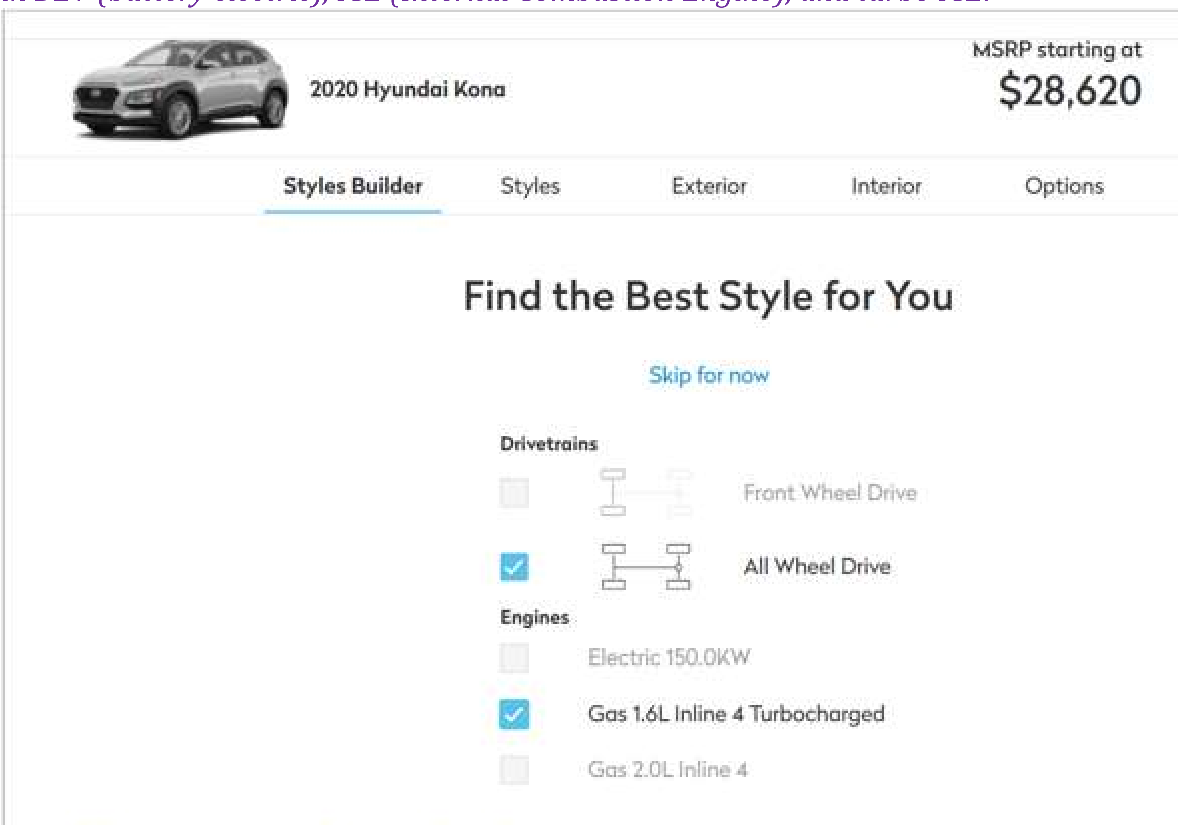
PS#9, Due in class, Monday, March 9nd

1. Please repeat my comparison of an electric car with an ICE. Imagine planning to use this car for 11 years – the average time for a car to stay on the road. Feel free to use the two versions of the Hyundai Kona that I used in class, but you can also look at other cars and trucks.
   a) Please compare the sticker prices and performance data,
   b) Please estimate how many miles you will drive in the car's lifetime.
   c) Please compare the costs of fuel for the two different cars.
   d) Please compare the maintenance costs for the two different cars.
   e) Please compare the lifetime CO_2 emissions of the two different cars.
   f) Please make any other comparisons that may be relevant.
   g) Which would you buy if given the choice?

In class I showed how I did this comparison with the Hyundai Kona, that you can choose to have in BEV (battery electric), ICE (Internal Combustion Engine), and turbo ICE:



https://www.truecar.com/hyundai/kona/

Drive:	Elect 150 kW (201 HP)	Atkinson 147 HP
Cost:	\$37,750	\$19,100
Efficiency	258 mi/64 kWh	27/33 mpg
0-60 mph	7.6 s	10 s
100 miles	4 mi/kWh=25 kWh	1.8/1.5 = 3.7 gal
Cost:	\$3.72	\$12.8
CO2:	~8 kg	~37 kg

