Executive Summary
MECH 206P Design & Professional Skills

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Which form of sustainable energy will bring the greatest benefit for transport and why?

Energy, the stored ability of a body to do work, is the backbone driver of development and success in economies and societies. Almost every activity in every industry hinges on its availability. In order to meet an energy demand of approximately 18 billion tonne oil equivalents by 2035 and to cater to the needs of 9 billion people by 2050, it is pivotal to find an inexpensive, attainable and environment friendly solution (Chu and Majumdar,p.294). Currently, we meet our energy demands by exploiting fossil fuels or non-renewables like natural gas, coal and oil, at the cost of emitting carbon dioxide into the atmosphere (refer to Figure 1). This poses deleterious climate change risks like global warming that could rise sea levels, cause water shortages, disrupt food systems and induce extreme weather events which could inflict yearly losses of over $150 billion (Chu and Majumdar,p.302).

Firstly, this summary will talk about why battery based electrification may prove to be an effective sustainable solution to the transport sector. Then, it will throw light on the performance and costs aspects of battery based electrification that reflect it could be an ideal solution with eco-friendly, effective and desirable benefits. This summary will portray how battery based electrification in a hybrid model, to power the existent transport system, promises to provide the greatest benefit and why it could be the sought after solution.

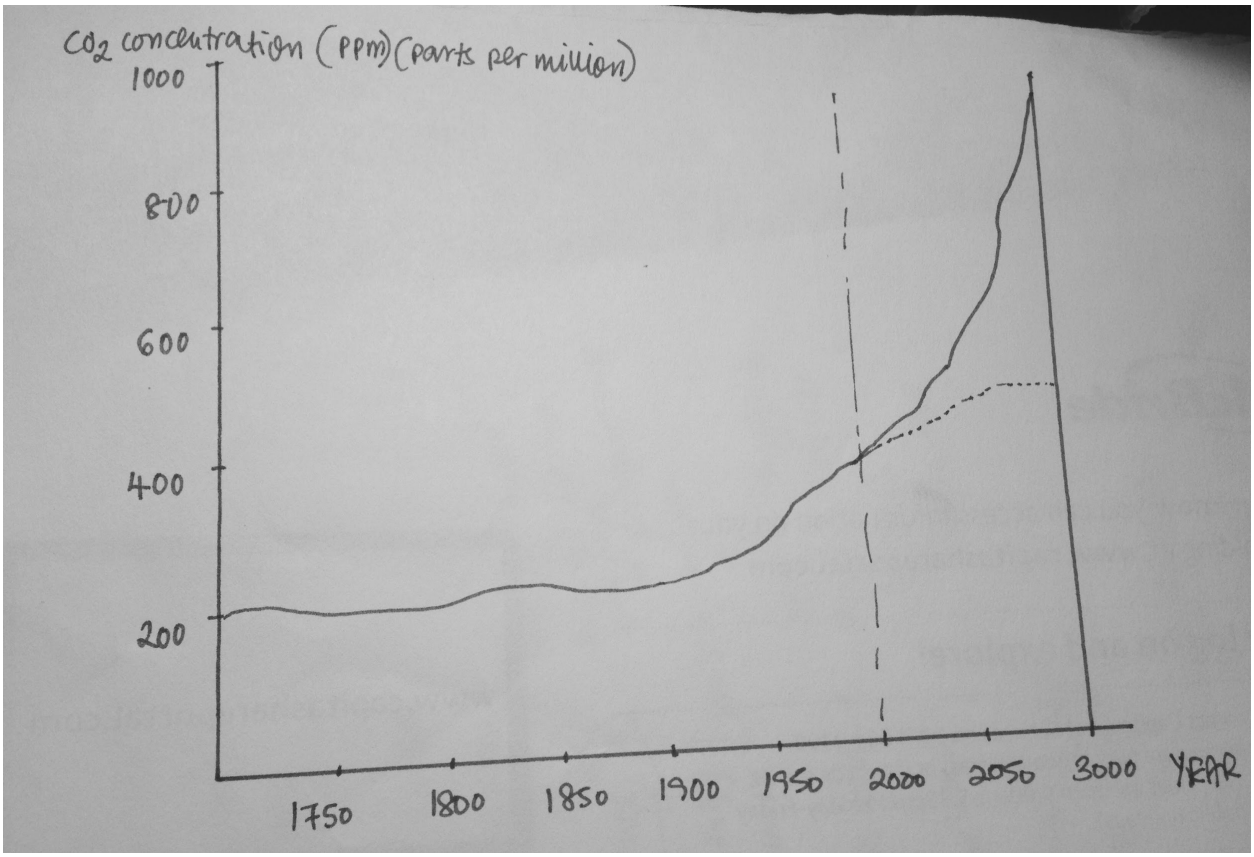

Figure 1: The graph above depicts how carbon dioxide concentration in parts per million has varied and may vary with time under current circumstances. The dotted line showcases how it could respond if the the hybrid model discussed in later in this summary is implemented.

