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INTRODUCING THE SOCIAL COST OF BLACKOUTS

A Pragmatic Guide for Policymakers

Isaac Orr and Mitch Rolling
Always On Energy Research

Balancing climate ambition with the real costs of unreliable power.

This report makes the case for integrating the Social Cost of Blackouts into regulatory impact analyses to ensure that policymakers account for the full set of real-world costs and benefits—protecting reliability, economic prosperity, and human welfare.

Blackouts impose massive economic and human costs.

Reliability is under pressure as policy and resource choices evolve.

A complete cost-benefit framework requires both the Social Cost of Carbon and the Social Cost of Blackouts.

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POLICY RECOMMENDATIONS

- The U.S. Environmental Protection Agency (EPA) and other federal regulatory agencies should be required to use the Social Cost of Blackouts as part of the cost-benefit analyses conducted in their rulemakings to estimate the economic and human costs of blackouts resulting from their proposed regulations and policies.
- To model the Social Cost of Blackouts, the EPA and other federal regulatory agencies must first be required to analyze the hourly reliability of proposed rulemakings and regulations to diagnose years with blackout events.
- EPA must be required to coordinate with the Federal Energy Regulatory Commission (FERC) and the U.S. Department of Energy (DOE) to assess the reliability threat that proposed rules may have on the reliability of the grid.
- The U.S. Energy Information Administration (EIA) should consider incorporating questions related to the cost of damage experienced by industrial, commercial, and residential sectors in its annual surveys.[1]

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[1] Archana Ghodeswar et al., "Quantifying the Economic Costs of Power Outages Owing to Extreme Events: A Systematic Review," *Renewable and Sustainable Energy Reviews,* October 2024, https://www.sciencedirect.com/science/article/abs/pii/S136403212400710X.

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INTRODUCTION

Recent blackouts in Spain, Texas, and California illustrate the significant economic and human consequences of electricity outages, including billions of dollars in economic damages, lost productivity, food spoilage, and, in the most tragic circumstances, the loss of human lives.

Federal regulatory bodies, such as the U.S. Environmental Protection Agency (EPA) and state utility regulators, routinely employ externality cost estimates for carbon dioxide and other greenhouse gases (GHGs) using a metric called the Social Cost of Carbon (SCC)—a forward-looking estimate of the economic damages caused by each incremental ton of GHGs emitted—in cost-benefit analyses for the regulations they promulgate or in the integrated resource plans (IRPs) they evaluate.

However, despite the well-known harms of blackouts, these bodies do not employ an equivalent forward-looking Social Cost of Blackouts (SCB) metric to quantify the negative economic, human health, and environmental costs of power outages resulting from the regulations they enact or the IRPs they approve.

This unbalanced focus on emissions-related externalities, while failing to account for the externalities of blackouts, has led to declining reserve margins across the country as regulations and IRPs have favored intermittent wind and solar resources over dispatchable generators, leaving the American electric grid less prepared to handle electricity load growth and increasingly at risk of rolling blackouts.

> This report examines how blackouts affect economic and human welfare, provides a snapshot of the state of reliability on the American electric grid, and offers a practical guide for modeling the economic impact of electricity shortfalls stemming from specific policy proposals, ensuring that the economic and social dangers of unreliable electricity are given equal consideration to emissions reductions in future regulatory proceedings.

This report examines how blackouts affect economic and human welfare, provides a snapshot of the state of reliability on the American electric grid, and offers a practical guide for modeling the economic impact of electricity shortfalls stemming from specific policy proposals, ensuring that the economic and social dangers of unreliable electricity are given equal consideration to emissions reductions in future regulatory proceedings.

THE SOCIAL COST OF BLACKOUTS

Blackout costs are often difficult to quantify because they depend on several factors, including the duration of the power outage, the time at which it occurs, whether the outage was expected or unexpected, the weather or environmental conditions during the outage, and each customer's individual electricity needs.[2, 3]

The challenge is compounded when we consider that each electricity customer will incur unique costs associated with not having power. For example, a blackout for one household might mean candles, flashlights, and board games, while a power outage for their next-door neighbor on an oxygen machine might be life-threatening.[4]

While readers are likely most aware of the economic and human impacts of blackouts on residential customers, studies consistently find that the costs of not having electricity are greatest for commercial and industrial customers. According to a study from the Oak Ridge National Laboratory:

> *The commercial sector bears the largest burden, followed by the industrial sector, and residential costs are relatively lower. The type of customer affected also influences costs, with large commercial and industrial consumers experiencing significantly higher expenses compared with smaller customers.*
>
> *Furthermore, the duration of the power outage plays a crucial role. Longer outages lead to increased economic losses because of disrupted operations, decreased productivity, spoilage of perishable goods, and other related expenses.*[5]

To help give the reader more insight into the economic harm caused by blackouts for individual facilities, Always On Energy Research used the Customer Damage Function (CDF) calculator developed by the National Renewable Energy Laboratory (NREL) to model the costs of power outages to an illustrative grocery store, shown in Figure 1.

Grocery Store Analysis

Grocery stores are at risk for high costs during blackouts because they contain large amounts of perishable items that begin to expire without refrigeration. Using assumptions obtained from The Food Industry Association in the CDF, Always On calculated that a typical grocery store would lose $822,000 within 24 hours, a figure that includes spoiled food, labor costs, and lost sales, with damage reaching $1 million if the power outages last for 72 hours (see Figure 1).[6]

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[2] Madeline Macmillan et al., "Shedding Light on the Economic Costs of Long-Duration Power Outages: A Review of Resilience Assessment Methods and Strategies," Lawrence Berkeley National Laboratory, May 2023, https://eta-publications.lbl.gov/sites/default/files/erss_manuscript_preprint_0.pdf.

