NOSTROMO ICEBRICK® VPP

Become a Grid-Interactive Energy Efficient Building

NOSTROMO
COOLING GLOBAL WARMING

Content

Abbreviations

BTM	Behind the Meter
CAISO	California Independent System Operator
CCA	Community Choice Aggregator
CPUC	California Public Utilities Commission
DER	Distributed Energy Resources
DOE	Department of Energy
DR	Demand Response
ESaaS	Energy Storage as a Service
EV	Electric Vehicle
GEB	Grid-Interactive Energy Efficient Building
FERC	Federal Energy Regulatory Commission
FTM	Front of the Meter
HVAC	Heating, Ventilation and Air Conditioning
ISO	Independent System Operator
LBNL	Lawrence Berkeley National Laboratory
LSE	Load Serving Entity
PCM	Phase Change Material
RA	Resource Adequacy
RTO	Regional Transmission Organization
VPP	Virtual Power Plant

About VPPs

General

Virtual power plants (VPPs) are decentralized, grid-integrated networks of distributed energy resources (DERs), managed centrally to provide grid flexibility and reliability, in contrast to traditional centralized, large power plants. VPPs manage DERs like residential solar panels, energy storage systems, and controllable loads (such as thermostats or EV chargers), managing them as a unified system, using advanced software and digital communication technologies. VPPs integrate these diverse DERs into a cohesive system that acts as a single grid-scale entity, capable of supplying energy to the power grid or adjusting demands as needed. By aggregating these resources, VPPs can balance supply and demand in real-time and optimize energy production, consumption and storage.

VPPs can leverage both behind-the-meter (BTM) and front-of-the-meter (FTM) resources, depending on their design, purpose, and the specific resources available. However, VPPs rely primarily on BTM resources, as they are already grid-connected, thereby avoiding the long interconnection timelines (which can last years and add significant costs). BTM resources provide primarily demand management, by reducing load on transmission and distribution infrastructure, enabling consumer participation, and improving grid resilience by diversifying and distributing energy generation and storage points. On the other hand, BTM resources are more challenging to manage and control, and they are often voluntary and dependent on consumer action, which reduces their reliability. As explained in Section 3, the Nostromo IceBrick VPP is fully-automated and does not depend on consumer behavior, making it as reliable as most FTM resources.

The Value of VPPs

Value to the Power Grid and Society

A. *Enhanced Grid Reliability and Stability*

VPPs provide grid operators with additional tools to maintain stability by responding to fluctuations in supply and demand, whether in real time or on a preset schedule. By modulating demand, VPPs prevent blackouts, stabilize voltage and maintain frequency, as well as prevent overloads where infrastructure may reach its capacity limits. Also, their ability to "island" sections of the grid during emergencies improves recovery times and system stability. VPPs have recently played a significant role in preventing blackouts and brownouts, notable instances include the California heatwaves in August 2024,[1] and the Texas winter storms in February 2023.[2]

B. *Load Balancing*

VPPs enable dynamic load balancing by shifting energy consumption to times of high renewable energy production or low grid demand. This reduces the strain on the grid during peak times and allows for better utilization of low-cost and clean resources, primarily renewables.

C. *Integration of Renewable Energy and Decarbonizing Power*

VPPs facilitate the integration of intermittent renewable energy sources such as solar and wind into the grid. By combining energy storage systems and demand response capabilities, they help smooth out the variability of these resources, ensuring consistent energy supply. VPPs using storage not only provide grid stability, but also serve to capture renewables at

[1] https://www.bloomberg.com/news/newsletters/2024-08-19/virtual-power-plant-is-the-grid-s-invisible-weapon-against-blackouts?utm_source=chatgpt.com
[2] https://www.utilitydive.com/news/Texas-to-expand-ADER-80-mw-distributed-energy-resources/702641/?utm_source=chatgpt.com

times of overproduction, for later use when these sources are not available.

