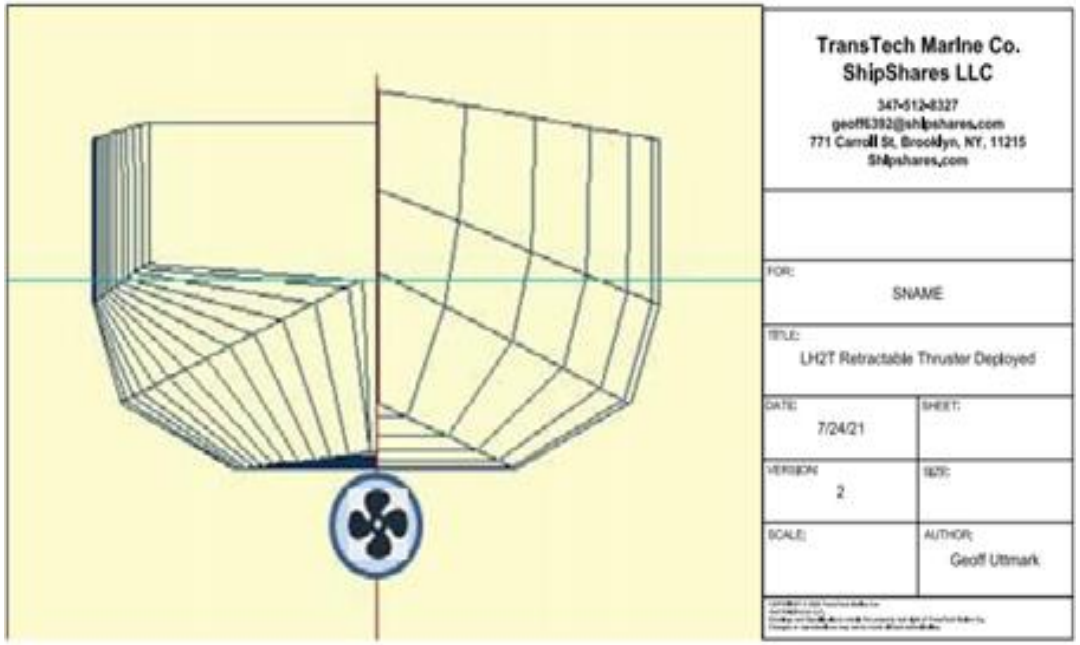


Hybrid WIT-LH2T

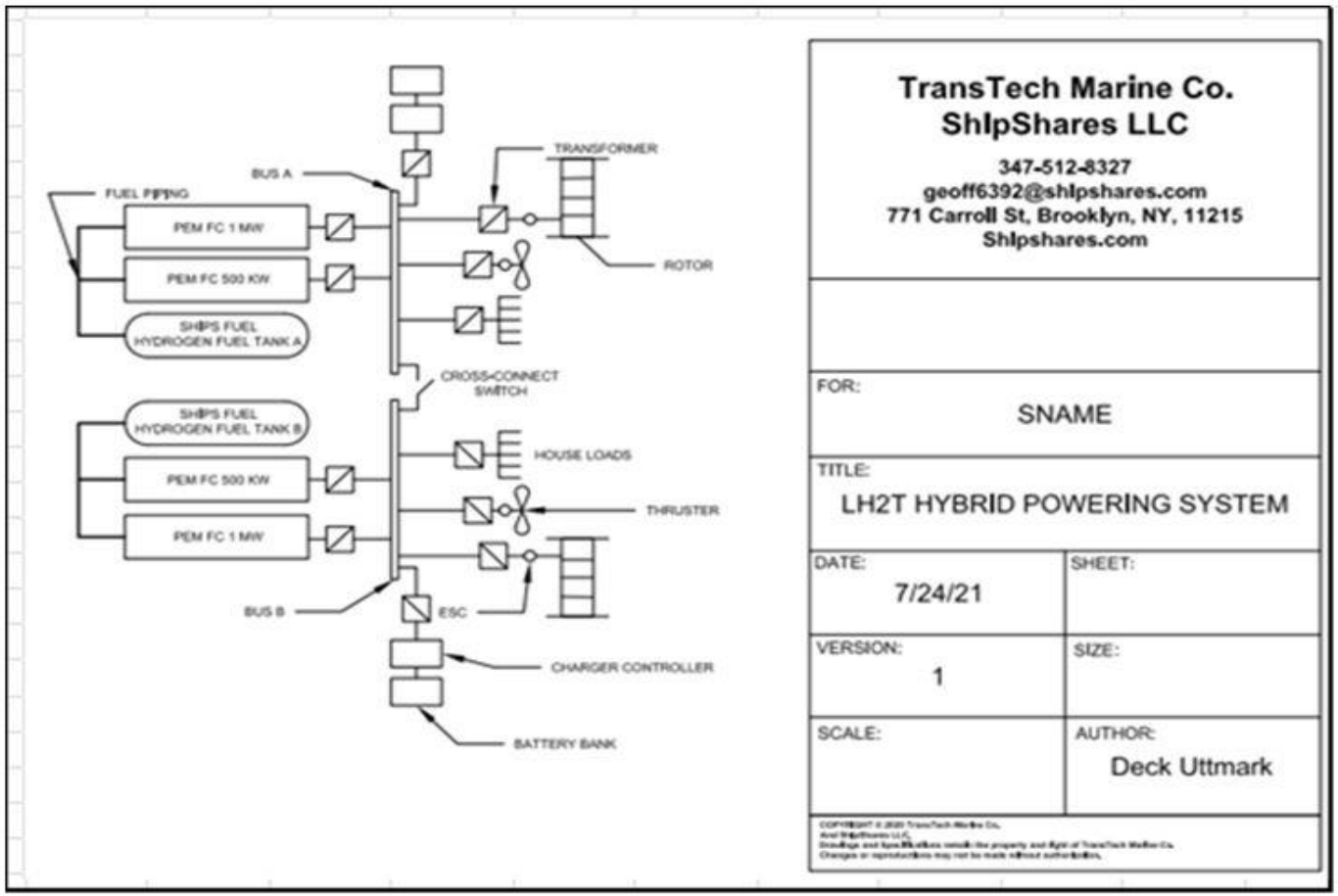
LH2T Principal Dimensions
(Preliminary)

LOA	350.0	ft.
LBP	345.0	ft.
Beam	60.0	ft.
Depth	31.5	ft.
Draft	15.0	ft.
Cb	0.562	
Cp	0.661	
Cm	0.851	
Cwp	0.755	
CDWT	730 LT 10,000 cu m LH2	
Displ	5064	LT sw
DLR	123	
Tpi	37.8	LT / in.

