VIRGINIA

Energy Storage Task Force: Final Report

Acknowledgements

The Virginia General Assembly created the Virginia Energy Storage Task Force and charged it with assessing costs and benefits of energy storage installations; assessing energy storage deployments in the bulk market, utility system, and behind-the-meter; and investigating barriers, incentives, and targets. This charge demanded input from across public and private sectors, and throughout the interconnected organizations and infrastructure that comprise the grid. The participants in the Task Force meetings rose to the challenge, and collectively contributed to this document.

The Virginia State Corporation Commission would like to thank the dozens of representatives of municipalities and communities; Virginia Offices and Departments; regulated, competitive, and rural electric service cooperatives; large energy-use customers; and energy storage companies who dedicated their time and effort to ensure this document provides a relevant, accurate, and valuable perspective on energy storage in Virginia.

In addition to contributions as members of the Task Force, several members served as chairs for topic-specific subgroups. The Virginia Energy Storage Task Force and State Corporation Commission would like to thank these individuals for their additional contributions and direction.

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The full list of Task Force members and meeting participants can be found in the appendices to this document.

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This document captures a snapshot of where energy storage stands in the Commonwealth of Virginia, and what promises and challenges are anticipated on the road ahead. As the deployments anticipated in these pages become reality and the barriers and challenges discussed here are toppled and overcome, the path will need to be revised and reimagined. Energy storage holds great promise; the input of Task Force members testifies to that promise. The next step will be to reimagine this document's thesis of "how to make it happen" into the future grid's "how to make it even more effective." Realizing the benefits and manifesting these promises will be the ultimate reward for the hard work of all those who contributed to this document.

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Executive Summary

This report was generated based on input from Virginia's Energy Storage Task Force, which was created at the direction of Virginia's General Assembly with their passage of HB 1183. The formation of the Task Force reflects Virginia's recognition of the important role energy storage will play in reaching the renewable portfolio standard targets set out in the Virginia Clean Economy Act (VCEA). Most relevant to this report, the VCEA requires investor-owned utilities to petition the Commission for necessary approvals to construct or acquire 3.1 gigawatts of energy storage by 2035, with an additional goal of 10 percent of that capacity coming from behind-the-meter (BTM) sources.

Energy storage provides a crucial benefit through its ability to smooth and offset load from intermittent wind and solar generation. These renewable technologies are necessary parts of a zero-carbon grid and therefore energy storage is also an essential part of Virginia's future grid. Some benefits associated with energy storage are therefore the same as those from achieving a zero-carbon grid including reducing greenhouse gas emissions associated with the electric grid and improving air quality.

Energy storage systems provide numerous other benefits for the grid as bulk market devices, utility integrated systems, and BTM deployments. Many of energy storage's benefits manifest as services they provide to the grid, which are called *use cases.* Use cases include, but are not limited to, voltage and capacity support, frequency response, energy shifting, non-wires alternatives, back-up generation, and demand response. Individual energy storage deployments can provide multiple use cases in an operating mode called *value stacking* which is one of the major benefits of energy storage systems.

Another important characteristic of energy storage systems is the numerous and diverse technologies available for deployment, allowing energy storage installations to be tailored based on geographic factors, energy demand, and other situation-specific variables. However, not all storage technologies can provide all storage use cases and certain technologies are better than others at providing certain services. Task Force members were particularly adamant about the need for "technology agnosticism" when planning for future grid needs. The evolution of the grid is uncertain, and the future mix of services required from energy storage throughout the Commonwealth will dictate which technologies are best to deploy in Virginia.

Different technologies also have different risks and barriers (*e.g.*, land use, real or perceived safety concerns, equitable access), which must be addressed to ensure systems are safe, reliable, and available. Outside of specific technology barriers and risks, there are regulatory, market, and local barriers facing deployments of energy storage devices in the bulk market, utility system, and BTM. These barriers are presented throughout this report and are included with the associated benefits of deployment in different market segments.

These technologies also all carry both soft and hard costs to deployment which can be weighed against their benefits to determine overall effectiveness of an energy storage system. Soft costs include interconnection fees, permitting costs, overhead costs, site design, and other costs not directly tied to the construction of energy storage installations. Some of these costs can be influenced by the Virginia State Commission Corporation (SCC) and the General Assembly by changing permitting requirements for energy storage devices or altering and influencing the interconnection process. Several recommendations to this affect are made in this report. Hard costs are much more dependent on the specific technology being deployed. Virginia can also help lower these costs in a variety of ways

including by making the installation process transparent and easy to follow, investing in research, development, full-scale demonstrations, and pilots for these devices, incentivizing customers directly for behind-the-meter installations, and allocating federal or regional funds to support energy storage projects. Most of these actions require future discussion on the source and amount of funds that would be required.

Discussion of these benefits, barriers, technologies, and costs is informed by Task Force discussions, and is therefore not comprehensive. The References Appendix includes material providing further information on energy storage and deployments nationally. The report focuses on the energy storage topics most relevant to Virginia and its ratepayers.

The Task Force included a group of diverse stakeholders that met for thirteen separate meetings from February 2021 to September 2021 to discuss items specified by the General Assembly and the SCC. Throughout these meetings, recommendations related to energy storage and its deployment and operation in Virginia were encouraged and discussed. These recommendations are divided into two categories in this report: consensus recommendations (i.e., those that were generally supported by Task Force members) and non-consensus items. The Task Force suggests immediate consideration of consensus recommendations by the General Assembly and SCC and believes implementation of these recommendations will help Virginia reach VCEA targets and become a national leader in energy storage. Table ES-1, below, presents these recommendations. The Task Force also urges further consideration of non-consensus recommendations (available in the body of report) as resolutions on many of these ideas can help set clearer guidelines for stakeholders deploying energy storage systems in the Commonwealth.

Table ES-1: Consensus Recommendations from the Task Force did not necessarily receive unanimous support but were generally supported by a collection of different stakeholder groups

Consensus Recommendations
Permitting and Regulation
Improve energy storage permitting to be more supportive of faster deployment
Develop a guidebook to help local jurisdictions, developers, and installers standardize and navigate both the interconnection process and local zoning and land use approval processes for energy storage
Behind the Meter Incentives
Provide a behind the meter incentive directly to consumers to increase energy storage deployments (potentially through bring your own device programs)
Additional Reports, Studies, and Models
Learn lessons from other states on research, development, and deployment, pilot programs, permitting, interconnection, distributed energy resources, bring your own device programs, etc.
Bring in a 3rd party consultant to analyze existing and future grid needs in Virginia tied to implementation of the Virginia Clean Economy Act
Develop a roadmap to help Virginia stakeholders understand how to reach Virginia Clean Economy Act goals
Education Programs
Train local first responders on fire safety related to energy storage devices
Stand up consumer energy storage education programs
Continue to convene stakeholder groups such as the Virginia Energy Storage Task Force

Funding and Incentives
Allocate additional funding or support for SCC or similar entities
Increase state funding for research, development, demonstration, and pilot project for energy storage technologies
Use money from the regional greenhouse gas initiative to push energy storage forward in the state
Leverage federal funding for internet access
Integrated Resource Planning (IRP) Process
Ensure the IRP process includes energy storage issues mentioned in HB1183
Technology/Infrastructure
Cast a wide technology net
Support advanced metering infrastructure
Other
Create resilience centers that utilize energy storage to provide power to distressed communities in times of power loss

Conclusions and Next Steps

While the recommendations in this report represent necessary steps to realize the Commonwealth's desire to address the Virginia Clean Economy Act energy storage targets, the Virginia Energy Storage Task Force does not perceive any of the identified barriers to energy storage as detrimental or insurmountable. Rather, the Task Force recommends that it continues to meet to monitor target progress and to perform dedicated discussion and analysis, resulting in informed recommendations that unpack the complexities of energy storage and provide clear paths forward for the Commonwealth's energy storage efforts.

1. Introduction

Virginia established itself as part of the group of trailblazing states setting carbon-free electricity goals with the signing of the Virginia Clean Economy Act (VCEA) on April 11, 2020.[1] In this legislation, Virginia put forth the largest target for energy storage deployments in the country (3,100 megawatts (MW) by 2035). This target is an important recognition that carbon-free goals rely on deployment of renewable technologies that will require energy storage to deliver reliable, uninterrupted power to Virginia's citizens and industries. It is important to remember that Energy Storage targets are a piece of a larger effort to move toward a decarbonized grid in Virginia and any actions or efforts undertaken in support of energy storage deployments should be conducted in a way that reduces overall greenhouse gas (GHG) emissions and other contributions to climate change in the state.

Formation and Actions of the Virginia Energy Storage Task Force

To help the Virginia legislature guide the future of energy storage that will be driven by the VCEA's targets, the Virginia General Assembly instructed the Virginia State Commission Corporation (SCC) to create the Virginia Energy Storage Task Force through HB 1183. The Task Force's purpose is three-fold: assess the potential costs and benefits of energy storage installations; assess how different stakeholders deploy energy storage resources in the bulk market, the utility system, and behind-the-meter; and address many diverse topics around incentives and targets. Additionally, in HB 1183, the General Assembly directs the Task Force to:

> *"Evaluate and analyze regulatory, market, and local barriers to deployment of distribution and transmission connected bulk energy storage resources to help integrate renewable energy into the electrical grid, reduce costs for the electricity system, allow customer to deploy storage technologies to reduce their energy costs, and allow customer to participate in electricity markets for energy, capacity, and ancillary services."*

The SCC also provided additional questions and assignments to the task force in Case No. PUR-2020-00120. Most of these assignments were addressed by the Task Force and corresponding questions and answers can be found in Section 7 of this report.

The Task Force consists of more than 100 members from many different organizations. These organizations include regulated electric service providers, competitive electric service providers, rural electric cooperatives, PJM (Virginia's regional transmission organization (RTO)), commercial and industrial customers and related associations, energy storage companies and their associations, the Virginia Solar Energy Development and Energy Storage Authority, the Virginia Department of Energy (formerly the Virginia Department of Mines, Minerals and Energy), and the Office of the Attorney General.

The Task Force discussed requested topics through thirteen facilitated meetings. Five Task Force meetings addressed wide-ranging, higher-level topics. The first meeting explored general benefits and concerns tied to energy storage installations and what ideal deployments would look like in Virginia. The next three meetings tackled each of the different market segments requested in the Task Force legislation (*e.g.*, bulk market, utility system, behind-the-meter), focusing on the specific barriers,

[1] governor.virginia.gov/newsroom/all-releases/2020/april/headline-856056-en.html

opportunities, and costs and benefits tied to these energy storage deployments. The last meeting afforded Task Force members an opportunity to provide additional feedback on the recommendations outlined in this report. To encourage open and honest communications between participants, the source of comments was kept anonymous in notetaking and reporting of meeting results. As such, there is little attribution in this report given to the stakeholder groups who were supporters or detractors of any ideas.

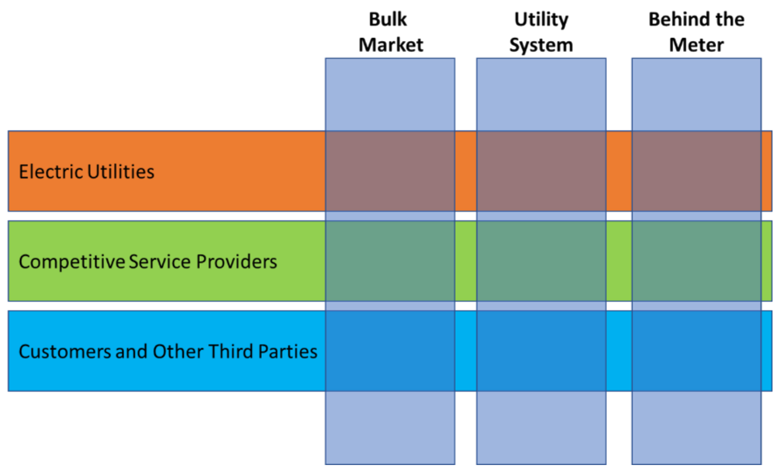

Figure 1: The Virginia Energy Storage Task Force and its Steering Committee identified this framework to shape discussions over the course of its meetings. Each electricity system segment (bulk market, utility, and BTM) was covered during a separate meeting.

In addition to five large Task Force meetings, eight targeted discussion meetings addressed more specific topics. While all Task Force members were encouraged to join these meetings, the topics lent themselves to a more specific group of participants. These groups covered the following areas: technology, permitting and regulations, hosting capacity and integrated resource plans (IRPs), goals and metrics, customer engagement and equity, and markets. The technology subgroup met twice while all others had one session.

All participants were given the chance to review and comment on the first draft of this Final Report and their comments were tracked and addressed where possible.

VCEA Targets

The VCEA sets a renewable portfolio standard (RPS) of 100 percent carbon-free energy by 2050 for its two largest investor-owned utilities (IOUs), Dominion Energy Virginia (Dominion) and Appalachian Power (APCo), which provided approximately 80 percent of electricity to customers in the Commonwealth in 2019, according to the EIA.[2] The VCEA also establishes energy efficiency standards and seeks to advance offshore wind, solar power, and distributed generation. Most relevant to this report, the VCEA requires Virginia's IOUs to petition the Commission for necessary approvals to construct or acquire 3.1 gigawatts (GW) of energy storage capacity by 2035 and sets a goal that 10 percent of that capacity come from behind-the-meter (BTM) sources.

Definition of Energy Storage

The SCC defines energy storage as: "any technology that is capable of absorbing energy, storing that energy for a period of time, and re-delivering that energy after storage" (Commonwealth of Virginia, 2020). The Task Force accepts the existing definition which has been subject to public comment and is inclusive and adaptable to future technology development and includes a broad technology scope. While the definition does not specify that energy storage technologies must be charged by green or

[2] eia.gov/electricity/state/Virginia/.

renewable electrons, this distinction is not necessary since the VCEA's RPS of 100 percent carbon-free electricity by IOUs will result in storage primarily charged by clean electrons.

Driving Forces of Energy Storage Deployments

Carbon-free[3] electricity goals are one of the biggest drivers of energy storage installations in the Commonwealth with cost declines and resilience needs driving deployment as well. It is anticipated that these goals will be met largely by increasing installations of variable renewable energy generation from onshore and offshore wind and solar systems. Increased carbon-free generation and the VCEA energy storage goals together will have a dramatic impact on how the electric grid operates in Virginia. Energy storage supports more variable renewable energy generation by smoothing intermittence. Energy storage technologies and applications are also considered crucial to meeting the carbon reduction goals of the VCEA.

Other driving factors for energy storage deployment in Virginia may include non-wires alternatives projects which can delay and/or eliminate the need for traditionally disruptive and expensive transmission and distribution (T&D) wires installations. BTM applications for industrial, commercial, and residential customers may also lead to further installations as those customers seek to install back-up power or seek to improve their electricity rates through arbitrage. There are many other uses for energy storage (covered in this report) that may drive new deployments in Virginia.

What is clear is that energy storage is essential for maintaining a reliable, affordable, and equitable grid and more than the mandated 3.1 GW of energy storage will likely need to be installed by 2035. Fortunately, the costs of energy storage have been declining rapidly and are expected to continue to do so with further development and deployment. It is important to note, however, that storage is not inherently clean and that merely deploying storage will not necessarily, on its own, result in systematic emissions reductions.

Achieving Near- and Long-term Energy Storage Targets

Currently, lithium-ion batteries are the most prevalent energy storage technology on the market and are expected to remain so in the short-term. Lithium-ion batteries dominate the market because they are currently the lowest cost storage technology and mesh well with solar and other renewable deployments. Current systems mostly operate by providing around 4 hours-per-battery of reliable energy delivery at full output which can balance energy discharge from high production periods (mid-day) to high demand periods (afternoon to evening). Slowing or staggering output from these batteries can extend useful energy deliveries over longer periods.

As Dominion and APCo put plans in motion to reach their first interim targets (275 MW by 2025; 1,350 MW by 2030), most installations will consist of lithium-ion batteries. However, further developments and changes to grid needs should expand the technology portfolio beyond just lithium-ion batteries for the remaining deployments needed to reach 2035 goals. An overview of the technologies explored by the Task Force which will contribute to the energy storage targets is presented later in this report.

As the grid continues to evolve to support more renewable generation, more energy storage that can shift load beyond 4 hours will be required. Developments of technology types that can offset generation

[3] "Carbon-free" is often used as a shorthand for reducing greenhouse gases generally. Significant greenhouse gases from energy production and use include carbon-dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).

by days, weeks, and months may ultimately be required to ensure the grid can maintain current electricity costs and continue to operate reliably. Therefore, technology developments may be required to cost-effectively provide 10-hour and multi-day storage in Virginia to support the grid of 2035 and beyond.

Benefits of Energy Storage

Strategic deployment of energy storage installations provides multiple benefits. By affording a means to hold generated energy for later consumption, storage technologies balance both demand load and generation capabilities. Traditional patterns of high demand in commercial zones during the day and residential zones in mornings and evenings have shifted since the beginning of the COVID-19 pandemic, with an increase in telework. In addition, continued development and deployment of renewable energy generation—including distributed generation—will provide new sources of electricity beyond traditional generation.

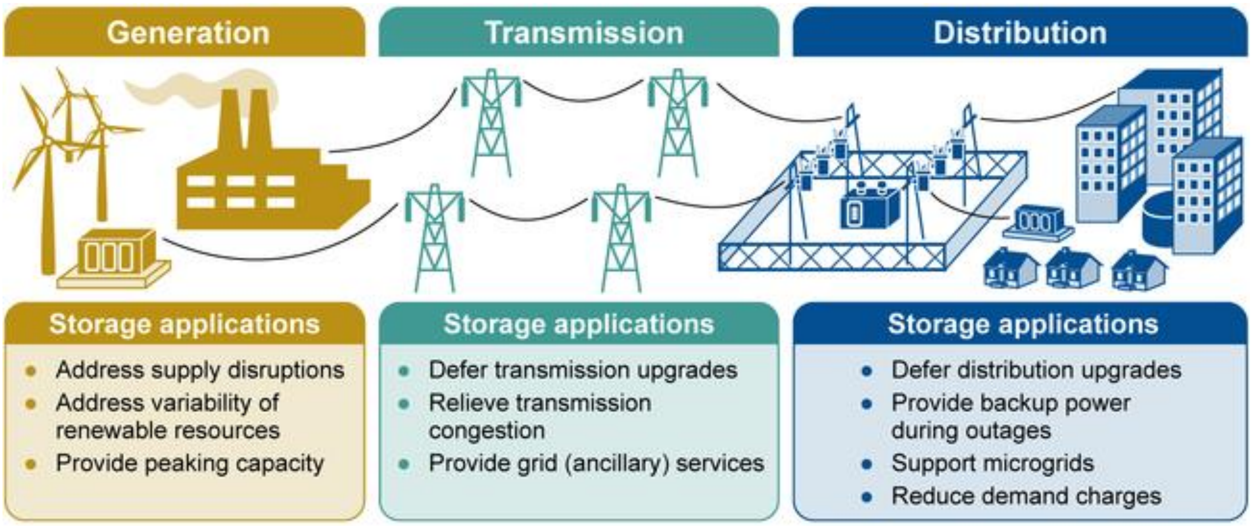

Figure 2: Energy storage offers benefits across the power grid, from generation to end-use.
Source: U.S. Government Accountability Office | GAO-18-402

Advancing energy storage technologies will improve the ability to balance supply and demand cycles by absorbing excess generated energy at times of reduced demand and/or increased generation and providing a reservoir of energy for times of increased demand and/or reduced generation. This reservoir will help to stabilize the operation of the grid and thereby improve both its reliability and resilience. Means to store energy will also allow an even greater increase in deployment and integration of renewable energy resources, as the ability to store excess generation and draw on the stored capacity during reduced generation will moderate fluctuating generation cycles inherent to most renewable energy sources. Energy storage, particularly in combination with other distribution energy resources and energy efficiency, can also provide cost-effective non-wire alternatives by avoiding or deferring investments in conventional (poles-and-wires) transmissions and distribution assets. These operational improvements may yield reduced costs for generation and system operations, which in turn can provide savings to energy customers. Facilitating increased deployment of distributed energy resources (DERs) and storage technologies may also allow some customers to participate in energy, capacity, and ancillary markets.

