STATE OF VERMONT
PUBLIC UTILITY COMMISSION

Case No. 20-____-PET

Petition of Green Mountain Power for approval	)
of its Climate Plan pursuant to the Multi-Year	)
Regulation Plan proceeding May 24, 2019 Final	)
Order and 30 V.S.A. § 218d	)

PREFILED DIRECT TESTIMONY OF MICHAEL BURKE ON BEHALF OF GREEN MOUNTAIN POWER

January 30, 2020

Summary of Testimony

Mr. Burke provides testimony regarding projects in the Transmission & Distribution ("T&D") category of the Climate Plan ("CP"). He discusses why hardening these systems is appropriate to respond to increasingly severe weather events on behalf of customers. He describes the types of T&D projects that GMP would expect to complete as a part of the CP and outlines the criteria these projects will meet to justify their inclusion under the CP. He also describes the benefits GMP customers and the State of Vermont can expect from these grid hardening and climate resiliency measures.

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Introduction

Q1. Please state your name and occupation.

A1. My name is Michael Burke. I am the Chief of Field Operations for Green Mountain Power ("GMP").

Q2. Please describe your background.

A2. I have worked for Green Mountain Power since 1997, serving in many roles with the company, including customer service, meter service, and engineering design prior to my current role leading field operations. Since 2009, I have served as the field operations chief for GMP, overseeing the planning and execution of all of our T&D field activities, including all restoration efforts from severe weather events. I received a Business Management Degree from Champlain College, completed the Vermont Department of Labor Lineman Apprenticeship three-year course, and have taken numerous engineering and operations courses while employed at Green Mountain Power.

Q3. Have you previously testified before the Public Utility Commission ("Commission" or "PUC")?

A3. No, I have not previously testified before the PUC in a contested case, though I have participated in workshop proceedings before the Commission, including the grid resilience and reliability workshop the Commission had on January 11, 2018 and the PUC Line Extensions Rule 5.600 workshops.

Q4. What is the purpose of your testimony in this case?

A4. I provide testimony regarding projects in the Transmission & Distribution ("T&D") category of the Climate Plan. I discuss why hardening these systems is appropriate to respond to increasingly severe weather events. I describe the types of T&D projects that we would expect to complete as a part of the CP, including the use of innovative techniques such as cable-in-conduit undergrounding, and I outline the criteria we have used to identify these projects and justify their inclusion in GMP's capital work under the CP. I also describe the benefits GMP customers and the State of Vermont can expect from GMP doing these grid hardening and climate resiliency measures.

Q5. How has Vermont's landscape and weather changed in your experience with the company?

A5. The Vermont landscape is much different today than when many of the existing utility lines were built. The tree canopy, for instance, is now matured. In many cases it towers over our existing distribution system with mature trees outside of our rights of way, commonly reaching 100' in height. The vast majority of our distribution rights of way have 25' clearances—only 12.5' on each side of the pole—and we currently do not have the opportunity to expand these clearances. With these relatively narrow corridors, our power lines are vulnerable to trees well outside of our maintained rights of way. Vermont's matured tree canopy and changing landscape, along with the increased severity of weather, demand a more robust electrical grid to withstand the forces that threaten our ability to reliably and safely deliver power to our customers.

Q6. Can you summarize why GMP believes T&D hardening projects are an essential part of the CP?

A6. Yes, we are concerned by the extent and frequency of damage we have seen from increasingly severe storms hitting Vermont and its effect on our customers. All one has to do is look at our very good response and reliability metrics day to day on the one hand, and the increasing number of severe storms and storm-driven outages on the other, to understand that even our well-run, well-maintained system cannot withstand the impacts that the climate crisis is throwing at us. While GMP is proud that we continue to meet our reliability criteria outside of Major Storms as described in our service quality plan, it is the Major Storms that have driven up costs and the frequency of outage events, along with non-major storm severe weather. Going back approximately 30 years, we have seen the five worst outage-causing storms in the past eight years, with four of those occurring in just the last five years, as shown in this chart:

Chart 1. Storms 2012–2020

Storm	Events	Customers Affected	Customers out at Peak
Hurricane Irene – Aug 28th to Sept 3rd, 2011	**1,604**	**140,655**	**57,000**
Merger			
Superstorm Sandy - Oct 29th to Oct 31st, 2012	920	42,076	
Severe Thunderstorms - June 2nd to June 3rd, 2013	443	26,339	18,000
Severe Thunderstorms - Sept 11th to Sept. 13th, 2013	1,195	46,588	32,000
December Ice Storm - Dec 22nd to Dec 24th, 2013	416	38,156	11,000
Severe Thunderstorms - July 3rd to July 6th, 2014	619	35,230	22,000
Heavy Wet Snow event, Dec 9th to Dec 17th, 2014	**3,130**	**147,832**	**39,000**
Severe Thunderstorms - July 23rd to July 25th, 2016	742	35,761	26,000
Heavy Wet Snow - Oct 26th to Oct 28th, 2016	879	33,653	16,750
Gravity Wave Wind Event - May 5th to May 7th, 2017	570	30,651	23,000
Halloween Gradient Wind Event - Oct 29th to Nov 4th, 2017	**2,688**	**124,825**	**81,000**
Gradient Wind event - April 4th to 6th, 2018	884	54,854	34,000
Thunderstorms and Gradient wind event - May 4th to 6th, 2018	995	58,214	38,000
Heavy Wet Snow and Wind Event - Nov 26th to Dec 3rd, 2018	**2,686**	**114,213**	**52,000**
High Wind Nor'easter - Oct 16th to Oct 19th, 2019	725	36,864	14,800
High Winds & Flooding Event - Oct 31st to Nov 4th, 2019	**1,709**	**113,964**	**56,000**

