Multi-Sector Approach to Reducing Greenhouse Gas Emissions in the Metropolitan Washington Region: Renewable Energy Supplemental Analysis

Technical Report

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Metropolitan Washington Council of Governments

Submitted by: ICF International

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Report Background and Purpose

On November 12, 2008, the members of the Metropolitan Washington Council of Governments (COG), representing 22 local governments,[1] collaboratively adopted voluntary goals to reduce greenhouse gas (GHG) emissions in pursuit of "a more accessible, sustainable, prosperous, and livable National Capital Region." These goals are ambitious – reducing GHGs by 20% below 2005 levels by 2020 and by 80% below 2005 levels by 2050 – and place the region as a national leader in calling for aggressive action to address climate change.

As a growing region, the National Capital Region is expected to add about 2.3 million people by 2050 to the 4.7 million that lived in the region in 2005. The *National Capital Region Climate Change Report*, which included the GHG goals, business as usual (BAU) projections of growth in population, housing, employment, and energy use, suggested that total GHG emissions in the region would increase by 33% by 2030 and 43% by 2050.[2] Consequently, attaining the GHG reduction goals will be challenging, and will require significant reductions in emissions across all sectors. Moreover, it was recognized that strategies to meet the goals would require "a coordinated effort involving actions on the part of individuals, businesses, federal and state policy and regulations, academic research and development, and new technologies."[2]

Over the past several years, COG has made progress in understanding the nature of regional emissions through development of a 2005 and 2012 GHG inventory and forecast, and in identifying opportunities for reductions in various sectors through development of the National Capital Region Climate Change Report, "What Would It Take?" study, and the regional Climate and Energy Action Plans.[3] Many local governments in the Washington region have become national leaders in adopting programs to reduce GHG emissions, by promoting building energy efficiency and transit-oriented development, and many communities have also signed agreements such as Cities for Climate Protection and Cool Counties. In its 2010 and 2013 Climate and Energy Action Plans, COG identified a range of actions and is tracking progress toward these actions. COG also conducted focused analyses of transportation GHG reduction strategies through its "What Would It Take?" Scenario Study, and has explored various scenarios for land use development.

The primary technical report on GHG reduction strategies in the region was developed and published in 2015. This Supplemental Analysis to the "Multi-Sector Approach to Reducing Greenhouse Gas Emissions in the Metropolitan Washington Region" is intended to help understand and refine the regional

[1] Charles County became a member in 2012.
[2] Prepared by the Climate Change Steering Committee COG Board of Directors, *National Capital Region Climate Change Report*. November 12, 2008. Available online at: http://www.mwcog.org/uploads/pub-documents/zldXXg20081203113034.pdf
[3] National Capital Region Transportation Planning Board, *What Would it Take?* May 18, 2010. Available online at: http://www.mwcog.org/uploads/pub-documents/qF5eXVw20110617114503.pdf.

renewable energy goal of 10% of total electricity consumption that was set previously. This report includes additional analysis of renewable energy issues and opportunities with comparisons that are easy to understand and explain to stakeholders and policy makers. The approach to creating the outcomes for this report was to:

- Document the renewable energy goal in terms of total megawatt hours (MWh), by sector and by COG jurisdiction, and aggregate summaries for Virginia, Maryland, and the District of Columbia
- Estimate equivalent renewable energy deployment needed to reach the goal – specifically solar PV capacity, and number of systems, along with other viable technologies, as appropriate
- Document regional desire and opportunities for green power purchasing
- Explain constraints and their impact
- Compare potential with existing goals and external examples (e.g., from related regional goals and accomplishments from across the country)
- Provide assumptions, references and calculations for renewable energy penetration and potential for continued evaluation of renewable energy potential relative to COG goals.

Background Data and Methodology

Regional Electricity Consumption and 10% Renewable Goal

Energy Consumption Projections

ICF obtained historical energy consumption data for 2005 and 2012 by jurisdiction from COG. Total electricity consumption for 2012 was then multiplied by 10% to come up with a target of 6,018 million kilowatt hours (kWh). The historical electricity consumption across all market sectors by jurisdiction is provided in Table 1 in terms of million kWh, with the 10% goal at the bottom of the table.

Table 1. Historical electricity consumption in the COG region (million kWh)

Jurisdiction	State	2005	2012
Montgomery County	MD	10,349	9,265
Prince Georges County	MD	6,095	7,406
Frederick County	MD	5,064	2,972
Charles County	MD	1,353	1,333
Alexandria	VA	1,748	1,757
Arlington	VA	3,097	3,241
Fairfax City	VA	328	306
Fairfax County	VA	12,148	13,050
Falls Church	VA	126	131
Loudoun County	VA	2,442	5,116
Manassas City	VA	638	813
Manassas Park	VA	71	81
Prince William County	VA	2,947	3,825
Washington	DC	11,736	10,878
Total		**58,142**	**60,176**
10% Goal			**6,018**

Energy consumption for the COG region was then projected across all sectors. Residential energy consumption was projected by taking projected population growth and historical energy intensity trends by jurisdiction, and applying them to the 2012 consumption data. Historical population figures for 2005 and 2012 and projected population growth rates were obtained from COG. Commercial, industrial, and government energy consumption projections were generally considered to continue on their current energy growth trends from 2005 to 2012. In cases such as Frederick and Prince William County where significant shifts in consumption occurred, the statewide average growth in electricity consumption

from 2005 to 2012 was used to project consumption in the jurisdiction. Table 2 shows projected electricity consumption within the COG region using this methodology and associated renewable energy levels to meet the 10% target.

