Commonwealth of Virginia
STATE CORPORATION COMMISSION

DAVID ESSAH, Ph.D.
DIRECTOR

DIVISION OF
PUBLIC UTILITY REGULATION
P.O. Box 1197
Richmond, Virginia 23218-1197
(P) 804-371-9611 (F) 804-371-9350

April 14, 2023

The Honorable Glenn Youngkin
Patrick Henry Building
1111 East Broad Street
Richmond, Virginia 23219

The Honorable J. Chapman Petersen
Chairman, Committee on Agriculture, Conservation and Natural Resources
Pocahontas Building
900 East Main Street
Richmond, VA 23219
district34@senate.virginia.gov

The Honorable R. Lee Ware
Member, Virginia House of Delegates
Chairman, Committee on Agriculture, Chesapeake and Natural Resources
Pocahontas Building
900 East Main Street
Richmond, VA 23219
DelLWare@house.virginia.gov

Dear Governor Youngkin, Senator Peterson and Delegate Ware:

Pursuant to Chapter 70 of the 2022 Virginia Acts of Assembly ("Chapter 70"), please find enclosed the Virginia Renewable Energy Facilities Task Force Report. As directed by Chapter 70, the Staff of the State Corporation Commission ("Staff"), through a third-party facilitator, convened a stakeholder workgroup to analyze the life cycle of renewable energy facilities, including solar, wind, and battery storage components, and prepared the enclosed report.

The Staff wishes to acknowledge and express appreciation for the participation of the Department of Environmental Quality, the Department of Energy, and all the stakeholders who assisted in this public process as directed by Chapter 70.

Please let me know if the Commission may be of further assistance.

Respectfully submitted,

David N. Essah

David N. Essah, Ph.D.

Enclosure

FINAL REPORT

MARCH 1, 2023

VIRGINIA RENEWABLE ENERGY FACILITIES TASK FORCE

Contents

Executive summary 2

Summary of presentations and discussion for policymakers 2

Task Force recommendations: 3

Introduction 5

Legislative charge and State Corporation Commission additions 5

Process 6

Summary of discussion and recommendations 8

Summary of presentations and discussion for policymakers 9

General life cycle analysis 10

Analysis of feasibility, costs, recycling and salvage opportunities, waste strategies, and liability for the decommissioning of materials used in renewable energy facilities 12

Analysis of potential impacts of underground infrastructure post-decommissioning 13

Analysis of potential impacts of the life cycle on farming, forestry, and sensitive wetlands 14

Analysis of potential impacts of life cycle and decommissioning costs on brownfields or previously developed project sites as compared to life cycle and decommissioning cost on agricultural or forest lands 16

Analysis of ratepayer impacts 17

Analysis of potential beneficial economic impacts of solar, wind, and battery storage development 18

Non-consensus topics 19

Conclusion 20

Appendices 21

Appendix A: List of task force members 22

Appendix B: Meeting agendas 23

Appendix C: Meeting summaries 40

Appendix D: Task Force charter 97

Executive summary

House Bill 774 ("HB 774"), identical to Senate Bill 499, of the 2022 Virginia General Assembly session, directed the Virginia State Corporation Commission ("SCC") to create a Task Force, in consultation with the Virginia Department of Energy ("Virginia Energy") and the Virginia Department of Environmental Quality ("DEQ"), to analyze the life cycle of renewable energy facilities, including solar, wind, and battery storage components. HB 774 directs the SCC to submit a report of the Task Force's analysis to the Governor and the Chairs of the House Committee on Agriculture, Chesapeake and Natural Resources and the Senate Committee on Agriculture, Conservation and Natural Resources no later than May 1, 2023 analyzing various topics related to end-of-life and decommissioning, land use, and economic and ratepayer impacts for renewable energy.

A Task Force of representatives from about 30 relevant state agencies and stakeholder sectors met between October 2022 and January 2023 to learn about and share research related to the life cycle of renewable energy facilities in Virginia. Facilitated by the Keystone Policy Center, an independent nonprofit, the Task Force heard presentations from outside experts and fellow Task Force members, reviewed relevant resources, dialogued with one another, shared learnings from related state efforts, and ultimately developed a summary of the Task Force's learnings as well as recommendations for state agencies in response to charge questions posed by the Legislature and the SCC. A detailed list of all these learnings and recommendations appears later in this report, and the following summarizes the key learnings of the group.

Summary of presentations and discussion for policymakers

- Life cycle greenhouse gas emissions from renewable energy electricity generation are significantly less than those from fossil fuel-based technologies.
- Except for batteries, most renewable energy[1] components will not reach the end of their life for decades, at which point the waste, recycling, and circular economy landscape is likely to have changed dramatically.[2] In the interim, the state can prioritize education to local leaders and the public on current end-of-life options and support the development of robust, locally acceptable decommissioning methods and plans.
- As with other types of large development, there are many variables that determine the impacts of underground infrastructure post-decommissioning. Landowners or local government can work with developers to determine whether it is preferable for all infrastructure to be removed or for some to be left in place.
- Virginia has abundant undeveloped land that is potentially suitable for solar, but there are many factors that impact the feasibility of a cost-effective solar project on any given property, thereby limiting total available land area. These include but are not limited to local values, priorities, and ordinances; agricultural use and habitat value; developer priorities and needs; landowner participation; transmission capacity; and terrain.
- Brownfields may be suitable and offer advantages for smaller scale solar development, but siting on brownfields is more complex and/or expensive than other sites. For instance, installing solar

[1] Unless otherwise specified, references to "renewable energy" in this document includes solar, on- and offshore wind, and battery storage.

[2] According to the Solar Energy Industry Association's presentation in Meeting 2, all of Virginia's 2.5 gigawatts ("GW") of solar capacity has come online since 2016 and 75% of that has come online since 2020. Since most solar projects have a 25- to 30-year life span, solar panels will not be decommissioned in significant numbers for at least two decades from now. Wind projects have a similar life span, but because there are still very few wind turbines in Virginia, the timeline will be even longer for wind that is installed in the future.

on landfills usually requires a ballasted system with concrete foundations rather than the typical driven post foundation for fixed tilt and tracking systems; geotechnical aspects of brownfields may increase solar installation costs; soil may be significantly disturbed; and legal liability and multiple owners of the land (such as having different surface and subsurface rights) can complicate development.

- Different types of energy have different attributes and cost considerations. The elimination of fuel costs can reduce and stabilize rates for renewable energy compared to fossil fuel generation.
- Renewable energy can bring near-term and longer-term economic benefits to localities, regions, and the state (e.g., annual county tax revenue payments for the life of the project, fixed landowner payments for the life of the project, jobs, and more), along with contributing to climate change mitigation and potential grid resilience. Potential tradeoffs must be assessed on a project-by-project and regional/cumulative basis.
- Virginia does not have many utility-scale onshore wind projects underway, so takeaways related to wind energy are oriented towards planning for potential future onshore development and considering the land-based impacts of offshore wind development.
- The land footprint currently used for siting battery storage is minimal relative to solar development, and often coincident to generation, so takeaways related to battery storage are oriented towards proper accounting for storage in decommissioning requirements and consideration of the role Virginia wants to play in the battery recycling and/or circular economy.

Task Force recommendations[3]

- The Task Force recommends that Virginia Energy, in collaboration with DEQ, the Virginia Economic Development Partnership ("VEDP"), and relevant stakeholders, should share and/or develop resources,[4] including decommissioning benchmarks and best practice guidance, for the general public and elected officials to better understand opportunities for reuse, recycling, and disposal of solar, wind, and energy storage components.
- The Task Force recommends that DEQ, in collaboration with Virginia Energy and relevant stakeholders, should share and/or develop resources for the general public and elected officials on how renewable energy components are classified and designated as waste materials.
- The Task Force recommends that Virginia Energy, in collaboration with DEQ, VEDP, and relevant stakeholders, should collaborate on opportunities to attract recycling and/or circular economy-oriented facilities for cobalt, solar panels, wind blades, and other components.[5]
- The Task Force recommends that Virginia Energy, in collaboration with DEQ, should review existing research and, if needed, work with stakeholders to conduct more state-specific research on the impact of the specific types of underground infrastructure that may be left in place post-decommissioning (e.g., electrical cabling, steel posts, concrete) on future land use and how the impacts vary between different geological conditions throughout Virginia.
- The Task Force recommends that Virginia Energy, in collaboration with DEQ, should share information on the impacts of underground infrastructure with the general public, landowners, and local elected officials.

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[3] Recommendations are not listed in order of priority. Rather, they follow the Task Force's discussion, which was organized by charge question.

[4] For instance, American Clean Power aggregates resources here: https://energystorage.org/about-esa/energy-storage-corporate-responsibility-initiative/.

[5] Outside of Virginia, there are counties, states, and countries creating policies to attract these industries; Virginia should draw on learnings and best practices from other localities wherever possible.

- The Task Force recommends that Virginia Energy, in collaboration with DEQ, Department of Conservation and Recreation, Department of Forestry, the Virginia Cooperative Extension, Department of Wildlife Resources, Department of Historic Resources, Virginia Department of Agriculture and Consumer Services, and relevant stakeholders, should provide accurate and up-to-date tools to assist local planning staff and elected officials in making renewable energy facilities siting decisions. Such tools may incorporate or consider spatial data layers like prime soils, agricultural use and crop value, impervious surface, acid forming soils, habitat cores, carbon sequestration potential, recreation and scenic resources, and electric infrastructure information, such as by providing the VaLEN tool created through the stakeholder work group established pursuant to Chapter 488 of the 2022 Virginia Acts of Assembly's enactment clause three("HB 894 Stakeholder Work Group").[6]
- The Task Force recommends that Virginia Energy should review existing research and conduct new research, if needed, in collaboration with relevant stakeholders, on the economic and life cycle benefits and impacts of renewable energy on farming, forestry, and sensitive wetlands, including collecting data on different types of land that have been converted to renewable energy development and distribution of financial benefits within communities.
- The Task Force recommends that Virginia Energy, in collaboration with DEQ and VEDP, should continue to promote solar development on brownfields.
- The Task Force recommends that the General Assembly consider funding the Virginia Brownfield and Coal Mine Renewable Energy Grant Fund and Program, incentive programs, and/or subsidies to overcome otherwise cost-prohibitive obstacles (e.g., high interconnection costs) that are typical in brownfield development.
- The Task Force recommends that Virginia Energy, DEQ, other relevant agencies, and electric utilities should continue maximizing benefits under the Bipartisan Infrastructure Law and Inflation Reduction Act, and other available federal funding sources, for opportunities that may aid in cost relief for customers.
- The Task Force recommends that Virginia Energy should share and/or develop resources, such as the Virginia SolTax Model,[7] to educate elected officials and the general public on the economic impacts of renewables, including:
    - Reinforcing the use of available tools by localities to evaluate options for tax revenue through either the Machinery & Tools (M&T) tax or through revenue-sharing;
    - Making available to localities a model or best practices on ordinances that enable revenue-sharing for solar and energy storage; and
    - Continued or new analysis of the macroeconomic impacts and benefits of renewable energy development in Virginia, with transparency, clarity, and consistency with respect to the assumptions used in such analysis.
- The Task Force recommends that VEDP, in collaboration with Virginia Energy, the Virginia Community College System, and the Virginia Energy Workforce Consortium, should explore policies and partnerships for job training/workforce development in Virginia related to the manufacturing, installation, maintenance, recycling, and decommissioning of renewable energy facilities.

[6] In connection with the HB 894 Stakeholder Work Group, the Virginia Cooperative Extension developed the Virginia's Land & Energy Navigator tool. The tool is scheduled to be released in early 2023.
[7]The Virginia SolTax Model, available from: https://solar-tax-webapp.herokuapp.com/, was developed by the Weldon Cooper Center at UVA, Virginia Energy, and others for use by localities to help them decide which taxation model to use for solar generating facilities.

Introduction

In its 2020 session, the Virginia General Assembly passed the Virginia Clean Energy Economy Act ("VCEA"). The VCEA created the Commonwealth's first Clean Energy Standard, with the goal of shifting the grid to 100% clean energy by 2050 by deploying resources such as distributed and utility-scale solar, onshore and offshore wind, and energy efficiency and demand response programs. Currently, solar energy generates 5.1% of electricity in Virginia, with 2,613 megawatts ("MW") of installed solar capacity, 618 MW under construction, and 3,143 MW in development.[8] Offshore wind projects are under development, with an estimated 10 GW to be installed by 2030, and while onshore wind still represents a very small portion of Virginia's generation portfolio, meeting the goals of the VCEA will involve deployment of additional wind resources, along with additional solar and battery storage. The proliferation of renewable energy facilities in Virginia calls for consideration of the impact of these facilities over the years they are in use and beyond, including consideration of their short- and long-term impact on communities, land, customer rates, local and state economics, and more.

A diverse group of about 30 relevant state agencies and stakeholder organizations met between October 2022 and January 2023 to address the questions posted in HB 774, focused on the life cycle of renewable energy facilities including solar, wind, and battery storage components. This final report of the HB 774 Task Force includes a summary of presentations and discussion, recommendations for the Legislature, and a summary of topics that merit further consideration.

Legislative charge and State Corporation Commission additions

Virginia House Bill 774 and the identical Virginia Senate Bill 499 read as follows:

1. *§ 1. The State Corporation Commission shall create a task force, in consultation with the Department of Energy and the Department of Environmental Quality, to analyze the life cycle of renewable energy facilities, including solar, wind, and battery storage components. The analysis shall assess the (i) feasibility, costs, recycling and salvage opportunities, waste strategies, and liability for the decommissioning of materials; (ii) potential impacts of underground infrastructure post-decommissioning; (iii) potential impacts of the life cycle on farming, forestry, and sensitive wetlands; and (iv) potential beneficial economic impact of solar, wind, and battery storage development. The task force shall include representatives of local governments, the Virginia Solar Energy Development and Energy Storage Authority, the Department of Energy, and the Department of Environmental Quality and at least one representative for each of the following sectors: agriculture, forestry, regulated electric service providers, competitive electric service providers, rural utility consumer services cooperatives, and renewable energy service providers, as well as organizations with expertise in the climate and environment. The State Corporation Commission shall submit a report of the task force's analysis to the Governor and the Chairs of the House Committee on Agriculture, Chesapeake and Natural Resources and the Senate Committee on Agriculture, Conservation and Natural Resources no later than May 1, 2023.*

In its Request for Proposals ("RFP") #159 for Renewable Energy Facilities Task Force Facilitation Services, the SCC included additional items[9] (italicized below) in the final list of analyses the Renewable Energy Facilities Task Force ("Task Force") was charged with completing, expanding on the list from the legislation. The facilitators and Task Force referred to this longer list from the SCC RFP as the "charge questions." The Task Force meetings and discussion aimed to distill both takeaways and recommendations, where possible, for each charge question:

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[8] These numbers are drawn from state data that the Solar Energy Industry Association provided to the Task Force.

[9] The SCC considered these additional items to be relevant to the HB 774 tasking and associated discussions.

1. Feasibility, costs, recycling and salvage opportunities, waste strategies, and liability for the decommissioning of materials used in renewable energy facilities;
2. Potential impacts of underground infrastructure post-decommissioning;
3. Potential impacts of the life cycle on farming, forestry, and sensitive wetlands;
4. *Potential impacts of life cycle and decommissioning costs on brownfields or previously developed project sites as compared to life cycle and decommissioning cost on agricultural or forest lands;*
5. *Potential ratepayer impacts; and*
6. Potential beneficial economic impacts of solar, wind, and battery storage development.

Process

In October 2022, the SCC hired the Keystone Policy Center[10] to facilitate the Task Force. Prospective Task Force members were invited to join the Task Force in October 2022, via invitation from the SCC and facilitators. The SCC and facilitators confirmed that all of the legislatively required agencies and stakeholder categories were represented on the Task Force, but also opened participation to other willing organizations with a material interest in the work of the Task Force. A complete list of Task Force members appears in Appendix A. The purpose, governance, and responsibilities of the Task Force were further defined in the group's charter, included as Appendix B.

The Task Force held five virtual six-hour meetings between October 28, 2022 and January 10, 2023. Based on the voluminous and technical nature of information the Task Force was charged with analyzing, the facilitators planned a meeting schedule that ensured that every charge question and every type of renewable facility referenced in HB 774 (solar, wind, and battery storage) would receive adequate time for presentation and discussion. However, overall conversations focused more on solar than on other technologies because of its proliferation in Virginia as compared to wind and battery storage technologies. At the outset of the process, the facilitators emphasized that the group would be covering many technical topics—some of which had robust existing resources associated with them and some of which did not— in a relatively short time. The goal for the Task Force was to work carefully within the time allotted to cover all the charge questions, recognizing that this approach might prevent analysis from being as technical or deep as it could be on some topics. Generally, each topic was addressed with presentations from invited expert speakers and/or Task Force members, followed by questions, then dialogue among Task Force members to discuss and begin to distill key takeaways and recommendations.

The Task Force strived for consensus in its findings and recommendations. Consensus was defined as general agreement shared by all the people in a group; it reflects a recommendation, option, or idea that all participants can support or abide by, or, at a minimum, to which they do not object. In other words, consensus is a recommendation, option, or idea that all can live with.

Meetings roughly followed the timeline indicated in the graphic below:

[10] Headquartered in Keystone, CO with offices in Denver and Washington, DC, Keystone has provided independent facilitation services in a variety of project contexts since 1975. Keystone shepherds shared-goal partners to find mutually agreeable solutions in energy, environment, education, health, agriculture, emerging genetic technologies, natural resources, and tribal communities. More information about the Keystone Policy Center is available on its website at www.keystone.org.

Figure 1

	October 28	November 16	November 29	December 14	January 10	January-March
SOLAR	Present, discuss	Review draft findings, more discussion	Review draft findings, more discussion		Review findings	**Draft Report (Jan 31) and Final Report (March 1)**
WIND		Present, discuss	Review draft findings, more discussion		Review findings	
BATTERY			Present, discuss	Review draft findings	Review findings	
CROSS-CUTTING	Present, discuss LCA overview	Present, discuss economic impacts		Present, discuss ratepayer impacts	Review findings	

VA Renewable Energy Facilities Task Force Scope and Timeline

Meeting 1 was held on October 28, 2022. During this meeting, facilitators reviewed the Task Force scope, legislative charge, meeting plan and timeline, and discussion and decision guidelines. Drs. Thomas Gibon of the Luxembourg Institute of Technology and Garvin Heath of the National Renewable Energy Laboratory ("NREL") presented overviews of life cycle assessments for renewable energy, presenting resources from both the United Nations Economic Commission for Europe and NREL. They also both presented more detailed analyses of the solar energy life cycle, with a focus on end-of-life. Judy Dunscomb of The Nature Conservancy then presented on land use and solar energy. Collectively, these presentations addressed the first four charge questions related to solar energy. The Task Force discussed its takeaways and outstanding questions related to each of these.

Meeting 2 was held on November 16, 2022. During this meeting, facilitators reviewed the takeaways from Meeting 1. Next, Will Giese of the Solar Energy Industry Association presented on end-of-life topics (the state of waste disposal, recycling, and the circular economy) with a focus on Virginia, building on questions from Meeting 1 discussion. Tyler Fitch of Synapse Energy presented an overview of the economics of renewable energy in the Southeast, discussing solar, wind, and battery storage. Dr. Lee Daniels, Virginia Tech Professor Emeritus of Plant and Environmental Sciences, presented on the impacts of underground renewable infrastructure (mainly solar) on land and soil. The meeting then turned to a presentation of the wind energy life cycle from Dr. Aubryn Cooperman of NREL. Judy Dunscomb of The Nature Conservancy returned to present on the land use impacts of wind. Finally, Frank Oteri and Matilda Kreider, both of NREL, spoke briefly about their research on wind energy and community planning. Collectively, these presentations addressed the first four charge questions related to solar energy; the first four charge questions related to wind energy; and the sixth charge question for all types of renewable energy. The Task Force discussed its takeaways and outstanding questions related to each of these.

Meeting 3 was held on November 29, 2022. At the beginning of the meeting, facilitators reviewed the takeaways from Meetings 1 and 2. David Murray of American Clean Power then presented on state-specific economic impacts of solar energy, building on the more regionally focused presentation in Meeting 2. Next, Frank Oteri and Matilda Kreider of NREL presented on wind facility decommissioning in the planning phase. Finally, Dustin Weigl of NREL presented on the battery storage life cycle, end-of-life opportunities for batteries, and the land use impacts of batteries, which is minimal as it relates to Virginia. Collectively, these presentations touched on the sixth charge question related to solar energy; the first, second, and fourth charge questions related to wind energy; and the first four charge questions related to battery storage. The Task Force discussed its takeaways and outstanding questions related to each of these.

Meeting 4 was held on December 14, 2022. The first half of the meeting was spent in detailed review of the draft Task Force takeaways and recommendations developed to date, with Task Force members reviewing each recommendation so that the facilitators could gauge consensus and edit accordingly. In the second half of the meeting, Task Force members and one outside presenter—Sam Brumberg of the Virginia, Maryland, and Delaware Association of Electric Cooperatives; Will Cleveland of the Southern Environmental Law Center; Irene Cox, a master's degree candidate at the University of Virginia; Scott Gaskill of Dominion Energy Virginia; and Cliona Mary Robb, representing the Solar Energy Development and Storage Authority—spoke on a panel convened to discuss ratepayer impacts of renewable energy. Their remarks addressed the fifth charge question for all types of renewable energy. The Task Force then discussed its takeaways and outstanding questions related to the potential ratepayer impacts of renewable energy.

Between Meetings 4 and 5, the facilitators updated the draft takeaways and recommendations with feedback from Meeting 4 and circulated the updated draft for review and written comment by all Task Force members between December 15, 2022 and January 9, 2023. Task Force members were asked to indicate if they had priority takeaways or recommendations; only a few indicated any prioritization. Therefore, takeaways and recommendations in this report are likewise not prioritized.

Approximately two-thirds of the Task Force members submitted comments on the draft takeaways and recommendations during the December to January review period. Meeting 5 was held on January 10, 2023. During that final meeting, facilitators provided an overview of comments received on the draft takeaways and recommendations, with Task Force members providing additional feedback and edits. For this review, Task Force members were instructed to identify their support of or neutrality regarding the consensus takeaways and recommendations.

Takeaways, recommendations, and this report were drafted in January 2023 and circulated to the Task Force for final review, with final comment due by mid-February. All consensus takeaways and recommendations are included in this report, along with a summary of topics which were discussed but not supported for inclusion in the final takeaways and recommendations.

Agendas and summaries of all meetings are included as Appendices C and D.

Summary of discussion and recommendations

This section summarizes the takeaways from Task Force presentations and discussions and includes recommendations for consideration by the Legislature. It includes both a high-level summary of the presentations and discussion and more detailed summaries and recommendations organized by charge question. The "summary of presentations and discussion" sections synthesize the information presented to and discussed by the Task Force in response to key questions posed by the legislation and the SCC.

These summaries are high-level, consensus-based characterizations of the presentations, conversations and learnings that occurred within the timeline and scope of the effort, with recognition that further nuance and detail will apply to each specific topic and situation. The summaries do not reflect endorsement by individual members or participating agencies of any specific technologies, policies, programs, or projects.

Summary of presentations and discussion for policymakers

- Life cycle greenhouse gas emissions from renewable energy electricity generation are significantly less than those from fossil fuel-based technologies.
- Except for batteries, most renewable energy[11] components will not reach their end-of-life decades, at which point the waste, recycling, and circular economy landscape is likely to have changed dramatically.[12] In the interim, the Commonwealth can prioritize education of local leaders and the public on current end-of-life options and support the development of robust, locally acceptable decommissioning methods and plans.
- As with other types of large development, there are many variables that determine the impacts of underground infrastructure post-decommissioning. Landowners or local governments can work with developers to determine whether it is preferable for all infrastructure to be removed or for some to be left in place.
- Virginia has abundant undeveloped land that is potentially suitable for solar, but there are many factors that impact the feasibility of a cost-effective solar project on any given property, limiting total available land area. These include, but are not limited to, local values, priorities, and ordinances; agricultural use and habitat value; developer priorities and needs; landowner participation; transmission capacity; and terrain.
- Brownfields may be suitable and offer advantages for smaller scale solar development, but siting on brownfields is more complex and/or expensive than other sites. For instance, installing solar on landfills usually requires a ballasted system with concrete foundations rather than the typical driven post foundation for fixed tilt and tracking systems; geotechnical aspects of brownfields may increase solar installation costs; soil may be significantly disturbed; and legal liability and multiple owners of the land (such as having different surface and subsurface rights) can complicate development.
- Different types of energy have different attributes and cost considerations. The elimination of fuel costs can reduce and stabilize rates for renewable energy compared to fossil fuel generation.
- Renewable energy can bring near-term and longer-term economic benefits to localities, regions, and the Commonwealth (e.g., annual county tax revenue payments for the life of the project, fixed landowner payments for the life of the project, jobs, and more), along with contributing to climate change mitigation and potential grid resilience. Potential tradeoffs must be assessed on a project-by-project and regional/cumulative basis.

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[11] Unless otherwise specified, references to “renewable energy” in this document include solar, on- and offshore wind, and battery storage.

[12] According to the Solar Energy Industry Association’s presentation in Meeting 2, all of Virginia’s 2.5 GW of solar capacity has come online since 2016 and 75% of that has come online since 2020. Since most solar projects have a 25- to 30-year life span, solar panels will not be decommissioned in significant numbers for at least two decades. Wind projects have a similar life span, but because there are still very few wind turbines in Virginia, the timeline will be even longer for wind that is installed in the future.

