Singapore Battery Consortium

Q4 Newsletter

Understanding curation of recent industry developments and technology news

Recent industry developments and technology news are specifically curated based on the relevance to the progression of the industry. Each news event is categorized based on importance and area of focus (see below for description for both).

SK innovation

15 January 2020

SK Innovation announces 10 GWh exp(1)sion of factory in U.S. (1)

Very (3)rtant | Ener(4)orage

SK Innovation will build its second U.S. factory in Georgia, from which it intends to ship another 9.8 GWh to VW in Tennessee. Its total production goal of 100 GWh by 2025 outpaces its publicly known manufacturing projects, so expansions near already-planned facilities will likely be a forthcoming trend. In the Southeast U.S., automotive manufa(2)ers are nearby: VW is in Tennessee, Daimler has factories in South Carolina and Alabama, where Hyundai also is, and Volvo, BMW, and Kia are located in Georgia. Clients should expect SK Innovation to ramp up production near customers and keep chipping away at its 2025 goal.

1. **Link**: Hyperlink to original news article. Note some news articles may be behind paywall.
2. **Analysis**: Writeup of the news event as it relates to industry development and recommendations for action.
3. **Importance**: Take on the potential importance of the event from "Truly Disruptive" to "Ignore"
4. **Area of Focus**: Category of the news event based on the to the topic.

Importance	Description
Truly Disruptive	A game-changing, landmark development
Very Important	Significant news that will have strong implications
Average Importance	Worth noting, but not likely to be too important or disruptive
Low Importance	An over-hyped development, which is not worth monitoring closely
Ignore	Misleading or irrelevant development, worth being cautious about

Area of Focus	Description
Built environment energy use	Hardware and software technologies for commercial and residential energy consumption
Business models and regulations	Novel business models for energy production, consumption, and distribution, as well as policies with transformational impact on new energy technology development
Energy for mobility	Energy sources for powering road, rail, aviation, and marine – includes movement of goods and people
Energy storage	Various forms electrochemical energy storage, such as Li-ion and solid-state batteries
Stationary storage	Utility-scale and long-duration energy storage for grid services, renewables integration and backup, and microgrid support

Solid Power continues to be an industry leader in solid-state battery development

8 October 2020

Boston Dynamics says energy storage is limiting factor for humanoid robots

Very Important | Energy storage

Speaking at the AUVSI XPONENTIAL 2020 conference, Marc said that the commercialization of the company's humanoid Atlas robot will require an extremely energy-dense battery, preferably five to 10 times what is currently available. Marc said other technological barriers like manufacturing capabilities and compute power are generally sufficient today. Atlas uses a 5 kW hydraulic power unit to power 28 hydraulic joints, allowing the robot to do stunts near the level and accuracy of an Olympic gymnast. Although the robot is still a couple of years away from commercialization, lightweight materials and innovative battery chemistries will enable it to run untethered for longer than 30 minutes.

19 October 2020

Solid Power produces and delivers its first generation 10-layer, 2 Ah cells

Very Important | Energy storage

The cells exhibit improved room-temperature operation and discharge rates up to 5C, and Solid Power will deliver several hundred cells to partners by the end of 2020. The company was producing 2 Ah batteries last year on its pilot roll-to-roll production line but has since improved battery performance. In particular, the 5C discharge rate was increased from 1C last year. Solid-state batteries (SSBs) are typically limited by slower charge/discharge rates, but lithium metal anodes can enable higher rates. Solid Power leads in SSB production, having successfully completed roll-to-roll production and cell stacking, a feat that competitors continue to struggle with.

27 October 2020

Singapore consortium to pilot country's first floating energy storage system

Average Importance | Stationary storage

Singapore's Energy Market Authority (EMA) and Keppel Offshore & Marine (O&M) jointly awarded the research grant to the Envision Digital-led consortium to pilot a 7.5 MW/7.5MWh Li-ion floating energy storage system on Keppel's Floating Living Lab (FLL), expecting to complete the project in 2023. This project is part of EMA and Keppel O&M's $10 million partnership to develop innovative energy solutions in the marine sector, including "distributed energy resources, digitalization, and emerging low carbon alternatives." Floating energy systems, such as floating PV, are gaining attention as alternatives for renewable generation in land-constrained areas, and this project will likely show potential opportunities for system integration.

Synergies between electric vehicles, energy storage, and the power grid continue to emerge

29 October 2020

Tesla Energy Plan launches in U.K. to build residential VPP in partnership with Octopus Energy

Very Important | Built environment energy use

Homes with rooftop solar and Tesla Powerwalls can join the Tesla Energy Plan to be a part of Tesla's Virtual Power Plant (VPP) in the U.K. The plan offers 100% renewable electricity and the most attractive electricity rates in the U.K. – flat import and export rates of £0.08 ($0.1) and £0.11 ($0.14) for Tesla vehicle and non-Tesla vehicle owners, respectively. In addition, the plan removes the daily standing charge, which translate in an average saving of £75 ($96) per household per year. The latter in combination with the low import and high export rates will translate into considerable electricity bill savings. In the U.K., Tesla is moving fast to offer compelling bundles of products and services.

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2 November 2020

Kaluza and Bosch trial direct-to-car smart charging

Average Importance | Energy for mobility

Kaluza and Bosch combined the capabilities of their digital platforms and embedded vehicle technologies, connecting directly to electric vehicles (EVs) to manage their charging process without the need for smart charging hardware. The partners claim a key benefit of managing charging events at the vehicle instead of the charging point is that the process now works "around user settings and vehicle data." This may open up opportunities for energy retailers to offer smart charging services as part of their electricity tariffs; however, more comprehensive details of the trial are needed.

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3 November 2020

Long-awaited SAE J2954 standardized wireless charging for BEVs

Very Important | Energy for mobility

Wireless charging has thus far failed to gain meaningful market share in BEVs. In some ways, it faces similar challenges as hydrogen fuel cell vehicles – no infrastructure has been built, as there are no cars that support it. The long-awaited J2954 standard aims in part to solve this problem, as the standard provides industrywide guidance to ensure systems are interoperable and safe. Clients should expect this announcement to accelerate adoption of wireless charging systems for battery electric vehicles, which to date have mostly consisted of limited pilot projects.

