Solar, Transportation

Schwartz Problem Set #8, Due Tuesday (following Monday Schedule).

1. I bought a Nissan Leaf last summer… it was $9,000 with 13,000 miles on it. It has a 20 kWh battery and a range of about 80 miles.
   a) Estimate my mileage in miles/kWh. 4 miles/kWh
   b) On the highway at 60 mph, the power meter on the car bounces between 10 kW and 20 kW. Please verify that the mileage is (or isn't) consistent with this power reading. 60 mi/h)/(4 mi/kWh) = 15 kW
   c) The car has a maximum power output of 80 kW. Please estimate the maximum power average cruising power in Horse Power. If 1 hp ~ 750W = 0.75 kW, then cruising power is 20 hp, and max hp is a little over 100 hp.

2. A Toyota Corolla is kind of like a Leaf, but burns gasoline, getting 40 mpg at highway speeds.
   a) Please convert this to kW in terms of rate of consumption of chemical potential energy. At 60 mi/hr and 40 mpg, we will 1.5 gallons in an hour. A gallon is about 3 kg of gasoline at 46 MJ/kg, that's about 135 MJ/gallon. P=E/t = 1.5*135 MJ/3600s = 56 kW
   b) We assume that the Corolla and the Leaf put out about the same amount of power while driving on the highway. If the Leaf turns chemical potential energy of the battery into mechanical work at an efficiency of 80%, what is the efficiency of conversion for the Toyota? The relative input power of the two vehicles is 56 kW/15 kW ~3.75. Efficiency of Corolla is then 80%/3.75 = 21%. Keep in mind that the Corolla, for an ICE has very high efficiency.

3. A Toyota Corolla gets better mileage on the highway, where the Leaf gets better mileage driving around town. Why is this?
   a) All things being the same, why would mileage for any vehicle be lower at much higher speeds? Energy use = F*x, in driving, force is essentially frictional force, which increases with speed. So the faster you go, the greater the force is that the engine has to put out, so the work is greater, requiring more energy to do the same trip.
   b) While the ICE (internal combustion engine) gets moderately better mileage at lower speeds the BEV (battery electric vehicle) gets WAY better mileage at lower speeds. Why is there a bigger difference for the BEV? While the ICE gets lower efficiency at lower powers (because of increased throttling losses and constant parasitic losses such as moving the engine itself), the BEV gets lower efficiency at higher engine power because some power is required to drive the current from the battery.
   c) What other feature of a BEV allows it to get better mileage than an ICE driving around town? Regenerative breaking… In fact, when all put together, a BEV gets better mileage in the city, the ICE gets better mileage on the highway, and the hybrid gets about the same mileage.

4. Consider the different transportation technologies: ICE, BEV, Hybrid, Plug in Hybrid, H_2 Fuel Cell, and maybe something else that you could add. Please identify the pros and cons of each technology.