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# GRID-IMPACT FACTORS OF FIELD-TESTED RESIDENTIAL PROTON EXCHANGE MEMBRANE FUEL CELL SYSTEMS

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*Energy transition requires flexible power sources to compensate renewables intermittency (or storage, or demand)*

→ *For example : "Teaching the duck to fly"*


→ *Power sources shall be considered regarding :*

- *Efficiency*
- *LCA carbon footprint*
- *Load factor*
- *(Utilization & capital) costs*
- *Power density*
- *etc*
- *Supply & Demand cover factors*

$\gamma_s$ $\gamma_d$

***Both helps evaluating how the electrical production matches the demand :***

→ $\gamma_s$ *: What is the share of energy not rejected on the grid ?*
→ $\gamma_d$ *: What is the share of the demand provided by the power source ?*

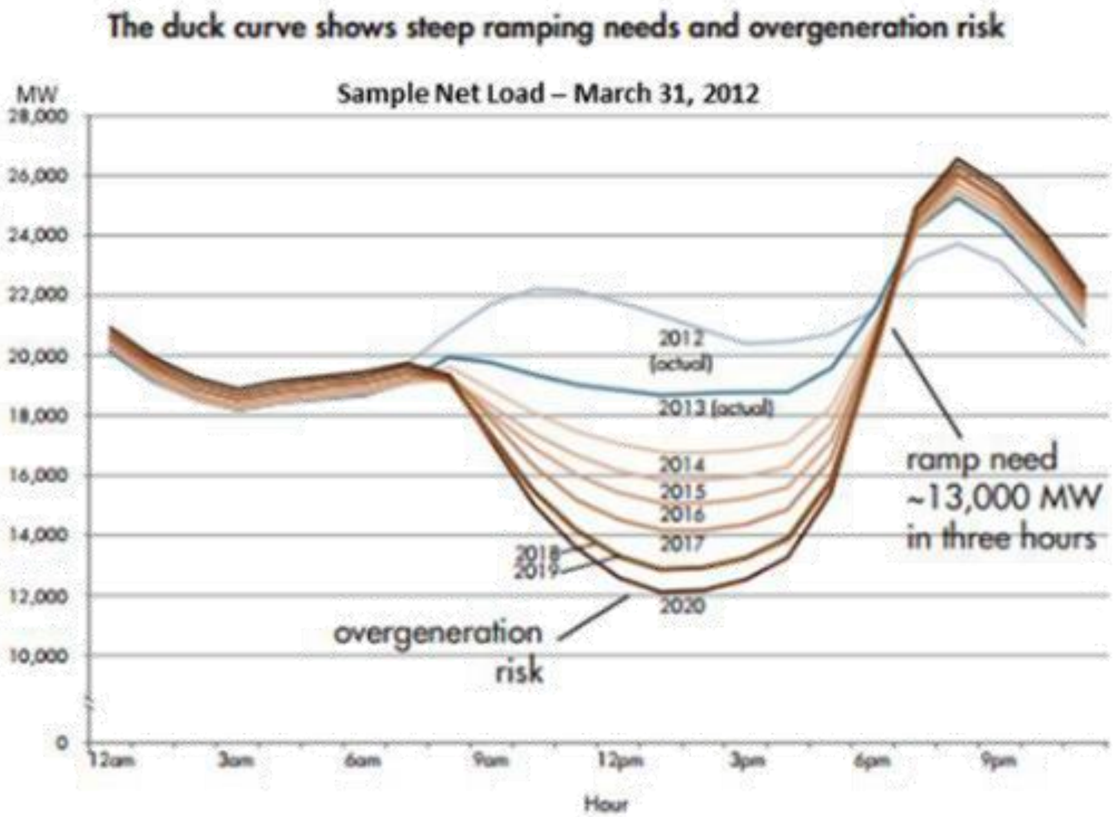



**Fig. 1 -** "Duck curve" is worsen with higher renewable share (in California)

Source : California ISO

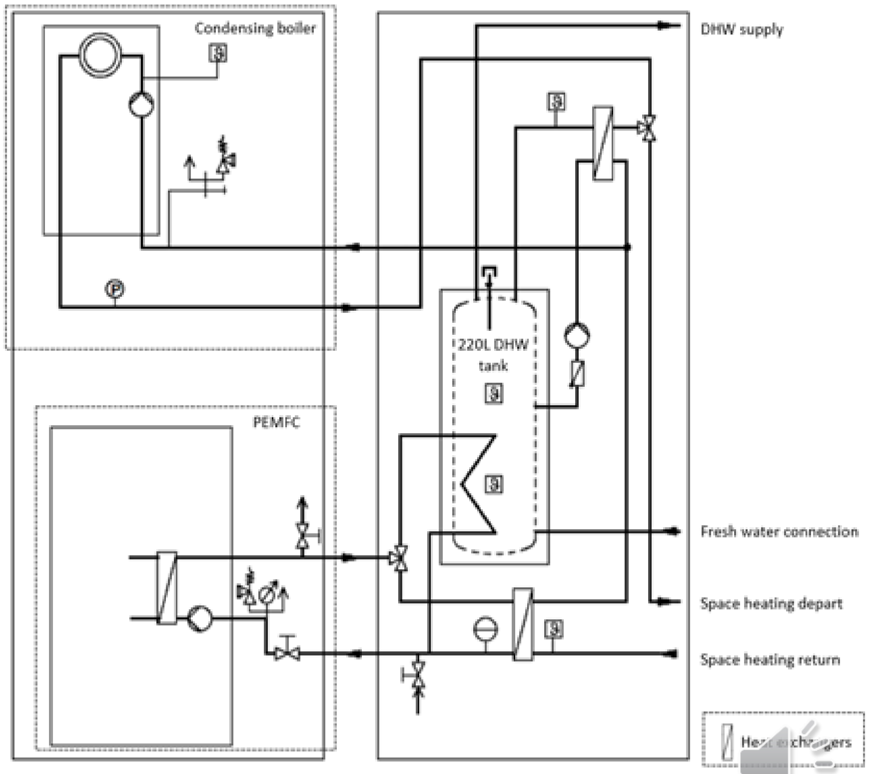
$$\gamma_s = \frac{\int \min\{P_D, P_S\}dt}{\int P_S dt}$$

$$\gamma_d = \frac{\int \min\{P_D, P_S\}dt}{\int P_D dt}$$

*See paper*

## *The system :*

| | PEMFC gas boiler hybrid |
|---|---|
| Heating output | 0,9 - 30.8 kWth (boiler only) but 8 – 30,8 kWth (with FC + boiler) |
| Electrical output FC | 750 W |
| Thermal output FC | Up to 1.1 kW |
| Yearly electrical production | Up to 6200 kWhel |
| FC LHV electrical efficiency | 37% |
| DHW tank capacity | 220L |

