GREAT RIVER ENERGY®

2023-2037 Integrated Resource Plan

Submitted to the Minnesota Public Utilities Commission
Docket No. ET-2/RP-22-75
March 31, 2023

Message From the CEO

Thank you for your interest in Great River Energy and our power supply strategy. Great River Energy has been thoughtfully planning and executing the transition of our power supply portfolio for more than a decade, and we are proud of what we have accomplished and the direction we are heading.

By working with our member-owner cooperatives, Great River Energy is rapidly decarbonizing, our transmission system remains reliable, and our wholesale electricity rates are well below the regional average.

Working closely with our members allows us to address challenges proactively and take early action. In recent years, we have closed or sold three generating facilities while more than doubling our portfolio of renewable resources.

This filing is groundbreaking for our cooperative for a number of reasons. Number one, it represents the first plan filed under the Minnesota Carbon Free Standard and the federal Inflation Reduction Act. Second, this plan includes only renewable energy and storage resources planned for addition in the planning period. Finally, this plan has Great River Energy on track to meet or exceed all requirements currently in state law.

By 2035 GRE's retail electric sales will be provided by a 90% carbon-free power supply in alignment with the Minnesota Carbon Free Standard. Emissions from our power supply portfolio will also be over 90% reduced from 2005 levels.

The integrated resource planning process is an important responsibility for Great River Energy, and one we take seriously. The following report demonstrates how Great River Energy's power supply strategy reflects the values of our membership, balances the priorities of a variety of stakeholders, and supports Minnesota's energy priorities.

GREAT RIVER ENERGY

David Saggau
President and CEO

1 Introduction

This Integrated Resource Plan (IRP) provides a comprehensive view of Great River Energy's (GRE's) portfolio plan over the next 15 years. The plan represents our intent to continue meeting our members' energy needs in a cost-effective and environmentally responsible manner. The passage of Minnesota's new carbon-free energy standard (CFS) in February of 2023 changed the state's energy policy landscape. The new CFS mirrors GRE's actions over the past decade in preparation for a carbon-constrained future. By 2026, GRE will add 866 megawatts (MW) of new wind generation to our existing 960 MW of wind generation and expects to serve the majority of our retail electric sales with renewable energy. By 2035, GRE's retail electric sales will be 90% carbon-free and carbon emissions will be more than 90% reduced from 2005 base levels.

GRE's preferred expansion plan (Preferred Plan) builds on changes in our resource portfolio that have already significantly reduced carbon emissions and increased generation from carbon-free resources. Our Preferred Plan includes only carbon-free resources consisting of wind, solar and storage. No new thermal resource additions are present in the modeling throughout the IRP planning period, nor are they currently part of our future plans.

We also describe more recent innovative initiatives, such as collaborations with our members that will increase their contractual ability to develop distributed energy resources as well as new beneficial electrification and transmission investment initiatives. In addition, GRE continues to innovate with its membership on its nation-leading demand-response program to control peak loads.

GRE's partnership with Form Energy is also discussed in this plan as an innovative project seeking further understanding of a promising long-duration energy storage technology. This multi-day storage (MDS) resource could provide dispatchable energy over a period of days, not hours, helping with reliability while also providing the benefits of shifting renewable energy on a daily, weekly, or seasonal basis.

Over the 15-year IRP planning period, GRE is well-positioned to meet our members' future power supply needs while adapting to a changing industry. We forecast a 15-year compound annual growth rate of 0.50% for energy and a growth rate of 0.40% for demand.

Consistent with our triple bottom line, which balances affordability, reliability, and environmental stewardship, GRE has worked hard over the years to reduce the environmental impact of our operations. Between 2005 and 2021, carbon dioxide (CO_2) emissions have decreased by 19%, sulfur dioxide (SO_2) emissions have decreased by 83%, and total nitrogen oxides (NOx) emissions have decreased by 65%.

This IRP is the first plan filed since our historic move away from a generation portfolio that relied heavily on fossil fuels, and provides our vision, initiatives, future resource plan, and implementation actions. It aligns with our mission to provide our members with affordable, reliable energy in harmony with a sustainable environment. GRE made difficult portfolio decisions over the past 15 years. However, these decisions were made with intention and have positioned us to track for compliance with the recently enacted CFS and the increased renewable energy standard (RES). As a result, we expect to experience minimal member impact due to changing policies and standards at the state and federal level. Like GRE's 2017 IRP, this plan meets the five factors to consider in Minnesota Administrative Rules for Integrated Resource Plans. It continues to meet our members' needs and reflects our vision to innovate, collaborate, and lead to competitively power the future.

2 Non-technical summary

2.1 Great River Energy overview

Great River Energy provides electricity to approximately 1.7 million people through its 27 member-owner cooperatives and customers. Through our member-owners, we serve two-thirds of Minnesota geographically. GRE crafts and maintains a portfolio of power generation and transmission resources to deliver reliable, affordable wholesale electricity to its member-owner cooperatives and customers through participation in the regional energy market.

Our members range geographically across Minnesota from the suburbs of the Twin Cities to the Arrowhead region in northern Minnesota, to farming communities in the far southwest corner of the state. In terms of energy sales, our system-wide load characteristics are 61% residential and 39% commercial and industrial.

GRE owns and maintains $2.9 billion in assets that include nine power generating stations and over 4,400 miles of transmission lines. We are the second largest power supplier in Minnesota by peak demand. We provide our members with a diverse energy supply fuel mix, including wind, hydroelectric, natural gas, coal, and fuel oil sources. We thoughtfully design and maintain a portfolio of generation and transmission resources to provide reliable and affordable wholesale electricity to our members. Our generation resources, both owned and contracted through power purchase agreements, are of varying sizes, locations, and fuels with each serving to add value to our resource portfolio. Our transmission lines and substations are designed to reliably deliver electricity where and when needed.

The GRE power supply portfolio was created as a cooperative endeavor, with every decision made by the members and in the best interests of the members.

2.2 Vision and mission

GRE continues to operate with intention in an environment of change in the energy industry. Our vision is: “Innovate, collaborate, and lead to competitively power the future.” Our mission, which is derived directly from these principles, is to provide our members with safe, affordable, and reliable energy in harmony with a sustainable environment.

Consistent with our vision and mission, GRE’s resource portfolio continues to transition to the future, while providing our members with reliable and affordable rates in a manner that minimizes environmental impact. This transition has put GRE in a strong position, which minimizes risk while preparing for additional future environmental regulations and market conditions.

This IRP draws on our vision and mission, giving GRE a path forward that best meets our members’ needs in a changing environment.

2.3 Our members

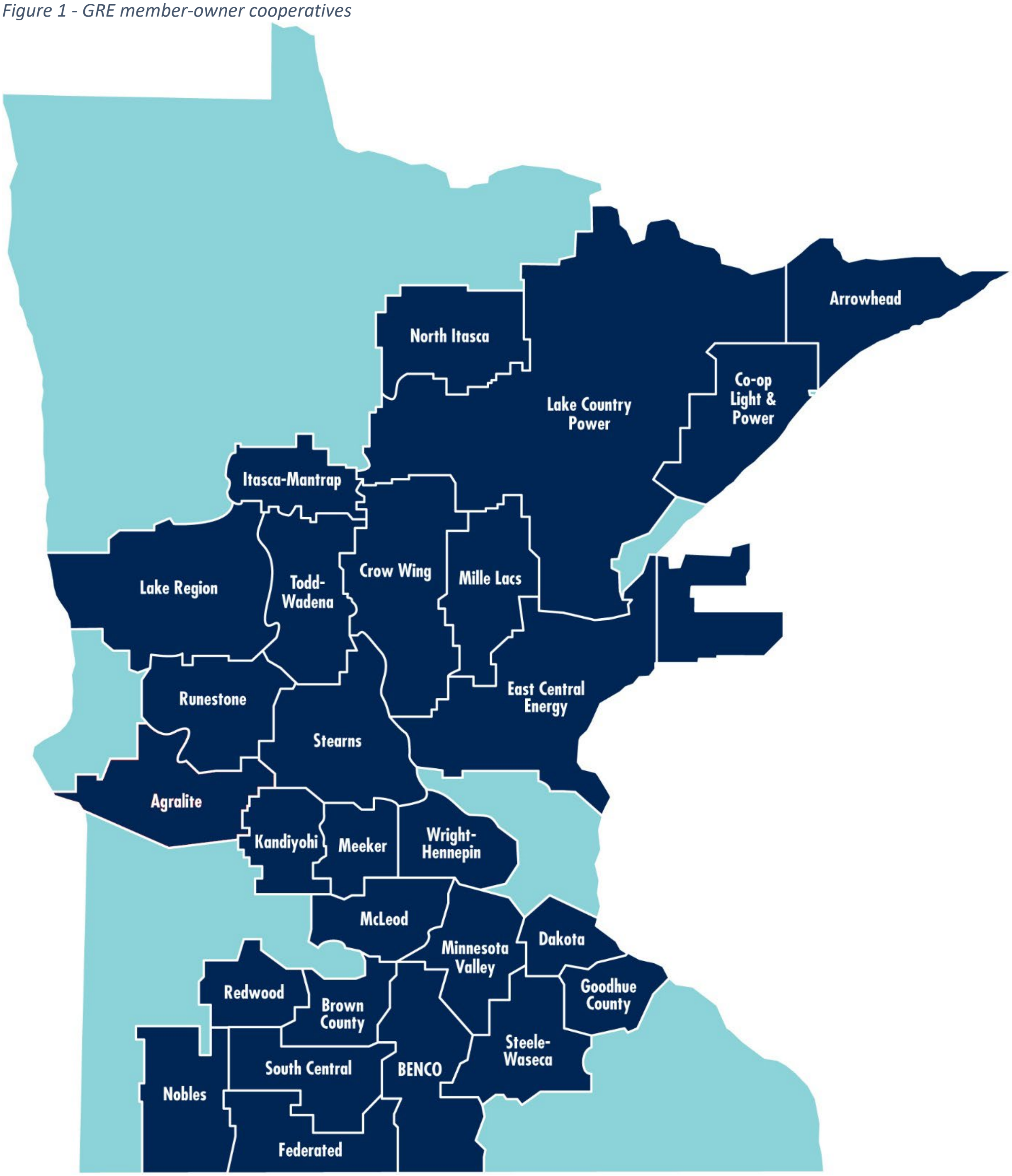
As a cooperative, GRE’s members are both owners and customers. Cooperatives provide services to their members on a not-for-profit basis and meet members’ collective needs more effectively than if each member acted independently. Cooperatives are governed by a board of directors elected from the membership which sets policies and procedures that are implemented by the cooperative’s management.

GRE provides services to two types of members: All-Requirements (AR) members and Fixed Obligation (Fixed) members. The 19 AR members purchase all their power and energy requirements from GRE, subject to limited exceptions. The eight Fixed members buy a fixed portion of their power and energy requirements from GRE and purchase all supplemental requirements from an alternate power supplier. Table 1 below provides the names, types and headquarters locations of our members:

Table 1 - GRE member-owners and locations

Member	Location
Agralite Electric Cooperative (Fixed)	Benson, Minnesota
Arrowhead Electric Cooperative, Inc. (AR)	Lutsen, Minnesota
BENCO Electric Cooperative (AR)	Mankato, Minnesota
Brown County Rural Electric Association (AR)	Sleepy Eye, Minnesota
Cooperative Light & Power (AR)	Two Harbors, Minnesota
Crow Wing Power (Fixed)	Brainerd, Minnesota
Dakota Electric Association (AR)	Farmington, Minnesota
East Central Energy (AR)	Braham, Minnesota
Federated Rural Electric Association (Fixed)	Jackson, Minnesota
Goodhue County Cooperative Electric (AR)	Zumbrota, Minnesota
Itasca-Mantrap Cooperative Electrical Association (AR)	Park Rapids, Minnesota
Kandiyohi Power Cooperative (AR)	Spicer, Minnesota
Lake Country Power (AR)	Cohasset, Minnesota
Lake Region Electric Cooperative (AR)	Pelican Rapids, Minnesota
McLeod Cooperative Power Association (AR)	Glencoe, Minnesota
Meeker Cooperative Light & Power Association (Fixed)	Litchfield, Minnesota
Mille Lacs Energy Cooperative (AR)	Aitkin, Minnesota
Minnesota Valley Electric Cooperative (Fixed)	Jordan, Minnesota
Nobles Cooperative Electric (AR)	Worthington, Minnesota
North Itasca Electric Cooperative, Inc. (AR)	Bigfork, Minnesota
Redwood Electric Cooperative (Fixed)	Clements, Minnesota
Runestone Electric Association (AR)	Alexandria, Minnesota
South Central Electric Association (Fixed)	Saint James, Minnesota
Stearns Electric Association (AR)	Melrose, Minnesota
Steele-Waseca Cooperative Electric (AR)	Owatonna, Minnesota
Todd-Wadena Electric Cooperative (AR)	Wadena, Minnesota
Wright-Hennepin Cooperative Electric Association (Fixed)	Rockford, Minnesota

Figure 1 - GRE member-owner cooperatives



2.4 Governance process

GRE is governed by a board of directors that includes 22 directors, each of whom is a member of the board of directors of one of our AR member cooperatives. Our member cooperatives are governed by their boards of directors who are elected by their member-consumers. GRE's members provide direction and oversight at many levels and work with us through regular meetings with member leaders, regional meetings, and member staff working groups.

2.5 Generation resources

GRE's generation resources include nine power plants as well as purchased power and capacity from several wind farms and other generating facilities, resulting in up to 3,550 MW of nameplate generation capability. Our resource portfolio is a diverse mix of wind, natural gas, fuel oil, hydroelectric, bi-lateral contracts, and coal sources (Appendix B).

GRE's peaking resources, which consist primarily of combustion turbines, provide critical capacity and operational flexibility to backstop the intermittent wind resources in our resource portfolio. While these primarily natural gas fired peaking units supply a small amount of our energy (historically 1% to 3% of our total annual energy production) they serve as GRE's primary capacity resource. We have up to 1,740 MW of nameplate peaking generation in our resource portfolio, all located in Minnesota. Figures 2 and 3 indicate our 2021 generation portfolio nameplate capacity and energy production by type, respectively. These resources provide reliability benefits to GRE's members and to the MISO grid as a whole.

Figure 2 - GRE 2021 portfolio nameplate capacity mix

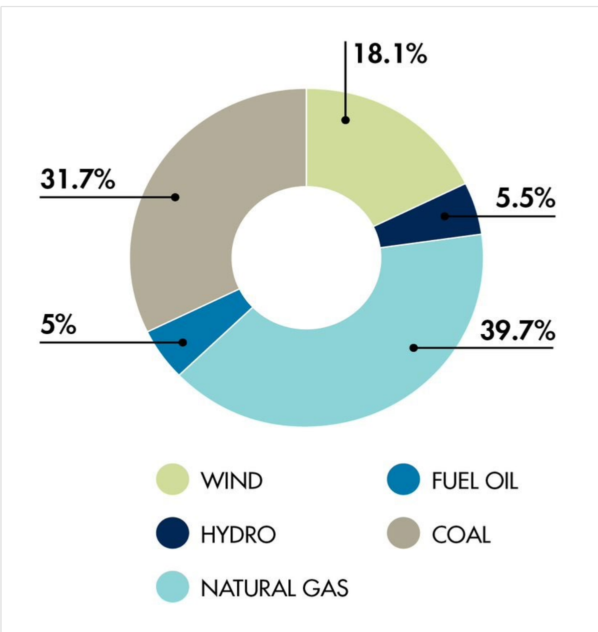
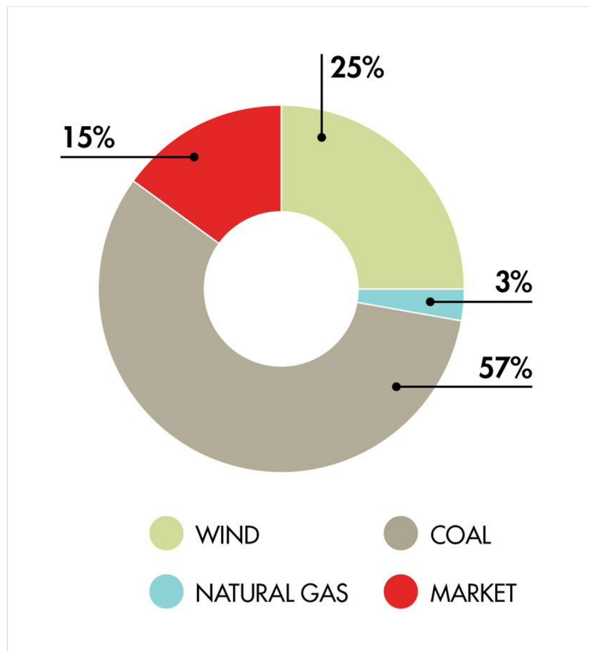


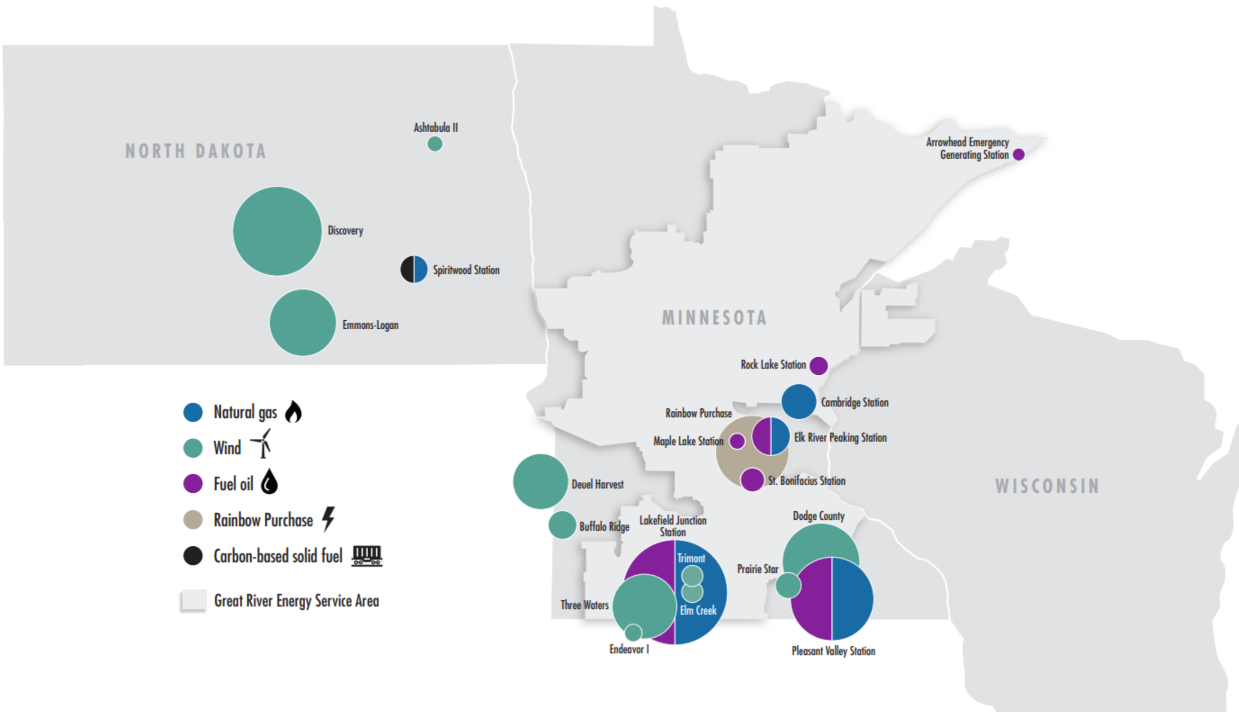
Figure 3 - GRE 2021 portfolio energy generation mix



Our generation resources are located in Minnesota and North Dakota. We have procured wind through power purchase agreements (PPAs) in Minnesota, North Dakota, and Iowa. We also have a diversity exchange agreement with Manitoba Hydro that provides GRE with seasonal capacity benefits and obligations throughout the year. Figure 4 shows the location of GRE's generating resources. A detailed list of resources can be found in Appendix B – Power Supply Resources.

GRE's wind portfolio continues to provide substantial benefits to the members as we build out the last several hundred megawatts of planned capacity, estimated to be completed in 2025. Most of the existing wind resources were signed over the previous five years and provide low-cost, fixed-price energy hedges to GRE's members. These resources are a core foundation of the energy portfolio and provide the renewable energy certificates (RECs) necessary for future compliance with the Minnesota RES and CFS.

Figure 4 - GRE generation portfolio locations – current and planned



3 The Preferred Plan

GRE's Preferred Plan represents a prudent pathway to serve members with energy that is reliable, affordable, and environmentally responsible. The Preferred Plan includes a portfolio of renewable energy and reliable resources that are backed up with existing flexible natural gas peaking plants with fuel oil backup for resiliency, combined with ready access to the electricity market to purchase additional energy when needed. Our robust demand-response programs supplement GRE's portfolio of carbon-free energy resources and reliability resources by reducing the peak demand on our system at the times of highest grid stress.

