Review of Apparent Inc.'s Technology and Corporate Outlook

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APPARENT

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EXECUTIVE SUMMARY

Apparent, Inc. (Apparent) is an energy technology company with a software- and hardware-based control system solution to aggregate and manage behind-the-meter (BTM) distributed generation. Its technology is centered around their Intelligent Grid Operating System (igOS) and has been developed from the ground up. The grid operating system provides an integrated platform to monitor and control a prosumer's (a customer who both produces its own electricity and consumes electricity from a utility's system) energy sources at the solar and battery module level; the prosumer's local energy consumption; and the sale of energy, capacity, and ancillary services to the energy market. Apparent engaged Sargent & Lundy (S&L) review of Apparent's technology and assess its corporate growth potential.

APPARENT'S TECHNOLOGY

As the world transitions to cleaner energy sources, the power grid is also becoming more decentralized and data-driven, or digitized.[1] The energy distribution system has seen a rush of distributed energy resources (DER) being installed BTM, which has resulted in many energy consumers becoming energy prosumers. A challenge for utilities is that high DER and inverter-based generation penetration, if not properly managed, can result in electrical stability issues for a power grid. Utilities have been trying to address the challenge of high DER penetration in the electrical system by limiting the number of inverter-based resources added (e.g., rooftop solar photovoltaic [PV], battery energy storage system [BESS]), in addition to potentially reducing the compensation schemes given by programs like net metering.[2]

Apparent's energy platform provides a solution for both utilities and prosumers, allowing for the dynamic control of generation and demand at the local level while responding to the electricity markets in real time to provide support to the electrical grid. Apparent's software-based control system will help users get the most value out of their installed energy generation resources by allowing them to participate in real-time markets. The igOS source code was developed with use-case flexibility in mind: It supports bi-directional power flows and both real and reactive power, which are the fundamental components of a power system. Apparent's technology can primarily serve two main purposes: demand-side management and prosumer electricity / ancillary service market participation. As a result, Apparent is the central energy management system (EMS), DER aggregator, and mediator between the prosumers and the utility / energy market for any entity that integrates Apparent's technology. Overall, Apparent's technology has the potential to bridge the gap between today's electrical system and the future's higher renewable energy electrical system,

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[1] S. Smith, J. Wei, B. Jones, and C. Amon, "A framework for the utility customer of the future: The journey to a smart platform," Deloitte Insights, Deloitte, February 19, 2020, https://www2.deloitte.com/us/en/insights/industry/power-and-utilities/energy-platform-elevated-human-experience-utility-customer.html.
[2] T. Stanton, National Regulatory Research Institute; *Review of State Net Energy Metering and Successor Rate Designs*, March 2019, https://pubs.naruc.org/pub/A107102C-92E5-776D-4114-9148841DE66B/.

specifically with respect to its ability to better help utilities manage electricity supply and load, meet ancillary service demands, and save money for its adopters.

CORPORATE GROWTH POTENTIAL

As electrification progresses, electric vehicles (EVs), smart electric appliances, and other smart home devices will come online. U.S. policies[3] and customer demand[4] are expected to result in electric vehicles making up to half of automobile sales by 2030. EVs offer untapped potential to leverage their energy storage resource for participation in the energy markets and local demand charge management. Apparent's technology offers a solution that can help harness the benefits of this energy storage potential.

The California Energy Commission recently awarded a $6 million grant to the Los Angeles Department of Transportation to install one of the largest EV fleet charging systems in the United States—a system that will use Apparent's technology to form an EV-charging microgrid. The charging system will include Apparent's igOS to integrate and control the charging infrastructure with the energy generation, all while coordinating the charging of electric busses. These opportunities are only expected to grow with the passage of the H.R.3684, the Infrastructure Investment and Jobs Act, which became law on November 15, 2021. This law has allocated $7.5 billion towards the nationwide deployment of EV charging stations. Companies with technologies that can help to better control and manage this charging infrastructure, like Apparent, are well positioned for future growth.

Currently, Apparent has few direct competitors, specifically those offering mainly a software- or cloud-based control system for DERs. Competitors offering similar technology mainly focus on one or two use cases (demand response or energy sales), have slower response times (in some cases several minutes), or do not offer third-party device integration. Apparent's technology provides benefits beyond those offered by many of their competitors: It allows users to be direct participants in the energy / ancillary service market in real time, which provides users an additional source of revenue while helping provide ancillary services to the overall electrical grid. The technology can be offered to residential, commercial, and industrial prosumers, adding renewable DERs to increase their own energy resiliency, decrease carbon-emissions, and generate multiple revenue streams (through reduced demand charges, reduced energy cost, and energy / power / ancillary services sales to the electricity market).

Moving forward, both the power grid and energy markets will continue to increase in complexity. Decentralization, decarbonization, and digitalization of the power grid will be more prevalent, bringing new

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[3] "Fact Sheet: President Biden Announces Steps to Drive American Leadership Forward on Clean Cars and Trucks," Briefing Room, The White House, August 5, 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/08/05/fact-sheet-president-biden-announces-steps-to-drive-american-leadership-forward-on-clean-cars-and-trucks/.
[4] U.S. Energy Information Administration, "*Transportation,*" from the *Annual Energy Outlook* chart library, February 3, 2021, https://www.eia.gov/outlooks/aeo/pdf/05%20AEO2021%20Transportation.pdf.

deployments of DERs, more stakeholders, and new technologies. In the future, there will likely be a significant need for coordinating, integrating, and managing prosumers' assets on both sides of the meter, in addition to a need for a local system operator or DER operator to aid the transmission system operator and distribution system operator in controlling / managing the grid.[5] Currently, there is a need for an organization to take the role of the mediator (as a local system operator, EMS, and DER aggregator) with the technology capable of benefiting all stakeholders. With its technology to date, Apparent can fulfill that role.

As a local system operator, Apparent could also bring visibility to the transmission system operator and distribution system operator about the DER resources on the other side of the meter, through the aggregation of power data (i.e., generation data, demand data, and other related real-time data). The value of this data, combined with dispatchable controls, would benefit both the market and prosumers as electricity and ancillary services are traded in real time.

[5] K. Lorenzo, P. DeMartini, and J. Taft, *A Tale of Two Visions: Designing a Decentralized Transactive Electric System*, *IEEE Power and Energy Magazine* 14, no. 3, pp. 63–69, May–June 2016, https://ieeexplore.ieee.org/document/7452738.

1. BACKGROUND AND CURRENT TRENDS

The electric power sector is experiencing an ongoing transition in the way the grid is managed, how electricity is generated, and how wholesale electricity energy markets operate. This transition began several years ago, and at the current pace of change, the electric power sector of today will likely look vastly different in the future. The power sector will likely be shaped by three main trends: decentralization, decarbonization, and digitalization. All power sector stakeholders (generators, utilities, operators, energy traders, and consumers) will feel these trends' impact—with the potential for consumers to benefit the most. Below, these trends are discussed in detail, each from the consumer's perspective.

- **Decentralization.** Grid decentralization includes deploying distributed energy resources (DER) connected behind-the-meter (BTM) at the consumer point of consumption. These resources typically include solar PV, energy storage, electric vehicles (EVs), and small wind turbines. The DER portfolio is likely to continue to expand in the future by being installed at an accelerated pace with connected BTMs in single family homes, commercial and industrial (C&I) facilities, and community aggregations.

