The rise of the energy smart home

A plain language introduction to how household energy technologies are changing electricity systems and helping consumers save money

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CLEAN ENERGY CANADA

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The rise of the energy smart home: A plain language introduction to how household energy technologies are changing electricity systems and helping consumers save money

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Introduction

Around the world, demand for electricity is growing rapidly, leading the International Energy Agency to refer to this moment as the Age of Electricity.[1] This energy transition isn't happening in a silo—it's taking place against a backdrop of swiftly changing global politics and technology shifts.

Whether it is geopolitics reshaping energy supply chains, the falling prices of clean energy technologies (such as wind, solar, and batteries), shifting consumer preferences towards electrification, or new innovations like AI, meeting this growing demand for electricity will require a fundamental rethink of how we plan, build out, and operate our electricity system.[2]

Nowhere is a fundamental rethink more required than on the consumer's side of the electricity meter. Until recently, consumers have largely been passive actors, incentivized to embrace energy efficiency to lower their energy use, but otherwise playing a small role in the overall energy system. However, as jurisdictions increasingly look to optimize the use of low-cost renewables and the electrification of our heating and transportation systems advances, household and business-level technologies are becoming a major new resource modern electricity grids can leverage.

Known as "distributed energy resources" (DERs), consumer-based energy technologies offer a critical opportunity to reduce energy bills, enhance energy security, and ensure that they are meeting the growing demand for electricity as cost-effectively as possible. "Energy smart homes"—households that have electrified aspects of their energy systems and combined it with smart communication technologies—can be managed as a coordinated and aggregated resource, becoming a "virtual power plant" (VPP) that utilities can use as a larger resource that can help reduce, shift, or generate electricity when needed.[8]

While there are opportunities for DERs and VPPs across industrial, commercial and household customers, this paper primarily looks at the increasingly important role that energy smart homes are playing in meeting growing electricity demand. Given the cost pressures many families face, understanding—and seizing—the opportunities energy smart homes present is critical to help reduce household energy costs and build a more reliable and secure energy system. It outlines how the rise of distributed energy resources at the household level is transforming how we plan and operate our energy systems, what global leaders have been doing in this space, and what steps Canadian provinces should take to keep up.

The growing role of households in the energy system isn't theoretical — jurisdictions across the world are already seeing the benefits. In Australia, nearly 21% of the country's electricity was generated by energy smart homes and businesses in 2023-2024.[3] In the U.K, over two million households and businesses are helping lower consumer energy costs through participation in demand flexibility programs as of 2025.[4] And here in Canada, over 200,000 households have signed up for Ontario's Energy Peak Perks program, receiving financial incentives for helping reduce energy usage during moments of soaring demand.[5]

While nearly every province in Canada is taking steps in the right direction to advance DERs, some are moving faster than others. Seizing the opportunity that energy smart homes and VPPs present should be a priority for every jurisdiction across the country.

How energy smart homes are changing electricity systems

The transformation of our power grids

Canadian electricity grids are at a major crossroad. Nearly every province in the country is projecting significant increases in electricity demand in the coming years at a scale and speed never seen before. And this growth isn't isolated to a single sector. It's coming from rising electric vehicle adoption, growing interest in efficient electrified heating, and the benefits of cost savings, competitiveness, and energy security that come from electrified industrial processes.

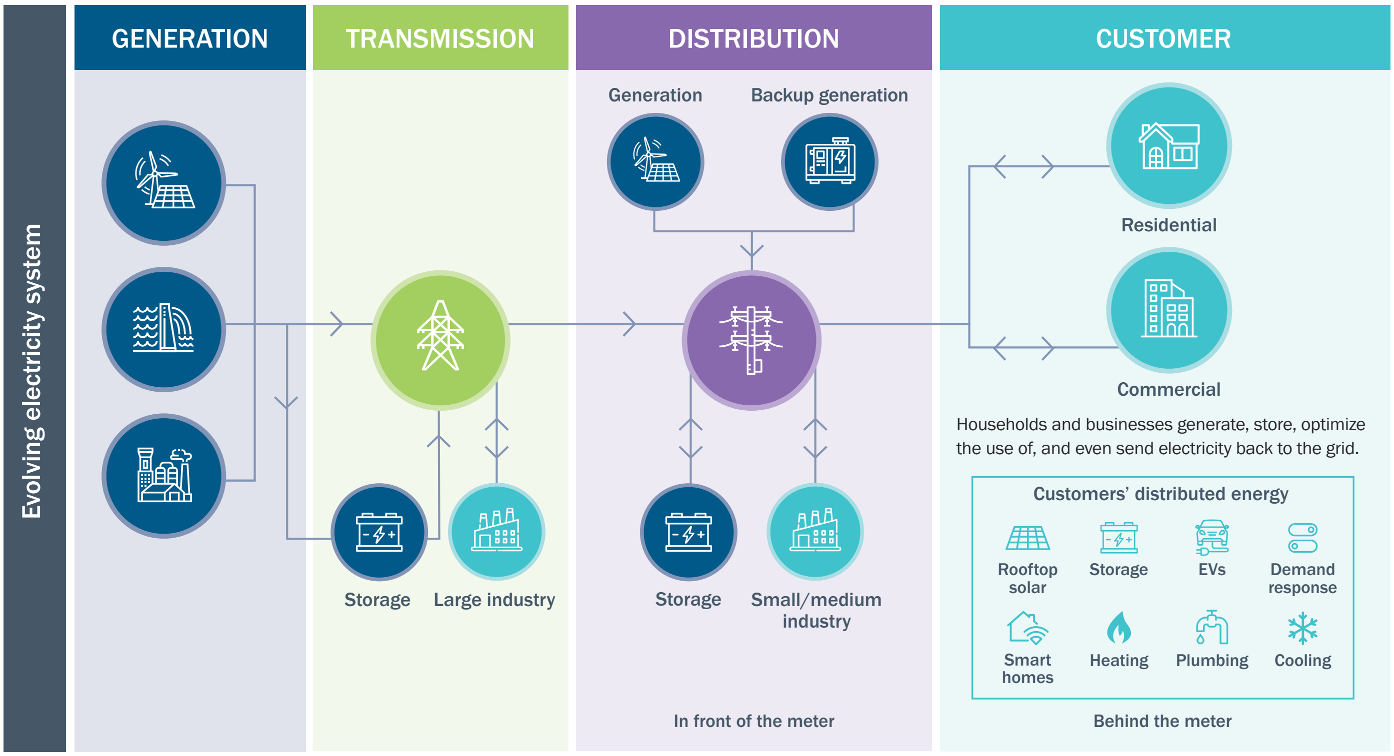
At the same time, the electricity system—and the utilities and system operators that run them— have a vital role to play in achieving the nation's net-zero targets. We therefore need to focus on decarbonizing our existing system while also driving further deployment of new clean energy resources.[6] Addressing both the need to decarbonize and the growing demands from electrification will require new approaches from governments, system planners, and utilities to keep electricity affordable and leverage new technologies.