Plug in hybrid electric vehicles (PHEV) and electric vehicles, which encompass electrification by batteries, could transform the transportation landscape by leading us towards a liquid fuel independent solution. This solution shows promise as the energy density could be improved ten fold with developments in battery types (Chu and Majumdar,p.295). Also, the costs associated with producing a vehicle battery are projected to fall to $\$150kWh^{-1}$ from $\$650kWh^{-1}$ (Chu and Majumdar,p.295). Overall, this solution could be feasible if the battery systems performance is maximised and cost is minimised.

The growth of our transport system, powered by fossil fuels bounded with carbon emissions, could result in uncontrollable climate change, if the appropriate precautionary measures are not taken or changes are not implemented. The proposition that a 160km PHEV could compete against the traditional Internal Combustion Engine (ICE) Vehicles within a decade, indicates that this could be the answer (Chu and Majumdar,p.295). Also, the expected introduction of a 200 Watt-hour kg^{-1} battery pack that can be fully charged in 3 hours strengthens this solution's case (Chu and Majumdar,p.295). Although, costs will be needed to be further lowered, this solution is still attainable.

The downsides of this solution revolve around capacity and making optimum choices to ensure maximum effectiveness. The fact that only 50% of battery capacity is harnessed, showcases a low efficiency and high energy loss tendency (ibid,p.295). There also exists a trade off between charging time and battery lifetime which makes it essential to select a practical blend (ibid,p.295). However, it is possible to curtail these drawbacks.

The benefits of this solution are immense and achievable. Firstly, battery based electrification is green, pollution free could replace fuel based vehicles. Unlike fuel-cell based electrification, which needs a low carbon source for hydrogen and supply infrastructure, the charging stations for this solution can be easily built on the existent power grid and it can be seamlessly integrated with the prevalent transport system. This PHEV or electric vehicles also prove economically viable as compared to vehicles run on compressed natural gas (CNG) which have a payback period of around 10-15 years and need $100 billion for infrastructure (Chu and Majumdar,p.296). While a means to effectively concentrate biomass to make biofuels competitive is still to be developed, battery based electrification has been propelled by notable progress in battery components and volumetric

adjustments made to account for mechanical stresses (ibid,p.297).

With the prevalent dynamism of the transport system, it is unreasonable to expect one solution to contribute the greatest benefit. The hybrid model being proposed consists of clean energy generation via solar, wind or nuclear and effective PHEV sourcing this power. In this way, the electricity to run the batteries is also produced in a sustainable way ensuring a low carbon footprint in the entire cycle. This solution should be gradually introduced in order to accommodate an effect transition. Since fossil fuel energy consumption cannot be abruptly halted, we should attempt to implement "carbon capture, utilization and storage" (CCUS) to mitigate emissions (Chu and Majumdar,p.301). Also, certain common trends can be put into practise like making vehicles 10% lighter to improve fuel consumption by 6-8%, improving energy efficiency by minimizing friction and bolstering energy recovery (ibid,p.295). In all, a hybrid solution could augment reliability, break the link between fossil fuels and growth, and introduce integration benefits by offsetting the disadvantages of individual sustainable energy sources.

In conclusion, the summary throws light on energy's importance and it's growing demand, the ill-effects of fossil fuels and it's detrimental consequences. It then argued why and how battery based electrification could prove to be one of the greatest contributors for transport by elaborating on how it fitted into the current situation. It also expanded on its positives and negatives with respect to the the other alternatives. Then the summary depicted a hybrid solution and general relevant inferences from the text.

References:

Chu, Steven, and Arun Majumdar. 'Opportunities And Challenges For A Sustainable Energy Future'. *Nature* 488.7411 (2012): 294-303. Web.