  DERs are typically comprised of inverter-based resources, and these resources traditionally do not provide electrical inertia to the system; therefore, utilities have previously limited the amount of solar and storage generation capacity that could be installed in a specific feeder or lateral. Recently, FERC Order 2222 has opened the door for consumer-based distributed generation to participate in the wholesale electricity market through aggregators to sell their energy, capacity, and ancillary services to other consumers.

- **Decarbonization.** This trend primarily consists of the power sector moving away from carbon-emitting generation sources, specifically through replacing traditional fossil fuel generation (e.g., coal, diesel, natural gas) with carbon-free generation alternatives (e.g., solar PV, wind, hydro, geothermal, biomass). The main driver of decarbonization has been the findings of scientific studies on the impacts of carbon emissions on climate change, including the work related to the International Plant Protection Convention on climate change and the recommendations to transition developed countries' energy systems away from fossil-fuels and towards renewables. A fairly continuous decline in manufacturing costs for solar modules, inverters, and batteries—plus new government energy policies, renewable portfolio standards, and manufacturing / consumer incentives—have helped push energy systems to adopt larger amounts of renewable energy sources.

- **Digitalization.** This process has two goals: add automation to the grid (even BTM) and use data to gain grid visibility and control. This process will aggregate the demand-side information in terms of load (smart home appliances, EV, central heating and cooling systems, smart meters, etc.) and generation (DER, EV, etc.). Data mining, data aggregation, and data processing can be beneficial in two fronts: optimizing the resources to balance the utility's load and generation and creating an efficient operation of power flows in the grid and cash flows in energy markets.

These trends are reshaping the electric power sector, resulting in the rapid adoption of customer-based DER in the grid. This has created a new type of energy customer: the prosumer, or a customer who both produces its own electricity and consumes electric power from a utility's system. Prosumers today have mostly joined simple, yet financially-rewarding, programs like net-metering and demand response. Those programs allow DERs (and/or heating systems) to respond to utility signals to support the grid (after the fact) with dispatchable capacity and/or load shedding.

As the globe moves towards a more decentralized grid with bi-directional power flows, decarbonization priorities, and enhanced digitalization, there will be an increased need for software-based solutions to make fast decisions and balance consumer demand / generation and facilitate energy trading, all in real time. Currently, decentralized generation is used in traditional net energy metering programs that, when combined with demand response programs, give some benefits to consumer – granted, without optimization; however, most of the current DERs are not integrated with the energy / ancillary services market, or if they are aggregations, will mostly compete in the day-ahead energy market (instead of real time).

Apparent’s software-based control system will help users get the most value out of their energy resources by allowing them to participate in real-time markets. This system also allows for

- balancing the prosumer’s demand with their own generation or energy from the grid,
- acting on the electricity rate tariff for the consumer at the time (time-of-use pricing) and the revenue benefits from selling services to the wholesale market, and
- meeting power quality requirements to avoid demand charges.

Apparent offers a software- and hardware-based control system to help prosumers integrate and manage their energy resources in the most optimal and efficient way. Its technology is centered around their Intelligent Grid Operating System (igOS) and can support the future grid through:

- **Decentralization.** Apparent’s control system facilitates and increases the ability for users to install DER in their facilities, BTM, or distribution system. The technology is flexible and scalable, which enables the addition of new resources without adding new infrastructure to the grid and while providing complete demand-side management control.
- **Decarbonization.** The system aggregates clean inverter-based resources like solar PV, wind, and BESS. It can optimize the generation process to prioritize renewables to meet the customer’s demand, or charge batteries with excess solar generation.
- **Digitalization.** In Apparent’s system, power data is generated, collected, and made available to a central control (or system operator) up to four times per second to allow for automated real-time decisions (dispatching specific DERs, etc.) and optimize the power system (dynamically BTM), with the prosumer’s best interest in mind and/or as required by the distribution system operator.

2. MARKET ANALYSIS AND COMPETITIVE LANDSCAPE

2.1. MARKET ANALYSIS

The market size of the electric power transmission system in the United States is approximately $414 billion with over 8,000 operating businesses.[6] Following a downturn in 2020 because of the COVID-19 pandemic, electricity consumption is projected to recover, and profitability gains are expected as system energy efficiency continues to improve. Per IBIS*World*, successful smart grid integration is an important basis of competition over the next five years. Operators are incentivized to invest in smart grid technology as a result of tax credits, which ultimately will help to lower carbon emissions and improve transmission reliability.

Utility investment in grid modernization and smart distribution systems such as DERs is projected to be substantial in the near- and long-term horizons. The growth of DERs will require substantial investment from consumers, utilities, and system operators; however, investments into DERs should also result in substantial system-wide electricity savings over the long term. A study by Vibrant Clean Energy[7] evaluating the potential value DERs found that DERs could provide the U.S. electricity system cumulative system-wide savings of $155 billion by 2035 and over $300 billion by 2050. By simulating DER deployment in alignment with historical data, the study concluded that substantial cost savings could be realized with little change to total system generating capacity. Optimization in the tails of power generation and demand amplify savings across the entirety of the system, from generating plants to the end-user. This result is consistent with National Renewable Energy Laboratory analyses addressing the U.S. power system in highly electrified futures: They concluded demand-side flexibility can lower power system operation costs by providing high-value grid services during periods of system stress and increasing use of more-efficient, lower-cost units.[8]

Some of the cost savings theorized were realized in real terms by solutions provided by Apparent's technology. A-175 kW solar system installed by Apparent (without energy storage) was able to match reactive power demands, improving power quality to a savings extent of approximately $100,000 per year. Apparent projects with a combined capacity of 40 MW are expected to be complete by end of 2023, most of which include integration of energy storage systems, which should further help to boost project savings levels. Additionally, shuttle and bussing electrification projects are currently in development. These projects are concentrated mainly in California, Hawaii, and Texas—key markets to building a customer base and

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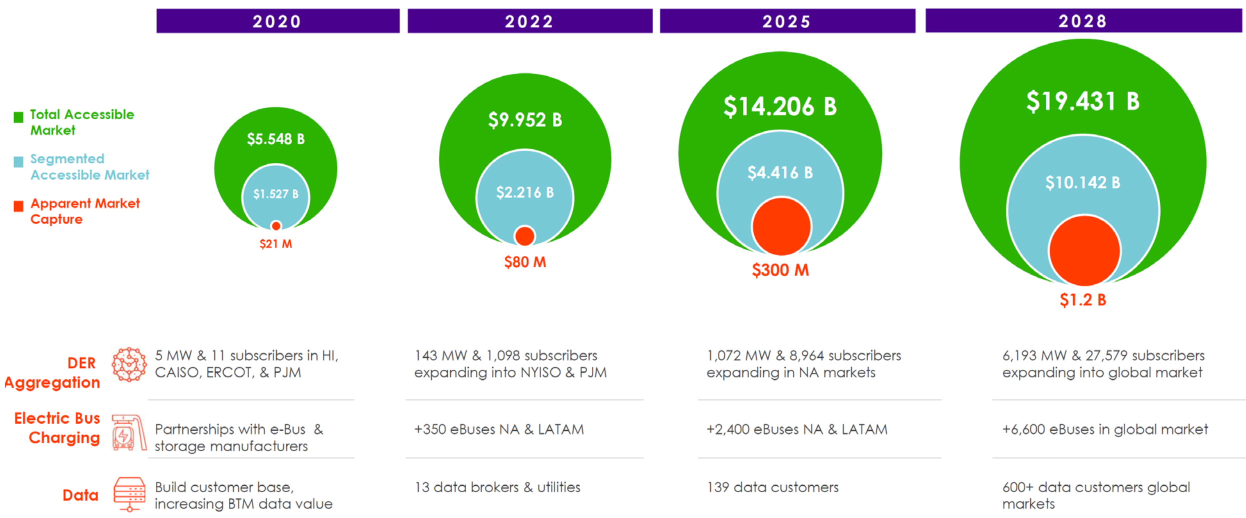
[6] *Electric Power Transmission Industry in the US*, IBIS*World*, November 2021, https://www.ibisworld.com/united-states/market-research-reports/electric-power-transmission-industry/.
[7] C. T. M. Clack, A. Choukulkar, and B. Coté, *Why Local Solar For All Costs Less: A New Roadmap for the Lowest Cost Grid*, Vibrant Clean Energy, December 1, 2020, https://www.vibrantcleanenergy.com/wp-content/uploads/2020/12/WhyDERs_TR_Final.pdf.
[8] E. Zhou and T. Mai, *Electrification Futures Study: Operational Analysis of U.S. Power Systems with Increased Electrification and Demand-Side Flexibility*, National Renewable Energy Laboratory, May 2021, https://www.nrel.gov/docs/fy21osti/79094.pdf.