As head of our field operations for many years, what keeps me up at night is the increasing frequency of damaging storms, which then causes increased recovery costs for our customers. That pattern is not an acceptable future for our customers. We simply must accelerate the way we do system hardening if we want to keep Vermont strong in the years ahead.

For our T&D system, the Plan recommends prioritizing and accelerating our circuit hardening projects, using resilient construction techniques whenever possible and adding remote operation capabilities to our sub-transmission load break switches, which will enable us to drastically reduce the amount of time our sub-transmission lines are out due to faults. This Plan also includes the ability to propose non-construction expenditures, such as widening vegetation clearances on critical, single feed radial sub-transmission corridors. Finally, the Plan recommends accelerating certain substation relocations based on hydrologic analysis of 100-year and 500-year floodplains. Since 2011, we have had four substations flooded and/or damaged during high precipitation events due to their location in floodplains. Relocating these facilities is essential to mitigate the increase in severe precipitation events.

Q7. What do you estimate is the overall spending that would be required to undertake the T&D projects you describe below as a part of the CP?

A7. Currently, we have identified approximately 109 T&D projects that fit the criteria we have selected, above and beyond our business as usual base capital plan, for consideration over the next five years. All of these projects fit the criteria I discuss in this testimony to improve our grid resiliency. Of these projects, 63 are distribution line upgrades. *See* **Exhibit GMP-MB-1**. If undertaken collectively over a period of years, I estimate that the spending for these distribution line projects over multiple years would be approximately $37M based upon initial, high-level budgeting for these projects. This is based upon our standard, preliminary estimating tools, and is designed to give the Commission a sense of the scale of improvements needed over time in our opinion for safety and reliability, over and above our base spending levels. Obviously, the actual cost and schedule will depend upon the specific permitting, planning, and project execution undertaken, and will be governed by the processes laid out in the testimony of Eddie Ryan. For an example of how GMP will present analysis of these projects annually, see **Exhibit GMP-MB-2**.

For substation projects, we have identified 10 substations for relocation in the next several years due to their presence in either the 100-year floodplain or 500-year floodplain. *See* **Exhibit GMP-MB-3**. Collectively, the preliminary estimate for these relocation projects is $42,100,000. *See* **Exhibit GMP-MB-4**.

Lastly, we propose to invest $9,000,000 in 36 Motor Operated Air Break installations on our sub-transmission system over the next five years, for the reasons discussed below. *See* **Exhibit GMP-MB-5.**

Again, all of these estimates are preliminary, and the projects will be further refined as we move forward and would occur over a period of years.

Q8. Over what timeframe are you recommending these projects take place?

A8. When developing our project criteria and list, we kept in mind a five-year planning horizon. We expect, however, an annual process of project selection and review, and expect to fold this process into future rate case and IRP processes. There are two main factors that will affect our ability to advance these projects. First, due to the size of many of these projects, an Act 250 permit will need to be secured. In some instances, the Act 250 process has been quite efficient, while in other instances we've witnessed the process continue for more than two years. Second, we have to manage our ability to advance the CP projects while simultaneously advancing other planned and required capital projects, including those that GMP does not have control over such as for VTrans, solar development interconnection, line extensions, telecommunications, and customer requests.

On an annual basis, I estimate that the initial list of projects—if taken on in its entirety—would take more than five years to complete. We used a five-year horizon to develop the initial project list, but recognize that this type of planning must be ongoing. We also need to allow for reassessment and reexamination of priorities as we evolve the way utility planning is done to better factor in the impacts of the climate crisis now upon us. That is why our Climate Plan, unlike some I have seen in other states, proposes a set of criteria and annual process, rather than $X millions (or billions, in some cases) of spending over a set number of years.

There is no doubt in my mind that this type of comprehensive resiliency planning needs to be integrated fully into our way of doing business going forward. GMP maintains 9,978 miles of overhead lines. Even if we undertook all of the targeted undergrounding of single-phase distribution lines, more expansive use of tree wire, sub-transmission corridor widening, installation of self-healing technology, and other projects identified in the Plan, we would still have significant maintenance challenges ahead. Given what I have seen since taking on my current role at GMP, I think of the Plan projects as being absolutely necessary to preserve and improve the level of service we are providing our customers, in light of intensifying weather patterns, increasing storm restoration costs, proliferating Distributed Energy Resources that require reliability to operate, and growing electrification in order to help reduce carbon.

