

Ship Energy Performance Framework

Case Study: Onboard Carbon Capture system for a Very Large Gas Carrier

Tier 3: Improvement Investigation



CASE

ABS received many requests from shipowners to provide decision support for onboard carbon capture systems (OCCS) if future greenhouse gas (GHG) regulations account for carbon capture.

A shipowner requested ABS to compare a base vessel using heavy fuel oil (HFO) to alternative OCCS scenarios with 80 percent and 50 percent nominal capture rates, considering capital expenditure (CAPEX) and operating expenditure (OPEX) for system and regulatory compliance costs.

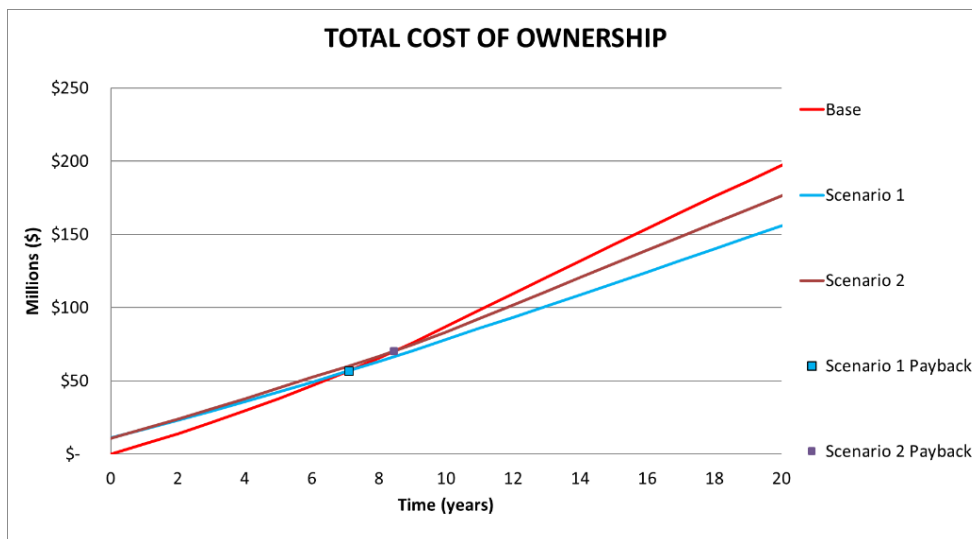
METHODOLOGY

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 CAPEX, additional energy, fuel price, regulatory compliance cost and annual maintenance, to quantify the economic feasibility and desirability of the two scenarios under consideration.

DELIVERABLES

- Discounted Payback of the scenarios investigated:

Base: Conventional Vessel	OCCS 80% Capture Rate	OCCS 50% Capture Rate
	Scenario 1	Scenario 2
Discounted Payback Time [y]	7.09	8.45



- Net Present Cumulative Cost:

NET PRESENT CUMULATIVE COSTS			
Year	BASE	Scenario 1	Scenario 2
2030	\$ -	\$ 10,890,500.00	\$ 10,590,500.00
2031	\$ 6,732,799.32	\$ 16,807,516.60	\$ 17,148,381.75
2032	\$ 13,909,916.90	\$ 22,918,114.01	\$ 23,870,483.30
2033	\$ 21,500,970.55	\$ 29,208,276.31	\$ 30,743,888.76
2034	\$ 29,480,066.67	\$ 35,666,475.14	\$ 37,758,076.99
2035	\$ 37,819,303.61	\$ 42,279,735.15	\$ 44,901,102.63
2036	\$ 46,494,993.83	\$ 49,037,424.22	\$ 52,163,276.11
2037	\$ 55,783,950.43	\$ 56,033,460.89	\$ 59,450,165.24
2038	\$ 65,645,525.74	\$ 63,251,039.82	\$ 66,722,148.42
2039	\$ 76,040,848.70	\$ 70,674,050.55	\$ 74,702,070.15
2040	\$ 86,932,757.92	\$ 78,287,053.63	\$ 83,345,095.12
2041	\$ 98,285,737.04	\$ 85,904,780.54	\$ 92,608,324.30
2042	\$ 109,572,976.03	\$ 93,432,353.62	\$ 101,898,551.55
2043	\$ 120,790,775.00	\$ 101,039,934.37	\$ 111,208,700.41
2044	\$ 131,935,644.16	\$ 108,718,831.06	\$ 120,532,015.17
2045	\$ 143,004,296.47	\$ 116,460,721.84	\$ 129,862,050.18
2046	\$ 153,993,640.54	\$ 124,257,642.51	\$ 139,192,659.45
2047	\$ 164,900,773.70	\$ 132,101,974.73	\$ 148,517,986.52
2048	\$ 175,722,975.26	\$ 139,986,434.48	\$ 157,832,454.70
2049	\$ 186,457,699.94	\$ 147,904,060.91	\$ 167,130,757.46
2050	\$ 197,102,571.54	\$ 155,848,205.45	\$ 176,407,849.16

- Sensitivity analysis: CAPEX Difference vs. HFO costs:

OCCS 80% Capture Rate									
		Cost of Scenario							
		\$15,890,500	\$13,390,500	\$12,390,500	\$11,640,500	\$10,140,500	\$ 9,390,500	\$ 8,390,500	\$ 5,890,500
HFO \$/MT	\$ 150	7.54	6.70	6.34	6.07	5.45	5.13	4.69	3.53
	\$ 250	7.93	7.08	6.71	6.42	5.82	5.49	5.05	3.83
	\$ 350	8.31	7.46	7.10	6.82	6.21	5.89	5.42	4.16
	\$ 450	8.72	7.87	7.50	7.22	6.62	6.30	5.85	4.53
	\$ 550	9.14	8.29	7.94	7.65	7.06	6.73	6.28	4.97
	\$ 650	9.57	8.74	8.37	8.10	7.50	7.19	6.74	5.43
	\$ 750	10.04	9.20	8.84	8.56	7.99	7.66	7.23	5.98
	\$ 850	10.47	9.67	9.32	9.05	8.46	8.16	7.73	6.49
	\$ 950	10.94	10.16	9.82	9.54	8.98	8.67	8.25	7.07
	\$ 1,050	11.44	10.63	10.30	10.06	9.49	9.20	8.79	7.63
	\$ 1,150	11.97	11.14	10.80	10.55	10.04	9.75	9.34	8.22
	\$ 1,250	12.57	11.68	11.34	11.08	10.55	10.29	9.92	8.83
	\$ 1,350	13.24	12.29	11.91	11.64	11.10	10.83	10.46	9.44
OCCS 50% Capture Rate									
		Cost of Scenario							
		\$15,590,500	\$13,090,500	\$12,090,500	\$11,340,500	\$ 9,840,500	\$ 9,090,500	\$ 8,090,500	\$ 5,590,500
HFO \$/MT	\$ 150	9.08	8.16	7.81	7.56	7.04	6.74	6.31	5.01
	\$ 250	9.49	8.52	8.14	7.87	7.34	7.07	6.65	5.38
	\$ 350	9.95	8.90	8.51	8.22	7.65	7.38	7.01	5.79
	\$ 450	10.47	9.34	8.91	8.60	7.99	7.71	7.33	6.20
	\$ 550	11.04	9.82	9.37	9.02	8.39	8.07	7.67	6.58
	\$ 650	11.70	10.38	9.87	9.52	8.81	8.48	8.04	7.00
	\$ 750	12.45	11.01	10.46	10.06	9.30	8.93	8.47	7.36
	\$ 850	13.30	11.73	11.13	10.70	9.86	9.46	8.94	7.75
	\$ 950	14.31	12.57	11.91	11.44	10.51	10.06	9.50	8.19
	\$ 1,050	15.50	13.55	12.82	12.29	11.27	10.78	10.14	8.70
	\$ 1,150	16.96	14.72	13.89	13.30	12.16	11.62	10.91	9.29
	\$ 1,250	18.83	16.17	15.21	14.53	13.23	12.62	11.82	9.98
	\$ 1,350	N/A	18.02	16.87	16.05	14.54	13.83	12.92	10.84

- Sensitivity analysis: CAPEX Difference vs. CO₂ — Discharge Cost:

OCCS 80% Capture Rate									
		Cost of Scenario							
		\$15,890,500	\$13,390,500	\$12,390,500	\$11,640,500	\$10,140,500	\$ 9,390,500	\$ 8,390,500	\$ 5,890,500
CO ₂ Capture Cost per MT	\$ -	3.27	2.77	2.57	2.42	2.12	1.97	1.76	1.25
	\$ 25	3.83	3.26	3.03	2.86	2.50	2.33	2.09	1.48
	\$ 50	4.59	3.93	3.66	3.45	3.04	2.83	2.55	1.82
	\$ 75	5.65	4.88	4.56	4.32	3.82	3.57	3.23	2.34
	\$ 100	7.08	6.24	5.89	5.60	5.02	4.71	4.29	3.20
	\$ 125	8.88	8.04	7.66	7.38	6.78	6.45	6.02	4.69
	\$ 150	11.01	10.22	9.88	9.60	9.04	8.73	8.31	7.12
	\$ 175	13.95	12.91	12.52	12.22	11.64	11.36	10.98	10.01
	\$ 200	19.63	17.87	17.22	16.74	15.82	15.38	14.80	13.43
	\$ 225	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	\$ 250	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	\$ 275	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	\$ 300	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

OCCS 50% Capture Rate									
		Cost of Scenario							
		\$15,590,500	\$13,090,500	\$12,090,500	\$11,340,500	\$ 9,840,500	\$ 9,090,500	\$ 8,090,500	\$ 5,590,500
CO ₂ Capture Cost per MT	\$ -	5.17	4.44	4.14	3.91	3.44	3.20	2.88	2.05
	\$ 25	5.94	5.13	4.79	4.54	4.03	3.75	3.39	2.44
	\$ 50	6.78	6.01	5.63	5.35	4.78	4.48	4.08	3.00
	\$ 75	7.72	6.97	6.62	6.35	5.77	5.44	5.00	3.76
	\$ 100	8.92	8.02	7.69	7.43	6.92	6.60	6.19	4.87
	\$ 125	10.68	9.52	9.07	8.76	8.14	7.84	7.45	6.34
	\$ 150	13.51	11.89	11.29	10.84	9.97	9.57	9.04	7.82
	\$ 175	19.06	16.32	15.33	14.63	13.30	12.67	11.86	9.98
	\$ 200	N/A	N/A	N/A	N/A	N/A	20.40	18.54	14.78
	\$ 225	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	\$ 250	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	\$ 275	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	\$ 300	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

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.
- An additional composite boiler is needed to provide the additional steam required for OCCS without generating additional emissions from boiler use.
- While the OCCS nominal capture rates were given as 80 percent and 50 percent, the analysis showed that the net (actual) capture rates were 58.9 percent and 41.9 percent on average, respectively. This is due to the additional consumption for capture and liquefaction.
- Assuming that the net capture rates can be achieved and that the future regulations accept carbon capture as a solution for the reduction of GHG intensity and therefore compliance, the payback periods appear to be 7.0 and 8.5 years, respectively.
- Due to the additional consumption required by the system, an increase in the cost of fuel will delay the payback. Similarly, increasing the CAPEX will also delay the payback of the investment.
- If the CO₂ discharge cost (per metric tonne of captured CO₂) is above \$200, then the installation of OCCS will not be desirable.

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