Costs of Energy Storage

Many different cost categories were identified throughout the Task Force's meetings. These costs come into play throughout the lifecycle of an energy storage device and not all are accounted for in every cost comparison or cost benefit analysis. The Task Force was unable to come to consensus on the best metrics to evaluate the cost of an energy storage system as these costs are heavily dependent on the size, use, and location of the system. There are some accepted ways to measure costs across technologies including a levelized cost of storage (LCOS) and technology baselines. One of the most prevalent LCOS is published by Lazard who presented during the second Technology subgroup meeting.[4] For technology baselines, the National Renewable Energy Laboratory (NREL) publishes an Annual Technology Baseline which provides transparent breakdowns of its cost analyses.[5]

Soft Costs

Soft costs refer to interconnection fees, permitting costs, overhead costs, site design, and other costs that are not directly related to the actual construction of the energy storage installation. Before an energy storage installation moves forward with any physical infrastructure development, a site must be selected. The exact site selected is based on several factors including the expected use case of the storage technology and the cost of land in the area. Locating storage in or near high use areas can potentially benefit system operations and reduce transmission costs. Hosting capacity tools can help developers pick a site with fewer grid constraints resulting in potentially lower network upgrade costs to the developer.

When developers want to connect to the grid, they must submit an interconnection application to the relevant utility, join the interconnection queue, and an interconnection study must be performed. All of these actions carry a cost. Also, developers must pay for the infrastructure to physically connect their device to the grid as well as pay for any upgrade necessary to ensure that their connection can be made safely and reliably.

Deployment of energy storage in Virginia is governed by energy storage regulations promulgated by the SCC and Virginia Department of Environmental Quality (DEQ). Depending on the type of license sought, the type of applicant, and the application path, a registration fee may be required.[6] Outside of those regulations, permitting costs may also be required of energy storage deployments on the grid. All these actions also take time which also adds to the bill for developers though costs list employee pay and interest payments.

Additionally, the RTO managing Virginia's grid, PJM, has an interconnection study queue process for energy storage projects. This study process must be followed before such facilities can receive permission to be electrically connected and participate in regional markets. The time involved in this study process slows the deployment of energy storage systems and translates into additional development costs for energy storage installations.

[4] lazard.com/media/451566/lazards-levelized-cost-of-storage-version-60-vf2.pdf.
[5] atb.nrel.gov/electricity/2021/index.
[6] See SCC's rule 20VAC5-335-90 (Licensing of energy storage aggregators)

Some secondary grid costs include the operation and maintenance of capacity markets and grid operation which will be complicated by the bi-directional and distributed nature of energy storage. Similarly, models that simulate the grid or provide clarity on hosting capacity have computational costs that increase as the complexity of the grid increases with more energy storage devices in place.

Hard Costs

Hard costs are expenses directly attributable to construction including labor, land purchase and shaping, the technology, and other materials. The research and development (R&D) costs of technologies also play into the ultimate cost for the technology from manufacturers. Additionally, supply chain costs such as materials, manufacturing, and transportation all factor into the price developers pay for their equipment. Not surprisingly, these costs vary heavily between different technology types and installation sizes. Continued development and improvements to economies of scale can drive down costs in the future, however.

Other Lifecycle Costs

Part of the cost of technologies is their operations and maintenance (O&M) costs. These costs are variable depending on the siting of the technology and the nature of the energy storage device itself. O&M profiles also change over time as assets age. O&M costs for the most commonly deployed energy storage technologies are significantly lower than that of conventional assets that provide capacity, such as traditional generators.

Other costs to consider when thinking about the entire lifecycle of energy storage device include environmental costs such as emissions (or avoided emissions) or water usage. Additionally, some Task Force members encouraged the legislature to consider sourcing of materials for energy storage devices, notably cobalt which has dubious supply lines. It should be noted that the U.S. government and industry are working to address supply chain risks and vulnerabilities for energy storage technologies.

Other lifecycle costs include disposal and recycling costs which may be mitigated by re-purposing or re-using older energy storage devices but are often not accounted for in cost benefit analyses. There are also costs tied to ensuring safety of certain storage technologies. These costs can manifest themselves as requirements for more land purchase if setbacks require more empty space around an installation.

Customer Costs

As the grid transitions to zero-carbon generation and requires more new energy storage infrastructure, utilities may need to pass certain costs through to ratepayers (*e.g.,* capital investments) while other costs will be shifted to developers or to other stakeholders. Some consumers may voluntarily invest in energy storage for their own benefit (*e.g.,* BTM installations). Important in the discussion of costs are which specific costs end up being presented directly to the ratepayers. Public opinion can sour quickly if energy storage is associated with unexpected spikes in electricity prices. Avoiding this situation with proper planning and communicating the benefits of energy storage deployments will be important to show how the systems are either contributing to lower electricity costs or providing customers value.

Recommendations of the Task Force

Task Force members provided more than 50 recommendations for the state legislature, the SCC, and other Virginia stakeholders, covering ten topic areas. After discussion, some recommendations were consolidated, and others removed resulting in the 40 recommendations below. While some ideas received general support (17 recommendations), others remained in limbo due to differing viewpoints on the topics (23 recommendations). Recommendations that received general support and those that lacked consensus are summarized below.

Consensus Recommendations
Permitting and Regulation
Improve energy storage permitting to be more supportive of faster deployment
Examine and reevaluate permitting requirements to ensure the intent of policy directions matches the language in the process or legislation (i.e., some technical details are portrayed incorrectly or in restrictive ways that do not support broader energy storage solutions). Permitting rules should account for technology diversity because storage facilities can look and operate differently depending on the technology used. Passing technology specific legislation will require that relevant lawmakers keep track of research, development, and deployment (RD&D) in the energy storage space. Additionally, Task Force participants recommend harmonizing permitting requirements between the SCC and DEQ. The Commonwealth should also strive for a streamlined permitting process that promotes development of all energy storage, keeping in mind the varying attributes at each facility. For example, BTM storage should be differentiated from other front-of-the-meter solutions where possible.
Develop a guidebook to help local jurisdictions, developers, and installers standardize and navigate both the interconnection process and local zoning and land use approval processes for energy storage
For developers that are new to Virginia, the path from planning to deployment is filled with uncertainty. Additionally, counties throughout the Commonwealth currently have a patchwork of approval and zoning requirements. A guidebook that covers all the permitting and regulations relevant to energy storage deployments at the bulk-, utility-, and BTM-scale would help new installers navigate the procedures for installation. Such a guidebook should address permitting and regulations from PJM, the Commonwealth, IOUs, and locals while ensuring to maintain adequate safety protections. Some Task Force participants emphasized the need to also include suggested standards for local governments related to zoning and approvals (*i.e.*, provide a model ordinance). Additionally, this guide could be expanded to include ideas for customers looking to install BTM devices. Industry or an energy storage focused non-governmental organization could be asked to fulfill this recommendation.
Behind the Meter Incentives
Provide a BTM incentive directly to consumers to increase energy storage deployments (potentially through bring your own device (BYOD) programs)
There are a number of incentives that can be provided to encourage consumer deployment of energy storage systems. Funding for BYOD programs is one way to encourage those BTM systems. An example of this type of program can be seen in Vermont where Green Mountain Power and

Renewable Energy Vermont provide a direct payment to consumers to allow grid operators to utilize consumers BTM devices for grid services.[7] Systems like these do need to be cognizant of not overdrawing for grid services and giving consumers enough capacity to draw on their own devices for back-up power.

Other ways to provide incentives to consumers would be tax credits or utility rebates. The key issue facing regulators is how to cost-effectively finance such incentives in Virginia without one customer class directly subsidizing another. Once funding pathways are established, these types of programs can be effective in increasing BTM deployments.

Additional Reports, Studies, and Models

Learn lessons from other states on RD&D, pilot programs, permitting, interconnection, DERs, BYOD programs, etc.

Virginia's ambitious energy storage targets may be the highest in the country, but they are not the first. California, New York, New Hampshire, and Massachusetts, among others, have already put energy storage targets and incentives in place. The value energy storage is already providing can be seen in these states' grids. California in particular continues to deploy large amounts of energy storage with over 1.5 GW planned for deployment in 2021. Virginia can learn lessons from the successes and challenges that these states have experienced in their infrastructure build outs. Legislations and regulations on BYOD programs, aggregation, BTM, net metering, advanced metering infrastructure (AMI) and emission management can be usefully emulated in Virginia to design an ecosystem that will help reach the VCEA's goals efficiently.

Bring in a 3rd party consultant to analyze existing and future grid needs in Virginia tied to implementation of the VCEA

The VCEA mandates substantial changes to the generation portfolio of the grid through ambitious net-zero targets. The resulting changes in infrastructure will result in a grid that will be unrecognizable in several decades. An uncertain future is attended by risks and challenges to deployments that can endanger the reliability and cost of the grid. A simulation of the optimum mix of energy storage resources and other clean energy technologies that will be needed to achieve VCEA requirements and maintain reliable electric service will help identify the use cases of energy storage required by a low-carbon grid. Energy storage capacity and duration needs by technology types (short and long duration) would also be evaluated in this effort. Inputs to this analysis could be aligned with Phase I and Phase II utility IRP inputs, as defined by the VCEA. Any exploratory modeling activity should be performed in parallel to current energy storage developments and should not delay current efforts.

Develop a roadmap to help Virginia stakeholders understand how to reach VCEA goals

While this report provides a starting point for understanding the state of energy storage and related barriers and benefits of energy storage deployments, further exploration of specific policy actions that can be taken to address associated these barriers is warranted. A road mapping effort would give another chance for stakeholders to discuss and come to consensus on more specific recommendations that eliminate the most disruptive barriers to energy storage deployment. This

[7] greenmountainpower.com/rebates-programs/home-energy-storage/bring-your-own-device/

approach may be duplicative with the 3rd party consultant effort above, and these two could be combined.

Education Programs

Train local first responders on fire safety related to energy storage devices

Operation of most electrical equipment and energy storage technologies have attendant risks of fire. Due to the different technologies in use, energy storage devices are not a monolith in types or natures of risk, and the understanding of the chemical and thermal properties of different technologies is essential for firefighters, electric line workers, and other emergency personnel to respond appropriately to fires (both electrical and chemical) at energy storage devices. A training program that educates responders about differences in battery technologies and the potential for back feed onto the grid from any energy storage device is essential for safe deployment and operation of energy storage devices.

Current practices put vendors and technology providers in charge of training first responders. At a minimum, the state should be sure to work with vendors to enhance this education with safety courses and by maintaining accurate safety resources. Some Task Force participants suggested utilizing an independent state-run safety commission. Funding for this activity is uncertain, but many Task Force members felt this was worth of receiving state funding.

Stand up consumer energy storage education programs

As energy storage programs are put into place and BTM installations are encouraged to reach the 10% VCEA goal, customers will play an important part of the continued evolution of energy storage in Virginia. Helping ratepayers understand the use cases of energy storage and the options for technology, size, and location of BTM devices will encourage future deployments. Any consumer outreach should be coordinated to eliminate the patchwork of recommendations that can result from a disjointed approach. An agency like the Division of Energy would be well suited to align the state's approach to customer outreach.

Continue to convene stakeholder groups such as the Energy Storage Task Force

The short timeframe of the development of this report was insufficient to drive consensus on many recommendations. A continued normal cadence of meetings with this same or similar groups related to energy storage would be supported to drive some of these topics forward. Additionally, direct communication and engagement with local stakeholder groups and customers themselves was absent for this effort. Expanded effort and engagement, especially with environmental justice-affected and fenceline communities, around energy storage and other VCEA actions is warranted.

Other Funding and Incentives
Additional funding or support for SCC or similar entities
Potentially increase funding or support for the SCC to give them more resources to dedicate to exploring energy storage permitting requirements and to review more proposed changes that can help deploy more energy storage in Virginia. The SCC is funded independently and changes to legislation might be required to increase SCC's resources from the Commonwealth's general fund. Task Force members expressed that increased funding is preferred over standing up a new agency.
Increase state funding for RD&D and pilot projects for energy storage technologies
Task force participants were supportive of additional funds being utilized to help with energy storage technology development and to support future full-scale demonstrations and deployments. The Task Force did not discuss the specific funding sources for such projects.
Use money from the regional greenhouse gas initiative (RGGI) to push energy storage forward in the state
With regards to RGGI funds, the Task Force made a general suggestion to dedicate these funds toward energy storage for resilience through incentives, rebates, etc. There are other states that can be looked at as examples for how to utilize RGGI funds effectively including New York and Maine. One specific recommendation by Task Force participants was to use RGGI funds to support energy storage resilience projects that provide communities with assistance toward climate adaptation.
Leverage federal funding for internet access
Advanced electrical operation is dependent on real-time information provided from distributed generators and consumers of energy. The backbone of all communications infrastructure relies on the internet. Rural customers in Virginia have limited access to high-speed internet, which will limit the operation of advanced infrastructure. Where possible, Virginia should accept federal funding *(e.g.*, from Rural Utility Service, Virginia Telecommunication Initiative (VATI), American Rescue Plan (ARPA) or other funding sources) to expand internet access. In addition to improving grid operations, fast internet access enables job growth and productivity. This recommendation will support the efforts of Virginia's Electric Cooperatives, who are working toward the Commonwealth's broadband goals.
Integrated Resource Planning (IRP) Process
Ensure the IRP process includes energy storage issues mentioned in HB1183
HB1183 directed the SCC to set up this Task Force to perform the duties outlined in this report. This recommendation therefore stresses that as IRPs are developed by instate utilities, they include how the utility plans to overcome any regulatory, market, or local barriers to energy storage deployment. In addition, the IRP should set out how storage technologies are expected to impact system costs and how the utility is working toward ensuring that customers can install devices BTM and participate in energy storage markets. Also, the IRP should detail how energy storage deployments are impacting the T&D system, whether it be through non-wires alternatives or other utility services.

Technology/Infrastructure

Cast a wide technology net

Policymakers should be made aware that energy storage does not just refer to lithium-ion batteries, despite their dominance in the market today. Numerous other energy storage technologies have characteristics that can support the grid in diverse and useful ways. Any legislation or communication around energy storage should be sure to account for a variety of use cases of energy storage and the value of diverse energy storage technologies to achieve them. The Commonwealth should also seek to avoid lock in by mature and market penetrated technologies at the expense of potentially superior future technology improvements.

Support AMI

It should be noted that AMI refers to a system that enable two-way communication between consumers and utilities using smart meters, communications infrastructure, and data systems. AMI can provide both the utility and consumers more granular minute-to-minute data regarding energy use and production, enabling greater transparency into grid operations, DERs, and deployment of time of use (TOU) rates and similar tariffs. While AMI is not necessary for the deployment of BTM storage, the additional insights AMI can provide and the rate structures it enables reveal, enhance, and provide a platform to fully utilize the benefits BTM storage creates. To do so, the AMI would have to be set up so that it separately measures the operation of BTM storage outside the operation of other connected DER. Another potential benefit of AMI is that it can allow consumers access to data on their energy use and how their DERs are being used by the grid. Policymakers, regulators, utility leaders, and other stakeholders should also consider the lessons learned by other states with substantial AMI deployment, such as California, to maximize the cost-benefit ratio of AMI.

Other

Create resilience centers that utilize energy storage to provide power to distressed communities in times of power loss

Centers like those described above would result in more state funded energy storage deployments and provide services to underserved and disadvantaged communities. With increases in impactful natural disasters around the country, ensuring that Virginia's citizens remain protected and safe through public projects like resilience centers would be a major service to the people of the Commonwealth.

Recommendations Lacking Consensus

Permitting and Regulation

Improve and/or standardize the distribution system interconnection study process to make it easier for energy storage resources to connect to the grid

The study process should ensure that interconnection actions are specifically designed and appropriate for the real-time operating characteristics of energy storage. PJM is considering standardization of the process as well. Task Force participants noted it would be useful for that standardization to include more transparency as the PJM process is much longer than 6 months and is typically the slowest phase of the interconnection process.

This recommendation lacks consensus because it is difficult for the SCC and Virginia's legislature to dictate that PJM should speed up the interconnection process and help align the process for all developers in Virginia. Some Task Force participants were also not convinced that energy storage need a specific carve out as there was more concern around improving standard regulations in general. Also, requests for a more transparent process must be balanced with the need for security as utilities cannot disclose critical energy infrastructure information (whether locally or federally designated) for safety and security reasons.

Lower soft costs by accelerating deployments in the near-term

Soft costs refer to interconnection fees, permitting costs, overhead costs, site design, and other costs that are not directly related to the actual construction of the energy storage installation. These soft costs can be lowered over time as developers, regulators, permitters, customers, and other market participants learn from early deployments and can lower the time and effort required for these procedures. Soft costs can account for nearly half of storage costs. While subsidies or other financial assistance for early deployments would be welcomed by developers, they were not viewed as necessary by all Task Force participants.

Reconsider permitting and RFP requirements for third-party systems, specifically the siting and spacing restrictions

Dominion currently follows Virginia adopted versions of the International Fire and Building Codes that are typically enforce by local county officials when projects are built. These codes include the Virginia Uniform Statewide Building Code and the Virginia Statewide Fire Prevention Code. Dominion also plans to design projects that comply with the National Electric Code. The requirements for setbacks and spacing in Dominion's RFPs are in place for safety reasons but some Task Force members felt these requirements are stricter than other established industry practices. Some Task Force participants suggested aligning Dominion's requirements with other industry best practices to help decrease systems costs and allow systems to be installed in locations that may provide the highest value. This recommendation will require further negotiation to move forward as Dominion has its own concerns around fire safety of energy storage devices.