Q9. Given the extensive infrastructure GMP maintains, how will these projects affect the overall reliability and resiliency of the T&D system?

A9. These projects will have a positive impact on reliability and resiliency in two ways. First, the T&D projects will improve reliability during normal conditions and smaller weather events by hardening the distribution lines so they are better able to carry power through routine tree contacts and other incidents that might otherwise create a fault and cause a power outage. Second, during larger and more severe weather events, these T&D projects will harden mainline feeders and sub-transmission lines against damage—both directly and through self-healing and automatic switching—so that they are able to tolerate a higher threshold of weather impacts. These resiliency projects are at the center of the distribution system feeding power to distribution lines further out. During recovery events, the greater the ability for these lines to stay on, the faster and less costly the recovery efforts will be.

Q10. Will outages actually be reduced through these efforts?

A10. Yes. On individual circuits and areas of service where the CP resiliency projects are carried out, we certainly will see better reliability as compared to not delivering these hardening projects. In these project areas, we believe there will be a clear reduction in outage frequency and duration. We know that through analysis of similar resiliency projects we have already completed where we have documented significant outage reductions.

However, none of that is to say that we will prevent all outages occurring from severe weather. Major storm impacts will continue to be a reality. In fact, they likely will increase even with this work, as the weather patterns continue to worsen in line with the climate experts' forecasts. That is why GMP is taking a comprehensive approach to safety, reliability, and resiliency, with innovations like storage and technology advancements on communication as detailed in the testimony of Mr. Castonguay, Mr. Otley, and Mr. Dincecco. We view the Climate Plan as a bulwark against the more severe outcomes that are likely to occur in the absence of this work. The way I see it, with increased storm severity and frequency, a more mature and faster growing tree canopy than in the days when much of the grid was built in Vermont, and the rural character of much of our territory that exposes thousands of miles of line to threats, the Plan projects are critical, knowing that without this work, outages will increase and reliability will likely decrease while storm recovery costs keep going up.

I. Impacts to the T&D System Due to Extreme Weather

Q11. What types of impacts to the T&D system has GMP experienced due to severe weather, and how has that affected customers?

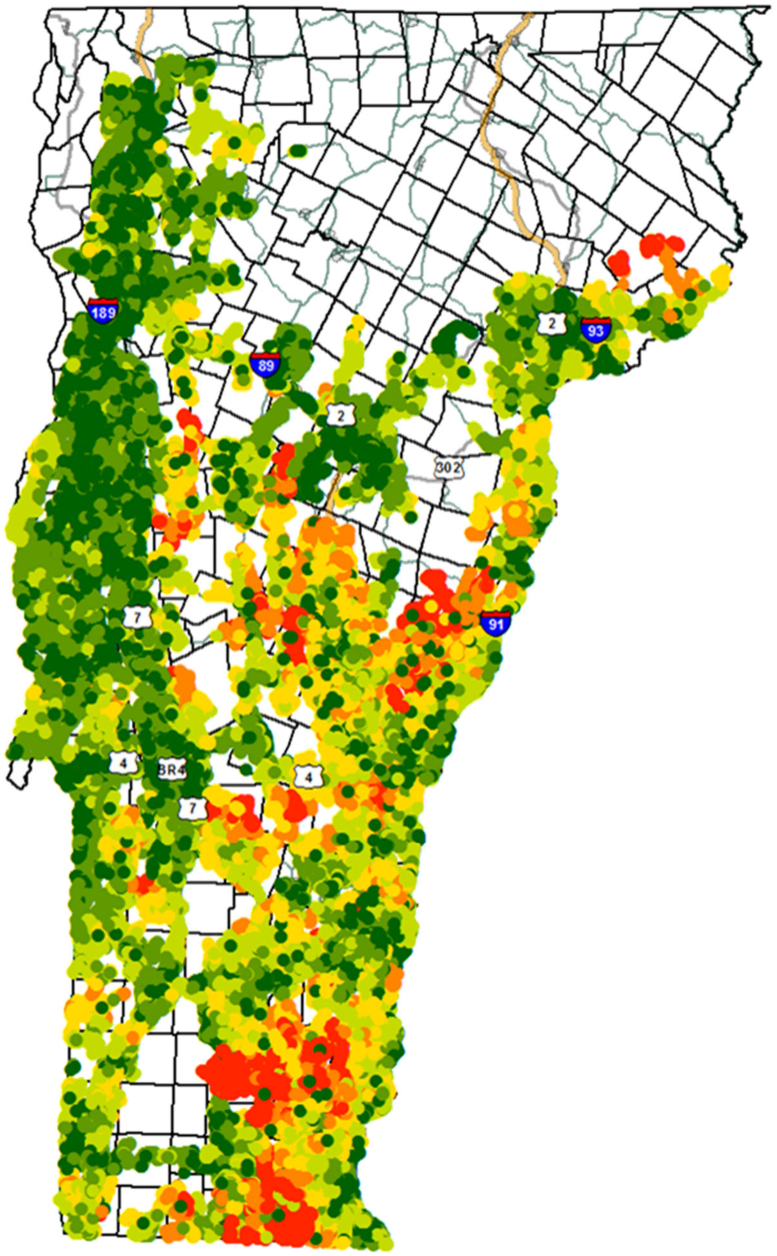
A11. The impacts to GMP's T&D system from extreme weather are best illustrated by our outage history over the past decade. The two most frequent weather types that cause outages are high winds and heavy precipitation, usually in the form of heavy, wet snow and ice. These weather systems, along with a mature growth tree canopy, are extreme hazards for our grid and are a driver of major storm repair costs for our customers. As the Commission knows, those costs amount to nearly $24M just for the years immediately prior to the current Multi-Year Regulation Plan (or "Regulation Plan") and because these are mostly immediate maintenance and repair costs and not capital project expenses, most of these costs cannot be amortized over many years. As a result, the direct and immediate rate impacts to customers are larger than making the investment in grid hardening. Meanwhile, the proactive grid hardening projects help reduce outage experiences going forward and also help over time to allow the system to manage Distributed Energy Resources and increased electrification.

