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WHITE PAPER

Virtual Power Plants Go Global

A Commercial Pathway for Moving from VPP to DERMS

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Commissioned by Enbala

Peter Asmus

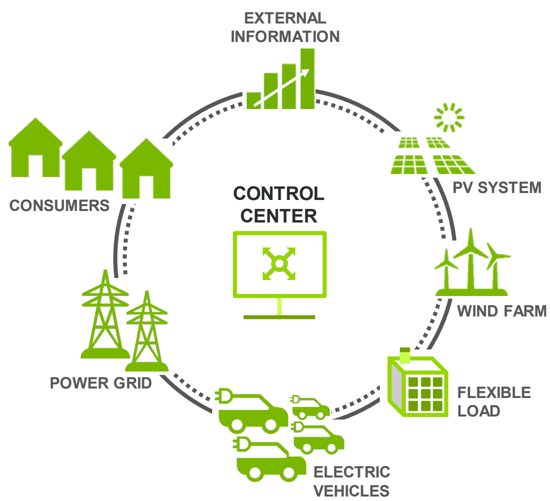
Research Director

Section 1
EXECUTIVE SUMMARY

1.1 Virtual Power Plants Go Global

As distributed energy resources (DER) continue to proliferate, so do the reliability challenges associated with smaller, diverse, and dispersed assets now populating the world's aging grid infrastructure. In the past, one of the chief concerns of utilities and grid operators was managing the intermittency of wholesale renewable energy sources, such as wind. Today, the diversity of resources being added to the power grid now include EVs—with mobile loads equivalent to a home—and rooftop solar PV coupled with energy storage devices at residences. As the aging grid infrastructure was not designed for two-way power flows, these recent trends create new challenges—as well as opportunities. A transformation is needed. As the platforms required to manage a more DER-dominated grid emerge, virtual power plants (VPPs) provide the necessary software to deal with these challenges and keep electric grids in a state of constant, delicate, and reliable balance.

Figure 1-1. The Virtual Power Plant Transformation Shift



(Source: Navigant Research)

Across Europe and Asia Pacific markets, utilities are joining their North American counterparts in seeking to modernize legacy demand response (DR) programs, widening the pool of DER assets and the services they can provide. This white paper shows that the need for grid balance is a global phenomenon. It highlights the ever-growing pool of diverse assets being rolled into VPPs and setting the stage for future DER management systems (DERMS). The VPP market is much more mature, but the evolution to DERMS is likely a natural response to the need for optimization of distribution networks due to the anticipated explosion of prosumer DER assets.

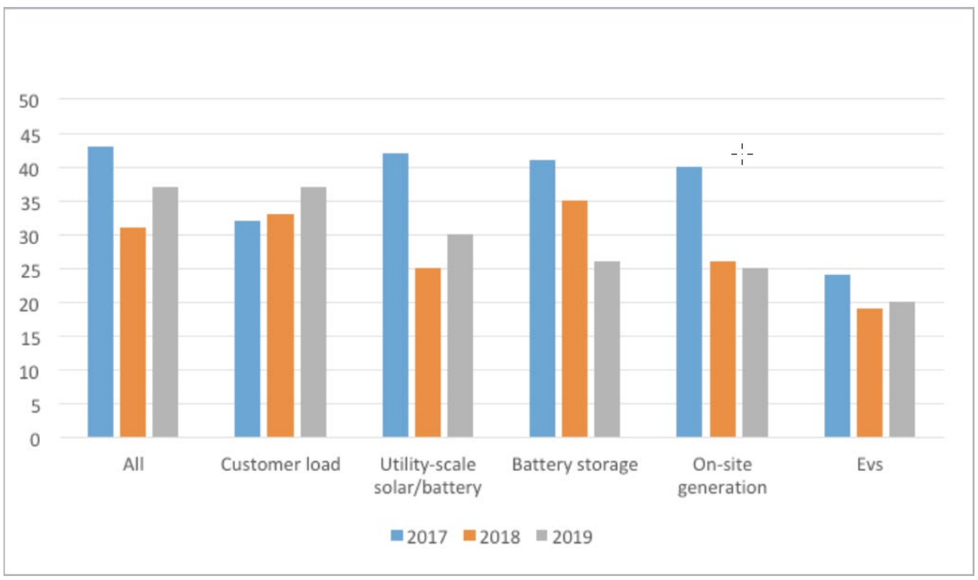
Section 2
DER MARKET TRENDS SURVEY UPDATE

2.1 Utility Drivers for Grid Asset Control and Optimization

Enbala has conducted a survey of the DistribuTECH conference attendees over the last 3 years. While attendee demographics shift annually, the survey provides a snapshot of top-of-mind trendlines among energy market participants—predominantly in North America, but also in Asia Pacific and Europe. The surveys reflect common concerns for utilities and grid operators as the world undergoes dramatic changes.