D. *Reduced Need for New Infrastructure*

Serving the top 1% of demand can result in up to 9% of total infrastructure costs, such as new power plants or transmission lines, and the top 10% of demand accounts for about 25% of total costs. So, if the demand curve would be "flattened" by reducing peak demand, more energy could be delivered over the same fixed costs, increasing capacity utilization and cutting infrastructure costs per delivered kilowatt-hour.[3] Therefore, by optimizing demand, VPPs can reduce the need for investments in infrastructure. This is particularly beneficial in urban areas or regions with constrained grid infrastructure.

According to the Brattle Group (May 2023), excluding societal benefits (i.e., emissions and resilience), the net cost to the utility of providing "resource adequacy" (RA) from VPPs is only roughly 40% to 60% of the cost of the alternative options. Extrapolating from this observation, a 60 GW VPP deployment could meet future resource adequacy needs at a net cost that is $15 billion to $35 billion lower than the cost of the alternative options over the ensuing decade. When accounting for additional societal benefits, the VPP is the only resource with the potential to provide resource adequacy at a negative net cost. 60 GW of VPP could provide over $20 billion in additional societal benefits over a 10-year period.[4]

E. **Promote Energy Justice**

VPPs democratize the power market by enabling consumers to participate in the energy market, using existing or dedicated resources, for economic

[3] https://www.weforum.org/stories/2022/07/clean-energy-future-relationship-to-grid-must-change/
[4] https://www.brattle.com/wp-content/uploads/2023/04/Real-Reliability-The-Value-of-Virtual-Power-Technical-Appendix_5.3.2023.pdf

benefits, operational enhancements and support their decarbonization goals.[5]

It can also protect consumers from potential cost increases resulting from new demand by large users (currently most often data centers), which require more infrastructure, which generally rolls over to ratepayers, although it should be the responsibility of such large users to mitigate.[6]

Benefits for VPP Participants

A. *Revenue Generation*

Consumers can earn money by participating in demand management programs where they reduce consumption during peak demand periods.

B. *Improved Resilience*

Revenue from participation helps finance on-site energy systems, like storage, which, in turn, provide backup energy for the facility.

C. *Contribute to Decarbonization Goals*

CO_2 emissions from buildings' energy use accounted for about 37% of global CO_2 emissions in 2020.[7] These include scope 1 (on-site consumption) and scope 2 (purchased power). In office buildings, scope 2 emissions typically constitute the largest portion of total emissions, often ranging from 50% to 70%. This is primarily due to electricity usage for lighting, heating, ventilation, air conditioning (HVAC), and office equipment. For example, Federal buildings would be defined as "net-zero

[5] NREL 2023
[6] See for example Ohio ratepayers requesting FERC intervention to prevent potential rate increase to finance infrastructure upgrade for powering an Amazon data center (Utility Dive, Nov 18, 2024), and a FERC rejection of an interconnection agreement amendment related to another Amazon data center in Pennsylvania over similar concerns (Utility Dive, Nov 5, 2024).
[7] Greenhouse Gas Emissions Accounting in Buildings (NREL 2022)

emissions" if, at an agency level, the targeted scope 1 and scope 2 emissions from all facilities are reduced by the maximum extent feasible, with remaining emissions balanced so the annual emissions equal zero.[8]

Storage is a very effective tool for cutting a building's Scope 2 emissions, possibly the most impactful one as it can potentially eliminate them completely. That's because the carbon-intensity of grid-supplied power varies hourly, according to the mix of generation resources feeding the grid during each time of the day. Therefore, using low-carbon grid-electricity to charge the building's energy storage system, and using it later when grid-electricity has high carbon intensity, can significantly reduce the building's Scope 2 emissions, up to 100% if it can capture enough zero emission power (from on-site resources or when the grid is powered only by renewables), to meet its energy needs at other times.

A storage-VPP that operates based on carbon signals, where participants charge during maximal renewable generation, and discharge when it is minimal, will enable participants to maximize reduction of their Scope 2 emissions, while earning participation revenue and helping the grid be more efficient and emission-free.

