Note:

The following document is addressed to National Grid plc, a multinational utility corporation responsible for power distribution for a majority of the Commonwealth of Massachusetts.

A Financial Incentive Program for Electric Vehicles:

A Proposal for a Private Utility Provider

Overview:

Consumer adoption of electric vehicles (EV's) has been slow in the United States. A proven method of encouraging consumers to purchase a product is to provide financial incentives. As a major utility provider in the New England area, National Grid can contribute to these incentives by providing rebates for in-home chargers for electric vehicles. Providing these rebates will help reduce the cost of purchasing an EV and ensure that consumers use efficient and high-quality chargers. National Grid can facilitate the transition from internal combustion engine vehicles to EV's by providing rebates for in-home chargers and help bring about a greener future.

Electric Vehicles Technology and Sales:

Electric vehicles are categorized into two main technology classes. Plug-In Hybrid Electric Vehicles (PHEV) are electric vehicles that convert gasoline directly to electricity to power their electric drive systems. This process is more efficient then using an internal combustion engine to power a car and allows the vehicle to carry a smaller battery. Common PHEV's are the Toyota Prius Prime and BMW i3. According to the National Household Travel Survey, conducted by Oak Ridge National Laboratories, less than 25% of daily trips exceed 10 miles. [1] If a PHEV is consistently charged, then it rarely needs to generate power onboard and is often exclusively operating on battery power. Battery Electric Vehicles (BEV) only use an onboard battery for energy storage. This form of energy storage requires a larger battery, but the vehicle produces zero emissions and does not directly use any fossil fuels. Common BEV's are the Tesla Model 3 and Chevrolet Bolt.

In 2017, electric vehicles made up only 1.2% of new car sales in the United States with a total of about 198,000 new EV's sold and a total stock of 762,000 EV's [2]. This data, provided by the International Energy Agency (IEA), shows a slow growth of market share in the US over the last five years. EV sales, including both PHEV's and BEV's has only grown 0.8% since 2012. The IEA's Electric Vehicle Initiative *2018 Global EV Outlook* states that the United States has committed to having 3,300,000 EVs in eight states combined by 2025 [2]. In order to reach this goal, the government and private companies, like National Grid, will have to incentivize the purchase and adoption of EV's.

Utilization and Success of Incentivization:

Currently, the largest barrier to electric vehicle adoption is the cost of purchasing a new EV. According to research from Sierzchula et al. at Delft University of Technology, "EV purchase prices, which are heavily dependent on battery costs, have been identified as being the most significant obstacle to widespread EV diffusion" [3]. Because battery cost is a factor of battery technology and scale of production, it will take a significant amount of time for the price

of EV's to be competitive with gas powered vehicles. To reduce the obstacle of price today, National Grid can help incentivize the purchase of EV's with rebates of their own.

In Norway, which has the highest market share for EV's in the world [2], financial incentives have been a driving force in increasing their sales. Data from a survey of Norwegian citizens who have purchased EV's showed that for 80% of the respondents, being exempt from import tax (VAT) and sales tax were decisive factors in their decision to purchase an EV [4]. These financial incentives provided savings of up to $70,000 for a Tesla Model S. The article from the journal Transportation Research, that details the results of this survey also states that, "up-front costs are more heavily emphasized than reductions in variable costs" [4]. For first time EV owners, a large portion of this up-front cost includes the purchase and installation of an in-home charger. According to the Department of Energy's *Plug-In Electric Vehicle Handbook for Consumers* the cost of an in-home slow-charger can range from $500 to $2000 before installation [5]. Covering this cost would reduce the cost of a $30,000 EV up to 6%. Norway is an exemplary model of implementing incentives on a national scale, but for a private company like National Grid, reducing the up-front cost of an EV by even 5% has the potential to go a long way.

Implementation of Incentive Program:

A well thought out strategy is crucial for the success of this financial incentive program. Initially, a rebate program like this would be best implemented as a regional program. National Grid should target a state that they provide utilities for and has a pre-existing tax incentive program for EV's. Massachusetts offers rebates of up to $2500 through the MOR-EV program [6]. This is on top of the Federal EV tax credit program, which offers up to $7500 in tax refunds [7]. Because these financial incentives already exist at the state and federal level, further reducing the up-front cost of an EV will have a greater impact on the consumer's decision to purchase an EV.

National Grid is the entity best suited to provide these incentives because of their role as a home utility provider. Because National Grid provides electricity for a majority of households in Massachusetts, it will have more direct access to the infrastructure needed to support these in-home chargers. National Grid will also directly receive the benefits from the adoption of EV's as a result of this incentive program. If the program is successful in Massachusetts, National Grid could expand it to other regions that they provide utilities for.

Implementation of a Vehicle to Grid Solution:

With National Grid providing connections for EV's to their grid with in-home chargers, they are presented with the unique opportunity to use EV's for energy storage. In a vehicle to grid (V2G) scheme, excess power produced during off peak demand is stored in the batteries of unused electric vehicles [8]. This works very well with EV's because they are often charged at night when demand is lowest. This power can then be used to supplement the grid during peak hours, reducing the load on power plants. In the model proposed in the paper by Srivastava, this power is sold back to the utility provider. By offsetting the cost of in-home chargers, National Grid could potentially use a V2G system without buying back the stored energy. While PHEV's have a smaller battery than BEV's, both need to be connected to the grid to charge. By

increasing the number of EV's on the road, there is more opportunity for National Grid to distribute this energy storage.