Table 2. Projected total electricity consumption in the COG region (million kWh)

	Projected Consumption				10% Renewable Energy Goal			
Year	VA	MD	DC	Total	VA	MD	DC	Total
2015	29,369	21,300	10,531	**61,200**	2,937	2,130	1,053	**6,120**
2016	29,794	21,439	10,419	**61,652**	2,979	2,144	1,042	**6,165**
2017	30,232	21,594	10,311	**62,137**	3,023	2,159	1,031	**6,214**
2018	30,685	21,766	10,204	**62,655**	3,068	2,177	1,020	**6,265**
2019	31,152	21,955	10,099	**63,207**	3,115	2,196	1,010	**6,321**
2020	31,634	22,162	9,997	**63,793**	3,163	2,216	1,000	**6,379**
2021	32,132	22,387	9,897	**64,416**	3,213	2,239	990	**6,442**
2022	32,647	22,630	9,799	**65,076**	3,265	2,263	980	**6,508**

State RPS Requirements

Overview of State RPS Requirements

Twenty-nine states and Washington, D.C. have mandatory renewable portfolio standard (RPS) policies while eight states have voluntary RPS policies (Figure 1). RPSs require utilities to supply a given percentage of electricity from renewable sources, sometimes with technology-specific requirements (e.g., solar carve outs). For states that specify percentage targets, these range from near-term targets of 2-30 % renewable energy over the next decade, to Hawaii's long-range target of 100 % by 2045. Out of the 13 states and Washington, D.C. that make up the PJM RTO region, only three states do not have some form of RPS.

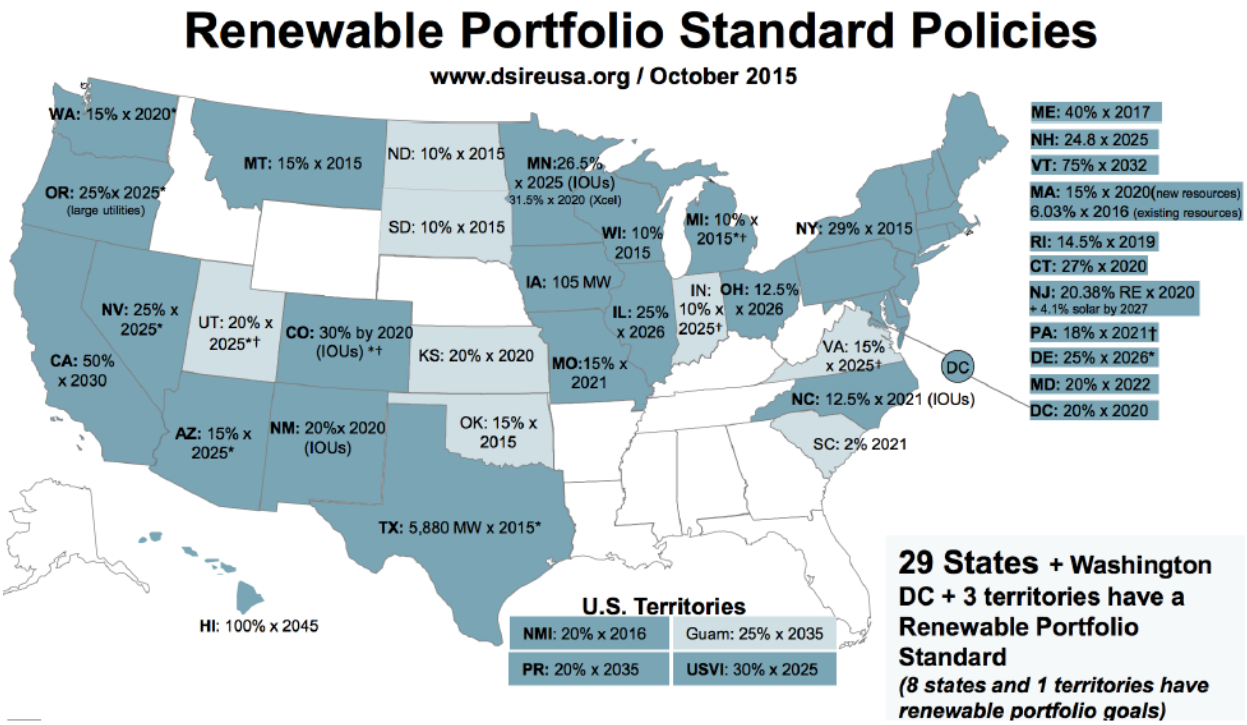

Figure 1. U.S. Renewable Portfolio Standard Policies as of October 2015
Source: DSIRE, accessed at: http://www.dsireusa.org/resources/detailed-summary-maps/

COG RPS Requirements

In the COG region, Maryland has a mandatory RPS requirement of 25% by 2020, Washington, D.C. has a mandatory RPS requirement of 20% by 2020,[4] and Virginia has a voluntary RPS of 15% by 2025 which Dominion has thus far been on track to meet by achieving its interim targets.

Some state RPS programs including those in Maryland and Washington, D.C. limit the portion of their RPS target designated for large scale hydro resources. These limits may decrease over time until large scale hydro resources are no longer eligible to meet RPS requirements. COG members have decided to exclude large-scale hydro in the 10% regional target, as well as tidal, wave, and ocean thermal power. The target technology list is shown in Table 3, with each technology being categorized in the following manner for COG regional target:

1: Priority technologies included in the target (currently being deployed)
2: Future opportunities included in the target (technically feasible but not currently being deployed)

[4] Washington, D.C.'s RPS also includes a carve-out of 2.5% to come from solar energy by 2023.