opportunities for Apparent's igOS to reach data criticality. Figure 3-1 shows Apparent's market growth projection and their estimated potential share (as of 2019).

Figure 3-1 — Projected Apparent Growth Forecast



Courtesy of Apparent, Inc.

While the projected timeline may be slightly delayed due to the 2020 global pandemic, market magnitude and growth forecasts in Figure 3-1 are consistent with projections from Vibrant Clean Energy and National Renewable Energy Laboratory, as detailed earlier, and S&L's opinion.

2.2. CURRENT AND FUTURE GROWTH AVENUES

There are several potential applications of Apparent's technology both in the near- and long-term horizons. In the near term, it will be important for Apparent to focus on applications that can be implemented within the constraints of today's energy markets and infrastructure, which will result in their customers being able to realize immediate cost savings. Implementing Apparent's technology has real cost saving benefits to customers today, in addition to revenue streams for Apparent. Two specific use cases are demand charge management and power factor correction.

- **Demand Charge Management.** Demand charge management (DCM) is a demand-side solution that is an important part of Apparent's technology. DCM helps reduce the customer's demand charges, thus reducing the customer's electric utility bill. Apparent's control system optimally dispatches the customer-owned energy resources during peak hours to reduce the maximum demand or "peak demand" as seen by the customer meter. Utility demand charges are typically based on electricity consumption during peak demand hours; thus, by reducing electricity consumption during these times, Apparent's technology can reduce the demand charge the customer pays on their utility bill. This charge reduction can be significant depending on the $/kW rate the customer pays, in addition to the customer's peak demand level itself. Moreover, reducing the peak demand helps on increasing the load factor (peak demand divided by average demand), which is a factor the utility uses to assign an electricity rate to the customer. The higher the load factor, the lower the electricity rate. Thus, Apparent's DCM application helps the customer to lower their peak demand, which translates into lower demand charges, a higher load factor, and ultimately a lower electricity bill.

Note that DCM solutions are not unique to Apparent's technology; however, the method that Apparent uses for DCM is both unique and more effective than other solutions currently in the marketplace. Many competitor solutions for DCM are static or much slower to respond to deviations, meaning that they employ a methodology or algorithm that follows an unchanging or slow-moving process. As a result, real-time deviations in customer energy usage / energy production, or changes over time, may result in less than optimal outcomes in terms of DCM. In contrast, Apparent's technology is dynamic and can respond to deviations in real time, meaning that it is continuously responding to variables such as customer energy usage / production. As a result, Apparent's technology is able to achieve better DCM outcomes.

- **Power Factor Correction.** The power factor is a metric that captures the power quality at the customer's point of measurement. Commercial and industrial customers are charged separately for the power factor measured at their meter. By definition, the power factor is the ratio between real/active power to total apparent power. Ideally, a customer would want their power factor at 1.0 to ensure all the power consumed is real power; however, in C&I facilities, power factors tends to be lower than 1.0. Utilities charge a fixed rate for the difference between 1.0 (sometimes 0.85) and the actual power factor of the customer. This charge is to compensate the utility for the reactive power that the utility needs to provide to bring the customer's power factor up to 1.0 (to provide overall electrical system stability). Apparent's control system installed in a customer's facility ensures the inverter-based resources generate both real and reactive power to meet both the energy and reactive power needs of the customer. The control system can dispatch the microinverter or other inverter-based resources to produce the reactive power needed to maintain the customer's power factor at much closer to 1.0. This ultimately results in a reduction in the power factor charge on the customer's utility bill.

  As with DCM, the dynamic monitoring / adjustment method to power factor correction inherent to Apparent's technology is different than many of the other technologies currently on the market today. Much of Apparent's competition use technology based on a static reference point or a dynamic reference point that adjusts slowly; thus, if real-time deviations occur (i.e., to customer energy consumption or production), or deviations occur over the course of an extended period, the customer may not realize the full benefit of the power factor correction solution. A technology that incorporates a real-time adjustment method, like that used by Apparent, can better respond to deviations and can provide a more effective demand charge and power factor correction for the customer.

Apparent's revenue streams are tied to the fees charged for providing the services listed above, in addition to others, and can vary from customer to customer depending on the specific services Apparent provides. The services are based on customers' need / preference, the electrical market in which the customer is located, and other related items. In general, the additional services that Apparent can provide to their customers (from which they are able to derive additional revenue) can be summarized as 1) energy (real power, reactive power, apparent power), 2) capacity, and 3) ancillary services (voltage/VAR support, frequency support, regulation up/down, and black start).

A summary of some technology applications and potential growth areas for Apparent are summarized. The number of future applications is very large, particularly when envisioning a decentralized but highly connected electrical grid of the future. For longer-term future applications, we view Apparent's technology and company focus not as disruptive to and in conflict with the direction public utilities are moving, but as complementary. With the push for cleaner, renewable generation, the electricity grid and generation landscape are transitioning—and with this transition comes challenges associated with grid stability, optimally matching supply with demand, and generation decentralization. Apparent's technology offers a solution that would help to bridge and transition the electrical system of today to the electrical system of the future. Some near- and longer-term technology applications are provided as follows:

- **BTM DER – Small C&I Facilities.** An immediate-term application of Apparent's technology is in small C&I facilities, particularly those that have installed or are considering installing solar PV and/or BESS. Apparent's technology will help these customers manage their own demand, in addition to electricity generation they have installed, all the while enabling them to participate in the real-time energy and ancillary services markets.
- **BTM DER – Large C&I Facilities.** Large C&I facilities, such as data centers, large factories and manufacturing facilities, solar projects, etc., would be able to make use of Apparent's technology on a larger scale than small C&I facilities, allowing them to realize significant energy savings / realize revenues from energy and ancillary services markets. Larger facilities would likely be more willing to install the technology following proof of success in smaller applications.
- **Electric Vehicles.** The forecasted growth of future EV adoption provides the opportunity for a company like Apparent to use their technology to help facilitate vehicle-to-grid, vehicle-to-home, and vehicle-to-building energy transfer applications. These applications (facilitated by Apparent's technology) allow the EV's battery to also power the interconnected structure and/or participate in the energy or ancillary services markets. The market for these kinds of applications is only expected to grow with the passage of the H.R.3684, the Infrastructure Investment and Jobs Act, which became law on November 15, 2021, and allocated $7.5 billion towards the nationwide deployment of EV charging stations. Apparent's plan is to first focus on implementing its technology onto large EV fleets, such as school bus EVs or airport shuttles. With successful adoption into large EV fleets, additional avenues for technology adoption, such as residential EVs, should follow.

