EnergyHub

The future of flexibility: **Unlocking the full value of VPPs for a changing grid**

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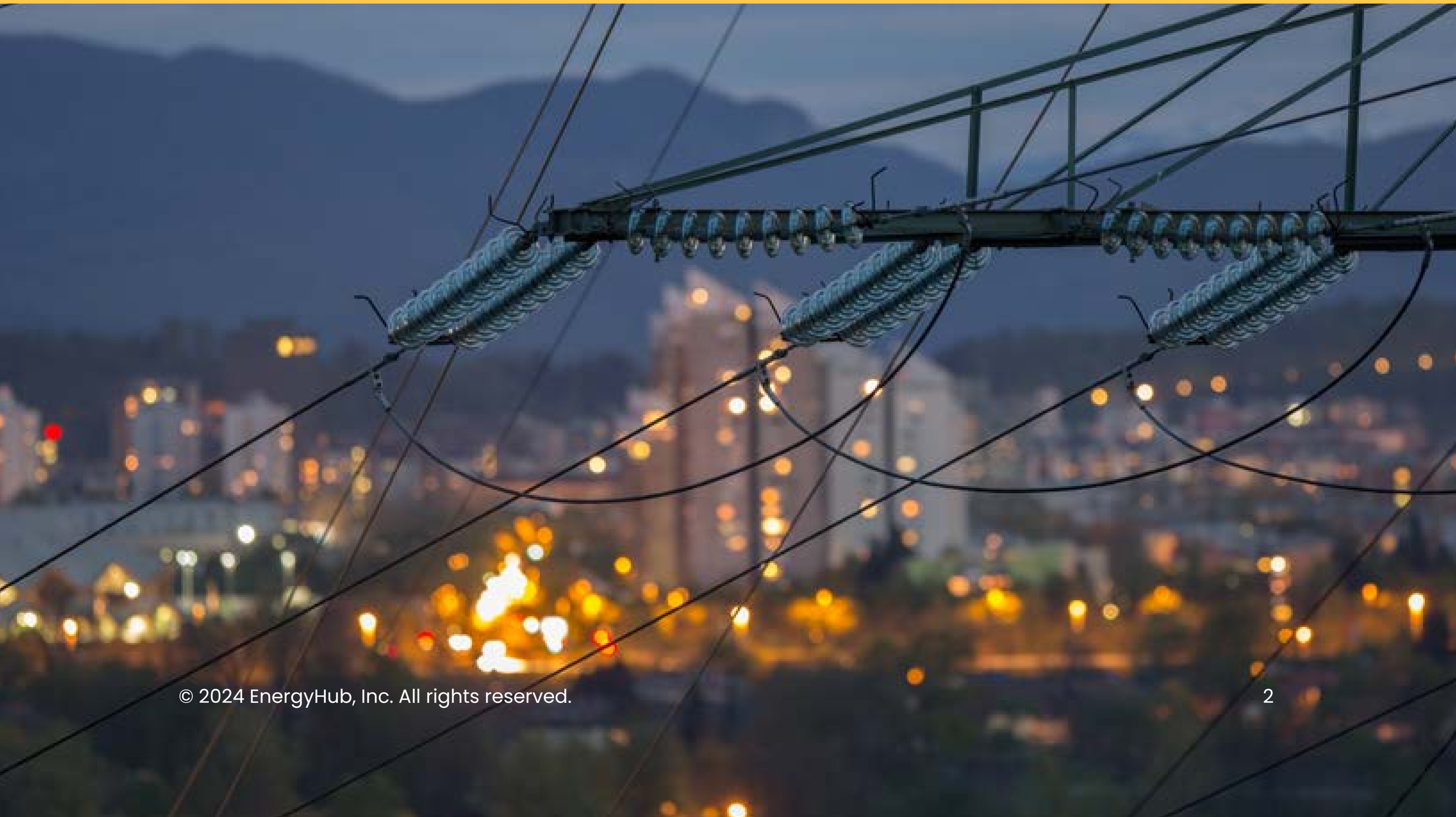


Introduction

Load growth is back — **and it's time to adapt**.

After two decades of flat or declining load growth, U.S. electricity demand is **predicted** to rise by almost 5% over the next five years, driven largely by increases in electric vehicle (EV) charging, domestic manufacturing, and **data centers**.

This anticipated load growth poses sweeping challenges for the grid, impacting everything from resource adequacy to transmission and distribution infrastructure planning. In some states, utilities are facing the possibility that they may not be able to build new generation resources fast enough to maintain a reliable, affordable energy supply.