The difficult choices GRE has made over the past decade have been instrumental in transitioning our current energy and capacity portfolios. The latest step in this transition was the sale of Coal Creek Station (CCS) to Rainbow Energy Center, LLC (Rainbow) and the high-voltage, direct-current (HVDC) system to Nexus Line, LLC (Nexus). The transaction closed on May 2, 2022. Rainbow now owns and operates the 1,151-MW power plant, while GRE operates and maintains the HVDC system for Nexus under a 20-year agreement. GRE's portfolio was developed thoughtfully over time and with intention to provide members with an affordable and reliable power supply that minimizes impact to the environment. By 2035, GRE's retail electric sales will be 90% carbon free and carbon emissions will be more than 90% reduced from 2005 base levels. These developments help to minimize our members' future risk from federal and state greenhouse gas (GHG) regulations and make the energy they receive from GRE more attractive to residential, commercial, and industrial end-users that prioritize the low-carbon energy characteristics they will be receiving from GRE's power supply.

GRE has developed a Preferred Plan that is low-cost, low-risk, reliable, and resilient. It provides options to manage our generation fleet in a carbon-constrained future. GRE's Preferred Plan reflects the values of its membership and helps to advance Minnesota toward its CFS and RES as our portfolio is rapidly transitioning from one based historically on coal to one with low carbon intensity and a majority of renewable energy. The balance between carbon-free energy resources and existing peaking resources in the new portfolio is important for reliability and risk mitigation while maintaining cost effectiveness. The Preferred Plan provides flexibility to respond to market trends and transitions in the energy industry, while providing a hedge to market price exposure in concert with our triple bottom line: affordable rates, reliable energy, and environmental stewardship.

GRE's Preferred Plan is summarized in Table 2. The Preferred Plan does not include any new fossil fuel-based generation during the planning period and continues to build on our strong existing base of renewable energy.

Table 2 - The Preferred Plan

	Preferred Resource Plan		
	Year	**MW**	**Type**
Planning period	2023	105	Buffalo Ridge Wind
		-500	Rainbow Energy Center, LLC PPA reduction
		200	Deuel Harvest Wind
	2024	259	Dodge County Wind
		207	Three Waters Wind
		1.5	Form Energy battery storage pilot project
	2025	400	Discovery Wind
		-200	Rainbow Energy Center, LLC PPA reduction
	2026		
	2027		
	2028		
	2029		
	2030	200	Storage resource
	2031	-350	Rainbow Energy Center, LLC PPA reduction
		200	Solar resource
	2032	400	Wind resource
	2033		
	2034		
	2035		
	2036		
	2037		

The development of the Preferred Plan was guided by GRE's load forecasts, capacity expansion modeling, and projected capacity position. Modeling confirms that GRE's current portfolio and planned wind additions will meet near-term capacity and energy needs. Modeling results indicate that future capacity and energy needs could be met by a mix of new storage, wind, and solar resources, with a greater share of wind resources to meet energy needs. Modeling also showed value in a flexible storage resource being able to charge at times of low market prices and discharge to meet peak energy needs. A range of modeled sensitivities provide insight into the robustness of the Preferred Plan. Modeled scenarios and results are further discussed in Section 5.6. Our expected nameplate capacity and energy mixes for 2037 are depicted in figures 5 and 6.

Figure 5 - Expected nameplate capacity by source in 2037

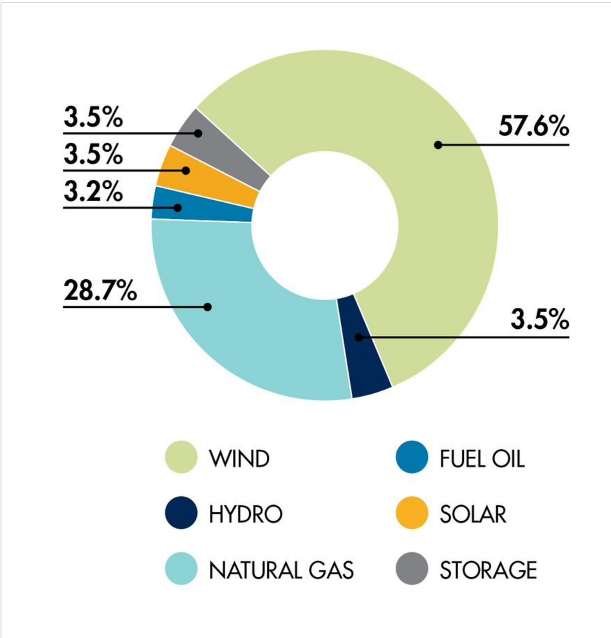
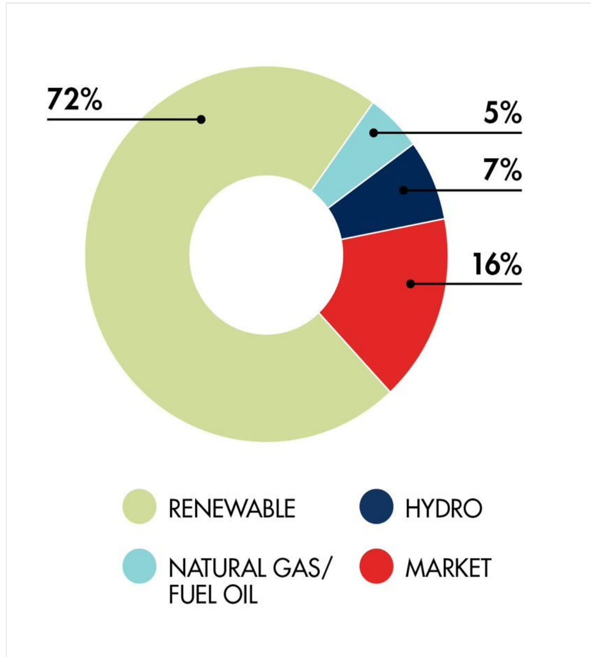


Figure 6 - Expected energy by source in 2037



GRE's Preferred Plan includes the five-year action plan further described below.

3.1 Five-year action plan

GRE's five-year action plan is to:

- Continue operation of all generation units.
- Continue PPA with Rainbow Energy Center, LLC.
- Step down 1050 MW Rainbow PPA to 350 MW.
- Continue operation and maintenance of the Nexus HVDC transmission line.
- Convert Cambridge Unit 2 to dual-fuel operation.
- Add 1.5 MW Form Energy multi-day storage pilot project at Cambridge Station.
- Begin pumped hydro energy storage feasibility study.
- Add up to 866 MW of wind PPAs.
- Increase Renewable Member Resource Option from 5% to 10%.
- Continue registration of demand response resources within the Midcontinent Independent System Operator (MISO) capacity market, beginning with commercial and industrial member loads.
- Invest in MISO's Long-Range Transmission Plan.

3.2 Electric rates and resource decisions

As a cooperative, GRE is committed to fiscal responsibility and keeping our electric rates as low as practicable, given regulatory and other constraints. Our electric rates are not subject to review by the Public Utilities Commission (PUC) but are established as set forth in our contracts with our members. Our member contracts also specify the requirements for approving new supply-side resources. New resources are approved by GRE's board of directors, and new resources of significance also require the approval of a dual majority of the AR members. These approval processes ensure that the costs and benefits of new resource decisions are understood and borne by the AR members. The Fixed members do not participate in decisions concerning new resources, nor do they share in those resources.

We are committed to assisting our members in implementing conservation and energy efficiency to help their member-consumers make the most of the energy they use and minimize the need for new supply-side resources. GRE and our members have met, and will strive to continue to meet, Minnesota's 1.5% Energy Savings Policy Goal. In addition, we have improved the utilization of our generation assets through efficiency improvements, natural gas conversions, and commercialization of waste heat and other byproducts of generating electricity.

We use capacity expansion optimization modeling that identifies a least cost plan in our Preferred Plan development process. In addition, we actively participate in MISO's energy markets and pursue bilateral capacity transactions to minimize overall costs. GRE's Preferred Plan results in lower revenue requirements than many other expansion plans considered and continues the utilization of our low cost and energy efficient generating facilities through the planning period.

4 Current outlook

4.1 Fulfilling our triple bottom line

Cost and reliability remain priorities for members as GRE transitions to a low-carbon portfolio of energy resources.

Our wholesale power rates are well below the weighted regional average cost of electricity and are projected to remain stable into the future. The transition of the power supply portfolio away from fossil fuels and toward a renewable energy dominant mix has been accomplished with no significant increase from our forward projections of rates prior to those actions. Our rate path today is the same as it was before decarbonization actions due to significant decisions the cooperative made, like accelerating depreciation of coal assets, and securing large scale low-cost wind energy from 2017 to 2021. The cooperative's transmission reliability is excellent as well, achieving record levels in eight of the company's 10 reliability measurements in 2021.

4.2 Portfolio changes since GRE's last IRP filing

The power supply portfolio will serve our member-owner cooperatives with clean, affordable, and reliable energy for decades. This resource plan will build on GRE's 2017 resource plan, which laid out the beginnings of a large-scale transition in GRE's power supply that continues today. Actions pre-dating the 2023 filing included:

- Retirement of Stanton Station coal generation facility in 2017.
- Retirement of Elk River Station waste-to-energy generation facility in 2019.
- Addition of Emmons-Logan wind PPA in 2020.

- Conversion of Spiritwood Station (Spiritwood) to a natural gas and coal generation facility, reducing the carbon intensity of that resource in 2020.
- Completion of Trimont wind generating facility re-power in 2021.
- The sale of Coal Creek Station (CCS) to Rainbow Energy Center, LLC in 2022.

4.3 Minnesota 100% carbon-free standard

In early 2023, Minnesota enacted a new CFS requiring electric utilities to serve 100% of retail electric sales with technology that does not emit carbon dioxide by 2040. Cooperatives have an interim requirement of 60% by 2030, which is a lower percentage than the 80% by 2030 interim requirement for investor-owned utilities. All utilities have an interim requirement of 90% by 2035. The law also includes an increase to the RES to 55% renewable by 2035 (from 25% by 2025). The CFS includes several flexible methods of compliance. For example, an individual Renewable Energy Certificate (REC) is allowed to satisfy both the CFS and the RES. In addition, a utility can partially satisfy the CFS with (i) the carbon-free portion of facilities that are only partially carbon-free and (ii) the utility's net market purchases to the extent the generation mix in the market is carbon-free as determined by the PUC.

The power supply decisions GRE has made over the past 15 years combined with the ability to retire RECs to satisfy the CFS puts GRE in an excellent position to meet the standards in the law. GRE's 15-year Preferred Plan and five-year action plan do not include additional carbon-based generation resources. GRE expects to be at least 35% carbon-free in 2023 using the carbon-free calculation outlined in the CFS. As illustrated in the Preferred Plan, GRE anticipates its 2037 energy generation mix to be comprised of 79% renewable energy (wind, solar and hydroelectric), 5% natural gas and near negligible fuel oil, and 16% market purchases. This energy profile does not account for GRE's REC retirements, nor does it account for carbon-free energy attributed to market energy purchases. More guidance is still needed regarding the carbon intensity from net energy purchases from the MISO market. By meeting the CFS, GRE will also meet the new RES requirement simultaneously as its carbon-free portfolio is comprised of renewable and hydroelectric resources.

4.4 Coal Creek Station (CCS)

GRE began the accelerated depreciation of all coal-fired generation facilities in 2013. That decision allowed GRE to divest itself of CCS in the way that most benefited the member-owners, allowing for two positive outcomes. First, and most importantly, the sale of CCS and the HVDC system to Rainbow and Nexus, respectively, was predicated on GRE's ability to deliver 400 megawatts of wind energy to load at the Dickinson terminal. This outcome helps to avoid the impacts of congestion to the member-owners from other wind assets and takes advantage of the high value HVDC system to deliver wind energy instead of fossil fuel-based power to Minnesotans.

The sale of CCS also included an initial 1,050 MW PPA with Rainbow for the sale to GRE of financially settled energy in Minnesota, and capacity in the form of MISO Zonal Resource Credits (ZRCs). This PPA provides a much-needed energy hedge until 2031, providing a glide path to transition away from carbon-emitting resources and allowing GRE to meet the financial expectations of our member-owners. The PPA steps down 500 MW from the original 1,050 in 2023, and an additional 200 MW in 2025 before the final 350 MW amount is eliminated in 2031 at the expiration of the agreement. The contract helps to bridge the capacity gap between today and the early 2030s, allowing technology to develop and cost curves to mature for new and existing carbon-free technologies to serve the members and provide GRE with ZRCs needed for compliance with MISO's current and future resource adequacy requirements.

These high value hedges are a critical part of a thoughtful evolution of the power supply and provide financial security while GRE determines the next resources to enter the portfolio.

In 2022, natural gas markets experienced unusual volatility which resulted in higher than typical locational marginal prices in MISO. The PPA with Rainbow created a fixed price hedge for GRE's member-owners that helped ensure financial stability in this changing market environment and will continue to do so until 2031. The Rainbow contract has been a net positive contributor to GRE's monthly financial results, helping to offset challenging conditions related to negative congestion at the wind facilities GRE has under contract and higher than expected power market prices in 2022.

4.5 Form Energy

While providing excellent service today, GRE regularly tests technologies and business strategies to improve the way it will serve member-owners long into the future.

GRE's Cambridge Energy Storage Project was originally announced in May of 2020 as the first project with Form Energy. It will be a 1.5 MW multi-day battery pilot project with the potential to turn variable sources of renewable energy into dependable, dispatchable energy resources. A battery that discharges over several days could provide electricity long enough to outlast most periods of extreme weather, which can pose challenges to the electric grid.

The project will be located at GRE's Cambridge Station in Cambridge, Minnesota. GRE has reviewed several evolutions of Form Energy's iron-air battery technology, including the progression of its iron anode and assembly designs. The Cambridge Energy Storage Project is scheduled to break ground during the first quarter of 2024 with a commercial operation date target of December 2024.

Once operational, GRE will own and operate the Cambridge Energy Storage Project. This project is a major step forward in understanding how, and to what extent, long-duration energy storage resources can be utilized in GRE's future resource plans.

Form Energy presented company updates in December 2022, noting it had acquired $820 million in venture capital. The company hired over 350 team members and built an additional manufacturing facility in Pittsburgh. Form also selected Weirton, West Virginia, for the site of its new full-scale manufacturing and assembly facility. The GRE pilot project will be the first full-scale battery unit off that assembly line. Black and Veatch was selected as the engineering, procurement and construction firm. All Black and Veatch labor will be hired out of the Minnesota union hall.

In addition to the pilot project, GRE and Form Energy have been consistently engaged in analytics work to learn more about multi-day energy storage resources through modeling exercises. Recent findings are shared in Appendix F, which includes analytics surrounding the ability of multi-day storage assets to meet stringent clean energy demands by new large load customers. One key finding demonstrated that iron-air multi-day energy storage batteries provide resiliency benefits across weather years, when compared with shorter-duration lithium-ion batteries, as the longer durations are able to smooth out year-to-year variability in renewable energy production. This, among other findings, can certainly be applied to GRE's long-term resource planning efforts.

4.6 Pumped hydro energy storage

GRE's Preferred Plan indicates a 200 MW energy storage resource need in 2030. As a result, it is prudent that GRE continue to evaluate all energy storage technologies including electrochemical, thermal, mechanical, and pumped hydro.

The idled mine pits and rock and overburden stockpiles on Minnesota's Mesabi Iron Range create an undulating, post-industrial landscape that has long been considered a potentially ideal site for pumped hydro energy storage (PHES).This method stores energy in the form of gravitational potential energy of water, pumped from a lower elevation reservoir to a higher elevation. Low-cost surplus off-peak electric power is typically used to run the pumps. During periods of high electrical demand, the stored water is released through turbines to produce electric power. The advantages of considering the Mesabi range for PHES include topographic relief that can provide 350 feet or more of potential head difference for siting upper and lower PHES reservoirs, unnatural water bodies that are not subject to the same permitting requirements as natural lakes and streams, the proximity of high voltage power lines, and greater public acceptance of industrial land uses.

Barr Engineering has performed at least four concept studies of PHES on the Mesabi Range dating back to the 1990s, including a joint study with GRE in 2011. Since this comprehensive study was published in 2011, several changes have occurred that may influence the costs (e.g., federal incentives, inflated construction costs) as well as the regulatory environment and construction feasibility of a potential PHES project on the Mesabi Range.

GRE has partnered with Barr Engineering again to begin a new concept-level screening of PHES on the Mesabi Iron Range to determine if the time is right for a deeper feasibility study. Although not directly modeled in this IRP, GRE is considering several carbon-free storage resources to satisfy known capacity needs throughout the planning period.

4.7 Beneficial electrification

As GRE supplies clean, affordable energy, the cooperative and its member-owners are committed to electrifying the economy. Cooperatives play an important role in fostering electric transportation, home heating and cooling, business applications, agriculture, manufacturing techniques, and more.

While the term "beneficial electrification" might be new, GRE and its members have long prioritized end-use electrification when beneficial. As technology has advanced and matured, GRE and its members have a broader and more robust portfolio of beneficial electrification programs. Many of these programs are offered in conjunction with our demand-side management programs to combine not only quality of life, but also provide rate benefits.

Advancing air source heat pumps (ASHPs), water heating, electric transportation, electric vehicle (EV) infrastructure, and electric school buses are areas of emphasis for Minnesota's rural electric cooperatives.

Because of the economic and energy savings related benefits that ASHPs provide end use members, GRE is heavily involved with advancing ASHP adoption across our member-owners' service area. GRE's ASHP efforts include sponsorship of the Minnesota ASHP Collaborative which, over the last few years, has been instrumental in advancing ASHP education with member-consumers and contractors. GRE member-owners provide strong rebates on ASHP systems via the state's Energy Conservation and

Optimization (ECO) program. GRE member-owners have rebated over 2,200 ASHPs since 2020 and the trend in adoption continues to grow. In addition to these efforts, GRE member utilities offer off-peak rates and programs that help to make heating and cooling with ASHPs the low-cost choice in rural areas served by our member-owners. With tax credits and direct equipment incentive programs on the horizon via the Inflation Reduction Act (IRA), GRE is preparing for greater adoption of ASHP equipment across our member-owner systems over the next several years.

GRE and members offer many different water heating programs, including electric thermal storage, peak shave, and general coordination and assistance in electric water heating. Heat pump water heating programs are being pursued, and there is significant market research that is still being conducted to understand the efficacy and market saturation potential of these recent technologies.

When it comes to the electrification of transportation, GRE has been active with a variety of market stimulation, education and awareness campaigns, and direct incentive offerings for on-road and off-road transportation and the associated charging infrastructure. GRE and our member-owners offer EV-specific rates for both residential and commercial EV charging that encourages flexible and off-peak charging with the build out of EV infrastructure. In addition, GRE's REVOLT™ program allows our members who purchase an EV to ensure the electricity used to charge their vehicle is 100% carbon free by retiring RECs on their behalf, beyond GRE's RES requirements. To advance our EV objectives, GRE is continually active with our member-owners in sponsoring demonstration projects and events for fleet EVs, electric forklifts, ride and drive events, and various EV related educational activities in greater Minnesota.

As part of a proactive strategy to implement a statewide EV charging network, cooperative leaders are advocating with legislators and Gov. Tim Walz's administration to distribute funding to rural Minnesota for infrastructure costs necessary for EV adoption. The Minnesota Department of Transportation is designating $68 million in federal funding for EV fast chargers over the next five years. Up to 80% of the costs for deploying fast chargers can be paid for through the federal grant under the state plan.

The Minnesota Rural Electric Association (MREA) is also collaborating with Beneficial Electrification League (BEL) to deploy electric school buses. An additional $5 billion is being distributed by the federal Environmental Protection Agency (EPA) under the infrastructure bill to help school districts purchase low- or zero-emission buses, with at least half targeted specifically at all-electric buses. BEL and MREA are encouraging the EPA to adopt a program allowing for 100% of the costs of a first bus and related electrical infrastructure to be covered by a grant to each school district. Districts will soon be able to apply for rebates.

4.8 Wind additions

GRE is increasing renewable wind generation by adding power purchase agreements with five large wind facilities: Buffalo Ridge Wind, Deuel Harvest Wind, Discovery Wind, Dodge County Wind, and Three Waters Wind.

The Buffalo Ridge wind project, located in southwest Minnesota, became commercially operational in December of 2022, and has 105 MW of generation capability.

The Deuel Harvest wind project is in South Dakota and began commercial operation in 2019; however, GRE began purchasing 200 MW of generation capability from the project in 2023.

