Schedule MR-2

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MISSOURI INTERSTATE TRANSMISSION NEED

THE PUBLIC BENEFIT OF GRAIN BELT EXPRESS

August 2022

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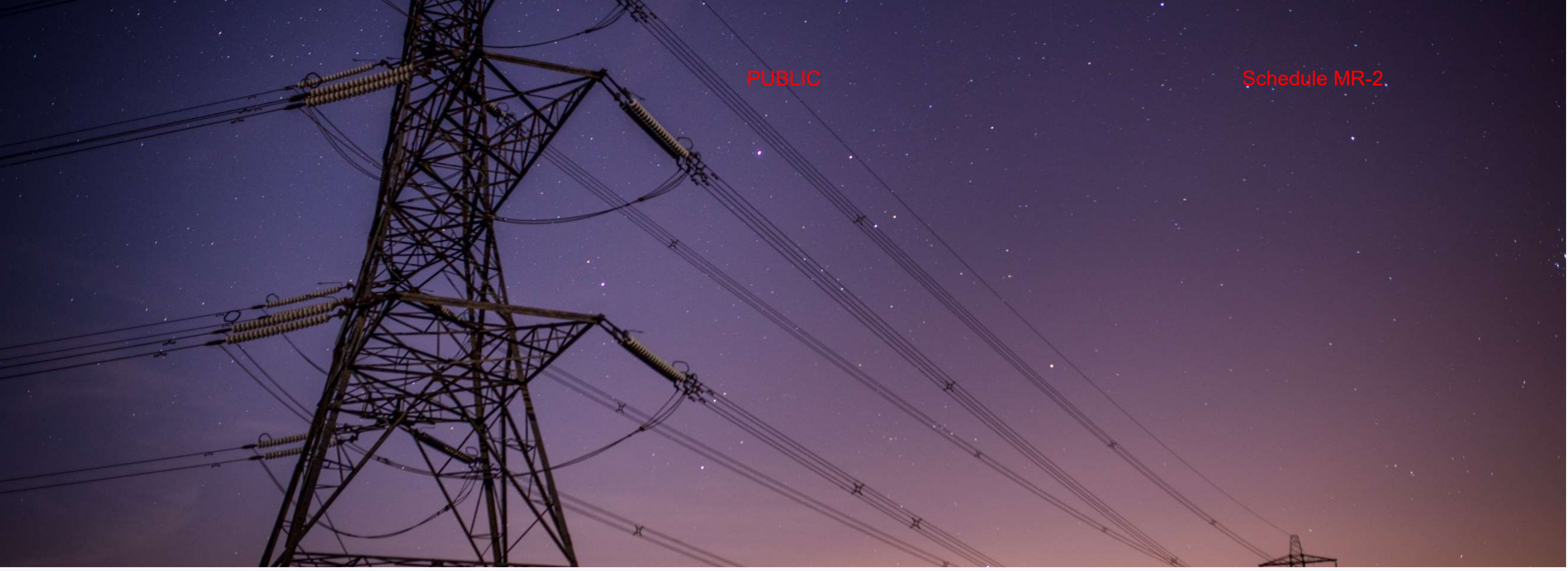
Executive Summary

The highly efficient Grain Belt Express High Voltage Direct Current (HVDC) line and associated renewable generation (collectively referred to as "Grain Belt Express" or "GBX") are projected to create significant cost savings and co-benefits for Missouri residents. PA conducted a market analysis and estimated the ratepayer and emissions impacts under two cases: (i) the "Status Quo Case" in which GBX can deliver 500 MW to the Maywood – Spencer substation in Missouri (part of the MISO wholesale power market), and (ii) an "Expanded GBX Case" in which a larger GBX configuration is able to deliver approximately 5,000 MW, both to GBX's Missouri points of interconnection as well as into the PJM wholesale power market. Specifically, under the Expanded GBX Case, dedicated, *new* solar and wind resources from western Kansas would be transmitted to the (i) Ameren Missouri (AMMO) service territory in Missouri (1,500 MW); (ii) Associated Electric Cooperative (AECI) service territory in Missouri (1,018 MW); and (iii) American Electric Power Indiana (AEP-Indiana) service territory in Indiana (2,500 MW).

Transmitting GBX's dedicated low-cost solar and wind resources into the Midwest and adjacent service territories is expected to ***reduce energy and capacity costs in Missouri by over $17.6 billion in the 2027-66 period. Over this same period, Grain Belt Express is projected to reduce emissions of CO_2, SO_2, and NOx in Missouri by 9.3%, 19.2%, and 17.2%, respectively, enhancing local utilities' abilities to meet their climate and reliability goals while also delivering immediate local air quality and health benefits.*** These benefits are particularly salient to environmental justice communities who have historically faced disproportionate harm from pollution – GBX's delivery of clean energy to the region enables more swift righting of this injustice. Additionally, GBX could be a potentially important solution for regional utilities to meet net-zero emissions targets, such as those targeted by Ameren. Quantifying these emissions benefits to the State, ***the Expanded GBX Case offers Missouri over $7.6 billion in social benefits from 2027-66, in addition to the over $17.6 billion in savings in the energy and capacity costs over this same period – bringing the total cumulative benefit to nearly $25.3 billion by 2066***.



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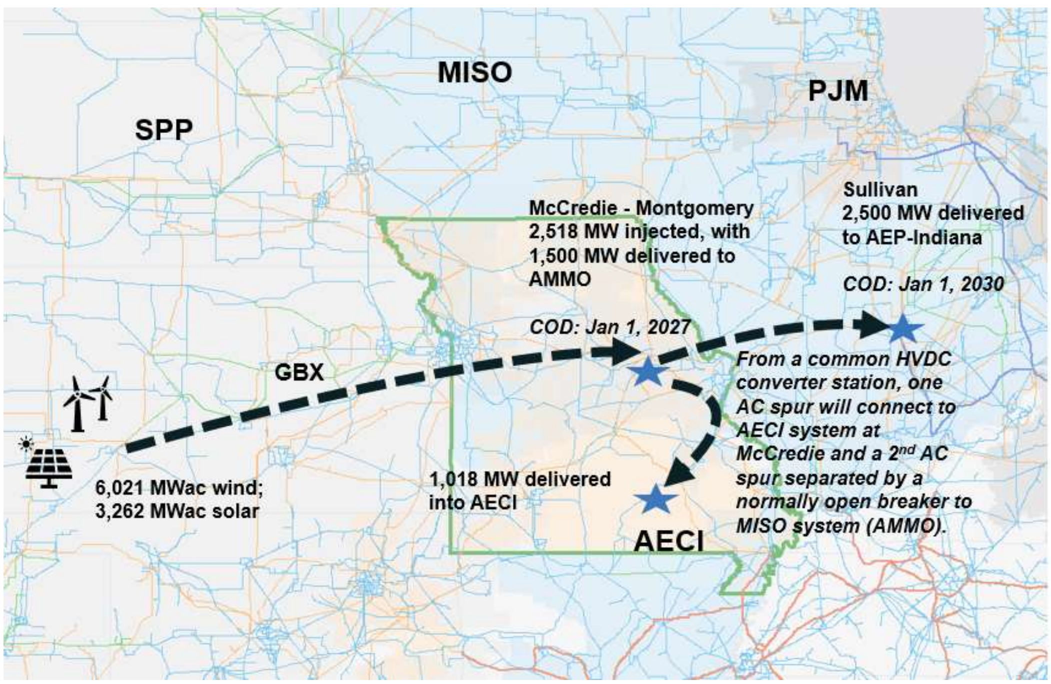
1 Introduction