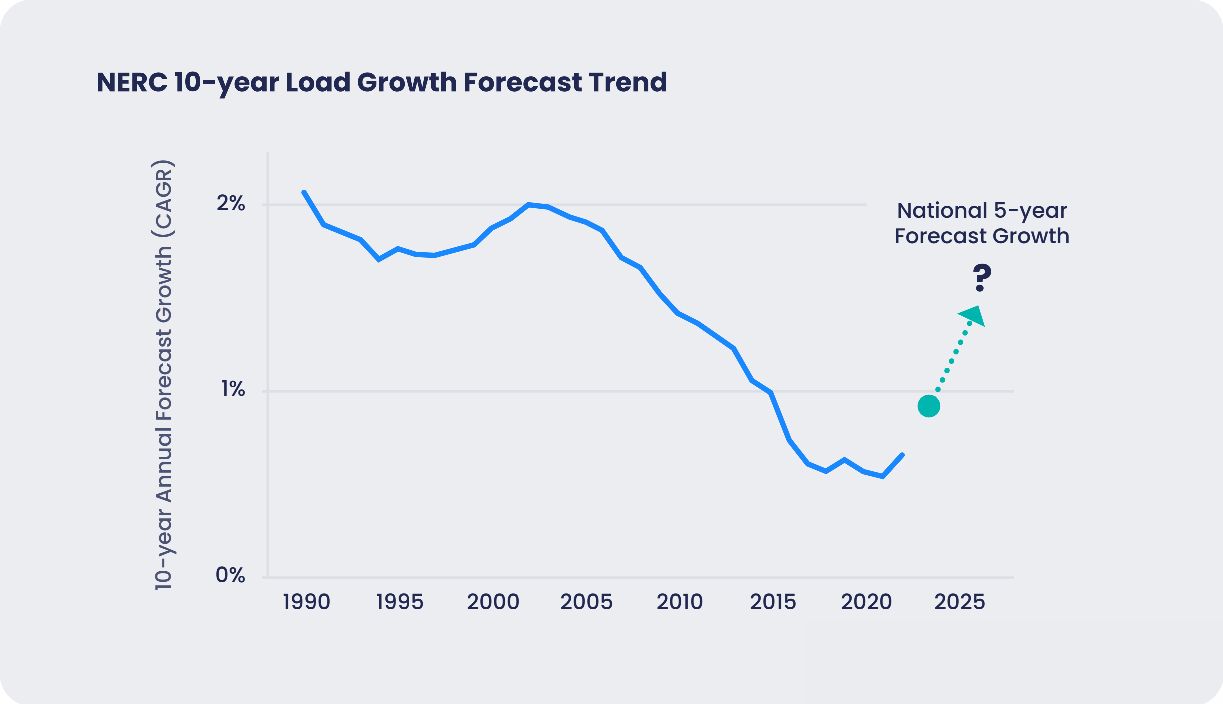
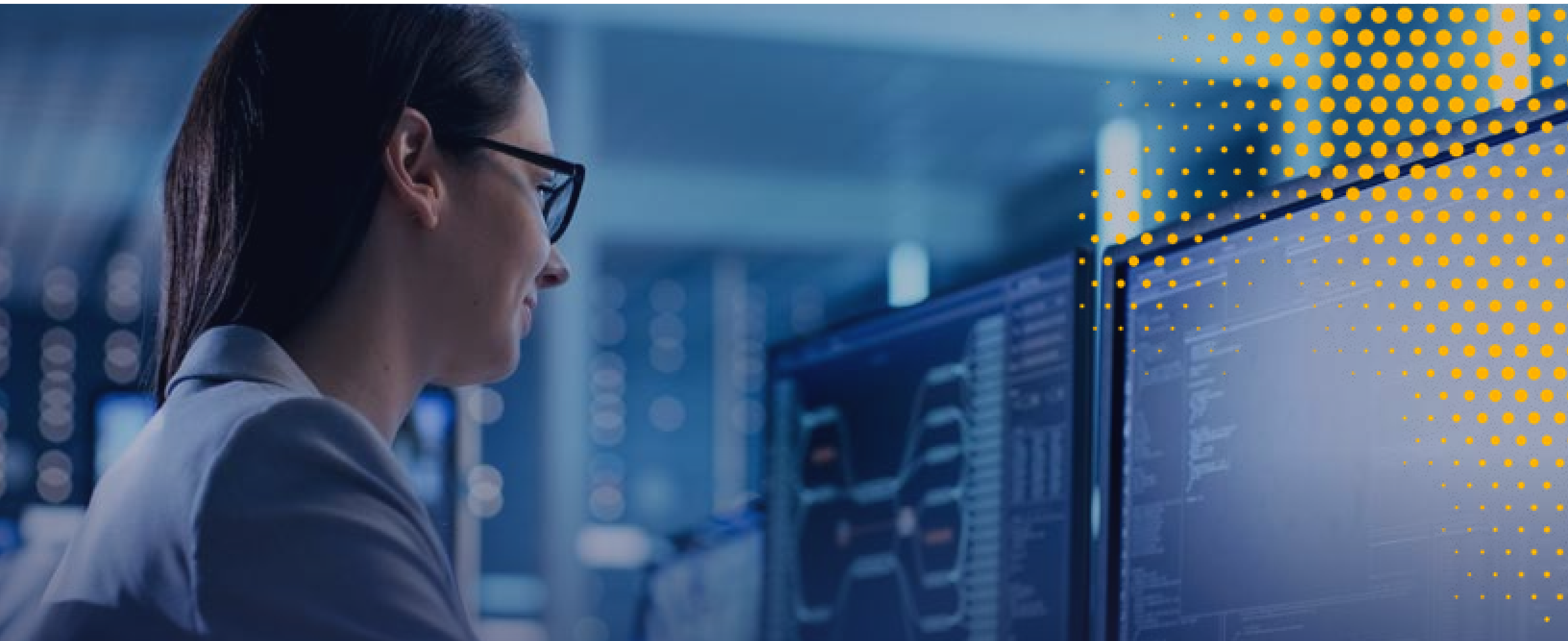


