ALL ELECTRIC FERRY BATTERY SIZING STUDY

BATTERY SIZING AND SHORE POWER CHARGING CAPACITY REQUIREMENTS FOR CASCO BAY LINES

OCTOBER 30, 2025

Casco Bay Lines
Portland, Maine

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THE SHEARER GROUP

INTRODUCTION

The Shearer Group, Inc (TSGI) was tasked to provide an analysis to determine the required battery size and shore charging power infrastructure for an all-electric ferry operating only on battery energy storage to replace the MAQUOIT II. This analysis uses the schedule of the MAQUOIT II and operational profiles based upon resistance data from a CFD analysis of the hull form of the replacement vessel. From the operational profiles the amount of energy storage needed to operate on batteries only is calculated.

The battery sizing analysis is done for 8, 9, 10, and 11 knot transit speeds at a vessel draft of 7'. The different speeds require different propulsion power demands and duration of time spent in transit/at dock which impacts battery and charging requirements. In addition, two different lithium-ion battery chemistries, nickel manganese cobalt (NMC) and lithium iron phosphate (LFP), were analyzed in this study. The allowable charging rate depends upon the chemistry of the battery for a given nominal battery size. Also, to protect the batteries, only a percentage of the battery's capacity is usable. Therefore, the required nominal battery size will depend on the battery chemistry and the allowable range of the battery state of charge. In this study it is assumed that the state of charge of NMC batteries must be kept between 40-80% and LFP batteries between 10-80%.

OPERATIONAL PROFILE

The MAQUOIT II typical schedule has 4 distinct routes that it regularly transits with up to 7 runs a day. In this analysis we labeled these runs as "Run A", "Run B", "Run C", and "Runs D1, D2, D3, D4".

- Run A is scheduled to depart Portland at 8am and goes to Chebeague Island, Cliff Island, Long Island, Great Diamond, Little Diamond, and back to Portland.
- Run B is scheduled to depart Portland at Noon and goes to Cliff Island, Chebeague Island, Long Island, and back to Portland.
- Run C is scheduled to depart Portland at 4:15pm and goes to Diamond Cove, Great Diamond, Little Diamond, and back to Portland.
- Runs D1, D2, D3, and D4 are runs from Portland to Peaks Island and back to Portland that depart Portland at 7:15, 8:15, 9:15, and 10:30 respectively.

Runs A, B, and C occur every day of the week and Runs D1, D2, D3, and D4 occur Sunday through Thursday. To create the ferry schedule at different speeds, the departure times from Portland are held constant (matching the existing schedule) and the following stops are scheduled based on assumed maneuvering time, dock time, and transit times. The resulting time at dock in Portland is used to determine the amount of battery charging achieved before the vessel's departure from Portland. This required assumptions regarding the amount of time required to connect vessel to the shore power and the amount of time before departure the vessel is disconnected from shore power. The assumptions made are shown in Appendix I. The required time to connect and disconnect will depend on the vessel and shoreside technology installed.

TRIP ENERGY REQUIREMENTS

To determine the required battery sizing the amount of electrical energy required on each leg of trip was calculated. Using the resistance data calculated from a CFD analysis of the hull form, the brake horsepower requirement (power from the engine/generator) is calculated using assumptions made regarding propeller and hull characteristics as well as mechanical and electrical losses. The assumptions made are detailed in Appendix I.

An average maneuvering/acceleration/deceleration power demand and duration was added to each leg. The total energy required for each trip starting and ending in Portland was evaluated for each transit speed.

These energy usages were used to evaluate the difference between starting and ending battery energy after each trip. Each trip's energy usages are shown in the following table for the corresponding transit speed.

Table #1 – Trip Energy Requirements

	8 Knots	9 Knots	10 Knots	11 Knots
Trip	Energy Usage (kWh)	Energy Usage (kWh)	Energy Usage (kWh)	Energy Usage (kWh)
Trip A	649	791	1007	1345
Trip B	561	701	912	1243
Trip C	352	419	520	679
Trip D	538	643	800	1047

BATTERY SIZING

To operate utilizing only the batteries, the batteries must be sized to store enough usable energy to make the entire trip's transit distance at the desired speed. It must also be sized large enough such that the charging rate required to meet the next trip's energy requirements do not exceed the batteries' allowable power draw. The maximum power that batteries can charge and discharge is dependent on the battery capacity and the allowable C-rate of the battery's chemistry. A C-rate of 1C corresponds to a full charge/discharge of the batteries' nominal capacity in one hour. The maximum C-rate of the NMC batteries and LFP were kept below 1.5C and 0.5C respectively.

At each shore charging power capacity level the minimum required installed nominal battery capacity was found. The battery size was iterated through for each desired shore power capacity such that the minimum available usable battery energy was greater than the reserve energy requirement. In this study a usable reserve energy requirement of 100kWh is assumed. In Appendix I the amount of usable battery energy is shown at the end of each run and after each charging opportunity.

The following tables list the required installed nominal battery capacity for shore power capacities between 500 kW to 1.5 MW. The tables assume a maximum of 3MWh of battery energy storage can be installed on the vessel. Values above 3MW are replaced with an 'x'. This assumption is dependent on final arrangement of systems and generators. The charts that follow the tables show the required battery capacity calculated for each shore charge capacities regardless of the vessel space restrictions for higher speeds and lower shore charging capacities.

Table #2 – NMC Required Nominal Battery Size (Maxed at 3MWh)

NMC Required Nominal Battery Size (kWh)					
Transit Speed (kts)	Shore Power Capacity				
	500 kW	750 kW	1000 kW	1250 kW	1500 kW
8	x	2893	1872	1872	1872
9	x	x	2229	2229	2229
10	x	x	2766	2766	2766
11	x	x	x	x	x

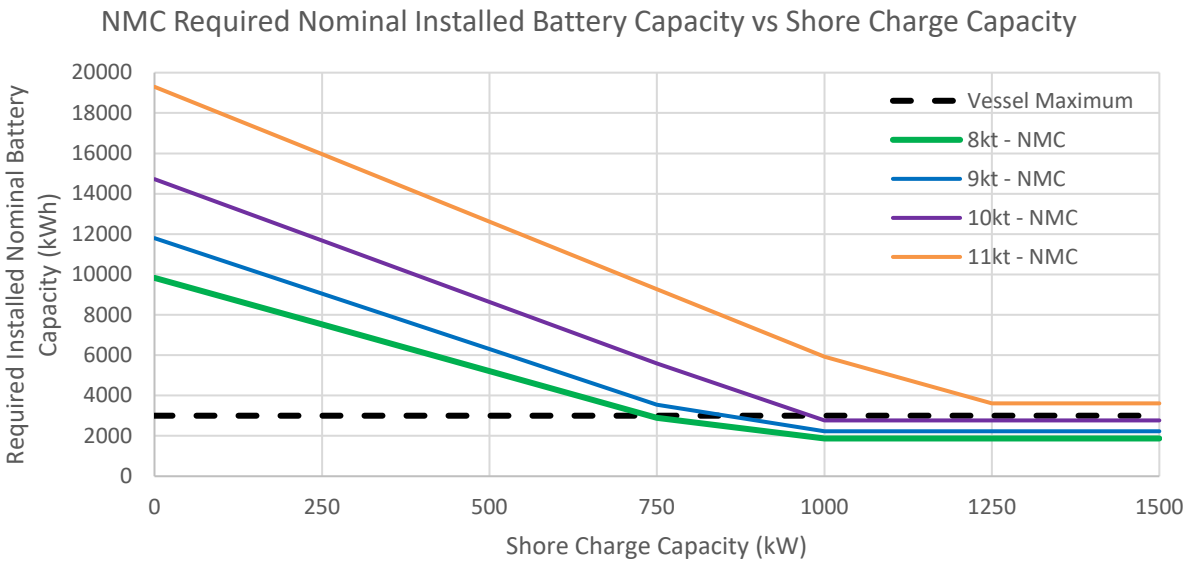

Figure #1 – Required NMC nominal battery capacity versus shore charge capacity.

