2016 Economic Study

Carbon Allowance Cost Sensitivity

Draft Results

ISO new england

Planning Advisory Committee

Michael I. Henderson

DIRECTOR, REGIONAL PLANNING AND COORDINATION

BACKGROUND SUMMARY

Carbon Allowance Cost Sensitivity Study Request

- Discussions concerning the carbon allowance cost sensitivity study request have been ongoing
  - Stakeholders' comments on the cost of carbon were posted in November and December 2016
  - The ISO also held discussions with representatives of Natural Resources Defense Council (NRDC), Boreas Renewables, and Synapse Energy
- Today the ISO is seeking PAC input on the draft results of the Carbon Allowance Cost Sensitivity Study conducted for 2030
  - Some previous material is shown for information and framing the discussion
  - In accordance with stakeholder requests, results of simulations with a higher carbon allowance price of $64/short-ton will be discussed

References: Comments on Cost of Carbon and 2016 Economic Study Phase I Presentations

- Comments on Cost of Carbon by Stakeholders
  - https://www.iso-ne.com/static-assets/documents/2016/12/2016_economic_study_comments_20161212.pdf
  - https://www.iso-ne.com/static-assets/documents/2016/12/nrdc_and_boreas_renewables_2016_economic_study_comments.pdf
  - https://www.iso-ne.com/static-assets/documents/2016/11/nrdc_2016_economic_study_comments_102416.pdf
- 2016 Economic Study Phase I Presentations To Date
  - https://www.iso-ne.com/static-assets/documents/2017/01/a6_2016_economic_studies_preliminary_high_level_order_of_magnitude_transmission_development_costs_scenario_6_update.pdf
  - https://www.iso-ne.com/static-assets/documents/2017/01/a6_2016_economic_study_executive_summary_supplement_total_costs_scenario_6.pdf
  - https://www.iso-ne.com/static-assets/documents/2016/12/a9_1_2016_economic_study_executive_summary_and_metrics_update.pdf
  - https://www.iso-ne.com/static-assets/documents/2016/12/2016_economic_study_spilled_energy_presentation_1211416_a09.pdf
  - https://www.iso-ne.com/static-assets/documents/2016/11/2016_economic_study_draft_results_sensitivity.pdf
  - https://www.iso-ne.com/static-assets/documents/2016/11/2016_economic_study_executive_summary_metrics_pac111616_a05.pdf

References: Comments on Cost of Carbon and 2016 Economic Study Phase I Presentations, cont.

- 2016 Economic Study Phase I Presentations To Date, Cont.
  - https://www.iso-ne.com/static-assets/documents/2016/11/a5_2016_economic_study_high_level_phase_1_observations_and_messages.pdf
  - https://www.iso-ne.com/static-assets/documents/2016/10/2016_economic_studies_high_level_transmission_costs_rev1.pdf
  - https://www.iso-ne.com/static-assets/documents/2016/10/a2_2016_economic_study_draft_results_part_3.pdf
  - https://www.iso-ne.com/static-assets/documents/2016/09/a6_2016_economic_study_draft_results_part_2.pdf
  - https://www.iso-ne.com/static-assets/documents/2016/09/a7_2016_economic_study_part_2_appendix.pdf
  - https://www.iso-ne.com/static-assets/documents/2016/08/a6_2016_economic_study_draft_results.pdf
  - https://www.iso-ne.com/static-assets/documents/2016/08/a6_2016_economic_study_draft_results_appendix.pdf
  - http://www.iso-ne.com/static-assets/documents/2016/07/a6_2016_economic_study_update.pdf
  - http://www.iso-ne.com/static-assets/documents/2016/06/a9_2016_economic_study_assumptions.pdf
  - http://www.iso-ne.com/static-assets/documents/2016/05/a3_2016_economic_study_scope_of_work_assumptions.pdf
- Resource Portfolio Standards Worksheet
  - http://www.iso-ne.com/static-assets/documents/2016/05/a3_2016_economic_study_scope_of_work_rps_spreadsheet.xlsx

RESULTS AND OBSERVATIONS

NEPOOL Six Base Scenarios

1. **RPS + Gas:** Physically meet Renewable Portfolio Standards (RPS) and replace generator retirements with natural gas (combined cycle units)
2. **ISO Queue:** Physically meet RPS and replace generator retirements with new renewable/clean energy
3. **Renewables Plus:** Physically meet RPS, add renewable/clean energy, EE, PV, PEV, storage, retire old generating units
4. **No Retirements (beyond FCA #10):** Meet RPS with resources under development and use RPS Alternative Compliance Payments (ACPs) for shortfalls, add natural gas units
5. **Gas + ACPs:** Meet RPS with resources under development and use ACP, replace retirements with natural gas
6. **RPS + Geodiverse Renewables:** Scenario 2 with a more geographically balanced mix of on/offshore wind and solar PV

Carbon Allowance Price Assumption and Sensitivity Cases Simulated

- Stakeholders requested sensitivity analysis with different assumptions for carbon emission prices
  - Previous simulation results used $24/short-ton (2015$) for 2030
  - Previous results will be compared with a carbon allowance price of $64/short-ton (2015$) for 2030*
- The six scenarios were simulated with and without modeling transmission constraints, totaling 12 cases, for 2030
  - Except for the cost of carbon at $64/short-ton, all other assumptions remain the same

