Predicting the implications of transforming public transport depots in China into energy hubs

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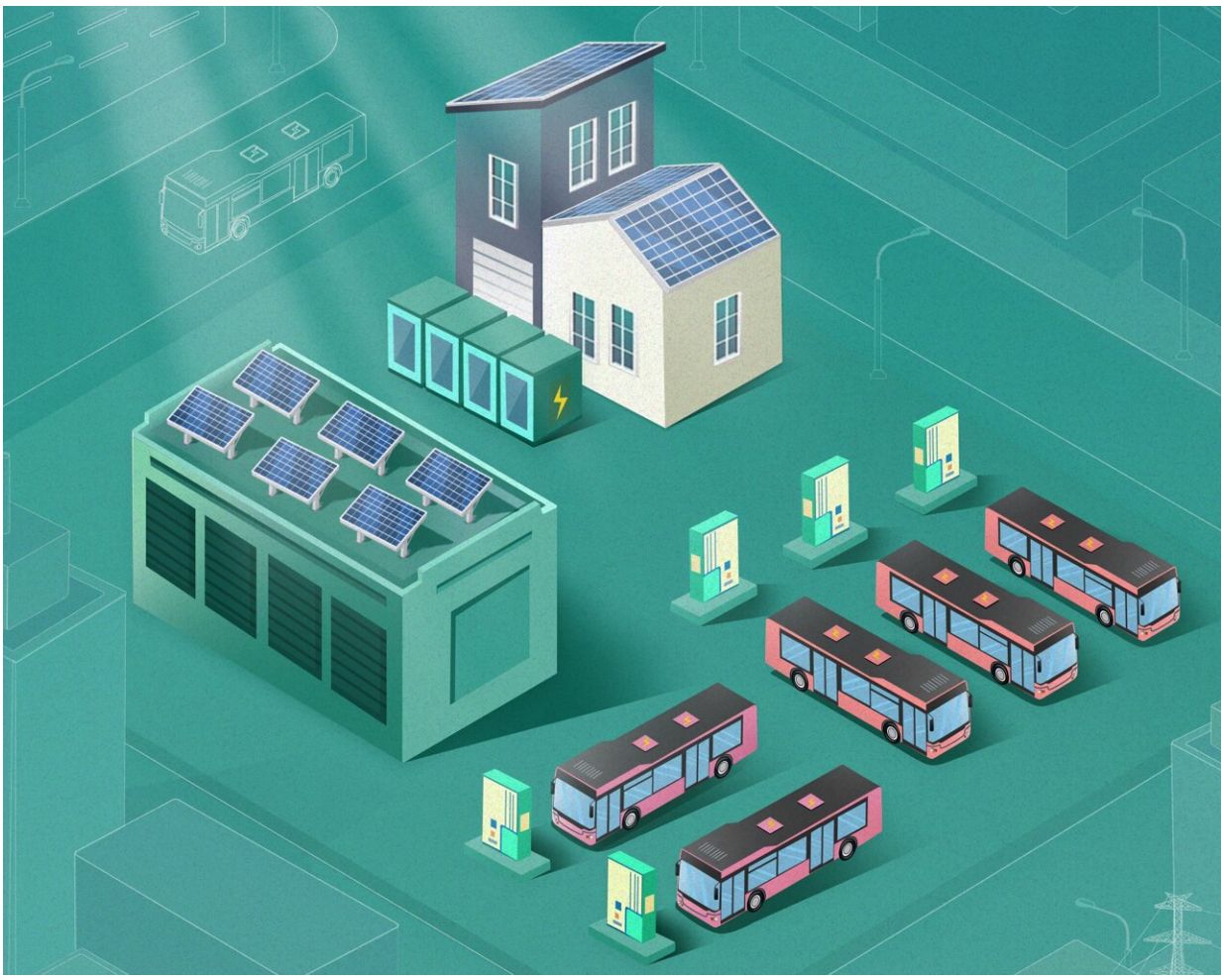

Credit: Liu et al

To reduce carbon emissions and mitigate climate change on Earth, governments and companies worldwide have been investing in the electrification of both public transport and private vehicles. China is among the countries that started exploring the electrification of transportation, starting with the introduction of electric buses (EBs).