RECENT INDUSTRY DEVELOPMENTS AND TECHNOLOGY NEWS

BEV cost parity goes far beyond reduction of battery prices

UBS

3 November 2020

Citing sub-$100/kWh batteries in 2022, UBS predicts BEV and ICE cost parity in 2024

Average Importance | Energy for mobility

Most agree that the electric powertrain will be cheaper at some point during the 2020s. It is worth keeping in mind that the answer to when BEVs are cheaper than ICE is much too complex to put a single number on. In reality, there will be a range of years when BEVs will reach cost parity, depending on the specific region, vehicle segment, and how much range the vehicle offers. Additionally, studies like this one that focus on batteries overlook cost reductions that arise from pack and vehicle design, such as cell-to-pack designs, as well as cost reductions from power electronics and other non-battery components.

SKELETON TECHNOLOGIES

9 November 2020

Skeleton raises €41.3 million as it emerges as a leader in the supercapacitor industry

Low Importance | Energy storage

Compared to batteries, Lux expects supercapacitors to remain a much smaller market, as they can't compete in the electric vehicle space. However, as forms of heavy-duty transportation like buses and trucks begin to electrify, supercapacitors offer greater C-rates during charging and discharging – useful for hybridization or used in tandem with hydrogen fuel cells. Clients should regard Skeleton as a leader in the space, and the recent funding will be important to deliver on recently announced contracts with customers, as it claims a €150 million commercial order backlog.

NIO

9 November 2020

Nio announces cell-to-pack technology and larger 100 kWh pack

Average Importance | Energy for mobility

Nio had previously offered different battery pack sizes in its vehicles, and as we previously noted, due to its battery swapping pursuits, could more flexibly integrate new technologies into its existing fleet. Nio's recent announcement isn't just about different-sized packs and a new chemistry (Lux suspects this is an LFP chemistry); it also marks Nio's adoption of cell-to-pack technology. While its battery swapping pursuits mean Nio is unable to integrate cells as a structural member of the vehicle as BYD and Tesla have done, a demonstrated ability to integrate new pack designs and chemistries into existing vehicles is a notable achievement.

Automakers continue to commit to electrification with rollout of dedicated BEV platforms

9 November 2020

In change of strategy, BMW to build dedicated BEV platform

Very Important | Energy for mobility

While high-volume manufacturers have pursued dedicated battery electric vehicle platforms (BEV), such as Volkswagen's MEB and PPE or General Motor's BEV3 platform, BMW had focused on a singular platform that can support all powertrain types, from combustion-based vehicles to hybrids and fully electric. However, BMW has now changed its tune and will design its own dedicated platform for battery electric vehicles. Clients should recognize two factors that likely played a role: increasing confidence in the outlook for BEV sales and better access to cost reductions at the vehicle level, such as BYD and Tesla using structural batteries.

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3 December 2020

Li-Cycle begins operations of its second battery recycling facility

Average Importance | Energy storage

Li-Cycle is able to process a wide range of battery chemistries in its recycling process, recovering aluminum, copper, and black mass through a battery deactivation and shredding process. While the company has developed its own hydrometallurgical process to recover metals from the black mass, it currently sells most of it to other materials recovery companies. Li-Cycle will be opening its own hydrometallurgy facility in 2022 so that it can begin processing black mass at scale. Clients should view the opening of a second facility as promising but look for further scaling of Li-Cycle's hydrometallurgical technology as a marker of success for its full recycling process.

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7 December 2020

Hyundai reveals E-GMP platform as automakers continue to design dedicated BEV platforms

Very Important | Energy for mobility

While Hyundai was known to be working on a dedicated electric platform, the company revealed key details publicly for the first time. Overall, the design mirrored many others – standardized modules and a flexible platform mean it can underpin many vehicles and increase part sharing for reduced costs, with improvements in energy density and costs compared to previous models built on modified ICE platforms. However, Hyundai is differentiated in that it includes a bidirectional onboard charger to enable V2G out of the box, as well as other functions like letting one vehicle charge another. Unlike Tesla and BYD, the company is not making the battery a structural member of the vehicle.

RECENT INDUSTRY DEVELOPMENTS AND TECHNOLOGY NEWS

Hype continues to run rampant in the battery startup space

9 December 2020

QuantumScape finally shares some data but fails to justify the hype

Average Importance | Energy storage

QuantumScape showed data from single-layer pouch cells that indicated fast charging (15 minutes to 80% SoC) and 800 cycles at a 1C charge/discharge rate, which represent some of the better lab-scale results seen for a lithium anode cell. However, after more than a decade and $300 million to develop the battery, the company has failed to show a cell ready for commercialization, as it did not discuss its inability to make multilayer pouch cells and has yet to provide any validation of manufacturing costs. Lux remains unconvinced that QuantumScape will meet its 2025 timeline for commercialization, as it is still only sharing lab-scale results and needs to focus on manufacturing to justify its lofty valuation.

10 December 2020

Solid Power shares new battery data demonstrating progress toward commercialization

Very Important | Energy storage

The 22-layer, 20 Ah cells achieve 330 Wh/kg and are produced on a roll-to-roll battery production line. The company also revealed further details on the 2 Ah cells it delivered to validation partners in October; the products show cycling stability at near room temperature at C/10 discharge rates, with rates up to 3C possible at 70 °C. Solid Power is well-positioned to begin automotive qualification for its batteries in the next two years and anticipates further discharge rate and energy density improvements. Solid Power gains a valuable foothold in the market as one of the only all-SSB startups producing its technology on a pilot line while achieving high energy density cells.