VPP Operation

Key components of a VPP include:

- Distributed Energy Resources (DERs), such as solar panels, storage systems, and controllable loads like HVAC systems or EV chargers.
- Advanced Software Platforms: Cloud-based software that enables real-time monitoring, data analytics, optimization and reporting.

[8] The Federal Buildings Performance Standards (Executive Office of the President, December 2022)

- Communication Infrastructure: Internet of Things (IoT) devices and smart meters that facilitate seamless data exchange between the grid operator, the VPP, and participants.

The operation of a VPP involves several coordinated steps that ensure the seamless integration and optimization of distributed energy resources. Here's an overview:

A. *Connecting the DERs*

The VPP resources are recruited and connected to the VPP software platform through IoT devices, smart local controls and advanced sensors, enabling real-time monitoring and control.

B. *Data Collection and Analytics*

The VPP's management system collects data from each connected resource to determine available energy output or load reduction. The Nostromo IceBrick VPP management system also optimizes the available energy with the forecasted load profiles of the host-facility and its operational preferences.

Advanced VPPs, such as Nostromo IceBrick VPP, that enable participation in the wholesale energy markets, also collect market information, such as wholesale energy prices and hourly carbon intensity, to maximize the total benefit from each dispatch cycle. Advanced analytics then apply this data to determine the most efficient way to operate the VPP resources, both individually and as a whole.

C. *Optimization and Dispatch*

The VPP software can optimize the operation of the connected resources to achieve one or more of the following objectives:

- Meet expected financial returns for participants

- Ensure grid stability and reliability
- Minimize energy waste and emissions

When participating in the wholesale electricity markets, the VPP platform also bids the available energy or demand reduction in the marketplace.

D. *Real-Time Communication*

The VPP platform provides seamless communication between the grid operator and participants ensures rapid response to changing conditions.

E. *Reporting and Settlements*

The VPP operator collects operational data in real-time for reporting and receives performance-based payments from the market or grid operator, which it shares with participants based on the bi-lateral agreement between them.

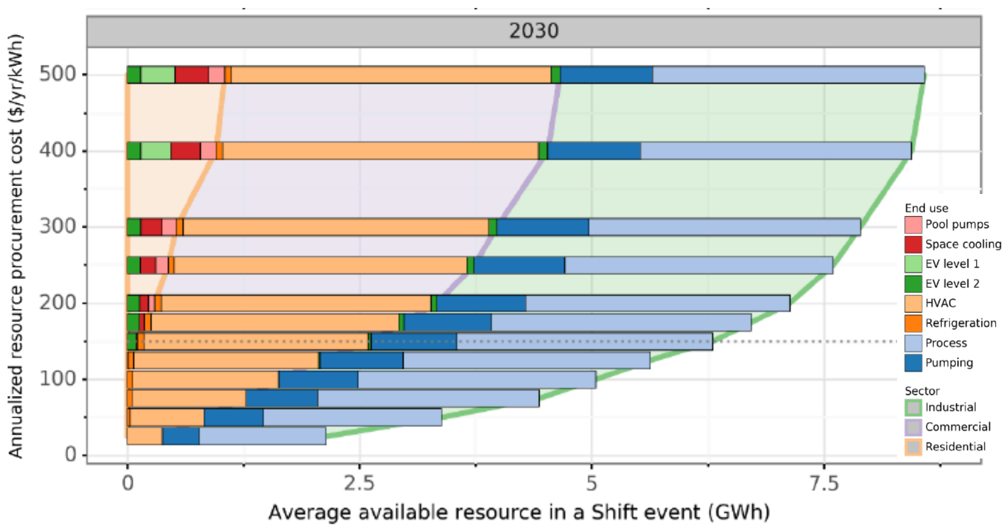
The IceBrick Thermal Energy Storage System as a VPP Resource