  In fact, the California Energy Commission recently awarded a $6 million grant to the Los Angeles Department of Transportation to install one of the largest EV fleet charging systems in the United States—a system that will make use of Apparent's technology to form an EV-charging microgrid. The charging system will include Apparent's igOS to integrate and control the charging infrastructure with the energy generation, all while coordinating the charging of electric busses.
- **BTM DER – Residential.** A more intermediate-term growth target is residential applications, particularly rooftop solar and/or residential BESS. Successful adoption and high penetration of Apparent's technology into the residential space will likely require some level of demonstrated

success in the listed target markets above, in addition to increased adoption of rooftop solar and BESS within the residential sector.

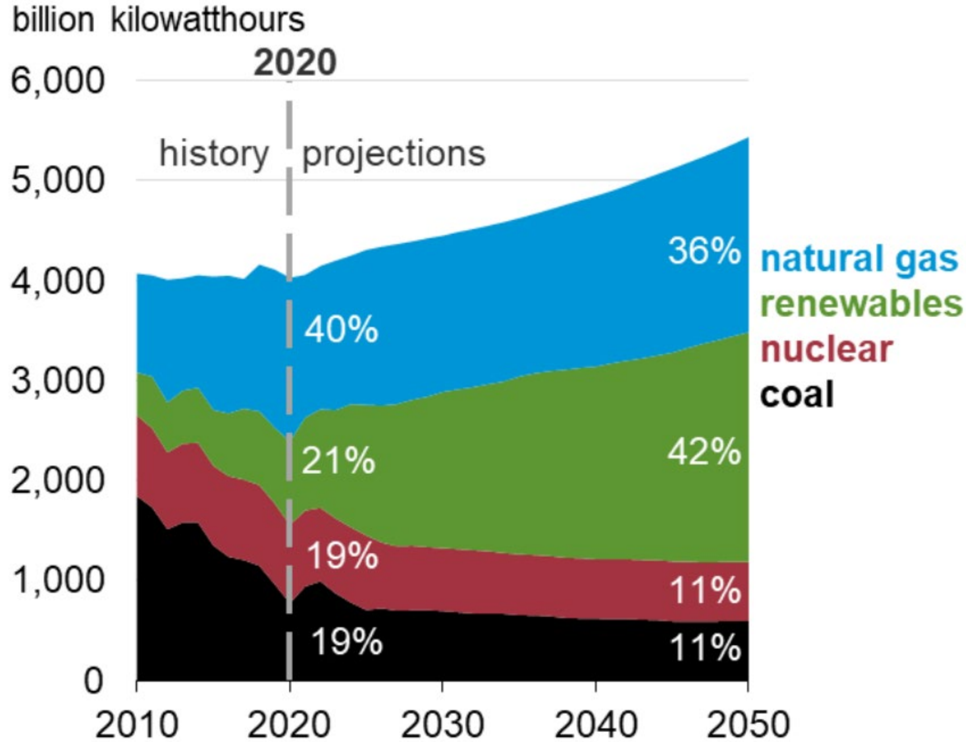
An important benefit of the adoption of Apparent's technology is that it allows Apparent to become an aggregator of energy resources and operator of virtual power plants. In addition, Apparent can collect a significant amount of data on energy consumption, generation, power quality, etc., from its users. This data is valuable to utilities, system planners and operators, and energy traders, and ultimately allows Apparent to transition into more "in front of the meter" applications.

At a high level, Apparent's focus on data, coupled with its technology's dynamic data analysis and equipment response characteristics and position the company for strong growth opportunities as the world moves to a more decentralized and digitalized energy landscape. The critical consideration when thinking about data is the timing at which information can be obtained and acted upon. For example, grid operators can make more informed decisions that create less congestion on the grid if the proper signals and data are available instantaneously and can processed sooner. Energy asset operators and companies are often technically limited in their ability to quickly respond to a market or system event. The reason stems from the fact that the speed of data collection and equipment response time is often too slow to effectively respond to the event. Unfortunately, the slower a market participant can respond to an energy market or system event, the less economic value that participant can derive from taking advantage of imbalances in energy supply and demand.

The key benefit of Apparent's technology relates to its fast operational speeds. Apparent's igOS automatically sends commands at speeds of 4 to 60 times per second; thus, computations related to available energy, capacity, and ancillary services happen on a virtually continuous basis. As a result, the technology can support local system demands while simultaneously informing market participants for deficiency or localized energy market improvements. This translates into higher market revenue potential for individuals that have integrated Apparent's technology into their local electrical systems.

Independent system operators such as California ISO, ERCOT, PJM, MISO, and SPP are all projecting continued increases in solar and wind generation, both of which are inverter-based generation resources. The projected U.S. electricity generation by fuel type from the U.S. Energy Information Administration's *Annual Energy Outlook 2021* forecasts the renewable mix increasing from 21% today to 42% in 2050. This projection is based on today's laws and regulations; renewables could grow even more in the event of future legislation, regulations, or standards.

Figure 3-2 — U.S. Electricity Generation Outlook



Source: U.S. Energy Information Administration, *Annual Energy Outlook 2021: with projections to 2050, Narrative,* Figure 11 – U.S. electricity generation from selected fuels AEO2021 Reference case, p. 16, https://www.eia.gov/outlooks/aeo/pdf/AEO_Narrative_2021.pdf.

As a result of the increase in inverter-based renewables (i.e., wind and solar PV), there will be a growing need for grid ancillary services to help maintain overall grid stability. In its *2020 Annual Report on Market Issues and Performance*, California ISO notes its reliability and ancillary services concerns when it states the "need to maintain adequate flexibility from both conventional and renewable generation resources to maintain reliability as more renewable resources come on-line."[9] Similarly, the *2020 State of the Market Report for ERCOT Electricity Markets* anticipates that the non-wind fleet will operate for fewer hours as wind penetration increases, but notes "a growing need for non-wind capacity to satisfy ERCOT's reliability requirements" as peak net load is projected to continue increasing.[10] Apparent's technology can help to provide the grid's ancillary service needs at both the distribution and transmission system levels, particularly in the form of reactive power compensation, in both BTM and front-of-the-meter applications by interconnecting solar and energy storage resources to the grid.

In addition, with higher amounts of renewable energy with intermittent generation profiles (i.e., solar PV and wind), there will be an increasing need for energy storage to manage times when electrical supply is greater

[9] California ISO, *2020 Annual Report on Market Issues and Performance*, August 2021, p. 17, http://www.caiso.com/Documents/2020-Annual-Report-on-Market-Issues-and-Performance.pdf.
[10] Potomac Economics, *2020 State of the Market Report for the ERCOT Electricity Markets*, May 2021, p. 27, https://www.potomaceconomics.com/wp-content/uploads/2021/06/2020-ERCOT-State-of-the-Market-Report.pdf.

