RP 2022-01: Vessel Electrification Investigation for the NCDOT Ferry System

December 4, 2023

Western Carolina University

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Agenda

1. Project Overview
2. Analysis – Methods & Options
3. Results
4. Analysis Inputs
5. Conclusions
6. Next Steps

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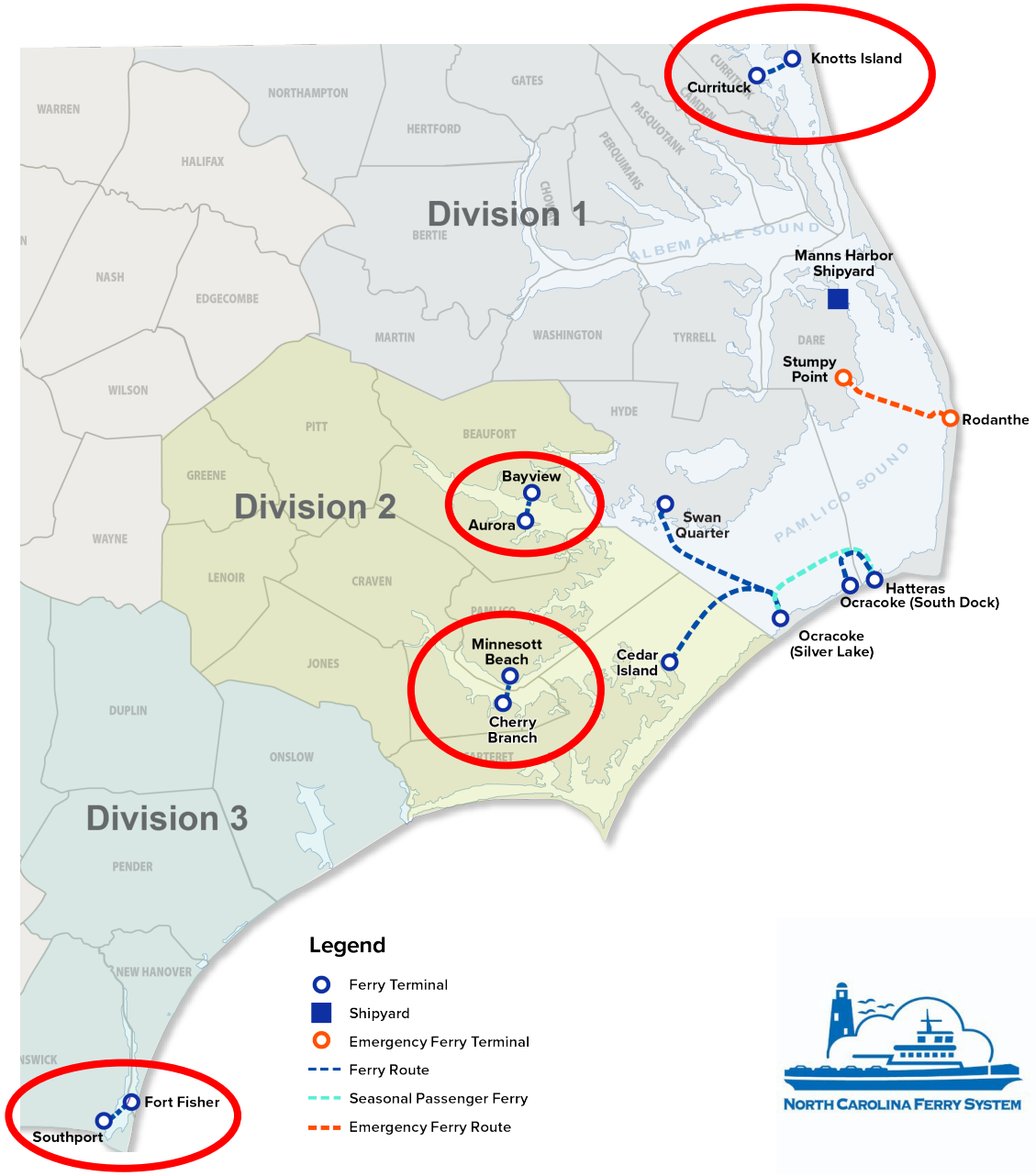
1. Project Overview

Assess electrification options for four short haul routes:

1. Technical and Economic Feasibility
2. Workforce and Environmental Impacts
3. Implementation Planning



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NORTH CAROLINA FERRY SYSTEM

2. Options Analyzed – Vessel

Diesel Mechanical	Diesel Electric	Diesel Electric w/ Peak Shaving	Plug-In Hybrid	Plug-In Electric	Fuel Cell Electric
• Diesel powered • Mechanical drive	• Diesel powered • Electric drive	• Diesel powered • Electric drive • On-board ESS	• Electric power • Electric drive • On-board ESS	• Electric powered • Electric drive • On-board ESS	• Electric powered • Electric drive

• Dual ICE propulsion
• Primary & backup ICE generator sets
	• Improved load matching
	  • Smaller ICE
	  • Reduced maintenance
		• Optimized ICE generator sets
		  • Increased fuel efficiency
		  • Reduced maintenance
		• ESS for low load and peak power requirements
			• ESS charged from shore
			• On-board generation for backup and/or range extension
			• Low-cost electric power
			• “Unlimited” range
				• ESS charged from shore
				• Low-cost electric power
				• Zero local emissions
				• No ICE maintenance
					• On-board fuel cell generation
					• Refueled from shore connection
					• Zero local emissions
					• No ICE maintenance

