

# Scientists showcase the potential of demand response in reducing carbon dioxide emissions

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## Predicting Grid User Behavior for Cheaper Electricity and Lower CO<sub>2</sub> Emissions

In electric grids, there is usually a mismatch between power supply and demand

**Customer side**  
Variable power consumption  
Renewable energy generation

**Provider side**  
Over-dimensioned only to meet short surges in demand  
⚠️ Higher CO<sub>2</sub> emissions

Demand response (DR) programs incentivize users to avoid using appliances during peak hours by adjusting electricity price according to demand

How can we accurately estimate the potential benefits of DR programs? ?

### Novel framework for estimating optimal DR potential

**Resident behavior detection model**

- ✓ AI-based model that uses real sub-metering data
- ✓ Predicts house occupancy and power consumption

**Behavior data**

**Renewable energy forecasting model**

- ✓ Estimates solar power generation (Generation forecasting data)

**Optimal DR management model**

- ✓ Determines optimal control of appliances (air conditioning, light dimmers, electric vehicle chargers)

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**Framework tested through simulations (Denver, Colorado)**

Considers limits on user discomfort

- ➔ Lower electricity prices
- ➔ Lower CO<sub>2</sub> emissions (7.7 metric tons less per year per household)
- ➔ Avoids over-dimensioning power plants

The proposed framework will help showcase the potential of demand response programs

Resident Behavior Detection Model for Environment Responsive Demand Response  
Baek et al. (2021)  
IEEE Transactions on Smart Grid | 10.1109/TSG.2021.3074955

Gwangju Institute of Science and Technology

New artificial intelligence-based framework estimates the demand response potential in improving power consumption and reducing carbon footprint. Credit: Gwangju Institute of Science and Technology (GIST)

Electrical grids are almost always over-dimensioned to meet short surges in energy demand. Put simply, power stations need to have an excess

number of generators only to be able to provide electricity during peak hours. This mismatch between power supply and demand and the inefficient operation of power stations lead to higher carbon dioxide (CO<sub>2</sub>) emissions. Moreover, distributed energy resources such as rooftop solar panels, which are becoming popular, only increases the supply–demand mismatch.

Fortunately, [communication technologies](#) have unlocked a clever strategy to address this problem: Demand response (DR) programs. In this scheme, users are incentivized to use less electricity during peak hours by reducing the electricity price outside of projected peak hours and informing consumers about the prices in advance. Furthermore, they can be integrated with the management of distributed [energy resources](#) to take load off the grid whenever necessary.

However, few studies have focused on estimating the potential benefits of DR programs using real-world user behavior data. To this end, a team of scientists from the Gwangju Institute of Science and Technology (GIST) in Korea have developed a novel artificial intelligence (AI)-based approach that analyzes and extracts the behavior of grid users in terms of energy consumption per household. In their paper, which was published in *IEEE Transactions on Smart Grid* in September 2021, the authors describe a data-driven framework that estimates the optimal DR management for each household, taking into account user appliances and behavior patterns as well as the predicted generation of energy from distributed sources.

The researchers tested their model through simulations using data from the real world. "In our simulations, we considered and quantified the level of user discomfort related to the dynamics of home appliances in each household and then used it to estimate the optimal DR potential," explains Prof. Jinho Kim, who headed the study. The team also calculated the potential contributions of DR programs in terms of

reduction in CO<sub>2</sub> emissions and the cost of managing coal-powered generators.

Overall, this study showcases how AI can be leveraged to improve our electricity consumption, realizing both lower prices and a smaller carbon footprint. "Our results show that big data-based analysis can be used to convert information about household [energy demand](#) into large-scale integrated resources," highlights Prof. Kim. "We believe this technology can be further expanded to improve the efficiency and coupling of other sectors, including water, heat, gas, and electric vehicles sectors."

We certainly hope his vision is realized soon.

**More information:** Keon Baek et al, Resident Behavior Detection Model for Environment Responsive Demand Response, *IEEE Transactions on Smart Grid* (2021). [DOI: 10.1109/TSG.2021.3074955](https://doi.org/10.1109/TSG.2021.3074955)

Provided by GIST (Gwangju Institute of Science and Technology)

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