Key changes to Canadian electricity grids

HISTORICALLY	ENERGY TRANSITION	2050 CLEAN ENERGY SYSTEM
Centralized		✓ Distributed
Scarce		✓ Abundant
Analog		✓ Digital and smart
Fossil fuel dominated		✓ Clean electricity dominated
Passive consumer		✓ Active consumer
Energy systems planned separately		✓ Integrated planning across systems

Most governments in Canada have begun undertaking important reforms to the ways they govern, regulate, and operate the electricity system, in large part driven by the need to find the most cost-effective ways to meet this growing demand for clean electricity. Growing electricity supply while mitigating a corresponding increase in electricity costs for consumers is one of the most pronounced challenges facing regulators. It has led governments of all stripes to embrace renewables as one of the lowest-cost resources and is driving increased consideration of the role that households—and the clean energy technologies they are adopting—have in meeting this demand for electricity.

The shifting structure of electricity systems



From energy smart homes to virtual power plant

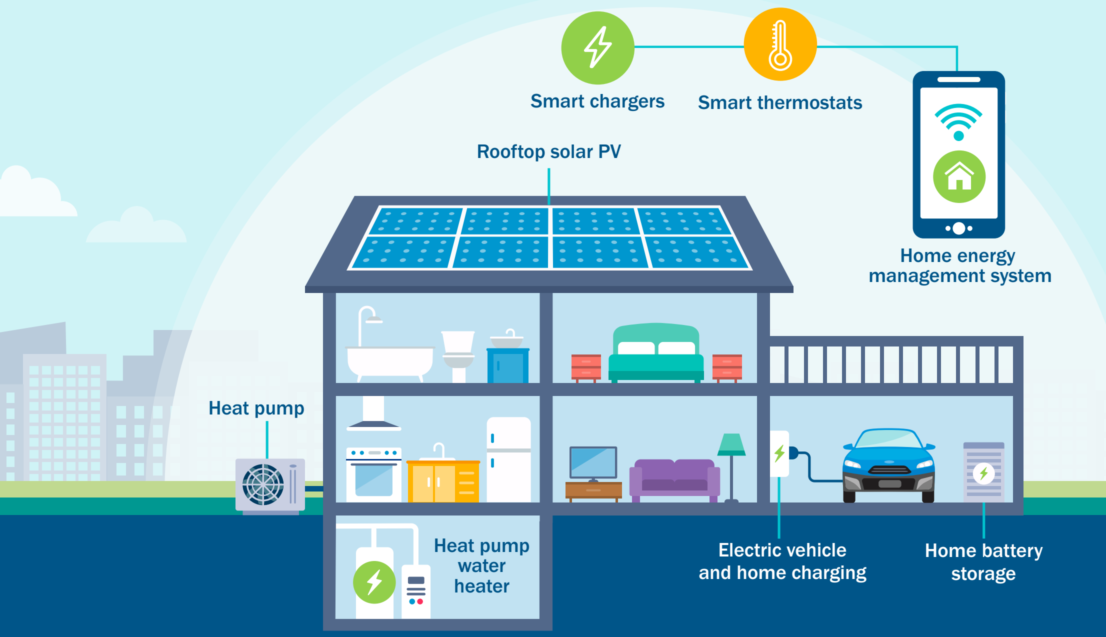
One of the most significant transformations to our electricity system is happening at the consumer level. The combination of smart, digital systems with the increasing electrification of the energy systems in our households, businesses, and industries is creating the potential for an important new resource.

Whether it's a heat pump to provide heating and cooling, an EV to replace a gas car, or a rooftop solar and home battery to help power a home, there is a suite of new electric technologies that households are increasingly turning to in order to save money.[7] But the value of these technologies to the energy system is only just starting to be fully appreciated.

Often these electric technologies are paired with smart technologies such as smart phone apps, smart thermostats, and home energy management systems that let us measure, adjust, and control our energy use in real time. When combined, electric and smart household technologies— referred to as DERs—can be transformed into a new demand-side resource. Instead of needing to add new electricity generating capacity to the grid or invest in new transmission and distribution lines, utilities can leverage a VPP where the source of demand itself is used to help shape demand and reduce peaks in load, allowing utilities to re-distribute existing energy where it's most needed in a given moment and ultimately saving costs.

DERs, VPPs, DSM, NWA...

While this paper seeks to be accessible to a wide audience, the literature surrounding virtual power plants and energy smart homes can be highly technical and rife with acronyms. **Appendix C** offers a list of terminology and acronyms commonly found in the literature for reference, along with their definitions.

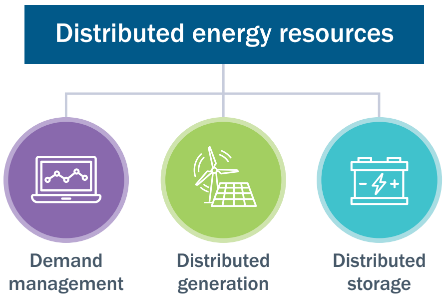


Electric technologies — from EVs, to heat pumps, to home batteries — when combined with **smart technologies** that let us measure, adjust and control our energy use in real time, are signaling the arrival of the "smart grid" and the "energy smart home."

Types of distributed energy resources

A variety of clean energy technologies can be leveraged as DERs and can be found in residential as well as commercial and industrial settings. They can be broadly grouped into three categories:[9–11]

- **Demand management:** e.g. EV chargers, smart thermostats paired with heat pumps and other electric heating, ventilation, and air conditioning systems, electric water heaters, smart panels that can balance load and reduce the local peak demand, lighting, appliances, or machinery
- **Distributed generation:** e.g. rooftop solar (which becomes dispatchable when paired with battery storage) and fuel-based generators
- **Distributed storage:** e.g. home batteries, EV batteries with bi-directional charging



The benefits of energy smart homes

Whether leveraging a DER on its own or participating in a VPP, energy smart homes can provide a multitude of benefits for households and the broader energy system.

For households, the increasing adoption of clean energy technologies and the potential for energy smart homes to be leveraged as a VPP can help reduce energy bills in at least five distinct ways:

1 Fuel switching	2 Efficiency	3 Time of use	4 Energy services	5 Capital cost reduction
Using a less costly source of energy	Using less power through more efficient equipment	Using power when it is cheaper due to rate design	Getting paid by the utility to meet the grid's energy needs (through generation, load reduction, shifting, etc.)	Reducing overall system costs passed on to the consumer by avoiding expensive build out

From a grid-level perspective, bringing energy smart homes together as VPPs provides numerous benefits—also called "value streams"—for both the energy system and consumers.[9]

Utilities can leverage energy smart homes to shape demand on the grid to achieve affordability benefits. It can help reduce the extent to which they need to make investments in the grid, such as new electricity generation to meet peak loads or in transmission and distribution infrastructure.