Air Conditioning Loads - The Main Driver of Grid Insability

Air conditioning is the single, largest contributor to peak loads, especially during summer months, and general variability of demand for electricity.[9,10] In some areas, air conditioning can represent up to 50% or more of the peak electricity demand.[11] According to LBNL, commercial air conditioning accounts for about one third of the total demand on the grid that can be

[9] International Energy Agency, World Energy Outlook 2024 (page 18).
[10] World Economic Forum (July 2022)
[11] International Energy Agency, The Future of Cooling (2018)

shifted with energy storage, and almost the entire potential in the commercial building sector.[12]



LBNL, supply curve of load-shifting potential, by end-use of electricity and market segments

The IceBrick System

Nostromo's IceBrick system combines two core technologies: 1) the IceBrick thermal energy storage module, and 2) the Cirrus cloud-based management system.

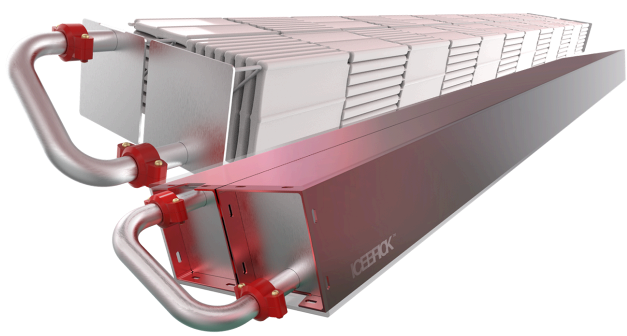
The IceBrick Modules

The IceBrick thermal energy storage modules are compacted and modular, to enable simple retrofit of existing buildings with a minimal footprint. Each IceBrick module stores approximately 10 ton-refrigeration-hours of cold energy, equivalent to 7-11 kWh (depending on the type of HVAC system installed in the building and displaced during discharge of the IceBrick system). Cold energy is stored by freezing water into ice in a highly efficient process, enabled by proprietary thermo-dynamic design and

[12] The California Demand Response Potential Study, Phase 3: Final Report on the Shift Resource through 2030 (LBNL, July 2020), page xvi).

freeze-promoting agents. Water as phase-changing material PCM) has very high energy storage density when changing phase (i.e., freezing or melting). This is due to its high “latent heat”, namely the capacity of materials to absorb cold-energy from the environment when changing phase, which is highest after ammonia, and 80 times more (in the case of water) than the energy needed to only change temperature (“sensible heat”). This energy is available when discharging to cool the building’s circulating chilled-water, instead of using its energy-intensive chillers, thereby reducing the building electricity demand by about a half.

When the IceBrick system discharges its cold energy the building receives precisely the amount of cooling it demands, without noting the difference between the source of energy. In other words, the operation is seamless to the building and its occupants, with the only notable effect being the sharp drop in electricity use.

