STATE OF VERMONT
PUBLIC UTILITY COMMISSION

Case No. 23-3501-PET

Petition of Green Mountain Power for approval of its zero outages initiative as a strategic opportunity pursuant to 30 V.S.A. § 218d and GMP's multi-year rate plan	

PREFILED DIRECT TESTIMONY OF

KEVIN J. MARA

ON BEHALF OF THE

VERMONT DEPARTMENT OF PUBLIC SERVICE

March 15, 2024

Summary: My testimony discusses system reliability and metrics within the context of Green Mountain Power's Corporation's ("GMP") Zero Outages Initiative ("ZOI").

Mr. Mara Sponsors the Following Exhibits:

Exhibit DPS-KJM-1	Professional Resume of Kevin Mara
Exhibit DPS-KJM-2	National Benchmarking
Exhibit DPS-KJM-3	Pole Aging
Exhibit DPS-KJM-4	Storm Costs
Exhibit DPS-KJM-5	OH v UG Costs
Exhibit DPS-KJM-6	PW of UG v OH
Exhibit DPS-KJM-7	Battery Usage
Exhibit DPS-KJM-8	Battery Long Outages

Q1. Please state your name, title, and business address.

A1. My name is Kevin J. Mara. My business address is 1850 Parkway Place, Suite 800, Marietta, Georgia 30067. I am the Executive Vice President of the firm of GDS Associates, Inc. ("GDS") and Principal Engineer for a GDS company doing business as Hi-Line Engineering.

Q2. Please describe GDS Associates, Inc.

A2. GDS is an engineering and consulting firm with offices in Marietta, Georgia; Austin, Texas; Auburn, Alabama; Bedford, New Hampshire; Augusta, Maine; Orlando, Florida; Folsom, California, Redmond, Washington; and Madison, Wisconsin. GDS has over 180 employees with backgrounds in engineering, accounting, management, economics, finance, and statistics. GDS provides rate and regulatory consulting services in the electric, natural gas, water, and telephone utility industries. GDS also provides a variety of other services in the electric utility industry including power supply planning, generation support services, financial analysis, load forecasting, and statistical services. Our clients are primarily publicly owned utilities, municipalities, customers of privately-owned utilities, groups or associations of customers, and government agencies.

Q3. Please describe your educational background and experience.

A3. I received a degree of Bachelor of Science in Electrical Engineering from Georgia Institute of Technology in 1982. Between 1983 and 1988, I worked at Savannah Electric and Power as a distribution engineer designing new services for residential, commercial, and industrial customers. From 1989 to 1998, I was employed by Southern Engineering Company as a planning engineer providing planning, design, and consulting services to publicly owned electric utilities. In 1998, I, along with a partner, formed a new firm, Hi-Line Associates, which specialized in the design and planning of electric distribution systems. In 2000, Hi-Line Associates became a wholly owned subsidiary of GDS Associates, Inc. and the name of the firm was changed to Hi-Line Engineering, LLC. In 2001, we merged our operations with GDS Associates, Inc., and Hi-Line Engineering became a department within GDS. I serve as the Principal Engineer for Hi-Line Engineering and am Executive Vice President of GDS Associates. I have field experience in the operation, maintenance, and design of transmission and distribution systems. I have performed numerous planning studies for electric cooperatives and municipal systems. I have prepared short circuit models and overcurrent protection schemes for numerous electric utilities. My experience includes assisting utilities with improving system reliability. I have also provided general consulting services, underground distribution design, and territorial assistance. I am a registered engineer in Georgia as well as in 22 other states.

Q4. Have you previously testified before the Vermont Public Utility Commission ("Commission")?

A4. Yes. I submitted testimony in Case Nos. 18-0974-TF, 20-0276-PET, and 21-2707-PET before the Commission.

Q5. Have you testified before any other regulatory commissions?

A5. Yes. I have submitted testimony before the following regulatory bodies:

- Federal Energy Regulatory Commission
- District of Columbia Public Service Commission
- Florida Public Service Commission

- Public Utility Commission of Texas
- Michigan Public Service Commission
- Maryland Public Service Commission
- Corporation Commission of Oklahoma

I have also submitted expert opinion reports before United States District Courts in California, South Carolina, and Alabama.

Q6. What are your qualifications to provide testimony before the Commission?

A6. I have 40 years of experience as a planning and distribution engineer specializing in electric utility systems. In this capacity as a distribution engineer, I have assisted electric utilities in the design, construction, and planning of their electric distribution systems. This work has included development of distribution system over-current protection, over-voltage protection, reliability improvements, and planned system upgrades. I have worked for electric utilities from Florida to Alaska in many different operating environments, and I have experience in a very diverse array of utility designs and operations. Over the last twelve years, I have provided testimony in the District of Columbia as well as for working groups encouraging and supporting Potomac Electric Power Company efforts to move from a system with very poor reliability to become one of the most reliable systems in the United States. I have also testified regarding the adequacy of the Storm Protection Plans of Florida Power & Light, Duke Power, Tampa Electric and Florida Public Utilities Company. These separate plans address a wide range of methods to improve reliability and resiliency in hurricane and storm prone Florida. I also serve as a member of the National Electric Safety Code in the Structures subcommittee, and I am also a representative on the American Society of Civil Engineers committee developing a new standard for the Minimum Loads for Structures Supporting Overhead Power Lines and Wired Telecommunication Infrastructure. My professional resume is attached as **Exhibit DPS-KJM–1**.