Discovery Wind is being developed in North Dakota by Apex Clean Energy (Apex) near the CCS site. This project will have a 400 MW generation capability and utilize the HVDC system connecting CCS to the Twin Cities area. The utilization of the HVDC line delivers Discovery Wind directly to load in the Twin Cities and surrounding area without the need for additional AC transmission construction. On Sept. 9, 2022, Apex filed the MISO Surplus Interconnection Service (SIS) request on behalf of Discovery Wind, which included project site control documents. The project is estimated to be online in mid-2025. GRE, in collaboration with Apex and Rainbow, has been regularly active in engaging with the community and listening to landowners regarding the Discovery Wind project. This level of community involvement has helped critical parties to understand the benefits of the project for surrounding communities, GRE, Rainbow, and Apex, which has been reflected in the number of landowners who have signed up for the project to date. Currently Apex has nearly 50,000 acres of land signed up for the project, and continues to work toward a spring 2023 timeframe to submit permitting applications for a 2025 commercial operation date.

The Dodge County Wind project is a 259 MW MISO SIS project located in southeast Minnesota. This project will interconnect at one of GRE's natural gas combustion turbine generating facilities, Pleasant Valley Station (PVS). By utilizing MISO's SIS process at a low capacity factor peaking plant generator, Dodge County Wind will avoid the cost impacts of network upgrades and delays in progressing through the MISO queue and should avoid any generation conflicts with the host generator as well. The interconnection necessitates a dedicated transmission tie line from the wind facility to PVS. The Certificate of Need, site permit, and transmission route permit are currently in the regulatory process at the PUC. Although the project has experienced significant regulatory delays, GRE still hopes for the facility to be commercially operational in 2024.

The Three Waters Wind project is a 207 MW MISO SIS project located in southwest Minnesota. The project seeks to interconnect via GRE's Lakefield Junction Station (LJS), another low capacity factor combustion turbine. Interconnection applications are in progress with MISO, and this project is anticipated to be commercially operational in 2024.

4.9 Cambridge Unit 2 dual fuel

GRE has filed both modified site construction permit and Title V air permit modifications to allow the addition of a secondary fuel source (ultra-low sulfur diesel) at its Cambridge Station Unit 2 combustion turbine. The purpose of the project is to create financial and fuel hedge benefits as well as satisfy reliability imperatives while also furthering GRE's climate resiliency and decarbonization initiatives following the sale of CCS. The modification maintains GRE's commitment to MISO for electrical grid capacity, bolsters winter reliability and capacity accreditation potential for the generator, and supports GRE's wind power purchases as replacements for CCS's annual power production. The request for a minor alteration to the site permit to reflect the secondary fuel source remains pending before the PUC in Docket No. ET-2/GS-22-122.

The Cambridge Unit 2 dual fuel modification allows for continued energy generation during periods of extreme weather, such as a polar vortex or when natural gas generation is limited or completely curtailed. Although GRE anticipates fewer than 48 hours of annual operation, this modification enhances reliability and resiliency for GRE's member-owners. The Cambridge Unit 2 conversion was anticipated to be commercially operational in winter of 2023 in order to support reliability and winter capacity accreditation for GRE's portfolio. However, because of regulatory delays, the project has been pushed back, and is anticipated to be commissioned in late 2024 and operational for the winter of 2024-25.

4.10 Spiritwood Station

Spiritwood Station (Spiritwood), located 9 miles east of Jamestown, North Dakota, is a combined heat and power (CHP) facility with the capacity to generate up to 99 MW of electricity. In addition, it supplies process steam to industrial customers near the plant. Spiritwood commenced commercial operation in 2014 and uses Best Available Control Technologies to control emissions.

Spiritwood differs from traditional electric generating plants in that its purpose is to generate both electricity and process steam. Its steam customers include Harvestone, an adjacent agriculture ethanol biorefinery.

Most conventional coal-based power plants are 30% to 35% efficient. As a CHP plant, Spiritwood is more efficient because it takes advantage of the energy in the low-grade steam. In a conventional power plant, that steam is typically released to cooling towers. Since the low-grade steam from Spiritwood Station is used as process steam for the adjacent facilities, the plant is up to 65% efficient.

4.10.1 Spiritwood Station natural gas conversion

Spiritwood can now generate electricity with 100% natural gas. We are currently co-firing the boiler with natural gas and coal based on daily economics. This provides both economic and environmental benefits. Because natural gas has a lower carbon content per unit of heat content relative to coal, firing natural gas in lieu of coal produces fewer tons of GHG while producing the same amount of heat and power. Co-firing also allows the boiler to operate at lower steam loads during times when MISO prices are low. This provides opportunities to increase the natural gas co-firing capability when economic to do so. Due to the nature of the fluidized-bed boiler, the plant can also co-fire with biomass. GRE is currently assessing the feasibility of different biomass fuel options as well for the future.

4.10.2 Ordered modeling of Spiritwood Station retirement

Order point 4a in the Nov. 28, 2018, Order accepting the 2018-2032 IRP filing in Docket No. ET-2/RP-17-286 stated that in its next filing, GRE must:

> "Evaluate the cost-effective retirement of each of its coal plants, including CCS and Spiritwood, using an appropriate capacity expansion model which must include Commission-approved externality costs and carbon dioxide regulatory costs in its analysis."

Consistent with the PUC's directive, the results of GRE's evaluation of Spiritwood is set forth in Section 5.6. GRE's evaluation includes the fact Spiritwood has long-term steam supply contracts and road and water bond liabilities with Stutsman County and the city of Jamestown. Decommissioning of the plant would result in liquidated damages and early termination penalties to cover these liabilities — significantly adding to the cost of any proposed retirement scenario.

GRE evaluated the economic selection of retirement of Spiritwood during the modeling process. The retirement scenario developed offered Spiritwood retirement in 2030 for economic selection, and the retirement costs included the contract termination costs discussed above. The Spiritwood retirement option was not economically selected. Although it was not economically selected in that modeling exercise, a case assuming Spiritwood retirement in 2030 was included as one of the sensitivities summarized in Section 5.6. Retirement of Spiritwood would drive further capacity additions to the GRE portfolio, increasing costs, on top of incurring high retirement costs.

Spiritwood is a reliable CHP resource for our members and supplies process steam to industrial customers. The station provides seasonal capacity and acts as a hedge against market prices for our load. It is fully in compliance with state and federal environmental standards. We expect Spiritwood to continue operating well into the future and have no plans for retirement.

4.10.3 Transmission impacts and the broader societal impacts of retirement scenarios

Order point 5a in the Nov. 28, 2018, Order accepting the 2018-2032 IRP filing, the PUC directed GRE to "[m]ake clear both the transmission impacts and the broader societal impacts of any unit retirement scenarios." Spiritwood has a positive impact on the local economy. The facility supports over 100 direct and indirect high-paying jobs. The station pays the city of Jamestown $750,000 per year for water use in addition to approximately $50,000 per year in county taxes. Spiritwood also sponsors various community events and recently pledged financial support for the Two Rivers Activity Center Building in Jamestown as well as a new pumper truck for the Jamestown Rural Fire Department.

GRE performed a preliminary transmission impact study on a hypothetical Spiritwood retirement. No adverse transmission reliability effects were found.

4.10.4 Spiritwood Station carbon capture and sequestration

GRE is performing a feasibility study to install carbon capture and sequestration at Spiritwood while continuing to burn natural gas and lignite coal. The IRA has provided the opportunity for enhanced tax incentives on carbon capture and sequestration as well as better terms for monetizing these tax incentives for not-for-profit companies like GRE. Our internal team of GRE staff is working with contractors such as the Electric Power Research Institute (EPRI) and the University of North Dakota's Energy & Environmental Research Center (EERC) as well as others to support this effort.

4.11 Transmission

Minnesota's electric transmission system — the high-voltage power lines that transmit electricity from power generation facilities to customers — is part of an overall regional transmission grid operated in coordination with other systems through the Upper Midwest and eastern United States.

GRE's primary transmission responsibilities include meeting its obligations under the all-requirements transmission service contract with its member owners and transmission system reliability via operation of a local balancing authority area.

GRE addresses member reliability through maintenance, replacement and upgrades to its more than 4,400 miles of transmission facilities. Improving resilience of the transmission system to address the frequency and duration of outages to GRE transmission facilities has been a focus area over the last two years by incorporating findings from a study of future weather-related risks and learnings from major storm responses.

In support of regional reliability, MISO approved a portfolio of transmission projects on July 25, 2022, as part of the first phase of its Long-Range Transmission Plan (LRTP). MISO approved 18 projects across its Midwest subregion in total, six of those in the Upper Midwest. GRE will have partial ownership in two of the 18 projects.

One of these projects, Iron Range – Benton County – Big Oaks, is a double-circuit 345-kilovolt (kV) transmission line that will span approximately 150 miles from northern to central Minnesota and support grid reliability in the Upper Midwest. GRE announced its intent to build the line with Minnesota Power jointly.

The transmission line will run from Minnesota Power's existing Iron Range Substation in Itasca County to GRE's Benton County Substation and replace an existing GRE transmission line from the Benton County Substation to a new substation in Sherburne County (Big Oaks) and an existing GRE transmission line from Benton County to Xcel Energy's Sherburne County Substation. The Big Oaks Substation will be built as part of a separate project.

Proactive investments to maintain a reliable and resilient regional power grid are necessary as more low-cost renewable energy is brought online, existing power plants are retired, electrification continues to grow, and extreme weather events become more frequent.

Planning for the approximately $970 million transmission line is in its early stages. Subject to board approval, the two utilities intend to seek a Certificate of Need and Route Permit from the PUC in late 2023. The PUC will determine need and the final route. Subject to regulatory approvals, the transmission line is estimated to be in service by 2030.

Prior to the MISO announcement, GRE prepared by engaging with local consultants to support efforts with initial stakeholder outreach and permitting. In addition, an initial conversation with the PUC and Minnesota Department of Commerce staff was held introducing the project and anticipated timeline. Minnesota Power and GRE began coordinating with landowners, local governments, agencies, Tribal Nations and tribal organizations, and other interested parties in late 2022 and into early 2023. Engagement opportunities, including open house meetings and workshops, have offered the project community an opportunity to ask questions and provide input on the project planning and routing.

The second project, Big Stone South – Alexandria – Big Oaks, is an approximately 239-mile project extending from eastern South Dakota to central Minnesota. It will consist of single circuit 345-kV transmission line from Otter Tail Power Company's existing Big Stone South Substation in South Dakota to Missouri River Energy Services existing Alexandria Substation near Alexandria, Minnesota, the installation of a second 345-kV circuit on the open (spare) position on existing transmission line structures between the Alexandria and Monticello substations, and a crossing of the Mississippi River where it will interconnect at the new Big Oaks Substation.

Planning for the estimated $574 million project to address voltage and thermal overloading issues is in the very early stages.

4.12 Connexus Energy transition

On Aug. 30, 2022, GRE's member-owner cooperatives — including Connexus Energy (Connexus) — approved the termination of Connexus' membership in GRE, and approved GRE continuing to provide power supply and transmission service to Connexus as a customer through long-term power supply and transmission service agreements.

In the new power supply arrangement, GRE will serve as energy market participant for all Connexus needs for at least 10 years. Connexus will participate in all existing and committed GRE resources as of the effective date and identified in the power supply agreement.

In the new transmission service arrangement, GRE will continue to own, plan, build, operate, maintain, and contract for the transmission system necessary to provide Connexus with transmission and ancillary services.

The new customer agreements went into effect Jan. 1, 2023, and will extend through the end of 2045.

5 Plan development

The overarching goal of our planning process is to identify a resource plan that will meet members' future energy and capacity needs while retaining flexibility to navigate an evolving industry. As we move through this process, we take stock of where we have been, assess where we are today, and project where we are headed in the future.

The planning process — and the future vision of the portfolio we present here — is shaped by our strategies, regulatory and legislative requirements, environmental policy, PUC feedback from previous IRP filings, and stakeholder input. The process begins with data and information gathering and then proceeds to forecasting and capacity expansion modeling, the results of which inform the selection of a Preferred Plan.

5.1 GRE member-owner engagement

As a cooperative, power supply decisions are made by and for the members. Throughout this resource planning process, GRE has continued to provide regular portfolio updates to member staff and the GRE board of directors. The member-owner cooperatives continue to provide valuable input surrounding all issues impacting GRE's long-term capacity, energy and transmission plans.

GRE held regional meetings in August 2022 to further inform member-owners and solicit additional feedback. At these meetings, GRE staff presented the strategic planning process used to ensure future energy reliability, sustainability, and affordability. These meetings were held at McLeod Cooperative Power in Glencoe, Lake Country Power in Cohasset, and Stearns Electric Association in Melrose. Additional meetings were also held with GRE member advisory groups as requested. Member-owners were supportive of GRE's long-range portfolio plans, and reliability and resiliency efforts. Additional presentations and discussions regarding GRE's IRP and portfolio strategy were held in September of 2022 at member-manager and board-of-director strategy sessions. The resulting IRP Preferred Plan was presented to GRE's board of directors in February of 2023.

5.2 Member-consumer survey

Great River Energy periodically surveys member-consumers served by our 27 member-owner cooperatives to measure opinions on important energy issues, identify member-consumer expectations and better understand member-consumer views. Detailed below are some key findings of the most recent research conducted in 2021:

- When asked to name the highest priority initiatives for GRE, most member-consumers included increasing renewable energy and keeping costs as low as possible in their top two priorities. No other initiatives were named by more than one-third of member-consumers.
- 57% of member-consumers want GRE to use renewable energy for at least two-thirds of its energy supply by 2050, doubling the interest in renewable energy compared to our 2019 survey.

However, only 22% agreed that 90% to 100% renewable energy was their preferred goal for 2050.
- 85% of member-consumers support GRE's efforts to reduce carbon dioxide emissions, achieving Minnesota's 80% GHG goal by 2032 and providing 50% renewable power to cooperative members by 2030.

A full summary of 2021 GRE's Member-Consumer Survey can be found in Appendix E.

5.3 External stakeholder engagement

GRE hosted a meeting at its Cambridge Station power plant on Aug. 18, 2022, to solicit initial feedback on its IRP planning process and portfolio changes to date. In addition to the IRP discussion, attendees toured Cambridge Station Unit 1 and Unit 2, and attended a presentation from Form Energy on the long-duration storage project currently planned for Cambridge Station. During the tour, Unit 2 was dispatched for operation in the MISO real-time market, providing an opportunity to tour the facility while in operation supporting the reliability of the grid. GRE also discussed the importance of Cambridge Station's back-up system operations center as well as the station's black-start capabilities — the ability to assist bringing the electrical grid back online should a blackout occur.

Attendees represented a variety of organizations including GRE member-owner distribution cooperatives, energy and environmental advocacy groups, and organized labor representatives. Among the attendees were: Clean Grid Alliance, Clean Up the River Environment (CURE), East Central Energy, Form Energy, Fresh Energy, the International Union of Operating Engineers Local 49, Laborers' International Union of North America, MREA, Public Employees for Environmental Responsibility (PEER), and Todd-Wadena Electric Cooperative. The IRP discussion was moderated by Great Plains Institute, which provided meeting minutes including supporting comments, concerns, and requests for additional clarification.

GRE appreciated the strong turnout and continues to review all stakeholder feedback. After assessing initial stakeholder comments, GRE scheduled follow-up meetings with individual attendees to further discuss their thoughts on the direction of GRE's IRP as well as pricing of resource additions.

GRE had follow-up meetings with PEER and CURE in October of 2022 to further discuss the sale of CCS to Rainbow Energy, the resulting GRE power and capacity agreement, and pricing. In addition, GRE met with Fresh Energy, CURE, and other clean energy organizations in November and December of 2022 to discuss potential resource additions and associated resource pricing for our IRP capacity expansion modeling.

In January 2023, GRE met with the Minnesota Department of Commerce to review GRE forecasting methodology, including the use of Itron forecasting software. GRE again met with representatives from the Minnesota PUC, Minnesota Center for Environmental Advocacy, Clean Grid Alliance, Fresh Energy, CURE, and LIUNA in February of 2023 and presented our modeling results and Preferred Plan.

5.4 Planning tools

GRE has expanded its use of the Itron suite of tools (Forecast Manager, Metrix ND, and Metrix LT) for load forecasting in the 2023-37 IRP. Optimizing access to regional end-use data and statistically adjusted end-use models, the GRE forecast has incorporated the impacts of usage efficiencies directly into the forecasting process along with traditional econometric variables. Diverging correlation of sales and econometric variables has encouraged focus on the increasing impact of consumer end uses.

GRE has transitioned from System Optimizer, an ABB product, to EnCompass, developed by Anchor Power Solutions, for capacity expansion modeling in our 2023-37 IRP. EnCompass is proven and broadly accepted by customers and environmental groups. It serves as the basis for regulatory filings in 17 states, including Minnesota.

5.5 Load forecasts

GRE is a 27-member generation and transmission cooperative, with 19 of our members being All-Requirements (AR) and eight being Fixed (Fixed) or partial requirements. The AR members purchase all of their demand and energy needs from GRE, with the limited exception of the Renewable Member Resource Option (Section 11). Fixed members purchase a fixed amount of capacity and energy from GRE, and purchase their remaining energy and capacity needs from an alternative power supply provider.

5.5.1 Forecast development

The 2023 IRP forecast extends from January 2023 through December 2038. The forecast is developed in three phases. First, the AR cooperative hourly forecast is developed based on class monthly sales and the AR system load data. Second, the Fixed cooperative hourly forecasts and other major adjustment forecasts are developed based on known obligations. Finally, external forecasts for EVs and behind-the-meter photovoltaics (PVs) are created. The hourly results from these three phases are aggregated to create the final hourly system forecast. These three main modeling processes are summarized below.

- **AR forecast.** The forecast begins with developing the long-term sales forecast for GRE's AR cooperatives. This forecast combines three modelling processes. First, the monthly class sales forecast is developed by modelling individual class sales and combining the results into the monthly AR system forecast. Second, the AR system peak forecast is developed by modelling the AR monthly peaks. Third, the AR system shape forecast is developed by modelling the AR system hourly load shape. The three forecasts are combined by calibrating the system shape forecast to the monthly sales and peak forecasts. The result of this process is the hourly forecast for AR cooperatives.
- **Fixed and other adjustments**. After the AR hourly forecast is complete, it is adjusted to include the hourly impacts of Fixed Members, Harvestone, Alliant, and transmission losses. For each adjustment, hourly shapes are calibrated to the monthly or annual energy forecasts to create the hourly forecasts.
- **EVs and PVs.** Finally, the forecast is adjusted for two major uncertainties: EVs and behind-the-meter PVs. Hourly shapes for these factors are calibrated to monthly forecasts to create the hourly forecasts.

The three main modeling results are combined to create the base GRE system hourly forecast. The hourly load forecast captures the impact of economic drivers, weather, and load shapes.

5.5.2 Fixed members' demand and energy purchases

GRE has 27 member-owner cooperatives, eight of whom are Fixed requirements member-owners, whose power supply from GRE was fixed effective as of a date they elected. An alternative supplier provides the Fixed member-owners with any additional power supply requirements, while they remain responsible for a share of the cost of the resources in GRE's power supply portfolio as of the effective date of each of their elections to fix (referred to as "fixed resources"). When GRE sells or retires a fixed resource, six of the eight Fixed members have the right to reduce their fixed supply from GRE based on the size of the exiting resource as compared to their other fixed resources.

The six fixed requirements member-owners with the right to reduce all elected to reduce their purchases from GRE upon the sale of CCS — a 1,151 MW baseload generation resource — which occurred on May 2, 2022. As the largest fixed resource in GRE's portfolio, the sale of CCS resulted in a significant reduction in the supply GRE provides to these six Fixed members: Agralite Electric Cooperative, Crow Wing Power, Federated Rural Electric Association, Meeker Cooperative Light & Power Association, Redwood Electric Cooperative, and South Central Electric Association. The six Fixed member-owners' collective annual billable energy saw a 92% reduction, an amount of 829,789 megawatt-hours (MWh), and their summer demand was reduced 48%, a total of 74.9 MW.

5.5.3 Forecast results

The total system grows from 11,225,803 MWh in 2023 to 12,099,344 MWh in 2038 with an average annual growth rate (2023-38) of 0.50%. The system peaks move consistently with the energy forecast with average annual growth rate (2023-38) of 0.40% (summer peak). Annual forecast values are shown in Tables 3 and 4 below.