What is Grain Belt Express?

Grain Belt Express is a proposed highly efficient HVDC transmission line that can directly deliver 5,000 MW of dedicated clean energy from exceptionally strong *new* wind and solar resources in Sunflower Electric Power Corporation's service territory in western Kansas to customers in the AMMO (Missouri), AECI (Missouri), and AEP (Indiana) service territories. The AMMO service territory is part of the broader MISO (Midcontinent Independent System Operator) wholesale power market operating across 15 Midwestern US states and Manitoba. The AEP-Indiana service territory is part of the broader PJM wholesale power market operating across 13 U.S. states and the District of Columbia. Service territories in the State of Missouri include the MISO and SPP wholesale power markets (as well as a small piece of the SERC electricity region), and energy directly delivered to one area of these wholesale power markets can have broader impacts on power prices throughout the region given the interconnected nature of the transmission grid in the Eastern Interconnection.

The following analysis quantifies the benefits to Missouri of Grain Belt Express, with its configuration illustrated in Figure 1-1.

Figure 1-1: Grain Belt Express "Expanded GBX Case" Configuration



How will Grain Belt Express impact Missouri residents?

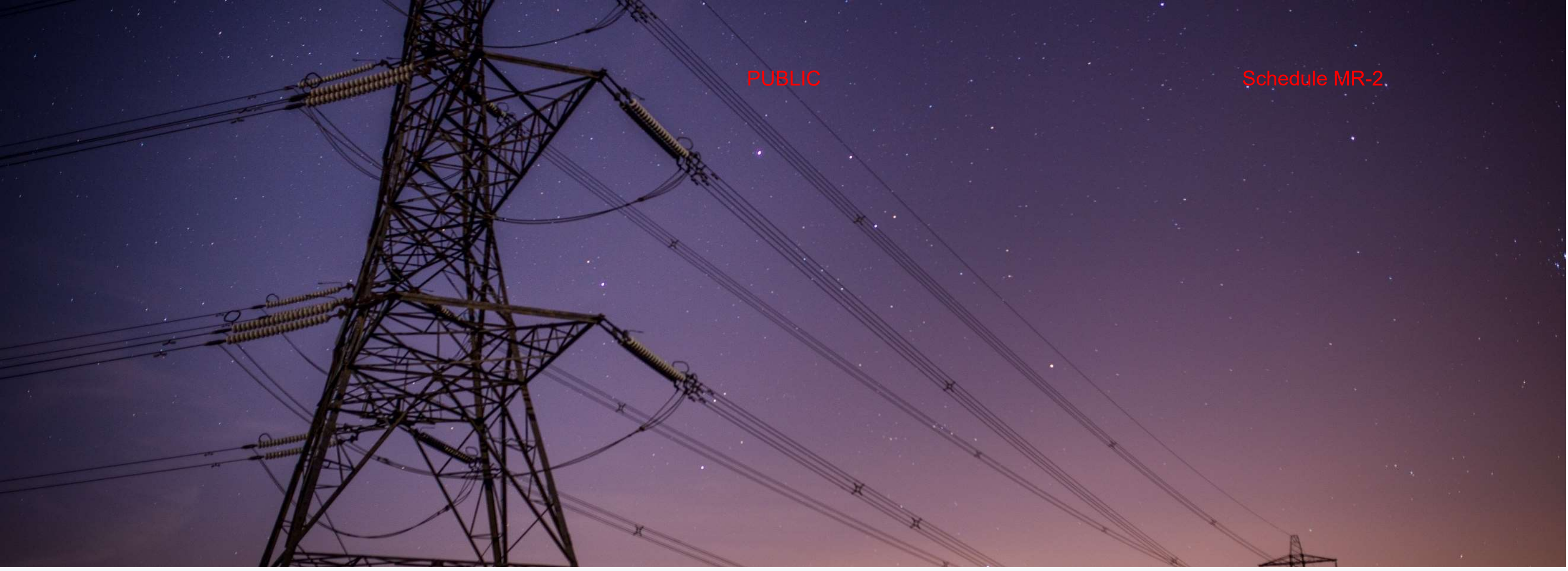
PA conducted a forward-looking, long-term analysis that assessed (i) the wholesale (energy and capacity) market impacts of the addition of the Expanded GBX Case configuration (shown in Figure 1-1); and (ii) how the addition of this configuration would enable emissions reductions within the State. GBX's primary advantages are:

- Comparatively stronger dedicated clean solar and wind resources in western Kansas (vis-à-vis relatively lower quality renewable resources in service territories such as Missouri and Indiana) are transmitted directly via efficient, controllable HVDC technology to MISO, SPP, PJM, and SERC AECI service territories, lowering energy costs in states including Missouri;
- Dedicated solar and wind resources transmitted via GBX displace more emissions-intensive generation in the Midwest – including the State of Missouri – helping local utilities achieve their decarbonization goals; and
- GBX increases the geographic diversity of renewable resources feeding the Eastern Interconnection via an HVDC line that can be controlled by MISO and SPP system operators, all else equal increasing the reliability and resiliency of a grid becoming more intermittent as it quickly decarbonizes.

