Appalachian Mountain Advocates

West Virginia
Post Office Box 507
Lewisburg, WV 24901
(304) 645-9006

Virginia
415 Seventh Street NE
Charlottesville, VA 22902
(434) 529-6787

www.appalmad.org

August 11, 2017

VIA ELECTRONIC FILING

Mr. Joel H. Peck, Clerk
c/o Document Control Center
State Corporation Commission
Tyler Building — First Floor
1300 East Main Street
Richmond, Virginia 23219

RE: Commonwealth of Virginia, *ex rel.* State Corporation Commission
In re: Virginia Electric and Power Company's Integrated Resource Plan filing pursuant to Virginia Code § 56-597 *et seq.*

Case No. PUR-2017-00051

Dear Mr. Peck,

Please find attached for filing in the above-captioned case:

- the Direct Testimony of William M. Shobe on Behalf of the Sierra Club;
- the Direct Testimony of Gerald Braun on Behalf of the Sierra Club; and
- the Direct Testimony of William Penniman on Behalf of the Sierra Club.

Should you have any questions or concerns regarding the filing, please do not hesitate to contact me directly at (434) 738 – 1863.

Thank you,

Evan D. Johns
APPALACHIAN MOUNTAIN ADVOCATES
415 Seventh Street Northeast
Charlottesville, Virginia 22902

Copied: Service List
Commission Staff

DIRECT TESTIMONY OF
GERALD W. BRAUN

ON BEHALF OF
THE SIERRA CLUB

BEFORE THE
STATE CORPORATION COMMISSION OF VIRGINIA
CASE NO. PUR-2017-00051

Commonwealth of Virginia, *ex rel.* State Corporation Commission,
In re: Virginia Electric and Power Company's Integrated Resource Plan filing
pursuant to Virginia Code § 56-597 *et seq.*

Summary of the Direct Testimony of Gerald W. Braun

My testimony includes the following findings and recommendations:

1. Alternative, less arbitrarily constrained, plans for renewable power deployment should be considered, including a plan that includes wind generation and energy storage, independently owned utility scale solar generation, as well as customer owned on-site and community owned shared solar generation.

2. Capacity and energy gaps presented for the Plan's base case should also be computed for alternative electricity usage scenarios, including scenarios that call for more aggressive energy efficiency and demand side incentives and programs and/or that account for fuel substitution in either or both Virginia's building and transportation sectors.

3. The Commission should evaluate the relative ratepayer cost of utility and independently financed renewable power deployment—both through cost of generation modeling and inquiries to other state commissions that are successfully pursuing market based renewable electricity sourcing.

4. The Company's Plan is subject to potential major course corrections during the planning period. The Company and the Commission should be alert to further decentralized energy technology tipping points and further rapid cost shifts that may require reconsideration of planned investments in centralized plants whose economic viability could be short lived.

5. The Commission should require the Company develop near- and long-term integrative deployment plans for wind, solar and storage resources that reduce long-term ratepayer cost and eliminate the need for further fossil generation expansion. These plans should be subjected to independent review.

6. The assertion in the Plan that the only technically and economically viable on-shore wind siting areas are on mountain ridges is inconsistent with global and U.S. wind industry experience and should not be accepted by the Commission as a valid planning assumption.

7. Costs of transportation-derivative, grid-tied battery systems are plunging, raising questions in the utility industry about the future need for additional deployment of combustion turbines for peaking purposes.

Q: Please state your name, address and affiliation.

A: My name is Gerald W. Braun. I am Chair for the Integrated Renewable Energy Systems Network (IRESN), Inc. My address is 2421 Hepworth Drive, Davis, California.

Q: Please describe your experiences and qualifications.

A: I hold a BS in Mechanical Engineering from the University of Michigan as well as MS and Nuclear Engineer degrees from MIT. At Southern California Edison, I led the first utility system planning analysis to determine the economic value of solar power plants in a vertically integrated electric system. At the U.S. Department of Energy, I organized and directed the national R&D program for utility scale solar technology. At Bechtel, I managed solar and wind R&D projects, including siting and final design of a 30-MW commercial solar power plant. At PG&E, I organized and directed the company's RD&D programs for renewable and natural gas conversion and electricity storage. At Solarex and BP Solar, I managed thin film panel product lines and created programs to introduce thin film panels in grid-tied applications in the United States, starting in Virginia, through the Virginia Alliance for Solar Energy. I was the founding president of Standard Solar, a retail solar company which continues to serve the greater Washington, DC area. At the California Energy Commission, I directed California's public benefits R&D programs in renewable energy, and organized the first round of the Commission's current program engaging communities throughout California in renewable integration studies and demos. At UC Davis, I directed the California Renewable Energy Center and initiated a program focused on renewable integration. I currently chair IRESN, Inc., a California non-profit mutual benefit corporation informing integrative deployment of renewable energy resources. I am also a member and former chair of the Gas Technology Institute's Public Interest Advisory Committee.