Q12. What are the most challenging circuits in GMP's service area and why?

A12. We define our most challenging reliability circuits to be those with the poorest reliability metrics, which are listed below. The list shown below is generated annually as part of our PUC Rule 4.900, Electric Outage Reporting. Along with identifying lowest performing circuits, included below is a "heat map" that shows the areas most affected by outages. In the map, red indicates higher outage counts while green indicates fewer. GMP has no customers on the ridgeline of the Green Mountains, which explains why there are no outages shown on the map in this north/south swath where the Green Mountains are located. Looking at the map, you can see our higher elevation customers just below those ridgeline summits of the Green Mountains; this is where some of the most severe weather hits, as indicated by the red shading on the map. As the elevation drops further to the foothills and valley floors, so does the severity of the weather, which is again reflected in the map with increasing presence of yellows and greens and less reds.

Lowest Reliability Rank*	Circuit	Communities Served	Customers
1	Royalton (SH-G35)	Sharon, Strafford	1,336
2	Brattleboro (EJ-G7)	Townshend, Jamaica	2,615
3	Springfield (RA-G23)	S Londonderry	519
4	Springfield (LO-G26)	Windham, Londonderry	963
5	Springfield (LO-G27)	Londonderry, Weston	1,854
6	Royalton (WK-G81)	Barnard	1,264
7	Royalton (EB-Y38)	Pomfret, Barnard	232
8	Royalton (RO-G62)	Rochester	1,304
9	Royalton (PS-G43)	Randolph, Braintree	1,987
10	Royalton (ST-G45)	Stockbridge, Pittsfield	1,024
11	Springfield (BV-G44)	Reading, Weathersfield	781
12	St. Albans (BEL-G1)	Belvidere Ctr	43
13	Springfield (CV-G65)	Cavendish	321
14	Royalton (WK-G82)	Woodstock	1,006
15	Middlebury (SL-W1)	Leicester, Salisbury	296
16	Royalton (RC-G51)	Randolph, Brookfield	867
17	White River Jct (EL-G40)	West Fairlee, Thetford	996
18	Springfield (CH-G11)	Chester, Grafton	1,597
19	Rutland (MH-G13)	Mount Holly	1,820
20	Sunderland (RA-G22)	Jamaica, Winhall	940

* Five Year Average Ranking (2015-2019)



As the table and map illustrate, our lowest performing circuits often have common characteristics. Many of our twenty worst circuits are located in mid-elevation rural areas, on both sides of the Green Mountain ridgelines. Rural areas have historically been reliability challenges due to the length of line miles and presence of dense, high tree canopy that parallel but fall outside of our relatively narrow rights of way, in comparison to more urban areas with less tree canopy. Higher wind speeds, down-sloping winds, and more frequent frozen precipitation are also more common at these elevations. As Mr. Hill describes, in strong low-pressure storms, both sides of the elevated territory along the ridges of the Green Mountains experience the down-sloping wind phenomena, which occurs when the wind aligns with the mountain terrain to gain speed as it travels down in elevation toward valley floors.

II. Criteria for T&D Projects Selection Under the Plan

Q13. Describe the criteria you will use to identify the types of T&D projects you will include under the Plan.

A13. We've identified the T&D projects to be included in the Plan by first setting aside the projects we had already planned to do as part of our current Multi-Year Regulation Plan and focusing instead on additional projects that we believe need to be accelerated for the reasons we are describing here. We used several criteria to rank our distribution circuits, or sections of them, based on the magnitude of the impact we believe the hardening investments will have for the customers and the type and size of loads served.

