COMMENTS ON PROPOSED CO_2 BUDGET TRADING PROGRAM

Richard H. Ball, Ph.D.[1]

Summary

The proposed regulation program has the potential for an important step toward reducing CO2 emissions in the Virginia electric power sector. That is very important to reducing the impacts of global climate change, ocean acidification, and the local environmental impacts of fossil fuel combustion. However, the degree those objectives are realized depends greatly on the details about which EGUs are covered, the magnitude of the cap, and other program details. In my remarks, I particularly focus on the choice of a baseline value for the Cap as of 2020 and also note some of the effects of the criteria for inclusion of EGUs.

I offer some quantitative analysis of factors that should influence the choice of a 2020 Baseline and criteria for EGU coverage. I believe that choosing a baseline as high as 33 or 34 MMT of CO2, as suggested for comment in the proposed regulation, would be much too high and lead to much less reduction in Virginia CO2 emissions by 2030 than is feasible and desirable. For example, the ICF/DEQ Policy scenarios show very low reductions in CO2 emission reductions (9% for Case 2, as shown in Appendix C, and even less for Case 1). Emissions have already been coming down since 2016 and most projections indicate that a trend in that direction is likely to continue in that direction even in the absence of the proposed regulation. I offer several lines of evidence for that, including calculations of actual 2017 emissions in Virginia for overall electric power emissions and emissions specifically from likely EGUs covered by the ED 11 regulation. **If the Virginia ED 11 Baseline is set in the range of about 30 to 34 MMT of CO2, the program might fail to achieve CO_2 reductions that are substantially greater than what would happen even in the absence of the ED 11 program.**

My conclusion from the scenario analyses in the Appendices is that it would be feasible to achieve reductions under a Base Cap of 28 MMT with an aggressive, but feasible Solar or wind expansion program and phasing out a substantial amount of higher ED 11 CO2 carbon sources along with considerable natural gas generation while maintaining a steady level of total Virginia generation. It also implies that it makes little sense to continue expanding natural gas generating sources since they are likely to be constrained in their generation. A steady level of generation would be consistent with an aggressive program of Energy Efficiency measures, which might be implemented as a result of new legislation enacted and signed in the 2018 session of the Virginia General Assemblye.

RGGI forwarded their comments and recommendations to Virginia earlier today, which include an important paragraph:1

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[1] Retired Energy and Climate Science Analyst, 4022 Downing St., Annandale VA 22003.

> "Virginia has proposed a starting 2020 state budget of 33-34 million tons. The RGGI states recognize the importance of Virginia's allowance budget in establishing the stringency of Virginia's program and its impact on the overall stringency of the regional program. The RGGI states' considerations are informed by our track record of successfully reducing emissions faster than expected at the time of RGGI's initial program design. Due in part to Virginia's newly planned investments in complementary programs such as energy efficiency and clean and renewable energy; Virginia is likely to have similar opportunities to achieve greater reductions than expected. As such, the RGGI states encourage Virginia to take this into account when setting an allowance budget. Virginia could realize a measure of climate leadership by adopting a lower starting allowance budget than currently set forth in proposed regulation. Setting Virginia's initial budget at an appropriately ambitious level is particularly important given the nature of the consignment auction to private entities."

Hence RGGI expects Virginia to reduce its Baseline cap, although they did not specify a particular value.

In the Scenarios and analysis I present in the Appendices, I have borrowed results on the likely list of ED 11 EGUs that will be covered under ED 11 and the associated estimated generation, and CO2 emissions from the comments submitted by the Virginia Chapter of the Sierra Club.[2]

Another conclusion is that the ICF modeling results published by DEQ in the autumn contained some out-of date assumptions due to subsequent events. In Appendix C I conclude that:

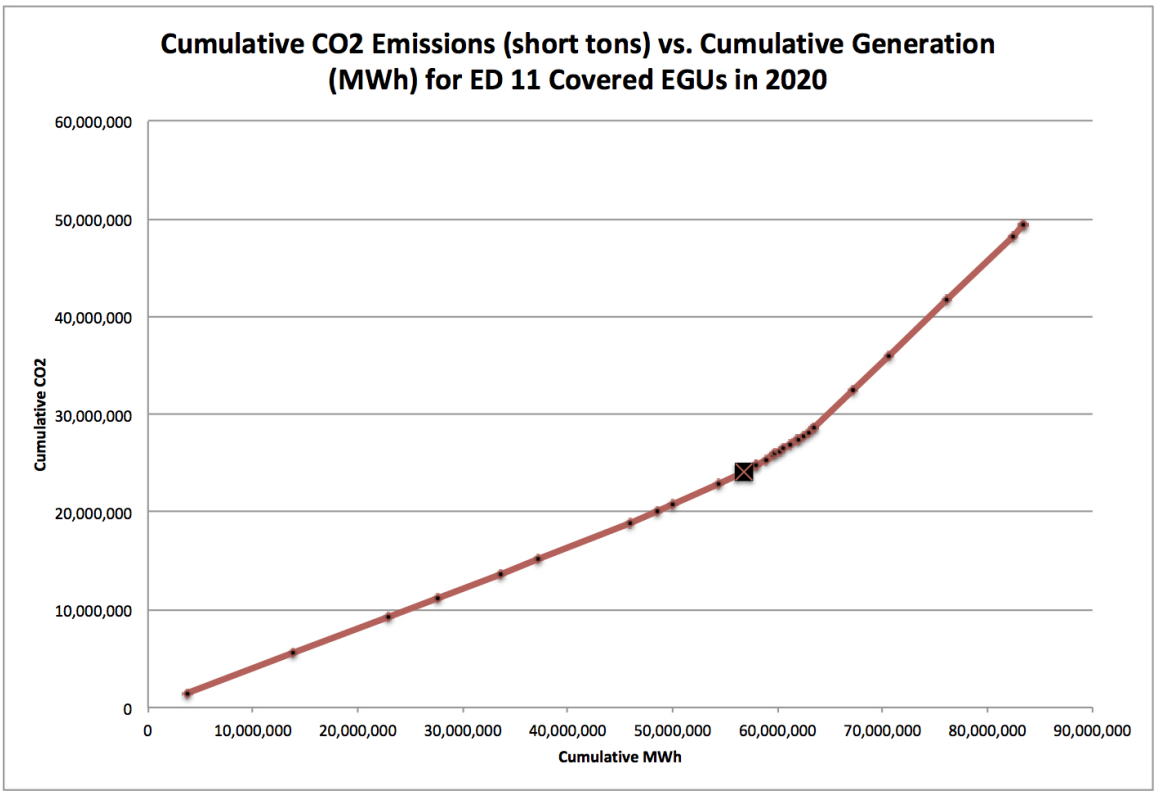
> "The ICF results were furnished in autumn, 2017 before actual 2017 results for Virginia were known and before SB 966 was passed in the 2018 Session of the General Assembly, and before the announcement of retirement plans for a number of EGUs, so those factors could not be reflected in the modeling. **In particular, CO2 emissions by 2020 EGU-covered units in 2017 was overestimated in the ICF modeling as 32 MMT CO2, compared with the Sierra Club's estimate of 29 million tons based on actual 2016 data. Those factors also may have led to overestimation of subsequent modeled results for 2020 through 2030. Hence I look at likely emission reductions for other Baseline Cap values than just 33 MMT under several different policy assumptions."**

I appreciate the opportunity to provide comments on the proposed ED 11 regulations and endorse the efforts that DEQ has undertaken.

Appendix A. Potential ED 11 CO2 Emissions Reductions by 2020 based on a Generation vs. CO2 Cumulative Supply Curve.

In this Appendix we utilize the technique of constructing a generation supply curve to estimate the maximum potential for reducing ED 11 CO2 emissions by 2020. This same technique theoretically could be applied to reducing future emissions out to 2030, but that would require assumptions about what new generation sources, whether fossil or non fossil, would be available and what levels of total Virginia generation would be met by then.

The supply curve below is established by considering all ED 11 power plants likely to be available by 2020 and their potential maximum output of both generation and CO2 emissions. These are arranged in order based on lowest CO2 rate (lb-CO2/MWh). Then cumulative CO_2 emissions vs. cumulative generation is plotted, as shown in the figure below. The first point applies to the new Greensville NGGC power plant, assumed to have the lowest CO2 rate based on its air permit. For the purpose of this curve, maximum capacity factors are assumed for each EGU.