Table #3 – LFP Required Nominal Battery Size (Maxed at 3MWh)

LFP Required Nominal Battery Size (kWh)					
Transit Speed (kts)	Shore Power Capacity				
	500 kW	750 kW	1000 kW	1250 kW	1500 kW
8	2975	1653	1542	1542	1542
9	x	2028	1627	1627	1627
10	x	x	1880	1880	1880
11	x	x	x	2287	2287

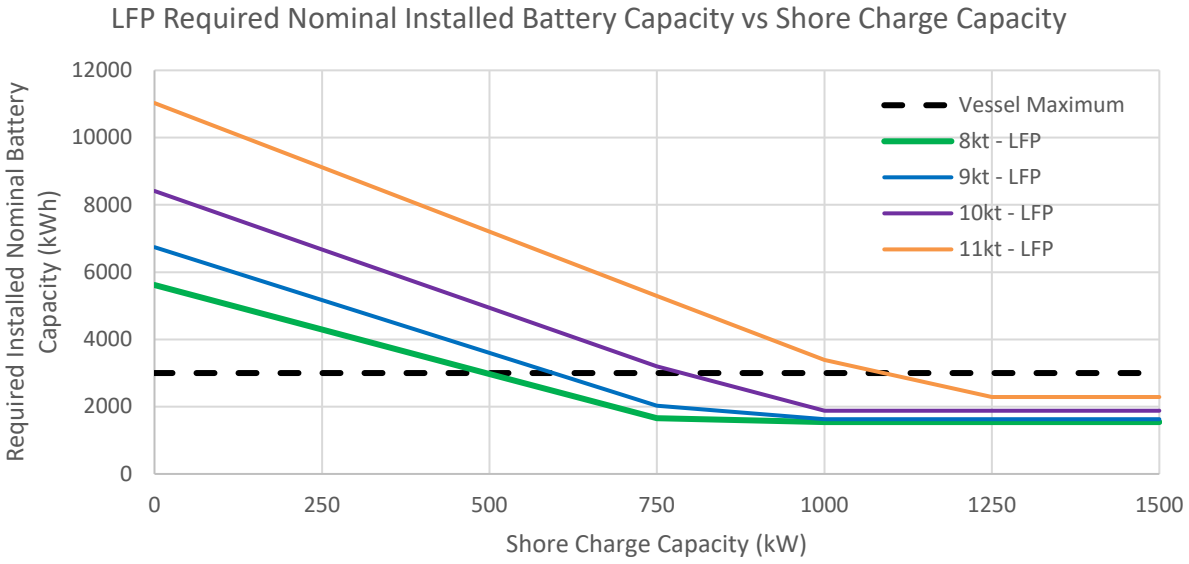

Figure #2 – Required LFP nominal battery capacity versus shore charge capacity.

INCREASING THE MAXIMUM INSTALLED BATTERY CAPACITY

It is assumed that the replacement ferry will have generators onboard. This results in a preliminary estimate of 3MWh maximum of installed nominal battery capacity onboard. However, if the generators were foregone for additional battery space, then the installed battery capacity could be increased. This would increase the range of possible operating speeds and required shore power charging capabilities. For example, if 6 MWh of LFP batteries are installed on the vessel and the shore charging capacity is kept at 500kW then the vessel would now be able to operate up to 10 knots and meet the schedule (Point A on Figure #3). Or possibly at a transit speed of 8 knots with 6 MWh of LFP batteries installed on the vessel, no shore charging would be required during the day, and the vessel could be charged only overnight at off peak hours (Point B on Figure #3).

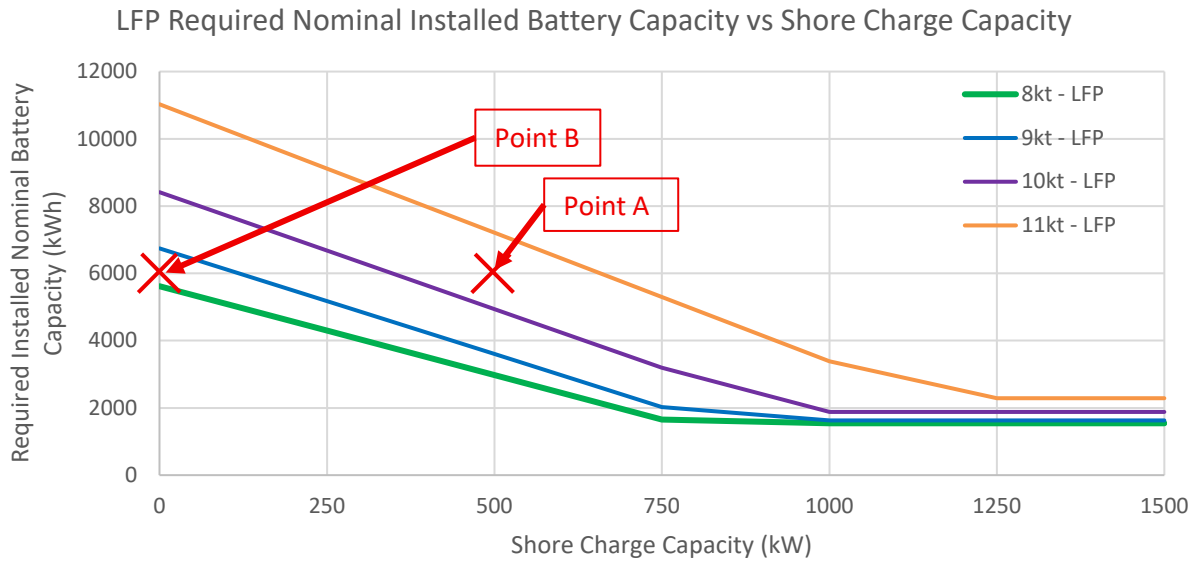

Figure #3 – Possible battery size and operating speeds with more hold space dedicated to batteries.

SUMMARY

TSGI has determined the installed nominal battery capacity for an all-electric ferry operating only on battery energy storage for available shore power capacities between 0 and 1.5 MW. The battery size was iterated through for each desired shore power capacity such that the minimum available usable battery energy was greater than the reserve energy requirement.

APPENDIX I

23494-199-7 All Electric Ferry Battery Sizing Calculations

REVISION HISTORY					
REV	ZONE	DESCRIPTION	DATE	BY	CHECK
0	-	1. INTIAL RELEASE	30OCT25	MDL	-

GENERAL NOTES

-

NO.	DRAWING	TITLE
4	23494-199-6	All Electric Ferry Battery Sizing Study
3	23494-199-2	Ferry Operational Profile Calcs
2	23494-199-1	Ferry Propulsion System Analysis Calcs
1	23494-099-1	Ferry Propulsion System Feasibility Study

REFERENCES

TITLE: ALL ELECTRIC FERRY BATTERY SIZING CALCS

FOR: CASCO BAY LINES

VESSEL: MAQUOIT II REPLACEMENT | HULL NO: -

DATE: 30OCT25 | SCALE: N.T.S.

DWG. NO: 23494-199-7 | REV: 0

DRAWN BY: MDL | CHECK BY: -

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Overview

These calculations determine the required battery size and charging power infrastructure needed for the MAQUOIT II replacement vessel to operate on battery energy storage only. This analysis uses the schedule of the MAQUOIT II and operational profiles developed in Reference 3. The operational profiles use resistance data from a CFD analysis of the hull form of the replacement vessel. From the operational profile the amount of energy storage needed to operate on batteries only is calculated. This analysis is done for 8, 9, 10, and 11 knot transit speeds at a vessel draft of 7'. The different speeds require a different propulsion power demand and result in a different durations of time spent in transit/at dock impacting battery and charging requirements. It must be noted that the required battery sizes vary based on the battery chemistry used. The allowable charging rate depends upon the chemistry of the battery for a given nominal battery size. In addition, to protect the batteries, only a percentage of the battery's capacity is usable. Therefore, the required nominal battery size will depend on the battery chemistry and the allowable range of the battery state of charge. In this study it is assumed that the state of charge of NMC batteries must be kept between 40-80% and LFP batteries between 10-80%.