As utilities increasingly draw on these demand-side resources to support the operation of their grids, ratepayers, in turn, benefit from lower future costs and thus more affordability.[9]

An energy smart home's ability to contribute to resource adequacy at low cost also helps ensure grid reliability and resilience.

Additionally, VPPs can help reduce carbon and local air pollution where fossil-fuel power generation has traditionally been used to meet peak demand by leveraging a VPP to shrink or meet peaks in demand. Using an energy smart home to shift demand can also reduce curtailment of clean electricity from variable renewables like wind and solar expanding their value, and the associated cost savings, to the grid.[9]

Definition of curtailment

Curtailment refers to "the intentional reduction of instantaneous power from supply or demand resources to aid balancing of the electricity grid."[12]

Energy smart homes can also offer utilities a large degree of flexibility and versatility due to the varying characteristics of different DERs.[9] Depending on the DERs available to a utility or grid operator, these assets can be combined in different configurations, or portfolios, of VPPs, tailored to meet the specific needs of the grid and thus maximize their value to that grid. For example, some systems may focus on leveraging energy smart homes with storage (through EVs or home batteries) to complement variable renewables, while others may seek to leverage the demand management potential of technologies like water heaters and heat pumps to help reduce demand peaks.

Ultimately, energy smart homes and VPPs empower communities and individual consumers by enabling them to contribute local resources to help make the grid more reliable, resilient, and affordable.[9] This way, the DERs in their home offer them agency in the wider energy transition.

VPP value proposition

Resource adequacy

- Integrate distributed generation and storage capacity
- Shift demand to follow supply

Affordability

- Defer grid capex (generation, transmission & distribution)
- Avoid fuel costs
- Compensate consumers and businesses

Reliability & resilience

- Integrate back-up power
- Eliminate single-point-of-failure

Decarbonization & air pollution reduction

- Add distributed renewable generation
- Reduce curtailment of renewables
- Reduce reliance on fossil fuels

Transmission & distribution infrastructure relief

- Increase efficiency by smoothing peaks
- Alleviate congestion with local dispatch

Community empowerment

- Enable consumers to optimize energy cost, use and source
- Retain and create good jobs

Versatility & flexibility

- Customize design to fit grid needs
- Reconfigure as needs evolve

Source: Adapted from U.S. Department of Energy.[9]

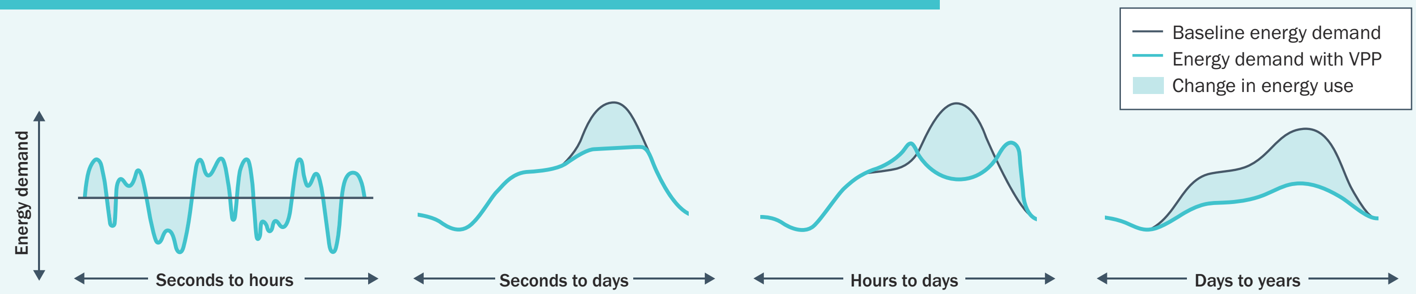
How DERs work and help shape grid demand

Demand for electricity fluctuates over the course of both the day and the year. Electricity grids must be planned and built to ensure they can meet daily and annual peaks, which traditionally has required expensive infrastructure that is only required during limited periods of time. Reducing the size of peaks and shifting when they occur can therefore be very valuable. While one DER in a single household will have a negligible effect on the grid, the true value of residential DERs can be realized when many are aggregated as a VPP and operated in tandem.[13]

DERs brought together into a VPP can be used to shape demand on the grid in a variety of ways, including by shifting, shedding, and modulating or shimmying load:

- **Shimmying:** Moving demand over very short timescales
- **Shedding:** Curtailing load to reduce peaks
- **Shifting:** Moving demand away from periods of high load
- **Shaping:** Changing demand in a structural way over the long term

Types of flexible demand by timescale and their potential benefits



SHIMMY
- Storage (batteries)
- Water heaters

SHED
- Commercial & industrial loads
- Lighting

SHIFT
- EV chargers
- Smart thermostats
- Smart water heaters
- Storage

SHAPE
- Solar with storage
- Efficiency (e.g. heat pumps replacing resistive heat technology)

