# V2G from Electric School Buses: The Impact on Children, Communities and Supply Chain Management

Pallav Prakash

*Program Management Office (Net Zero Transition), Zum Services Inc.,*
*275 Shoreline Drive, Suite 200, Redwood City CA 94065, USA*
pallavprakash@gmail.com

**Received** November 18, 2023, **Accepted:** December 06, 2023, **Published Online:** December 31, 2023
**Reviewers**: Anonymous Peer Review
**Citation:** Prakash, P., 2023. V2G from Electric School Buses: The Impact on Children, Communities and Supply Chain Management. *International Journal of Supply Chain Management*, *12*(6), 1-14, https://doi.org/10.59160/ijscm.v12i6.6210

***Abstract*— Electric vehicles (EVs) are rapidly acquiring significance in the day-to-day lives of the masses and so is the vehicle to grid technology (V2G). While nations across the globe are pushing for rapid adoption, they have to first address the challenges of grid overload and shutdown and intermittency of electricity supply from renewable sources. V2G technology provides a respite but is not without drawbacks. The electric school buses (ESBs), that remain idle for most part of the day, have emerged as the preferred choice in implementing V2G with obvious health, environmental and economic advantages. ESBs may appear initially as the new solution to public transportation, but it will affect our lives in many aspects besides being the environmental solution to public transportation. These EVs can be used for multifaceted functionalities than just being restricted to be a charging tool, a load balancer for the Grid or just as a means of transportation. In our digitized world the need for uninterrupted energy has attained a lot of importance. Innumerable solutions and diversified usage of EVs can be innovated from EVs existing energy sources (the batteries) to its in-built technological systems. The V2G concept, combined with smart grid technologies, offers an optimal system for the realization of the benefits offered to users, utilities, economics and the environment by electric vehicles. Electric school buses (ESB) can be used effectively to build a cleaner supply chain. This article delves into the benefits that ESBs confer upon school children, upon the communities and the economy. The health, environmental and economic benefits outweigh the initial costs involved with acquisition and usage of ESB fleet. The sustainability of using the V2G technology using school buses in supply chain management, especially where the supply chain is spread across remains a concern and warrants further research. Nevertheless, beyond a doubt, electric school buses will play a significant role so far as improving the health of the children and communities and reducing emission of pollutants is concerned.**

***Keywords*—** *Vehicle to grid, V2G, EV, Charging, supply chain, clean energy, logistics, electric school buses.*

## 1. Introduction

The use of electric vehicles as the primary means of private transportation is increasingly becoming a universal phenomenon buoyed by lesser costs, increased vehicle range and solving of various consumer issues that have been facilitated through favourable government policies [1]. While countries tread the path of energy transition and EVs are rapidly getting incorporated in modern daily life [2], the energy suppliers are faced with double challenge - the increasing need to harness intermittent sources of energy such as solar and wind without having the ability to store the energy produced at a large scale [3] as well as the need to guarantee the constancy of the grid and the ability to gratify the consumer demand instantly. A study carried out by the U.S. Department of Energy (DOE) showed that the rising demand from plug-in EVs and a number of other technologies that need electricity have the potential to amplify the load on the power grids by as much as 38% over the next 27 years [4]. It is a challenging task. Both government agencies and power companies are putting in a lot of effort to handle and fulfil this demand.

In order to maximize the benefits that can be derived from renewable energy, such technologies are required that can make it possible for the EV batteries to store the generated energy when available freely – and feed this energy back into the grid at times of high electricity demand [5]. This is made possible using the V2G Technology. This novel technology enables bi-directional charging, which makes it possible to charge the EV batteries and draw the energy that is stored in those batteries of the vehicles and thrust it back to the power grid. In basic terms, vehicle to grid makes it possible for the EVs to export their battery capacity that remains unused, back to the grid for the purpose of covering for the interruptions in renewable energy generation or provision of support at times when the demand is at its peak [2]. This article evaluates the benefits derived by children and communities from application of V2G technology using electric school buses.

## 2. Literature Review

As a potential solution for climate change, battery electric vehicles (BEVs) are being considered widely as they offer the use of a source of energy other than the forever depleting fossil fuels to run the vehicles and are emission-free [6]. Though used interchangeably bi-directional charging and V2G are not exactly the same. While the former refers to 2-way charging which means charging and discharging, V2G refers to only the single flow of energy from the battery of the vehicle to the grid, i.e. Flow in a single direction only [7] . However, bidirectional technology can only be effectively implemented using the V2G technology [8].

Vehicle-to-grid or V2G technology signifies the efforts towards creating bi-directional link between the transportation system and the electric power system in manners that have the potential to better the sustainability and security of both transport and power systems. For EVs a transition to V2G could actually result in the simultaneous improvement in the efficiency as well as profitability of electricity grids, reduction in emission of greenhouse gases (GHG) from transport, accommodating sources of energy that are low-carbon, and reaping the benefits of saving costs for owners, drivers, and other users. In tems of technicality, a V2G configuration signifies that personal vehicles gain the prospect of becoming not only automobiles, but also turn out to be transportable, self-contained resources which can manage the flow of power and replace the requirement for electricity-powered utility infrastructure. These automobiles function as vehicles as and when the drivers require them but transform into sources of power or options for storage of energy at times of peak demand and they can be recharged at off-peak hours such as later part of the day when the vehicle is not being used or at night [9]. Nevertheless, there are literary works that often fail to differentiate between V2G and other forms of vehicle-grid-integration

### 2.2 Benefits of using V2G

V2G technology can make it possible for a massive number of electric vehicles to work together and perform like a huge energy distribution system, providing important services to the power grid. A way in which it can do this is through the supply of energy when the energy demand is at its highest, and charging up at those times when energy demand is comparatively low, thus helping to effective balance the grid [10]. Apart from improving the stability of the grid, electric vehicle owners also get the option or the opportunity to generate revenue from the electricity that they export. This is an important factor as it can help to bring down the vehicle ownership costs over its lifetime. From the perspective of network operators, V2G has the potential to help to negate expensive infrastructure upgrades, another factor that can ultimately lead to the reduction of cost of electricity for all the end users [2]. The semiconductor technology allows vehicle-to-grid or V2G bidirectional charging to offer battery power for the purpose of reinforcing electric grids at peak hours and provide power for household consumption at times when electric power is most expensive or availability is significantly low [11]. Transitioning to electric school buses would provide numerous benefits to both communities and the environment [12].