Table 3 - System forecast summary (MWh)

Year	AR	FM	Harvestone	Alliant	Losses	EV	PV	Total Energy (MWh)
2023	9,140,512	1,506,103	41,936	-	525,240	19,074	(7,061)	11,225,803
2024	9,211,394	1,506,103	41,936	-	527,872	28,710	(11,108)	11,304,907
2025	9,240,111	1,506,103	41,936	112,706	534,899	37,546	(14,569)	11,458,731
2026	9,279,658	1,506,103	41,936	112,706	536,774	46,073	(18,082)	11,505,168
2027	9,325,320	1,506,103	41,936	112,706	538,938	54,090	(21,734)	11,557,359
2028	9,383,811	1,506,103	41,936	112,706	541,699	61,735	(25,536)	11,622,453
2029	9,414,261	1,506,103	41,936	112,706	543,136	68,695	(29,491)	11,657,345
2030	9,449,204	1,506,103	41,936	112,706	544,747	75,847	(33,560)	11,696,983
2031	9,486,533	1,506,103	41,936	112,706	546,480	83,174	(37,826)	11,739,107
2032	9,540,794	1,506,103	41,936	112,706	549,015	90,844	(42,318)	11,799,080
2033	9,571,504	1,506,103	41,936	112,706	550,429	98,084	(47,153)	11,833,609
2034	9,618,327	1,506,103	41,936	112,706	552,599	105,598	(52,455)	11,884,814
2035	9,664,675	1,506,103	41,936	112,706	554,749	113,104	(58,012)	11,935,260
2036	9,726,423	1,506,103	41,936	112,706	557,627	121,012	(63,776)	12,002,030
2037	9,762,686	1,506,103	41,936	112,706	559,308	128,443	(69,858)	12,041,325
2038	9,816,437	1,506,103	41,936	112,706	561,822	136,486	(76,146)	12,099,344
15 Yr CAGR (2023-2038)	**0.48%**	**0.00%**	**0.00%**	**0.00%**	**0.45%**	**14.02%**	**17.18%**	**0.50%**

Table 4 - System peak summary (MW)

Year	AR	FM	Harvestone	Alliant	Losses	EV	PV	Total Peak (MW)
2023	1,877	220	6	-	104	4	(1)	2,210
2024	1,875	220	6	-	105	6	(2)	2,210
2025	1,881	220	6	21	106	8	(3)	2,239
2026	1,886	220	6	21	107	10	(1)	2,248
2027	1,892	220	6	21	107	11	(2)	2,255
2028	1,899	220	6	21	108	13	(5)	2,261
2029	1,905	220	6	21	108	14	(5)	2,269
2030	1,911	220	6	21	109	16	(6)	2,276
2031	1,917	220	6	21	109	18	(6)	2,284
2032	1,924	220	6	21	110	19	(7)	2,291
2033	1,930	220	6	21	110	21	(5)	2,302
2034	1,937	220	6	21	111	22	(9)	2,307
2035	1,945	220	6	21	111	24	(10)	2,317
2036	1,954	220	6	21	112	25	(11)	2,326
2037	1,962	220	6	21	112	27	(3)	2,344
2038	1,954	219	6	20	112	38	(3)	2,346
15 Yr CAGR (2023-2038)	**0.27%**	**-0.03%**	**-0.01%**	**0.00%**	**0.47%**	**16.24%**	**7.16%**	**0.40%**

Four alternative scenarios provide reasonable planning bounds that capture both economic and weather uncertainty. The economic scenarios show that annual average system energy growth ranges between 0.14% and 0.64% (low and high scenarios). The weather scenarios show that the base forecast energy may increase 2.82% (extreme scenario) or decrease 2.86% (mild scenario) in 2023. Figure 7 and Figure 8 below display the scenario comparisons for energy and demand below.

Figure 7 - Scenarios: Energy forecast comparison

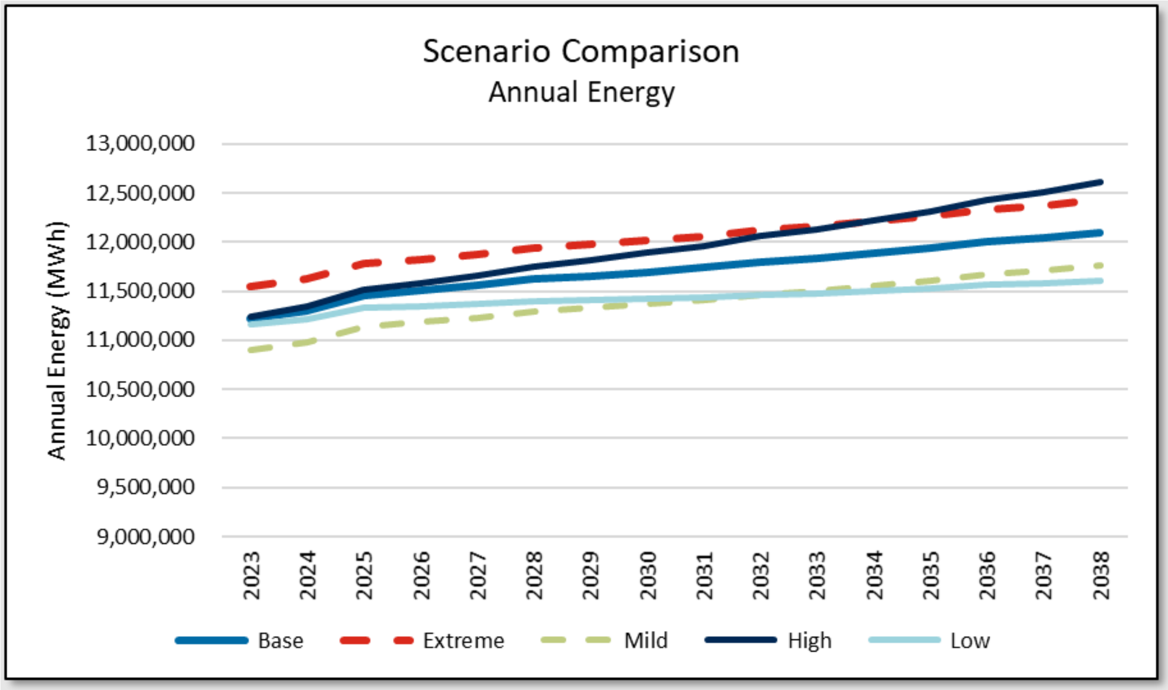
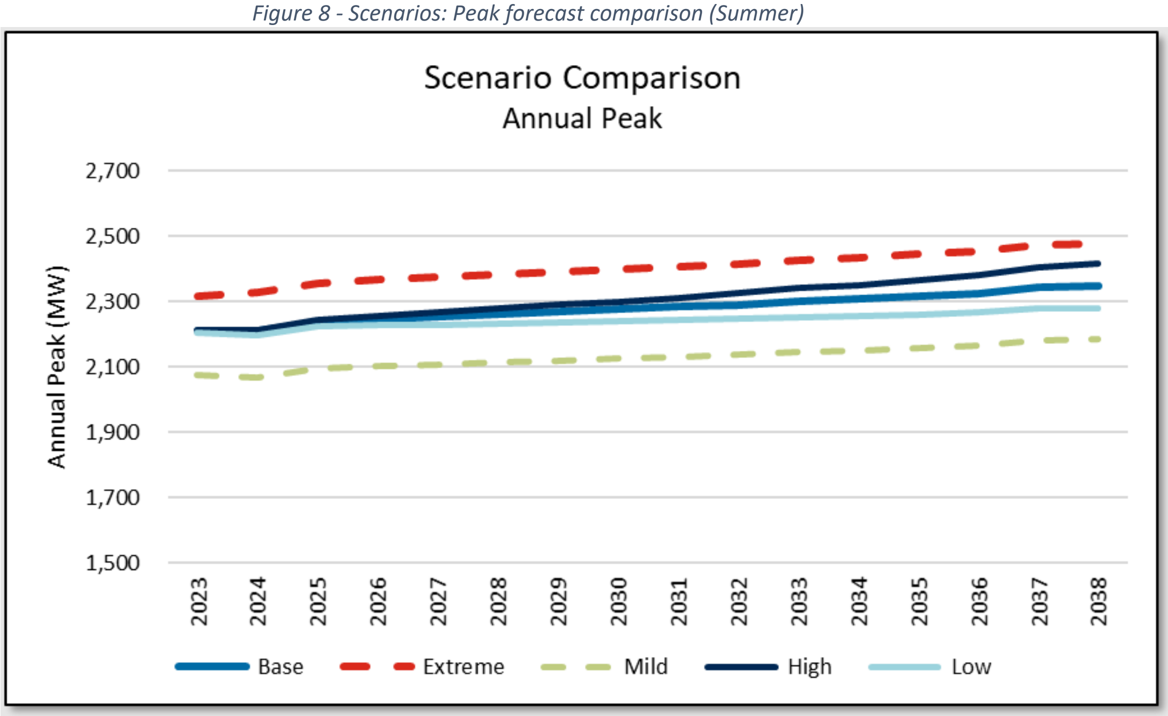


Figure 8 - Scenarios: Peak forecast comparison (Summer)



5.5.4 Southern Minnesota Energy Cooperative

Southern Minnesota Energy Cooperative (SMEC) was formed in 2013 by 12 electric distribution cooperatives as a single point of contact for the proposed purchase of Alliant Energy's electric service territory in southern Minnesota. SMEC members who are also members of GRE are:

- BENCO Electric Cooperative (AR)
- Brown County Rural Electrical Association (AR)
- Federated Rural Electric (Fixed)
- Minnesota Valley Electric Cooperative (Fixed)
- Nobles Cooperative Electric (AR)
- Redwood Electric Cooperative (Fixed)
- South Central Electric Association (Fixed)
- Steele-Waseca Cooperative Electric (AR)

Four of the 12 members of SMEC are AR members of GRE. SMEC's purchase agreement with Alliant provides that Alliant will be the power supplier to the load SMEC purchased from Alliant. The four AR members who are members of SMEC have agreed that GRE will supply their respective portions of the load acquired from Alliant starting in 2025. This is expected to increase our demand forecast by approximately 21 MW and our energy requirement forecast by approximately 112,705 MWh. These demand and energy requirements are included in our demand and energy forecasts.

5.6 Capacity expansion model

5.6.1 Model development

Ultimately, GRE seeks to identify a low-cost, low-risk, and flexible resource plan that meets members' energy and capacity requirements as the industry continues to experience change and uncertainty.

The process begins with data and information gathering, then proceeds to forecasting and capacity expansion modeling, the results of which inform the selection of a Preferred Plan. Model development includes the following activities:

- Engage stakeholders.
- Determine modeling assumptions and requirements.
- Evaluate conservation and energy efficiency potential.
- Develop econometric energy and load forecasts to determine growth for our AR members.
- Develop system energy and demand requirements using the AR forecasts and adding in Fixed member requirements and known future additions or subtractions.
- Develop our load and capability position.
- Identify regulatory and legislative requirements, including externalities and regulatory costs.
- Model scenarios that include sensitivities to identify potential expansion plans using a capacity expansion plan optimization model.
- Develop a base case.
- Evaluate reliability, costs, environmental impacts, and risks of different expansion plans.
- Identify a Preferred Plan that meets our members' needs while complying with all regulatory and legislative requirements.

5.6.2 Planning reserve margins

MISO is undergoing a significant change in its current construct for resource adequacy, transitioning from evaluating reliability and reserve margin requirements on a single summer peak to four seasonal peaks. This change impacts the determination of planning reserve margins (PRM), and the accreditation of thermal and non-thermal resources throughout the planning period. GRE understands that this is an evolving matter and used the best available conservative data available at the time modeling assumptions were finalized.

The following seasonal PRMs were applied in each year of capacity expansion scenarios:

- Summer 2023 PRM of 7.4%
- Fall 2023 PRM of 14.9%
- Winter 2023-24 PRM of 25.5%
- Spring 2024 PRM of 24.5%

5.6.3 Potential resources

Table 5 - EnCompass modeled supply-side resources

Supply-side resources					
Resource	2030 Cost	Capacity accreditation			
		Winter	Spring	Summer	Fall
Combustion turbine	$933/kW	100%	84%	80%	84%
Four-hour lithium-ion battery	$895/kW	95%	95%	95%	95%
Wind PPA	$45/MWh	40%	23%	18%	23%
Solar PPA	$50/MWh	6%	15%	45%	25%

In determining the future resources made available to the model for capacity expansion work, GRE considered a more systematic approach to modeling and included information that makes clear the type of resource added in the scenarios. This realistic and achievable set of new generation assets could be pursued over the planning period. Notable is the omission of new natural gas combined cycle generation. The forward forecast and existing strong capacity position due to prior planning does not require a large capacity resource with commensurate energy production. Additionally, GRE and its members have worked hard to reduce the potential carbon policy risk that our portfolio presents in the future. A new large fossil-fuel generator is not aligned with our forward outlook at the current time.

Carbon-free resources are anticipated to represent all of GRE's power supply investments over the planning period. The model was presented with wind, a combustion turbine, solar, and energy storage, represented here as 4-hour lithium-ion based energy storage, as supply-side resource selection options. These options are detailed in Table 5 and further detailed in Appendix H. GRE modeled one energy storage resource type and duration as there are still many unknowns about future pricing and technology advancements. Selection of this battery storage resource in the capacity expansion model indicates benefit of a high-accredited capacity value, flexible resource to the future GRE portfolio. GRE will continue to monitor pricing trends and resource options in its long-term planning process.

Demand-side resources were also offered for economic selection across capacity expansion scenarios: demand response (33 MW) and energy efficiency (20 MW). These potential resources would be incremental to GRE's existing demand response and energy efficiency programs. Due to the size and saturation of these existing programs, the incremental capacity offered for selection had high costs. These potential demand-side resources are also further detailed in Appendix H. These resources were not economically selected by the model in the capacity expansion, but GRE did include a sensitivity case where they were both added as part of this analysis.

As there is uncertainty about future seasonal PRM values, there is also uncertainty about future seasonal resource accreditation values. GRE modeled the capacity accreditation values cited in Table 5 above and also ran a sensitivity scenario with lower future capacity accreditation values for battery storage and renewable resources (in most seasons) to capture some of that uncertainty.

5.6.4 Environmental and regulatory costs

In compliance with Minnesota Docket Nos. CI-07-1199, CI-14-643 and DI-19-406, GRE includes environmental externality sensitivities. For these sensitivities, GRE includes the criteria values for PM2.5, NOX and SO2 defined in Minnesota Docket No. CI-14-643 and the CO2, for 2020-24, and Regulatory Cost of Carbon values determined in Minnesota Docket Nos. CI-07-1199 and DI-19-406 under Minn. Statute 216H.06 for years 2025-37. Table 6 below provides environmental and escalated regulatory costs of carbon used by GRE in its modeling. Table 7 provides Criteria Pollutants and associated escalated cost use in EnCompass modeling

Table 6 - Environmental and regulatory costs

Environmental cost values for CO_2 (2023 dollars per net short ton)			Regulatory cost of carbon CO_2 (2023 dollars per net short ton)	
Year	Low	High	Low	High
2023	$11.32	$52.91	-	-
2024	$11.56	$53.97	-	-
2025	$11.80	$55.02	$5.00	$25.00
2026	$12.04	$56.08	$5.10	$25.50
2027	$12.28	$57.14	$5.20	$26.01
2028	$12.53	$58.20	$5.31	$26.53
2029	$12.76	$59.25	$5.41	$27.06
2030	$13.01	$60.31	$5.52	$27.60
2031	$13.24	$61.36	$5.63	$28.15
2032	$13.49	$62.41	$5.74	$28.72
2033	$13.72	$63.47	$5.86	$29.29
2034	$13.97	$64.52	$5.98	$29.88
2035	$14.20	$65.58	$6.09	$30.47
2036	$14.45	$66.63	$6.22	$31.08
2037	$14.68	$67.69	$6.34	$31.71

Table 7 - Criteria Pollutants use in Encompass Modeling

	Criteria Pollutants 2023-2037 Values (2023 dollars per ton)									
	PM2.5		**NOX**		**SO2**		**Pb**		**CO**	
Year	Low	High	Low	High	Low	High	Low	High	Low	High
2023	$4,107.53	$10,087.78	$2,372.26	$7,612.74	$4,095.58	$9,981.41	$689.81	$768.72	$0.34	$0.70
2024	$4,189.68	$10,289.53	$2,419.70	$7,764.99	$4,177.49	$10,181.04	$703.60	$784.10	$0.35	$0.71
2025	$4,273.48	$10,495.32	$2,468.10	$7,920.29	$4,261.04	$10,384.66	$717.68	$799.78	$0.36	$0.73
2026	$4,358.95	$10,705.23	$2,517.46	$8,078.70	$4,346.26	$10,592.36	$732.03	$815.78	$0.37	$0.74
2027	$4,446.13	$10,919.33	$2,567.81	$8,240.27	$4,433.19	$10,804.20	$746.67	$832.09	$0.37	$0.76
2028	$4,535.05	$11,137.72	$2,619.17	$8,405.08	$4,521.85	$11,020.29	$761.60	$848.73	$0.38	$0.77
2029	$4,625.75	$11,360.47	$2,671.55	$8,573.18	$4,612.29	$11,240.69	$776.84	$865.71	$0.39	$0.79
2030	$4,718.26	$11,587.68	$2,724.98	$8,744.64	$4,704.54	$11,465.51	$792.37	$883.02	$0.40	$0.80
2031	$4,812.63	$11,819.44	$2,779.48	$8,919.54	$4,798.63	$11,694.82	$808.22	$900.68	$0.40	$0.82
2032	$4,908.88	$12,055.83	$2,835.07	$9,097.93	$4,894.60	$11,928.71	$824.39	$918.70	$0.41	$0.84
2033	$5,007.06	$12,296.94	$2,891.77	$9,279.89	$4,992.49	$12,167.29	$840.87	$937.07	$0.42	$0.85
2034	$5,107.20	$12,542.88	$2,949.61	$9,465.48	$5,092.34	$12,410.63	$857.69	$955.81	$0.43	$0.87
2035	$5,209.35	$12,793.74	$3,008.60	$9,654.79	$5,194.19	$12,658.85	$874.84	$974.93	$0.44	$0.89
2036	$5,313.53	$13,049.61	$3,068.77	$9,847.89	$5,298.07	$12,912.02	$892.34	$994.43	$0.45	$0.91
2037	$5,419.80	$13,310.61	$3,130.15	$10,044.85	$5,404.03	$13,170.26	$910.19	$1,014.31	$0.45	$0.92

5.6.5 Modeling variables

Table 8 summarizes variables and sensitivities used in GRE's capacity expansion modeling.

Table 8 - Modeling variables and sensitivities

EnCompass modeling variables		
Variable	**Sensitivities**	**Description**
Load Forecast	Low	10/90 Forecast
	Base*	50/50 Forecast
	High	90/10 Forecast
	Extreme Weather	Extreme Weather Forecast for Two Summers & Winters
MISO Market Prices	Low	Expected Values -30%
	Base*	ACES MN Hub Cost Curve
	High	Expected Values +100%
Natural Gas (NG) Prices	Low	Expected Values -30%
	Base*	ACES Ventura Hub Forward Curve
	High	Expected Values +100%
MISO Market Purchases	None	No MISO Market Energy Purchases
	Base*	Up to 25% MISO Market Energy Purchases
	High	Up to 75% MISO Market Energy Purchases
MISO Reserve Margin	Existing Seasonal*	Summer 2023 PRM (UCAP) of 7.4%; Fall 14.9%; Winter 25.5%; Spring 24.5%
	Higher Summer; Lower Other Seasons	Summer 2023 PRM (UCAP) of 12.4%; Fall 9.9%; Winter 20.5%; Spring 19.5%
Spiritwood Station Retirement	None*	No Retirement May Be Selected
	Forced	Forced Retirement in 2030
Combustion Turbine	Base*	NREL ATB "Moderate" Price
Wind	Low	Wind Power Purchase Agreement @ $35/MWh
	Base*	Wind Power Purchase Agreement @ $45/MWh
	Self-Build	NREL ATB "Moderate" Price with Declining Cost Curve & Production Tax Credit
Solar	Low	Solar Power Purchase Agreement @ $40/MWh
	Base*	Solar Power Purchase Agreement @ $50/MWh
Storage	Base*	4-hour Lithium-ion Battery – NREL ATB "Moderate" Price with Declining Cost Curve
	High	4-hour Lithium-ion Battery – NREL ATB "Moderate" Price Flat (Without Cost Curve)
	None	No Battery Storage Offered as Resource Addition
Demand Response	Base*	New Capacity Addition Offered for Economic Selection
	Forced	Incremental New Capacity Added
	High	Planned LMR Registration Provides Increased Capacity
Energy Efficiency	Base*	New Capacity Addition Offered for Economic Selection
	Forced	Incremental New Capacity Added
Seasonal RRA	Low	RRA Future Accreditation Estimates
	Base*	MISO LOLE ELCC Accreditation Estimates
CT Dispatch	Start-Up Costs	Partial Commitment CT Dispatch Modeling
Existing Contracts	Extend Wind	Existing Elm Creek & Prairie Star Wind PPAs Extended Through Study Period
	Hydro Ends	Existing Manitoba Hydro Contract Not Extended
*Base Case Scenario		

5.6.6 Model results

In GRE's resource planning process, the load and energy requirements of our members must be met along with MISO's resource adequacy requirements. The Federal Energy Regulatory Commission (FERC) accepted MISO's proposed seasonal resource adequacy requirements on Aug. 31, 2022, and GRE implemented these seasonal requirements in the IRP modeling in order to best plan for reliability and future resource needs. Although there is still a great deal of uncertainty around future resource accreditation and seasonal PRM, GRE sought to align resource planning assumptions with the best available information during the IRP modeling. GRE assumed that current accreditations and seasonal PRM would be maintained into the future. Building on capacity length in the near-term, GRE believes our current portfolio and Preferred Plan are robust but we will continue to monitor trends and changes in MISO and update modeling internally as needed as we plan with our member owners. Figure 9 shows the net position of GRE's current portfolio without any resource additions beyond those currently planned, which are included in GRE's five-year action plan. GRE's capacity and energy needs arise in the early 2030s.