/ less than electrical demand. Both renewable energy and energy storage prices have fallen dramatically over the most recent decades; however, replacing conventional generation technologies (i.e., thermal generation) with renewable energy plus energy storage may not result in a net reduction in energy costs across all regions of the U.S. (particularly those with low solar / wind generation potential). Technologies like Apparent's can help users save money in different and innovative ways as they transition to renewable energy, such as through demand charge reduction and power factor correction, which ultimately will help the country's transition into renewable energy be more cost effective.

2.3. COMPETITIVE LANDSCAPE

Apparent has performed a competitive landscape analysis that has identified several competitors (Figure 3-3) that include companies providing traditional EMS and alternative solutions. The most well-known companies identified that more closely compete with Apparent include AutoGrid, Enbala, AMS Technologies, OpusOne GridOS, and Energy Hub. In the competitive analysis, it was noted that these companies either focus on just one or two of the use cases on which Apparent also focuses (demand response, curtailment, etc.), have an incrementally slower response time, do not act the local BTM premise, cannot communicate with third party assets, or simply do not facilitate the customer's participation in the energy market. The results of the competitive analysis performed by Apparent are provided in the following figure.

Figure 3-3 — Apparent's Competitive Analysis Chart

FEATURES	SERVICES	Apparent	ABB	Advanced Microgrid	Amply	Autogrid	ChargePoint	Enel X	Engie-Greencharge	EvGO	Geli	Itron-Comverge	Leap	Olivine	Opus One	Scale Microgrid	Schneider Electric	Sonnen	Sunverge	Stem	Tesla	ViriCity
Data Collection & Communications	Monitoring of energy systems	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Energy system data collection (in any length of time)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Equipment level data collection in sub-seconds	√										√										
	Bi-directional communication in sub-seconds	√																				
Produces Energy & Services	Capacity	√	√					√									√	√	√		√	√
	Curtailment	√	√					√									√	√	√		√	√
	Frequency up/down	√																				
	Volt-VAR and Volt-Watt	√																				
	Dynamic NXO (Curtailment) <1 second	√																				
	Dynamic frequqency up/down <1 second	√																				
	Dynamic Volt-VAR and Dynamic Volt-Watt <1 second	√																				
Manages DER Assets	Capacity	√		√		√	√	√	√	√		√	√		√	√	√		√	√		√
	Curtailment	√		√		√	√	√	√	√		√	√		√	√	√		√	√		√
	Frequency up/down	√																				
	Volt-VAR and Volt-Watt	√																				
	Dynamic NXO <1 second	√																				
	Dynamic frequqency up/down <1 second	√																				
	Dynamic Volt-VAR and Dynamic Volt-Watt <1 second	√																				
Manages Storage-Power Control System	Capacity	√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Frequency up/down	√		√		√		√	√							√	√	√	√	√	√	√
	Volt-VAR and Volt-Watt	√		√		√			√							√	√	√	√	√	√	√
	Dynamic NXO <1 second	√																				
	Dynamic frequqency up/down <1 second	√																				
	Dynamic Volt-VAR and Dynamic Volt-Watt <1 second	√																				
Software Management & Control	ESS integration	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Customer Load Balancing (load following)	√		√	√	√	√	√	√		√	√	√	√	√				√	√	√	√
	Dynamic Customer Load Balancing (<1 sec)	√																				
	Dynamic ESS -all wave forms (<1 sec)	√																				

S&L notes that a few additional competitors have recently emerged in the U.S. and abroad. These companies offer software-based solutions to manage the customer's energy resources and allow them to participate in the market, all in real time, and appear to rely on a remote cloud-based control system to control and dispatch the resources; however, they do not appear to integrate key hardware (microinverters, data devices, gateway) to control the resources at the module level. Publicly available information from these competitors also does not mention whether their systems can operate the resources in all four electrical quadrants (± real power and ± reactive power) dynamically and at the meter, to ensure the local demand and energy requirements are optimally balanced. Apparent's technology addresses these grid needs in terms of real power, reactive power, power quality, and reliability by allowing them to be managed through the features of their solution. Finally, information is not readily available on whether Apparent's competitors offer flexibility in their product offerings, if use cases can be augmented (e.g., EV integration, non-export use case, demand charge management with power factor correction).

Apparent's competitive advantage is in the differentiation they offer with true decentralization support, offering user application flexibility, market-level DER aggregation, and local energy management in real-time. Apparent's solution also provides for BTM digitalization, generating power data, data visibility, automation, and control of the assets at the module level. Overall, Apparent's technology offers an energy control platform that allows prosumers to leverage their DER assets locally and in the wholesale market to meet their own demand, maximize revenue potential, and support the grid.

3. APPARENT TECHNOLOGY OVERVIEW

Apparent is a clean energy technology company participating in the electric power industry with an automated control system for energy management of prosumer's energy resources. The technology offering is built around igOS, a trademarked EMS that is an intelligent software-based control system with sophisticated capabilities to provide:

- monitoring, communication, and control of energy sources in real time;
- data aggregation, data processing, and decision-making algorithms;
- connection to a cloud-based platform with machine learning capabilities;
- virtual integration of energy resources with the wholesale energy market; and
- reporting, analysis, and visualization through the Energy Review portal.

The igOS is the brains of Apparent's technology and is hosted in a Gateway device—a proprietary hardware with standard communication protocols—which is the central communication device receiving the information from all sources and sending commands. The Gateway is shown in Figure 4-1.

Figure 4-1 — Apparent's igOS Gateway

The igOS relies on the Apparent REactive hardware installed on site for the sensing and control command executions and grid functionalities from the different resources. The proprietary and patented hardware include:

- Apparent's solar PV microinverters (SG424U CA and SG424U HI);
- battery power control system (PCS) (Blade Inverter [SG2K]);

- a data device used as a meter with a sampling rate of four times per second and standard current transformer/voltage transformer; and
- a hall effect integrated chip (IC) for current sensing at distribution panels.

All these hardware components communicate bi-directionally with the igOS through the Gateway and are connected physically by means of wired ethernet network. The combination of Apparent's hardware and software technologies create a flexible energy platform that can be used to support multiple applications, including:

1. BTM energy management of generation and demand
2. DER[11] aggregation for wholesale market participation
3. Central control system for DER sources BTM in segregated locations
4. EV grid integration with or without market participation and BTM

The Apparent hardware combined with the versatile igOS capabilities provides Apparent with a significant competitive advantage in the market and positions them to go beyond an EMS provider to include a virtual power plant / DER aggregator, DER management system for utilities or community aggregations, and local system operator or DER operator.

The flexibility of Apparent's technology allows the company to target a wide range of potential customers: residential (< 30 kW), small and medium C&I (<5 MW), large C&I (>5 MW), energy traders, and even electric utilities (IOU, Co-Ops, municipalities).

