Mitigating Power Grid Challenges In Charlottesville:

Microgrid-Powered EV Parking Lots with Wireless Charging

"Why are we adding fleets of EVs to a struggling power grid? How can we still adopt EVs without impacting the grid?"

Ensuring Equity and Accessibility of EVs for all

Communities in Charlottsville while Mitigating their Acceptance of Microgrid-Powered EV Parking Lots

"How do the communities in Charlottesville perceive new technologies in their backyard?"

A Thesis Prospectus
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On my honor as a UVA student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction:

The power grid in the United States is struggling to meet the growing demand for electricity. The imminent transition to electric vehicles (EVs) poses additional strain on an already burdened grid. This context calls for an intervention that can alleviate the pressure on the grid while supporting the adoption of EVs.

One notable example that exemplifies this issue is the situation that unfolded in Texas in February 2021. Texas experienced a severe winter storm that led to an unprecedented demand for heating and electricity, resulting in widespread power outages and a strain on the grid (Popik & Humphreys, 2021).

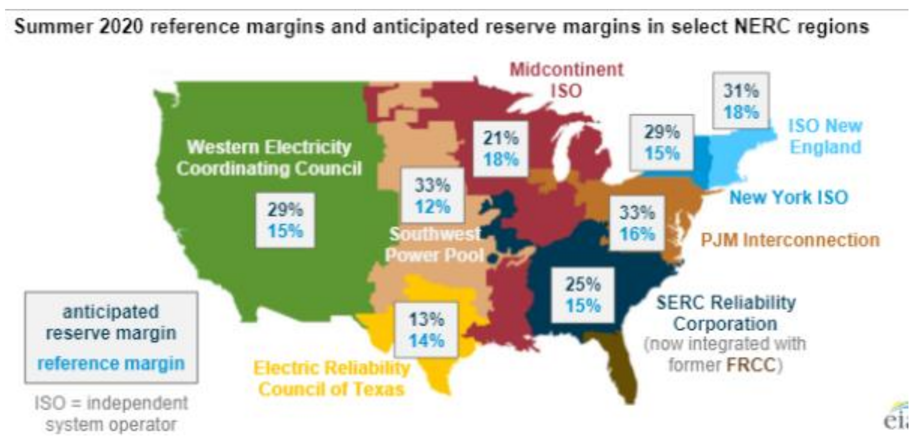

Figure 1 Summer 2020 anticipated power reserve by state. From: The 2021 Texas Electric Grid Failure: 2021

The figure above shows how far each state's power consumption is from reaching the full supply of power. Texas is the lowest one with 13%. This means that if the residents of Texas consume 13% more than their usual power consumption, The power grid might start to cut power on some sections of the state due to the overload. According to Thomas Popik and Richard Humphreys "During the week of February 14, fossil fuel-fired generation plants, fuel supply infrastructure, and wind turbines experienced temperature-related malfunctions. In order to maintain internal temperatures, homes consumed far more electricity than normal in winter. This combination of generation freeze-ups and higher electricity demand caused ERCOT to order rolling blackouts from February 15 until February 18. At the peak of the blackouts, approximately one-third of ERCOT electricity consumers were without electricity, (Texas Electric Grid Failure, February 2021) .

Figure 2 Residents of Texas lining up for gas tanks due to the blackout, From: "Texas power outages" (2021)

The picture was taken in Texas, and it shows residents lining up for Gas tanks since they have lost electricity and their house heating. The picture shows the struggle that anyone can suffer from due to the fragile power grid.

In this context, the imminent transition to electric vehicles (EVs) raises the red flag for how the power grid can't survive such burden. We know that EVs require a significant amount of electricity for charging, and as their popularity continues to grow, the demand for charging infrastructure and energy supply will increase substantially. Without proactive measures, the integration of EVs into the existing grid can exacerbate the strain and potentially lead to further challenges in maintaining a reliable power supply. (Popik & Humphreys, 2021)