11 December 2020

Hydro-Québec moves into stationary storage market with Li-ion battery system

Average Importance | Stationary storage

Hydro-Québec has established a subsidiary, EVLO Energy Storage Inc., to produce energy storage systems (ESS) utilizing its own power controls and energy management system paired with LFP Li-ion batteries. The product has been used in pilot projects operated by Hydro-Québec and rural microgrid systems, and EVLO has signed an MOU for a 9 MWh system for French transmission provider RTE. Hydro-Québec's experience as a utility provider and extensive R&D efforts are two key differentiators for EVLO. Clients should note that battery technology is rapidly becoming the less important feature of an ESS; rather, the digital tools that optimize energy storage technology for different applications are increasingly important.

Finding the Right Fit for Vehicle-to-Grid

The electrification of the vehicle fleet means increased electricity demand and strain on power grids, but also a great opportunity. When plugged into a charging station, electric vehicles become a part of the grid, and thus can be used as grid assets. For several years, smart charging have been highly successful, essentially turning electric vehicle charging stations into demand response assets. However, beyond smart charging, discharging the electric vehicle battery to inject power into the grid or to serve a local site is poised to offer much greater potential upside.

LUX TAKE

With vehicle-to-grid, the electric vehicle takes on the role of a stationary energy storage system, charging and discharging as needed to fulfill a desired application. Much is still not yet understood about vehicle-to-grid but has implications for many roles and types of players across an emerging value chain.

Source: Enel

Evaluating six use-cases for plug-in vehicles, considering both fleets and privately-owned vehicles

	Charging & Fleets	Service	Description
Privately-owned vehicles	Charging at home	Frequency regulation	This includes plug-in vehicle owners with residential chargers in their residence, making capacity available for frequency regulation
	Charging at work	Frequency regulation	This includes allowing employees to make capacity available for frequency regulation while parked at the office; public parking structures in high-capacity areas offer a similar use case
	Charging at work	Demand charge reduction	This includes workplace chargers, allowing employees to make capacity available for peak-shaving on-site, to reduce demand charges on electricity bills
Fleet-owned vehicles	Electric bus fleets	Frequency regulation	This includes operators of bus fleets servicing urban areas, making capacity available for frequency regulation
	Service and delivery fleets	Frequency regulation	This includes fleets that leave a central location to delivery goods or provide services, such as grocery delivery fleets or last-mile couriers, making capacity available for frequency regulation
	On-site fleets	Frequency regulation	This includes fleets of vehicles owned on a military base, municipality, or university campus, in which vehicles are made available to employees with capacity made available for frequency regulation

Four factors influence the value of vehicle-to-grid from the perspective of the participant

Contributing Factor	Weight	Explanation
Size of fleet	10%	The fleet size is the total vehicle battery capacity that a participant could offer to the V2G aggregation. A passenger vehicle charging at home would only have one small battery to offer, while a bus fleet would have many large batteries. Larger fleets will be easier for aggregators to integrate, and thus aggregators will be able to pass along a larger share of revenues to the customer per vehicle. This difference in aggregator fees is a small one, hence fleet size has a relatively small impact on the total value of V2G.
Availability	30%	The availability is the number of hours the vehicle would be available each day, and the value of those hours. For frequency regulation, where prices are relatively consistent over the course of the day, scoring is based only on the number of hours that the vehicle is plugged in at the relevant location (minus charging time). For demand charge management, the energy storage is only required at times that the site will experience its peak, so as long as participating vehicles will have availability during that time window, the total number of hours of availability is not relevant.
Scheduling visibility	30%	Scheduling visibility accounts for the visibility that the aggregator will have into the vehicle's hours of availability. If a participating vehicle is not operating on a known schedule, aggregators must bid in less capacity than they expect to have to ensure that they do not under-deliver, which reduces the earnings per vehicle.
Perceived value	30%	Perceived value accounts for the level of motivation that the participant will feel when presented with the opportunity to earn revenue from V2G services. This factor takes into account the three factors above, in that a higher revenue potential per vehicle will increase the perceived value score. It also takes into account the participant's finances; a company in the business of operating vehicle fleets will have more motivation to pursue a new revenue stream from that fleet than a company for which a vehicle fleet is auxiliary.

These additional actors define the barriers for vehicle-to-grid from the perspective of the participant

Contributing Factor	Weight	Explanation
Infrastructure cost	50%	Infrastructure cost accounts for how averse the participant will be toward the up-front cost of V2G charging stations, including any grid infrastructure upgrades that the participant would need to pay for to accommodate the charging station. For example, the cost of a V2G charging station may be the same for a commercial fleet as it is for a homeowner, but a homeowner may be more averse to making a capital investment of several thousand dollars.
IT security risk	10%	IT security risk highlights the risk to the participant of private information – in particular, information about the vehicle's schedule – being compromised through participation in V2G. For consumers, this reflects privacy concerns, as well as concerns that knowledge of a vehicle's schedule could let a potential burglar know when they are not home. For fleets with public schedules or schedules that are not sensitive, IT security is unlikely to be a barrier. In general, IT is only a small concern and unlikely to be a significant driver in these decisions, hence its small weighting.
Impact of an interruption	40%	Impact of an interruption captures the risk that an unforeseen event (such as an emergency) will require the participant to disconnect from the charger unexpectedly, without sufficient time for the vehicle to charge, and the subsequent impact on the participant in that situation. For consumers, these types of unforeseen situations are not uncommon, and the impact could be that the participant does not have sufficient charge to get to their destination, which would be a strong detractor.

For each of the six applications, we assign scores to the drivers and barriers on Slide 10 and Slide 11. Each factor is scored on a scale of 1 to 5. For drivers, a score of 1 represents a weakly positive impact on vehicle-to-grid adoption and a score of 5 indicates a very positive impact on vehicle. For barriers, the same scoring metric is applied using a scale of -1 to -5, where a score of -5 indicates a very negative impact on vehicle-to-grid adoption.

Plotting drivers and barriers to show relative strength of each application for vehicle-to-grid

Weighted, unitless scores for drivers are stacked above the x-axis, while scores for barriers are stacked below the x-axis. The maximum possible scores for drivers and barriers are +5 and -5, respectively.