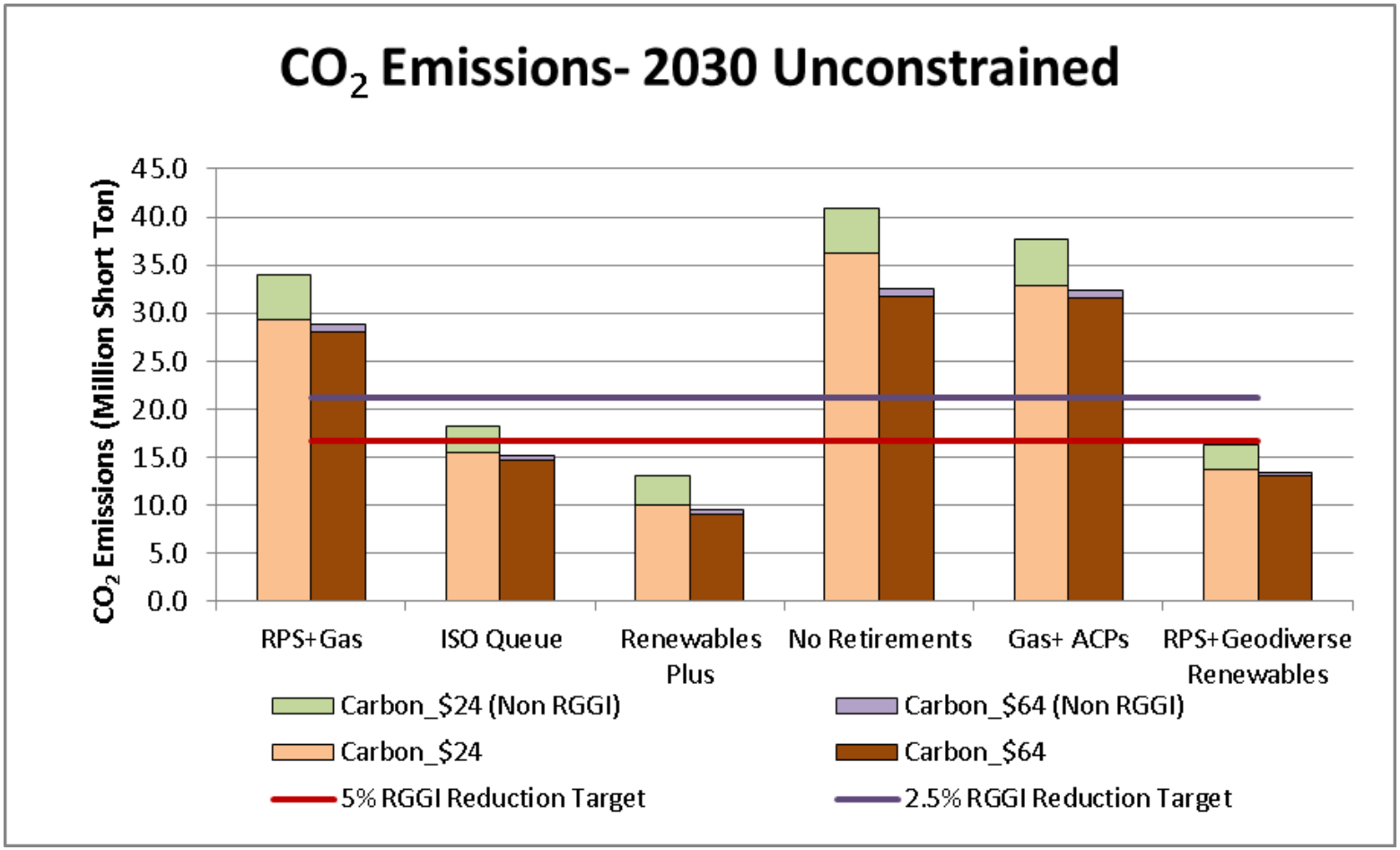
* Estimated social cost of carbon expressed in 2015$ by the US government inter-agency task force for 2030 was provided by Synapse Energy.

Effect of Higher Carbon Allowance Costs Applied to All Generating Units

- Higher carbon prices reduce emissions only when carbon prices effect the economic dispatch order of generating units and lower carbon emitting replacement energy is available
  - Example: Coal-fired units are competitive with natural gas-fired units in Scenario 4. Increasing carbon prices increases the relative cost of coal-fired generation compared with natural gas-fired units.
- Natural gas-fired generating units remain on the margin a significant amount of time across all cases
- As previously discussed with stakeholders, carbon allowance prices were assumed for all generating units
  - Applying carbon prices to only units greater than 25 MW (RGGI units) could have the effect of increasing emissions because high emitting small units, such as biomass, would be in merit more of the time

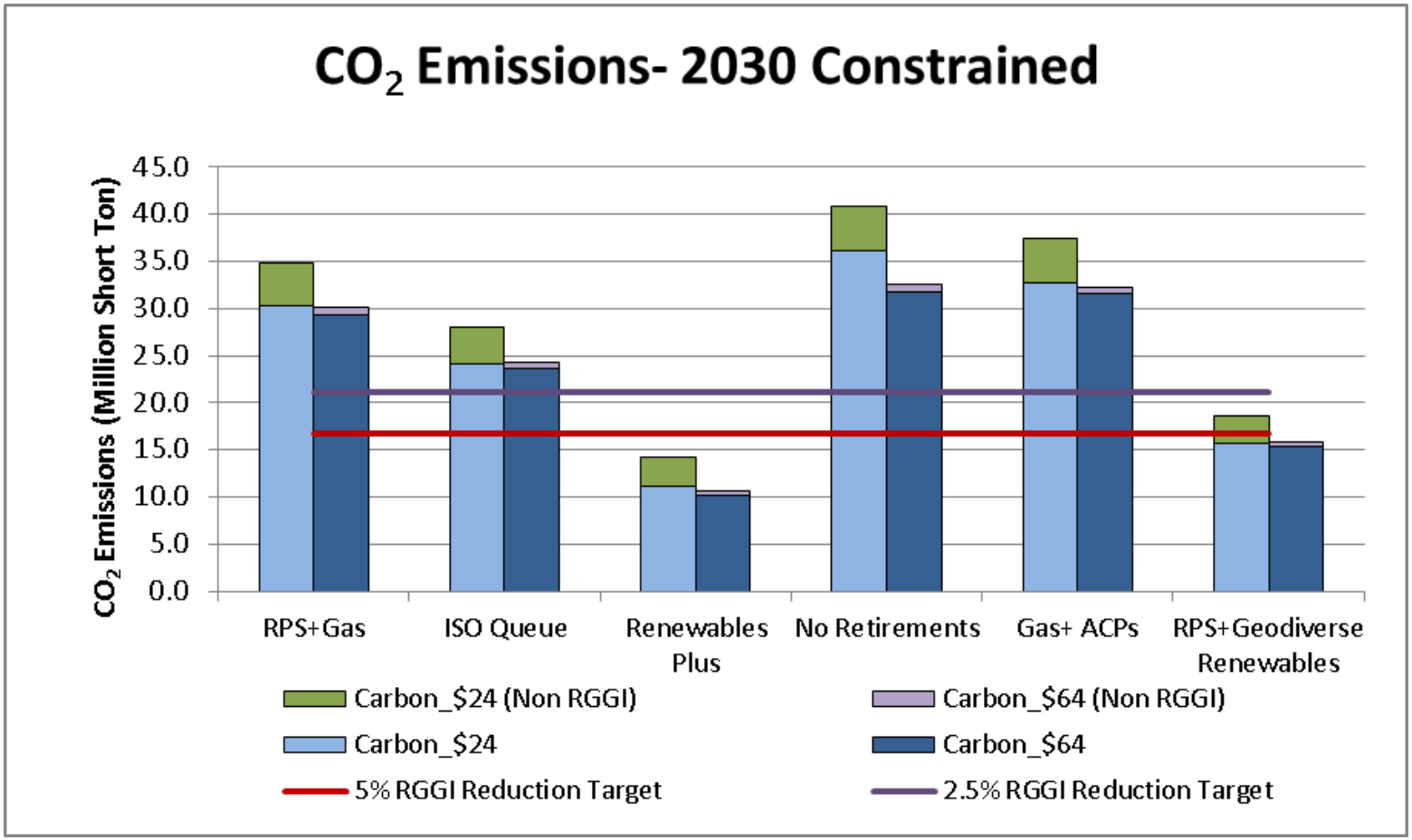
Annual New England CO_2 Emissions (M Short-ton) - 2030