Figure 1: 10-year load growth forecast. (Credit: **NERC**)

Enter virtual power plants (VPPs).

According to the **U.S. Department of Energy**: "VPPs are aggregations of distributed energy resources (DERs) such as smart appliances, rooftop solar with batteries, EVs and chargers, and commercial and industrial loads that can balance electricity demand and supply and provide grid services like a traditional power plant."

VPPs help stabilize the grid, especially during time periods when the grid is approaching its limits. They can also be built quickly to meet load growth needs, while simultaneously addressing challenges like transmission and distribution grid congestion and volatile wholesale energy prices.



This white paper explains VPPs' value proposition for a **rapidly evolving power system**, addresses long-standing misconceptions, and suggests a path forward for fully leveraging VPPs to deliver a **reliable, resilient, and flexible electricity grid**.

An electricity industry in flux

Recent years have brought challenges very different from those that utilities encountered over the past century, including widespread obstacles to new infrastructure development, ambitious clean energy mandates, and the persistent need to strengthen the grid in the face of more extreme weather.

Adding today's steep load growth projections to the mix has made solving these challenges even more difficult. As the consultancy E3 recently **wrote**:

> "Planning for load under uncertainty is nothing new, but the **scale and speed of this load growth**, combined with today's supply side constraints, is unprecedented."
>
> –E3

These constraints include the time, expense, and difficulty involved in building power plants and related infrastructure to deliver electricity where it's needed. Natural gas plants, the go-to solution for addressing peak demand growth, have drawn increased scrutiny for their carbon emissions. Meanwhile, clean energy resources such as solar, wind, and batteries sit in **years-long interconnection queues**.

Further, anticipated load growth may occur at different rates at different times, as E3 points out, with ebbs and flows across two decades en route to an electrified economy (Figure 2). This dynamic is especially problematic for large conventional plants and the investment capital they put at risk.