Q7. What is the purpose of your testimony in this proceeding?

A7. My testimony describes and proposes five (5) interim metrics, exclusive of major storms, to measure GMP's ZOI resilience/reliability performance under the Vermont Department of Public Service's ("Department") Option II. These interim metrics may also be considered under Option I if/when GMP and stakeholders engage in a longer, more robust ZOI planning process. **Table 1 below summarizes the Department's proposed interim metrics for Option II:**

Table 1: Department's Proposed Interim Metrics for Option II	
1	33% improvement in SAIDI/SAIFI for rural feeders over 2023 SAIDI/SAIFI
2	Forced Outage Rate per Hundred miles of Zone 1 Spacer Cable ≤ 3.0
3	Storm costs, downward trend in rolling five-year average costs – less than $13 million by 2030.
4	Battery Failure to Start Index ≤ 5%
5	Report CEMI-8 for all residential customers

<u>SYSTEM RELIABILITY AND BENCHMARKING</u>

Q8. What is your understanding as to why GMP is proposing the ZOI?

A8. As stated in Mr. Michael Burke's Prefiled Direct Testimony, Vermont has experienced devasting impacts from extreme storms over the last two years. These catastrophic events included heavy rain, heavy wet snow, high wind events, and severe thunderstorms.

Further, Mr. Burke states that because of climate change, GMP believes their system will be subjected to more severe weather in the years ahead.

Utilities can plan and build a power system for normal weather, but it is difficult to create a system that is immune to all severe weather. Thus utilities, to an extent, are at the mercy of these events. This is why the impacts of extreme storms are excluded from reliability indices. However, from a customer standpoint, the power is out regardless of the cause, and these customers suffer through these extreme events, especially if the events are long in duration.

GMP's recognition of the customer plight and initiating the ZOI is completely understandable, and I would agree needed, subject to the Department's recommendations in this proceeding.

Q9. Can you describe how the electric utility industry and the Commission define reliability?

A9. Yes. Electric utilities have a duty to provide safe, reliable, and affordable electric service. This duty for reliable service does not mean 100% reliability, but it is a core function of an electric utility. Many jurisdictions, including Vermont, require utilities to report on system reliability. Reliability is typically measured and reported through reliability indices such as System Average Interruption Frequency Index ("SAIFI"), Customer Average Interruption Duration Index ("CAIDI"), and System Average Interruption Duration Index ("SAIDI"), which are defined in Institute of Electrical and Electronics Engineers ("IEEE") Standard 1366. In Vermont, utilities generally report SAIFI and CAIDI. SAIFI is often thought of as the frequency of outages. CAIDI is the time it takes to restore power after an outage occurs. SAIDI is the sum of the outage times experienced by a customer. The relationship is simply that SAIDI is equal to SAIFI times CAIDI. The way to consider this is if a customer that, on average, has two outages per year and each outage takes, on average, one hour to restore power, then that customer has experienced two hours of outage in a single year.

Comparison of these indices is normally done excluding major event days, which are also referred to Major Service Outages or Major Storm Events. The IEEE Standard 1366 methodology for determining what a major storm is differs from the method used in Vermont, but the purpose is the same, which is to exclude outages caused by major storms from the reliability indices.

Q10. Does GMP have specific performance standards for SAIFI and CAIDI?

A10. Yes, as detailed in Mr. Bill Jordan's and Ms. Anne Margolis' Prefiled Direct Testimonies, each utility in Vermont has a Service Quality and Reliability Plan ("SQRP") approved by the Commission. The GMP SQRP performance measure for SAIFI is 2.4 and GMP's performance measure for CAIDI is 2.7, or 162 minutes.[1]

Q11. Has GMP met these performance standards for SAIFI and CAIDI?

A11. Yes. I understand from Mr. Jordan's Prefiled Direct Testimony that these performance standards have been met for the years 2013 through 2023. However, in my opinion these performance standards are not significantly challenging to GMP. The standards used for GMP are in the fourth quartile for utilities when compared to national benchmarking data and when comparing to regional peer groups of utilities.

[1] See **Exhibit DPS-CMF-2**, GMP SQRP, Monitoring & Reporting Plan, Revised 8/8/14.

Q12. How do GMP's reliability statistics compare to other utilities?

A12. One comparison can be made using the national benchmarking data published by IEEE that includes 260 utilities serving over 70 million customers.[2] To further the comparison, I excluded major storms. In this data set for 2021, the median value of SAIFI is 1.1, or 1.1 outages per customer per year. The GMP SAIFI value for 2021 was 2.01, or nearly double the national median value at the top of the fourth quartile of utilities. For CAIDI, the national median value in 2021 was 121 minutes, and GMP's CAIDI for 2021 was 129.5 minutes. For SAIDI, which is often used to measure customer satisfaction, the national median is 136 minutes, and the GMP's value is 269 minutes, which is in the top of the fourth quartile. The fourth quartile values are clearly considered to indicate poor reliability in this benchmarking data. This is more clearly shown in **Exhibit DPS-KJM-2.**

Q13. Regional differences could affect reliability comparisons. Can you compare GMP to other utilities in the region?