Transmission Unconstrained



Annual New England CO_2 Emissions (M Short-ton) - 2030

Transmission Constrained



Annual New England CO_2 Emissions (M Short-ton) - 2030

Transmission Constrained and Unconstrained

Scenarios	Transmission Constrained			Transmission Unconstrained		
	Carbon_$24	Carbon_$64	Difference	Carbon_$24	Carbon_$64	Difference
RPS + Gas	34.8	30.1	-4.7	34.0	28.7	-5.3
ISO Queue	28.1	24.3	-3.8	18.2	15.1	-3.1
Renewables Plus	14.3	10.7	-3.6	13.1	9.5	-3.6
No Retirements	40.8	32.5	-8.3	40.9	32.5	-8.4
Gas + ACPs	37.5	32.3	-5.2	37.6	32.3	-5.3
RPS + Geodiverse Renewables	18.6	15.8	-2.8	16.3	13.4	-3.3

Change in Emissions Due to Higher Carbon Allowance Costs Applied to All Generating Units

- High renewable cases (Scenarios 2 (ISO Queue), 3 (Renewable Plus) , and 6 (RPS + Geodiverse Renewables)) show the lowest overall CO2 emissions
  - Independent of carbon costs, Scenarios 3, 6, and 2 (the three lowest emitting cases) may meet RGGI regional targets for the transmission unconstrained cases
  - Scenarios 3 and 6 (the two lowest emitting cases) may meet RGGI targets for the constrained cases
- For a given scenario, higher allowance prices reduce systemwide emissions primarily due to higher operating costs for coal-fired and non-RGGI generating units, including heavy carbon producers burning coal, wood, and municipal solid waste
  - Scenario 4 (No Retirements) shows the greatest sensitivity to carbon pricing, followed by Scenarios 5 (Gas and ACPs) , 1 (RPS + Gas) , 6, and 3
  - With the exception of Scenario 4, total systemwide emissions of RGGI generating units reduce a relatively small amount for higher carbon prices because lower carbon emitting replacement energy is not available
  - Emissions of non-RGGI carbon emitting generating units reduce more significant amounts than RGGI units when exposed to RGGI allowance pricing. This is particularly true of Scenarios 2 and 5 constrained.

Potential RGGI Nine-State CO_2 Cap under Consideration for 2025 and 2030

RGGI Cap Trajectory	2025 Cap (Short-ton)	2030 Cap (Short-ton)
2.5%/year reduction	68,403,313	58,631,411
3.5%/year reduction	64,494,552	50,813,890
5.0%/year reduction	58,631,411	39,087,608

- The RGGI CO_2 Budget Trading programs regulate emissions from fossil fuel-fired generating units with a capacity of 25 MW or greater located within the RGGI States (New England states, Delaware, Maryland and New York). Of the 164 RGGI affected generating units, 62 are located in New England.
- There are units greater than or equal to 25 MW that are exempt from the Budget Trading Program because they do not meet RGGI applicability due to vintage, fuel mix, or other reason

New England CO_2 Emissions for RGGI Units as Percentage of RGGI Nine-State Cap – 2030

Carbon Allowance Cost at $24/short-ton cases

Scenario Carbon_$24	RGGI Sources New England (k Short Tons)	2.5% Cap	3.5% Cap	5.0% Cap
RPS + Gas_Unc	29,288	50.0%	57.6%	74.9%
ISO Queue_Unc	15,410	26.3%	30.3%	39.4%
Renewables Plus_Unc	10,052	17.1%	19.8%	25.7%
No Retirements _Unc	36,171	61.7%	71.2%	92.5%
Gas + ACPs_Unc	32,827	56.0%	64.6%	84.0%
RPS + Geodiverse Renewables_Unc	13,774	23.5%	27.1%	35.2%
RPS + Gas_constrained	30,302	51.7%	59.6%	77.5%
ISO Queue_constrained	24,103	41.1%	47.4%	61.7%
Renewables Plus_constrained	11,065	18.9%	21.8%	28.3%
No Retirements_constrained	36,109	61.6%	71.1%	92.4%
Gas + ACPs_constrained	32,749	55.9%	64.4%	83.8%
RPS + Geodiverse Renewables_constrained	15,761	26.9%	31.0%	40.3%

New England CO_2 Emissions for RGGI Units as Percentage of RGGI Nine-State Cap – 2030