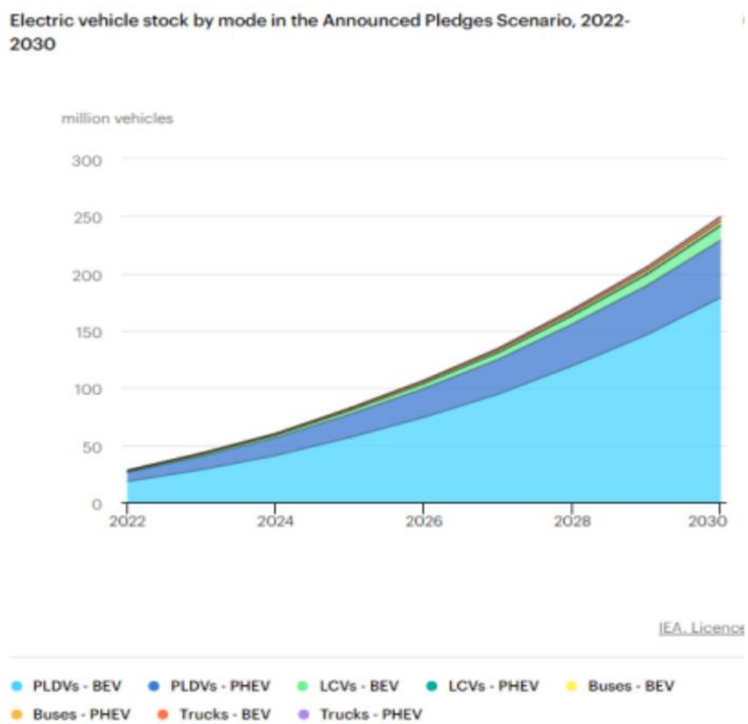

Figure 3 The projection of EVs production in the coming 20 years. From:" Electric Vehicle Deployment – Global EV Outlook" 2023

The Figure above shows how fast the EVs are taking over. Manufacturing growth is becoming exponential. In 2022, 40 million of EVs were manufactured. The projection is showing 250 million by 2030 which is five times the current production in just 8 years (Global EV Outlook 2023).

Technical Topic:

Why are we adding fleets of EVs to a struggling power grid? How can we still adopt EVs without impacting the grid?

To address these challenges, we propose the implementation of microgrid-powered EV parking lots equipped with wireless charging infrastructure. Each parking spot in the lot would be covered with solar panels, providing a dedicated and renewable energy supply for EV charging. Wireless charging technology enables fast and convenient charging experiences for EV owners parking to either go shopping or to run errands. According to Zuzhao and Yuanqi , “ In the past decade, the global electric vehicle (EV) market has been growing exponentially thanks to the rapid advancement of battery technologies. To support further penetration of EVs, it is critical to develop smart charging stations that could satisfy the charging needs in a cost-effective manner” (Ye, Z., Gao, Y (2022)).

The Design will address many issues that surround EVs while eliminating the main risk of destabilizing the power grid. The design will be isolated from the grid. If enough parking lots like these are to be designed, we can power as many EVs we need in the future.

The parking lot will be equipped with solar panels on its surface. These solar panels generate electricity by converting sunlight into (DC) electricity through the photovoltaic effect. The DC electricity generated by the solar panels is then converted into alternating current (AC) electricity using an inverter. AC electricity is the standard form of power used by most electrical devices and charging systems (Harry Powell*, 2022).*

Wireless Charging Technology is used instead of traditional plug-in charging stations. Wireless EV charging, also known as inductive charging, eliminates the need for physical cables and plugs. It works by using electromagnetic fields to transfer energy from the charging infrastructure to the EV's receiving coil (Ye, Gao, & Yu, 2022).

When an EV owner parks his car, it will automatically start charging. The duration of the charging depends on how long the car is parked and the amount of energy stored in the facility. Cloudy and rainy days can impact the maximum charging power each car is allowed to receive.

This intervention of microgrid-powered EV parking lots with wireless charging builds off existing technologies in several ways.

Microgrids themselves are not a new concept, however, their application specifically in EV parking lots is a novel approach. By integrating islanded microgrids into the parking lot infrastructure, we create a localized energy system that can meet the specific demands of EV charging, reducing reliance on the main grid (Kamel et al., 2023).

Solar Energy can be based on existing solar panels that have been widely used to generate renewable energy. They can be utilized to cover the parking lots, acting as a clean and sustainable energy source for charging electric vehicles. By incorporating solar energy generation directly into the parking infrastructure, we optimize energy production and minimize transmission losses (Ziemba & Szaja, 2023).

As for Wireless Charging, it is not entirely new. However, its integration into EV parking lots is an innovative application that eliminates the need for physical cables and connectors, providing a more convenient and user-friendly experience for EV owners. By embedding wireless charging infrastructure in each parking spot, EV users can simply park their vehicles and have them charged automatically.