- Virginia does not have many utility-scale onshore wind projects underway, so takeaways related to wind energy are oriented towards planning for potential future onshore development and considering the land-based impacts of offshore wind development.
- The land footprint currently used for siting battery storage is minimal relative to solar development, and often coincident to generation, so takeaways related to battery storage are oriented towards proper accounting for storage in decommissioning requirements and consideration of the role Virginia wants to play in the battery recycling and/or circular economy.

General life cycle analysis

A life cycle assessment ("LCA") is a systematic process that evaluates the environmental impacts of products, processes, and services, generally analyzing three phases: 1) upstream processes, or everything before a facility/plant is put in the ground, 2) operational processes, and 3) downstream processes, or decommissioning through end-of-life. Because HB 774 directed the Task Force to "analyze the life cycle of renewable energy facilities," the Task Force meetings included an overview of the findings of LCAs on renewable energy facilities before exploring the specific charge questions in more depth.

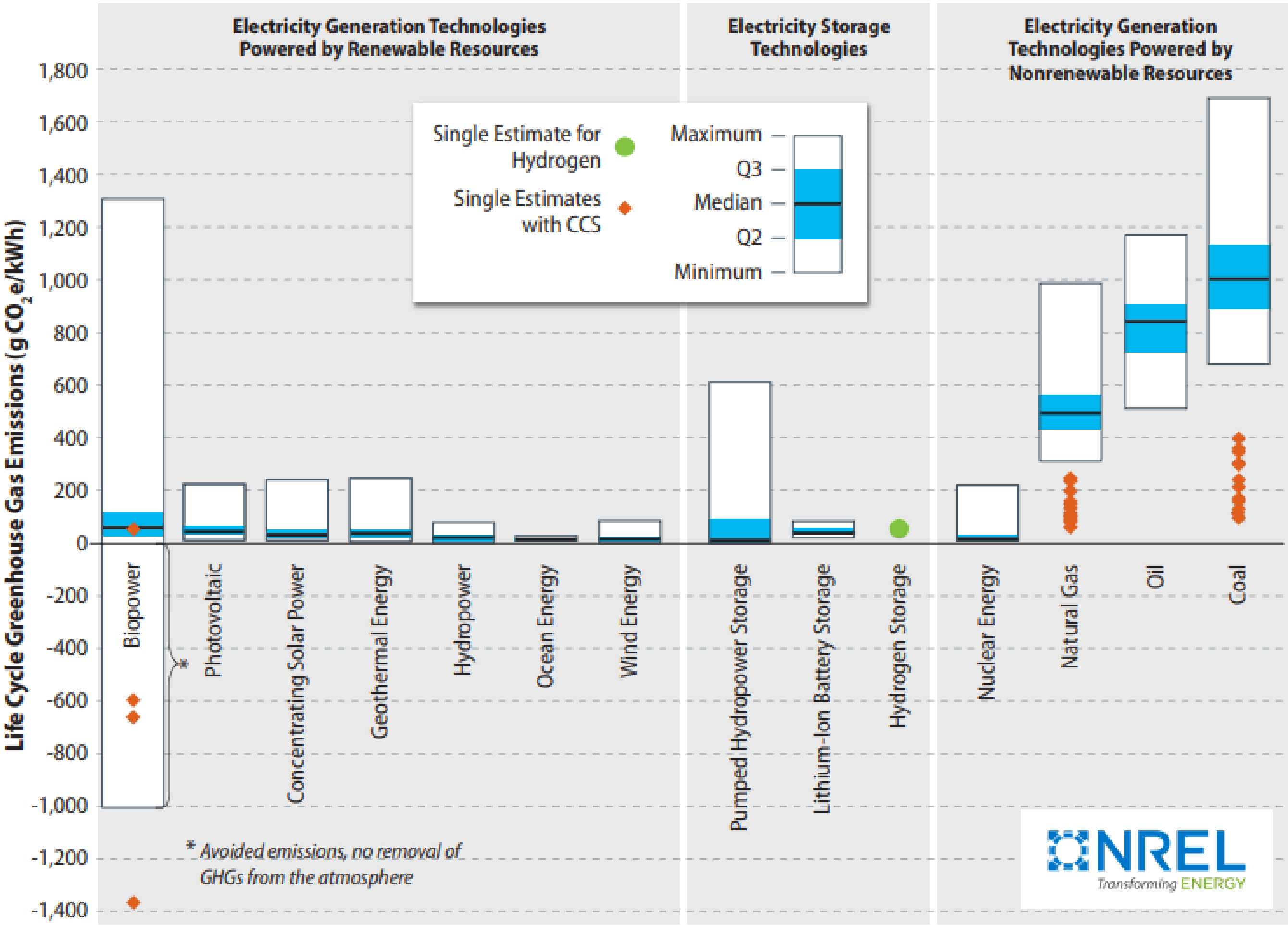
Summary of presentations and discussion:[13,14]

- Life cycle greenhouse gas ("GHG") emissions from renewable electricity generation technologies are significantly less than those from fossil fuel-based technologies. The proportion of GHG emissions from each life cycle stage differs by technology. For fossil-fueled technologies, fuel combustion during operation of the facility emits the vast majority of GHGs. For nuclear and renewable energy technologies, most GHG emissions occur upstream of operation. It is currently possible to reach under 40g CO_2 eq/kWh (grams of CO_2 equivalent per kilowatt-hour ("kWh")) for almost all renewable technologies. By comparison, without carbon, capture, and storage (CCS), coal and natural gas emit 1,000g CO_2 eq/kWh and 500g CO_2 eq/kWh, respectively. CCS can reduce emissions to 100-200g CO_2 eq/kWh for coal and natural gas. [See Figure 2 below.]
- Decarbonization comes with co-benefits, but there are potential tradeoffs in mineral depletion and land transformation or long-term land use.
    - There is a positive feedback cycle in which low-carbon production of electricity becomes even more low-carbon with advancing technology. The production of wind turbines and solar panels in 2050 will be in a more low-carbon context, as industry is becoming more efficient. The future potential of GHG emissions from these sources could be less than 10g CO_2 eq/kWh.
    - Land use can be a concern for renewables, depending on what is considered land use and what resources are required to support land-intensive renewable energy development.
    - Material requirements are important, and LCAs are not well equipped to characterize these. Supply risk, geographic variability risk, and dependence on other countries should be factored in. Specialty materials, like precious metals and rare earth elements, may become subject to supply risk for wind and solar, and more work is needed to understand this concern.

[13] National Renewable Energy Laboratory. 2021. "Life Cycle Greenhouse Gas Emissions from Electricity Generation: Update." Available from: https://www.nrel.gov/docs/fy21osti/80580.pdf.
[14] United Nations Economic Commission for Europe. 2021. "Life Cycle Assessment of Electricity Generation Options." Available from: https://unece.org/sites/default/files/2021-10/LCA-2.pdf.

Figure 2

Figure 2. Life cycle greenhouse gas emission estimates for selected electricity generation and storage technologies, and some technologies integrated with carbon capture and storage (CCS).



Analysis of feasibility, costs, recycling and salvage opportunities, waste strategies, and liability for the decommissioning of materials used in renewable energy facilities

Summary of presentations and discussion:

- Solar and wind infrastructure is not yet reaching the end of its initial service life in quantities that justify a robust recycling and reuse industry. It will be at least 20-30 years before the vast majority of solar facilities and any wind facilities are decommissioned in Virginia.
- The bulk of near-term recycling needs will be for some solar components, like inverters, and batteries. The battery recycling and reuse industry is likely to be driven by electric vehicle proliferation rather than stationary storage.
- Most solar panels can be disposed of in an ordinary landfill as universal waste,[15] or recycled. If solar panels are classified as hazardous waste (i.e., because they include a particular level of hazardous materials), they need to be disposed of in accordance with hazardous waste regulations.[16]
- Most components of a wind turbine are made of steel or iron, which are already easy to recycle. The concrete foundation is recyclable, but is also large, heavy, of relatively low value material, and can generally be left in the ground after the top portion (typically the upper four feet) is removed. Blades are of composite material that is harder to recycle and generally is sent to landfills at end-of-life. This quantity impacts landfills due to the volume of the blades. Some waste recycling companies recycle wind blades, and such companies are on the increase as the need grows, though none are currently in Virginia. New recycling techniques or materials are needed for wind blades and research is underway.
- Recycling of renewable energy components is likely to fit better into the existing linear nature of supply chains, but developing policies, incentives, and subsidies to encourage the investment in infrastructure for a circular economy may help keep the value of the industry and its materials in the Virginia economy, in addition to having greater environmental benefits than recycling or disposal.
- The end-of-life research and development landscape is changing rapidly, which is likely to lead to additional options for waste, recycling, and reuse in the future.
- The Bipartisan Infrastructure Law and Inflation Reduction Act are likely to radically change both recycling and manufacturing capabilities for renewable technologies. Virginia is poised to capitalize on the economic opportunities if policy decisions and state incentive programs continue to promote the rapidly growing industry.

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[15] Universal waste is a subset of hazardous waste that includes wastes generated from a wide variety of sources (e.g., individuals, government agencies, hospitals, businesses, etc.) in a variety of settings, not just in traditional industrial settings. Universal wastes may contain mercury, lead, cadmium, copper, and other substances hazardous to human and environmental health. More information about the Virginia DEQ's standards for treatment of universal waste can be found on their website: https://www.deq.virginia.gov/land-waste/solid-hazardous-waste/hazardous-waste/universal-waste-requirements.

[16] Modern commercial solar panels do not contain sufficient hazardous materials to pose a danger to the environment and human health. The federal government has a test to evaluate the toxicity characteristic leaching procedure ("TCLP"). Solar panels that fail the TCLP test are required by the federal government to be disposed of as hazardous waste. The Environmental Protection Agency cannot say definitively if all solar panels are or are not hazardous waste. It is the responsibility of the generator of the solar panel waste to determine if solar panels are hazardous by performing the appropriate tests or by using generator knowledge. Other state disposal regulations are here: https://www.epa.gov/hw/state-universal-waste-programs-united-states.

- Renewable energy facilities may be decommissioned or repowered before or after the manufacturer's end-of-life date based on many factors such as reliability and/or efficiency improvements, which could alter the timing of disposal/recycling requirements with respect to the project life cycle.
- Solar and wind sites are likely to be repowered, which may delay full decommissioning and reduce land requirements for energy replacement. Repowering of these facilities, however, may trigger additional stakeholder engagement and local land use discussion.
- Virginia statutes[17] require localities and developers to create decommissioning plans for solar sites and allow for decommissioning plans to be developed for wind and storage.

Task Force recommendations:

- The Task Force recommends that Virginia Energy, in collaboration with DEQVEDP, and relevant stakeholders, should share and/or develop resources,[18] including decommissioning benchmarks and best practice guidance, for the general public and elected officials to better understand opportunities for reuse, recycling, and disposal of solar, wind, and energy storage components.
- The Task Force recommends that DEQ, in collaboration with Virginia Energy and relevant stakeholders, should share and/or develop resources for the general public and elected officials on how renewable energy components are classified and designated as waste materials.
- The Task Force recommends that Virginia Energy, in collaboration with DEQ, VEDP, and relevant stakeholders, should collaborate on opportunities to attract recycling and/or circular economy-oriented facilities for cobalt, solar panels, wind blades, and other components.[19]

Analysis of potential impacts of underground infrastructure post-decommissioning

Summary of presentations and discussion:

- When a solar installation is decommissioned, the general practice is to remove the steel post from the ground. Decommissioning plans, developed in coordination with the landowner or local government in accordance with electrical code, may require the underground cabling of a solar installation to be removed or it may be left in the ground if the landowner or local

[17] Details regarding bonding provisions for decommissioning of solar energy equipment, facilities, or devices can be found in § 15.2-2241.2 of the Code of Virginia (https://law.lis.virginia.gov/vacode/title15.2/chapter22/section15.2-2241.2/). Details regarding the role of local governments in achieving objectives of the Commonwealth Clean Energy Policy can be found in § 45.2-1708 of the Code of Virginia (https://law.lis.virginia.gov/vacode/title45.2/chapter17/section45.2-1708/).

[18] For instance, American Clean Power aggregates resources here: https://energystorage.org/about-esa/energy-storage-corporate-responsibility-initiative/.

[19] Outside of Virginia, there are counties, states, and countries creating policies to attract these industries; Virginia should draw on learnings and best practices from other localities wherever possible.

government prefers that to the soil disturbance that would otherwise be caused by removal.[20,21,22]

- At the point of decommissioning onshore wind turbines, the foundations will likely have been in the ground for decades. Decommissioning plans, developed in coordination with the landowner or local government, generally call for leaving foundations in the ground, as that is often the preferred and least intrusive option for the soil and the surrounding landscape.

Task Force recommendations:

- The Task Force recommends that Virginia Energy, in collaboration with DEQ, should review existing research and, if needed, work with stakeholders to conduct more state-specific research on the impact of the specific types of underground infrastructure that may be left in place post-decommissioning (e.g., electrical cabling, steel posts, concrete) on future land use and how the impacts vary between different geological conditions throughout Virginia.
- The Task Force recommends that Virginia Energy, in collaboration with DEQ, should share information on the impacts of underground infrastructure with the general public, landowners, and local elected officials.

Analysis of potential impacts of the life cycle on farming, forestry, and sensitive wetlands

Summary of presentations and discussion:

- Meeting the VCEA's goal of 16,100 MW for energy generation from solar and onshore wind would require about 161,000 acres of land if all of that generation were solar.[23]
- Using very basic modeling[24] based on slope, distance to transmission, land cover, and contiguity of area, Virginia has abundant potentially suitable land for solar installations. Whether that land is actually appropriate and viable for solar development depends on many factors and potential constraints. These include but are not limited to local values, priorities, and ordinances; agricultural use and habitat value; developer priorities and needs; landowner participation; transmission capacity; and terrain.
- There is some flexibility in how solar is sited, designed, and operated, and the details impact the possibility for co-benefits, mitigated harm, and overall life cycle impacts—for example, for soils, wildlife, GHG emissions and sequestration—on different types of land. The degree to which land can be restored to its pre-project functionality (or close to pre-project functionality) depends on

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[20] Ohio Department of Health. 2022. "Ohio Department of Health Solar Farm and Photovoltaics Summary and Assessments." Accessed at: https://ohiodnr.gov/wps/wcm/connect/gov/fc124a88-62b4-4e91-b30b-bc1269d0dde5/ODH+Solar+Farm+and+PVs+Summary+Assessments_2022.04.pdf?MOD=AJPERES&CONVERT_TO=url&CACHEID=ROOTWORKSPACE.Z18_K9I401S01H7F40QBNJU3SO1F56-fc124a88-62b4-4e91-b30b-bc1269d0dde5-o3S-Ssh.

[21] NC Clean Energy Technology Center. 2017. "Health and Safety Impacts of Solar Photovoltaics." NC State University. Accessed at: https://content.ces.ncsu.edu/health-and-safety-impacts-of-solar-photovoltaics.

[22] Matsuno, Yasunari. December 2013. Environmental Risk Assessment of CdTe PV Systems to be considered under Catastrophic Events in Japan. First Solar. Accessed at: https://www. firstsolar.com/-/media/First-Solar/Sustainability-Documents/Sustainability-Peer-Reviews/Japan_Peer-Review_Matsuno_CdTe-PV-Tsunami.ashx.

[23] The Nature Conservancy. 2021. "Solar Siting in Virginia." Available from: https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/virginia/Pages/solar-siting-va.aspx.

[24] Ibid.

many factors including soil compaction, vegetation and stormwater management, and whether grading was involved.

- There are already robust and extensive state and federal regulations in place around avoiding, minimizing, and mitigating impacts to sensitive wetlands.
- While benefits can be amplified and negative impacts mitigated by where solar projects are sited, factors like PJM Interconnection LLC's ("PJM") interconnection process, the tendency of larger land parcels in Virginia to be forested or agricultural, land price, local government land use decisions, and the actual cumulative proliferation of solar facilities will limit the choice developers have in siting.
- Rooftop solar[25] reduces land use impacts and provides economic and energy management benefits, but locating rooftops that are viable for solar is complex and more expensive per kWh compared to utility-scale solar, at scale.
- There are various potential economic opportunity considerations when it comes to the interplay of solar siting, agriculture, and forestry, for instance:
    - The potential positive or negative economic impacts of solar on farming do not only impact farmers and agriculture, but also have multiplier impacts and potentially significant effects on other upstream agribusinesses.
    - The opportunity to plant native pollinator friendly vegetation on solar sites may provide benefits and impact maintenance needs, erosion control, weed control, etc.[26]
    - The economic value of agrivoltaics are state-, project-, and soil- specific, and may require state funding, incentives, and/or subsidies to be cost-effective for developers at scale.[27]
    - Solar can provide a stable additional revenue stream when appropriately co-located on agricultural lands, compared to other traditional forms of land development that eliminate the option to maintain existing farming practices.
- Virginia wind resources are located offshore or in the western part of the Commonwealth, where there is less agricultural land compared to other parts of Virginia, but these resources have the potential to impact other conservation resources.[28] However, the impacts to existing agricultural activities from wind is significantly less than that of utility-scale solar development.
- Land use for transmission facilities for offshore wind will have the most significant near-term impact from wind development in Virginia, so land viability related to offshore wind may be a consideration for future research.

[25] Details regarding local regulation of solar facilities can be found in § 15.2-2288.7 of the Code of Virginia (https://law.lis.virginia.gov/vacode/title15.2/chapter22/section15.2-2288.7/).
[26] The Department of Conservation and Recreation's Virginia Pollinator Smart program already provides resources in this vein: https://www.dcr.virginia.gov/natural-heritage/pollinator-smart.
[27] State-specific research through a partnership between the Virginia Department of Energy and the Virginia Cooperative Extension is underway.
[28] The Nature Conservancy uses ConserveVirginia to define conservation lands. This dataset was created by the Department of Conservation and Recreation, Division of Natural Heritage, to prioritize conservation efforts by mapping areas of highest conservation priority based on data inputs from various agencies and non-profits. The resulting land conservation priority map represents a wide array of conservation values including biodiversity, agricultural and forest resources, historic and cultural resources and scenic areas.

- Wind may have a relatively smaller infrastructure footprint compared to other generation facilities as well as other land uses, because it is generally compatible with other uses, including agriculture.[29,30]
- Compared to solar and wind, siting for battery storage is largely driven by grid needs and has a relatively small footprint relative to the installation near which it would be sited.
- According to safety code standards, batteries used for utility-scale storage generally need to be sited with a minimum of a 10-foot buffer from vegetation.[31]

Task Force recommendations:

- The Task Force recommends that Virginia Energy, in collaboration with DEQ, Department of Conservation and Recreation, Department of Forestry, the Virginia Cooperative Extension, Department of Wildlife Resources, Department of Historic Resources, Virginia Department of Agriculture and Consumer Services, and relevant stakeholders, should provide accurate and up-to-date tools to assist local planning staff and elected officials in making renewable energy facilities siting decisions. Such tools may incorporate or consider spatial data layers like prime soils, agricultural use and crop value, impervious surface, acid forming soils, habitat cores, carbon sequestration potential, recreation and scenic resources, and electric infrastructure information, such as by providing the VaLEN tool created through the stakeholder work group established pursuant to Chapter 488 of the 2022 Virginia Acts of Assembly's enactment clause three ("HB 894 Stakeholder Work Group").[32]
- The Task Force recommends that Virginia Energy should review existing research and conduct new research, if needed, in collaboration with relevant stakeholders, on the economic and life cycle benefits and impacts of renewable energy on farming, forestry, and sensitive wetlands, including collecting data on different types of land that have been converted to renewable energy development and distribution of financial benefits within communities.

Analysis of potential impacts of life cycle and decommissioning costs on brownfields or previously developed project sites as compared to life cycle and decommissioning cost on agricultural or forest lands

Summary of presentations and discussion:

- Brownfield site development for solar projects can be viable under certain conditions (for instance, if there is existing nearby interconnection and transmission infrastructure) and may minimize additional impacts on land and soil compared to siting on greenfield property.[33]

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[29] The footprint of the concrete foundations for wind turbines has the lowest average land use of any generation facility, though accounting for total land project area increases the land use as compared to other facilities such as coal mines, ground-mounted solar, hydropower, etc.

[30] United Nations Economic Commission for Europe. 2021. "Life Cycle Assessment of Electricity Generation Options." Available from: https://unece.org/sites/default/files/2021-10/LCA-2.pdf.

[31] Safety codes and standards UL 9540, UL 1642, UL 1973, UL 1741, and UL 62109 govern battery storage.

[32] In connection with the HB 894 Stakeholder Work Group, the Virginia Cooperative Extension developed the Virginia's Land & Energy Navigator tool. The tool is scheduled to be released in early 2023.

[33] The Virginia Department of Energy published *Developing Renewable Energy and Energy Storage Facilities on Brownfields and Previously Coal Mined Lands in Virginia: A Handbook* on October 17, 2022 detailing these opportunities and considerations, available from: https://energy.virginia.gov/public/documents/Public%20Meetings/HB%201925%20Handbook_FINAL%20w%20Comments.pdf.

- Due to ongoing development restrictions and human health concerns on the land, solar may be one of the only options for reuse of certain lands.
- While there are thousands of brownfield sites in Virginia, siting on brownfields is generally more expensive and less efficient and can have legal and environmental complications as compared to other sites, which impacts their ultimate viability for renewable energy. For instance, installing solar on landfills usually requires a ballasted system with concrete foundations rather than the typical driven post foundation for fixed tilt and tracking systems; geotechnical aspects of brownfields may increase solar installation costs; soil may be significantly disturbed; and legal liability and multiple owners of the land (such as due to different surface and subsurface rights) can complicate development.
- Sites that have been reclaimed more recently may be more viable than sites reclaimed many years ago, because there may be more information available about the site and/or an opportunity for current owners to collaborate on reclamation with prospective future developers.

Task Force recommendations:

- The Task Force recommends that Virginia Energy, in collaboration with DEQ and VEDP, should continue to promote solar development on brownfields.
- The Task Force recommends that the General Assembly consider funding the Virginia Brownfield and Coal Mine Renewable Energy Grant Fund and Program, incentive programs, and/or subsidies to overcome otherwise cost-prohibitive obstacles (e.g., high interconnection costs) that are typical in brownfield development.

Analysis of ratepayer impacts

Summary of presentations and discussion:

- Different types of energy have different attributes and cost considerations. As the grid transitions across the country to incorporate more renewable energy, utilities, regulators, and policymakers are making decisions at the intersection of reliability, affordability, and sustainability.[34]
- Any new investment cost for a utility, whether for a fossil fuel energy project or a renewable one, can put upward pressure on customer rates in the near term. Renewable energy may reduce rates and rate fluctuation in the long term because it eliminates fuel costs and may eventually be more dispatchable as storage proliferates, compared to a reliance on the commodity market for coal and gas generation.
- The cost to customers, benefit to farmers, and ultimate viability of an agrivoltaic project is variable based on the details of each individual project and site.
- The social cost of pollution and GHG emissions is factored into project approval at the state level in Virginia but is not explicitly accounted for in customer rates.[35]

[34]Virginia Energy and partners are conducting analysis on how the VCEA may impose disproportionate impacts on historically economically disadvantaged communities. The results of this analysis will be delivered in 2023 and every three years thereafter. The impacts assessed therein will include retail electric rates and a macroeconomic analysis. This study is a requirement of the VCEA.

[35] See the final order for PUR-2021-00146 from https://www.scc.virginia.gov/docketsearch/DOCS/6rd901!.PDF.

Task Force recommendations:

- The Task Force recommends that Virginia Energy, DEQ, other relevant agencies, and electric utilities should continue maximizing benefits under the Bipartisan Infrastructure Law and Inflation Reduction Act, and other available federal funding sources, for opportunities that may aid in cost relief for customers.

Analysis of potential beneficial economic impacts of solar, wind, and battery storage development

Summary of presentations and discussion:

- The Inflation Reduction Act is likely to continue to grow renewable energy development nationwide, and solar, wind, and battery storage are likely to continue to be cost-effective.
- Compared to fossil fuel-powered generation, renewable energy sources could provide fuel price stability, hedging against unforeseen electricity rate increases caused by geopolitical forces (e.g., in 2022), which can have an economy-wide impact.
- The construction phase of renewable energy development can bring a significant influx of spending into the rural communities that otherwise would not receive that amount of tax revenue.
- It is difficult to quantify exactly what the job gains and ratepayer savings of a renewable energy project will be without a specific cost-benefit analysis based on location, project size, and other site-specific information. Much cost-benefit analysis is site- or state-specific and depends on what a particular community or resource wishes to prioritize; there are always tradeoffs.
- Solar energy development involves quick deployment and creates short-term construction jobs. Compared to the fuel costs for fossil fuel technologies, solar energy development shifts spending from fuel to capital expenditure and labor. The primary economic impact of a solar facility is on local tax revenues.
- Rooftop solar is less cost-effective per kWh and generates less tax revenue than utility-scale but creates more jobs per kWh and can drive distribution-level savings for participating customers.
- Compared to other industries like residential and commercial development, solar development offers tax revenue without strain on local public services (water, sewer, schools, roads, etc.).
- Policy has a large impact on the economic and climate benefits of the renewable energy industry and to whom they accrue.[36] For instance, localities in Virginia can pass ordinances to enable revenue sharing for solar and energy storage.[37]
- Wind development creates high-quality ongoing local jobs, and there is a great deal of potential for growth of an offshore wind energy supply chain economy in Virginia. Compared to fossil fuel technologies, it shifts spending away from fuel to capital expenditure and labor.
- Due to the relatively early stages of the industry, there is limited data on the job creation impacts associated with utility-scale battery energy storage deployment; however, it appears there are economic benefits to the localities as well as grid resiliency improvements.