Apparent's technology can be deployed in multiple applications and currently has a wide range of use cases, which can be grouped in two main categories:

1. **Demand-Side Management for Prosumers**
    a. Real-time BTM supply and demand energy management including
        i. Demand Response through open ADR
        ii. Peak-shaving, load-shifting
        iii. Reactive power support
        iv. Real-time load balancing / load following
        v. Optimal resources dispatching with machine learning
        vi. Economic dispatching considering time-of-use and retail pricing
        vii. Dynamic no-export power with or without curtailment

[11] **Resources:** Solar PV, wind, conventional generation, battery energy storage systems, EVs, and flexible load.

b. Scalable and modular renewable DER integration to the grid including community aggregations (community solar, etc.) and microgrids

c. BESS – batteries and EVs – integration to the grid

d. DCM with EVs, energy storage, solar PV microinverter through power factor correction BTM

2. Market Participation for Prosumers

a. Wholesale electricity market participation of DERs in both the real time and day ahead market for

   i. energy

   ii. capacity

   iii. ancillary services

   iv. Renewable Energy Credit

b. Ancillary services can include

   i. reserved capacity for regulation

   ii. non-spinning reserves

   iii. frequency response for voltage support

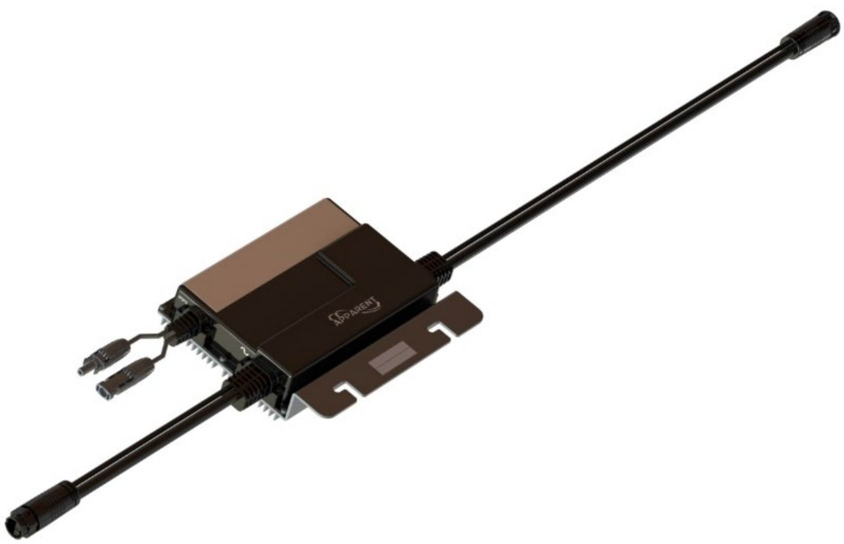
Today, because of FERC Order 2222 (issued September 2020), prosumers with electricity generating resources can take full advantage of the same benefits to supply their own demand while they also sell electricity to generate revenue. Conventional EMS has existed to provide some of the benefits above; however, most of them do not offer the in real-time controls capability of active and reactive bidding participation in the energy / ancillary service markets. With Apparent's technology, prosumers can take full advantage of their resources and participate in these markets and earn additional revenue while also moving towards clean energy and decreasing their electricity costs.

The following subsections discuss the different key components that make up Apparent's technology.

3.1. APPARENT'S MICROINVERTER

Apparent's solar PV microinverter plays a key role in Apparent's solution to deliver dynamic real and reactive power to the grid. The solar PV microinverter (SG424U HI/CA) is a single-phase 120 V AC, 60 Hz, DC/AC inverter with a rated real output power of 250 W AC and maximum apparent power of 325 VA. Each microinverter attaches directly to a single PV module rated up to 325 W DC and performs maximum power point tracking at each PV module. This way the maximum output power of an entire PV array can be extracted on any given day, regardless of individual module's adverse conditions (soiling, shadowing, etc.). This in turn gives microinverters an advantage to string and central inverters that operate at the level of the lowest performing module in a string, creating a negative impact of the energy production of the entire string. Apparent's microinverter can be seen in Figure 4-2.

Figure 4-2 — Apparent's Solar PV microinverter SG424 CA



Apparent's microinverter can produce and deliver up to 230 VAR reactive power dynamically. This allows for up to 230 W AC of real power at that maximum reactive power point (230 VAR) or 200 VAR power, while using the full amount of real power (250 W AC), to avoid a reduction of real power while still producing reactive power. This is accomplished by operating the microinverter as a voltage source converter, controlling the waveforms of the inverter with respect to the grid source.

The microinverter can operate in two power quadrants to absorb and inject reactive power while injecting real power to the grid with a power factor range of ± 0.76 (± 0,707 HI) and a minimum power factor of ± 0.29, which is better than comparable microinverters on reactive power production.

The igOS control system can integrate the microinverters capabilities with the consumer's load to expand the two-quadrant operation to the full four quadrants of the power system. This is possible due to the microinverter's capability to increase and decrease real power while maintaining the same amount of reactive power at its output. If the solar generation is decreased enough to create an incoming power demand at the customer's meter, with the microinverters absorbing/injective reactive power, then the customer will be seen as operating in the third or fourth quadrant, respectively. This is essentially a control of the microinverter's voltage waveforms with respect to the current output and the power demand/consumption information at the customer's meter. The same operation is possible with other inverter-based resources with reactive power support such as BESS and EVs with Apparent's microinverter for batteries or third-party inverters. The four-quadrant operation, from an inverter/generator perspective, is explained below:

- **First Quadrant.** Facility injects real and reactive power at metering point.
- **Second Quadrant.** Facility injects real power and absorbs reactive power at metering point.
- **Third Quadrant.** Facility absorbs real power and reactive power at metering point.
- **Fourth Quadrant.** Facility absorbs real power and injects reactive power at metering point.

The following list includes Apparent's features that classifies its microinverter as a smart grid inverter and advanced inverter.

- **Smart Grid Features**
    - Real power curtailment
    - Controlled VAR injected leading and lagging
    - Voltage and Frequency ride-through
    - Harmonics control
- **Advanced Inverter Features**
    - Volt-Var support
    - Volt-Watt support
    - Frequency-watt support

Additionally, the following features are unique to Apparent's microinverter.

- Apparent's inverter differentiating features:
    - Total harmonic control
    - Impedance matching maximum power point tracking
    - Reactive power generation without loss of maximum real output power generation

The total harmonic control can help prosumers reduce the cost of their electricity bill by increasing the power quality of their electric system with the help of the inverters. Apparent's impedance matching algorithm increases the power output of each module, which increases the available generation and revenues to prosumers. Finally, the reactive power capability of Apparent's microinverter allows for a higher reactive power generation, from each module, which can help reduce demand charges in the customer's bill or sell ancillary services for voltage regulation in the energy market.

The SG424U microinverters have been certified to the following standards which has been further evaluated by DNV GL:

- UL 1741: 2010 2nd edition
- UL 1741SA: 2016
- CSA C22.2.107.1-01 (2011)
- Supplemental UL 1741 requirements for Hawaiian Electric, Pacific Gas and Electric, Southern California Edison, and San Diego Gas & Electric
- National Electric Code rapid shutdown requirements

Using the California Energy Commission criteria, the Apparent microinverters have a 91.5% efficiency in converting the DC power from the PV module to real AC power output. Additionally, there is some power clipping, which naturally happens when limiting the real AC power to 250 W when using modules larger than 250 W DC, for example the maximum 325 W DC module. That translates to a DC/AC ratio of 1.3, which is consistent with the industry average. We note that some PV modules are now typically rated 400 W DC; thus, the DC/AC ratio will be higher than the average mentioned above.