Set up tariff rates to deal with and recognize the bi-directional nature of storage

This recommendation was to have the SCC, utilities, and/or the General Assembly design tariffs that follow cost causation principles and send price signals that incentivize the most valuable operation of energy storage, whether that be charging or discharging energy. Utilities have a wide range of tariffs based on the load profile and electricity needs of customers and assets, and a similar one could be introduced for the services storage provides. Additionally, different tariffs may be required for front of the retail meter systems versus behind the retail meter deployments.

Some challenges of this approach are that it is difficult to draw a jurisdictional line and say how the tariff should be set up. There will be different cost recovery mechanisms required. In addition, the costs of a tariff proceeding for smaller utilities may be an issue, and other mechanisms to approve such tariffs may be needed. This recommendation was not widely enough supported to be driven to consensus by the group.

Conduct a preapplication process that looks at the ability to both inject and withdraw power at the same location to eliminate more interconnection studies

A preapplication process would reduce surprises tied to interconnection especially if storage devices are initially looked at as both a generator and consumer of energy. The incorporation of bidirectional consideration would be helpful later in the interconnection process. This is a proactive approach that would make assumptions on the long-term operating modes of an energy storage system to prevent the need for future studies. The burden of this preapplication would fall on developers unless it is supported in another fashion. An additional challenge with this approach is that the operating paradigm of an energy storage system can change over its 20-year operation even with foresight. This was not a consensus recommendation because it is a specific recommendation that Task Force participants felt could either help deployments or become a hurdle based on any potential preapplication process' design and implementation. Careful consideration is required before introducing such as process.

Additional Reports, Studies, and Models

Produce a full lifecycle assessment (LCA) of different technologies

An LCA would look to provide a general resource for evaluating technologies with some assumptions based on location and technology metrics such as discharge time and rates. Participants also indicated that the life cycle assessment should consider supply chains, environmental impacts, and decommissioning.

This recommendation did not receive consensus because some participants felt that while good in theory, LCAs can be used to throw up obstacles to future energy storage developments. Additionally, the assumption of LCAs can hamper their accuracy. The federal government and national developers are also assessing concerns over disposal and material sourcing which could make this effort duplicative if Virginia undertakes it on its own. Supporters of this recommendation indicated that it should be undertaken even with national efforts to provide Virginia its own perspective on technologies and installations.

Develop a transparent, statewide hosting capacity platform

Hosting capacity tools show sites that can utilize capacity and provide a signal on good areas to consider development for energy storage systems. Dominion has recently started publishing its own hosting capacity tool, which it updates quarterly. This recommendation wants hosting capacity evaluated for the entire state.

This recommendation lacked consensus because the information provided by a hosting capacity tool can quickly become outdated as the analysis can only be run so often. This is primarily due to the model complexity and the computing power necessary to run a full analysis, with computing time taking days to weeks depending on the depth of the analysis and the size of the system. This currently limits the effectiveness of the tools, although it should be noted that future advancements in computing power will lower the processing times and costs. Additionally, grid security concerns exist around showing specific locations that are ideal for deployment which limits the granularity the tool can provide. The Task Force does encourage others to develop a hosting capacity tool like Dominion's, while also recognizing that development of such a tool would be costly.

Conduct a study on geological storage in Virginia that can be used for hydrogen, air, or carbon dioxide storage

Proponents of this recommendation indicated that the Virginia Department of Energy would likely be the best agency to perform this study (partnership with USGS could also be explored). This study was not widely accepted as a recommendation because numerous studies have already been conducted on geological storage, including work by Virginia Tech, and can be used if required.

Generate a committee report on what Virginia's citizens need and want from energy storage in their communities

The Department of Housing and Community Development has put together a working group that is looking at providing energy efficiency and renewable energy technology to those that cannot afford those installations. Energy storage could be included in these efforts. This recommendation was not supported heavily so remains without consensus.

Behind the Meter Incentives

Utilize energy storage when deploying charging infrastructure for electric vehicles (EVs)

Storage can be a cost-effective solution for meeting increased distribution capacity needs of direct current (DC) fast charging infrastructure. As fleet, medium, and heavy-duty vehicles continue to electrify there will be continued expansion of charging infrastructure. Stationary storage installed at these charging locations can be utilized for both transportation and grid needs. While there were no major objections to this recommendation, the overlap with transportation electrification caused some pause from participants and not enough support was garnered to reach consensus.

Enable TOU rates and other price signals to encourage new BTM installations

In addition to TOU rates, demand charges can also play a role in incentivizing BTM installations for certain customer segments. All price signals should also be considered, not just TOU rates. Some participants expressed a need to allow for more experimentation with rates. It is not a fast process to get a rate experiment approved. This recommendation did not reach consensus because of its complexity but all agreed that it is worth further discussion.

Targets

Provide clearer goals and targets that include duration and metrics for future requests for energy storage deployments

This recommendation would encourage the Virginia legislature to set goals in terms of megawatt-hours (MWh) or encourage targets to refer to a minimum threshold for a storage duration. The Task Force was split on providing this clarity as anything beyond a capacity target (*e.g.*, MW) is unnecessary at this time. Also, the optimal mix of storage durations and responsiveness will vary over time along with the mix of resources. Any change to energy storage targets should consider what that change will signal to developers, utilities, and other stakeholders.

Review targets on a set schedule so that targets can be potentially accelerated based on progress

This recommendation would encourage the state to evaluate its interim targets on a fixed timeline to determine if more aggressive targets are needed. More aggressive targets would certainly increase energy storage installations in the Commonwealth and would open capacity for more grid deployments of renewable energy. If modeling efforts are undertaken, then that data-driven approach can contribute to the discussion on revising targets.

The idea of evaluating interim targets on a set timeline was not universally accepted by the Task Force. Most Task Force participants were comfortable revisiting targets in the event of a major industry event such as a federal clean energy standard that has a clear impact on fossil fuel retirements and the timeline for net-zero generation in the Commonwealth.

Other Funding and Incentives

Develop an incentive program for non-wire alternatives

The VCEA requires that utilities file for non-wire alternative programs. The Task Force expressed that it is best to wait for responses before the Commission requests additional incentives to encourage these programs. The Commission and General Assembly must first work together to determine what these programs should look like and what parts of the program could be cost recoverable. Non-wires alternatives are particularly useful for the Commonwealth to consider because these programs and solutions can be set up without relying on outside regulatory bodies.

Markets

Clarify accounting for energy storage in the renewable energy certificates (RECs) market

There are two ways to judge power delivered by energy storage systems as related to RECs: either by the power that was used to charge the system or the amount that was discharged. Due to round-trip energy losses, the discharged power will be less than the amount used to charge a storage device. Most Task Force participants expressed that the creation of RECs should be determined by the energy generated by the eligible generators, not based on the discharge from the storage device. The counter argument to this would be that if energy storage systems with low round-trip efficiencies are used, the actual amount of renewable power delivered to the grid will be much lower than what is created by eligible generators which may create some uneven incentivization for utilizing energy storage in RECs markets. While these concepts were also raised in a proceeding a few months ago, it is still worthy of more discussion but was too complex to reach consensus in the Task Force given the time.

Ensure that energy storage can receive compensation for all values it provides

Without access to multiple revenue streams, energy storage systems are unable to value stack efficiently to provide the best value to the grid at the lowest cost to ratepayers. This recommendation was not supported widely enough to be considered a consensus recommendation.

Explore the potential for recycling markets for retired energy storage deployments and their infrastructure

A recycling market would set up a system that can handle end of life batteries and other energy storage deployments to reduce negative environmental impacts and encourage reuse of batteries (second life batteries) or their components. The recommendation to explore the use of these markets was not supported widely enough to be considered a consensus recommendation.

Request for Proposal (RFP) Processes

Allow for independent management of competitive procurement processes to ensure fairness

This was a contentious topic that was not supported by all members of the Task Force and therefore did not achieve consensus. Supporters indicated that allowing independent management of the RFP process would improve competition and transparency and lower costs while providing more value to ratepayers. Opposition to this recommendation indicated that it adds another level of cost as an independent management through third parties requires that third-party to come up to speed on everything happening with the RFP. This adds to the inefficiency of the process and can lead to further delays.

Issue RFPs directly from the state requesting energy storage at state facilities

An RFP of this nature would allow the state to inject funds into energy storage deployments and contribute to the state's own energy storage targets. This recommendation was not fully supported and did not reach consensus status.

Technology/Infrastructure

Minimize stranded assets across the grid and repurpose existing assets

This recommendation would be supported by the 3rd party evaluation and road-mapping recommendations which would allow the state to have a better understanding of how to minimize current and future stranded grid assets. Larger energy storage systems with immovable infrastructure may result from poor grid planning. Also, some participants mentioned that pipelines can potentially be repurposed to store hydrogen. Other participants noted that energy storage in particular is able to avoid becoming stranded because many technologies are modular enough to be moved in the future. The difference in opinions on the potential for storage to become a stranded asset and the fact that there is not a clear pathway to achieve this recommendation through legislation led this recommendation to not achieve consensus.

Other

Allow for rate basing of advanced analytics and similar analyses

This recommendation would encourage the use of more data driven approach to grid management and operation by allowing utilities to recoup spending on modeling and analysis. This idea did not reach consensus as some Task Force participants indicated that utilities are not currently compensated for this type of work other than as a general business expense and there is not much of a basis to start doing so.

Encourage utilities to implement distribution energy resource management systems (DERMS) on a wider scale
DERMS allow utilities to more actively monitor and control distributed systems in their grid operations and can increase the effectiveness of energy storage systems. The Task Force did not agree on whether these types of systems should be mandated in the state, and the weaker recommendation to simply encourage DERMS installations was not widely supported by the group.
Include a rider that benefits environmental justice and disadvantaged communities
With Virginia's recent passage of their Environmental Justice Act, disadvantaged communities have been prioritized for further assistance. A rider that provides benefits to these communities by funding energy storage deployments in these communities would be one way to provide new assistance to help maintain grid reliability in these areas which do experience blackouts more often. This item did not reach consensus because representatives of disadvantaged communities were not represented in this Task Force.

2. Technologies and Use Cases

To achieve the goals of energy storage in Virginia, primary consideration needs to be given to the desired outcomes of energy storage initiatives and deployment in the Commonwealth. Leading with this "use case" approach ensures adequate consideration of the variety of factors that impact success for energy storage projects. Taking this technology-agnostic approach first allows for selection of appropriate energy storage solutions that will result in the best contribution to the grid and Virginia's electricity consumers.

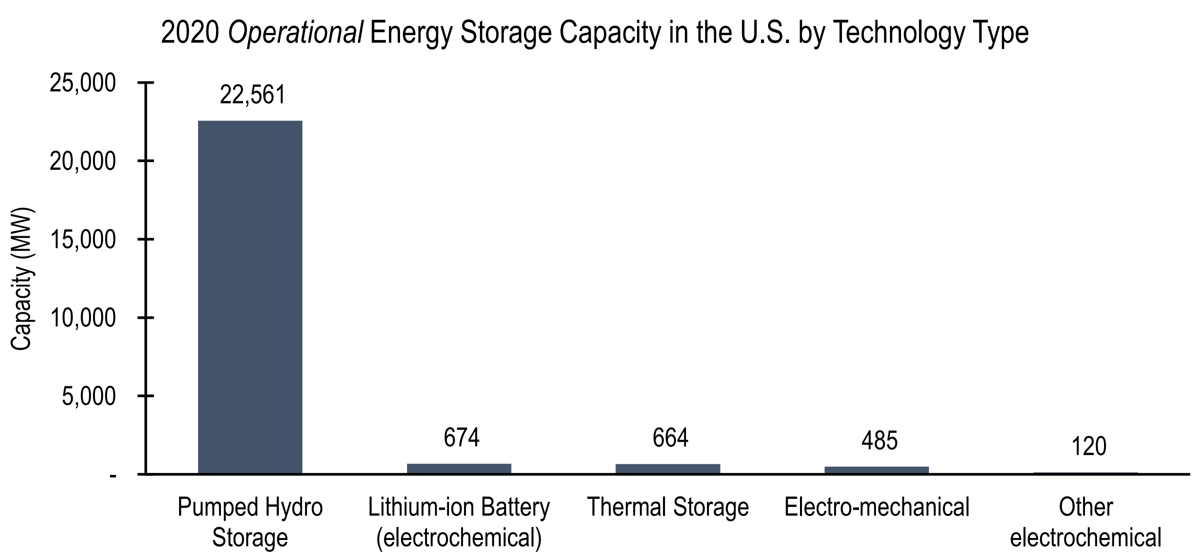

Figure 3. Energy Storage Capacity in Operation in the U.S. as of 11-17-2020. Data from DOE Global Energy Storage Database website maintained by NTESS. (https://www.sandia.gov/ess-ssl/global-energy-storage-database-home/). Some data in this dataset is self-reported and may be incomplete.

While past and current markets are dominated by two technology types—pumped hydro and lithium-ion batteries (See Figures 3 and 4)—the penetration of these technologies is mostly due to scale, cost, and needs of the grid to this point. As the grid continues to evolve to accept more renewables, a diverse technology portfolio will be necessary to maintain a reliable and affordable grid for Virginia. As such, legislation around energy storage deployments should avoid overtly favoring certain technologies for energy storage.

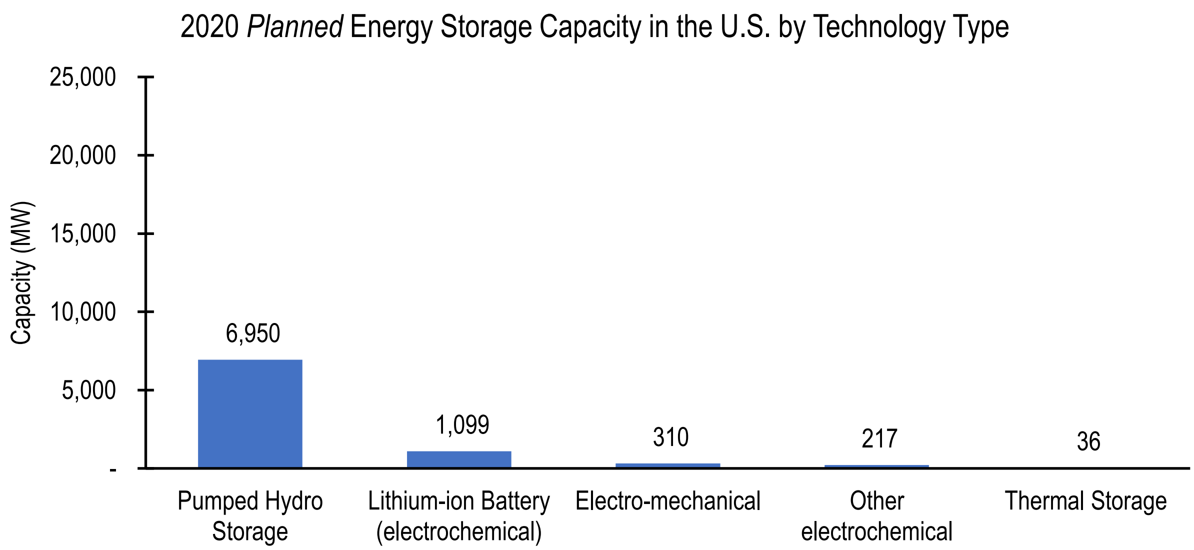

Figure 4. Planned Energy Storage Capacity (under construction, announced, or contracted) in the U.S. as of 11-17-2020. Data from DOE Global Energy Storage Database website maintained by NTESS. (https://www.sandia.gov/ess-ssl/global-energy-storage-database-home/). Some data in this dataset is self-reported and may be incomplete.

The ability of certain new technologies to provide specific services at lower costs will drive the emergence of new technologies in the marketplace. While one of the greatest benefits of energy storage is the ability for a single installation to provide many different services, not all technologies are well suited for all applications. Technologies like green hydrogen, pumped-hydro, liquid-air, compressed air, and other battery chemistries may be better suited to provide low-cost storage for extended durations. As renewable generation technologies increasingly penetrate the grid, such long-duration storage installations may become essential to support the grid.

Future energy storage planning needs to consider the use case of energy storage installations: without these specifics, new grid deployments may not optimally serve the grid. However, requiring only specific uses for energy storage limits their potential service, as these technologies can provide multiple services. While current market structures and operating dynamics of the grid do usually limit energy storage installations to one or two uses today, future developments are expected to unlock more uses for a single energy storage application and any limits put on those operating functions through legislation or regulation will be a burden to grid operation.

Technology Types

Each technology can be compared by several metrics, including energy density, cost, duration, roundtrip efficiency, and capacity. Such metrics provide a benchmark to compare technologies that may emerge from future R&D. As the cost, benefits, and considerations for installing technologies in each sector are different, each technology type is discussed on its own in the corresponding sectors.

Technology types can be categorized by several key components: scale, duration, cost, and use cases. Legislation that requires a focus on any one of these areas may promote the deployment of one technology type over another. While this is not necessarily bad, it is important to consider given the interconnected nature of these components. For example, a desire to install long-duration storage to handle monthly load shifts may lend itself toward one technology while fast-response peak generation may warrant use of a completely different technology type.

Pumped-Storage Hydroelectricity

Figure 5. Bird's eye view of the Bath County pumped hydro facility.

More than 22 GW of energy storage capacity in the United States is currently provided by pumped-storage hydroelectricity (pumped hydro).[8] It is an efficient form of readily dispatchable, long-duration, and high-capacity storage. Many of these facilities were developed in the 1970s and operate today, showing that energy storage can be economical while providing critical resilience and reliability to a grid powered by non-variable sources let alone variable ones. Pumped hydro storage is a capable of providing most of the bulk-service uses of energy storage including load-shifting and ancillary services. However, based on its heavy land-use, high capital cost, and environmental impacts, new pumped hydro installations are unlikely in the Commonwealth. The restrictions to possible siting locations also limits their potential benefits. While Virginia is home to the largest pumped hydro facility in the world (the Bath County Pumped Storage Station which has a maximum generation capacity of 3,003 MW),[9] no new installations are expected by 2050. Dominion has scoped a new project that currently remains on hold.

Lithium-ion Batteries

Figure 6. A lithium-ion battery module comprised of many individual cells. Large numbers of these cells put together form a large-scale lithium-ion deployment.

Gaining in prevalence since the early 2000s, lithium-ion batteries dominate the energy storage landscape in newly installed grid, vehicle, and personal electronic applications. The high energy density and decreasing costs of this battery chemistry have led to wider adoption over the last 20 years. Almost all near-term energy storage deployments in the PJM planning queue are lithium-ion batteries[10] and similarly, near-term targets will result in more lithium-ion deployments. While much of the discussion of energy storage installations today may be

[8] eia.gov/electricity/data/eia860m/
[9] eia.gov/state/?sid=VA
[10] pjm.com/planning/services-requests/interconnection-queues.aspx

understood by many to mean lithium-ion batteries, given the dynamic and evolving nature of energy storage technologies, decision makers in Virginia should be mindful to not favor any particular technology.