Table 3. Renewable technology classifications for regional renewable energy targets

Renewable Energy Technology	COG Regional Target
Solar Photovoltaics	1
Solar Thermal Electric	1
Solar Water Heat	2
Solar Space Heat	2
Solar Thermal Process Heat	2
Wind (All)	1
Qualifying Biomass	1
Hydroelectric <30MW	2
Geothermal Electric	2
Geothermal Heat Pumps	1
Geothermal Direct-Use	1
Municipal Solid Waste	1
Landfill Gas	1
Anaerobic Digestion	1
Fuel Cells using Renewable Fuels	1

Renewable energy levels increase over time at varying rates for each state and Washington, D.C., including the treatment of large-scale hydro resources. Table 4 shows renewable energy targets over time for each state. As states limit portions of their targets that can be met by large scale hydro, this table shows both the target escalation with large hydro, and without large hydro to align with COG's definition of renewable energy for their 10% goal.

Table 4. COG Region State Renewable Energy Targets

	VA Voluntary RPS[a]		MD RPS		DC PRS	
Year	With Large Hydro	Without Large Hydro[b]	With Large Hydro	Without Large Hydro	With Large Hydro	Without Large Hydro
2012	2.3%	1.5%	9.0%	6.5%	8.0%	5.5%
2013	2.3%	1.5%	10.7%	8.2%	9.5%	7.0%
2014	2.2%	1.4%	12.8%	10.3%	11.1%	8.6%
2015	2.2%	1.4%	13.0%	10.5%	12.7%	10.2%
2016	3.7%	2.4%	15.2%	12.7%	14.3%	12.3%
2017	3.7%	2.4%	15.6%	13.1%	16.0%	14.5%
2018	3.6%	2.3%	18.3%	15.8%	17.7%	16.7%
2019	3.6%	2.3%	20.4%	20.4%	19.4%	18.9%
2020	3.5%	2.3%	25.0%	25.0%	21.6%	21.6%
2021	3.5%	2.2%	25.0%	25.0%	21.9%	21.9%
2022	5.9%	3.8%	25.0%	25.0%	22.2%	22.2%
2023	5.8%	3.7%	25.0%	25.0%	22.5%	22.5%
2024	5.7%	3.7%	25.0%	25.0%	22.5%	22.5%
2025	7.1%	4.5%	25.0%	25.0%	22.5%	22.5%

[a] Virginia has a voluntary renewable energy goal of 15% by 2025. However, the 15% is based on 2007 retail sales minus nuclear generation from 2004 to 2006. The result is a lower percentage of total projected retail sales (7.1%) by 2025.

[b] To remove hydro from Virginia's RPS targets, ICF assumed the share of RECs that Dominion used to meet their target that came from hydro (36%) would be carried forward to future years.

Utility-Provided Renewable Energy

Using the energy consumption projections described above, ICF took the following steps to project renewable energy consumption within the COG region:

Renewable Energy Projections

Historical and projected utility-provided renewable energy percentages are primarily based on RPS targets from Virginia, Maryland, and Washington, D.C. and specified above in Table 4.

Virginia: Virginia's voluntary RPS aims for 15% renewable energy by 2025. However, since the renewable percentages are tied to 2007 sales data and exclude historical nuclear sales, the percentage of renewable energy achieved through the RPS is only 7.1% of projected sales in 2025. After excluding large hydro sales, the renewable energy percentage is estimated to increase from 1.4% in 2015 to 4.5% in 2025. Dominion Virginia Power is the only utility in the COG region participating in Virginia's RPS, and thus ICF has applied these percentages to Dominion's projected renewable energy. As for NOVEC and City of Manassas, which make up 12% and 3% of COG's Virginia electricity sales respectively, ICF applied the percentage of renewable energy coming from the SERC Virginia/Carolina region according to

reference case projections from AEO 2015.[5] These estimates come out to projections of 4.5% renewable energy in 2015, rising to 6.2% in 2025. The current share of hydro in the PJM region for 2015 (1%) was then removed from these totals to come up with a non-hydro renewables share projection of 3.5% in 2015 and 5.2% in 2025.

Maryland: Maryland's RPS requires 25% renewable energy by 2020.[6] There is a "Tier II" requirement that can be met by hydro resources but this is phased out by 2019.[7] Not including hydro resources, Maryland's RPS requirements show that renewable energy resources must make up 10.5% of sales in 2015, rising to 25% in 2020.

Washington, D.C: Washington D.C.'s RPS requires 20% renewable energy by 2020, rising to 22.5% by 2023 through additional solar requirements. There is a "Tier II" requirement for hydro resources but this gets phased out by 2020.[8] Not including hydro resources, Washington, D.C.'s RPS requirements show that renewable energy resources must make up 10.2% of sales in 2015, rising to 22.5% in 2025. Note: as of May 2016, there is a bill pending that could increase the RPS to 50% by 2032.

This analysis assumes that the region's three municipal solid waste power plants are accounted for in the reported total renewable energy sources from regional utilities. This is a conservative assumption to avoid potential double-counting of the clean power output.

Table 5 summarizes utility-driven green power procurements by jurisdiction over the next decade.

[5] AEO projections can be accessed at: http://www.eia.gov/forecasts/aeo/data/browser/#/?id=62-AEO2015&region=3-16

[6] For this analysis, we have updated the Maryland RPS assuming that SB 921 will pass into law by May 27, 2016.

[7] Tier II resources are not restricted to hydro. For instance in 2016 Tier II requirements of 2.5% can be met by either hydro resources or other resources such as solar, wind, and biomass.

[8] Tier II resources are not restricted to hydro resources.

