

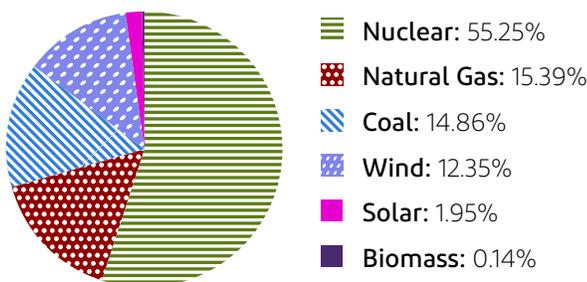
# Beyond Emissions: Measuring the Full Impact of Bidirectional Charging on Communities

## Introduction

As Illinois moves toward a cleaner energy future, ComEd is exploring innovative solutions like bidirectional charging to support the state’s goal of 1 million electric vehicle (EV) registrations by 2030. Bidirectional charging allows EVs to not only draw power from the grid but also send energy back to homes, buildings or the grid itself. This two-way energy flow can improve grid reliability, reduce energy costs and lower emissions that benefit both customers and communities.

ComEd is launching a study to examine the range of potential customer benefits resulting from bidirectional charging programs. While traditional approaches to study bidirectional charging focus primarily on grid impacts, ComEd is expanding the focus to assess environmental and social impacts like greenhouse gas (GHG) emissions, air quality and community health impacts by leveraging a combination of advanced analytical tools to assess these impacts.

### Electricity Sources



**Note.** Hydro accounts for 0.05%, too small to be visually represented in the chart.

### Annual Emissions per Vehicle

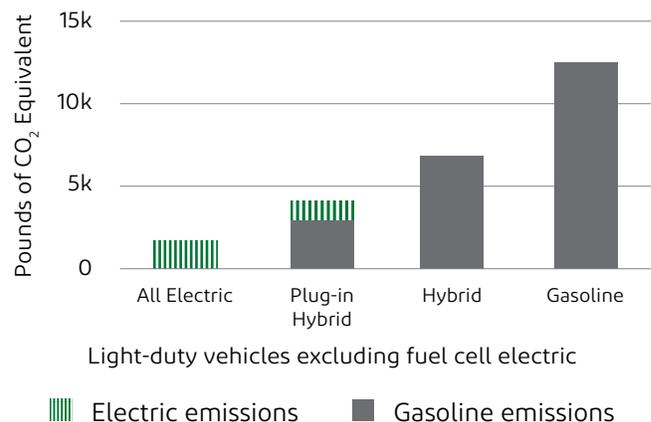


Figure 1. Illinois State Averages: Emissions Comparison of Conventional and Electric Vehicles Based on the State’s Electricity Mix<sup>1</sup>

## Traditional Approaches

Historically, studies on bidirectional charging have focused on its potential to improve energy system efficiency and reliability and also reduce emissions through smarter load management. This means using EVs and battery energy storage systems not just as consumers of electricity but as flexible energy resources that can store and return power to the grid when it's most needed. For example, during times of high electricity demand—often referred to as “peak periods”—parked EVs connected to a bidirectional charger can discharge stored energy back to the grid to help meet demand, reducing the need to activate peaker plants. Peaker plants are typically fossil fuel-powered facilities that are expensive to operate and emit high levels of pollutants. By discharging stored renewable power and eliminating the need to turn on peaker plants to generate additional energy, bidirectional charging can help lower energy costs, reduce GHG emissions and improve overall grid reliability.

Many researchers are also interested in how bidirectional charging can help mitigate the “duck curve,” a phenomenon in which solar energy generation peaks during the day but demand for electricity spikes in the evening (Figure 2). Without effective energy storage and redistribution, this mismatch can lead to over-generation during the day and shortages at night. While implementors continue to examine specific use cases, bidirectional charging technology has the potential to store excess solar energy when it's produced and release it back to the grid when customers need more energy, making the grid more stable and sustainable.

Over time, research on bidirectional charging research has evolved. Early research mostly studied whether the technology could work and how much money or energy it might save in different situations. However, more recent analyses have begun to explore broader impacts, including environmental and social outcomes. Despite this shift, there remains a significant gap in understanding how bidirectional charging affects customers directly. In particular, the implications for GHG emissions and public health have become a major focus only within the last few years.