A13. Yes. Using U.S. Energy Information Administration ("EIA"), Form EIA-86 Annual Electric Power Industry Report, I pulled utilities that are contained in the 2022 GMP Benchmarked performance report. Some of the utilities in the peer group included utilities that are not in the region, and I excluded these utilities. My data set had eight (8) other utilities in New England and New York for comparison to GMP in terms of SAIFI, CAIDI, and SAIDI.

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[2] IEEE Benchmark Year 2022 Results for 2021 Data.
https://cmte.ieee.org/pes-drwg/wp-content/uploads/sites/61/2022-Benchmarking-Survey.pdf

As shown in **Table 2**, GMP does not compare favorably with other regional utilities in terms of SAIFI without Major Storms.

Table 2: SAIFI

	SAIFI - WITHOUT MAJOR STORMS				
Utility	**2018**	**2019**	**2020**	**2021**	**2022**
Versant Power		1.96	2.40	1.97	2.46
Green Mountain Power Corp	1.86	1.46	1.97	2.08	1.97
Central Maine Power Co	1.85	1.53	2.04	2.04	1.71
Central Hudson Gas & Elec Corp	1.50	1.20	1.29	1.40	1.30
Fitchburg Gas & Elec Light Co	1.57	1.24	1.27	1.27	1.10
Unitil Energy Systems	1.20	0.85	1.60	1.04	0.88
Rochester Gas & Electric Corp	0.75	0.72	0.88	1.13	0.83
Public Service Co of NH	1.07	0.74	0.81	0.83	0.68
Liberty Utilities (Granite State Electric)	1.02	0.92	1.00	0.86	0.64
Median Value	1.35	1.20	1.29	1.27	1.10

In terms of CAIDI, GMP values were the highest of the data set for 2022 as shown in **Table 3**.

TABLE 3: CAIDI

	CAIDI - WITHOUT MAJOR STORMS				
Utility	**2018**	**2019**	**2020**	**2021**	**2022**
Green Mountain Power Corp	139.20	115.80	136.80	129.60	142.20
Liberty Utilities (Granite State Electric)	154.97	125.20	101.38	127.17	132.74
Versant Power		154.40	132.70	110.49	132.47
Central Hudson Gas & Elec Corp	121.80	148.33	142.33	162.36	132.46
Public Service Co of NH	112.16	111.66	118.82	116.32	116.05
Central Maine Power Co	127.46	124.05	108.24	107.65	100.87
Rochester Gas & Electric Corp	107.20	110.83	106.20	107.79	97.94
Unitil Energy Systems	96.34	97.67	75.21	98.70	80.53
Fitchburg Gas & Elec Light Co	68.94	67.39	50.95	60.66	65.18
Median Value	112.16	115.80	108.24	110.49	116.05

Finally, the comparison of SAIDI shows that GMP has below average reliability compared to the peer group as shown in **Table 4**.

Table 4: SAIDI

	SAIDI - WITHOUT MAJOR STORMS				
Utility	**2018**	**2019**	**2020**	**2021**	**2022**
Versant Power		302.00	319.00	218.00	326.00
Green Mountain Power Corp	258.91	169.07	269.50	269.40	280.13
Central Maine Power Co	235.80	189.80	220.80	219.60	172.49
Central Hudson Gas & Elec Corp	182.70	178.00	183.60	227.30	172.20
Liberty Utilities (Granite State Electric)	158.07	115.69	100.87	108.73	84.29
Rochester Gas & Electric Corp	80.40	79.80	93.46	121.80	81.29
Public Service Co of NH	119.90	82.63	95.77	96.78	78.80
Fitchburg Gas & Elec Light Co	107.97	83.56	64.90	77.10	71.44
Unitil Energy Systems	115.80	82.53	120.04	102.75	70.79
Median Value	138.99	115.69	120.04	121.80	84.29

From this regional comparison, I conclude that GMP has significant work ahead to improve reliability and resiliency.

Q14. In your opinion, should SQRP values for reliability be revisited by the Commission, GMP, and stakeholders?

A14. Yes. There is significant room to challenge improved performance by GMP. In fact, GMP's ZOI will require new metrics to monitor and judge the success of the program. I address suggested metrics later in my testimony.

TRADITIONAL RELIABILITY IMPROVEMENT METHODS

Q15. What is your understanding of the ZOI?

A15. At a high level, GMP is planning to use spacer cables in Zone 1 out of the substation to make the first critical path of a circuit less likely to experience an outage. Also, where appropriate, GMP plans to convert overhead lines to underground lines primarily in sections of the feeder that GMP refers to as Zones 2 and 3.[3] Finally GMP plans to use battery storage in the homes for customers located in Zone 4, which are often homes that are the furthest from the substation. ZOI Phase I includes capital investments in transmission and distribution infrastructure of $250 million and $30 million for battery systems.

Q16. In your experience, what are the traditional methods used by electric utilities to improve their service reliability and resiliency?

A16. In my experience, utilities utilize any number of different coordinated initiatives. The most common initiative is enhanced vegetation management. Trees are, for many utilities including GMP, the number one cause of outages. Expanding tree trimming using techniques like ground-to-sky clearing resulting in no limbs or branches over hanging the power lines; increased trim width often includes acquiring additional right of way; expanded hazard tree removal; and shorter trim cycles. Providing greater space between power lines and trees is also a proven method to reduce squirrel-caused outages. Finally, improved right of way maintenance provides for better and easier access for repair crews.

