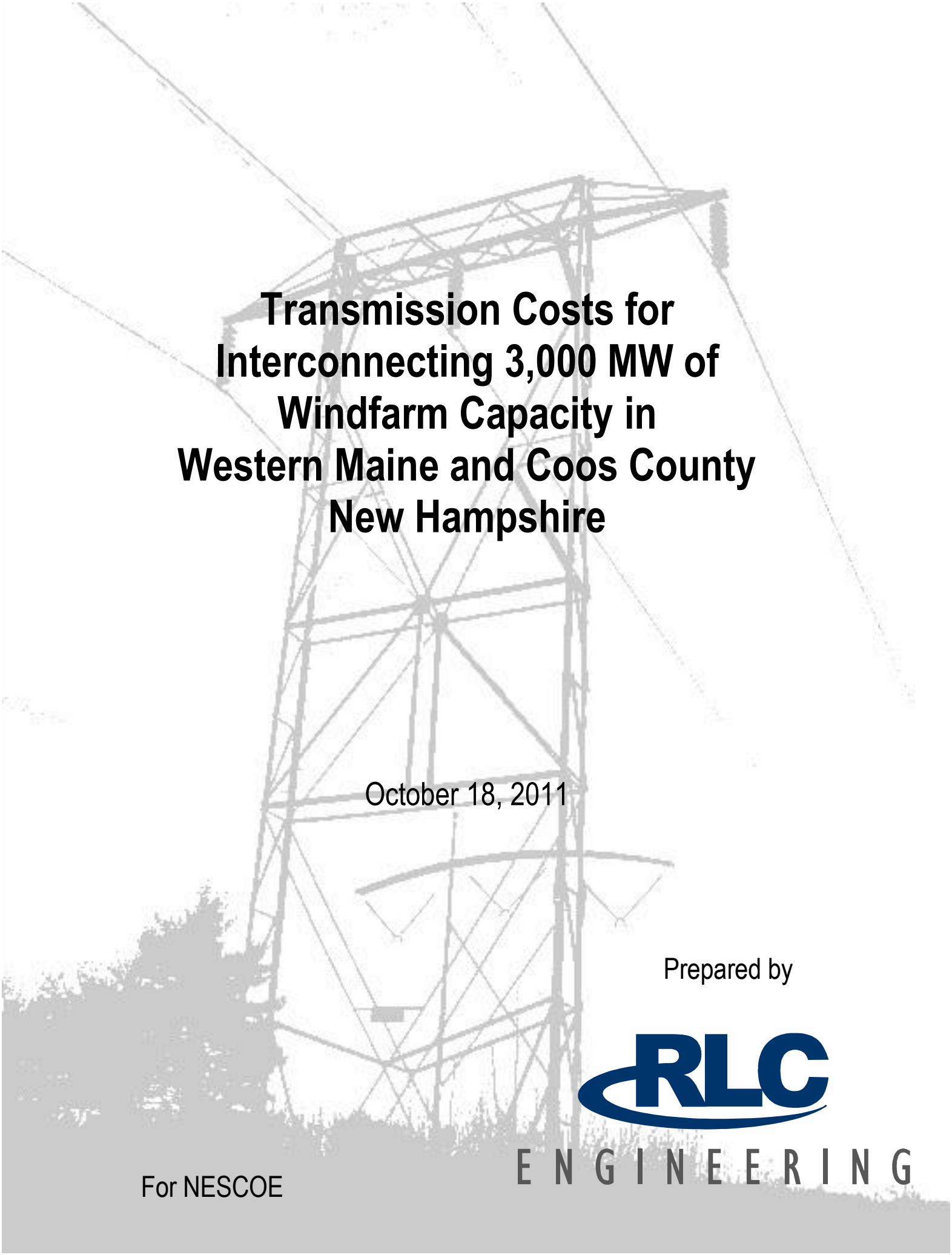

Transmission Costs for Interconnecting 3,000 MW of Windfarm Capacity in Western Maine and Coos County New Hampshire

October 18, 2011

Prepared by

RLC ENGINEERING

For NESCOE

Transmission Costs for Interconnecting 3,000 MW of Windfarm Capacity

in Western Maine and Coos County New Hampshire

CONTENTS

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CONCLUSIONS

The addition of up to 2,000 MW of new wind generation in the Wyman Hydro and Rumford areas of western Maine and up to an additional 1,000 MW in Coos County, NH requires the addition of significant transmission infrastructure. The estimated cost of the transmission required to move the western Maine energy to the coastal Maine area and the Coos County energy to northeastern Massachusetts is shown in Table 1.

	Wyman Hydro Area			Rumford Area			Coos County Area			Total		
Year	Cumul. Cap. MW	Cumul. Constr. Costs	Cumul. Annual Rev. Rqmt.	Cumul. Cap. MW	Cumul. Constr. Costs	Cumul. Annual Rev. Rqmt.	Cumul. Cap. MW	Cumul. Constr. Costs	Cumul. Annual Rev. Rqmt.	Cumul. Cap. MW	Cumul. Constr. Costs	Cumul. Annual Rev. Rqmt.
2016	296	315	50	-	-	-	300	216	35	596	531	85
2018	1,123	641	103	-	-	-	300	216	35	1,423	857	137
2019	1,123	641	103	250	105	17	300	216	35	1,673	962	154
2021	1,123	641	103	500	407	65	1,000	1,683	269	2,623	2,731	437
2022	1,623	828	132	500	407	65	1,000	1,683	269	3,123	2,918	467

Table 1. Construction Costs for New Transmission Capacity, Millions of 2016 Dollars

The transmission facilities whose costs are included in Table 1 would NOT increase transfer capability from coastal Maine to load centers farther to the south. Thus, if new renewable energy from western Maine cannot be consumed by load in Maine or displace existing generating resources, then additional transmission resources would be needed to move that energy south. One way to move large amounts of power from coastal Maine to load centers to the south would be an undersea DC cable from Wiscasset, Maine to Salem Harbor, Massachusetts. Indicative costs for such a cable, including converter stations on both ends, are shown in Table 2.