Carbon Allowance cost at $64/short-ton cases

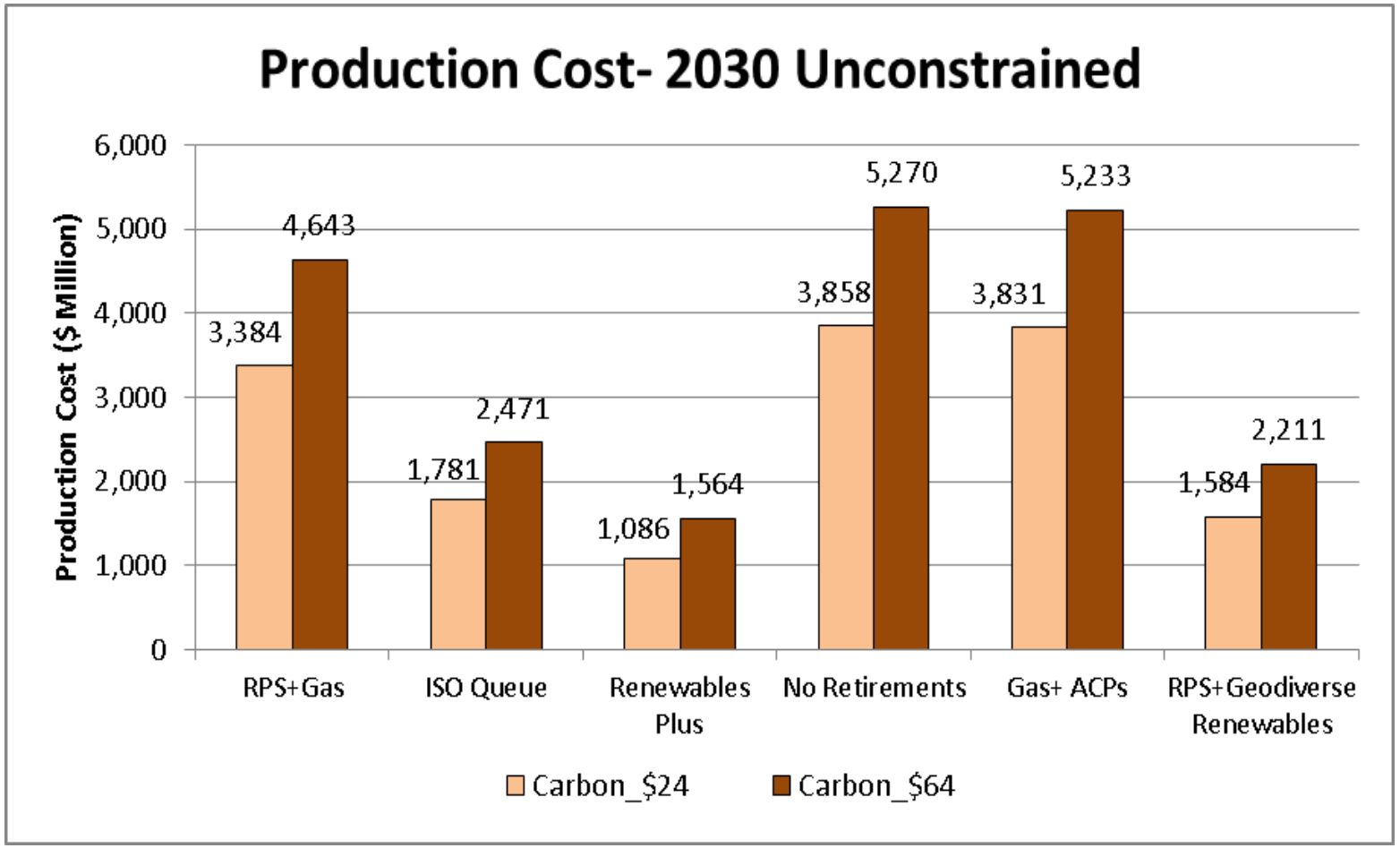
Scenario Carbon_$64	RGGI Sources New England (k Short Tons)	2.5% Cap	3.5% Cap	5.0% Cap
RPS + Gas_Unc	28,031	47.8%	55.2%	71.7%
ISO Queue_Unc	14,655	25.0%	28.8%	37.5%
Renewables Plus_Unc	9,030	15.4%	17.8%	23.1%
No Retirements _Unc	31,753	54.2%	62.5%	81.2%
Gas + ACPs_Unc	31,566	53.8%	62.1%	80.8%
RPS + Geodiverse Renewables_Unc	13,036	22.2%	25.7%	33.4%
RPS + Gas_constrained	29,339	50.0%	57.7%	75.1%
ISO Queue_constrained	23,669	40.4%	46.6%	60.6%
Renewables Plus_constrained	10,232	17.5%	20.1%	26.2%
No Retirements_constrained	31,752	54.2%	62.5%	81.2%
Gas + ACPs_constrained	31,561	53.8%	62.1%	80.7%
RPS + Geodiverse Renewables_constrained	15,324	26.1%	30.2%	39.2%

Summary – RGGI-wide Emissions

- Higher CO_2 allowance costs may lower total New England emissions by a few million short tons, but New England's CO_2 emissions from RGGI sources as a percent of the total RGGI cap continue to be in the 50% to 81% range for Scenarios 1 (RPS + Gas), 4 (No Retirements), and 5 (Gas + ACPs)
- Historically, New England RGGI CO_2 cap share and emissions have roughly averaged one-third of the total RGGI cap in any given compliance year
- Higher New England CO_2 emissions would require:
  - Use of banked allowances
  - Purchase allowances from neighboring states
  - Use of offsets
  - Release of additional allowances by the states