I note the last changes to GMP's vegetation management practices for both transmission and distribution occurred in 2018.[4] However, I understand that on circuits with a higher density of customers (75 or more customers/mile), GMP manages vegetation on a five-year cycle, which represents about 13% of all distribution lines.[5] I note that a five-year trim cycle is not addressed in current GMP Vegetation Management practices.

[3] Exhibit GMP-MB-7 Rev Circuit Zone Map for identification of zones on a circuit.
[4] GMP 2021 Integrated Resource Plan Appendices F and G.
[5] GMP Response to Q.DPS.GMP.1-103.

The following **Table 5** shows that trees continue to remain the number one cause of outages on GMP's system even though there has been a reduction from 2018 to 2023.

Table 5: % of Customer Outage Hours due to Trees

Year	% of Customer Hours of Outages Attributed to Trees Excluding Storms
2013	55%
2014	66%
2015	56%
2016	72%
2017	85%
2018	82%
2019	82%
2020	73%
2021	70%
2022	75%
2023	67%

GMP witness Mr. Michael Burke expressed concern that the "longer growing season is resulting in rights-of-way that will require much more expensive and frequent trimming. This will increase costs to an unsustainable level." However, the GMP data shows that the compounded growth rate in right-of-way maintenance has increased 5.3% between FY20 and FY24 which, in my opinion, is reasonable and in line with expected increases in labor costs.[6]

Another common practice utilities use to improve reliability is more aggressive replacement and renewal of aging infrastructure, including wooden poles. For instance, the Florida Public Service Commission ("PSC") ordered that all wood poles must be

[6] Case No. 23-3501-PET, Burke PFT of 10/9/23 at 8, lines 2-3; GMP Discovery Response to Q.DPS.GMP.2-103 in this proceeding.

inspected using sound-bore techniques to identify poles that no longer meet the strength requirements set forth in the National Electric Safety Code ("NESC").[7] In Order PSC-06-0144-PAA-EI, the Florida PSC noted that for "named storms impacting Florida in 2004 and 2005, the number of failed poles resulting from a storm are correlated with the number of days required to restore service to customers," which emphasizes the value of pole inspections and replacement of aged infrastructure. My analysis of the age of GMP's wood poles shows that 25% of the poles in service are older than 50 years and 38% are older than 40 years.[8] Wood poles are normally depreciated over 30 years but often have a service life longer than 30 years. This aged fleet of poles impacts reliability, resiliency, and storm restoration costs.

Other common upgrades are automated self-healing systems, some form of storm hardening, and targeted undergrounding. GMP is proposing these types of projects as part of its ZOI.

Q17. In your opinion will the hardening proposed by GMP improve reliability?

A17. At a high level, I do expect the hardening activities to improve the reliability and resiliency of the system. If we ignore the storage solution proposed by GMP, it seems that GMP should have a goal or target for SAIDI/CAIDI values resulting from these improvements. Because GMP is starting with rural feeders and applying the ZOI by focusing on areas of poor performance, measuring and monitoring progress will be a challenge for stakeholders and regulators if only total system indices are used.

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[7] Florida PSC Order PSC-06-044-PAA-EI; NESC Rule 260B.
[8] See **Exhibit DPS-KJM-3**.

Q18. What is your opinion of using untraditional solutions for improving reliability?

A18. In my opinion, every system has unique challenges and, for GMP, conflicts with the abundant vegetation and aged infrastructure are significant challenges as well as the increased number of catastrophic weather events. These challenges result in a higher frequency of outages, which drives SAIFI to higher levels. Reducing the occurrences of outages will in turn reduce SAIDI. Storm hardening and targeted undergrounding help with reducing SAIFI. However, the use of batteries in homes does not reduce outages, rather the use of batteries can provide some level of comfort while repairs are made to the grid. But these repairs need to be made, at a cost to ratepayers, and need to be completed quickly since the batteries have a short discharge life during an outage. Tracking SAIFI and SAIDI is a means to determine the health of the grid not only for reliability, but resiliency. Low SAIFI/SAIDI values will result in lower storm repairs. Battery storage does not reduce storm repairs.

ZERO OUTAGE INITIATIVE

Q19. Earlier you discuss at a high level your understanding of the ZOI. Can you please expound on your understanding of the total planned ZOI?

A19. Yes. The proposal by GMP is Phase I of a larger initiative. Phase I addresses the first two years of the initiative with a budget of $280 million. The next phase(s) are less defined than Phase I. GMP has said that the solutions will evolve over time and may adapt to technological advances. Overall, GMP has offered a potential total ZOI budget of $1.5 billion.[9] The end goal of the ZOI is zero outages for all customers.

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[9] See **Exhibit DPS-AM-3**.

Phase I includes various hardening programs, including spacer cable in Zone 1, hardening overhead in Zones 2 and 3, targeted undergrounding in Zones 2 and 3, and the use of batteries in Zone 4. There is more automation for self-healing and also community Battery Energy Storage Systems to assist with reliability and resiliency.

The selection for hardening and ZOI initiatives will be determined by GMP with a focus on projects in rural, heavily forested areas of the state that are experiencing the greatest impacts from climate change with some weighting with the Center for Disease Control's Social Vulnerability Index.[10]

The greatest impacts from climate change appear to have focused on areas of the system with poorer reliability rather than other parts of the system.

Q20. Regarding the storm restoration costs, do you believe it is necessary to rapidly deliver the ZOI?