Under GRE's Preferred Plan, we will meet our load requirement and MISO's current seasonal PRM over the 15-year planning period. The Preferred Plan capacity additions that are beyond the five-year action plan begin in 2030 in order to meet the capacity need that arises in 2031. Figure 9 depicts GRE's portfolio model length without the addition of new resources while Figure 10 shows that resource additions in the Preferred Plan meet projected capacity needs in all four seasons through the planning period. This figure illustrates the expected accredited capacity against MISO's current seasonal PRM requirements. The length shows capacity beyond what is required to meet the PRM. Based on current estimates, the Preferred Plan also provides additional capacity length in each season, which helps the plan to be more robust across potential changes to resource adequacy requirements and capacity accreditation. This figure is fundamentally different than the MISO Module E process whereby formal compliance with resource adequacy requirements is evaluated, and it is meant as a representative look at future capacity position.

Figure 9 Planning model length – No New Resources

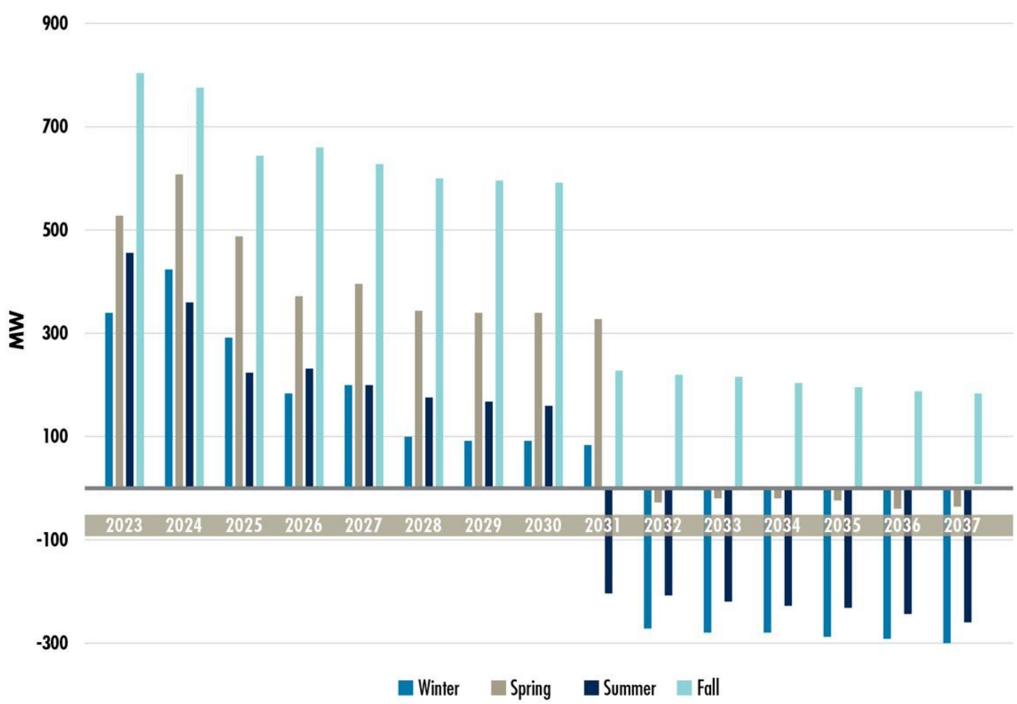
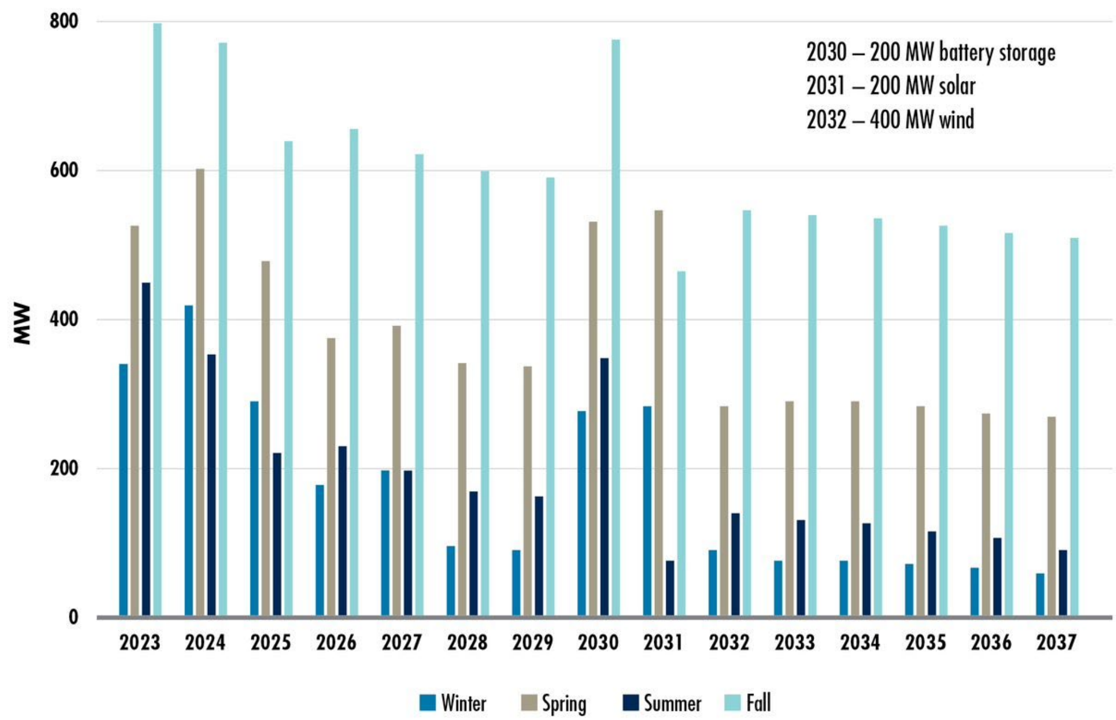


Figure 10 Planning Model length – Preferred Plan



The Preferred Plan was directly informed by EnCompass modeling of the GRE portfolio. Base case and sensitivity variables are defined in Table 8 above. Across all scenarios modeled, the most frequently selected resource types for expansion were battery storage, wind, and solar resources. The Preferred Plan includes all three of these resource types as they were all added in the base case in addition to multiple sensitivity scenarios.

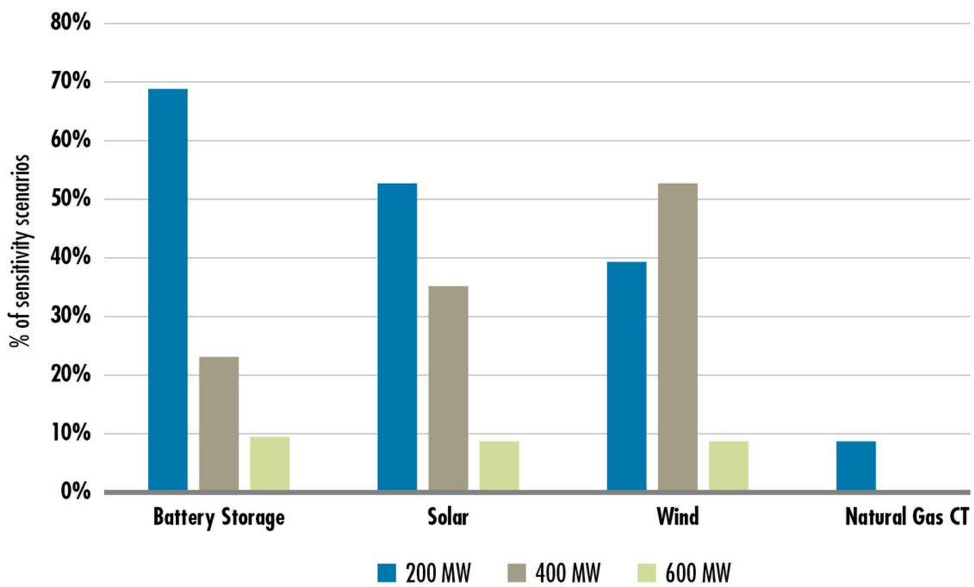
By examining modeling results, GRE sees each resource type contributing its different characteristics to GRE's resource mix to meet portfolio needs. Battery storage has high capacity accreditation across seasons and is able to charge at times of lower prices and discharge to help meet peak energy needs. This flexibility makes it an attractive resource in the model to create a least-cost portfolio. Solar has its highest capacity accreditation in the summer and also adds energy, primarily on peak. Wind has its highest capacity accreditation in the winter and produces the highest total amount of energy of these resources. Together, these resources meet GRE's seasonal capacity needs and energy needs that arise in the early 2030s. The battery's flexibility also allows it to dispatch to reduce the total cost of the portfolio.

The size (MW) of each capacity expansion resource in the Preferred Plan was also driven by the modeling results. Based on the size of GRE's future capacity and energy need, supply-side resources were offered in 200 MW increments for modeling purposes. These resource sizes are meant as a guide when evaluating future resource additions.

Figure 11 below depicts the frequency that respective amounts of each type of resource were selected across sensitivity scenarios during EnCompass capacity expansion modeling. This shows that the majority of scenarios added 200 MW of battery storage, 200 MW of solar, and 400 MW of wind, which are the sizes represented in the Preferred Plan.

Although a natural gas CT was not included in the Preferred Plan, one driver of natural gas CT addition for a least-cost portfolio identified was restricting market energy purchases. When GRE owned or contracted resources were required to meet all of GRE's capacity and energy needs, a 200 MW natural gas CT was added along with additional 200 MW battery storage and 200 MW solar resource ("No Market Purchases" scenario).

Figure 11 - Proportion of sensitivity scenarios with each resource size and type



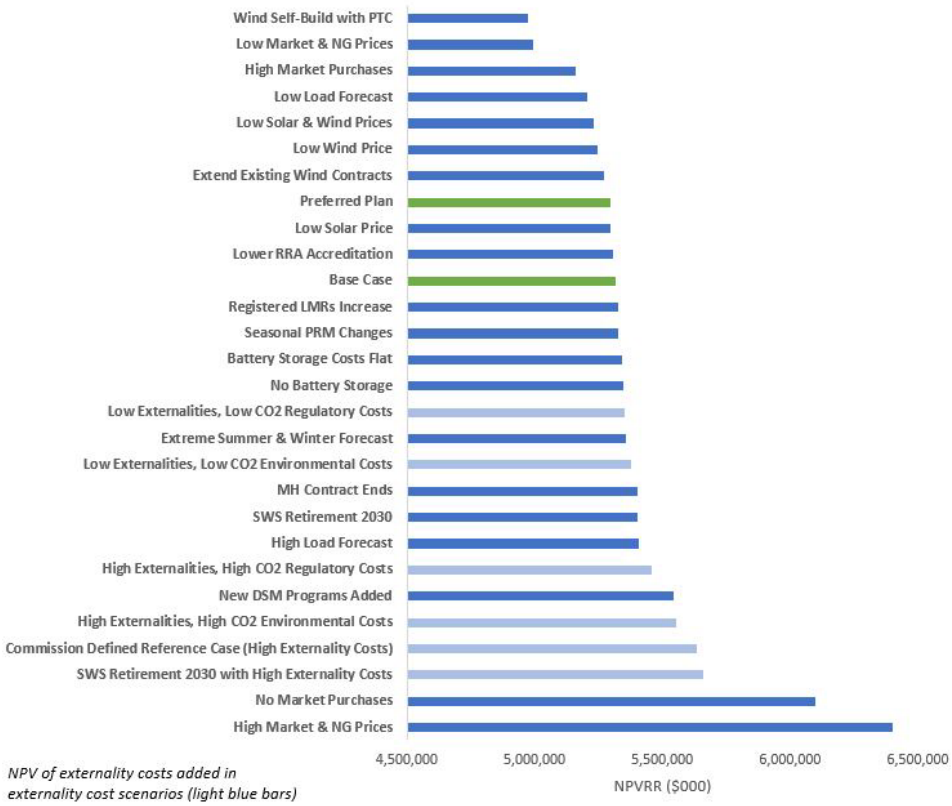
GRE modeled a number of sensitivity scenarios using the variable ranges defined in Tables 7 and 8 above. These scenarios were used to evaluate the robustness of the Preferred Plan and identify drivers of different resource additions. Table 9 summarizes the change in resource type and amount (additions or subtractions) by modeled scenario as compared to the base case capacity expansion, which aligns with the Preferred Plan. The majority of scenarios showed capacity expansion additions of wind, solar, and storage, which supported inclusion of all three resource types in the Preferred Plan.

Table 9 - Sensitivity scenario results compared to Base Case and Preferred Plan

EnCompass capacity expansion plan comparison – supply-side resources				
Scenario	**Battery Storage**	**Solar**	**Wind**	**CT**
Base Case/Preferred Plan	**200 MW**	**200 MW**	**400 MW**	**-**
Low/High CO2 Environmental & Regulatory Externalities, Criteria Pollutant Externalities	-	-	-	-
High Load Forecast	-	-	-	-
Low Load Forecast	-	-	- 200 MW	-
Extreme Summer & Winter	+ 200 MW	+ 200 MW	-	-
High Market & High NG Prices	+ 400 MW	+ 200 MW	+ 200 MW	-
Low Market & Low NG Prices	+ 200 MW	+ 200 MW	-200 MW	-
No Market Purchases	+ 200 MW	+ 200 MW	-	+ 200 MW
High Market Purchases	-	-	-	-
Seasonal PRM Change	-	+ 200 MW	- 200 MW	-
SWS Retirement in 2030	+ 200 MW	-	-	-
Low Solar Price	-	+ 400 MW	- 200 MW	-
Low Wind Price	-	-	-	-
Low Solar & Wind Price	-	-	-	-
Storage Costs Flat	-	-	-	-
No Battery Storage Offered	(- 200 MW)	+ 200 MW	- 200 MW	+ 200 MW
Self-Build Wind with PTC	+ 400 MW	- 200 MW	+ 200 MW	-
Forced DSM Programs Addition	-	+ 200 MW	-200 MW	-
Registered LMRs Increase	-	+ 200 MW	-200 MW	-
Lower RRA Accreditation	-	-	--	-
Granular CT Modeling	-	+ 400 MW	- 200 MW	-
Elm Creek & Prairie Star Extended	-	-	- 200 MW	-
Manitoba Hydro Contract Ends	+ 200 MW	-	-	-

Drivers of lower cost portfolios than the base case include lowering prices of wind, solar, market purchases, and natural gas, which follows expected trends. Drivers of higher cost portfolios than the base case include higher prices of market purchases and natural gas, higher demand and energy needs, Spiritwood Station retirement and associated costs, addition of new high-cost energy efficiency and demand response programs, and restriction of market purchases to serve net energy. Figure 12 depicts the net present value of revenue requirement by scenario modeled in EnCompass.

Figure 12 - Net present value of revenue requirement by scenario



6 Minnesota Renewable Energy Standard compliance

GRE's most recent RES compliance filing was filed on May 20, 2022, Docket Nos.: E-999/PR-22-12, M-22-85 and PR-02-1240. After passage of the revised RES in February 2023, GRE continues to project compliance at both current and future levels. Today, GRE is retiring RECs equal to 25% of retail electric sales. Regarding future compliance, the biennial filing estimated GRE could comply with the Minnesota RES through 2040 at then currently approved levels. No obstacles are anticipated in meeting the current objective or standards. Even with the increased RES goal of 55% beginning in 2035, GRE anticipates an energy mix capable of satisfying that requirement as early as 2025, but will continue retiring RECs at current levels until the RES increases in 2035.

7 Minnesota Renewable Energy Standard rate impact

Since the 2017 IRP filing, GRE has continued to meet the Minnesota RES with wind added for compliance and for economic reasons. It is important to differentiate these two types of wind additions. Wind added for policy compliance only would be represented by a wind project, or an energy source, that is unnecessary from an energy position or future hedge perspective and is only being added to comply with a standard. Alternatively, economic wind additions would be characterized as new resources brought on to satisfy a need in the portfolio and represents a tangible and necessary addition to the power supply to meet current and future internal hedged energy requirements. GRE has been in compliance with the RES every year and has economically added new wind generation from 2017 to 2022. These new resources were unnecessary for meeting the 25% RES level and were pursued for the value that they represent to the portfolio. Therefore, there is no rate impact to the RES, as this wind would have been added to the portfolio absent an RES. Additional wind generation above and beyond the RES requirement has been added based on least-cost economics as a hedge against GRE's member load. These resource selections were approved by GRE's members and the incremental cost of these resources are currently reflected in GRE's wholesale rates to its members. Therefore, the current rate impact of the RES is unchanged from GRE's last reported 2017 IRP values.

8 Environmental update

GRE is in full compliance with all applicable environmental regulations and is well-placed and preparing to comply with all expected future regulations.

Consistent with our triple bottom line, which balances rates, reliability, and environmental stewardship, GRE has worked hard over the years to reduce the environmental impact of our operations. Between 2005 and 2021, we achieved the following emission reductions across our energy supply portfolio:

- Carbon dioxide (CO_2) emissions have decreased by 19%.
- Total sulfur dioxide (SO_2) emissions have decreased by 83%.
- Total nitrogen oxides (NOx) emissions have decreased by 65%.

As discussed elsewhere in the IRP, these reductions are a result of GRE's portfolio evolution that includes the retirements of Stanton and Elk River Stations. These reductions are based on end-of-year 2021 data. They do not currently reflect the sale of CCS and the corresponding PPAs for wind, which will show further reductions starting in 2023 and beyond.

This section discusses significant environmental regulations that currently apply to GRE's power supply resources as well as those which are pending. To begin, GRE closely monitors EPA's activities with respect to any regulations that may impact our operations. We will remain fully engaged with environmental regulatory changes on both federal and state levels and are prepared to take actions necessary to comply with new requirements.

Significant environmental regulations that impact, or could potentially impact, GRE power supply facilities include:

- The Acid Rain Program.
- The Clean Air Visibility or "Regional Haze" rule.
- The Cross-State Air Pollution Rule and Good Neighbor Plan.
- National and Minnesota Ambient Air Quality Standards (NAAQS and MNAAQS)
- The Mercury and Air Toxics Standards (MATS) rule.
- The Coal Combustion Residuals (CCR) rule.
- Greenhouse gas rules and emissions
- Polychlorinated biphenyls (PCBs) in electrical equipment

The portfolio evolution efforts have greatly reduced, if not eliminated, environmental risks associated with other regulatory programs such as EPA's Effluent Limitations Guidelines and 316(b) cooling water regulations, among others.

Before discussing regulatory compliance, it is important to understand that GRE continues to enhance our environmental stewardship by:

- Evolving our portfolio by adding up to 866 MW of renewable resources by 2025.
- Operating our facilities consistent with a third party audited, ISO 14001 conforming environmental management system.
- Supporting electrification efforts that better align with the generating profile of renewable energy resources and reduce emissions from the transportation sector.

8.1 Acid Rain Program

The Acid Rain Program (ARP) is under Title IV of the Clean Air Act. It requires nationwide reductions of SO_2 and NOx emissions. It has two mechanisms. First, it allocates SO_2 allowances under a cap-and-trade mechanism to electric generation facilities based on historic emissions. It also sets an annual NOx emission rate based on the type of generation for older units. Spiritwood Station, as well as several of GRE's combustion turbine stations, are regulated by the ARP.

Each unit covered by the ARP is required to hold and retire one SO_2 allowance for each ton of SO_2 emissions on a calendar year basis. The EPA allots a pre-determined number of SO_2 allowances to specified legacy units for each year. Excess allowances from these legacy units can be used for compliance by other affected units in a utility's fleet. Excess allowances can also be sold into the market, which has been created by the ARP. Given significant nationwide reductions in SO_2 emissions since the program's inception, the SO_2 allowance market is virtually non-existent.

GRE's power supply units have been performing better than ARP requirements for many years. Therefore, GRE has an excess of SO_2 allowances that guarantees compliance with the program requirements by all its affected units with no additional investment.

8.2 Clean Air Visibility and Regional Haze

EPA published final regional haze regulations in 1999. The intent of the Regional Haze Rule is to gradually improve visibility in Class I areas, such as national parks and wilderness areas, with a goal of reaching "natural conditions" by 2064. The first phase of this rule required certain older power plants to install Best Available Retrofit Technology to control SO_2, NOx, and particulate matter emissions. Spiritwood Station was not subject to this first phase of the regional haze rule.