Specifically, PA's analysis finds that GBX would:

- Collectively lower energy and capacity costs in Missouri by approximately 6.1% (over $17.6 billion, on an undiscounted basis) over the 2027-66 period;

- Reduce 2027-66 emissions of CO_2, SO_2, and NOx in Missouri by 9.3%, 19.2%, and 17.2%, respectively, enhancing local utilities' abilities to meet their climate and reliability goals while also delivering local air quality and health benefits; and
- Offers Missouri over $7.6 billion in social benefits from avoided emissions in the 2027-66 period, in addition to the over $17.6 billion in savings in the energy and capacity markets over this same period – bringing the total cumulative benefit to nearly $25.3 billion by 2066.

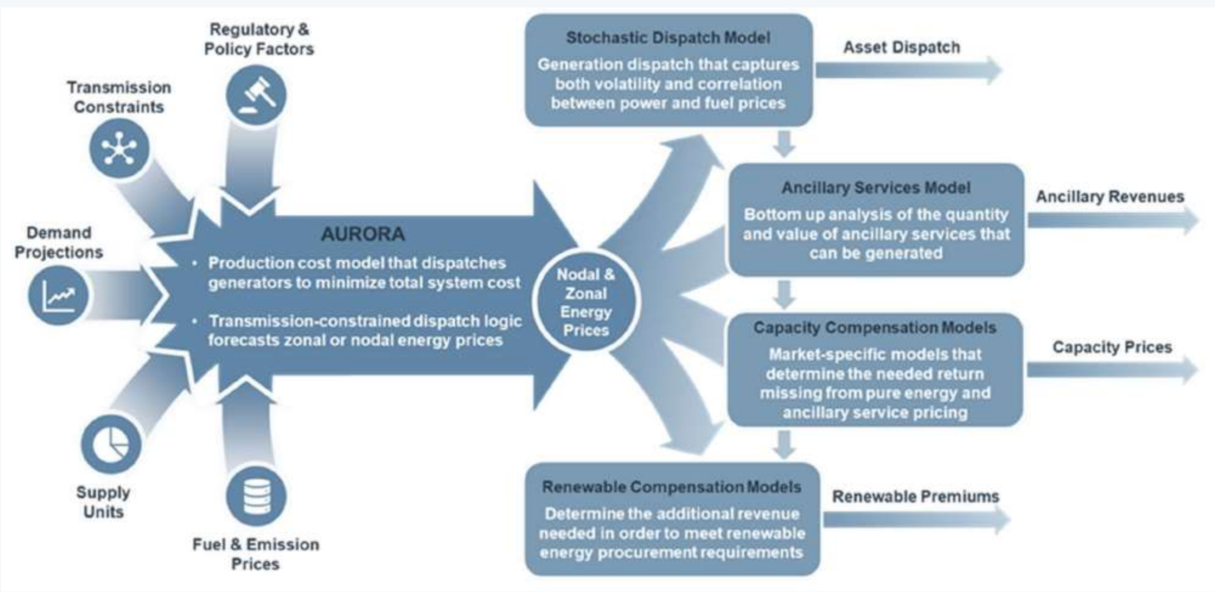


2 Methodological Overview

2.1 Wholesale Market Modeling Methodology

To evaluate the potential impacts of GBX, PA used its proprietary electricity market modeling process. The core of PA's modeling process uses an industry standard chronological dispatch simulation model (Aurora[1]) to simulate the hourly operations of the Eastern Interconnection, which includes (among others) SPP, MISO, PJM and SERC, through 2041.[2] Aurora is widely used by electric utilities, power market regulators, independent system operators, and other market consultants. This model enables PA to project hourly power prices, energy flows, the development of new power plants, and the operating profiles of the power plants and transmission lines within a given system; in this case, SPP, MISO, PJM and SERC as part of the larger Eastern Interconnection. PA's analysis included the use of Aurora in both zonal and nodal configurations.

Figure 2-1: PA's Modeling Approach



To forecast the long-term wholesale natural gas prices that are used in Aurora, PA uses the GPCM® Natural Gas Market Forecasting System™ (GPCM). GPCM models natural gas production, existing pipeline flows and constraints, new pipeline construction, and natural gas demand from the power sector and residential, commercial, and industrial sectors for the entire United States. PA used GPCM to develop a long-term forecast of both Henry Hub natural gas prices and

[1] Licensed to PA by Energy Exemplar.

[2] PA's fundamental models typically extend-out to 20-years from the current date. Results beyond 2041 are based on simplified trending approaches.

the prices of regional natural gas pricing hubs applicable to the project regions. GPCM is used across the energy industry, including by government agencies such as the Federal Energy Regulatory Commission (FERC) and the Canadian National Energy Board (NEB), as well as independent system operators such as MISO.

2.2 Project-specific Market Modeling Methodology

PA modeled the Eastern Interconnection under two scenarios. This includes a scenario with the full ~5,000 MW GBX HVDC line constructed as illustrated in Figure 1-1 (the "Expanded GBX Case") as well as a status quo scenario with only the currently permitted 500 MW of delivery into the AMMO service territory (the "Status Quo Case"). The scenarios are built utilizing PA's proprietary base case market assumptions, with the exception of nationwide carbon pricing.[3] For the purposes of this analysis, PA assumed that a national carbon pricing regime would be implemented in 2026. The carbon price is set at $24.55/short ton in 2026 (nominal dollars) and increases at 2.2% per year, tracking inflation throughout the study period.[4]

In order to ensure "firm" delivery of renewables in all hours – and limit issues associated with intermittency – the dedicated solar and wind resources in western Kansas will be "oversized" (i.e., totalling approximately 9,300 MW, under the Expanded GBX Case) relative to GBX's HVDC capacity (i.e., approximately 5,000 MW under the Expanded GBX Case).[5] For the first ten years of operations, PA modeled GBX using a "solar curtailment first" priority scheme. More specifically, in order to preserve the benefits associated with the Production Tax Credits (PTC) that the dedicated wind resource is expected to be eligible for, PA's analysis preferentially allowed for solar generation to be curtailed first (instead of wind) during hours when the combined dedicated renewables output exceeded the HVDC's line's total capacity.[6]

In order to isolate the wholesale market impacts from the Expanded GBX Case, PA held all other assumptions constant between the two Cases. Importantly, PA's analysis does not alter future resource planning decisions between the two Cases. For example, while the addition of GBX could facilitate the additional future retirement of legacy thermal resources within the studied regions, such potential incremental retirements were not considered to ensure that changes in market dynamics could be attributed to GBX and not the impacts of other resource changes.