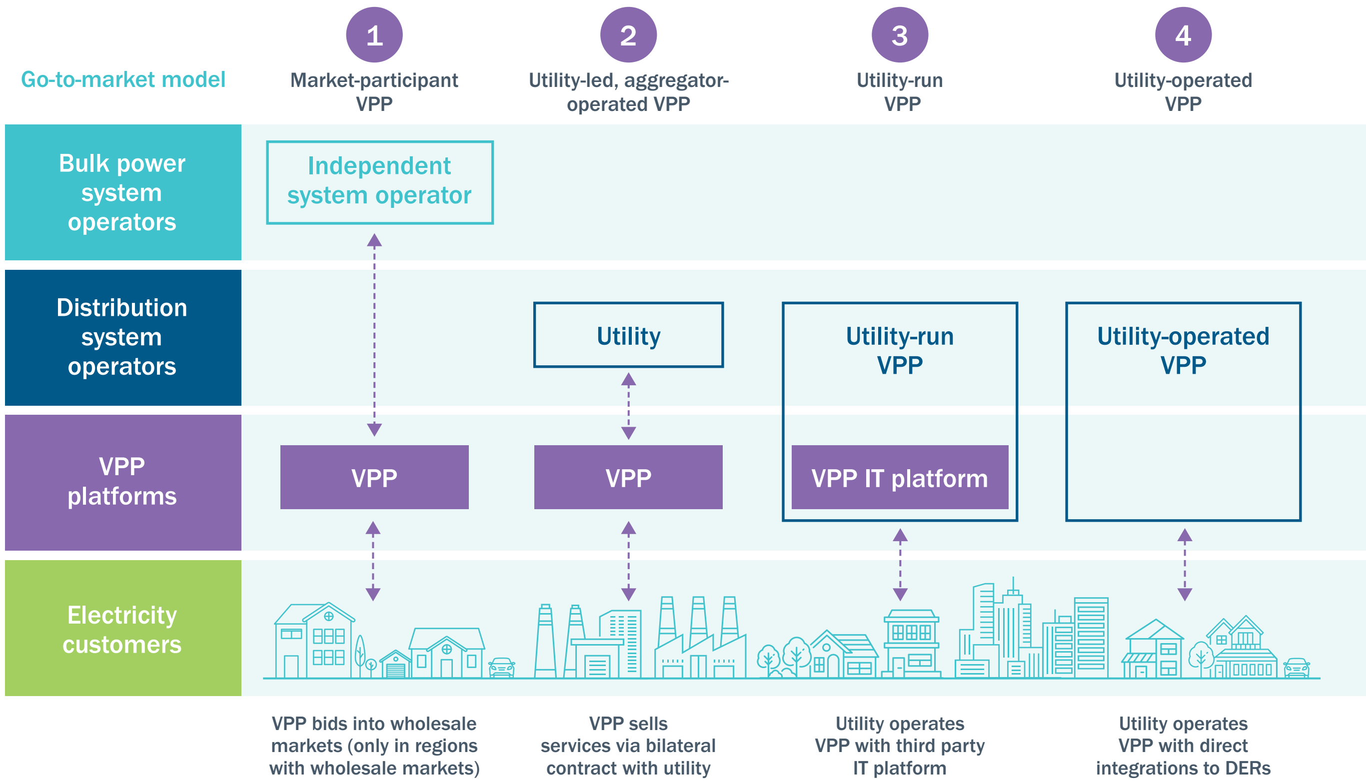
		Wholesale market and grid scale renewable support	Avoided capital costs	Contingency and emergency reserve	Distribution network support	Frequency control ancillary services
SHIMMY	Moving demand over very short timescales to alleviate short term issues.	N/A	N/A	N/A	High	High
SHED	Curtailing load to provide peak reductions and support emergencies/ contingency events.	Medium-Low	High	High	Low	Medium-Low
SHIFT	Encourages movement from periods of high demand to times of surplus variable renewable energy and/or lower demand.	High	Medium-High	Low	Medium-Low	N/A
SHAPE	Creating structural and ongoing changes in demand over longer periods.	Medium-High	Medium-High	Low	Medium-Low	N/A

Source: Adapted from U.S. Department of Energy and Institute for Energy Economics & Financial Analysis.[9,14]

*The table above provides a generalized overview of potential benefits from the different ways in which DERs can help shape demand. Specific opportunities will differ from grid to grid based on local factors.

Given the significant differences in energy system governance and operation across provinces, there is no one-size-fits-all approach to how VPPs are deployed and run. Instead, a variety of different models and structures may be used, including the following:

VPP market participation models



Source: Adapted from U.S. Department of Energy.[9]

A growing priority globally and in Canada

The potential for energy smart homes and VPPs to help meet growing electricity demand is significant. Globally, the IEA estimates that around one-quarter of energy demand in 2050 could be flexible, with demand response potentially delivering up to half the short-term flexibility required to meet total electricity demand.[15]

This is largely due to the fact that DERs are expected to grow significantly in the coming decade. The global market for the top six mass-manufactured clean energy technologies, which includes four that are relevant at the household level – namely solar PV, EVs, batteries, and heat pumps – is set to rise from US$700 billion in 2023 to more than US$2 trillion by 2035.[16]

And this opportunity isn't just theoretical or long term. While no two jurisdictions have identical opportunities—factors like geography, consumer preferences, and energy system structures all play a role—VPPs are increasingly being deployed in jurisdictions right across the world, including in Canada.

On the global stage, Australia, California, and the United Kingdom have all been leaders in different areas of DER adoption and VPP integration, providing important case studies for other jurisdictions.

In Australia, nearly 21% of the country's electricity was generated by energy smart homes and businesses in 2023-2024, with a goal of achieving nearly 50% by 2050.[3]

In the U.K, over two-million households and businesses are already participating in demand flexibility programs as of 2025, driving savings on energy bills and helping to reduce electricity demand during peak periods.[4]

And in California, VPPs are helping the state maximize its growing renewable resources, with modelling showing that by 2035, statewide VPP potential could meet 15.3% of expected peak demand (up from 3.2% in 2024). According to some estimates, just five technologies—if scaled and brought together as VPPs—could provide consumer savings of up to US$550 million per year in California.[8]

Appendix B provides an overview of the key actions these leading jurisdictions have taken to achieve success.

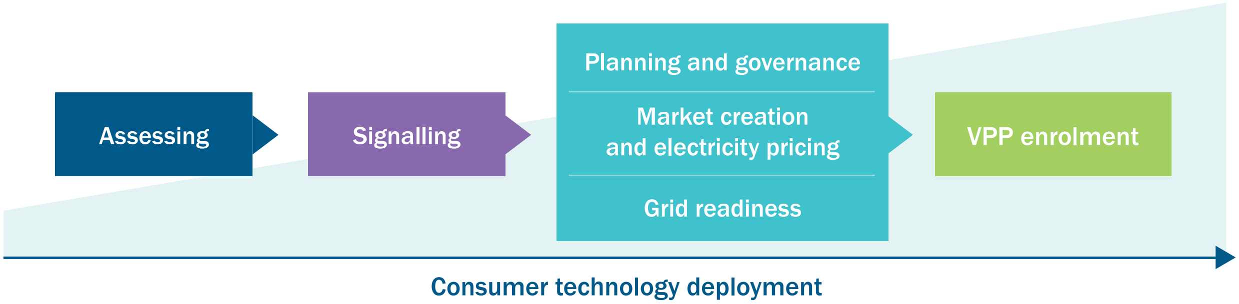
And the story is similar here at home. Canadian provinces are starting to explore the full potential that DERs might play—although they still have a long way to go. In Ontario, for example, DERs could satisfy a material portion of the province's electricity needs. Estimates accounting for real-world conditions (expressed as "achievable potential") indicate DERs could meet between 1.3 and 4.3 GW (5-14%) of peak summer demand by 2032, equivalent to 39-62% of Ontario's incremental summer capacity needs over the next decade.[17] RBC estimates that energy smart homes could save Ontario ratepayers up to $500 million annually.[18] A more comprehensive list of the initial actions Canadian provinces are taking can be found in **Appendix A.**

Framework for action

With clear benefits and a growing number of international jurisdictions centering the role of energy smart homes and VPPs in their energy systems, understanding how to maximize this potential is vital.