Q: What is the scope and purpose of your testimony in this case?

A: My testimony concerns the treatment of renewable energy integration and deployment in the 2017 Integrated Resource Plan (IRP or Plan) for Virginia Electric and Power Company (the Company).

Q: Can you summarize your principal comments and recommendations?

A: In summary, the Company's renewable portfolio standards (RPS) obligations in Virginia are modest relative to comparable utilities under comparable regulation in other states.[1] As a result, the Company's Plan can be compliant with its RPS obligations while restricting its next fifteen years of renewable energy deployment to a narrow wedge bounded by assumed low electricity consumption growth, Company financing of new generation, and parallel expansion of natural gas fueled generation. Alternative, less arbitrarily constrained, plans for renewable power deployment should be considered, including a plan that includes wind generation, energy storage, independently owned utility scale solar generation, and customer owned on-site and community owned shared solar generation.

1 PJM, "Comparison of Renewable Portfolio Standards Programs in PJM States" (2017), available at http://bit.ly/2vLqygz.

Q: Why and how should the Company consider the option of additional non-utility solar generation?

A: The Company's Plan reflects a proposed shift away from a short-term program (SPP) that included competitively sourced solar electricity, to a long-term plan to invest in "utility scale" solar power projects in its service territory and to cement its position as the primary renewable electricity asset owner in its service territories. There has been considerable innovation in solar generation financing and siting that results in lower weighted average costs of capital and brings accumulating and relevant solar industry experience to bear regarding siting, technical and economic optimization, maintenance and project upgrades.

The shift away from competitive sourcing of renewable electricity may result in higher retail electricity prices and slower, less cost-effective development of renewable resources than in states providing competitive opportunities for the U.S. and global renewable energy industries. It may be in Virginia's long-run interest to create a state level market attractive to stable, mature, and well-qualified renewable electricity suppliers.

Q: Do you have a specific recommendation?

A: Yes. The Commission should carefully review the relative cost of utility and independently financed renewable deployment with reference to up to date merchant plant and utility cost of generation models as well as inquiries to state commissions that are successfully pursuing market-based renewable electricity sourcing. Cost of generation analyses should address both community scale and utility scale supply resources.

Q: What contingencies related to existing generation should be considered, and why?

A: The plan is robust relative to external regulatory contingencies, especially CPP-related. These contingencies lend themselves to available planning tools and defensible assumptions. There are other categories of combined internal and external contingencies for which completely defensible assumptions are not possible. Specifically, the plan does not consider more disruptive scenarios driven by technology and cost tipping points impacting the global power sector.[2] For example, all existing generation may continue to be economically viable during the planning period if costs of solar and wind generation and energy storage were not changing. However, these costs are anything but static now and still trending sharply downward.

Wind, solar PV and transportation battery technologies are on progress curves that can overturn long-term planning assumptions in a matter of years. The Company's business experience has been with large projects and systems having long lead times and long economic lives. Recent energy sector history demonstrates that plug-and-play renewable energy and storage technologies can penetrate markets much faster than technologies having scale economies that result in long lead times and necessarily long economic lives.

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2 For example, potentially disruptive shifts triggered by solar, storage, and self-driving and electric vehicles.

Renewable electricity deployment is experiencing year over year growth that has, in the short span of one decade, driven solar and wind power costs through a previously unimagined transition to costs that are competitive with the fuel and operations cost of fully amortized "conventional" generation, i.e. fossil and nuclear.