As Figure 2-1 shows, the distributed energy resources (DER) that utilities and grid operators are seeking to control are diverse, ranging from loads to generation, energy storage to EVs. These findings confirm Navigant Research contention that the virtual power plant (VPP) market is shifting to the mixed-asset segment. VPPs, and ultimately DER management systems (DERMS), will both be designed to network and optimize the full spectrum of DER due to advances in artificial intelligence, scalability, and speed.

Figure 2-1. Types of DER Being Integrated into VPPs/DERMS

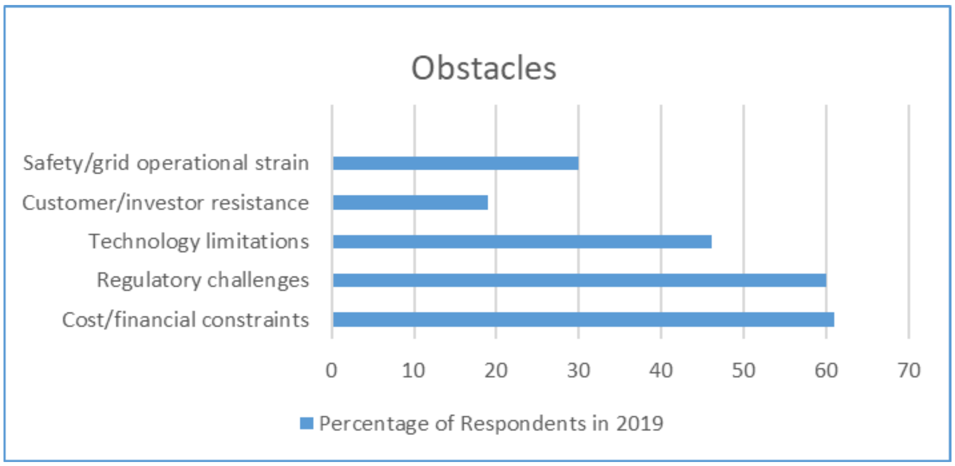


(Source: Enbala)

Approximately 25% of the survey respondents have a VPP or DERMS platform in place to control and manage DER. When asked about the programs for which these assets are being used, respondents name automated DR and integrated energy efficiency as the top two applications. This is consistent with results from the previous 2 years; however, 2019 showed a decrease in respondents saying they had DERMS pilots underway, dropping from 52% in 2018 to 38% in 2019.

Despite these perceived obstacles, there are many compelling reasons to invest in DER assets and the hardware and software technologies that control and manage them. Chief among them are meeting grid reliability concerns and sustainability/carbon reduction goals. Some 61% of the 2019 survey respondents said grid reliability was their primary investment driver, followed by 48% who cited sustainability goals and 47% who focused on increasing opportunities for customer choice. These drivers are closely aligned to results from 2018 and 2017. Addressing declining electric supply was ranked highly as an investment driver in 2019, with 38% of the respondents saying it was a key reason to invest. This is higher than reflected in the survey results for the previous 2 years.

Figure 2-2. Obstacles to VPP/DERMS Implementation



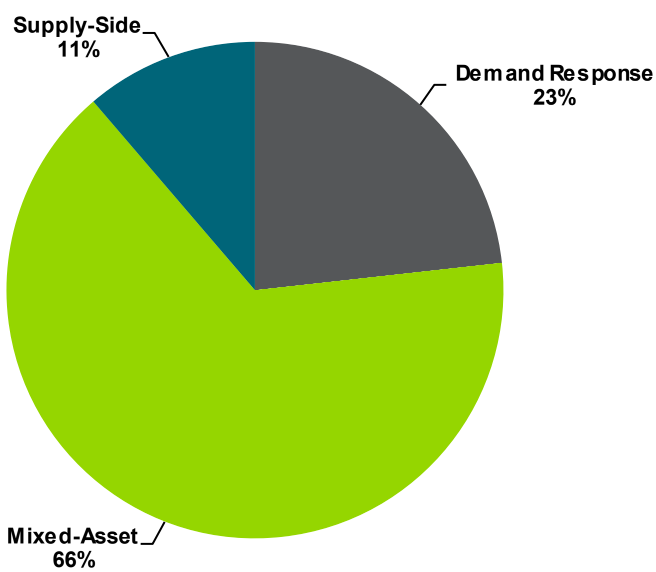
(Source: Enbala)