May-21



Hybrid WIT-LH2T



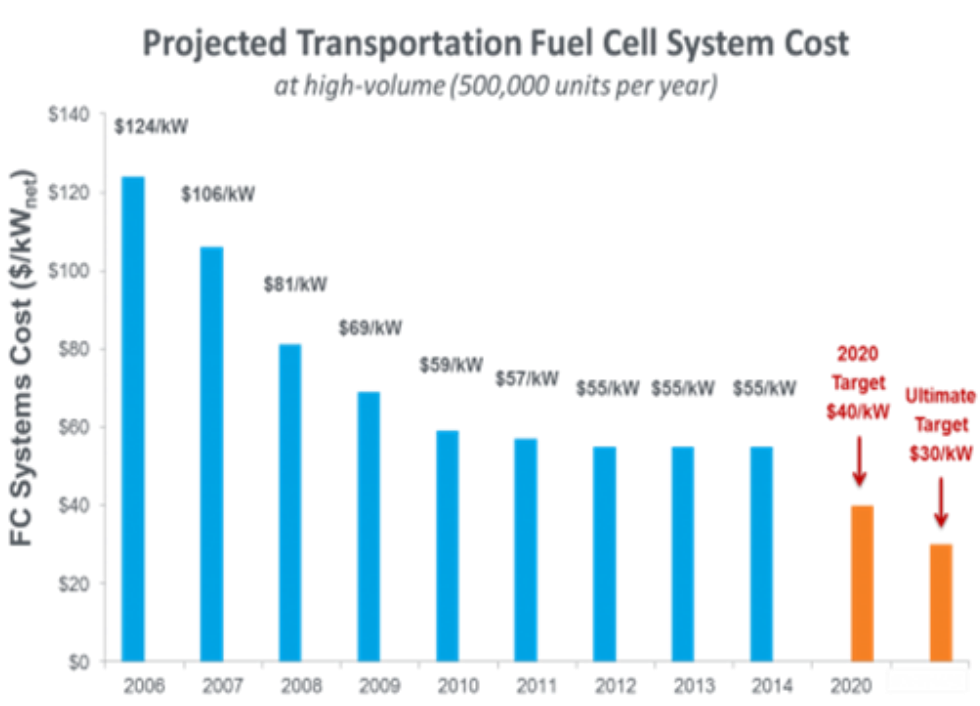
Hybrid WIT-LH2T

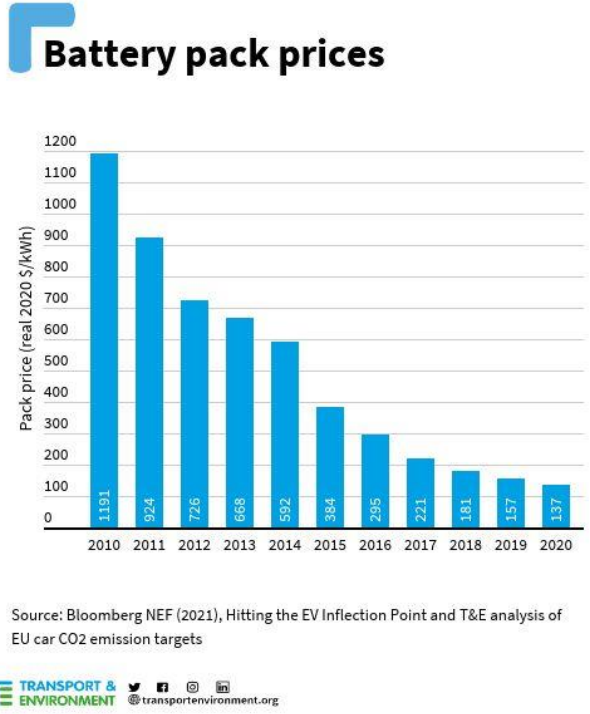
Summary of Powering Scenarios

Scenario	Wind Conditions	Use Rotors	Use Thrusters	Speed	Tot. Load (inc. House)	FC Output	Battery Output	Time to 50% DOD	Range
1	Favorable	Yes	No	14.0	450 kW	450 kW	0	NA	1500 Nm
2	Favorable	Yes	No	14.0	450 kW	0	450 kW	22 hrs	311 Nm
3	Unfavorable	No	Yes	14.0	450 kW	1800 kW	300 kW	33 hrs	467 Nm
3	Unfavorable	No	Yes	7.5	600 kW	0	600 kW	17 hrs	125 Nm

TTMC July 2021 ARR

Fuel Cell & Battery Pack Price Trends





LH2T Funding

TransTech SHIP COST ESTIMATOR

Summary Sheet

Owner:	SNC Transport	LOA:	381.00	Speed / Props:	140 / 2 rotors	Date:	30 Sept 2021
		LBP:	376.00	Machy Type:	Fuel Cell		
Type:	LH2T v2.0	Beam:	86.10	BPH / SHP:	2000	Project No:	SNC
		Depth:	42.40	Range (n.m.):	1500		
Trade:	L. Ontario - ECUS / Carib.	Draft (full load):	15.00	Crew	12	Prepared By:	G. F. Uttmark
		Light Ship:	3925.00	Passengers:	0		TT / SS
		Deadweight:	1000.00	Displacement:	4925.00		