Methodology

First, the amount of electrical energy required on each leg of trip was calculated. This is dependent on transit speed and assumptions including hull and propeller characteristics, propulsion system efficiencies, house electrical power demands, and battery cooling electrical power demands. An average maneuvering/acceleration/deceleration power demand and duration was added to each leg. Next, the total energy required for each trip starting and ending in Portland is evaluated for each transit speed. This energy was used to evaluate the difference between starting and ending battery energy after each trip. From Reference 3, the time at dock was utilized to determine the amount of battery charging achieved before the vessel's departure from Portland. Finally, for each transit speed the minimum battery size required for a range of available shore power capacity is evaluated. This required assumptions regarding reserve energy requirements, time required to connect vessel to the shore power, and the amount of time before departure the vessel is disconnected from shore power. The required time to connect and disconnect will depend on the vessel and shoreside technology installed. The required battery size is iterated through for each fixed shore power capacity such that the minimum available usable battery energy is greater than the reserve energy requirement at all times.

Provided Schedule

The following schedule was provided to TSGI. This sequences of events determined the operating profile of the ferry.

Trip	Prescribed Event
Trip A	Leaves Portland 0800
	Leaves Chebeague Island 0910
	Leaves Cliff Island 0940
	Leaves Long Island 1005
	Leaves Great Diamond 1020
	Leaves Little Diamond 1025
	Arrives Back in Portland 1040
Trip B	Leaves Portland 1200
	Leaves Cliff Island 1335
	Leaves Chebeague Island 1400
	Leaves Long Island 1420
	Arrives Back in Portland 1450
Trip C	Leaves Portland 1615
	Leaves Diamond Cove 1705
	Leaves Great Diamond 1715
	Leaves Little Diamond 1720
	Arrives Back in Portland 1735
Trip D1	Leaves Portland 1915
	Leaves Peaks Island 1945
Trip D2	Leaves Portland 2015
	Leaves Peaks Island 2045
Trip D3	Leaves Portland 2115
	Leaves Peaks Island 2145
Trip D4	Leaves Portland 2230
	Leaves Peaks Island 2255

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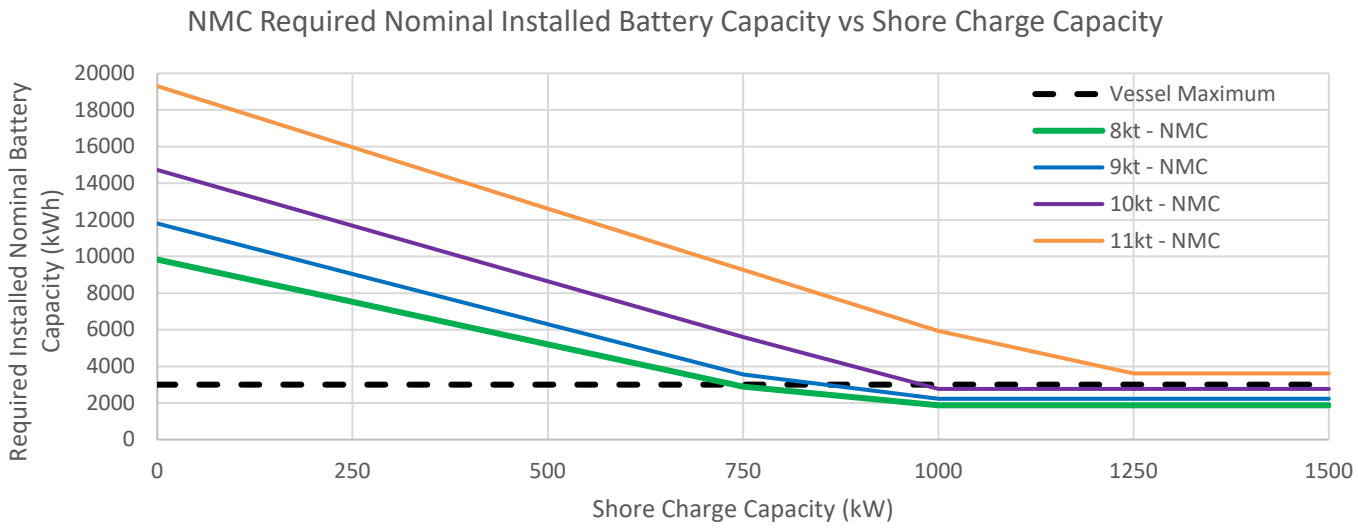
Summary of Results

At each shore charging power capacity level the required installed nominal battery capacity was found. The following tables list the required installed nominal battery capacity for shore power capacities between 500 kW to 1.5 MW. The tables assume a maximum of 3MWh of battery energy storage can be installed on the vessel. Values above 3MW are replaced with an 'x'. This assumption is dependent on final arrangement of systems and generators. Battery size requirements greater than 3MW for higher speeds and lower shore charge capacities are shown in the charts following the tables.

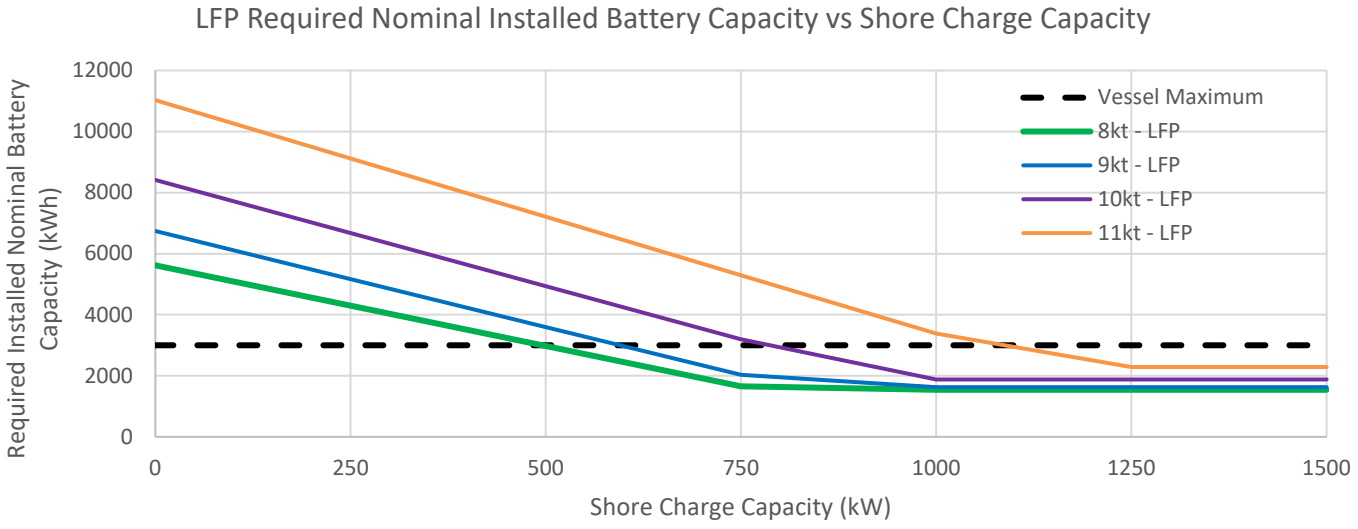
NMC Required Nominal Battery Size (kWh)

Transit Speed (kts)	Shore Power Capacity 500 kW	750 kW	1000 kW	1250 kW	1500 kW
8	x	2893	1872	1872	1872
9	x	x	2229	2229	2229
10	x	x	2766	2766	2766
11	x	x	x	x	x



LFP Required Nominal Battery Size (kWh)

Transit Speed (kts)	Shore Power Capacity 500 kW	750 kW	1000 kW	1250 kW	1500 kW
8	2975	1653	1542	1542	1542
9	x	2028	1627	1627	1627
10	x	x	1880	1880	1880
11	x	x	x	2287	2287



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Battery Only Operations

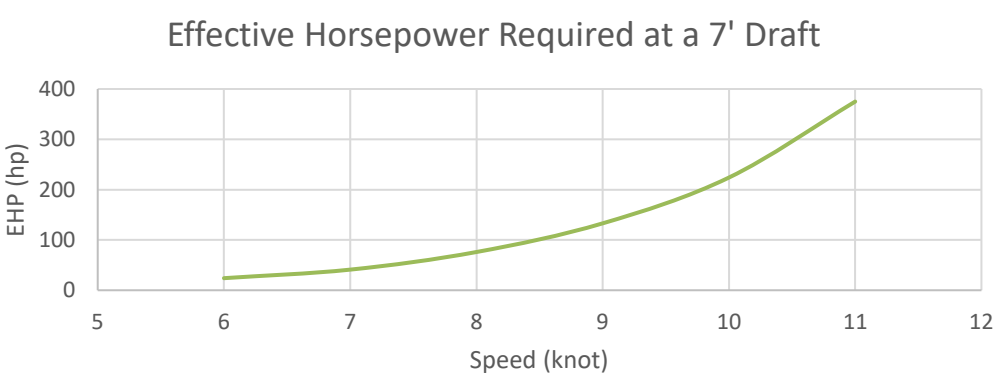
Assumptions:

Draft	7	ft	
Added appendage resistance	1.1		
Prop efficiency	0.5		η_{prop}
Shaft efficiency	0.98		η_{shaft}
Gear box efficiency	0.98		η_{gear}
Motor efficiency	0.98		η_{motor}
Electrical efficiency	0.99		η_{elec}
Base house power demand	30	ekW	P_{house}
Battery cooling power demand	30	ekW	$P_{cooling}$
NMC battery efficiency	0.98		η_{batt}
NMC maximum sustained C-rate	1.5		$C\text{-rate}_{max}$
NMC maximum SoC	0.8		SoC_{max}
NMC minimum SoC	0.4		SoC_{min}
LFP battery efficiency	0.98		η_{batt}
LFP maximum sustained C-rate	0.5		$C\text{-rate}_{max}$
LFP maximum SoC	0.8		SoC_{max}
LFP minimum SoC	0.1		SoC_{min}

CFD Data

CFD Run:	108' Dbl Chine 7' Draft
Length (ft)	108
Beam (ft)	33
Draft (ft)	7
Disp (LT)	374

Speed (kts)	EHP
6	24
7	41
8	76
9	133
10	224
11	375



Battery Power Requirements

Speed (kts)	Effective Power Req. (kW)	Delivered Power Req. (kW)	Transit Propulsion Electrical Power Req. (ekW)	Transit Electrical Power Req. (ekW)	NMC Req. Battery Size for <1.5 C-rate (kWh)	LFP Req. Battery Size for <0.5 C-rate (kWh)
7	31	67	72	132	88	264
8	57	125	134	194	129	388
9	99	218	234	294	196	588
10	167	367	394	454	303	909
11	280	615	660	720	480	1441

Note: At slower speeds the maneuvering power requirements will increase the required battery size

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Energy Requirements

Assumes a total of 4 min of Maneuvering/Acceleration/Deceleration @ an average of 600 ekW power requirement during each leg

		8 Knots		9 Knots		10 Knots		11 Knots	
Leg	Distance (nm)	Transit time (min)	Energy Usage (kWh)	Transit time (min)	Energy Usage (kWh)	Transit time (min)	Energy Usage (kWh)	Transit time (min)	Energy Usage (kWh)
Portland - Chebeague Island	6.77	51	204	45	261	41	348	37	483
Chebeague Island - Cliff Island	1.93	14	87	13	103	12	128	11	166
Cliff Island - Long Island	3.52	26	125	23	155	21	200	19	270
Long Island - Great Diamond	2.09	16	91	14	108	13	135	11	177
Great Diamond - Little Diamond	0.71	5	57	5	63	4	72	4	86
Little Diamond - Portland	1.85	14	85	12	100	11	124	10	161
Portland -Cliff Island	7.84	59	230	52	296	47	396	43	553
Cliff Island - Chebeague Island	1.93	14	87	13	103	12	128	11	166
Chebeague Island - Long Island	2.32	17	96	15	116	14	145	13	192
Long Island - Portland	4.45	33	148	30	185	27	242	24	331
Portland - Diamond Cove	3.88	29	134	26	167	23	216	21	294
Diamond Cove - Great Diamond	1.48	11	76	10	88	9	107	8	137
Portland - Peaks Island	2.2	17	93	15	112	13	140	12	184

Individual Trips Required Transit Energy Requirements

The following totals represent the energy requirements for each of the MAQUOIT II trips before it returns to Portland and can recharge the batteries

Trip A

Leg	8 Knots Energy Usage (kWh)	9 Knots Energy Usage (kWh)	10 Knots Energy Usage (kWh)	11 Knots Energy Usage (kWh)
Portland - Chebeague Island	204	261	348	483
Chebeague Island - Cliff Island	87	103	128	166
Cliff Island - Long Island	125	155	200	270
Long Island - Great Diamond	91	108	135	177
Great Diamond - Little Diamond	57	63	72	86
Little Diamond - Portland	85	100	124	161
SUM:	**649**	**791**	**1007**	**1345**

Trip B

Leg	8 Knots Energy Usage (kWh)	9 Knots Energy Usage (kWh)	10 Knots Energy Usage (kWh)	11 Knots Energy Usage (kWh)
Portland - Cliff Island	230	296	396	553
Cliff Island - Chebeague Island	87	103	128	166
Chebeague Island - Long Island	96	116	145	192
Long Island - Portland	148	185	242	331
SUM:	**561**	**701**	**912**	**1243**

Trip C

Leg	8 Knots Energy Usage (kWh)	9 Knots Energy Usage (kWh)	10 Knots Energy Usage (kWh)	11 Knots Energy Usage (kWh)
Portland - Diamond Cove	134	167	216	294
Diamond Cove - Great Diamond	76	88	107	137
Great Diamond - Little Diamond	57	63	72	86
Little Diamond - Portland	85	100	124	161
SUM:	**352**	**419**	**520**	**679**

Trip D

	8 Knots Energy Usage (kWh)	9 Knots Energy Usage (kWh)	10 Knots Energy Usage (kWh)	11 Knots Energy Usage (kWh)
Portland - Peaks Island	93	112	140	184
Peaks Island - Portland	93	112	140	184
SUM:	**538**	**643**	**800**	**1047**

Individual Trips Required Transit Energy Summary

Trip	8 Knots Energy Usage (kWh)	9 Knots Energy Usage (kWh)	10 Knots Energy Usage (kWh)	11 Knots Energy Usage (kWh)
Trip A	649	791	1007	1345
Trip B	561	701	912	1243
Trip C	352	419	520	679
Trip D	538	643	800	1047

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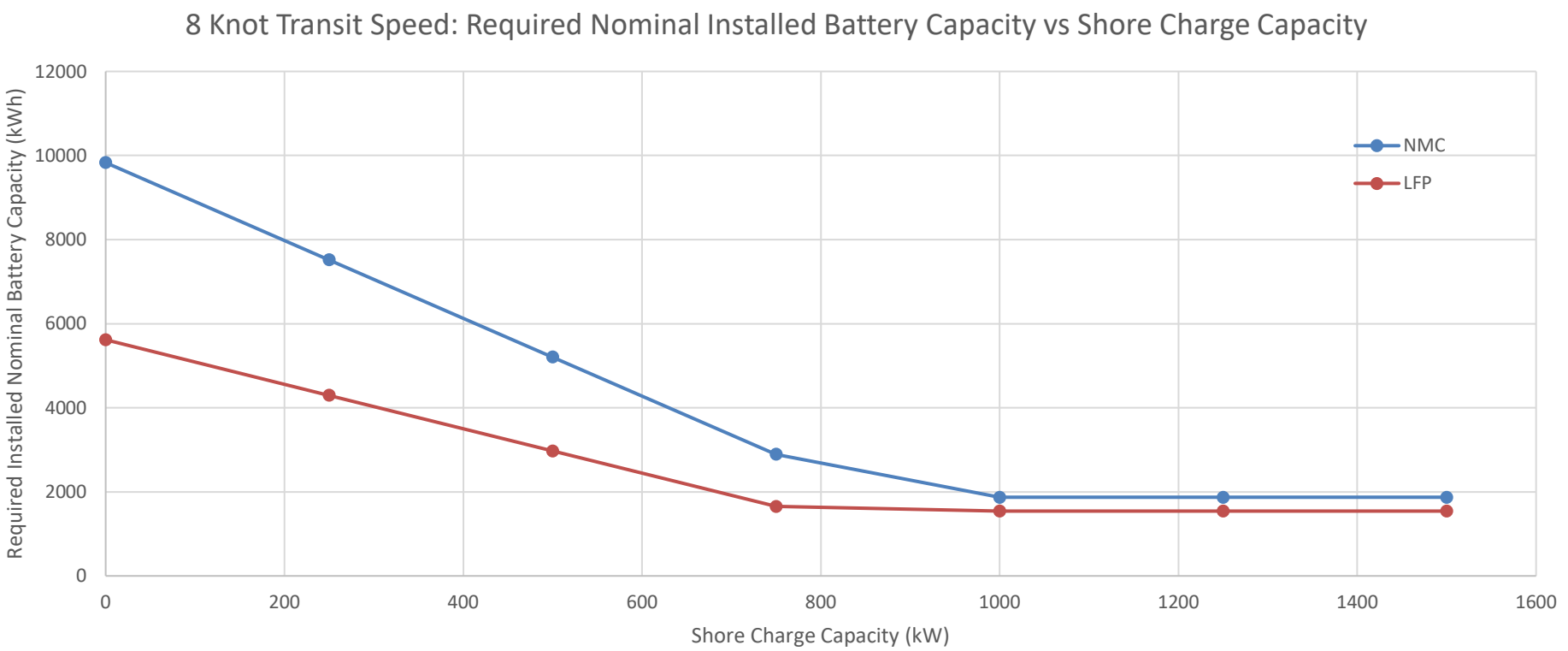
8 Knot Transit Speed: Battery Sizing and Required Shore Capacity