Section 3
FLEXIBILITY NEEDED IN THE EVOLVING DER SPACE

3.1 Expanding the Universe of VPP Portfolios and Use Cases

The buzz around DERMS remains high. However, most utilities and aggregators start their journey to DERMS with VPP use cases centered around the monetization of revenue streams from DR, capacity, and ancillary services such as frequency regulation markets. While some of these markets have existed for quite some time, the needs of the grid have evolved to mixing and matching diverse aggregations of DER, instead of siloed solutions zeroing in on just load or just generation. The rapid increase in deployment of energy storage has shifted the entire global VPP market to the mixed-asset VPP model. Enbala's CONCERTO™ software platform is one example of the continued evolution of this DER optimization and management. The company is among the key players setting the stage for the convergence of mixed-asset VPPs into DERMS.

Chart 3-1. Cumulative VPP Projects by Segment, World Markets: 2Q 2019



(Source: Navigant Research)

CONCERTO recognizes this new reality with the following software upgrades:

- **Mixed-Asset VPP Support.** The deployment of VPPs globally must address the control nuances of different markets, different asset types (from rooftop solar PV panels to industrial boilers and chillers and everything in between), and each vendor's different interfaces and device controls. The use of common asset models and robust application programming interfaces (APIs) ease integration. These models enhance ongoing support for mixed-asset aggregations as VPP markets continue to expand both vertically (digging deeper into smaller residential DER asset pools) and horizontally (expanding across new geographies and utility structures).

- **Diverse Grid Services Support.** The VPP controls platform will need to employ a flexible topology and architecture. This is especially true as VPPs expand into different markets featuring different DER assets that are optimized according to different regulations and policies. Flexibility will enable the broadest set of grid services, from VPP-oriented capacity and ancillary services to DERMS-oriented reactive power and voltage optimization use cases for feeder and distribution network operations.
- **Real-Time Data Computation.** The days of manually controlled DR may not be completely over, but state-of-the-art grid service markets require a more advanced architecture. Customer loads, generation, and energy storage all need to be coordinated to respond to the real-time needs of both transmission and distribution networks. The processing of real-time data to optimize VPPs that may include literally thousands of diverse assets speaks to the need for delivering both speed and accuracy for DER fleet optimizations. In the foreseeable future, there will continue to be traditional, slow, and early notification assets that can provide substantial capacity (such as complex industrial process loads). Still, the VPP and DERMS market require modern communication and controls to respond to this real-time data—often in less than a second—and to guide each asset to provide the required grid service near-instantaneously in the case of frequency response grid services.

3.2 An Evolving and Flexible Platform Architecture

As the pool of assets being rolled into VPPs and DERMS continues to grow, customers need a flexible platform architecture that can meet three essential market needs. Markets for DER-based grid services will evolve at a different pace in each geography and in each market segment, and that fact will shape these needs. For example, the control needs for a VPP focused on residential customers offering up small rooftop solar PV systems to a VPP requires an API approach that may differ significantly from a large industrial plant with assets like rotating machinery. How can a platform be created to address these two very different VPP applications—and everything in between—as well as future scenarios?

The answer is a modern, API-driven software platform that serves as a fundamental framework for both VPP and DERMS grid services and can be fine-tuned to meet the following three goals:

- **Scalability:** Cloud-based computing, such as Amazon Web Services, enables both the horizontal and vertical scale of deployments. This means VPPs can dig deeper into large asset pools, squeezing more value from previously untouched assets. It also means VPPs can be configured to handle the massive computing requirements of operations such as real-time customer baseline calculations, or the load balancing needed for 4-second automatic generation control signal processing and optimization for frequency regulation.