Item	Quantity Tons	Material Cost Per Unit Quantity	Manhour Labor Per Unit Quantity	Material Cost	Labor Hours	Labor Rate	Labor Cost	Total Cost
Hull	3480	1100	36	3828000	125280	37.50	4698000	8526000
Outfit	1120	19500	50	21846396	56016	80.00	4481312	26327708
Machinery	374	50000	40	18716000	14973	150.00	2245920	20961920
Other	200	3000	100	600000	20000	35.00	700000	1300000
SUB-TOTAL (1)	5175	8694	42	44990396	216269	56	12125232	57115628
Indirect Pct. (Pct. of Materials Cost & Pct. of Labor Cost)				0.100			0.070	
				4499040			848766	
Engineering Pct. (Pct. of Materials Cost & Pct. of Labor Cost)				0.100			0.030	
				4499040			363757	
TOTAL DIRECT COST				53988475			13337755	67326230
Overhead Pct. (Pct. of Total Direct Labor Cost)							0.600	
Overhead								8002653
SUB-TOTAL								75326884
Profit & Escalations Pct. (Pct. of Total Direct Cost + Overhead)							0.100	
Profit & Escalations								7532888
SUB-TOTAL								82861772
Spare Parts Per Vessel Pct.(Pct. of Direct Materials Cost)							0.000	
Spare Parts Per Vessel								0
TOTAL FIXED PRICE PER VESSEL								82861772
Allowance for Series Production (Neg. Pct. of Fixed Price)							0.000	
Allowance for Series Production								0
TOTAL PRICE PER VESSEL EX - WORKS								$82,861,772

LH2T Unit Constrution Cost Learning Curve

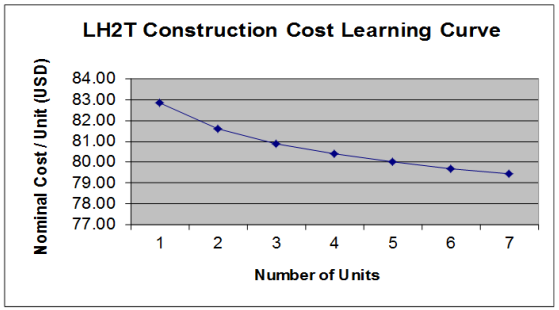
Formula: Y = a*(X^b)

a = cost of first unit

X = number of units

b = slope of the learning curve (plotted on log-log scale)

a =	82,861,000	82,861,000	82,861,000	82,861,000	82,861,000	82,861,000	82,861,000
X =	1	2	3	4	5	6	7
b =	-0.021804	-0.0218044	-0.0218044	-0.021804	-0.021804	-0.02180437	-0.0218044
y =	82.86	81.62	80.90	80.39	80.00	79.69	79.42



How to determine the value of "b":

The cost of one vessel, a, is quoted at	$82,861,000
A sistership, a2, is quoted at	$80,375,170
Average cost per ship =	$81,618,085

S = decimal ratio of the cost per unit every time production is doubled = 2^-b

= Average Unit Cost / First Cost = 0.985 = 2^-b

using rules of logariths, b = log S / log 2 = **-0.02180437**

Compute Multiple Ship Price:

Cost of each of n ships = a * (n^b)

Let "n" = 4

Each of 4 ships cost = **$80,393,814**

Compute Incremental Ship Price:

Incremental cost of additional ship "m" =

Cost of "m" ships - cost of "m - 1" ships

Let "m" = 5

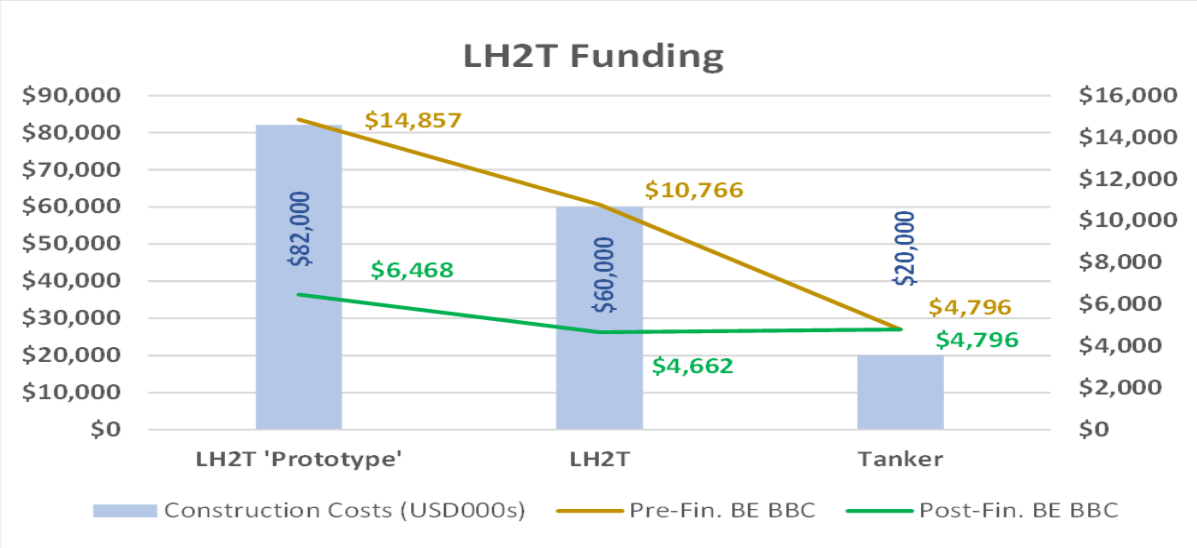
Incremental cost of 5 th ship = **$78,442,782**