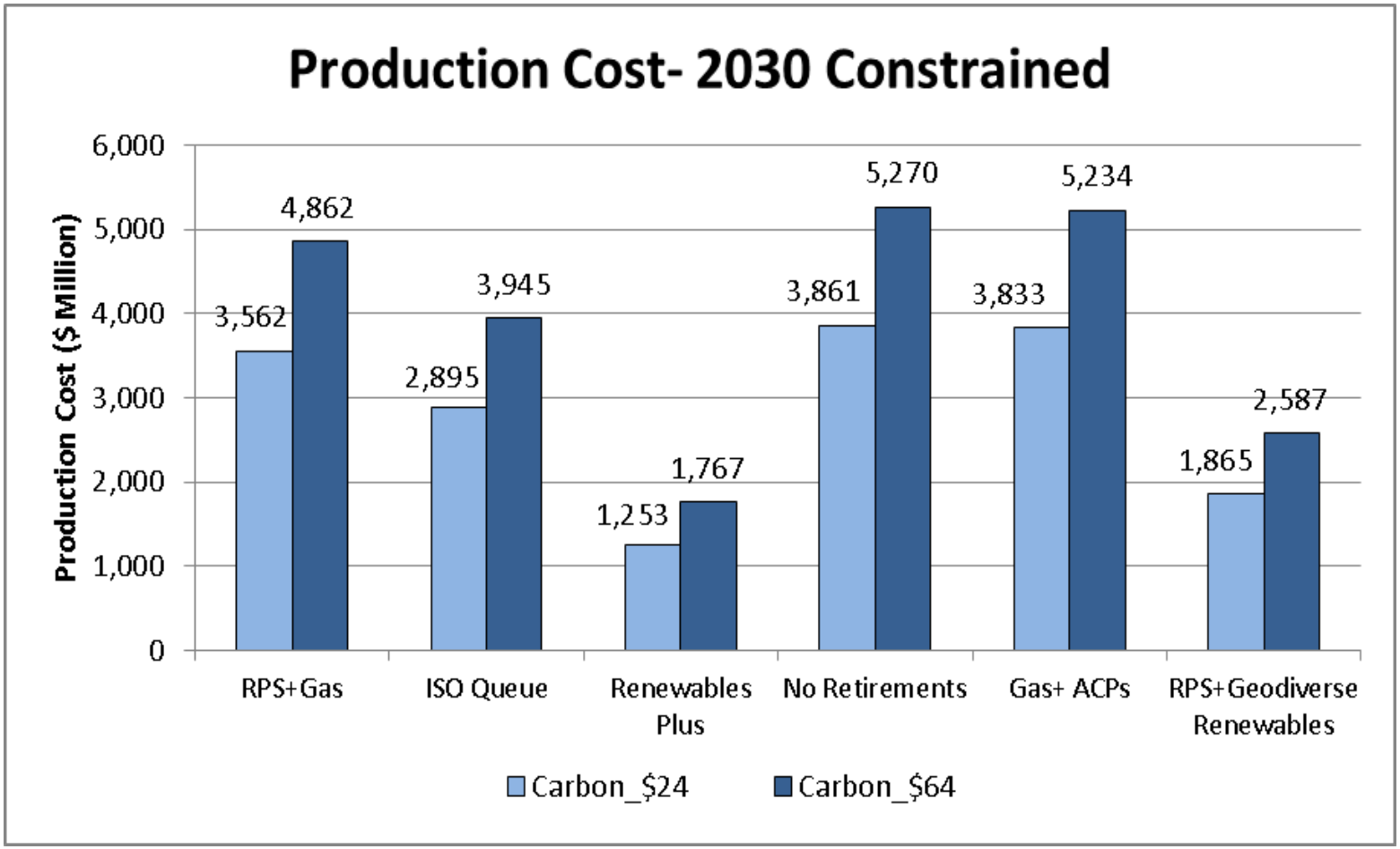
Annual New England Production Cost ($M) - 2030

Transmission Unconstrained



Annual New England Production Cost ($M) - 2030

Transmission Constrained



Annual New England Production Cost ($M) - 2030

Transmission Constrained and Unconstrained

Scenarios	Transmission Constrained		Transmission Unconstrained		Production Cost Savings by Relieving Constraints	
	Carbon_$24	Carbon_$64	Carbon_$24	Carbon_$64	Carbon_$24	Carbon_$64
RPS + Gas	3,562	4,862	3,384	4,643	178	219
ISO Queue	2,895	3,945	1,781	2,471	1,114	1,474
Renewables Plus	1,253	1,767	1,086	1,564	167	203
No Retirements	3,861	5,270	3,858	5,270	3	0
Gas + ACPs	3,833	5,234	3,831	5,233	2	0
RPS + Geodiverse Renewables	1,865	2,587	1,584	2,211	281	376

New England Production Cost ($M) – 2030

Production costs largely reflect fuel-related costs, including dispatch, unit commitment, and emission allowance costs

- Increasing the CO_2 allowance adder results in higher production cost as expected
  - From the highest to the lowest annual production cost of the scenarios, the $64/short-ton CO2 allowances adder does not alter the production cost ranking of the scenarios
    - The highest production cost scenario remains Scenario 4, the No-Retirement Scenario, at $5,270 M (transmission constrained and unconstrained)
    - The lowest production cost scenario is Scenario 3, the Renewables-Plus Scenario, at $1,564 M (transmission unconstrained)

