Chapter 6: Cross-Case Comparison

6.1 Overview

This chapter compares the three supply scenarios using visualizations from the D-series figures.

6.2 Optimal Configuration Summary

Case	Shuttle Size	NPC (20yr)	LCOAmmonia	Travel Time	Vessels/Trip
Case 1	2,500 m3	**$237.05M**	**$1.01/ton**	1.0 hr	N/A (multi-trip)
Case 2-1	10,000 m3	$747.18M	$3.17/ton	5.73 hr	2
Case 2-2	5,000 m3	$402.37M	$1.71/ton	1.67 hr	1

6.3 D-Series Figures

Figure D1: NPC vs Shuttle Size

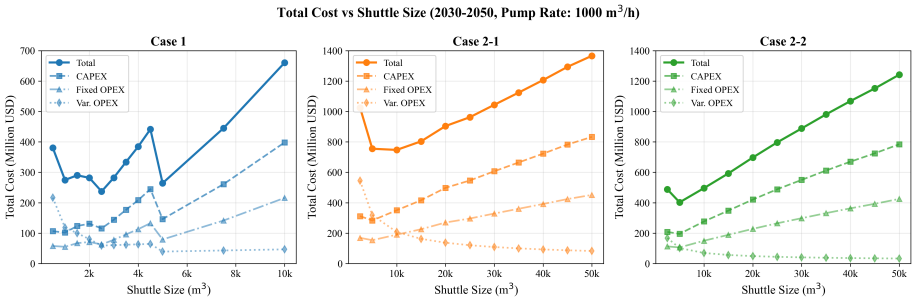

Figure 1: D1: NPC vs Shuttle Size

Key Observations: - Case 1 shows clear minimum at 2,500 m3 - Case 2-1 (Yeosu) minimum at 10,000 m3 - Case 2-2 (Ulsan) minimum at 5,000 m3 - All cases show U-shaped cost curves

Figure D2: Annual Cost Evolution

Key Observations: - Costs scale linearly with demand growth (50 to 500 vessels) - Case 1 consistently lowest cost across all years - Case 2-1 consistently

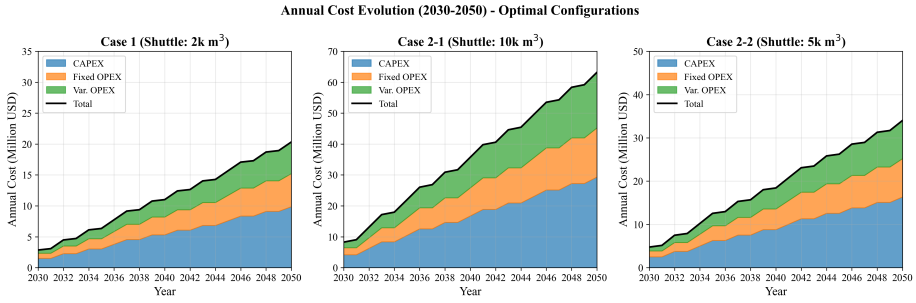

Figure 2: D2: Yearly Cost Evolution

highest cost

Figure D3: Fleet Size & Annual Supply

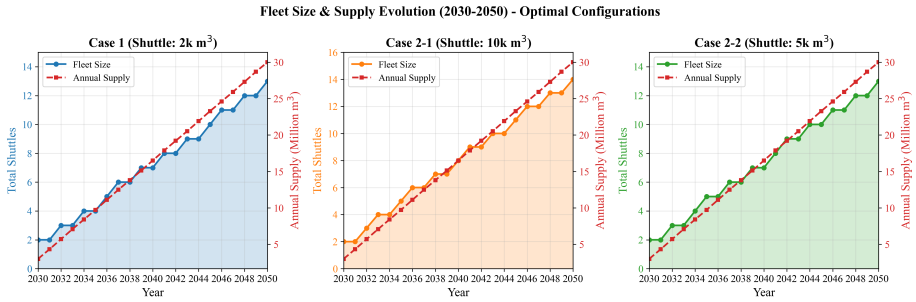

Figure 3: D3: Fleet & Demand

Key Observations: - Fleet size grows proportionally with demand - Case 1 requires more shuttles (smaller size) but lower total cost - Case 2 cases require fewer but larger shuttles

Figure D4: Annual Cycles

Key Observations: - Case 1 has highest cycle frequency (shorter cycles) - Case 2-1 has lowest frequency (longest cycles) - Higher frequency = better asset utilization

Figure D5: Utilization Rate

Key Observations: - All optimal configurations achieve 100% utilization - No wasted capacity in optimal scenarios