### 2.3 Environmental Benefits

The adoption of V2G technology, will make it possible for the school buses to transform from being a source of pollution to turning into an essential part of the clean energy ecosystem [13]. Electric school buses with V2G will not only cut down GHG emission thus safeguarding the communities they serve, but can also play a crucial part in delivering energy stability to those communities that require [14]. A zero-emission electric school bus that replace just one diesel school bus is estimated to lessen toxic emissions by 54,000 pounds on a yearly basis. The massive batteries utilized by the electric school buses also provide the perfect device for storage of energy [14]. Using V2G technology, these buses develop the ability to store electricity and provide it when needed, help in bringing down reliance on fossil fuels and reducing

harmful emissions, thus contributing to a greener future [13].

When it comes to environment, V2G significantly cuts down the carbon emissions as this technology assists EVs to better utilize renewable energy in terms of volumes. V2G downsizes carbon emissions by rendering EVs to optimally employ energy in terms of capacity. Using specific V2G software allows the EVs to get charged when renewable sources are available freely and then when solar and wind generation is low, it can help feed it back into the network. In other words, through the application of V2G software EVs can charge from charging ports which are freely available and in return plug back into the network when other alternate energy sources like wind and solar energy are not available. [2]

## 2.4 Benefits to Children

An iconic feature of American life is that that students in almost all communities across the Midwest students use yellow school buses as the mode of transport to school and back, making it the largest form of public transportation in the US as per the industry white paper prepared by the National School Transportation Association [15]. It is as common a feature as every other common aspect of regular American life, - a very prevalent aspect of life in America so much so that its presence is likely to be overlooked. However, the diesel engine of an average school bus is not as pleasant as its exterior look. It causes air pollution and poses significant health risk for children, not to mention the carbon emissions that is aggravating the widely talked about menace of climate change. Presently a small fraction of about 480,000 US school buses is battery powered and only a small transition from just 10% of regular ICE school buses to emission free electric school buses can make a huge difference and has now become essential for our communities future [16].

After considering the entire range of public fleet vehicles, school buses appear to be of particular interest since they have emerged as the key reason behind the disproportionate health effects, specifically when it comes to health effect of school children. Health concerns have emerged due to release of harmful pollutants including particulate matter by the diesel buses and these emissions sometimes reach levels that are disproportionately higher compared to ambient pollution levels, especially inside the cabin of the vehicle. As a matter of fact, it has been estimated that as much as 0.3% of air inside the cabin of the bus comes from the exhaust generated by the bus. For instance, school buses can significantly impact the ambient aerosol levels and in so doing have a direct impact on the health of children. This kind of distress has provided the much-needed push for the development and execution of quite a few policies that require the diminution of pollution caused by exhaust from school bus. That is why it has become essential to understand the supply chains of Electric School Buses and the cost-effectiveness of electric school buses need to be analyzed in order to establish that they can be used effectively to avoids such health impacts [17].

Children's lungs are still in the development stage and they are more prone to the harmful effects of the air pollutants generated by diesel engines which use dirty fossil fuel. It has been seen that kids living in environmental justice communities and availing the services of diesel school buses suffer from higher rates of asthma and other lung ailments and are therefore excessively impacted by the diesel bus rides to school and similar ones that drive through their areas. While the market price of electric school buses is higher initially, it actually costs less to run and maintain which makes it a more judicious investment in the long run. Additionally, the same bus batteries perform the role of electrical grid resource by storage of clean energy and can be utilized in terms of peak demand periods or even in emergency situations. ELPC is coordinating with school authorities, district administrators and government agencies to resolve cost barriers and roll out the electric school bus program successfully across the Midwest [18].

## 2.5 Benefits to Communities

There are several benefits of an electric vehicle (EV) that include reduction in dependence on oil, increase in charging efficiency and reduction in emission of carbon dioxide. EVs have a unique advantage.it is possible for them to connect to the grid applying the V2G vehicle-to-grid technology [18]. There is limited usage of EV for vehicle-to-grid applications which makes it possible for vehicles to access the distribution network directly [19]. The concept of V2G aids in creating a broad array of distributed energy storage devices that will be available instantly and in introducing various applications and types of batteries into the market [20].

V2G technologies allows an idle EVs to transfer the power back from batteries to the grid which makes this technology particularly useful at a time when any area or region is experiencing pressure on power supply due to peak electricity demand since it is possible for V2G to provide power back to the grid to bring down the strain on the grid. V2G technology

can also provide the fleet managers a significant amount of savings in terms of cash back since units (kWh) of electricity are returned to the grid which will result in lower costs generated from utility providers [12]. Majority of the vehicles remain stationary for at least 95% of the time, which makes it possible for the V2G technology to leverage that inactivity and makes a two-way exchange of energy possible amongst the vehicles and grid [21]. The energy from the EV batteries is available to the electric grid to serve peak needs, with the vehicles recharging during non-peak hours. Making use of EVs as decentralized electric storage resources brings down the need for capital investments required for the grid to support ever-increasing demand to the minimum and at the same time lowers the cost of operation [22]. When the demand for electricity, was at its peak and available only for premium pricing, the electric school bus used V2G technology and contributed to reduction of carbon emissions in Beverly, Massachusetts and led to lesser need to fire up expensive fossil fuel "Peaker" power plants [23].

For the implementation of V2G, it is necessary to consider 2 key connections:

- An electrical power connection that connects a vehicle to the power grid for transmission of electrical energy.
- Logic and control connections that would be used for sending feedback signals indicating the time when power needs to be sent and the direction in which it is to be sent.

## 2.6 Benefits to the Power Sector

We may be in love with the idea of clean energy produced from renewable sources using solar panels and wind turbines, but the fact remains that the output generated from renewable energy sources like these is a lot less predictable when compared with the output generated from a power plant. The rapid propagation of renewable energy sources through the use of photovoltaic (PV) systems exerts significant pressure on what is called the "duck curve" challenge. During seasonal or everyday peak irradiation, the energy produced from the renewable source is much higher in volume compared to the required volume of energy which is symbolized by the duck's belly, that has slumped over the years with the increase in the energy produced using PV systems. It may become necessary for the utility providers to pare down the PV energy production at times when the irradiation is at its peak, which will result in the reduction of the benefits, both environmental and economic, derived from it. With the setting of the sun, it becomes essential for the power generation plants to ramp up electricity production (represented by the duck's neck) as quickly as possible making the balancing of these energy curves a costly affair. It is here that a network of electric vehicles connected using the Vehicle to Grid technology can help to ease the peaks and troughs thus balancing the grid. The fleets of electric school buses can be used as Battery Energy Storage System or BESS for the purpose of storing excess electricity during the times the net load is low, and release the energy back to the grid at times of demand picking up [22].

