THE VALUE OF LOST LOAD IN ELECTRICITY-INTENSIVE INDUSTRIES: COMBINING STATED- AND PRODUCTION VALUE APPROACHES

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Overview

The value of lost load (VoLL) is critical in evaluating the economic impact of electricity supply interruptions, particularly for electricity-intensive industries. VoLL is a monetary metric quantifying the cost of unsupplied energy (€/kWh) during outages, providing valuable insights for policymakers, utility providers, and industrial stakeholders. Electricity-intensive industries are especially vulnerable to power outages due to their reliance on continuous operations. Disruptions can lead to production losses, equipment damage, and extended downtime, inflicting significant economic costs. In Sweden, core industrial sectors such as pulp and paper, chemicals, mining, and steel manufacturing, are crucial to the national economy and exemplify high values due to their heavy reliance on electricity. With the rise of renewable energy sources, increasing electricity demand and geopolitical turbulence, ensuring grid reliability while managing costs has become an urgent priority for policymakers. This study underscores the importance of VoLL in decision-making for grid investments, reliability standards, and demand-side management. It explores the economic ramifications of power disruptions in electricity-intensive industries, leveraging a mixed-method approach that integrates and compares new collected survey data with publicly available microeconomic data insights. While there is an extensive literature on estimating country level and overall economy VoLL, this study contributes by integrating and comparing a unique data of official production values and stated survey responses matched at plant level. In this way, discrepancies in VoLL approaches can be highlighted and discussed.

Methods

While the concept is straightforward, accurately estimating VoLL remains a significant challenge. This study employs a dual approach to assess the plant level costs of power outages: a production theory-based estimation and a survey-based stated cost analysis. The production value estimation is based on official microeconomic data collected by Statistics Sweden in 2022. The stated cost approach is based on a survey targeting the 1,000 largest electricity-consuming plants in Sweden. The survey, conducted between November 2023 and January 2024, received 359 responses from plant level representatives. Questions probed production processes, recovery capabilities, costs of hypothetical outages of varying duration, investments in backup systems, etcetera.

Data from survey responses were matched and complemented with plant-level economic data, enabling a nuanced understanding of outage impacts across different sectors and electricity consumption scales. The analysis includes calculating traditional metrics such as value added (VA) and VA-based VoLL, as well as direct cost-based VoLL from stated costs. The study also uses Tobit regressions to analyze factors affecting the cost of electricity interruptions, considering variables such as electricity use, outage duration, and production hours.

Results

The study demonstrates that traditional metrics, such as VA based measures, significantly underestimate the financial impact of power outages. While the average lost VA per hour is calculated to be about 6 thousand Euro from officially reported data, the stated cost of a one-hour outage is significantly higher, averaging 84 thousand Euro. This stark difference indicates that relying solely on VA as a metric underestimates the true economic burden on electricity-intensive industries. The VA approach often overlooks indirect costs, such as restarting operations, material spoilage, and extended downtime impacts, which are better captured through stated cost data.

The study compares VoLL derived from two approaches. When calculated using reported VA, the VoLL is approximately 2.3 €/kWh, whereas VoLL based on stated costs is much higher, around 131 €/kWh for an average outage. These findings reveal substantial discrepancy between theoretical, VA-based, calculations and the real-world financial impacts, particularly for electricity-intensive sectors like pulp and paper or steel manufacturing. This underscores the importance of incorporating stated cost data into VoLL estimations to achieve a more accurate understanding of outage costs.

Shorter outages are disproportionately costly relative to their length, primarily due to high fixed costs associated with initial disruptions. These costs may include immediate production losses, damage to machinery, or the need for rapid response measures. As the duration of the outage extends, the marginal cost of each additional hour decreases, reflecting the fact that many fixed costs are already incurred in the initial hours of disruption.

The consequences of outages often extend well beyond their immediate duration. Restarting production processes, repairing equipment, and addressing other disruptions can require significantly more time and resources. Many businesses reported that the effects of a one-hour outage could linger for months, with some stating that they are unable to fully recover from the losses even 12 months after the event. These extended disruptions underscore the enduring consequences of power outages, particularly for electricity-intensive industries.

Whether a plant operates in forestry, steel, chemistry, or mining/mineral production, the economic impact of an outage is more closely tied to the volume of electricity consumed than to the specific sector. High electricity use, regardless of the industry, emerges as the primary driver of outage costs.

Plants with extensive production schedules, like 24/7, tend to report higher stated costs of power outages. Their continuous operations make them particularly vulnerable to disruptions. However, increase in outage costs diminishes as total production hours rise, indicating a nonlinear relationship between production hours and stated costs.

Compared to broader economic sectors studied in previous research, energy-intensive plants report relatively lower VoLL estimates. Despite their high electricity use, these industries may have developed specific coping mechanisms or adaptive strategies that mitigate some of the financial impacts of power outages.

Conclusions

This study underscores the substantial economic impacts of power outages on electricity-intensive industries and highlights the limitations of traditional metrics like value added in capturing these costs. The findings emphasize a comprehensive approach that integrates stated cost data to reflect the real-world consequences of outages more accurately. By integrating stated and production-based approaches, this study provides a comprehensive evaluation of VoLL in electricity-intensive industries. The findings emphasize the critical need for accurate VoLL estimates to guide investments, policy decisions, and operational strategies. As electricity systems evolve toward higher renewable penetration, maintaining a balance between cost efficiency and reliability will be paramount. This research lays the groundwork for informed decision-making, ensuring sustainable and resilient energy systems in the face of growing demand and climatic uncertainties.

References