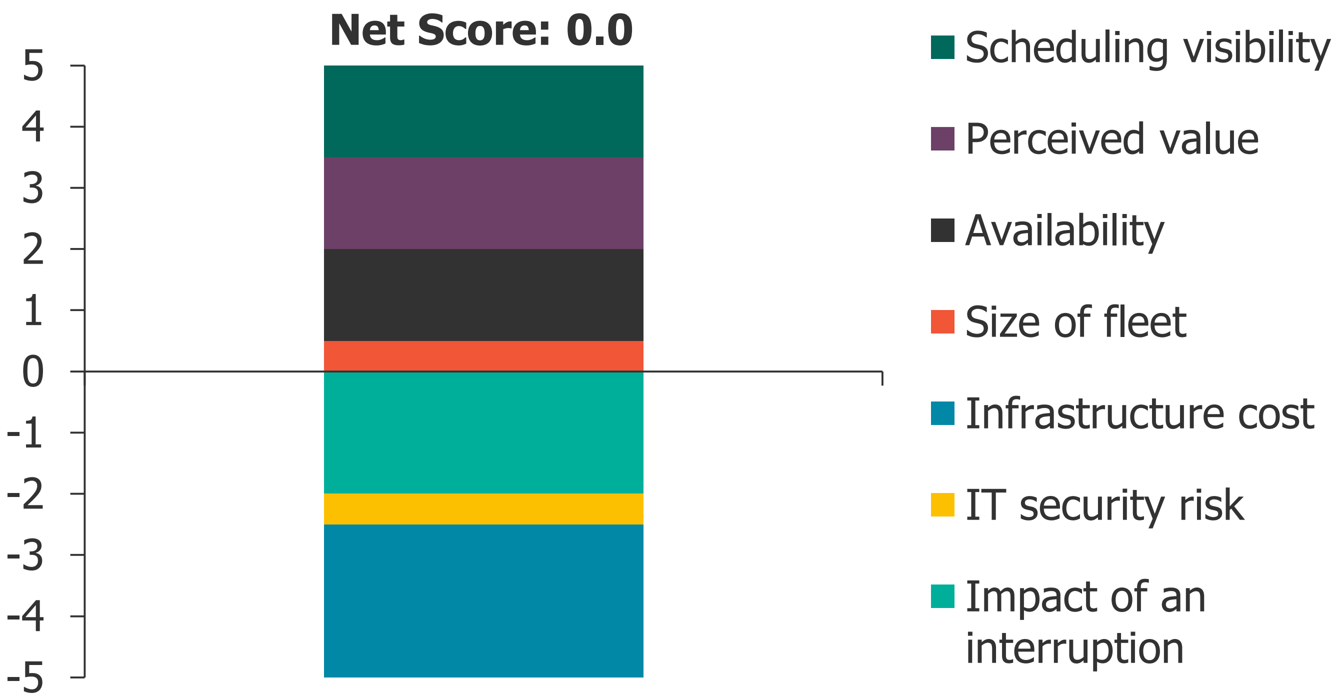
The most important determinant of the likelihood of adoption in an application is its net score – shown in at the top of the bar.

The net score is calculated as the sum of the positive driver score and negative barrier score. The strongest applications will see a positive net score, indicating that the drivers outweigh the barriers.

Applications with negative net scores are unlikely to see significant adoption unless barriers can be overcome or more revenue potential is made available.

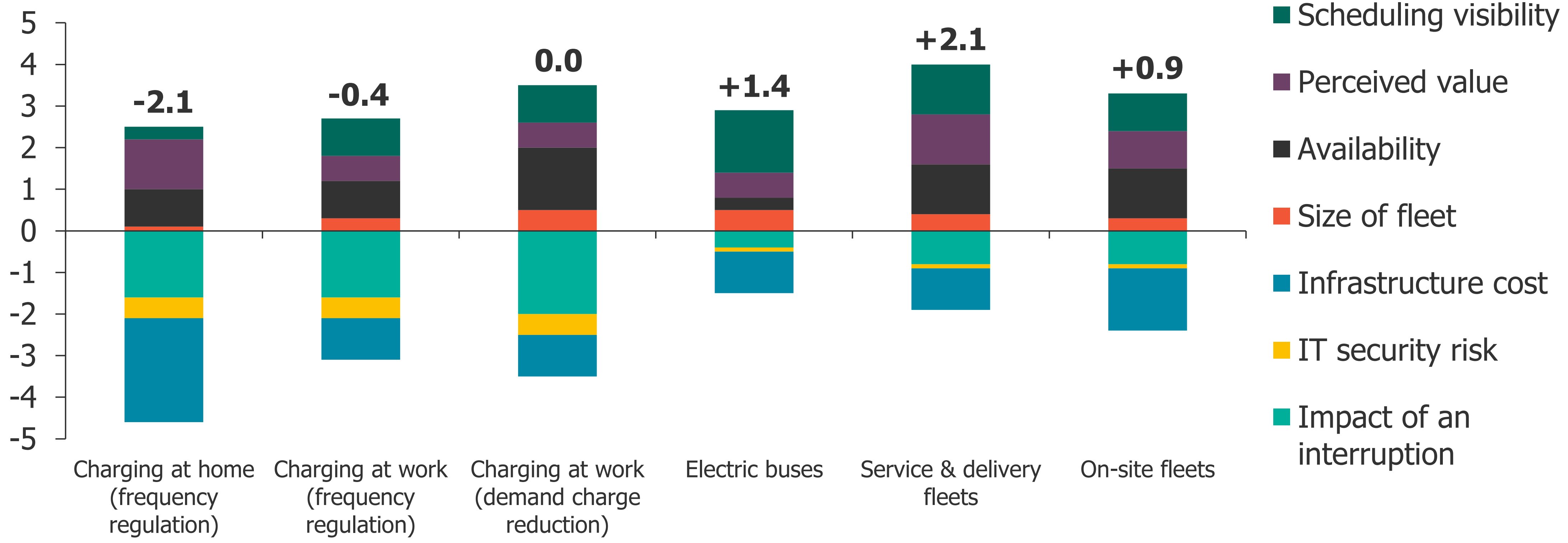
Finding the Right Fit for Vehicle-to-Grid

Weighted factors impacting adoption



Fleet applications are the most attraction option for vehicle-to-grid functionality

Finding the Right Fit for Vehicle-to-Grid
Weighted factors impacting adoption



Fleet applications are the most attraction option for vehicle-to-grid functionality

Overall, fleet applications are more attractive than private vehicle applications, but not because of a difference in revenue potential. Rather, private vehicle owners will see greater barriers and risks than fleet owners will in adopting vehicle-to-grid.