	600 MW Cable & Converter Stations	800 MW Cable & Converter Stations
Installation Cost	1,600	1,900
Annual Revenue Requirement	256	304

Table 2. Estimated Construction Costs for Undersea DC Cable, Millions of 2016 Dollars

BACKGROUND / OBJECTIVES

NESCOE retained RLC Engineering (RLC) to identify transmission elements that could be necessary to interconnect large amounts of renewable generation in the northern Maine and Coos County, New Hampshire regions. Subsequently, NESCOE advised RLC to focus on Coos County and the western portion of northern Maine and to consider a staged approach for construction. Based on preliminary transmission options developed by RLC, NESCOE advised RLC to provide cost estimates for transmission facilities necessary to interconnect up to 1,000 MW of new renewable generation in Coos County and up to 2,000 MW of new wind capacity in western Maine.

NESCOE also advised RLC for the western Maine area to initially identify only transmission elements necessary to deliver the incremental energy to coastal Maine. This would allow incremental wind energy from those areas to compete with other generation located throughout Maine, but would not increase the overall transfer capacity between Maine and the rest of New England.

To identify the cost of transmission facilities that could be used to move incremental energy from coastal Maine to southern New England load centers, NESCOE requested that RLC separately estimate the cost of a 600 to 800 MW DC connection between Wiscasset, Maine and Salem Harbor, Massachusetts.

Similarly, the Coos County upgrades would allow incremental generation in that region to compete with generation in the "southern NH / northern MA" area but would not increase transfer capacity to load centers farther south.

STUDY APPROACH

RLC reviewed public documents and prior studies to determine current export capabilities and plans for increases to that capability in the study areas. RLC used the general guideline that a 345 kV transmission line can provide 500 MW of transfer capability. RLC also used the general guideline that the loss of a transmission line should not result in the need to drop generation. However, no load flow simulations were performed to determine if any reliability criteria would be violated with the addition of the proposed transmission facilities. This is not a system impact study. Rather, it is intended to provide indicative representations of the costs that might be involved in connecting large amounts of wind generation in western Maine and Coos County. Alternative interconnection configurations were not analyzed and it is possible that more effective solutions could be found. Transmission Operators have had no input in the development of these configurations and estimates. Therefore, operational concerns may exist that have not been addressed here. Nevertheless, the information presented here should help inform decisions related to the total economics of interconnecting a large amount of new wind generation.

POSSIBLE GENERATION LOCATIONS

There are many possible siting combinations for new wind resources in western Maine and Coos County, New Hampshire. However, the following points led NESCOE to direct RLC to provide cost estimates for the transmission additions shown in Table 3:

- Limit Wyman Hydro area new generation to about 1,500 MW to keep the number of 345 kV lines to three or fewer. Note that the" Western Maine Renewable Integration " study showed increased capacity of 1,123 MW. Thus, with the assumed addition of another 500 MW from a third 345 kV line, the total capability increase referenced here is 1,623 MW.
- Limit the Rumford area new generation to 500 MW to keep the number of lines from the north into Larrabee Road at two.
- Limit Coos County area new generation to 1,000 MW or less to keep the number of 345 kV lines less than or equal to 2.

	Wyman Area MW	Rumford Area MW	Coos Area MW	Total Annual MW	Cumulative MW
2016	296	0	300	596	596
2018	827	0	0	827	1,423
2019	0	250	0	250	1,673
2021	0	250	700	950	2,623
2022	500	0	0	500	3,123
Total	1,623	500	1000	3,123	

Table 3. Annual Additions of New Transmission Capacity

TRANSMISSION FOR 1,000 MW FROM WYMAN HYDRO AREA

The Western Maine Renewable Integration study, dated February 18, 2011 and performed by RLC Engineering for Central Maine Power Company in MPUC Docket 2010-180, identified a list of upgrades that would be required to gain up to an additional 1,123 MW in export capability from the Wyman Hydro area. A summary of that report was presented to ISO-New England's Planning Advisory Committee on April 14, 2011 and may be found at http://www.iso-ne.com/committees/comm_wkgrps/prtcpnts_comm/pac/mtrls/2011/apr142011/cmp_submission_to_nescoe.pdf. These facilities are assumed to meet the needs for the first 1,000 MW of new transmission capacity envisioned in this study. To avoid confusion with figures from that earlier study, the 1,123 MW amount is used throughout the remainder of this report rather than 1,000 MW. This was referred to as the "ultimate build out" and included two new 345 kV paths out of Wyman Hydro and several auto transformers at Wyman Hydro. That study also identified a staged approach for expanding the transmission system. Two significant steps in that staged approach include one that can be accomplished at the 115 kV level and another that encompasses the entire project. The 115 kV step would build some facilities to 345 kV standards but operate them at 115 kV until other facilities are constructed. That step would increase transfer capability by 296 MW at a cost of $272 million expressed

in 2011 dollars. The entire project would have a cost of $553 million expressed in 2011 dollars. This build out did NOT include upgrades to move the power south of Surowiec Substation and the coastal Maine area, however.

