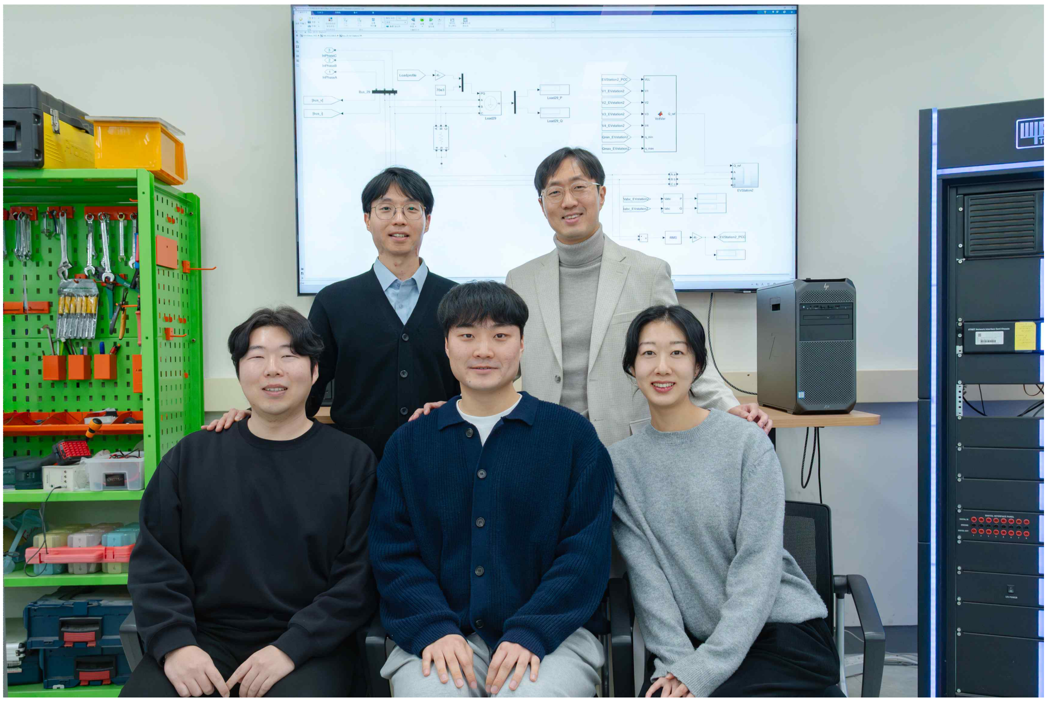
GIST develops 'virtual battery' technology to bundle thousands of EVs into a single power resource for trading

- Professor Yun-Su Kim's team from the Department of Electrical Engineering and Computer Science develops swarm control technology that integrates electric vehicles into a 'virtual battery' without sensitive data, accurately implementing power market bidding and individual vehicle-level charging and discharging

- Applicable to scales of up to 5,000 vehicles… Up to 14.9% cost reduction, raising expectations for V2G commercialization

*- Published in **eTransportation**, the world's most prestigious academic journal in the field of transportation science and technology*



▲ (From top left) Department of Electrical Engineering and Computer Science PhD student Woan-Ho Park, Professor Yunsu Kim, and PhD students Seong-Hyeok Ko, Joonbyeok Hwang, and Jin Sol Hwang

Gwangju Institute of Science and Technology (GIST, President Kichul Lim) announced that a research team led by Professor Yun-Su Kim of the Department of Electrical Engineering and Computer Science has developed a "Robust Virtual Battery" model that enables multiple electric vehicles (EVs) to be bundled together and utilized as a single "battery," even allowing for actual power market trading.

This technology overcomes the limitations of existing technologies by ensuring that power management is possible without knowing the battery status or capacity of individual vehicles, and by guaranteeing that established power plans can be accurately distributed and executed across each vehicle.

Accordingly, this is expected to accelerate the commercialization of vehicle to grid (V2G) technology, which connects electric vehicles to the power grid.

> ** vehicle to grid (V2G): A technology that connects electric vehicles to the power grid to supply surplus power from the EV battery to the grid or to charge from the grid when necessary.*

With the recent surge in the adoption of electric vehicles (EVs), they are garnering attention not merely as a means of transportation, but as "mobile power plants"—or distributed energy resources (DER)*—that store and supply electricity.

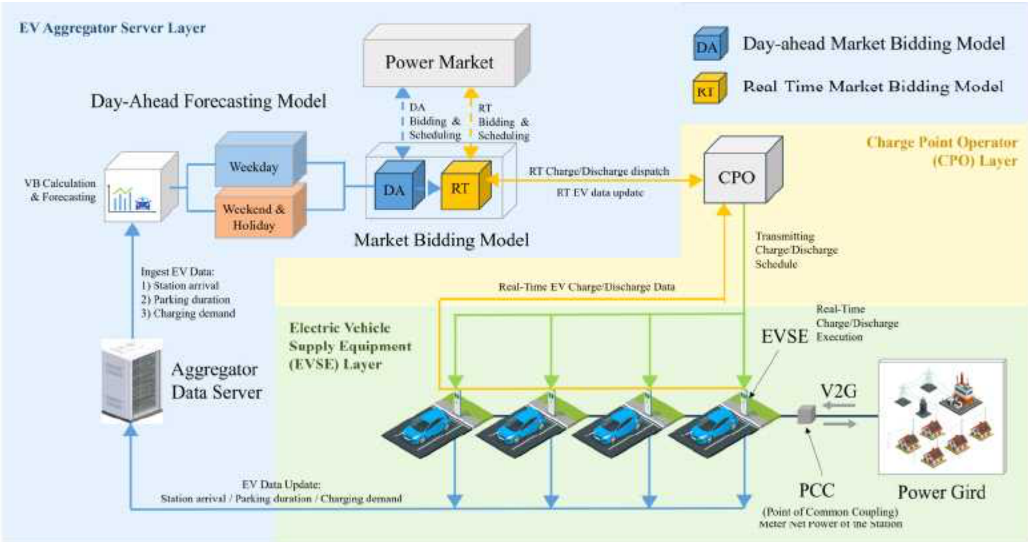
However, unlike solar power or power plants, EVs have limitations in that they are highly mobile and battery capacities and conditions vary from vehicle to vehicle, making it difficult to operate multiple units stably as a single unit.