Apparent has protected its microinverter technology with several US and international patents, including:

- US 7839025: Power extractor detecting a power change
- US 7960870: Power extractor for impedance matching
- US 8013474: System and apparatuses with multiple power extractors coupled to different power sources
- US 8013583: Dynamic switch power converter
- US 8212399: Power extractor with control loop
- US 8693228: Power transfer management for local power sources of a grid-tied load
- US 9690313: Power transfer management for local power sources of a grid-tied load
- US 9130390: Power extractor detecting power and voltage changes
- US 10158232: Total harmonic control
- US 10784684: Total harmonic control

Most of the listed patents deal with the proprietary method of power extraction, maximum power point tracking, and power transfer. According to the DNV GNL report, Apparent "describes their [maximum power point tracking] algorithm as a 'Hill Climbing' method similar to the 'Perturb and Disturb' method widely used in the PV solar industry. The algorithm executes every 2 cycles (about 33 milli-seconds) for a fast response to dynamically changing irradiance conditions."

3.2. APPARENT'S PCS OR "BLADE INVERTER"

Apparent's battery PCS (Blade Inverter) is a single-phase 120-V AC, 60-Hz, 1.5-kW AC power microinverter for BESS. The Blade Inverter was built around the same solar PV microinverter underlying technology. It provides the same functionalities as the solar PV microinverters to a battery module with the additional bi-directional power capabilities to charge and discharge the batteries.

Just as with the microinverters, which connect to directly to each PV module for higher power extraction, the Blade Inverter connects directly to each batter module in a large BESS. This helps operate each battery module at its maximum power depending on its temperature and other characteristics. Traditional designs string modules in series, just as in PV design, and a battery management system decides the operation level of all battery modules based on the lowest performance module in a string. The string methodology sacrifices power with the benefit of lower control complexity.

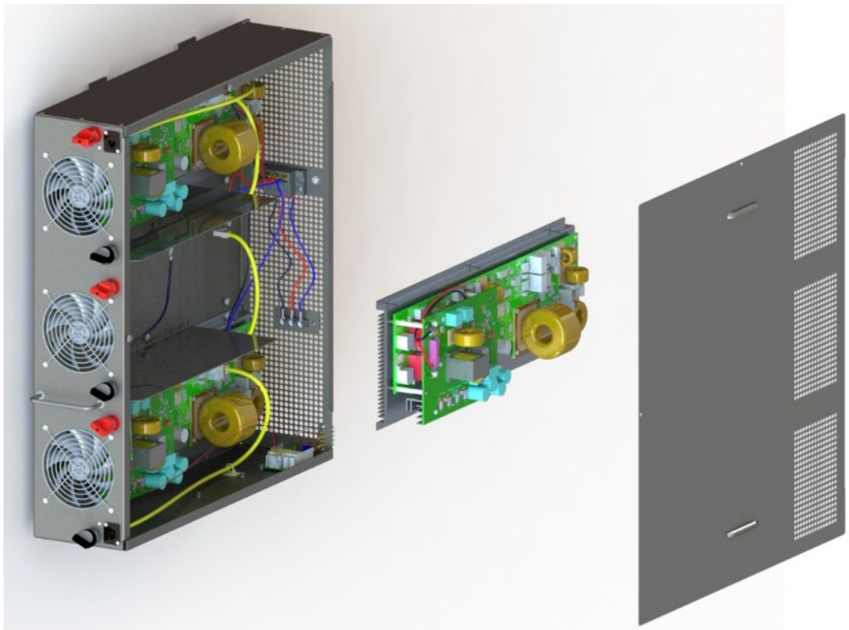
Connecting a Blade Inverter to each battery module has additional benefits beyond increasing power exchange. Module-level information is fed directly to the inverter without the need of communication protocol translations between the batteries, battery management system, and inverter controller. The Blade Inverter acts as the battery management system and inverter controller at the same time, and with a direct ethernet connection to the battery modules, the BESS response time can be increased significantly.

Moreover, just as in the case of microinverters for PV, if one module is out of service due to adverse conditions (high temperature, etc.) then that single module can be taken offline and the rest of modules can continue to operate at the most optimal level. In a traditional string configuration, if one battery module is offline, the entire string is taken offline, which would adversely impact overall power and energy production. The Blade Invert can be seen in Figure 4-3.

The "power-reactive power" or P-Q curve for the Blade Inverter would look similar to the solar PV microinverter's P-Q curve, with the difference that all four quadrants will show reactive power support (absorbing and injecting) when the battery is either charging (importing power) or discharging (exporting power). Since the technology is shared, the same microinverter U.S. patents apply, with the two below being directly applicable:

1. US 8013474: System and apparatuses with multiple power extractors coupled to different power sources
2. US 8013583: Dynamic switch power converter

Figure 4-3 — Apparent's Battery PCS (Blade Inverter)



The Blade Inverter can also be used to connect EVs to the grid. Given that EVs rely on a stationary battery, the EVs can also be thought of as a BESS. The Blade Inverter can become the charger of EVs, facilitating the charge and discharge of an EV's battery to tap into this resource, if integration of the EV to the grid is needed. A third-party charger can be used, if proprietary chargers are required by the EV manufacturer, in which case the charger will simply connect directly to the igOS to send statuses and receive commands for operation.

3.3. APPARENT'S DATA DEVICE AND HALL EFFECT IC

There are two auxiliary devices that Apparent has developed to support their control system with the measuring and data collection required. Apparent designed a data device to act as a bi-directional meter, sensing and collecting time-stamped power data (current, voltage, frequency, harmonics, real / reactive / apparent power), with a fast sampling rate of up to four times per second. This allows the igOS to make decisions in sub-seconds / real time. The device uses conventional current transformers and voltage transformers for instrumentation, tapping to different voltage levels (120 V, 12 kV, etc.). The data device can be seen in Figure 4-4.

Figure 4-4 — Apparent's Data Device Used as a Meter

The second measuring device is a hall effect sensor on an IC, which can be installed at the circuit breaker of customer distribution panel (which is typically located externally to the customer's main premises). The IC sensor can measure current on each circuit branch and provides an unintrusive way to measure power as close to the main loads as possible. The hall effect sensor can be seen in Figure 4-5.

Figure 4-5 — Apparent's Hall Effect Sensor

The data device along the hall effect sensor helps the igOS create the "energy signatures" for each generating source and load behind the customer's meter. This information is used in the decision-making process of the igOS system to understand the current state of demand and generation before acting on market signals or customer's goals.