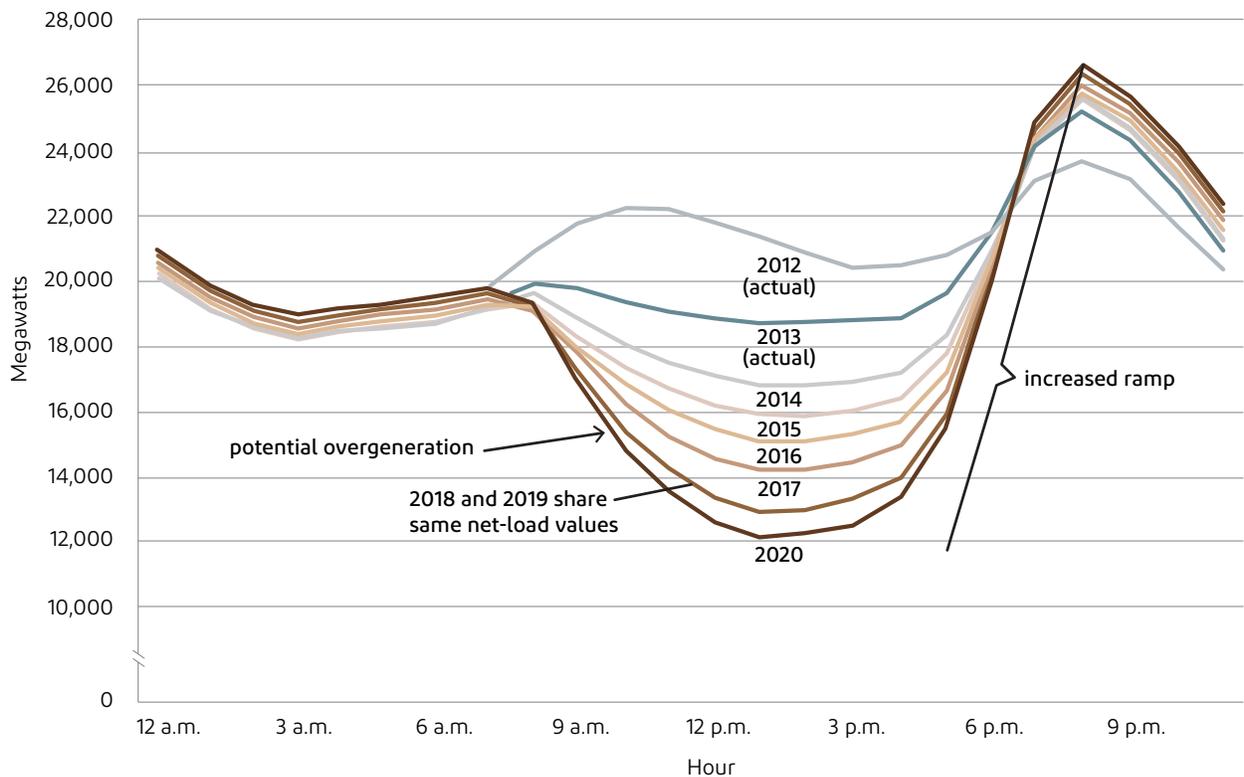


Figure 2. Duck Curve Illustration of Net Load (March 31)<sup>2</sup>

# ComEd Bidirectional Charging Study Framework

While traditional research has focused primarily on how this technology affects the electric grid—such as improving energy efficiency and reducing emissions—ComEd has commissioned a study that expands the lens to include the environmental and social impacts on customers and communities. This broader approach reflects a growing recognition that energy technologies must be evaluated not only for their technical performance but also for how they affect people’s lives.

To guide this analysis, ComEd has identified four key impact categories: climate change, air quality, resource efficiency and human health. While traditional studies have largely focused on resource efficiency, the ComEd framework gives greater attention to the other three—areas that more directly affect community well-being. While resource efficiency remains important, ComEd is exploring how it intersects with other impacts to provide a more complete picture.

Impact Category	Traditional	ComEd Study	Current Conditions	Importance
Climate Change		Y	Transportation is the leading contributor to statewide GHG emissions, making up 25.86% of Illinois GHG emissions or 60.06 MMTCO <sub>2</sub> e in 2021. <sup>3</sup>	Supports statewide emission reduction goals to reduce GHG emissions by 50%–52% below 2005 levels by 2030 and to reach net zero within 25 years (or by 2050) <sup>4</sup>
Air Quality		Y	Fossil fuel peaker plants, typically located in or near disadvantaged communities, emit pollutants such as nitrous oxide (N <sub>2</sub> O), sulfur dioxide (SO <sub>2</sub> ) and fine particulate matter (PM2.5) while in operation. <sup>5</sup>	Enhances local air quality and public health
Resource Efficiency	Y	Y	Expensive fossil fuel peaker plants are called upon to operate in high-demand periods.	Promotes cost-effective and sustainable resource use
Human Health		Y	Exposure to air pollutants such as N <sub>2</sub> O, SO <sub>2</sub> and PM2.5 can contribute to respiratory and cardiovascular problems. <sup>6</sup>	Reduces exposure to harmful pollutants

The study will leverage a combination of advanced analytical tools to assess these impacts. For environmental outcomes, ComEd is applying Prospective Life Cycle Assessment, a method that estimates the future environmental effects of technologies like bidirectional charging over their lifetime. This is paired with Multi-Criteria Decision Analysis, which helps weigh different environmental factors—such as carbon emissions, air pollutants and energy use—to support informed decision-making.