Trip Energy Requirements

At dock power requirements	30	ekW
Time to plug into shore power after arrival	1	min
Time to unplug shore power before departure	1	min
Reserve Energy (Usable) Required	100	kWh

	Transit Energy Usage (kWh)	Time at Dock (hrs)	Dock Energy Usage (kWh)	Time Available to Charge (hrs)
Trip A	648.7			
Between Trip A & B		0.62	18.5	0.58
Trip B	560.7			
Between Trip B & C		1.38	41.5	1.35
Trip C	351.9			
Between Trip C & D1		1.20	36.0	1.17
Trip D1	538.5			
Between Trip D1 & D2		0.15	4.5	0.12
Trip D2	538.5			
Between Trip D2 & D3		0.15	4.5	0.12
Trip D3	538.5			
Between Trip D3 & D4		0.40	12.0	0.37
Trip D4	538.5			
Total	**3715.2**	**3.90**	**117.0**	**3.70**



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8 Knot Transit: Speed Battery Sizing and Required Shore Capacity

NMC Battery and Shore Capacity Sizing

Shore Charge Rate (kW):	0	250	500	750	1000	1250	1500
Nominal Battery Capacity (kWh):	9830	7518	5205	2893	1872	1872	1872
Usable Battery Capacity (kWh):	3932	3007	2082	1157	749	749	749
Usable Energy Deficit (kWh):	100	-825	-1750	-2675	-3083	-3083	-3083
Battery Maximum Charge Rate (kW):	14746	11277	7808	4339	2808	2808	2808
Usable Battery Energy @ (kWh):							
Start Trip A	3932.2	3007.2	2082.2	1157.2	748.7	748.7	748.7
End Trip A	3283.5	2358.5	1433.5	508.5	100.0	100.0	100.0
Start Trip B	3265.0	2485.8	1706.6	927.5	664.8	810.7	956.5
End Trip B	2704.3	1925.1	1145.9	366.8	104.1	250.0	395.8
Start Trip C	2662.8	2221.1	1779.4	1337.8	1412.6	1896.0	2379.3
End Trip C	2310.9	1869.2	1427.5	985.9	1060.8	1544.1	2027.4
Start Trip D1	2274.9	2124.9	1974.9	1824.9	2191.4	2966.4	3741.4
End Trip D1	1736.4	1586.4	1436.4	1286.4	1653.0	2428.0	3203.0
Start Trip D2	1731.9	1611.1	1490.2	1369.4	1765.1	2569.3	3373.5
End Trip D2	1193.4	1072.6	951.8	830.9	1226.6	2030.8	2835.0
Start Trip D3	1188.9	1097.3	1005.6	913.9	1338.8	2172.1	3005.5
End Trip D3	650.5	558.8	467.1	375.5	800.3	1633.7	2467.0
Start Trip D4	638.5	638.5	638.5	638.5	1155.0	2080.0	3005.0
End Trip D4	100.0	100.0	100.0	100.0	616.5	1541.5	2466.5
Minimum Usable Battery Energy (kWh)	100.0	100.0	100.0	100.0	100.0	100.0	100.0

> Reserve Energy Requirement

LFP Battery and Shore Capacity Sizing

Shore Charge Rate (kW):	0	250	500	750	1000	1250	1500
Nominal Battery Capacity (kWh):	5617	4296	2975	1653	1542	1542	1542
Usable Battery Capacity (kWh):	3932	3007	2082	1157	1079	1079	1079
Usable Energy Deficit (kWh):	100	-825	-1750	-2675	-2753	-2753	-2753
Battery Maximum Charge Rate (kW):	2809	2148	1487	827	771	771	771
Usable Battery Energy @ (kWh):							
Start Trip A	3932.2	3007.2	2082.2	1157.2	1079.4	1079.4	1079.4
End Trip A	3283.5	2358.5	1433.5	508.5	430.7	430.7	430.7
Start Trip B	3265.0	2485.8	1706.6	927.5	862.0	862.0	862.0
End Trip B	2704.3	1925.1	1145.9	366.8	301.3	301.3	301.3
Start Trip C	2662.8	2221.1	1779.4	1337.8	1300.6	1300.6	1300.6
End Trip C	2310.9	1869.2	1427.5	985.9	948.8	948.8	948.8
Start Trip D1	2274.9	2124.9	1974.9	1824.9	1812.3	1812.3	1812.3
End Trip D1	1736.4	1586.4	1436.4	1286.4	1273.8	1273.8	1273.8
Start Trip D2	1731.9	1611.1	1490.2	1369.4	1359.3	1359.3	1359.3
End Trip D2	1193.4	1072.6	951.8	830.9	820.8	820.8	820.8
Start Trip D3	1188.9	1097.3	1005.6	913.9	906.2	906.2	906.2
End Trip D3	650.5	558.8	467.1	375.5	367.8	367.8	367.8
Start Trip D4	638.5	638.5	638.5	638.5	638.5	638.5	638.5
End Trip D4	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Minimum Usable Battery Energy (kWh)	100.0	100.0	100.0	100.0	100.0	100.0	100.0

> Reserve Energy Requirement

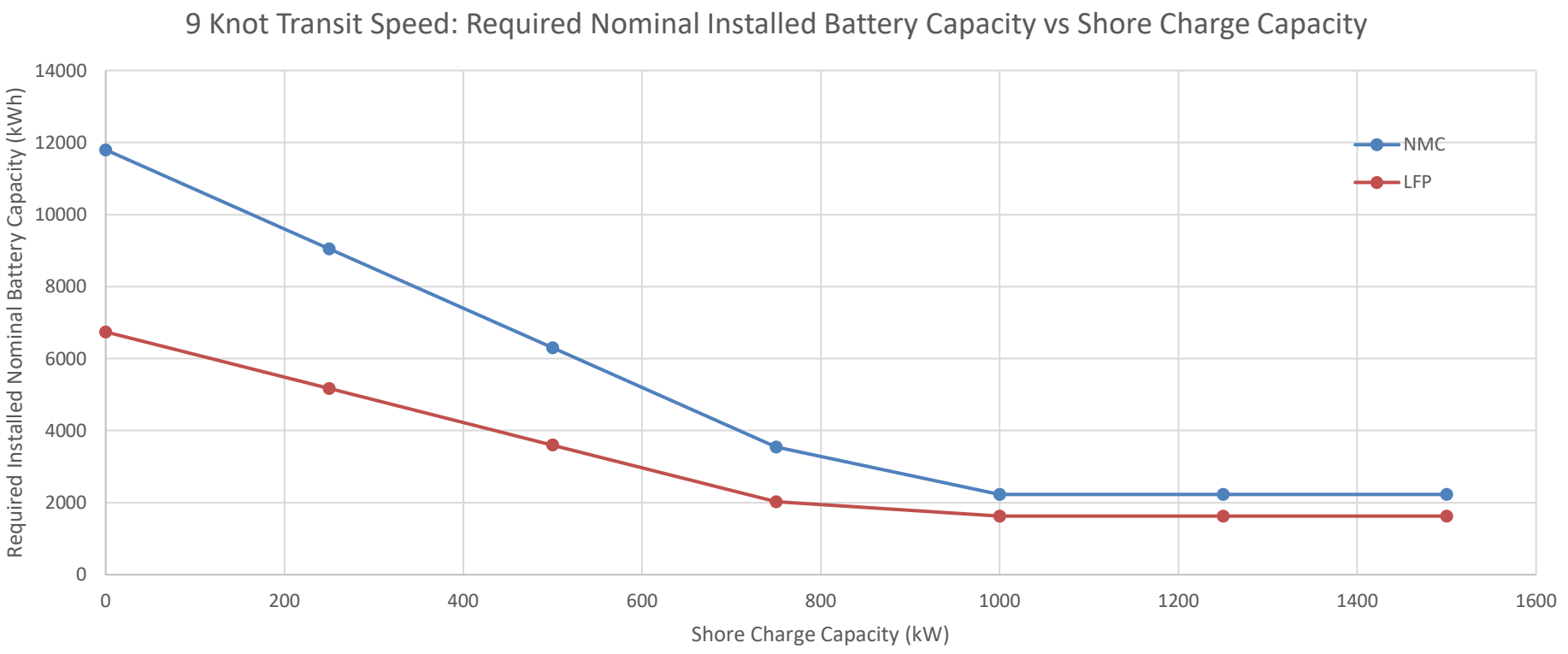
PROJECT:	23494	CASCO BAY LINES	Rev:	0	By:	MDL
CALC:	ALL ELECTRIC FERRY BATTERY SIZING CALCS: 9kt Transit Speed		Date:	30OCT25	Checked:	-