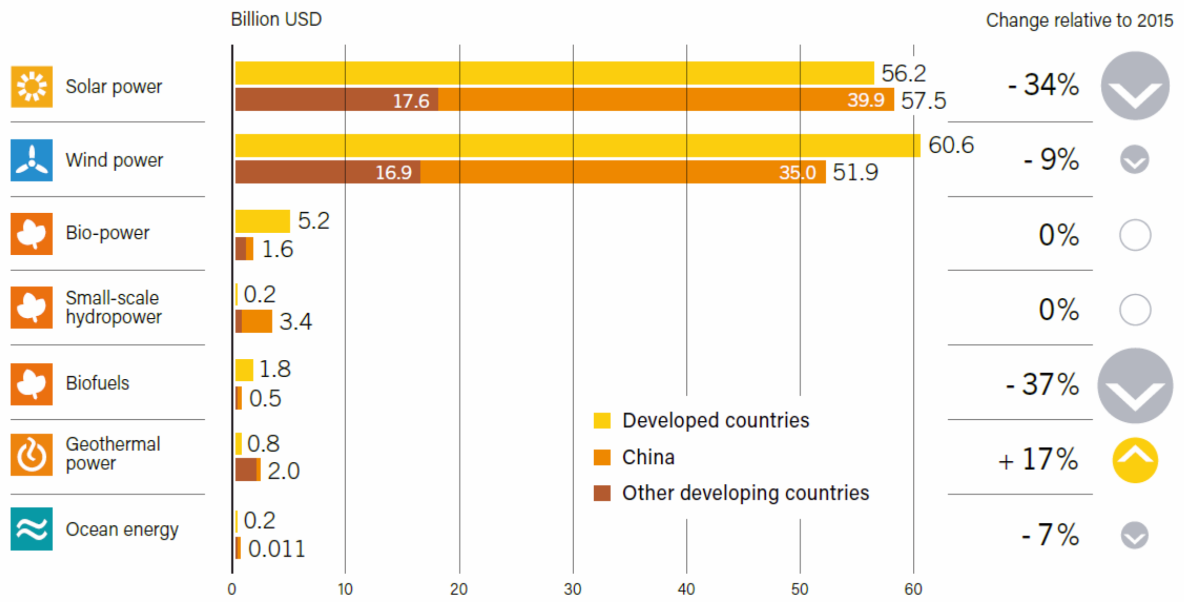
Q: Do you have a specific recommendation?

A: The Company and the Commission should be alert to further technology tipping points and further rapid cost shifts that may require reconsideration of planned investments in centralized plants whose economic viability could, plausibly, be short lived. In general, The Company's Plan is subject to potential major, possibly necessary, course corrections during the planning period. Such potential course corrections should be evaluated in future IRP development and specifically acknowledged in the 2017 IRP.

Q: Why should the Company's 2017 Plan include wind power projects and power purchases?

A: Wind is a generation resource that complements solar and vice versa. Wind and solar industries are gaining traction in global electricity markets at comparable rates and deployment scale, i.e. rates and scale that dwarf those of other renewable and non-renewable electricity industries as illustrated in the chart below.

Figure 43. Global New Investment in Renewable Energy by Technology, Developed and Developing Countries, 2016



Source: BNEF

The extent and value of these complementarities may not have been evaluated by the Company and are not considered in the Plan

Q: Do you agree with the Company's outlook for on-shore wind?

A: No.

Q: What do you recommend?

A: The planning assumption that there are no economically and environmentally developable on-shore wind resources in the Company's service area should be tested, not only through further study but through contract offers that set a price the Company is willing to pay and are accompanied by a clear intention to contract with any environmentally developable wind power projects that are economically developable at the price. It may require more than one round of contract offers to assure project developers that their work to identify viable siting areas and sites will be repaid by serious interest on the Company's part. In any event, the assertion in the plan that the only technically and economically viable on-shore wind siting areas are on mountain ridges is inconsistent with global and U.S. wind industry experience and should not be accepted by the SCC as a valid planning assumption.

Q: Do you have any comments regarding off-shore wind?

A: Yes. Off shore wind is a reasonably attractive potential long term and potentially large-scale addition to the Company's renewable portfolio. There is an emerging wealth of design and operational experience that could inform a roadmap to cost-effective, minimum risk and environmentally acceptable deployment. Off-shore and on-shore wind may be viable at quite different project scales. Yet the IRP provides a cost comparison at roughly the same scale without reference to any siting assumptions. In coastal areas, the distinction between off-shore and on-shore is blurred by different structural and mooring concepts applied on-shore, near shore and in deep water. There is a need for a deeper analysis than is reflected in the IRP

Q: Do you have a specific recommendation?