2.3 Energy, Capacity, and Emissions Savings Calculations

Feeding the assumptions from Section 2.2 above into the Aurora wholesale modeling described in Section 2.1 (coupled with PA's proprietary capacity compensation modeling) allows the calculation of wholesale pricing and emissions outcomes in both Cases. These results are translated from a "transmission zone" wholesale pricing basis (mapped to the corresponding ISO/RTO) to a "State-level" cost to load basis using the methodology described below.

First, PA identified the relevant transmission zones within the State (specifically, SPP KCPL, SPP Empire District Electric, SPP City of Independence, SPP City of Springfield, MISO Zone 5, and SERC AECI). Next, PA allocated the share of the State's total energy demand to each of these zones, based on forecasted energy demand outcomes in each of these zones.[7] Then, PA determined a proxy Missouri energy price, based on projected zonal prices and the shares of each of the zones that constitute the State. Further, these prices were adjusted to be reported on a "load-weighted" basis, by accounting for when load occurs, as well as where on the system load is projected to be more (or less) concentrated, versus price impacts at these various locations, which was informed by PA's nodal analysis. Finally, PA applied these load-weighted State-level prices to the energy demand outlook for Missouri (represented as a summation across its underlying transmission zones) to derive a view of Missouri energy costs to load.

Capacity costs for Missouri were calculated in a somewhat similar fashion. First, PA derived a forecast of peak demand for the State using the average Missouri energy demand (calculated from underlying transmission zone forecasts), and

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[3] The assumption of a carbon pricing regime is a relatively common practice in utility (e.g., Ameren in their IRP) and ISO (e.g., MISO in their LRTP) planning processes. Carbon pricing can be reflected as a broad 'shadow cost' within fundamental market models to satisfy regulatory dictates, and it being used as a modeling variable is not necessarily tied to/dependent on actual legislative outcomes at the federal level.

[4] PA's federal carbon price assumptions are broadly representative of values commonly utilized in utility resource planning and regulatory processes in the region. The use of an alternative carbon price assumption (either higher or lower) will still result in directionally consistent outcomes (i.e., ratepayer savings), albeit with differences in specific benefits values.

[5] In addition to energy impacts, PA – in consultation with GBX LLC – assumes that this "oversizing" will present the opportunity for GBX to firm its reliability-weighted capacity to ensure full deliverability of its capacity rights (for PJM: 2,000 MW under the Expanded GBX Case; for MISO: 500 MW under the Status Quo Case and 1,440 MW under the Expanded GBX Case). This approach was adopted primarily due to the lack of market rules/guidance surrounding the capacity accreditation for a unique resource such as GBX, due to factors such as its resources (i) being "quasi-firm" (i.e., the resources are oversized relative to the line); and (ii) having complementary diurnal and seasonal wind and solar generation profiles, etc.

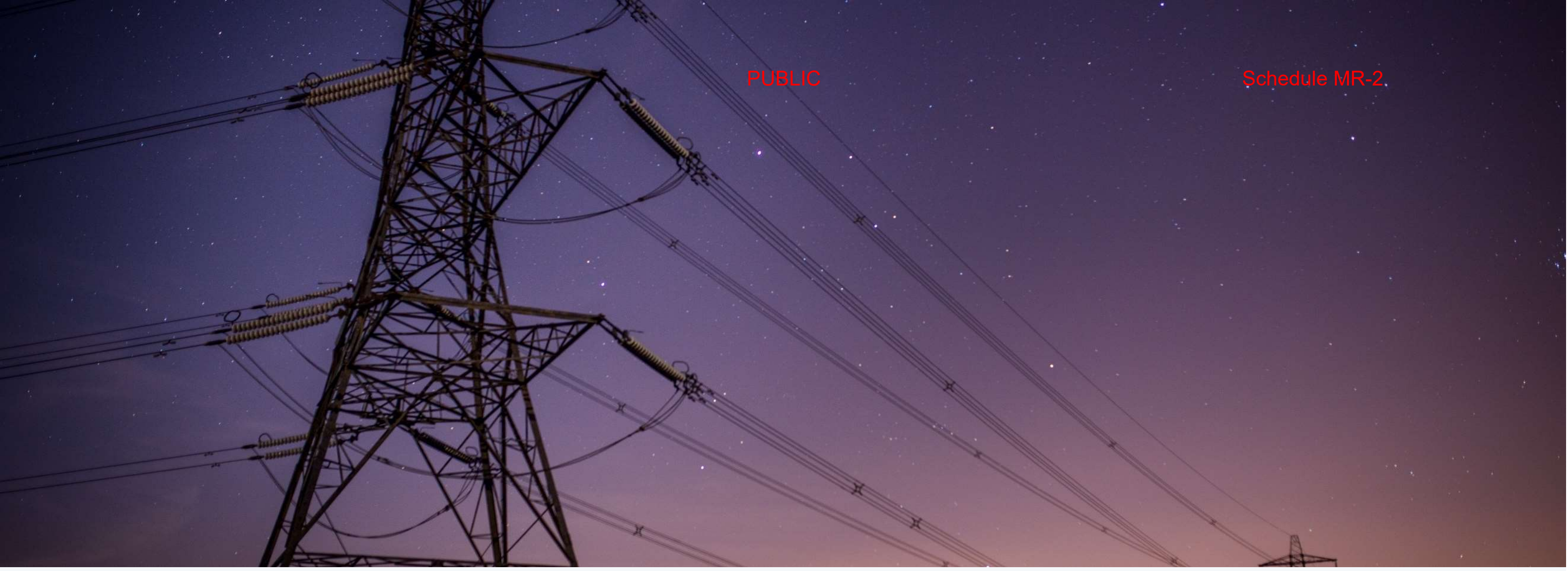
[6] Note that the expected 8,760 patterns of GBX's associated facilities equate to an approximate 47% (pre-curtailment) around-the-clock capacity factor for wind, and 30% for solar.

[7] Energy demand for MISO Zone 5 is based on the 2022 MISO LOLE report, while that for SPP is taken from the 2021 NERC ES&D, and AECI is based on the FERC 714 filing.

a projected load factor. Since capacity requirements in each of the MISO and SPP markets require load-serving entities to cover both peak load and reserve requirements, PA adjusted the peak demand for Missouri upward to include a load-weighted-average reserve requirement based on the reserve requirements in each of the SPP and MISO markets and their respective load shares in Missouri. PA also used the shares of MO demand that are attributable to SPP versus MISO, to derive a weighted-average State-wide capacity price, based on the underlying forecast of SPP and MISO capacity prices.[8] Finally, the projected state peak demand, plus additional reserve requirement, was applied to the State-wide capacity price, to infer the Missouri capacity costs to load.