One important note about lithium-ion batteries is that there are two dominant battery chemistries: Lithium Iron Phosphate (LFP) and Lithium Nickel Manganese Cobalt (NMC). There is currently a shift in the industry from predominately NMC chemistries to LFP due to several factors. One is that the fire safety of LFP batteries is superior to NMC. Secondly, there are social concerns over the sourcing of cobalt for NMC batteries. Much of the cobalt supply originates from foreign regions that rely on child labor and mining operations with unjust working conditions.

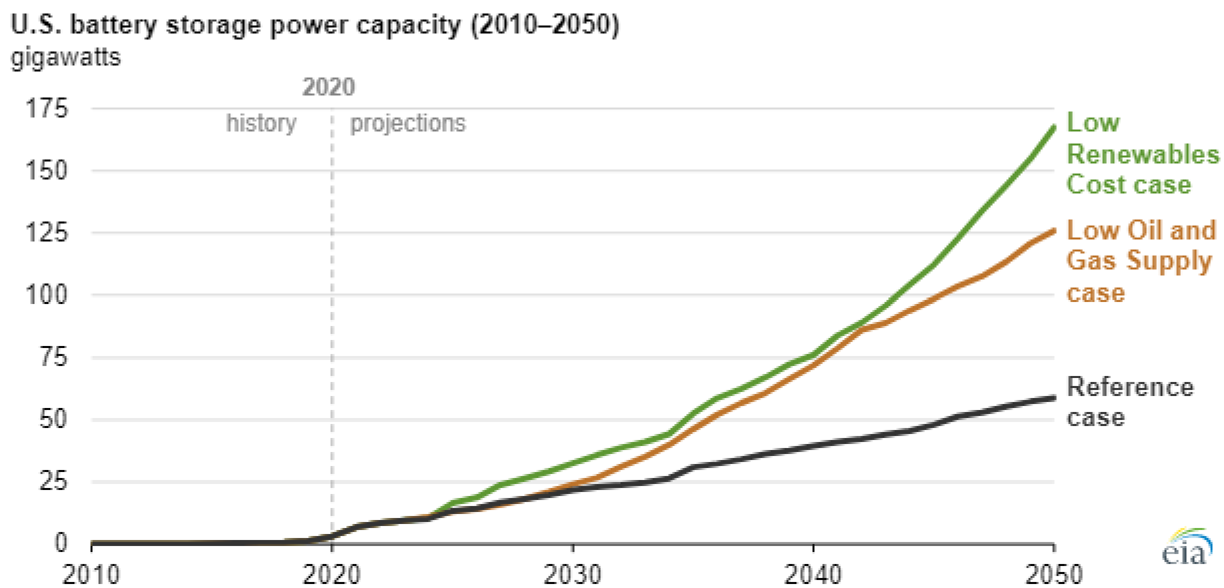

Figure 7: The U.S. Energy Information Administration projects increased adoption rates of battery-based storage through 2050.[11]

Benefits of lithium-ion batteries are their low cost, adaptability of size, and locational flexibility. Batteries in general are desirable energy storage devices because they are electrochemical and store energy in constrained containers and release energy in an easily controllable reaction. The lack of thermal and mechanical components of batteries eliminates concerns tied to noise, space, and physical part movements. The biggest concern tied to lithium-ion batteries is thermal runaway resulting in fire. To combat these concerns, spacing requirements are typically put on bulk systems to limit chain reactions. Individual lithium-ion batteries are also not well suited to provide load for durations longer than 8 hours although battery discharge can be staggered to enable longer durations from larger lithium-ion systems.

Other Electro-chemical Batteries

Lithium-ion batteries have become popular because of their high energy density and increasing low costs due to heavy adoption over the past decade. However, there are many other battery chemistries at all stages of development from heavily established to new research. Some of these chemistries have

[11] eia.gov/pressroom/presentations/AEO2021_Release_Presentation.pdf

lost support over the years such as lead-acid batteries, which are used heavily in gas powered automobiles but have environmental problems and are heavy and large. Other rechargeable battery technologies include Nickel Cadmium (NiCd) and Nickel Metal Hydride (NiMH). These batteries have lost favor as Li-Ion batteries have decreased so much in cost. Additionally, cadmium has sourcing issues and both nickel-based batteries suffer from memory effect which can reduce their capacity over time.

There are several battery technologies with a higher theoretical storage potential than Li-Ion batteries that are at early development stages. These include chemistries such as zinc-air, lithium-air, sulfur-air, sodium-sulfur, and a variety of solid-state chemistries. Sodium is an attractive material to replace lithium because it is more abundant and cheaper. However, these technologies remain at the bench scale. If the development of past battery chemistries is used as a guide, it could take decades to advance these far enough for commercial use. Another emerging battery chemistry that may offer a cheaper solution than any of these technologies is iron-air batteries. These batteries do have a larger footprint for similar MWh capacities.

One other common battery type is flow batteries such as vanadium redox flow. These batteries are interesting because they can use a fluid to store energy which is easier to store and handle than solid components. These types of batteries are better suited for longer durations than traditional electrochemical chemistries. There are some deployments of flow batteries at the commercial scale, but the cost of these systems remains higher than other commercial systems. Economies of scale could bring those costs down as demand for longer-term storage rises.

Hydrogen

Hydrogen is the subject of much interest in net-zero plans because of its ability to decarbonize sectors of the economy that are very difficult to electrify such as manufacturing. For hydrogen to be considered an energy storage technology, it must be produced via electricity taken from the grid and dispatch electricity back to the grid. The source of energy used to generate hydrogen is particularly important for its contributions to net-zero targets. “Green hydrogen” is of particular interest and is produced utilizing energy from renewable resources to perform electrolysis. As with other storage technologies, hydrogen can also be produced via electrolysis relying on grid electrons which may not be 100% renewable as well. The preference for energy storage systems would be to utilize green hydrogen, which emits no CO_2 on a roundtrip basis. This process can be coupled with using wastewater for electrolysis to create a highly sustainable process.

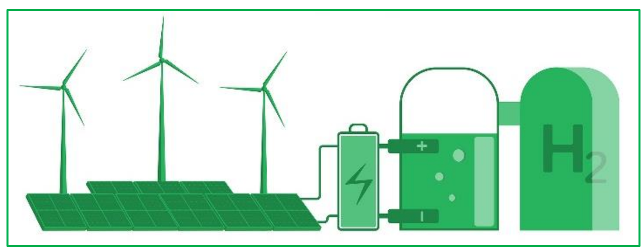

Figure 8. "Green hydrogen" is created when renewables are used to power an electrolysis process separating water into hydrogen and oxygen. The hydrogen is stored and utilized later for power production.

Hydrogen can provide several services that other energy storage technologies cannot since it is a thermal resource. Thermal energy from hydrogen combustion can be used for heating and grid inertia. Since it is a gas, it can also be transported via pipeline and stored in large containers or geologic formations. Large scale storage can allow hydrogen to provide long duration and seasonal storage. There are concerns tied to hydrogen use due to its explosive potential, and care must be taken with its handling.

Compressed Air Energy Storage (CAES)

CAES systems take air and compresses it into a storage container or larger geological formation. This air is then expanded later to recapture energy. There are different operating modes for CAES deployments that improve efficiency by capturing heat that is released during compression as well and storing that heat via thermal energy storage so it can be used later to improve round trip efficiency.

CAES is typically more cost effective at larger scales and is dependent on the availability of storage for large volumes of air. Its use in Virginia is incumbent on lowering the cost of these deployments and locating areas that are conducive to large scale storage. Air storage would compete for the same resources as hydrogen as well.

Liquid-Air Energy Storage (LAES)

LAES uses a comparable operating mode to pumped hydro but requires a much smaller footprint and is not geographically constrained, allowing it to be situated at areas on the grid with high locational value. An LAES system cools ambient air to cryogenic temperatures and stores the liquid in above-ground tanks. When electricity is needed, the liquid is converted back into a gas via direct heat and that gas is used to power a turbine and generate electricity. The smaller footprint of LAES makes it more desirable for use in space constrained areas. There are several developers of LAES interested in Virginia which may result in deployments in the state.

Figure 9. This image shows liquid oxygen stored in above ground silos. LAES systems can store their liquid-air storage medium in similar tanks.

Mechanical Storage Devices

Mechanical storage devices utilize potential and kinetic energy to store power for the grid. The most utilized mechanical technology is the flywheel, which operates by spinning up a wheel using electricity and using that rotational energy to provide back to the grid after a short time. While flywheels have been commercialized at larger scales, the technology is limited in its use to short durations due to the difficulty in maintaining rotation for long periods of time. While useful for ancillary services, kinetic energy devices will have difficulty providing support for renewable technologies with longer duration storage.

Figure 10. Flywheels are typically housed in these types of containers, so that the friction around the flywheel can be reduced and the wheel can be contained. Larger deployments feature more independent housings.

Other mechanical storage technologies utilize gravitational potential energy to store power. Some examples are cranes that lift large rocks and trains that are powered up large slopes. These heavy objects are released and their movement back down to the lowest point can be used to generate power. The use of gravitational storage has been deployed in some niche areas. The operating principle for gravitational storage devices is similar to pumped hydro and it is therefore able to provide many grid services.

Thermal Storage

Some thermal solutions store ambient or concentrated solar energy, waste heat, or electrically produced heat in a liquid or solid medium (*e.g.*, molten salt). Other convert water into ice to store energy. Either solution can turn that thermal energy back to electrical energy or take a more efficient path and utilize thermal energy directly for heating or cooling.

Figure 11. Tanks like these can be installed on commercial and residential properties to store water heated by electricity or the sun. This simple form of energy storage uses this water at a later time to reduce heating loads.

Thermal energy storage is one of the few technology types deployable at the BTM scale. Thermal systems can operate in tandem with some solar cells or be used directly for HVAC systems with hot water heaters, for example, at industrial, commercial, or residential facilities/homes. It is more difficult to measure the energy in MWh for thermal systems if the power is utilized directly for heating and cooling purposes.

Use Cases

Use cases are the operational benefits of energy storage deployments and reflect the primary sources of income for these devices. One unique aspect of energy storage devices is the vast array of uses they can provide.[12] Some technologies are better at providing certain use cases. For example, short-duration energy storage technologies are more suitable for immediate grid or consumer needs like peak shaving during high-load periods, while longer-duration storage can potentially shift energy availability between seasons. Given this, one of the important considerations for future grid development is installing the proper energy storage system for the use. For example, while lithium-ion batteries are expected to be selected through most procurement processes over the next five to ten years, these batteries are not well suited to provide long duration storage. When renewable penetrations increase in Virginia,

[12] rmi.org/insight/the-economics-of-battery-energy-storage-how-multi-use-customer-sited-batteries-deliver-the-most-services-and-value-to-customers-and-the-grid-executive-summary/

Stakeholder Group	Energy Service
ISO/RTO	• Energy arbitrage • Frequency regulation • Spin/non-spin reserves • Voltage support • Black start
Electric Utility	• Resource adequacy • Distribution deferral • Transmission congestion relief • Transmission deferral
Electric Customer	• Time-of-use bill management • Increased PV self-consumption • Demand charge reduction • Backup power

Figure 12: The Rocky Mountain Institute (RMI) identified services pertinent to three key components of the electricity system as part of its 2015 analysis of the economics of battery energy storage.[7] Although specific to battery energy storage, several Task Force members noted this report and its analysis of services as a useful construct when considering use cases.

technologies like pumped hydro, LAES, CAES, hydrogen, or other battery chemistries may be better suited to provide the use of long duration storage that may be necessary for the grid.

One important note around use cases is that while energy storage devices can provide multiple services, they are typically only developed with a single use case in mind. While developers would like to be able to provide multiple services (and be compensated for each use), the current set up of the grid, its operation, and the design of power markets prohibit energy storage from operating in multiple modes effectively. A single device operating with multiple use cases is referred to as *value stacking*. If done properly, energy storage devices can be utilized more often to provide services to the grid and decrease their payback periods. An example of value stacking is a BTM energy storage installation at a large industrial plant that capture rooftop solar and time-shift availability of this energy, provide for backup power during an outage, and allow the plant to participate in a demand response curtailment.

Summarized below are the use cases brought up throughout the Task Force's meetings:

Bulk Market Services

Black Start

When the grid experiences a large blackout event, generators or systems that can restore power to the grid provide black start capabilities. Large energy storage systems can provide this service due to their ability to quickly ramp up electrical discharge. These devices would typically be expected to operate long enough for generating assets to come back online.

Voltage/Capacity Support

While the average consumer may expect that all power that comes from the grid is provided at the traditional 120 Volts, grid operators actually adjust the voltage within a tight range around 120 Volts to deal with variable production and demand on the grid. At times where generating assets are unable to provide the minimum acceptable voltage, energy storage systems can be called on to increase output onto the grid to raise the voltage.

Spinning Reserves

Some energy storage technologies can provide instantaneous power to the grid in the case of an unexpected drop in generation. These devices are referred to as spinning reserves as traditionally, the systems would have to be in operation to provide this service. Batteries in particular are adept at providing this service.

Frequency Response

The grid operates using alternating current (AC), which must maintain a phase matched frequency of 60 Hz to ensure all electrical consumers have a consistent and predictable power source. As generation and demand assets are turned on and off at different locations around the grid, frequency is impacted and must be maintained. Some energy storage technologies provide their own synchronous inertia to maintain grid stability. Electrochemical energy storage devices are typically direct current (DC) which can be converted to AC using an inverter at a particular phase and frequency so that the grid maintains its stability.

Intraday Load Shifting

Grid operators use various forms of data to predict future operating conditions including weather, time of year, time of day, and past operating schedules. Energy storage devices are unique because they can both use and reuse electricity in a planned way to shift the consumer load and generation required at different times of day. Energy storage devices are encouraged to operate in this way by marginal prices set in capacity markets where the systems can charge at low price periods and discharge at times of higher prices. This arbitrage results in a profit for the energy storage system while also reducing operation of more expensive generating assets.

Long Duration Capacity Shifts

Solar and wind generation tends to be higher at certain times of year which can result in excess production during those time periods. Similarly, overall energy demands (electricity and gas) tend to be higher during the winter than the summer due to building heating requirements. As the grid continues to decarbonize, the grid will either have to install enough renewable resources to meet load at the highest demand time of the year or can rely on long duration energy storage systems to shift power production from certain months to others. This will reduce the overall cost of assets required to balance the grid year-round. Use of energy storage systems for this capability is currently negligible.

Avoiding Curtailment

As more renewable technologies are put onto the grid, there will be more excess energy generated during times of high sun or wind resulting in greater generation than required by the grid. Without a use for this energy, it is curtailed which reduces profits for generating assets and generally wastes energy. Energy storage systems are able to capture that energy to avoid these curtailment circumstances.

Critical Infrastructure Resilience

Energy storage devices are adaptable, can be flexibly sited, and can, when properly used, ensure continued operation of vital services such as defense systems and healthcare facilities. These resilience services are traditionally provided by diesel generators which are loud and polluting.

Utility Services

Non-Wires Alternatives

Both at the transmission and the distribution levels, energy storage systems can reduce or eliminate the need for upgrades in areas with projected load growth, as non-wires alternatives. Energy storage devices can store power during times of lower demand and release that power nearer to the load during peak demand periods thus avoiding the need to increase maximum line capacity. Additionally, energy storage systems can relieve congestion on power lines by similarly reducing the peak load a line sees by charging and discharging at strategic times. All of these actions are referred to as non-wires alternatives because they eliminate the need for upgrading or installing more power lines. Non-wires alternative solutions used for this purpose are not impacted by PJM and are Virginia specific solutions.

Peaking Power

As Virginia's IOUs are expected to always fulfill grid demand, they often rely on gas peaker plants to deal with large upticks in demand. Utilities can reduce their reliance on these fossil fuel powered plants by instead utilizing energy storage systems to handle peaking demand spikes throughout their service territory.

BTM[13] Services

Transportation Electrification

Energy storage systems, particularly batteries, are gaining as an automotive power source, which is increasing customer ownership of battery systems. While these batteries are currently limited to providing power strictly to cars, vehicle to home (V2H) and vehicle to grid (V2G) services that would allow these batteries to operate as both grid and transportation assets are being explored in several states including Virginia.

Back-up Generation (Outage support)

Energy storage systems can supplement and potentially replace traditional hydrocarbon-based backup power to provide local power for homes and businesses in blackout situations. Need for backup power varies by customer site and size. For instance, a hospital or major manufacturing facility may need to ensure uninterruptible service via multiple forms of backup generation including energy storage. Energy storage can reduce or eliminate the need for non-diesel alternatives in these cases. In cases where energy storage cannot provide total back-up support, systems such as fuel cells and natural gas should be explored to replace diesel.

[13] A note about *Behind the Meter* in the context of this report. Several representatives of smaller local distribution companies (*e.g.*, electric cooperatives and municipal power utilities) noted that because they purchase power from the PJM market to distribute to their customers, their *meter* lies between the transmission company and their local service territory, making "BTM" (where the "meter" is the wholesale meter) apply to their entire service territory. However, in the context of this report, this segment of the grid is referred to as the *Utility*, while *BTM* refers to the end-use customer (industrial, commercial, or residential) side of the meter. BTM is used in a *retail* sense in this report.

Demand Response

When the grid is stressed by excess consumption and insufficient supply, utilities can utilize programs that tell large consumers or aggregated users to lower their electricity demand. User-owned energy storage systems that are charging or have charged during this period can also provide this demand response service by ceasing to charge and starting to discharge to the customer or back to the utility system.

Microgrids/Islanding

Larger BTM applications for energy storage systems can support an ecosystem where commercial, industrial, or residential customers are able to operate with their own generating assets combined with energy storage systems. These systems can, in theory, separate from the grid entirely (islanding). The concept of localized grids is often referred to as microgrids. Energy storage systems are essential to allowing a microgrid to operate effectively.

Time of Use Rate Management

In Virginia, commercial and industrial customers can participate in a *Time of Use* tariff that encourages shifting of demand to certain times of day with lower electricity rates. Energy storage systems allow these customers effectively to shift load themselves to minimize electricity payments.

3. Barriers

To deploy energy storage technologies effectively in the future, barriers to deployment must be addressed or eliminated so that system benefits outweigh system costs. This section presents these barriers in four categories: market barriers, local barriers, regulatory barriers, and other barriers. Further barriers specific to bulk, utility, and BTM deployments are discussed in more detail in their subsequent sections below.

