How Self-Consumption Can Contribute to the Next Phase of Electrification

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Abstract

This article examines how self-consumption can support the next phase of electrification by complementing centralized supply, easing peaks, and stabilizing electricity prices. In addition, when paired with electric mobility, it offers a practical though partial route to meet rising demand more sustainably and strengthen progress toward decarbonization.

Introduction

The world is moving fast into the "Age of Electricity". Over the last decade, electricity use grew at twice the pace of total energy demand. From now until 2035, it is set to grow six times faster, driven by the uptake of electric vehicles (EVs), air conditioning, chips, artificial intelligence, and other electrified end uses[1]. This is not a marginal shift, it is the demand side reality of the next stage of the transition.

That acceleration raises climate concerns. Energy is responsible for more than three-quarters of global greenhouse gas emissions (GHG), primarily from the burning of fossil fuels. Current carbon dioxide (CO_2) trends still run above what is required to avoid the worst impacts of climate change. The transition will only succeed if electrification advances with a rapid decarbonization of supply. Renewable energy is pointed out as one solution to the growing energy challenges (Asif & Muneer, 2007). Renewable resources such as solar, wind, biomass, waves, and tidal energy are abundant, inexhaustible, and environmentally friendly.

However, a key question remains. Can available renewable resources and the networks that deliver them keep pace with such rapid growth in electricity use? Self-consumption is a possible way to support and complement that effort. Self-consumption means generating renewable power where it is used and consuming it on-site (Gautier et al., 2019). It is a way of decentralizing energy production. In practice, there are two main forms. First, all electricity is used or stored at the premises, so nothing flows back to the grid. Second, any surplus can be exported and paid for, depending on national rules and local grid capacity. This second form introduces the prosumer, a renewable self-consumer who generates, consumes, stores, and sells power, taking part in the market (Gallego-Castillo et al., 2021). In both cases, households and firms move from passive users to active participants in the energy transition. As a result, self-consumption can democratize access to clean energy by allowing households and firms to produce part of what they use, supporting a more inclusive and fair energy transition.

Centralization vs decentralization of production

Large central renewable plants remain essential for scale and for cutting emissions. They have delivered real gains, yet they often need heavy new infrastructure and face losses when production and use are not aligned (Kabeyi & Olanrewaju, 2025). Decentralized power systems can substitute for central supply, where generators are placed closer to demand, which mitigates transmission losses. In these settings, solar installations are often more economically viable (Javid et al., 2021). Decentralization also changes who participates. Households and communities can generate and store electricity and share surplus within local schemes. Consumers move from passive price takers to active price makers and engage directly with energy markets (Hasan & Yousefi, 2023; Mansouri et al., 2022). The system becomes more integrated, vertically from supply through to demand, and horizontally across power, heat, and gas. The result is a system that is more secure and more competitive, where exposure to supply shocks is reduced.

Self-consumption is often realized through rooftop solar photovoltaics (PV) installed on residential buildings. It has a clear impact on household energy use, from domestic tasks and lighting to water heating and charging EVs. This local clean generation helps meet growing electricity demand, reduces reliance on the grid during peak periods, and supports greater energy independence. When combined with energy storage, the contribution of solar energy to the resilience of the energy system becomes even more powerful. Batteries allow solar systems to supply electricity even at night or during grid disruptions.

Taking these factors into account, increasing self-consumption is a vital step toward meeting rising electricity demand. Outcomes will not follow from infrastructure alone. Progress requires innovation in technology and in policy that aligns local generation with use and supports decarbonization. It also requires a clear view of the drivers of adoption for households and firms. Because individuals are at the center of these choices, understanding what lowers barriers and lifts uptake is essential.

Price dynamics and market design

Self-consumption can potentially influence electricity price stability by shifting demand toward on-site

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renewable generation and storage. Using data from a pilot with 39 households, van der Stelt et al. (2018) show that household and community energy storage combined with demand-side management can significantly increase PV self-consumption and reduce grid imbalance between supply and demand. By aligning local generation with household use, these systems lower reliance on grid imports during peak hours, which reduces exposure to high tariffs and supports a smoother load profile. At a broader scale, peer-to-peer trading mechanisms can channel surplus self-generated electricity to nearby consumers, creating local market equilibria that benefit both prosumers and consumers. Indeed, An et al. (2022) demonstrate that by defining optimal trading prices between consumers and prosumers, peer-to-peer exchanges can provide competitive pricing that improves the match of local supply and demand, contributing to more efficient and stable energy markets.