The aforementioned processes were applied to both Cases, and the differences between the two yielded savings to Missouri residents due to GBX. These benefits are described in detail in the following sections.

[8] Note that PA ascribed SPP capacity prices to the AECI region as a proxy.



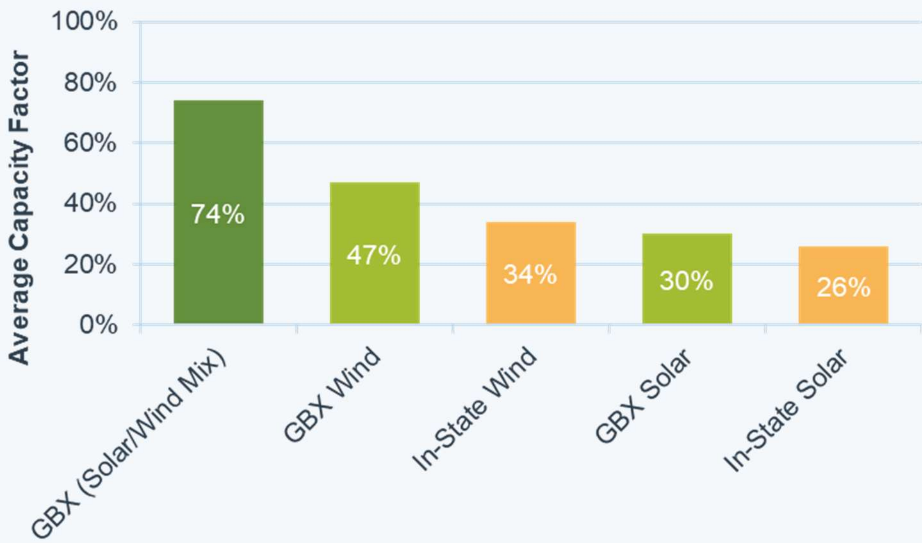
3 Ratepayer Impacts

The Expanded GBX Case is projected to lower wholesale energy pricing for Missouri customers in two ways. First, low-cost, high-capacity factor renewable generation is projected to put downward pressure on power pricing within the MISO and SPP wholesale power markets, particularly during the evening peak when the capacity factor of dedicated renewable resources transmitted via GBX is significantly stronger than a typical Midwestern (including Missouri) solar or wind profile (see Figure 3-1). Second, incremental reliability-weighted capacity via GBX will tend to increase available supply in the MISO power market, putting downward pressure on capacity prices in several years, all else equal. Together, these impacts reduce costs to ratepayers across the State of Missouri.

3.1 GBX versus In-State Resource Comparison

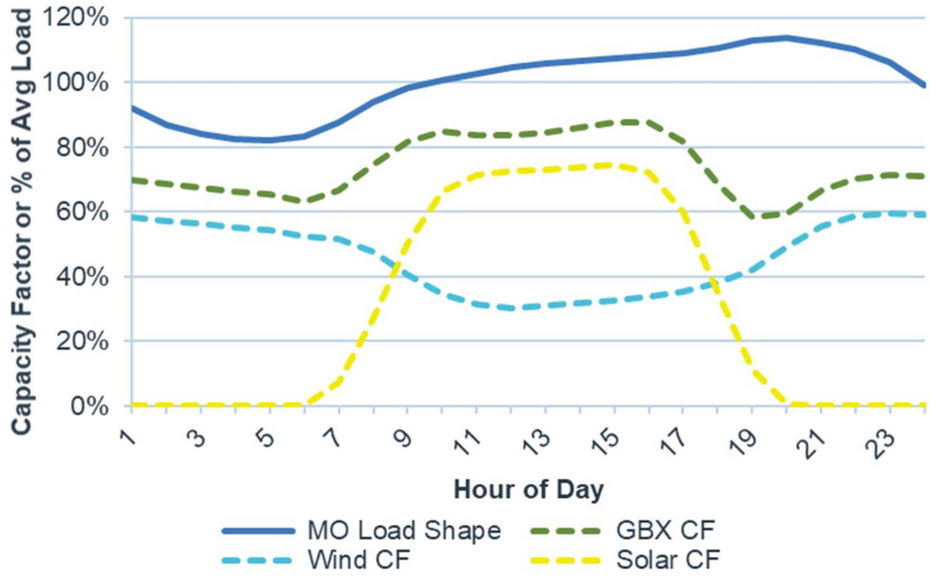
As shown in Figure 3-1 below, the renewable resources delivered by GBX have considerably higher capacity factors than typical Midwestern (including Missouri) resources – particularly when the complementary production profiles (see Figure 3-2) of these wind and solar assets are collectively transmitted over GBX. GBX's average all-hours capacity factor of 74% is even more notable considering that this value is "post-clipping" – i.e., the GBX renewables are oversized relative to the line, and therefore there are times (e.g., April afternoons) during which the renewable overproduction must be curtailed ("clipped") and GBX is at 100% utilization.

Figure 3-1: Average All-Hours Capacity Factors[9]



[9] GBX line capacity factors are net of clipped renewable production owing to over-generation from GBX Wind and GBX Solar resources in some hours.

Figure 3-2: GBX Capacity Factor (CF) vs. MO Load Shape



3.2 Energy Price Impacts

Given the interconnected nature of the electricity grid, incremental clean energy injected under the Expanded GBX Case results in reduced around-the-clock (ATC) zonal power prices in MISO Zone 5 (northern and eastern MO), SPP Zones, (western and southern MO), and SERC AECI (MO-wide). Low-cost energy from GBX displaces higher cost power from inefficient generators at the top of the dispatch stack in SPP, MISO, and SERC. From 2027-41, GBX reduces ATC annual power prices by an average of 2.7% in MISO Zone 5, 1.1% in SPP South[10], and 4.1% in SERC AECI, thereby saving State residents electricity costs. As noted in Section 3.4 below, these benefits are further accentuated on a load-weighted basis.[11]

3.3 Capacity Price Impacts[12]

Capacity price impacts depend largely on two competing factors:

1. Injecting cheap, clean power into a zone lowers energy prices and therefore spark spreads, all else equal. This in turn reduces power plants' earnings in the energy market. Capacity markets are intended to provide critical generators that are needed for reliability their "missing money" – in other words, the compensation generators need to remain online (beyond what they earn in the energy market). Capacity prices therefore typically rise (all else equal) when energy prices fall, because generators are now faced with a greater missing money need to be incentivized to remain online.
2. Adding additional capacity into a zone (such as injection via GBX) raises the zone's "reserve margin," a measure of reliability-rated generation capacity versus expected peak load. All else equal, adding additional capacity (thereby increasing reserve margins) lowers capacity prices, as the available "supply" of capacity is now greater relative to the expected "demand".