[3] Archana Ghodeswar et al., "Quantifying the Economic Costs of Power Outages Owing to Extreme Events: A Systematic Review," *Renewable and Sustainable Energy Reviews,* October 2024, https://www.sciencedirect.com/science/article/abs/pii/S136403212400710X.

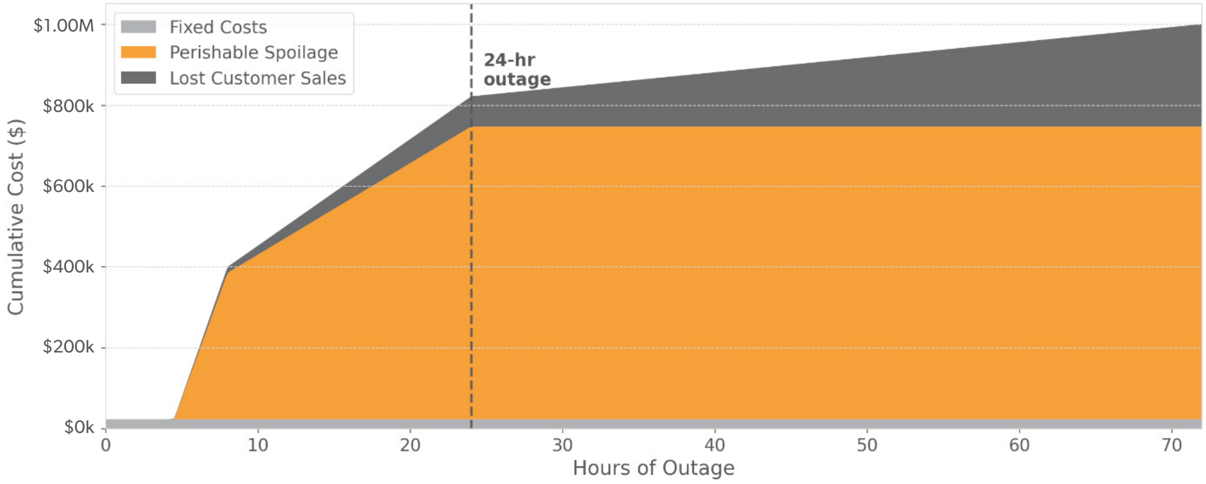
[4] Sean Ericson and Lars Lisell, "A Flexible Framework for Modeling Customer Damage Functions for Power Outages," Energy Systems, October 30, 2018, https://link.springer.com/article/10.1007/s12667-018-0314-8.

[5] Archana Ghodeswar et al., "Quantifying the Economic Costs of Power Outages Owing to Extreme Events: A Systematic Review," *Renewable and Sustainable Energy Reviews,* October 2024, https://www.sciencedirect.com/science/article/abs/pii/S136403212400710X.

[6] National Renewable Energy Laboratory, "Customer Damage Function Calculator," Accessed April 12, 2026, https://cdfc.nlr.gov/.

FIGURE 1: OUTAGE COST ANALYSIS - GROCERY STORE

(CUMULATIVE COST OVER TIME)



Facility	Building Type	Outage Duration	Total Outage Cost
Grocery Store	**Grocery / Food Services**	**24 Hours**	**$822,163**

Figure 1. Spoilage begins around 4.5 hours, as fresh foods like meat, dairy, and other refrigerated foods begin to expire.

Spoilage losses are minimal for the first four hours because the U.S. Food & Drug Administration (FDA) states that unopened refrigerators can keep perishable foods safe for up to four hours.[7] After this mark, fresh refrigerated foods begin to spoil, and frozen foods begin to spoil between 8 hours and 24 hours.

While these CDF calculations were based on a hypothetical facility using reasonable assumptions, it helps to illustrate how power outages can cause substantial losses for businesses that ripple through the entire economy. Unfortunately, the risk of power outages is growing in the United States, representing a growing threat to the economic well-being of American families and businesses.

THE STATE OF THE GRID: WHY RELIABILITY MATTERS NOW

For many years, the reliability of the power grid was taken for granted, especially regarding outages caused by insufficient reliable power plant capacity. As a result, the cost of blackouts has been an understudied aspect of the electric system and a nonexistent consideration in regulatory cost-benefit analyses, leading to declining reserve margins nationwide.

For example, the North American Electric Reliability Corporation's (NERC) 2019 Long-Term Reliability Assessment (LTRA) identified no regions at high risk of rolling blackouts over the five-year time window studied.[8]

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[7] U.S. Food & Drug Administration, "Food and Water Safety During Power Outages and Floods," Accessed May 13, 2026, https://www.fda.gov/food/buy-store-serve-safe-food/food-and-water-safety-during-power-outages-and-floods.

[8] North American Electric Reliability Corporation, "2019 Long-Term Reliability Assessment," https://www.nerc.com/globalassets/programs/rapa/ra/nerc_ltra_2019.pdf.

