

Hybrid, Plug-In Hybrid or Full Electric?

Background

The gradually increasing electrification of the road vehicle fleet has reached a level where the vehicle customer in some cases can choose between conventional, hybrid, plug-in hybrid and full electric versions of the same vehicle model. The difference in ownership economy and environmental impact are differentiators that may determine the choice of which vehicle to buy. It is however not an obvious choice and different voices provide conflicting arguments on availability of mineral resources, availability of clean electricity and lifetime of batteries.



This home assignment is about a comparison of the three different drive trains Hybrid, Plug-In Hybrid and Full Electric in the very same vehicle. The vehicle selected for comparison is the Kia Niro, which comes in these three versions. They will be compared on the following aspects:

1 Operational cost and depreciation.

The operational cost is limited to the energy consumption. The following assumptions apply:

- a. Gasoline price: 1.5 Euro/liter.
- b. Electricity price: 0.17 Euro/kWh.
- c. Depreciation: 50 % of purchase price the first 50000 km, assuming this distance is travelled in 5 years.
- d. Battery cost: 100 Euro/kWh on system level.

2 CO₂ emissions.

The CO₂ emissions are based upon the following assumptions:

- a. Gasoline: 2300 g CO₂/liter; 9.1 kWh/liter
- b. Electricity: Swedish, European, Global and Chinese electricity mix. For the student to find.
- c. Battery manufacturing: With the different electricity mixes, assuming XX kWh electricity per kWh battery capacity. XX is for the students to find in literature. A scientific article is available at the course home page as a start.

The assignment

- 1 Work alone or in groups of two, not more.
- 2 Use the simulation program “ParallelHybrid” and “GeneralFEVmodel” to simulate all three vehicle versions. It is possible with some settings in the code to shift between Hybrid and Plug In Hybrid in the “Parallel” version, about line 99 in the code. The files can be downloaded from the course homepage. You must populate the models with the correct values of Vehicle mass, Frontal area, Roll and Drag-coefficients, Combustion engine power and max torque, Battery size etc. They are all denoted XXX in the code.
- 3 Study the ratio of Combustion engine power vs Electric traction drive power for the Hybrid vehicle assuming the same total tractive power (ICE+Electric) by running a sweep of Electric/Total power from 10 to 40 % and evaluating the fuel consumption in the WLTP3 cycle. Compare your findings to the real Kia Niro hybrid specifications, both in terms of power and in terms of fuel consumption.
- 4 Run all three drive trains through the WLTP3 cycle and calculate the fuel-, and electric energy-, consumption. The fuel economy for the Plug In Hybrid is complicated to express as one figure only (e.g. [l/10km]) and you benefit from keeping the gasoline and electric energy consumption apart. Even so there is still no strict rule for how large part of the drive cycle that should be run with the battery depleted in the Plug In Hybrid. There is a suggestion – that you run the same drive cycle (WLTP3) three consecutive times. That will deplete the battery after about two of these series and the third will be run with the ICE much more engaged. That is a reasonably good approximation of how a real plug in hybrid is used.
- 5 Calculate the Operational cost (energy cost and battery depreciations cost according to the assumptions above) and the related CO₂ emissions (from the energy with different sources and electricity mixes) for all three vehicles.
- 6 Search information on the CO₂ emissions related to battery manufacturing under different conditions, like different electricity mixes and related the CO₂ from battery manufacturing to the CO₂ related to operation of the three different vehicles under the different conditions in item 5 above.
- 7 Write a report presenting the thoughts behind your solution and the results, supported with a presentation of your simulation model, your control strategy and simulation results. Submit the report by e-mail and Meng (meng.lu@iea.lth.se) no later than **Oktober 18th**. Use the filename student1_student2_assignment2.xxx”. The report must be complete including front page and table of contents, all in one file. The report must be in “pdf” or Microsoft Word format.

Presentation @ BW

You should present your own arguments for WHY one of the three vehicles (Hybrid, Plug In Hybrid, Full Electric) is the preferred choice at certain markets. The markets are either Europe, Asia/China or the US with everything that implies regarding electricity generation.

You may argue as you like, for purchase price, environmental impact, life cycle cost.

Be a car salesman and convince the customer!