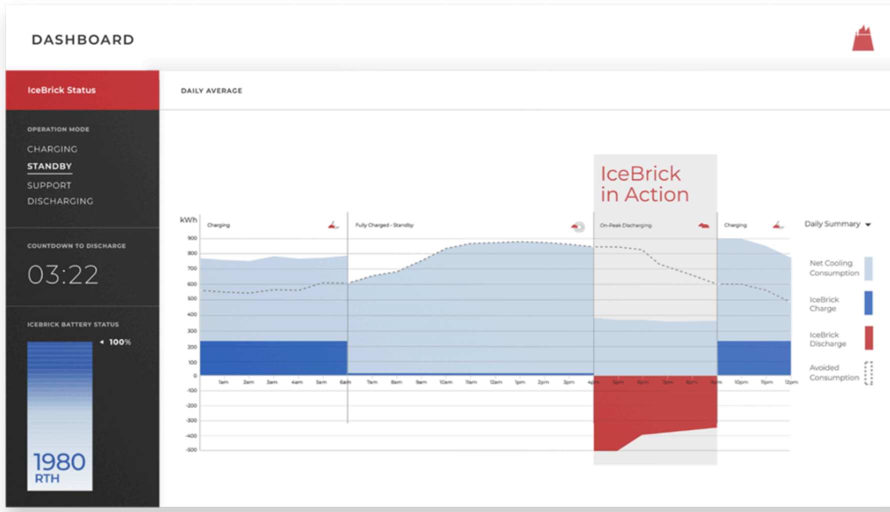


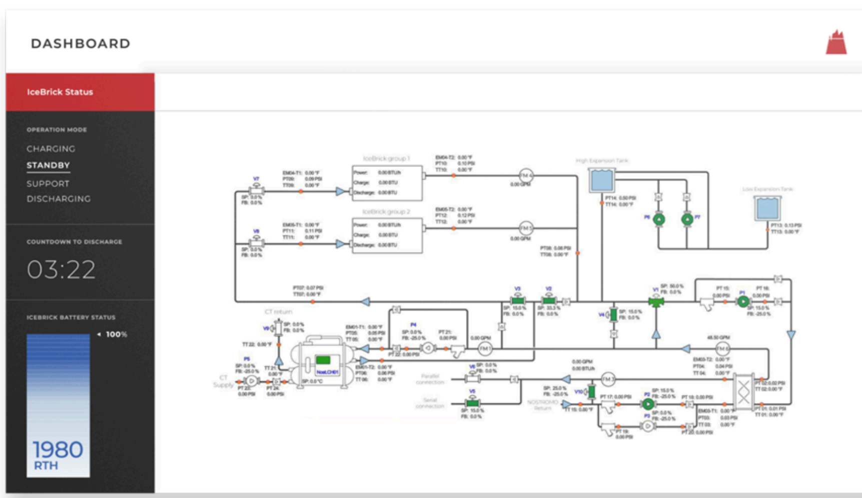
IceBrick Gen 2, made of recycled aluminum

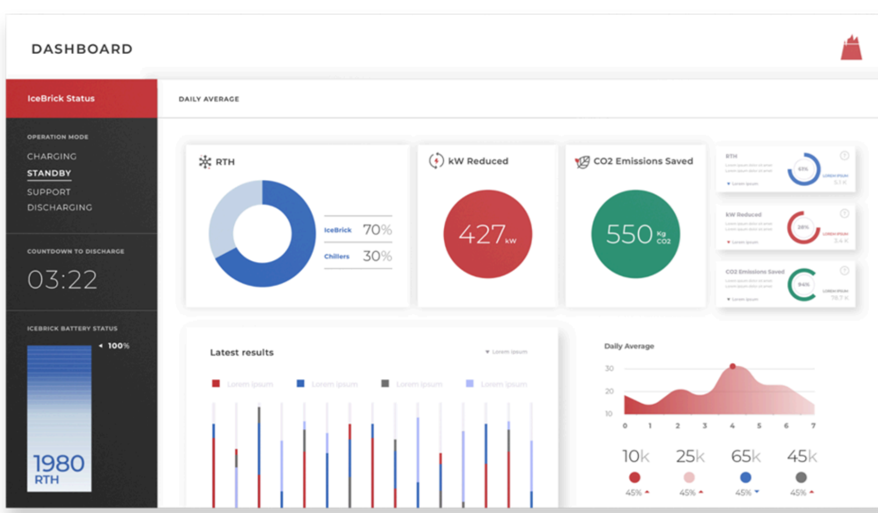
IceBrick system at the Beverly Hilton

System Management

The IceBrick systems are managed by Nostromo's cloud-based management software system, Cirrus™ via secured communication links. The management system provides full control of each IceBrick system and constantly monitors their operation, energy status and health, based on real-time data from dozens of sensors and meters installed in the system and transmitted to the cloud-based management system via the onsite controller. Cirrus also generates forecasts for the site's electricity and cooling loads, which it uses to plan each day a customized dynamic cycle (charge and discharge) for each individual IceBrick system, to optimize the value of the stored energy.