Private vehicle owners are typically more sensitive to upfront costs. Adding a CHAdeMO port to provide vehicle-to-grid functionality adds costs over conventional Level 2 charging – a 10 kW DC fast-charger could cost between $3,000 and $5,000 with installation, while Level 2 chargers providing AC power cost between $500 and $1,000. Although revenues may create a beneficial long-term economic case, the upfront costs may be high enough to deter private vehicle owners from the initial investment in infrastructure. Third-party financing, which could pay for the infrastructure and share revenues, could remove this barrier as it did for the solar industry.

Scheduling and security concerns are more of a barrier to private vehicle owners than fleets. Owning or leasing a vehicle offers freedom of mobility to consumers, who are not reliant on public transportation schedules or availability of alternatives. However, bidding into frequency regulation markets requires visibility into schedules – as much as one day in advance – while also limiting the availability to use a vehicle while it is participating in frequency regulation services and opening the possibility that the vehicle may not be fully charged if the owner decides to use it sooner than planned. Additionally, private vehicle owners have more information at risk compared to fleet vehicles, as compromised vehicle-to-grid systems could make a residential address and schedule of when the owner is home available – posing a security concern. Fleet vehicles, such as public buses, already post public schedules and generally have less concerns of information security.

USE CASE: CHARGING AT HOME (FREQUENCY REGULATION)

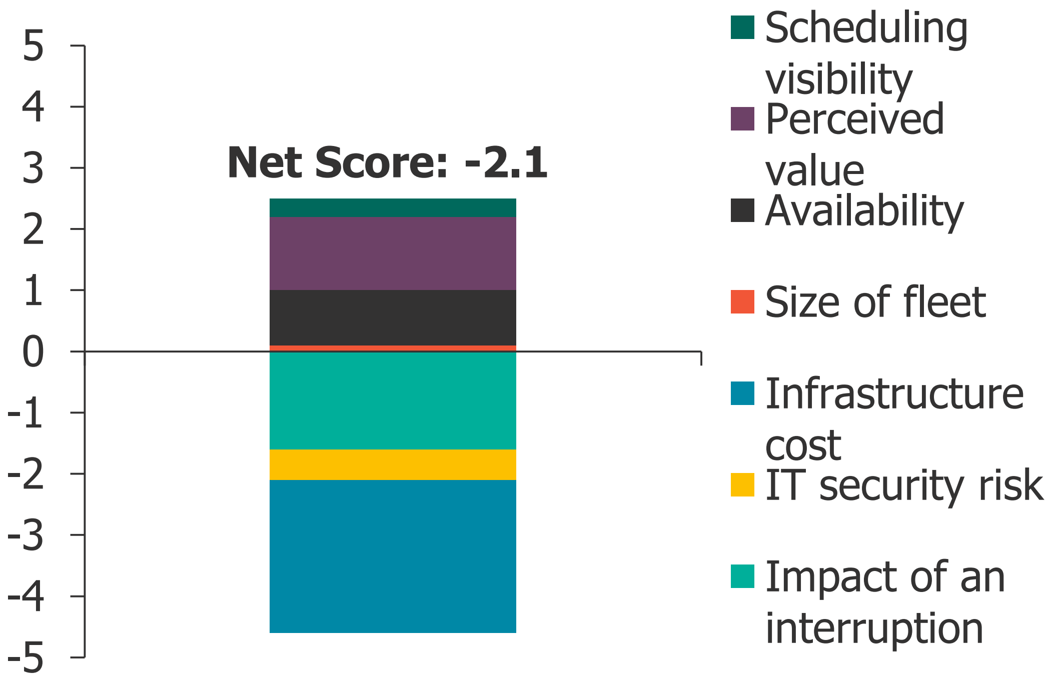
Very poor fit for vehicle-to-grid

The impact of infrastructure costs and revenues generated varies widely among vehicle owners. Consumers that opt for high-priced vehicles, such as Tesla's $70,000 Model S, will view the costs to install V2G capable infrastructure much differently than owners of lower-cost vehicles like the $30,000 Nissan Leaf. Owners of higher-priced EVs will view costs as less of a barrier, although conversely also see revenues as less valuable. In this analysis, we consider a lower-priced EV where owners are more sensitive to installation costs and revenue generation.

Scheduling issues are a much larger barrier to V2G adoption in residential charging than other applications, due to the larger impact that charging interruptions have. Frequency regulation is typically a charge-neutral application, where the battery's state-of-charge is similar at the end and beginning of a frequency response event, preventing a battery from charging while participating. Consumers that own electric vehicles will be forced to choose between generating revenue from V2G and adding range by charging. This poses a barrier, as consumers will typically want a full state-of-charge in order to use the vehicle in case of emergency.

