Research Proposal - Decarbonization of Household Electricity Consumption using Battery Stack

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Research Question: *To what extent does the use of a home battery help reduce a household's CO_2 emissions derived from electricity consumption. The analysis of a reinforcement learning based model of the charge/discharge strategy.*

The goal of this paper can be achieved by simulating a house's electricity consumption and the carbon intensity of the electricity in the grid, while training a model which has the goal of minimizing the carbon emissions by controlling when a battery charges from the grid, or discharges to meet the electricity requirements of the household. The aims of the research are exemplified through the extent of which the model proves to be successful. I. e. how successful the model is (while considering obvious limitations) directly dictates the answer to the research question.

The environment will be simulated using real-world, hourly, data of the carbon intensity and a households energy consumption. Additionally, a set-capacity battery will be available for the agent to perform actions on. This custom environment will be set up in OpenAI's Gymnasium framework. Envision the simulated environment as a 'game level' for which the agent(who controls the charge/discharge strategy) is trained to achieve a high score(or in this case, a low score). The action space of the agent is discrete, with the three available commands being 'Charge', 'Discharge' or 'Do Nothing'. A Deep Q-Network Agent will be used as the reinforced learning method, due to its compatibility with discrete action spaces and relative simplicity, but this choice is not definitive yet.

The performance of the algorithm will be assessed by comparing the cumulative CO_2 emissions with the charge/discharge algorithm of the battery in place, with the baseline CO_2 emissions of the household. That is, we want to investigate if it is possible to reduce overall CO_2 emissions using the strategy.

This approach is scientifically, and real world, relevant because such a system could be trained to manage a house's battery charge strategy, to meet specific energy demands and local carbon intensity fluctuations. From the point of view of classic machine learning principles, in this case the lack of extensive, quality, data does not let us test how well the model generalizes to different environment data. On the other hand, overfitting to the data in the environment could arguably be good, considering the cyclicity of energy consumption and carbon intensity data.

The biggest challenges are designing the reward function so that it balances the short and long term expected reward.