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[36] See Definitions; Negotiations, siting agreements; Powers of host localities; Effect of executed siting agreement, land use approval. §§ 15.2-2316.6 - 9 of the Code of Virginia (https://law.lis.virginia.gov/vacode/title15.2/chapter22/section15.2-2316.6/). Certified pollution control equipment and facilities. § 58.1-3660 of the Code of Virginia, (https://law.lis.virginia.gov/vacode/title58.1/chapter36/section58.1-3660/).

[37] See Revenue share for solar energy projects and energy storage systems. § 58.1-2636 of the Code of Virginia (https://law.lis.virginia.gov/vacode/title58.1/chapter26/section58.1-2636/).

- If appropriately planned and coordinated, battery storage complements and enables penetration of wind and solar in addition to providing benefits to the grid as a viable standalone technology. Energy storage technologies can reduce costs for ratepayers in a variety of ways, including by storing energy when the price of electricity is low and discharging that energy later during periods of high demand and thus higher prices. Energy storage, by increasing grid resilience and reliability, can also prevent or minimize power outages that result in costly damages or disruptions to homes and businesses.
- Proactive outreach, planning, and ordinance development by a community can ensure they are setting their own standards for any potential future renewable energy development. Early preparation for potential development generally begets economic benefit.

Task Force recommendations:

- The Task Force recommends that Virginia Energy should share and/or develop resources, such as the Virginia SolTax Model,[38] to educate elected officials and the general public on the economic impacts of renewables, including:
  - Reinforcing the use of available tools by localities to evaluate options for tax revenue through either the Machinery & Tools (M&T) tax or through revenue-sharing;
  - Making available to localities a model or best practices on ordinances that enable revenue-sharing for solar and energy storage; and
  - Continued or new analysis of the macroeconomic impacts and benefits of renewable energy development in Virginia, with transparency, clarity, and consistency with respect to the assumptions used in such analysis..
- The Task Force recommends that VEDP, in collaboration with Virginia Energy, the Virginia Community College System, and the Virginia Energy Workforce Consortium, should explore policies and partnerships for job training/workforce development in Virginia related to the manufacturing, installation, maintenance, recycling, and decommissioning of renewable energy facilities.

Non-consensus topics

A few topics elicited a great deal of discussion but did not result in agreement on generalized takeaways and recommendations:

- **Transmission costs related to renewable energy:** The group discussed the impact of renewable energy on transmission costs in considering whether renewable energy generally increased or decreased transmission costs. The group acknowledged that there are too many variables to make generalized statements about the relationship between transmission costs and renewable energy facilities.
- **Differences between rooftop solar and ground-mounted solar:** While there are differences between rooftop solar and utility-scale ground mounted solar in terms of land use, siting requirements, costs, jobs, and tax revenue, and some of the Task Force's summary takeaways address this, the Task Force could not agree upon generalized statements about the differences in impacts on customer rates. While rooftop solar is not expressly part of the charge questions, it came up in discussion as a way to minimize land use for solar. Discussion highlighted the nuance and complexity in siting rooftop solar.

[38]The Virginia SolTax Model, available from: https://solar-tax-webapp.herokuapp.com/, was developed by the Weldon Cooper Center at UVA, Virginia Energy, and others for use by localities to help them decide which taxation model to use for solar generating facilities.

- **Weighing benefits and tradeoffs for renewable energy projects:** The group considered a recommendation to provide/develop resources or a tool for localities to weigh benefits, impacts, and tradeoffs of renewable energy projects, but the Task Force agreed that considerations are so situation-specific that developing such a tool may be impossible. The group agreed that communities and elected officials need resources to make decisions about how renewable energy facilities fit with their values and economic vision for the community, but that there will always be a great deal of nuance to these decisions and true opportunity costs are not always knowable.
- **Forestry and solar:** The Task Force received written comments from the state forester related to the relationship between forested land and solar, and in particular related to the impact of forest conversion to open space. The comments came late enough in the Task Force process that the group did not have sufficient time to discuss and ask follow-up questions regarding the comments provided, so they are not addressed in detail in this report. However, the Task Force hopes that resources and research aggregated or developed in response to other recommendations will consider these dynamics and potential tradeoffs.

The theme of these non-consensus topics is that generalized takeaways are difficult to provide absent project specifics. Many statements *may* be true about a particular project but are not necessarily true in all cases because renewable energy facilities will have different benefits, impacts, and needs depending on a long list of factors that includes utility type and structure, local ordinances and regulations, site location, site type, facility type, land and soil, and many more.

Conclusion

Deployment of solar, wind, and battery storage facilities across the Commonwealth to meet the goals set by the VCEA has the potential to benefit Virginians at the local, regional, and state level. Such a significant transition and deployment of resources and new infrastructure necessitates careful consideration of impacts and opportunities related to facility end-of-life and decommissioning, land use, rates, and economics. The Task Force hopes that its report and recommendations help state leadership better understand these topics, ultimately in service of providing communities, local leaders, state leaders, and other stakeholders with the resources they need to understand and properly plan for Virginia's transition to 100% clean energy.

Appendices

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Appendix A: List of task force members

- American Clean Power Association
- American Farmland Trust
- Apex Clean Energy
- Appalachian Voices
- Appalachian Power
- Chesapeake Climate Action Network
- Dominion Energy
- EDF Renewables
- Invenergy
- Land and Liberty Coalition
- MAREC Action
- Old Dominion Electric Cooperative
- Rappahannock Electric Cooperative
- Reed Smith
- Siemens Gamesa Renewable Energy
- Solar Energy Industries Association
- Southern Environmental Law Center
- Strata Clean Energy
- Urban Grid
- Virginia Agribusiness Council
- Virginia Association of County Officials
- Virginia Department of Energy
- Virginia Department of Environmental Quality
- Virginia Farm Bureau
- Virginia Forest Products Association
- Virginia Municipal League
- Virginia, Maryland, and Delaware Association of Electric Cooperatives
- Virginia Office of the Attorney General
- Virginia Solar Energy Development and Storage Authority

Appendix B: Meeting agendas

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Commonwealth of Virginia
STATE CORPORATION COMMISSION

KEYSTONE POLICY CENTER

Virginia Renewable Energy Facilities Task Force
Meeting #1 Agenda

Date: October 28, 2022
Time: 8:30am – 2:00 pm Eastern

Access information:

Microsoft Teams: Click here to join the meeting from your computer, mobile app, or room device
Meeting ID: 252 190 202 157
Passcode: jEk7ak
Download Teams | Join on the web

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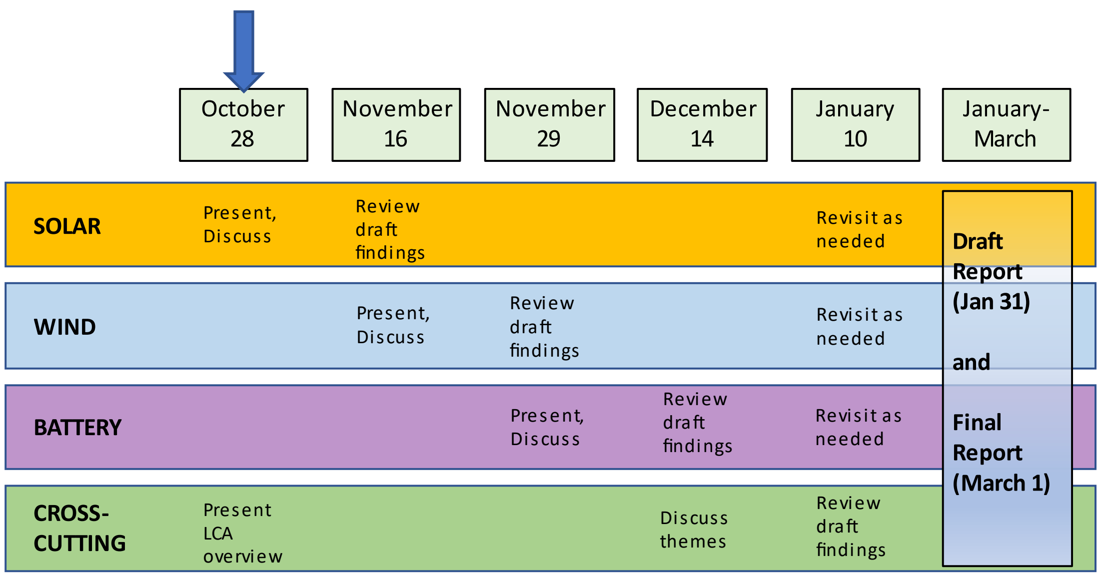
Time	Item	Presenter(s)
8:30am	**Welcome, Introductions**	SCC TF members
8:45am	**Task Force Scope** • Legislative charge • Meeting plan and timeline • Discussion and decision guidelines	SCC & Keystone Policy Center (facilitators)
9:15am	**Overview of Renewable Energy and Life Cycle Assessments (LCAs): State of the Science & Solar LCAs** ***Resources:*** • Life Cycle Assessment of Electricity Generation Options, United Nations Economic Commission for Europe (Executive Summary P. 6-7) • Life Cycle Greenhouse Gas Emissions from Electricity Generation: Update, National Renewable Energy Laboratory (NREL)	**Thomas Gibon,** Researcher, ERIN, SUSTAIN UNIT, Luxembourg Institute of Science and Technology **Garvin Heath,** Distinguished Member of the Research Staff, Strategic Energy Analysis Center, National Renewable Energy Laboratory

10:30am	**Break**	
10:45am	**Solar Energy Life Cycle: Presentations & Q&A** *Focus on: End of Life & Land Use* ***Resources:*** • Solar Futures Study, NREL • Land use ○ Solar Siting in Virginia, The Nature Conservancy ○ **In**novative **S**olar **P**ractices **I**ntegrated with **R**ural Economies and **E**cosystems (InSPIRE, Department of Energy) • Waste, recycling, and decommissioning ○ Environmental and Circular Economy Implications of Solar Energy in a Decarbonized U.S. Grid, NREL ○ Best Practices at the End of the Photovoltaic System Performance Period, NREL ○ Solar Photovoltaic Module Recycling: A Survey of U.S. State Policies and Initiatives, NREL ○ A Circular Economy for Solar Photovoltaic System Materials: Drivers, Barriers, Enablers, and U.S. Policy Considerations, NREL ○ A Survey of Federal and State-Level Solar System Decommissioning Policies in the United States, NREL ○ Human Health Risk Assessment Methods for PV | Part 3: Module Disposal Risks, International Energy Agency	**Judy Dunscomb,** Senior Conservation Scientist, Virginia, The Nature Conservancy **Thomas Gibon,** Researcher, ERIN, SUSTAIN UNIT, Luxembourg Institute of Science and Technology **Garvin Heath,** Distinguished Member of the Research Staff, Strategic Energy Analysis Center, National Renewable Energy Laboratory
12:30pm	**Break**	
12:45pm	**Solar Energy Life Cycle: Discussion** • Key insights against charges: ○ Feasibility, costs, recycling and salvage opportunities, waste strategies, and liability for the decommissioning of materials used in renewable energy facilities;	TF members

	○ Potential impacts of underground infrastructure post-decommissioning; ○ Potential impacts of the life cycle on farming, forestry, and sensitive wetlands; ○ Potential impacts of life cycle and decommissioning costs on brownfields or previously developed project sites as compared to life cycle and decommissioning cost on agricultural or forest lands; ○ Potential ratepayer impacts; and ○ Potential beneficial economic impacts of solar, wind, and battery storage development. • Areas of uncertainty & outstanding questions	
1:45pm	**Next Steps**	Keystone
2:00pm	**Closing Comments & Adjourn**	SCC



VA Renewable Energy Facilities Task Force Scope and Timeline

Commonwealth of Virginia
STATE CORPORATION COMMISSION

KEYSTONE POLICY CENTER

Virginia Renewable Energy Facilities Task Force
Meeting #2 Draft Agenda

Date: November 16, 2022
Time: 8:30am – 3:00 pm Eastern

Access information:
Microsoft Teams: Click here to join the meeting from your computer, mobile app, or room device
Meeting ID: 252 190 202 157
Passcode: jEk7ak
Download Teams | Join on the web

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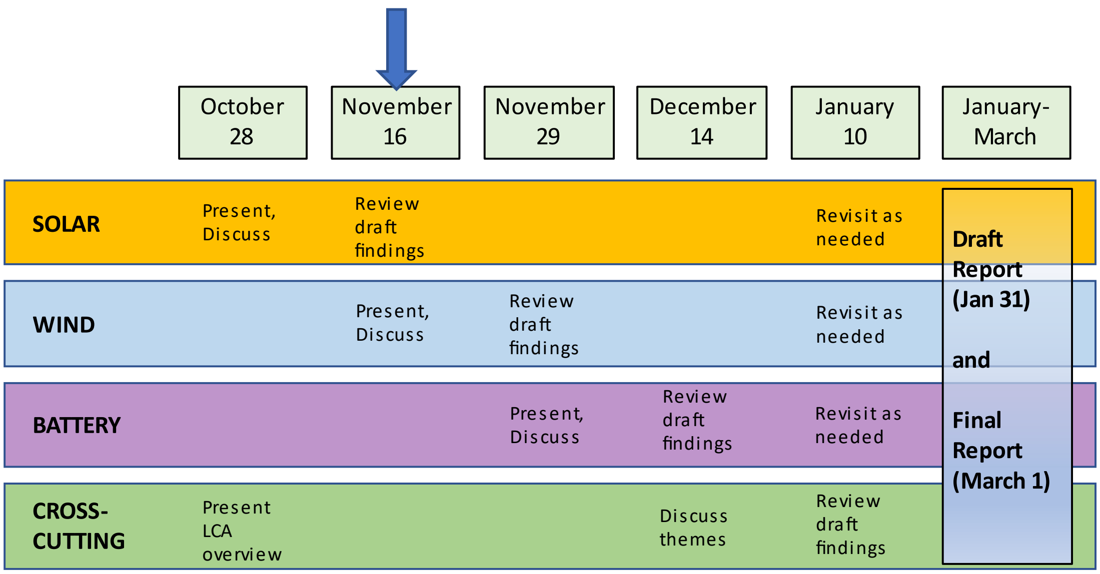
Time	Item	Presenter(s)
8:30am	**Welcome, Introductions**	SCC & Keystone Policy Center (facilitators)
8:45am	**Review of Meeting 1 and Solar Takeaways**	Keystone
9:00am	**End-of-Life Options for Solar in the Region** • State of waste disposal, recycling, and the circular economy in Virginia and across the nation • Lessons from North Carolina • Q&A ***Resources:*** • Plan and Recommendations for Financial Resources for Decommissioning of Utility-Scale Solar Panel Projects (North Carolina DEQ)	**Will Giese,** Task Force member and Southeast Regional Director, Solar Energy Industry Association **Virginia Manufacturers Association** (invited)
10:00am	**Break**	
10:15am	**Additional Solar and Wind Insights**	**Tyler Fitch,** Senior Associate, Synapse Energy

	• Economics of renewable energy in the Southeast • Impacts of underground infrastructure post-decommissioning • Q&A	**Dr. Lee Daniels**, T.B. Hutchenson Jr. Professor, School of Plant and Environmental Science, College of Agriculture and Life Sciences, Virginia Tech
11:45 a.m.	**Task Force Discussion** • Key insights against charge questions • Areas of uncertainty & outstanding questions	TF members
12:15pm	**Break**	
12:45pm	**Wind Power Life Cycle: Lunch Presentations** • Overall LCA takeaways • Waste, recycling, and salvage opportunities and decommissioning liability • Impacts of the life cycle on farming, forestry, wetlands and considerations for different types of lands • Briefing on NREL research on wind energy and community planning in preparation for Nov. 29 meeting • Q&A ***Resources:*** Same as last week, for reference on wind LCAs: • Life Cycle Assessment of Electricity Generation Options, United Nations Economic Commission for Europe (Executive Summary P. 6-7) • Life Cycle Greenhouse Gas Emissions from Electricity Generation: Update, National Renewable Energy Laboratory (NREL) Other resources: • Assessing Future Energy Development across the Appalachian Landscape Conservation Cooperative: Final Report	**Dr. Aubryn Cooperman**, Researcher III-Mechanical Engineering, National Renewable Energy Laboratory **Judy Dunscomb,** Senior Conservation Scientist, Virginia, The Nature Conservancy **Frank Oteri,** Researcher III-Market Research Analysis and **Matilda Kreider,** Wind Community Planning and Equity Post-Graduate Intern, National Renewable Energy Laboratory
2:15pm	**Wind Power Life Cycle: Discussion**	TF members

	• Key insights against charge questions • Areas of uncertainty & outstanding questions	
2:50pm	**Next Steps**	SCC
3:00pm	**Closing Comments & Adjourn**	

Charge Questions:

- Feasibility, costs, recycling and salvage opportunities, waste strategies, and liability for the decommissioning of materials used in solar energy facilities;
- Potential impacts of underground infrastructure post-decommissioning;
- Potential impacts of the life cycle on farming, forestry, and sensitive wetlands;
- Potential impacts of life cycle and decommissioning costs on brownfields or previously developed project sites as compared to life cycle and decommissioning cost on agricultural or forest lands;
- Potential ratepayer impacts; and
- Potential beneficial economic impacts of solar, development.



VA Renewable Energy Facilities Task Force Scope and Timeline

Commonwealth of Virginia
STATE CORPORATION COMMISSION

KEYSTONE POLICY CENTER

Virginia Renewable Energy Facilities Task Force
Meeting #3 Draft Agenda

Date: November 29, 2022
Time: 8:30am-3:00pm Eastern

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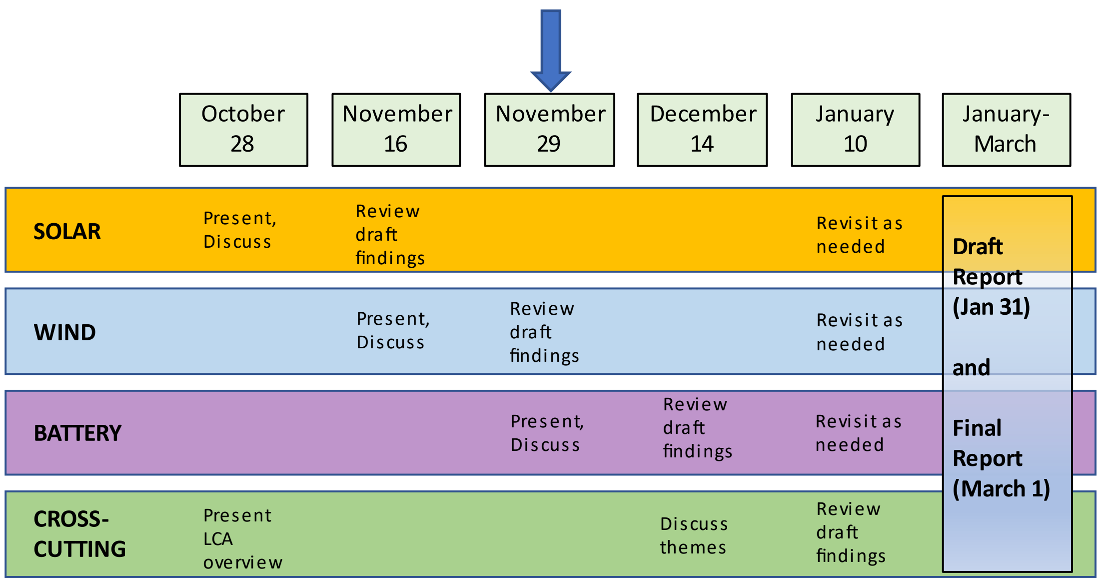
Time	Item	Presenter(s)
8:30am	**Welcome, Introductions**	Keystone Policy Center (facilitators)
8:45am	**Review of Meeting 2 and Draft Takeaways and Recommendations**	Keystone
9:15am	**State-Specific Economic Impacts for Solar**	**Stephanie Johnson,** Executive Director, Chesapeake Solar & Storage Association (invited) **David Murray,** Director of Solar Policy, American Clean Power
10:15am	**State-Specific Economic Impacts for Solar: Discussion** • Key insights against charge questions	TF members

	• Areas of uncertainty & outstanding questions	
10:30am	**End-of-Life Best Practices and Decommissioning Requirement Recommendations for Wind** • Addressing decommissioning in the planning phase • Learnings from end-of-service forum • Q&A	**Frank Oteri,** Researcher III-Market Research Analysis and **Matilda Kreider,** Wind Community Planning and Equity Post-Graduate Intern, National Renewable Energy Laboratory
11:30am	**Wind End-of-Life: Discussion** • Key insights against charge questions • Areas of uncertainty & outstanding questions	TF members
11:45am	**Break**	
12:15pm	**Battery Storage Life Cycle and End-of-Life Opportunities: Lunch Presentation** • Life cycle analysis • Waste opportunities • Land use • Q&A	**Dustin Weigl,** National Renewable Energy Laboratory
1:30pm	**Battery Storage Life Cycle: Discussion** • Key insights against charge questions • Areas of uncertainty & outstanding questions	TF members
2:00pm	**Break**	
2:15pm	**Next Steps: Discussion** • Review of next steps and opportunities for feedback • Review of what's been covered so far • Discussion: What is still missing?	Keystone and TF members
3:00pm	**Closing Comments & Adjourn**	

Charge Questions:

- Feasibility, costs, recycling and salvage opportunities, waste strategies, and liability for the decommissioning of materials used in renewable energy facilities;
- Potential impacts of underground infrastructure post-decommissioning;
- Potential impacts of the life cycle on farming, forestry, and sensitive wetlands;
- Potential impacts of life cycle and decommissioning costs on brownfields or previously developed project sites as compared to life cycle and decommissioning cost on agricultural or forest lands;
- Potential ratepayer impacts; and
- Potential beneficial economic impacts of renewable energy development.



VA Renewable Energy Facilities Task Force Scope and Timeline

Commonwealth of Virginia
STATE CORPORATION COMMISSION

KEYSTONE POLICY CENTER

Virginia Renewable Energy Facilities Task Force
Meeting #4 Draft Agenda

Date: December 14, 2022
Time: 8:30am-3:00pm Eastern

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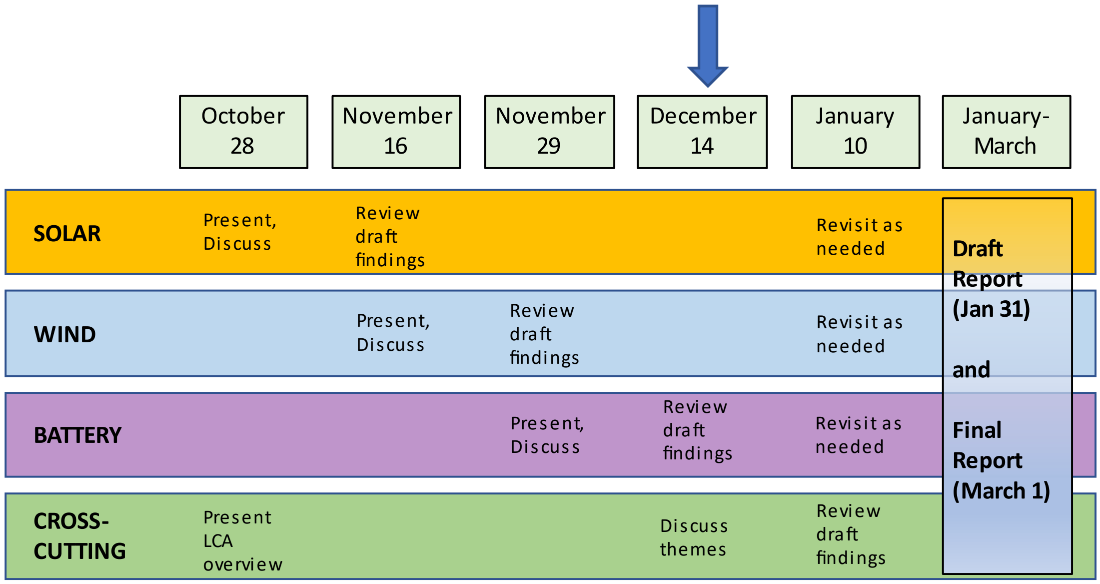
Time	Item	Presenter(s)
8:30am	**Welcome, Introductions**	Keystone Policy Center
8:45am	**Additional State-Specific End-of-Life Details: Presentation/Q&A** • Where are renewable energy elements—solar panels, wind blades, and batteries—going right now if they need to be disposed of in VA? • If there are existing facilities that could take renewable energy materials and are not doing so, why not?	Virginia Manufacturers Association SMEs (TBC)

	• Are there existing facilities in VA with hazardous waste permits? What is known about how long it takes to secure a hazardous waste permit in VA? • Are any facilities in VA accepting turbine blades? • Is there data on the growth projections for batteries in need of recycling/landfilling?	
9:30am	**Additional State-Specific End-of-Life Details: Discussion** • Additional insights against charge questions	TF members
9:45am	**Break**	
10:00am	**Draft Takeaways and Recommendations: Discussion & Consensus Check**	TF members
12:00pm	**Break**	
12:30pm	**Ratepayer Impacts of Renewable Energy: Panel** • Ratemaking 101: How are utilities in Virginia regulated? What factors influence the rates that utility customers pay? How is that different for different types of utilities? • What do we know about the impacts of solar, wind (onshore and off), and battery storage on rates? • Are there any notable differences in the approach to ratemaking for different types of energy technologies? What is the appropriate allocation of costs of renewable projects undertaken for Virginia Clean Economy Act compliance? • How are useful life and depreciation currently being calculated for any online or proposed renewable energy projects? Are there any notable differences in the approach to these questions when you compare fossil technologies to renewable technologies? Have there been any changes to the approach to	**Sam Brumberg,** Vice President of Regulatory Affairs and General Counsel, Virginia, Maryland, & Delaware Association of Electric Cooperatives **Will Cleveland,** Senior Attorney, Southern Environmental Law Center **Irene Cox,** Master of Public Policy Candidate, University of Virginia **Scott Gaskill,** General Manager for Regulatory Affairs, Dominion Energy **Cliona Mary Robb,** Chair, Solar Energy Development and

	these questions as renewable technologies have evolved? • How are externalities accounted for in ratemaking and overall cost recovery for utilities? ***Resource:*** • Virginia SCC Status Report on the Implementation of the Virginia Electric Utility Regulation Act (September 2022)	Energy Storage Authority
2:00pm	**Ratepayer Impacts of Renewable Energy: Discussion** • Key insights against charge question: What are the potential ratepayer impacts of renewable energy development?	TF members
2:30pm	**Next Steps: Review & Discussion** • Review of next steps and opportunities for feedback • Q&A	Keystone and TF members
3:00pm	**Closing Comments & Adjourn**	

Charge Questions:

- Feasibility, costs, recycling and salvage opportunities, waste strategies, and liability for the decommissioning of materials used in renewable energy facilities;
- Potential impacts of underground infrastructure post-decommissioning;
- Potential impacts of the life cycle on farming, forestry, and sensitive wetlands;
- Potential impacts of life cycle and decommissioning costs on brownfields or previously developed project sites as compared to life cycle and decommissioning cost on agricultural or forest lands;
- Potential ratepayer impacts; and
- Potential beneficial economic impacts of renewable energy development.



