ECE 398GG Electric Vehicles Prof. G. Gross
Quiz 3 FALL 2022
Thursday, March 24, 10:30 a.m.
20 minutes

name: **last 4 digits of the UIN:**

Problem 1: 120 points

This problem requires you to either **prove** or **disprove** the statement in the last sentence of each part of this problem. You must **show** all your work and **state with justification** any assumptions you wish to introduce. Each of the three parts is worth **40 points**.

a. According to the *EPA*, the 2021 *GM Bolt* has a fuel efficiency of 29 *kWh*/100 *mi*. The corresponding fuel efficiency figure of merit in *mpge* (miles per gallon equivalent) is above 115 *mpge*.

The *mpge* evaluation requires the *EPA* value of 33.705 *kWh* of energy contained in each gasoline *gal* of fuel. It follows that [33.705 *kWh/gal*] / [29 *kWh*/100 *mi*] = 116.2 *mpge* > 115 *mpge*

b. Consider the use in 2020 in the Midwest of an *EV* with 25 *kWh*/100 *mi* fuel efficiency. The *EV* is charged with the electricity of the region with CO_2 total output emission rate of 984.98 *lb*/*MWh*, which is above the national average of 818.29 *lb/MWh*. The *EV*'s tailpipe emissions exceed 100 *g/mi*.

818.29 *lb/MWh* is equivalent to 371 *g/kWh* and so 984.98 *lb*/*MWh* is equivalent to 371 *g/kWh* x 984.98/818.29 = 447 *g/kWh*. The multiplication of 447 *g/kWh* by 25 *kWh/* 100 *mi* results in 112 *g/mi* > 100 *g/mi*.

c. A possible replacement for fossil fuels is biomass, which can be burned in a steam generation plant. One such plant can convert each 1 *kg* of biomass into 1 *kWh* of electricity. We consider an *EV*, whose consumption is 25 *kWh*/100 *mi*, charged at a charger connected to the distribution grid with the electricity generated by the biomass steam plant. For an input of 20 *kg* of biomass into the plant, the *EV* can travel less than 25 *mi*. You may use in your proof the assumed efficiency values in the *w-t-w* analysis in the handouts.

Incorrect: 20 *kg* biomass x 1 *kWh*/1 *kg* biomass x 0.95 x 0.85 x 100 / 25 *kWh* = 64.6 *mi* > 25 *mi*

grid charging

I will accept the explicit inclusion of the efficiencies of:

(i) *AC-DC* conversion efficiency of 0.95

(ii) *DC-AC* conversion efficiency of 0.95

(iii) *Battery charge-discharge efficiency* of 0.94 =➔ charging efficiency of 0.85

(iv) drivetrain -motor efficiency of 0.95

even with a higher efficiency above 0.85 for the charging.

Problem 2: 80 points

For the statements below, **circle** each correct statement. To receive full marks for each answer, we not only discourage guesses, but you **must** provide a justification of why you chose to circle or not circle each statement.

- We use the *EPA* fuel efficiency ratings in the *w-t-w* analysis for both the *ICEV*s and the *EV*s.

Solution: Correct statement since all manufacturers must submit the required data from which the fuel efficiency figures in *mpg, mpge* or *kWh*/100 *mi* are determined.

- An *EV* which is charged by CO_2-free electricity generated by renewable wind and solar resources and whose batteries are manufactured by CO_2-free electricity has life cycle emissions of 0 *g/mi*.

Solution: Correct statement since the electricity generation has no CO_2 emissions and the battery manufacture had no emissions. However, if someone mentions the emissions in the manufacture of solar panels or wind farm components, their transportation and their installation, I am also accepting that answer.

- The lower the electricity consumption in units of *kWh*/100 *mi*, the lower is the fuel efficiency in units of *mpge* (miles per gallon equivalent).

Solution: Incorrect, exactly the opposite is the case: consider the case with two different fuel efficiencies with $FE_1 < FE_2$. To restate the efficiencies in units of *mpge*, we need to bring in the fact that each gasoline *gal* contains 33.705 *kWh* of energy. Then, it follows from the *mpge* definition that

[33.705 *kWh/gal*] / [FE_1 *kWh*/100 *mi*] > [33.705 *kWh/gal*] / [FE_1 *kWh*/100 *mi*]

because $FE_1 < FE_2$.

- The *w-t-w* analysis for an *ICEV* and an *EV* are identical and the decomposition is carried out into the same two components.

Solution: Incorrect, because in *EV* analysis, there is no well *per se*, there is no pump and the tank becomes the battery. The *ICEV* parts of *well-to-pump* and *pump-to-wheels* are replaced by *well-to-battery* and *battery-to-wheels*.

- The resource generation mix of the electricity where a vehicle is used impacts equally the efficiency and emissions analysis of both the *ICEV*s and the *EV*s.

Solution: Incorrect, because the resource generation mix of the electricity impacts the *EV* analysis, but has no impact on the *ICEV* analysis, as electricity is not involved in the frictional losses.