Market Barriers

Interconnection issues related to large energy storage deployments span wholesale and retail markets, in part because capacity accreditation on the wholesale side of the market and interconnection reforms did not initially account for energy storage. To address this, energy storage needs to be studied as both a producer and consumer of electricity. From an interconnection perspective, the former poses the greater issue. Interconnection timelines pose a challenge to energy storage for both front-of-meter or BTM deployments, as even if utilities expedite their interconnection processes, permitting time varies by area of governance. The PJM interconnection queue is currently the largest lag and the last hurdle most energy storage developments end up clearing. PJM is currently running workshops to receive input to help clear the backlog. Any changes would not be filed to FERC until 2022 and would only impact resources that enter the queue ex post.

Wholesale Market Barriers

One historical barrier to participation in wholesale markets, is that there was a ten-hour duration requirement for participating in capacity markets. On July 30, 2021, FERC accepted changes to this rule that would allow storage resources to receive capacity accreditation based on the technology’s ability to meet load requirements which may alleviate this barrier going forward.

Additional issues arise when the bidirectional abilities of energy storage systems are considered by wholesale markets. Typically, storage devices can only receive compensation from one market mechanism and cannot be compensated for both charging and discharging. Virginia's existing market structures also do not address bidirectional energy storage. In addition, there also remains uncertainty around how energy storage will be implemented in the PJM RTO in response to FERC Order 2222; these market structures may supersede with or need to be integrated with any state-level market structure(s).

Retail Market Barriers

Soft costs will be higher with any new market, including Virginia. Therefore, near-term soft costs are likely to be high. Deployment will drive down costs on either side of the meter. Other markets that have seen greater deployment are sources for lessons learned about capacity and energy payments (*e.g.*, ERCOT, New York State, and NYSERDA have taken a dual track that can provide a model, particularly in their incentives and educational offerings).

On the retail side, the structure of DERs may also present barriers. Utility dispatch systems also have requirements for peak load management and demand management. There are also currently prohibitions against selling ancillary services and arbitraging energy when opportunities do not exist.

Local Barriers

As energy storage is deployed throughout the state, developers will run into a patchwork of permitting requirements, tax exemptions, and siting approvals at the local level. Additionally, some Virginia counties are addressing energy storage through a Special Exception process. This can add $100,000 in costs, a lengthier approval time, and, perhaps most importantly, the uncertainty of the legislative approval process. While zoning ordinances do address legitimate county concerns, such as safety, local requirements may end up dissuading developers if they are too onerous which could lead them to pursue installation in other states that provide greater certainty, a more efficient process, and fewer soft costs.

Public Resistance

There is always a danger of local resident resistance to energy storage installations (*i.e.*, NIMBY, or "not in my backyard"). Planning processes should neither assume local support nor oversimplify potential resistance to projects. Use of the term "NIMBY" itself can delegitimize concerns of residents or cluster concerns into an amorphous amalgam. Community education and outreach should seek genuine understanding of concerns and address them individually. For example, anecdotal evidence suggests some members of the public share particular concern about explosions related to batteries. Therefore, education should emphasize efforts to ensure safety and reduce fire and other hazards.

Regulatory Barriers

A significant barrier is that regulation and permitting is still evolving as PJM, the utilities, and the SCC continue to evaluate how storage will be treated. Additionally, the fact that energy storage developments need to comply with regulations from local entities, the state, the utilities, and PJM complicates all deployments. PJM in particular poses barriers to integration of storage technologies, as its scope includes both generation and transmission, and its motivators encompass markets and geography far beyond Virginia. Energy storage projects in Virginia should be designed with the scope of PJM in mind, to improve PJM's understanding of attendant benefits and safety risks and to increase likelihood of evolution in a desired direction.

Other Barriers

Stakeholder Uncertainty

A barrier to integration of storage—particularly in the context of transmission—is uncertainty about the technology, given the lack of storage deployments in use today. Advocacy for integration to new markets is difficult with the lack of precedents. Large-scale energy storage poses significant challenges for effective integration into the grid. Inherent engineering uncertainties attend larger-scale projects, and the current low-cost/high-reliability state of the grid imparts an “if it ain’t broke, don’t fix it” perspective.

This limited knowledge base is tied directly to another significant barrier to the further deployment of energy storage resources: high capital costs. Barriers to technological development begin with attendant costs. Cost reduction begins with accurate understanding of technology performance. Additional RD&D and pilot projects may be required, but such initiatives necessitate funding support. Utilities may struggle to support necessary testing and piloting of new technologies, which in turn hampers deployment. Fortunately, much can be learned from demonstrations and pilots undertaken by other utilities and research organization, so duplicative efforts can be avoided.

Cost Calculations

The growing diversity of available storage technologies complicates the calculation of optimal technology or technologies for any particular application. Different use cases with shifting T&D and BTM benefits, and drawbacks make calculations challenging. One attempt to provide a standard base of comparison for storage options is a LCOS calculation. For the past several years, LCOS calculations have included environmental costs (*e.g.*, pollution, the social cost of carbon, etc.). Care must be taken when drawing assumptions from LCOS: For instance, while lithium-ion systems may appear a clear leader, casual calculation may misrepresent their actual cost.

Calculations should compare systems that can provide similar durations of support. To the extent longer duration sizes are an option, the variable cost for operating (*i.e.*, average cost of duration) should be calculated. When building to long-term storage (*e.g.*, 10-hour, diurnal, or even seasonal), larger-scale technologies demand consideration as profiles for cost increase. Larger scale also attends geographic considerations and cost-of-electricity curves.

Project Initiation

Acquiring and building energy storage sites is a long and laborious process, demanding extra effort to speed distribution-level installations. Initial priorities include determining technical requirements and applying for permits. These processes take time and impose limits on the nature of energy storage systems. Examples of technical requirements include spacing between containers, site equipment, and property lines.

Operational Barriers

While normal load swing and load diversity are planned for and should accommodate outages of small or mid-sized BTM systems, outages of very large storage systems (BTM or utility-owned) could potentially lead to overloading of grid equipment without proper planning (variable load is a frequent issue for utilities). To measure actual load BTM, the utility needs to know the full load without the storage resource or other back-up generation to plan for worst-case scenarios. In the case of storage device failure, a utility would have to reach out to the storage owner(s) to determine the true load profile of the grid. In the case of critical providers (such as hospitals and wastewater treatment plants), whether the utility or critical provider owns and operates the resource needs to be absolutely clear, adding another potential layer of complexity. This manual process of determining actual load will likely lead to some degree of error in the load profile.

4. Bulk Market

The Virginia General Assembly outlined the direction of the Task Force in HB 1183, including a charge to assess how a variety of parties, "are able to deploy energy storage resources in the *bulk market*, in the *utility system*, and in *behind-the-meter* applications." This direction led to dedicated discussions for each of these segments of the power system. Outcomes of these discussions are covered in the next three sections of this report, starting with the Bulk Market. Each Section contains an overview of benefits and challenges identified by the Task Force. Note that several of the identified benefits and challenges can apply to more than one segment of the power system. Rather than repeat these items, benefits and challenges are placed in the power system segment where they best fit.

General Benefits

Grid Resilience

Energy storage systems can contribute to the overall resilience of the electric grid by absorbing surplus energy during times of excess generation to avoid overburdening the transmission grid. This stored energy is then, in turn, available during times of high energy demand. By acting as a buffer in this capacity, strategic deployment of energy storage installations can eliminate the need for other types of grid hardening technology such as construction of new generation or transmission. Additionally, although transmission systems offer the ability to deliver significant amounts of electricity, the delivery capacity is finite. During periods of very high demand, availability of energy storage placed closer to load centers can help avoid congestion on transmission lines.

Deferring Upgrades

Energy storage systems offer a viable means to address T&D planning criteria violations such as thermal overloads and voltage violations (*e.g.*, when the voltage dips below acceptable operating thresholds on the grid). Another key aspect of energy storage is its ability to reduce the total GW of generation required on the system. Energy storage systems provide a means of utilizing the excess capacity during the non-peak times (*i.e.*, majority of the year). Given the seasonal load difference, this is one area where long-term energy storage projects have a strong use case and can help to contribute to system upgrade deferral.

Meeting Climate Goals

Energy storage systems are great complements to variable renewable energy systems like wind and solar power because of their ability to stabilize provision of power by these zero-carbon technologies. The availability of renewable resources and their electricity production potential in Virginia does not always align with demand in the Commonwealth, which means massive amounts of renewable capacity are necessary to meet customer demand. The path to achieving the goals outlined in the VCEA is therefore not cost effective without energy storage.

Additionally, urban and dense suburban areas experience the greatest demand due to customer load, yet these are areas where fossil fuel-based peaking generators have not been sited due to air quality regulations or availability of suitable land for the generating plant. Energy storage systems can offer a viable alternative without worsening local air quality by allowing for peak shifting (*e.g.*, storage of non-peak generated electricity and releasing it during peak times). Energy storage technologies discussed by the Task Force and in use today do not produce greenhouse gases at their installation sites.

Increasing Return on Equity

A proactive approach to deploying both renewable energy and energy storage technologies may result in surplus power that the utility can sell off-system and then return that income to ratepayers. In addition, using energy storage for off-system sales can reduce the overall fuel costs and the collection from ratepayers of the associated fuel factor/rider.

Reducing Energy Imports

Energy storage technologies can help offset periods of low production by renewable energy generation, which addresses one current risk that the VCEA faces in the prospect of increasing renewable energy deployments. Times of low power production due to decreased wind and sunlight would demand the Commonwealth import power, and such times also carry increased risk of blackout if the grid does not have enough capacity to deal with renewable production shortfalls. Additionally, imported power cannot be guaranteed to come from non-carbon emitting sources. The impact of foreseeable power shortfalls can be reduced by installing enough energy storage to handle 4- to 8-hour outage periods.

Load Matching

Energy storage technologies offer load matching capabilities both as peaker and in demand response technology. This flexibility combined with the previously discussed environmental benefits makes them ideal candidates for the Virginia grid.

Providing a Peaking Alternative

Energy storage is a viable replacement for peaking capacity in urban areas. Some forms of energy storage provide instant grid response and current technology can provide cost effective power for up to four hours. The emissions profiles of traditional peaking plants are much higher as they are fired primarily with natural gas and other fossil fuel feedstocks while energy storage technologies are non-greenhouse gas emitting.

Challenges still exist to siting any energy project in an urban environment, including space constraints and local environmental impact. Energy storage solutions are not immune to these challenges, but the Task Force recognized that benefits may outweigh these challenges.

General Barriers

Scale-up

Lithium-ion batteries are the major energy storage type seeing large deployment as of this writing. There are some challenges for lithium-ion to continue to scale up around processing and manufacturing capacity. Additionally, lithium-ion batteries have several limitations at the bulk level and as noted above, other storage technologies are entering the marketplace that might offer additional strengths. To mitigate the limitations inherent in any single technology, Virginia should take a long-term view of its needs and options.

Opportunity Cost

Identifying the best cost or value of an investment is difficult to determine for energy storage systems due to the large variety of input and outputs to the systems and their flexibility. Developers may consider nearby states for energy storage sites rather than Virginia when comparing best cost solutions. Economics dictate the location and scale of development, rather than any individual state's preference.

Additionally, it is important to understand the differences in value streams from different technologies that operate at different durations. These cost structures will present a problem for systems operating at longer term durations as they may not present as well versus shorter term duration installations. One metric that can help compare technology types and durations in the levelized cost of energy (LCOE) or the LCOS. The levelized cost of energy metric is a way to compare storage to other electrical generators. Some Task Force members advocate for use of LCOS over LCOE due to the fact that energy storage is not a generating asset. Storage both charges and discharges, and these properties must be considered when weighing costs of energy storage.

Technological performance and life cycle also impact decisions of scale and location of installation. For instance, batteries have a short lifespan when compared to other long duration energy storage or long life grid assets, which can moderate batteries' long-term profitability.

Technology Acceptance

For consumers, almost all energy storage discussion is about batteries, specifically lithium-ion batteries. Consumers are familiar with the technology: consumer electronic devices and EVs employ predominantly lithium-ion technology. Additionally, the high energy-density and small form of these batteries lend themselves well to BTM applications. The vast majority of new behind-the-meter installations are expected to employ lithium-ion as the development of new battery chemistries is a slow process.

Energy storage technologies other than batteries will likely be necessary to reach the VCEA's goals, so metrics and discussion should not be restricted to lithium-ion batteries. The acceptance and prevalence of other technologies should be a point of emphasis as part of stakeholders' education.

Siting

Siting barriers exist for all types of large energy storage installations and vary by technology. While a technology like pumped hydro is heavily dependent on geological formations, other technologies like batteries have siting requirements tied to safety regulations and local ordinances. Setback, spacing, and fire regulations limit where energy storage installations can be installed and can result in reductions in capacity and potential locations, which can ultimately derail projects.

Permitting Issues

Improvements to the permitting processes—including targeted legislation—may reduce the cost of connection studies. Some members of the Task Force noted the high soft costs of energy storage, including permitting costs, which will be especially prevalent as the Commonwealth begins to invest in energy storage projects. As some regions or localities within Virginia create permitting efficiency and these costs are driven down, developers may choose to favor locations based on this economic factor over other need-based drivers.

PJM/FERC Rules

Until recently, organizations such as PJM and the Federal Energy Regulatory Commission (FERC) had limited rules dedicated to energy storage. As the need for energy storage schemes has evolved, so too have rules from these bodies. The current structure of grid markets makes it difficult for grid resilience or grid investment deferral systems to be functionally used in capacity markets as well. This reduces profit streams and restricts the possibility of value stacking.

Integration of energy storage systems into the Virginia grid must comport with FERC Order 841 (“Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators”). PJM is among the most advanced ISO/RTOs addressing this Order, but the complexity of integrating many distributed energy storage devices presents challenges.

Additionally, in late 2020, FERC issued Order 2222 to permit the use of DERs, which include smaller energy storage facilities, in aggregated form even when such resources are connected to the distribution grid. While supportive of energy storage solutions, this Order also presents a need for PJM to revise its tariffs for DERs (and potentially energy storage specific DERs) to allow for market participation. Members of the Task Force recognized that the planning needs associated with complying with these Orders remains difficult, especially because PJM has not yet made it compliance filing in the 2222 docket.

In the wholesale market, PJM’s minimum offer price rule may impact storage markets. Integration of storage resources should be structured to allow participation in capacity markets. Past minimum price efforts have focused on state-subsidized renewables. The market will strip out state revenues to determine the minimum offer for resources participating in the market—if the market clears below the price, the resource will not make money. On July 30, 2021, PJM did file reforms to the minimum offer price rule that would significantly roll back the screening of state-subsidized renewables. FERC could rule on this proposal as early as the end of September 2021, which should help alleviate this barrier.

Energy Storage Implementation Process Duration

The process from ideation to agreements can take years. Some processes can be conducted concurrently, automated, and improved to limit the time required for permitting and studies to allow for faster time to deployment. The time to construction is a big issue for developers at both front of the meter and BTM installations. Some utilities have expedited processes to speed up timeframes, but such procedures are not ubiquitous.

The current installation process for bulk market operators involves working with PJM, utilities (including electric cooperatives or municipal power utilities where relevant), local governments, and the SCC. For PJM, there is a process that all developers and utilities must follow to deploy their resources. This process includes working through interconnection agreements and permitting bodies. The utilities, local governments, and SCC all have their own approval requirements which makes developing a project a very complicated and time-consuming process (without accounting for any of the actual construction and technology costs).

Because of interconnection processes, bulk market deployments are only possible with coordination with utilities. The largest of these regulated organizations in Virginia (Dominion and APCo), issue requests for proposal (RFPs) to indicate how much energy storage they want in certain locations. Developers then submit their plans with associated costs to the utility.

Improved Planning

In this case, planning is the act of studying the grid and looking at future development cases and needs. This can uncover areas that will be subject to voltage/thermal problems in the future and can help determine proper siting of transformers and other grid assets (like energy storage devices). Proper planning can maximize the value an energy storage deployment is able to provide to the grid while simultaneously allowing developer to recoup their costs as quickly as possible.

Challenges include the need for improved processes and regulations that address the unique nature of energy storage. The absence of adequate energy storage modeling, as stated below, was cited as a potential barrier to planning improvement.

Modeling Needs

RTOs like PJM use modeling to perform current state and predictive analyses of grid operations. Additionally, models are used to make future projections about load growth on the system and to examine scenarios to maintain or improve reliability considering these growth projections.

Current models do not adequately represent the unique and dispersed nature of the growing energy storage system. As FERC Order 2222 introduces aggregated energy storage to the grid, models will need to be adapted to accommodate these new energy storage resources that function as not just energy providers through discharge, but also, as energy consumers through charging. An additional note for models is that energy storage devices cannot discharge without charging first.

Members of the Task Force noted the absence of a Virginia-specific modeling platform that examines energy storage capability and future needs across traditional service territory lines in the Commonwealth. This limits the ability of grid operators, energy storage developers, and other interested stakeholders to plan for and site energy storage in the most effective way. Members of the Task Force pointed to Dominion Energy's Hosting Capacity Tool[14] as an example of what an energy storage model might look like. This tool focuses on identifying potential sites for new clean energy installations in Dominion's Virginia and North Carolina service territories.

Energy Storage as a Generator and Consumer

There is some contention on whether energy storage should be viewed as a generating asset. Energy storage does not produce energy on its own but must be charged by other sources. For this reason, energy storage devices are not inherently low-carbon as they can be fueled by fossil fuel assets. It is important to recognize that other VCEA targets for renewable deployments cannot be ignored to reach net-zero. That said, Task Force members did not suggest adding language to any targets indicating that energy storage devices be solely charged by renewable resources in the interim.

Aside from charging source concerns, the idea of energy storage as a generator also complicates its operation and treatment on the grid. Since it can provide many of the same services as a generator

[14] dominionenergy.com/projects-and-facilities/electric-projects/energy-grid-transformation/hosting-capacity-tool

when charged, energy storage devices are allowed to operate in capacity markets by PJM. It is prudent to explore how energy storage devices can be compensated correctly and be subject to certain market mechanisms other than just DER and generation. PJM is exploring additional ways to treat energy storage devices in the future that may be different from today.

5. Utility System

General Benefits

Avoiding Stranded Assets and Extending Asset Life

The use of energy storage has the potential to increase the utilization of current assets, including currently stranded assets such as pipelines and wires near retiring fossil fuel generation, and minimize the risk of stranded assets in the future. It can also be used to repurpose assets. For example, some Task Force members pointed out the use of existing natural gas transmission and distribution pipeline to store green hydrogen as a form of energy storage that can be used to generate electricity. Other examples include decreased load on electric transmission and distribution system components due to distributed energy storage, which in turn may lead to longer lives for these system components.