As shown in Figure 3-3, these competing factors cause capacity pricing outcomes between the two Cases to exhibit different effects over time. For example, Expanded GBX Case capacity pricing in MISO Zone 5 is lower in the late 2020s to mid-2030s because the effect of additional capacity on the Zone is greater than the effect of reduced energy prices in the Zone. In the long term, however, Expanded GBX Case pricing is higher when the effect of lowered spark spreads dominates (a trend also germane to SPP pricing outcomes).

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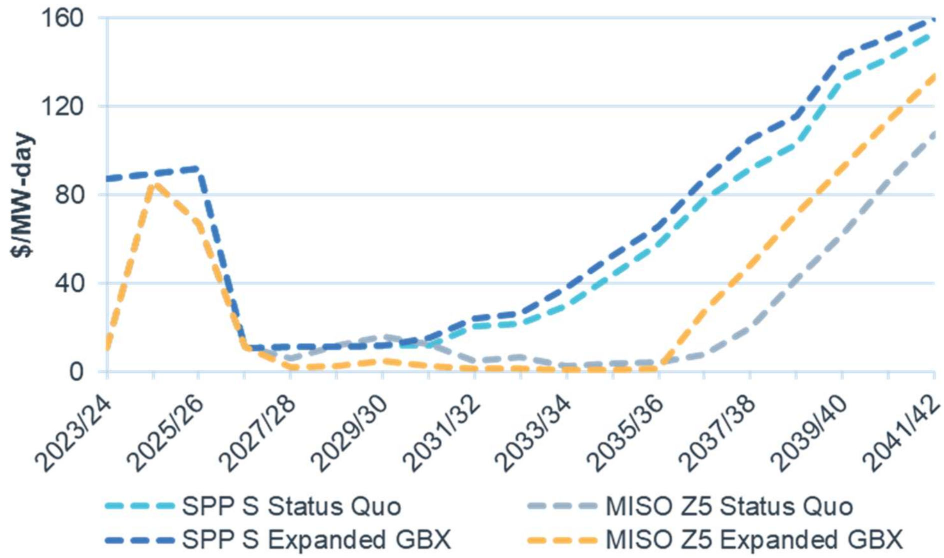
[10] SPP South is a liquid hub that is broadly indicative of regional power price outcomes.

[11] Note that power prices referenced here are based on short-run marginal costs/market clearing prices (that reflect the variable dispatch costs of the price-setting generator in any given time-period). These do not, however, factor-in any ancillary services or uplift components, both of which would likely not see meaningful deviations between the two Cases described herein.

[12] PA does not assume any major changes to capacity market designs/constructs (e.g., RMR contracts, resource-specific procurement, etc.) over the study period when calculating capacity price impacts. This is a conservative assumption as market construct evolution may be necessary over time to adequately compensate resources for reliability and resiliency benefits in a quickly decarbonizing grid.