At the system level, self-consumption's impact on household electricity prices depends strongly on regulatory design. Fett et al. (2019) find that in Germany, less than one-third of the potential increase in household electricity prices is attributable to self-consumption itself, while feed-in remuneration and the reallocation of grid levies play a larger role. Their simulations show that tariff structures (whether based on consumption, capacity, or fixed charges) determine whether self-consumption moderates or amplifies overall price pressures. Importantly, they highlight that policy choices, such as self-consumption charge or revised allocation of grid costs, can limit price increases while still encouraging adoption of rooftop PV and storage. Thus, while self-consumption can contribute to stabilizing prices at both the household and market level, its effectiveness depends on supportive regulatory and market frameworks.

Self-consumption and transport decarbonization

Transport accounts for about 15 percent of total GHG emissions and roughly 23 percent of global energy-related CO_2[2]. Decarbonizing this sector is unavoidable, and electric mobility is the central pathway because it replaces fossil fuels with electricity. Yet climate gain is conditional. An EV charged with electricity produced from fossil sources delivers only part of the environmental benefit and generates new concerns regarding electrification.

Self-consumption can address both concerns. It lowers emissions and helps manage the extra electricity required by transport. When households or firms pair an EV with PV installed on-site, the vehicle is charged with clean power produced where it is used. Charging from on-site generation lowers the carbon intensity of every kilometer driven (Khan et al., 2018). In practical terms, this new energy demand is met with a clean supply. Decentralized renewable energy can therefore not only reduce emissions from household energy use, for example, air conditioning, but also decrease the emissions associated with charging, which accelerates the decarbonization of transport.

In terms of demand response capacity, solar-powered EV charging can reduce reliance on the traditional grid and help avoid overloads at peak times. Local generation shortens the delivery path of electricity and can lower transmission losses, which improves grid performance and strengthens energy security (Maghami, 2025). Yet, this magnitude is context dependent and rests on sizing, timing, and operation, including the alignment of charging with daytime PV output. As EV numbers grow, higher PV penetration helps to moderate the added stress by matching local generation with local load.

The interaction extends beyond technological integration. Self-consumption can impact the adoption dynamics of road transport choices. There is evidence that decentralized renewable energy can accelerate EV uptake. Early PV adopters are more likely to consider EV because both purchases fit within a broader home plan that reshapes electricity use and can influence perceived home value. In practice, PV and EV can act as complements, both in purchase decisions and in day-to-day operation (Rai et al., 2016).

Yet, one should note that electric mobility will raise electricity demand. Self-consumption does not remove that fact. It can offset part of the increase with the new cleaning generation created by adopters themselves. This is why a co-diffusion lens matters. PV can raise EV adoption and, at the same time, supply the electricity those vehicles require. Importantly, there is a lack of empirical analysis that jointly examines EV and self-consumption adoption within a spatial and temporal framework (Wen et al., 2023). These technologies have synergies, and consumers play a growing role in sustainable technology uptake. However, identification of the relationships and spillovers is still limited. A co-adoption perspective is needed that considers integration in the electricity network and the way adoption diffuses across space.

Policymakers and researchers should further explore this co-diffusion pathway. First, understanding which factors drive joint adoption and how local conditions shape outcomes, then designing interventions that recognize households and firms as system actors in the transition. It is also necessary to establish the direction of causality and to assess whether self-consumption is a causal factor or whether simultaneity is present. If PV and EV adoption move together mainly because of socio-economic drivers, preferences, or local infrastructure, support for pairing has low additionality. Clear identification helps design policies that foster co-adoption, manage the rise in electricity demand from EVs, and decarbonize that extra need for energy at the least cost. In the "Age of Electricity", self-consumption paired with electric mobility presents a practical route to decarbonize demand partially while meeting it.

Conclusion

Electricity demand is set to rise sharply, raising concerns about costs, infrastructure, and the ability to decarbonize supply fast enough. Self-consumption offers a practical complement to centralized generation by easing stress during peak hours, moderating household exposure to high tariffs, and channeling local surplus through peer-to-peer exchanges that foster more competitive pricing. Self-consumption also supports progress in road transport. Electric mobility remains central to decarbonization, but its benefits depend on the carbon intensity of electricity and its added load on networks. Pairing EVs with on-site renewables lowers the carbon intensity of charging, reduces local stress at peak hours, and can accelerate adoption when households view PV and EVs as complementary. The next step is to examine these interactions in practice and to clarify the drivers of co-adoption across households and firms. With robust evidence, policy can encourage this pathway as a pragmatic contribution to meeting rising demand while advancing decarbonization at lower cost. Co-adoption is not a panacea, but when supported by the right conditions, it can play a meaningful role in shaping a more resilient and sustainable electricity system.

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Notes

[1] Source: IEA, https://www.iea.org/spotlights/the-world-is-moving-at-speed-into-the-age-of-electricity. Accessed 28 August 2025.

[2] Source: IPCC, https://www.ipcc.ch/report/ar6/wg3/chapter/chapter-10/. Accessed 29 August 2025.