Table 5. Projected Utility-Provided Renewable Energy Purchases by Jurisdiction (% of Annual Sales)[a]

Jurisdiction	State	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Montgomery County	MD	10.5%	12.7%	13.1%	15.8%	20.4%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%
Prince Georges County	MD	10.5%	12.7%	13.1%	15.8%	20.4%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%
Frederick County	MD	10.5%	12.7%	13.1%	15.8%	20.4%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%
Charles County	MD	10.5%	12.7%	13.1%	15.8%	20.4%	25.0%	25.0%	25.0%	25.0%	25.0%	25.0%
Alexandria	VA	1.4%	2.4%	2.4%	2.3%	2.3%	2.3%	2.2%	3.8%	3.7%	3.7%	4.5%
Arlington	VA	1.4%	2.4%	2.4%	2.3%	2.3%	2.3%	2.2%	3.8%	3.7%	3.7%	4.5%
Fairfax City	VA	1.4%	2.4%	2.4%	2.3%	2.3%	2.3%	2.2%	3.8%	3.7%	3.7%	4.5%
Fairfax County	VA	1.5%	2.5%	2.4%	2.4%	2.4%	2.4%	2.4%	3.8%	3.8%	3.7%	4.6%
Falls Church	VA	1.4%	2.4%	2.4%	2.3%	2.3%	2.3%	2.2%	3.8%	3.7%	3.7%	4.5%
Loudoun County	VA	1.6%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	3.9%	3.9%	3.8%	4.6%
Manassas City	VA	3.5%	3.5%	3.9%	4.2%	4.4%	4.7%	4.9%	5.1%	5.1%	5.2%	5.2%
Manassas Park	VA	3.5%	3.5%	3.9%	4.2%	4.4%	4.7%	4.9%	5.1%	5.1%	5.2%	5.2%
Prince William County	VA	2.6%	3.1%	3.3%	3.4%	3.5%	3.7%	3.8%	4.5%	4.5%	4.5%	4.9%
Washington	DC	10.2%	12.3%	14.5%	16.7%	18.9%	21.6%	21.9%	22.2%	22.5%	22.5%	22.5%

[a] Renewable energy percentages do not include large hydro.

Distributed Generation Summary

Table 6 shows actual distributed generation figures in 2015 for the COG region followed by projected distributed generation for the region through 2022.

Table 6. Distributed generation projections for the COG region (cumulative annual in million kWh)

Year	VA	MD	DC	Total
2015	7	150	18	176
2016	9	180	22	211
2017	11	216	26	254
2018	14	259	32	305
2019	17	311	38	366
2020	21	373	46	440
2021	26	448	55	529
2022	28	470	57	555

Distributed generation growth projections were based on the average rates from 2010 to 2015, capped at 20% to 25% per year for the first six years and then projected at 5% growth per year starting in 2022. These assumptions are conservative when compared to growth rates to reflect an increased installed baseline and also avoid forecasting exponential growth curves over the planning horizon that might distort related analyses. The starting point for distributed generation kWh values was total deployed solar capacity (in MW_{DC}) as reported by COG. These numbers were then converted to kWh using solar yield calculations for each area – Maryland, Northern Virginia and DC based on the PVWATTS model using a typical solar system design. Multiplying the capacity (MW_{DC}) by the annual solar yield results in the total annual output from these systems and this was used in the cumulative distributed generation baseline and forecasts. These solar yield ratios were also used for consistency to calculate the implied solar capacity in future years that would be necessary to produce the expected solar kWh production forecasts.

Regional Green Power Purchases

Regional voluntary green power purchases were obtained from EPA's Green Power partnership. Green power purchases are split into the following categories:

- **RECs**: Independent REC purchases that are not bundled with electricity.
- **Green Marketing:** Short term bundled green power with RECs through a competitive supplier.
- **Green Pricing:** Short term bundled green power with RECs through a regulated utility.
- **Power Purchase Agreements (PPAs):** Long-term bundled renewable energy purchase contracts.

- **On-Site Renewables:** Generation from on-site power production (primarily solar PV). This was NOT included to avoid the potential for double-counting with regional distributed generation reported by the utility interconnection data.

EPA's Green Power Partnership (GPP) provided data on local purchases as well as national totals for companies headquartered within the COG region. For companies headquartered in the COG region, green power purchases were conservatively apportioned to the COG region. However, since these are estimates, they could be refined by engaging EPA further. There are also companies in the GPP dataset that are headquartered outside of the COG region with operations inside the COG region that have not been attributed towards the COG green power total.

Table 7 shows green power purchases from the COG region for 2015. Unbundled RECs are the most popular green power choice, followed by Green Marketing which largely stems from purchases from the District of Columbia government.[9] Voluntary green power purchases in the COG region made up 2.9% of overall electricity consumption in the COG region in 2015. These estimates do not include individual green power purchases at the consumer level, such data was not readily available.

Table 7. Green Power Purchases within the COG Region for 2015 (million kWh)

Jurisdiction	State	Total Green Power Purchases
Montgomery County	MD	670
Prince Georges County	MD	139
Frederick County	MD	0.1
Charles County	MD	0
Alexandria	VA	8
Arlington	VA	31
Fairfax City	VA	0
Fairfax County	VA	16
Falls Church	VA	1
Loudoun County	VA	0
Manassas City	VA	0
Manassas Park	VA	0
Prince William County	VA	0
Washington	DC	931
Total		**1,796**

[9] In July 2015, the District of Columbia government signed a PPA to supply 35% of the government's electricity with Wind Power. More information is available at: http://mayor.dc.gov/release/mayor-bowser-announces-groundbreaking-wind-power-purchase-agreement

For additional information on the differences between various green power options and the environmental claims that can be made through them, see Table 16 in the Supporting Data section.

To project future voluntary green power purchases, an annual growth rate of 10% is assumed. This figure is backed up by the most recent trend of national green power market sales from 2013 to 2014.[10]

Regional Renewable Energy Strategies

Three major categories of renewable energy strategies were included in this Supplemental Analysis with each area represented by a particular set of programs that could be implemented to drive faster deployment of solar power, based on local opportunities and national best practices. Table 8 shows a summary of these programs' potential for incremental clean energy supply in the region by 2022 followed by an explanation of the assumptions for each area.