FIGURE 2: RISK AREA SUMMARY 2026-2030

(SHOWS HIGHEST RISK CLASSIFICATION THAT OCCURS IN THE FIRST 5 YEARS AND STATES INITIAL YEAR OF OCCURRENCE)

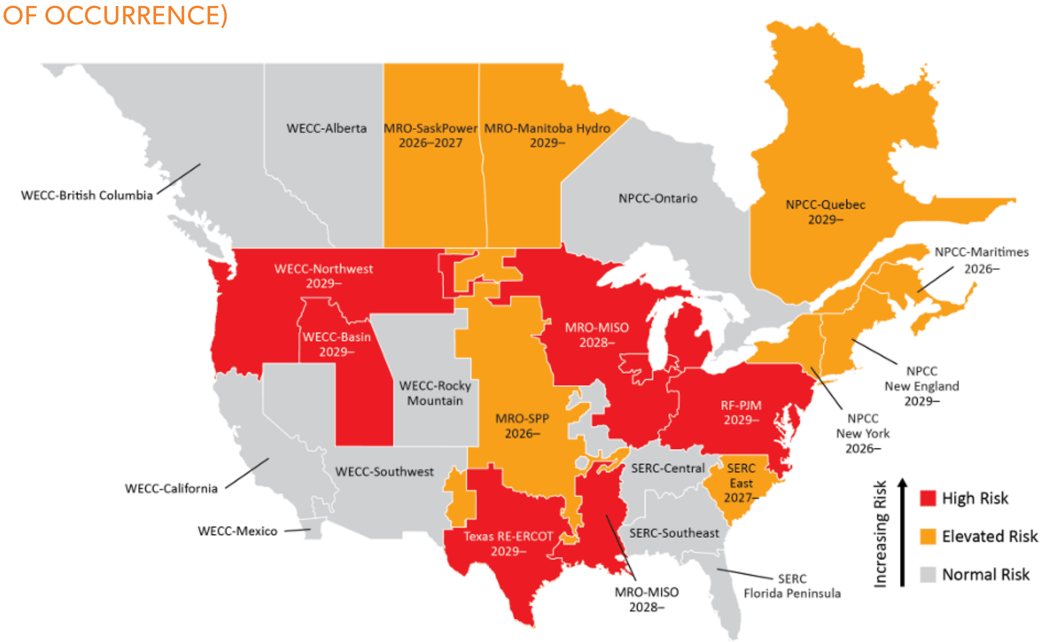

Figure 2. The 2025 NERC LTRA shows that half of the country is at a high risk of blackouts by 2030, including regional transmission organizations (RTOs) like PJM, which serves the most customers, and MISO. In a separate 2026 sensitivity assessment, NERC found that MISO's reliability outlook improved substantially if approximately 25 gigawatts (GW) of mostly natural-gas-fired generation resources fast-tracked for interconnection under MISO's Expedited Resource Addition Study (ERAS) were added on schedule.[10]

However, NERC warns in its 2025 LTRA that half of the country is at a high risk of rolling blackouts by 2030, and that four additional regions within the United States will be at elevated risk of rolling blackouts during periods of elevated electricity demand (See Figure 2).[9]

These risks are not trivial. In testimony to Congress on the lessons from Winter Storm Fern, NERC President and CEO James B. Robb warned:

> *Reliability risk in North America continues to rise. The continent is at risk of more frequent and more serious long-duration reliability disruptions, including the possibility of national consequence events. A supply and demand problem remains the central challenge for reliability of the bulk power system (BPS).*[11]

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[9] North American Electric Reliability Corporation, "2025 Long-Term Reliability Assessment," January 2026, https://www.nerc.com/globalassets/our-work/assessments/nerc_ltra_2025.pdf.

[10] North American Electric Reliability Corporation, "2025 LTRA Sensitivity Case: Addition of ERAS Resources in the MISO Assessment Area," April 2026, https://www.nerc.com/globalassets/our-work/assessments/2025-ltra-sensitivity-miso-eras.pdf.

[11] James B. Robb, "Winter Storm Fern Lessons: Supplying Reliable Power to Meet Peak Demand," Testimony of James B. Robb, U.S. House Energy and Commerce Energy Subcommittee Hearing," March 17, 2026, https://d1dth6e84htgma.cloudfront.net/03_17_2026_ENG_Testimony_Robb_90d31af898.pdf.

While most customer outages occur on the distribution system, generation-side risks stemming from declining reserve margins are a growing threat to grid reliability in the United States, as Robb explained:

> *I would say that in general, it's very unusual to see resource-driven outages. Most outages have always been because of problems on the distribution system…* ***We're in a very unique period of time where we're seeing resource deficiency.***[12, 13] [Emphasis added]

The U.S. faces a deficiency of generation resources for three main reasons. First, years of policy-driven coal plant retirements (and sometimes nuclear plants, as well) have reduced the dispatchable capacity available to meet reserve margins. Second, the addition of intermittent wind and solar resources does not provide the same reliability value to the grid as dispatchable sources. Third, data centers and electrification efforts are driving massive growth in electricity demand.[14]

A U.S. Department of Energy (DOE) report published in July 2025 analyzed these risk factors and concluded that firm capacity retirements and data center demand growth could cause a 100-fold increase in the risk of power outages in 2030.[15] In this scenario, the DOE found that regions across the United States could experience millions of megawatt-hours (MWh) of unserved load under worst-case wind and solar performance.

However, the DOE study did not provide a framework for estimating the monetary value, or Social Cost, of these modeled outages, nor did it provide a roadmap for incorporating them into a regulatory cost-benefit analysis, which is the purpose of this report.

CALCULATING THE SOCIAL COST OF BLACKOUTS IN SEVEN STEPS

Always On recommends using the Interruption Cost Estimate (ICE) calculator developed by Lawrence Berkeley National Laboratory (LBNL) to estimate the economy-wide costs of power interruptions because it accounts for factors such as outage duration, timing, and customer type.