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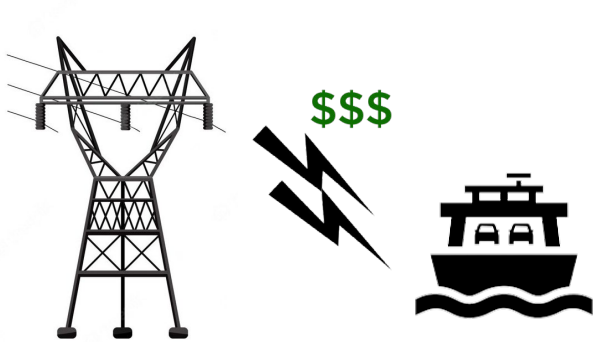
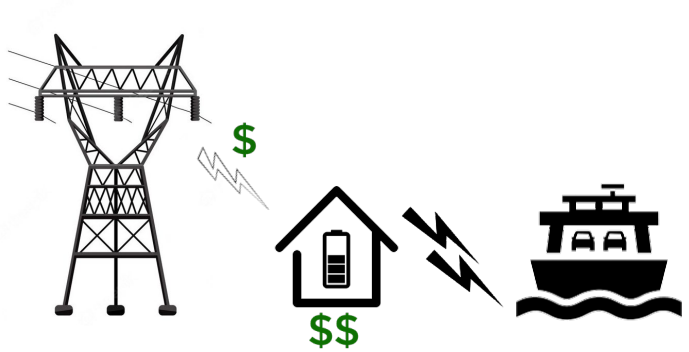
Baseline		**Option 1**	**Option 2**		

2. Options Analyzed – Charging



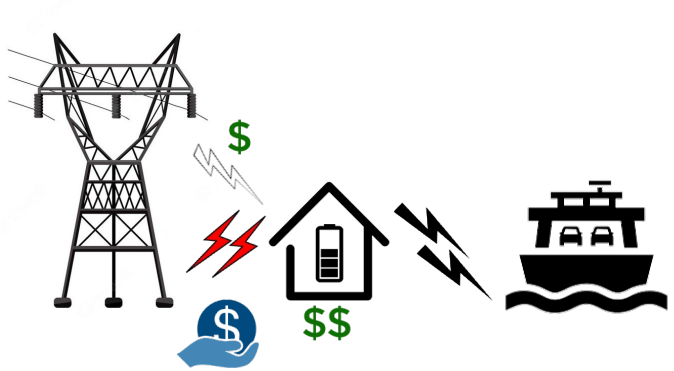
Grid → Vessel

- Grid connection through stepdown transformers, AC/DC conversion, filters, rapid charging system, etc.
- High power demand
- High demand charges



Grid → Shoreside ESS → Vessel

- Grid connection to ESS
- ESS capital and replacement costs
- Low power demand / demand charges
- High power from ESS to vessel



Grid → Shoreside ESS → Vessel
Grid ← Shoreside ESS

- Grid connection to ESS
- ESS capital and replacement costs
- Low power demand / demand charges
- High power from ESS to vessel
- Periodic utility access for demand response → Revenue generated

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2. Analysis Method

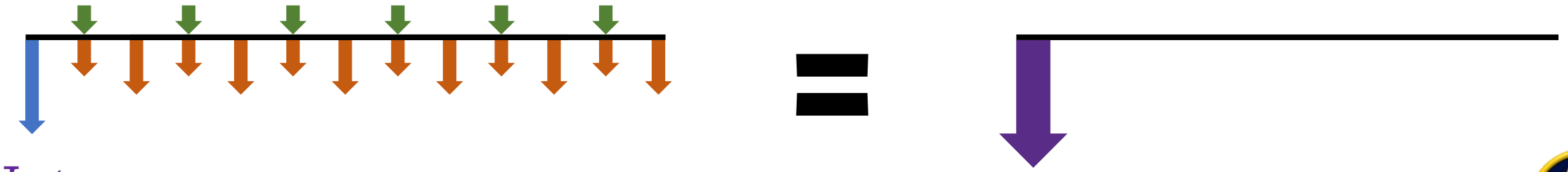
Net Present Value

of

Life Cycle Costs

Equivalent value of cash inflows and outflows at present time

Recurring and nonrecurring costs throughout asset life



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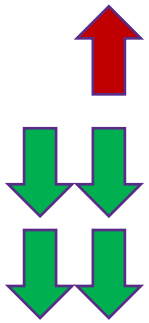
2. Analysis Method

Cost components

Diesel Mechanical

- Equipment capital
- Fuel
- Maintenance

Electrical



- Equipment capital
- Fuel
- Maintenance
- Facilities capital
- Batteries (with replacement)
- Electricity