Figure 3-3: Projected Capacity Prices in Missouri

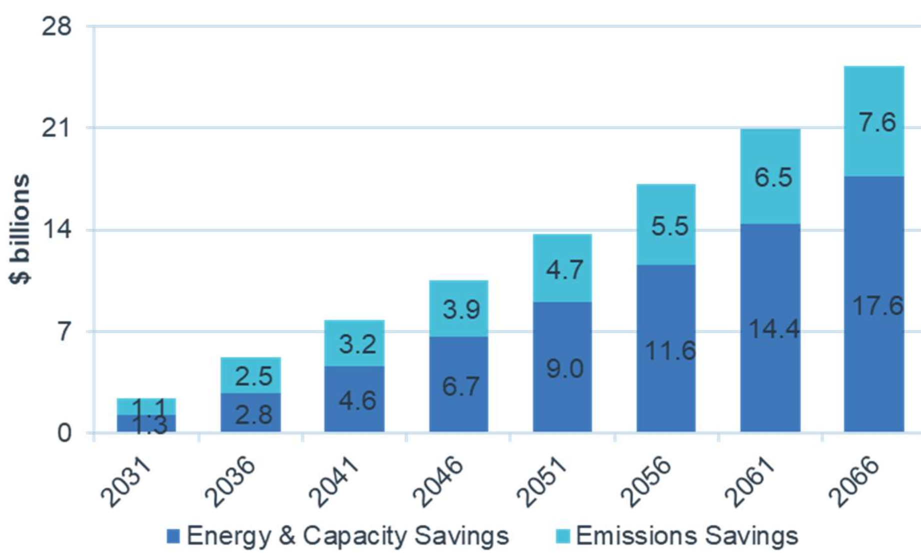


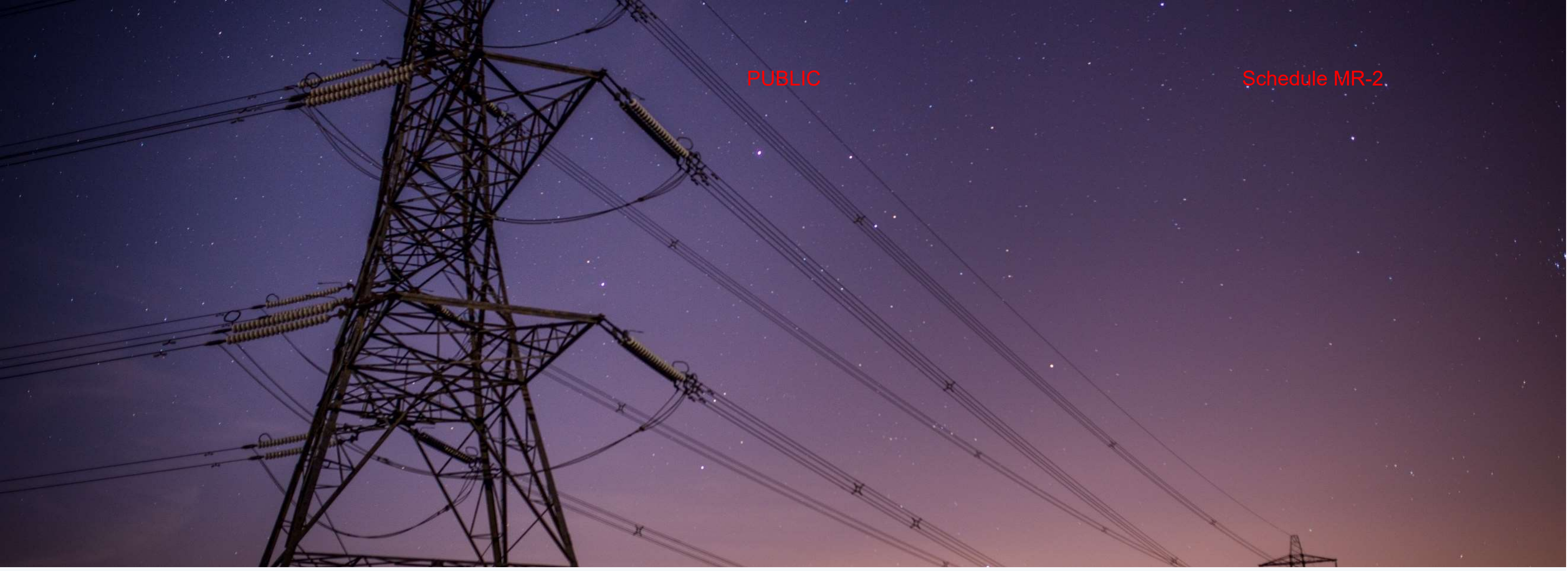
3.4 Ratepayer Impacts

In the Expanded GBX Case, the inclusion of the line and its associated renewables would result in total energy and capacity expenditures for Missouri residents that are over $17.6 billion lower (~6.1%) from 2027-66.

As discussed in detail in Section 4.1, GBX provides additional social benefits in the form of reduced emissions. In order to financially quantify the many benefits of these emissions reductions (health, environmental, etc.) to the State of Missouri, PA applied a social cost of carbon (SCC) to the CO_2 emissions reductions (appropriate financial benefit rates were also applied to SO_2 and NO_x emissions reductions). As shown in Figure 3-4 (and in Table 4-1 in Section 4.1), ***the Expanded GBX Case offers the State over $7.6 billion in social benefits from 2027-66, in addition to the over $17.6 billion in savings in the energy and capacity markets – bringing the total cumulative benefit to nearly $25.3 billion by 2066***.

Figure 3-4: Projected Cumulative Savings for Missouri due to GBX





4 Additional Benefits of GBX

In addition to savings in the energy and capacity markets, GBX delivers substantial additional benefits to Missouri residents in the form of emissions reductions, environmental justice, and enhanced grid resilience. These benefits are particularly relevant in light of utility decarbonization commitments, such as Ameren's targets of 60% carbon emissions reductions by 2030, 85% by 2040, and net-zero by 2045 (all versus 2005 levels).

4.1 Emissions Reductions and Environmental Justice

The Expanded GBX Case offers substantial emissions reductions within the State of Missouri, reducing emissions of CO_2, SO_2, and NOx in Missouri by 9.3%, 19.2%, and 17.2%, respectively over the 2027-66 period. For comparison, in-State CO_2 emissions savings facilitated in the Expanded GBX Case from 2027-66 are approximately equivalent to removing over 13 million gasoline cars from Missouri roads for one year.[13]

As shown in Table 4-1, the Expanded GBX Case facilitates nearly 67 million tons of emissions reductions within (or attributable to) the State from 2027-66. However, due to the regional nature of power grids (and the global nature of the CO_2 issue), these Missouri-only benefits do not tell the entire story. Over the 2027-66 period, CO_2 emissions reductions in the broader MISO, SPP, and PJM regions (excluding Missouri) due to GBX are nearly 369 million tons (over 5 times the reductions attributable to Missouri alone).

Figure 4-1: Cumulative Regional CO2 Savings due to GBX

[13] Calculated from https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.

While CO_2 emissions are a global issue, GBX also significantly reduces emissions of SO_2 and NOx criteria pollutants, providing even more tangible benefits to Missouri residents in the form of reduced air pollution (and therefore reduced respiratory illness and distress, saving lives and healthcare costs). This benefit is particularly salient in light of the historically disproportionate impacts of air pollution on disadvantaged communities. By effectively injecting clean power into the Midwest, GBX reduces the region's reliance on fossil generators and considerably improves local air quality and human health.