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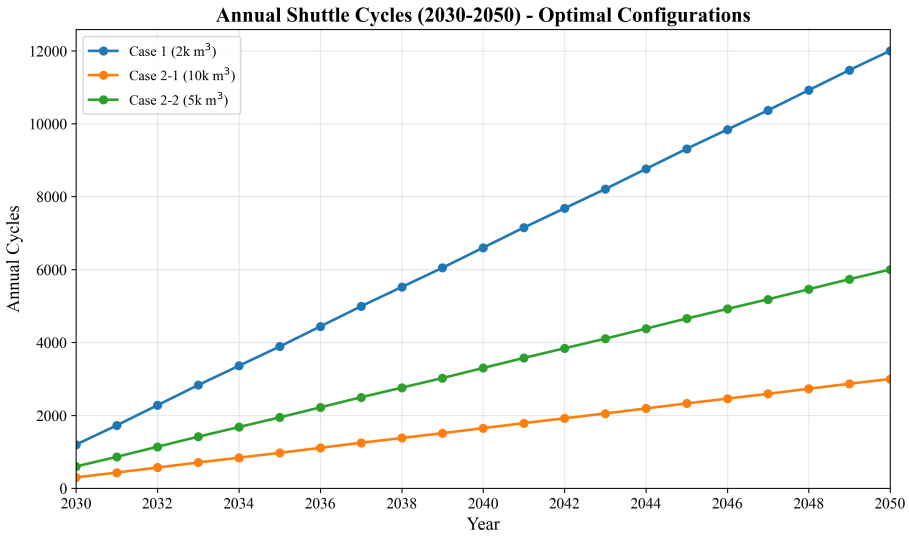