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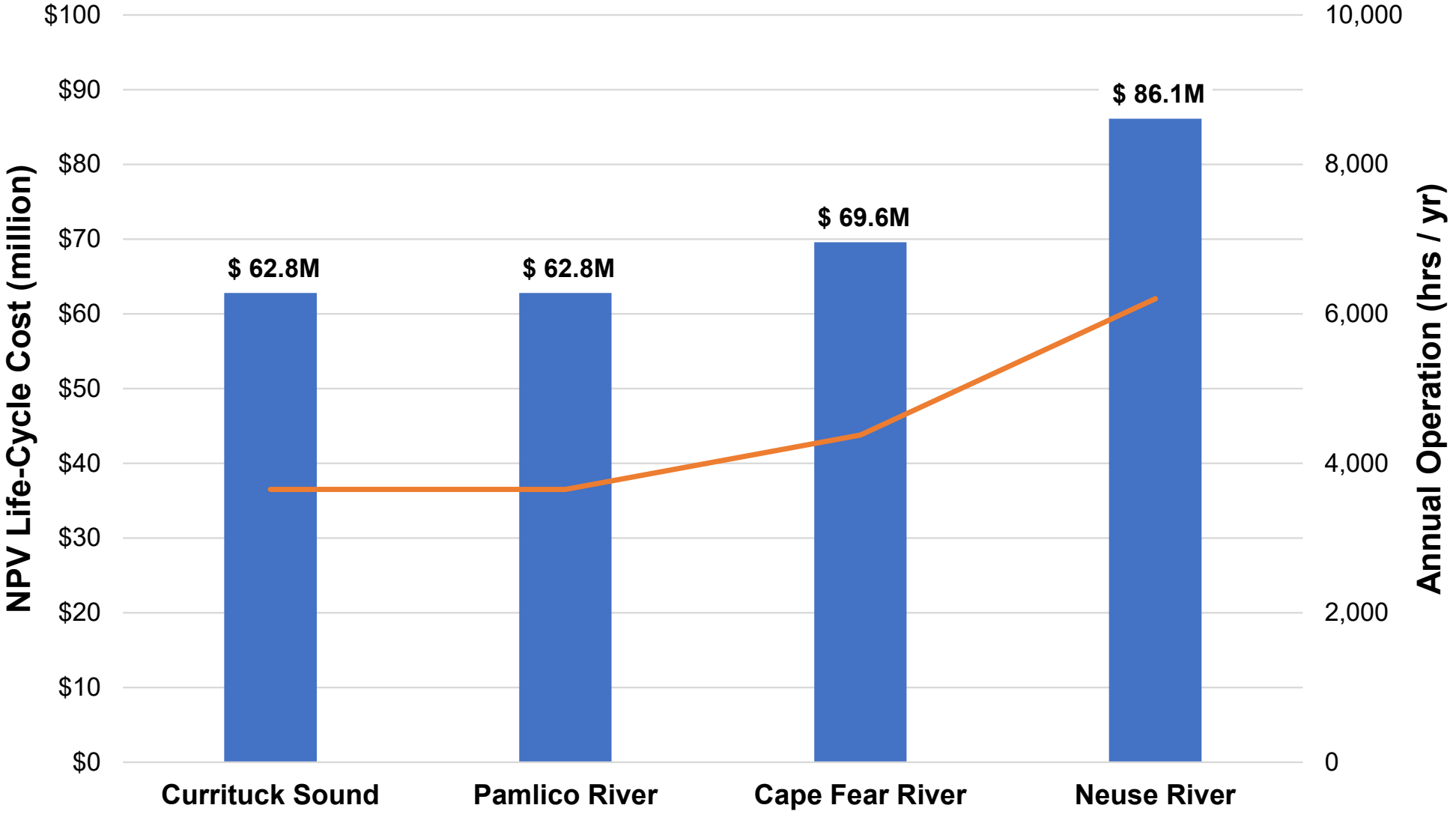