A: Yes. At a minimum, the cost comparison in Figure 5.2.2 should be independently validated or updated for Virginia and North Carolina sites by owners and operators of commercial shallow water wind plants elsewhere. Comparisons of generic options do not adequately inform the IRP in this case.

Q: Is the VOWTAP project's cost a reason to disqualify off-shore wind from further consideration in the Company's Plans?

A: No. Costs presented in Figure 5.2.2 cannot be evaluated without knowing their basis. The VOWTAP project appears to be an R&D demo at a scale that would not be expected to be commercially feasible. Its relevance to comparative evaluation of renewable power portfolio choices is questionable. As commercial projects move forward elsewhere on the U.S. East Coast, they may provide a more reliable cost benchmark than might be possible based using VOWTAP information.

Q: Why do you suggest that the Company's IRP should include energy storage?

A: Batteries are a multi-benefit capacity resource that complements wind and solar generation, which are, per se, without coupled storage, primarily energy rather than capacity resources. Battery or other storage deployment is the best option to complement early and mid-stage penetrations of variable renewable resources in a large or small grid.

At high penetration levels, natural gas fueled peaking capacity may also be a viable complement. However, some major west coast utilities are beginning to see storage as a better choice.[3] Their most recent experience has been positive, and it is noteworthy that

3 "Five years ago, I would not have believed that we would run solicitations and come out with over 400 contracts for over 450 MW of batteries and other storage in the timeframe we have," Nichols said. "I wouldn't have thought we'd have contracted for 160 MW of [behind-the-meter] energy storage for our customers." Gavin Bade, *ESNA 2017: How storage enables SCE to avoid siting new gas plants*, UTILITY DIVE (August 10, 2017), available at http://bit.ly/2wPxKoO.

deployment lead times have been very short, and they are relying on a mix of utility scale and behind-the-meter storage.

Q: Will the IRP's plan for natural gas combined cycle and combustion turbine generators eliminate the need for battery storage?

A: According to the Plan, penetration of the Company's generation portfolio by variable resources will reach seven to eight percent of retail sales at the end of the planning period. This is not high enough to create a need for additional natural gas generation resources that may generate pollutants and require fueling over several decades. Such investments may become "stranded," resulting in unfavorable rate implications. Further, at solar and wind penetrations in the low single digits, as is the case currently for the Company, utility electric systems typically have sufficient levels of more flexible generation to accommodate solar/wind variability. In these cases, there is no specific need for either additional peaking or storage capacity. However, as noted earlier, storage has multiple benefits, especially when deployed on-site and or in a micro-grid context.

Q: Do you have a specific recommendation?

A: The Commission should require the Company develop near and long term integrative deployment plans for wind, solar and storage resources. These plans should be subjected to independent review. One goal should be to validate or refute the need for additional fossil generation resources during the planning period and to determine if a mix of solar, wind and battery storage is a more cost-effective approach to generation expansion.

Q: Is the mix of solar, wind and storage you envision all at "utility scale"?

A: No, but some additional utility scale storage may result in better overall system economics. The IRP provides information about the state of development of utility scale battery storage technologies. As shown in Figure 5.4.2, some technologies have achieved commercial readiness. In fact, some have been commercially ready and economically feasible for many years, even decades. Their limited deployment is more an artifact of imperfect grid electricity market structures and non-integrative decision-making, *i.e.* an inability to coordinate capital allocations related to the complete menu of specific economic benefits and avoided costs. Benefits arising out of increased deployment of variable generation resources could tip the balance in favor of mature utility scale battery technologies.

I don't believe they will. Inability to penetrate grid markets has denied utility scale developers the opportunity to reap manufacturing-driven cost reductions. Meanwhile, lithium ion battery costs have come down at an average year over year rate close to 15% per year for over 15 years. Costs of battery pack for smaller stationary and vehicle applications are projected to continue to follow this curve. Some analysts even see a future in which transportation-derivative batteries will have costs lower than the costs of the transmission investments their on-site use would avoid.[4]

As electric vehicles become more prevalent, the benefits of their dual use in conjunction with behind-the-meter solar power will include minimizing power flow to and from the

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4 Swedbank, *Clean Disruption: Why Conventional Energy and Transportation Will be Obsolete by 2030* (2016), available at http://bit.ly/2vVNh9V.

local grid, and even services to the local grid. In such scenarios, it may be advantageous to shift the balance away from utility scale supply and storage toward community and building scale solar and storage. Preliminary case study analysis suggests this may be compatible with reasonably foreseeable solar, wind and EV deployment rates in certain cases.[5] The IRP does not anticipate this scenario. Future IRPs should consider it.

