Hydrogen-based energy storage for a distributed generation system

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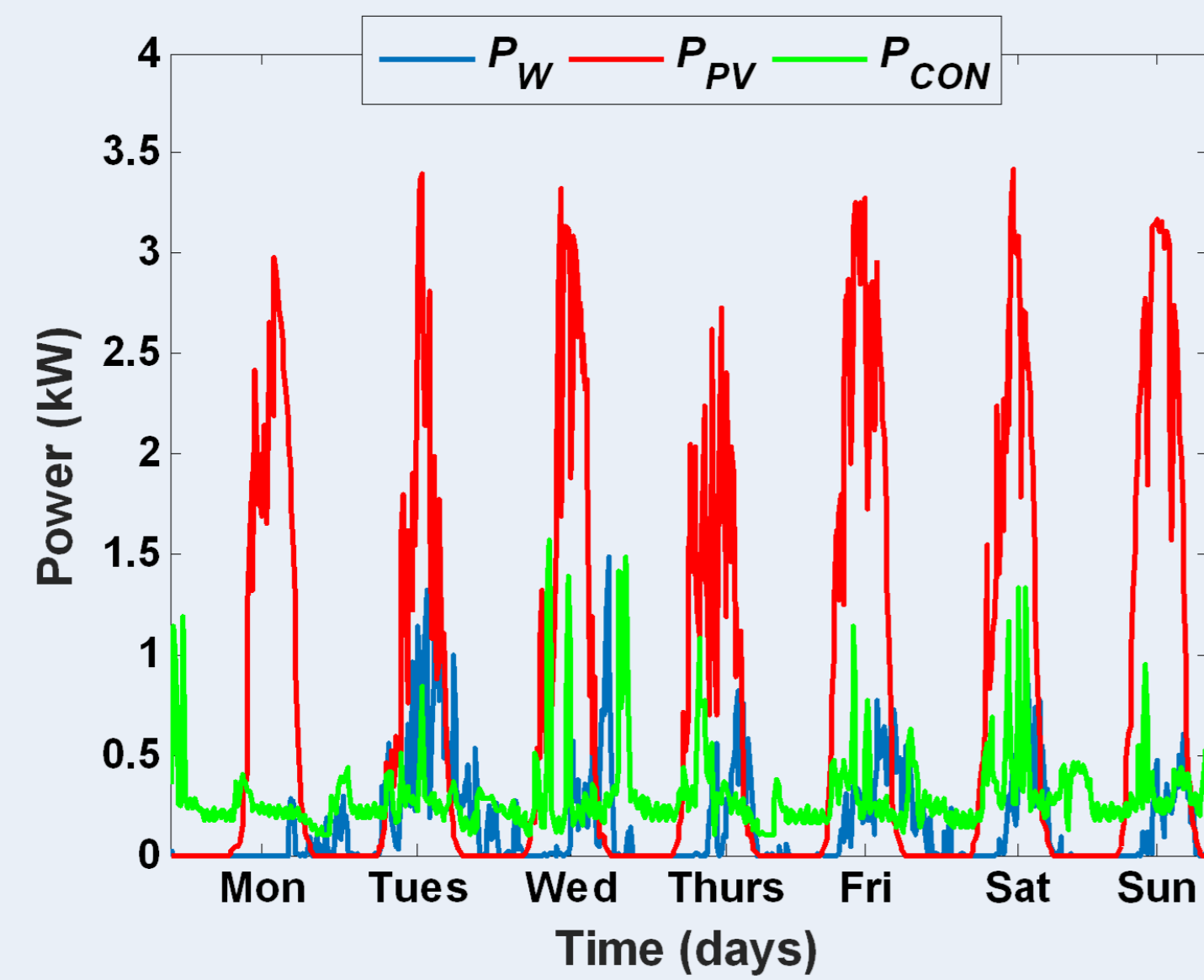
PURPOSE

Sizing methodology for hydrogen energy systems for a distributed generation system