While existing assets may experience longer lives thanks to new energy storage deployments, some Task Force members pointed out common risks of any investment into new technology, such as adding potential instability into the market or missing out on other ever-developing technological landscape investments while putting resources into getting energy storage up and running. In effect, due to the evolving nature of the energy storage technology and market, any project implemented now will also represent an additional asset that will remain fixed and potentially outdated in the future. However, many Task Force members agreed that these risks are worthwhile to achieve the goals of energy storage.

Avoiding High Energy Costs

Implementation of energy storage into the grid can supplement generation during peaking periods, allowing utilities to avoid the highest marginal cost of production generators. This will benefit both the utility as well as the consumer. Additionally, as noted earlier, energy storage systems would provide a capacity resource to attenuate quickly changing load and cost curves.

For instance, an energy storage solution located directly at a DC fast-charging station in certain cases could avoid the need for capacity increases to serve the fast chargers.

Alternative to Other T&D Solutions

As conditions stand, energy storage represents a technologically viable alternative to traditional T&D solutions for a variety of issues including alleviating thermal overload on substation transmission. Rather than construct large and costly infrastructure, or even invest in infrastructure improvement to handle worst-case load scenarios, energy storage presents a real non wires alternative by collocating energy storage with load centers.

General Barriers

Uncertainty of True Load

As energy storage devices are deployed on the grid, the ability of the utility grid operator to control distribution may decrease. An example provided from the Task Force notes that if an energy storage device exists on a distribution system (BTM), while it is functioning normally, it may provide local power to the customer. But if that customer-side energy storage device fails, demand may increase proportionally. This was cited by some as an operational challenge. Other members of the Task Force noted, however, that existing distributed energy resources (residential solar, for instance) offer the same challenge, albeit one that could be solved through proper planning and grid operator interventions. To address this issue, utilities may need to plan for worst case energy supply needs.

Absence of Price Signals

Currently, price signals specific to energy storage are not available. The Task Force noted this as a barrier to full implementation of energy storage, especially with the deployment of BTM energy storage. The Task Force recommended a compensation/incentive mechanism, with possibilities ranging from Time-of-Use rates to storage-specific demand response.

Large consumers in Virginia can participate in a demand response program via PJM that includes support for energy storage, among other DERs. This program includes price signals and high-demand forecasts to these larger customers.

Nascent Energy Storage Aggregation and Metering Infrastructure

Although FERC Order 2222 supports DER aggregation for market participation, this direction is new, and the market is evolving. Impacts to utilities remain focused on the distributed nature of many end-points of energy storage with possible impact on the distribution system during faults. As the DER aggregators become more present in Virginia, better management of these resources may become a necessity especially because FERC Order 2222 treats even single energy storage points as “aggregations.”

To effectively manage bi-directional energy storage charge and discharge in an aggregated fashion, bi-directional communication with the device is required. This allows for aggregators, or, in the case of demand response, grid operators, to see and control devices. Members of the Task Force pointed out that AMI devices that support this two-way communication are not deployed across the entire state. While many acknowledged that AMI provides connectivity and operational benefits for BTM energy storage, including inherent bi-directional metering and communication capability, some pointed out that AMI may not be required to operate energy storage devices adequately. For instance, some energy storage devices already provide for direct communication beyond the meter to aggregators or other service providers.

Absence of Standards May Slow Adoption

When operating a distribution system, utilities require an operational understanding of connected devices. Some Task Force members notes that although some standards do exist for energy storage, there needs to be more uniform adoption of these standards across devices, and, where applicable among energy storage integrators and even localities enforcing these codes and standards. An example provided was the absence of revenue-grade metering on some energy storage devices. Without an adequate alternative, bi-directional, communicating meter at the customer site, operating a grid-connected energy storage system would be difficult. Other members noted that any standards should however be balanced and not create new burdens to deployment.

Economic Impacts of a Complex Energy Storage System

Energy storage solutions may allow utilities to reduce cost in general but determining the overall cost impact is complex. The onus is on utilities to calculate the costs associated with energy storage or the relatively small incremental benefits in comparison to T&D development. This becomes challenging in a highly integrated T&D system. However, members of the Task Force did acknowledge that this challenge exists for other system design changes as well.

6. Behind the Meter Applications

General Benefits

Maximize Local Use of DERs

In traditional distributed solar installations, customers essentially use the grid as energy storage. While availability of distributed generation on the broader grid presents benefits as discussed in the previous section on the utility system, customers must participate through selling and re-purchase of power when needed.

With local storage available to the customer behind the meter, those with renewable energy resources can capture and store surplus energy for later use. While grid connectivity remains a necessity for most, the need for constant offtake from the grid is reduced in this design.

Demand Charge Reduction

As noted above, the round-trip costs of customers exporting power to the grid and then re-consuming it can be reduced through BTM energy storage. Tariffs for DER supply back to the grid are often lower than the consumption charge. In addition, delivery service fees are eliminated for locally produced and consumed power. As technology improves and costs subsequently decrease, the economic value of such a recapture and storage mechanism becomes more favorable for consumers.

Backup Power – Static and Vehicle-based

Commercial, industrial, and residential customers alike benefit from power reliability. In the case of critical services organizations such as hospitals, first responders, and even among some manufacturers, power outages can cause severe, costly, and dangerous disruptions. Many of these organizations have invested in backup power solutions that rely on fossil fuels to generate power. As an alternative, locally stored, renewably generated power provides some similar backup options for these customers, while also eliminating the pollution from combustion-driven backup systems. Residential customers have similar needs for service reliability and could also benefit from local BTM storage.

Members of the Task Force pointed out the specific benefits of EV-based energy storage which not only allow for this backup solution, but also provide for value stacking by supporting an additional, transportation use case. Some members also acknowledged that the consumer sentiment for procuring BTM energy storage may be improved in the EV use case since purchase of EVs is becoming more popular among residential customers. Additionally, the Task Force discussed the value of EVs in aggregate for fleets owned by organizations or districts, citing examples of school bus electrification and use as an energy storage means.

Participation in Alternate Tariffs, Demand Response

Utilities and RTOs have introduced Time of Use rates intended to push consumer demand to off-peak times. Reduced rates during these periods offer economic incentives to customers to delay electricity consumption. In large manufacturing processes, these savings can be substantial. Available BTM energy storage allows these customers to shift usage by locally discharging energy storage during peak times and charging energy storage from the grid during off-peak hours.

General Barriers

Education is Needed for Customers, Installers, and Localities

Residential consumers may not yet be knowledgeable enough about the energy grid to make informed decisions regarding BTM solutions. To ensure consumers are making wise choices about energy storage solutions and how they integrate with the grid and DERs, reliable information must be made available to these customers.

Customers intent on installing BTM solutions for energy storage depend on installers and integrators to ensure systems are appropriately and safely operating on their BTM site and with the grid. The novelty and unique nature of BTM solutions require additional training and education for these installers.

Local jurisdictions must also be aware of the codes and standards, as well as best practices associated with energy storage installations, including BTM deployments. The Task Force discussed the challenges associated with ensuring that those responsible for codes and permits are aware of the safety issues (and, possible misconceptions) surrounding energy storage. Yet, there is limited information available and those standards that exist are not uniformly understood across localities.

Environmental Justice Communities need to have Equitable Access to Energy Storage

The Task Force noted a particular deficit when it comes to equitable access to energy storage. The Virginia Environmental Justice Act addresses the need for resources, including those contemplated in energy storage, to be equitably available to environmental justice communities.[15] Often, the ability to make decisions about DERs or energy storage is limited within these communities either through economics or due to status as non-homeowners. In addition to addressing these issues, the Task Force recognized that participating in DER and energy storage schemes must be made available to these community members and include an education component.

Much of Virginia is rural. Whether classified as Environmental Justice Communities or not, many rural areas may lack access to fiber and broadband. This lack of communication technology will be a hindrance to full participation in dispatchable energy storage mechanisms for these customers. Task Force members noted that federal funding may be increasing to make high speed internet available via infrastructure investment, but due to the distances between rural customers, this may delay their full participation in energy storage. The Electric Cooperatives did note that they are working hard on bridging the "digital divide."

Safety Standards and Awareness Needs

Many members of the Task Force noted a strong need for safety awareness and safe installation and operation of BTM energy storage. While not a barrier per se, the Task Force noted a lack of consistently

[15] https://lis.virginia.gov/cgi-bin/legp604.exe?201+ful+CHAP1257

available information about safety. Examples of safety issues include the potential for grid back feed during outage events. Like local backup generators that are grid-tied, if appropriate cutoff mechanisms are not used during backup supply usage of energy storage, the distribution grid may become energized, putting line workers at risk. Another example includes safety awareness needs surrounding batteries and thermal runaway. Consumers and local first responders alike need to be aware of the reality of these problems.

Compensation and Incentivization

Statewide demand response for energy storage programs has not yet been developed. Barriers noted elsewhere contribute to this gap, including availability of demand response programs for residential customers. Members of the Task Force noted a proposed energy storage demand response program recently established in Connecticut[16] that provides a consumer incentive to participate in demand response. In this case, consumers opt-into the program and then are permitted to participate in up to 30 events per season, receiving financial incentives for participation.

Task Force members noted that residential and industrial/commercial customers do have different needs and behaviors when it comes to electric rate incentives. These consumers large differences in electricity consumption volume, decision making times and capital investment time horizons, and in access to technology. For instance, residential consumers may not have a tolerance for long capital investment payback periods, while commercial customers may. Additionally, residential consumers may not have access to funding to cover costs of BTM energy storage while industrial and commercial customers may have more financing options. Somewhat conversely, while most industrial and commercial consumers have a more straightforward, financially oriented perspective on energy investment choices, some residential consumers may select energy storage solutions based on other factors such as renewable energy capture.

Just as the complexity of pricing energy storage on the utility scale makes investment decisions difficult, so too does inadequate financial information about the variables associated with BTM energy storage complicate smaller scale storage investments. The Task Force recognized that any incentives to BTM energy storage should reflect the value of the storage as it applies to the grid or local equivalent.

V2G

While the adoption of EVs is increasing, the complexities of a V2G solution are not well understood. Current vehicle battery technologies are designed for charging from conventional power sources and discharging through transportation use. Cycling batteries via discharge directly to the grid may introduce unintended wear on the battery systems in these vehicles and reduce their life. Participating in V2G discharging may also void vehicle warranties. Other practical challenges include the customers need for available capacity in the vehicle on demand as well as the transient nature of vehicle-based energy storage. Task force members acknowledged that not all vehicles would present suitable use cases for V2G solutions. For example, livery operators and transportation companies *(e.g.*, taxis, Uber, Lyft) may not have the predictable driving patterns to allow for V2G participation. However, daily commuters may be able to reasonably plan for idle vehicle times while at work or at home when grid discharge could be viable.

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[16] https://portal.ct.gov/PURA/Press-Releases/2021/PURA-Establishes-Statewide-Electric-Storage-Program

There was much discussion about the use of V2G and its contributions to energy storage targets. Some Task Force participants believe that if vehicles are used for grid purposes, they should have their capacity prorated if it is to count toward energy storage targets. This idea of proration was contested by other participants. The issue of counting toward targets is particularly salient because of the 10% BTM target in Virginia. Overall, it was recommended that Virginia continue to monitor the V2G situation across the country as well as action from PJM and FERC on related aggregation of vehicular resources.

Lessons from Other States

The Task Force identified that a few other states have developed mechanisms to promote BTM energy storage that could be suitable for Virginia. Some of these methods were direct reactions to barriers present in those states.

California, for instance, has adopted Self-Generation Incentive Program (SGIP),[17] a rebate program for homeowners who want to install a home battery in conjunction with solar panels, with eligibility including those living in high fire-risk zones, those considered low-income, or those whose life depends on constant access to electricity. This is the largest energy storage incentive program to date. Additionally, New York and Connecticut are developing declining block rates energy storage programs. While soft costs would be high initially in these programs, costs would decrease for higher levels of energy storage deployment.

Privacy and Security

As with any grid-connected communicating device, consumers of all types (industrial, commercial, and residential) may express concern about personal information privacy or security of their systems. While this may range from inconvenience or a minor concern for some customers, larger industrial customers may be subject to information security regulations that restrict their ability to expose information via grid-connected equipment. Regardless of implementation, the Task Force recognized the need for improved security for communicating energy storage devices.

7. Other Topics Discussed by the Task Force

The December 18, 2020 SCC Order in Case No. PUR-2020-00120 posed a number of questions for possible consideration by the Task Force related to energy storage deployment in Virginia. The table below summarizes the responses to those questions:

Additional Questions Posed to the Task Force
What are the cost and benefits of more aggressive interim targets?
The Task Force was asked about setting more aggressive interim targets and could not reach consensus on whether they would be necessary. Ultimately, the Task Force concluded that more time was required to assess whether current targets should be changed, and future modeling and road-mapping activities can help the state determine if it needs to set more aggressive targets. The group stopped conversation at the need for more aggressive targets and did not discuss their cost and benefit implications.

[17] cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/self-generation-incentive-program

Are specific requirements necessary for distribution-connected and stand-alone storage?
The Task Force did not feel any additional requirements were necessary related to energy storage targets set by the VCEA.
Should municipal utility energy storage deployments count toward a utility's interim targets?
The Task Force did not think this was necessary as utilities are expected to meet their targets as set.
Should a third-party administrator be required to evaluate bids to ensure all energy projects are competitively procured in a fair, impartial, and transparent manner?
This remained a contentious topic and no consensus was reached on whether this should be a recommendation of the Task Force. The discussion is summarized in Section 1 above.
Should rules be expanded to require cost-benefit analyses and identify compliance and Commission oversight procedures?
The Task Force discussed the need for LCAs and was unable to reach consensus on whether to recommend these for the state. Cost-benefit analyses fall into a similar category.
Should the rules require utilities to report on the results of completed RFPs?
Utilities were receptive to continued conversation on transparency and edits to the RFP process, but the Task Force was not able to reach consensus on this topic.
Should rules identify procedures for evaluating the outcome of completed RFPs to determine benefits and lessons learned?
This idea was not specifically discussed by the Task Force and was not suggested as a recommendation during any of the Task Force's facilitated meetings.
Should rules provide a comment period or petition to hold proceedings to further shape future RFPs?
Any changes to RFP processes will require further discussion as no consensus was reached on changing the current RFP procedure. Dominion was open to discussion, but also indicated that actions like these add time and cost to RFP issuances which can delay deployments.
Should the Commission direct utilities to specifically propose BYOD programs?
The Task Force indicated that BTM deployments in general should be supported which is accomplished by the mandates set forth in the VCEA requiring 10% of energy storage targets be filled by BTM storage. A specific direction toward BYOD programs was not viewed as necessary.
Should the Commission change the non-wire alternative programs scope?
These programs are still in development and do not need to be changed at this time.
Should the Commission change the peak reduction programs scope?
This question was not specifically posed to the Task Force.
How can the costs of public notice be minimized while still ensuring adequate public notice?
This question was not specifically posed to the Task Force.

8. Conclusion and Next Steps

The VCEA laid the groundwork for improved energy storage adoption across the Commonwealth and the size of the targets set forth in the Act firmly puts Virginia in a position to be among the leaders of the nation in clean energy and energy storage. There is much work remaining to ensure energy storage adoption is successful in the Commonwealth and to assure Virginia continues to deliver on the promise of clean energy storage in the decades to come.

Energy storage technologies, policies, regulations, costs, benefits, and opportunities continue to evolve. To fully influence, embrace, and improve energy storage adoption in Virginia, the Task Force recommends that it continues to meet to address particularly complex and challenging topics in this nascent area of the energy ecosystem. Analysis of the complex costs and benefits of grid-connected energy storage and the impacts of deployment must be considered further. Understanding and implementing incentives is likely needed to promote broad scale adoption. Improving planning, siting, and integration processes will further enhance adoption. Additionally, guidance and training on the benefits and safety considerations of energy storage are needed.

While these and the other recommendations in this report represent important steps forward, the opinion of the Virginia Energy Storage Task Force is that none of the barriers to energy storage identified should slow down the Commonwealth's desire to move forward with action on the VCEA energy storage targets. Rather, the Task Force recommends that it continue to monitor target progress and to perform dedicated discussion and analysis, resulting in informed recommendations that unpack the complexities of energy storage and provide clear paths forward for the Commonwealth's energy storage efforts.

Appendix: Task Force Membership

Jessica Ackerman, Virginia Municipal League

Irfan Ali, Balico, LLC

Blair Anderson, Amazon Web Services

Peter Anderson, Appalachian Voices

Steven Arabia, LS Power

Scott Baker, PJM

Richard Ball, Virginia Chapter Sierra Club

Chelsea Barnes, Appalachian Voices

Audrey Bauhan, Dominion Energy

Megan Bechtel, Strata Solar, LLC

Hannah Bent, ENGIE

Julian Boggs, Energy Storage Association

Arlen Bolstad, SCC

Blayne Brittingham, Virginia Renewable Energy Alliance

Lee Brock, Rappahannock Electric Cooperative

Meade Browder, Virginia Office of the Attorney General

Sam Brumberg, Virginia, Maryland, and Delaware Association of Electric Cooperatives

Jason Burwen, Energy Storage Association

William Castle, Appalachian Power

William Chambliss, SCC

Kathryn Chelminski, Ameresco

Sonny Ciampanella, CNX

Mike Cizenski, SCC

David W. Clarke, Eckert Seamans Cherin & Mellott, LLC

Larry Corkey, Virginia Department of Energy

Rob Corradi, Sun Tribe Solar

Andrew Cotter, Central VA Electric Cooperative

Matt Cousins, Dominion Energy

Ann Creasy, Virginia Chapter Sierra Club

Kate Creef, Virginia Office of the Attorney General

Alicia Cundiff, Spotts Fain

Patrick Cushing, Williams Mullen

Kerinia Cussick, Center for Renewables Integration

Jason De La Cruz, Dominion Energy

Chip Dicks, Gentry Locke

Steve Donches, Nelis Law

Paul Duncan, MPR Associates, Inc.

Dave Eichenlaub, SCC

Ricky Elder III, Dominion Energy

David Essah, SCC

Tim Faherty, Dominion Energy

Will Giese, Solar Energy Industries Association

Harry Godfrey, Virginia Advanced Energy Economy

Diana Godlevskaya, Southeastern Wind Coalition

Yarden Golan, Energix Group

Nitzan Goldberger, Borrego Solar

John Griffith, American Electric Power

Justin Gundlach, Institute for Policy Integrity at NYU Law School

Gregory Habeeb, Gentry Locke

Nathan Hanson, LS Power

William H. Harrison, IV, SCC

Jason Hathcock, Strata Clean Energy

Michael Herbert, Delorean Power LLC

Blan Holman, Pine Gate Renewables

Todd House, Washington Gas

Brad Ives, Strata Solar, LLC

Gil Jaramillo, Northern VA Electric Cooperative

Gus Johnson, Dominion Energy

Ken Jurman, Virginia Department of Energy

Dr. Michael Karmis, Virginia Tech

Andrew Kent, Washington Gas

Raafe Khan, Pine Gate Renewables

Ted Ko, Stem, Inc.