In addition to the improvement of students' health and wellness and improvement of driver and community health through the reduction of emissions, sophisticated V2G capabilities also make it possible for the users to store clean electrical energy and to create further revenue through the resale of unutilized energy back to the grid at times when the demand is at its peak. Companies such as Blue Bird who are the torch bearers in V2G technology and leads the community, state and country towards a future that is based on clean energy [23]. The advent of the Distributed Energy Resource management system (DERMS) has resulted in the creation of new opportunities that will help to take care of grid integration challenges and at the same time increase grid flexibility as well as hosting capacity, alongside enhancement of reliability and safety of the system. A DERMS control system makes it possible for the grid operator or utility provider to optimize its control of the grid and DER, in a preemptive manner thus bringing down grid disruption and synchronizing DER dispatch, at every possible and practicable juncture with the purpose of supporting and fulfilling the operational needs [24].

Electric vehicles, through the use of V2G technology, can provide services to the electrical grid. Demand for electricity varies constantly based on consumer activities. These constant change in the demand is accounted for by the frequency regulation market and enables the grid to match electricity generation to the current load. Hydroelectric pumps, flywheels and combustion-based turbines are in general used for storage by the frequency regulation market, but electric vehicles provide unique storage facilities that are more efficient than the conventional methods. Once the vehicles are parked and connected to the charger, they can provide storage for the electrical grid. To add on, vehicle owners can play a role in the frequency regulation market and receive due remuneration for the service provided. This capacity of electric vehicles to act as secondary storage devices is an added benefit of electrical vehicle adoption. Literature published on the subject shows that V2G has been established as a potential revenue source for participating in the

frequency regulation market. There have been a lot of details put forth on the rising cost of control measures to fight climate change and means to control these rising costs but we do not see the same fervor for adopting mechanisms to lessen the cost of fighting climate change due to transportation with special emphasis on V2G technology.

It must be admitted that notwithstanding our love for the idea of generating clean energy from wind power (using wind turbines) and solar power (using solar panels), the turnout from these kinds of renewable sources of energy has a much lower level of predictability compared to that generated by a power plant. At the time of peak irradiation, on a daily or seasonal basis, the renewable source of energy generates a volume of energy that is higher than what is necessary. A network of electric vehicles created by connecting EVs using the V2G technology can assist in the alleviation of the "peaks and troughs" and in the balancing of the grid. It is possible for the fleets of school buses run on electric power to function as Battery energy storage systems (BESS) for the storage of excess electricity especially during those hours when the net load is low, and then release the stored energy back to the power grid during those hours when the demand for power strengthens again [22].

The V2G enabled electric buses would entail a savings of $6,070 per seat in net present value for the school and transform to a net present benefit after five years of continuous service. Not considering external conditions, net present benefit stands at $5,700 per seat. It is estimated that if the entire school district transitions to V2G enabled electric buses, net present savings would be somewhere around $38 million or more. Additionally, it has been empirically proved that two electric school buses can send 10 megawatts of total energy back to the grid, which is equivalent to power requirement for around 600 homes [22].

Therefore, it is surprising (or not) that the inconsequential school bus is emerging as an ideal candidate for the drive towards a low carbon grid. The initial vision being to lessen carbon emissions by shifting from diesel-powered to electrified fleets. In the USA, the US EPA Clean School Bus Program has kept $5 billion in reserves so that they can upgrade existing older school buses to clean, zero-emission electric models in the next 5 years. US PIRG states that, almost half a million school buses transport half of America's school children to school and back, but just 1% or less of this fleet is electric. If we take into account that diesel emission contains more than 40 cancer inducing chemicals, the health benefits of a fully electric school bus fleet become crystal clear.

## 3. Methodology

This research is qualitative secondary research, using data and information available on public domain such as newspapers, scholarly articles published in such reputed journals as International Journal Of Supply Chain Management, research articles published by renowned research houses and data published by government agencies. The research uses data collected by others. Secondary analysis of qualitative data helps to address the questions that have remain un-addressed by previous research or have arisen as a result of further research.

## 4. Supply Chain & Electric School Buses

A supply chain is instrumental in converting raw materials and varied parts into a ready to use device or product which is then shipped to the end-user or customer. It comprises of a very intricate network of actions and businesses that operates with synergy from the extraction of supply of raw materials, manufacturing of the product, the assembly line integrating working sections to packaging, to distributors and retailers delivering the end product to the customers [25]. It is a complicated administrative process handling logistics system which converts raw materials into finished goods and deliver them to the end consumers' doors [26]. Door step delivery or Last-mile delivery is a vital part of supply chain and logistics management since it plays a very important part in maintaining customer delight and keeping the customers satisfied [27]. Customer satisfaction has significant bearing on the survival and progress of any business. EVs can become a useful component in this logistics management leg of supply chain management.

### 4.2 Supply Chain Management – importance of Transportation

Supply chain management (SCM) involves the active management of activities that constitute the supply chain with the purpose of maximizing the values delivered to customer and achieve a sustainable competitive advent age. This denotes a deliberate attempt by the supply chain companies towards development and regular functioning of supply chains in a manner that is considered to be most active & efficient. Activities of a Supply Chain includes everything from design and development of product, to sourcing, manufacturing, and logistics,

together with the information systems that is required for coordinating these activities [28]. Transportation forms an important part of Supply Chain Management as it is crucial to the success of any business and is considered to be one of the 3 fundamental components of Supply Chain Management, the other two being Purchasing (sourcing) and Planning (scheduling) [29]. Transportation methods make deliveries to and from the manufacturing and warehousing facilities thus making the flow of activities smooth and ensures the timely arrival of products at their designated destinations [30]. Efficient logistical planning for transportation helps to maintain the inventory costs at the minimum level, which in turn makes the inflow and outflow of goods from the warehouse smoother, much more efficient and unhindered. Improving and easing the flow of goods in and out of a company's warehouse translates to reduction of costs for inventory storage and maintenance as well as lessening transportation cost and adding to customer satisfaction by bringing down lead time or the duration from demand generation to actual delivery of the product [27].