A20. I believe the recent high frequency of storms highlights the need to start a program of improving reliability and resiliency. However, reducing the storm restoration costs should not be the only driving factor, rather reliability and resiliency which are the customers' experience should be paramount. In my experience, storms occur in cycles with some years experiencing more storms than other years. **Exhibit DPS-KJM-4** shows a graphic of the storm costs over the eleven-year period from 2013 to 2023. For the five-year period between 2018 and 2023, the storm restoration costs were $53.0 million. For the five-year period between 2014 and 2017, the storm restoration costs were $52.7 million. So, some

[10] See **Exhibit DPS-AM-2**: GMP Discovery Response to Q.DPS.GMP.2-33 in this proceeding.

years the cost is higher and some years the cost is lower but viewed over a larger period, the costs have been relatively constant.

Q21. Regarding targeted undergrounding, do you agree that this solution should be used to improve system reliability and resiliency?

A21. Yes. Targeted undergrounding is a valuable tool and can be used effectively for improving system reliability. However, it is important to recognize that undergrounding existing overhead lines is generally not cost effective even when significant tree cover is present, and therefore should only be used in specific applications. Mr. Burke stated that undergrounding will be a preferred solution wherever possible, which I maintain will add significant cost to the ZOI and ratepayers, especially when these single-phase lines have few customers.

In **Exhibit DPS-KJM-5**, I show that the cost to underground a single-phase line on GMP's system is $308,728 per mile, while the cost to rebuild an overhead line along the road is $187,962 per mile. Further, I used GMP's cost benefit model to develop the present worth differential of overhead and underground using the construction costs in **Exhibit DPS-KJM-5**.[11] The resulting lifetime cost for moving an existing overhead line to the road will be 60% of the cost of undergrounding the same line, as shown in **Exhibit DPS-KJM-6**.

To complete GMP's goal of zero outages, it is necessary to underground a significant number of miles of these single-phase lines. According to GMP, there are 3,500 miles of single-phase line that would need to be undergrounded at a cost of $308,000 per

[11] GMP Discovery Response to Q.DPS.GMP.1-28a in this proceeding.

mile.[12] This component alone will cost over $1.1 billion. Further these single-phase lines directly serve only 63,000 customers. So, while improved reliability is important, the cost must be balanced with the benefit. This, alone, demonstrates the need for a more thorough ZOI plan, as recommended by the Department in **Option I**.

Q22. Will undergrounding, as described by GMP, eliminate outages?

A22. No. GMP plans to underground existing overhead single-phase lines, which are often routed across the country. These existing lines are located in challenging rights-of-way and difficult to access by utility crews, so these lines will be undergrounded parallel to the road. When there are customers along the path, GMP will not be undergrounding the service conductor to the home nor replacing the overhead transformer serving the customer.[13] In fact, I suspect there will be short sections of overhead lines necessary to connect these services to the new underground conductors. This reduces the cost of undergrounding by leaving the existing overhead service and the overhead transformer, but these system components are prone to outages (lightning, squirrels, birds, trees, tree limbs, etc.). So, the investment in undergrounding will still leave pockets of vulnerability.

Q23. What is your opinion of the spacer cable plan for Zone 1?

A23. Spacer cable is a viable option for improving system reliability. The covered conductor can continue to deliver energy to customers when trees and tree limbs come into contact with the insulation over the conductor. It is important for all stakeholders to understand that the spacer cable does not have a grounded sheath (metallic sheath over the

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[12] GMP Discovery Response to Q.DPS.GMP.1-42 in this proceeding.
[13] See GMP Discovery Response to Q.DPS.GMP.2-99 in this proceeding.

insulation).[14] Since the energized line is hazardous to humans, a spacer cable that has fallen from a pole should not be touched. The spacer cable design is compact and supported by a messenger cable with a very high tensile strength to limit the sag that can also serve as the neutral conductor. This system of conductors should improve service reliability if designed properly, and adequate maintenance of the right-of-way continues to allow an active hazard tree mitigation program for Zone 1.

Q24. Do you have specific concerns regarding the design of the spacer cable?

A24. Yes. GMP is designing distribution in compliance with the NESC Rule 250B, which calls for loading of the line with 0.5 inches of ice and a 40 mile-per-hour ("MPH") wind. GMP clearly meets the requirements of the NESC. However, Mr. Burke expressed concerns about more frequent and more intense storms. The NESC also has extreme wind loading, which applies a 90 MPH wind gust at a height of 33 feet above-ground-level for southern Vermont (NESC Figure 250-2b). This 90 MPH wind gust is based on a 50-year mean recurrence interval, which means the annual probability of exceedance is 0.02 or 2% each year (1/50) and is often applied to the design of distribution lines. Mr. Burke stated that a storm near Colchester resulted in wind speeds of 69 MPH (a constant 69 MPH wind speed converts to a wind gust of 89.7 MPH).[15] Lines designed for a 40 MPH wind would be expected to fail in this windstorm. In this case, Mr. Burke noted that there were few outages, which is good, but in my opinion, this occurred partly because the line was newly

[14] Ground sheath is a metallic wire or wires applied over the insulation to maintain ground potential of zero volts on the exterior of the cable.
[15] See GMP Discovery Response to Q.DPS.GMP.2-17 in this proceeding.

constructed. However, compounding the probability of extreme wind speeds year after year along with poles that, based on **Exhibit DPS-KJM-3**, may have a service life as long as 50 years, I maintain a prudent design may need to meet the *extreme wind* (NESC Rule 250C) and *extreme ice with concurrent wind* (NESC Rule 250D) NESC standards. This adds cost to the design but clearly recognizes the risk of extreme winds based on recorded wind histories.