ICE also has the advantage of relying on standard utility reliability metrics already collected throughout the electric industry, making it practical for incorporation into regulatory proceedings and reliability planning.

While the Customer Damage Function (CDF) calculator discussed earlier in this report is helpful for estimating blackout costs at individual facilities, the ICE calculator, based on surveys from a broad range of customers and industries, is better suited for estimating the macroeconomic impacts of policy-driven blackouts.

The seven basic steps regulatory agencies should take to calculate the SCB are detailed below.

1. Determine the installed capacity of the future power system under the proposed regulation, resource plan, or legislation using nameplate capacity.

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[12] While no national dataset provides an exact percentage breakdown by system layer, multiple federal, industry, and academic sources consistently find that most customer outages originate on the distribution system.

[13] Roshni Anna Jacob et al., "Real-Time Outage Management in Active Distribution Networks Using Reinforcement Learning Over Graphs," Nature Communications, June 2024, https://pmc.ncbi.nlm.nih.gov/articles/PMC11150389/.

[14] Electric Power Research Institute, "Powering Intelligence," February 25, 2026, https://powering-intelligence.epri.com/introduction.html.

[15] U.S. Department of Energy, "Evaluating the Reliability and Security of the United States Electric Grid," Resource Adequacy Report, July 2025, https://www.energy.gov/sites/default/files/2025-07/DOE%20Final%20EO%20Report%20%28FINAL%20JULY%207%29.pdf.

2. Model the future hourly electricity demand using a combination of load growth forecasts, historical load curves, and projected data center demand to create realistic, forward-looking load shapes.

3. Calculate the historic hourly wind and solar capacity factors for a given region for multiple years by dividing the historic hourly generation of the resource by the total installed capacity in that year.

4. Using the projected load shape, determine if the installed capacity in the future resource portfolio would be capable of meeting demand using historical hourly wind and solar capacity factors.

5. If the modeled system produces rolling blackouts, frequently referred to as "capacity shortfalls," using historical wind and solar capacity factors, determine the length of the blackouts in hours, the number of unserved megawatt-hours, and the depth of the blackouts.

6. Convert these modeled blackout metrics into CAIDI, SAIFI, and SAIDI values that can be entered into the ICE calculator.

7. Enter these criteria into the ICE model to determine the cost of blackouts.

While each of these steps requires substantial technical analysis and modeling expertise, the methodology itself is transparent, replicable, and grounded in existing reliability and economic tools already used throughout the electric industry.

As demonstrated in the case study below, establishing a formal Social Cost of Blackouts framework will allow regulators to evaluate reliability risks alongside emissions impacts and produce more balanced and economically complete policy analyses.

CALCULATING THE SOCIAL COST OF BLACKOUTS: A CASE STUDY ON THE SOUTHWEST POWER POOL

To demonstrate how LBNL's ICE calculator can be used to determine the SCB for a particular policy, we will examine a 2024 case study of the Biden administration's Final Carbon Rules for greenhouse gas emissions from existing coal and new natural gas power plants in the Southwest Power Pool (SPP) region.[16] This analysis was originally conducted by Always On on behalf of the State of North Dakota's Transmission Authority.[17]

To evaluate the reliability implications of these regulations, Always On used EPA's assumptions from its Integrated Planning Model (IPM), as presented in the agency's Regulatory Impact Analysis (RIA). Specifically, we relied on IPM's projected capacity buildout and demand growth forecast to define the future generation mix and hourly load shapes in the SPP region.

The RIA is intended to estimate the costs, benefits, and broader economic impacts of proposed environmental regulations. Because it establishes the resource mix and operating conditions of the future grid, it also provides the foundation for evaluating the reliability implications of those regulations.

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[16] The finalized rule was officially titled, "New Source Performance Standards for Greenhouse Gas Emissions from New, Modified, and Reconstructed Fossil Fuel-Fired Electric Generating Units; Emissions Guidelines for Greenhouse Gas Emissions from Existing Fossil Fuel-Fired Electric Generating Units; and Repeal of the Affordable Clean Energy Rule."

[17] North Dakota Transmission Authority, "Analysis of Finalized Rule for Greenhouse Gas 2024," North Dakota Industrial Commission, 2024, https://www.ndic.nd.gov/sites/www/files/documents/Transmission-Authority/Publications/Other%20Studies/Analysis-of-Finalized-Rule-for-Greenhouse-Gas-2024.pdf.