Logistic Benefits of Increased Electric Vehicle Usage for National Grid:

By incentivizing the purchase of EV's with in-home charger rebates, National Grid will benefit from their expanded use as well. National Grid will have the opportunity to select which in-home chargers to provide rebates for based on their potential for use in a V2G system and efficiency. With a V2G system in place, National Grid will have an unprecedented ability to store electricity for on-demand use. This will reduce the load on power plants in the grid and allow them to generate a more constant amount of electricity. National Grid will be able to optimize use of each plant in order to achieve the best efficiency and least strain on the plant itself. Data from the IEA's 2018 Global EV Outlook shows that, "Power demand and road mobility demand are both characterized by two peaks during morning and evening hours and a period of low demand during night time" [2]. Because EV's will be charging in off peak hours, the grid usage will become more stable. However, in order for an EV to provide power back to the grid a special type of charger is necessary. Through their incentive program, National Grid can encourage the use of V2G by providing larger rebates for chargers that have this ability.

Similarly, National Grid will have the ability to ensure that consumers use high-quality chargers over less efficient and lower cost models. If a consumer were purchasing a charger without any rebate, they would most likely choose the cheapest charger available. These low-cost chargers are often made with lower quality components which waste more energy in the charging process. As the numbers of EV owners and in-home chargers increase, the amount of energy lost to inefficiencies in charging will increase as well. In order to maximize the efficiency of their system, National Grid would need to curate a selection of high-quality chargers to provide a rebate for.

Financial Benefits of Increased Electric Vehicle Usage for National Grid:

Potentially the most significant benefit to promoting EV adoption will be the financial outcomes. With more consumers driving EV's and charging them at home, utility usage will increase dramatically. By 2030, EV's are predicted to use up to 62% of the world's total energy demand, with 10% of that occurring in the United State [2]. EV's will expand the market for utility companies, increasing profits. The initial cost of providing rebates may be significant, but the long-term reward will be well worth the investment today.

With V2G technology, EV's can also help reduce operating costs. By helping distribute peak demand and reduce strain on power plants, less maintenance will be necessary to maintain these plants. With a model where National Grid provides rebates for in-home chargers and the user agrees to allow their EV to be integrated into the grid, National Grid will be expanding its system with every purchase. In the proposed V2G solution, National Grid will also avoid needing to buy energy back from the consumer during peak hours. While consumers are mostly concerned with the up-front cost of EV's National Grid can afford to focus on the long-term benefits. By investing in EV adoption today, National Grid will also be investing in their future.

Conclusion:

By providing rebates for in-home chargers, National Grid can help make EV's more competitive in the personal vehicle market. Increasing the market share of EV's will help reduce transportation emissions by reducing the number of conventional vehicles in use. Cost is one of the driving factors in a consumer's decision-making process when buying a new car. Reducing the up-front cost will increase EV purchases and market share. EV's provide more than environmental benefits for consumers and National Grid. Integrating EV's into the power grid for temporary energy storage in a V2G system can help stabilize power plant demand throughout the day. Increased grid usage at night from EV charging will help decrease the difference in demand between day and night and allow power plants to run at a consistent level without wasting excess energy. National Grid is in a unique position to promote the adoption of EV's in the Massachusetts area. Energy is a core part of National Grid's identity. As an industry leader, National Grid should lead the way in advancing electric transportation.

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[2] International Energy Agency, “Global EV Outlook 2018” [Online]. Available: https://webstore.iea.org/global-ev-outlook-2018 [Accessed Oct 24 2018].

[3] William Sierzchula, S. Bakker, K. Maat, and B. Wee, “The influence of financial incentives and other socio-economic factors on electric vehicle adoption” Energy Policy, vol. 68, May, pp. 183-194, 2014. [Online]. Available: Science Direct, http://www.sciencedirect.com. [Accessed Oct 25 2018].

[4] K. Y. Bjerkan, T. E. Nørbech and M. E. Nordtømme, “Incentives for promoting Battery Electric Vehicle (BEV) adoption in Norway,” Transportation Research Part D: Transport and Environment, vol. 43, March, pp. 169-180, 2016. [Online]. Available: Science Direct, http:// www.sciencedirect.com. [Accessed Oct 25 2018].

[5] National Renewable Energy Laboratory, “Plug-In Electric Vehicle Handbook for Consumers,” Department of Energy Office of Energy Efficiency and Renewable Energy, 2015 [Online]. Available: https://www.afdc.energy.gov/uploads/publication/pev_consumer_handbook.pdf. [Accessed Oct 23 2018].

[6] mor-ev.org, “MOR-EV”, Center for Sustainable Energy, [Online]. Available: https://mor-ev.org/ [Accessed Oct 23 2018].

[7] fueleconomy.gov, “Federal Tax Credits for All-Electric and Plug-in Hybrid Vehicles”, Department of Energy Office of Energy Efficiency and Renewable Energy, 2018 [Online]. Available: https://www.fueleconomy.gov/feg/taxevb.shtml [Accessed Oct 25 2018].

[8] A. K. Srivastava, B. Annabathina and S. Kamalasadan, “The Challenges and Policy Options for Integrating Plug-in Hybrid Electric Vehicle into the Electric Grid,” The Electricity Journal, vol. 23, no. 3, pp 84-91, 2010. [Online]. Available: Science Direct, http:// www.sciencedirect.com. [Accessed Oct 24 2018].