In 2022, North Dakota's Department of Environmental Quality (NDDEQ) issued its state implementation plan (SIP) for the second phase of the Regional Haze Rule. Because of its location being relatively far from Class 1 areas and its state-of-the-art emission controls, Spiritwood was exempted from any requirements under NDDEQ's second phase SIP. NDDEQ is expected to issue its third phase of requirements starting in 2028 and will continue in 10-year cycles thereafter until 2064. Similar to Spiritwood, GRE's Minnesota combustion turbines have also been exempted from both the first and second phases of the Regional Haze Rule, which is in part a function of their low emissions and their distances from the Class I areas. At this time, it is not known if GRE's power supply resources will be impacted by future phases of the regional haze rule.

8.3 Cross-State Air Pollution Rule

The EPA promulgated a series of rules including the Cross-State Air Pollution Rule (CSAPR) designed to address interstate transport and contribution of upwind states' emissions to nonattainment of National Ambient Air Quality Standards in downwind states. The CSAPR was finalized by the EPA on July 6, 2011, and, after lengthy challenges and legal actions in several federal courts, the stay of the rule was lifted with compliance beginning Jan. 1, 2015.

CSAPR covers GRE's combustion turbine peaking plants in Minnesota but not Spiritwood in North Dakota. For our Minnesota combustion turbine plants, there are enough SO_2 and NOx allowances to meet compliance without needing additional controls. In other words, EPA's annual allowance allocations are sufficient to meet compliance with any excess allowances being banked for use in future years as needed. If GRE's combustion turbines were to operate in response to unexpectedly high peak demands and emit more than the current year allocated and any banked allowances, GRE would then need to purchase additional allowances. GRE's peaking turbines operate mostly on pipeline natural gas, which has inherently low sulfur content, or on ultra-low sulfur diesel as a back-up fuel. In addition, GRE's larger peaking plants are all equipped with dry low-NOx burners to control NOx emissions. No additional controls are needed to comply with these requirements.

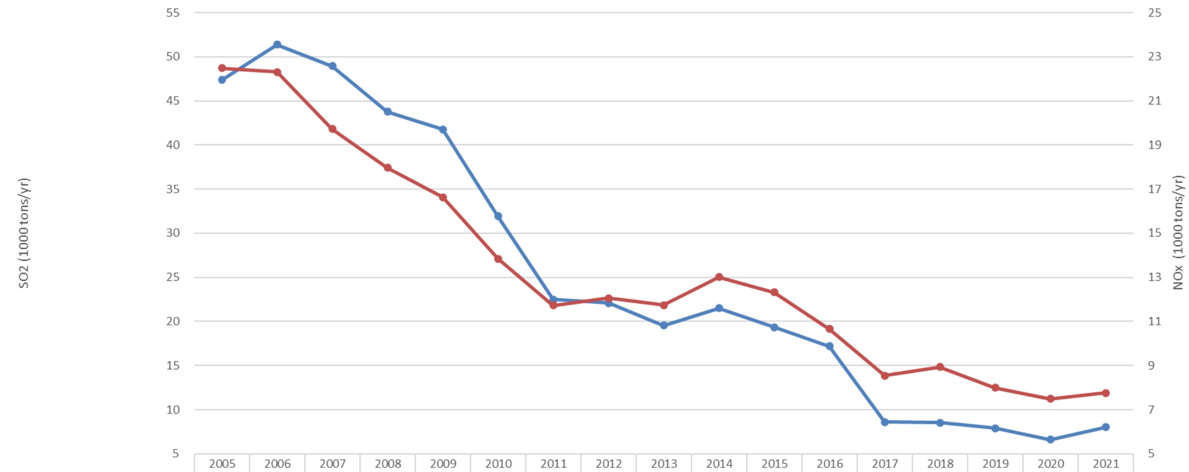
8.4 Good Neighbor Plan – CSAPR update

EPA's draft Good Neighbor Plan, published in April 2022, revised the CSAPR regulations to include an Ozone Season Group 3 trading program. Minnesota's proposed plan for addressing its contribution to downwind ozone non-attainment was not deemed sufficient by EPA. EPA subsequently issued its draft federal plan. The proposed EPA Good Neighbor Plan establishes another trading group with associated NOx and SO_2 allowances to reduce Minnesota's contribution to downwind states' ozone non-attainment. Under EPA's proposed plan, compliance is expected to begin in 2023 for the summer ozone season. GRE's initial analysis indicates that only 85% of the needed NOx allowances will be allocated based on 2021 plant operations as the historical high year from EPA's baseline period. EPA has proposed a dynamic allowance allocation process starting in 2026, which could create allowance price spikes or scarcities. This might cause utilities to curtail operations even during peak grid events, potentially causing reliability issues. EPA issued a pre-publication version of its final rule on March 15, 2023. GRE is currently evaluating it for any changes or additional impacts.

8.5 Sulfur dioxide and nitrogen oxides

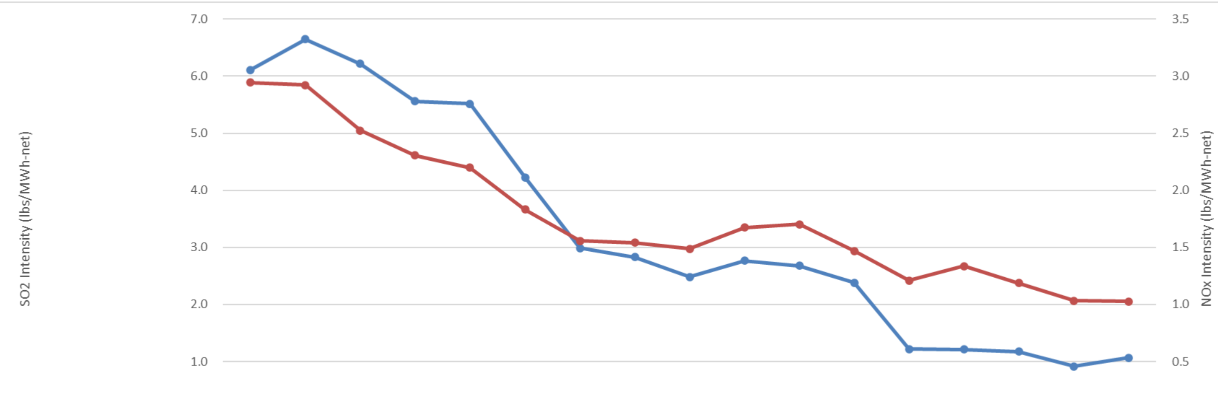
In concert with our triple bottom line, GRE has worked hard to reduce SO_2 and NOx emissions and intensities from our coal-fired power plants. Between 2005 and 2021, SO_2 and NOx emissions were reduced by 83% and 65%, respectively, across our energy supply portfolio (See Figure 13). During this same timeframe, SO_2 and NOx intensities were reduced by 83% and 65%, respectively (See Figure 14).

Figure 13 - GRE SO2 and NOx emissions trend



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
SO2 Emissions	47	51	49	44	42	32	22	22	20	22	19	17	9	9	8	7	8
SO2% change	0%	8%	3%	-8%	-12%	-33%	-53%	-53%	-59%	-55%	-59%	-64%	-82%	-82%	-83%	-86%	-83%
NOx Emissions	22	22	20	18	17	14	12	12	12	13	12	11	9	9	8	7	8
NOx % Change from 2005	0%	-1%	-12%	-20%	-26%	-38%	-48%	-46%	-48%	-42%	-45%	-53%	-62%	-60%	-64%	-67%	-65%

Figure 14 - GRE SO2 and NOx emission intensity trend



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
SO2 Intensity (lbs/Net MWh)	6.1	6.6	6.2	5.6	5.5	4.2	3.0	2.8	2.5	2.8	2.7	2.4	1.2	1.2	1.2	0.9	1.1
SO2 % Change from 2005	0%	9%	2%	-9%	-10%	-31%	-51%	-54%	-59%	-55%	-56%	-61%	-80%	-80%	-81%	-85%	-83%
NOx % Change from 2005	0%	-1%	-14%	-22%	-25%	-38%	-47%	-48%	-50%	-43%	-42%	-50%	-59%	-55%	-60%	-65%	-65%
NOx Intensity (lbs/Net MWh)	2.9	2.9	2.5	2.3	2.2	1.8	1.6	1.5	1.5	1.7	1.7	1.5	1.2	1.3	1.2	1.0	1.0

SO_2 and NOx emissions are regulated under the ARP, Regional Haze Rule, CSAPR, and National Ambient Air Quality Standards (NAAQS).

8.6 National Ambient Air Quality Standards

Minnesota and North Dakota are currently in attainment with the NAAQS. As a general overview, the EPA sets standards for particulate matter (less than 10 microns and less than 2.5 microns), SO_2, NOx, and ozone, among other criteria pollutants. The EPA then periodically reassesses these standards and issues new standards (levels) that are protective of human health (primary) and the environment (secondary), with an adequate margin of safety. Upon issuance of a new standard, the EPA provides guidance to the states on how they must assess their attainment status for the NAAQS. In response to the EPA's standards, states submit a SIP to maintain attainment with the NAAQS and/or to bring a non-attainment area into attainment, as applicable. Depending on the area of non-attainment and the pollutant of concern, there can be several control methods to address a non-attainment designation as determined by the state.

The EPA is now requiring more modeling demonstrations where monitors do not exist to assess attainment status. It is possible that more areas around the country will be considered as non-attainment or "unclassifiable" as states assess their attainment status and develop their respective implementation plans. As a final category, the EPA designates some areas as "unclassifiable/attainment" when there is sufficient information that a state is attaining or is likely to attain the standard based on pending changes.

For the 2010 SO_2 standards, Minnesota and North Dakota data for the period 2009-11 show attainment. Despite this attainment data, the EPA deferred any designations until the second-round submittals in 2016 for modeling data or source size exclusions. Minnesota and North Dakota completed their respective second round submittals. The EPA determined that Minnesota is in attainment and that certain counties in North Dakota were unclassifiable/attainment.

With respect to particulate matter (PM_{10} and $PM_{2.5}$), the EPA lowered these standards in 2012. State monitoring data from 2011-13 showed attainment for both Minnesota and North Dakota. The EPA designated these states as unclassifiable/attainment. EPA has recently proposed an even lower particulate matter standard. EPA's modeling shows that Minnesota and North Dakota would be in attainment with the proposed standard.

With respect to ozone, the EPA lowered the primary 1-hour standard to 70 parts per billion in 2015. States completed their infrastructure and transport plans by 2018, with implementation plans due in 2021. Ambient monitoring data demonstrates attainment with the ozone standards in Minnesota and North Dakota. However, EPA has proposed that Minnesota contributes to downwind ozone non-attainment and proposes the Good Neighbor Plan as a solution (See discussion on EPA's proposed Good Neighbor Plan).

8.7 Mercury and Air Toxics Standards

Since the early 2000s, GRE has been an industry leader in researching mercury reduction technologies at our coal fired plants. We worked with Electric Power Research Institute, U.S. Department of Energy, Lignite Research Council, and University of North Dakota Energy & Environmental Research Center, among others, to identify and test novel mercury reduction technologies. As a result of more than a decade of collaborative research, GRE was uniquely positioned to respond to EPA's Mercury and Air Toxics Standards (MATS) rule, which became effective in 2015. Specifically, Spiritwood installed a carbon injection system and uses it, along with spray drier/baghouse controls, to comply with the MATS limits. Spiritwood meets acid gas requirements through inherently low chlorine coal (lignite), through operating its spray dry baghouse scrubber and through surrogate SO_2 monitoring with continuous emission monitors. With respect to non-mercury metals, Spiritwood maintains compliance with the particulate matter limit of 0.03 lb/MMBtu through operating the existing baghouse as a highly efficient particulate matter control device.

8.8 Coal combustion residuals

GRE continues to pursue beneficial use opportunities for the remaining coal combustion products generated at Spiritwood. As a by-product of coal combustion, Spiritwood generates approximately 40,000 tons of fly ash per year. Fly ash can be used in concrete and other products such as cultured stone, carpet backing, and tiles. Beneficial use of ash for concrete in lieu of landfilling avoids cement production, reducing CO_2 emissions in the cement production process. For each ton of fly ash that is used as a cement replacement, greenhouse gas emissions are estimated to be reduced by approximately 0.8 tons. If identified, these alternative uses may eventually help offset the plant's operating costs and environmental impact.

Spiritwood began commercial operation in 2014. It does not have on-site disposal, and there is not a permitted landfill in the vicinity. The plant's CCRs are shipped to CCS under contract with Rainbow Energy for onsite disposal.

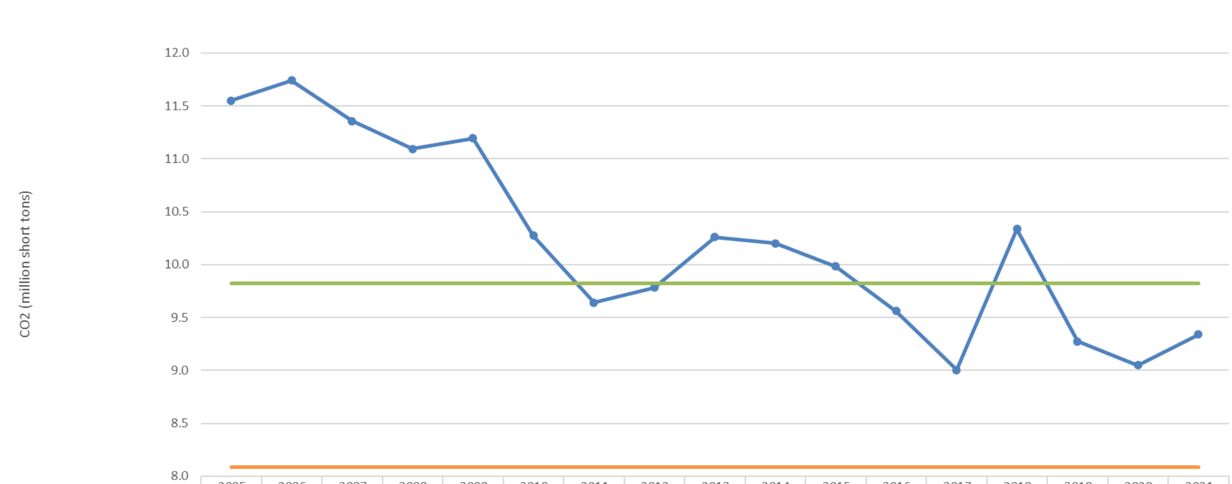
For emerging regulations, we cannot predict, with any certainty, final requirements and their potential effects on our generating resources. Nevertheless, we have included a discussion of the status of the following regulations and their potential impact to our facilities:

- Greenhouse gas emissions.
- The Regional Haze Rule — third and subsequent phases.
- NAAQS, which are standards that are both existing and emerging.
- Phase-out rule for polychlorinated biphenyls in electrical equipment.

8.9 Greenhouse gas emissions

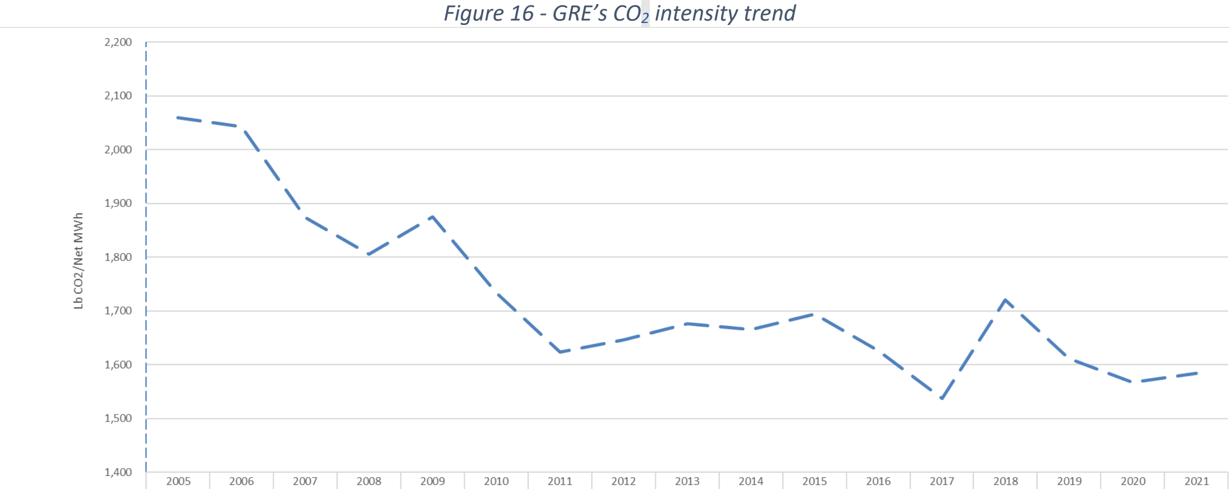
In addition to meeting environmental regulatory requirements, we strive to comply with Minnesota's GHG reduction goals of 30% by 2025 and 80% by 2050 under the Next Generation Energy Act. GRE's CO_2 emissions associated with the entirety of our portfolio, PPAs, and market interactions have decreased by 19% between 2005 and 2021. GRE is on track to meet the state's 30% goal in 2025 (See Figure 15). The carbon intensity has decreased by 23% over this same time frame. (See Figure 16) By 2035, GRE's retail electric sales will be 90% carbon free and carbon emissions will be more than 90% reduced from 2005 base levels. These developments help to minimize our members' future risk from federal and state greenhouse gas (GHG) regulations and make the energy they receive from GRE more attractive to residential, commercial, and industrial end-users that prioritize the low-carbon energy characteristics they will be receiving from GRE's power supply.

Figure 15 - GRE's CO_2 emissions trend



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
CO2 (million Tons)	11.6	11.7	11.4	11.1	11.2	10.3	9.6	9.8	10.3	10.2	10.0	9.6	9.0	10.3	9.3	9.1	9.3
% Redcn(2005)		-2%	2%	4%	3%	11%	17%	15%	11%	12%	14%	17%	22%	11%	20%	22%	19%
Nxt GenAct 15% by 2015																	
Nxt GenAct 30% by 2025																	

Figure 16 - GRE's CO_2 intensity trend



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Carbon Intensity	2,060	2,043	1,874	1,805	1,875	1,734	1,624	1,646	1,677	1,666	1,694	1,625	1,538	1,720	1,611	1,567	1,583
% Redn from '05		1%	9%	12%	9%	16%	21%	20%	19%	19%	18%	21%	25%	16%	22%	24%	23%

8.10 EPA's carbon reduction rules for the electric sector: Clean Power Plan and Affordable Clean Energy rule

In 2015, President Barack Obama's EPA issued the Clean Power Plan (CPP) regulating carbon emissions from electric generating units. The CPP was subsequently stayed by Supreme Court in 2016, pending judicial review in the District of Columbia Circuit. In 2017, President Donald Trump's EPA published notice in the Federal Register that it "will initiate proceedings to suspend, revise or rescind this rule." In 2019, they then issued the final Affordable Clean Energy rule, which was vacated by the courts in 2021 and remanded to the EPA. Under President Joe Biden's administration, the EPA is expected to issue draft rules in 2023, and to potentially finalize those rules in 2024. Until legal, regulatory and/or congressional actions take place, it is unclear what the future impact of federal GHG regulations will be on GRE's resources.

8.11 Minnesota Next Generation Energy Act

In 2007, the Minnesota Legislature enacted the Next Generation Energy Act, which was codified in Minnesota Statutes Chapter 216H. Minn. Stat. § 216H.02 Subdivision 1 states:

It is the goal of the state to reduce statewide greenhouse gas emissions across all sectors producing those emissions to a level at least 15% below 2005 levels by 2015, to a level at least 30% below 2005 levels by 2025, and to a level at least 80% below 2005 levels by 2050.

In support of the state's GHG reduction goals, GRE's total portfolio met the 15% reduction in 2016. Further, GRE's total portfolio is on track to meet the 2025 target.

Methodology for calculating GRE's contribution to statewide CO_2 emissions

GRE's historical and forecasted contributions to statewide CO_2 emissions are calculated using the retail ratepayer methodology recommended by the Department of Commerce[1]:

- Start with total annual Minnesota member retail sales in MWh.
- Calculate direct emissions (tons) by multiplying MWh generated times the corresponding CO_2 intensities from GRE owned generation, assuming no net annual market sales.
- If there are net annual sales from GRE-owned resources, subtract these emissions by multiplying average GRE owned CO_2 intensity times the number of MWh sold.
- Calculate emissions associated with PPAs and net annual market purchases by multiplying annual MWh times the corresponding carbon intensity.
- For PPA MWhs without a corresponding REC retirement in M-RETs, the Midwest Reliability Organization West (MROW) regional grid carbon intensity will be applied.