Q25. In terms of the residential batteries, what is your understanding of the current use of batteries on GMP's system?

A25. GMP has a number of programs that encourage the use of home batteries, such as Tesla Power Walls. Many are used for demand-side management and to provide power in the event of an outage, a secondary function. The advantage of the demand-side management is that the battery's function of reducing peak demands helps to offset the cost of the battery. This, in turn, allows the secondary function of providing backup power from a unit that is already in service and has a cost benefit to GMP. Obviously, this becomes a win-win for GMP and the customer since they both achieve value from the battery system.

Q26. Is there communication between GMP and the battery systems in the homes?

A26. In order for GMP to control the batteries, there is a communication link to the battery system that allows GMP to switch the battery on or off for peak events, as needed. This communication allows GMP to record battery usage even during an outage. I understand the communication link is often an internet connection at the house.

Q27. In the event of an outage, do the batteries automatically backup the electrical appliances in the home?

A27. It depends on the wiring of the battery system. First, we need to understand that when utility power is available, the battery system is connected to the grid. The battery inverter has protection that isolates the battery from the grid in the event of outages or excursions in voltage and frequency significantly above or below nominal requirements. To safely re-energize the home, the home must first be disconnected from the grid, such as by opening the main breaker in the home. GMP installs an automatic disconnect switch for the home as part of the installation package of battery system.[16] Once isolated, the battery can then power the load in the home. The typical residential battery is rated for 13 kWh with a maximum output of 5.76 kW.[17] Because the peak capacity is relatively low (5.76 kW), it is necessary to control and manage the appliances to be fed by the battery. In some cases, the load shedding relay function in the battery control can automatically control retrofitted breakers. Alternately, a subpanel can be wired with only emergency circuits in the home.

Q28. Is GMP proposing to install 13 kWh batteries for homes in Zone 4?

A28. I understand that GMP will offer up to two batteries with each battery rated for 13 kWh. I assume that smaller homes may only require a single battery. If customers desire more capacity, the customer will be able to add on to the system at their expense.[18]

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[16] See GMP Discovery Response to Q.DPS.GMP.2-100 in this proceeding.
[17] See GMP Discovery Response to Q.DPS.GMP.2-109 in this proceeding.
[18] See GMP Discovery Response to Q.DPS.GMP.2-112 in this proceeding.

Q29. Have you analyzed how batteries are used by residential customers during an outage?

A29. Yes. GMP provided a data set of the battery usage during outages for the period from 2018 to 2023.[19] The data included 2,411 locations and 34,773 outage events. The number of battery systems that experienced an outage increased from 463 in 2018 to 2,030 in 2023. This increase is simply the expansion of the program over time.

The data shows that 5% of the time, the batteries provided no power to the home during the outage as shown **Exhibit DPS-KJM-7**. In my opinion, this is due to the unavailability of the battery to the customer. Some cases could be communication issues not capturing the data, but when power from the battery is restored to the home, internet routers would have power.

I also analyzed the battery usage during an outage event. For outages lasting less than one (1) hour, 52% of homes used less than 300 watthours (0.3 kWh) from the battery. The GMP residential customer average hourly usage was 0.79 in 2022 and 0.81 in 2021. If residences only had essential appliances in use, then this value of 0.3 kWh seems reasonable. For outages lasting longer than 59 minutes but less than 120 minutes, 51% of the homes used less than 1.0 kWh of energy during the outage.

The largest user of emergency power in the home is refrigeration load. A refrigerator typically has a demand of 150 watts and can run for one to two hours.

The data was inconclusive if battery systems were depleted during an outage. However, my analysis detailed in **Exhibit DPS-KJM-8** showed outage durations between 24 hours to 72 hours affected 2,246 events at 1,272 different homes. Of these events, 642

[19] See GMP Discovery Response to Q.DPS.GMP.1-31 in this proceeding.

used only five watts or less, which could be an indication of a depleted battery at a home and represents roughly 29% of the events during these long outage events. For these events, 616 homes used more than 13 kWh from their battery, indicating they either had two 13 kWh batteries in the home or had supplemental solar for charging the batteries. This group made up nearly 27% of the homes during these long outage events. Also, some customer may have not conserved energy usage, as recommended during an outage, and other customers may wisely conserve, but when the battery no longer has capacity to maintain electric service, both types of customers will be without power.

Q30. Regarding the availability of energy from a battery system, what reporting metrics do you suggest for battery storage on residential homes?

A30. First, I recommend GMP track the availability of batteries when grid power is lost. For standby generators, this is referred to as failure to start ("FTS"), and studies have shown that FTS ranges from 0.13% to 1.65%, but these standby generators are often used for safety purposes such as emergency lighting in hotels and schools. Referencing **Exhibit DPS-KJM-7**, GMP's data shows that 5% of battery systems did not produce electricity. I suggest that GMP track customers with a battery fail to start to supply index ("BFTSI"), which is the sum of customers with battery systems that failed to provide backup power during an outage divided by the total customers with batteries. Based on the data available, the metric or goal should be 5% or less. It is important that, if customers are paying for a backup battery system, then the system should operate when required. This metric will help track future maintenance of the battery system, which is more than a battery. It includes the automatic transfer switch, load shed logic circuits, relay controls, and other components of the energy management system embedded in the battery system which is owned and operated by GMP.