To develop our recommendations, we utilized our twenty lowest performing circuits metrics coupled with a series of screening criteria. Together these factors are used to rank our distribution circuits, or sections of them, based on the magnitude of the impact the hardening investments will yield including:

- twenty lowest performing circuits, storm outage metrics;
- type, age, condition, and location of asset;
- the number of customers served by each circuit;
- outage hours and expected benefit from hardening; and

- the critical facilities served by the circuit.

Project prioritization will be based on a combination of an assessment of these criteria paired with the local experience of our knowledgeable field teams. Furthermore, our efforts will be aimed at improving the worst areas first.

Q14. Do all customers benefit from this work?

A14. Yes. All GMP customers benefit from the targeted CP improvements, some directly and some indirectly. Clearly, customers in the targeted areas benefit directly by experiencing higher reliability. But what we know is that with every severe weather event, significant resources are devoted to restoring power in the areas where CP hardening projects are being proposed, something all customers pay for in the form of storm restoration costs. Once the hardening projects have been completed, those areas will command less outage restoration resources, which will reduce maintenance costs and allow those restoration resources to be redistributed throughout the state during severe weather events to expedite restorations elsewhere. This proactive work is important for safety and reliability.

Q15. Can you provide an example of a T&D project you have already undertaken to address the type of damage you expect to see as a result of severe weather, and tell us what the outcome was?

A15. Yes. Our HR-G38 Circuit that serves the Bristol/Starksboro/Lincoln area provides an example of the results we have seen from prior hardening investments. Located in the mid-level elevations west of the Green Mountains in an area where down-sloping winds commonly occur, this circuit was consistently one of our lowest performing reliability circuits. The circuit was originally built in the late 1940s. It now coexists within a mature growth forest where 50'–100' trees stand just outside the right of way. It serves primarily a rural area consisting of residential customers. We implemented major upgrades to the circuit between 2016 and 2017 with the aim of hardening it against the effects of damaging storms, including heavy snow and high winds. As part of the project, we rebuilt and relocated just over seven miles of cross-country distribution to roadside with storm-hardened construction techniques. Since the conclusion of the project, outages on this line have dropped by approximately 70% compared to what they would have been without the hardening project, even in the face of several severe weather events since the upgrades were completed. The outage history since the rebuild project was completed shows there were no outages other than three instances where line crews requested the line to be deenergized so they could safely and quickly remove trees that had fallen on the line. Previously, these types of incidents would have meant that customers would experience outages lasting up to several days due to the remote, cross country nature of the line and the damage the line would incur during severe weather.

In other parts of our system where we have completed storm hardening projects, customers are not only experiencing reduced outages but also shorter outages, as we are often responding to incidents where we only have to remove trees or limbs from lines instead of having to repair and rebuild entire sections of line. We have also experienced the positive effects of hardening in severe weather events in Sharon, Strafford, Wilmington, Whitingham, and Pownal, among other areas. During a heavy, wet snow event in late November 2018, GMP crews removed 11 trees from an energized line between Sharon and Strafford. Due to the tree resistant covering on the line, the customers never lost power throughout the event despite the tree contacts. Even more recently, we have completed a self-healing project that will reduce outages for customers in South Burlington, and has given us experience to deploy this technique elsewhere. These are some examples of how the storm hardening investment can benefit our customers in terms of reduced damage and customer outage time.

To help inform the Plan selection criteria, we took key projects mentioned above and analyzed outage data to estimate the customer benefits from the projects. Specifically, based on data from similar storm hardening projects in recent years, we have seen, on average, a 66% reduction of outages in the project area attributable to the upgrade where the storm hardening projects have been undertaken.

III. Description of T&D Projects for the CP

Q16. What specific types of T&D projects appear necessary to you based upon the weather impacts you have seen?

A16. T&D hardening efforts will include the use of several types of resilient construction techniques.

The first includes utilizing cable-in-conduit installations to underground rural single-phase residential lines, where geography and soil conditions make this technique feasible.

Second, we will utilize tree wire in areas where the loads are smaller, the lines are located off road (i.e. cross-country), and/or in less densely populated areas.

Third, spacer cable will be used as part of main line feeder roadside construction wherever the threat of future tree growth exists.

Fourth, we plan to increase self-healing capabilities in areas where we have feeder back up capabilities, or can add that capability, and where it makes sense to isolate a particular section of line when a fault occurs. As part of the self-healing arrangement, the faulted section of a line can be isolated from the remainder of the circuit allowing the power to be restored to the un-faulted line section within five seconds. This capability has been successfully used on areas of our grid where we have critical load, such as downtowns, airports, etc. The key to these projects is in having the feeder backup capability to begin with, then adding the self-healing technology to the sections of line that we want to isolate when a fault occurs. For decades, we have used manual distribution feeder backup schemes to increase resiliency in areas served by radial feed sub-transmission lines; while this has been adequate, the greater reliance on the grid as we increase electrification now demands better tools. The logical next step using modern technology is to add feeder automation equipment and communications to convert these manual feeder backup areas, to self-healing circuits.