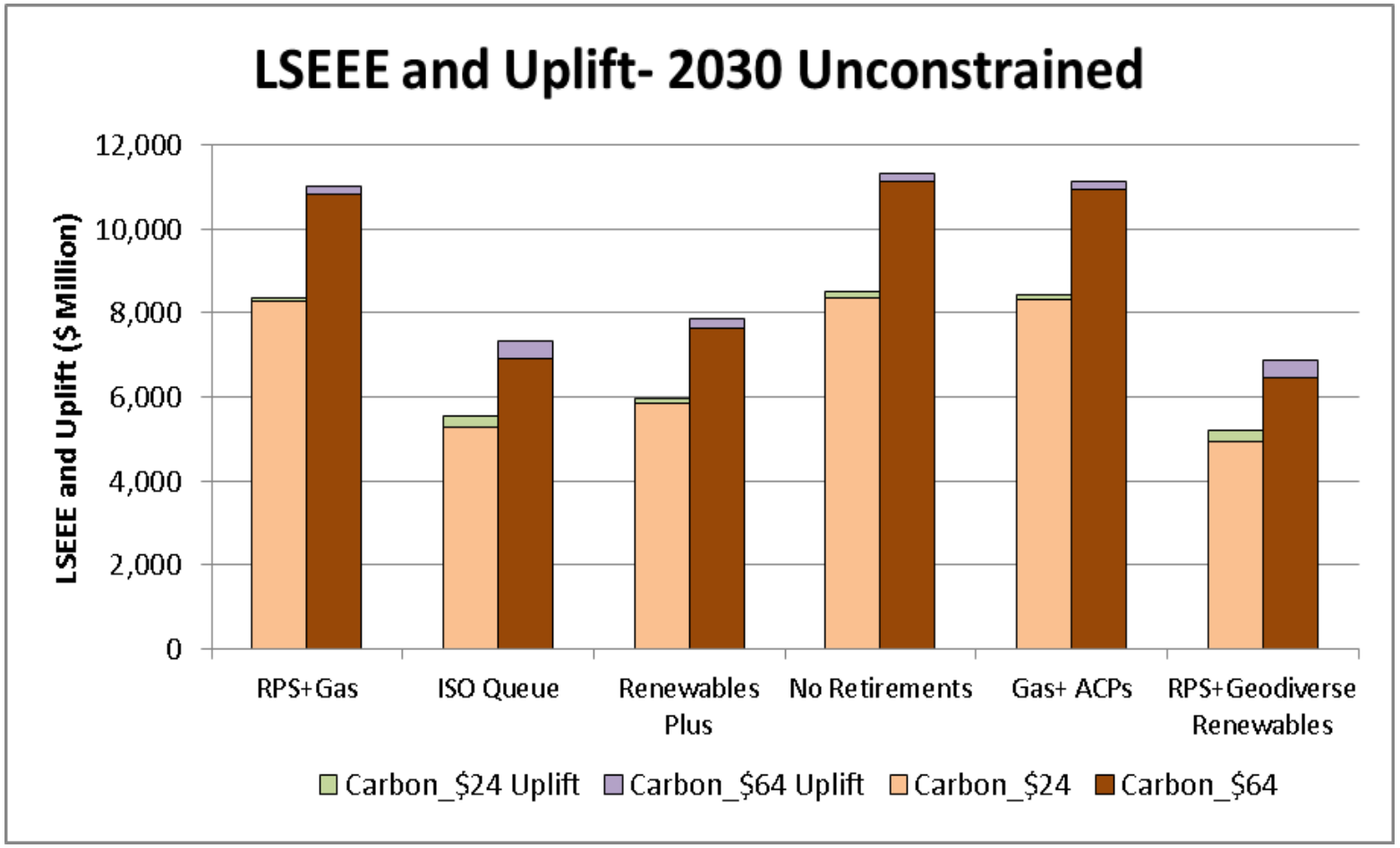
New England Production Cost ($M) – 2030, cont.

Production costs largely reflect fuel-related costs, including dispatch, unit commitment, and emission allowance costs

- Increasing the CO_2 allowance adder increases congestion for scenarios 1 (RPS + Gas), 2 (ISO Queue), 3 (Renewables Plus), and 6 (RPS + Geodiverse Renewables)
  - Relieving transmission constraints results in the highest production cost savings for Scenario 2, the ISO Queue Scenario, at $1,474 M annually
- Higher carbon prices have little effect on congestion for Scenarios 4 (No Retirements) and 5 (Gas + ACPs)

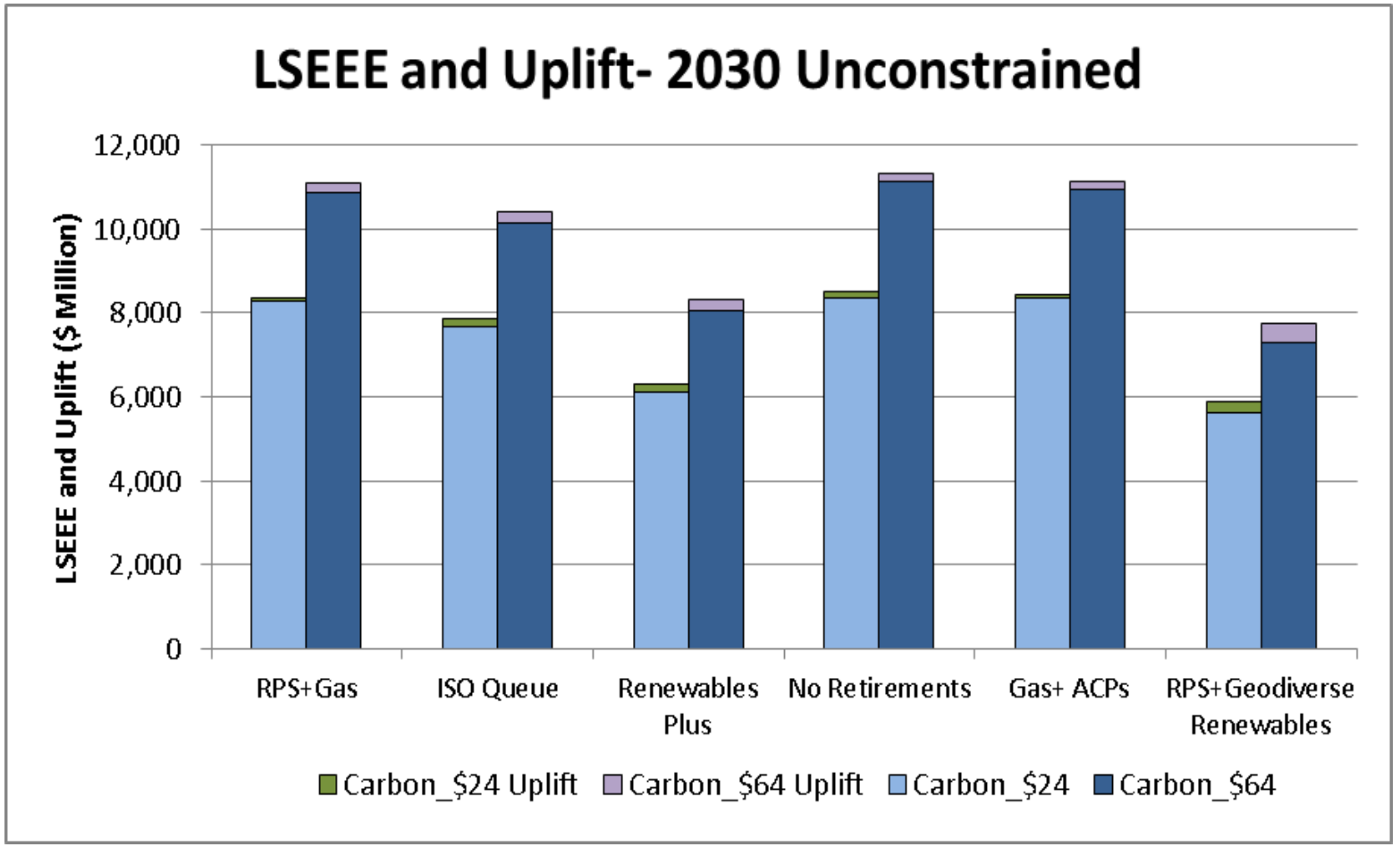
Annual NE LSE Energy Expenses and Uplift ($M) - 2030