- Optimization of the grid power consumption
- Satisfaction of technical requirements of grid power
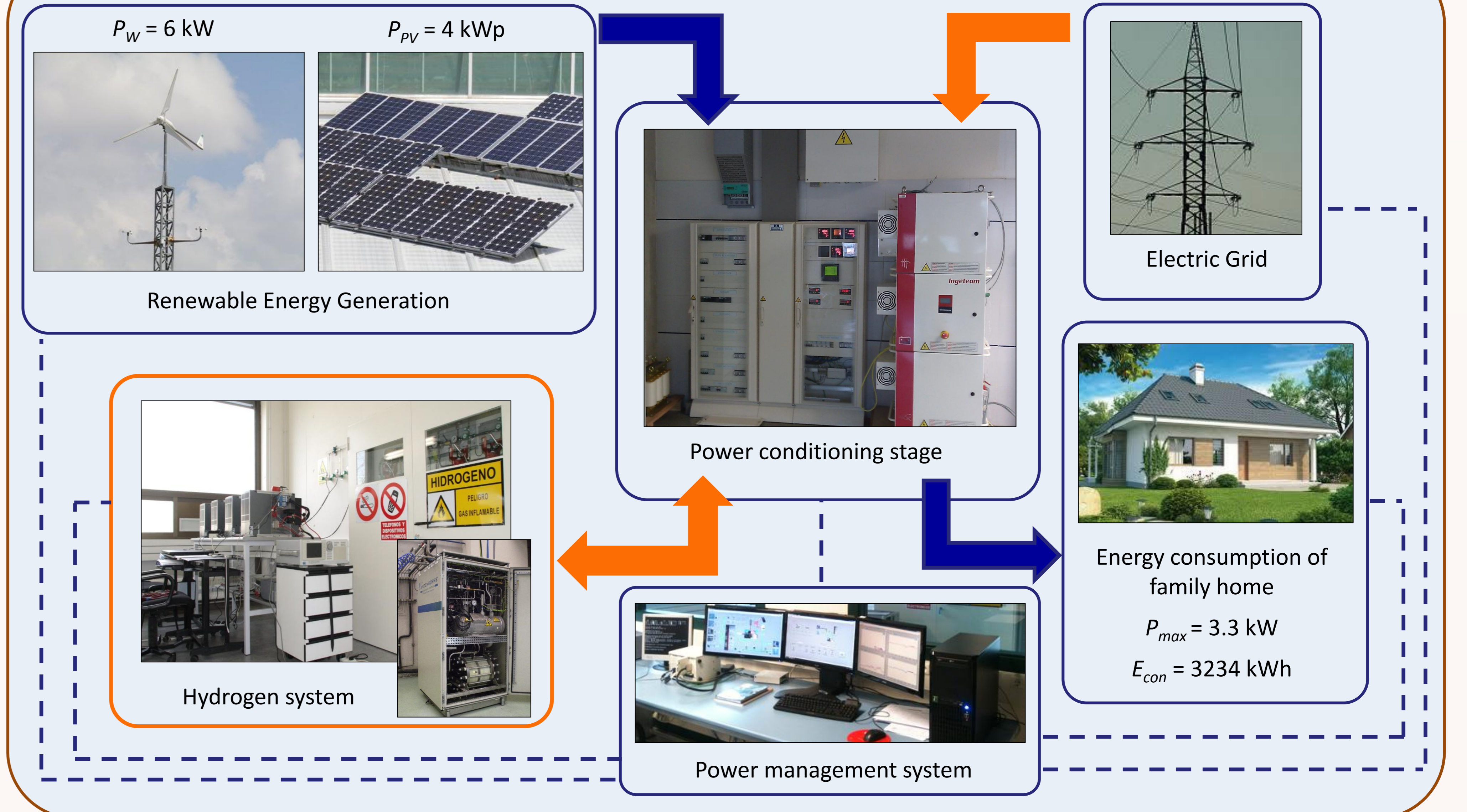- Optimization of the storage system size