Q: Do you have other specific recommendations?

A: New peaking generation deployment may not be needed nor cost effective on a life cycle basis. Consideration of natural gas fueled additions in the IRP generation expansion plan should be deferred pending a more rigorous and robust evaluation of mid-Atlantic area wind power costs and development potential as well as battery storage cost trends and deployment options.

Q: Why do you suggest that alternative plans be developed that include customer owned on-site and community owned shared solar generation?

A: The plan does not adequately justify assumptions regarding the portfolio of "utility scale," "community scale," and on-site solar generation, nor does it address the local energy integration issues that may arise in areas where community and customer investments begin to impact local grid planning and operations. Local deployment of

5 California Energy Commission, *Davis Future Renewable Energy and Efficiency*, Appendix D (2015), available at http://bit.ly/2uvBizO.

renewable energy resources can be economically beneficial to communities choosing to facilitate it.[6]

The Company's 2017 Plan does not consider emerging integrative opportunities at the intersection of the power and transportation sectors, nor does it consider integrative opportunities arising as local jurisdictions adopt local resiliency goals and pursue integrative strategies regarding local infrastructure and utility services.

Communities in all regions of the U.S. adopt goals related to environmental stewardship and climate action and resiliency. Typically, their goals are unachievable where electricity service is vertically integrated. This partially explains the movement of large numbers of California cities and counties to consider and implement Community Choice.

Community Choice is not available in Virginia or North Carolina, but there may be ways the Company and the local jurisdictions it serves can collaborate in pilots or programs where facilitation of local renewable power projects is coordinated, thus mitigating project schedule and cost impediments.

Some states encourage integration of behind-the-meter solar and building energy usage via net zero building standards. The next stage in the evolution of related local solar and end-use optimization may be at the community or neighborhood level. It is worth

6 *See, e.g.*, Center for Climate Protection, *Community Choice Energy: What is the Local Economic Impact? San José, California, Case Study* (2016), available at http://bit.ly/2vVBAA4; Gerry Braun *et al.*, *Energy Infrastructure Finance: Local Dollars for Local Energy*, 28 ELECTRICITY JOURNAL 6 (2015), available at http://bit.ly/2hRF4O1.

mentioning that in settled northern California communities where per-capita local solar deployment greatly exceeds the average in Virginia, the local grid owner has been able to accommodate residential solar penetration levels up to 50% of existing residential building stock. In new communities and neighborhoods up to 100% of new buildings have behind-the-meter solar. There is no evidence that significant "integration costs" are being incurred by PG&E, the utility.

Considering the surprisingly high estimated costs of utility scale solar integration provided in the IRP, the apparent opportunity to minimize integration costs at distribution system and feeder levels and competing opportunities to maximize economies of scale at larger solar PV projects sizes suggests the possible value of an investigation to determine the best long-term balance among building, community and utility scale solar supply in support of the Company's next IRP.

Q: Does the discussion of grid modernization in Section 5.1.3 identify a valid outlook?

A: It does. However, it contains two specific statements that do not fully comport with relevant experience and/or the outlook of grid transformation thought leaders.

Q: What is the first of those statements?

A: On Pages 82 – 83 of the Plan, the Company states:

> To the extent that DER proliferation and the adoption of EVs and battery storage continues, the Company must be prepared to meet a new paradigm that will require the Company, over the near future, to transform its existing electric delivery from its original one-way design to a modern two- way network capable of facilitating instantaneous energy injections and withdrawals at any point along the network while continuing to maintain the highest level of reliability while maintaining

> service levels that customers expect and deserve. The first step in this transformation process is a modernization of the distribution grid.

DER "proliferation" proceeds at widely varying rates across the country. State, local and electric utility policies and programs play a decisive role in regulating the pace of DER deployment. California has not yet modernized its local ("distribution") grids, but it did launch the California Solar Initiative, which, based on incentives averaging less than $1000/kW resulted in 3 GW of installed capacity which, since incentive funds were depleted 8 years into a 10-year program, has since then grown to 5 GW. Meanwhile, traditional revenue metering was replaced by meters enabling two-way communication between the meter and the electric system.