Thankfully, a common playbook has emerged as more and more jurisdictions are taking steps to reform their energy systems in ways that maximize the role that energy smart homes can play in meeting energy demand. Jurisdictions that are embracing DERs have generally followed along a common path despite differences in governance, market structures, and regulatory environments.

Efforts to advance DERs and VPPs can be conceptualized based on the framework outlined below, which has been developed based on a review of relevant literature and the actions taken in the three international case studies highlighted in **Appendix B**. Many of the outlined steps may be advanced simultaneously, whereas others will likely proceed in a sequential manner.



Assessing

Assessment focuses on understanding the technical, economic, and achievable potential of DERs in meeting specific energy systems needs. It is typically one of the first steps that jurisdictions take and ideally includes the publication of relevant studies.

Key steps include:

- DER potential studies
- Modelling that accounts for DERs and flexibility as a resource alongside other traditional resources when looking at how the system might operate in the future

Signalling

Following the assessment of DER potential, many jurisdictions will signal DER-related priorities by publishing concrete policy directions in the form of roadmaps, strategies, or other plans to guide energy system actors, ensure coordination, and sequence reforms.

Key steps include:

- Roadmaps
- Targets
- Broad policy direction (efficiency/demand-management first, electrification focus, etc.)

Planning and governance

Planning and governance tackles the fundamental structures that underpin the electricity system. Building out the infrastructure, deploying technologies, and coordinating the use of VPPs at both a bulk system and distribution level all require new approaches and incentives.

Key steps include:

- Planning reforms: integrated planning, distribution-level planning, DER/VPP resource adequacy assessments, requirements or incentives to consider non-wires alternatives, transmission-distribution coordination
- Governance: creation of a new distribution system operator role, clarify role of third party providers/aggregators, establish new business models, etc.
- Incentives for utilities: non-wires alternatives policies, compensation for DER investments, etc.
- Codes, standards, and regulations: equipment efficiency requirements, building codes, reforming connection horizons (timelines associated with new loads connecting to the system), etc.

Market creation and electricity pricing

To ensure DER and VPP contributions are properly valued and compensated, and consumers are incentivized to adopt them, energy system actors should ensure DERs and VPPs are able to participate in various types of energy markets, including traditional energy markers, capacity markets (where power producers are paid for their ability to deliver electricity when needed) and other flexibility or ancillary markets (such as compensating a producer for providing frequency services). Additionally, pricing and rate structures should be leveraged as a key tool that helps optimize and incentivize DER usage during desired time periods.

Key steps include:

- Market creation / value streams: ensuring DERs/VPPs can participate in energy, capacity, flexibility, and ancillary markets where relevant
- Pricing and rate design: time-of-use rates, real-time pricing, feed-in-tariffs, industrial rates, etc.

Grid readiness

Energy system actors must also ensure that the energy system infrastructure—both physical and digital—that is required to fully leverage DERs, as well as the data protocols that support them, are modernized. These measures range from ensuring the deployment of devices that measure and/or control DERs in a household, to deploying the physical infrastructure required at a distribution level to ensure adequate electricity capacity, to implementing the technical systems that ensure cybersecurity.

Key steps include:

- Technical solutions: smart meters, asset measuring devices, utility/system operator management software (automated interactions, optimization of energy use, integration across both distribution and bulk-system)
- Data usage and protection: data exchange between actors, interoperability standards (ensuring different digital systems can communicate), data protection, cybersecurity
- Distribution system upgrades: infrastructure investments, capacity mapping, etc.

Consumer technology deployment

While jurisdictions often follow the previous steps in a somewhat sequential manner, the deployment of consumer technologies is an ongoing process. Consumers may embrace technologies on their own initiative, but government programs are often put in place to accelerate and expand uptake.

Key steps include:

- Consumer programs: financial supports/incentives, consumer education, etc.

VPP enrolment

Finally, as jurisdictions reform their markets and governance structures, they typically stand up new incentives and pilot projects to test the operation of VPPs at scale and enrol a sufficient number of consumers to ensure meaningful resources are available.

Key steps include:

- Pilots
- Programs and incentives

Current state of DERs and VPPs in Canada

Some Canadian provinces, most notably Ontario, have begun assessing DER and VPP potential and produced roadmaps and other plans to set out the broad direction towards evolved electricity systems. Some progress has also been made on pilots, and a few VPP enrolment programs are active across the country.

However, there has been limited progress on the utility-centric elements of advancing DERs and VPPs in Canada that have been core components of the approach in leading jurisdictions, specifically in planning and governance, market creation and electricity pricing, and grid readiness. Government support to deploy consumer technologies has also been generally lacking. While multiple provinces support heat pumps, many do not offer incentives for other DERs like home batteries and rooftop solar. EV and home charging incentives are also less widespread, and many of the ones that do exist are now being phased out or canceled.

Overall, while there have been some positive signs of progress in parts of Canada, much more needs to be done before VPPs can become a reality across the country.

The remainder of this section summarizes the state-of-play on DERs and VPPs in Canada using the framework for action outlined above. A province-by-province overview is included in **Appendix A**.

Assessing

Some provinces (namely, Alberta, Manitoba, Ontario and New Brunswick) have studied DERs to varying degrees and published assessments. In Ontario, for example, the Independent Electricity System Operator (IESO) commissioned a study on the potential of DERs in the province in 2022, and found that DERs could deliver as much as 5-14% of summer peak demand by 2032.[17] The Alberta Electric System Operator (AESO) has been publishing a series of papers on DER integration, and utilities in Manitoba and New Brunswick have published integrated resource plans that either recognize decentralization as an important driver of change or whose scenarios were informed by different levels of DER uptake.[19–21] Efficiency Manitoba also published a study on the province's demand side management potential in 2022, which included insights for distributed generation.[22]

Signalling

Some provinces (Alberta, Ontario, Quebec, New Brunswick and Nova Scotia) have produced roadmaps, plans, or strategies to advance DERs and VPPs. For example, Ontario's Minister of Energy directed the IESO and OEB to advance work on DERs in 2023 and 2024, with the province launching its first integrated energy resource plan in 2025.[23–25] The plan included the stated intention of developing a DER strategy. The province previously published a DER roadmap in 2021, followed by a progress update in 2023.[26,27] In Alberta, AESO published a DER roadmap in 2020, with several annual updates since then.[28] Hydro-Québec's action plan of 2023 included the priorities of reducing and shifting consumption and increasing generation capacity through DERs.[29] New Brunswick and Nova Scotia identified distributed generation and load management as relevant resources in their respective plans.[30,31]

Planning and governance

Only a few provinces (British Columbia, Alberta, and Ontario) have advanced planning or governance reforms, such as enabling procurement of DERs to defer grid investment or work on transmission-distribution interoperability.[32–34] Only one province (Quebec) has a building code requirement for one DER technology in new construction (EV charging), although some municipalities (notably Toronto and Vancouver) also have put in place such requirements.[35–37] Additionally, the 2030 national building codes are expected to include requirements related to heat pumps, energy performance, lighting and electrical power systems.[38]

