A new optimization model could bring higher solar-power integration

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Solar power has been established as a source of mainstream power generation across the globe. With numerous installations of photovoltaic (PV) systems for residential homes at or near the distribution site, there is a challenge to balance supply and demand to make these intermittent energy sources reliable. Too little sun means low solar generation and poor PV system efficiency. Excessive generation can jeopardize normal operation of electricity networks.

Demand response (DR) is one promising way to increase operational flexibility and energy efficiency. However, little research has been conducted on a large scale to quantify the benefits of DR in residential communities.

To fill this gap, researchers at the Universiti Teknikal Malaysia Melaka (UTeM) in Malaysia incorporated DR scenarios in simulated comprehensive network case studies based on 100 urban low-voltage network samples. Their research showed the significance that DR can have on network operations with different levels of PV penetration. The researchers report their findings this week in the *Journal of Renewable and Sustainable Energy*.

"We highlight [the] importance of the paradigm shift from the traditional 'generation to follow demand' to 'demand to follow generation' in renewable-rich energy mix scenarios," said Chin Kim Gan, UTeM associate professor and co-author of the paper.

DR initiatives, through the use of advanced building controls or manually reducing power during hours of peak demand, encourage consumers to reduce their electricity use in exchange for lower electric bills and other incentives.

Three case studies were developed to investigate how various DR scenarios would affect network performance. Malaysia was chosen as the location because of its consistent tropical weather pattern, with sunny days about 50 percent of the time. Different degrees of DR participation at varying levels of PV penetrations were considered for each case study for a total of 10,000 network analyses performed for each case study.

In the first case study, consumers responded to their own demand profile without PV generation (e.g., they delayed using their washing machine until later in the evening). In the second, participants responded to their own PV-generation profiles. For them, DR consisted of load shifting (e.g., taking a hot shower in the morning when local solar power is available).

In the last case study, consumers considered both their own demand and PV generation profiles simultaneously (e.g., they decreased their use of air conditioning after receiving a signal from a central DR optimizer).

DR applications with 100 percent PV penetration (in the third case study) provided the best use of solar energy and influenced network performance the most, reducing energy consumption at peak demand by 32 percent, reducing network losses by 42 percent and improving network utilization by 12 percent.

Gan said that these benefits would be even greater with the integration of energy storage systems and other smart-grid technologies, such as building sensors and smart meters.

"Although demand response provides notable benefits to the network, it cannot by itself fully unleash benefits of intermittent renewable energy, particularly when the output of generation is higher than the demand," Gan said. "Demand response, therefore, coupled with the integration of energy storage and energy management systems would likely maximize the benefits of renewable energy in future energy systems."

More information: "Assessment of distribution networks performance considering residential photovoltaic systems with demand response applications," *Journal of Renewable and Sustainable Energy* (2017). DOI: 10.1063/1.4993048

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