The black square point pertains to the values of 56,768,747 MWh and 24,119,979 short tons CO2. It corresponds to generation by all NGCC plants and no other ED 11 units, such as gas turbine peaking units, all steam plants, and other fossil fuels. That

total generation is larger than the estimated output of ED 11 plants in either 2016 or 2017. So it would allow for some growth in total Virginia generation by 2020, or possible reductions in output of non-ED11 EGUs **However, it should be emphasized that this result is hypothetical and would not necessarily be expected to result from the ED11 program or any other proposed policy, except possibly policies that mandated either minimum CO2 dispatch or a very tight Baseline in ED 11 of the order of 24 MMT CO2.**

However, this result also illustrates another point, which is that addition of more new natural gas generating units beyond 2020 will make it harder to reduce Virginia CO2 emissions by 30% by 2030. **We already have too much natural gas capacity in place to achieve substantial emission reductions in line with global CO2 goals! To get 2030 ED 11 emissions down to 24 MMT, it would require retirement or reduction below maximum output of substantial existing natural gas capacity, as well as coal and petroleum capacity, about 9.4 GW total.**

In Appendix C, we consider a scenario to meet a lower CAP through 2030 using the supply curve methodology,

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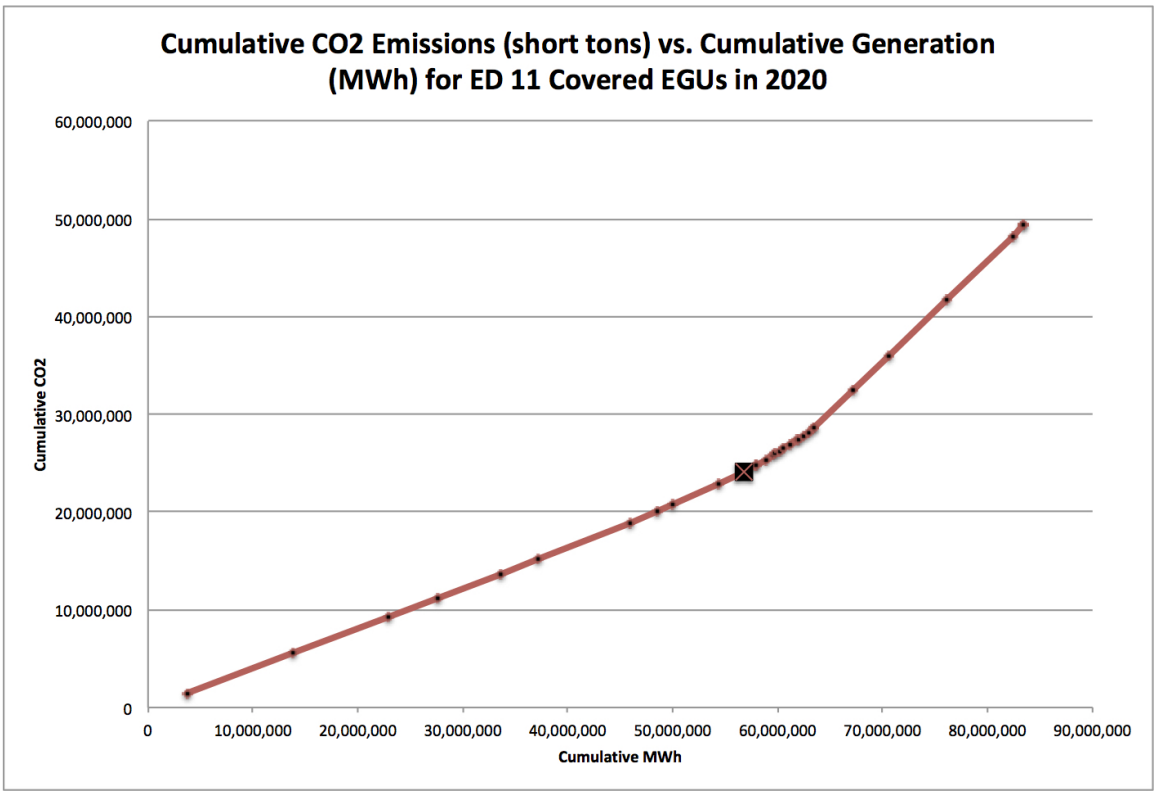

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Appendix B. Simple Hypothetical Scenario of 2020 Maximum Potential CO2 Emission Reductions

This Appendix uses the previously mentioned estimates of 2016 ED 11 generation and CO2, along with EIA data on other Virginia generation in those years, to create some simple scenario estimates of 2020 potential ED 11 emissions to draw inferences about potentially feasible Caps. *

For that purpose we add in the potential output of new generation units expected to be on line by 2020. Essentially we hold total generation and that from other sources from 2016 constant through 2020.