Despite its predicted advantages for reducing carbon emissions, transitioning from fuel-based to electric public transport could put a significant strain on electricity grids, thus the effects of this transition should first be carefully considered.

In a recent paper published in *Nature Energy*, a research team at Beihang University and other institutes set out to investigate the possible implications of transforming public transport depots in China into renewable energy hubs.

"In recent years, we have observed rapid advancements in transportation electrification as a strategy to combat climate change," Xiaolei Ma, co-author of the paper, told Tech Xplore.

"For instance, according to the International Energy Agency, electric car sales neared 14 million in 2023, bringing the total number of electric cars on the roads worldwide to 40 million. However, the surge in charging demands poses new challenges for power grids, such as increased operational and expansion costs, as well as the risk of overloads."

The positive effects of electrifying public transport will ultimately be limited if this transition is not accompanied by a shift toward renewable energy production. While some past studies have investigated the possibility of integrating photovoltaics (PVs) and electric vehicle charging stations, the implications of this specifically following the introduction of EBs in urban environments have not yet been thoroughly

explored.

"Our primary objective was to present a universal framework that combines data-driven and model-driven approaches to provide insights for the widespread adoption of solar PV and energy storage within urban public transport networks," Ma said. "The universal framework we devised combines data-driven and model-driven approaches."

As part of their study, Ma and his colleagues specifically set out to predict the implications of a possible transition from fuel-based buses to EBs in Beijing. To do this, they analyzed data collected across Beijing's entire public transport network, including GPS trajectories, vehicle information, and bus depot details. Their analyses also considered the recorded weather conditions and solar irradiance in Beijing in recent years.

"Our study simulates a baseline scenario where EBs replace all other fuel types within Beijing's bus fleet," Ma explained. "The complete fleet electrification is simulated by estimating EB energy consumption, optimizing EB battery capacities, and optimizing EB charging schedules with perfect foresight.

"To transform bus depots into energy hubs, we first estimate solar PV generation. We then maximize the economic profits for solar PV and energy storage by optimizing the installed capacity of solar PV, energy storage capacity, bus charging schedules, and the usage of solar PV and energy storage across different market scenarios."

The researchers' case study spans across a 25-year period in the future, starting from 2050. Their analyses were aimed at predicting how the conversion of public transport depots across Beijing into renewable energy hubs, beginning in 2021, would affect carbon emissions.

"The case study shows that solar photovoltaic reduces the grid's net charging load by 23% during electricity generation periods and lowers the net charging peak load by 8.6%," Ma said. "Integrating energy storage amplifies these reductions to 28% and 37.4%, respectively.

"Whereas unsubsidized solar photovoltaic yields profit 64% above costs, adding battery storage cuts profits to 31% despite offering grid benefits. Negative marginal abatement gains for CO_2 emissions underscore the economic sustainability."

Overall, the findings of the analyses run by Ma and his colleagues suggest that electrifying public transport in Beijing by converting transport depots into energy hubs would be feasible and effective in reducing carbon emissions.

In the future, this team's work could inspire other researchers and policymakers both in China and other countries to start devising strategies aimed at mitigating the vulnerability of electricity grids to support the effective deployment of EBs.

"Our findings could also catalyze policy measures to expedite the deployment of solar PV and energy storage at other large-scale energy consumption centers, such as public EV charging stations and railway stations," Ma added.

"Our future work will focus on the long-term operational durability of the integrated transportation-energy systems and consider external factors such as energy market dynamics and advancements in energy storage technologies."

More information: Xiaohan Liu et al, Transforming public transport depots into profitable energy hubs, *Nature Energy* (2024). DOI: 10.1038/s41560-024-01580-0