### 4.3 Rationale for Using Electric Vehicles in Supply Chain Management

Across industries logistics have emerged as a crucial success factor, and electric vehicle are the epicenter of this growth. Integration of EV technologies into supply chains would help, through digital integration, in providing 2better insight into round the clock supply chain activities [31]. The electric vehicles have provided a new platform and have revealed novel options for greener, cleaner and safer transportation. The emergence of autonomous vehicles and advanced driver assistance systems (ADAS) have provided EV drivers and operators with the peace of mind that they are using better and smarter machines that are better capable of responding to charging in the driving environment compared to those in the seat [31].

It must be kept in mind that EVs are not restricted to roads only. Organizations that are in the business of warehousing, mining, construction and vehicles that provide ground support for aviation have already started adopting machines and vehicles running on electricity for their operations. Shifting to electricity run machines and vehicles across these areas indicates that it is possible for businesses to achieve the benefits of cleanliness and agility offered by pure electric vehicles while leveraging opportunity charging at charging points at public places or at home in order to make sure that the vehicles are always powered [31].

Additionally, electric vehicles have the added benefit of the least number of moving parts, which is the reason for a large number of people considering them to have higher reliability compared to their internal combustion engine counterparts. It is possible for the fleet operators, through leveraging connectivity, to acquire real-time insights into their vehicles in terms of their performance and status which helps the operators to perform maintenance activities at a faster rate [31].

### 4.4 Importance of Electric School Buses and V2G

Thanks to ever-increasing population and the consequent rise in demand, there is continuous and significant growth in the cost of energy. There is only one way to cut down the operational costs, from the perspective of both environmental impact and finance, and that is reduction of the volume of energy consumed for the completion of tasks pertaining to business operations. If the trends in the EV industry are to be followed, digital technologies are turning out to have better proficiency in managing the manner in which energy is utilized and the price that has to be paid by the ultimate user — primarily by way of smart charging; however, regenerative braking can be a solution yet to be leveraged to its full potential [31]. Fixed routine and foreseeable routes, charging during mid-da y and evening hours make school buses perfect fit for electric power.

In conjunction with providing benefits to the schools and students, electric school buses are also fast turning out to be a coveted product for utility services providers who are seeing electric school buses as the means for electricity storage and likely assets in vehicle to grid scenarios. To be specific, electric school buses are lucrative to service provider companies especially because they can use electrical energy stored on these buses to handle the demand pressure created during peak periods and build flexibility into their electrical grid. [32]. A strategic, well-timed and well managed transition to clean energy and clean transportation can go miles to make sure that it becomes possible for each and every community to access, utilize and reap the benefits of electric school buses. A large number of the individual players such as school administrative

districts, transportation service providers, utility services, bureaucratic policy makers, electricity service providers, investors and school bus manufacturers and operators – have important part to play in this game [33].

It is surprising, to an extent, that the inconsequential American yellow school bus is fast emerging as an ideal candidate for the drive towards a low carbon grid. To begin with, there is the vision to bring down the carbon emissions through the shift from diesel-powered to electrified fleets. In the USA, the US EPA Clean School Bus Program has kept $5 billion in reserves so that they can upgrade existing older school buses to clean, zero-emission electric models in the next 5 years [34]. Despite the fact that almost half a million school buses transport up to 50% of the US school children to school and back, but, as US PIRG states, just a percent or less of this fleet is electric [35]. If we take into account that diesel emission contains more than 40 cancer inducing chemicals, the health benefits of a fully electric school bus fleet become crystal clear [22].

Using state of the art modern V2G technology, electric school buses can better realize their full potential in terms of performance. They can reduce load on the grid and at the same time act as emergency back-up power [23]. Electric school buses are bringing in the next era of connectivity and paving the way for distributed energy resource management. During the last couple of years, an increasing number of corporates – which take in well-established manufacturers of school buses - have begun the production of school buses that run on electric power, there has been steady increase in government subsidies and the support from environment regulators and non-profit organizations have been successful towards teaching school districts, service providers and the general populace about the advantages of adopting electric school buses as the preferred mode of transferring students to and from schools [16]. It is possible for the electric school bus enterprises to work with manufacturers and policymakers to promote and encourage sensible bus procurement and operations. This may consist of improvement of mining practices for battery components, making recycling of batteries integral to bus programs or revamping existing diesel buses with new electrical and mechanical fittings to reduce existing infrastructure disposal issues [33].

It is also essential that we consider the cost benefits analysis of integrating school buses into the V2G usage model. A study carried out by the Center for Carbon-Free Power Integration of the University of Delaware has found that shifting to an electric bus with V2G capabilities from a conventional diesel-run ICE bus would save $6,070 per seat [17]. Without the added revenue that these electric school buses can draw post V2G enablement, they would actually lose their cost-effectiveness and ultimately turn out to be an expensive un-economic proposition whose per seat costs run into several thousand dollars ($2,000 per seat) [22].

In the near future, the concept of integration of distributed energy resources (DERs) to build a microgrid is likely to become highly significant [36]. In general, DERs include various types of small-scale devices that produce renewable energy, for instance solar panels, wind turbines, batt other than school buses, other electrified fleets for public buses, delivery trucks, vans and even cars may become an essential part of the intelligent Distributed Energy Resources (DER) ecosystem [24]. Implementation of bi-directional EV charging at the global level and supplementing it by V2G services has resulted in the transition of the EV battery pack from being simply a consumer product that supplies power to the electric vehicles to a device that makes it possible to supply electricity back to the power grid. Herein comes the utility of electric school buses as they have enormous batteries. It is possible to equip electric school buses with vehicle to anything (V2X) or bidirectional charging capabilities which will allow them to act as “mobile power units.” With the help of suitable and meticulous planning, it is possible for the electric school buses to provide something better than simply being the means of transportation to vulnerable areas, like acting as an emergency source of power at the time of grid outages and making the charging infrastructure better [33].

Other than school buses, other electrified fleets for public buses, delivery trucks, vans and even cars may become an essential part of the intelligent DER ecosystem. Global implementation of the bi-directional EV charging and addition of V2G services, the EV battery pack transitions from being just a consumer product that powers the EV and becomes enabled to supply electricity back to the grid [22]. In comparison to diesel engines, service requirements are substantially lowered and we are providing 100% green transportation for the students (Blue-Bird, 2021). Service requirements are significantly lesser when compared with diesel

engines and to add on cent percent of the student transportation system is being run on green energy in comparison to vehicles that use diesel engines, there has been substantial reduction in service requirements from schools providing electric bus services and several of the schools are now in a position to provide 100% green transportation for their students [22]

## 5. Problems in Using ESBs and V2G Network

On the face of it, it looks like electric vehicles are destined for disaster and doomed to fail to achieve the desired results for the power grid. Beyond a doubt the age-old, rusty power network in the United States is not in a position to handle or fulfil the demand for charging the massive electric vehicle batteries [37]. But a new analysis suggests that just a handful of Electric Vehicle owners could make the grid more flexible and reliable by plugging into a system called vehicle-to-grid charging (V2G), or bidirectional charging [37, 38, 39]. In order for the V2G grid to be effective and useful to the country, community or users and turn out to be a reliable source of power supply and a dependable power storage, it is necessary that a large number of these electric school buses become part of it. However, just like any other technology, the novel V2G technology is not without drawback.

