

## Renewable Energy: Hydrogen Exercise

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

---

### 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 3000 h annual load for the electricity generation. Assume continuous power generation for 12 hours at these conditions for an optimal day. The electricity is converted (AC/DC converter, efficiency 95 %) and used in an electrolyzer (efficiency 70 %) to produce hydrogen at 1 atm and 25°C. 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  $\rho_{air}$  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. Further, the  $\gamma$  value for hydrogen is 1.41.

- (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<sup>2</sup> panels, working at 15 % efficiency, and effectively producing 1500 h/yr at an equivalent solar input of 700 W m<sup>-2</sup>. Max storage (after electrolysis) corresponds to 10 h 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 per 100 km (33 MJ/L for gasoline)?