VA Renewable Energy Facilities Task Force Scope and Timeline

Virginia Renewable Energy Facilities Task Force
Meeting #5 Draft Agenda

Date: January 10, 2023
Time: 8:30am-3:00pm Eastern

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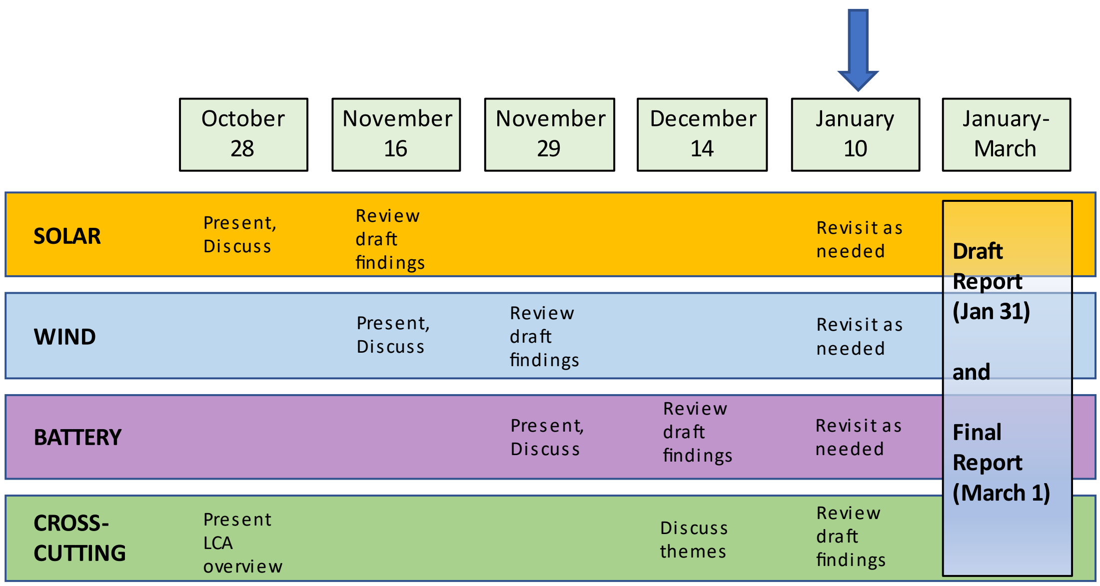
Time	Item	Presenter(s)
8:30am	**Welcome, Introductions**	Keystone Policy Center
8:45am	**High-Level Overview of Feedback Received**	Keystone
9:00am	**Detailed Review of Feedback on Takeaways/Recommendations** • Where is there clear consensus? • Where is there consensus with suggested changes?	Keystone and TF members

	• Which takeaways/recommendations are not supported by the group? • Have any priorities emerged?	
11:00am	**Break**	
11:30am	**Detailed Review of Feedback on Takeaways/Recommendations (cont., if needed)** • Where is there clear consensus? • Where is there consensus with suggested changes? • Which takeaways/recommendations are not supported by the group? • Have any priorities emerged?	Keystone and TF members
1:30pm	**Break**	
1:45pm	**Detailed Review of Feedback on Takeaways/Recommendations (cont., if needed)** • Where is there clear consensus? • Where is there consensus with suggested changes? • Which takeaways/recommendations are not supported by the group? • Have any priorities emerged?	Keystone and TF members
2:45pm	**Next Steps: Review & Discussion** • Review of next steps and opportunities for feedback • Q&A	Keystone and TF members
3:00pm	**Closing Comments & Adjourn**	

Charge Questions:

- Feasibility, costs, recycling and salvage opportunities, waste strategies, and liability for the decommissioning of materials used in renewable energy facilities;
- Potential impacts of underground infrastructure post-decommissioning;
- Potential impacts of the life cycle on farming, forestry, and sensitive wetlands;
- Potential impacts of life cycle and decommissioning costs on brownfields or previously developed project sites as compared to life cycle and decommissioning cost on agricultural or forest lands;
- Potential ratepayer impacts; and
- Potential beneficial economic impacts of renewable energy development.



VA Renewable Energy Facilities Task Force Scope and Timeline

Appendix C: Meeting summaries

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Virginia Renewable Energy Facilities Task Force
October 28, 2022 Meeting Summary

Meeting Purpose: This was the first of five virtual meetings of the Virginia Renewable Energy Facilities Task Force created by HB 774 / SB 499, which directed the State Corporation Commission (SCC) in consultation with the Department of Energy (VADOE) and the Department of Environmental Quality (VADEQ) to create a task force to analyze the life cycle of renewable energy facilities in the Commonwealth.

Meeting Participants: The meeting was attended by approximately 50 participants, including representatives from 23 Task Force member organizations, guest speakers, and staff of the SCC (convening agency) and Keystone Policy Center (facilitators). *See Appendix A for the full list of organizations represented at this meeting.*

Discussion Summary

I. WELCOME

David Essah, Director of Public Utility Regulation, Virginia SCC, welcomed everyone to the meeting and introduced Keystone Policy Center as the third-party organization contracted to facilitate the Task Force.

Mallory Huggins, Lead Facilitator, Keystone Policy Center, reviewed discussion protocols and provided an overview of the Task Force legislative charge and meeting timeline. The Task Force will meet virtually five times between October 2022 and January 2023, after which Keystone will compile a report of the Task Force's recommendations to the SCC. Mallory noted that, among the six charge questions to the Task Force, not every topic has robust research available. In addition to policy recommendations, the final recommendations to the SCC could include the identification of outstanding questions or a recommendation for more research on a given issue. *See Appendix B for a list of the Task Force charge questions.*

II. OVERVIEW OF RENEWABLE ENERGY AND LIFE CYCLE ASSESSMENTS (LCAs)

Presenter: Dr. Thomas Gibon, Researcher, Environmental Research and Innovation, SUSTAIN UNIT, Luxembourg Institute of Science and Technology

Dr. Gibon provided an overview of the purpose and scope of Life Cycle Assessments (LCAs), which are a tool for attributing environmental impacts to products and services. He noted that environmental impact assessments are needed for technical, chemical, and environmental decision making on the design of future electricity systems. Some state regulations (e.g., California's low carbon fuel standard) and many European directives recommend or demand the use of LCAs. The EU Joint Research Center provides a long list of impact categories to be assessed in environmental LCAs, focusing on climate change but also including air pollution, toxicity, radiation, eutrophication, and resources of land, water, materials, and energy carriers.

Dr. Gibon presented the results of the Life Cycle Assessment of Electricity Generations Options report, of which he was the lead author. This report was part of the carbon neutrality toolkit produced by the United Nations Economic Commission for Europe (UNECE) to assist policymakers in making informed decisions to attain carbon neutrality.

Life cycle GHG emissions

Dr. Gibon reviewed the results of life cycle GHG emissions (measured in g CO_2 eq/kWh) per technology, and highlighted the following considerations:

- Coal and natural gas were evaluated with and without carbon, capture, and storage (CCS). Coal without CCS emits 900-1100g CO_2 eq/kWh. CCS does not reduce emissions to zero but, in the best case scenario, reduces emissions to 100-200g CO_2 eq/kWh.
- Hydropower emissions were evaluated separately for 660MW and 360MW generation plants, and 360MW is more representative of hydro plants around the world, emitting 6-11 CO_2 eq./kWh.
- The variability range for coal emissions depends on the supply of coal.
- Concentrated Solar Power (CSP) emissions vary depending on the amount of sun available per square meter per year, while Photovoltaics (PV) emissions vary depending on the type of PV and type of mounting.
- Across the lifecycle, from extraction to end of life, it is possible to reach under 10g CO_2 eq/kWh for almost all renewable technologies.

Life cycle land occupation

Dr. Gibon reviewed the results of life cycle land occupation (measured in m2-annum/MWh) per technology, and highlighted the following considerations:

- Land occupation results varied more than GHG emissions. Upstream factors are the primary source of variability for fossil fuels, while land use for renewables is highly dependent on performance of the equipment, the potential combination with other uses (such as agriculture), and what is considered land use (direct or project area).
- Coal can be mined open pit or underground, and this is the primary variable in the land use scores shown for coal. Natural gas production's footprint is mostly underground, so the overall life cycle of land use is very low. Nuclear power's land occupation is the lowest of all resources.
- Wind generation was measured to have very low life cycle land occupation, on par with the lowest scores in other technologies. But Dr. Gibon cautioned that if you were to include the surface area of a wind farm, rather than just the area under each turbine, the land occupation of wind will be much higher than shown in UNECE's report. Photovoltaics have similar considerations for what constitutes land use. For a more nuanced review of land occupation, Dr. Gibon recommended the Our World In Data collaboration of their results, and the Energy Pathways to 2050 report by RTE, France's Transmissions Systems Operator, which differentiates land use between shared use, artificialized land, and sealed areas.
- Combining PVs and agricultural farms may provide co-benefits.
- The UNECE report focuses on kWh and does not go beyond that. It's important to consider that other existing and future infrastructure, such as roads and buildings, take up a large amount of space compared to new power infrastructure.

Life cycle dissipated water

Dr. Gibon reviewed the results of life cycle dissipated water (measured in m^3/MWh, or l/kWh) per technology, and highlighted the following considerations:

- All thermal technologies use water for cooling. Photovoltaics require some water to clean the panels, but most renewable energies don't need much water at all.
- Adding CCS technologies to coal or natural gas uses ~15-20% more water per kWh because they require more stock to run the capturing equipment. Therefore, while CCS decreases life cycle GHG emissions, it has the potential to increase other impacts in proportion.

Life cycle material requirements
Dr. Gibon reviewed the results of life cycle material requirements (measured in g/MWh) per technology, and clarified it is not a measurement of the materials that end up in the equipment, but a measurement of all the material that has been dug up at some point in the life cycle to make it possible to produce one kWh per grid. CSP and PV have the highest life cycle material requirements of all technologies, with hard coal and wind as the second most material intensive technologies.

Aggregate life cycle indicators
Dr. Gibon reviewed the results of aggregate life cycle indicators per technology. He noted that aggregating these impacts to a single score comes with several caveats and considerations, such as *What is the value of climate change? What is the long-term global impact compared to local and short term impacts?*

Key takeaways from the UNECE report
Dr. Gibon shared his key takeaways from the report:

- GHG emissions are very low for all renewable energy technologies; most emissions are embodied in infrastructure.
- Nuclear power has a very specific environmental profile, showing low impact on all the indicators, due to the very high energy density of uranium.
- Land occupation can be a concern for renewables, depending on what you consider land occupation and what surface is accounted for.
- Material requirements are important, and LCAs are not as well equipped to characterize these. Supply risk, geographic variability risk, and dependence on other countries should be factored in. Specialty materials, like precious metals and rare earth elements, may become subject to supply risk for wind and solar, and more work is needed to understand this concern.

Prospective assessments
Dr. Gibon also provided an overview on the potential of prospective assessments, which place the potential impacts in a future context. He highlighted the following considerations:

- There is a positive feedback cycle in which low carbon production of electricity becomes even more low carbon with advancing technology. The 2050 production of wind turbines and solar panels will be in a more low-carbon context, as industry is becoming more efficient. The future potential of GHG emissions from these sources could be <10g/kWh.
- Decarbonization comes with a lot of co-benefits, but there are potential tradeoffs in mineral depletion and land transformation or occupation.

Presenter: Garvin Heath, Distinguished Member of the Research Staff, Strategic Energy Analysis Center, National Renewable Energy Laboratory (NREL)
Dr. Heath provided his perspective on the degree to which LCAs may or may not help to answer the Task Force's charge questions. He noted the term "life cycle" includes where materials come from, as well as the manufacturing, siting and construction, and end of life for energy facilities. He noted the charge to the Task Force emphasizes the end-of-life phase, with less focus on the upstream phase of material acquisition and manufacturing, so LCAs might not have as much relevance. However, the framing of LCAs is important for context, and Task Force participants can decide how much time should be spent on the LCAs themselves versus other research more directly relevant to the charge questions.

Dr. Heath presented results from NREL's life cycle assessment harmonization project, an analysis of 3,000 individual LCAs from across the globe. The LCAs were screened for their quality, relevance, and transparency; more than half of the 3,000 were screened out, and all the remaining studies are represented in the report data. The ranges reported represent the variabilities of region, technology, assumptions of technology performance, and methods among the individual studies. For example, the assumption of GHG emissions has changed over the two decades since these studies took place.

Life cycle GHG emissions

Similar to Dr. Gibon's takeaways, Dr. Heath noted the results of the harmonization study show that life cycle GHG emissions of renewables and nuclear energy have very low central tendency, which is quite distinct from fossil energy technologies.

The study divided the life cycle into three phases: 1) upstream processes, or everything before the plant gets put in the ground, 2) operational processes, and 3) downstream processes, or decommissioning through end of life. Across the life cycle of PVs, the benchmark is about 40g CO_2 eq/kWh, compared to coal at about 1,000g CO_2 eq/kWh. Notably, the stage where most of these emissions happen is quite different. The operations phase of PV has very little GHG emissions, whereas in coal almost all the emissions are in this phase. Downstream processes, or end-of-life phases, are relatively small in their contribution to total GHG emissions.

The variation of the range of emissions from PVs is primarily from embodied carbon. Low embodied carbon PV modules can reduce emissions by up to 10X; even at the high end of the range, the benchmark for PV is very different than the benchmark for coal or natural gas.

Balance Of System recycling

Dr. Heath noted that when discussing Balance of System (BOS) recycling in wind or solar, it's not a reference to recycling a turbine or PV module, but recycling all the other components (e.g., the racking, wiring, and inverters). Two different "thin film" technologies were assessed, including CdTe, which is a large part of the U.S. market. The analysis of both showed that BOS recycling, much more than dematerialization or increased module efficiency, provides for important reductions in impacts of carcinogens and metal depletion. Carcinogenic emissions are strongly linked to the demand for copper, and recycling displaces future production of those metals.

Key takeaways

Dr. Heath shared his key takeaways from the harmonization project:

- Renewable energy technologies, and storage, provide GHG emission reduction benefits compared to incumbent fossil energy technologies and the current grid average.
- Most carbon for renewables is from the manufacturing phase.
- The end-of-life phase was found to be a small contributor to emissions. However, LCAs have not paid as much attention to this phase, partially because it is considered a small contributor, and there is a relative lack of data.
- If recovering PV materials and putting those back into the supply chain, a "credit" should be offered for offsetting virgin mining of those same materials. BOS recycling is important to consider, in addition to module recycling, and is easier to achieve.

Presenter Q&A

After both presentations, Task Force participants raised the following questions:

- What studies are available on the economic viability of agrivoltaics?

    - Dr. Heath noted that the question of economic viability is not specifically addressed in LCAs, but [USDOE's InSPIRE project]() covers economic benefits.
- Was the loss of timber, one of our best carbon sinks, calculated in the LCAs?
    - Dr. Gibon noted that in LCAs, a factor of zero is applied to all the CO_2 that is biogenic, but that is currently under debate, as Europe cuts trees at a much faster rate than they burn them.
    - Dr. Heath noted that LCAs are capable of accounting for loss in carbon stock but most LCAs are done for generic technologies, not for a specific site and its conditions. Virginia LCAs could account for forestry conditions, if a particular site was being proposed to convert forestry land to solar.
- From the local government perspective, addressing concerns and uncertainty about financial liability for decommissioning is critical. Citizens have voiced concerns about millions of panels being decommissioned in future decades while without a viable East Coast recycling option. Localities are financially bonding solar development projects and, in a sense, are just as liable as the developer.
    - Dr. Heath suggested seeking learnings from other states. He noted that recycling options do currently exist on the East Coast and the industry will be grown exponentially by the time a new solar project being permitted today will be decommissioned.
- How do land use projections account for eventual retirement of a given PV or wind facility?
    - Dr. Heath noted that in LCAs, land occupation is typically considered over the project period, and anything after decommissioning is outside of the boundaries of the LCA. He also noted that the land use score does not measure underground use, but *land surface occupation.*
    - Dr. Gibon agreed, noting that the UNECE's LCA measurement for land use is square meters *per year.*
- What assumptions are made about repowering existing PV sites to optimize for interconnection, or the need to acquire more land for replacement?
    - Dr. Heath noted the definition of repowering is taking one project site and repowering with new components within the anticipated life of the project (i.e., within the 30-year warranty period of installed PV modules) for economic advantage or natural disaster recovery. Repowering is not planned for up front, so it is outside the boundaries of an LCA. He noted that inverters don't last for the entire project period, and a good LCA would account for the materials, installment, and disposal of additional inverters. In the U.S., repowering is often forced by an extreme weather event. Often, updated technology in the replaced modules provides a higher value for the same land use.
    - Dr. Gibon noted that the first wind turbines installed in the EU are now at their end of life and are being replaced with more energy efficient turbines. This avoids some emissions in the site development phase, as existing roads and foundations can be used. When the first wind farm is retired, more data will be available.
- Could the theory of energy cannibalism in the short-term counteract Dr. Gibon's statement that electricity decarbonization of renewable energy technologies becomes more low carbon as they are deployed?
    - Dr. Gibon acknowledged there will be a phase where the energy system is heavily dependent on fossil fuels even as production of renewable energy infrastructure ramps up. We must burn fuels to create a new low carbon energy system for the future. While the emissions over 30 years are shown as one point on the report, most emissions for renewables happen at the beginning, with small emissions during the operations and

decommissioning phases. If upscaling those numbers, it is important to differentiate those phases and not upscale the total value.
  - Dr. Heath added that those early emissions do matter and are accounted for in climate modeling but, in the long run, the benefits of a conversion to renewables is consequential and could not be achieved otherwise. Additionally, renewables are not an isolated system but are displacing other sources that have much higher emissions.
- Does the ground-mount PV values account for fixed tilt vs. tracking systems?
  - Dr. Gibon noted that UNECE's study looked only at fixed tilt, but the benefits of using tracking vastly outweigh the carbon cost.
  - Dr. Heath noted that NREL's harmonization includes studies of both. There is some additional embodied carbon in the pneumatics and operation of a tracking system, but there is also improvement in energy yield.
- Do the PV carbon values account for night time power use for site maintenance?
  - Dr. Heath noted that they do.
  - Dr. Garvin shared a Techno Ecological Synergies of Photovoltaics study, which reviews many types of PV designs including agrivoltaics, pollinator habitat, low-impact PVs, and rooftop installation.

III. SOLAR ENERGY'S LIFE CYCLE: LAND USE AND END-OF-LIFE

Presenter: Judy Dunscomb, Senior Conservation Scientist, The Nature Conservancy of Virginia
Judy presented on The Nature Conservancy's (TNC) work to understand the impacts of renewable energy development and land use in Virginia (including the surface area used for offshore wind), and ways to minimize or offset these impacts.

Simple Solar Model
TNC developed a model that evaluates the physical overlap of potentially solar suitable sites and resources of conservation concerns in Virginia. This model, called the Simple Solar Model, accounts for major variables that drive where solar energy occurs on land. The variables for Virginia are:
- Slope of 15% or less
- Distance to transmission of 3 miles or less
- Land cover, which excludes already developed places and open water
- A contiguous area of either 10-30 acres (small, community scale projects) or <100 acres (for <10MW generating projects)

Judy noted the model is not a map of current or forecasted solar development and does not make value judgements about TNC's preferred development sites. The model is strictly the physical characteristics of land that make it suitable for solar.

Solar Suitable Sites in Virginia
According to this model, 8.7 million acres of potentially solar suitable land exist in Virginia. Judy noted the model likely over-represents suitable areas since it does not account for land prices and transmission capacity, but despite the model being overly inclusive, sites are largely falling within the identified areas. 92% of solar projects in the PJM queue fell within the identified areas.

TNC looked at the interaction between areas suitable for solar energy development and lands that are important for conservation by applying the Conserve Virginia layer, which represents a large range of resources valued by stakeholders including: agriculture and forestry, natural habitat and ecosystem diversity, floodplains and flooding resilience, cultural and historic preservation, scenic preservation, protected landscapes resilience, and water quality improvement. 2.2 million acres in Virginia were shown to be both suitable for solar and conservation priority lands, which leaves much acreage still available for development that would avoid direct conflict with other important resources. However, there is currently still a lot of conflict between these two areas. At the time of the 2020 study, forested land was the site for about 58% of all the solar facilities, and cropland was about 25%.

Judy hypothesized the following potential reasons for this conflict:

- The enormous backlog in the PJM queue means that it takes developers a long time for any given project to proceed, likely driving them to prefer one large project over multiple small projects.
- Large land ownerships in Virginia tend to be forested, in the hands of either timber management or a real estate trust. It is much easier for a developer to do a project with a single owning entity.
- Forested and agricultural lands in western Virginia are cheaper than the lands in Northern Virginia.
- Potential impacts to converted land

Judy referenced the work of Dr. Lee Daniels, Professor of Crop and Soil Environmental Sciences at Virginia Tech, which illustrates the impacts of grading on soil texture and structure, including:

- Change in soil texture and structure (permeability, fertility, and acid drainage because of things that were deeply buried now being exposed, releasing aluminum, iron, and other acidic materials)
- Change in wildlife habitat value
- Change in the ability of the land to sequester carbon

Judy noted that every forecast for getting to net zero includes some carbon sequestration being performed by the land (trees, marshes, etc.) and there is a need to protect, and likely expand, the ability of the land to do that.

Dr. Daniels' work points to several soil challenges in the operational phase, such as soil compaction during construction that may be difficult to remediate, and concentrated local runoff on panels which can lead to local rilling. Soil challenges in the closure phase include soil disturbance during removal of site infrastructure, difficulty in returning any highly productive agricultural land (e.g., row crops) to its prior use without heavy tillage, and heavily disturbed areas (e.g., roads) being unlikely to return to any higher use than pasture or forestry. Dr. Daniels has cautioned against being overly confident that highly productive agricultural lands could readily be returned to their existing levels of soil productivity, as there is still a lot to learn.

Judy added that these concerns are largely connected with the extent of grading on the site, but some Virginia sites have minimal grading and, if you can segregate the topsoil and not get into the deep clay subsoils, decommissioning is a lot easier and less impactful to the land.

Wildlife, forests, and carbon
Judy noted a preponderance of solar suitable areas in the Piedmont and Coastal Plain habitats, while the preponderance of sites with ecological value is in the west. Therefore, the potential for conflict in these site types is limited and should be manageable.

She added that many don't realize Virginia's southern loblolly pine plantations, even while regularly harvested, are still significant carbon sinks because they grow quickly and draw a lot of carbon out of the air. Additionally, although it is not the preferred method of achieving carbon sink, their paper products largely wind up in landfills and become fairly good carbon sinks.

Potential for solar development on degraded lands
TNC identified 260 mined lands, many of which are large acreage sites, that intersected with solar suitable sites in Virginia. They also identified many brownfields that could be suitable, although the size of those sites were not always a good fit for the simple solar model, which excludes areas of 30-100 acres.

Judy noted that previously mined lands and brownfields have great potential for solar development, although there are some barriers. The biggest barrier is that reclaimed land comes with uncertainty over what is in the current soil profile and the civil cost is hard to know at the outset, although there are federal and state policy funding streams to help in this regard. TNC has acquired 120K acres in Virginia and is working with Sun Tribe and Dominion Energy on projects looking to understand the barriers to developing on previously mined lands. TNC is also currently developing a utility scale project on mine lands in southwestern Virginia.

When developing on degraded land, typically any issues with compaction and soil disturbance have already occurred, so there are no new impacts to those resources during operation. The wildlife impact and carbon storage are also in more degraded states, resulting in less of a value loss. An NREL study on rooftop solar potential in Virginia concluded that ~30% of Virginia's 2017 energy sales could be met through rooftop generation, which would avoid the wildlife, stormwater, and carbon issues.

To dig into the life cycle of solar in Virginia, it will be necessary to develop predictive capacity. One great unknown is how much solar development Virginia will have, but scenarios could be run. Expansive spatial data layers are available and understanding land uses, and the values they provide, is a good way to predict where solar development is likely under a given scenario. A model accounting for transmission congestion and capacity does not exist, but it could be done with time and funding.

Presenter Q&A
Task Force participants raised the following questions:

- Would a smaller, community scale solar project be more appropriate for degraded lands?
    - Judy noted that it depends on the site. Many brownfields are small, but many mine lands are large.
- Have you heard of work in New York showing that land was more fertile after solar use than before?
    - Judy noted the Cornell Soil Lab developed practices to improve fertility on former tobacco lands, though those sites were pretty depleted to begin with.
    - Dr. Heath noted that NREL coordinates an effort with U.S. Department of Energy called InSPIRE, which provides best management practices for low impact solar development.