### 5.2 Lack of Understanding & Control and Inadequate Infrastructure

The key concern of the electric vehicle owners with V2G emanates from the apparent absence of control. Due to the fact that an average EV user is not well acquainted or familiar with the energy markets and hence these markets are not that well known to these users which makes them a little apprehensive about the V2G market. They consider V2G markets to be somewhat risky — EV owners are aware that the V2G technology is good, but do not fully understand how it works [40]. Despite the learning curve being steep, the potential holds massive promise. Perceived uncertainty that results from the apparent lack of or inadequate understanding of the technology and the consequences of its adoption leads to apprehensions and acts as a deterrent for the adoption of the electric vehicle. A key success factor in the speedy adoption and implementation of electric school buses, V2G technology and smart grid technology is the adequacy of the infrastructure in place [41, 42].

### 5.3 Higher Cost of Using Electric School Buses

Electric school buses provide various benefits to the environment, to students, communities and schools. However, none of these advantages come free of cost. Electric School Buses are high-priced. Roughly $250,000 would be needed to purchase the battery-electric versions of small-sized "Type A" school buses as against $50,000 to $65,000 cost for a diesel version; full-size "Type C" or "Type D" buses are available in the range from $320,000 to $440,000 in electric form as compared to approximately $100,000 for diesel [16]. The upfront expenditure for acquiring a fleet of electric school buses may often become daunting in the absence of government incentive. It is true that the schools can use the V2G technology and utilize these school buses during their idle times to send power back to the grid during peak demand hours and earn revenue from it to offset the costs involved. Nevertheless, they require financial assistance from the government before they can acquire a fleet and start earning from the application of the V2G technology. Electric School Buses just like other electric vehicles, will be in need of new infrastructure. A school district or bus operator will at least need to install EV chargers and retrain their technicalities in order to be able to service the battery-electric drivetrains and control systems of the new buses [16].

### 5.4 Problems with Bi-directional Charging

Ther has been a nationwide of deployment of zero emission school buses in the US as School district administrators and state leaders are committed to protect children from carbon emissions and the overall communities that they are duty bound to serve [43]. Along with this transition from conventional ICE vehicles to electricity run vehicles, there has been development in charging infrastructure and charging technology to ease the load on the grid for charging EVs. The manipulation of charging time and volume of load getting charged to enhance operational effectiveness of the charging system is called Smart Charging; mostly induced by the reduction of the pressure created by peak demand on the network [44, 45]. Uni-directional chargers simply shift their load to off-peak periods thus reducing peak demand on the network but with the introduction of smart bi-dimensional chargers, peak load of the grid can be lessened to much larger extent [46]. In the case of bi-directional chargers, vehicles are equipped to send power back to the grid and this is often referred to Vehicle to Grid (V2G)

services. The only issue with bi-directional smart chargers which provide additional flexibility is the cost of installation and maintenance. Despite bi-directional smart charging providing added flexibility compared to unidirectional smart chargers, the cost of installation is and implementation significantly high [47].

## 6. Discussion

Electric school buses might appear as the new solution for pollution-free transportation of school children. Besides transportation, they are likely to have significant impact on several important factions of our day-to-day lives. Electrical utilities in the US are positioned to play a key role in the transition of American school buses. From diesel fuel to electricity, while federal and state level investments are imperative, other funding and financing opportunities have the ability to fast track the transition, which would mean health, economic and climate benefits to more communities across the country. Electrical school buses would function as giant mobile batteries to support the grid through use of V2G technologies.

The next generation EV innovation termed as Vehicle to Anything (V2X) which is an all-encompassing term for the usage of energy stored in EV batteries and its ability to supply power to end users at critical facilities. V2X is the next level power exchange system that can revolutionize flexible energy sources and its inherent benefits. Cyber physical infrastructure would be the basic hardware for these V2X systems.

Demand for electricity is not steady. Instead, it keeps fluctuating constantly depending on the activities of the consumers. The market for regulation of frequency takes care of this fluctuation and makes it possible for the electric grid to match the load to the electricity generation. When electric vehicles, especially electric school buses that remain idle for the most part of that day, are parked and remain connected to the charger, they are capable of providing storage for the electric grid. In turn, the owners of the electric school buses can take part in the market for frequency regulation and get paid for the services rendered. Revenue earned from providing the storage capability of electric vehicle acts as incentive for the embracing of electric vehicles. The literature has been able to show that V2G technology has been corroborated as a potential source for earning decent amount of revenue as a player in the market for frequency regulation.

## 7. Recommendation

ESBs with their enormous batteries that provide effective solution for energy storage can be used much more functionally rather than just an electrical tool, a load for the grid, or a vehicle for transportation. In addition, the need for energy in our digitalized world is constantly increasing and becoming much more critical. For this reason, better diversified usage areas and solutions need to be created through the use of existing energy capacities and technological systems of these electric school buses. This concept which is called vehicle-to-anything (V2X), the broader term used to describe the energy storage within an ESBs and its ability to supply power for particular end users, will act as the next-level power exchange system that can impart higher and better flexibility in terms of energy mobility and benefits. The system should be designed with cyber–physical infrastructure. Using the cyber–physical system's relationship makes it possible to use the energy potential of electric school buses with smart algorithms in different fields for different needs and economic gains (Elma, et al., 2022).

Utilizing the cyber-physical relationship would enable the use of electricity charged vehicles as power sources by the usage of customized algorithms which will determine criticality of need and disburse power accordingly between the household utilities This could be at a micro level as cited in the example above and the same algorithms can be used in different fields for greater of humanity in addition to economic benefits due to optimal power usage (Elma, Cali, & Kuzlu, 2022).