Bonnie Lamond, High View Power

Matthew G. LaRocque, PJM

Andrew Lawson, Washington Gas

Chang Lee, Dominion Energy

Joe Lerch, Virginia Association of Counties

Josh Levi, Data Center Coalition

Patrick Lewis, Gentry Locke

Steven Lichtin, esVolta, LP

Sam Lines, Able Grid Energy Solutions

Zac Lowe, Southern Company Gas

Dr. Colleen Lueken, Fluence

Ashley B. Macko, SCC

Madison Matherley, Dominion Energy

Duncan McIntyre, Highland Electric Transportation

Morgan Messer, Shenandoah Valley Electric Cooperative

Will Mitchell, Strata Solar, LLC

Matt Moran, Gentry Locke

Cody Murphey, Eckert Seamans Cherin & Mellott, LLC

David Murray, MDV-SEIA

Peter Nedwick, Dominion Energy

Jeremy Niederjohn, Con Ed Clean Energy Businesses

Brad Nowak, Williams Mullen

John Ockerman, Ockerman Automation Consulting, Inc.

Conor O'Donnell, Spotts Fain

Tommy Oliver, Roanoke Gas Company

Steve Padgett

William Penniman, Virginia Chapter Sierra Club

Bill Pezalla, Old Dominion Electric Cooperative

Kiva Pierce, SCC

Drew Price, Hexagon-Energy

Michael Purdie, Dominion Energy

Cliona M. Robb, Thompson McMullan

Joshua Rogol, Strata Solar, LLC

Joshua Ross, Con Ed Clean Energy Businesses

Itamar Sarussi, Energix Group

David Savage, Open Road Renewables

Vinod Siberry, DOE Office of Electricity

Jon Sisler, Shenandoah Valley Electric Cooperative

Morgan Slaven, Shenandoah Valley Electric Cooperative

Rachel Smucker, Clean Choice Energy

Ben Spear, Urban Grid

Howard Spinner, Northern VA Electric Cooperative

Meade Spotts, Spotts Fain

Bryan Stogdale, Columbia Gas of Virginia

Cyrus Tashakkori, Open Road Renewables

Abigail E. Thompson, Gentry Locke

Tyson Utt, Commonwealth Energy Partners, LLC

Brett Vassey, Virginia Manufacturers Association

Michael Volpe, Open Road Renewables

Jerry Warchol, Dominion Energy

Shepelle Watkins-White, Virginia Natural Gas

Alexandra Wyatt, GRID Alternatives

Daniel Zambory, American Electric Power

Appendix: Meeting Agendas

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VIRGINIA ENERGY STORAGE TASK FORCE MEETING #1 AGENDA

Date: February 25, 2021
Time: 9:00am – 3:30pm
Facilitator: Chris Kelley

Access information:

Click here to join the meeting
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Phone Conference ID: 830 353 096#
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Time	Item	Presenter
9:00am	Welcome	Chris Kelley, David Essah
9:10am	Introductions	All
9:40am	Introduction to Energy Storage Legislation	TBD
10:10am	BREAK	
10:25am	Task Force Overview	Chris Kelley, David Essah
10:45am	Facilitator Guidance and Expectations	Chris Kelley
11:00am	Topic 1: General Characteristics of an Ideal Deployment • Overview discussion of vision for future deployment of energy storage in Virginia • Participants will contribute thoughts on characteristics including ideal size/capacity, capability, geography, regulatory environment, or other attributes.	All
12:00pm	LUNCH	
12:30pm	Topic 1 Continued: General Characteristics of an Ideal Deployment • Vision discussion continued including market, costs, time for deployment. • Participants will be asked to help prioritize themes	All
1:30pm	BREAK	

VIRGINIA ENERGY STORAGE TASK FORCE MEETING #1 AGENDA

Time	Item	Presenter
1: 40pm	Topic 2: Benefits of an Ideal Deployment • Participants will be asked to identify the types of benefits derived from effective energy storage implementation. • Who (what groups or individuals) benefit from deployment? • Are benefits quantifiable? How?	All
2:10pm	BREAK	
2:20pm	Topic 3: Challenges and Barriers to Ideal Deployment • Given the ideals described earlier, what barriers may stand in the way of achieving this vision? • What risks should the General Assembly or other stakeholders be aware of?	All
3:20pm	Wrap Up and Next Steps	Chris Kelley, David Essah
3:30pm	ADJOURN	

VIRGINIA ENERGY STORAGE TASK FORCE MEETING #2 AGENDA

Date: March 18, 2021
Time: 9:00am – 3:30pm
Facilitator: Chris Kelley

Access information:

Click here to join the meeting
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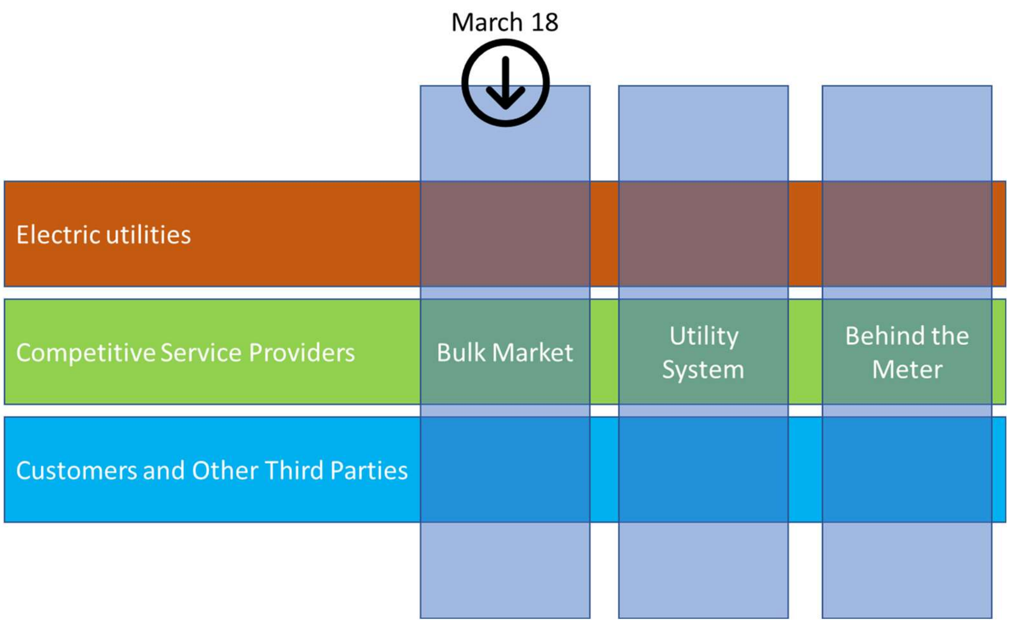
Time	Item	Presenter
9:00am	Welcome	Chris Kelley, David Essah
9:05am	Introductions (new members)	New Members
9:15am	Energy Storage Perspectives from PJM	Scott Baker
9:45am	Task Force Scope and Steering Committee Update	Chris Kelley
10:15am	BREAK	
10:30am	Facilitator Guidance and Expectations	Chris Kelley
10:40am	Topic 1: Bulk Energy/Regional-Level Benefits • Consider bulk energy/regional/transmission operation, what benefits would energy storage represent?	All
11:20am	Topic 2: Bulk Energy/Regional-Level Impacts • Consider bulk energy/regional/transmission operation, what challenges or barriers would energy storage present?	All
12:00pm	LUNCH	
12:30pm	Topic 3: Actions to Meet Goals of Energy Storage • What actions (operational, regulatory, infrastructure, investment, or any other) are needed to achieve the benefits for energy storage at the bulk/transmission level?	All

VIRGINIA ENERGY STORAGE TASK FORCE MEETING #2 AGENDA

Time	Item	Presenter
1:30pm	Topic 4: Risks and Mitigations • Consider the actions identified in the previous discussion. What risks does the General Assembly need to be made aware of? • What specific mitigations could the General Assembly or other stakeholders take to address these risks?	All
2:00pm	BREAK	
2:15pm	Subgroup Topics • Review identified subgroup topics that warrant further discussion. Add to list as needed. • Identify chairs for each group (submit interest via post-meeting survey)	All
3:15pm	Wrap Up and Next Steps	Chris Kelley, David Essah
3:30pm	ADJOURN	



VESTF Large Meeting Framework

VIRGINIA ENERGY STORAGE TASK FORCE MEETING #3 AGENDA

Date: April 15, 2021
Time: 9:00am – 3:30pm
Facilitator: Chris Kelley

Access information:

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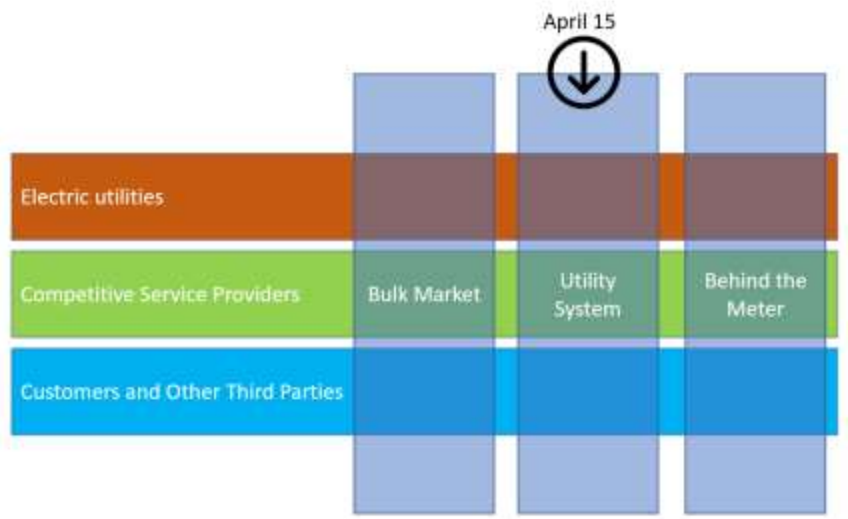
Time	Item	Presenter
9:00am	Welcome	Chris Kelley, David Essah
9:05am	Introductions (new members)	New Members
9:15am	Survey Results, Facilitator Guidance, and Expectations	Chris Kelley
9:30am	Update from Subgroups • Improved Planning and Hosting Capacity • Technology	Daniel Zambory, Ricky Elder, Joe Lerch
9:50am	Topic 1: Energy Storage Definition • Consider definitions and use cases offered by the legislation and/or regulations for Energy Storage • Do these definitions and use cases change in the future? In what ways do these support the needs of Virginia, particularly? • Do the use cases need to be clarified in any way? Are there others to consider?	All
10:45am	BREAK	
11:00am	Topic 2: Utility System (Distribution and Utility Transmission)	All

VIRGINIA ENERGY STORAGE TASK FORCE MEETING #3 AGENDA

Time	Item	Presenter
	• Consider the current and future operations of utility energy service delivery. What benefits would energy storage represent?	
12:00pm	LUNCH	
12:30pm	Topic 3: Utility System Impacts • Consider utility energy service delivery now and in the future. What challenges or barriers do these entities face related to energy storage deployment and use?	All
1:15pm	Topic 4: Utility Actions to Meet Goals of Energy Storage • What actions (operational, regulatory, infrastructure, investment, or any other) are needed to achieve the benefits for energy storage at the utility system level?	All
2:00pm	BREAK	
2:15pm	Topic 5: Risks and Mitigations • Consider the actions identified in the previous discussion. What risks does the General Assembly need to be made aware of? • What specific mitigations could the General Assembly or other stakeholders take to address these risks?	All
3:00pm	Discussion Summary	Chris Kelley
3:15pm	Wrap Up and Next Steps	Chris Kelley, David Essah
3:30pm	ADJOURN	

VESTF Large Meeting Framework



VIRGINIA ENERGY STORAGE TASK FORCE MEETING #4 AGENDA

Date: June 30, 2021
Time: 9:00am – 3:30pm
Facilitator: Chris Kelley

Access information:

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Time	Item	Presenter
9:00am	Welcome	Chris Kelley, David Essah
9:05am	Facilitator Guidance and Expectations	Chris Kelley
9:15am	Update from Subgroups • Markets • Goals and Metrics • Technology	Colleen Lueken, Ricky Elder, Joe Lerch

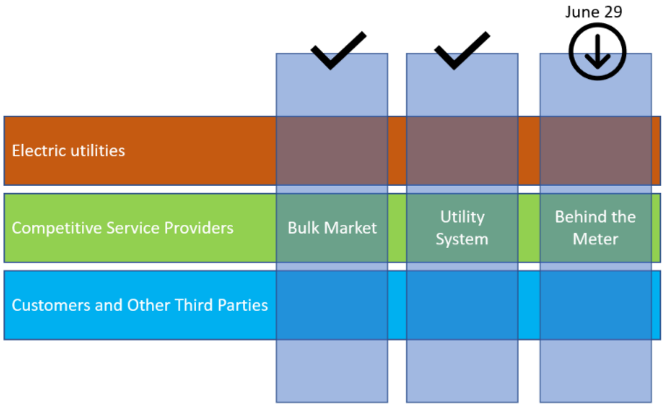
9:45am	Topic 1: Behind the Meter Energy Storage Opportunities
	• At least 10% of energy storage is expected to be positioned behind the meter (BTM). What can be done today to address this target? Does this differ for residential vs. industrial & commercial customers? Are the opportunities equitable?
	• What solutions are emerging to address BTM storage? What is the timing of these emerging solutions?
	  ○ Near-term (0-2 years away)
	  ○ Medium-term (2-5 years away)
	  ○ Long-term (greater than 5 years away)
		All

10:45am	BREAK	

VIRGINIA ENERGY STORAGE TASK FORCE MEETING #4 AGENDA

11:00am	Topic 2: Behind the Meter Energy Storage Challenges • Given the targets, what barriers are present for achieving behind the meter storage? Consider regulatory, stakeholder, consumer knowledge, environmental justice, technical or other factors.	All
12:00pm	LUNCH	
12:30pm	Presentation: Metrics-Based Storage Evaluation: Key Considerations for the VESTF	Ryan Hledik and Roger Lueken The Brattle Group
1:15pm	Discussion: Task Force Next Steps, Approaches • General Assembly Expectations and Needs. What topics should be addressed now? What topics require further analysis?	All
2:00pm	BREAK	
2:15pm	Topic 3: Behind the Meter Storage - Actions and Next Steps • Consider the barriers and opportunities for BTM storage. What actions should we recommend for the General Assembly (direct or indirect) to overcome barriers and promote opportunities? • Are there specific risks that the General Assembly should be aware of?	All
3:00pm	Discussion Summary	Chris Kelley
3:15pm	Wrap Up and Next Steps	Chris Kelley, David Essah
3:30pm	ADJOURN	

VESTF Large Meeting Framework



VIRGINIA ENERGY STORAGE TASK FORCE MEETING #5 AGENDA

Date: August 25, 2021
Time: 9:00am – 3:30pm
Facilitator: Chris Kelley

Access information:

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Time	Item	Presenter
9:00am	Welcome	Chris Kelley, David Essah
9:05am	Update on Schedule and Draft	Chris Kelley
9:15am	Update from Subgroups • Permitting and Regulation • Customer Engagement and Equity	Chris Kelley
9:30am	Recommendations: Work through list of recommendations. • Attempt to achieve consensus. • Discuss those items that will lack consensus • Eliminate recommendations that are not generally supported	All
10:45am	BREAK	
12:00pm	LUNCH	
2:00pm	BREAK	
3:00pm	Discussion Summary	Chris Kelley
3:15pm	Wrap Up and Next Steps	Chris Kelley, David Essah
3:30pm	ADJOURN	

Below categorizations are based on discussion held during task force meetings to date

🟢 General Consensus 🟡 No Current Consensus 🔴 Currently Lacks Support

Recommendation	Status
Permitting and Regulation	
Permitting and legislation improvement: Examine and reevaluate permitting requirements and legislation as it pertains to energy storage. Ensure the intent of directions matches the language in the process or legislation (some technical details are portrayed incorrectly or in restrictive ways that don't support broader energy storage solutions). • Align SCC Process with DEQ process to streamline permitting and low costs of deployment	🟢 ⚪ ⚪
Improve and/or standardize interconnection study process to make it easier for energy storage resources to connect to the grid	⚪ 🟡 ⚪
Lower soft costs through pilot and R&D programs	⚪ 🟡 ⚪
Distribute soft costs (e.g. with riders)	⚪ 🟡 ⚪
Make an agency or new government body to expedite permitting and identify other opportunities for improvement (such as those identified by this task force.	⚪ ⚪ 🔴
Loosen permitting requirements. Specifically, reduce siting and spacing restrictions.	⚪ 🟡 ⚪
Develop a permitting guidebook to help developers/installers navigate interconnection process in Virginia.	⚪ 🟡 ⚪

Level-set Requirements: Harmonize PJM and Virginia requirements related to interconnection and operations including tariff structures, regulations, etc.	○ ● ○
Set up tariff rates to deal with and recognize the bi-directional nature of storage.	○ ● ○
Develop a model ordinance that can be used at a local level. This can eliminate redundancies and deference to local agencies. Uniform process should be blessed by SCC. Understanding not to remove local zoning authority.	○ ● ○
Reduce time to deployment through a cost mechanism. This could include a standard development fee.	○ ● ○
Have a preapplication process that looks at the ability to both inject and withdraw power at the same location to eliminate more interconnection studies	○ ● ○
Additional Reports, Studies, and Models	
Learn lessons from other states on R&D, pilot programs, permitting, interconnection, DER, BYOD, etc.	● ○ ○
Produce a full lifecycle analysis of different technologies based on some assumptions of location, metrics, etc.	○ ● ○
Hosting Capacity: Develop statewide transparent hosting capacity platform. This includes information and sharing among regional transmission operators and local distribution companies. Apply this approach to distributed energy resources (DER) as well as energy storage, improving ability for energy storage providers to connect.	○ ● ○
SCC Proceeding (Alternative to new governmental body): Conduct an SCC proceeding on T&D planning to send signals for energy storage and DER. This proceeding would provide direction in lieu of standing up a separate governmental agency. The proceeding should review, among other topics, ratepayer impact of energy storage.	○ ● ○
Create a mathematical model that simulates the whole grid. The model should look at how resources on the grid interact and allow Virginia to make decision on the best plans, technologies, and use cases for future development. This model will also point toward the lowest cost solution.	● ○ ○
Conduct a study on caverns and geological storage in the state and how it can be used. Relevant to compressed air storage, hydrogen, and CO_2 sequestration.	○ ● ○