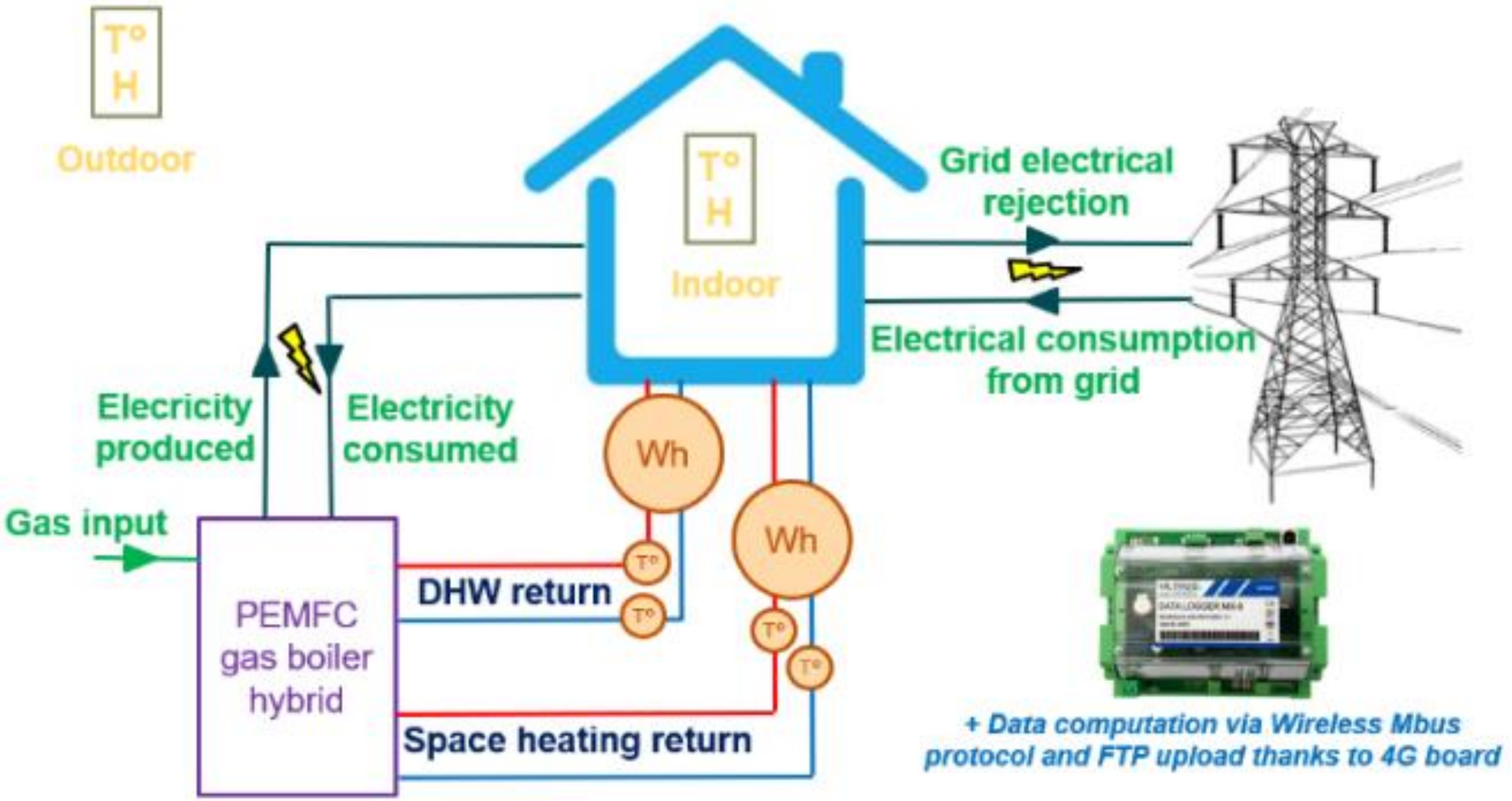




*Natural gas-fed, heat-driven system :*

*PEMFC turned off if DHW tank is thermally loaded and if there is no more space heating demand;*

*Also turned off if return temperature >50°C*