EXPERIMENTAL DATA

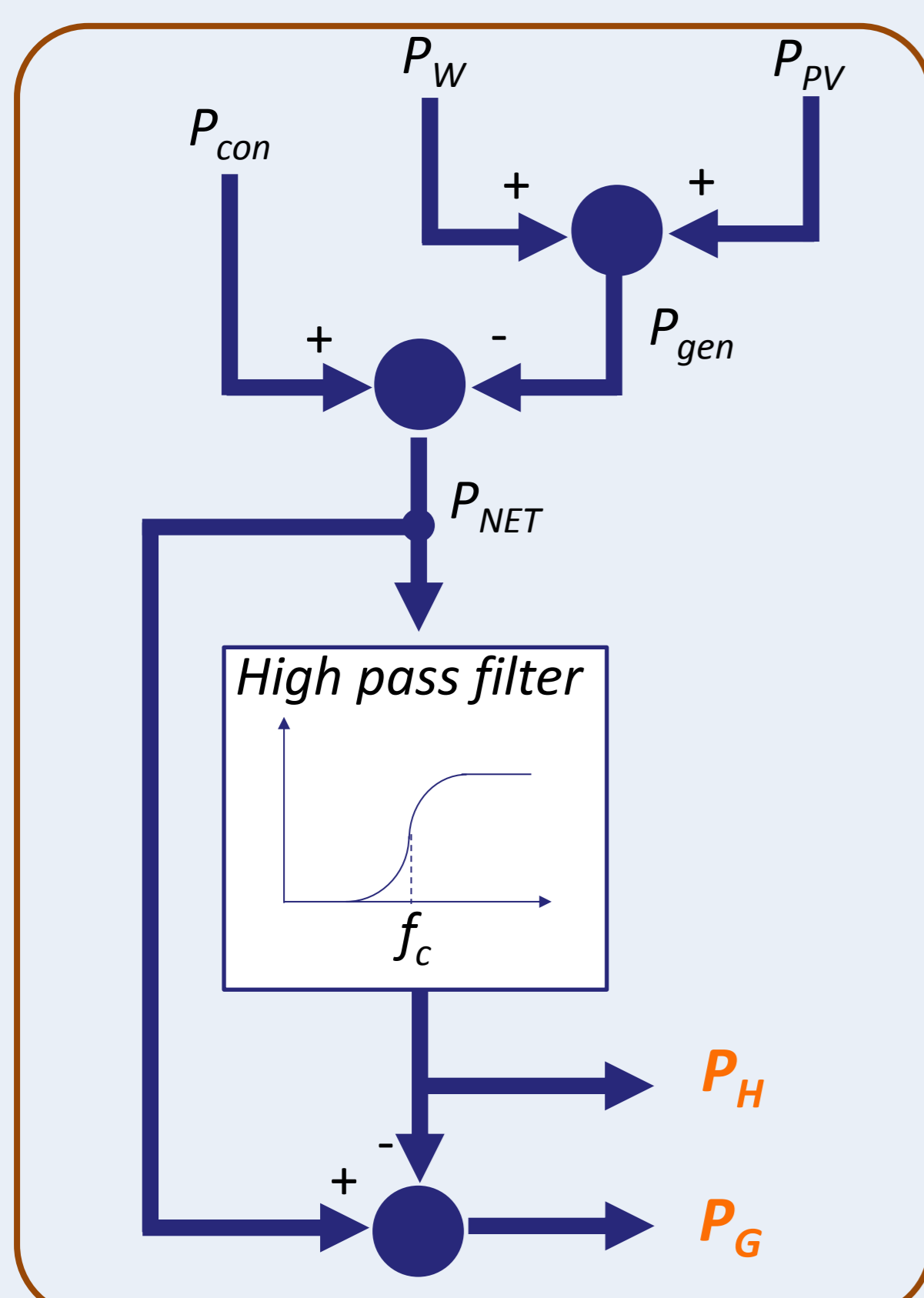- Electrical power measured in the experimental microgrid:
  - ✓ P_W
  - ✓ P_{PV}
  - ✓ P_{con}

MICROGRID DESCRIPTION

P_W = 6 kW P_{PV} = 4 kWp

Renewable Energy Generation

Power conditioning stage

Hydrogen system

Power management system

Electric Grid

Energy consumption of family home

P_{max} = 3.3 kW

E_{con} = 3234 kWh

SIZING METHOD

P_W P_{PV} P_{con} P_{gen} P_{NET}

High pass filter

f_c

P_H P_G

Considerations:

- No injection into the grid => $P_G > 0$
- Fuel cell and electrolyser performance:

Fuel Cell (FC)   Electrolyzer (WE)