Transmission Unconstrained



Annual NE LSE Energy Expenses and Uplift ($M) - 2030

Transmission Constrained



Annual NE LSE Energy Expense plus Uplift ($M) – 2030

Transmission Constrained and Unconstrained

Scenarios	Transmission Constrained		Transmission Unconstrained	
	Carbon_$24	Carbon_$64	Carbon_$24	Carbon_$64
RPS + Gas	8,377	11,079	8,368	11,037
ISO Queue	7,856	10,416	5,532	7,348
Renewables Plus	6,291	8,321	5,983	7,868
No Retirements	8,518	11,340	8,510	11,341
Gas + ACPs	8,451	11,140	8,442	11,143
RPS + Geodiverse Renewables	5,891	7,760	5,196	6,894

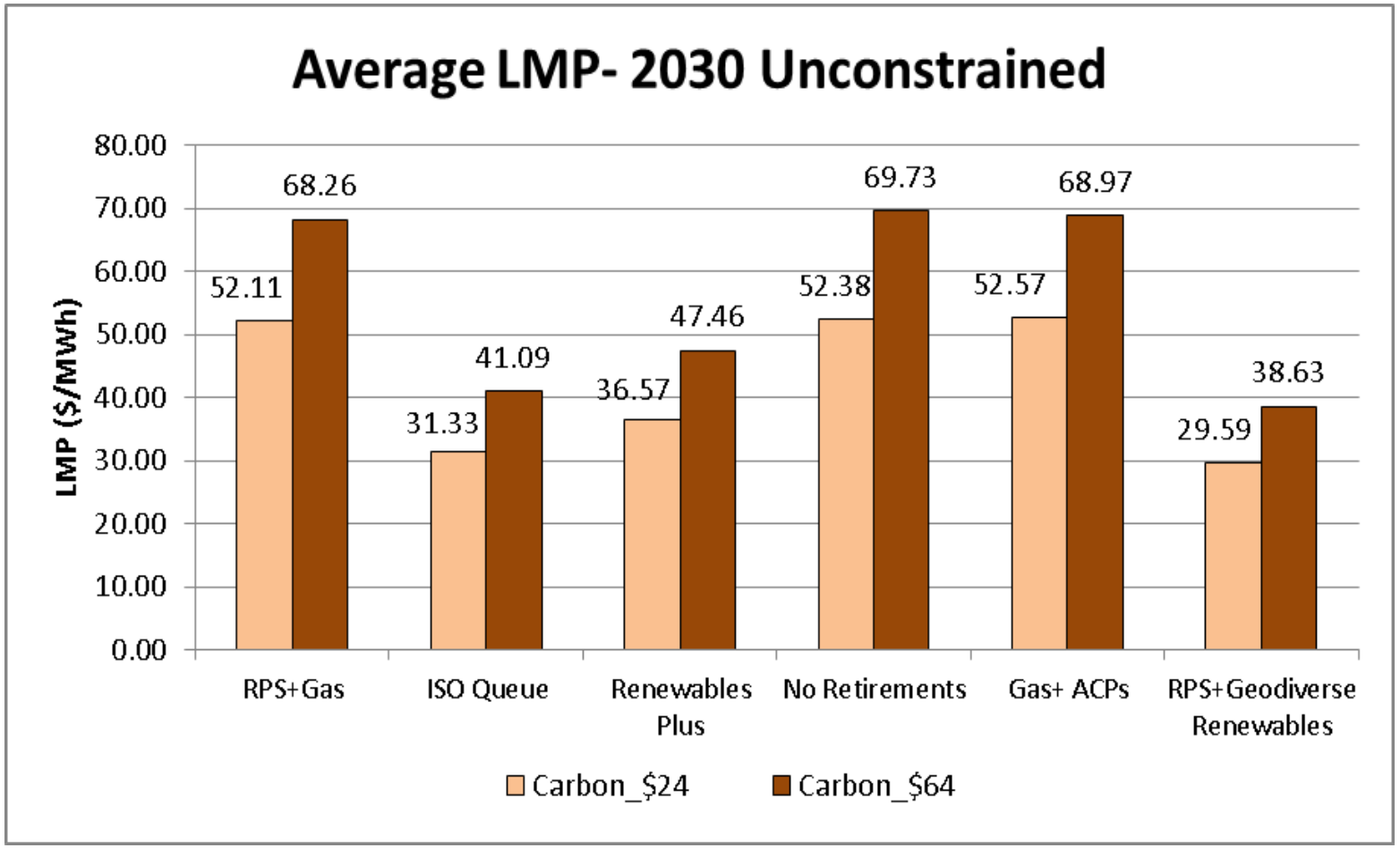
Annual New England LSE Energy Expense plus Uplift ($M) - 2030

The resource mix and fuel prices drive average clearing prices and LSE Energy Expenses