In particular, existing technology had a problem where the plan and actual operation did not match because errors occurred in the process of dividing and applying it to individual vehicles even when an overall power plan was established (a problem where the 'disaggregation* feasibility' of actually dividing and executing it to individual vehicles was not secured).

Furthermore, concerns regarding the leakage of personal information have been raised due to the need to collect data on battery status and usage for each vehicle.

> ** distributed energy resource (DER): Refers to small-scale energy resources that produce, store, or utilize energy. Representative examples include solar power, wind power generation, Energy Storage Systems (ESS), and Electric Vehicles (EVs).*

> ** disaggregation: This is the process of dividing the overall power plan of the integrated virtual battery into individual commands that each electric vehicle can actually charge and discharge. During this process, allocation is performed by considering each vehicle's available charging time, connection status, and constraints to ensure that the overall plan aligns with actual operation.*

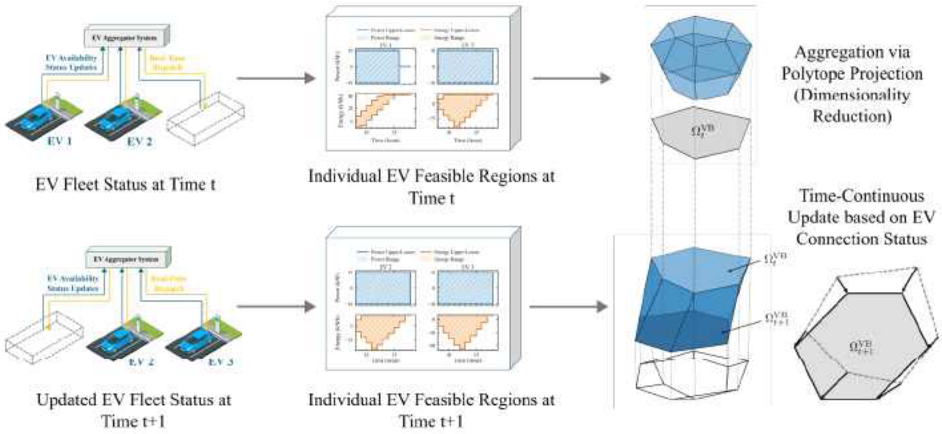


▲ ***An integrated virtual battery framework for electric vehicles to participate in the power market. This is a process in which an integrated electric vehicle management system exchanges information in real-time with charging stations and chargers to determine the timing of power transactions.***

To address this issue, the research team proposed a mathematical model that groups multiple electric vehicles into a single set and represents them as a 'virtual battery (VB).'

This model calculates the range of power storage and supply at once by treating the entire system as one large battery, rather than individually calculating the complex battery states of each vehicle.

This significantly reduces the number of variables that need to be calculated, allowing the potential power supply to be determined within a short timeframe and enabling power management using only minimal information, such as the target charge amount and charger connection time. Furthermore, it overcomes the limitations of existing methods by mathematically proving that the overall power plan can be implemented without error through the actual charging and discharging of individual electric vehicles.



▲ ***A real-time virtual battery configuration diagram linking individual electric vehicles into a single unit. It visualizes the process of combining the spare battery space of multiple electric vehicles into a single large "virtual battery" that changes size over time.***

This virtual battery configuration can also be utilized in the actual power market.

By linking multiple electric vehicles into a single unit, it can participate in both the advance and real-time power markets, automatically establishing supply and storage strategies based on power demand and prices.

Through this, precise power supply and demand control and market response become possible, such as supplying electricity during high-demand hours and utilizing storage when power is low. The research team conducted power market simulations based on data from thousands of electric vehicles over an eight-month period, revealing that operating costs could be reduced by a minimum of 8.8% to a maximum of 14.9% compared to existing methods.

Furthermore, the study demonstrated the feasibility and scalability of the system for actual power grid application by enabling participation in the power market with rapid computational speeds, even for large-scale EV groups of 5,000 vehicles.

In particular, the study confirmed that the theoretical model can be accurately implemented in real-world environments, noting that the discrepancy between the overall power plan and actual vehicle operation was very small.

Professor Yun-Su Kim stated, "Through this research, we have laid the foundation for utilizing large-scale electric vehicles as a single, reliable power resource." He added, "By reducing the gap between market planning and actual individual EV operation, this will accelerate the commercialization of vehicle to grid (V2G) technology and contribute to enhancing the flexibility and stability of the power grid."

This research, supervised by Professor Yun-Su Kim of the Department of Electrical Engineering and Computer Science at GIST and conducted by doctoral students Woan-Ho Park, Jin Sol Hwang, Seong-Hyeok Ko, and Joonbyeok Hwang, was supported by Hyundai Motor Group.

The research results — Robust virtual battery optimization for EV fleet aggregation: Operational feasibility in day-ahead and real-time markets — were published online on March 9, 2026, in *eTransportation*, the world's most prestigious academic journal in the field of transportation science and technology (ranked 1st in the Journal Critical Impact Factor).

Meanwhile, GIST stated that this research achievement was considered to have both academic significance and potential for industrial application, and that discussions regarding technology transfer can be conducted through the Technology Commercialization Office (hgmoon@gist.ac.kr).