A recent incident brought home to us the importance of this technology. In a recent outage situation, a customer dropped a large tree on a radial feed sub-transmission line, bringing five spans of poles and wire to the ground in the process. The restoration effort took eight hours to rebuild the damaged portion of the line, affecting all customers along it in the process. If a proposed self-healing scheme had been in place prior to this incident, 83% of the customers on that circuit would have been back on in five seconds. Unfortunately, in the current configuration, 1,570 customers were without power for the full eight hours while repairs were made. This is just one example of the dramatic improvement self-healing system can provide our customers.

Fifth, the addition of motor operated air break ("MOAB") switches to the sub-transmission system also will help reduce the length and breadth of outages. MOABs allow our control rooms to remotely sectionalize faulted sub-transmission line sections, allowing the power to be restored to the un-faulted line sections within minutes. Without these switches, when faults occur on the line the customers remain without power until we can dispatch a switching crew to the area to manually operate the switches. Manual switching can add anywhere from one to four hours to a transmission outage depending on location, road conditions, severity of the weather, availability of crews not already working on outages, etc.

GMP has identified 36 locations on our sub-transmission system where resiliency can be improved with the installation of MOABs. It should be noted that many of the candidate sub-transmission lines where the MOABs would be installed include multiple distribution substations where we would potentially have the ability to reduce outage times for thousands of customers at a time.

In order for MOABs to be operated, the control rooms need to be able to communicate with them. This is one of the reasons we are also looking at whether we should, as a part of any Plan project, also run fiber in order to support our infrastructure (now and into the future), aid field communications, and potentially help communities that are underserved with broadband, consistent with State goals.

Sixth, substation hardening will focus on accelerated relocation of facilities that are otherwise located in areas of inundation as identified by our analysis of 100-year and 500-year floodplains data.

Seventh, we will also be looking at the implementation of enterprise-wide feeder backup software system, commonly known as a Network Management System, that will assist system operators in safely and reliably carrying out feeder backup actions in the presence of distributed generation and storage. These tools look at real time loads and generation on circuits to be tied together and proposes configurations to the system without running the system outside of tolerances. Currently this is done by manually looking at loads and estimating system capabilities utilizing static procedures. This project is a significant undertaking and we envision will take time to develop; therefore, we are not including this project in the preliminary Climate Plan list.

Eighth, there are other activities we will likely propose as Plan projects in coming years that will improve resiliency. Specifically, we will work to widen our easements so we can remove hazard trees that have the potential of striking our lines on radial sub-transmission corridors. To do this, first we will work to secure wider corridor easements to do this targeted hazard tree removal on our radial sub-transmission system to 150 feet (75 feet either side); we expect to do this for targeted tree removal only and not simply removing all trees through clear cutting. Then, we will work to remove individual hazard trees that have the potential of contacting our facilities, while preserving low-growth, compatible vegetation that does not pose a threat to our lines. This will result in GMP gaining the clearance needed in the face of the taller tree canopy. We have at least 14 radial feed sub-transmission lines to target with this resiliency improvement and we are working on project planning and cost estimates for acquiring the property rights and carrying out this work.

Expanding the radial sub-transmission rights of way in this manner differs from our normal rights of way maintenance in that the expanded rights of way out to 150' would likely extend to include preexisting buildings and structures located directly adjacent to our lines and would not allow for clear cutting. Targeted hazard tree removal may be the preferred strategy in balancing the need for grid resiliency with customer's desire to have trees on their property. We envision this work will take a significant amount of property owner outreach and negotiations in order to secure the easements to perform this work, so these projects are not included in our preliminary project lists attached to my testimony.

Q17. Why are these T&D projects different than the business as usual capital and O&M spending undertaken by GMP?

A17. All of these projects focus solely on the criteria listed above for resiliency and hardening our system in response to the impacts from the weather trends caused by the climate crisis. GMP's usual set of projects within its T&D capital plan limits the work we do steadily hardening lines from our twenty lowest reliability circuit list because of the additional projects we are required to complete on an annual basis for telecommunications providers, state and town road relocation projects, other VTrans projects, developers, and customers. The projects recommended in the Plan focus solely on resiliency and would be delivered in addition to our annual business as usual work.

Looking ahead, I believe we must change the way we conceive of business as usual and invest greater time and resources into the resiliency of our T&D system. We need to make these investments especially now as we move toward a more distributed grid because Vermonters will depend upon the backbone of the T&D system as we electrify and as individual homeowners or businesses begin to have the capability to "island" themselves through targeted storage and renewable generation in partnership with GMP.