Scenario relative to 2016 ED 11 Results

New Sources by 2020	Gen (MWh)	CO2 Emissions (Short Tons)
Greensville CC	**9,002,270**	**3,600,908**
Doswell GTs (2 units)	**399,277**	**257,933**
Stonewall CC	**4,232,023**	**1,745,709**
SUBTOTAL	**13,633,569**	**5,604,550**
New Solar*	**4,383,000**	**0**
TOTAL	**18,016,569**	**5,604,550**

***Assumed 2000 MW @ 25% Capacity Factor

In the scenario below, total Virginia Generation is assumed to stay the same in 2020 as 2016; new sources enable all ED 11 coal emissions and generation to be eliminated and then sufficient ED 11 natural gas generation to keep overall generation the same.

Hypothetical 2020	MWh	CO2
New Sources	**18,016,569**	**5,604,550**
2016 ED 11 Sources	**54,105,459**	**33,778,956**
Displaced Coal Sources	**-15,408,561**	**-16,134,939**
Displaced Natural Gas Sources	**-2,608,009**	**-1,304,004**
Other Non-ED11 Sources*	**38,449,417**	**6,528,537**
Retired EGUs**	**-2,431,001**	**-3,205,156**
TOTAL Virginia Electric Industry	**92,554,876**	**29,777,105**
ED 11 Totals by 2020	**54,105,459**	**21,944,563**

*2016 Total Generation, Generation from Other sources, and Total CO2 Emissions based on values from "Total Electric Industry Sources" from EIA's 2016 State data report.

**EGUs announced for retirement before 2020 but which were operational in 2016. They were not included in 2016 ED 11 Source estimates but implicitly were counted in Other Non-ED 11 sources.

The result is that total CO2 emissions from the Electric sector for all of Virginia in 2016 would be reduced from 40 MMT to about 30 MMT by 2020, and emissions from ED 11 sources would be reduced from about 34 MMT to about 22 MMT by 2020. Of course, that is not a realistic estimate of what would happen due to the ED 11 regulations; it is an estimate of what would be physically feasible to achieve while maintaining the same level of total generation as 2016. Actual 2017 CO2 from ED 11 sources was even lower than 2016, estimated to be about 29 MMT, so they were already headed downward substantially.

Looking to the future out to 2030, there would be no remaining ED 11 coal plants to retire under this scenario, only natural gas units and perhaps smaller amounts units using other fuels, with potential replacement by even lower emitting EGUs. We consider some scenarios about that in Appendix C.

Appendix C. Implications of Various Scenarios for CO2 Reductions By 2030

This Appendix examines how much total CO2 reductions might be decreased under the ED 11 program under various scenarios, emphasizing the consequences of what baseline CO2 value is established for 2020. Of course, there are many factors that affect the outcomes, including economics, amount of net allowances purchased at the RGGI auction by Virginia EGU owners, changes in domestic sales of power, and changes in the level of imports of power from outside the RGGI region. Several scenarios will be analyzed. Those include the modeling scenarios commissioned by DEQ from ICF Corp. using their IPM model and several simple ones I create here without a formal model, based in part on results from Appendices A and B.

C 1. The ICF IPM Cases.

DEQ's IPM results included two business-as-usual-type ("Reference") cases based on assumptions from RGGI and by DEQ based on Dominion IRP projections. For each of those baselines, changes due to compliance with RGGI were analyzed (the "Policy" cases) for both Virginia and other RGGI states. That modeling looked at economic optimization taking into costs of reducing emissions in competition with cost of purchasing allowances, new EGU additions, increasing imports, and other factors. Explanations of the assumptions for the modeling were presented by DEQ.[3] They indicate that Reference Case 2 and Policy Case 2 were based on assumptions provided by DEQ, including use of Dominion Resources 2017 IRP projections and a baseline cap value of 33 MMT CO2. We analyze Policy Case 2 against several options, recognizing that modeled results would depend on those options. An important factor is that EGUs can reduce their net allowance purchases by banking of any early excess of allowances over their state allocation of allowances, and use them later to reduce their necessary CO2 reductions to avoid purchasing more allowances. So I calculate net allowance purchases based on each baseline and modeled CO2 emissions for Virginia plants as a whole (the available model results do not show results for individual EGUs).