DASHBOARD
IceBrick Status
OPERATION MODE
CHARGING
STANDBY
SUPPORT
DISCHARGING
COUNTDOWN TO DISCHARGE
03:22
ICEBRICK BATTERY STATUS
100%
1980
RTH
DAILY AVERAGE
IceBrick
in Action
kWh
Daily Summary
Net Cooling Consumption
IceBrick Charge
IceBrick Discharge
Avoided Consumption


DASHBOARD
IceBrick Status
OPERATION MODE
CHARGING
STANDBY
SUPPORT
DISCHARGING
COUNTDOWN TO DISCHARGE
03:22
ICEBRICK BATTERY STATUS
100%
1980
RTH


DASHBOARD
IceBrick Status
OPERATION MODE
CHARGING
STANDBY
SUPPORT
DISCHARGING
COUNTDOWN TO DISCHARGE
03:22
ICEBRICK BATTERY STATUS
100%
1980
RTH
DAILY AVERAGE
RTH
IceBrick 70%
Chillers 30%
kW Reduced
427 kw
CO2 Emissions Saved
550 Kg CO2
Latest results
Daily Average
10k
25k
65k
45k

Nostromo VPP Platform

General

The IceBrick systems are a “demand response” (DR) resource, as they can reduce the demand on the registered utility meter upon discharging their energy. “Demands response” has been traditionally based on asking consumers to simply lower electricity use by reducing use of appliances. As such, participation often disrupts the consumer’s operation or conditions, therefore almost always voluntary and hence less reliable. The advent of energy storage technologies introduced the potential for automated DR, which is not only independent of customer behaviors and real-time action, but is seamless from the customer’s perspective, as the energy will keep flowing, but from storage rather than the power grid.

Using energy storage for DR also enables more accurate measurement of actual performance of each resource, for better management and compensation. Traditional DR performance measurement is based on reduction of load compared to a “baseline”, which is calculated based on historical consumption. This “baseline” approach has been widely criticized for being inaccurate, complex and unfair, mostly due to the differences between the conditions (e.g., weather) when the baseline was calculated and the conditions at the time of participation. Despite these limitations, there is no alternative way to measure “non-consumption”. However, energy storage enables us to measure load reduction very accurately, by sub-metering the output of energy from the storage, which replaces, and therefore equal to the load reduction, namely the energy not drawn from the grid.

The Cirrus™ VPP System

The IceBrick systems were designed to be operated as a VPP, by being managed by the cloud-based Cirrus software. The Cirrus platform can communicate to a local utility or to the marketplace (through scheduling coordinator), in order to signal availability, receive dispatch requests and report performance. For example, to participate in the wholesale market, the Cirrus platform can bid the available energy as a "demand response" resource (namely, reducing loads), and receive dispatch schedules based on market pricing, or receive specific requests from a local utility during an event. Cirrus can then operate the IceBrick systems located in a certain market as a single fleet, or (in certain markets, following FERC Order 2222)[13] enable single systems to participate individually, as an independent grid resource.

Cirrus illustration

Regulatory Procedures and Compliance ("Resource Adequacy")

In order to directly participate in the wholesale market, a resource has to be "qualified" for the maximum capacity that it may bid into the market. For example, demand response resources in California, have to be qualified annually for their qualified capacity in the following year, namely their

[13] See Section 4

“resource adequacy" (RA) values. Once awarded RA values, the resource can also sell the qualified capacity to any of the regulated load serving entities (LESs), such as utilities or community choice aggregators (CCAs) to capture additional revenue.

The IceBrick systems are the first thermal energy storage technology to be recognized by the California Public Utilities Commission (CPUC) for qualified capacity and receive “resource adequacy” (RA) credits as a supply-side DR resource, meaning that they can participate and bid their energy capacity directly into the CAISO market. Accordingly, an owner or operator for an IceBrick system may apply to the CPUC each year, provide initially simulated-projected performance, and in subsequent years actual-historical performance data, to be awarded its qualified capacity values for the following year. Once it has been issued its qualified capacity, each IceBrick system[14] can be registered on the CAISO market as an individual supply-side DR resource.