Presenter: Garvin Heath, Distinguished Member of the Research Staff, Strategic Energy Analysis Center, National Renewable Energy Laboratory (NREL)

Dr. Heath presented an overview of PV and end of life management. He noted that the warranty period for solar panels is 30 years, which is considered the life of a solar project. At the end of that life cycle, the project could be repowered or decommissioned and returned to its original condition.

NREL developed a model called PV in the Circular Economy, or PViCE, which projects when output of PV materials is expected, based on reliability of modules and known deployment of modules in an area. Since glass is 80% of the mass of a PV module at end of life, they focused on glass. For VA, they looked at three scenarios: 1) decarbonization, 2) decarbonization with electrification, and 3) a reference scenario.

What's in a PV module?

Dr. Heath noted a PV module is typically composed of: 1) a surrounding aluminum frame with one layer of glass on top, 2) a bottom layer of polymer and metal, which electrically isolates the model to avoid charge leaking out, and 3) the semiconductor between those layers, of which the dominant technology is crystalline silicon. One reason PV modules are difficult to recycle is that this "sandwich" includes polymer adhesive layers, which hold the module together to provide reliable performance for the warranty period. The precious metals contained inside are present in very small quantities distributed throughout these surfaces, so it takes more effort to recover them.

Circular economy

Dr. Heath noted the linear economy we have today disposes of products at the end of their life. In contrast, a circular economy tries to retain as high a value of the materials as possible and keep them in the economy. A recycling economy lies in between linear and circular economies. A circular economy is preferable as it has more pathways than a recycling economy, but recycling is an important backstop. The motivation for trying to recover PV modules is their value, of which economic value is one measure. A 2016 study estimated that retired PV modules could hold of a value of $15 billion and produce 2 billion new panels; the revised study will show numbers far higher because deployment has been greater than predicted.

PVs and human health

NREL performed risk assessments for three different scenarios of potential human exposure to the metals in PV modules: 1) PV exposed to fire, 2) an operating PV with broken glass, allowing water to enter and leak metals onto the surface, 3) landfilling of PV modules. Human health assessments use the most risk conservative assumptions possible; yet in all three scenarios, cancer and non-cancer human health risks from the fate of the metals were at least 10X, and sometimes 100X, below U.S. EPA risk thresholds.

Management options

Dr. Heath reviewed the management options for retired PV equipment, noting there is no data on the prevalence of any option, but all are in use today:

- **Reuse:** Retired PV panels and BOS equipment such as inverters may be suited for direct reuse, or repaired for reuse. Markets are available online and getting more robust.
- **Recycle:** Individual chemical and/or material elements can be returned to the value chain.
- **Disposal:** PV modules are sent to a landfill.
- **Storage:** Owners whose modules have reached end of life and are not happy with the available options may store them for the time being.

Retired PV trends
Dr. Heath noted that only a few PV manufacturers have a program to reuse or recycle retired modules. Only a handful of third-party companies repair or resell them, likely because there is a relatively small amount of retired PV systems. Less than 10% of PV modules in the U.S. are recycled today. Evidence suggests that the cost of recycling ranges from $15-45/module, compared to about $1/module for nonhazardous landfill disposal and $5/module for hazardous waste disposal. As more modules are sent to recyclers, processes will improve and costs will go down.

The benefits of material recovery include landfill capacity extension, environmental stewardship, enhanced environmental quality, and increased domestic material security.

The challenges to reuse and recycling are:
- Technologies for reuse or recycling, while growing, are not as efficient as they could be
- Lack of information and data
- Unclear, complex, and varied laws and regulations
- Lack of economic motivation while recycling costs more than landfilling
- Low market confidence in repaired, refurbished, or reused PV equipment

Of note, there is a low probability of solar sites being abandoned; NREL is aware of only one abandoned solar project in the US.

Policy considerations
Dr. Heath noted that solar decommissioning policies in the U.S. take the form of federal, state, or local legal mandates/requirements or voluntary guidance. These policies most often apply at the time of initial project development, and typically apply to utility scale industrial solar developers, not to individuals installing solar panels on residential rooftops.

Decommissioning a PV system typically requires removing the array, removing wiring and inverters, and restoring the land or infrastructure to its original use or a new use. Decommissioning plans usually have no specified disposition of the materials, such as requiring recycling at end of life, although they could. The perceived risk from these decommissioning policies can result in deployment delays, prescriptive decommissioning requirements, higher cost performance guarantees, project cancellation, and in some cases, jurisdictions banning solar until policies have settled. Penalties can also be significant for violating decommissioning requirements.

Cost estimates are sometimes required and used as a basis for calculating financial assurance. There is no national or state standard for what is included in a cost estimate or how it is calculated; developers and project owners are eager for guidance. NREL found 18 examples of publicly available cost estimates, ranging from $-23.35 to $73.33/kWh.

The choice of financial assurance instrument (surety bonds, letters of credit, parent guarantees, or escrow accounts) can affect important factors such as whether costs are capital costs or operating costs, amounts owed, and the time period in which it is owed. Policies that do not allow for salvage value impact the financial assurance amount and may impact end of life equipment decisions.

There is no centralized decommissioning policy but there are potentially a lot of solar sites to be decommissioned around 2030. Of note, universal waste frameworks don’t increase the likelihood of recycling PV modules; they assume the product is hazardous waste, which doesn’t incentivize recycling.

Dr. Heath also noted that language matters; modules at the end of their life should be referred to as "retired" rather than "waste" because they can still hold value.

Presenter Q&A

Task Force participants raised the following questions:

- Does Europe have guidance we can look to regarding recycling and reuse of PV modules?
  - Dr. Heath noted that Europe is further along in recycling but does not necessarily have a policy instrument for decommissioning.
- With the likely increase in domestic manufacturing of PV modules due to the Inflation Reduction Act, do you expect increasing value in the raw materials pulled from recycled modules?
  - Dr. Heath would predict an increase in the value of raw material. He noted there are currently no U.S. manufacturers of solar glass, which requires a specific input material and process, but he expects demand for that manufacturing to come to the U.S.
  - Dr. Heath added that First Solar manufactures a thin film technology called cadmium telluride. They are recovering and remanufacturing their own material, which maintains the security of their own supply. Hopefully other manufacturers will follow suit.
  - Dr. Heath noted that while the Task Force's focus is on renewables, we will need energy from somewhere. The Task Force should also consider the impacts of other potential energy generation options that would be used if we were not using the solar, wind, and batteries specific to the Task Force's charge.
- Any reflections on near term opportunities to mitigate the concerns of site abandonment or prohibitive requirements on project development?
  - Dr. Heath noted that Virginia has a net zero GHG emissions goal, and national pathways to achieve that revolve around decarbonizing the electric sector. To achieve its goal Virginia will need to find ways to deploy solar, wind, and batteries, which largely drive decarbonization.
  - Judy noted that much of the facility development costs of renewable energy are expended upfront. Natural gas also has a lot of upfront expenses, while coal expenses are the highest expense during extraction. In comparison to the cost of continuing to mine coal, the economic benefit of abandoning a solar facility would be small because its operations phase does not cost much, and it continues to provide returns as long as it is functional and plugged into the grid.
- Is there a way to assess the likelihood of repowering solar vs. returning to original land use?
  - Dr. Heath was not aware of any study, but noted the logic points to repowering as the most likely since our need for power is not predicted to decrease.

IV. TASK FORCE DISCUSSION OF SOLAR ENERGY LCAs

Task Force participants and facilitators summarized some of their individual key takeaways and reflections from the presentations on the four charge questions related to end-of-life and land impacts. Takeaways are considered preliminary work products until assessed for group consensus and finalized in the final report.

Takeaways and reflections re: *Feasibility, costs, recycling and salvage opportunities, waste strategies, and liability for the decommissioning of materials used in renewable energy facilities*

- Beyond the panels themselves, other parts of the solar facilities will need to be recycled or disposed of on an earlier timeframe than the panels themselves (e.g., 10 years for inverters v. 30 years for modules).

- The use of adhesives and painted metals for solar panels makes recycling somewhat complicated. It may be necessary to make recommendations that differentiate between the two waste streams of PVs—those that are hard to recycle (the modules), and those that are easier to recycle (the mountings and inverters).
- It is important to consider the full circular economy, and not limit the Task Force's findings to recycling. Recycling currently fits better into the existing linear nature of supply chains, but circular economy policies, reuse, and remanufacture may help retain a greater proportion of the value of the original materials in addition to having greater environmental benefits than recycling or disposal.
- Some panels that have reached the end of their life are currently being stored until a desirable solution is more readily available or affordable for owners. While that is not a long-term solution, it points to a short-term solution that could work as the end-of-life market for solar develops and scales up. That said, while developers or states might be comfortable with uncertainty around the fate of PV modules at end of life, at the local government level, that uncertainty is often the reason projects get denied. Developing a roadmap to decommissioning or requiring recycling can give critical assurance to the public and localities. Concerns about loss of landfill space are real.
- End-of-life research has received relatively little attention and thus there is still a relatively small amount of data on this topic.
- While decommissioning plans are built into community and utility-scale solar plans, special attention should be paid to supporting residential and commercial rooftop solar users in recycling, reusing, or otherwise properly disposing of their solar materials.
- After the useful life of a panel, they can continue to operate at reduced efficiency. Panels lose 0.5% efficiency per year.
- A lot of panels are not used until the end of their useful life because it's more economical to replace them with more efficient panels. Some large solar farms have worked with groups like Habitat for Humanity to repurpose older panels for residential use, though that raises some questions about liability.

Possible focus for recommendations:

- Mandate, prohibit, or incentivize certain actions (e.g., requirements or guidelines for developers, incentives for development of in-state waste or recycling facilities, development of the circular economy industry).
- Develop a roadmap to decommissioning to give more assurance to localities and the public.
- Develop more robust tools/analysis for determining whether/when to replace, reinstitute, dispose, or recycle panels and whether/when to repower or decommission a site.

Takeaways and reflections re: *Potential impacts of underground infrastructure post-decommissioning*

- There seem to be a lot of unknowns around the impact of underground infrastructure post-decommissioning. While it may be valuable to learn from other states (for instance, Cornell's studies), soils in Virginia are different than other states.
- Any assurance that highly productive agricultural lands can readily be returned to even approach existing pre-project functionality may be overly confident. But, whether this is true is associated with the extent to which there is grading on solar sites.

Takeaways and reflections re: *Potential impacts of the life cycle on farming, forestry, and sensitive wetlands*

- There is a lot of flexibility in how solar is sited, and the details impact the possibility for co-benefits, mitigated harm, and overall life cycle impacts on different types of land.
    - For ag lands, panels can be sited high enough to allow tractors, husbandry, etc. underneath. The value and impacts of agrivoltaics are state and soil specific, but various bodies are researching these impacts (e.g., NREL's PV SMaRT research, DOE's work with the cooperative extension).
    - Solar sites can change soil texture and structure, wildlife habitat value, and carbon sequestration capacity.
    - The degree to which land can be restored to its pre-project functionality (or close to pre-project functionality) depends on many factors including whether grading was involved.
    - Distributed solar lessens land use impacts.
    - NREL is supporting research on soil health and stormwater with large scale solar. It is not specific to Virginia, but highlights that solar impacts will vary depending upon how projects are constructed, what kind of soil and materials you start with, and what type of vegetation there is.
- While benefits can be amplified and negative impacts mitigated by where solar projects are sited, factors like PJM's interconnection process slowing down studies, the tendency of larger land parcels in Virginia to be forested or agricultural, land price, and the actual proliferation of solar facilities will limit the choice developers have in siting.
- Rooftop solar is attractive for mitigating land use impacts, but siting rooftop solar is more complex than it seems.
    - DC, Maryland, and Virginia have a solar carveout for their REC programs, so the cost specific to solar is higher than it is in the Virginia market and thus many Virginia entities sell into those markets instead of in Virginia.
    - When it comes to utility scale solar, there may be roadblocks with utilities leasing roof space. Putting solar on industrial rooftops is a lot harder than it sounds.
    - AC units can also impact what can go on a roof.
    - Virginia has a pilot program working to install on corporate building rooftops.

Possible focus for recommendations:

- Conduct a robust land use impact study to support decision-making about renewable siting. This could lead to a tool that incorporates spatial data layers (prime soils, impervious surface, acid forming soils, habitat cores, carbon sequestration potential, recreation and scenic resources, etc.) and a predictive model that also accounts for data on transmission congestion/capacity and develops scenarios for different amounts of solar. It could also weigh land use impacts against economic impacts.
- Implement polices that make rooftop solar more feasible.

Takeaways and reflections re: *Potential impacts of life cycle and decommissioning costs on brownfields or previously developed project sites as compared to life cycle and decommissioning cost on agricultural or forest lands*

- Brownfield site development can be a good solution if there is existing interconnection and transmission infrastructure.

- There are many brownfields that could be suitable for solar development. Since compaction has already happened, anything you do to that site afterwards will be an improvement (versus siting on greenlands).
- Sites that have more recently been reclaimed seem to have more viability because there is more information available about the site.
- Installing solar on landfills usually requires a ballasted system with a concrete block, which can have more environmental implications than the typical steel mounting for fixed tilt and tracking systems.

Areas of uncertainty and outstanding questions

Task Force participants identified their outstanding questions surrounding solar life cycles:

- Where do damaged panels requiring replacement currently go?
- What companies actually recycle these components, where are they located, and what is the impact of transporting recyclables to them?
- How can homeowners/businesses be supported in disposing or recycling solar panels?
- Does the advanced plastics/recycling state incentive cover solar? How do existing requirements for recycling/waste for commercial business in VA relate to this?
- Does repurposing older solar panels at large facilities for residential use shift liability from the corporation to the individual?
- How might funds from the Inflation Reduction Act or technical assistance (e.g. from NREL; from EPA's RE-Powering America's Land Initiative) support solar development on mine lands?
- Cost estimates for decommissioning vary widely. What can we learn from depreciation studies and regulatory revenue requirement cases about how utilities are accounting for these costs?
- What would it take to get a solar waste or recycling facility up and running in the state?
- How could existing solar production numbers translate to reuse in a circular economy?

Task Force participants identified specific considerations around economic benefits and ratepayer impacts they would like to understand further:

- Economic benefits or impacts of solar in general, including to the farming and forestry industries and host communities
- Ratepayer impacts including as related to agrivoltaics or developing on degraded land
- How policy frameworks dictate if financial assurance is a capital or operating cost

Task Force participants suggested potential resources on the topic of solar life cycles:

- SWANA's Virginia chapter and/or the Virginia Manufacturers' Association may be able to speak more about the current state of waste and recycling in the state and what it might take to get facilities in the state.
- SEIA has a program for helping developers connect to recycling.
- Other relevant state Task Forces (e.g. HB206 in Virginia) and North Carolina's decommissioning task force.
- TNC and Sun Tribe are researching the economic impacts and benefits of developing solar on minelands.
- Virginia's DOE has developed the SolTax model to help developers and local governments understand long term revenue sharing.
- Virginia Tech researchers could go deeper on post-decommissioning impacts.

V. CLOSING

Mallory invited Task Force participants to reach out to her with any additional speaker or topic suggestions for future meetings. The second meeting of the Task Force will take place on Wednesday, November 16 and will open with a review of this meeting’s discussion.

Participants were reminded that the VA SCC is the only entity that can speak on behalf of the Task Force, and no attributed information about this meeting should be shared without express permission.

APPENDIX A

Virginia Renewable Energy Facilities Task Force

October 28, 2022 Meeting Participant List

Participants representing the following Renewable Energy Facilities Task Force member organizations were present at the October 28, 2022 virtual meeting:

- American Clean Power Association
- American Farmland Trust
- Appalachian Voices
- Appalachian Power
- Chesapeake Climate Action Network
- Dominion Energy
- EDF Renewables
- Invenergy
- Old Dominion Electric Cooperative
- Rappahannock Electric Cooperative
- Reed Smith (observer)
- Southern Environmental Law Center
- Strata Clean Energy
- Urban Grid
- VA Agribusiness Council
- VA Association of County Officials
- VA Dept. of Energy
- VA Dept. of Environmental Quality
- VA Dept. of Forestry
- VA Farm Bureau
- VA Forest Products Association
- VA Office of the Attorney General
- VA Solar Energy Development and Storage Authority

In addition to Task Force members, staff from the convening agency (VA SCC), staff from the third-party facilitation entity (Keystone Policy Center), and guest speakers were also present at the meeting.

APPENDIX B
Virginia Renewable Energy Facilities Task Force
Charge Questions

The Task Force is charged with considering the following charge questions:

- Feasibility, costs, recycling and salvage opportunities, waste strategies, and liability for the decommissioning of materials used in renewable energy facilities;
- Potential impacts of underground infrastructure post-decommissioning;
- Potential impacts of the life cycle on farming, forestry, and sensitive wetlands;
- Potential impacts of life cycle and decommissioning costs on brownfields or previously developed project sites as compared to life cycle and decommissioning cost on agricultural or forest lands;
- Potential ratepayer impacts; and
- Potential beneficial economic impacts of solar, wind, and battery storage development.

Virginia Renewable Energy Facilities Task Force
November 16, 2022 Meeting Summary

Meeting Purpose: This was the second of five virtual meetings of the Virginia Renewable Energy Facilities Task Force created by HB 774 / SB 499, which directed the State Corporation Commission (SCC) in consultation with the Department of Energy (VADOE) and the Department of Environmental Quality (VADEQ) to create a task force to analyze the life cycle of renewable energy facilities in the Commonwealth. *See Appendix A for a list of the Task Force charge questions.*

Meeting Participants: The meeting was attended by approximately 55 participants, including representatives from 25 Task Force member organizations, guest speakers, and staff of the SCC (convening agency) and Keystone Policy Center (facilitators). *See Appendix B for the full list of organizations represented at this meeting.*

Discussion Summary

I. REVIEW OF MEETING ONE AND SOLAR TAKEAWAYS

Mallory Huggins, Lead Facilitator, Keystone Policy Center, welcomed everyone to the meeting and reviewed discussion protocols.

Mallory reviewed preliminary participant takeaways and reflections from the first meeting, which focused on an overview of renewable energy life cycle assessments, and an in-depth look at the life cycle of solar energy. She noted the potential recommendations presented should not be considered as fixed recommendations from the Task Force, but will be refined and presented for discussion at future meetings. *See VA RETF Meeting 1 Summary (p. 11-14) for these Meeting 1 takeaways, reflections, and potential recommendations.*

II. END-OF-LIFE OPTIONS FOR SOLAR IN THE REGION

Presenter: Will Giese, Task Force member and Southeast Regional Director, Solar Energy Industries Association (SEIA)

Will provided an overview of waste disposal, recycling, and the circular economy in Virginia and across the nation.

PV panel waste

Will shared the global volume forecast of cumulative PV panel waste (per millions mt), from 2016 to 2050, when many facilities will have reached end-of-life. He noted the linear increase in this global forecast was relevant to Virginia, as 75% of the state's solar was installed within the past couple years. He noted the issue of PV panel waste is a problem, but it is one that will not happen for decades.

He noted that because most PV systems in the US are in the early stages of their life cycle, the majority of materials currently recycled are from manufacturer scrap or warranty-related returns. Over 80% of a module's weight is comprised of glass and aluminum, which are both fairly easy to recycle. Other materials in the module can also be recycled: the silver, sealants, compound semiconductors, copper, silicon, aluminum, polymers, and other various metals. When looking at the relative material value of a module, 47% comes from silver, 26% from aluminum, 11% from silicon, 8% from copper, and 8% from glass.

SEIA is helping members develop recycling processes and start up recycling facilities which could be used by any party to recycle PV modules. Within the SEIA network, there are 20 recyclers across the US that already process PV materials, and the Association is aware of another 10 recyclers that may come online in the next year. SEIA is seeking to expand their network of recyclers; incorporate batteries—which have a shorter usable life than PV modules—into their program; continue advocacy work with states; encourage and support a growing body of research data; and support a circular economy by developing a reuse market and refurbishment protocols.

Decommissioning policies
Will shared examples of state decommissioning policies, which run the gamut from Texas' straightforward statute focused on clarifying rules around decommissioning and strengthening consumer protection to Louisiana's statute, which includes more rigorous end-of-life requirements such as potentially unlimited fees for developers and immediate financial assurance (though with an exemption for utility-scale solar).

SEIA has worked with industry and stakeholder committees to develop model decommissioning policy language. Will noted that, while any policy should be tailored to its specific location, the common elements of the process and the final model language are:

- Convene a group of stakeholders who can participate actively
- Assess the previous and expected growth of solar and storage in the state
- Assess the application of Resource Conservation and Recovery Act and scope
- Identify existing and future resources and infrastructure for the recycling process
- Review other state's findings and circular economy approaches
- Review updated research, including conducting a cost-benefit analysis
- Explore financing mechanisms and volume estimations
- Provide detailed recommendations to the legislature
- Recommend at least one year for study

Will noted that decommissioning happens for fossil fuel plants as well, but decommissioning solar is a very different scenario and should be treated accordingly. For example, many solar systems are installed under power purchase agreements with a must-run requirement, making abandonment unlikely.

Opportunities for Virginia
The Inflation Reduction Act (IRA) creates many opportunities for the clean energy economy, and the DOE has put out a request for information on how the Defense Production Act can be leveraged to accelerate production of key technologies, strengthen US power grid reliability, and deploy clean energy.

The US has roughly 1,200 GW of electric capacity, more than half of which is likely to reach end-of-life in the next ten years. In addition, of the 600 GW installed since 2002, 300 GW comes from fossil fuels that are likely to be increasingly phased out before 2040 to meet climate goals.

Virginia has roughly 29 GW of electric capacity. Of the 18 GW in fossil fuel capacity, 8 GW is nearing the end of its usable life. Since 2016, 4 GW of fossil fuel capacity has come online, and all of Virginia's 2.6 GW of solar capacity has come online.

Establishing recycling facilities
Will noted that the time involved in getting a recycling facility up and running is highly dependent on the permitting process and timeline, but once a permit is in hand, the average time to full production is 30-90 days. In Virginia, the total time including permitting is generally less than a year.

For most recyclers, there is not currently enough PV waste to justify facility creation. In the Southeast US, there is presently a lot of installation of solar but not much near-term decommissioning. Warranty replacements are happening, but generally the manufacturer handles those modules, and damaged panels can be landfilled in some conditions.

Will noted it is difficult to expect solar recyclers to start facilities now and potentially operate at a loss until the volume materializes in 20 years, but policies and a pipeline could be developed to support the establishment of facilities and processes when they are truly needed. He added that recycling isn't the only option; a module can still have use after the end of its warranty, for resale or refurbishment.

Presenter Q&A
Task Force members raised the following questions and comments:

- Is there a role for municipal recycling operations to collect inverters, batteries, and modules from residential solar customers for aggregation and delivery to the nearest existing recycling facility in the region?
    - Will noted that inverters are typically handled as e-waste. For leased residential rooftop solar, installers often handle the removal of the modules. For individually owned residential rooftop, it is a tougher issue; he would not encourage residents to go onto their roofs, but reach out to their installer.
- Many citizens in rural Virginia have not reached a level of comfort with solar energy development, and local governments need to have hard and fast data and solutions to answer the questions frequently raised in public hearings around end of life.
- Is there enough production capacity in the US for PV modules? Citizens have expressed concern over where panels are produced currently and to ease those concerns, localities may start requiring US-made panels for solar projects.
    - Will noted that PV materials do come from other countries, although much of the module assembly happens in the US. SEIA has worked on traceability protocols to ensure human rights concerns are not an issue in the solar panel supply chain: https://www.seia.org/research-resources/solar-supply-chain-traceability-protocol
    - Will added that the IRA has created immense opportunity for manufacturers to set up operations in the US and he would predict PV module manufacturing facilities opening in Virginia within the next several years.
- Could a Solar Guide for Residents be created, to help educate the public about where panels come from and how they can be recycled, reused, or disposed of? This could support municipal supervisors and help localities own the issues and solutions.
    - Will agreed this could be useful and will discuss internally at SEIA.
- What is the reason for Ohio having a high number of recycling facilities compared to their total installed capacity? Is that due to Sun Power proximity, state policy, reuse opportunities, or something else?
    - Will hypothesized that Ohio's heavy manufacturing industry may be more adept at handling the recycling of a variety of products and expanding to include additional materials.

- Solar panels do not all have to be treated as hazardous solid waste. Most commercial solar panels being produced today can be disposed of in an ordinary landfill. Some of the older models may contain hazardous materials that would qualify them as hazardous waste; this is determined with a Toxicity Characteristic Leaching Procedure (TCLP) test.
  - Will agreed that the majority of silicate panels pass the TCLP test. Thin film panels may not, but most utility-scale systems are not using these.
  - It was noted the Sussex regional landfill has stated they're not accepting solar panels, and it could be useful to survey Virginia landfills and waste management around their policies for PV materials, and awareness of the TCLP test.

III. ADDITIONAL SOLAR AND WIND INSIGHTS

Presenter: Tyler Fitch, Senior Associate, Synapse Energy Economics
Tyler provided an overview of the economics of renewable energy in the Southeast US.

What do we mean by "economic impact"?
Tyler noted the importance of opening an economic impact analysis with the questions: what impacts are we considering, and what are the alternatives to what we are considering? Resource decisions do not happen in a vacuum, and it is necessary to define your baseline and alternative scenarios. For instance, you could compare scenarios of repowering a coal plant vs. retiring it and installing solar, or compare different types of energy resources.

There are three categories of economic impacts: economy-wide impacts *(GDP, jobs, etc.),* grid economics *(cost to serve compared to the alternatives*), and externalities *(health impacts, etc.).* Scope of geography and timeline are important considerations; job impacts in particular can be widely different in the first decade vs. subsequent decades.