9 Knot Transit Speed: Battery Sizing and Required Shore Capacity

Trip Energy Requirements

At dock power requirements	30	ekW
Time to plug into shore power after arrival	1	min
Time to unplug shore power before departure	1	min
Reserve Energy (Usable) Required	100	kWh

	Transit Energy Usage (kWh)	Time at Dock (hrs)	Dock Energy Usage (kWh)	Time Available to Charge (hrs)
Trip A	791.4			
Between Trip A & B		0.85	25.5	0.82
Trip B	700.6			
Between Trip B & C		1.62	48.5	1.58
Trip C	418.9			
Between Trip C & D1		1.33	40.0	1.30
Trip D1	642.7			
Between Trip D1 & D2		0.18	5.5	0.15
Trip D2	642.7			
Between Trip D2 & D3		0.18	5.5	0.15
Trip D3	642.7			
Between Trip D3 & D4		0.43	13	0.40
Trip D4	642.7			
Total	**4481.6**	**4.60**	**138.0**	**4.40**



PROJECT:	23494	CASCO BAY LINES	Rev:	0	By:	MDL
CALC:	ALL ELECTRIC FERRY BATTERY SIZING CALCS: 9kt Transit Speed		Date:	30OCT25	Checked:	-

9 Knot Transit Speed: Battery Sizing and Required Shore Capacity

NMC Battery and Shore Capacity Sizing

Shore Charge Rate (kW):	0	250	500	750	1000	1250	1500
Nominal Battery Capacity (kWh):	11799	9049	6299	3549	2229	2229	2229
Usable Battery Capacity (kWh):	4720	3620	2520	1420	891	891	891
Usable Energy Deficit (kWh):	100	-1000	-2100	-3200	-3728	-3728	-3728
Battery Maximum Charge Rate (kW):	17699	13574	9449	5324	3343	3343	3343
Usable Battery Energy @ (kWh):							
Start Trip A	4719.6	3619.6	2519.6	1419.6	891.4	891.4	891.4
End Trip A	3928.2	2828.2	1728.2	628.2	100.0	100.0	100.0
Start Trip B	3902.7	3006.9	2111.1	1215.2	891.2	1095.3	1299.5
End Trip B	3202.1	2306.3	1410.5	514.6	190.5	394.7	598.9
Start Trip C	3153.6	2653.6	2153.6	1653.6	1725.4	2325.4	2925.4
End Trip C	2734.7	2234.7	1734.7	1234.7	1306.5	1906.5	2506.5
Start Trip D1	2694.7	2519.7	2344.7	2169.7	2566.5	3491.5	4416.5
End Trip D1	2052.1	1877.1	1702.1	1527.1	1923.8	2848.8	3773.8
Start Trip D2	2046.6	1909.1	1771.6	1634.1	2068.3	3030.8	3993.3
End Trip D2	1403.9	1266.4	1128.9	991.4	1425.6	2388.1	3350.6
Start Trip D3	1398.4	1298.4	1198.4	1098.4	1570.1	2570.1	3570.1
End Trip D3	755.7	655.7	555.7	455.7	927.4	1927.4	2927.4
Start Trip D4	742.7	742.7	742.7	742.7	1314.4	2414.4	3514.4
End Trip D4	100.0	100.0	100.0	100.0	671.8	1771.8	2871.8
Minimum Usable Battery Energy (kWh)	100.0	100.0	100.0	100.0	100.0	100.0	100.0

> Reserve Energy Requirement

LFP Battery and Shore Capacity Sizing

Shore Charge Rate (kW):	0	250	500	750	1000	1250	1500
Nominal Battery Capacity (kWh):	6742	5171	3599	2028	1627	1627	1627
Usable Battery Capacity (kWh):	4720	3620	2520	1420	1139	1139	1139
Usable Energy Deficit (kWh):	100	-1000	-2100	-3200	-3480	-3480	-3480
Battery Maximum Charge Rate (kW):	3371	2585	1800	1014	814	814	814
Usable Battery Energy @ (kWh):							
Start Trip A	4719.6	3619.6	2519.6	1419.6	1139.2	1139.2	1139.2
End Trip A	3928.2	2828.2	1728.2	628.2	347.8	347.8	347.8
Start Trip B	3902.7	3006.9	2111.1	1215.2	986.9	986.9	986.9
End Trip B	3202.1	2306.3	1410.5	514.6	286.2	286.2	286.2
Start Trip C	3153.6	2653.6	2153.6	1653.6	1526.2	1526.2	1526.2
End Trip C	2734.7	2234.7	1734.7	1234.7	1107.3	1107.3	1107.3
Start Trip D1	2694.7	2519.7	2344.7	2169.7	2125.1	2125.1	2125.1
End Trip D1	2052.1	1877.1	1702.1	1527.1	1482.4	1482.4	1482.4
Start Trip D2	2046.6	1909.1	1771.6	1634.1	1599.0	1599.0	1599.0
End Trip D2	1403.9	1266.4	1128.9	991.4	956.3	956.3	956.3
Start Trip D3	1398.4	1298.4	1198.4	1098.4	1072.9	1072.9	1072.9
End Trip D3	755.7	655.7	555.7	455.7	430.2	430.2	430.2
Start Trip D4	742.7	742.7	742.7	742.7	742.7	742.7	742.7
End Trip D4	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Minimum Usable Battery Energy (kWh)	100.0	100.0	100.0	100.0	100.0	100.0	100.0