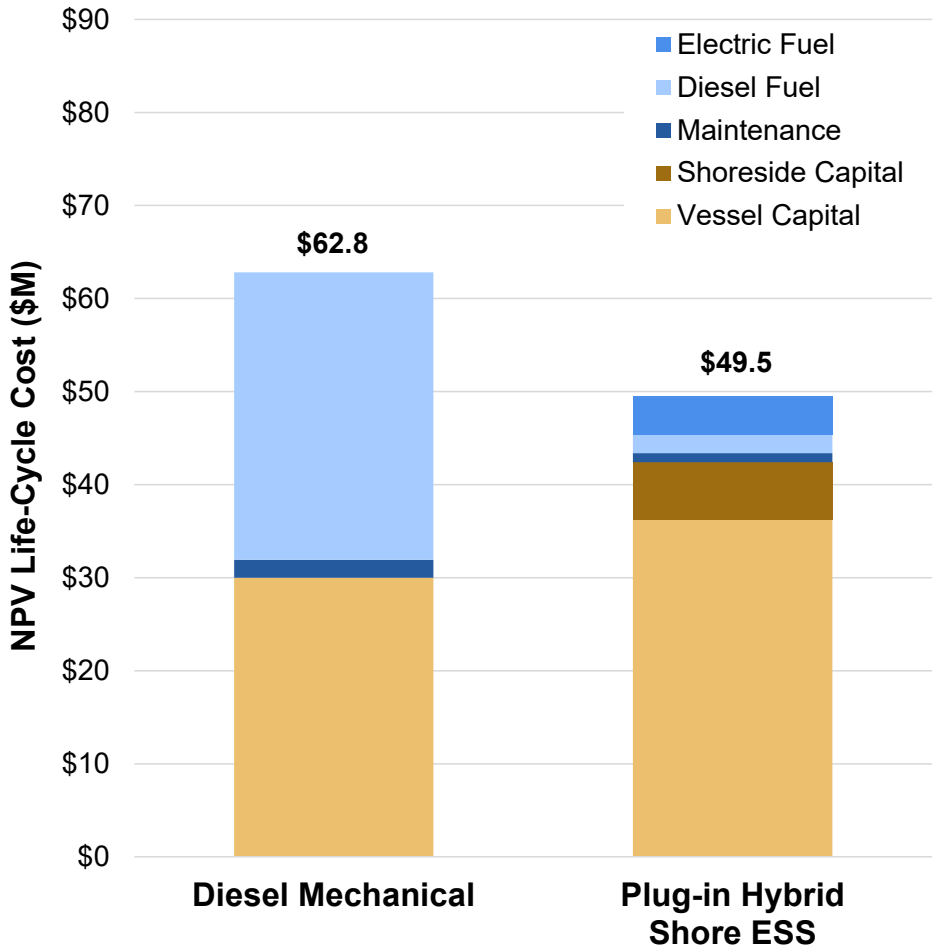
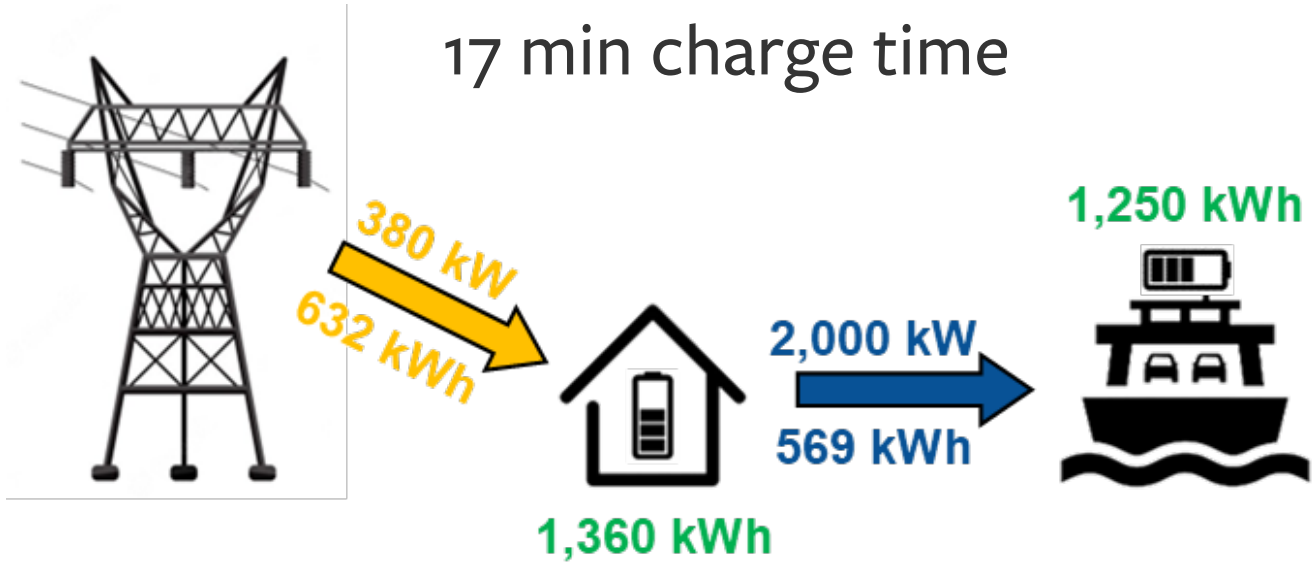
3. Results – DM Vessels