H_2 tank

$P_H < 0$ $P_H > 0$

$\eta_{FC} = 0.5$ $\eta_{WE} = 0.65$

- Electrolyser power is limited => $P_{WEmax} = 3$ kW

Sizing of the H_2 tank energy capacity:

$$DA = DA_0 + C_\eta E_H$$

- $P_H < 0 => C_\eta = 1/\eta_{FC}$
- $P_H > 0 => C_\eta = \eta_{WE}$

Required Energy of hydrogen tank:

$$E_{TH} = max(DA)$$

Cut-off frequency:

- $f < f_c$ => Hydrogen Power
- $f > f_c$ => Grid Power

Filter time constant ranges ($1/f_c$)

From 12 hours to 15 days (360 hours)

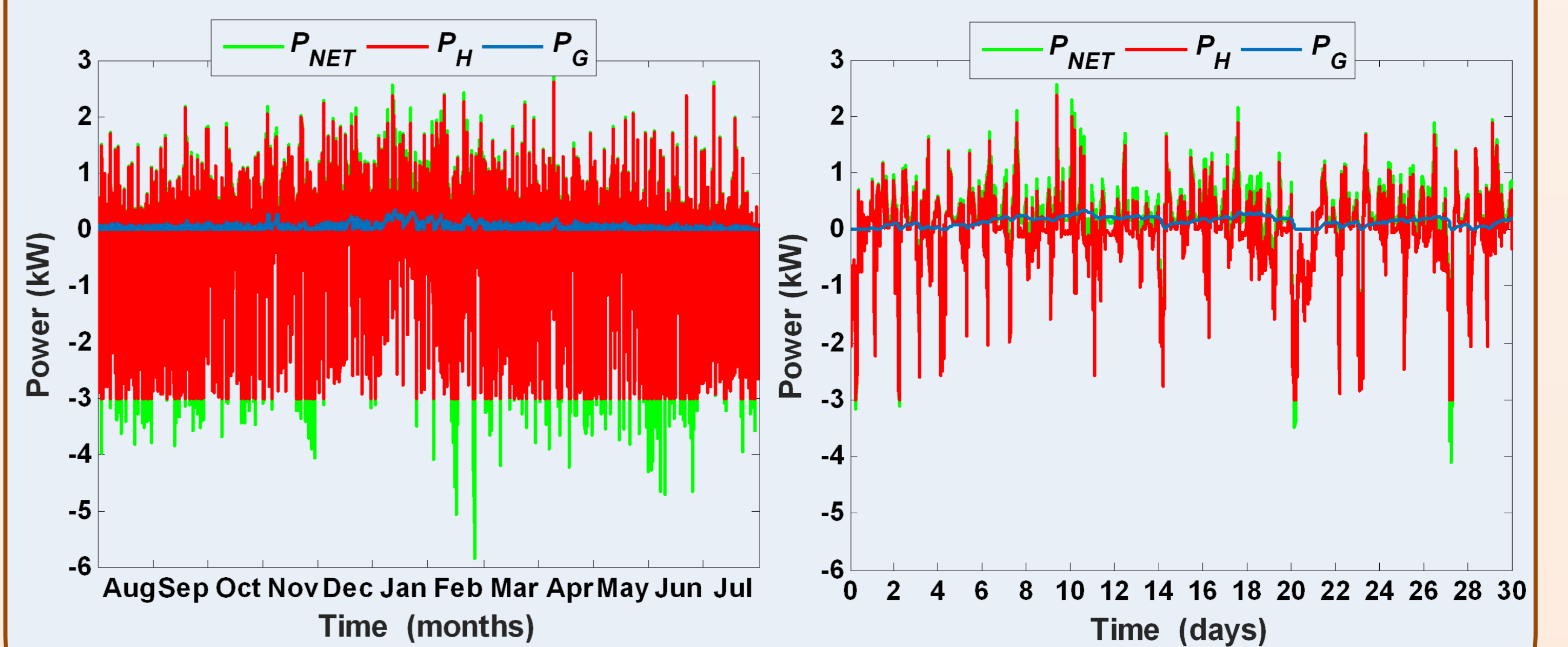## RESULTS
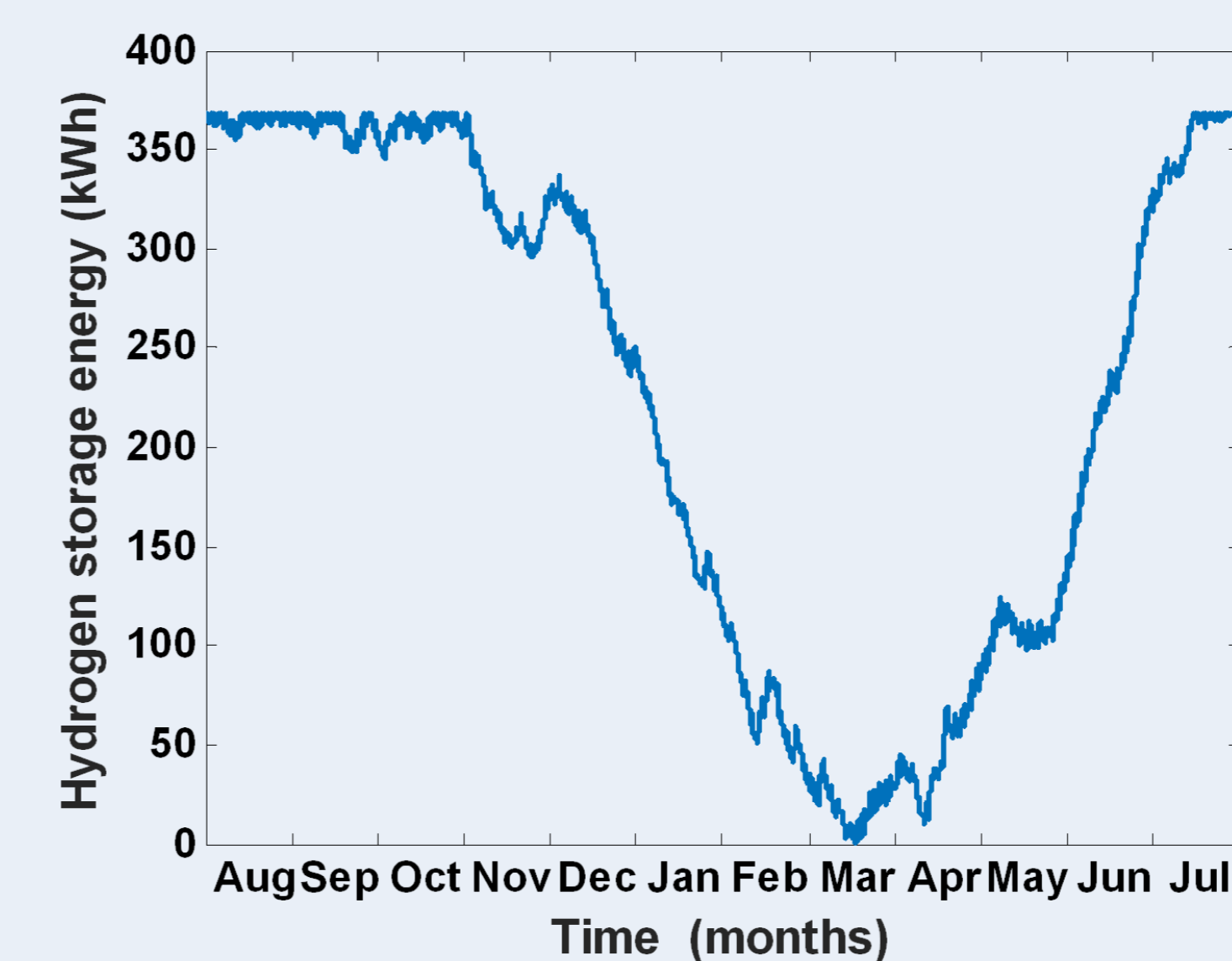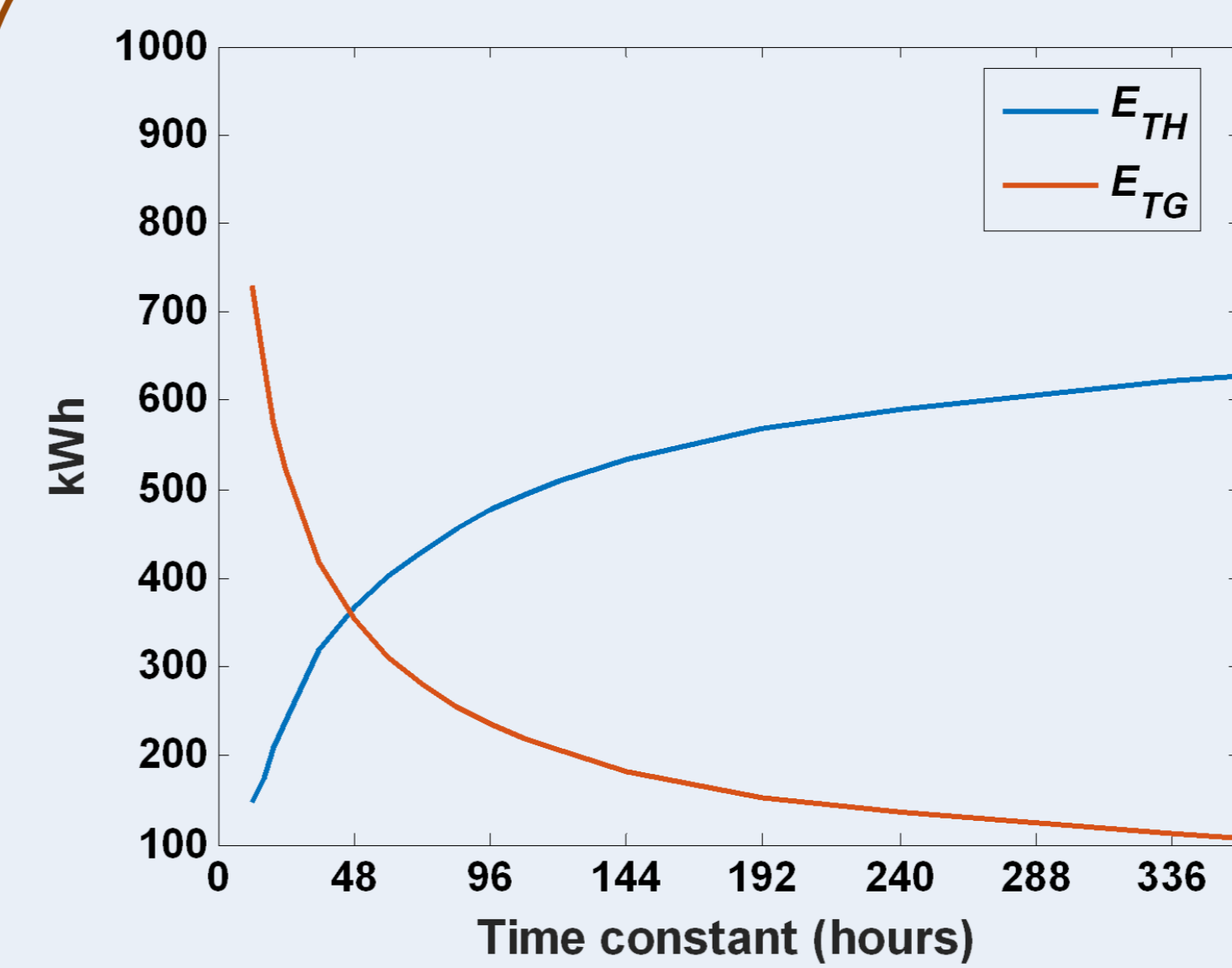
Solution:

$$1/f_c = 48 \text{ hours}$$

Hydrogen system:

- E_{TH} = 368 kWh
- P_{WE} = 3 kW
- P_{FC} = 3 kW

Grid requirements:

- E_{TG} = 354 kWh
- P_G = 0.34 kW

Operation of the electrical microgrid in the course of a year

SUMMARY

Sizing methodology of Hydrogen energy storage systems for an experimental grid-tied microgrid

- Feasible storage system complemented by the grid
  - ✓ Annual Energy supplied by the grid
    - => Less than 10 % of the annual consumption
  - ✓ Grid power
    - => Slow variations
    - => 90% reduction of subscribed power