TT/SS Sept 2021

LH2T Funding

Main Assumptions (USD) & Drivers	LH2T [1]	LH2T	Tanker
Construction Costs	82,200,000	60,000,000	20,000,000
incl. Outfit	*46,200,000*	*33,500,000*	-
" *Machinery*	*13,800,000*	*10,000,000*	-
Depreciation (Yrs) [2]	30/50	30/50	15
BE BBC (30/15 Yrs Depr., resp.) [3]	$14,857	$10,766	$4,796
Non-carb	$4,130	$2,961	
Owner's Share Carb Component [4]	$2,338	$1,701	
Adjusted BE BBC	$6,468	$4,662	$4,796

[1] Initial Production.
[2] RV of 20% of initial CC at end of econ life.
[3] 'Break-even Bareboat Charter Equivalent' used for the sake of comparison.
[4] 'Split the Steel': shared by stakeholders, incl. gvt support based on existing financial schemes.

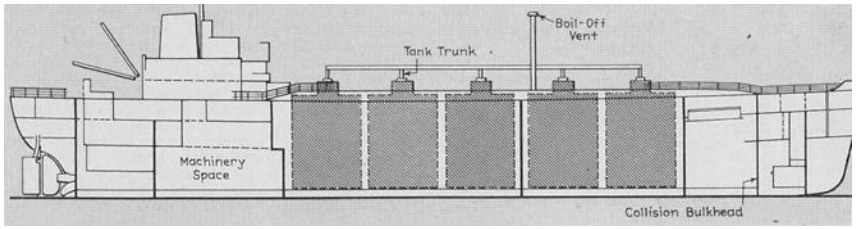


Est. 1979

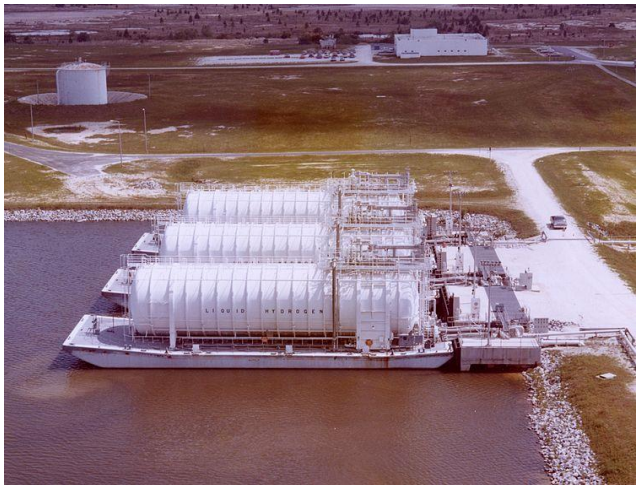
Est. 1979
ShipShares.com

Roland Capital
航士高资本

An Opportunity for US Commercial Shipyards



1958 - US Built (Converted)
First LNG Carrier



1978 - US First to Transport
H_2 by Sea

The fossil age is ending.

The hydrogen age is beginning.

Marine shipping can deliver the future.

Thank You.