FIGURE 3: BIDEN EPA'S ASSUMED NAMEPLATE CAPACITY IN SPP BY YEAR, FINAL CARBON RULE

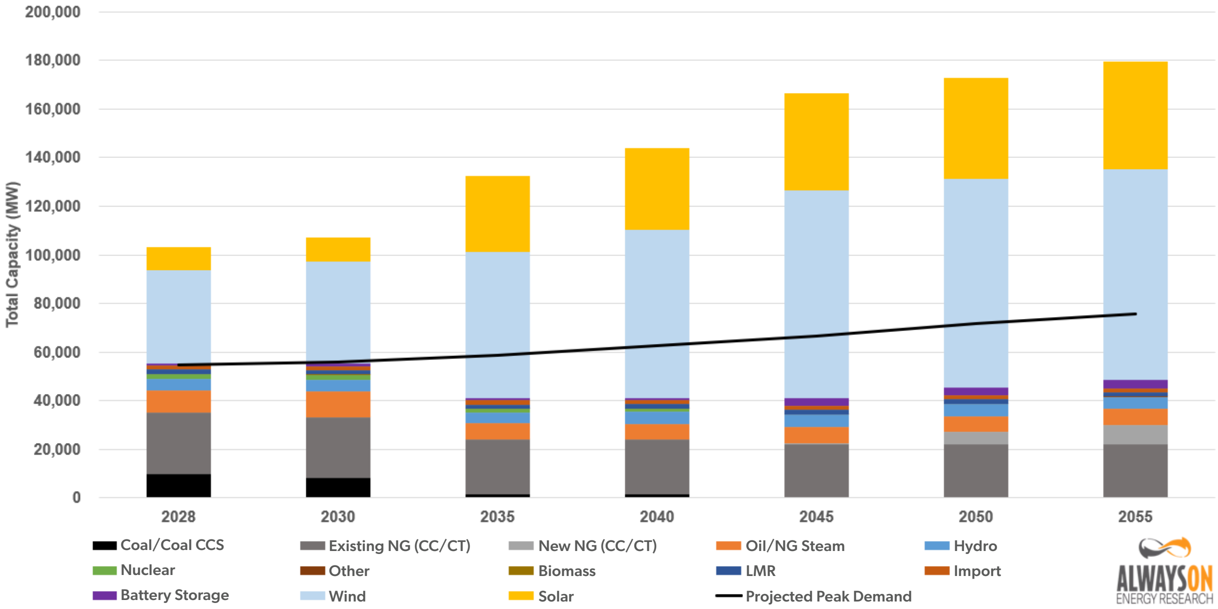

Figure 3. The Biden EPA's modeled SPP grid would have insufficient thermal capacity to meet projected peak demand beginning in 2035, making the region reliant upon the performance of wind, solar, and battery storage.

1. Determining Future Installed Capacity

According to the Biden EPA's IPM modeling, which shows the modeled power plant capacity in 2028, 2030, 2035, 2040, 2045, 2050, and 2055, almost all the existing coal capacity in SPP would retire by 2035, and new natural gas capacity additions would be modest until 2045 (see Figure 3). EPA projects rising demand will be satisfied by building more wind, solar, and, to a lesser extent, battery storage capacity from 2028 through 2040.

2. Model the Future Hourly Electricity Demand

Always On determined the future hourly electricity demand by upwardly adjusting the hourly demand from five historical test years (HTYs)—2019, 2020, 2021, 2022, and 2023—to meet the projected future peak demand in EPA's modeling, as shown in Figure 3.[18] The historic hourly demand data was obtained from the U.S. Energy Information Administration's (EIA) Hourly Electric Grid Monitor.[19]

3. Calculate the Historic Hourly Capacity Factor of Wind and Solar Resources

Hourly wind and solar capacity factors were calculated by dividing the hourly generation data for 2019, 2020, 2021, 2022, and 2023 by the installed capacity of each intermittent resource in that year. Hourly generation data was obtained from the EIA Hourly Electric Grid Monitor, and installed capacity was obtained from EIA 860 data.

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[18] North Dakota Transmission Authority, "Analysis of Finalized Rule for Greenhouse Gas 2024," North Dakota Industrial Commission, 2024, https://www.ndic.nd.gov/sites/www/files/documents/Transmission-Authority/Publications/Other%20Studies/Analysis-of-Finalized-Rule-for-Greenhouse-Gas-2024.pdf.

[19] U.S. Energy Information Administration, "Hourly Electric Grid Monitor," U.S. Department of Energy, Accessed May 13, 2026, https://www.eia.gov/electricity/gridmonitor/dashboard/electric_overview/US48/U.S48.

FIGURE 4: EPA SPP CAPACITY SHORTFALLS IN 2040 USING 2021 HOURLY DEMAND AND WIND AND SOLAR CAPACITY FACTORS

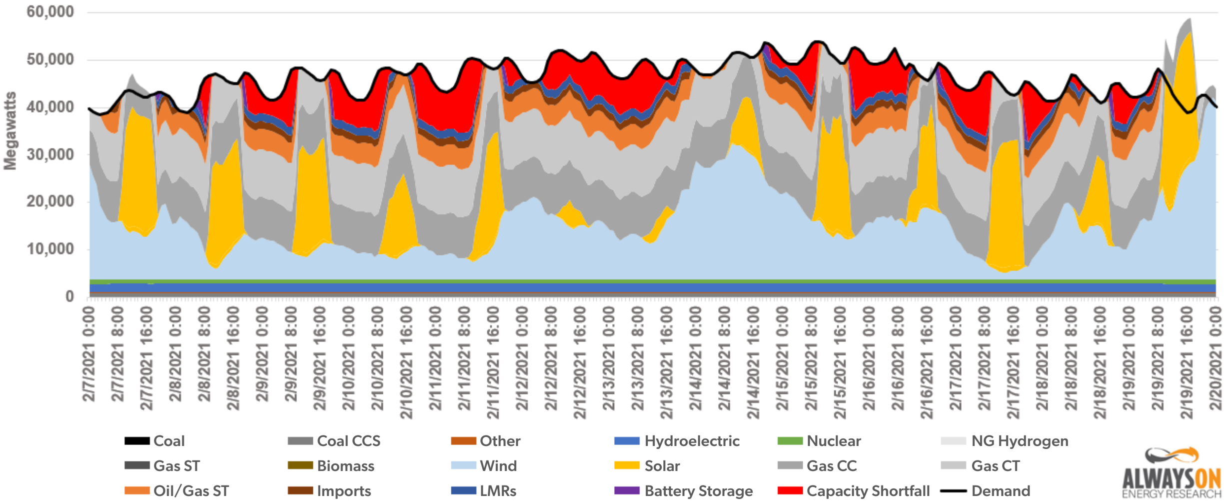

Figure 4. Always On modeling determined that 13 separate blackout events would occur in the summer of 2040 if the SPP system is characterized by the generation portfolio modeled by the Biden administration and wind and solar perform as they did in 2021.