TRANSMISSION FOR AN ADDITIONAL 1,000 MW FROM WESTERN MAINE

Considering that wind facilities for an additional 1,000 MW of new wind capacity in western Maine would likely be geographically diverse beyond the Wyman Hydro Area, it was decided to identify facilities necessary to connect an additional 500 MW in the Wyman Hydro area and 500 MW in the Rumford area. This could be accommodated with a third 345 kV line from Wyman Hydro to Larrabee Road and two 345 kV lines from a new Rumford 345 kV substation to a new substation in Livermore Falls and on to Larrabee Road Substation. The Rumford portion of this expansion could also be staged as explained below.

Central Maine Power Company is currently heavily engaged in constructing facilities associated with the Maine Power Reliability Program. Therefore, it is unlikely that they would be able to construct facilities beyond the early stages of those identified in the Western Maine Renewable Integration study by 2016. That leads to a possible phased construction path as outlined here:

- Phase 1 – 2016 – Appendix 1 Page 1 - Construct two new 345 kV paths out of Wyman Hydro, one to Detroit and the other to Larrabee Road, but operate them at 115 kV. This would increase transfer capability by 296 MW.
- Phase 2 – 2018 – Appendix 1 Page 1 - Convert the Phase 1 facilities to 345 kV. Upgrade or build new 345 kV substations at Wyman Hydro, Detroit, and Larrabee Road. This is the "ultimate build out" plan described in the Western Maine Renewable Integration study with a total increase in transfer capability of 1,123 MW.
- Phase 3 – 2019 – Appendix 1 Page 2 - Construct a new 115 kV collection station in Rumford and a 345 kV transmission line, operated at 115 kV, from that substation to Livermore Falls. This would increase transfer capability by 250 MW.
- Phase 4 – 2021 – Appendix 1 Page 3 - Construct a second 345 kV transmission line from Rumford to Livermore Falls and convert the previously built line to operate at 345 kV. Build a 115 to 345 kV substation in Rumford and a 345 kV substation in Livermore Falls. Tie the 345 kV line between Wyman Hydro and Larrabee Road into Livermore Falls. Construct a new 345 kV line from Livermore Falls to Larrabee Road and continuing on to Surowiec. This would increase transfer capability by 250 MW.
- Phase 5– 2022 – Appendix 1 Page 4 - Expand the collector substation at Wyman Hydro and construct a third 345 kV line out of Wyman Hydro to the Livermore Falls substation. This would increase transfer capability by 500 MW.

Construction cost estimates for the western Maine area, described more fully below, are included on pages 1-4 of Appendix 1.

COOS COUNTY WIND

The Coos County Loop currently consists of two 115 kV lines with an export capability of 150-175 MW. In order to export large quantities of renewable generation, up to 1,000 MW, transmission upgrades would be required. This could be accomplished in two phases:

- Phase 1 – 2016 – Appendix 1 Page 5 - Construct a high voltage "gathering systems" in the Coos region to collect the energy from approximately 300 MW of new generation in that area, and deliver the energy from those units to the Moore/Comerford region. This system could be built to 345 kV standards but initially operated at 115 kV until new capacity grows beyond the capability of the 115 kV system. That energy would then be transmitted over the existing 230 kV transmission lines from Moore/Comerford to New England loads. No upgrade to the 230 kV transmission from the Moore/Comerford region would be needed for this phase.
- Phase 2 – 2021 – Appendix 1 Page 6 - Convert the gathering system constructed in Phase 1 to 345 kV and expand it to two lines. Build two 345 kV lines along existing 115 kV rights-of-way from Littleton through Woodstock and Ashland to a new Merrimack 345 kV substation and on to a new Dunbarton 345 kV substation. Upgrade the two existing 230 kV lines from Dunbarton to Tewksbury to 345 kV. This system, including Phase 1 and Phase 2 facilities, would have the capability of delivering 1,000 MW of new capacity to the Tewksbury area.

Construction cost estimates for the Coos County area, described more fully below, are included on pages 5 and 6 of Appendix 1.

CONSTRUCTION COST ESTIMATES

RLC developed "Order of Magnitude" cost estimates for the facilities identified above. ISO-New England's Attachment D to Planning Procedure 4 defines this level of cost estimate applicable for projects that have a level of definition from 0% to 15% and with an accuracy range of -50% to +200%. That is consistent with the estimates developed by RLC for this study. The estimates were assembled using assumed unit costs; dollars per mile for transmission lines and dollars per major component for substation improvements. A 25% markup was applied for overheads, engineering and permitting and then a 30% allowance was added for contingency. Contingency here is for expected expenditures that are not specifically identified. It is not intended to be an allowance for uncertainties in material or labor costs or significant obstacles to construction that may be encountered. An adder of 10% was applied as an allowance for funds used during construction (AFUDC). Estimates were developed in 2011 dollars and escalated to 2016 at 3.0% per year. Real estate costs have not been included because most of the transmission line work identified would be on existing rights-of-way. No reconnaissance was performed to determine if additional real estate would be required.