The ICF results were furnished in autumn, 2017 before actual 2017 results for Virginia were known and before SB 966 was passed in the 2018 Session of the General Assembly, and before the announcement of retirement plans for a number of EGUs, so those factors could not be reflected in the modeling. **In particular, CO2 emissions by 2020 EGU-covered units in 2017 was overestimated in the ICF modeling as 32 MMT CO2, compared with the Sierra Club's estimate of 29 million tons based on actual 2016 data. Those factors also may have led to overestimation of subsequent modeled results for 2020 through 2030. Hence I look at likely emission reductions for other Baseline Cap values than just 33 MMT under several different policy assumptions.**

Some general results of DEQ/ICF cases are that Virginia generation remains roughly flat over time from 2017 to 2030 in the Policy cases but increases substantially in the Reference cases, while in the rest of RGGI it decreases over

time. In the Policy Case 2 (Virginia Assumptions), CO2 decreases only 9.5% between 2020 and 2031 and 17.3% in Virginia, while the total for all RGGI plus Virginia decreases 13.4% from 2020 to 2031 and 19.3% from 2017 to 2031. Solar generation in Virginia increases from 700 GWh in 2017 to 5,324 in 2031. In the rest of RGGI solar increases from 1925 GWh in 2017 to 13,474 in 2031, while total generation decreases from 316,625 to 304,587 in 2031 (6%), but solar generation is a relatively small fraction of the total in both Virginia (5.5%) and the rest of RGGI (4.4%).

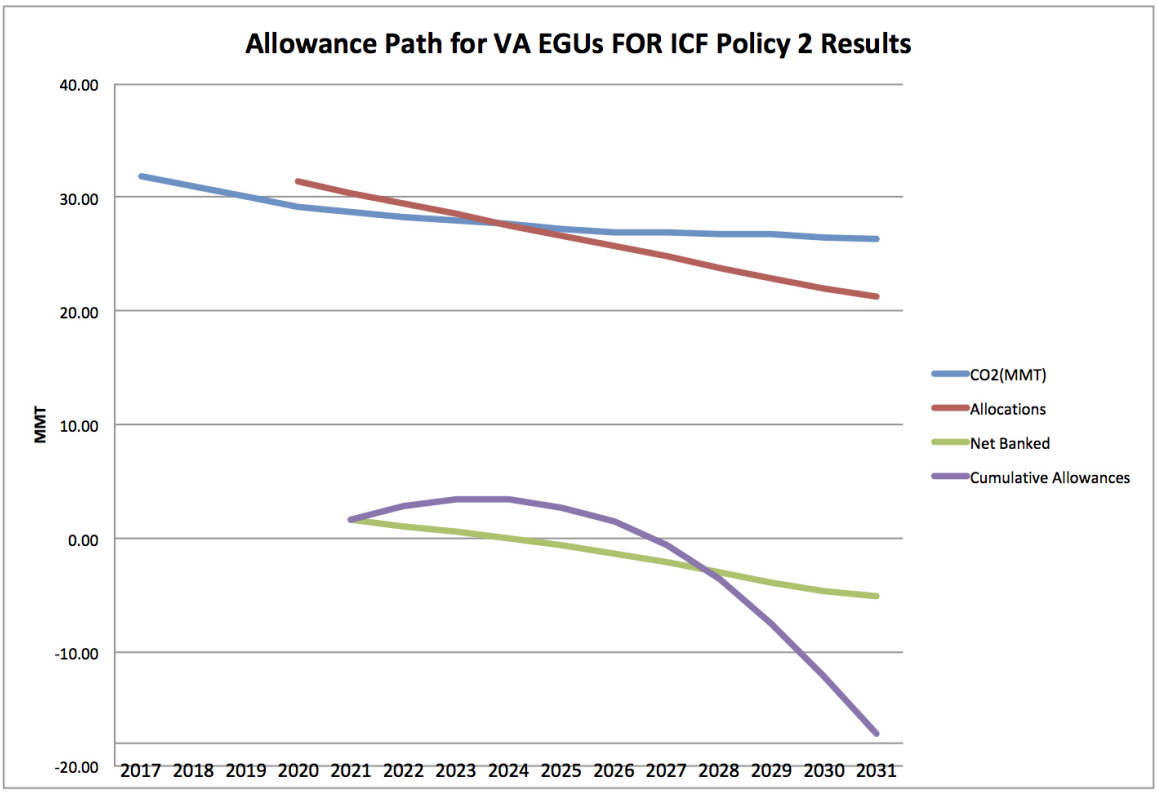
C 2. The ICF IPM Policy Case 2.