Policies need to be drawn and implemented in order to incentivize adoption of electric buses by public the usage of batteries with higher efficiency, and further develop on V2G capabilities. Deployment of electric school buses on a large scale will ensure that electric vehicles with V2G capability can be more instrumental in improving grid as well ensuring a community's stability. The BIDERECTION Act would exploit this ability of ESBs to send power back to the grid and can also act as a promotional campaign to ensure deployment of electric school buses on a large scale to ensure EVs [43]. The BIDIRECTIONAL Act will help school districts in Maine and all over America move towards operational electric buses and also ensure that the vehicles bring in greater stability their communities. Bringing forth electric bus investments in the Inflation Reduction Act, would lead towards America's clean energy becoming an achievable reality in the near future. It will ensure a win win situation for all stakeholders and I hope it can get widespread support from both democrats and

republicans alike [14].

This is the perfect time for manufacturers, utility providers, policymakers and various other stakeholders to work in tandem with the purpose of deploying electric school buses throughout the entire nation and for prioritizing communities that have hitherto remained underserved. The V2G programs has the potential to turn into an important fraction of this transition and provide the value not only to the community but also to the grid overall. However, a larger volume of research pertaining to the viability of, the benefits and challenges faced by the V2G technology is necessary. A clear comprehension of the potential revenues that can be generated using the electric school bus battery storage, for instance, can help utilities and school districts to improve their plans for upfront purchase and rationalization of operational costs. In addition to this, accurate definition of the technology and the related training necessary for application of V2G technology to electric school bus will be extremely important in the effective adoption of V2G electric school buses. Creating the level playground for the equitable deployment of electric school bus having V2G applications makes continued research and collaboration across diverse stakeholders an absolute necessity.

## 8. Conclusion

Expenditure on fuel for the yellow school buses, externalities related to health that are caused by diesel exhaust, and alteration in climate caused by incessant pollution from combustion of fossil fuel are the major concerns that have been instrumental in driving the faster adoption and the use of electric vehicles. The need of the hour is the adoption of smart solutions for handling the rapidly growing demand for energy supply, clean energy transportation and cleaner and leaner supply chains to confer health, environmental and economic benefits. The above discussion establishes that electric school buses, a widely used transportation system, is capable of providing services to the electric grid through the application of V2G technology.

The application of the Vehicle-to-grid (V2G) technology and policies make additional economic incentives available to the vehicle owners by opening up an avenue for generation of additional revenue when the vehicle is parked and is idle. Of all public fleet vehicles, school buses are of particular interest because they cause disproportionate health effects, especially on school children's health. Benefits of transitioning to electric school buses are not just limited to the environmental aspect. The high-capacity batteries that are utilized also double up as immense energy storage equipment. Numerous automakers and battery charging companies are carrying out research with the vehicle-to-grid (V2G) technical knowledge that facilitates vehicles to send energy back to the grid.

Major electric bus manufacturers and other organizations are already on board and providing full support such as Blue Bird, Highland Electric, Lion Electric, Nuvve, Proterra, Zum Services, and Xcel Energy to name a few. Electric school buses with V2Gcapability are an excellent opportunity to generate clean energy and ensuring grid stability and it would be a disadvantage for all stakeholders if this were not implemented. Greenhouse gas emissions get reduced which protects the communities that they serve and also make an impact by playing a key role in providing energy from stable electrical grids to communities in need.

Apart from the fact that the electric school buses, or ESBs, help the environment, by not discharging fumes from diesel combustion or other emissions, they are also better for the children who use them for school commutation, particularly the ones that are suffering from asthma and various other chronic respiratory conditions. Similar to other electric vehicles, electric school buses also have the prospective to have lesser maintenance costs over a period of time compared with their internal-combustion engine counterparts. In addition to this the high sized batteries of these electric school bus can store and later supply energy for powering up buildings and other devices, be it on a temporary basis to help tide over an emergency or on a more regular basis for be a part of the bigger picture pertaining to the renewable-energy strategy.

The BIDIRECTIONAL Act is fine tuned to hasten adoption of EV school buses while using them for more than just a ride to school, other benefits like grid stability gives them an edge over other transport systems which do not have so much idle time. Vehicle-to-grid school buses are yet another tool which is sensible and will help in creating a reliable grid, promulgate the usage of clean energy and bring down financial impact for local towns and school districts. The Environmental Protection Agency (EPA) has declared that it would be almost doubling

EPA clean school bus program funding to $965 million in the first round. Federal funding is the primary source of revenue required for this transition but in addition strong and able state leadership will also be an essential part if these clean energy machines are going to be accepted by all. To state an example, the state of Virginia has recently completed 500,00 electric school bus miles and this was primarily possible due to the initiative taken by

the state leadership to make 13,000 electric school buses operational in 2019. They currently have the nation's second largest V2G electric school bus fleet [14].

While implementation of V2G technology using electric school buses can be actively use to create positive impact on the health of the children and the communities and help to reduce toxic emissions thus bettering the environment, it is still in nascent stage. The extent to which it will be successful will only be clear with time. Its use in supply chain management is also expected to make the system greener, though sustainability still remains a concern.

## References

[1] N. Altin and M. SARP, "Review on Vehicle-to-Grid Systems: The Most Recent Trends and Smart Grid Interaction Technologies," GAZI UNIVERSITY JOURNAL OF SCIENCE, no. 33, pp. 394-411, 2020.

[2] A. B. Britto and Kevin Krannich, "Why do we need vehicle to grid technology: Elektrobit," 2021. [Online]. Available: https://www.elektrobit.com/blog/vehicle-to-grid-technology/#:~:text=On%20an%20environmental%20level%2C%20V2G,and%20wind%20generation%20is%20low.. [Accessed 06 Oct 2023].

[3] R. Group, "What's the deal with V2G, or vehicle-to-grid?," 08 Apr 2019. [Online]. Available: https://www.renaultgroup.com/en/news-on-air/news/whats-the-deal-with-v2g-or-vehicle-to-grid/. [Accessed 06 Oct 2023].

[4] EV Connect, "What Is Vehicle-to-Grid Technology and How Does It Work?," Dec 2020. [Online]. Available: https://www.evconnect.com/blog/what-is-vehicle-to-grid-for-electric-vehicles. [Accessed 06 Oct 2023].

[5] InsideEVs, "How Does Vehicle To Grid (V2G) Work?," 29 Jul 2020. [Online]. Available: https://insideevs.com/news/436503/vehicle-to-grid-explained/. [Accessed 06 Oct 2023].

