APPENDIX I

Global Warming Potential (GWP) of EVs

In a report by the European Commission published in 2020, a comprehensive look into the overall environmental impact using life cycle assessment (LCA) was conducted. This study covers fuel and electricity production, vehicle production, use and operation, and end-of-life.

The results of this study are measured by global warming impact (GWP) based on emissions. Lower medium vehicles, shown in Figure 1, include the following passenger vehicles: class C vehicles (e.g. Ford Taurus) and medium SUVs (e.g. Ford Escape). Urban buses, shown in Figure 2, include models that have a single deck and are 12 meters long.

In Figure 1 and Figure 2, the following fuel types are represented:

- ICEV-G – gasoline fueled internal combustion engine
- ICEV-D – diesel fueled internal combustion engine
- ICEV-CNG – compressed natural gas fueled internal combustion engine
- HEV-G – gasoline and battery hybrid electric vehicle
- HEV-D – diesel and battery hybrid electric vehicle
- PHEV-G – gasoline and battery plug-in hybrid electric vehicle
- PHEV-D – diesel and battery plug-in hybrid electric vehicle
- FCEV – hydrogen fuel cell electric vehicle
- BEV – battery electric vehicle

The calculated GWP for 2020, 2030, and 2050 for each fuel type is shown for Figures 1 and 2. For 2050, the “TECH1.5” scenario reflects projected adjustments in infrastructure, policy, etc. to align with the Paris Agreement and keep global temperature increase to a 1.5°C maximum. The GWP for 2020 and 2030 are based on baseline conditions in 2020.

The results of this study indicate that for both classes of vehicles, **battery electric vehicles (BEVs) have the lowest overall global warming potential** projected over the next several decades.
As shown in Figures 1 and 2, adjustments in infrastructure and sources of energy over time will result in a significant decrease in the lifecycle emissions of battery electric vehicles and plug-in hybrid electric vehicles compared to internal combustion engine vehicles.

The primary energy sources for electricity in the State of Pennsylvania are coal, gas, and nuclear power. Shown in Figure 3.1, the percentage of coal sourced electricity has decreased while gas sourced electricity has increased between 2004 and 2019. Figure 3.2 shows a decrease in oil...
sourced electricity and an increase in renewable power sources (water (hydro), biomass, and wind) between 2004 and 2019.

**Figure 3.1.** Pennsylvania electric grid source trends from 2004-2019 (source).

**Figure 3.2.** Pennsylvania electric grid source trends from 2004-2019, breakdown of “other” sources shown in Figure 3.1 (source).

According to data from the EPA, Pennsylvania’s carbon dioxide equivalent emissions (CO₂e) have also decreased between 2004 and 2019 and are projected to continue to drop due to the increase in lower emission electricity sources as shown in Figures 3.1 and 3.2.
In March of 2021, Pennsylvania governor Tom Wolf announced a major clean energy initiative that will implement 191-megawatts of new solar energy arrays across the state by 2023. This will increase the percentage of solar powered electricity in Pennsylvania to nearly 50% of the state’s total electricity and further decrease the CO$_2$e emissions associated with electricity production.

Figure 4 indicates West Philadelphia’s three main electricity sources: nuclear power, coal, and natural gas. These sources have been trending towards an increase in renewable sources, predominantly in wind and solar.

![Figure 4. West Philadelphia electricity sources (source).](image)

In 2020, Penn also signed a Power Purchase Agreement (PPA) that involves the construction of two solar energy facilities in central Pennsylvania. Penn will purchase all electricity produced. An estimated 75% of the campus’s electricity demand will be met with solar power once this is implemented. This PPA will also shift Penn’s electricity to be predominantly sourced from renewable sources. Additionally, as the United States moves towards carbon neutrality, it is expected that clean electricity sources will become more accessible, thus further lowering the emissions associated with the electricity used to power EVs (as demonstrated in Figures 1 and 2’s 2050 TECH 1.5 scenarios).

Overall, the current and projected electricity sources for our area and their associated emissions make EVs highly beneficial for reducing Penn’s fleet emissions.