- **Flexibility:** APIs offer ease of integration of DER assets with any vendor, each bringing their own interface and control nuances. Flexibility for customers—from large industrial sites to small residences—may include asset telemetry and control options from smart inverters to smart thermostats. The universe of opportunities for VPPs is expanding rapidly, so flexibility is the name of the game.
- **Resiliency:** Resilience represents the high availability and fault-tolerant configurations designed to support the system availability required in all energy trading, distribution, and transmission grid markets. Extreme weather trends underscore the need for not only situational awareness, but also the ability to isolate grid problems while maintaining vital grid functionality to ride through or limit grid outage impacts.

3.3 A Global Power Systems View of DER Assets

Any viable VPP or DERMS solution needs to incorporate a power system view within its optimization and control architecture. Broader market trends point to moving beyond siloed solutions, targeting specific DER assets and evolving toward platforms that can connect to and control the value that exists in diverse, mixed-asset pools. This transition requires architecture design, APIs, and a grid services viewpoint that supports current VPP market needs and anticipates upcoming DERMS requirements. Enbala is joined by many other innovators in this space. The end goal is a platform that can manage the full spectrum of DER assets to provide systemwide benefits to wholesale markets and targeted services at the distribution network level.

Section 4
EV USE CASES REFLECT VPP MARKET TRENDS

4.1 Extracting Value from Mobility Assets for Grid Services

Vehicle-grid integration (VGI) enables EVs to participate in grid balancing schemes as generation or demand assets for grid operators. EV batteries can respond more quickly and accurately to grid signals than other utility grid service assets, such as natural gas-powered peaker plants. This speed and accuracy could boost grid efficiency, but in most markets, these performance advantages are not compensated accordingly. Nevertheless, the availability of EVs to respond to grid signals at any time is sporadic. As a result, many early VGI pilots have targeted plug-in EV (PEV) charging at workplace PEV fleets. If integrated into VPPs, EVs themselves can be transformed from a grid challenge into a DER opportunity. If creatively controlled, software can tune EVs to do the following:

- Reduce negative impacts of EV charging loads on grid stability
- Regulate frequency and offer voltage support for power grids
- Enable mobile EV energy storage devices to become a grid balancing resource

EVs are ideally suited for frequency regulation, a major VPP use case. They can also provide reactive power and voltage balancing—services that are more aligned with DERMS deployments by utilities. EVs offer several components and services of value: last resort stationary storage services, loads that (if curtailed or modulated) represent DR resources, and loads coupled with energy storage for optimized DR firming and flexible capacity. Early discussions of vehicle-to-grid focused on the use of vehicles to store energy in bulk and make it available to the grid or building at times when electricity is more expensive. While this market continues to have potential, attention has shifted to the use of EV loads for DR and to charging for frequency regulation. Using PEVs in frequency regulation has a lesser impact on vehicle batteries and automakers view it with greater acceptance. Along with DR, frequency regulation is also the prime service PEVs are expected to provide to microgrids and VPPs, ultimately addressing voltage concerns.

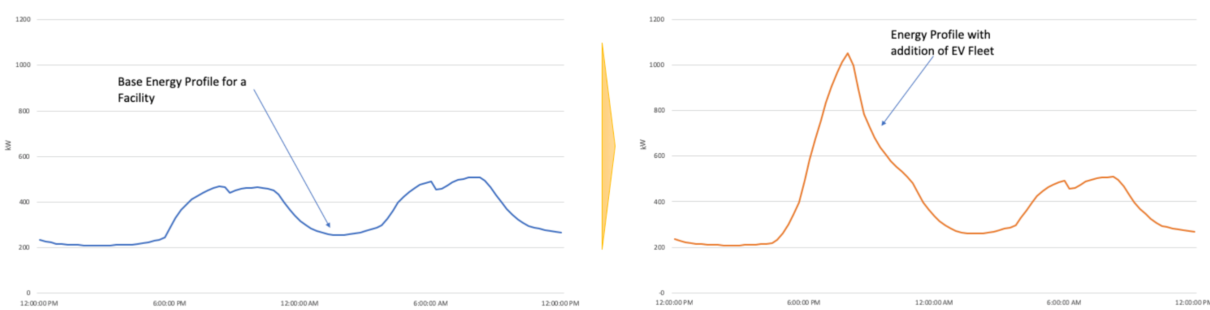
4.2 EV Fleet Management and Optimization

To tap EVs as a reliable grid asset, a fleet of EVs parked at a work site is the most attractive value proposition since such fleets can provide significant capacity and there is a higher probability of that capacity being available during a typical 9-5 work day. Developing common communication protocols and interfaces across the vendor ecosystem is the end goal. The first step requires company-by-company integration and industrywide collaboration during pilot programs and early deployments. However, this approach eventually becomes cumbersome as the list of vendors grows on both sides of the equation. Interoperable systems ultimately will make EV assets a standard component of future mixed-asset VPPs.