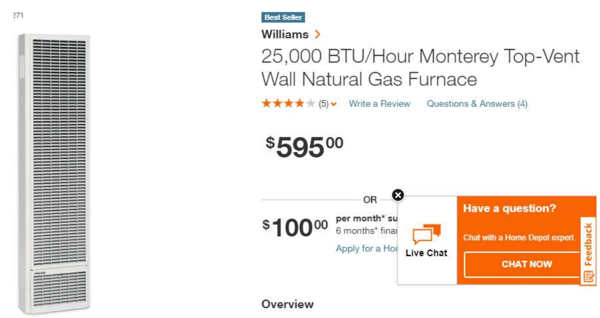
Let's say I drive the car 100,000 miles, this would amount to a cost of \$3,700 for electricity, versus \$13,000 for the ICE (before the price of gasoline dropped to nothing because of Saudi Arabia's stunt with the petroleum market. The emissions would be 8 and 37 tons of CO2 for the two cars, respectively… If there were a \$100 per ton of CO2 tax, it would increase the cost of driving these cars by \$800 and \$3700, respectively. It's also worth noting that down the road in California, we may have carbon free electricity for all, so CO2 emissions could drop further for the BEV.

2. Let's say you live in a moderately cold place… like the temperature is just freezing around you, 0 Celsius and you like your house warm, let's say 25 C. Your house requires on average about 1000 W to stay warm. You can use either a heat pump or burn natural gas. As we pointed out in the last problem set, NG (because of fracking) is at an all time low: ½ cent/kWh.
   a) Is 25 C actually warm? What is it in Celsius? *~ 77 F*
   b) What is the maximum COP (coefficient of performance) possible under these circumstances? *For an ideal Carnot heat exchanger, we'd get a COP ~ 12.*
   c) What if the heat exchangers to the house and the outside world required about 10 C difference in temperature to drive 1000 W of thermal power? What would be the maximum COP you could expect <u>*now*</u>? Keep in mind that there will be other losses, and this still represents a "best case scenario". *This would increase the dT we are pumping across by 20C, dropping the COP to about 7.*
   d) In the above scenario, how much electrical power is required to drive 1000 W of thermal energy to the house? *Power_electric_in ~ 1000/COP ~ 140 W*
   e) How is it that a heat pump can put more energy into your house than electrical energy consumed? *It pumps heat from the cold outside into the house.*
   f) If you buy a natural gas heater, assume it is 80% efficient because some of the exhaust to the outside world is still hot. *I'll need to consume NG power at a rate of about 1200 W to put 1000 W into the house.*
   g) For an entire year of heating, please calculate the total energy needed by each technology. For the heat pump, please put your answer in kWh. For the NG heater, please put your answer in MMBTU (or millions of BTU, which is about a GJ). *E = P*dt,*
   *Electric Energy = 0.14 kW * 8760 hr = ~1200 kWh*
   *NG Energy = 1200 W * 3.14*10^7s ~ 38 GJ ~ 38 MMBTU*

h) How much money will each of these two heating technologies cost you for a year?
Electricity: 1200kWh$0.15/kWh ~ $180*
*NG 38 MMBTU * $3.00/MMBTU ~ $114*

i) How much CO_2 is emitted by each of these two heating technologies for a year?
*Electricity: 1200 kWh * 1/3 kg/kWh = 400 kg*
*NG: 38 GJ*15g/MJ * (44g CO2 / 12 g C) = 2100 kg… lots more!*

j) How much does a heat pump for a house cost vs installing a NG heater? *Looks like they are about the same. The heater is about twice as powerful as the heat pump… But you'd expect this because it's way easy to just burn natural gas as opposed to drive a compressor. In any case, 12,000 BTU per hour is 12 MJ / hr ~ 3 kW… more than enough!*



k) Are there any other considerations to take into account? *YES! How cool (pun intended) would it be in the hot hot summer to turn the switch on your heat pump to drive the cycle the other way around and pull heat from your house at about 3 kW!!*

l) Which would you buy for your little home if you were building one now? *OK, I haven't had a heater in the house or annex for some time now… I should buy one… or two…. Or I'll just plant another deciduous tree on the south side and add more insulation.*

3. Please repeat your assessment #9 in fine form. The assessment with some (hopefully) helpful comments has been posted on the main class website.
See solutions.

4. Representing a renewable energy company installing Vestas (Vestas.com) turbines, you are looking for places to install wind turbines! You are thinking of paying a farmer to install them on his corn field… but then another farmer boasts that she has an average wind speed that twice as high because her pasture land is on a hill top. BUT she wants you to pay her <u>*three times as much*</u>. On top of that, the installation costs (about 1/3 of the entire turbine costs) will be 50% higher because of the hill top site.
   a) Should you blow the extra money to put the turbines on the hill top? Explain. *YES! This ruthless price gouger obviously knows here energy technologies. The accessible power scales like the wind speed CUBED!. So with twice the average speed, you'd expect 8 times as much power generated (2^3).*
   b) The hill top is way out in a rural area… what other expenses would this present? *We have to connect to the grid. Thus, there are probably more expenses for the hill top site, unless there was once a coal facility in the area that is going out of business.*