Stakeholders will need to conduct more research to learn how often batteries were depleted during an outage. Based on the available data, about 3% of all events had the battery system producing more than 13 kWh, which could be two battery units or solar coupled with batteries. In fact, for outages lasting eight hours or less, only 1% of events used more than 13 kWh.

Q31. Are you aware of if/how GMP plans to provide batteries for commercial loads?

A31. No. GMP has not addressed the use of batteries on commercial loads such as grocery stores, restaurants, gas stations, etc. For these businesses, a battery that limits operable appliances results in business closures. For example, if a restaurant cannot use dishwashers, electric cooking surfaces, etc., the restaurant will need to close, and this would be true of many other different businesses. Another complicating factor is that a business requiring three-phase service requires a unique battery system not offered by Tesla. Thus, the need for three-phase and much larger battery systems in terms of kW and kWh makes batteries for commercial customers, in my opinion, not feasible at this time. To be fair, GMP has used utility scale battery storage to provide backup power to a distribution circuit, which may include commercial customers. However, if the distribution circuit has an outage, the utility scale battery can no longer deliver energy and, thus, zero outages cannot be achieved.

Q32. In your opinion does a battery system prevent an outage?

A32. No. The battery system does not prevent an outage, it can only restore power to a home during a grid outage, and GMP will still need to effect repairs to the grid. This means there will be costs associated with outage restoration and storm restoration. The amount of work will be dependent on the extent of the outage, but GMP must recognize that time is of the essence since the battery has a finite charge.

Customers with battery systems are also aware that the battery generally supplies only partial power to the home due to limited kW (5.6 kW per battery unit). To conserve the energy stored in the battery, appliances that should not be used include the dishwasher, dryer, washer, air conditioner, heater, car charger, and electric hot water heater. GMP sends email notifications to customers a day or two before a storm and explains how the customer may extend the battery life.[20]

Q33. Is there any concern about the frequency that a battery system is used?

A33. While some customers will be satisfied that a battery system is available, the frequency of outages for customers with a battery system included an average of 4.58 outages in one year with a maximum of 19 outages in 2022 and an average outage occurrence of 4.65 in 2023 with a maximum outage occurrence of 24.

Q34. Regarding the frequency of events, what reporting metrics do you suggest for battery storage on residential homes?

A34. I discussed the high frequency of outages on homes with batteries. In IEEE 1366, there is an index for capturing customers with multiple interruptions ("CEMIn"). CEMIn is a count

[20] See GMP Discovery Response to Q.DPS.GMP.1-56 in this proceeding.

of the number of customers with "n" or more interruptions. The following table shows states and utilities now reporting CEMIn. CEMIn is used by several jurisdictions to track customers who may experience very poor reliability by means of multiple interruptions per year.

Table 6: CEMI Reporting in the United States[21]

State	CEMI Reporting
California	Requirement to report CEMI-12
Connecticut	Requirement to report CEMI-3 to 10
Delaware	Requirement to report CEMI-8
DC	Requirement to report CEMI-8
Florida	Requirement to report CEMI-5 for utilities > 50,000 customers
Maryland	Requirement to report CEMI-2, 4, 6, and 8
Michigan	Requirement to report CEMI-1 to 10
New Jersey	Atlanta City Electric reporting CEMI on a company and district basis
North Dakota	Requirement to report CEMI-4 to 6
Washington	Avista reporting on CEMI-0 to 6

In 2023, 343 GMP customers with batteries experienced CEMI-8 (8 or more outages in a year) out of a population of 2030 customers, or 16.8%. I recommend that GMP report CEMI-8 for residential customers, both with and without battery systems. The report should include the number of customers and percentage of total customers. This can also be reported by circuit (circuits with customers served where CEMI-8 is occurring) and/or it can be reported graphically showing hot spots via a heat map.

To be clear, I believe a CEMI-8 should be cause for concern, especially when, on GMP's system, the average customer only experiences 1.97 outages.[22] However, given GMP's experience, it is important to have a realistic start for reporting.

[21] Considerations for Resilience Guidelines for Clean Energy Plans, September 2022, PNNL-33277.
[22] 2022 SAIFI value for GMP. Reference Table 2 of my Direct Testimony.

Q35. How much of the system will be upgraded in Phase I of ZOI?

A35. It is difficult to answer this question because GMP has not stated what specifically will be accomplished with its proposed $250 million budget for transmission and distribution ("T&D") improvements. The following table shows my estimate of the cost for T&D upgrades for the Bethel Circuit BE-G28[23] and East Jamacia Circuit FJ-G7.[24]

Table 7 T&D Upgrades

	Bethel Circuit BE-G28			
Zone	Miles	Upgrade	Unit Cost/ Mile	Extended Cost
1	2.2	Space Cable	$700,000	$1,540,000
2	6.3	UG or Hardening	$300,000	$1,890,000
3	33.7	UG or Hardening	$300,000	$10,110,000
4	25.3	No Action		
Total	67.5			$13,540,000
	East Jamacia Circuit EJ-G7			
Zone	Miles	Upgrade	Unit Cost/ Mile	Extended Cost
1	14.5	Space Cable	$700,000	$10,150,000
2	20.8	UG or Hardening	$300,000	$6,240,000
3	12.7	UG or Hardening	$300,000	$3,810,000
4	52.7	No Action		
Total	100.7			$20,200,000

Source of Unit Costs: GMP Response Q.DPS.GMP.1-67

The average rural circuit has a total length of 58.4 miles.[25] Thus, I would estimate that GMP could upgrade about 12 to 15 circuits out of 154 rural circuits with a budget of $250 million. There is also funding from the MYRP, but this was very site specific and may not address an entire circuit as proposed in the ZOI.