> Reserve Energy Requirement

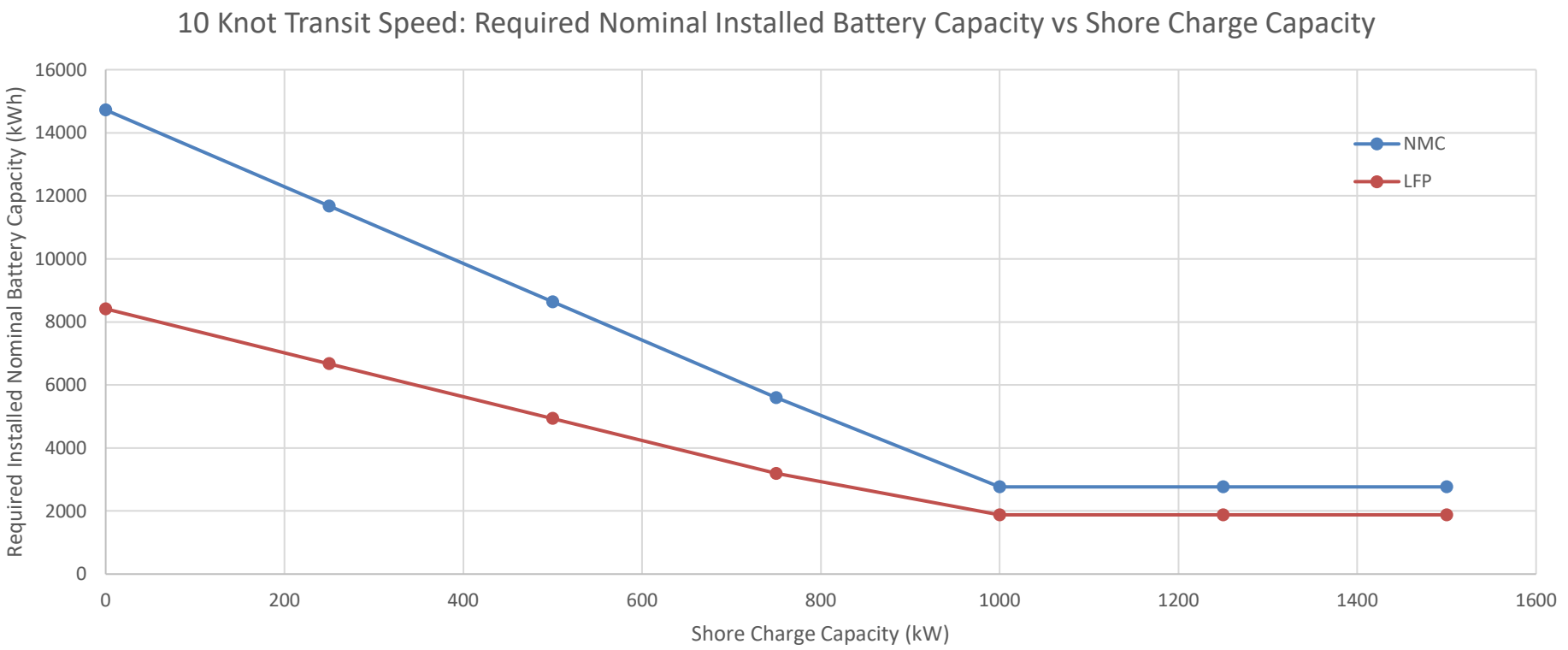
PROJECT:	23494	CASCO BAY LINES	Rev:	0	By:	MDL
CALC:	ALL ELECTRIC FERRY BATTERY SIZING CALCS: 10kt Transit Speed		Date:	30OCT25	Checked:	-

10 Knot Transit Speed: Battery Sizing and Required Shore Capacity

Trip Energy Requirements

At dock power requirements	30	ekW
Time to plug into shore power after arrival	1	min
Time to unplug shore power before departure	1	min
Reserve Energy (Usable) Required	100	kWh

	Transit Energy Usage (kWh)	Time at Dock (hrs)	Dock Energy Usage (kWh)	Time Available to Charge (hrs)
Trip A	1006.6			
Between Trip A & B		1.02	30.5	0.98
Trip B	911.6			
Between Trip B & C		1.80	54.0	1.77
Trip C	519.9			
Between Trip C & D1		1.40	42.0	1.37
Trip D1	799.8			
Between Trip D1 & D2		0.20	6.0	0.17
Trip D2	799.8			
Between Trip D2 & D3		0.20	6.0	0.17
Trip D3	799.8			
Between Trip D3 & D4		0.45	13.5	0.42
Trip D4	799.8			
Total	**5637.2**	**5.07**	**152.0**	**4.87**



PROJECT:	23494	CASCO BAY LINES	Rev:	0	By:	MDL
CALC:	ALL ELECTRIC FERRY BATTERY SIZING CALCS: 10kt Transit Speed		Date:	30OCT25	Checked:	-

10 Knot Transit Speed: Battery Sizing and Required Shore Capacity

NMC Battery and Shore Capacity Sizing

Shore Charge Rate (kW):	0	250	500	750	1000	1250	1500
Nominal Battery Capacity (kWh):	14723	11681	8640	5598	2766	2766	2766
Usable Battery Capacity (kWh):	5889	4673	3456	2239	1107	1107	1107
Usable Energy Deficit (kWh):	100	-1117	-2333	-3550	-4683	-4683	-4683
Battery Maximum Charge Rate (kW):	22085	17522	12960	8397	4150	4150	4150
Usable Battery Energy @ (kWh):							
Start Trip A	5889.2	4672.6	3455.9	2239.2	1106.6	1106.6	1106.6
End Trip A	4882.7	3666.0	2449.4	1232.7	100.0	100.0	100.0
Start Trip B	4852.2	3881.4	2910.5	1939.7	1052.8	1298.7	1544.5
End Trip B	3940.6	2969.8	1999.0	1028.1	141.3	387.1	632.9
Start Trip C	3886.6	3357.5	2828.3	2299.1	1853.9	2541.4	3228.9
End Trip C	3366.7	2837.6	2308.4	1779.2	1334.1	2021.6	2709.1
Start Trip D1	3324.7	3137.2	2949.7	2762.2	2658.7	3687.9	4717.1
End Trip D1	2524.9	2337.4	2149.9	1962.4	1858.9	2888.1	3917.2
Start Trip D2	2518.9	2373.1	2227.3	2081.4	2019.6	3090.4	4161.2
End Trip D2	1719.1	1573.3	1427.5	1281.6	1219.8	2290.6	3361.4
Start Trip D3	1713.1	1609.0	1504.8	1400.6	1380.4	2492.9	3605.4
End Trip D3	913.3	809.1	705.0	600.8	580.6	1693.1	2805.6
Start Trip D4	899.8	899.8	899.8	899.8	983.8	2200.5	3417.1
End Trip D4	100.0	100.0	100.0	100.0	184.0	1400.6	2617.3
Minimum Usable Battery Energy (kWh)	100.0	100.0	100.0	100.0	100.0	100.0	100.0

> Reserve Energy Requirement

LFP Battery and Shore Capacity Sizing

Shore Charge Rate (kW):	0	250	500	750	1000	1250	1500
Nominal Battery Capacity (kWh):	8413	6675	4937	3199	1880	1880	1880
Usable Battery Capacity (kWh):	5889	4673	3456	2239	1316	1316	1316
Usable Energy Deficit (kWh):	100	-1117	-2333	-3550	-4474	-4474	-4474
Battery Maximum Charge Rate (kW):	4207	3338	2469	1599	940	940	940
Usable Battery Energy @ (kWh):							
Start Trip A	5889.2	4672.6	3455.9	2239.2	1315.7	1315.7	1315.7
End Trip A	4882.7	3666.0	2449.4	1232.7	309.1	309.1	309.1
Start Trip B	4852.2	3881.4	2910.5	1939.7	1202.7	1202.7	1202.7
End Trip B	3940.6	2969.8	1999.0	1028.1	291.2	291.2	291.2
Start Trip C	3886.6	3357.5	2828.3	2299.1	1897.4	1897.4	1897.4
End Trip C	3366.7	2837.6	2308.4	1779.2	1377.6	1377.6	1377.6
Start Trip D1	3324.7	3137.2	2949.7	2762.2	2619.9	2619.9	2619.9
End Trip D1	2524.9	2337.4	2149.9	1962.4	1820.1	1820.1	1820.1
Start Trip D2	2518.9	2373.1	2227.3	2081.4	1970.7	1970.7	1970.7
End Trip D2	1719.1	1573.3	1427.5	1281.6	1170.9	1170.9	1170.9
Start Trip D3	1713.1	1609.0	1504.8	1400.6	1321.6	1321.6	1321.6
End Trip D3	913.3	809.1	705.0	600.8	521.7	521.7	521.7
Start Trip D4	899.8	899.8	899.8	899.8	899.8	899.8	899.8
End Trip D4	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Minimum Usable Battery Energy (kWh)	100.0	100.0	100.0	100.0	100.0	100.0	100.0

