Ship Energy Performance Framework

Case Study: Pathways to Compliance of a Newbuilding 15k TEU Containership

Tier 3: Improvement Investigation

CASE

A containership operator considering newbuilding options for a 15k TEU containership with delivery in 2030 requested ABS investigate the design's desirability in case of methanol or ammonia as fuel. The operator is considering the vessel operating on green methanol as the base case and requested ABS to compare operating on liquefied natural gas (LNG) until 2039, and either converting to green ammonia in 2040 or operating on e-diesel or e-LNG from 2040, or retrofitting for onboard carbon capture in 2040.

METHODOLOGY

ABS carries out life-cycle cost analysis (LCCA) by applying proprietary tools based on the methods in the National Institute of Standards and Technology Handbook 135. The LCCA is based on cash flows, such as capital expenditure (CAPEX), fuel price, regulatory compliance cost, and annual maintenance, to quantify the economic feasibility and desirability of the pathways under consideration.

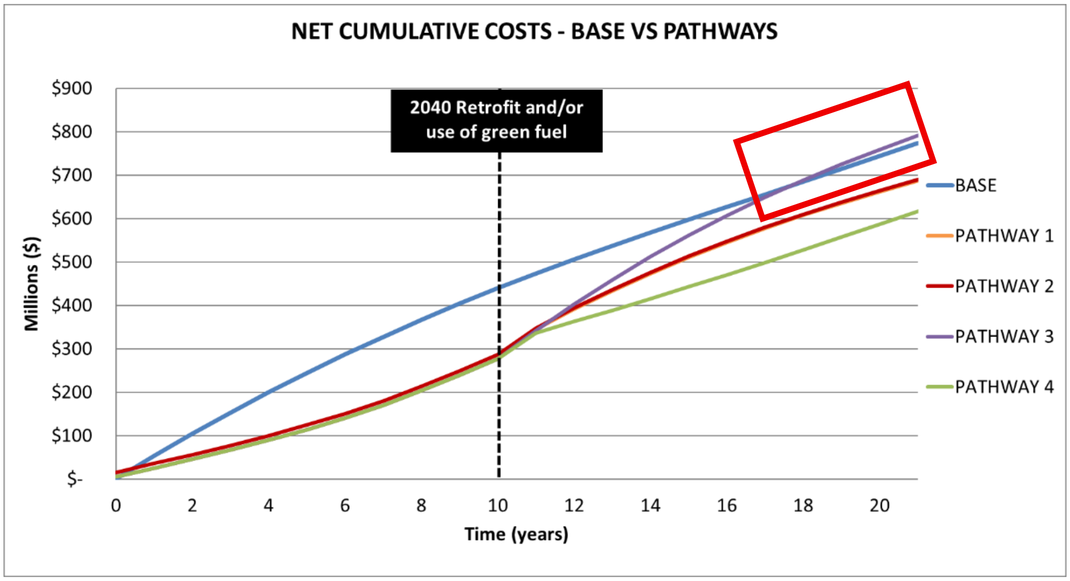
DELIVERABLES

- Discounted Payback of the pathways investigated:

Discounted Payback Time [y]	PATHWAY 1	PATHWAY 2	PATHWAY 3	PATHWAY 4
	0.15	0.46	0.15	0.15
Base: Methanol Vessel	LNG DF Full Ammonia Retrofit 2040	LNG DF Ready Ammonia Retrofit 2040	LNG DF e-diesel after 2040	LNG DF OCCs 2040

- Net Present Cumulative Cost:

	NET PRESENT CUMULATIVE COSTS				
Year	BASE	PATHWAY 1	PATHWAY 2	PATHWAY 3	PATHWAY 4
2030	$ -	$ 5,000,000.00	$ 15,000,000.00	$ 5,000,000.00	$ 5,000,000.00
2031	$ 53,290,018.52	$ 25,578,672.03	$ 35,578,672.03	$ 25,578,672.03	$ 25,578,672.03
2032	$ 104,277,739.75	$ 46,306,998.86	$ 56,306,998.86	$ 46,306,998.86	$ 46,306,998.86
2033	$ 153,052,118.43	$ 67,224,770.07	$ 77,224,770.07	$ 67,224,770.07	$ 67,224,770.07
2034	$ 199,698,879.18	$ 89,767,404.47	$ 99,767,404.47	$ 89,767,404.47	$ 89,767,404.47
2035	$ 244,300,629.25	$ 114,343,452.96	$ 124,343,452.96	$ 114,343,452.96	$ 114,343,452.96
2036	$ 286,936,967.43	$ 140,895,779.94	$ 150,895,779.94	$ 140,895,779.94	$ 140,895,779.94
2037	$ 327,696,391.14	$ 170,576,934.84	$ 180,576,934.84	$ 170,576,934.84	$ 170,576,934.84
2038	$ 366,652,088.25	$ 203,276,348.63	$ 213,276,348.63	$ 203,276,348.63	$ 203,276,348.63
2039	$ 403,874,574.84	$ 238,884,494.66	$ 248,884,494.66	$ 238,884,494.66	$ 238,884,494.66
2040	$ 439,431,788.76	$ 277,293,001.73	$ 287,293,001.73	$ 277,293,001.73	$ 277,293,001.73
2041	$ 473,389,180.04	$ 345,336,253.32	$ 347,895,314.17	$ 342,101,656.28	$ 336,395,400.66
2042	$ 506,041,309.77	$ 390,976,768.08	$ 393,535,828.93	$ 402,698,355.62	$ 362,774,410.87
2043	$ 537,435,424.32	$ 433,671,918.48	$ 436,230,979.34	$ 459,255,063.03	$ 388,796,756.60
2044	$ 567,769,632.62	$ 473,529,391.16	$ 476,088,452.01	$ 511,937,698.97	$ 415,424,788.65
2045	$ 597,332,222.68	$ 510,653,708.99	$ 513,212,769.84	$ 560,906,339.44	$ 442,633,665.90
2046	$ 626,372,790.76	$ 545,146,309.86	$ 547,705,370.71	$ 606,315,408.07	$ 470,398,529.26
2047	$ 655,517,777.96	$ 577,356,177.00	$ 579,915,237.85	$ 648,584,296.70	$ 498,707,365.60
2048	$ 684,763,039.75	$ 607,379,073.78	$ 609,938,134.64	$ 687,856,792.27	$ 527,535,194.50
2049	$ 714,103,810.40	$ 635,307,277.40	$ 637,866,338.25	$ 724,312,361.19	$ 556,857,145.22
2050	$ 743,534,765.30	$ 661,482,115.13	$ 664,041,175.98	$ 758,431,063.87	$ 586,648,497.30
2051	$ 773,050,079.39	$ 686,516,103.98	$ 689,075,164.83	$ 790,992,916.00	$ 616,884,717.99



- Case study using 60 percent light fuel oil (LFO) and 40 percent green methanol as a base pre-2040, 100 percent green methanol from 2040:

	NET PRESENT CUMULATIVE COSTS				
Year	**BASE**	**PATHWAY 1**	**PATHWAY 2**	**PATHWAY 3**	**PATHWAY 4**
2030	$ -	$ 5,000,000.00	$ 15,000,000.00	$ 5,000,000.00	$ 5,000,000.00
2031	$ 35,555,041.19	$ 25,578,672.03	$ 35,578,672.03	$ 25,578,672.03	$ 25,578,672.03
2032	$ 69,774,434.32	$ 46,306,998.86	$ 56,306,998.86	$ 46,306,998.86	$ 46,306,998.86
2033	$ 102,705,840.79	$ 67,224,770.07	$ 77,224,770.07	$ 67,224,770.07	$ 67,224,770.07
2034	$ 135,011,574.99	$ 89,767,404.47	$ 99,767,404.47	$ 89,767,404.47	$ 89,767,404.47
2035	$ 166,902,082.16	$ 114,343,452.96	$ 124,343,452.96	$ 114,343,452.96	$ 114,343,452.96
2036	$ 198,438,713.08	$ 140,895,779.94	$ 150,895,779.94	$ 140,895,779.94	$ 140,895,779.94
2037	$ 232,423,413.09	$ 170,576,934.84	$ 180,576,934.84	$ 170,576,934.84	$ 170,576,934.84
2038	$ 263,889,823.66	$ 203,276,348.63	$ 213,276,348.63	$ 203,276,348.63	$ 203,276,348.63
2039	$ 295,395,981.01	$ 238,884,494.66	$ 248,884,494.66	$ 238,884,494.66	$ 238,884,494.66
2040	$ 326,985,063.40	$ 277,293,001.73	$ 287,293,001.73	$ 277,293,001.73	$ 277,293,001.73
2041	$ 360,942,454.68	$ 345,336,253.32	$ 347,895,314.17	$ 342,101,656.28	$ 336,395,400.66
2042	$ 393,594,584.41	$ 390,976,768.08	$ 393,535,828.93	**$ 402,698,355.62**	$ 362,774,410.87
2043	$ 424,988,698.96	**$ 433,671,918.48**	**$ 436,230,979.34**	**$ 459,255,063.03**	$ 388,796,756.60
2044	$ 455,322,907.25	**$ 473,529,391.16**	**$ 476,088,452.01**	**$ 511,937,698.97**	$ 415,424,788.65
2045	$ 484,885,497.31	**$ 510,653,708.99**	**$ 513,212,769.84**	**$ 560,906,339.44**	$ 442,633,665.90
2046	$ 513,926,065.39	**$ 545,146,309.86**	**$ 547,705,370.71**	**$ 606,315,408.07**	$ 470,398,529.26
2047	$ 543,071,052.60	**$ 577,356,177.00**	**$ 579,915,237.85**	**$ 648,584,296.70**	$ 498,707,365.60
2048	$ 572,316,314.38	**$ 607,379,073.78**	**$ 609,938,134.64**	**$ 687,856,792.27**	$ 527,535,194.50
2049	$ 601,657,085.04	**$ 635,307,277.40**	**$ 637,866,338.25**	**$ 724,312,361.19**	$ 556,857,145.22
2050	$ 631,088,039.94	**$ 661,229,698.40**	**$ 663,788,759.25**	**$ 758,431,063.87**	$ 586,648,497.30
2051	$ 660,603,354.03	**$ 685,231,996.16**	**$ 687,791,057.01**	**$ 790,992,916.00**	$ 616,884,717.99