It is important to note that the Department of Commerce retail ratepayer method is silent with respect to treatment of RECs. GRE believes that by making the accounting correction as described in this last bullet, the result is more accurate and is verifiable through M-RETs. Further, it will be more consistent with eventually demonstrating compliance with the recently promulgated CFS that explicitly allows REC retirements.

Here are additional clarifying comments on the Department of Commerce method. Where a bilateral agreement exists for energy purchases and sales that refers to a specific energy source, we used the carbon intensity (lb. CO_2/MWh) for that energy source. In the case of the PPA with Rainbow, the energy received is part of a MISO Financial Schedule arrangement, which is a financial instrument that does not affect the flow of electricity and does not specify an individual generator. However, GRE has taken the step to assign the carbon intensity of Rainbow to the energy associated with this PPA.

[1] Public Comments of the Minnesota Department of Commerce, Division of Energy Resources, January 4, 2016, Minnesota Power 2015-2029 Integrated Resource Plan, Docket No. E015/RP-15-690; Comments of the Minnesota Department of Commerce, Division of Energy Resources, March 27, 2014, Southern Minnesota Municipal Power Agency 2014-2018 Integrated Resource Plan, Docket No. ET9/RP-13-1104.

If an energy purchase is not part of a bilateral agreement or the agreement does not identify a specific source for the energy, regional average emission rates are used. The Department of Commerce recommended using the average CO_2 emission rates for the MROW as provided in the EPA's eGRID database. The eGRID database typically has a data lag of one to two years (e.g., its 2021 release contained 2020 emissions data).

If an energy sale is not part of a bilateral agreement, such as our sales to MISO that do not cover our members' retail load, the carbon intensity of GRE's portfolio of energy resources is used to quantify the CO_2 emissions associated with the net annual energy sales.

In 2021, GRE retired RECs representing 25% of annual member retail load. The associated MWh from these retired RECs are treated as carbon free. For the remaining wind generated MWh, the RECs have not been retired and are banked. GRE's carbon accounting for 2021 therefore uses the 2021 regional (MROW) carbon intensity for wind or solar generated MWh when corresponding RECs are not retired.

The results of the calculations for GRE's contribution to statewide CO_2 emissions are summarized in Table 10 below for actual emissions in 2005 and 2021, and forecasted emissions in 2037 under the Preferred Plan.

Table 10 - GRE's contribution to statewide CO_2 emissions

Source	Actual 2005 (tons)	Actual 2021 (tons)	Forecasted 2037 (tons)
CO_2 from GRE's power plants	13,186,213	9,501,086	479,565
CO_2 associated with non-specific net market purchases	-1,633,482	108,695	1,145,161
CO_2 associated with retirement of non-energy-related RECs	-	-273,138	-1,052,051
GRE's contribution to statewide CO_2 emissions	**11,552,731**	**9,336,642**	**572,676**
CO_2 reduction relative to 2005		**19%**	**95%**

In addition to further reductions in the CO_2 emissions from our energy portfolio, GRE is participating in innovative initiatives that can help to reduce emissions from other sectors of the economy.

8.12 Polychlorinated biphenyls in electrical equipment

GRE has maintained a proactive program to identify, retire and replace aging oil-filled electrical equipment. In 2022, 103 transformers associated with the electrostatic precipitator at CCS were sold to Rainbow. These transformers represented the only remaining oil-filled electrical equipment known to contain polychlorinated biphenyls (PCBs) in the GRE asset fleet. Moreover, GRE will continue to identify, test, and phase out oil-filled electrical equipment manufactured prior to 1980, across mostly our transmission division. Generally, this oil-filled equipment is considered unknown, or potentially containing PCBs, due to dates of manufacturing. To confirm PCBs by testing, the equipment would need to be destroyed. This effort does not represent a significant cost to GRE's power supply operations.

9 Demand-side management

GRE operates one of the most robust demand response (DR) programs in the nation, and prioritizes these resources as they bring value to both the membership and GRE. These programs intentionally change our members' end-users' electric usage patterns from their normal consumption patterns in response to changes in the price of electricity or incentive payments. The programs are largely designed to induce lower electricity use at times of high wholesale market prices and, if possible, shift the electricity use to times when wholesale market prices are at their lowest, which has historically been during overnight hours. By actively engaging tens of thousands of our members' end-use consumers, GRE's member-owners can reduce exposure to electric price volatility and the need for additional generation capacity, while enhancing system reliability and member value.

9.1 Demand response history through present

GRE and our member-owners have been investing in DR since 1979. The first attempt to alter member consumption was accomplished using a simple time clock which limited a water heater's consumption to the middle of the night. Today, we still invest in technologies that shift member loads. Time clocks were replaced over time by direct load control technologies which use radio waves and paging networks to communicate varying strategies to hundreds of thousands of deployed devices. Since 2015, GRE and our member-owners have been engaged in a series of grid modernization efforts to shift load management functionality to devices that communicate through Advanced Metering Infrastructure (AMI). GRE has implemented a Demand Response Management System (DRMS). The DRMS serves a centralized scheduling and dispatch of member-owner demand response and allows our system operations personnel to respond to market dispatch signals for demand response. GRE's members are in different stages of AMI and load management device deployment. GRE intends to retire the legacy load management radio communication system on Jan. 1, 2026.

Since 1979, GRE and our members have saved hundreds of millions of dollars from joint investment in DR. The value of these DR resources continues to increase as the dollars saved from the investment in the program begin to accumulate. The development of wholesale power markets combined with advancements in DR technologies allow utilities to realize more value from DR resources than was previously possible.

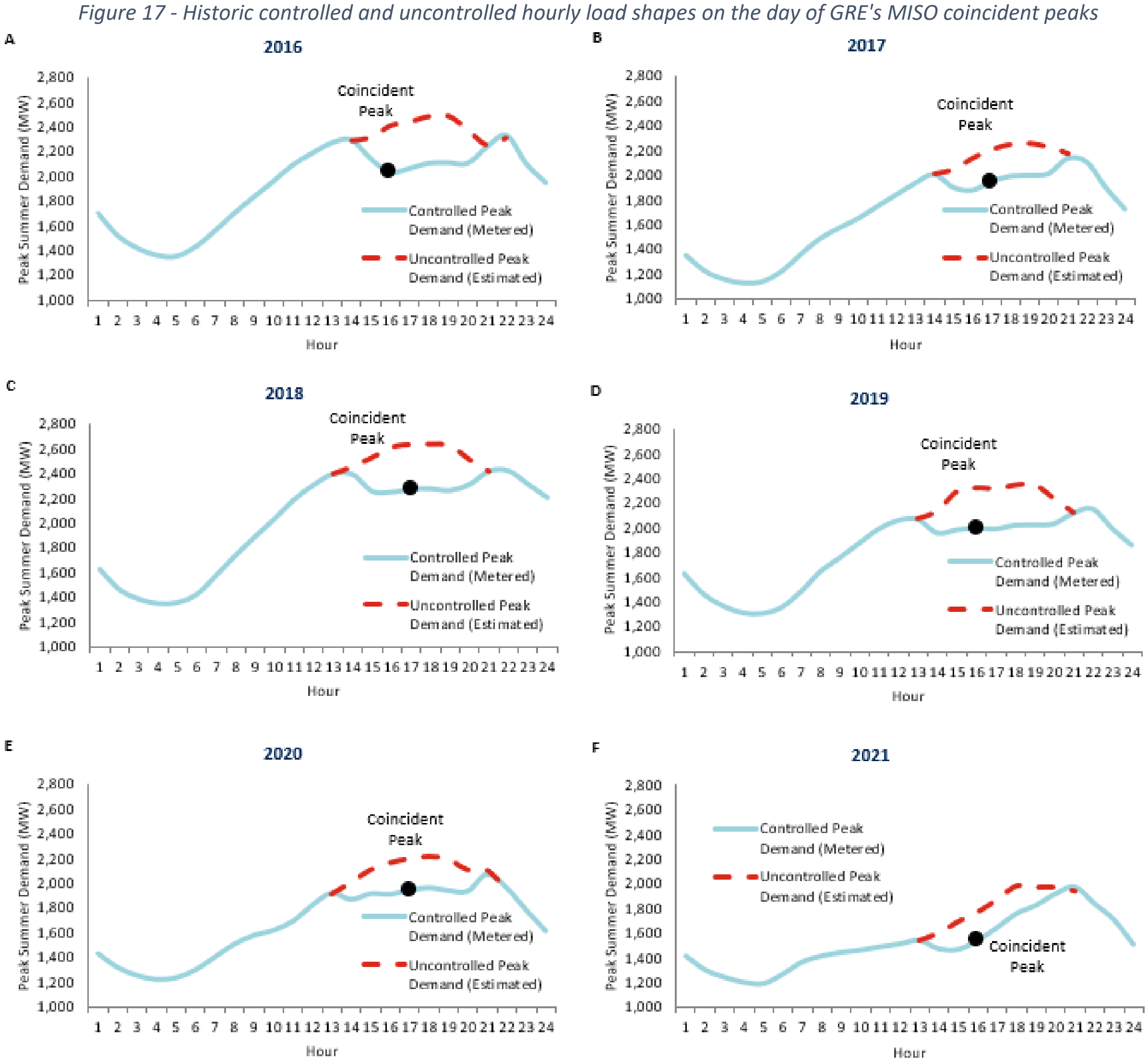
Historically, DR activities were utilized to reduce the peak load for the utility investing in the DR resources. That method of controlling resources is typically referred to as peak shaving. Peak shaving still plays a significant role in the overall value of DR. Moving forward, GRE is working with our member-owners to focus on wholesale market presentment of DR resources. This began in the 2022-23 planning year when seven member-owners elected to participate in a load modifying resource (LMR) registration pilot program. All interruptible commercial, industrial, and agricultural (CI&A) resources were registered as LMRs during the 2023-24 planning year along with two member-owners' cycled air conditioning resources. This approach helps maximize the capacity value of DR resources and relies on metering data to characterize the DR availability associated with each resource.

Methodology

To fully take advantage of the benefits of the DR resources that we have invested in, loads are typically controlled on summer peak days from 1 p.m. to 10 p.m. This large window of control is necessary as it captures multiple value streams. MISO's wholesale energy market prices typically peak between 1 p.m. and 4 p.m. Controlling loads between these hours provides a cost savings opportunity as lower cost energy can be purchased later in the day. We control loads between 4 p.m. and 7 p.m. to reduce the system load or coincident system peak.

Controlling for the system peak reduces our capacity requirements and was the initial incentive that drove investment in DR. Control after 7 p.m. is to avoid setting a new system peak when the loads being controlled are restored. If we release control of the loads at 7:01 p.m., a new system peak may be established from the surge of consumption that would occur due to all the controlled devices resuming the consumption of electricity at the same time. To avoid this rebound peak, control of the appliances is maintained until enough load is removed from the system due to the natural ramp down of consumption later in the evening hours as shown in Figure 17.

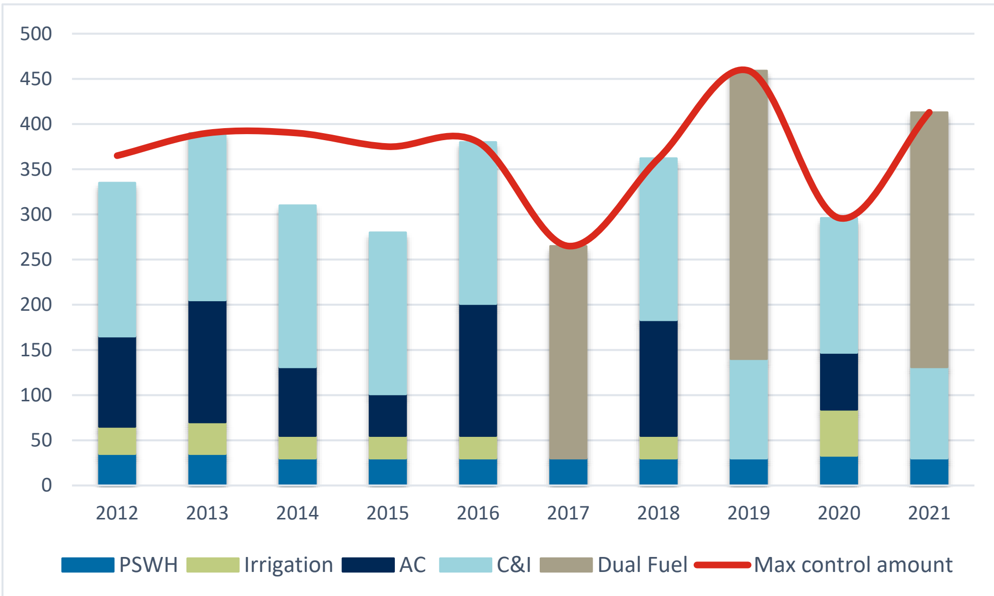
Figure 17 - Historic controlled and uncontrolled hourly load shapes on the day of GRE's MISO coincident peaks



Our overall maximum control amount capability has exceeded 400 MW during winter control events and can approach 400 MW during the summer months. This reflects our growing ability to reduce our system peak through DR mechanisms, and our ongoing commitment to addressing reliability from the demand side as well as the supply side.

Our DR efforts have been in five core areas: peak shave water heating, irrigation, cycled air conditioning, winter dual fuel, and C&I interruptible load, as shown in Figure 18.

Figure 18 - Maximum annual demand response (MW) impacts by year 2012-21



GRE forecasts the monthly coincident peak as opposed to the uncontrolled coincident peak. The monthly coincident peak is the largest metered peak in each month. The uncontrolled monthly coincident peak is an estimated peak based off the type and quantity of each DR program: peak shave water heating, irrigation, and cycled air-conditioning.

The total embedded DR savings is the area between the estimated uncontrolled coincident peak and the metered coincident peak. Summer controlled and uncontrolled GRE coincident peak and associated demand response can be clearly seen as the shaded area in green found in Figure 19. Figure 20 depicts winter controlled and uncontrolled GRE coincident peak and associated demand response.

Figure 19 - Summer controlled and uncontrolled GRE coincident peak and associated demand response

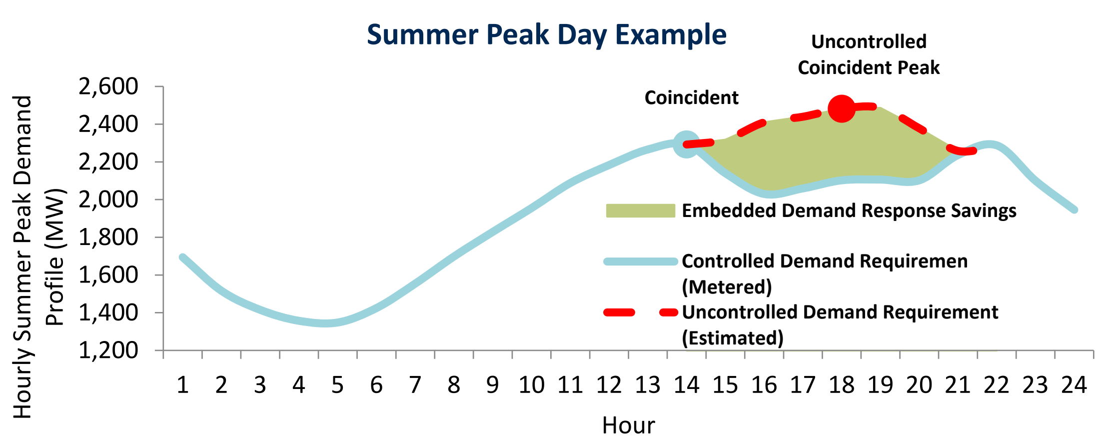
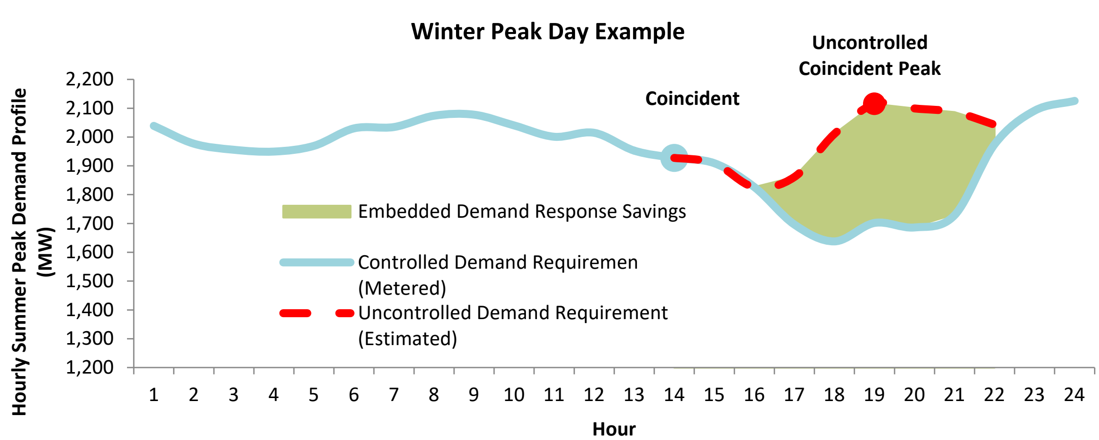


Figure 20 - Winter controlled and uncontrolled GRE coincident peak and associated demand response



9.2 Demand response management system

In 2015 GRE implemented a modern DR management system: Open Access Technology International, Inc.’s (OATI) webDistribute system. The new system will allow more precise control and allow for interconnection with growing load control technologies, such as smart thermostats and Wi-Fi-enabled devices.

With two-way communication, we will be able to accurately monitor the effectiveness of our DR efforts, including water heaters, pumps, space heaters, electric thermal storage devices, EV chargers, and distributed energy resources for member-owned generators and to analyze data to improve our programs continually. We can manually create and schedule events, or events can be triggered automatically based on time-of-day or system conditions. OATI webDistribute provides after-the-fact performance reporting for the overall system or each member using meter data. We are beginning to transition existing demand response programs to this new system. The system will then be made available to our members, who can benefit from the system's additional capabilities. OATI has previously supplied GRE with OATI webCompliance, which helps us proactively improve overall efficiency and reliability.

10 Energy efficiency

As a member-owned cooperative, member-consumers are the driving force for the business structure and decisions made by GRE and its member-owners. GRE's portfolio of energy efficiency and beneficial electrification programs provide cost-effective means of delivering energy services as well as cost savings to member-consumers while playing a key role in the decarbonization of Minnesota's economy. Residential consumers account for 85% of total accounts across the GRE membership. This reality brings about many opportunities as well as hurdles to delivering cost-effective, coordinated energy efficiency and beneficial electrification programs. However, a significant percentage of overall energy savings achievements are realized by large CI&A consumers.

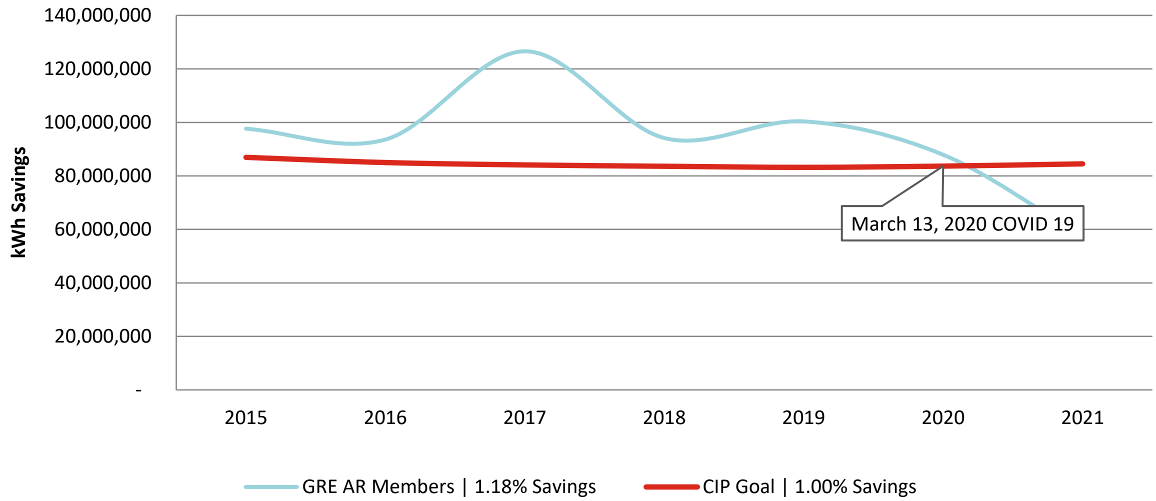
GRE and our members work cooperatively with end-user members to implement energy efficient and beneficial electrification technologies that provide energy, economic and environmental benefits. A key strength of our efficiency portfolios are the close relationships that our members have with their member-consumers, which enables a high level of awareness of energy efficiency and beneficial electrification opportunities and the implementation of cost-effective energy efficiency programs.

