Virtual power plant 270 kWh

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For more than a century, the prevalent image of power plants has been characterized by towering smokestacks, endless coal trains, and loud spinning turbines. But the plants powering our future will look radically different--in fact, many may not have a physical form at all. Welcome to the era of virtual power plants (VPPs).

A virtual power plant is a system of distributed energy resources--like rooftop solar panels, electric vehicle chargers, and smart water heaters--that work together to balance energy supply and demand on a large scale. They are usually run by local utility companies who oversee this balancing act.

A VPP is a way of "stitching together" a portfolio of resources, says Rudy Shankar, director of Lehigh University"s Energy Systems Engineering, that can help the grid respond to high energy demand while reducing the energy system"s carbon footprint.

The "virtual" nature of VPPs comes from its lack of a central physical facility, like a traditional coal or gas plant. By generating electricity and balancing the energy load, the aggregated batteries and solar panels provide many of the functions of conventional power plants.

Kevin Brehm, a manager at Rocky Mountain Institute who focuses on carbon-free electricity, says comparing VPPs to traditional plants is a "helpful analogy," but VPPs "do certain things differently and therefore can provide services that traditional power plants can"t."

One significant difference is VPPs" ability to shape consumers" energy use in real time. Unlike conventional power plants, VPPs can communicate with distributed energy resources and allow grid operators to control the demand from end users.

For example, smart thermostats linked to air conditioning units can adjust home temperatures and manage how much electricity the units consume. On hot summer days these thermostats can pre-cool homes before peak hours, when air conditioning usage surges. Staggering cooling times can help prevent abrupt demand hikes that might overwhelm the grid and cause outages. Similarly, electric vehicle chargers can adapt to the grid"s requirements by either supplying or utilizing electricity.

These distributed energy sources connect to the grid through communication technologies like Wi-Fi, Bluetooth, and cellular services. In aggregate, adding VPPs can increase overall system resilience. By coordinating hundreds of thousands of devices, VPPs have a meaningful impact on the grid--they shape demand, supply power, and keep the electricity flowing reliably.

Until recently, VPPs were mostly used to control consumer energy use. But because solar and battery

technology has evolved, utilities can now use them to supply electricity back to the grid when needed.

In the United States, the Department of Energy estimates VPP capacity at around 30 to 60 gigawatts. This represents about 4% to 8% of peak electricity demand nationwide, a minor fraction within the overall system. However, some states and utility companies are moving quickly to add more VPPs to their grids.

Green Mountain Power, Vermont"s largest utility company, made headlines last year when it expanded its subsidized home battery program. Customers have the option to lease a Tesla home battery at a discounted rate or purchase their own, receiving assistance of up to $10,500, if they agree to share stored energy with the utility as required. The Vermont Public Utility Commission, which approved the program, said it can also provide emergency power during outages.

In Massachusetts, three utility companies (National Grid, Eversource, and Cape Light Compact) have implemented a VPP program that pays customers in exchange for utility control of their home batteries.