The estimates for the Wyman Hydro Area phase 1 and phase 2 additions are from the February 18, 2011 report "CMP Western Maine Renewable Integration Study", escalated from 2011 to 2016 at 3% per year. Estimates for all other transmission system additions are shown in Appendix 1. Summaries of costs for the various phases of construction are shown in Tables 4 and 5.

Western Maine Construction Phases					
Phase	Added Line Capacity MW	Miles of New or Rebuilt 345 kV Lines	Miles of New or Rebuilt 115 kV Lines	Number of New 345/115 kV Transformers	Cost in 2016 Dollars, Millions
1 – Wyman Area	296	0	115	0	315
2 – Wyman Area	827	104	0	3	326
3 – Rumford Area	250	23	0	0	105
4 – Rumford Area	250	63	0	2	302
5 – Wyman Area	500	47	0	1	187

Table 4. Summary Costs for Western Maine Construction

Coos County Construction Phases					
Phase	Added Line Capacity MW	Miles of New or Rebuilt 345 kV Lines	Miles of New or Rebuilt 115 kV Lines	Number of New 345/230 kV or 345/115 kV Transformers	Cost in 2016 Dollars, Millions
1	300	55	0	1	216
2	700	331	0	7	1,467

Table 5. Summary Costs for Coos County Construction

Table 6 shows the various construction phases allocated to possible years that the projects might be placed in service. The staging of the construction could be moved to different years to best match expected availability of new sources of renewable generation. The particular sequence shown here is merely illustrative.

	Wyman Hydro Area			Rumford Area			Coos County Area			Total		
	MW	Million $	$/kW	MW	Million $	$/kW	MW	Million $	$/kW	MW	Million $	$/kW
2016	296	315	1,064	-			300	216	720	596	531	891
2018	827	326	394	-			-			827	326	394
2019	-			250	105	420	-			250	105	420
2021	-			250	302	1,208	700	1,467	2,096	950	1,769	1,862
2022	500	187	374	-			-			500	187	374
Total	1,623	828	510	500	407	814	1,000	1,683	1,683	3,123	2,918	934

Table 6. Estimated Construction Costs for New Transmission Capacity, 2016 dollars

REVENUE REQUIREMENT ANALYSIS

RLC assumed that transmission facilities built to accommodate the addition of large amounts of wind energy would be cost-of-service facilities for which revenues would likely to be regulated by FERC. Therefore, RLC calculated revenue requirements for the facilities identified above consistent with FERC revenue requirement rules. Nevertheless, there is still uncertainty as to just what those revenue requirements might be. It is impossible to accurately predict what the cost of funds will be, what local taxes will be, what the inflation rate will be, or what the cost of operation and maintenance will be. However, sensitivity to these parameters can be performed to develop a plausible range of carrying charge rates to apply to construction costs. This range is small compared to the accuracy range of the cost estimates underlying the revenue requirement calculations. RLC recommends that a 20-year levelized annual carrying charge rate of 16% be applied to new transmission construction costs in order to determine annual revenue requirements. This compares to a forecast of annual rates of 12% to 21% for regional network service for years 2011-2015 shown on slide 7 of the PTO AC – Rates Working Group presentation at the July 26-27, 2011 NEPOOL Reliability/Transmission Committee meeting. The calculation of the 16% rate, along with the assumptions underlying it, is shown in Appendix 2. This 16% rate results in the annual revenue requirements shown in Table 7 for the transmission facilities described above.

	Wyman Hydro Area			Rumford Area			Coos County Area			Total		
Year	Cumul. Cap. MW	Cumul. Constr. Costs	Cumul. Annual Rev. Rqmt.	Cumul. Cap. MW	Cumul. Constr. Costs	Cumul. Annual Rev. Rqmt.	Cumul. Cap. MW	Cumul. Constr. Costs	Cumul. Annual Rev. Rqmt.	Cumul. Cap. MW	Cumul. Constr. Costs	Cumul. Annual Rev. Rqmt.
2016	296	315	50	-	-	-	300	216	35	596	531	85
2018	1,123	641	103	-	-	-	300	216	35	1,423	857	137
2019	1,123	641	103	250	105	17	300	216	35	1,673	962	154
2021	1,123	641	103	500	407	65	1,000	1,683	269	2,623	2,731	437
2022	1,623	828	132	500	407	65	1,000	1,683	269	3,123	2,918	467

Table 7. Estimated Cumulative Annual Revenue Requirements, Millions of 2016 Dollars

MOVING POWER OUT OF MAINE

It is not clear what additional transmission capacity might be necessary or desirable to move increased wind energy from Maine to load centers farther south. Facilities being added with the Maine Power Reliability Project may increase existing transfer capabilities. Thermal units in Maine may either retire or otherwise be displaced by wind generation in Maine. Market conditions or operating agreements might allow storage capabilities at Wyman Hydro or Harris Hydro to be coordinated with wind availability. Other storage devices, either on the bulk system or distributed with load, might prove economical. Curtailment of wind generation during some periods might be economical when compared to the cost of transmission facilities required to avoid that curtailment. Due to stability concerns, new AC lines do not necessarily increase transfer capability out of Maine equivalent to the thermal capacity of the lines. Given these uncertainties, NESCOE did not ask RLC to develop a transmission configuration

that would be capable of moving an additional 2,000 MW of capacity out of Maine. Rather, NESCOE requested that RLC develop indicative cost estimates for installing an undersea DC cable with 600 to 800 MW of capacity from Wiscasset, Maine to Salem Harbor, Massachusetts, to serve as an illustrative example of the costs of one type of upgrade that could move significant quantities of energy from Maine to major load centers. Table 6 shows a summary of those cost estimates and more detail is provided in Appendix 3.