Table 8. Clean energy program potential in 2022 (million kWh)

Program	VA	MD	DC	Total
Aggregated Purchasing Programs	810	663	176	1,648
Community Solar	817	607	230	1,654
Incentives	4	29	4	36

Aggregated Purchasing Programs – these include residential, commercial and government aggregated solar purchasing programs that could be implemented and supported regionally. Program forecasts were updated from the initial analysis based on recent changes in the availability of the Investment Tax Credit and current solar adoption trends and includes the following assumptions:

- 1% of regional single family residences participate in aggregated purchase programs over a 3-year dedicated program across all jurisdictions in MD and DC, with 0.5% in VA jurisdictions.
- 1.25% of commercial energy usage offset potential in MD and DC, with 0.63% in VA over a 5-year dedicated program across all jurisdictions.
- 10% of municipal public energy usage offset potential in VA and MD over a 5-year dedicated effort. DC is not included because they are already at 100% clean energy purchases for their facilities and additional on-site generation would be increase total renewable consumption in this sector.

Community Solar – includes both residential and commercial shared solar projects. This strategy was added to the analysis based on the high level of interest and significant potential for this type of deployment across the region. In addition to other programs, the forecast estimated that 3% of energy usage in the residential and commercial sectors could be provided from community solar projects,

[10] For more information, see NREL's "Status and Trends in the U.S. Voluntary Green Power Market (2014 Data)" report at: http://www.nrel.gov/docs/fy16osti/65252.pdf

ramping up over a 6-year period. Based on emerging markets for community solar programs (e.g. Colorado and Minnesota) there is significant interest when these programs are implemented to create maximum impact for customers and developers. Community solar directly addresses many technical challenges from smaller distributed systems by reducing costs from bigger project sizes, providing access to customers in multi-family dwellings, and flexible options that can be made to fit both residential and commercial energy users. As a point of reference, the community solar program in Minnesota received over 1,000MW of new project applications within the first program year alone.

Incentives – these include Property Tax Abatements, Density Allowances, and Permit Fee Reductions only, and do not include any forms of rebates. The original forecasts were updated based on current trends in solar deployment and overall favorable conditions for the market regionally. For Maryland and the District of Columbia, the potential for a 10% increase in deployment trends were estimated, while in Virginia, the potential was estimated at 20% due to the smaller initial market size.

Key Finding: Region Approaching 10% Target

COG Region at 9.5% Renewable Energy in 2015

In 2015, COG is projected to reach 9.5% renewable energy consumption through utility-based renewable energy purchases, voluntary green power purchases, and distributed generation deployment. Highlights of the analysis of current electricity consumption are:

- Utility supplied non-hydro renewable energy makes up the largest share of the efforts to meet the 10% target and is estimated to represent 6% of regional consumption.
- Customer voluntary green purchases reported to EPA's Green Power Partnership are estimated at almost 3% of regional consumption.
- Distributed generation data provided by COG, primarily solar, makes up 0.3% of regional consumption.

Figure 2 provides a breakdown of contributions towards meeting the target, while Table 9 shows the relative contributions from each COG jurisdiction.

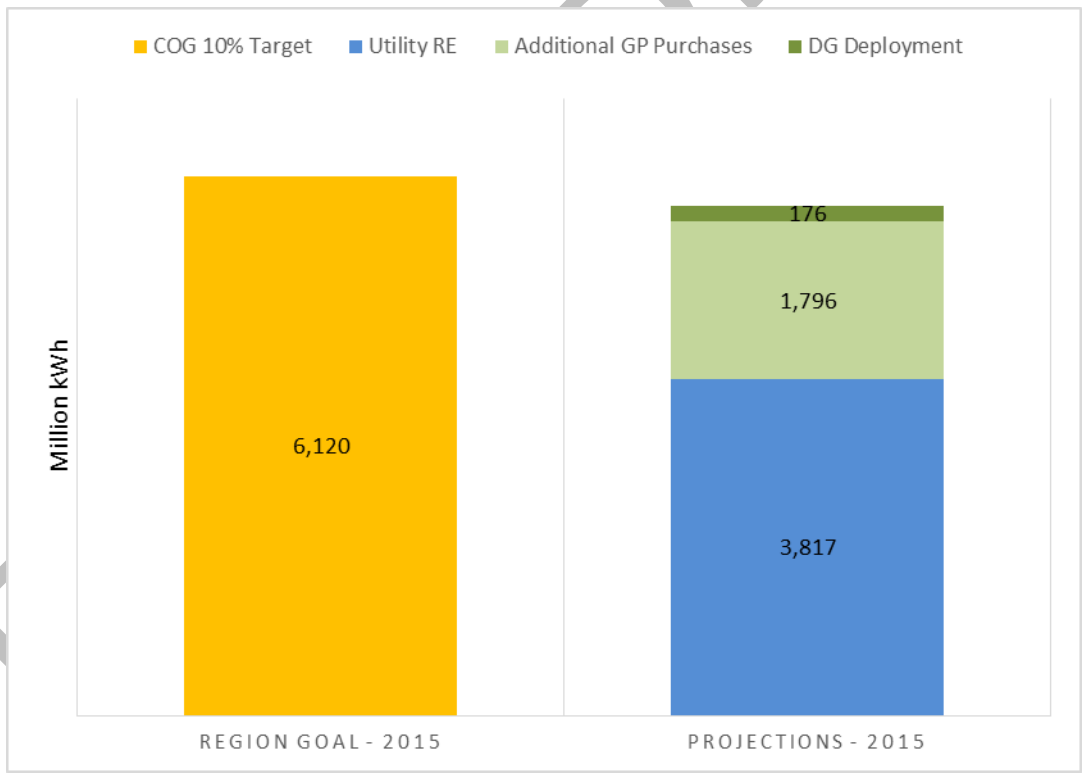

Figure 2. Actual and projected renewable energy consumption in the COG region for 2015

Table 9. 2015 renewable energy analysis by COG jurisdiction (million kWh)