Create a roadmap for technologies of the future in Virginia. Would look more into the metrics and use cases of technologies and the future of the grid to guide the legislature and SCC on areas to encourage with legislation and funding.	⚪🟡⚪
Generate a committee report on what Virginia's citizen need and want in communities with regards to energy storage.	⚪🟡⚪
Map grid resources so that backfeed can be understood to increase safety for linemen and other grid maintenance personnel.	⚪🟡⚪
Behind the Meter Incentives	
Encourage BTM storage by coupling with charging infrastructure with fleet and medium duty vehicles	⚪🟡⚪
Enable Time of Use rates and other price signals to encourage greater installations of BTM energy storage.	⚪🟡⚪
Actively support and encourage BYOD programs.	⚪🟡⚪
Support increased deployment of advanced metering infrastructure (AMI) to allow for better BTM aggregation and demand response capabilities.	⚪🟡⚪
Provide a BTM incentive directly to consumers to increase energy storage deployments	⚪🟡⚪
Work on BTM standards for aggregation with utilities to encourage more integration of aggregated resources	⚪🟡⚪
Education Programs	
Train firemen and local support personnel on fire safety related to different types of energy storage deployments	⚪🟡⚪
Standup customer education programs so users and consumers interested in BTM can better understand their energy storage systems	⚪🟡⚪
Convene regulatory, utility, and developer stakeholders to discuss the future of the energy storage system	⚪⚪🔴
Targets	
Do not mandate deployment plans for utilities to reach energy storage targets	⚪🟡⚪
Provide clearer goals and targets when requesting storage installations with regards to the duration and metrics of the energy storage deployments	⚪🟡⚪
Revise targets more often and set more interim targets based on progress of the energy storage ecosystem	⚪🟡⚪
Energy storage deployments by muni's should not count toward utility goals	🟢⚪⚪

Allow V2G to count toward energy storage targets	○ ● ○
Keep energy storage definitions outlined by the legislature in place	● ○ ○
Other Funding and Incentives	
Develop an incentive program for non-wire alternatives	○ ● ○
Additional SCC Funding: Virginia Legislature should provide additional funding to the State Corporation Commission (SCC) to support additional needs and actions recommended for energy storage in the Commonwealth. This would support detailed planning and proactive approaches to address disparate planning processes	● ○ ○
Increase state funding for R&D and pilot projects for energy storage technologies	○ ● ○
Use money from RGGI to push energy storage forward in the state	○ ● ○
Utilize federal funding to expand internet access (can help with DER, aggregation, AMI, and other BTM incentives for customers)	○ ● ○
Markets	
Set up clean energy or carbon markets (establish a price on carbon in the state)	○ ● ○
Create RECS markets for energy storage	○ ● ○
Ensure that energy storage can receive compensation for all value it provides. This includes participation in multiple markets (capacity, resilience, etc). The ability to receive multiple revenue streams will greatly increase deployments.	○ ● ○
Create recycling markets for retired energy storage deployments and their infrastructure	○ ● ○
RFP and IRP Processes	
RFP Process Improvement: The SCC should perform open stakeholder engagement in request for proposal (RFP) development. This will provide improved competition, support transparency, provide context around the processes and regulations, and support alignment with codes and standards.	○ ● ○
IRP Improvement: Review and improve the Integrated Resource Planning (IRP) process to include energy storage issues of HB1183.	

Consider combining the ITP process with Transmission and Distribution (T&D) planning at the State and PJM level. Clarify process guidance where terms or recommendations are confusing or inaccurate.	🟢 ○ ○
Allow for all-source bidding	○ 🟡 ○
Allow for independent management of competitive procurement processes to ensure fairness	○ 🟡 ○
Ensure continued support for private energy storage development outside the RFP process.	○ 🟡 ○
State could issue an RFP on BTM applications	○ 🟡 ○
Technology/Infrastructure	
Minimize stranded assets across the system and repurpose existing assets	○ 🟡 ○
Cast a Wide Technology Net: Consider a broad variety of technologies as they pertain to energy storage. Do not limit energy storage projects to one specific technology.	🟢 ○ ○
Focus on mature technologies when focusing on deployments	○ ○ 🔴
Other	
Allow for rate basing of advanced analytics and similar analysis	○ 🟡 ○
Provide reminders that GHG reductions are driving energy storage deployments to ensure no further support of fossil fuel resources	○ 🟡 ○
Create resilience centers that utilize energy storage to provide power to distressed communities in times of power loss	○ 🟡 ○
Have in state utilities implement DERMS on a wider scale	○ 🟡 ○
Include a rider that benefits environmental justice and disadvantaged communities. Blackouts tend to occur in these areas more often	○ 🟡 ○

VIRGINIA ENERGY STORAGE TASK FORCE CUSTOMER ENGAGEMENT AND EQUITY SUBGROUP AGENDA

Date: July 29, 2021
Time: 12:30pm – 3:00pm
Subgroup Chair: Harry Godfrey
Facilitator: Chris Kelley

Access information:

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Time	Item	Presenter
12:30pm	Welcome and Introductions	Chris Kelley, Harry Godfrey
12:40pm	Opening Remarks	Harry Godfrey
12:50pm	Presentation: Ted Ko, Stem • Behind the Meter (BTM) energy storage programs, processes, and effective lessons	Ted Ko, VP Policy & Regulatory Affairs, Stem
1:30pm	BTM Energy Storage – Opportunities & Impacts Discussion • What are the BTM use cases today? How do we foresee those evolving? • Who are the BTM storage customers today? Tomorrow? • How will the growth of BTM storage impact the operation & economics of the grid? How should the grid evolve to maximize benefits / minimize costs? • How may BTM storage interact with (A) other Distributed Energy Resources (DERs)? (B) Transportation electrification? • What are the considerations, challenges, and benefits of supporting a "Bring Your Own Device" (BYOD)	All (C. Kelley facilitates)

VIRGINIA ENERGY STORAGE TASK FORCE CUSTOMER ENGAGEMENT AND EQUITY SUBGROUP AGENDA

Time	Item	Presenter
	program for energy storage? What effective BYOD models are you aware of? • Is there a use case for BTM storage without DERs? • Technology: Are batteries the only solution for BTM energy storage? Future technologies?	
2:10pm	Driving Customer Engagement and Adoption Effectively and Equitably • Consider the direction on Environmental Justice (EJ) from the Commonwealth of Virginia. In what ways is this a factor for energy storage adoption? How can this group's recommendations best support the intent of Virginia's EJ law? • What role can BTM storage play in enhancing EJ in Virginia's communities? • What are the customer benefits of participating in an energy storage scheme and do these benefits warrant the investment? Does this vary by C&I vs. residential customers? How can / should (A) government (B) the utilities, and (C) the private sector enhance access to BTM storage for EJ communities? • What consumer protections should be considered for customers, especially those who may not readily understand benefits and impacts of participating in energy storage programs? • What improvements to interconnection processes should be made to increase customer willingness to adopt energy storage?	All (C. Kelley facilitates)
2:55pm	Closing Comments	Harry Godfrey
3:00pm	ADJOURN	

VIRGINIA ENERGY STORAGE TASK FORCE GOALS & METRICS SUBGROUP AGENDA

Date: April 27, 2021
Time: 12:30pm – 3:00pm
Facilitator: Chris Kelley

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Time	Item	Presenter
12:30pm	Welcome and Introductions	Chris Kelley, Steve Padgett
12:40pm	Opening Remarks	Steve Padgett
1:00pm	Guiding Direction: Goals & Metrics Established via Regulation and Legislation • Consider the goals established by the Virginia Clean Economy Act. In what ways can energy storage support these goals? Are they clear enough to provide direction to the energy storage community or are there clarifications or refinements the VESTF should offer to the general assembly? What downstream impacts do these goals have on E.S. adoption?	All (C. Kelley facilitates)
1:20pm	IRP and Modeling Metrics • What metrics for energy storage should be considered in the current IRP process[i]? Do current grid models include metrics that support energy storage across all use cases? What is missing or could be improved?	All (C. Kelley facilitates)

VIRGINIA ENERGY STORAGE TASK FORCE GOALS & METRICS SUBGROUP AGENDA

Time	Item	Presenter
2:00pm	VESTF Member Experience • Consider your experience with energy-related goals and measures that apply to your domain. These could be goals set for alternative energy sources, improved innovation, environmental protection, improved reliability, incremental progress goals, or others. Which of these goals and measures could be applied to energy storage in Virginia?	All (C. Kelley facilitates)
2:30pm	Recommendations for the *Task Force* • Given the energy storage challenges and opportunities that have been raised in other VESTF meetings, what measures could be used improve Virginia's success with promoting opportunities and overcoming challenges?	All (C. Kelley facilitates)
2:45pm	Priority Recommendations for the *General Assembly* • Subgroup participants will select priority goals and metrics for the VESTF and general assembly to consider.	All (C. Kelley facilitates)
3:00pm	ADJOURN	

[i] See SCC case on Dominion's IRP filing: PUR-2020-00035

VIRGINIA ENERGY STORAGE TASK FORCE IMPROVED PLANNING AND HOSTING CAPACITY AGENDA

Date: April 13, 2021
Time: 11:30am – 2:00pm
Facilitator: Chris Kelley

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Time	Item	Presenter
11:30am	Welcome	Chris Kelley, Daniel Zambory
11:40am	Opening Remarks	Daniel Zambory
11:55am	Planning Process Challenges • Consider the current planning processes and regulations. What are the challenges faced by the energy storage community? • Which stakeholder groups are affected most? How?	All (C. Kelley facilitates)
12:25pm	Planning Process Best Practices • Considering current planning processes, what works well? • Are there other practices from other regions or states that we could model?	All (C. Kelley facilitates)
12:40pm	Hosting Capacity Considerations • Who can/should develop processes? Should utilities develop their own processes? • Are there current versions of hosting capacity models/systems happening now?	All (C. Kelley facilitates)

VIRGINIA ENERGY STORAGE TASK FORCE IMPROVED PLANNING AND HOSTING CAPACITY AGENDA

Time	Item	Presenter
	• What improvements could be made? What are the pros and cons?	
1:10pm	Priority Recommendations • Subgroup participants identify the top recommendations or next steps to take.	All (C. Kelley facilitates)
1:30pm	Cost/Benefits of Recommendations • What information do we have to inform the costs associated with the recommendations? • What would be required to better understand costs? • Are benefits clear and if not how can we best clarify them? • Who should pay for these recommendations (how to split between customer/utility/developer, etc.)?	All (C. Kelley facilitates)
2:00pm	ADJOURN	

VIRGINIA ENERGY STORAGE TASK FORCE MARKETS SUBGROUP AGENDA

Date: April 23, 2021
Time: 9:30am – 12:00pm
Facilitator: Chris Kelley

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Time	Item	Presenter
9:30am	Welcome and Introductions	Chris Kelley, Colleen Lueken
9:40am	Opening Remarks	Colleen Lueken
10:00am	Markets Overview • What markets are available to energy storage? Consider front of meter and behind the meter (BTM), aggregations, renewables with storage, non-wires alternatives, or other delivery system areas. • What market opportunities exist in the region (PJM, The Regional Greenhouse Gas Initiative [RGGI], or others)? Are there state-specific markets in Virginia to consider?	All (C. Kelley facilitates)
10:30am	Market Barriers and Opportunities • What barriers remain for storage participation in energy markets? Do current structures support participation in multiple markets or with multiple contracts? Does the market support power purchase agreements (PPAs) with utilities for services? • What benefits or opportunities exist related to market engagement of energy storage? Does energy storage	All (C. Kelley facilitates)

VIRGINIA ENERGY STORAGE TASK FORCE MARKETS SUBGROUP AGENDA

Time	Item	Presenter
	offer unique or novel market options? Are there noteworthy opportunities specific to Virginia?	
11:00am	Behind the Meter Discussion • BTM solutions represent 10% of the target. What issues and opportunities are present behind the meter? How does this vary by customer and load type? By region (within Virginia)?	All (C. Kelley facilitates)
11:30am	Priority Recommendations • Subgroup participants identify the top recommendations or next steps to take.	All (C. Kelley facilitates)
11:50am	Cost/Benefits of Recommendations • What information do we have to inform the costs associated with the recommendations? • What would be required to better understand costs? • Are benefits clear and if not how can we best clarify them? • Who should pay for these recommendations (how to split between customer/utility/developer, etc.)?	All (C. Kelley facilitates)
12:00pm	ADJOURN	

VIRGINIA ENERGY STORAGE REGULATION AND PERMITTING SUBGROUP AGENDA

Date: July 30, 2021
Time: 9:30am – 12:00pm
Subgroup Chair: Cliona Robb
Facilitator: Chris Kelley

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Time	Item	Presenter
9:30am	Welcome and Introductions	Chris Kelley, Cliona Robb
9:40pm	Opening Remarks	Cliona Robb
9:50pm	Permitting processes and perspectives • With respect to energy storage installations, what factors are important for local officials to understand? • What safety factors need to be considered? Do these factors vary by energy storage technology or installation? • What challenges does the interconnection process pose? Are there clear methods to overcome these challenges? Prioritize permitting factors • Consider the factors identified above. Which of these are priority concerns for local officials to be aware of? (online prioritization exercise)	All (C. Kelley facilitates)
10:40am	Open regulation topics for discussion • What requirements are important for regulators to consider regarding stand-alone (not grid-connected) energy storage? What additional recommendations are important for distribution-connected energy storage?	All (C. Kelley facilitates)

VIRGINIA ENERGY STORAGE REGULATION AND PERMITTING SUBGROUP AGENDA

Time	Item	Presenter
	• Should energy storage of a municipal utility count toward a utility's interim energy storage target? • Procurement requirements: Some parties have recommended independent management of competitive procurements involving utility affiliates. Is this viable and what would such management entail? • Procurement requirements: The Commission considered the use of a third-party administrator to ensure energy storage projects are competitively procured in a, "fair, impartial, and transparent," manner. This is not a requirement at this time, but should this be considered?	
11:30am	Interim targets for energy storage • Consider existing energy storage targets established and the discussion of this task force to date. Are there interim targets we should recommend? Do these targets accelerate energy storage adoption? • Identify high level benefits and costs associated with each target. Target priorities • Given the targets identified what are the top priorities? (online prioritization exercise)	All (C. Kelley facilitates)
11:50am	Closing Comments	Cliona Robb
12:00pm	ADJOURN	

VIRGINIA ENERGY STORAGE TASK FORCE TECHNOLOGY SUBGROUP AGENDA

Date: April 14, 2021
Time: 10:00am – 12:30pm
Facilitator: Chris Kelley

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Time	Item	Presenter
10:00am	Welcome and Introductions	Chris Kelley, Joe Lerch, Ricky Elder
10:10am	Opening Remarks	Joe Lerch, Ricky Elder
10:20am	Technology Overview • What energy storage technologies should the Virginia General Assembly be aware of? Identify and describe these. • Are they shovel-ready or in R&D stages? • How can the identified technologies – on an individual basis and in concert with one another – be positioned to provide maximum benefits to producers and consumers alike?	All (C. Kelley facilitates)
10:40am	Technology Challenges and Opportunities • What challenges or downsides might the General Assembly need to know about each technology? • What are the top benefits?	All (C. Kelley facilitates)

VIRGINIA ENERGY STORAGE TASK FORCE TECHNOLOGY SUBGROUP AGENDA

Time	Item	Presenter
11:00am	Presentation: Energy Storage of All Durations for Virginia	Paul Browning, Mitsubishi Power Americas
11:30am	Technology Challenges and Opportunities (cont'd) • Additional challenges and benefits? What might you change given the landscape elsewhere (other states or regions)?	All (C. Kelley facilitates)
11:50am	Priority Recommendations • Subgroup participants identify the top recommendations or next steps to take.	All (C. Kelley facilitates)
12:10pm	Cost/Benefits of Recommendations • What information do we have to inform the costs associated with the recommendations? • What would be required to better understand costs? • Are benefits clear and if not how can we best clarify them? • Who should pay for these recommendations (how to split between customer/utility/developer, etc.)?	
12:30pm	ADJOURN	

VIRGINIA ENERGY STORAGE TASK FORCE TECHNOLOGY SUBGROUP AGENDA

Date: June 3, 2021
Time: 2:00pm – 4:30pm
Facilitator: Chris Kelley

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Time	Item	Presenter
2:00pm	Welcome and Introductions	Chris Kelley, Joe Lerch, Ricky Elder
2:05pm	Opening Remarks	Joe Lerch, Ricky Elder
2:10pm	Presentation: Roland Berger Consulting • Changing resource mix • Emerging grid challenges and energy storage technologies • Normalized approach to energy storage cost/benefits	Ben Lowe, Roland Berger, Energy Storage Association
3:15pm	Impact of emerging resources and technologies • In what ways does the changing landscape of energy resources and energy storage technologies impact Virginia's challenges and barriers to energy storage adoption and deployment?	All (C. Kelley facilitates)
3:45pm	Approaches to Cost and Benefits analysis of energy storage • Does Lazard's Levelized Cost of Storage model apply in Virginia? Are there other ways to normalize calculations across technologies or use cases? What next steps for this type of analysis do you recommend?	All (C. Kelley facilitates)

VIRGINIA ENERGY STORAGE TASK FORCE TECHNOLOGY SUBGROUP AGENDA

Time	Item	Presenter
4:15pm	Presentation: Net Load Forecasts • Energy storage topics of interest from presentation at National Regulatory Conference	Ricky Elder
4:25pm	Closing Comments	Joe Lerch, Ricky Elder
4:30pm	ADJOURN	

VIRGINIA ENERGY STORAGE DRAFT REPORT REVIEW AGENDA

Date: September 8, 2021
Time: 12:00-2:30pm
Facilitator: Chris Kelley

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Time	Item	Presenter
12:00pm	Welcome and Opening Remarks • Plan to review draft report today • Review each section • High level comments, impressions, recommendations	Chris Kelley, David Essah
12:05pm	1. Introduction, incl. Task Force, Targets, Definitions, Technologies, Benefits, Costs	All (C. Kelley facilitates)
12:30pm	1. Introduction: Recommendations	All (C. Kelley facilitates)
1:00pm	2. Technologies and Use Cases	All (C. Kelley facilitates)
1:15pm	3. Barriers	All (C. Kelley facilitates)
1:30pm	4. Bulk Market 5. Utility System 6. BTM	All (C. Kelley facilitates)

VIRGINIA ENERGY STORAGE DRAFT REPORT REVIEW AGENDA

Time	Item	Presenter
2:15pm	7. Other Topics addressed	All (C. Kelley facilitates)
2:30pm	ADJOURN	

Appendix: References

Over the course of Task Force meetings and discussions, members provided a variety of resources to better inform discussion including whitepapers, government and academic research, and independent analyses of energy storage.

Particularly, members noted the value of learning lessons from other states' endeavors with energy storage. While Virginia is among the leaders with the adoption of VCEA, members identified several states that offered valuable lessons (including benefits to stress and pitfalls to avoid) to learn from during Virginia's own energy storage efforts. While these lessons were shared and captured as part of this report, full details of many of these experiences are referenced below for further reading.

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