However, the basic functionality of California's distribution grids has not changed. As noted earlier, substantial local two-way power flow has been accommodated prior to grid transformation, which remains a topic of policy discussion. Further, California's "smart" meters do not provide information regarding total on-site electricity use but rather net on-site electricity use. In effect, California utilities have facilitated substantial deployment or proliferation of DERs without substantial local grid modernization. Modernization of the distribution grid is apparently not a necessary first step in the transformation process the Company envisions. More rapid and momentum generating on-site and shared solar deployment need not await complete or even partial grid modernization.

Q: What is the second statements that does not comport with the outlook of grid experts?

A: On Page 83 of the Plan, the Company states:

> In a future where potentially tens of thousands of DER devices are located at homes or businesses throughout Virginia, system operators will need the ability to monitor these devices . . . to adjust the distribution network appropriately so that overall electric service reliability can be safely and efficiently maintained.

Device monitoring by ISOs would be unnecessary and impractical. A better alternative will be the emergence of micro-grids and more active real-time distribution system operation. As this happens, transmission system operators will be able to continue to manage a limited number of portals between transmission systems and local distribution systems without needing visibility to individual devices behind-the-meter and feeding in at distribution voltages.[7]

Q: Do you have any concluding suggestions?

A: Renewable integration is a much more urgent concern for many other jurisdictions in the U.S. and around the world that are charged with implementing renewable portfolios up to 50%, in some cases relying almost exclusively on solar and wind. California is one such jurisdiction. The California Public Utilities Commission has published a white

7 Paul De Martini *et al.*, *Distribution Systems in a High Distributed Energy Resources Future* (2015), available at http://bit.ly/2wAVH3F.

paper on "Grid Integration Policy for a Low Carbon Future."[8] Virginia's need for a grid integration policy may be less urgent, but steps to develop one may be timely.

Q: Does that conclude your testimony?

A: Yes, it does.

8 "The process to achieve grid integration is to solve a set of three interlinked challenges, and to harness the opportunities created by these challenges: (1) to integrate wind and solar resources, in increasing amounts, onto the grid, particularly at the bulk or transmission level; (2) to respond to the changes in system-wide customer load due to increased rooftop solar installations and connected electric vehicles; (3) to bring about, in concert: changes to the characteristics of traditional resources, changes to the functionality and role of distributed energy resources, changes to operational and planning practices at both transmission and distribution levels, and changes to wholesale and retail markets and tariffs." California Public Utility Commission Staff, *Beyond 33% Renewables: Grid Integration Policy for a Low-Carbon Future* (2015), available at http://bit.ly/2uN5aCV.

CERTIFICATE OF SERVICE

I, Evan D. Johns, certify that, on August 11, 2017, I deposited true copies of the foregoing into the United States Mail, postage prepaid and addressed to the following:

Lisa S. Booth
DOMINION RESOURCES SERVICES
Legal Department
120 Tredegar Street
Richmond, Virginia 23219

C. Meade Browder, Jr.
OFFICE OF THE ATTORNEY GENERAL
DIVISION OF CONSUMER COUNSEL
202 North Ninth Street
Richmond, Virginia 23219

Alisson Klaiber
K.B. Clowers
Ashley Macko
OFFICE OF THE GENERAL COUNSEL
STATE CORPORATION COMMISSION
Post Office Box 1197
Richmond, Virginia 23218

William Cleveland
Greg Buppert
Nate Benforado
SOUTHERN ENVIRONMENTAL LAW CENTER
201 West Main Street, Suite 14
Charlottesville, Virginia 22902-5065

Louis R. Monacell
Edward L. Petrini
James G. Ritter
CHRISTIAN & BARTON
909 East Main Street, Suite 1200
Richmond, Virginia 23219

Vishwa B. Link
Jennifer D. Valaika
MCGUIREWOODS
Gateway Plaza
800 East Canal Street
Richmond, Virginia 23219-3916

Bruce H. Burcat
MID-ATLANTIC RENEWABLE ENERGY COALITION
29 North State Street, Suite 300
Dover, Delaware 19901

Eric J. Wallace
GREENEHURLOCKER
1807 Libbie Avenue
Suite No. 102
Richmond, Virginia 23226

Bobbi Jo Alexis
CULPEPER COUNTY ATTORNEY
306 North Main Street
Culpeper, Virginia 22701

Evan D. Johns (Virginia State Bar No. 89285)
Counsel for the Sierra Club