10.1 Historical achievements

Since 2015, GRE's members have realized collective results that exceed the 1.0% energy conservation goal that has been set by the Minnesota Legislature, with the exception of 2021 and the unprecedented effects of COVID-19. The blue line represents the Minnesota demand-side realized kilowatt-hour (kWh) savings achievements while the red line represents the 1% savings goal by year. These results are shown in Figure 21 below.

In 2021, our member-owners achieved combined energy reductions of 75 million kWh through efficiency savings. Annual Department of Commerce approval letters for our conservation improvement program are anticipated in April of 2023. Figure 21 depicts Historical AR member achievements 2015-21.

Figure 21 - Historical AR member achievements 2015-21



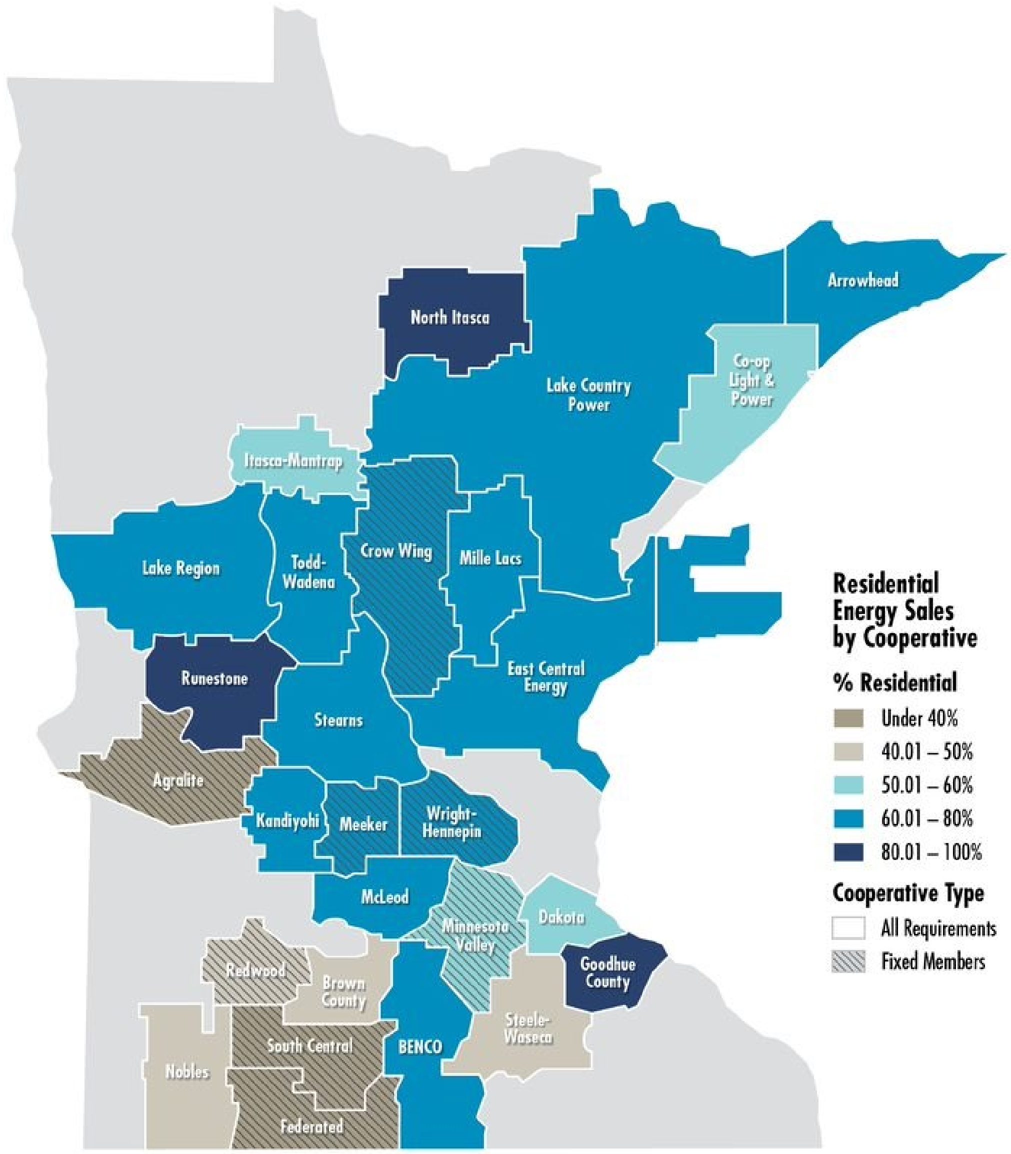
Annual variation in achievements can be expected, especially those reductions made by larger C&I members which do not always yield a smooth reduction curve as their efficient projects are intermittent.

10.2 End-use members

As shown in Figure 22, GRE's system is comprised mostly of residential end-use consumers. In fact, most of our members have residential sales that are in excess of 60% of total electricity sales. This characteristic has been reflected in GRE's energy efficiency and beneficial electrification program offerings and energy conservation achievements. Energy savings from efficient lighting, such as LED lighting, have yielded a sizeable percentage of the total energy savings achievements by all of GRE's member distribution cooperatives.

Residential programs require significantly more coordination than C&I programs. For these residential programs, outcomes can offer both greater engagement for future energy savings and beneficial electrification opportunities, while also decreased energy savings per home visit. Much of the more cost-effective energy savings measures such as LED lighting have been implemented, and more beneficial electrification programs such as ASHPs and heat pump water heaters come with enhanced quality of living and diminished energy savings. C&I energy savings programs remain the driving force of energy conservation across GRE members.

Figure 22 - Member residential energy sales 2021



Lighting is the primary driver of CI&A energy savings . ASHPs are the primary driver for residential savings within GRE's energy efficiency portfolio. As shown in Figures 21 and 22, GRE and our members realized approximately 55% of C&I energy savings in 2021 from lighting measures that were undertaken by member-consumers. This was driven in large part by the reductions in the cost of LED technologies and the wider availability of this technology for end use applications. Currently, many of our members are working to change out security lights, streetlights, and other outdoor lighting applications with LED (Figure 23.) Residential lighting programs were dramatically changed in 2021 through the elimination of new construction lighting energy savings. In the residential sector, only retrofit lighting projects qualify as energy savings. This has had a great impact on savings opportunities as the GRE membership is largely residential. Through this change, ASHPs have taken prominence as the greatest driver to energy savings. This change is demonstrated in Figures 24 with 51% of total residential energy savings realized from ASHP technology.

Figure 23 - Commercial energy savings – 2021 top programs

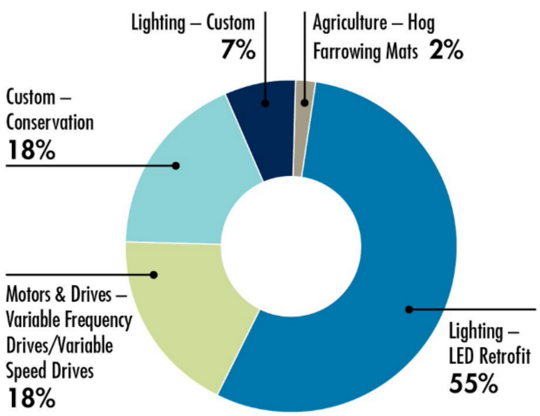
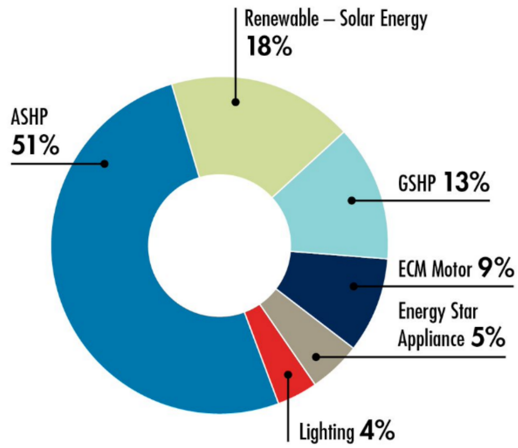


Figure 24 - Residential energy savings – 2021 top programs



Utility efficiency programs have operated under the assumption that end-use consumers would not choose a lower efficiency product over a higher efficiency product due to the incremental cost that is associated with the higher efficiency product. Policies that pushed utilities to offer incentives were focused on reducing or eliminating the incremental cost of the higher efficiency product.

10.3 Energy efficiency programs

GRE's energy efficiency programs use an "all of the above" approach to member energy efficiency engagement. The total program is made up of five components:

- **Equipment incentive programs -** These programs provide incentives for our members' end users to invest in equipment having greater efficiency than equipment that meets current federal standards. Incentives are based on the level of budget and the current commercial state of the technology. As technologies mature and the market for these technologies transform the overall rebate for those technologies will be decreased.

- **Consumer behavior programs –** Consumer behavior programs focus on educating end users about their energy use and providing relevant comparisons that seek to illustrate ways in which the member-consumer can reduce their consumption and lower their overall cost of energy. Several of GRE's members have employed tools like SmartHub, which leverages member-owner investments in Advanced Metering Infrastructure to present energy consumption data through an online web portal. In addition, several of our members have employed direct appeals to their end users to reduce their consumption during the hottest months of the year. These "Beat the Peak" programs ask member-consumers to voluntarily reduce their consumption and are associated with contests that reward end users that realize the greatest reduction in their overall electric consumption.

- **Supply-side efficiency –** Efficiency is a central focus of GRE's culture of business improvement. Recent generation efficiency improvements include combustion turbine tuning to minimize heat rates and major overhauls of several combustion turbines based on operating hours. In addition, GRE has also been actively engaging with third-party wind forecasting developers to identify improvements in day-ahead wind forecasting ability. Additional efficiency gains are being developed with regard to Ambient Adjusted Ratings of GRE's transmission lines which will aid in reducing both congestion charges and renewable energy generation curtailment.

- **Market transformation –** GRE's long history of efficiency engagement with our members has resulted in member-consumers who are well versed in the benefits associated with investments in efficiency. As the market share of products that carry labels indicating efficient products (e.g., ENERGY STAR®) have expanded, many members have adopted these technologies without taking advantage of rebate programs.

- **Demand response** – GRE's robust demand response efforts are focused on modifying the load curve during the periods of monthly peak demand, as well as ongoing efforts to shift as many end uses to off-peak periods as possible. The effort to shift end uses to off-peak periods is most pronounced in the areas of electric storage water heating and EV charging efforts. More information on our demand response program follows in the next section.

GRE plans the following energy efficiency program activities throughout the Five-Year Action Plan:

- Survey members in 2023 regarding key electric end uses within homes and businesses;
- Participate in research to further characterize energy efficiency end use technologies, including the expansion of the efficient fuel switching opportunities under the Energy Conservation and Optimization Act;
- Work with members to identify and market new programs that improve awareness of energy consumption, increase the adoption of efficient end-use technologies where practical, and minimize rate impacts; and
- Further evaluate the efficiency opportunities within our members' service territories.

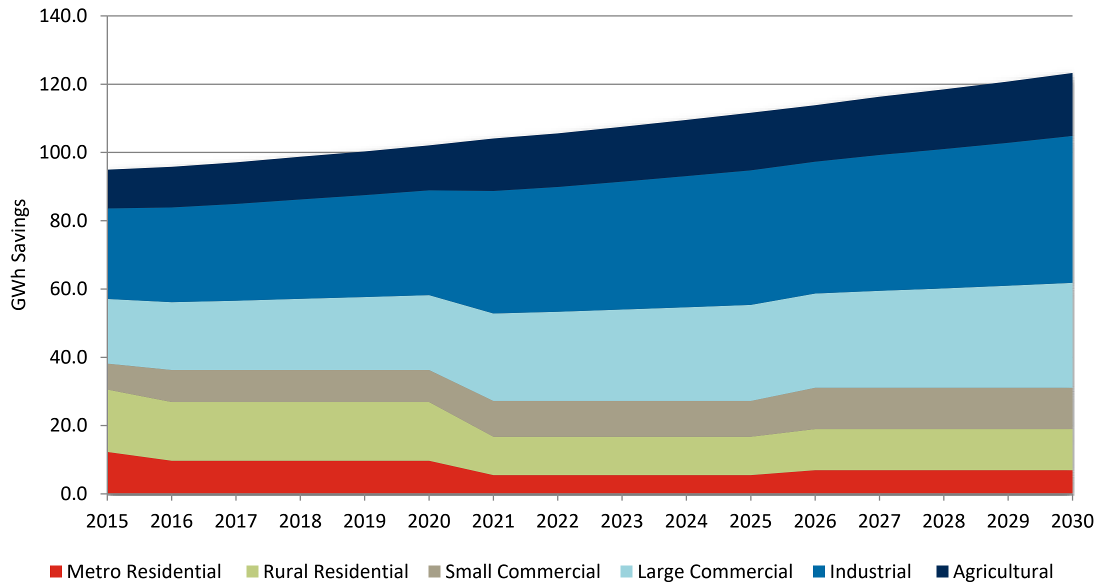
While GRE and its members are committed to achieving the energy-efficiency goals that have been established by the state of Minnesota, there are several challenges that could adversely affect the realization of these savings. Broadly speaking, these challenges fall into several categories:

- Rural, residential nature of GRE's service territory;
- Advancements in codes and standards, which limit both the number of opportunities and the incremental energy benefit associated with those opportunities;
- Market transformation of efficient technologies; and
- End users' investment appetites.

More than 80% of GRE members' end users are rural. Today, there are fewer residential energy savings opportunities due to continued improvements to building codes and appliance standards as well as limited new home construction. Additionally, nearly 80% of Minnesota residential cooperative members have income levels below the state average. This limits consumer investment in energy conservation.

A forecast of potential energy savings achievements by member end-use class is shown in Figure 25 below.

Figure 25 - Projected energy savings achievement by member class



Energy savings in the industrial class are expected to grow the most, while growth in the metro and rural residential classes are expected to decline.

GRE is committed to working with our members and their end users to build on their demonstrated past success in achieving energy efficiency savings. Our members will continue to strive to reach total savings and supply-side efficiencies equal to 1.5% of total retail energy sales. This will be accomplished by continuing energy savings equivalent to 1.0% through member-side activities, while obtaining 0.5% in supply side efficiencies throughout our members' and our systems.

GRE will continue to work with our members to identify the best means to improve efficiency in a manner that is consistent with the established delivery of programs that yields the most cost-effective results.

11 Renewable member resources

A provision in member-owners' power purchase contract (PPC) with GRE had allowed members to self-supply up to 5% of their energy needs with local renewable member resources (RMRs). This RMR Option has been in place without significant modification since the effective date of the 2008 PPC.

In early 2022, the AR members formed a committee to analyze and discuss possible updates to the RMR Option, including expanding the scope from 5% to 10%, providing additional flexibility in implementing the option, incorporating innovative applications of energy storage, encouraging resource aggregation, member renewable partnerships, leveraging economies of scale, and aligning pricing signals with Midcontinent Independent System Operator, Inc. (MISO) market.

As a result of the committee's analysis and discussions, GRE management, GRE Board, and AR members' general managers recommended that the RMR Option be updated to include the following provisions:

- Renewable member resources. RMRs must qualify as renewable generation under Minnesota law. An AR member's RMRs collectively can provide up to 10% (as opposed to the previous 5%) of the AR member's expected annual energy purchases from GRE. An RMR may incorporate a storage resource. RMRs may be aggregated and shared by more than one All-Requirements Member to enable market participation, optimize resource location and leverage economies of scale. RMRs may be eligible to export energy onto the transmission grid, in accordance with technical studies and limits, and MISO rules and may be eligible for compensation at energy market prices for the exported energy.

- Storage member resources. AR members may install storage member resources (SMR) up to 10% of their average hourly energy requirements from GRE. SMRs may be grid charged and/or charged by an RMR and may access a variety of MISO market value streams, including capacity, energy and ancillary markets. All SMRs, regardless of how they are charged, are treated as separate member resources and will have an ability to charge and discharge at MISO energy market prices.

- MISO participation. If an AR member determines that a member resource will participate in MISO, GRE will request the appropriate registration, accreditation, or other qualification and will serve as the MISO market participant for the member resource. The AR member will be responsible for the compliance of a member resource with all MISO requirements.

The proposed changes to the RMR Option necessitated an amendment to the GRE 2008 AR Power Purchase Contract (PPC). Per the terms of the PPC, the proposed amendment was approved by the GRE Board in January of 2023 and offered and accepted by each of the GRE's AR members in March of 2023. GRE is filing for RUS approval of the PPC amendment on March 30th. The new RMR option is expected to be effective by August 1, 2023.

12 Minnesota Administrative Rules for Integrated Resource Plans

Minnesota Administrative Rules 7843.0500 outline several factors for the Commission to consider in evaluating proposed resource plans:

Factors to consider. In issuing its findings of fact and conclusions, the Commission shall consider the characteristics of the available resource options and of the proposed plan as a whole. Resource options and resource plans must be evaluated on their ability to:

A. Maintain or improve the adequacy and reliability of utility service;

- Under the Preferred Plan, GRE's system growth is addressed by the addition of renewable resources and the continuation of our current, reliable generation portfolio.
- The Preferred Plan provides adequate capacity and energy to meet our members' requirements over the planning period.
- The Preferred Plan provides adequate capacity to comply with MISO's Resource Adequacy requirements, including MISO's Planning Reserve Margin, over the planning period.

- The Preferred Plan does not rely on MISO capacity auction to meet our members' needs.
- As a member of MISO, we have ongoing access to market energy in addition to our resource portfolio.
- We are actively engaged with MISO, other utilities, and stakeholders in planning and implementing regional and load-serving transmission upgrades and additions needed for reliable and economic operation of the electric system.

B. Keep the customers' bills and the utility's rates as low as practicable, given regulatory and other constraints;

- Our resource decisions are subject to the approval of our board of directors. In certain situations, resource decisions also require the approval of our members, as required under the power purchase contracts between GRE and its members. These approval processes ensure that resource decisions are in the best interest of the membership.
- We are committed to assisting our members in implementing conservation and energy efficiency to help their end-users make the most of the energy they use and to minimize the need for new supply-side resources. GRE and our members have met and will strive to continue to meet Minnesota's 1.5% Energy Savings Policy Goal.
- We use a capacity expansion optimization model that identifies a least cost plan in developing our Preferred Plan.
- The Preferred Plan results in lower revenue requirements than many other expansion plans considered.
- We have improved the utilization of our generation assets through efficiency improvements and commercialization of waste heat and other byproducts of generating electricity.
- We actively participate in MISO's energy markets and we pursue bilateral capacity transactions to minimize overall costs.
- Our Preferred Plan continues the utilization of our low cost and energy efficient generating facilities through the planning period.

C. Minimize adverse socioeconomic effects and adverse effects upon the environment;

- We are committed to assisting our members in implementing conservation and energy efficiency to help them and their customers make the most of the energy they use and to minimize the need for new supply-side resources.
- We plan to meet load growth with conservation and energy efficiency, renewable energy, and the market.
- We are supporting our members in their development of distributed energy resources.
- We are meeting Minnesota's Renewable Energy Standard and are on track to meet Minnesota's new 100% Carbon Free Standard.
- By 2035, GRE's retail electric sales will be 90% carbon-free and carbon emissions will be more than 90% reduced from 2005 base levels.

D. Enhance the utility's ability to respond to changes in the financial, social, and technological factors affecting its operations; and E. Limit the risk of adverse effects on the utility and its customers from financial, social, and technological factors that the utility cannot control.

- We have a diverse and reliable resource portfolio that includes conservation and demand response, renewable energy, hydro, natural gas, and coal of various sizes, locations, technology types, and contract terms.
- We have divested of CCS and entered into a PPA with Rainbow which provides a hedge to members as GRE transitions away from a historically coal-dependent cooperative. This transition has put the cooperative in a strong position that minimizes risk while preparing for additional future environmental regulations and market conditions.
- We have committed to developing and reviewing energy storage technologies that may act as a multi-day energy hedge and eliminate the need for future carbon-based energy or capacity resources.
- We have begun the process of converting Cambridge Unit 2 to dual-fuel operation; allowing for fuel oil operation when natural gas is uneconomic or unavailable.
- We have considered a range of sensitivities to identify a Preferred Plan that is robust in the face of a changing energy industry.
- We have ongoing access to MISO market energy in addition to the owned and contracted for resources in our Preferred Plan.
- We are operating Spiritwood Station, an efficient CHP facility, with the ability to generate electricity with 100% natural gas or Coal.
- We actively monitor the actions of the regulatory authorities, including the Commission, the Federal Energy Regulatory Commission, the North American Electric Reliability Corporation, the Midwest Reliability Organization, and others. We also participate in organizations and stakeholder groups that have an energy focus, including Electric Power Research Institute (EPRI), National Rural Electric Cooperative Association (NRECA), Minnesota Rural Electric Association (MREA), and others to monitor and anticipate developments that may impact us.
- We are fully engaging with our members in grid modernization initiatives, including pilot programs and data analysis.

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Appendix H – Potential Resources