Economy-wide impacts
Economy-wide impacts include direct, indirect, and induced effects. Direct effects are the immediate impacts of a change in spending *(e.g. purchasing and labor costs of equipment installation, taxes, and land payments)*, while indirect effects are the marginal impacts to a supply chain. Induced effects are changes in spending in the wider economy because of the direct and indirect impacts *(e.g. spending of wages from the new labor)*. Economic effects that happen outside of the geographic focus are subject to "leakage" and may not be counted in the overall economic impact *(e.g. overseas manufacturing*).

As a rule of thumb, construction labor impacts will be local, and capital purchase impacts depend on the domestic manufacturing content. Operations and maintenance (O&M) impacts are typically local. The commodity cost of the fuel is typically leaked, but the labor associated with maintaining transmission distribution is local.

In a scenario of the economic impact of 8GW of offshore wind in the mid-Atlantic through the mid-2030s, USDOE found that the 8GW would support 27,000 jobs. Tyler noted the direct impact of building the turbines was the smallest impact by far, illustrating the importance of considering indirect and induced effects.

Grid and ratepayer impacts
Tyler noted the key question for considering grid impact is "Compared to the baseline, does this change reduce the total system costs for the power sector?" Typically, solar generation is more efficient and can

reduce costs when compared to coal, which often translates to ratepayer impacts, but ratepayer impacts are complicated. This complexity includes the specifics of the rate design; the pass-through fuel costs that ratepayers are exposed to; the induced effect of ratepayer savings often being re-spent elsewhere in the economy, and the equity considerations of asymmetrical ratepayer impacts.

In one analysis, NextEra compared potential costs per MWh and found that wind and solar costs, even with a storage adder, were lower than the costs of existing natural gas, nuclear, and coal. A higher-complexity analysis, taking into account the complexities of a complete power sector, compared a coal-dependent power scenario with a ramped-up renewables scenario. The ramped-up renewables scenario had a marginally lower utility revenue requirement.

Externalities

Externalities can mean many things, including local air pollutants, aesthetics, water quality, and land impacts. Air pollutants are often a focus because they link closely to labor and productivity impacts. Tyler noted that carbon dioxide is integrated into Virginia's Clean Energy Act implicitly, but particulate matter may not be. In an case study on local pollution, EPA's AVoided Emissions and geneRation Tool (AVERT) showed a savings of 3-7cents for every kWh of generation avoided by utilizing solar, wind, or energy efficient systems.

Economic benefits by resource

Tyler noted that economic impact assessments are very context specific and, while he pulled from many assessments to make high-level conclusions, making any specific conclusions would require a new economic impact analysis for Virginia's purposes. He also noted that domestic sourcing and prevailing wage elements of the IRA could impact future assessments.

A resource's overall economic impact is comprised of 1) the jobs/GDP impacts of changes to capital investment, 2) the jobs/GDP impacts of changes to fuel and operations and maintenance, 3) the jobs/GDP impacts to grid economics and "re-spending", and 4) the jobs/GDP impact of externalities.

Solar

- On a per-dollar basis, construction of solar supports 1.5x more jobs than conventional generation.
- Solar requires less labor than conventional turbine generation and salaries vary.
- Solar requires zero fuel, keeps spending in-state, and avoids the commodity spending that typically comes with risk to ratepayers.
- Generally, solar is the least costly energy in most regions and creates cost savings.
- Transmission and interconnection costs are difficult to predict, which has a double-edged impact on economic impacts. The cost of services are likely higher if transmission costs are high, but transmission and distribution construction or labor to implement the connection of solar is likely to have a positive economic impact.
- The economic impact variances between utility-scale and rooftop solar include:
    - Rooftop solar generally results in more construction labor than utility-scale solar.
    - The levelized cost of utility-scale solar is 4-8x cheaper than rooftop solar, though rooftop solar provides some additional value to the distribution system.
    - Both rooftop and utility-scale solar avoid local air pollutants, though rooftop has more efficient use of space and land than utility-scale.

Offshore wind

- On a per-dollar basis, offshore wind supports 1.2x more jobs than conventional generation. Virginia could be a leader in offshore wind construction, so there is high potential for supply chain economic impacts.
- Generally, offshore wind technicians have more to do so we expect to see more and higher-quality jobs compared to solar.
- Like solar, offshore wind requires zero fuel, keeps spending in-state, and reduces risks to ratepayers.
- Offshore wind has a higher average cost of energy because investment costs are high, but it is complementary with other clean energy technologies.

Battery storage

- Wide deployment of battery storage has only begun recently, so there are not many real-world examples of economic impacts.
- On a per-dollar basis, it will likely support 1.5x more jobs than conventional generation.
- Like solar and wind, it requires zero fuel and reduces risks to ratepayers.
- The more solar and wind on the grid, the more cost-effective battery storage is.

Energy efficiency

- Energy efficiency typically has the highest job impact for dollars invested; it requires much more labor and capital expenditure to retrofit buildings.
- Fuel costs are avoided.
- Energy efficiency is typically the least-cost resource.
- We should be integrating equity into who gets access to energy efficiency investments; there is uneven level of ratepayer impact.

Energy transition as a whole

Tyler noted that evaluating individual resources can miss the bigger picture; clean energy technologies are complementary and self-reinforcing. Solar and wind generation curves provide steadier energy supply than either resource alone, and increases in variable, zero-fuel-cost energy support the use of energy storage. All of these factors stimulate a need for transmission and distribution investments. There are robust findings that decarbonizing the economy will be a job creator across most geographies, including Virginia. In decarbonization scenarios, grid and renewable energy construction will drive employment through the mid-century.

Key conclusions

Tyler provided his key conclusions on the potential beneficial economic impacts for each technology the Task Force is charged with:

- **Solar:** Quick deployment and high job impacts will lead to substantial jobs in construction. Compared to conventional generation, solar shifts spending from fuel to capital expenditure and labor. The low cost of energy and reduction of fuel use leads to less costs and less risk for consumers. Rooftop solar is less cost-effective than utility-scale solar per kWh but has a greater economic impact and some distribution-level savings.
- **Wind:** Wind energy provides high-quality ongoing jobs, and there is potential for significant offshore wind supply chain economy in Virginia. Compared to conventional generation, wind shifts spending from fuel to capital expenditure and labor. Wind generation is complementary to solar production and reduces fuel use.

- **Battery Storage:** Battery storage enables solar and wind technologies, and has significant construction job impact through decarbonization scenarios.
- **Overall:** Together, clean energy technologies have the potential to reduce bills and drive new jobs.

Presenter: Dr. Lee Daniels, T.B. Hutchenson Jr. Professor, School of Plant and Environmental Science, College of Agriculture and Life Sciences, Virginia Tech
Dr. Daniels provided an overview of the impacts of underground infrastructure post-decommissioning. He noted that infrastructure removal generally involves similar challenges to those of site development.

Soil disturbance
Dr. Daniels noted that soil disturbance is very site-specific and can vary widely from less than 10%, on a steeply sloping site, to a majority of the site. He has worked with a site that had 60% soil disturbance to the areas associated with solar panel arrays. Major disturbances include roads, trenches, regrading, and the installation of stormwater basins or local pads. Virginia has acidic subsoil materials that often get exposed through cutting, grading, or retrenching and need to be remediated through lime and phosphorus applications. Acid forming materials must be avoided at all costs, and this is a particular concern in Spotsylvania and Stafford Counties.

Dr. Daniels noted that we do have the ability to successfully stabilize and revegetate disturbed areas, and we have experience in this through the mining, transportation, and construction industries. However, many sites will be extensively disturbed with large exposures of eroded or exhumed subsoil materials. Historically, much of the Middle Coastal Plain and Piedmont regions have already been disturbed through erosion of topsoil; the farming and logging industries have been dealing with this for some time, so we know how to manage it when exposed to surface.

Dr. Daniels noted that the HB206 task force has developed a good working definition of "significant disturbance" that needs to be mitigated or remediated. Most of the subsoil exposed in Virginia will be commonly acidic and very low in plant-available phosphorus; however this can be easily dealt with by applying fertilizer or lime. Cuts and fills on a site are fundamentally different in management and remediation needs, and there is almost no research to date. He noted we are still learning to what extent we can put in uniform management for a site vs. treating specific spaces.

Compaction
Regardless of the reason for disturbance, compaction is the dominant long-term issue. Compaction problems include widely fluctuating conditions between seasons; poor infiltration and water holding increasing local runoff; and direct impedance of rooting. Even tap rooted species, such as loblolly pine, may grow sideways roots when encountering compacted soil. Remedial action should include saving, storing, and reapplying topsoil; using lime, phosphorus, and organic matter amendments on exposed subsoils and returned topsoil layers; and applying tillage to reconstructed areas. These actions should occur during site development and be anticipated to recur when old infrastructure is removed.

On mining sites, we rip extensively but the ripper is a major piece of equipment that you could not put between solar panels. There are smaller versions of a chisel plow you could use between panel arrays.

One major risk in certain geologic provinces of Virginia, particularly the Upper and Middle Coastal Plains, are naturally occurring sediments at depth which contain sulfur. When that is exposed to the surface, it gets oxidized and turns into sulfuric acid. This is an extreme impact occurring at residential home sites in

Frederick and Spotsylvania Counties, and it is very expensive to mitigate. On solar sites, the riskiest area for this effect would be in the lower portions of sites lower in elevation. Specific guidance on recognizing, avoiding, and remediating acid sulfate soils is available via the Virginia Acid Sulfate Soil Risk Map.

Soil challenges during the operational phase
Dr. Daniels noted that compaction is inevitable during construction and may be difficult to remediate once the site is operational. Fixed solar panels concentrate runoff onto a "drip line" that can lead to local rilling and enhanced runoff. Establishing and maintaining uniform vegetation under or between low fixed panel arrays can be challenging, although this can be addressed with a broad scale seed mixture. Notably, the actual effects of large-scale panel arrays on stormwater runoff are not well studied beyond models and predictions; Virginia Tech is seeking cooperators to install field monitoring arrays to further this research.

In working with the Old Hickory active mining site, which has over 2,000 acres of land disturbance, 700 acres to date have been fully reclaimed and restored to vegetation. The underlying soil is highly productive, prime farmland. Of note, the lowest corn yields were associated with topsoil treatments so the preferred management practice of saving and respreading topsoil may not always be the best. Adding lime, organic matter, and phosphorus to the subsoil and tilling yielded 75-80% of prime yield a year later.

Long term site closure challenges
Dr. Daniels noted that infrastructure removal will likely re-expose subsoils and returning prime farmland takes heavy tillage. Dr. Daniels noted that successfully reclaiming prime farmland generally means reaching 75-80% of prime yield; the highest yield he has seen is 90%. Heavily disturbed areas, especially roads or those with extensive subsoil compaction, will more than likely have hayland, pasture, or forestry as their highest and best use.

Presenter Q&A
After both presentations, Task Force participants raised the following questions:

- How are land use externalities worked into solar economic impact analyses? For instance, we would need to incorporate the direct and indirect costs of agricultural displacement if large scale solar development occurs on productive farmland and does not allow for continued agricultural production.
    - Tyler noted he is not an agrivoltaics expert, but it is possible to do this with an economic impact analysis. He agreed this is an example of why it is important to be specific in designing your economic impact analysis and ensuring you are identifying and addressing the likely alternative outcome(s).
    - Dr. Daniels noted the importance of transparency when working with landowners, local governments, localities, and NGOs. To some extent, parts of a site will be disturbed and should temporarily be treated as a construction site. Cost projections should include any remedial measures to return to production in 25-30 years, but projecting agricultural markets for that timeframe is a challenge.
    - Dr. Daniels also noted a lot of concerns expressed during the HB206 Task Force were not over the actual productivity potential of the land, but the externalities of other support industries in the region that would be selling supplies and services to those farmlands.
        - A Task Force member echoed this concern, noting it is not just the support industries but the entire supply chain that agriculture and forestry supports.

        - Another Task Force member noted the impact to a farmer's bottom line if they are having to travel further for agricultural supplies and services.
    - One Task Force member noted that many farmers are making difficult financial decisions and in some cases the options are selling their land or leasing it for solar or wind development.
        - Another Task Force member noted that in Virginia, some lands that were not under development pressure from residential or retail before are now experiencing development pressure from solar.
        - Tyler noted that economic impact analysis can be a helpful tool, there are also policy questions to ask at a state or local basis around what we want our communities to look like.
- What is the definition of a "rolling site"?
    - Dr. Daniels noted a rolling site is anything with a slope in excess of 5%.
- What is the geographic diversity of where solar is being developed in Virginia, and how does that compare to other states?
    - Dr. Daniels noted Virginia is fairly unique in its strongly contrasting landforms; North Carolina has the most similarities. Some of Virginia's largest solar installations are in the Piedmont region which has no flat land. He noted that good research is being done in Minnesota and Wisconsin, but their soils and landscapes are completely different than Virginia and regionally specific work is needed for revegetation protocols, species mixes, and stormwater predictions.
- Are low tire pressure vehicles beneficial in terms of soil compaction?
    - Dr. Daniels noted that utilizing low pressure tires is a positive step, although evaluating soil moisture content at the time of trafficking is just as important. He noted that wider tires tend to have a fairly shallow effect so any necessary remediation is easier; best practices would be to combine lower vehicle weights, wider tires, and appropriate soil moisture content.
- What are the long-term effects, maintenance requirements, soil impacts, etc. of utilizing pollinator habitat as groundcover?
    - Dr. Daniels noted he has done work on that question for VDOT and the mining industry. The short-term challenge is getting at least 70% groundcover to achieve stormwater control, and the long-term challenge is integrating a species mix that can be established through succession, mowing management, or redrilling; many pollinator habitat species are not easy to establish. He noted that if utilizing only grasses, the site will have to be fertilized with nitrogen every 2-3 years. He added that establishing pollinator habitat itself is one thing, but integrating native species adds significant complexity.

<u>IV. WIND POWER LIFE CYCLE</u>

Presenter: Dr. Aubryn Cooperman, Wind Engineering Analyst, National Renewable Energy Laboratory (NREL)

Dr. Cooperman provided an overview of the wind life cycle relative to other technologies, and the waste, recycling, and salvage opportunities.

Life cycle of wind

Dr. Cooperman noted the life cycle GHG emissions from wind are fairly low, around 10gCo2eq/kWh, and remain relatively constant across a wide range of turbine sizes. In contrast with coal power generation, which has a lot of emissions during the operations phase, most of the GHG emissions in wind come during the initial upstream phase. This provides opportunities to realize gains by recycling materials back into the beginning of the process. Material requirements, mainly in manufacturing, are the largest relative impact category for wind power generation.

Decommissioning wind

Dr. Cooperman noted that wind decommissioning requirements may be set by a state, county, or municipality. They typically specify the depth to which foundations will be removed. For instance, the state of Oklahoma requires a minimum removal depth of 2.5 feet; Washington and Botetourt Counties in Virginia require a removal depth of 4 feet. Foundation removal strategies include partial removal (removal of the pedestal), full foundation removal, and recycling.

Concrete makes up 70% of the material of a land-based wind plant. While recycled concrete aggregate is worth $5-22/ton, transportation can be a barrier. Many wind plants are located in remote areas, and concrete is heavy and expensive to haul over long distances.

Wind turbines themselves are made up primarily of steel and iron. There is a robust recycling industry for steel and iron, and the salvage value of those materials is pretty high. Wind turbines have a small number of polymers and plastic components which are likely to be incinerated. There may be some potential for recycling these, but they are relatively small components of the turbine. The largest materials currently going into landfills are the glass and carbon composites, making up 6.4% of the turbine.

Dr. Cooperman shared the waste management hierarchy, with disposal at the bottom (least desirable) and prevention at the top (most desirable). She noted the goal was to employ more methods at the top of the hierarchy.

Disposal

Dr. Cooperman noted that turbine blades are non-hazardous but the breakdown of the organic components releases methane. The blades are very large and hard to break down; some locations have prohibited landfill disposal of blades.

A study comparing landfill capacity with the likely amount of blade material from wind turbines indicated the total volume of US cumulative blade retirements expected by 2050 represents 1% of landfill capacity. However, there are regional differences in both landfill capacity and expected blade volume, so it could be a significant concern in some locations.

Recycling and recovery

Dr. Cooperman noted three recycling methods for turbine blades are in use today or close to commercialization:

1. **Mechanical recycling**, or shredding and grinding blades for use in new material such as sound insulation, fiberboard panels, or 3D printing components. Mechanical recycling requires taking precautions to contain any dust released during the process.
2. **Pyrolysis,** a low-oxygen combustion process which produces hydrocarbons and fibers.
3. **Cement co-processing**, in which shredded blade material replaces coal in a cement kiln.

Mechanical recycling, cement co-processing, and pyrolysis with energy recovery have the lowest energy requirements per kg of composite material. Recovered fibers have a higher value than the cost of the recycling process. Of note, the value of recycled carbon fiber is higher than recycled glass fiber so different recycling methods may be preferred.

Reuse and Repurpose
Dr. Cooperman noted there are markets for secondhand blades, and there is potential to reuse complete turbines in distributed applications or developing countries; however, the cost and environmental impacts of transportation should be considered. Playgrounds, structural elements of bridges, roofing materials, and powerline support poles are all potential reuse markets; the challenge is identifying the appropriate needs in a locality since blades are difficult to transport.

Prevention
Dr. Cooperman noted that extending the lifetime of blades has both economic and environmental benefits, providing both more energy output and income. Lifetime extension applies not just to the blades, but to the entire turbine wind farm. Extension may involve slightly higher maintenance requirements in the later years.

Opportunities and challenges of decommissioning wind
Dr. Cooperman noted that a lot of materials currently used in turbines are recyclable, especially the large metal components. The composite materials currently used in blades poses a challenge; universities, labs, startup companies, and turbine manufacturers are currently looking to develop new recycling techniques or new materials that could be more easily recycled. Concrete foundations can be recycled but they are large, heavy, and of relatively low value so achieving it economically is a challenge.

Presenter: Judy Dunscomb, Senior Conservation Scientist, The Nature Conservancy of Virginia
Judy Dunscomb provided an overview of the land use impacts of onshore and offshore wind.

Onshore wind
Judy noted that Virginia currently has 0 MW capacity of onshore wind. Solar appears to be a more appealing option for developers on shore in Virginia, possibly because onshore wind is more expensive, and the suitable sites for solar are less constrained.

NREL mapped the wind speeds in Virginia, measured at 100m above surface level, which indicated the areas commercially viable for wind are located along the ridgetops in the western Virginia, an area with very high conservation value forests. Endangered species mortality is a concern for wind development and, while there are ways to deal with bat mortality, Judy noted we do not have good ways to deal with the forest fragmentation impact of onshore wind.

Judy noted that onshore wind energy and farming can be quite compatible because of the spacing between turbines, but we do not currently have wind energy technologies that would allow us to put turbines on the areas that contain most of Virginia's agricultural lands; turbines would need to be 140m above surface level to capture the necessary wind speeds in those areas.

In acknowledging the Task Force's charge to look at the impacts of life cycle and decommissioning costs on brownfields, Judy noted that most brownfields in Virginia are not suitable for a utility-scale wind project, but could potentially accommodate a smaller wind project.

Offshore wind
Two offshore wind projects are currently in the process of coming on shore in Virginia; Dominion's Coastal VA Offshore Wind (CVOW) Project and Avangrid's Kitty Hawk Wind.

Judy noted that most offshore wind effects occur in the marine environment, which appear out of the Task Force's scope, but the impacts of onshore transmission for offshore wind are relevant. In the mid-Atlantic, there are a fairly limited number of interconnection points close to shore to access the highly desirable 500kV transmission lines and it is reasonable to speculate there will be significant interest in having inter-ties come ashore in Virginia Beach. The onshore transmission component of offshore wind will likely have a concentrated footprint in Virginia Beach, but it could be a significant one. Judy noted that power lines are not incompatible with agriculture, so the larger impact of transmission is on wetlands and high conservation value lands in this area. It could be useful to figure out a way to accommodate multiple projects connecting to the 500kV line through a transmission corridor, rather than each project individually seeking to come through this resource-rich and population-heavy area.

Presenter: Frank Oteri, Researcher III-Market Research Analysis, National Renewable Energy Laboratory (NREL)
Frank Oteri presented an overview of NREL's research on wind energy and community planning. He noted that the timeline of decommissioning can be difficult to pin down, as many projects can be extended through repowering. Through a stakeholder engagement and outreach program supported by US DOE's Wind Energy Technologies office, NREL has created tools to help communities make wind development decisions; understand siting, permitting, and installation processes; weigh the costs and benefits of wind energy; and collaborate or partner with academic, scientific, and non-governmental organizations.

Frank noted that Virginia is in a unique position since it has no land-based wind projects and would therefore have at least 25 years before the first wind project is decommissioned. He noted that Virginia appears to be preparing for more development, but there are currently no state or local standardized processes for wind energy decommissioning. Across the US, some states have set standards for decommissioning; some simply require that each project have a decommissioning plan, others go into detail on infrastructure removal, financial assurance, and land restoration. Most commonly, there is a mixture of state and local authority in decommissioning. Frank noted that the industry is changing rapidly and it would be ideal to make decommissioning policies flexible, and to revisit every few years.

Frank noted that, as a state working toward more wind energy, the Virginia perspective is key to informing NREL's work on wind energy decommissioning and he hopes to engage further with Task Force members.

Presenter Q&A
After the wind life cycle presentations, Task Force participants raised the following questions:

- Should we be addressing decommissioning at the state level, or do localities have the authority to put these polices in place?
    - A Task Force member noted that localities have existing authority on decommissioning. Rocky Forge Wind has been permitted in Botetourt County; it could be useful to review their decommissioning plan as an example.
- To date, there doesn't seem to be a market driver for onshore wind development in Virginia. Do you expect to see that change?

    - Frank noted the renewable electricity Production Tax Credit (PTC) remains the primary driver for land-based wind across the US. However, the future for land-based wind is drastic under the Biden administration goals and there may not be a single state that can reach their goals without deploying it.
- What are the impacts of leaving the concrete foundations of wind turbines in place?
    - Dr. Cooperman noted the impacts are similar to other concrete structures, and the primary concern around depth of removal is being able to utilize the land for agriculture and not hitting the concrete with plowing or other equipment.
    - Frank noted that what is needed for backfilling depends on the land use and the type of land. He noted there is also concern with fully removing the foundations and the potential displacement of water.
- How does wind differ from other technologies? Does the difficulty of transporting blades point to more localized recycling needs?
    - Dr. Cooperman noted there is motivation to develop better methods for dismantling blades on site. With heavy cutting and grinding equipment onsite, blades can be reduced to smaller pieces which minimizes the transportation problem, since they are not exceptionally heavy.
    - Frank noted that current recyclers generally recover the materials themselves and do a lot of onsite preparation to reduce their size before transporting. If repurposing, the entire decommissioning method changes as blades are taken down individually.

V. TASK FORCE DISCUSSION OF TAKEAWAYS

Twice over the course of the day, presenters, Task Force participants, and facilitators summarized some of their individual key takeaways and reflections related to the charge questions. The facilitators tracked and shared these preliminary takeaways and reflections throughout the process, including in summary documents. With the exception of takeaways offered by presenters, these early-draft takeaways are not included in the summaries that are appended to the final report, as the more relevant final list of takeaways and recommendations is instead included in the main section of the report. However, the summary list of areas of uncertainty and outstanding questions is included below.

Areas of uncertainty and outstanding questions

Solar:

- If it doesn't make sense for recyclers to get set up now, what should be happening now? Store panels, landfill, send to few existing recyclers, refurbish? Could panels just stay in the ground if they aren't causing any harm?
- How are landfills currently treating solar panels in VA and are the panels correctly being treated as hazardous waste or not?
- Are there existing facilities in Virginia with hazardous waste permits?
- Should considerations be different for panels produced in the US versus elsewhere?
- Are there any real-world case studies of the economic impacts of a solar project in Virginia?
- Is there any research on farmers making choices to sell off their land for strip malls/warehouses/etc. versus selling for renewables? It would be good to be able to consider the counterfactual.

Wind:

- What are blade manufacturers currently doing?

- Are Virginia landfills currently accepting any blades?
- Will composite materials from the offshore wind projects be coming to Virginia landfills?
- Would a proliferation of land-based wind turbines in western Virginia have a tourism-related economic impact?

APPENDIX A
Virginia Renewable Energy Facilities Task Force
Charge Questions

The Task Force is charged with considering the following charge questions:

- Feasibility, costs, recycling and salvage opportunities, waste strategies, and liability for the decommissioning of materials used in renewable energy facilities;
- Potential impacts of underground infrastructure post-decommissioning;
- Potential impacts of the life cycle on farming, forestry, and sensitive wetlands;
- Potential impacts of life cycle and decommissioning costs on brownfields or previously developed project sites as compared to life cycle and decommissioning cost on agricultural or forest lands;
- Potential ratepayer impacts; and
- Potential beneficial economic impacts of solar, wind, and battery storage development.

APPENDIX B
Virginia Renewable Energy Facilities Task Force
November 16, 2022 Meeting Participant List

Participants representing the following Renewable Energy Facilities Task Force member organizations were present at the November 16, 2022 virtual meeting:

- American Clean Power Association
- American Farmland Trust
- Apex Clean Energy
- Appalachian Voices
- Appalachian Power
- Chesapeake Climate Action Network
- Dominion Energy
- EDF Renewables
- Invenergy
- Land and Liberty Coalition
- MAREC Action
- Rappahannock Electric Cooperative
- Reed Smith (observer)
- Solar Energy Industries Association
- Southern Environmental Law Center
- Strata Clean Energy
- VA Agribusiness Council
- VA Association of County Officials
- VA Dept. of Energy
- VA Dept. of Environmental Quality
- VA Farm Bureau
- VA Forest Products Association
- VA, MD, & DE Association of Electric Cooperatives
- VA Office of the Attorney General
- VA Solar Energy Development and Storage Authority

In addition to Task Force members, staff from the convening agency (VA SCC), staff from the third-party facilitation entity (Keystone Policy Center), and guest speakers were also present at the meeting.