4.2.1 Host Site Energy Optimization

VPPs can help control unnecessary electricity costs by moderating load surges from fleet charging while creating new DR revenue streams based on the same loads previously viewed as a problem, a win-win scenario. Uncontrolled EV loads drive up peak demand, increasing costs for the host site and across the entire utility service territory or balancing region. Many utilities have exceptionally high demand charges to incentivize the shifting of energy from high demand periods. Moderating EV charging loads through VPPs can lower overall peak demand, which is especially critical during high peak demand times of the day. The beauty of the mixed-asset VPP solution is that other DER assets—including stationary energy storage—can be added to the resource mix to help reduce grid impacts and provide DR capabilities while also leveraging critical peak pricing capacity. Figure 4-1 shows the challenge of EV charging load at the site. Specifically, the arrival of vehicles for charging in the late afternoon and evening creates a high energy demand that needs to be mitigated and managed.

Figure 4-1. Impacts of EV Charging at Host Site



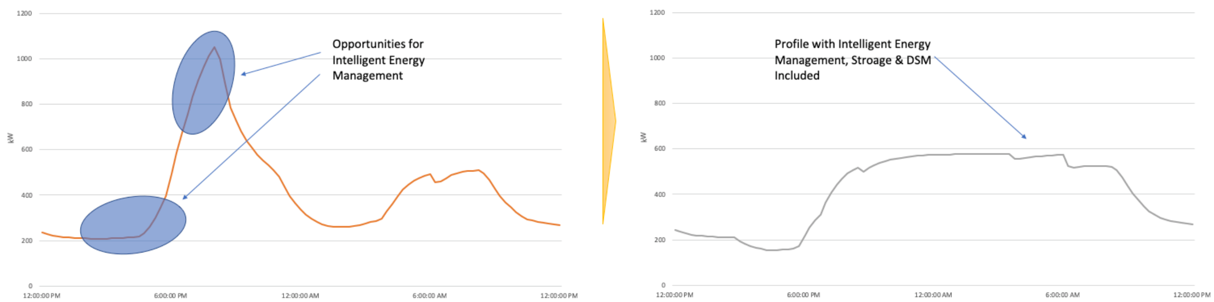
(Source: Enbala)

4.2.2 Orchestrate EVs for Grid Services

Though optimizing EV assets to the benefit of the site host is an important driver for VPP participation, the real value proposition of the VPP rests with benefits flowing to the entire grid ecosystem. In a single day, multiple value streams can be stacked from EV assets, the classic bidirectional value exchange. Again, using a California utility as an example, revenue streams for capacity can reach $30/kW during summer. EVs can also provide regulation services in wholesale markets such as the California Independent System Operator or the Pennsylvania-New Jersey-Maryland Interconnection market. The ability to add on-site energy storage, local site energy generation in the form of PV and intelligent management of the assets to manage overall energy demand AND deliver grid benefits is the value of a multi-asset VPP. This example of multi-service optimization (shown in Figure

4-2) indicates where peak demand management value accrues to the host site, DR value accrues to the grid operator and host site, and frequency regulation value accrues to the grid operator—and is a perfect example of the value stacking possible in the case of EVs integrated with a VPP. Add voltage management and reactive power control, and the VPP is on its way to DERMS.

Figure 4-2. Stacking Multiple Value Streams from EV Charging Management via VPPs



(Source: Enbala)