Nostromo provides this service to its customers participating in any of its VPP programs.

Commercial Arrangements

Every commercial building with an IceBrick system can participate in a VPP or standalone in California (if it has qualified capacity of at least 100 kW). The financial terms, namely how proceeds from market participation are shared, will vary according to the commercial arrangement on which the IceBrick system was installed. The IceBrick system is available in two ways: (1) direct purchase by the customer, or (2) as a service (Energy Storage as a Service), where the customer hosts it but the system is owned by Nostromo (or a financing partner). Customers under Nostromo’s service (ESaaS) program will

[14] IceBrick systems in California (and other markets which implemented FERC Order No. 2222) can register as individual resources if they have qualified capacity greater than 100 kW, which would be the case for most IceBrick systems; smaller systems can aggregate with others or be part of a larger VPP.

always be part of a VPP, and the commercial terms are provided in the ESaaS agreement. For customers who purchased and own their IceBrick system, VPP participation is optional, and they can contract with Nostromo or with any third-party VPP service provider that operates in their market.

The Future of VPPs

FERC Order No. 2222

In September 2020 the Federal Energy Regulatory Commission (FERC) issued Order No. 2222, marking a transformative step in enabling DERs to participate in U.S. wholesale electricity markets. By mandating the integration of aggregated behind-the-meter DERs into regional transmission organization (RTO) and independent system operator (ISO) markets, the order aims to enhance grid flexibility, efficiency, and reliability while supporting decarbonization goals.

FERC Order 2222 requires RTOs and ISOs to revise their market rules to allow aggregated DERs to participate alongside traditional generators. The aggregation of these resources allows them to meet the minimum thresholds for wholesale market participation, opening new revenue streams and enabling broader adoption of clean energy technologies.

According to Order 2222, minimum capacity for participation will not exceed 100 kW. The output capacity of most IceBrick systems exceeds this limit and therefore IceBrick customers will have the option to participate in the wholesale energy markets on a standalone basis, or as part of a VPP, which aggregates multiple DERs.

Implementation of Order 2222 requires overcoming coordination and technical challenges. The pace of implementation varies among RTOs and

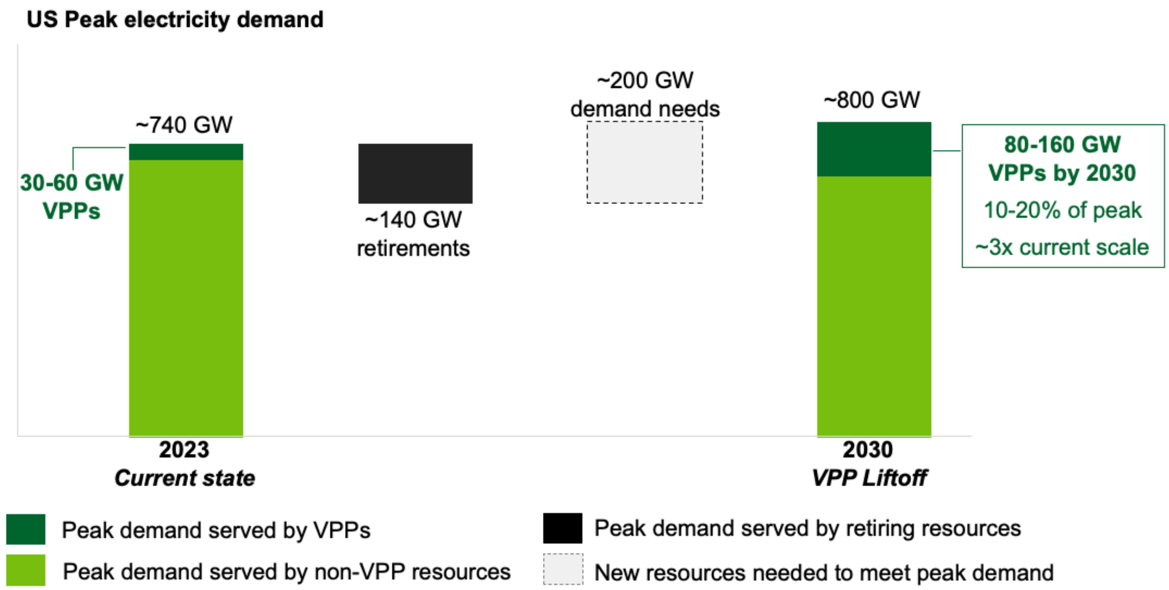
ISOs, with full compliance expected between 2023 and 2029. Challenges such as technical integration, coordination among stakeholders, and regulatory complexities contribute to these varied timelines. CAISO (California's ISO) is considered the most advanced in implementation of Order 2222.