	600 MW Cable & Converter Stations	800 MW Cable & Converter Stations
Installation Cost	1,600	1,900
Annual Revenue Requirement	256	304

Table 8. Estimated Construction Costs for Undersea Cable, Millions of 2016 Dollars

APPENDIX 1

WESTERN MAINE WIND: PHASE #1

(Wyman: 296 MW)

Total in 2011 Dollars		$272,000,000	Note 1
Annual Escalation Rate	3.0%		
Year to Escalate to	2016		
Total Escalated Cost in Given Year, Rounded to Millions		$315,000,000	

WESTERN MAINE WIND: PHASE #2

(Wyman: 1123 MW)

Total in 2011 Dollars		$281,000,000	Note 2
Annual Escalation Rate	3.0%		
Year to Escalate to	2016		
Total Escalated Cost in Given Year, Rounded to Millions		$326,000,000	

Note 1: From PAC Presentation April 14, 2011, 115 kV upgrades only.
Note 2: From PAC Presentation April 14, 2011, Total cost for full build out of $553 million less $272 million for phase 1.

APPENDIX 1

WESTERN MAINE WIND: PHASE #3

(Rumford: 250 MW)

Substations		
Collection Substation		
• Site Development – New 115 kV Subtation		$1,200,000
• Six 115 kV Line Terminations - 1.5 Breaker Configuration		$10,800,000
Livermore Falls Substation		
• Site Development – Expansion 115 kV Subtation		$250,000
• One 115 kV Line Termination - 1.5 Breaker Configuration		$1,800,000
345 kV Transmission Lines		
• Collection Sub to Livermore Sub - New: 2x1590 (23 mi.)		$36,800,000
Sub-Total		$50,850,000
Overheads, Engineering, Permitting (25%)		$12,712,500
Contingency (30%)		$19,068,750
AFUDC (10%)		$8,263,125
Total in 2011 Dollars		$90,894,375
Annual Escalation Rate	3.0%	
Year to Escalate to	2016	
Total Escalated Cost in Given Year, Rounded to Millions		$105,000,000

APPENDIX 1

WESTERN MAINE WIND: PHASE #4

(Rumford: 500 MW)

Substations		
Collection Substation		
• Site Development – New 345 & 115 kV Substation		$1,200,000
• Four 345 kV Line Terminations - 1.5 Breaker Configuration		$9,000,000
• Two 115 kV Line Terminations - Transformer Configuration		$2,400,000
• Two 345/115 kV Transformers		$13,200,000
Larrabee Road Substation		
• Site Development – Expansion 345 & 115 kV Substation		$250,000
• Two 345 kV Line Terminations - 2 Breaker Confiuration		$6,000,000
Livermore Falls Substation		
• Site Development – New 345 kV Substation		$1,200,000
• Five 345 kV Line Terminations - 1.5 Breaker Configuration		$11,250,000
345 kV Transmission Lines		
• Livermore Falls Sub to Larrabee Sub - New: 2x1590 (24.1 mi.)		$38,560,000
• Livermore Falls Sub to Collection Sub - New: 2x1590 (23 mi.)		$36,800,000
• Larrabee Sub to Surowiec - New: 2x1590 (16.1 mi.)		$25,760,000
Sub-Total		$145,620,000
Overheads, Engineering, Permitting (25%)		$36,405,000
Contingency (30%)		$54,607,500
AFUDC (10%)		$23,663,250
Total in 2011 Dollars		$260,295,750
Annual Escalation Rate	3.0%	
Year to Escalate to	2016	
Total Escalated Cost in Given Year, Rounded to Millions		$302,000,000

APPENDIX 1

WESTERN MAINE WIND: PHASE #5

(Wyman: 1623 MW)

Substations		
Wyman Substation		
• Site Development – Expansion 345 kV Substation		$250,000
• Two 345 kV Line Terminations - 1.5 Breaker Configuration		$4,500,000
• One 115 kV Line Termination - Transformer Configuration		$1,200,000
• One 345/115 kV Transformer		$6,600,000
Livermore Falls Substation		
• Site Development – Expansion 345 kV Substation		$250,000
• One 345 kV Line Termination - 1.5 Breaker Configuration		$2,250,000
345 kV Transmission Lines		
• Wyman Sub to Livermore Sub - New: 2x1590 (47 mi.)		$75,200,000
Sub-Total		$90,250,000
Overheads, Engineering, Permitting (25%)		$22,562,500
Contingency (30%)		$33,843,750
AFUDC (10%)		$14,665,625
Total in 2011 Dollars		$161,321,875
Annual Escalation Rate	3.0%	
Year to Escalate to	2016	
Total Escalated Cost in Given Year, Rounded to Millions		$187,000,000

APPENDIX 1

COOS COUNTY WIND: PHASE #1

(Coos: 300 MW)