By combining microgrids, solar panels, and wireless charging infrastructure, we create a solution that caters to the unique energy demands of electric vehicles. This integration ensures efficient energy generation and ultimately reducing strain on the main grid and enabling sustainable EV adoption.

Installing a Microgrid powered parking lot in the area of Charlottesville, close to the University of Virginia (UVA) or downtown, could offer numerous benefits while addressing some of the parking challenges faced by the university. The University of Virginia often struggles with parking availability, especially during peak hours and busy academic seasons.

According to Zhang & Frimpong, “As colleges’ population grows, the demand for and supply of parking spaces on college campuses become crucial TDM considerations” (Zhang ,Frimpong 2021).

By establishing a solar-powered parking lot near the university or downtown, additional parking spaces can be created to accommodate the growing number of vehicles, including faculty, staff, and students, while promoting the use of electric vehicles. Charlottesville and UVA are known for their commitment to sustainability and environmental conservation. A solar-powered parking lot aligns well with the school's efforts to reduce its carbon footprint. Utilizing solar energy to power EV charging stations would not only reduce greenhouse gas emissions but also set an example of eco-friendly practices for the community.

With that been said, UVA is known for its limited space and land for parking. Finding suitable locations for a large parking lot with sufficient space for solar panels and charging pads near UVA might be challenging. Limited available land and regulations could pose obstacles.

STS Topic:

How do the communities in Charlottesville perceive new technologies in their backyard?

The socio-technical aspect of this design focuses on examining the social and cultural implications of implementing microgrid-powered EV parking lots.

The successful implementation of the project is determined by the public perception and acceptance of electric vehicles and renewable energy technologies. By providing convenient and reliable data, the communities in Charlottsville can be swayed to welcome such an idea in their backyard.

What are the general perceptions of Electric Vehicles?

Cultural norms and beliefs play a significant role in shaping people's attitudes towards EVs. Cultural contexts can influence how individuals perceive EVs in terms of environmental consciousness and social status. Cultures that prioritize environmental sustainability and have a strong awareness of climate change may view EVs more favorably after learning about the proposed micro-grid. This could stem from cultural values that emphasize ecological responsibility and conservation. In such contexts, EV adoption can be perceived as a proactive step towards reducing carbon emissions and combating climate change.

4G and 5G antennas are a case example of how the public can perceive a new technology in a negative way. Misinformation and conspiracy theories can rapidly spread about the 5G technology. False claims linking 5G to the COVID-19 pandemic or other unrelated health issues have fueled public skepticism, (KELLY, S , 2021).

Moreover, using Winner’s "Do Artifacts Have Politics?" as a framework, we can avoid any political implication in our design. The UVA community might perceive EVs as luxurious. Therefore, some groups might see the project as a symbol of economic disparity and exclusion. EVs are expensive. Therefore, the majority of the EV owners might be from wealthy families to a certain point. As a solution, communicating with the UVA community directly can be the key to avoiding such political association with our artifact.

To avoid any misinformation, before implementing microgrid-powered EV parking lots, the city of Charlottesville and UVA should conduct extensive outreach programs and town hall meetings. This approach allows residents, faculty, staff, and students to voice their opinions, raise concerns, and provide valuable feedback on the project. Actively involving the community in the decision-making process.

Involving local communities in the planning and decision-making process for microgrid-powered EV parking lots can ensure that their needs and concerns are considered. Seeking feedback and incorporating community preferences can lead to more inclusive and socially accepted design.

Examining the sociotechnical aspects is crucial to ensure the successful implementation of this project. By understanding the social dynamics and cultural influences, we can anticipate and address potential challenges, foster public acceptance, and design interventions that align with societal needs and aspirations.

Conclusion:

In conclusion, the prospectus proposes the implementation of microgrid-powered EV parking lots with wireless charging infrastructure to address the strain on the power grid caused by the growing demand for electricity and the transition to electric vehicles in Charlottesville. This innovative approach combines microgrids, solar panels, and wireless charging technology to create a localized and renewable energy supply for EVs, reducing reliance on the main grid. Additionally, the study emphasizes the importance of examining sociotechnical aspects, including community engagement and perceptions, to ensure successful implementation. By fostering public acceptance, cultural understanding, and inclusivity, this intervention aims to pave the road for a greener future where EVs are adopted all over the world without impacting our main power grid.

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