Virginia Renewable Energy Facilities Task Force
November 29, 2022 Meeting Summary

Meeting Purpose: This was the third of five virtual meetings of the Virginia Renewable Energy Facilities Task Force created by HB 774 / SB 499, which directed the State Corporation Commission (SCC) in consultation with the Department of Energy (VADOE) and the Department of Environmental Quality (VADEQ) to create a task force to analyze the life cycle of renewable energy facilities in the Commonwealth. *See Appendix A for a list of the Task Force charge questions.*

Meeting Participants: The meeting was attended by approximately 44 participants, including representatives from 22 Task Force member organizations, guest speakers, and staff of the SCC (convening agency) and Keystone Policy Center (facilitators). *See Appendix B for the full list of organizations represented at this meeting.*

Discussion Summary

I. REVIEW OF MEETING TWO

Mallory Huggins, Lead Facilitator, Keystone Policy Center, welcomed everyone to the meeting and reviewed discussion protocols.

Mallory reviewed preliminary participant takeaways and reflections from the second meeting, which focused on the life cycles of solar and wind energy. She noted the potential recommendations presented should not be considered as fixed recommendations from the Task Force, but will be refined and presented for discussion at future meetings. *See VA RETF Meeting 2 Summary (p. 13-16) for these Meeting 2 takeaways, reflections, and potential recommendations.*

II. STATE-SPECIFIC ECONOMIC IMPACTS FOR SOLAR

Presenter: David Murray, Director of Solar Policy, American Clean Power Association
David provided an overview of the economic impacts of solar energy in Virginia. He noted an anticipated increase in electrification of buildings and vehicles, and retirement of traditional energy generation plants, will likely lead to a greater need for energy production in Virginia in the coming years.

Utility-Scale Solar
David noted that job impacts of utility-scale solar include the need for engineers, attorneys, and wildlife consultants during site selection, and the creation of ~200 construction jobs throughout construction. He added that solar facilities do not require many ongoing jobs in their operations phase.

David acknowledged that, due to drastic changes in tax regimes since the report was written, Mangum Economics staff cautioned against relying on specific findings of their January 2020 report on solar development in Virginia. However, the report can still inform why some counties consider solar an attractive economic investment. The Mangum study compared four economic development opportunities from a rural county perspective: housing development, additions to manufacturing, continued use in agriculture, and solar development. The study found that solar generally does not place any additional requirements upon counties in terms of additional water or sewer lines and, because it has few full-time operational jobs, it does not strain public services such as emergency response, schools, etc. Generally, a solar facility pays taxes while requiring very little from the county in return, and the tax benefits that accrue year after year are higher than personal and real estate property taxes.

As PV modules have gotten more efficient, and the solar industry has gotten more efficient in building and deploying, the decreased cost of energy production has provided the industry with more flexibility in how much revenue a project can provide to a county. Solar developers and county officials convened to develop tools counties could choose to use to extract revenue from solar projects, which informed the 2020 tax regime change for solar facilities in Virginia. One of the first tools agreed upon was a revenue share mechanism (up to $1400/MWac) to ensure a county has predictable, consistent income from a solar facility over its estimated 30+ year lifetime. The siting agreement legislation also provided opportunities for localities to negotiate terms to potentially include financial compensation to address the locality's capital needs.

David noted that the amount a solar project can provide to a county or municipality depends on several factors, some of which are outside a developer's control, such as: the cost of upgrading generation and transmission infrastructure; any cost to mitigate ecological impacts in environmentally sensitive areas; and any increased requirements for decommissioning and recycling.

David shared the following figures from American Clean Power:

- Solar energy generates 5.1% of electricity in Virginia; enough to power 435,449 homes. Of note, Virginia shares its grid with 12 other states and it's impossible to tell how much is received from solar on any given day; some days may be as low as 1% while other days as high as 20%.
- Virginia has 2,613 MW of installed solar capacity, with an additional 618 MW under construction and 3,143 MW in development. This does not include tens of thousands of MW in the interconnection queue, many of which may not come to fruition.
- Solar energy in Virginia has led to 3,780 jobs, including engineers, technicians, attorneys, and trade association professionals.
- The total investment cost of solar in Virginia, including the value of the equipment as well as the total cost of projects, is $4.1 billion.
- $10.5 million in state and local taxes, including permitting fees, has been generated from solar; an additional $13.9 million has been generated in land lease payments.
- In offsetting more traditional forms of energy with higher emissions and water use, solar has avoided 3.9 million metric tons of CO_2 emissions and saved 452 million gallons of water.

Distribution-Scale and Behind-the-Meter Solar

David noted that, in general, the impacts described for utility-scale solar are similar in ground-mounted distribution-scale. However, in commercial and residential rooftop solar, labor costs go up and tax benefits may go down. The development cycle of rooftop solar installation is much shorter and does create full-time jobs with competitive wages.

A Task Force member provided additional context for the economic impacts of distribution-scale solar based on their experience with 1-5 MW projects:

- Electrical contractors and vegetation managers are primarily local hires.
- Small distribution-scale projects allow local municipalities and rural electric cooperatives to invest in generating their own electricity. There are direct ratepayer benefits to generating electricity locally, and any rate savings realized by cooperatives or municipalities should be passed down to the ratepayers.

III. END-OF-LIFE BEST PRACTICES AND DECOMMISSIONING REQUIREMENT RECOMMENDATIONS FOR WIND

Presenters: Frank Oteri, Researcher III-Market Research Analysis, and Matilda Kreider, Wind Community Planning and Equity Post-Graduate Intern, National Renewable Energy Laboratory (NREL)
Frank and Matilda provided an overview of wind decommissioning considerations including potential ordinance components, stakeholder concerns, and conditions unique to offshore wind.

Wind energy ordinances
Frank noted that creating a wind energy ordinance can be a meaningful way for communities to prepare early for the prospect of development and establish standards that meet their needs. These ordinances can also indicate to developers that a community may be ready for wind development.

Frank noted the following decommissioning elements could be components of an ordinance:

- Type of financial assurances
- Timeline to post financial assurances and the frequency for updating them
- Salvage estimate with decommissioning costs
- Decommissioning timelines
- Removal requirements for above-ground components and infrastructure
- Removal depths for below ground infrastructure
- Land restoration requirements
- Decommissioning assessments, via third party or county review
- Landowner agreements for waivers pertaining to access roads or other infrastructure that might be located on an individual's property
- Hazardous and solid waste removal requirements
- Conditions that trigger decommissioning (*e.g., a length of time the facility is not operating*)
- Conditions that trigger a locality taking over (*e.g., the point at which the community can access the decommissioning bond and take over the decommissioning if the stated timeline for removal has not been met*)

Frank noted that ordinances can also cover repowering; for example, one local ordinance stated that repowering would not require new permits unless the total turbine height increased by more than 15 feet.

Concerns raised in NREL stakeholder forums
Frank shared the following stakeholder concerns[39] around end of service, gathered during forums with local decisionmakers and representatives from various state agencies:

Stakeholder concerns regarding blade disposal/landfilling:

- Difficult to manage and not enough equipment
- What are blade preparation requirements for landfilling?
- What are equipment requirements for landfilling?
- Who is tasked with segmenting blades prior to landfilling? Does that fall on the developer or solely on the community?
- What are best practices when planning for blade landfilling standards?

[39] Note that these are reflective of the stakeholders Frank and his team reached out to, not the stakeholders that make up this Task Force.

Stakeholder concerns regarding blade recyclers:

- General availability
- Transportation/onsite blade prep; what are the local impacts?
- What are the existing recycling laws/solid waste laws and how do they apply to wind energy?
- Who is tasked with segmenting blades prior to transportation/recycling?
- History of past recycling failures

Stakeholder concerns regarding decommissioning/repowering:

- How long does it take to decommission?
- How does topography play a role in restoration best practices?
- Stormwater management during construction/deconstruction
- What are the impacts to leaving foundations in the ground? To what extent does the base need to be removed? To what extent do the wires need to be removed?
    - Frank noted that stakeholders want more nuance than simply to what depth the foundations will be removed, and to better understand best practices depending on land use and type of land.
- How are access roads dealt with? Can landowners keep them beyond the lifetime of a project?

Stakeholder concerns regarding developers/owners/operators:

- What happens if a company goes bankrupt? What happens when a company is sold or otherwise unable to finance decommissioning?
- How reliable are bonds or other financial assurances?
- How do we make sure the money is there?
- When will it be decommissioned, if at all, given partial and full repowering? Will it be returned to land use?

Frank noted that NREL offers multiple resources to help communities weigh the benefits and impacts of wind energy on the WINDExchange project website.

End-of-service considerations for offshore wind

Matilda noted that, to date, few offshore wind projects have been decommissioned, so the assumptions are largely based on learnings from land-based wind decommissioning and learnings from the construction process of offshore wind.

Matilda noted the lifespan of offshore wind turbines is estimated at 20-25 years, which is a little shorter than land-based turbines due to the harsher marine environment. Some components of the turbine may be replaced earlier in the lifespan due to technology advancements or component wear. In Virginia, Matilda noted that Dominion's Coastal VA Offshore Wind project will have 176 turbines in operation by 2026, making it the largest offshore wind project in the US.

Matilda noted that the environmental impacts of offshore wind decommissioning are expected to be the same as those that occur during construction. Leaving some components in place, rather than re-disturbing the area, may benefit the marine environment. Additionally, the underwater structures may serve as artificial reefs, which benefits fish and some other marine life.

Offshore wind decommissioning can be done via full decommissioning *(everything down to the foundation)* or partial decommissioning *(leaving a portion of the underwater structure)*. All offshore wind projects fall under the Bureau of Ocean Energy Management (BOEM) jurisdiction. As such, developers must provide decommissioning plans at the outset of development, and financial assurance through the project's lifetime. BOEM requires all components to be removed down to 15 feet below seabed unless authorization for partial decommissioning is acquired. Matilda noted that, even though the decision-making happens at the federal level, it can impact local, state, and regional values. For instance, some communities may place a strong value on protecting the marine environment, or on preserving the local fishing economy.

Matilda noted that decommissioning also has local onshore considerations, such as: local processing may be required due to the size of the components; the required workforce will likely come from local or state sources; and onshore components (*i.e., substations, cables, transmission infrastructure*) may need to be decommissioned or transitioned to new uses.

Presenter Q&A
Task Force members raised the following questions:

- Is there a greater likelihood of repowering offshore wind compared to land-based wind?
    - Frank opined that both offshore wind and land-based wind are likely to be repowered for generations, although it is not yet known what the marine environment will do to foundations. He noted that if an area is already taken out of use for fishing or recreation, it is not ideal to take another area out of use. In addition, stakeholder views tend to shift towards more acceptance with time and introducing a new location would restart that timeline.
    - Matilda noted that the lease areas for offshore wind are much more constrained than land-based wind and a developer cannot easily go and build somewhere else, which will likely lead to more repowering.

IV. BATTERY STORAGE LIFE CYCLE AND END-OF-LIFE OPPORTUNITIES

Presenter: Dustin Weigl, Mobility Research Analyst, National Renewable Energy Laboratory (NREL)
Dustin provided an overview of the life cycle of stationary battery storage facilities.

Status of stationary storage
Dustin noted there has been rapid development of stationary storage. Massive demand for electric vehicle (EV) batteries is prompting increased manufacturing capacity and R&D funding, which also benefits stationary storage. Lithium batteries, the primary storage technology, have reduced in price by 89% since 2010. This creates a virtuous cycle: as costs decline, deployments increase, and with additional deployments there are additional cost declines through economies of scale and greater manufacturing capacity. With decreasing costs, storage has become an important and affordable driver of grid flexibility. Dustin added that storage and PV technologies are complementary, and seasonal storage is fairly critical for high penetration of renewables. Peak load for solar with no storage is quite high, so availability of dispatchable resources and/or storage alongside solar penetration helps flatten the peak and add flexibility.

When building stationary battery storage sites, the prime safety and maintenance considerations are related to precautions for thermal runaway, a cycle of increased energy and fire danger that could potentially lead to an explosion. Several safety codes are relevant for siting, and best practices include keeping vegetation away, installing fencing, and utilizing hazard detection systems. Dustin noted that, due to these safety considerations, some stakeholders may not want these batteries nearby, even if there are already solar installations on site.

Battery recycling
Dustin detailed the recycling methods for batteries: *direct recycling*, in which the cathode material is recovered and placed back into the manufacturing phase; *hydrometallurgy*, which uses chemical- and water- based processes to extract metal salts which go back into the cathode material; and *pyrometallurgy*, which essentially burns the battery to extract metals.

The US DOE sponsored “ReCell” program, currently in the R&D phase, is working to improve on existing battery technologies and develop more viable processes for direct recycling that cost less and use less energy. While direct recycling and hydrometallurgy require specific processes for batteries, pyrometallurgy is more flexible and existing plants may be able to process battery material. However, hydrometallurgy adoption is growing as it is a cheaper and less energy-intensive process than pyrometallurgy.

One of the biggest concerns with batteries is the supply of cobalt, a critical component of today’s battery chemistries. The US has essentially no domestic source of cobalt and is completely dependent on foreign sources; a majority of cobalt is mined and processed in the Democratic Republic of Congo. Recycling could provide a domestic source of cobalt, by recovering materials from batteries at end of use.

In the Northeastern US, there are currently three battery recycling facilities in operation; combined they handle 6,000 tons/year through pyrometallurgy and 5,000 tons/year through hydrometallurgy, which are very small amounts compared to those being recycled globally. Additional facilities are planned in the US, but Dustin noted it will be important to scale up recycling facilities faster to keep these critical materials in the US.

The primary value from battery recycling comes from the lithium, cobalt, and nickel, though other materials be recovered depending on the process used. For both cost and supply chain considerations, the US is strongly seeking to move away from cobalt-heavy battery chemistries and progressing towards nickel-heavy batteries. One complication is that this push towards nickel is reducing the incentive for battery makers to recycle, as the revenue prospect is reduced.

Dustin noted that stronger incentives are needed to collect stationary and EV batteries for recycling, which are costlier and more difficult to transport than portable batteries. The EU has a phased implementation for battery recycling between now and 2035, with specific recovery targets for valuable materials and a requirement to declare the content of recycled material for new batteries. In the US, eligibility for some of the EV incentives depends upon the batteries being sourced domestically, which can realistically only be achieved through recycled content. It’s unclear whether this will impact stationary storage batteries, which are not necessarily purchased at the private level.

Dustin noted that in his modeling of recycling capacities, comparing high EV adoption and low EV adoption scenarios, both the nickel supply from recycling and the nickel required for new batteries will increase over time. Even as more batteries reach their end of life, there is much higher demand for those batteries. Co-locating a manufacturing facility with a recycling facility so that recovered materials can go directly back into the manufacturing process can significantly improve the ability to meet that demand.

Second life applications

Dustin noted that second life batteries can help meet demand for new batteries, reducing the demand for critical battery materials, the strain on the supply chain, and the energy requirements of new battery development.

Batteries reaching the end of their life in high duty applications could be refurbished and used for years in another application. For instance, EV batteries at their end of life are at ~80% state of health; these could last an additional 10 years in a second life application such as grid services, or in forklifts, three-wheelers, or persuasive electric vehicles (PEVs).

Dustin noted that repurposing costs vary depending on the shape a particular battery is in, but it can be as low as $20/kWh/battery. Second life batteries currently cost up to 50% less than a new battery, although if the costs of new batteries continue to decrease, it could be problematic for the viability of second life batteries, for whom labor costs are a larger part. Dustin noted that lithium-ion batteries are considered hazardous materials and can be very difficult to transport; repurposing by region for a single battery type can help increase economies of scale and reduce transportation costs.

Dustin summarized the following challenges for battery second life in the US:

- Actual use cases in the real-world market
- Transportation and collection at scale, especially without incentives
- Cost, speed, and reliability of state of health testing
- Liability and change of ownership across battery lifetime
- Quality control assurances
- Matching battery characteristics *(form factor, voltage, capacity)* to the application
- Lack of regulations and incentives

Lifecycle analysis

Dustin noted that moving from high-cobalt batteries to low-cobalt batteries could realize significant reductions in GHG emissions and other environmental impacts, especially when paired with recycling. However, substituting cobalt with nickel does create potential increases in carcinogenic and non-carcinogenic toxicity.

Recycling battery materials to produce second life batteries significantly reduces environmental impacts; Dustin noted this reduction, along with the energy security concerns, makes a compelling argument for recycling.

Key takeaways

Dustin noted the following key takeaways for battery storage:

- Demand for lithium-ion batteries (including stationary storage, EV, and consumer electronics) is skyrocketing; this has led to quickly decreasing battery prices, in part due to increased manufacturing and recycling capacity.
- Some of these new recycling technologies can be profitable and energy efficient, and direct recycling can enable a much more circular economy.
- Second life applications can effectively extend the useful life of batteries, especially from intensive duty cycle applications, such as passenger vehicles.
- Several logistical and technical challenges must be addressed before second life utilization grows significantly, but it can be done.

- Lifecycle GHG impacts of battery stationary storage can be reduced significantly through recycling, with greater benefits from future low-cobalt chemistries. Dustin noted this move to low-cobalt will likely happen in the industry without any additional incentives required.

Presenter Q&A

Task Force members raised the following questions:

- In order for EV batteries to have a second life in utility-scale stationary storage, do they need to be refurbished and converted to a different state?
  - Dustin noted it depends on the specific battery condition, such as how much the vehicle was driven and whether the vehicle was involved in a crash. Many batteries may require evaluation of individual cells, although cells can be replaced relatively easily. Once a battery has been assessed and processed, it can be used for any application that can fit a battery of its size, shape, and voltage.
- What is the typical life of a stationary battery?
  - Dustin noted the lifespan of a stationary battery varies on its use; some batteries are cycled multiple times/day, while others are cycled once/month. Those that aren't cycled as regularly likely have a lifetime of 30 years. The batteries used in data centers (which require 99.9% reliability) may have over 95% state of health at their end of life and could be used for another 20-30 years in another application.
- What battery materials are not reused after recycling? Are they hazardous?
  - Dustin noted that during direct recycling, the logistical challenge of ungluing the module may be a large factor in which materials are not reused. He added that some of the materials can be hazardous, depending on the recycling process, although metallurgy offers some second uses for hazardous materials. For hydrometallurgical recycling, there are also concerns about needing to cleanse the water coming out of the process.
- What is the expected growth outlook for the battery recycling industry in the US?
  - Dustin noted they expect much more growth in the next couple years. Consumer electronic batteries contain cobalt that is extremely valuable to recyclers, and some consumers replace their phone every year. Compared to the availability of stationary storage or EV batteries, there are a lot of consumer electronics and manufacturing scrap, and a high incentive for recycling processes.
- What is the forecasted market share of stationary storage vs. EV batteries?
  - Dustin estimated batteries from stationary storage batteries may be 10% of the market, with another 5-10% being consumer electronics, and EV making up the remainder. He noted that the demand for stationary storage batteries is not large enough to encompass all the EV batteries that will reach their end of life, but perhaps the supply will decrease costs of stationary storage significantly in another ten years.

V. TASK FORCE DISCUSSION OF TAKEAWAYS

Over the course of the day, presenters, Task Force participants, and facilitators summarized some of their individual key takeaways and reflections related to the charge questions. The facilitators tracked and shared these preliminary takeaways and reflections throughout the process, including in summary documents. With the exception of takeaways offered by presenters, these early-draft takeaways are not included in the summaries that are appended to the final report, as the more relevant final list of takeaways and recommendations is instead included in the main section of the report. However, the summary list of areas of uncertainty and outstanding questions is included below.

Areas of uncertainty and outstanding questions

General:

- Do localities have permitting authority for transmission infrastructure?
- How do ratepayer impacts vary between scenarios with more stringent and less stringent decommissioning requirements?
- Are there industries/services that tend to grow or build up around the proliferation of solar development?

Battery Storage:

- How is the waste management industry in Virginia thinking about stationary battery storage waste streams?
- In the event of a battery storage system fire, what are the gases emitted and what are the best response practices?
- To what extent, if any, would a continued dependence on foreign sources of cobalt incur risks of increased battery costs and/or instability of supply?
- If moving to a low-cobalt and high-nickel battery chemistry, will there still be incentive to recycle?

VI. NEXT STEPS

Pursuant to the final Task Force report, Mallory shared the proposed timeline for remaining Task Force discussions, feedback, and review of written recommendations generated from the discussions:

- **December 9: Preliminary draft of takeaways and recommendations.** Keystone to send draft takeaways and recommendations to the Task Force for internal review prior to the next meeting. This document will primarily be a synthesized version of the reflections and takeaways previously noted in each meeting summary.
- **December 14: Task Force meeting #4.** Discussions on ratepayer impacts; outstanding questions on wind, solar, and battery; draft takeaways and recommendations; and a consensus check on the takeaways from meetings 1-3.
- **December 15: Complete draft of takeaways and recommendations.** Keystone to send updated draft of takeaways and recommendations to the Task Force.
- **December 15 – January 9: Written feedback on draft takeaways and recommendations requested.** Task force members to review and provide written feedback on the draft takeaways and recommendations. All major substantive feedback should be provided by January 9.
- **January 10: Task Force meeting #5.** Discussion of substantive feedback received; attempt to resolve any major disagreements among members on takeaways and recommendations; consensus check.
- **January 31 – February 17: Task Force review of draft report.** Keystone to circulate the draft report to SCC and Task Force members for any concerns or clarifications. All feedback should be provided by February 17.
- **March 1: Final report.** Keystone to submit the final report to the SCC.

APPENDIX A
Virginia Renewable Energy Facilities Task Force
Charge Questions

The Task Force is charged with considering the following charge questions:

- Feasibility, costs, recycling and salvage opportunities, waste strategies, and liability for the decommissioning of materials used in renewable energy facilities;
- Potential impacts of underground infrastructure post-decommissioning;
- Potential impacts of the life cycle on farming, forestry, and sensitive wetlands;
- Potential impacts of life cycle and decommissioning costs on brownfields or previously developed project sites as compared to life cycle and decommissioning cost on agricultural or forest lands;
- Potential ratepayer impacts; and
- Potential beneficial economic impacts of solar, wind, and battery storage development.

APPENDIX B
Virginia Renewable Energy Facilities Task Force
November 29, 2022 Meeting Participant List

Participants representing the following Renewable Energy Facilities Task Force member organizations were present at the November 29, 2022 virtual meeting:

- American Clean Power Association
- American Farmland Trust
- Apex Clean Energy
- Appalachian Voices
- Appalachian Power
- Chesapeake Climate Action Network
- Dominion Energy
- EDF Renewables
- Invenergy
- Land and Liberty Coalition
- Rappahannock Electric Cooperative
- Reed Smith (observer)
- Siemens Gamesa Renewable Energy
- Southern Environmental Law Center
- Strata Clean Energy
- VA Agribusiness Council
- VA Association of County Officials
- VA Dept. of Energy
- VA Dept. of Environmental Quality
- VA Municipal League
- VA Office of the Attorney General
- VA Solar Energy Development and Storage Authority

In addition to Task Force members, staff from the convening agency (VA SCC), staff from the third-party facilitation entity (Keystone Policy Center), and guest speakers were also present at the meeting.

Virginia Renewable Energy Facilities Task Force
December 14, 2022 Meeting Summary

Meeting Purpose: This was the fourth of five virtual meetings of the Virginia Renewable Energy Facilities Task Force created by HB 774 / SB 499, which directed the State Corporation Commission (SCC) in consultation with the Department of Energy (VADOE) and the Department of Environmental Quality (VADEQ) to create a task force to analyze the life cycle of renewable energy facilities in the Commonwealth. *See Appendix A for a list of the Task Force charge questions.*

Meeting Participants: The meeting was attended by approximately 49 participants, including representatives from 23 Task Force member organizations, guest speakers, and staff of the SCC (convening agency) and Keystone Policy Center (facilitators). *See Appendix B for the full list of organizations represented at this meeting.*

Discussion Summary

I. WELCOME

Mallory Huggins, Lead Facilitator, Keystone Policy Center, welcomed everyone to the meeting and reviewed discussion protocols.

II. DRAFT TAKEAWAYS AND RECOMMENDATIONS

Mallory reviewed the draft list of Task Force takeaways and recommendations, gathered from prior meeting presentations and discussions, and distributed in advance of today's meeting, for input and consensus check among Task Force members. Task Force members talked through each takeaway and recommendation and indicated whether they had any concerns. Where a member indicated concern, the Task Force discussed possible changes to address those concerns. After the meeting, Mallory circulated a redlined version of the takeaways and recommendations, which included edits suggested during the meeting; green or yellow highlights to indicate whether members were generally supportive of a recommendation (green) or expressed concern (yellow); and the addition of takeaways and recommendations related to ratepayer impacts, which were discussed in depth for the first time during this meeting. This draft document is available on the Task Force SharePoint site.

III. RATEPAYER IMPACTS OF RENEWABLE ENERGY

Panelists: Sam Brumberg, *VP of Regulatory Affairs and General Counsel, Virginia Maryland & Delaware Association of Electric Cooperatives and Task Force member**; Will Cleveland,** Senior Attorney, Southern Environmental Law Center and Task Force member**; Irene Cox,** Master of Public Policy Candidate, University of Virginia**; Scott Gaskill,** General Manager for Regulatory Affairs, Dominion Energy and Task Force member**; Cliona Mary Robb,** Chair, Solar Energy Development and Energy Storage Authority and Task Force member*

Virginia's electric industry consists of three investor-owned utilities, or IOUs, (serving ~3.2 million customers in Virginia); 13 member-owned electric cooperatives (serving ~640,000 customers in Virginia); and a few municipal utilities.