Charging at Home

Weighted factors impacting adoption



USE CASE: CHARGING AT WORK (FREQUENCY REGULATION)

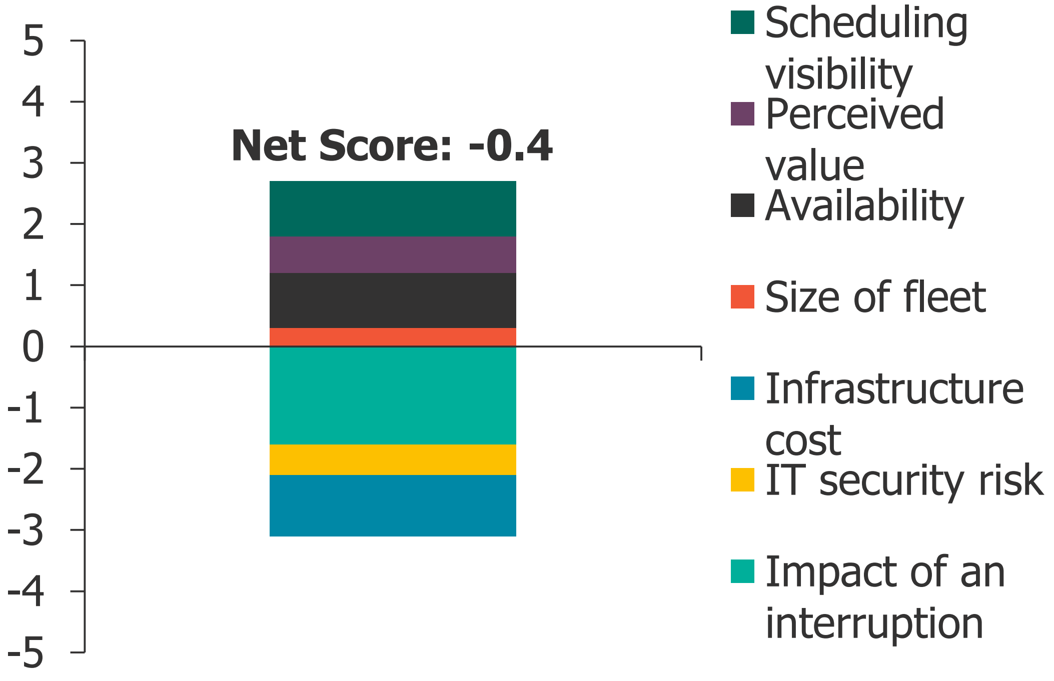
Poor fit for vehicle-to-grid

Workplace charging is a better fit than residential charging due to a lower impact of infrastructure costs – but still not a great fit. Many workplaces today are investing in charging infrastructure to support employees with plug-in vehicles, also viewing it as a way to increase environmental credentials and attract employees. The added cost of V2G-capable infrastructure is less impactful to the bottom line of businesses compared to private owners. Several options are available for revenue sharing, allowing the employer and employee to benefit from revenues generated; however, this would add complexity beyond ordinary programs for free workplace charging.

Scheduling is potentially more visible than residential applications. This can vary by workplace, but through either knowing employees shifts or having data on when people are typically plugged in at work, scheduling will be more predictable than in residential applications.

Charging at Work

Weighted factors impacting adoption



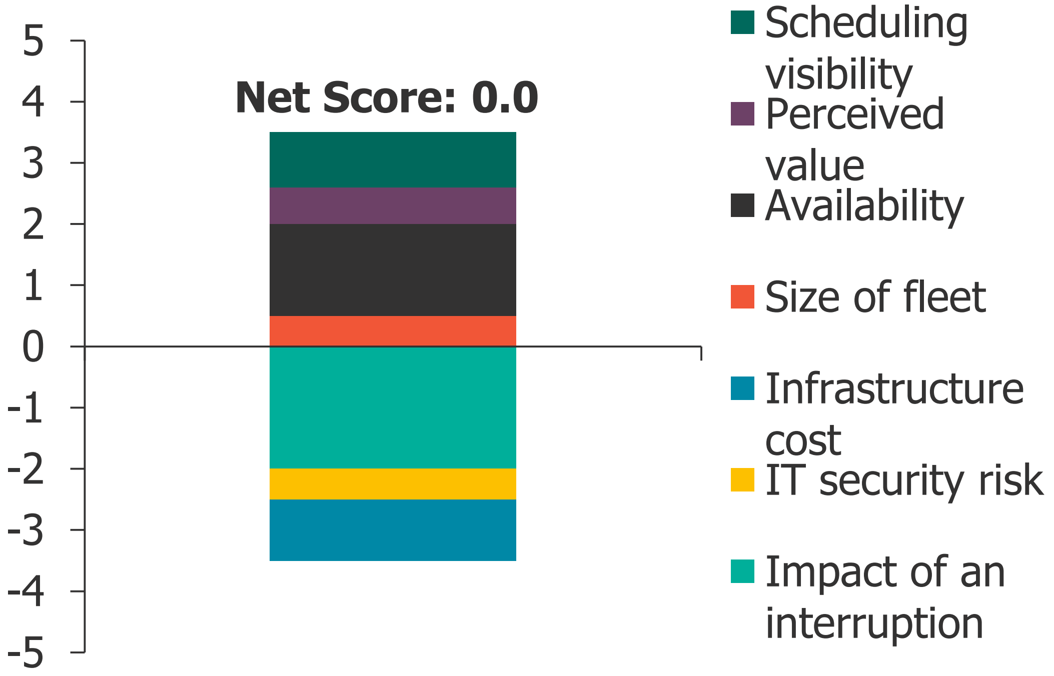
Lux Research

USE CASE: CHARGING AT WORK (DEMAND CHARGE REDUCTION)

Poor fit for vehicle-to-grid

Using V2G for reducing demand charges on the employer's utility bills eliminates the need for an aggregator to bid into a market. A demand charge imposes a fee on the customer's energy bill that scales with the customer's highest point of power demand – in other words, scaling with kW rather than kWh. Depending on the utility, demand charges can make up as much as half of the customer's energy bill, and thus have become the primary application for behind-the-meter energy storage in commercial applications. With the right arrangement, V2G could provide this service without the need for a stationary battery. Scheduling visibility is a low concern in this application, because there are not market-imposed penalties for underperformance; additionally, times that vehicles are plugged in are likely to line up with times when energy demand is needed, because office building demand peaks will often be in the afternoon.