State	Jurisdiction	Projected Consumption	Utility Supplied RE w/o Large Hydro	Customer Voluntary Green Power Purchases	DG Deployment	Total Projected RE	Total Projected RE (%)
MD	Montgomery County	8,777	922	670	48	1,639	18.7%
MD	Prince Georges County	8,089	849	139	60	1,049	13.0%
MD	Frederick County	3,104	326	0.1	29	355	11.4%
MD	Charles County	1,331	140	0	12	152	11.4%
MD	COG Total	**21,300**	**2,236**	**809**	**150**	**3,195**	**15.0%**
VA	Alexandria	1,752	25	8	0.5	33	1.9%
VA	Arlington	3,277	46	31	2	79	2.4%
VA	Fairfax City	295	4	-	-	4	1.4%
VA	Fairfax County	13,392	201	16	2	218	1.6%
VA	Falls Church	132	2	1	0.3	3	2.0%
VA	Loudoun County	5,602	92	0	2	94	1.7%
VA	Manassas City	768	27	0	0.1	27	3.5%
VA	Manassas Park	79	3	-	-	3	3.5%
VA	Prince William County	4,072	107	0	2	108	2.7%
VA	COG Total	**29,369**	**506**	**56**	**7**	**569**	**1.9%**
DC	Washington	**10,531**	**1,074**	**931**	**18**	**2,023**	**19.2%**
	TOTAL	**61,200**	**3,817**	**1,796**	**176**	**5,788**	**9.5%**

COG Region Can Reach 25% by 2022

Overall regional renewable energy consumption is projected to exceed 25% of regional electricity consumption by 2022. Highlights of the forecasted total electricity renewable energy consumption are:

- Utility supplied non-hydro renewable energy is expected to contribute the most renewable energy, representing over 14% of regional consumption.
    - Major drivers are the impact of mandatory RPS goals in MD and DC as shown in Table 4 above. These goals directly contribute to attainment of renewable energy targets within COG jurisdictions.
- Customer voluntary green purchases reported to EPA's Green Power Partnership are estimated at over 5% of regional consumption.

    - Due to the large impact of voluntary purchases by government agencies, commercial, and industrial energy users, the forecast through 2022 include a 10% annual increase in these voluntary purchases, increasing this component of renewable energy consumption up from 3% in 2015.
- Distributed generation data provided by COG, primarily solar PV, makes up 0.9% of regional consumption.
    - The forecast for these on-site renewables includes a conservative estimate of the annual growth potential in the region of 20-25% per year through 2020 then 5% thereafter compared to the compound growth rate through 2015 of 45% per year (which is based on a relatively low starting point in 2010).
- Additional regional strategies could potentially contribute 5% more renewable energy consumption.
    - As shown in Table 8 above, there are a number of strategies that emerged from the full Multi-Sector Approach to Reducing Greenhouse Gas Emissions in the Metropolitan Washington Region report last year (some assumptions have been updated as described above) and have the potential to make a significant contribution to the overall attainment of renewable energy targets regionally. The totals for potential solar deployment are shown in Tables 12 and 13 below.
- Figure 3 provides a breakdown of contributions to the projected 25% renewable energy total, while Table 10 shows the relative contributions from each COG jurisdiction.

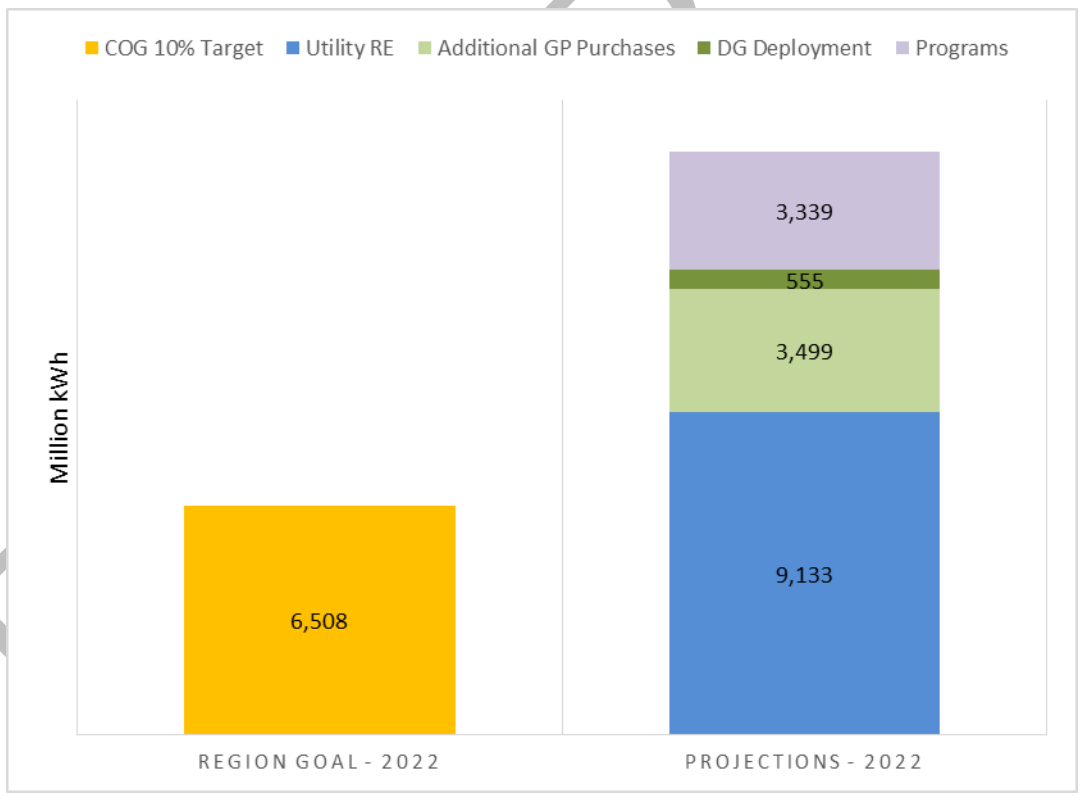

Figure 3. Regional 10% goal and projected renewable energy consumption in the COG region for 2022