4. Blackout Analysis Using Historic Wind and Solar Generation Data

The theory for the stress-testing proposed regulations using historical wind and solar availability is simple: If the EPA's modeled SPP grid cannot maintain reliability when hindcasting events from the recent past, we should have exceedingly little confidence that the system would maintain reliability in the distant future.[20]

Always On compared the estimated future SPP capacity from EPA's IPM modeling to historical hourly wind and solar performance to determine if EPA's modeled SPP grid (shown in Figure 3) would be able to meet the adjusted demand in all hours of the future modeled years based on wind and solar performance in 2019, 2020, 2021, 2022, and 2023.

The reliability analysis determined that the EPA's modeled SPP grid would result in 13 separate blackout events in 2040 if wind and solar perform as they did in 2021 (see Figure 4). The blackouts occur because the modeled SPP system would not have enough thermal capacity to meet its projected peak demand and would thus be subject to the performance of wind and solar to maintain reliability.

5. Determining Blackout Duration and Severity

Blackouts occurred in every historical test year evaluated in this analysis. The values shown in Table 1 represent total unserved energy and were calculated by multiplying each hourly electricity shortfall (MW) by the duration of the shortfall in hours.

Among the historical weather years analyzed, 2021 produced the greatest volume of unserved energy, while 2020 produced the least.

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[20] MISO's evolving resource adequacy and accreditation methodologies increasingly incorporate historical weather, load, and renewable generation performance during high-risk hours alongside traditional probabilistic reliability modeling. See Midcontinent Independent System Operator, "Resource Accreditation White Paper Version 1.1," 2024, https://cdn.misoenergy.org/Resource%20Accreditation%20White%20Paper%20Version%201.1630728.pdf.

TABLE 1: TOTAL MEGAWATT-HOURS OF UNSERVED ELECTRICITY DEMAND IN SPP UNDER BIDEN FINAL CARBON RULES

	2028	2030	2035	2040	2045	2050	2055	Total
2019	2,336	11,481	157,389	327,854	332,649	275,613	271,183	1,378,505
2020	0	0	122,456	232,589	243,625	190,871	189,259	978,800
2021	1,466	12,052	958,204	1,527,581	2,007,625	1,895,291	1,896,587	8,298,806
2022	604	27,668	467,164	843,236	914,724	880,436	903,176	4,037,008
2023	77,714	149,382	428,164	751,748	666,098	660,846	704,685	3,438,637

Table 1. The table shows the blackouts in each of the EPA's future modeled years (2028-2055) and the MWh of unserved demand based on the historical load shape and wind and solar output (ranging from 2019 to 2023).

6. Converting Blackout Metrics To SAIDI, SAIFI, and CAIDI

The ICE calculator utilizes three reliability metrics reported by utility companies to calculate the cost of blackouts. These metrics include the System Average Interruption Duration Index (SAIDI), the System Average Interruption Frequency Index (SAIFI), and the Customer Average Interruption Duration Index (CAIDI). SAIDI represents how many minutes of power outages per year the average customer experiences; SAIFI is the number of power outages the average customer experiences; and CAIDI is the average time it takes to restore power. These metrics are related to each other by the following formula:

$$CAIDI = \frac{SAIDI}{SAIFI}$$

As a result, finding two of these metrics will allow us to compute the third. For SAIDI, we need to determine the equivalent number of blackout hours experienced by the average customer. We can do this by dividing the total annual MWh of shortfalls by the average hourly load of the system. For CAIDI, we simply find the average length of every shortfall event in each test year. From here, we can derive SAIFI by dividing SAIDI by CAIDI.

For example, in EPA's modeled SPP grid using the 2021 historical test year, the system experienced 958,204 MWh of unserved energy in 2035, and the average hourly load on the system was 35,210 MW. Therefore, the equivalent outage duration would be approximately 27 hours, or 1,632.8 minutes, for the average customer. This value would then serve as the basis for calculating SAIDI. Since the average blackout event lasted 13.8 hours, or 828 minutes (which serves as CAIDI), the SAIFI would be 1.97 outage events per year.

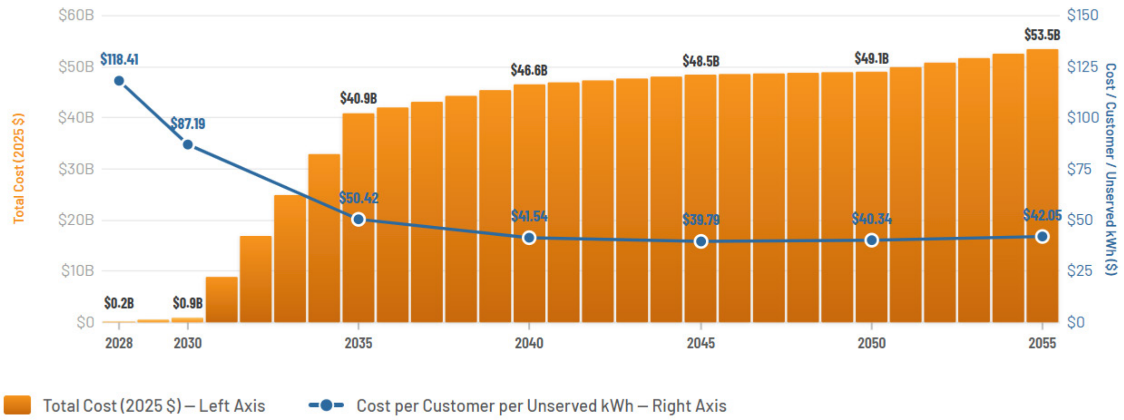
When calculated for each model year, these reliability metrics can then be entered into the ICE calculator to estimate the broader economic consequences of the modeled outages.