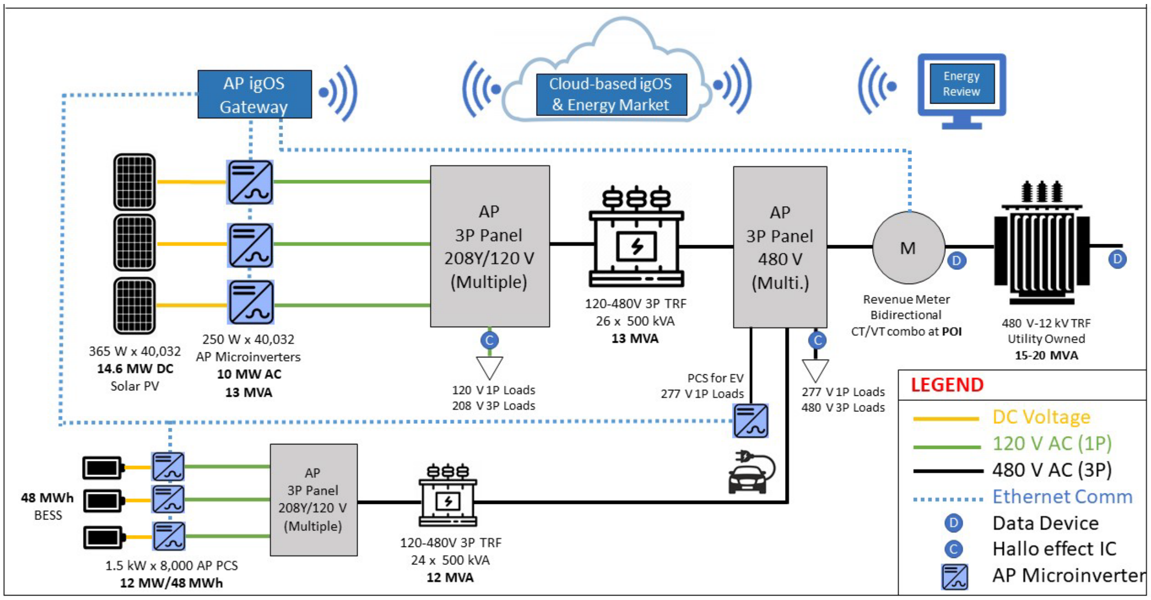
3.4. APPARENT'S IGOS

The igOS sits at the center of Apparent's bi-directional control system. The igOS is the brains of the system, controlling, monitoring, dispatching, acquiring all the information from the sources, meters, and energy market to make decisions multiple times per second. The igOS source-code was developed by Apparent from the ground up and it is protected by the following U.S. patents:

- US 9431828: Multi-source, multi-load systems with a power extractor
- US 10158233: Multi-source, multi-load systems with a power extractor
- US 9960601: Distributed power grid control with local VAR generation
- US 10063055: Distributed power grid control with local VAR control
- US 10003196: Energy signatures to represent complex current vectors
- US 10185346: Power transfer management for local power sources of a grid-tied load
- US 10686314: Power grid saturation control with distributed grid intelligence
- US 10879695: Grid network gateway aggregation
- US11056913: Intelligent Grid Operating System to Manage DER in a Grid Network
- US 11063431: Hierarchical and distributed power grid control

The igOS offers a control platform to work in conjunction with Apparent's microinverters and data devices, and it can also work with third-party assets if they can communicate with the system. Third-party assets can include string inverters, BESS, EV chargers, and other generating DER sources. To understand the operation of the igOS and how Apparent's technology can deliver on its multiple use cases and applications, a hypothetical solar plus storage project is shown in Figure 4-6. The project is a 10-MW_{ac} solar PV coupled with a 12-MW 4-hour BESS on the AC side.

Figure 4-6 — Example of Solar Plus Storage with Apparent's Technology



In Figure 4-6, all items in blue are Apparent's devices. Previous sections have covered the igOS gateway, solar PV microinverter, and BESS microinverter. All devices connect to igOS Gateway via an ethernet communication network, and they all exchange information via MODBUS TCP/IP protocol. The data devices and hall effect IC are not shown with communication connections; however, they also connect to the same ethernet network via ethernet cables. The network is supported by ethernet switches to accommodate the multiple devices throughout the site before connecting back to the igOS Gateway.

Apparent's solution is:

1. Microinverters are physically attached to each PV module as part of the DC stringing or to each battery module on the DC side of a BESS.
    a. For large projects, this constitutes tens of thousands of single-phase inverters interconnecting to the grid. The utility will consider all these individual inverters as part of the interconnection process.
2. The microinverters have sensing capability on the DC and AC side. They connect to the gateway via an ethernet cable to send status / receive commands from the igOS up to four times per second.
3. Typical status points are expected to be sent from the solar PV microinverters to the igOS including (not exhaustive and not including control points):
    a. AC voltage and current
    b. DC voltage and current
    c. Inverter status: on / off / restoring
    d. Power factor
    e. Operation mode

4. Typical status points are expected to be sent from the BESS microinverter to the igOS including (not exhaustive and not including control points):
    a. Battery state of charge
    b. Power, energy, power factor
    c. BESS mode: on / off / charging / discharging
    d. AC voltage and current
    e. DC voltage and current
    f. Fault status
5. Data devices and meters sense and collect the power information, four times per second, which is sent to the igOS. The typical information measured at the point of connection / metering includes:
    a. Bi-directional real/reactive/apparent power
    b. AC voltage and current
    c. Frequency
    d. Power factor
    e. Harmonics content
6. Due to the single-phase (1P) nature of the microinverters, a three-phase (3P) system needs to be designed/built with the microinverters. This is done by connecting three separate branches of microinverters to a 208/120 V AC distribution panel to form the A, B, and C phases, as Figure 4-6 shows.
7. Multiple distribution panels are used to collect the power from the microinverters. This is done at 3P 120 V AC, which is then stepped up to 3P 480 V AC through multiple step-up transformers. The power at 480 V AC is then recombined at the 3P 480 V AC distribution panels, which can also accommodate 3P loads and the coupling of the BESS microinverter system.
8. A Blade Inverter can then be connected to the 1P 277 V AC side of the 480 V panel to integrate an EV. Alternatively, a third-party EV charging stations can be connected at the 480 V panel at 3P or 1P voltage. The EV charging station native controller can be connected to the igOS by an ethernet connection and use MODBUS TCP/IP to bidirectionally communicate with the igOS if allowed by the charging station.
9. Finally, the collected power at 480 V AC is stepped up to the distribution system voltage (12 kV, 13.5 kV, etc.) through a single or multiple medium-voltage step-up transformer, which are typically pad mounted.
10. A bi-directional revenue meter and/or data device is connected at the point of interconnection, or at the multiple points of interconnection, to measure both the current demand, combined power by the resources and the excess generation.
11. The igOS Gateway aggregates all the information from the sources, data devices/meters, panels, and sensors, via the ethernet network, for processing. It also ensures the delivery of commands to the generation sources (DERs).

12. The igOS Gateway is also connected to the internet (via wired or wireless networks), to the cloud-based igOS system, which allows the system to virtually integrate the resources to the grid and make them available for trading in the energy market.
13. The aggregation of information in real-time, bi-directional exchange of information between the igOS Gateway, DER sources, data devices, processing of information, and executions of commands is expected to last seconds, in some cases less than a second, which gives Apparent the real-time energy management and control capability.

3.5. APPARENT'S SYSTEM AND COMMUNICATION SECURITY

An important part of Apparent's technology is system and communication security; key characteristics of which are as follows:

- Regarding the type of cyber security protocols implemented in Apparent's communication system (i.e., microinverters, data devices, and the Gateway), the inverter communication to the Energy Review portal is encrypted using secure socket layers (SSL) if the inverters are configured to report to the Energy Review through the Gateway.
- Similarly, communications between Apparent's cloud and Gateway are encrypted using SSL (SHA-2 and 2048-bit encryption) for sending status information. Any bi-directional communications are authenticated by public/private keys using the RIJNDAEL 256 cypher. These protocols are used for both wired and wireless connections.
- Related to igOS security, user interactions that take place over a web browser are all encrypted using SSL. Users' IP addresses must also be in the Gateway's whitelist before they are authorized to log in to the Gateway and the cloud servers. There are five privilege levels that users can be, from administrator to technician. Each webpage is given minimum access level, and if the user does not have the correct rights, they are unable to view the page. The Gateway can also turn off sections of pages for users who do not have the correct access level.
- Access to Energy Review portal is through Apparent's user authentication system. All interactions take place over SSL. The portal does not allow for remote operations over any systems.
- System level security is compliant Distributed Network Protocol 3 and International Electrotechnical Commission 61850 standards.
- From a physical security standpoint, Apparent's cabinets with the Gateway are always treated and secured by data server standards.