Table 10. 2022 renewable energy projections by state and category (million kWh)

State	Projected Consumption	10% RE Goal	Utility Supplied RE w/o Large Hydro	Customer Voluntary Green Power Purchases	DG Deployment	Programs	Total Projected RE	Total Projected RE (%)
MD	22,630	2,263	5,658	1,577	470	1,298	9,002	39.8%
VA	32,647	3,265	1,303	109	28	1,631	3,070	9.4%
DC	9,799	980	2,173	1,814	57	410	4,454	45.5%
TOTAL	**65,076**	**6,508**	**9,133**	**3,499**	**555**	**3,339**	**16,526**	**25.4%**

Local Renewable Energy Goals

For comparative purposes, U.S. cities have a wide range of renewable energy goals across varying time horizons. Within the COG region, renewable energy targets are specified as a percentage of community electricity consumption or municipal operations that are procured from renewable sources, or as a capacity of renewable energy to be installed in the jurisdiction. Table 11 presents these targets and renewable energy procurement targets for other U.S. cities as a planning reference looking forward to 2022 and beyond.

Table 11. Renewable energy targets from COG jurisdictions and other U.S. cities

Jurisdiction	Target Year	Target
Bowie, MD	2020	24 MW of solar PV
Rockville, MD	2022	20% renewable energy
Montgomery County, MD	2020	100% renewable energy for county operations
Washington, D.C.	Achieved	100% renewable energy for municipal operations
Washington, D.C.	2032	50% renewable energy (Sustainable DC Community Wide Target)
Arlington, VA	2050	160 MW of solar
San Jose, CA	2022	100% renewable energy Community Wide
San Francisco, CA	2020	100% renewable energy
Philadelphia, PA	None	20% alternative energy (achieved 15.2% as of 2014)
San Diego, CA	2035	100% renewable energy
Austin, TX	2020	50% renewable energy (65% by 2025)
Burlington, VT	Achieved	100% renewable energy

Solar PV Deployment Estimates

As part of the 2022 forecast for consumption of total renewable energy, the equivalent solar PV capacity was calculated by jurisdiction that would be required to meet these targets. Table 12 below shows the estimated cumulative capacity of solar PV in MW_{DC} that would be required to supply the total forecasted contribution of distributed generation deployment and programs shown in the prior section. State allocations are derived from the relative deployment forecasts and provided as a starting point for planning, but actual numbers are likely to be significantly different by 2022.

Table 12. Projected solar PV capacity by state in 2022.

State	Solar PV Capacity (MW)
MD	1,333.5
VA	1,110.9
DC	361.0
TOTAL	**2,805.3**
Less Existing Solar PV	*122.7*
Net New Solar PV	**2,682.6**

The total estimated solar PV deployment numbers above include 122.7MW of currently installed solar projects regionally. While other technologies will be deployed in addition to solar, looking at a scenario where all of the incremental renewable energy targets through 2022 were provided by solar PV, the region would require 2,682.6MW_{DC} of new project installations. Table 13 allocates this amount into three sectors based on the latest national statistics on cumulatively installed solar power through 2015. While the actual mix of solar installations by sector would likely not mimic the exact combination of the national average (and could certainly be influenced by local factors, policies and programs) this forms the starting point for further discussion of other scenarios. For reference and estimation of the potential to achieve this scale of deployment within the region, selected project-level statistics have been calculated and included.

Table 13. Scenario Potential solar PV deployment by sector for 2022

Year	Sector	MW	Projects	Notes
2022	New Residential	587.3	117,468	~10% of 2012 single family residences
2022	New Commercial	640.6	3,203	~3,800 acres needed
				(Pentagon with parking is ~1,000 Acres)
2022	New Utility	1,454	291	~8,700 acres needed
				(Dulles Airport is >12,000 Acres)

2022	**Total New**	**2,682.6**	**120,962**	

The assumptions used to determine the number of projects and regional metrics include:

- Average Residential project size is estimated at 5kW.
- While not all residential capacity will be on-site (some are considered to be available via community solar projects, the equivalent number of projects would be about 10% of existing single family homes.
- Average Commercial project size is 200kW.
- Due to rooftop and parking lot design constraints a conservative 6 acres per MW_{DC} was used to estimate required space for installing this quantity of solar capacity. For reference, the footprint of the Pentagon and surrounding parking lots is approximately 1,000 acres based on remote review.
- Average Utility-scale project size is 5MW.
- Due to potential siting and design constraints a conservative 6 acres per MW_{DC} was used to estimate required space for installing this quantity of solar capacity. For reference, the footprint of the Dulles International Airport is over 12,000 acres based on published information.
- Solar yield estimates were based on localized PVWatts calculations in Maryland, Northern Virginia and Washington DC for an average solar PV system that is oriented due south and at a 15 degree slope. These were used to determine the solar PV capacity in each area that would be required to generate the renewable power consumed in the 2022 scenario.

Constraints and Opportunities for Renewable Energy Growth

Based on an overall analysis of the renewable energy markets in the COG region and input from individual jurisdictions, a list of selected constraints and opportunities are described below. While not exhaustive, these include the areas of technical, policy, and economic considerations that should be taken into consideration when planning and implementing strategies to accelerate growth of renewable power.

Constraints

Table 14 shows potential technical, economic, and policy constraints for renewable energy deployment within the COG region.