[6] J. Buberger, M. Hohenegger, J. Estaller, A. Wiedenmann, W. Grupp, M. Kuder, A. Lesnicar, T. Weyh and W. Bliemetsrieder, "Bidirectional Charging for BEVs with Reconfigurable Battery Systems via a Grid-Parallel Proportional-Resonant Controller," Electricity, vol. 4, no. 2, pp. 171-184, 2023.

[7] GEO GREEN POWER, "What is Bidirectional Charging?," 30 May 2023. [Online]. Available: https://www.geogreenpower.com/blog/what-is-bidirectional-charging/. [Accessed 08 Oct 2023].

[8] Virta Global, "A quick guide to bidirectional charging," 10 Oct 2022. [Online]. Available: https://www.virta.global/blog/bidirectional-charging-as-a-v2g-solution. [Accessed 06 Oct 2023].

[9] B. K. Sovacool, L. Noel, J. Axsen and W. Kempton, "Beyond batteries: an examination of the benefits and barriers to plug-in hybrid electric vehicles (PHEVs) and a vehicle-to-grid (V2G) transition," Environmental Research Letters, vol. 13, no. 1, pp. 1095-1103, 2018.

[10] J. Svarc, "V2G Explained - Benefits of Vehicle-to-grid Technology: Clean Energy Review," 30 Jun 2023. [Online]. Available: https://www.cleanenergyreviews.info/blog/v2g-explained-vehicle-to-grid-benefits#:~:text=V2G%20technology%20can%20enable%20thousands,demand%2C%20effectively%20balancing%20the%20grid.. [Accessed 07 Oct 2023].

[11] Texas Instruments, "The vehicle-to-grid vision: unleashing the power of electric vehicles," 23 Aug 2022. [Online]. Available: https://news.ti.com/blog/2022/08/23/the-vehicle-to-grid-vision-unleashing-power-electric-vehicles. [Accessed 07 Oct 2023].

[12] J. Horrox, S. Nick and M. Casale, "Electric School Buses and the Grid: Unlocking the power of school transportation to build resilience and a clean energy future," Frontier Group, Santa Barbara, CA , 2022.

[13] Fermata Energy, "What should schools ask about Vehicle-to-Grid (V2G) and electric school buses?," 2023. [Online]. Available: https://fermataenergy.com/article/v2g-and-electric-school-buses. [Accessed 13 Oct 2023].

[14] P. Johnson, "BIDIRECTIONAL Act introduced in US Senate to promote electric school buses feeding grid," 30 Sep 2022. [Online]. Available: https://electrek.co/2022/09/30/bidirectional-act-promotes-electric-school-buses-with-v2g/. [Accessed 13 Oct 2023].

[15] NSTA, "The Yellow School Bus Industry - Industry White Paper," 2013. [Online]. Available: https://s3-us-west-

2.amazonaws.com/nsta/6571/Yellow-School-Bus-Industry-White-Paper.pdf. [Accessed 01 Nov 2023].

[16] J. Rosevear, "Electric school buses are giving kids a cleaner, but costlier, ride to class," 10 Dec 2022. [Online]. Available: https://www.cnbc.com/2022/12/10/electric-school-buses-give-kids-a-cleaner-but-costlier-ride-.html. [Accessed 04 Nov 2023].

[17] L. Noel and R. McCormack, "A Cost Benefit Analysis of a V2G-Capable Electric School Bus Compared," Applied Energy, vol. 126, pp. 246-265, 2014.

[18] Environmental Law & Policy Center, "Clean Transportation - Accelerating Rollout of Electric School Buses," 2023. [Online]. Available: https://elpc.org/projects/electric-school-buses-safe-ride-for-kids/. [Accessed 01 Nov 2023].

[19] H. Y. Yeo, "The Humble School Bus – A Promising V2G Use Case: Keysight," 07 Oct 2022. [Online]. Available: https://www.keysight.com/blogs/inds/2022/10/07/the-humble-school-bus-a-promising-v2g-use-case. [Accessed 31 Oct 2023].

[20] Blue-Bird, "Press Release: Blue Bird Delivers North America's First-Ever Commercial Application of Vehicle-to-Grid Technology in Electric School Bus Partnership with Nuvve and Illinois School Districts," 23 Mar 2021. [Online]. Available: https://www.blue-bird.com/about-us/press-releases/208-blue-bird-delivers-north-america-s-first-ever-commercial-application-of-vehicle-to-grid-technology-in-electric-school-bus-partnership-with-nuvve-and-illinois-school-districts. [Accessed 05 Nov 2023].

[21] IEEE SA, "IEEE Standards for the Evolving Distributed Energy Resources (DER) Ecosystem," 09 Nov 2021. [Online]. Available: https://standards.ieee.org/beyond-standards/ieee-standards-for-the-evolving-distributed-energy-resources-der-ecosystem/. [Accessed 31 Oct 2023].

[22] P. Johnson, "BIDIRECTIONAL Act introduced in US Senate to promote electric school buses feeding grid: Electrek," 30 Sep 2022. [Online]. Available: https://electrek.co/2022/09/30/bidirectional-act-promotes-electric-school-buses-with-v2g/. [Accessed 16 Nov 2023].

[23] Accenture, "What is supply chain management?," 2023. [Online]. Available: https://www.accenture.com/in-en/insights/supply-chain-operations/supply-chain-management-operations-index#:~:text=A%20supply%20chain%20transforms%20raw,distributors%2C%20retailers%20and%20the%20customer.. [Accessed 14 Nov 2023].

[24] McKinsey & Company, "What is supply chain?," 17 Aug 2022. [Online]. Available: https://www.mckinsey.com/featured-insights/mckinsey-explainers/what-is-supply-chain. [Accessed 14 Nov 2023].

[25] Datascope, "What is the Role of Transport Within the Supply Chain?," 23 Feb 2022. [Online]. Available: https://datascopewms.com/blog/what-is-the-role-of-transport-within-the-supply-chain/#:~:text=TRANSPORTATION%20IS%20USED%20TO%20BYPASS,role%20in%20keeping%20customers%20happy.. [Accessed 14 Nov 2023].

[26] NC State University, "What is Supply Chain Management (SCM)?," 19 Aug 2021. [Online]. Available: https://scm.ncsu.edu/scm-articles/article/what-is-supply-chain-management-scm. [Accessed 07 Nov 2023].

[27] Paul Rea, "The Three Most Foundational Supply Chain Elements: Fronetics," 2023. [Online]. Available: https://www.fronetics.com/the-three-most-foundational-supply-chain-elements/#:~:text=Generally%20the%20key%20aspects%20of,specific%20the%20procurement%20activities%20are.. [Accessed 11 Nov 2023].