- Case study \$100/metric tonne (MT) International Maritime Organization (IMO) Net-Zero Framework (NZF) Reward Units:

	NET PRESENT CUMULATIVE COSTS				
Year	BASE	PATHWAY 1	PATHWAY 2	PATHWAY 3	PATHWAY 4
2030	\$ -	\$ 5,000,000.00	\$ 15,000,000.00	\$ 5,000,000.00	\$ 5,000,000.00
2031	\$ 44,673,331.17	\$ 25,578,672.03	\$ 35,578,672.03	\$ 25,578,672.03	\$ 25,578,672.03
2032	\$ 87,295,336.54	\$ 46,306,998.86	\$ 56,306,998.86	\$ 46,306,998.86	\$ 46,306,998.86
2033	\$ 127,947,660.98	\$ 67,224,770.07	\$ 77,224,770.07	\$ 67,224,770.07	\$ 67,224,770.07
2034	\$ 166,708,932.18	\$ 89,767,404.47	\$ 99,767,404.47	\$ 89,767,404.47	\$ 89,767,404.47
2035	\$ 203,654,867.15	\$ 114,343,452.96	\$ 124,343,452.96	\$ 114,343,452.96	\$ 114,343,452.96
2036	\$ 238,858,375.13	\$ 140,895,779.94	\$ 150,895,779.94	\$ 140,895,779.94	\$ 140,895,779.94
2037	\$ 272,401,458.86	\$ 170,576,934.84	\$ 180,576,934.84	\$ 170,576,934.84	\$ 170,576,934.84
2038	\$ 304,351,000.63	\$ 203,276,348.63	\$ 213,276,348.63	\$ 203,276,348.63	\$ 203,276,348.63
2039	\$ 334,771,394.66	\$ 238,884,494.66	\$ 248,884,494.66	\$ 238,884,494.66	\$ 238,884,494.66
2040	\$ 363,724,635.23	\$ 277,293,001.73	\$ 287,293,001.73	\$ 277,293,001.73	\$ 277,293,001.73
2041	\$ 391,270,401.89	\$ 340,969,321.23	\$ 343,528,382.08	\$ 338,914,177.82	\$ 336,395,400.66
2042	\$ 417,697,653.35	\$ 382,370,096.11	\$ 384,929,156.96	\$ 396,416,237.88	\$ 362,774,410.87
2043	\$ 443,048,196.77	\$ 420,948,994.20	\$ 423,508,055.05	**\$ 449,968,441.14**	\$ 388,796,756.60
2044	\$ 467,514,860.27	\$ 456,810,105.40	\$ 459,369,166.25	**\$ 499,734,082.75**	\$ 415,424,788.65
2045	\$ 491,380,804.90	\$ 490,054,460.64	**\$ 492,613,521.49**	**\$ 545,870,689.90**	\$ 442,633,665.90
2046	\$ 514,890,649.26	**\$ 520,780,107.53**	**\$ 523,339,168.38**	**\$ 588,530,211.62**	\$ 470,398,529.26
2047	\$ 538,666,001.79	**\$ 549,332,737.80**	**\$ 551,891,798.65**	**\$ 628,129,637.22**	\$ 498,707,365.60
2048	\$ 562,698,026.03	**\$ 575,804,919.17**	**\$ 578,363,980.03**	**\$ 664,810,421.11**	\$ 527,535,194.50
2049	\$ 586,977,401.00	**\$ 600,285,826.28**	**\$ 602,844,887.13**	**\$ 698,749,765.10**	\$ 556,857,145.22
2050	\$ 611,494,379.51	**\$ 623,113,774.19**	**\$ 625,672,835.04**	**\$ 730,425,530.96**	\$ 586,648,497.30
2051	\$ 636,238,842.74	**\$ 644,898,355.45**	**\$ 647,457,416.30**	**\$ 760,615,599.77**	\$ 616,884,717.99

- Case study \$200/MT IMO NZF Reward Units:

	NET PRESENT CUMULATIVE COSTS				
Year	BASE	PATHWAY 1	PATHWAY 2	PATHWAY 3	PATHWAY 4
2030	\$ -	\$ 5,000,000.00	\$ 15,000,000.00	\$ 5,000,000.00	\$ 5,000,000.00
2031	\$ 36,056,643.83	\$ 25,578,672.03	\$ 35,578,672.03	\$ 25,578,672.03	\$ 25,578,672.03
2032	\$ 70,312,933.33	\$ 46,306,998.86	\$ 56,306,998.86	\$ 46,306,998.86	\$ 46,306,998.86
2033	\$ 102,843,203.54	\$ 67,224,770.07	\$ 77,224,770.07	\$ 67,224,770.07	\$ 67,224,770.07
2034	\$ 133,718,985.18	\$ 89,767,404.47	\$ 99,767,404.47	\$ 89,767,404.47	\$ 89,767,404.47
2035	\$ 163,009,105.05	\$ 114,343,452.96	\$ 124,343,452.96	\$ 114,343,452.96	\$ 114,343,452.96
2036	\$ 190,779,782.84	\$ 140,895,779.94	\$ 150,895,779.94	\$ 140,895,779.94	\$ 140,895,779.94
2037	\$ 217,106,526.57	\$ 170,576,934.84	\$ 180,576,934.84	\$ 170,576,934.84	\$ 170,576,934.84
2038	\$ 242,049,913.02	\$ 203,276,348.63	\$ 213,276,348.63	\$ 203,276,348.63	\$ 203,276,348.63
2039	\$ 265,668,214.49	\$ 238,884,494.66	\$ 248,884,494.66	\$ 238,884,494.66	\$ 238,884,494.66
2040	\$ 288,017,481.70	\$ 277,293,001.73	\$ 287,293,001.73	\$ 277,293,001.73	\$ 277,293,001.73
2041	\$ 309,151,623.75	**\$ 336,602,389.15**	**\$ 339,161,450.00**	**\$ 335,726,699.36**	\$ 336,395,400.66
2042	\$ 329,353,996.93	**\$ 373,763,424.14**	**\$ 376,322,484.99**	**\$ 390,134,120.15**	\$ 362,774,410.87
2043	\$ 348,660,969.21	**\$ 408,226,069.91**	**\$ 410,785,130.76**	**\$ 440,681,819.25**	\$ 388,796,756.60
2044	\$ 367,260,087.93	**\$ 440,090,819.64**	**\$ 442,649,880.49**	**\$ 487,530,466.54**	\$ 415,424,788.65
2045	\$ 385,429,387.13	**\$ 469,455,212.28**	**\$ 472,014,273.13**	**\$ 530,835,040.36**	\$ 442,633,665.90
2046	\$ 403,408,507.77	**\$ 496,413,905.20**	**\$ 498,972,966.05**	**\$ 570,745,015.16**	\$ 470,398,529.26
2047	\$ 421,814,225.63	**\$ 521,309,298.60**	**\$ 523,868,359.45**	**\$ 607,674,977.73**	\$ 498,707,365.60
2048	\$ 440,633,012.31	**\$ 544,230,764.57**	**\$ 546,789,825.42**	**\$ 641,764,049.96**	\$ 527,535,194.50
2049	\$ 459,850,991.60	**\$ 565,264,375.16**	**\$ 567,823,436.01**	**\$ 673,187,169.02**	\$ 556,857,145.22
2050	\$ 479,453,993.73	**\$ 584,745,433.25**	**\$ 587,304,494.10**	**\$ 702,419,998.05**	\$ 586,648,497.30
2051	\$ 499,427,606.09	**\$ 603,280,606.92**	**\$ 605,839,667.77**	**\$ 730,238,283.53**	\$ 616,884,717.99

CONCLUSION AND RECOMMENDATIONS

- The LCCA studies are vessel-specific due to the definition of the vessel's operational profile and design-based parameters.
- Sensitivity scenarios are required to capture uncertainties.
- Despite the extra cost for the LNG fuel gas supply system and tanks, comparing LNG-fueled to methanol-fueled (prior to 2040), it is apparent that the fuel cost is the most important factor, which leads to a very short payback and lower overall costs for the LNG option, despite the emission compliance penalty.
- Post-2040, despite the investment for the ammonia retrofit, the costs remain lower, whereas using e-diesel leads to higher costs.
- Comparing LNG-fueled vessels to the 60/40 split of LFO and green methanol until 2039, and from 2040 onwards to 100 percent green methanol to green ammonia, the methanol option is cheaper from 2043.
- If the IMO NZF Reward Units are provided for fuels below 19gCO_2e/MJ and 14gCO_2e/MJ after 2035, then the methanol option is potentially cheaper depending on the greenhouse gas intensity of the green methanol.

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