Charging at Work
Weighted factors impacting adoption



USE CASE: ELECTRIC BUSES

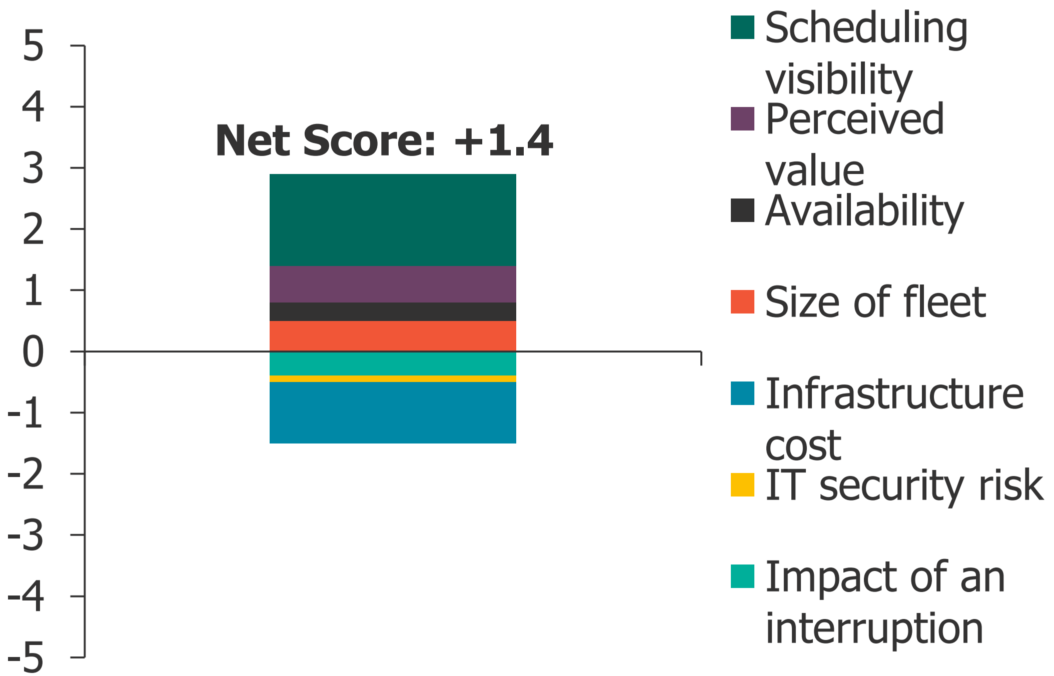
Strong fit for vehicle-to-grid

Electric buses have large fleets with a high degree of scheduling visibility, making them good candidates in terms of logistics. Revenues for electric buses participating in V2G services will typically be higher than other applications. A combination of large fleet size and larger, more powerful batteries can generate greater revenues for each hour made available for frequency regulation. Buses represent the lowest possible security risk, as schedules are already public and there is little useful information to steal.

However, the number of hours available to use for grid services limits revenue generation. Although there is high potential for generating revenues, the number of hours that the battery is available to participate in frequency regulation is limited. Bus fleet operators maximize value by maximizing the time the vehicle is in use, so there are fewer hours the bus can participate in grid services. The window of opportunity is further reduced by the inability to charge and participate in grid services, meaning there may only be a few hours per day to participate. Some types of fleets may see higher availabilities, though, like school bus fleets, representing a better opportunity for V2G.

Electric Buses

Weighted factors impacting adoption



USE CASE: SERVICE & DELIVERY FLEETS

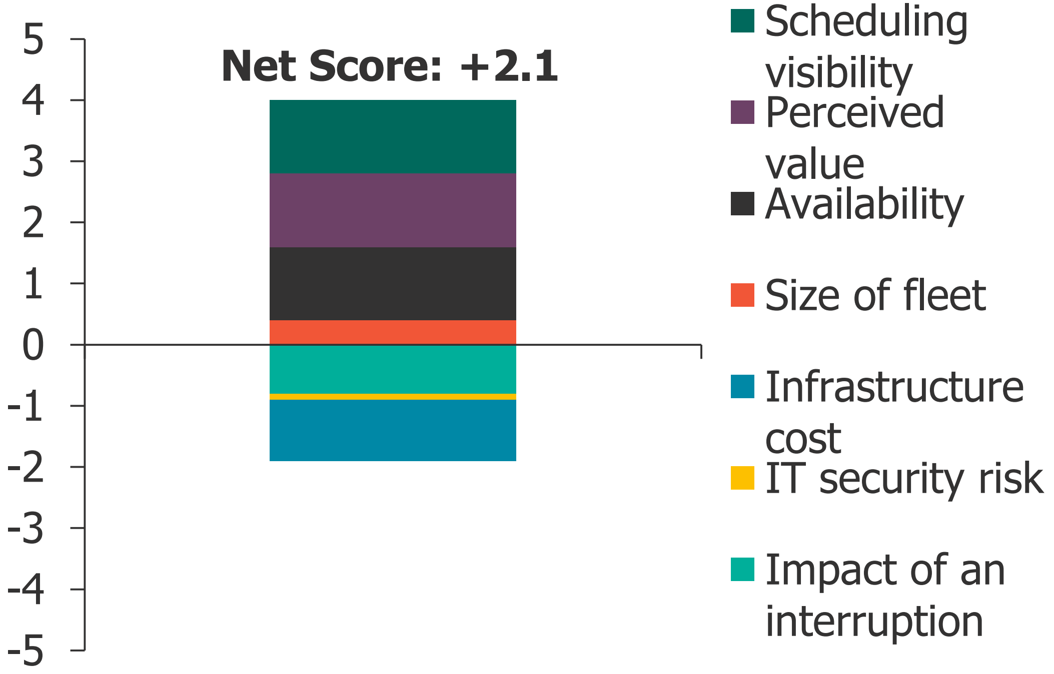
Very strong fit for vehicle-to-grid

Service and delivery fleets owned corporately are the most attractive application for V2G. Fleet operators for service and delivery fleets would place a high amount of value on revenues from V2G services. Managing fleets is mostly about driving out costs and improving operating margins, so added revenues are considered valuable. This type of application is most common in pilot projects. Availability of vehicles to participate in charging is likely known well in advance, and there are many large fleet applications that should provide a large number of available hours to participate in V2G. For example, grocery delivery vehicles primarily deliver food during morning hours, while cable and internet providers typically only operate during business hours.