[28] G. Anderson, "The Role of Transportation in Supply Chain Management," 20 May 2022. [Online]. Available: https://www.prologis.com/blog/role-transportation-supply-chain-management#:~:text=Transportation%20methods%20ensure%20deliveries%20to,your%20supply%20chain%20management%20strategy.. [Accessed 08 Nov 2023].

[29] T. Swallow, "Top 10 reasons EVs should be used in the supply chain: EV Magazine," 12 Apr 2023. [Online]. Available: https://evmagazine.com/top10/top-10-reasons-evs-should-be-used-in-the-supply-chain. [Accessed 06 Nov 2023].

[30] Thomas Built Buses, "Electric School Buses – Where Do They Perform Best?," 06 Oct 2020. [Online]. Available: https://thomasbuiltbuses.com/resources/articles/electric-school-buses-where-do-they-perform-best/. [Accessed 09 Nov 2023].

[31] E. Moses, "Electric School Buses Can Fight – or Further— Inequity in the US: World Resource Institute," 27 Jan 2023. [Online]. Available: https://www.wri.org/insights/electric-school-buses-equity-us. [Accessed 13 Nov 2023].

[32] U. EPA, "Clean School Bus Program Rebates: United States Environmentl Protection Agency," 28 Sep 2023. [Online]. Available: https://www.epa.gov/cleanschoolbus/clean-school-bus-program-rebates. [Accessed 31 Oct 2023].

[33] M. Casale and J. Horrox, "Electric School Buses and the Grid: US PRIG," 14 Mar 2022. [Online]. Available: https://pirg.org/edfund/resources/electric-school-buses-and-the-grid/. [Accessed 31 Oct 2023].

[34] K. Twaisan and N. Barışç, "Integrated Distributed Energy Resources (DER) and Microgrids: Modeling and Optimization of DERs," Electronics, vol. 11, no. 18, p. 2816, 2022.

[35] M. Simon, "Texas' Icy Disaster Makes the Case for Uniting the US Grid: Wired," 25 Feb 2021. [Online]. Available: https://www.wired.com/story/texas-disaster-makes-the-case-for-uniting-the-grid/. [Accessed 14 Nov 2023].

[36] A. Marshall and M. Simon, "Electric Vehicles Could Rescue the US Power Grid," 19 Sep 2022. [Online]. Available: https://www.wired.com/story/electric-vehicles-could-rescue-the-us-power-grid/. [Accessed 14 Nov 2023].

[37] M. Simon, "Hey EV Owners: It'd Take a Fraction of You to Prop Up the Grid," 23 Jan 2023. [Online]. Available: https://www.wired.com/story/hey-ev-owners-itd-take-a-fraction-of-you-to-prop-up-the-grid/. [Accessed 14 Nov 2023].

[38] Virta Global, "Vehicle-to-grid (V2G) technology: Key challenges and developments," 05 Oct 2023. [Online]. Available: https://www.virta.global/blog/v2g-technology-key-challenges-and-developments#:~:text=EV%20owners'%20main%20concern%20with,fully%20understand%20how%20it%20works.. [Accessed 14 Nov 2023].

[39] A. Serohi, "E-mobility ecosystem innovation – impact on downstream supply chain management processes. Is India ready for inevitable change in auto sector?," International Journal of Supply Chain Management, vol. 27, no. 2, pp. 232-249, 2022.

[40] N. Adnan, S. M. Nordin and O. M. Althawadi, "Barriers Towards Widespread Adoption of V2G Technology in Smart Grid Environment: From Laboratories to Commercialization," in Sustainable Interdependent Networks. Studies in Systems, Decision and Control, vol. 145, M. H. Amini, K. G. Boroojeni, S. S. Iyengar, P. M. Pardalos, F. Blaabjerg and A. M. Madni, Eds., Springer, Cham, 2018, pp. 121-134.

[41] G. Benetti, M. Delfanti, T. Facchinetti, D. Falabretti and M. Merlo, "Real-Time Modeling and Control of Electric Vehicles Charging Processes," IEEE Transactions on Smart Grid, vol. 6, no. 3, pp. 1375-1385, 2015.

[42] L. Gan, U. Topcu and S. H. Low, "Optimal decentralized protocol for electric vehicle charging.," IEEE Transactions on Power Systems, vol. 28, no. 2, pp. 940-951, 2016.

[43] K. Mets, T. Verschueren, F. De Turck and C. Develder, "Exploiting V2G to optimize residential energy consumption with electrical vehicle (dis)charging.," IEEE 1st International Workshop on Smart Grid Modeling and Simulation, SGMS, 2011.

[44] C. Crozier, T. Morstyn, M. Deakin and M. McCulloch, "The Case for Bi-directional Charging of Electric - Vehicles in Low Voltage Distribution Networks," Applied Energy, vol. 259, p. 114214., 2020.

[45] SAFE, "Advancing Vehicle to Grid Technology Adoption - Policy Recommendations for Improved Energy Security and Resilience," Jun 2022. [Online]. Available: https://electrificationcoalition.org/wp-content/uploads/2022/06/Advancing-V2G-Technology-Adoption.pdf. [Accessed 06 Oct 2023].

[46] O. Elma, U. Cali and M. Kuzlu, "An overview of bidirectional electric vehicles charging system as a Vehicle to Anything (V2X) under Cyber–Physical Power System (CPPS),"

Energy Reports - 2022 7th International Conference on Green Energy Technologies, ICGET 2022 July 28–30, 2022, Frankfurt, Germany, vol. 8, no. 14, pp. 25-32, 2022.

[47] CleanTechnica, "The Benefits Of Electric School Buses, V2G For Low-Income Communities," 30 Jul 2021. [Online]. Available: https://cleantechnica.com/2021/07/30/the-benefits-of-electric-school-buses-v2g-for-low-income-communities/. [Accessed 12 Oct 2023].

[48] EPRI Journal, "Vehicle-to-Grid: $1 Billion in Annual Grid Benefits?," 2022. [Online]. Available: https://eprijournal.com/vehicle-to-grid-1-billion-in-annual-grid-benefits/. [Accessed 12 Oct 2023].

[49] Awesense, "What are Distributed Energy Resources (DERs)?: Clean Energy Basics Vol. 2 – Let's define distributed energy resources!," 10 Mar 2021. [Online]. Available: https://www.awesense.com/distributed-energy-resources-der-basics/. [Accessed 31 Oct 2023]