Investor-owned utilities: regulation and rate-influencing factors

The three IOUs serving customers in Virginia are: Dominion Electric Virginia (Dominion) with 2.7 million customers; Appalachian Power Company (APCo) with 540,000 customers; and Kentucky Utilities/Old Dominion Power with 30,000 customers.

Will provided an overview of how IOUs in Virginia are regulated and the factors that influence the rates their customers pay. He noted that rates are intended to allow enough revenue each year for the utility to recover its costs, plus a fair rate of return. The profit is not unlimited; the SCC establishes each utility's profit margin, from which the annual budget (or the amount each year a utility needs to cover costs and reach this profit margin) is calculated.

The price per kilowatt-hour (kWh) is determined by dividing the utility's estimated revenue requirement by their estimated total annual sales for the coming year, though different classes of customers pay different rates. The total rate on a customer's bill has three main components: base rate, fuel factor rate, and the additional riders or rate adjustment clauses (RACs) which are usually project-specific surcharges. The rate for each rider varies depending on the costs recovered under that rider.

SCC's 2022 annual report on the implementation of the Electric Utility Regulation Act included a table identifying every RAC that applied to Dominion and APCo customers (as of July 1, 2022). The report also provided a cost per month the average residential customer pays for that rider. In July 2022, the average Dominion customer's bill totaled $136.93/month or ~$0.13/kWh. This total rate per kWh includes a base rate of $0.07/kWh, a fuel rate of $0.035/kWh, and multiple riders of varying rates.

It was noted by multiple panelists that, while the report's cost calculation assumed the average customer uses 1,000 kWh/month, the true average customer use is likely closer to 1,200 kWh/month.

Will noted that, between traditional and renewable energy sources, the process by which rates are set is generally the same, but where on a customer's bill the costs are recovered can differ. The fuel factor rate traditionally includes expenses beyond just the cost of fuel, such as costs incurred by the utility to purchase wholesale energy on behalf of their customers. However, renewable resources procured pursuant to the Virginia Clean Economy Act (VCEA) must have their costs and benefits recovered and booked in one place, outside of fuel factor or base rates.

For the most part, rates that customers pay are the capital, operations and maintenance (O&M), and fuel costs plus the utility profit margin. To the extent a facility has benefits for customers, those revenues will act as an offset to the price, but generally any capital cost the utility has to pay flows down to the customer.

Electric cooperatives: regulation and rate-influencing factors

Sam provided an overview of Virginia's electric cooperatives (co-ops), and the ways in which they differ from IOUs. He noted that co-ops also have a revenue requirement and divide by their number of customers to determine a rate, but what goes into that calculation differs from IOUs. Co-ops operate on a not-for-profit basis, and the ratepayers are also member-owners.

Sam noted that cooperatives are not vertically integrated like Virginia's IOUs. While Dominion owns generation, transmission, and distribution, most co-ops only own the distribution, get transmission from Dominion, and are responsible for sourcing their own power supply. Of the 13 co-ops in Virginia, one receives power from the Tennessee Valley Authority, a federally owned utility; nine are members of a generation and transmission cooperative, Old Dominion Electric Cooperative (ODEC), and three have contracts with utilities throughout the PJM region to provide wholesale power.

Virginia has some of the smallest (7-8,000 members) and some of the largest (over 150,000 members) co-ops in the US, but even the largest is small compared to Dominion's customer base of millions. Rates tend to be higher in co-operatives primarily due to the higher cost to operate in rural areas and the limited economies of scale.

For a distribution co-op, the expense to purchase power is recovered at cost through the electricity supply service rate, which includes the Power Cost Adjustment rider. Renewables under contract with the co-op, or its wholesale provider, are baked into the "energy supply service" rate and ultimately recovered that way, rather than incrementally through riders as for IOUs. Co-op members have the option to add additional renewables onto their own individual power mix through various programs. All co-op members have access to at least one green power rate.

Sam noted that, with a few exceptions, distribution co-ops were largely exempt from the mandates in the VCEA, primarily because they are not generation utilities.

Potential impacts of solar, wind, and battery storage on rates

Will noted that riders are reviewed and adjusted on an annual or semi-annual basis, and fuel factor rates are also adjusted every year, but base rates for Dominion have not been adjusted since 1992. Scott clarified that while the base rate has not generally changed, there were some reductions in 2018 related to the federal tax cut that were passed on and credits have also been introduced as riders, effectively acting as a base rate reduction.

Will noted that the addition of any new resource will mean an additional rider which, by definition, will mean an increase in rates, but that upward pressure is likely not unique to renewables. Every year the SCC conducts a proceeding to determine whether newly proposed resources for Dominion or APCo are necessary for compliance with VCEA and represent the least-cost manner. The SCC has the authority to deny any project that does not meet these criteria, and any denied project is not recoverable in rates.

Scott noted that utilities, their customers, and the SCC share a common goal of transforming and decarbonizing the grid in the long term while maintaining reliability and affordability. This is a challenging balance. He noted that renewables hold some great long-term benefits, such as fuel price stability and eliminating dependency on the commodity market, but in the short-term the transition to renewables will require investment, which come with rate increases.

Will agreed that reliability and affordability are key considerations of the clean energy transition. He noted that if a new solar or wind project is recovered through a rider, the cost of that project will be reflected as a line item on customer bills, but the bill will not necessarily reflect the benefit of that project, such as how it may reduce fuel factor rates by displacing the operation of coal or gas.

Sam noted that reliability and environmental concerns are also extremely important to the co-ops. Accessibility is also important; if a rural customer's bill is more than they can pay, they will get disconnected. He noted that cooperatives are actively pursuing renewable projects where they make sense for members and are placing them where they can provide not only energy but demand benefits.

Useful life and depreciation
Scott noted that Dominion performs a depreciation study on each of their generation assets every five years, at minimum. These studies look at the industry average, the condition of the plant, any capital improvements/refurbishments, and the end of useful life for every project. Depreciation is reflected in the revenue requirement, which is how utilities recover their capital investment, and that feeds into rates. The longer the depreciable life, the lower the annual depreciation expense; the shorter the depreciable life, the higher the annual depreciation expense as it is spread over fewer years. Typically, DEV has been utilizing a depreciation of 60-80 years for nuclear, 55+ years for coal, and 35 years for solar.

Irene noted that depreciation is essentially the value of tangible assets over time, and tangible assets include anything related to the property except the land itself. She noted that “useful life” for tax purposes is different from the actual technical life. While solar projects may have a technical life of 30 years, tax depreciation accounting uses an accelerated system called the modified accelerated cost recovery system. For tax purposes, a five-year useful life is assumed for most renewable energy projects, and a 20-year useful life is assumed for non-renewable electric plants.

Scott noted this shorter tax depreciation life means a higher annual depreciation expense and lower net income, and therefore lower taxes, in the short-term. Since taxes are a component of the revenue requirement, having this shorter depreciation life for tax purposes decreases cost to ratepayers in the short term.

Scott also noted the Inflation Reduction Act (IRA) will provide a big cost reduction to renewables. While some details are still being worked out, by and large the IRA increased and extended production tax credits and investment tax credits and provided additional options, such as direct pay tax credits, which are valuable for entities without tax liability, such as co-ops.

Sam noted that both ODEC member co-ops and distribution co-ops are excited about the direct pay tax credits. With the proper credits, incentives, labor agreements, and materials they could potentially get a credit of up to 70% of a solar project.

Decommissioning costs
Will noted that decommissioning costs would be included in the lifetime revenue requirement, which is part of a project’s application.

Scott noted that part of the revenue requirement is the asset retirement obligation (ARO) which contains decommissioning obligations. Those costs are gathered a little at a time from customers each year and calculated to be fully collected by the project’s end of life. When localities require a surety bond for their decommissioning, that cost also gets passed along as a project cost, although it is typically not a large amount.

Accounting for externalities
Will noted that “externalities” is an amorphous term and can mean many things. Externalities can potentially include transmission upgrades, distribution system upgrades, and congestion issues. There are environmental externalities such as associated pollution and other impacts not factored into rates. The VCEA does require the evaluation of a project to include the social cost of carbon as either a cost adder or cost reducer, depending on the type of facility. As an economic regulator, the SCC analyses the costs

and benefits of a proposed facility, and the social cost of carbon is now going to be included in that analysis.

Scott clarified that the social cost of carbon will be part of the decision-making process on whether a project moves forward, but it will not be a factor in ratemaking.

Sam noted that one externality for areas served by co-ops comes at the end of life for utility-scale solar projects; if a decommissioning bond is not sufficient to cover those costs, costs will ultimately be borne by the local government and if the solar developer no longer exists in the same form (e.g., it merged, was bought out, or went bankrupt), taxpayers may ultimately bear the burden.

Scott noted that all utility-owned, utility-scale projects have an ARO obligation that is factored into rates, and localities will not be left to bear those costs. Sam noted that, in his estimation, the majority of projects are owned by a third party. Irene noted that localities have many options available to them to ensure that burden doesn't fall on taxpayers. Will noted that a lot of third-party owned facilities are procured through power purchase agreements (PPAs); many of these include an option for the utility to buy out the project at the end of the term, which likely means they are converted into utility assets and factored into rates.

Key takeaways from panelists

Each panelist who is a member of the Task Force shared their key takeaways on the ratepayer impacts of renewable energy:

- On behalf of the Solar Energy Development and Energy Storage Authority, Cliona noted that utility-scale renewable energy facilities are likely to have the least potential for rate increases, due to efficiencies of scale. The cost of renewable energy facilities is largely in up-front capital costs, and long-term gains are realized in fuel costs. However, anything done to make utility-scale projects more expensive increases the ratepayer impact.[40]
- Will noted that a new investment cost of any kind is likely to put upward pressure on utility rates. The advantage of clean energy is the degree to which it can offset and displace other types of costs and reduce the net cost to ratepayers. It is important to look at net cost, not just capital cost.
- Sam noted that he generally agreed with Will's comments, but would add the caveat that co-operatives operate differently and their advice should be sought accordingly.
- Scott noted that it is necessary to balance reliability, affordability, and sustainability. A clean energy transition requires balancing the short-term costs of capital investment with the long-term benefits. All the costs of utility projects, including decommissioning, are ultimately passed on to customers and the more requirements, the more costs for ratepayers.

Panelist Q&A

Task Force members and facilitators raised the following questions:

- Do coal, nuclear, natural gas, and petroleum facilities put up decommissioning bonds?

[40] Cliona also noted that when it comes to acquiring land for renewable energy facilities, some forested land is actually timber land and should be considered differently than siting on forested land that is not used for timber. This takeaway is factored into the draft takeaways related to land use and the tradeoffs therein.

    - Scott noted that he was not sure, although they definitely have AROs. Dominion has retired a number of fossil units, and those expenses have all been recovered through base rates.
    - Irene noted that facilities for those resources are much costlier to decommission than a solar project, and commonly utilize pooled funds. In those cases, owners of the same category of facility deposit payments into a pooled decommissioning fund that each entity could access under certain conditions, such as bankruptcy.
- How would the potential salvage value of renewable energy facility components factor into decommissioning costs?
    - Irene noted that the current accounting standard is to factor in the salvage value as zero. While the opportunity for resale of solar panels is high, those markets haven't fully emerged yet.
    - Scott noted that they re-evaluate depreciation of projects at least every five years and, should this accounting standard change during the life of a project, it could be reflected in the updated depreciation rate.
        - Will noted that market forces and legislation might also change depreciation, prompting adjustment after the re-evaluation.
- What potential benefits to ratepayers or to general costs could be calculated from the reduced transmission costs and reduced line losses of decentralizing the electric grid through renewables?
    - Scott noted that transmission costs of renewable energy generation show up in generation and T1 riders. When a new generator is interconnecting, network upgrade costs are determined, and those costs are assigned to the generator and recovered through a generation rider. Costs which are not for a particular generator but for the broader system (e.g., new load, reliability) are recovered through the T1 rider. Recently, there has been a lot of activity on the cost allocation of transmission at FERC, which regulates these riders.
- Do cooperative and municipal utilities have any limits in their own generation capacity?
    - Sam noted the limiting factors are not statutory, but technical and contractual. Limitations on projects can depend on where the project is; transmission delivery points owned by Dominion come with physical limitations and they generally do not permit any project to be built that will cause backfeeding onto the transmission network. For co-ops, the decision to construct something new is driven by need.
- Is the ODEC arrangement limiting the amount of generation built by co-ops?
    - Sam noted that ODEC procures powers for members through an all-requirements contract; with few exceptions, their distribution co-op members purchase everything they need from ODEC. However, ODEC can build something else to supply their members.
- Does land cost show up in the base rates when a project is first established?
    - Cliona noted that land costs would be factored in with the capital cost.
- Are there any generalizations that can be made about the cost of transmission for renewables vs. fossil fuels?
    - Scott noted there are some benefits to distributed generation, such as lower line loss, but the general expectation is that transmission costs will go up over time to integrate renewables. The answer could be different as more battery storage is deployed, which comes with more options for siting strategically.

- Will there be an impact on ratepayers if roadblocks to deploying solar prevent Dominion from meeting its VCEA goals?
  - Will noted that if renewable energy credits (RECs) become too expensive, utilities can make a deficiency payment in lieu of procuring them and that payment would be recovered with ratepayers. However, a utility would only opt for a deficiency payment if that was of lesser cost to ratepayers than buying the requisite amount of RECs.
- On the SCC's 2022 report, what is the reason for the wide variety of rates between solar project riders?
  - Will noted that riders US-2, US-3, and US-4 are not for individual solar projects but portfolios of solar projects of various sizes and megawatts.
- What would trigger a proposed increase in the rate for a solar project rider, as seen in US-2 on the report?
  - Will suggested the most likely reason was a change in O&M costs; these costs are generally very low for solar but not nil.
- What was the outcome of the proposed increase?
  - A staff member from SCC noted that the current Rider US-2 rates were approved on 6/9/22 in SCC Case No. PUR-2021-00238, and the final approved rates result in a bill increase of $0.05 for a typical residential customer using 1,000 kWh per month.

IV. CLOSING AND NEXT STEPS

Mallory reviewed the next steps for the Task Force. Keystone will incorporate today's discussion into the draft takeaways and recommendations, then distribute an updated draft to the Task Force within 24 hours. Takeaways and recommendations which were identified, during today's conversation, as needing more attention will be clearly flagged within the document. Task Force members can provide their organization's written feedback via comment or redline edits made directly to their copy of the draft document, returned no later than January 9. Additional instructions will accompany the distribution of the document.

APPENDIX A
Virginia Renewable Energy Facilities Task Force
Charge Questions

The Task Force is charged with considering the following charge questions:

- Feasibility, costs, recycling and salvage opportunities, waste strategies, and liability for the decommissioning of materials used in renewable energy facilities;
- Potential impacts of underground infrastructure post-decommissioning;
- Potential impacts of the life cycle on farming, forestry, and sensitive wetlands;
- Potential impacts of life cycle and decommissioning costs on brownfields or previously developed project sites as compared to life cycle and decommissioning cost on agricultural or forest lands;
- Potential ratepayer impacts; and
- Potential beneficial economic impacts of solar, wind, and battery storage development.

APPENDIX B

Virginia Renewable Energy Facilities Task Force

December 14, 2022 Meeting Participant List

Participants representing the following Renewable Energy Facilities Task Force member organizations were present at the December 14, 2022 virtual meeting:

- American Clean Power Association
- American Farmland Trust
- Apex Clean Energy
- Appalachian Voices
- Appalachian Power
- Chesapeake Climate Action Network
- Dominion Energy
- EDF Renewables
- Invenergy
- Rappahannock Electric Cooperative
- Reed Smith (observer)
- Siemens Gamesa Renewable Energy
- Southern Environmental Law Center
- Strata Clean Energy
- VA Agribusiness Council
- VA Association of County Officials
- VA Dept. of Energy
- VA Dept. of Environmental Quality
- VA Dept. of Forestry
- VA, MD & DE Association of Electric Cooperatives
- VA Municipal League
- VA Office of the Attorney General
- VA Solar Energy Development and Storage Authority

In addition to Task Force members, staff from the convening agency (VA SCC), staff from the third-party facilitation entity (Keystone Policy Center), and guest speakers were also present at the meeting.

Virginia Renewable Energy Facilities Task Force
January 10, 2023 Meeting Summary

Meeting Purpose: This was the fourth of five virtual meetings of the Virginia Renewable Energy Facilities Task Force created by HB 774 / SB 499, which directed the State Corporation Commission (SCC) in consultation with the Department of Energy (VADOE) and the Department of Environmental Quality (VADEQ) to create a task force to analyze the life cycle of renewable energy facilities in the Commonwealth. *See Appendix A for a list of the Task Force charge questions.*

Meeting Participants: The meeting was attended by approximately 42 participants, including representatives from 19 Task Force member organizations, guest speakers, and staff of the SCC (convening agency) and Keystone Policy Center (facilitators). *See Appendix B for the full list of organizations represented at this meeting.*

Discussion Summary

I. WELCOME

Mallory Huggins, Lead Facilitator, Keystone Policy Center, welcomed everyone to the meeting and reviewed discussion protocols.

II. DRAFT TAKEAWAYS AND RECOMMENDATIONS

Mallory reviewed the draft list of Task Force takeaways and recommendations, including a summary of feedback received during the comment period and proposed changes to address the feedback. Task Force members talked through each takeaway and recommendation and indicated whether they had any concerns. During this meeting, members also suggested agencies that could be the lead(s) on the various Task Force recommendations; these suggested leads were confirmed with agency participants in the Task Force. Where a member indicated concern, the Task Force discussed possible changes to address those concerns.

IV. CLOSING AND NEXT STEPS

Mallory reviewed the next steps for the Task Force. Keystone will incorporate today's discussion and agreements into the takeaways and recommendations, prepare the final report, and circulate a clean and proposed final version of both to the Task Force and SCC for final review between January 31 and February 17.

APPENDIX A
Virginia Renewable Energy Facilities Task Force
Charge Questions

The Task Force is charged with considering the following charge questions:

- Feasibility, costs, recycling and salvage opportunities, waste strategies, and liability for the decommissioning of materials used in renewable energy facilities;
- Potential impacts of underground infrastructure post-decommissioning;
- Potential impacts of the life cycle on farming, forestry, and sensitive wetlands;
- Potential impacts of life cycle and decommissioning costs on brownfields or previously developed project sites as compared to life cycle and decommissioning cost on agricultural or forest lands;
- Potential ratepayer impacts; and
- Potential beneficial economic impacts of solar, wind, and battery storage development.

APPENDIX B
Virginia Renewable Energy Facilities Task Force
January 10, 2023 Meeting Participant List

Participants representing the following Renewable Energy Facilities Task Force member organizations were present at the January 10, 2023 virtual meeting:

- American Clean Power Association
- American Farmland Trust
- Apex Clean Energy
- Appalachian Voices
- Appalachian Power
- Dominion Energy
- EDF Renewables
- Invenergy
- Old Dominion Electric Cooperative
- Rappahannock Electric Cooperative
- Reed Smith (observer)
- Strata Clean Energy
- VA Agribusiness Council
- VA Association of County Officials
- VA Dept. of Energy
- VA Dept. of Environmental Quality
- VA, MD & DE Association of Electric Cooperatives
- VA Office of the Attorney General
- VA Solar Energy Development and Storage Authority

In addition to Task Force members, staff from the convening agency (VA SCC), staff from the third-party facilitation entity (Keystone Policy Center), and guest speakers were also present at the meeting.

Appendix D: Task Force charter

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Virginia Renewable Energy Facilities Task Force Charter October 2022

1. Purpose

Virginia House Bill 774 (HB 774) was enacted directing the State Corporation Commission (SCC) to create a Task Force, in consultation with the Department of Energy and the Department of Environmental Quality, to analyze the life cycle of renewable energy facilities, including solar, wind, and battery storage components. HB 774 directs the Commission to submit a report [Commission Report] of the Task Force's analysis to the Governor and the Chairs of the House Committee on Agriculture, Chesapeake and Natural Resources and the Senate Committee on Agriculture, Conservation and Natural Resources no later than May 1, 2023, assessing the

> "(i) feasibility, costs, recycling and salvage opportunities, waste strategies, and liability for the decommissioning of materials;
> (ii) potential impacts of underground infrastructure post-decommissioning;
> (iii) potential impacts of the life cycle on farming, forestry, and sensitive wetlands; and
> (iv) potential beneficial economic impact of solar, wind, and battery storage development."

2. Governance

This document constitutes the Task Force's governance charter as approved by the SCC; it may be amended by the SCC, with consideration of input from the Task Force.

3. Advisory Responsibilities and Disclaimers

The Task Force serves in an advisory capacity. It is not a decision-making body and has no authority on SCC decision and duties. Any materials circulated and any views expressed within the materials or Task Force discussions do not state nor reflect those of the Virginia SCC.

4. Task Force Membership and Participation

Per HB 774, the Commission Task Force shall include representatives of local governments, the Virginia Solar Energy Development and Energy Storage Authority, the Department of Energy and the Department of Environmental Quality and at least one representative for each of the following sectors: agriculture, forestry, regulated electric service providers, competitive electric service providers, rural utility consumer services cooperatives, and renewable energy service providers, as well as organizations with expertise in the climate and environment.

Task Force members should make every effort to attend scheduled meetings. No quorum is required.

Task Force members may rotate participation of individuals from within their organization if necessary to attend meetings, however, each organization should strive for consistency in the participation of a primary representative. If more than one representative from an organization attends the same meeting, one representative should be designated as the active participant and others should attend as observers. Participants that have missed the prior meeting should make efforts to prepare by catching up on missed materials and conversations, via the meeting summaries and/or briefings from their colleagues.

Task Force members, invited presenters, and guests are volunteers and shall not receive compensation for their participation in the Task Force.

The Task Force shall be disbanded upon completion of its work.

5. Consensus

Task Force members shall strive for consensus in their findings and recommendations. Consensus is defined as general agreement that is shared by all the people in a group; it reflects a recommendation, option, or idea that all participants can support or abide by, or, at a minimum, to which they do not object. In other words, consensus is a recommendation, option, or idea that all can live with.

Level of agreement will be assessed and recorded on final findings or recommendations; each member will indicate whether they can support or abide by it, and do not object; if no participants object, then consensus exists and will be recorded, along with a summary of rationale and perspectives as relevant. If any participant objects, then there is not consensus. In the absence of consensus, differing views and rationales will be recorded. Informal assessment of support for a recommendation or finding may be conducted iteratively throughout the process and will not be recorded.

	Consensus exists if ALL participants are at level 1 or 2 (green or yellow):
1	I **support** this recommendation or finding.
2	I do not fully agree with the decision, however **I can abide by or live with** this recommendation or finding.
3	I **object** to this recommendation or finding; I cannot support, live with, or abide by it.

6. Meetings, Meeting Records, and Reports

The SCC shall establish a schedule for Task Force meetings in consultation with the facilitators.

Facilitators will serve as third party contractors for the design, facilitation, and reporting for the process. The facilitator will manage meetings of the Task Force in the most informal manner possible.

Public observation and comment will not be a component of the meetings; those wishing to participate should volunteer for the Task Force and abide by this charter.

Unattributed meeting summaries will record the date, members present, location of the meeting (physical or virtual meeting), issues discussed, summary of presentations made, discussion themes, outcomes, and next steps. Summaries will be available for the Task Force members, and final summaries, meeting agendas, and a list of Task Force members will be available to the public through the final report delivered to the SCC and Virginia General Assembly.

Task Force meetings will be recorded for note-taking purposes and to share with Task Force members who are not able to attend the meetings live. These recordings will not be made publicly available.

A draft of the report of the Task Force's findings and recommendations will be circulated for Task Force feedback, before it is finalized. The final report will reflect issues considered, whether consensus was achieved on each recommendation or finding, and a summary of the rationale for both supportive and dissenting views.

7. Task Force Member Operating Principles

- **Collaboration**: Be open to different perspectives while striving for collective, mutually agreed upon outcomes.
- **Curiosity:** Listen actively to others while they are speaking. Try to look at the topic through another's eyes, even if you remain in disagreement with them. Be willing to examine the premise of your own positions. Agree succinctly; disagree judiciously.
- **Inclusivity**: Be mindful of the presence of multiple backgrounds and areas of expertise. Respect different perspectives and avoid the use of acronyms and technical language.
- **Preparedness**: Prepare for and actively participate in meetings.
- **Focus:** Help the facilitators keep to the agenda; maintain focus on the issues and objectives.
- **Distractions**: Be respectful and aware of the impact of multitasking or the appearance of multitasking during meetings, both virtual and in person.
- **Good faith**: Commit to honoring these guidelines in good faith as a team member. Refrain from behavior or comments that denigrate other Task Force members or are disruptive to the charge and progress of the group.
- **Confidentiality and attribution:** Discussions are not for attribution. Feel free to express your own views about this effort and the topic outside these meetings but refrain from characterizing the views of other participants. Working documents marked as draft/deliberative documents should not be circulated beyond Task Force members. Task Force members should consider information shared in meetings or documents circulated to the Task Force to be public (that is, not confidential and able to be referenced in summaries and the final report) unless this information is expressly labeled as confidential to the facilitators and other Task Force members.

8. External Communications

The SCC or its designee shall be the official spokesperson regarding the Task Force process and shall be responsible for managing communications about the Task Force to the media, legislators, Governor, and other policy makers.

Task Force members are free to discuss their work with any interested party but in so doing must clarify they are speaking for themselves, and not the Task Force, and must abide by any confidentiality provisions regarding draft/deliberative working documents. Task Force members are urged to use discretion when discussing the group. Consistent with operating principles, members will refrain from communications that denigrate other participants or are disruptive to the charge and progress of the group.