Substations		
Littleton Substation		
• Site Development – Rebuild 230 kV Substation		$1,250,000
• Four 230 kV Line Terminations - 1.5 Breaker Configuration		$7,800,000
• One 115 kV Line Termination - Transformer Configuration		$1,200,000
• One 230/115 kV Transformer		$5,800,000
345 kV Transmission Lines		
• Littleton Sub to Wind Farms - New: 2x1590 ACSR (55 mi.)		$88,000,000
Sub-Total		$104,050,000
Overheads, Engineering, Permitting (25%)		$26,012,500
Contingency (30%)		$39,018,750
AFUDC (10%)		$16,908,125
Total in 2011 Dollars		$185,989,375
Annual Escalation Rate	3.0%	
Year to Escalate to	2016	
Total Escalated Cost in Given Year, Rounded to Millions		$216,000,000

APPENDIX 1

COOS COUNTY WIND: PHASE #2

(Coos: 1000 MW)

Substations		
Collection Substation		
• Site Development – New 345 & 115 kV Substation		$1,200,000
• Four 345 kV Line Terminations - 1.5 Breaker Configuration		$9,000,000
• Two 115 kV Line Terminations - Transformer Configuration		$2,400,000
• Two 345/115 kV Transformers		$13,200,000
Merrimack 345 Substation		
• Site Development – Rebuild 345 & 115 kV Substation		$1,250,000
• Five 345 kV Line Terminations - 1.5 Breaker Configuration		$11,250,000
Dunbarton 345 Substation		
• Site Development – Build new 345 & 230 kV Substation		$1,250,000
• Six 345 kV Line Terminations - 1.5 Breaker Configuration		$13,500,000
• Two 230 kV Line Terminations - Transformer Configuration		$2,600,000
• Two 345/230 kV Transformers		$15,000,000
Dunbarton 230 Substation		
• Site Development – Build new 230 kV Substation		$1,250,000
• Four 230 kV Line Terminations - 1.5 Breaker Configuration		$7,800,000
North Litchfield Substation		
• Site Development – Rebuild 345 & 13.8 kV Substation		$1,250,000
• Six 345 kV Line Terminations - 1.5 Breaker Configuration		$13,500,000
• Two 13.8 kV Line Terminations - Transformer Configuration		$1,200,000
• Two 345/13.8 kV Transformers		$5,000,000
Tewksbury Substation		
• Site Development – Rebuild 345 & 115 kV Substation		$1,250,000
• Five 345 kV Line Terminations - 1.5 Breaker Configuration		$11,250,000
• Three 115 kV Line Terminations - Transformer Configuration		$3,600,000
• Three 345/115 kV Transformers		$19,800,000
345 kV Transmission Lines		
• Collection 345 Sub to Merrimack 345 Sub - New: 1 - 2x1590 (150 mi.)		$240,000,000
• Littleton Sub to Merrimack 345 Sub - New: 1 - 2x1590 (95 mi.)		$152,000,000
• Merrimack 345 Sub to Dunbarton 345 Sub - New: 2 - 2x1590 (8 mi.)		$25,600,000
• Dunbarton 345 Sub to N Litchfield Sub - Rebuild: 2 - 2x1590 (13 mi.)		$57,200,000
• N Litchfield Sub to Tewksbury Sub - Rebuild: 2- 2x1590 (22 mi.)		$96,800,000
Sub-Total		$708,150,000.00
Overheads, Engineering, Permitting (25%)		$177,037,500
Contingency (30%)		$265,556,250
AFUDC (10%)		$115,074,375
Total in 2011 Dollars		$1,265,818,125
Annual Escalation Rate	3.0%	
Year to Escalate to	2016	
Total Escalated Cost in Given Year, Rounded to Millions		$1,467,000,000

Regulated Utility Revenue Requirements Calculations

RLC Engineering **Appendix 2**

ASSUMPTIONS:
- Use beginning-year in-service convention
- Assume book basis = tax basis
- Ignore AFUDC tax effects

Construction Costs	
Gross Plant in-service	100.0
Year in Service	2011
Book life, years	40

Expenses as a Portion of Gross Plant	1st year	escalation
Operating expense	1.00%	3.0%
Maintenance expense	1.00%	3.0%
Property tax	1.50%	1.0%

Capital Structure	Portion	Rate
Short Term Debt	5.0%	4.00%
Long Term Debt	45.0%	6.00%
Preferred Stock	10.0%	7.00%
Common Equity	40.0%	13.00%
	100.0%	

Income Tax Rates	
Federal	35.00%
State	8.50%
Composite	40.53%

Tax depreciation rate, 15 year MACRS	5.00%	9.50%	8.55%	7.70%	6.93%	6.23%	5.90%	5.90%	5.91%	5.90%	5.91%	5.90%	5.91%	5.90%	5.91%	2.95%

SUMMARY RESULTS

NPV at Given Discount Rate	8.00%	10.00%	12.00%
10 year	$114.41	$105.21	$97.14
20 year	$154.55	$135.90	$120.78
30 year	$154.55	$135.90	$120.78

Levelized Revenue Requirement	8.00%	10.00%	12.00%
10 year	17.1%	17.1%	17.2%
20 year	15.7%	**16.0%**	16.2%
30 year	13.7%	14.4%	15.0%