Market creation and electricity pricing

Every province has at least one net metering or net billing program to incentivize DERs for electricity generation, but only two (British Columbia and Ontario) have optional time-of-use electricity rates.[39,40] No major progress towards creating a market for VPPs has been identified in Canada save for Ontario, which published a study on the incentives needed to deploy DERs in 2025 to help inform VPP market design.[42]

Grid readiness

Several provinces (British Columbia, Saskatchewan, Ontario, New Brunswick, Newfoundland and Labrador, and Prince Edward Island) are modernizing their grids through investments and technical solutions. Many of these, mainly in Atlantic Canada, are still in the process of rolling out smart meters, however—devices that are low-cost, easy to install, and critical for enabling VPPs. More advanced steps include the development of centralized capacity information maps in Ontario and investments in transmission and distribution system upgrades, such as in British Columbia.[43,44]

Consumer technology deployment

Several provinces have implemented subsidy programs for DER technologies. However, these have largely focused on heat pumps with much less support for EVs and home charging, home batteries, and rooftop solar. All provinces except for Alberta and Saskatchewan currently offer subsidies for residential heat pump installations. While all provinces apart from Alberta, Saskatchewan, and Ontario had EV incentives in place in 2024, only four (Manitoba, Quebec, Prince Edward Island, and Newfoundland and Labrador) continue to offer these in 2025, while at least one (Newfoundland and Labrador) plans to phase them out in 2026.[45–48] Incentives for installing home EV chargers have also been in decline across Canada, with only four provinces (British Columbia, Quebec, Nova Scotia, and Prince Edward Island) remaining in 2025 and one of them (Nova Scotia) closing its program at the end of the year.[49–52] Only British Columbia and Ontario offer incentives for both home battery storage and rooftop solar, while Manitoba, New Brunswick, and Prince Edward Island have rebates for the latter only.[53–57] Quebec offers rebates for thermal battery storage.[58]

VPP enrolment

Some provinces (British Columbia, Ontario, Quebec, New Brunswick, plus the territory of the Yukon) have enrolment programs enabling utilities to leverage residential smart thermostats in virtual power plants.[59–63] Ontario's "Peak Perks" program successfully enrolled 100,000 customers in 2024, a milestone that was doubled a year later.[64,65] Additionally, numerous pilot programs have been completed or are currently underway in many provinces (Alberta, British Columbia, Ontario, Quebec, New Brunswick, and Nova Scotia) with Ontario being home to a particularly large number. Highlights include BC Hydro's virtual power plant project in two communities, as well as a vehicle-to-grid project for medium- and heavy-duty vehicles; a virtual power plant pilot near Edmonton, Alberta; the SPEEDIER, vehicle-to-grid demand response, PowerShare, and GridExchange projects in Ontario; and the Smart Grid Atlantic research program across Atlantic Canada.[66–73]

Next steps

Energy smart homes and VPPs hold immense potential in meeting Canada's growing electricity demand, offering opportunities to reduce energy bills, enhance energy security, and save governments, utilities, and households money.

While most Canadian provinces have begun taking important steps in line with global best practices and the DER framework laid out in this paper, much more work is needed to unlock the full potential of DERs across the country. As provinces take more and more action to modernize their energy systems, enabling the operation of VPPs must be a key priority.

Based on the DER framework presented in this paper and the current state of play across Canada, provincial governments—as well as the utilities and system operators they regulate—should take the following top priority actions in the near-term to accelerate the deployment of DERs and VPPs in Canada.

Provinces and system operators

1. Conduct and publish assessments that quantify the potential role that DERs and VPPs can play on the grid, and incorporate DERs and their potential flexibility contributions in provincial energy systems modelling.
2. Provide clear signals to regulators, utilities, and system operators by setting out the direction of travel through the creation of DER roadmaps that outline concrete strategies, plans, and targets to drive action.
3. Advance utility-centric actions that are necessary for progress on DERs and VPPs, specifically in planning and governance, market creation and electricity pricing, and grid readiness.

Utilities

4. Provide financial support to help reduce the upfront cost of clean energy technologies to consumers, ensuring that DER deployment scales as utilities build capacity to leverage them as part of a VPP.
5. Design programs that equitably share the value of VPPs with individual customers and the system as a whole.

Appendix A: Highlights of DERs and VPPs in Canada by province

	BC	AB	SK	MB	ON	QC	NB	NS	PEI	NL
Highlights (details below)	Investments in grid readiness under BC Hydro's 10-year capital plan Optional time-of-use electricity rate, VPP enrolment program, some pilot projects Various rebates for the deployment of consumer technology	DER roadmap and papers on DER integration Enabling procurement of non-wires alternatives Some pilot projects	Rollout of smart meters Net metering program	Integrated resource plan Rebates for the deployment of consumer technology	DER potential study, DER roadmap, integrated energy resource plan Requirement for LDCs to publish information to develop centralized capacity maps Optional time-of-use electricity rate, VPP enrolment program, numerous pilot projects Some rebates for the deployment of consumer technology	Hydro-Québec's Action Plan 2035 highlighting role of DERs Building code requirement for EV charging in new construction VPP enrolment program, some pilot projects Various rebates for the deployment of consumer technology	Energy strategy, integrated resource plan Strategic plan to modernize the grid VPP enrolment program, some pilot projects Some rebates for the deployment of consumer technology	Power plan highlighting load management Some pilot projects Some rebates for the deployment of consumer technology	Rollout of smart meters Net metering program Various rebates for the deployment of consumer technology	Rollout of smart meters Net metering programs Some rebates for the deployment of consumer technology
Assessing		AESO series of papers on DER integration (2022+)[19]		Manitoba Hydro's 2023 Integrated Resource Plan (2023)[20]	IESO study on DER potential (2022)[17]		NB Power's 2023 Integrated Resource Plan (2023)[21]			
Signalling		AESO DER roadmap (2020), with several annual updates since then[74]			Minister of Energy directed IESO and OEB to advance work on DERs (2023, 2024)[23,25] IESO DER roadmap (2021)[26] IESO DER progress update (2023)[28] Integrated energy resource plan (2025)[24]	Hydro-Québec Action Plan 2035 (2023)[29]	Energy strategy (2023)[30]	2030 Clean Power Plan (2023)[31]		
Planning and governance	Municipal (City of Vancouver) requirement for EV readiness in new construction[37]	Government enabling procurement of non-wires alternatives (2024)[32]			IESO-commissioned transmission-distribution interoperability framework (2020)[34] OEB guidance on non-wires solutions (2024)[33] Municipal (City of Toronto) requirement for EV readiness in new construction[36]	Building code requirement for EV charging in new construction[35]				