We examine the results of this modeled case in terms of the implied allowance-banking path. To this we interpolate the ICF results to annual values.

Analysis Of Policy Case 2

Modeled VA Results			Interpolated Results		CO2 Allocations at 95%	Net Banked Allowances	Cumulative Allowances
Year	CO2 Emissions	Generation (GWh)	Year	CO2(MMT)	CAP @ 33	CAP @ 33	CAP @ 33
2017	31.93	96,788	2017	31.93			
2020	29.13	98,008	2018	30.99			
2023	27.93	96,921	2019	30.06			
2026	26.97	96,012	2020	29.13	31.35	2.22	2.22
2029	26.73	96,477	2021	28.73	30.41	1.68	3.90
2031	26.35	96,850	2022	28.33	29.47	1.14	5.03
			2023	27.93	28.53	0.59	5.63
			2024	27.61	27.59	-0.03	5.60
			2025	27.29	26.65	-0.64	4.96
			2026	26.97	25.71	-1.26	3.69
			2027	26.89	24.77	-2.13	1.57
			2028	26.81	23.83	-2.99	-1.42
			2029	26.73	22.89	-3.85	-5.27
			2030	26.54	21.95	-4.60	-9.87
			2031	26.35	21.29	-5.07	-14.94
					total allowances	-14.94	

Note that this scenario suggests that Virginia EGU owners, collectively, would buy about 17 million CO2 allowances and only reduce their emission level by 2.6 MMT, or 9% by 2030. The allowance path is also shown in the following Chart.



C 3. Other Policy Option Scenarios

In Appendix B our optimal 2020 scenario reduced CO2 ED 11 emissions to 21, 945 kton with a generation of 54,106 GWh. Consider three different options for the Baseline Emission Cap: a) 32 MMT, b) 30 MMT, and c) 28 MMT with a 3% annual decline starting in 2021. Assuming 95% of the cap is allocated to EGU owners, and generation is held constant at 54,106 GWh, and they actually achieve a CO2 total of cutting emissions by at least 30% between 2020 and 2030. While I presented a scenario in Appendix B that could achieve a reduction to only 22 MMT by 2020, the emission reduction scenarios here much less much less stringent values by 2020. Generally, these path have substantially higher emissions than that. To achieve those goals, they add generation by renewable wind or solar capacity each year. Results in terms of collective required renewable generation and change in banked allowances each year are shown in Tables C.3 and C.4.

Actual emission paths shown here are based on assumed CO2 rates that decline over time. These rates are higher than the average emission rates associated with the Supply Curve in Appendix A, allowing for more use of higher rate sources such as gas turbine peaking units. Solar power is factored into the net generation required of ED11 sources, initially based on the goal of recent legislation that encouraged achieving 5.5 GW of new solar by 2028. However, we up that goal to 7 GW by 2028 in the final scenario for a Baseline CO2 value of 28 MMT in Table C.4..

These three scenarios result in different levels of cumulative banked allowances. In the 32 MMT baseline, the assumed actual ED 11 emissions result in a large excess allowance by 2031, about 22 million. That suggests that a lower Base cap would be feasible. In the Base case of the Base Cap of 30 MMT, the result is an excess of 3 million by 2031, while still achieving the same 30% reduction in total emissions. By comparison, the allowance deficit in the ICF Policy Case 2 with a Base Cap of 33 MMT was estimated to be 15 million in Section C.2. A Base Cap of 28 MMT would lead to a significant deficit in allowances by 2031. In that case, we assume an increase in solar capacity to 7 GW by 2028, which reduces the required ED 11 generation further in order to reduce the allowance deficit to only 0.24 Million by 2031.

So the conclusion is that would be feasible to achieve reductions under a Base Cap of 28 MMT with an aggressive, but feasible Solar or wind expansion program and phasing out a substantial amount of higher ED 11 CO2 carbon sources along with considerable natural gas generation while maintaining a steady level of total Virginia generation. It also implies that it makes little sense to continue expanding natural gas generating sources since they are likely to be constrained in their generation.

