Chapter 1: Executive Summary

Key Findings

The MILP optimization identifies the most cost-effective ammonia bunkering configurations for Busan Port across three supply scenarios. **Case 1 (local storage) is the most economical**, followed by Case 2-2 (Ulsan), with Case 2-1 (Yeosu) being the most expensive due to longer transport distances.

Optimal Configurations (1000 m3/h Pump)

Case	Configuration	NPC (20yr)	LCOAmmonia	Fleet Size (2050)
Case 1: Busan Storage	2,500 m3 shuttle	**$237.05M**	**$1.01/ton**	~20 shuttles
Case 2-1: Yeosu	10,000 m3 shuttle	$747.18M	$3.17/ton	~10 shuttles
Case 2-2: Ulsan	5,000 m3 shuttle	$402.37M	$1.71/ton	~15 shuttles

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Cost Comparison

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Case 1 (Busan)  :              $237M (baseline)
Case 2-2 (Ulsan):                  $402M (+70%)
Case 2-1 (Yeosu):                        $747M (+215%)
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Why Case 1 is Optimal

1. **Short Travel Distance**: 1 hour round trip vs 3.34h (Ulsan) or 11.46h (Yeosu)
2. **Higher Utilization**: More cycles per year = better asset utilization
3. **Smaller Shuttles**: 2,500 m3 vs 5,000-10,000 m3 = lower CAPEX per unit

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Why 2,500 m3 Shuttle (Case 1)

Shuttle Size	NPC	LCO	Reason
2,000 m3	$281.7M	$1.20/ton	Higher OPEX (more trips)
2,500 m3	**$237.05M**	**$1.01/ton**	**Optimal balance**
3,000 m3	$282.25M	$1.20/ton	Higher CAPEX
5,000 m3	$264.24M	$1.12/ton	Overkill for demand

The 2,500 m3 shuttle requires 2 trips per bunkering call (5000 m3 demand), achieving optimal balance between: - Fleet size (capital cost) - Trip frequency (operating cost) - Asset utilization (efficiency)

Recommendation

For Busan Port ammonia bunkering infrastructure (2030-2050):

1. **Primary Recommendation**: Build local storage tanks at Busan Port with 2,500 m3 shuttle fleet
   - 20-year NPC: $237.05M
   - Levelized cost: $1.01/ton
2. **Alternative (if local storage not feasible)**: Ulsan supply with 5,000 m3 shuttle fleet
   - 20-year NPC: $402.37M
   - Levelized cost: $1.71/ton
   - Premium: +70% over Case 1
3. **Not Recommended**: Yeosu supply
   - 20-year NPC: $747.18M
   - Levelized cost: $3.17/ton
   - Premium: +215% over Case 1

Key Assumptions

- **Pump Rate**: 1000 m3/h (fixed for main analysis)
- **Discount Rate**: 0.0 (no time value of money adjustment)
- **Annualization Rate**: 7.0% (for asset cost spreading)
- **Demand Growth**: 50 vessels (2030) to 500 vessels (2050)
- **Bunker Volume**: 5,000 m3 per call