7. Determining the Social Cost of Blackouts

Using these outages as inputs to the ICE calculator, Always On determined a range of blackout costs for the Biden Final Carbon Rules by quantifying blackout costs in each EPA-modeled year and filling in the years in between.

FIGURE 5: ANNUAL COST OF FUTURE BLACKOUTS IN SPP UNDER EPA CARBON RULES USING 2021 HISTORICAL TEST YEAR

(PROJECTED OUTAGE COSTS BASED ON ALWAYS ON ENERGY RESEARCH MODELING, 2028-2055)



Source: Always On Energy Research modeling of EPA regulations; Interruption Cost Estimate (ICE) Calculator.
Costs expressed in 2025 dollars. Values represent total annual interruption costs and per-customer unit costs projected for the Southwest Power Pool (SPP) region under modeled regulatory scenarios.

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Figure 5. Annual blackout costs increase over time because the EPA's modeled SPP system does not retain sufficient dispatchable capacity.

In the best-case scenario, SPP would incur $260.5 billion in blackout costs through 2055, based on the 2020 historical test year. In the worst-case scenario, highlighted in Figure 5 above, SPP would incur $1.1 trillion in blackout costs through 2055 using the 2021 historical test year, which had the largest unserved electricity demand of the historical test years studied.

To align with the Biden EPA's methodology, Always On discounted these observed SCB damages using the EPA climate benefit discount rate of two percent and quantified the cost through 2047 for a direct comparison.[21] As a result, the discounted cost of blackouts observed in our modeling in SPP was $106 billion through 2047 using the 2020 historical test year, and $402 billion using the 2021 historical test year.

In addition to calculating the total annual cost of blackouts, the ICE model determined the average cost of unserved electricity on a per-kilowatt-hour (kWh) basis, as shown in Figure 5.

For example, the cost of blackouts ranges from $39.79 per kWh in 2045 to $118.41 per kWh in 2028, reflecting that, for society as a whole, the most expensive unserved energy hours are the earliest, and each incremental hour of blackouts is less expensive than the first. These translate to costs per MWh of $39,790 to $118,410 and are significantly higher than the standard value of lost load (VOLL) estimates published by RTOs such as MISO and PJM.

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[21] EPA's RIA quantified the cost and benefits through 2047, rather than 2055.

TABLE 2: NET BENEFITS OF THE ILLUSTRATIVE SCENARIOS AND BLACKOUT COSTS

(BILLIONS $)

Climate Benefits	**$270**
PM2.5 and O3 Related Health Benefits	**$120**
Compliance Costs	**$19**
EPA Calculated Net Benefits	**$370**
Social Cost of Blackouts (2020 Test Year)	**$106**
Social Cost of Blackouts (2021 Test Year)	**$402**
Always On Calculated Real Net Benefits (2020 Test Year)	**$264**
Always On Calculated Real Net Benefits (2021 Test Year)	**-$32**

Two percent discount rate applied to all costs and benefits.

Billions of 2019 dollars, discounted to 2024.

Values, except for Social Cost of Blackout values, obtained from Table ES-5 from the Regulatory Impact Analysis for the Final New Source Performance Standards for Greenhouse Gas Emissions from New, Modified, and Reconstructed Fossil Fuel-Fired Electric Generating Units; Emission Guidelines for Greenhouse Gas Emissions from Existing Fossil Fuel-Fired Electric Generating Units; and Repeal of the Affordable Clean Energy Rule. USEPA, Office of Air Quality Planning and Standards (OAQPS), Health and Environmental Impacts Division, [EPA-452/R-24-009] April 2024.

Table 2. When discounted at a two percent discount rate, the Social Cost of Blackouts in SPP exceeds the estimated net benefits for the Biden Final Carbon Rules for the entire country in the 2021 Test Year.

COMPARING THE SOCIAL COST OF CARBON AND THE SOCIAL COST OF BLACKOUTS

Most of the estimated benefits of the Biden Final Carbon Rules were climate benefits derived from the administration's Social Cost of Carbon estimates, which assume an average cost of $250 per metric ton of carbon dioxide averted. The remaining estimated benefits result from health benefits associated with lower modeled PM2.5 and ozone emissions.

According to the Regulatory Impact Analysis (RIA) prepared by the Biden EPA, the Final Carbon Rules would yield $270 billion in estimated present value climate benefits, $120 billion in health benefits from reducing emissions of ozone and small particulates, and only $19 billion in compliance costs, resulting in net benefits of $370 billion through 2047 using a two percent discount rate.[22]

Using the ICE calculator, Always On determined that the blackout costs observed in SPP—which serves just six percent of the nation's population—under the Biden Final Carbon Rules would be massive, ranging from $106 billion to $402 billion through 2047, and could negate all the estimated net benefits of the finalized rules nationwide.