Table 14. Renewable energy market constraints

Constraint Type	Constraint
Technical	Available land and high real estate prices make it difficult for large scale solar.
Technical	Secondary electrical network capacity concerns.
Economic	Commercial buildings have split incentives for solar development and electricity savings.
Policy	Government buildings may be subject to development restrictions and/or not be able to sign 20-year PPAs.
Policy	Third party solar project ownership challenges in Virginia.
Economic	Lower cost of electricity and lack of SREC market reduces project viability in Virginia.
Technical	Existing tree canopy and parking lot design concerns for large scale solar projects.
Technical	Density of older/historic buildings create siting issues.
Economic	Multi-family and low-income residents have challenges purchasing or financing renewable energy projects.

Opportunities

Table 15 shows potential technical, economic, and policy opportunities for renewable energy deployment within the COG region.

Table 15. Renewable energy market growth opportunities

Opportunity Type	Opportunity
Policy	Development of community solar and rooftop solar PV resources.
Economic	Aggregated purchasing programs will allow DC residents to support renewable energy where it is less expensive to build.
Technical	Efforts to expand Commercial green power purchasing can address technical issues with siting.
Economic	Engagement and cooperative development with local utilities can accelerate project development and reduce transaction costs.

Supporting Data

Table 16. Attributes of voluntary green power purchase options

Green Power Supply Options		Self-Generation	Physical or Financial/ Synthetic[a] PPAs	Bundled[b] Green Pricing / Green Marketing Products	Unbundled[c] RECs (from a REC marketer)
Your Impact on New Supply	Direct or Indirect	Direct[d]	Direct[d]/Indirect	Indirect	Indirect
What You Are Buying	RECs	Yes	Yes	Yes	Yes
	Commodity Electricity	Yes	Yes/No[e]	Yes	–
	Generating Asset	Yes	–	–	–
Your Relationship to Generator	Ownership	Direct/Buyer	Third-party	Third-party	Third-party
	On-site	•	•	–	–
	Off-site	•	•	•	•
Your Financial Impact	Cost or Savings	Savings over life of project	Savings over term of PPA	Cost premium	Cost premium
Your Claim Limits	Renewable Electricity Use or Build New Projects	I use renewable electricity[f] and I built a new project[g]	I use renewable electricity[f] and I built a new project[g]	I use renewable electricity[f]	I use renewable electricity[f]

Source: EPA's Green Power Partnership: https://www.epa.gov/greenpower/green-power-supply-options

Note: All green power supply options include the procurement of a REC, which substantiates the buyer's claim to be using renewable electricity from a zero-emissions resource. In the absence of owning a REC, the associated commodity electricity is not considered renewable and is assigned the environmental profile of the local grid mix.

[a] A financial, synthetic, or virtual PPA is a form of financial hedge. The renewable energy project sells electricity on a merchant basis, but enters into a contract with a third party (counterparty) that provides a floor under the electricity price. Project counterparties pay each other depending on whether the realized electricity price is higher or lower than the established PPA benchmark price. These types of PPAs are generally limited to locations where hedging counterparties can be found—therefore, areas that are deregulated and that have liquid spot markets for energy sales that permit the sale of the electricity output into day-ahead or real-time market (Chadbourn & Park, April 2014).

[b] Bundled products involve paying a single bill to a single supplier for the combined (e.g., bundled) RECs with the underlying commodity electricity service.

[c] Unbundled refers to buying your electricity and the environmental attributes separately from two different suppliers and paying two separate bills.

[d] To have a direct impact, an organizational buyer must engage with the project before it is built by signing a financeable long-term Physical or Financial PPA or by taking an investment position in the project itself.

[e] Yes for a physical PPA, No for a Financial / Synthetic PPA.

[f] To claim renewable electricity (green power) use from a zero-emissions resource, the buyer must own and retain the associated RECs.

[g] To claim to have built a new project or directly contributed to new supply, the buyer must directly engage with the project before it is built in a manner that is determined to be financeable. Signing Physical or Financial PPAs with underlying RECs does not constitute direct project engagement and does not offer the claim of having built a new project (see note d above).

Data Sources

Table 17. Data Sources for COG Analysis

Data Type Description	Source	Relevant link
Historical electricity consumption by jurisdiction	COG	N/A
Historical population figures	COG	N/A
Population growth forecasts	COG	N/A
Maryland RPS percentage requirements – used for utility renewables projections.	Maryland PSC	http://webapp.psc.state.md.us/Intranet/Reports/2014%20Renewable%20Energy%20Portfolio%20Report.pdf
Washington D.C. RPS percentage requirements - used for utility renewables projections.	DC PSC	http://www.dcpsc.org/customerchoice/whatis/electric/electric.shtm, see "Electricity Supplier Compliance Report Form for the District of Columbia Renewable Energy Portfolio Standard" form for breakout.
Dominion (Virginia) RPS baseline data, historical efforts to procure renewable energy to meet Virginia's RPS, and fuel sources of procured renewables.	Dominion's 2015 RPS Report	https://www.scc.virginia.gov/pue/renew/dvp_renew_15.pdf
Dominion RPS percentage targets and projected consumption	Dominion's 2015 IRP	https://www.dom.com/library/domcom/pdfs/electric-generation/2015-irp-final-public-version-internal-cover.pdf
Projected share of renewables from non-Dominion jurisdictions in Virginia	EIA's AEO 2015: Electric Power Projections by Electricity Market Module: SERC Virginia/ Carolina Region	http://www.eia.gov/forecasts/aeo/data/browser/#/?id=62-AEO2015&region=3-16
Historical green power purchase data by zip code, including Unbundled RECs, green marketing programs, green pricing programs, and PPAs	EPA's Green Power Partnership	https://www.epa.gov/greenpower, data obtained by contacting GPP directly.
Voluntary green power projections, 10% annual assumption	NREL's "Status and Trends in the U.S. Voluntary Green Power Market (2014 Data)"	http://www.nrel.gov/docs/fy16osti/65252.pdf
Distributed generation installations	COG	N/A