Figure 4: D4: Yearly Cycles

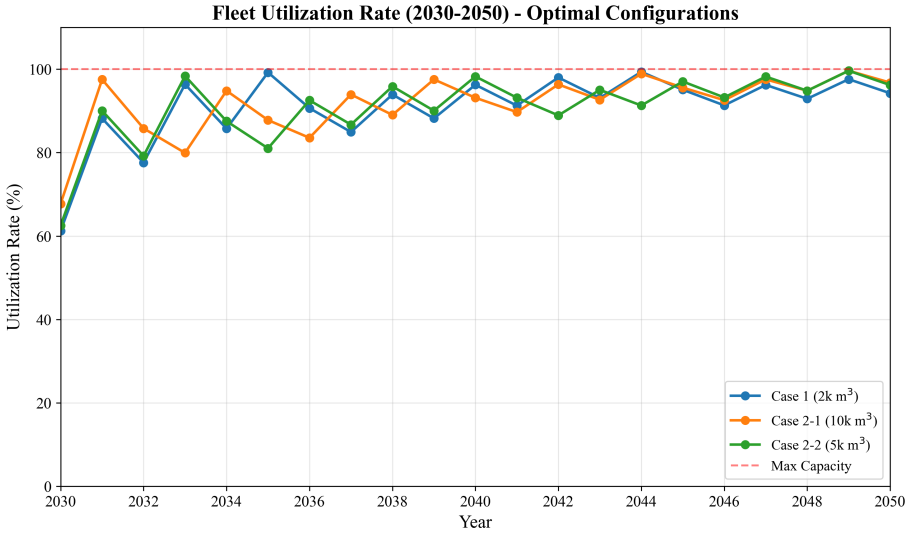

Figure 5: D5: Yearly Utilization

6.4 Additional Figures (Optional)

Figure D6: Cost Breakdown

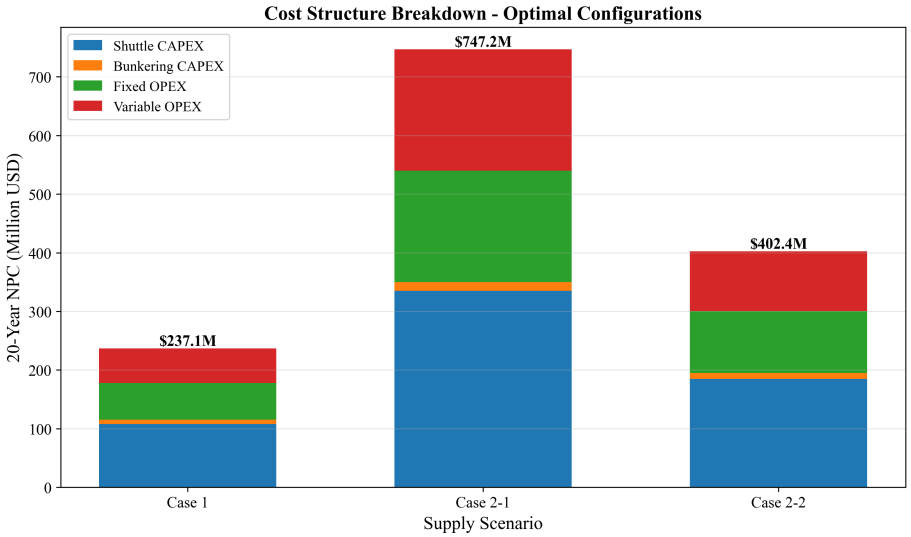

Figure 6: D6: Cost Breakdown

Cost Component	Case 1	Case 2-1	Case 2-2
Shuttle CAPEX	45.5%	44.9%	45.9%
Bunkering CAPEX	3.2%	2.0%	2.5%
Shuttle Fixed OPEX	24.6%	24.3%	24.9%
Bunkering Fixed OPEX	1.8%	1.1%	1.4%
Shuttle Variable OPEX	19.6%	26.1%	22.2%
Bunkering Variable OPEX	5.3%	1.7%	3.1%

Figure D7: Cycle Time Comparison

Case	Optimal Shuttle	Cycle Time	Components
Case 1	2,500 m3	8.17 hr	Shore 1.67 + Travel 2.0 + Setup 2.0 + Pump 2.5
Case 2-1	10,000 m3	36.13 hr	Shore 6.67 + Travel 11.46 + Port 2.0 + 2x8.0

Case	Optimal Shuttle	Cycle Time	Components
Case 2-2	5,000 m3	16.67 hr	Shore 3.33 + Travel 3.34 + Port 2.0 + 8.0

Figure D9: LCO Comparison

Levelized Cost of Ammonia (LCOAmmonia): - Case 1: $1.01/ton (baseline) - Case 2-2: $1.71/ton (+69% premium) - Case 2-1: $3.17/ton (+214% premium)

Figure D10: NPC Case Comparison

6.5 Case-by-Case Analysis

6.5.1 Case 1 vs Case 2-2 (Near Alternative)

Metric	Case 1	Case 2-2	Delta
NPC	$237.05M	$402.37M	**+$165.32M**
LCO	$1.01/ton	$1.71/ton	**+$0.70/ton**
Premium	-	+70%	-
Travel Time	2.0 hr RT	3.34 hr RT	+67%

Conclusion: Case 2-2 (Ulsan) is the best alternative if local storage is infeasible.

6.5.2 Case 1 vs Case 2-1 (Far Alternative)

Metric	Case 1	Case 2-1	Delta
NPC	$237.05M	$747.18M	**+$510.13M**
LCO	$1.01/ton	$3.17/ton	**+$2.16/ton**
Premium	-	+215%	-
Travel Time	2.0 hr RT	11.46 hr RT	+473%

Conclusion: Case 2-1 (Yeosu) should be avoided if possible due to high travel time.