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
REVENUE REQUIREMENTS																				
Other operating expenses	1.00	1.03	1.06	1.09	1.13	1.16	1.19	1.23	1.27	1.30	1.34	1.38	1.43	1.47	1.51	1.56	1.60	1.65	1.70	1.75
Maintenance	1.00	1.03	1.06	1.09	1.13	1.16	1.19	1.23	1.27	1.30	1.34	1.38	1.43	1.47	1.51	1.56	1.60	1.65	1.70	1.75
Book depreciation	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Property taxes	1.50	1.52	1.53	1.55	1.56	1.58	1.59	1.61	1.62	1.64	1.66	1.67	1.69	1.71	1.72	1.74	1.76	1.78	1.79	1.81
Interest Expense	2.85	2.72	2.57	2.43	2.30	2.18	2.07	1.96	1.84	1.73	1.62	1.51	1.39	1.28	1.17	1.07	1.01	0.97	0.93	0.88
Preferred Dividends	0.69	0.66	0.62	0.59	0.56	0.53	0.50	0.47	0.45	0.42	0.39	0.36	0.34	0.31	0.28	0.26	0.24	0.23	0.22	0.21
Current Income Taxes	3.12	1.11	1.28	1.42	1.55	1.66	1.62	1.46	1.29	1.13	0.97	0.81	0.64	0.48	0.31	1.38	2.48	2.42	2.36	2.30
Deferred Income Taxes	1.01	2.84	2.45	2.11	1.80	1.51	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	0.18	(1.01)	(1.01)	(1.01)	(1.01)
After Tax Earnings on Common Equity	5.38	5.14	4.86	4.59	4.35	4.12	3.91	3.69	3.48	3.27	3.06	2.84	2.63	2.42	2.21	2.03	1.91	1.83	1.75	1.67
Total Revenue Requirements	19.05	18.54	17.93	17.38	16.87	16.40	15.96	15.53	15.11	14.68	14.26	13.84	13.43	13.01	12.60	12.28	12.11	12.03	11.95	11.87
RETURN ON AVERAGE RATE BASE																				
Average net plant	98.75	96.25	93.75	91.25	88.75	86.25	83.75	81.25	78.75	76.25	73.75	71.25	68.75	66.25	63.75	61.25	58.75	56.25	53.75	51.25
Less avg. accum. deferred income taxes	(0.51)	(2.43)	(5.08)	(7.36)	(9.31)	(10.96)	(12.40)	(13.78)	(15.16)	(16.54)	(17.92)	(19.30)	(20.68)	(22.06)	(23.44)	(24.22)	(23.81)	(22.80)	(21.78)	(20.77)
Average rate base	98.24	93.82	88.67	83.89	79.44	75.29	71.35	67.47	63.59	59.71	55.83	51.95	48.07	44.19	40.31	37.03	34.94	33.45	31.97	30.48
Average pre-tax return (excl ST debt)	13.3%	13.3%	13.3%	13.3%	13.3%	13.3%	13.3%	13.3%	13.3%	13.3%	13.3%	13.3%	13.3%	13.3%	13.3%	13.3%	13.3%	13.3%	13.3%	13.3%
Return on average rate base	13.05	12.46	11.78	11.14	10.55	10.00	9.48	8.96	8.45	7.93	7.42	6.90	6.39	5.87	5.35	4.92	4.64	4.44	4.25	4.05
Less Interest Expense	(2.85)	(2.72)	(2.57)	(2.43)	(2.30)	(2.18)	(2.07)	(1.96)	(1.84)	(1.73)	(1.62)	(1.51)	(1.39)	(1.28)	(1.17)	(1.07)	(1.01)	(0.97)	(0.93)	(0.88)
Less Preferred Dividends	(0.69)	(0.66)	(0.62)	(0.59)	(0.56)	(0.53)	(0.50)	(0.47)	(0.45)	(0.42)	(0.39)	(0.36)	(0.34)	(0.31)	(0.28)	(0.26)	(0.24)	(0.23)	(0.22)	(0.21)
Less Current Income Taxes	(3.12)	(1.11)	(1.28)	(1.42)	(1.55)	(1.66)	(1.62)	(1.46)	(1.29)	(1.13)	(0.97)	(0.81)	(0.64)	(0.48)	(0.31)	(1.38)	(2.48)	(2.42)	(2.36)	(2.30)
Less Deferred Income Taxes	(1.01)	(2.84)	(2.45)	(2.11)	(1.80)	(1.51)	(1.38)	(1.38)	(1.38)	(1.38)	(1.38)	(1.38)	(1.38)	(1.38)	(1.38)	(0.18)	1.01	1.01	1.01	1.01
After Tax Earnings on Common Equity	5.38	5.14	4.86	4.59	4.35	4.12	3.91	3.69	3.48	3.27	3.06	2.84	2.63	2.42	2.21	2.03	1.91	1.83	1.75	1.67
Return on Equity	13.7%	13.7%	13.7%	13.7%	13.7%	13.7%	13.7%	13.7%	13.7%	13.7%	13.7%	13.7%	13.7%	13.7%	13.7%	13.7%	13.7%	13.7%	13.7%	13.7%
BALANCE SHEET, end of year																				
Assets																				
Gross plant	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Accumulated depreciation	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00	27.50	30.00	32.50	35.00	37.50	40.00	42.50	45.00	47.50	50.00
Net Plant	97.50	95.00	92.50	90.00	87.50	85.00	82.50	80.00	77.50	75.00	72.50	70.00	67.50	65.00	62.50	60.00	57.50	55.00	52.50	50.00
Liabilities & owners' equity																				
Accumulated deferred income taxes	1.01	3.85	6.30	8.41	10.20	11.72	13.09	14.47	15.85	17.23	18.61	19.99	21.37	22.75	24.13	24.32	23.30	22.29	21.28	20.26
Short-term debt	4.82	4.56	4.31	4.08	3.86	3.66	3.47	3.28	3.08	2.89	2.69	2.50	2.31	2.11	1.92	1.78	1.71	1.64	1.56	1.49
Long-term debt	43.42	41.02	38.79	36.72	34.78	32.98	31.23	29.49	27.74	26.00	24.25	22.50	20.76	19.01	17.27	16.06	15.39	14.72	14.05	13.38
Preferred stock	9.65	9.12	8.62	8.16	7.73	7.33	6.94	6.55	6.16	5.78	5.39	5.00	4.61	4.22	3.84	3.57	3.42	3.27	3.12	2.97
Common equity	38.59	36.46	34.48	32.64	30.92	29.31	27.76	26.21	24.66	23.11	21.55	20.00	18.45	16.90	15.35	14.27	13.68	13.08	12.49	11.90
Total	97.50	95.00	92.50	90.00	87.50	85.00	82.50	80.00	77.50	75.00	72.50	70.00	67.50	65.00	62.50	60.00	57.50	55.00	52.50	50.00
CURRENT INCOME TAXES																				
Revenues	19.05	18.54	17.93	17.38	16.87	16.40	15.96	15.53	15.11	14.68	14.26	13.84	13.43	13.01	12.60	12.28	12.11	12.03	11.95	11.87
Expenses																				
Other operating expenses	1.00	1.03	1.06	1.09	1.13	1.16	1.19	1.23	1.27	1.30	1.34	1.38	1.43	1.47	1.51	1.56	1.60	1.65	1.70	1.75
Maintenance	1.00	1.03	1.06	1.09	1.13	1.16	1.19	1.23	1.27	1.30	1.34	1.38	1.43	1.47	1.51	1.56	1.60	1.65	1.70	1.75
Property taxes	1.50	1.52	1.53	1.55	1.56	1.58	1.59	1.61	1.62	1.64	1.66	1.67	1.69	1.71	1.72	1.74	1.76	1.78	1.79	1.81
Tax depreciation	5.00	9.50	8.55	7.70	6.93	6.23	5.90	5.90	5.91	5.90	5.91	5.90	5.91	5.90	5.91	2.95	-	-	-	-
Interest, short and long-term debt	2.85	2.72	2.57	2.43	2.30	2.18	2.07	1.96	1.84	1.73	1.62	1.51	1.39	1.28	1.17	1.07	1.01	0.97	0.93	0.88
Taxable income	7.70	2.74	3.16	3.51	3.82	4.09	4.01	3.61	3.19	2.80	2.39	1.99	1.58	1.19	0.78	3.39	6.13	5.97	5.82	5.67
Current Income taxes @ composite rate	3.12	1.11	1.28	1.42	1.55	1.66	1.62	1.46	1.29	1.13	0.97	0.81	0.64	0.48	0.31	1.38	2.48	2.42	2.36	2.30
DEFERRED INCOME TAXES																				
Tax depreciation	5.00	9.50	8.55	7.70	6.93	6.23	5.90	5.90	5.91	5.90	5.91	5.90	5.91	5.90	5.91	2.95	-	-	-	-
Book depreciation	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Deferred income taxes at composite rate	1.01	2.84	2.45	2.11	1.80	1.51	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	0.18	(1.01)	(1.01)	(1.01)	(1.01)
Accumulated deferred income taxes, 12/31	1.01	3.85	6.30	8.41	10.20	11.72	13.09	14.47	15.85	17.23	18.61	19.99	21.37	22.75	24.13	24.32	23.30	22.29	21.28	20.26