	BC	AB	SK	MB	ON	QC	NB	NS	PEI	NL
Market creation and electricity pricing	Optional time-of-use electricity rate[39] BC Hydro self-generation program[75] FortisBC net metering program[76]	Micro-generation program[77]	SaskPower net metering program[78]	Manitoba Hydro net billing[79]	Optional time-of-use electricity rate[40] Net metering available at LDCs[80] OEB-IESO joint study on incentives needed to deploy DERs (2025)[42]	Hydro-Québec net metering[81]	NB Power net metering program[82]	Nova Scotia Power self-generation option[83] Community Solar Program (2024)[84]	Maritime Electric net metering[85]	Newfoundland Power net metering service option[86] Newfoundland & Labrador Hydro net metering program[87]
Grid readiness	BC Hydro 10-year capital plan (2024)[44]		Rollout of smart meters[88]		OEB strengthening cyber security (2025)[24] OEB requirement for LDCs to publish information to develop centralized capacity maps (2025)[43]		NB Power Strategic Plan 2023-2035 (2023)[89]		Rollout of smart meters[90]	Rollout of smart meters[91]
Consumer technology deployment	EV charger rebates[49] Heat pump rebates[92] Home battery storage and rooftop solar[53]			EV rebates[45] Heat pump rebates[93] Rooftop solar rebates[55]	Heat pump rebates[94] Home battery storage and rooftop solar[54]	EV rebates[46] EV charger rebates[50] Heat pump rebates[95] Thermal battery storage rebates[58]	Heat pump rebates[56] Rooftop solar rebates[56]	EV charger rebates[51] Heat pump rebates[96]	EV rebates[47] EV charger rebates[52] Heat pump rebates[97] Rooftop solar rebates[57]	EV rebates[48] Heat pump rebates[98]
VPP enrolment	BC Hydro Peak Saver program[59] BC Hydro VPP pilot[66] BC Hydro V2G pilot for MHDVs[67]	VPP pilot in Edmonton[68] Residential battery storage pilot[99]			IESO Save on Energy Peak Perks program[60] Alectra GridExchange pilot[72] Alectra Power.House Hybrid pilot[100] SPEEDIER pilot[69] IESO Interoperability and Non-Wires Alternative Demonstration pilot[101] Vehicle to Grid Demand Response pilot[70] Essex Powerlines PowerShare pilot[71]	Hilo program[61] Hydro-Québec Lac Mégantic microgrid[102] Hydro-Québec home-based batteries pilot[103]	NB Power Peak Rebate program[62] NB Power smart thermostat pilot[104] NB Power DER pilot[73]	Nova Scotia Power pilot[105] Efficiency Nova Scotia Eco Shift pilot[106]		

Appendix B: International case studies

While VPPs are seeing increasing deployment around the world, this report focused on three jurisdictions that are frequently identified in the literature as key leaders in the DERs and VPPs space to inform the development of the framework: Australia, the United Kingdom, and California.[11,107–109]

Australia: Global leader in the deployment and integration of smart home technologies

Globally, few jurisdictions have achieved more widespread adoption of smart home technologies than Australia, and their experience offers key insights for others.

Assessing

Guided by both national and regional roadmaps, Australia is preparing for a future in 2050 where as much as 45% of all electricity generated comes from smart-home technologies like rooftop solar.[110,111] The Integrated System Plan published bi-annually by the Australian Energy Market Operator (AEMO) regularly includes assessments of the role the DERs could play in meeting Australia's energy demand under different scenarios.[112]

Signalling

In 2017, Energy Networks Australia (the country's national industry body representing electricity transmission and distribution and gas distribution networks) and CSIRO (Australia's national science agency) came together to develop the Electricity Network Transformation Roadmap (ENTR), which provided a guide for the transformation of the national grid, and embraced the growing role of energy smart homes and DERs more generally.[110] Regions like Western Australia, have been proactive in developing their own regional roadmaps to address specific challenges and seize unique opportunities, a practice that will be important in Canada as well given the meaningful differences in energy system governance, consumer technology adoption and geography between provinces.[111]

Planning and governance

With households increasingly electrifying, Australia is racing to catch up with the grid modernization required to manage and optimize this growing resource. Major collaborations between the private sector, research institutions and the AEMO are looking at reforms spanning new governance models to technical changes in the operation of the grid.[113]

Market creation and electricity pricing and grid readiness

The AEMO has played an important role in advancing the technical and operational needs that increasing amounts of DERs require from the Australia energy system, helping establish dedicated DER programs in both major regions of the country.[114] These programs are designed to help assess, modernize and operationalize the integration of DERs to benefit consumers across the country and focused on a number of key priorities:[114]

- **Markets:** ensuring flexible resources are properly valued and incentivized
- **DER demonstrations:** designing and executing projects to trial innovative technologies, VPP models and other demand response mechanisms
- **Operations:** examining how DER assets integrate with other resources and address system-wide needs
- **Data and visibility:** developing a database of DER installations to support effective integration into the grid
- **Standards and connections:** ensure optimal DER technical performance and energy system security and enhance interoperability and cyber security protection
- **Engagement and collaboration:** broad engagement with stakeholders from across the energy sector, public sector, consumer forums, regulatory bodies, and research agencies

Consumer technology deployment

Nearly 21% of Australia's electricity was already being generated by households and businesses as of 2023-2024, with over 4 million households utilizing rooftop solar.[115,116] With roughly 11 million total households, Australia sees the highest number of household solar installations in the world, and is also seeing significant growth in batteries, where residential sales have tripled in the first half of 2025 from just 1 year ago.[117]

VPP enrolment

From 2019-2021, the AEMO ran a series of VPP demonstration projects in Australia, seeking to better understand how to best integrate DERs into the electricity market, while maximizing value to customers.[118] Despite the widespread adoption of household DERs, actual participation in VPPs is more limited at this point, with a 38,200 customers participating in virtual power plants across New South

Wales, Queensland, Victoria and South Australia as at January 2025 (in a region representing almost 10.1 million households).[119] Nonetheless, evidence shows that households participating in the VPP experienced lower electricity bills, and governments are actively working to establish market conditions and program supports that will help drive up enrolment.[119]

United Kingdom: global leader in establishing cutting edge governance structures to maximize the role of energy smart homes

Whereas Australia is a global leader in the deployment of certain smart-home technologies (namely rooftop solar, and increasingly batteries), the United Kingdom is a leader in advancing the governance and market reforms required to maximize the role they can play providing a clean, cheap and flexible resource, while giving consumers new ways to lower their energy bills.