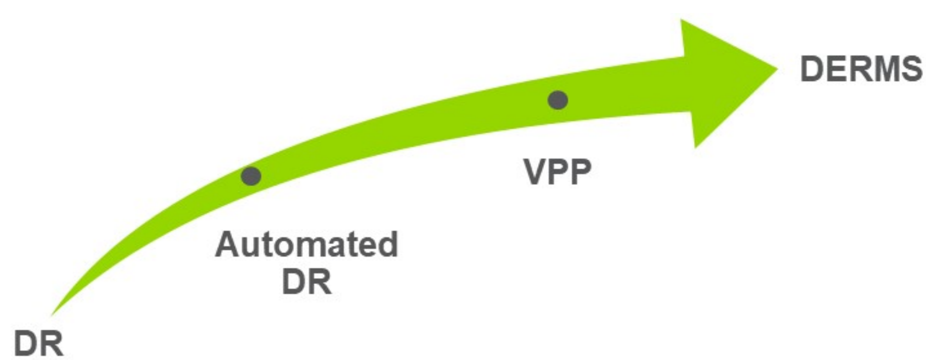
Section 5
THE JOURNEY FROM VPP TO DERMS

5.1 The Convergence of VPPs and DERMS

Though DERMS may be the new buzzword for those seeking solutions to DER challenges, the VPP use cases are more widely supported by regulatory structures, RFPs, and software technology advances. Each region around the world adds nuances to these use cases. The focus in North America, for example, has been more on regulated utility markets that are focused on DR. By contrast, Europe has seen a greater emphasis on large-scale renewable energy integration into wholesale markets since many DER portfolios are supported by feed-in tariffs rather than behind-the-meter energy consumption. Some view DERMS as a wider umbrella under which fall VPPs. Others, including Enbala, view DERMS and VPPs as essentially two sides of the same coin.

Today, organizations ranging from the Institute of Electrical Energy Engineers, to the Electric Power Research Institute, to the Smart Energy Power Alliance are all trying to come up with a definition for DERMS. Perhaps the best way to view the convergence of these two control platform concepts is that they are on a journey—heading toward a future where economic and grid stability functions are ideally solved by a single platform. Just as DR providers have gradually expanded their control functionality to include control generation and then energy storage, so to can VPP platforms evolve into a DERMS solution, shifting from wider area networks and wholesale market transactions to more targeted active power management on distribution feeders, solving voltage hotspots. Today, actual commercial solicitations for DERMS solutions are few and far between. The global market for controls is looking to the monetize value streams now possible from DER portfolios. As DER penetration increases in the distribution network, there will be a need for DERMS to solve grid reliability issues in a more surgical way.

Figure 5-1. From DR to VPP to DERMS



(Source: Navigant Research)

Section 6

ACRONYM AND ABBREVIATION LIST

DER .... Distributed Energy Resources

DERMS .... Distributed Energy Resources Management System

DR .... Demand Response

EV .... Electric Vehicles

kW .... Kilowatt

PEV .... Plug-in Electric Vehicle

PV .... Photovoltaic

SDG&E .... San Diego Gas & Electric

US .... United States

VGI .... Vehicle-Grid Integration

VPP .... Virtual Power Plant

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SCOPE OF STUDY

This white paper was commissioned by Enbala and focuses on the capabilities of Enbala's new CONCERTO platform. This is the first in a four-part series exploring how new software control systems can show near-term value within the VPP market, and also sets the stage for additional applications under a DERMS framework. It was developed in parallel with an update to Navigant Research's overall market forecast of VPP segments, including the mixed-asset segment. Navigant Research white papers are designed to be objective, third-party documents. As such, Navigant Research does not endorse any specific company or products.

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Navigant Research's industry analysts utilize a variety of research sources in preparing Research Reports. The key component of Navigant Research's analysis is primary research gained from phone and in-person interviews with industry leaders including executives, engineers, and marketing professionals. Analysts are diligent in ensuring that they speak with representatives from every part of the value chain, including but not limited to technology companies, utilities and other service providers, industry associations, government agencies, and the investment community.

Additional analysis includes secondary research conducted by Navigant Research's analysts and its staff of research assistants. Where applicable, all secondary research sources are appropriately cited within this report.

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NOTES

CAGR refers to compound average annual growth rate, using the formula:

$$CAGR = (\text{End Year Value} \div \text{Start Year Value})^{(1/steps)} - 1.$$

CAGRs presented in the tables are for the entire timeframe in the title. Where data for fewer years are given, the CAGR is for the range presented. Where relevant, CAGRs for shorter timeframes may be given as well.

Figures are based on the best estimates available at the time of calculation. Annual revenues, shipments, and sales are based on end-of-year figures unless otherwise noted. All values are expressed in year 2019 US dollars unless otherwise noted. Percentages may not add up to 100 due to rounding.

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1375 Walnut Street, Suite 100
Boulder, CO 80302 USA
Tel: +1.303.997.7609
http://www.navigantresearch.com