- Increasing the CO2 allowance adder results in higher LSE Energy Expenses as expected
  - From the highest to the lowest annual LSE Energy Expenses of the scenarios, the $64/short-ton CO2 allowance does not alter the LSE Energy Expense ranking of the scenarios
    - The highest LSE Energy Expense scenario continues to be Scenario 4, the No Retirement Scenario
    - The lowest LSE Energy Expense scenario continues to be scenario 6, the RPS + Geodiverse Renewables Scenario

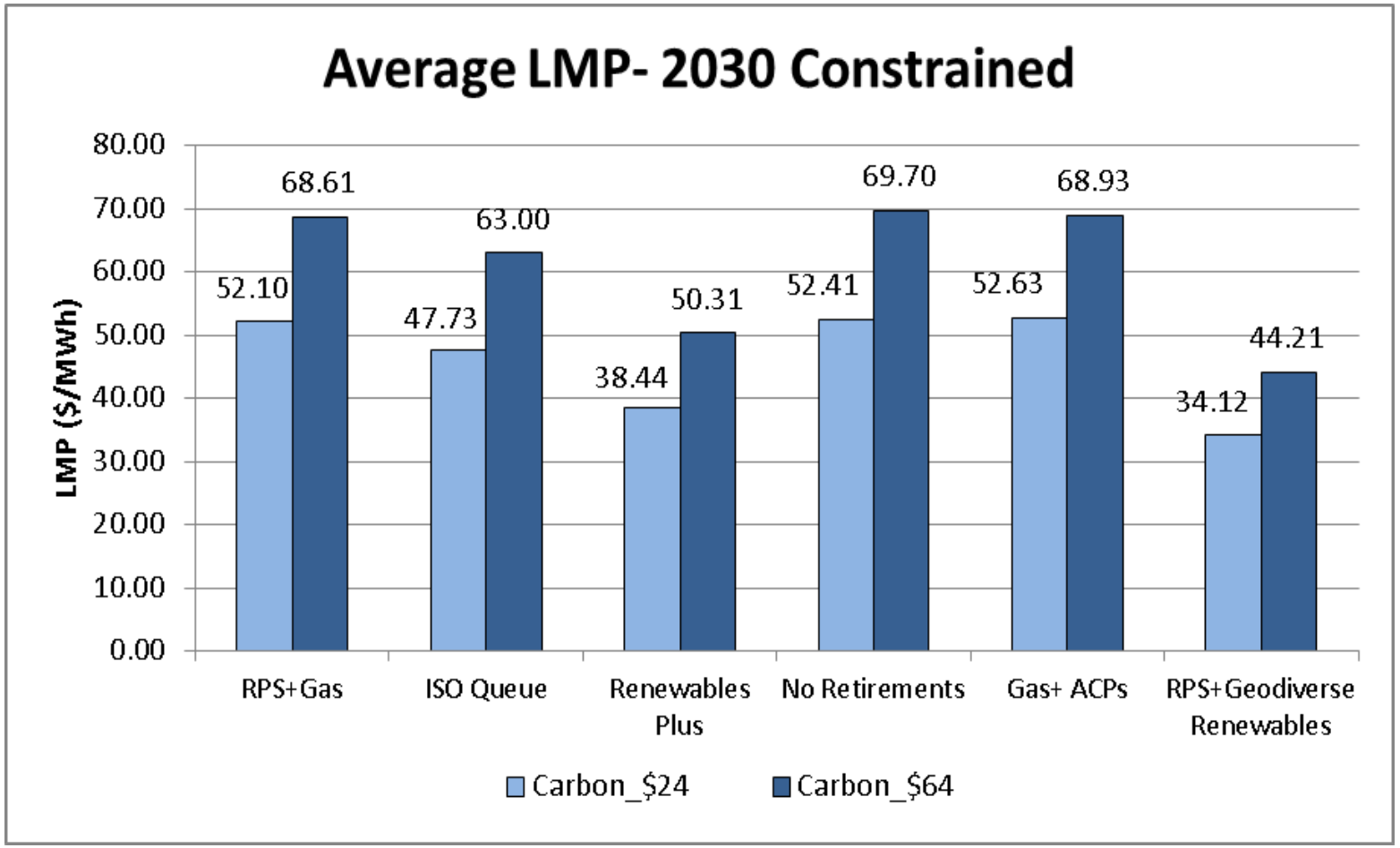
Annual Average System LMP ($/MWh)

Transmission Unconstrained



Annual Average System LMP ($/MWh)

Transmission Constrained



Average New England LMP ($/MWh) - 2030

Transmission Constrained and Unconstrained

Scenarios	Transmission Constrained		Transmission Unconstrained	
	Carbon_$24	Carbon_$64	Carbon_$24	Carbon_$64
RPS + Gas	52.10	68.61	52.11	68.26
ISO Queue	47.73	63.00	31.33	41.09
Renewables Plus	38.44	50.31	36.57	47.46
No Retirements	52.41	69.70	52.38	69.73
Gas + ACPs	52.63	68.93	52.57	68.97
RPS + Geodiverse Renewables	34.12	44.21	29.59	38.63

Average New England LMP ($/MWh) - 2030

Transmission Constrained and Unconstrained

- Independent of carbon prices, natural gas remains on the margin a significant portion of the time
  - Higher carbon prices increase LMPs
- Average LMP increased by about 30% for the 6 scenarios
  - Scenario 6, the RPS + Geodiverse Renewables Scenario, continue to have the lowest LMPs
    - $44.21/MWh under transmission constrained
    - $38.63/MWh under transmission unconstrained
  - Scenarios 1 (RPS + Gas), 4 (No Retirements) and 5 (Gas + ACPs) continue to have the highest LMPs ranging from $68.26/MWh to $69.73/MWh for both transmission constrained and unconstrained cases
  - Scenario 2, the ISO Queue Scenario, continues to have the biggest decrease in average LMP when transmission constraints are relieved
  - Average LMPs of scenarios 4 (No Retirements) and 5 (Gas + ACPs) change slightly with the transmission constraints modeled because these two scenarios have little congestions

Questions