6.5.3 Case 2-1 vs Case 2-2 (Direct Supply Options)

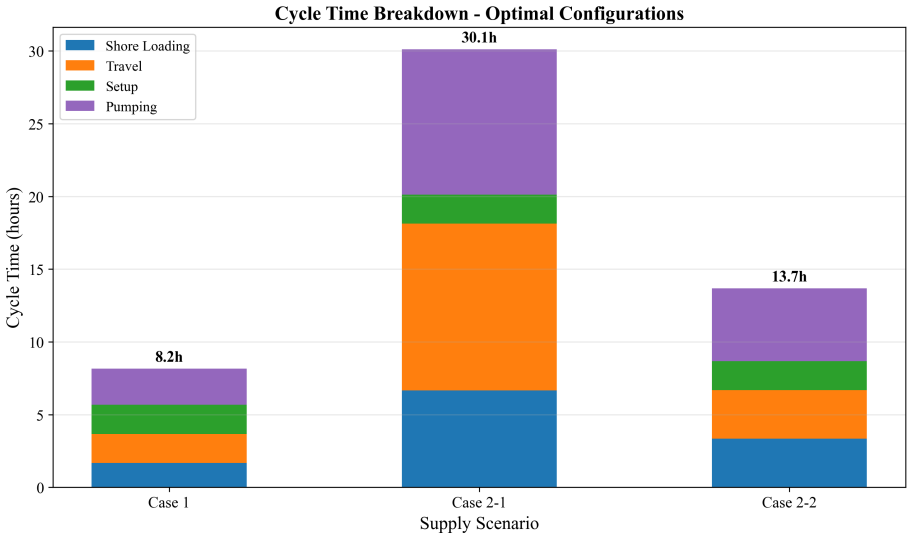

Figure 7: D7: Cycle Time

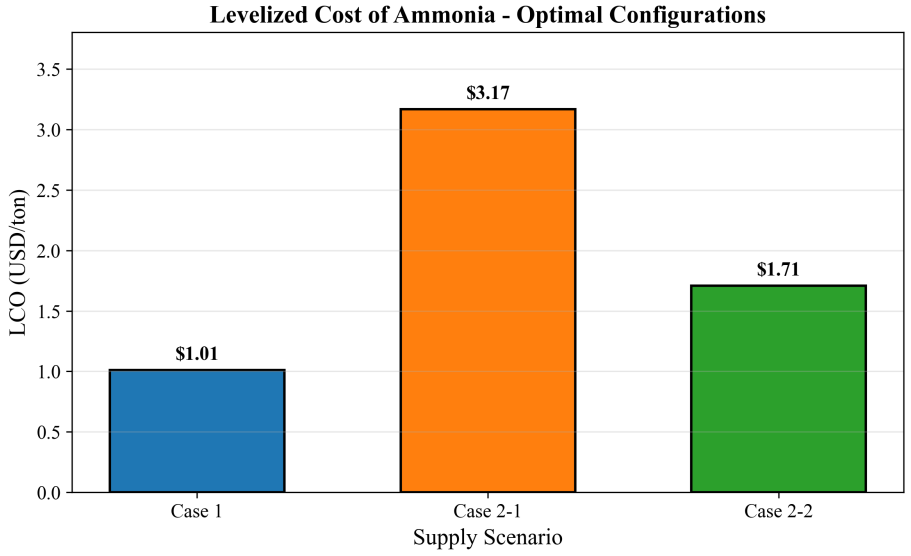

Figure 8: D9: LCO Comparison

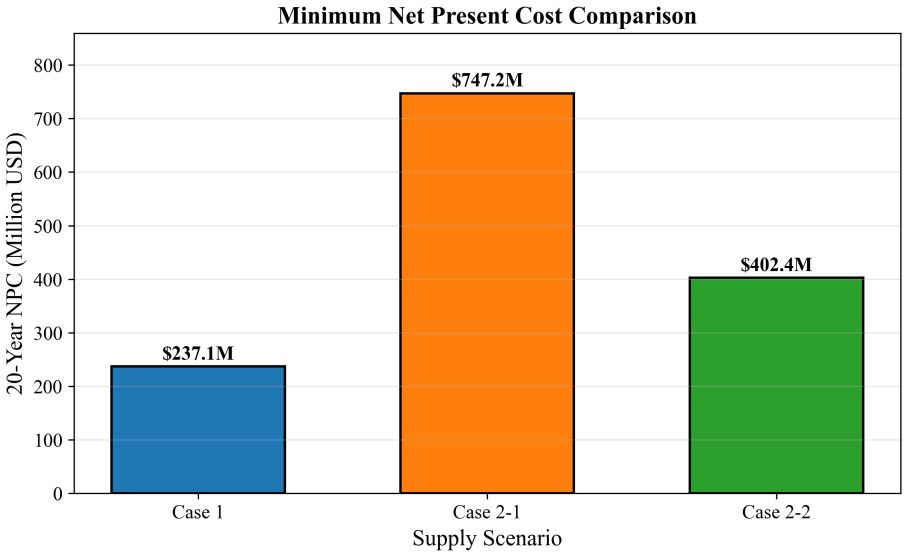

Figure 9: D10: NPC Comparison

Metric	Case 2-1	Case 2-2	Delta
NPC	$747.18M	$402.37M	**-$344.81M**
LCO	$3.17/ton	$1.71/ton	**-$1.46/ton**
Savings	-	46%	-
Distance	86 nm	25 nm	-71%

Conclusion: Ulsan is significantly better than Yeosu for direct supply scenarios.

6.6 Shuttle Size Selection Guide

Case	Under-sized	Optimal	Over-sized
Case 1	500-2000 m3 (high OPEX)	**2500 m3**	3000+ m3 (high CAPEX)
Case 2-1	2500-5000 m3 (high trips)	**10000 m3**	15000+ m3 (long cycles)
Case 2-2	2500 m3 (2 trips needed)	**5000 m3**	10000+ m3 (diminishing returns)

6.7 Economic Impact of Distance

Source	Distance	Travel Time	NPC vs Case 1
Busan Storage	0 nm	1.0 hr*	Baseline
Ulsan	25 nm	1.67 hr	+70%
Yeosu	86 nm	5.73 hr	+215%

*Case 1 travel time is port internal movement, not open sea transit.

Rule of Thumb: Each additional 10 nm adds approximately 25% to NPC for this demand profile.

6.8 Decision Matrix

Scenario	Recommended Case	Key Reason
Local storage feasible	**Case 1**	Lowest NPC
No local storage, proximity to Ulsan	**Case 2-2**	46% cheaper than Yeosu
No local storage, only Yeosu available	Case 2-1	Only option
Future demand uncertainty	Case 1 or 2-2	Smaller shuttles = flexibility