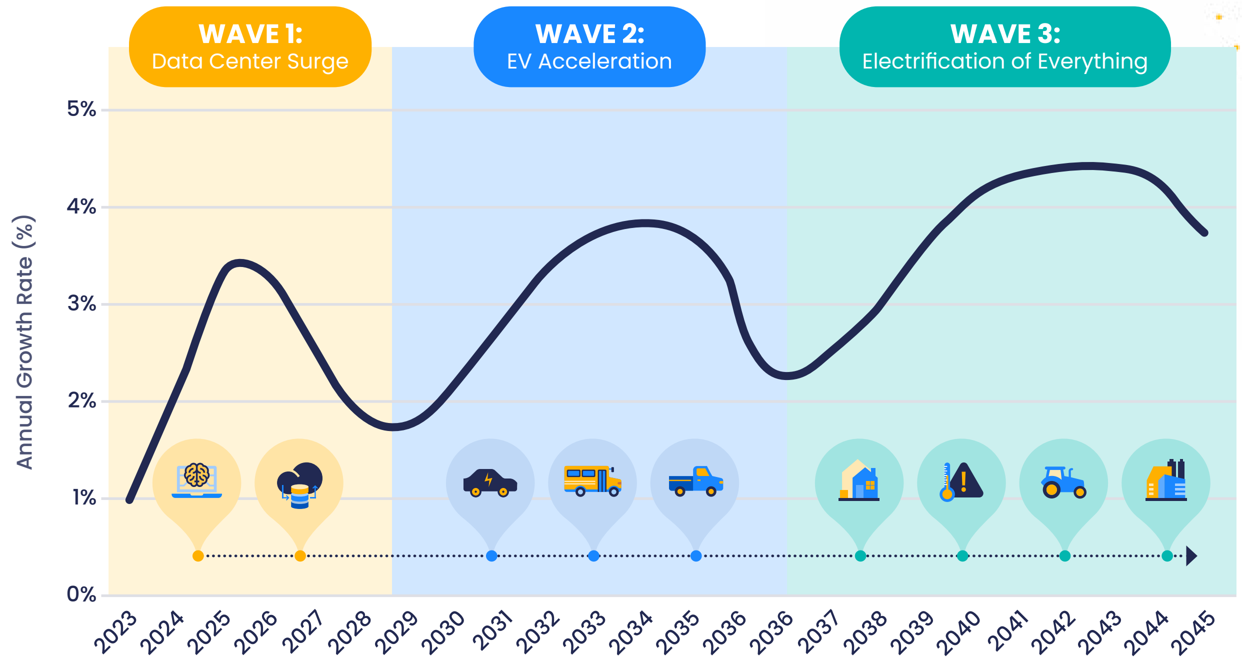


Figure 2: Waves of electricity load growth (illustrative). (Credit: E3.)

In light of these challenges and VPPs' prospective role in solving them, the U.S. Department of Energy (DOE) recently issued a target of 160 GW of new VPP capacity by 2030. But deploying VPPs anywhere near that scale starts with a fuller appreciation of the value they offer utilities.

VPPs vs. traditional power plants

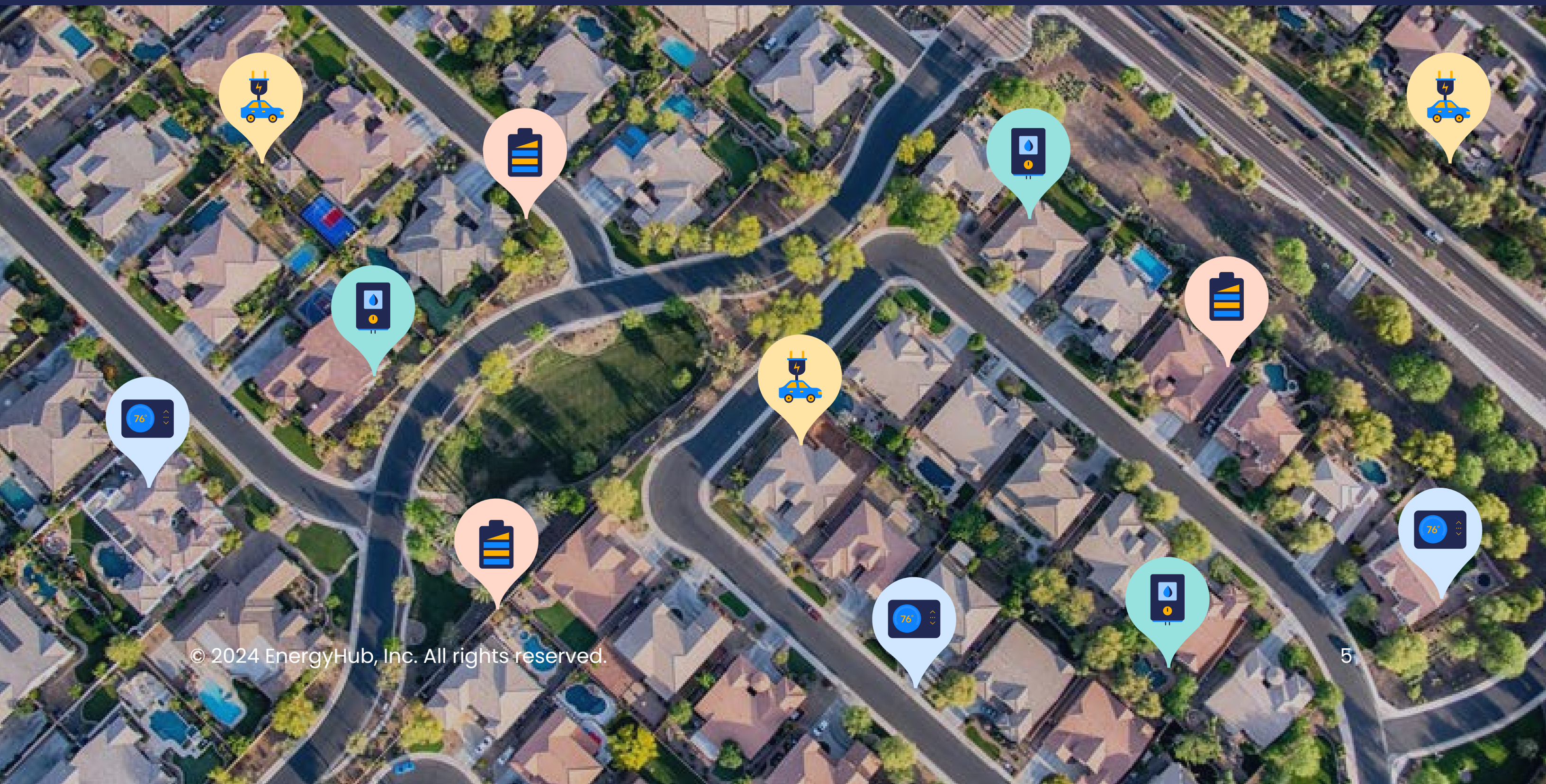
VPPs are aggregations of distributed energy resources (DERs) that utilities can call upon in addition to, or in lieu of, conventional supply resources. According to DOE, common DERs used in today's VPPs include:

Smart thermostats: Smart thermostats reduce heating and cooling activity during times of peak demand while preserving occupant comfort.

Electric vehicles: EV managed charging programs can adjust the level and/or timing of charging sessions to minimize grid stress while ensuring vehicles are ready when needed.

Behind the meter batteries: Residential energy storage can provide backup power to utility customers, reduce stress on local transmission and distribution infrastructure, and can provide grid ancillary services such as frequency regulation.

Smart water heaters: These units heat water when energy supply is abundant and avoid doing so when demand is high.



VPPs can comprise multiple DER types to capture greater grid value, and utilities can incentivize the adoption of particular DERs to meet local needs. Whereas large-scale generation can take years to build and even longer to interconnect, VPPs can be launched and scaled quickly at [40-60% lower cost](#).

Instead of merely toggling "on" or "off" to balance the grid sporadically throughout the year, VPPs can be dispatched year-round to support new program objectives beyond demand response like daily load shaping, integration of more renewable resources, and customer time-of-use rate optimization. At the distribution level, VPPs enable localized dispatch of DERs connected to specific assets, helping grid operators prevent overload and delay or avoid infrastructure upgrades. For markets and trading teams, VPPs can be monetized and bid into regional markets to optimize wholesale energy prices.

VPP Value Proposition

Figure 3: VPP value proposition. (Credit: [U.S. Department of Energy](#).)

Case studies: VPPs delivering a range of grid benefits across North America

According to market analysts, there are currently **over 500 VPPs** operating in North America.

Amid record-high temperatures, VPPs have played a key role helping utilities relieve grid stress during the 2024 summer season. California, the state with the **most VPP capacity**, has not only avoided outages but has even **exported excess electricity throughout the West**.

Examples of successful VPPs include everything from thermostat-based VPPs like Arizona Public Service (APS), which leverages over 90,000 DERs to keep power supply reliable in the face of extreme heat, to the multi-state ConnectedSolutions program, which dynamically dispatches over 200 MW of batteries, thermostats and EVs to support a range of bulk and distribution grid needs. Meanwhile, the Ontario IESO expanded its PeakPerks™ program to where it can deliver over 150 MW of peak demand reduction in less than a year thanks to strategic collaboration between the electricity provider, device partners, and EnergyHub.

CASE STUDY

PROGRAM GOALS:

- **Resource adequacy**
- **Customer choice**
- **T&D congestion relief**

DERS:

- **Thermostats**

DR EVENT STRATEGY:

A maximum of **three hours per event**; no more than **10 events/year**

INCENTIVE:

$75 upon enrollment and **$20** each additional year

SEASON LENGTH:

Summer: Jun 1 - Sept 30

TYPES OF DEVICES:

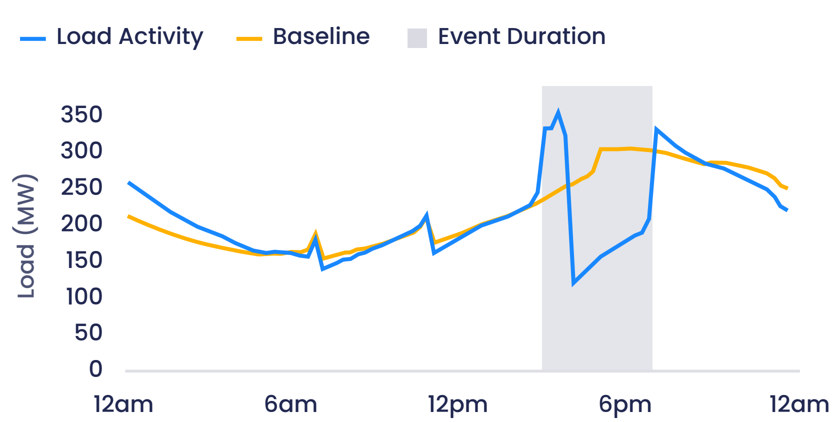
ecobee, **Renew Home** (Google Nest), **Emerson** (Sensi), and **Honeywell Home**

Rapid scale: Ontario's IESO builds Canada's largest residential virtual power plant in just six months

For the first time in over a decade, Ontario's Independent Electricity System Operator (IESO) identified a need to increase future electricity capacity and system reliability in its 2021 Annual Planning Outlook. To cost-effectively meet these objectives, the IESO selected EnergyHub's proven customer-centric platform as the launch pad for its new Save on Energy Peak Perks™ smart thermostat demand response program.

The program **enrolled more than 100,000 homes in its first six months** — creating the largest residential VPP in Canada — and continues to grow. The VPP can now deliver peak demand reduction of more than 150 MW, equivalent to taking a city the size of Barrie, Ont., off the grid during peak times.

Peak Perks™ delivers 157MW peak demand reduction



CASE STUDY

PROGRAM GOALS:

- Load shaping
- Customer cost optimization

DERS:

- Thermostats

DR EVENT STRATEGY:

A maximum of **three hours per event**; no more than **20 events/year**

INCENTIVE:

$50 upon enrollment and **$35** each additional year

TYPES OF DEVICES:

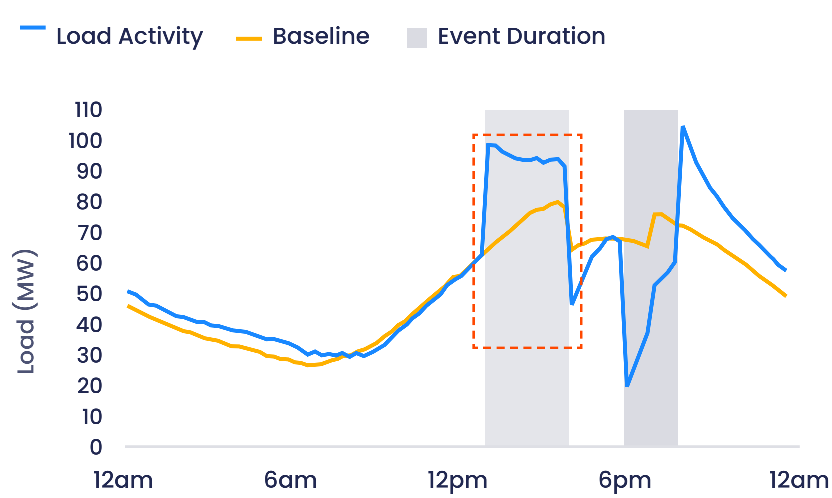
ecobee, **Renew Home** (Google Nest), **Emerson** (Sensi), **Honeywell Home**, **Alarm.com**, **Lux**, **Vivint**

Multi-value VPP: APS unlocks load shaping and more

Arizona Public Service (APS) has built one of the largest VPPs in North America with the EnergyHub platform. Comprised of more than 90,000 thermostats participating in the Cool Rewards program, the VPP consistently delivers over 100 MW of load shed.

To leverage this resource, APS has pioneered a unique "pre-cooling" gap dispatch strategy that maximizes the use of mid-day renewable generation resources, reduces customer time-of-use (TOU) costs, and creates a flatter load shape.

Pre-cool gap strategy (highlighted in red box) deployed during August 2024 Cool Rewards event



Interview:

The evolution of VPPs – from demand response to cross-DER flexibility

With Paul Hines, Vice President of Power Systems, EnergyHub

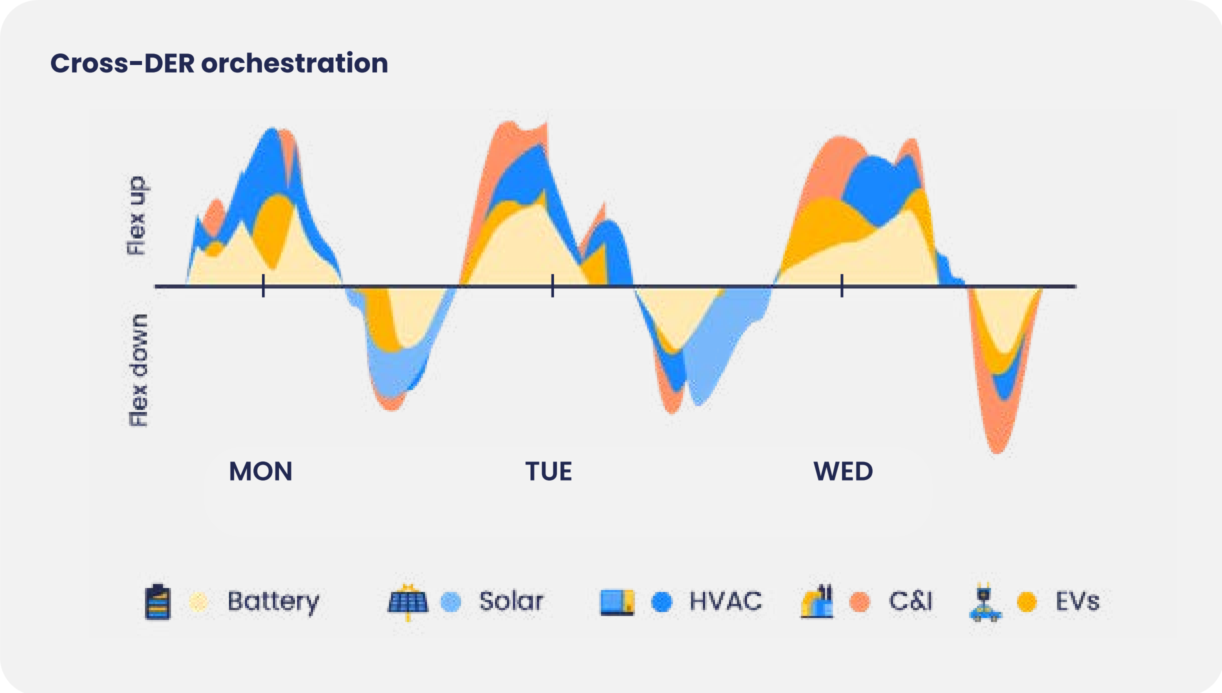
"With emerging DER classes like batteries, EVs, and building automation systems coming online, we're deploying VPPs in new ways," says Paul Hines, Vice President of Power Systems at EnergyHub. "But to reliably deliver the next evolution of cross-DER VPPs, the industry must lean into data-driven, scalable operations."

To understand the road ahead, it helps to look back at where we came from. "Twenty years ago, 'demand response' meant utilities would flip a one-way radio switch on customers' air conditioners and hope the device turned off. It was really difficult to measure the impact of those programs on the grid," Hines explains.

The advent of the Internet of Things (IoT) and advancements in customer DER technology over the past decade have radically transformed the flexibility landscape, enabling wireless DER dispatch and bi-directional communication about device participation and performance. Armed with more predictable results and more robust control, utilities started using aggregated DERs to deliver new value with strategies like load shaping and wholesale energy arbitrage, ushering in the transition from basic demand response to the era of VPPs.

> "But to reliably deliver the next evolution of cross-DER VPPs, **the industry must lean into data-driven, scalable operations."**
>
> –Paul Hines, Vice President of Power Systems, EnergyHub

"Now, VPPs are evolving to orchestrate several DER classes and deliver multiple grid benefits simultaneously. This requires new standards for how we collect, analyze, and apply the data we get from VPP programs." Hines says.



What's next: AI-driven predictive analytics

One of the most promising advancements in VPP technology is the use of predictive analytics. Drawing on a growing pool of DER data, utilities can leverage machine learning algorithms to forecast baseline loads and optimize VPP dispatch strategies accordingly.

"Predictive analytics allow us to anticipate demand peaks, renewable generation capacity, DER behavior, and more." Hines explains. So, for example, a utility with high solar generation can use a DERMS to forecast flexible capacity from a VPP made up of batteries, EVs and thermostats, and then choose the best times to charge and discharge those resources to balance the grid. Likewise, a utility facing a heat wave could compare the predicted load shed of different demand response event durations to ensure their dispatch strategy balances customer comfort with grid needs.

"It all comes down to ensuring the reliability of VPPs as part of the utility resource stack," says Hines. "With better data, we can unlock cross-DER optimization to deliver advanced grid services at scale and address the pressing challenges facing our grid."

How will the industry unlock VPPs' full potential?