Momentum behind converting fleets to electric is gaining as V2G approaches commercialization, so the two may go hand-in-hand. Similar to the RE100 group of companies that all aim to use 100% renewable energy, the EV100 group includes companies that are aiming to convert all corporate fleets to plug-in vehicles by 2030. As EV technology matures and prices fall, the total cost of ownership rivals internal combustion engine vehicles in some geographies.

Service & Delivery Fleets

Weighted factors impacting adoption



USE CASE: ON-SITE FLEETS

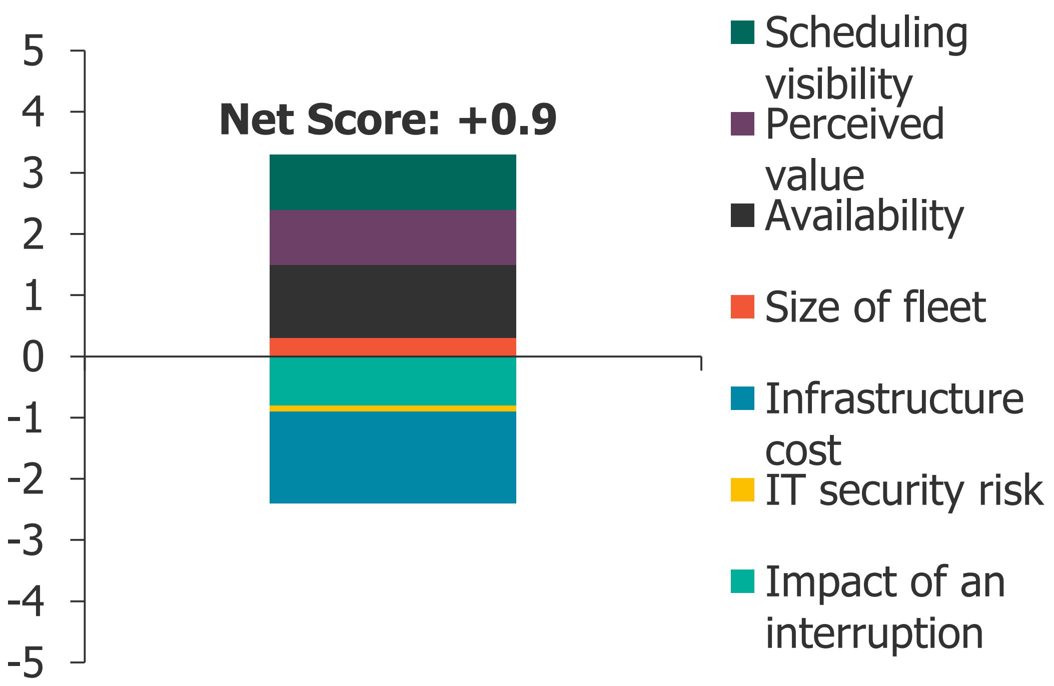
Moderate fit for vehicle-to-grid

Most on-site fleets offer a large number of available hours, making V2G valuable. Many on-site fleets, such as military campuses, universities, or ports, ask users to book vehicles in advance or are only made available during operating hours, allowing for ample time for vehicles to participate in grid services. This is also an application that was chosen for many pilot programs.

However, compared to other types of fleets, there are more bureaucratic barriers to V2G adoption in on-site fleets. For service and delivery fleets and bus fleets, fleet operation is of key importance to the owner's business, whereas on-site fleets have little impact on the fleet owner's profitability. Adopting new technologies that could reduce costs of fleet operation will be low on the priority list of an on-site fleet owner, trumped by larger initiatives. Therefore, V2G adoption in on-site fleets is more likely to be driven by a third-party fleet operator servicing the on-site fleet than by the owner of the on-site fleet.

On-site Fleets

Weighted factors impacting adoption



Source: Endesa

VEHICLE-TO-GRID

Vehicle-to-grid aggregation will become a crowded space

Although today vehicle-to-grid remains primarily in the pilot scale, the barriers to other players entering the market are low. Several other vehicle-to-grid aggregators will emerge with similar technologies in the coming years. These new aggregators will likely come from multiple angles. Virtual power plant aggregators can modify their existing software platforms to add features that allow them to interface with charging stations and vehicles. Charging station network managers are also strong contenders to move into the space, as many are already building familiarity with smart charging.

The developers with the best network of partners and customers will grow to be the strongest. Utilities may also emerge in a role as the customer interface, serving as a natural evolution from energy retailers to energy services companies. It is expected for utilities with existing virtual power plant capabilities to build out existing technologies, while others are likely to acquire developers of vehicle-to-grid software platforms.

VEHICLE-TO-GRID

Wider implementation will require automakers

Automakers must allow battery data, including state-of-the-charge and remaining capacity, for the most efficient use of vehicle-to-grid. While some developers are rolling out predictive algorithms that can participate in vehicle-to-grid without knowing this data, an optimal solution would require insight into various battery datasets.

Battery warranties guarantee vehicle owners that in the event a battery degrades quickly, they are not responsible to pay for a costly replacement. Most automakers like Nissan, General Motors, and BMW offer an eight-year, 100,000-mile warranty on battery, while Tesla offers unlimited mileage, but does not guaranteed remaining capacity. Added cycling of the battery without accruing miles puts automakers at a greater liability, and as vehicle-to-grid expands could become a sticking point for owners. To address this, those with stakes in the vehicle-to-grid supply chain must get automaker participation to guaranteed warranties are not impacted.

INNOVATE SMARTER & GROW FASTER

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