On the social side, ComEd is using Geographic Information System-based spatial analysis to identify communities that stand to benefit most from bidirectional charging. This mapping approach allows researchers to pinpoint areas with high potential for positive social impacts, such as improved air quality or reduced exposure to harmful pollutants.

To assess health-related impacts, ComEd is using Monte Carlo simulations—a forecasting technique that models a range of possible outcomes based on different assumptions. By applying pessimistic, moderate and optimistic scenarios over a 15-year horizon, the study aims to capture the full spectrum of potential health benefits and risks associated with bidirectional charging programs.

The environmental impacts being evaluated include reductions in carbon dioxide equivalent (CO<sub>2</sub>e), sulfur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>) and fine particulate matter (PM2.5)—all of which are linked to climate change and respiratory health issues. On the social side, the study may examine a range of factors depending on interim results. Factors may include human health indicators, job creation, access to jobs and more.

Impact Category	Methodology	Example Indicator
Global Warming Potential	<a href="#">IPCC AR6-100 or AR6-20</a>	kg CO <sub>2</sub> eq/kWh
Air Quality Impacts (NO <sub>x</sub> , SO <sub>2</sub> , PM2.5)	<a href="#">EPA TRACI 2.2</a>	Acidification Air (kg SO <sub>2</sub> eq/kg substance)
Resource Efficiency (raw material savings)	Material intensity reduction analysis	kg or % material savings
Human Health (cancer)	<a href="#">EPA TRACI 2.2</a>	Human Health Particulate Air (PM2.5 eq/kg substance)

Through this comprehensive framework, ComEd seeks to better understand how bidirectional charging can deliver meaningful benefits to customers—not just in terms of cleaner energy, but also in terms of healthier communities and greater equity.

While most existing research that leverages this combined methodology to analyze bidirectional charging has looked at impacts on a global or national scale, ComEd is one of the first to apply this complex combined methodology to study impacts within a localized geographic area.<sup>7</sup> By combining energy modeling, life-cycle analysis and spatial mapping to understand how bidirectional charging affects individual communities, this method helps identify where the benefits—like cleaner air and better energy resilience—are likely to be felt most. Few studies have applied this kind of integrated approach to the community level, making the ComEd planned study an important contribution to the field while also leveraging cutting-edge analytical tools to best understand a range of potential customer impacts.

## What’s Next?

ComEd is conducting a study to explore the environmental and social impacts of bidirectional charging technology. Insights from this study may help ComEd shape future programs and investments by examining how bidirectional charging technologies could best deliver benefits to all customers—whether through cleaner air; more reliable power; or support for [low-income](#) households, [Restore, Reinvest, and Renew](#) communities and [environmental justice](#) communities—jointly referred to as “Select Customers.” The findings may also guide how ComEd engages with communities and customers to expand access to these emerging solutions.

## Want to Learn More?

Learn more about bidirectional charging at the [Backup Power Capabilities—ComEd Customer Innovation](#) webpage. Visit the ComEd [Beneficial Electrification Plan Pilots](#) webpage and [V2G Pilot Program](#) webpage to learn how you can participate or benefit from upcoming initiatives. For additional information on ComEd available resources and programs, please visit [ComEd.com/EV](#).

<sup>1</sup> U.S. Department of Energy. (n.d.). *Emissions from Electric Vehicles*. Alternative Fuels Data Center. <https://afdc.energy.gov/vehicles/electric-emissions>

<sup>2</sup> U.S. Department of Energy. (n.d.). *Confronting the Duck Curve: How to Address Over-Generation of Solar Energy*. Office of Energy Efficiency & Renewable Energy. <https://www.energy.gov/eere/articles/confronting-duck-curve-how-address-over-generation-solar-energy>

<sup>3</sup> U.S. Environmental Protection Agency. (2024, March 1). *State of Illinois Priority Climate Action Plan*. <https://www.epa.gov/system/files/documents/2024-03/illinois-priority-climate-action-plan.pdf>

<sup>4</sup> State of Illinois. (2019, January 23). *Executive Order 2019-06: Joining the U.S. Climate Alliance*. <https://www.illinois.gov/content/dam/soi/en/web/illinois/documents/government/executive-orders/2019/19626-executive-order-2019-06.pdf>

<sup>5</sup> Clean Energy Group. (2025). *Peaker Power Plant Mapping Tool*. <https://www.cleaneenergy.org/initiatives/phase-out-peakers/maps/>

<sup>6</sup> U.S. Government Accountability Office. (2024, May 21). *Electricity: Information on Peak Demand Power Plants* (GAO-24-106145). <https://www.gao.gov/products/gao-24-106145>

<sup>7</sup> Pulkit Kumar et al. “A Comprehensive Review of Vehicle-to-Grid Integration in Electric Vehicles: Powering the Future,” *Energy Conversion and Management*: X. 25 (2025): Article 100864, <https://doi.org/10.1016/j.ecmx.2024.100864>