Today's VPPs are sometimes faulted for not offering much value beyond traditional demand response programs, which for decades have allowed utilities to maintain reliability by reducing customer loads at critical times. If that's true, then that's primarily a function of how VPPs are understood and what they've been allowed to do.

Fully leveraging VPPs to help utilities address a host of industry challenges will require a **greater understanding** of the value they provide, **stronger regulatory support**, and **better integrations** with customer DERs and utility control room systems.

Alignment around VPPs' value proposition

Compared to a physical generation asset, aggregated customer-owned DERs can still seem less reliable to grid operators and regulators — despite VPPs' long track record of helping maintain grid reliability. It's not uncommon for utilities to say that if they don't build a power plant, they need "100% confidence" in the resource that replaces it.

But no resource offers 100% reliability – not even conventional power plants – and that hasn't stopped the grid from operating reliably for over a century. Moreover, during Winter Storm Elliott, in 2022, it was natural gas plants that accounted for two-thirds of a **historic power outage** across the eastern and midwestern U.S. EnergyHub's VPP assets, meanwhile, delivered critical load relief.

A deeper understanding of VPPs' value requires clarity around what they are and what they can do. Ask a demand management team, a grid planning team, and a utility commission to define a VPP and you'll likely get three different answers. Resources like this white paper and others from **DOE**, **RMI**, and other **industry experts** continue to shed important light here.

And part of the solution lies within utilities, whose consideration of VPPs and other DERs is typically siloed within small, specialized teams. In many cases, utility business models haven't evolved to access the full potential of VPPs – **which highlights the importance of modernizing how utilities are regulated.**

Stronger regulatory support to accelerate deployment

More support in the regulatory arena is key to VPP growth, as DOE noted in its **report** last fall. This will involve both an appreciation for VPPs' unique value proposition – for example, the inherent advantage of operating a portfolio of thousands of resources over a large geographical footprint – as well as accounting for the risks of traditional power plants that often go unrecognized. To this end, **sophisticated tools have emerged** to help utilities and regulators plan investments in the distribution grid, where VPPs are deployed.

Despite portfolio-wide reliability averages that routinely top 98%, VPPs are often heavily discounted in planning exercises. In PJM, for example, demand response resources are automatically discounted to 74% of their nameplate capacity. With peak demands straining the grid and VPPs' proven role in relieving that strain, awarding more capacity credit to VPPs will allow utilities and consumers to get more value from them while incentivising investment in new VPPs.

VPPs will take a giant step forward when allowing customer-sited devices to export power to the grid becomes the rule and not the exception. Export can provide crucial support to customers and utilities during **power outages**, maximize value from EVs as **mobile energy storage** resources for the grid, and enable the widespread participation of DERs in wholesale markets as envisioned in **FERC Order 2222**.

Deeper integrations across the utility and customer device ecosystems

Data integrations are the backbone of VPPs, allowing utilities to reliably enroll customer devices, send dispatch signals, and receive performance data. Working with an Edge DERMS provider like EnergyHub can give utilities an advantage in this regard as they often bring well-established industry relationships and existing integration infrastructure that can help **scale flexibility programs quickly**. As new OEMs and device classes enter the market, the standard for DER integrations and data quality, latency, and completeness will continue to rise, making these strategic partnerships even more important.

Improving VPPs' integrations with control room systems, such as advanced distribution management systems (ADMS), can similarly provide much-needed insights and control. Currently, 16% of utilities **report** having no visibility into the location of behind-the-meter DERs on the distribution grid, and the majority only know the location of DERs that have submitted an interconnection request. Even worse, nearly a quarter report having no visibility into the actual load and generation behavior of the behind-the-meter DERs. Stronger ADMS-DERMS integrations can unlock tremendous value for utilities by improving grid planning and enabling localized dispatch to protect distribution assets from overload.

A key part of getting buy-in across the utility will be improving VPPs' reliability and telemetry to surpass that of conventional generation – **an outcome EnergyHub is working to make a reality by building and managing the largest ecosystem of device partners and customer DERs.**

Unlock the future of flexibility with EnergyHub

EnergyHub helps utilities build and manage the next evolution of grid-aware, cross-DER VPPs in a single platform.

With EnergyHub's end-to-end software and services, utilities achieve grid flexibility, reliability, and affordability through large-scale customer-centric program participation and cross-DER optimization — delivering more grid services than individually managed DER programs.

Learn more about the [EnergyHub Edge DERMS] and [schedule a demo].

info@energyhub.com

Or learn more at energyhub.com

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EnergyHub

Helping over 7w0 utilities unlock value from DERs at the grid edge.