As a result, after SCB costs for SPP are applied, the estimated net benefits of the regulation for the entire country are reduced to a range of -$32 billion, or a net cost, in the 2021 Test Year, to $264 billion in the 2020 Test Year (see Table 2).[23]

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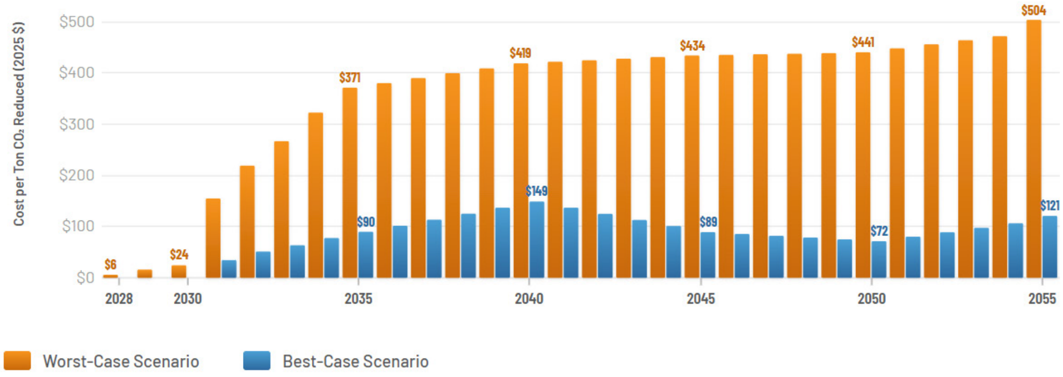
[22] U.S. EPA, "Regulatory Impact Analysis for the New Source Performance Standards for Greenhouse Gas Emissions from New, Modified, and Reconstructed Fossil Fuel-Fired Electric Generating Units; Emission Guidelines for Greenhouse Gas Emissions from Existing Fossil Fuel-Fired Electric Generating Units; and Repeal of the Affordable Clean Energy Rule," May 31, 2024, https://www.regulations.gov/document/EPA-HQ-OAR-2023-0072-8913.

[23] Table reconstructed from the "Regulatory Impact Analysis for the New Source Performance Standards for Greenhouse Gas Emissions from New, Modified, and Reconstructed Fossil Fuel-Fired Electric Generating Units; Emission Guidelines for Greenhouse Gas Emissions from Existing Fossil Fuel-Fired Electric Generating Units; and Repeal of the Affordable Clean Energy Rule" using Claude.

FIGURE 6: THE COST OF BLACKOUTS PER TON OF CO_2 AVERTED IN SPP

(WORST-CASE AND BEST-CASE SCENARIOS BASED ON ALWAYS ON ENERGY RESEARCH MODELING, 2028-2055)



Source: Always On Energy Research modeling of EPA regulations; Interruption Cost Estimate (ICE) Calculator. Costs expressed in 2025 dollars. Values represent the blackout cost per ton of CO_2 reduced projected for the Southwest Power Pool (SPP) region under worst-case and best-case modeled regulatory scenarios.

Figure 6. The Social Cost of Blackouts in SPP far exceeds the Social Cost of Carbon on a per ton of CO_2 avoided basis in the 2021 Test Year, and it is 61 percent lower in the 2020 Test Year.

Even in the best-case scenario (the 2020 Test Year), blackouts in SPP would still account for 29 percent of the estimated net benefits for the entire country and negate 40 percent of the estimated climate benefits stemming from the SCC.

Assessing the Social Cost of Blackouts per ton of carbon dioxide averted results in a cost of $395 per ton under the worst-case 2021 historical year, which is 58 percent higher than the Biden administration's SCC of $250. When using the best-case scenario with the 2020 historical test year, the average cost of a blackout per ton of carbon dioxide averted is $97 per ton, which is 61 percent lower. Figure 6 shows the annual cost per ton of carbon dioxide averted for both scenarios.

While proponents of EPA's Carbon Rules may argue that the blackout risks are uncertain and could be mitigated through additional resource development, doing so would still reduce the projected net benefits of the regulations. Building additional dispatchable generation would increase compliance costs and reduce the projected benefits by increasing emissions, while building additional wind, solar, and battery storage to maintain the same emissions reductions would also significantly increase system costs. As a result, the net benefits of the EPA-modeled system would likely be diminished, especially when applied across the broader United States.

This analysis shows that regulatory frameworks that quantify the Social Cost of Carbon while ignoring the Social Cost of Blackouts are incomplete. When even a single region, such as SPP, can impose blackout costs large enough to materially erode or fully offset projected national climate benefits, the omission changes the entire cost-benefit outcome.

Therefore, incorporating the Social Cost of Blackouts into regulatory impact analyses is not optional; it is necessary to ensure that policymakers evaluate the full set of real-world tradeoffs and maximize public welfare.

CONCLUSION

Regulatory bodies such as the EPA, state utility commissions, and regulated utilities use metrics like the Social Cost of Carbon to evaluate the economic costs of emissions associated with the nation's electricity system. However, without also evaluating the economic and human costs of electricity blackouts, these analyses remain incomplete.

The Social Cost of Blackouts framework proposed in this report is intended to provide regulators with a practical and transparent method for evaluating reliability risks alongside emissions impacts in future regulatory proceedings. By incorporating blackout costs into cost-benefit analyses, policymakers can better evaluate the real-world tradeoffs associated with proposed energy regulations and resource plans.

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Regulatory agencies should therefore be required to analyze the reliability implications of proposed rules and incorporate the economic costs associated with capacity shortfall events into their regulatory-impact and cost-benefit analyses.