DOE VPP Commercial Liftoff Report

In September 2023 the US Department of Energy (DOE) issued a report titled "Pathways to Commercial Liftoff: Virtual Power Plants".[15] The report outlines VPPs potential to reshape energy generation, distribution, and consumption by integrating distributed energy resources (DERs). According to the DOE, this approach offers economic, environmental, and societal benefits while addressing challenges such as grid reliability and decarbonization.

DOE estimates the peak loads on the national grid is expected to grow from 740 GW in 2023 to 800 GW in 2030, concurrent to the retirement of 140 GW of other resources, which means that 200 GW of peak-time delivery capacity will be required to meet demand (see chart below). The report estimates that half of the additional peak-time capacity, 80-160 GW, can be met with accelerated deployment of VPPs, which may save $10 billion annually in grid costs. In California, flexible demand from VPPs could lower the need for grid upgrades by as much as 70%.

[15] https://liftoff.energy.gov/vpp/



Source: US Department of Energy

According to the DOE, the barriers to expansion of VPPs are in the regulatory area (integration into utility planning and wholesale markets), lack of appropriate financial incentives, complex enrollment processes and infrastructure constraints.

Nostromo's VPP program overcame these barriers, through its modern system architecture and technology, designed for VPP operation, its operational flexibility, performance and compliance with energy market regulations. Nostromo has also made significant inroads in the regulatory landscape to facilitate participation of the IceBrick systems in the wholesale market. As a result, IceBrick users are able to seamlessly participate in the VPP market, enjoy its direct financial benefits and indirect community benefits, without impacting in any way their daily operations.

Grid Interactive Energy Efficient Buildings (GEBs)

The DOE VPP Commercial Liftoff report followed a May 2021 report by DOE and LBNL entitled "A National Roadmap for Grid-Interactive Efficient Buildings".[16] Grid-Interactive Efficient Buildings (GEBs) are equipped with smart technologies and DERs that dynamically respond to grid signals by reducing, shifting, or modulating energy demand while improving occupant comfort and reducing costs.

GEBs are typically large commercial buildings, so they can operate as either part of a VPP or sometimes even standalone. Their demand flexibility coupled with a grid-management interface can generate similar benefits to both the building and the power grid as a VPP.

According to DOE and LBNL, GEBs can save the U.S. electric power system $8-$18 billion annually by 2030, with cumulative savings of $100-$200 billion from 2021 to 2040, by reducing the need for costly generation and transmission infrastructure upgrades. National adoption could reduce CO2 emissions by 80 million tons annually by 2030, equivalent to the emissions of 17 million cars and support greater integration of renewable energy sources like wind and solar.

Most IceBrick systems have large enough energy capacity to operate as a standalone resource on the grid (in markets implementing FERC Order 2222), thereby enabling the building the choice between participating in the energy market on a standalone basis as GEB, or part of a muli-buildings VPP.

[16] https://gebroadmap.lbl.gov/