> Reserve Energy Requirement

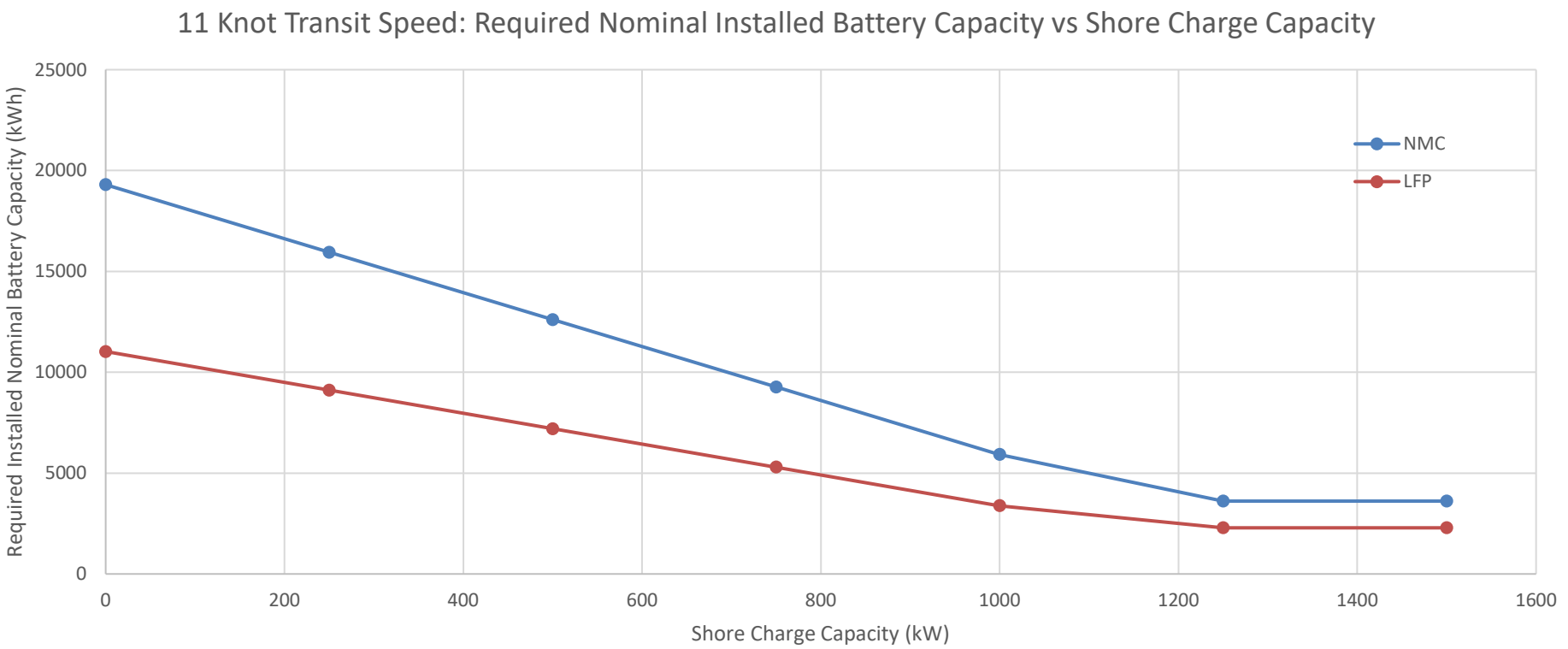
PROJECT:	23494	CASCO BAY LINES	Rev:	0	By:	MDL
CALC:	ALL ELECTRIC FERRY BATTERY SIZING CALCS: 11kt Transit Speed		Date:	30OCT25	Checked:	-

11 Knot Transit Speed: Battery Sizing and Required Shore Capacity

Trip Energy Requirements

At dock power requirements	30	ekW
Time to plug into shore power after arrival	1	min
Time to unplug shore power before departure	1	min
Reserve Energy (Usable) Required	100	kWh

	Transit Energy Usage (kWh)	Time at Dock (hrs)	Dock Energy Usage (kWh)	Time Available to Charge (hrs)
Trip A	1344.6			
Between Trip A & B		1.18	35.5	1.15
Trip B	1243.0			
Between Trip B & C		1.95	58.5	1.92
Trip C	678.6			
Between Trip C & D1		1.47	44.0	1.43
Trip D1	1046.7			
Between Trip D1 & D2		0.23	7.0	0.20
Trip D2	1046.7			
Between Trip D2 & D3		0.23	7.0	0.20
Trip D3	1046.7			
Between Trip D3 & D4		0.48	14.5	0.45
Trip D4	1046.7			
Total	**7452.9**	**5.55**	**166.5**	**5.35**



PROJECT:	23494	CASCO BAY LINES	Rev:	0	By:	MDL
CALC:	ALL ELECTRIC FERRY BATTERY SIZING CALCS: 11kt Transit Speed		Date:	30OCT25	Checked:	-

11 Knot Transit Speed: Battery Sizing and Required Shore Capacity

NMC Battery and Shore Capacity Sizing

Shore Charge Rate (kW):	0	250	500	750	1000	1250	1500
Nominal Battery Capacity (kWh):	19299	15955	12611	9267	5924	3612	3612
Usable Battery Capacity (kWh):	7719	6382	5044	3707	2369	1445	1445
Usable Energy Deficit (kWh):	100	-1238	-2575	-3913	-5250	-6175	-6175
Battery Maximum Charge Rate (kW):	28948	23932	18917	13901	8885	5417	5417
Usable Battery Energy @ (kWh):							
Start Trip A	7719.4	6381.9	5044.4	3706.9	2369.4	1444.6	1444.6
End Trip A	6374.8	5037.3	3699.8	2362.3	1024.8	100.0	100.0
Start Trip B	6339.3	5289.3	4239.3	3189.3	2139.3	1502.0	1789.5
End Trip B	5096.3	4046.3	2996.3	1946.3	896.3	259.0	546.5
Start Trip C	5037.8	4467.0	3896.2	3325.3	2754.5	2596.3	3363.0
End Trip C	4359.2	3788.4	3217.6	2646.7	2075.9	1917.7	2684.4
Start Trip D1	4315.2	4102.7	3890.2	3677.7	3465.2	3665.4	4790.4
End Trip D1	3268.6	3056.1	2843.6	2631.1	2418.6	2618.7	3743.7
Start Trip D2	3261.6	3099.1	2936.6	2774.1	2611.6	2861.7	4036.7
End Trip D2	2214.9	2052.4	1889.9	1727.4	1564.9	1815.0	2990.0
Start Trip D3	2207.9	2095.4	1982.9	1870.4	1757.9	2058.0	3283.0
End Trip D3	1161.2	1048.7	936.2	823.7	711.2	1011.4	2236.4
Start Trip D4	1146.7	1146.7	1146.7	1146.7	1146.7	1559.4	2896.9
End Trip D4	100.0	100.0	100.0	100.0	100.0	512.7	1850.2
Minimum Usable Battery Energy (kWh)	100.0	100.0	100.0	100.0	100.0	100.0	100.0

> Reserve Energy Requirement

LFP Battery and Shore Capacity Sizing

Shore Charge Rate (kW):	0	250	500	750	1000	1250	1500
Nominal Battery Capacity (kWh):	11028	9117	7206	5296	3385	2287	2287
Usable Battery Capacity (kWh):	7719	6382	5044	3707	2369	1601	1601
Usable Energy Deficit (kWh):	100	-1238	-2575	-3913	-5250	-6018	-6018
Battery Maximum Charge Rate (kW):	5514	4559	3603	2648	1692	1144	1144
Usable Battery Energy @ (kWh):							
Start Trip A	7719.4	6381.9	5044.4	3706.9	2369.4	1601.1	1601.1
End Trip A	6374.8	5037.3	3699.8	2362.3	1024.8	256.5	256.5
Start Trip B	6339.3	5289.3	4239.3	3189.3	2139.3	1536.1	1536.1
End Trip B	5096.3	4046.3	2996.3	1946.3	896.3	293.1	293.1
Start Trip C	5037.8	4467.0	3896.2	3325.3	2754.5	2426.6	2426.6
End Trip C	4359.2	3788.4	3217.6	2646.7	2075.9	1748.0	1748.0
Start Trip D1	4315.2	4102.7	3890.2	3677.7	3465.2	3343.2	3343.2
End Trip D1	3268.6	3056.1	2843.6	2631.1	2418.6	2296.5	2296.5
Start Trip D2	3261.6	3099.1	2936.6	2774.1	2611.6	2518.2	2518.2
End Trip D2	2214.9	2052.4	1889.9	1727.4	1564.9	1471.5	1471.5
Start Trip D3	2207.9	2095.4	1982.9	1870.4	1757.9	1693.2	1693.2
End Trip D3	1161.2	1048.7	936.2	823.7	711.2	646.6	646.6
Start Trip D4	1146.7	1146.7	1146.7	1146.7	1146.7	1146.7	1146.7
End Trip D4	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Minimum Usable Battery Energy (kWh)	100.0	100.0	100.0	100.0	100.0	100.0	100.0

> Reserve Energy Requirement