SCHOOL OF ENGINEERING
MECHANICAL ENGINEERING
LRESE - Laboratory of Renewable Energy Sciences and Engineering

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Renewable Energy: Exercise 10

In this exercise, you will calculate the capacity of a renewable power driven hydrogen filing station.

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1. Hydrogen from renewable electricity for mobility applications

   (a) Consider a hydrogen filling station fed by a renewable electricity produced by wind. The windmill has blades of 50 m diameter, with a power coefficient of 0.4, operating at an average wind speed of 9 m/s and 3000h annual load for the electricity generation. Assume continuous power generation for 12 hours at these conditions. The electricity is converted (AC/DC converter efficiency 95%) and used in an electrolyzer (efficiency 70%) to produce hydrogen. This hydrogen is stored in a storage tank at 400 bar. Take into account the compression loss. Fuel cell hydrogen cars come and tank daily at this filling station (3 kg hydrogen per car, for 300 km range, without battery). Filling losses are neglected. How many cars can be tanked daily on average, and at most, at this filling station?

   Hint: The power produced by a windmill can be calculated by the formula: P = $0.5\rho_{air}c_pAu^3$, where ρ_{air} is the density of air, c_p is the power coefficient, A is the projected area of the mill, and u is the wind velocity.

   (b) Consider a hydrogen filling station fed by a renewable electricity produced by solar photovoltaics. The PV farm consists of an area of 2000 m^2 panels, working at 15% efficiency, and effectively producing 1500 h/yr at an equivalent solar input of 700 W/m^2. Max storage (after electrolysis) corresponds to 10h of continuous power generation at these conditions. How many cars can be tanked daily on average, and at most, at this filling station?

   (c) What is the consumption (in kWh/km or MJ/km) of the car, counting from the produced electricity from the windmill or PV installation? How does this compare with an average gasoline car that consumes 7.5 L/km (33 MJ/L)?