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[23] Exhibit GMP-MB-9.
[24] Exhibit GMP-MB-8.
[25] Rural and Urban circuits are discussed later in Mr. Mara's Testimony.

The total costs to upgrade all rural circuits would be in the range of $3.1 billion (154 circuits at $20 million per circuit). However, not all circuits will need to be upgraded, and this estimate does not address any of the 117 urban circuits. This estimate serves as yet another reason why GMP should take the time to thoroughly plan its ZOI, as recommended in the Department's **Option I**.

Q36. Given the above testimony, to what reliability standards do you believe GMP should be held if the ZOI were to be approved?

A36. I have already discussed metrics for residential batteries.

For the level of investment proposed and the speed of roll-out as proposed, GMP should be held to a number of metrics to demonstrate that these innovative plans to move from very poor reliability to zero outages will succeed. Even GMP indicates that technology is changing fast, and the ZOI will change as it is being implemented. Therefore, tracking the progress of the ZOI implementation is extremely important for stakeholders. Furthermore, I believe these metrics should be used to incentive success.

One set of metrics should be SAIFI and SAIDI based upon where GMP intends to invest T&D dollars first – the rural areas. Specifically, there should be SAIFI/SAIDI goals for urban circuits with high customer density per mile of circuit and separate SAIFI/SAIDI goals for rural circuits with lower customer density per mile of circuit. Based on available data, I learned that the average customer density on GMP's system is 23 customers per mile of circuit.[26] Using data provided by GMP for average outage indices for the years 2013 through 2023, excluding extreme storms, I prepared a scatter plot comparing

[26] Case No. 20-0276-PET, GMP Response to DPS Data Request 65.

SAIDI/SAIFI and customer density.[27] Using this scatter plot, I determined that a customer density of less than 30 customers per mile captured rural circuits with poor reliability. The results show the following for the ten-year period:

Table 8: Customer Density

	Rural	**Urban**
Customers	147,195	116,455
Circuit Miles	8,987	2,032
Number of Circuits	154	117
Density	Less than 30 customers per mile	Greater than equal to 30 customers per mile
SAIFI	2.92	1.22
SAIDI	13.64	3.31
CAIDI	4.67	2.72

It is clear that the rural community receives less reliable service, which is why GMP is focusing its initial efforts of Phase 1 in this region. Thus, the metric to judge Phase I of the program is the improvement in SAIFI and SAIDI in the rural community. If the metric was applied to the entire system, the impacts of the urban area would dilute the improvements realized by the rural program.

My analysis is based on averages over ten years.[28] I also had data by feeder by year, but it included extreme storms, and I was not able to scrub that data to exclude extreme storm events to the point of matching system totals.[29]

[27] See GMP Discovery Response to Q.DPS.GMP.1-3 in this proceeding.
[28] See Id.
[29] See GMP Discovery Response to Q.DPS.GMP.2-90a in this proceeding.

Based on my analysis to identify rural circuits and my estimate of the number of circuits that will initially be upgraded, and assuming the upgrades will occur to the least reliable circuits, a 33% reduction in SAIFI and 33% SAIDI goal should be set for an interim metric while GMP takes the time fully plan its ZOI. I came to this conclusion by assuming no outages on the 12 circuits rural with the highest SAIFI. These reductions should be based on 2023 and 2022 outage data excluding extreme storms. This does not drive outages to zero, but it will greatly improve the reliability and resiliency of the system.

Another recommended interim metric involves tracking the number of outages in Zone 1 for upgraded systems. GMP seems very confident that the spacer cable solution will eliminate most outages. It is likely that this will be the case, but a metric demonstrating the result would be prudent for stakeholders to track. A similar metric used for transmission lines is Forced Outage Rate per Hundred Miles of Transmission per Year ("FOHMY"). This could easily be applied to the Zone 1 spacer cables. A Zone 1 failure should be a rare event and if one does occur, the circuit breaker in the substation will open. Thus, the number of outages can be tracked by the number of breaker operations with space cables in Zone 1. For transmission, a common goal is 2.0 FOHMY. For the spacer cable, a goal of 3.0 would be appropriate with the understanding the system is striving for zero outages.

Q37. Would you recommend any additional metrics?

A37. Yes. For storm repair costs, Mr. Burke's Direct Testimony discussed the storm repairs and how these T&D upgrades will reduce this cost. I calculated the five-year rolling total of storm restoration costs which are shown in a graph in **Exhibit DPS-KJM-4**. The rolling five-year average is between $8.6 million and 10.8 million. An interim metric should be set for the five-year rolling average to trend downward with an initial goal of less than $13 million with a longer-term goal of $8 million or less by 2030.

Q38. Does this conclude your testimony?

A38. Yes, it does.