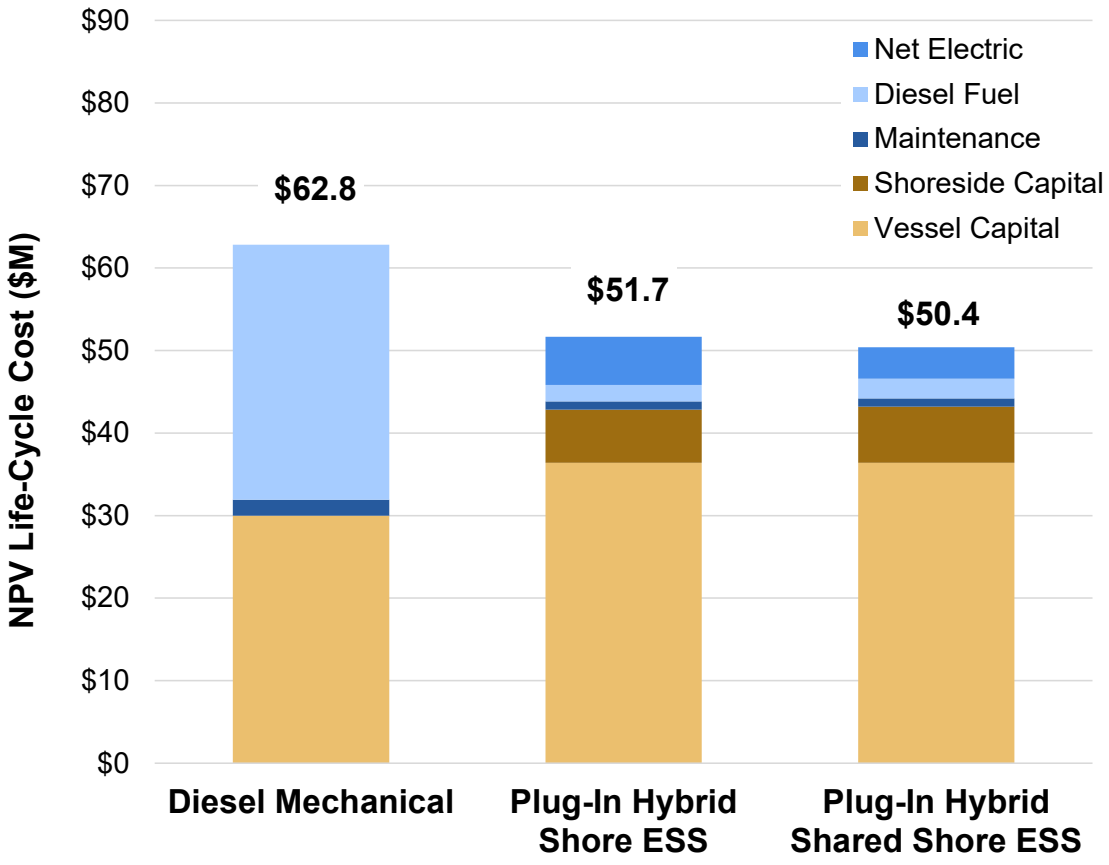


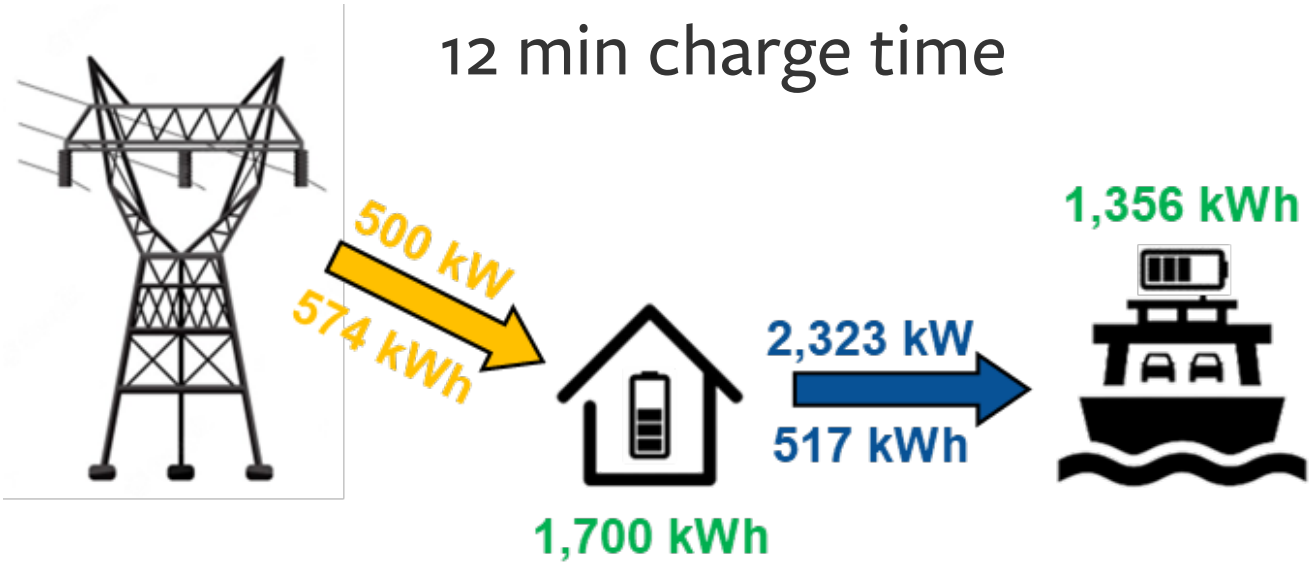
3. Currituck Sound



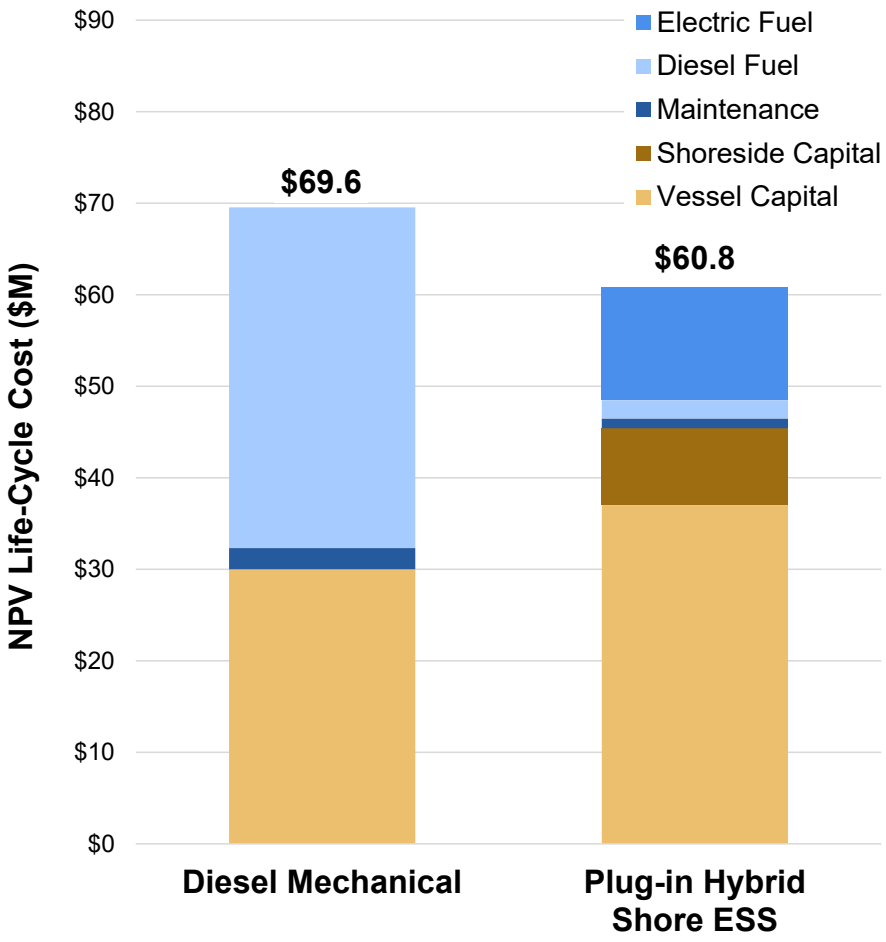


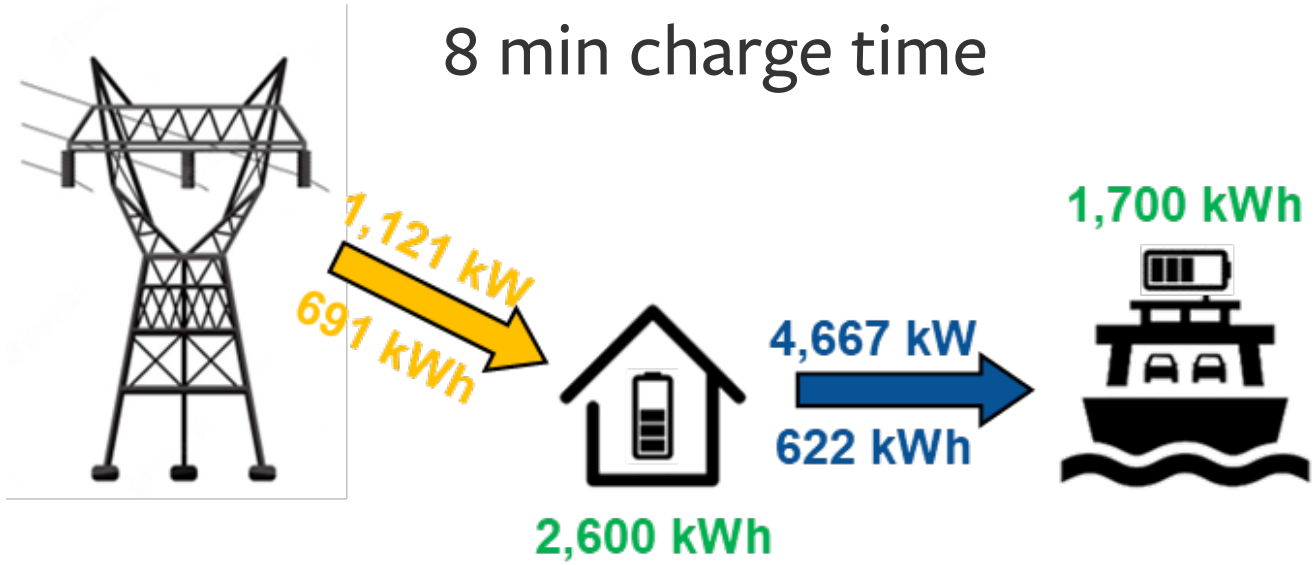
3. Pamlico River



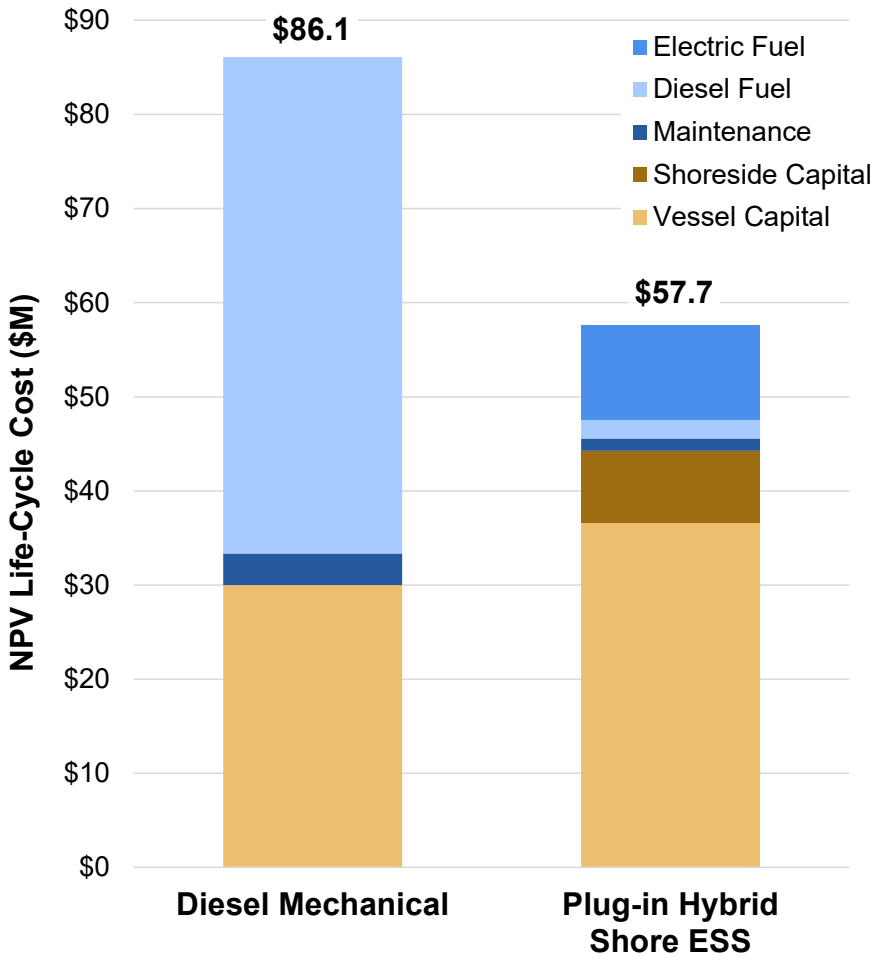


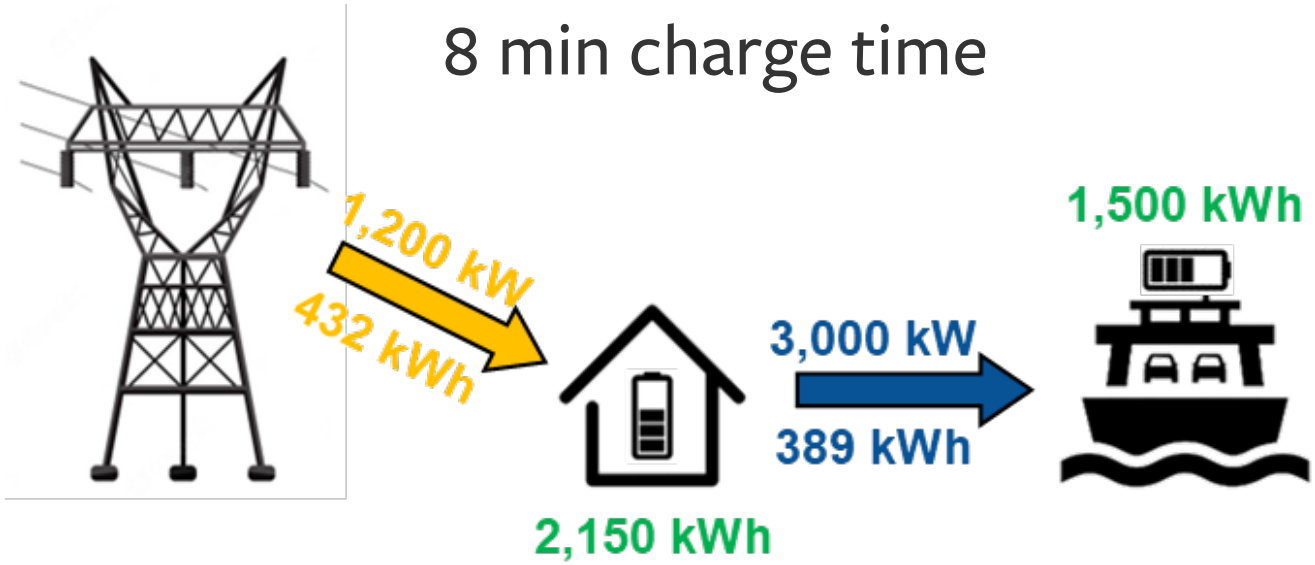
3. Cape Fear River





3. Neuse River





3. LCCA Summary

	Diesel Mechanical ($M)	Plug-In Hybrid w/ Shore ESS ($M)	Savings ($M)	Savings (%)
Currituck Sound	$ 62.8	$ 49.5	$ 13.3	21%
Pamlico River	$ 62.8	$ 50.4	$ 12.4	20%
Cape Fear River	$ 69.6	$ 60.8	$ 8.8	13%
Neuse River	$ 86.1	$ 57.7	$ 28.4	33%

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3. Results

Impact	Units	Plug-In Hybrid	Diesel Mechanical (Currituck Sound)	Diesel Mechanical (Neuse River)
CO_2e Vessel Only	Tons / year	166	2,490	4,233
CO_2e Vessel + Upstream	Tons / year	600	2,900	5,000
NO_x Vessel Only	Tons / year	3.4	50.3	85.5
PM_{10} Vessel Only	Tons / year	0.09	1.32	2.24
$PM_{2.5}$ Vessel Only	Tons / year	0.09	1.28	2.18
VOC Vessel Only	Tons / year	0.18	2.63	4.48
CO Vessel Only	Tons / year	0.55	8.19	13.92
SO_2 Vessel Only	Tons / year	0.0037	0.0557	0.0946
Health Impacts	$ per Year	~$25k to $55k	$313k to $704k	$612k to $1,217k