Table C.3 Scenarios of Potential Emission Reductions and Allowances at Base Caps of 32 and 30 MMT

Year	ED 11 +Solar Generation (MWh)	New Capacity for Solar Path to 5.5 GW By 2028	Generation for Solar Path to 5.5 GW By 2028	Net Required ED 11 Generation (MWh)	Net Allowance Allocations with CAP @ 32	With ED11 CO2 Reduction Rate and C: ED 11 CO2 (Short Tons)	ED 11 CO Rate (lb-CO2/MW
2016	54,105,459	0	0	54,105,459		33,778,956	1
2017	52,276,369	0	0	52,276,369		29,011,247	1
2018	54,105,459	0.5	1,104,750	53,000,709		30,153,179	1
2019	54,105,459	1	2,209,500	51,895,959		29,219,595	1
2020	54,105,459	1.5	3,314,250	50,791,209	30,400,000.00	28,298,999	1
2021	54,105,459	2	4,419,000	49,686,459	29,488,000.00	27,391,392	1
2022	54,105,459	2.5	5,523,750	48,581,709	28,576,000.00	26,496,773	1
2023	54,105,459	3	6,628,500	47,476,959	27,664,000.00	25,615,143	1
2024	54,105,459	3.5	7,733,250	46,372,209	26,752,000.00	24,746,501	1
2025	54,105,459	4	8,838,000	45,267,459	25,840,000.00	23,890,848	1
2026	54,105,459	4.5	9,942,750	44,162,709	24,928,000.00	23,048,183	1
2027	54,105,459	5	11,047,500	43,057,959	24,016,000.00	22,218,507	1
2028	54,105,459	5.5	12,152,250	41,953,209	23,104,000.00	21,401,819	1
2029	54,105,459	6	13,257,000	40,848,459	22,192,000.00	20,598,120	1
2030	54,105,459	6.5	14,361,750	39,743,709	21,280,000.00	19,807,409	
2031	54,105,459	7	15,466,500	38,638,959	20,368,000.00	19,029,687	
			% CO2 Reduction from 2020 to 2030			30.0%	

* Values in Red are estimated actual values of ED 11 output in 2016 and 2017

Table C.4 Scenario of Potential Emission Reductions and Allowances at Base Cap of 28 MMT With Additonal Solar Generation and a Base Cap of 28

Year	ED 11 +Solar Generation (MWh)	New Capacity for Solar Path to 7 GW By 2028	Generation for Solar Path to 5.5 GW By 2028	Net Required ED 11 Generation (MWh)	ED 11 CO2 (Short Tons)	ED 11 CO2 Rate (lb-CO2/MWh)	Allov Alloc with C 28
2016	54,105,459	0	0	54,105,459	33,778,956	1,249	
2017	52,276,369	0	0	52,276,369	29,011,247	1,110	
2018	54,105,459	0.5	1,095,750	53,009,709	30,158,300	1,138	
2019	54,105,459	1.14	2,490,341	51,615,118	29,061,470	1,126	
2020	54,105,459	1.77	3,884,932	50,220,527	27,981,036	1,114	26,600
2021	54,105,459	2.41	5,279,523	48,825,936	26,916,999	1,103	25,802
2022	54,105,459	3.05	6,674,114	47,431,345	25,869,357	1,091	25,004
2023	54,105,459	3.68	8,068,705	46,036,754	24,838,112	1,079	24,206
2024	54,105,459	4.32	9,463,295	44,642,163	23,823,263	1,067	23,408
2025	54,105,459	4.95	10,857,886	43,247,572	22,824,811	1,056	22,610
2026	54,105,459	5.59	12,252,477	41,852,982	21,842,754	1,044	21,812
2027	54,105,459	6.23	13,647,068	40,458,391	20,877,094	1,032	21,014
2028	54,105,459	7	15,340,500	38,764,959	19,775,380	1,020	20,216
2029	54,105,459	7.91	17,332,773	36,772,686	18,542,883	1,009	19,418
2030	54,105,459	8.82	19,325,045	34,780,413	17,333,810	997	18,620
2031	54,105,459	9.73	21,317,318	32,788,141	16,148,159	985	17,822
			% CO2 Reduction from 2020 to 2030		38.1%		

* Values in Red are estimated actual values of ED 11 output in 2016 and 2017

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[1] RGGI States' Comments on Proposed Virginia Regulation for Emissions Trading, April 9, 2018.

[2] COMMENTS OF THE VIRGINIA CHAPTER OF THE SIERRA CLUB ON PROPOSED CO2 BUDGET TRADING PROGRAM, April 9, 2018

[3] State Air Pollution Control Board, Nov. 16, 2017