There is a specific community resiliency and public safety aspect to this work, too. Not only do T&D outages affect our customers directly, but infrastructure damage from severe storms affects entire communities, disrupting everyday life and putting public safety at risk. In the past, we would have a severe storm and I would think to myself, "thankfully, we got through that without any emergencies, and got our customers back online." But as the number of severe storms has increased, I just do not feel we can continue business as usual on our current grid hardening efforts. Our well-trained and dedicated field operations teams do a great job of getting out in tough situations and getting people back online, but we need to do everything we can to put them in a position of succeeding.

Q18. What do you mean by "resilient construction techniques," which you mentioned as the way GMP would approach these T&D projects?

A18. For much of GMP's history, distribution lines have been built using overhead construction with bare wire. Traditionally, undergrounding has been expensive and difficult, due to the high labor costs of getting the underground infrastructure in the ground. More recently, GMP has been piloting a different technique and technology for undergrounding, and, in certain circumstances, we believe we can now cost-effectively deploy underground in certain locations in a way that is very similar to costs for rebuilds of overhead construction.

When we build overhead construction now, we are using stronger poles and wire that are designed to withstand tree contacts better, to harden against the impacts of increased storms. Specifically, we are installing equipment that can better withstand tree contacts without causing a fault or severe damage to our infrastructure. Severe damage cannot be always be avoided, even with the new storm hardened construction, but this stronger infrastructure will limit the extent of the severe damage when it does occur. Finally, the use of self-healing and automation technologies aid resiliency by cutting significantly the impact of any outage event.

Q19. Where would you expect to prioritize cable-in-conduit undergrounding above other measures?

A19. We will focus on utilizing cable-in-conduit for rural single-phase residential lines, where geography, soil conditions, and customer density make this technique feasible. There is no doubt that this technology can be cost-effective to use in certain single-phase distribution upgrade efforts because it drastically reduces all weather-related outages. Also, once installed, our customers will realize ongoing benefits in the form of reduced tree trimming and restoration costs in those areas. We will evaluate the feasibility of using this method for each of the single-phase line rebuilds we do, as the costs for a cable-in-conduit system appear to be relatively on par with the costs associated with relocating overhead, cross country lines to roadside rebuilds. In 2019, we installed over 50,000 feet (almost 10 miles) of single-phase underground using the new installation technique. We plan to use the knowledge gained to date in making decisions on where to utilize it. Most of the projects to date consist of smaller scale projects. We are in the process of installing a larger rebuild to prove out the cost-effectiveness at a greater scale.

Similar to the smaller projects, the knowledge gained with the larger scale projects will be used in the planning of future resiliency projects.

Q20. Tell me specifically about substations—how will the Plan approach resiliency upgrade projects for substations?

A20. We know from the 100-year and 500-year inundation maps and the recent work that was performed by VHB, as described in Jason Lisai's prefiled testimony, that some of our substations are located in these floodplains. *See* **Exhibit GMP-MB-4**. Our most significant substation incident occurred during Tropical Storm Irene when the expansive flooding from the Winooski River in Waterbury inundated our substation there, taking it out of service for an extended period of time. Since that event we have relocated our Waterbury substation to an area outside of the floodplain to ensure that our facility will not be compromised again in that way. The heavier, more frequent precipitation events that Vermont has experienced and will continue to experience put a small number of our substations at similar risk of inundation. We have looked at the 100-year and 500-year flood models, along with any history of inundation at those substations, to identify and prioritize the substations we are recommending for relocation in the Plan. While we would otherwise wait until these facilities are nearer the end of their useful asset life to perform upgrades, the threats and impacts of the climate crisis cause us to recommend that we accelerate these substation relocations for resiliency, safety, and for concerns for the environment that stems from our substation power transformers being compromised during a high-water event. *See* **Exhibit GMP-MB-3** for a list of the prioritization we have for these substation replacements.

Q21. What self-healing technology will you deploy as a part of the CP?

A21. These systems will be deployed mainly in areas that currently have—or can have—a feeder backup arrangement in place. Feeder backup allows for customers being fed off of one feeder to be picked up from another feeder in the event of one or the primary feeds being lost. As described above, GMP has had recent success with installing a self-healing system in the South Burlington area. We are also currently moving forward with a similar project in the Rutland area that will start with remote, control-room-based healing and evolve to a self-healing system. The self-healing system works by utilizing electronic microprocessor-based relays along with some combination of new fiber and/or cellular communications between the devices. As part of the operation, the protective devices detect faults and send communication to other protective devices to open or close, isolating the faults while quickly restoring power to the customers on the un-faulted section of line. The average timeframe of restoration of the un-faulted section of line is five seconds, which allows for distributed generation to drop out and avoids any power quality issues when the self-healing system closes back in.

Q22. What about remote customer islanding? What sort of analysis will GMP undertake as a part of the Plan for these areas of its system?