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4. Analysis Inputs

Capital Costs

- $30M Vessel
  - $4M for elec.
- Batteries
  - $700/kWh to $500/kWh
- Site specific grid improvements
- Elec upgrade - $1.25M
- Rapid charging system - $1.5M

Diesel Fuel

- $3.25/gal increasing $0.10 annually
- Based on recent costs and historical trends

Electrical

- Utility specific rate structures
  - Service Fees
  - Demand Charge
  - Energy Charge
- 2% annual cost increase based on historical trends

Maintenance

- ICE preventive maintenance
- Electrical component maintenance schedules
- Rapid charging

5. Conclusions

Electrification

- Significant economic advantages over the vessel life cycle
- An order of magnitude reduction in environmental/health impacts

One-Side Charging with ESS

- Technical, economical, and operational advantages
- Trade annual operating costs for capital costs
- Mitigate grid demand and infrastructure improvements

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6. Next Steps

Workforce Development

- Workforce impacts appear limited – similar to MV Salvo
- Leverage programs like NC MARTEC

Implementation Plan

1. Currituck – single vessel, simple operation, limited grid improvements
    a. Manns Harbor – slow charging equipment
2. Pamlico – single vessel, simple operation, interested utility partner
3. Neuse – multiple vessels, extensive operation, short charge time
4. Cape Fear – multiple vessels, economic advantage, demanding operation

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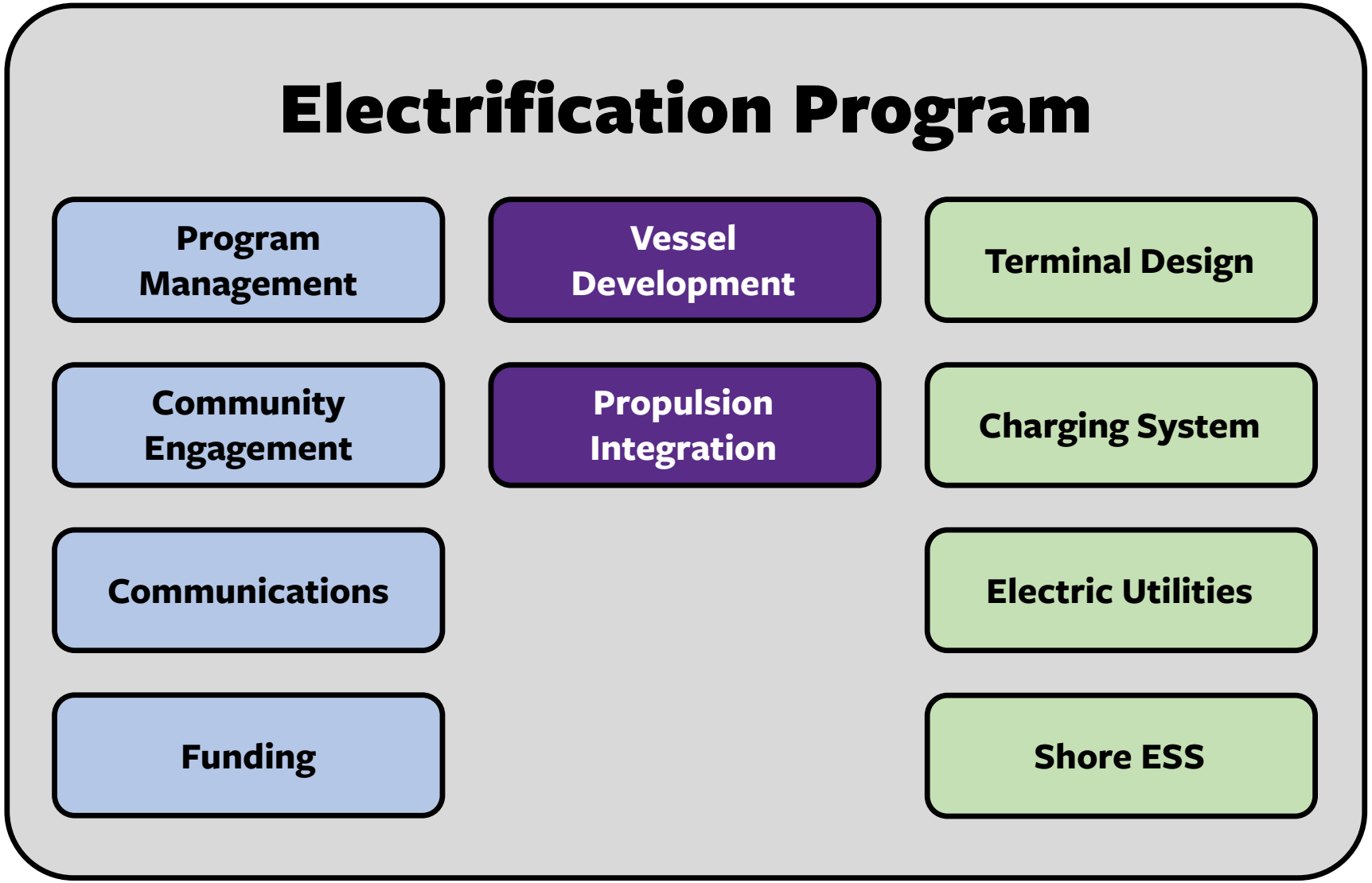
6. Next Steps



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