APPENDIX 3

HVDC SUBMARINE CABLE
Wiscasset, ME to Salem Harbor, MA

Substations/Converters		600 MW OPTION	800 MW OPTION
Wiscasset Maine: AC to DC Conversion Station			
• Site Development – New Conversion Station		$3,000,000	$3,500,000
• One 345 kV AC to 500 kV DC STATION		$120,000,000	$160,000,000
Salem Harbor Massachusetts: AC to DC Conversion Station			
• Site Development – New Conversion Station		$3,000,000	$3,500,000
• One 345 kV AC to 500 kV DC Converter Unit		$120,000,000	$160,000,000
500 kV DC Submarine Lines			
• Wiscasset to Salem Harbor - New Construction (130 mi.)		$520,000,000	$572,000,000
Sub-Total		$766,000,000	$899,000,000
Overheads, Engineering, Permitting (25%)		$191,500,000	$224,750,000
Contingency (30%)		$287,250,000	$337,125,000
AFUDC (10%)		$124,475,000	$146,087,500
Total in 2011 Dollars		$1,369,225,000	$1,606,962,500
Annual Escalation Rate	3.0%		
Year to Escalate to	2016		
Total Escalated Cost in Given Year, Rounded to Hundred Millions		$1,600,000,000	$1,900,000,000