A22. Mr. Castonguay covers the issue of microgrids and islanding in his testimony. GMP is working with partners to create the protection schemes that will allow us to operate our first distribution level microgrids capable of islanding defined areas of distribution system including solar generation paired with storage. This is new technology deployment, and we are working through load and protection challenges and hope to begin testing islanding capabilities this summer. It is our hope that the development of these capabilities will be a further element of our resiliency efforts for customers.

All of the above projects may be able to incorporate fiber to further resiliency and also potentially aid in the State's broadband goals. We have had preliminary discussions with the Department and VELCO about adding fiber runs as part of certain Plan projects. Over the past eight years or so, we have developed internal capability to successfully run fiber optics. We believe we can cost-effectively run fiber in these projects for only a modest increased cost since we are already deployed in the field, and the wide-ranging flexibility of fiber now and in the future limits the possibility of stranded assets. This is especially true when one considers the needs of our field crews for communications, the technology for automating our devices and the loads connected to it, and the expansion of wireless (including 5G) service for Vermonters.

Q23. Are all the T&D projects contemplated within the Plan's framework capital spending, or do some involve O&M?

A23. Nearly everything we are currently contemplating will be capital spending, not O&M. As noted earlier, we expect to widen most radial transmission corridors from the typical 100 feet to 150 feet by doing targeted removal of dangerous trees within a widened 50-foot corridor. While the initial work to do this will take a few years and will involve upfront capital expense to acquire the easements and selectively remove trees, there would be ongoing expense associated with maintaining these corridors thereafter, like the rest of our rights of way.

Q24. Does the Plan cover normal vegetation management practices?

A24. No, not as proposed, though we will continue to evaluate our distribution seven-year (with certain areas at five-year) trim cycle as we move forward. What we are seeing in damage from mature trees outside our rights of way cannot be controlled simply with increased traditional vegetation management, and that type of maintenance is also costly to customers annually. That is why we are looking to add to this work through these hardening projects and selective radial sub-transmission widening.

Q25. Will you utilize the Department of Energy's Interruption Cost Estimator tool ("ICE tool") as a part of your project prioritization?

A25. Yes, but it will be only one tool we use to screen projects. The ICE tool is helpful in that it is based on Department of Energy criteria and helps analyze the cost of outages and the benefits associated with reliability improvements. But it also has limitations, because it does not necessarily look at the effects on customers other than those based upon a strictly financial view and does not take into account the disruption of daily life and the requirements to rebuild aged or poor condition assets, among other things. But used in conjunction with our other criteria and our own experience on outage improvements from reliability projects, the ICE tool may be another data point to look at the benefits of some of the projects we plan.

Q26. List the T&D projects so far identified by GMP under these criteria.

A26. Attached as **Exhibit GMP-MB-1** is a list of all T&D projects that we have identified for consideration under the Plan criteria. As permitting and other planning needed to advance these projects occurs, we will place these projects within our yearly project plan and follow the budgeting, capital planning, and accounting processes described in Eddie Ryan's prefiled testimony.

I also attach, as **Exhibit GMP-MB-2**, sample individual project analysis sheets utilizing a small group of projects we rank highly based upon the criteria we have established. The project sheets highlight the specific details associated with the project including a map of where the improvement will be carried out, the communities that will benefit, the cost of the project, and the relevant criteria that will be used to inform our selection of projects each year, utilizing our own restoration history and information from the ICE tool. While we must use judgment and do not believe a single formula or metric should control whether we pursue any individual project, we are open to feedback during the review of this Plan regarding how to balance these project ranking criteria. We would expect to use this format in our annual Climate Plan project lists submitted to the Commission.

Q27. Are these all the T&D projects GMP proposes for the Plan? If not, how does GMP propose to address future, to-be-determined projects?

A27. No. This is a preliminary list, and annually we will review and propose projects as described by Mr. Otley and Mr. Ryan. We know that we will need to continue to push this type of storm hardening out to most if not all of our lines at some point in the future, and that innovative technologies and strategic measures may evolve in the years going forward. That sort of evolving and updated planning will give us our best chance to mitigate the effects of climate change, while continuing to make progress on Vermont's electrification and greenhouse gas reduction goals.

Q28. Can you talk about why the proposed changes above are necessary, appropriate, and in the best interest of GMP customers?

A28. As I describe above, our customers are seeing significant and increasing costs from major storm damage. This is happening despite overall excellent reliability, service quality, and outage response. That is a reality that we have to face and address. We view the T&D projects proposed within the Plan as a way to mitigate these trends, even though we recognize that nothing can stop all outages, just as nothing will stop the increased severity of weather in the short- and mid-term. For any project that actually moves forward in the CP, GMP will complete its normal capital review process. The criteria we will utilize to select projects to pursue as a part of the CP help ensure the projects are necessary, appropriate, and in the best interest of our customers, while project reporting under the CP and the normal GMP capital planning process provide additional opportunities for regulatory oversight.

Q29. Does this conclude your testimony at this time?

A29. Yes, it does.