Assessing

In 2025, the Future Energy Scenarios: Pathways to Net Zero (FES) was published by the National Energy System Operator (NESO), the fifteenth FES and the first for the NESO as the new energy system operator.[120] The independent scenarios in this most recent assessment considered the rise of DERs, and the potential for these resources to help meet the flexibility needs facing the UK energy system, and helped inform the energy strategy developed by the government.

Signalling

Since 2017, successive governments in the U.K. have developed roadmaps that sought to expand the role that consumer-based smart technologies play in providing the electricity grid with flexibility while keeping energy bills affordable and achieving other objectives like energy security and climate targets.[4,121,122] The most recent roadmap was a key action identified in the government's broader energy strategy of 2024, *Clean Power Action Plan in 2030,* which established targets and priority actions in four key areas: battery storage, consumer-led flexibility, interconnections, and general hurdles and enablers.[123]

Planning and governance and market creation and electricity pricing

The *Clean Flexibility Roadmap* of 2025—a guide to the creation of a "smart, secure, and decarbonised electricity system with clean flexibility at its core"—was developed through a partnership between the independent regulator (Ofgem), the National Energy System Operator (NESO), and the national government.[4] This roadmap is intended to guide the significant changes required in the way the U.K. plans and governs its electricity system, as well as supporting policy changes that reformed how energy markets operate and the integration of DERs to enable a prominent role for consumers in meeting energy system needs.[123] It's a key example of how a roadmap can be used to coordinate both the governance changes and the market reforms required to advance the role of energy smart homes.

Grid readiness

The UK government is in the process of rolling out smart meters across the country, having established minimum annual installation targets for smart meters in 2022.[124] As of the end of June 2025, 40 million smart and advanced meters were in homes and small businesses across Great Britain representing 69% of all meters.[125]

Consumer technology deployment

As of winter 2024/2025, over two million households and businesses across the U.K. participated in demand flexibility programs, saving money and helping to reduce electricity demand during periods of peak demand.[4]

VPP enrolment

There are a variety of companies who are offering VPP opportunities in the United Kingdom, largely focused on leveraging smart chargers and/or home energy batteries.[126]

California: A global leader in testing and scaling VPPs

In North America, few jurisdictions have gone farther to establish a prominent role for DERs in the energy system than California. Whether in the adoption of DERs by households, or in the legislative and regulatory reforms that the state has advanced, a growing share of California's energy needs are met through energy smart homes and businesses.

Assessing

For over a decade, California has been working to make DERs a larger part of its energy mix, with the first study quantifying the potential of this resource published in 2016, followed by more detailed assessments in the years after.[127]

Signalling

In the same year, the California Public Utilities Commission (CPUC) developed a *Distributed Energy Resource (DER) Action Plan* to serve as the roadmap for shaping the future of distributed energy resources in California.[128]

Planning and governance, market creation and electricity pricing and grid readiness

This initial roadmap was updated in 2022 with the publication of the D*istributed Energy Resources Action Plan 2.0,* which provided a coordinated strategic vision for DER policy in the state through 2026.[129] This latest strategy focuses on four key areas: improving the management of demand-side resources through rates and policies that support electrification, guiding utility infrastructure planning and operations, market reforms to ensure multiple streams of benefits can be secured, and improving the coordination, planning and development of consumer programs.[130]

VPP enrolment

The state is exploring how to best scale VPPs, with assessments showing that by 2035, statewide VPP potential could meet 15.3% of expected peak demand (up from 3.2% in 2024), and save consumers $550 million per year.[8]

Appendix C: Definitions

Aggregated distributed energy resources (ADERs): Aggregated distributed energy resources (ADERs): ADERs can be defined as groups of DERs capable of providing one or more services to the grid through dispatch or control. They can be managed and orchestrated by software that controls their operations. ADERs can consist solely of one technology (e.g. smart thermostats) or multiple technologies (e.g. batteries, rooftop solar, smart water heaters). This definition does not include energy efficiency, which cannot be controlled to provide grid services. The U.S. National Association of Regulatory Utility Commissioners (NARUC) uses the term ADERs interchangeably with virtual power plants.[131]

Demand flexibility: Demand flexibility is the capacity of energy consumers to change their energy consumption at various timescales. For example, this includes shifting energy-intensive processes away from peak system demand times to other hours of the day when more energy is available and at a lower price.[132]

Demand response (DR): Demand response refers to balancing the demand on power grids by encouraging customers to shift electricity demand to times when electricity is more plentiful or other demand is lower, typically through prices or monetary incentives. New digital technologies can help to automate demand response through connected devices.[133] Put differently, demand response is a way to balance electricity supply and demand by adjusting energy usage. To do this, a demand response event can be called during peak energy usage periods.[106]

Demand side management (DSM): DSM refers to a strategy that utilities can use to help balance the supply and demand of electricity, through adjustments in consumer behavior. For example, utilities can offer financial incentives or lower prices to consumers or companies who agree to reduce their usage during peak hours.[134]

Demand-side resources: These include any hardware or software adopted by electricity end users that could potentially provide grid services. Demand-side resources can be broadly grouped into three categories: flexible loads, distributed generation, and distributed storage.[135]

Distributed energy resources (DERs): While there is no universally-accepted definition, DERs can be described as devices or technologies that interface with the electricity system by consuming, storing, or injecting power at the distribution level, either by directly connecting to the distribution utility's wires or on an end-use customer's system.[136] DERs include distribution-connected renewable resources, energy efficiency, energy storage, electric vehicles, and demand response.[131] Expressed differently, DERs are equipment located on or near the site of end-use that can provide electricity demand flexibility, electricity generation, storage, or other energy services at a small (sub-utility) scale and are typically connected to the lower-voltage distribution grid.[9]

Distributed energy resource management system (DERMS): This term denotes software solutions that manage the use of DERs. DERMS can often refer to very different hierarchical levels of software solutions, aimed for different stakeholders and for satisfying completely different goals with using DERs. Specifically, DERMS can range from software solutions that are fully centralized (e.g. for utilities, distribution system operators) versus fully decentralized (e.g. for household consumers, including home energy management systems).[137]

Energy efficiency: Energy efficiency refers to how effectively energy is being used for a given purpose. For example, providing a similar—or better—level of service with less energy consumption on a per unit basis is considered an improvement in energy efficiency.[138] Some definitions of DERs include energy efficiency, while others do not.[136]

Non-wires alternatives (NWA) or non-wires solutions (NWS): These terms refer to the use of ADER grid services to defer or avoid new transmission and distribution grid assets.[131] In other words, these terms refer to any electrical grid investment that is intended to defer or remove the need to construct or upgrade components of a distribution and/or transmission system, or "wires investment".[139] NWS is also known as NWA.[33]

Virtual power plants (VPPs): This term refers to aggregations of DERs that can balance electrical loads and provide utility-scale and utility-grade grid services like a traditional power plant. Different VPPs can perform different services and deliver different benefits.[9]

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