Table 4-1: Emissions Reductions and Savings in Missouri due to GBX

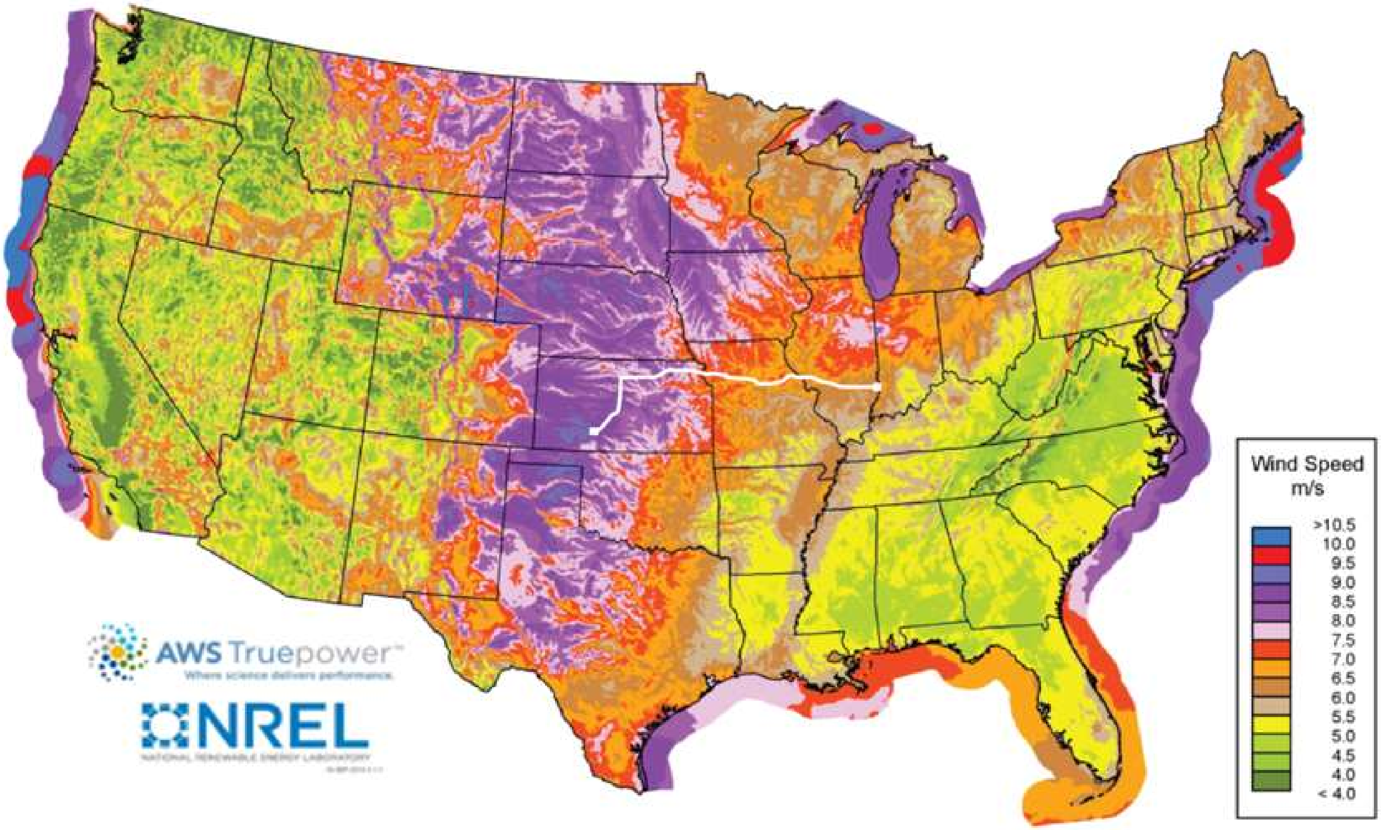
Period	CO_2 Savings (tons)	SO_2 Savings (tons)	NOx Savings (tons)	Total Emissions Savings ($ millions)
2027-31	15,759,239	24,595	17,582	1,120
2032-36	15,161,874	22,108	10,659	1,347
2037-41	6,779,412	3,938	2,360	713
2042-46	5,840,695	3,059	2,123	705
2047-51	5,840,695	3,059	2,123	786
2052-56	5,840,695	3,059	2,123	877
2057-61	5,840,695	3,059	2,123	977
2061-66	5,840,695	3,059	2,123	1,090
Total	**66,904,001**	**65,936**	**41,214**	**7,614**

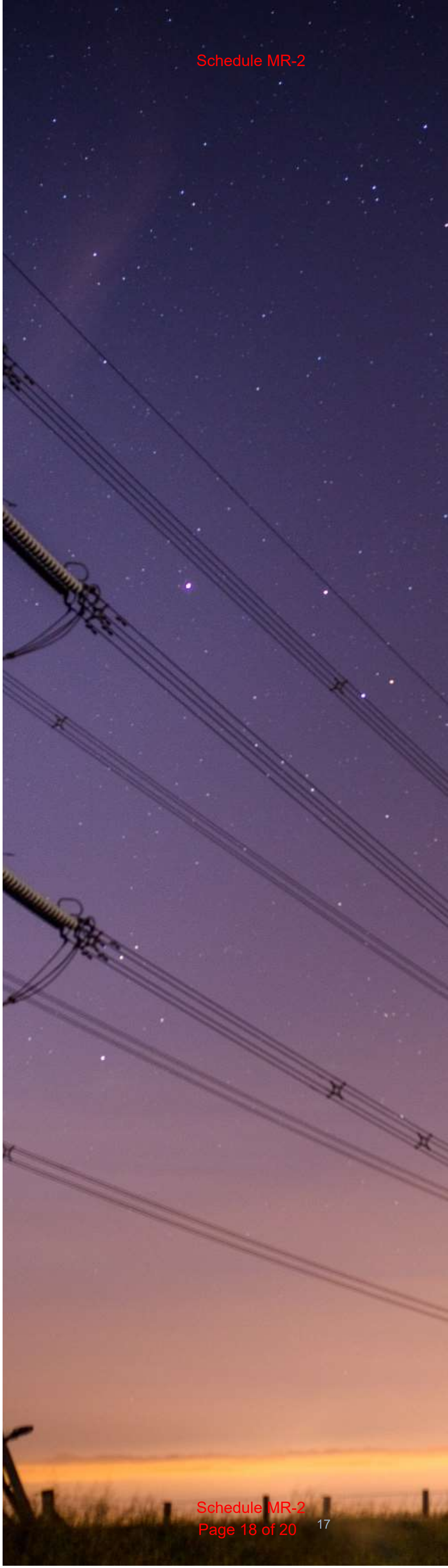
In order to financially quantify the benefits of these emissions reductions to the State of Missouri, PA applied a social cost of carbon (SCC) to the CO_2 emissions reductions (appropriate financial benefit rates were also applied to SO_2 and NO_x emissions reductions). As shown in Table 4-1 (and in Figure 3-4 in Section 3.4), the Expanded GBX Case offers the State over $7.6 billion in potential social benefits from 2027-66 (that would be in addition to the direct cost savings in the energy and capacity markets quantified in Section 3.4).

4.2 Enhanced Grid Reliability and Resilience

All else equal, adding transmission capacity to the power grid improves reliability by creating more numerous and robust energy pathways from sources to loads, allowing more economic flow as well as having more capacity available in the case of transmission and/or generator outages. This is true of both AC and DC transmission lines. HVDC lines (like GBX) in particular are considerably more efficient in transporting energy over long distances and can be controlled by system operators to improve system stability. Transmission lines that enable inter-regional transfer capability are especially useful, particularly in increasingly decarbonized grids, as they allow access to a greater diversity of resources. This diversity of resources can be both temporal (crossing time zones, which is especially helpful to meet peak hour demand) as well as spatial – different generation sources are built in different locations due to a variety of factors including proximity to load, siting and land availability, and resource quality. For example, as shown in Figure 4-2 below, GBX gives the Midwest access to very high capacity factor wind generation in Kansas, which is especially useful during evening peak hours (when demand and wind generation are strong, but solar generation is receding for the day). Additionally, the complementarity in diurnal production profiles of the solar and wind facilities feeding GBX further enhances resource diversification and supports grid resilience.

Figure 4-2: GBX Unlocks One of America's Strongest Wind Resources





APPENDICES

Appendix: Results

Placeholder Heading

[PA to determine which – if any – results and/or additional materials could be useful to include in an Appendix]

Figure A-1: Placeholder

Table A-1: Placeholder

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