## *Monitoring configuration :*

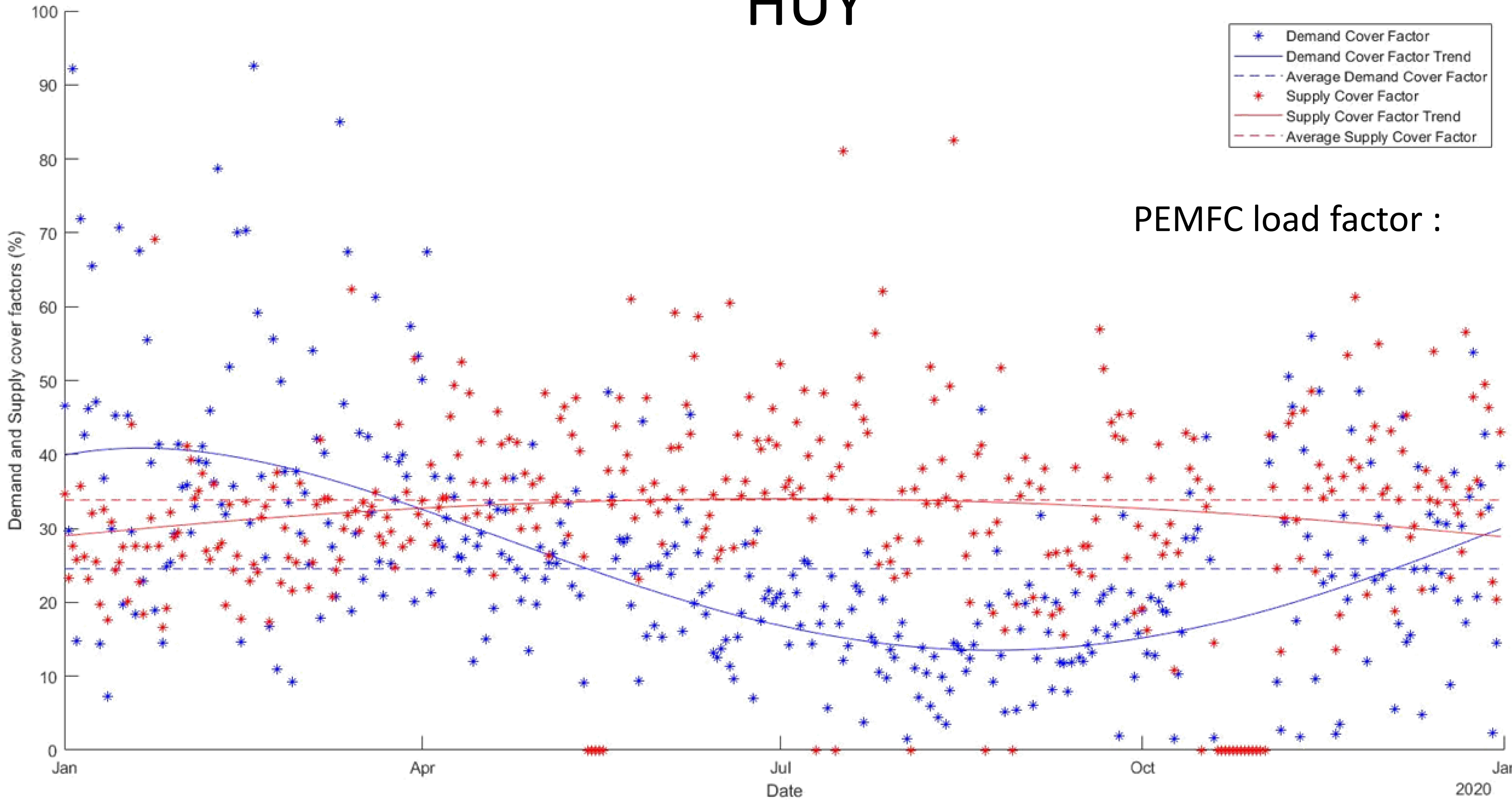




*2 houses monitored for the whole year 2020*
*Sample time <5 minutes*
*Oostmalle -> floor heating (1st floor only)*
*Huy -> high temperature terminal units*

*Results :*

# HUY




PEMFC load factor : Huy ≈ 35%
Oostmalle ≈ 52%

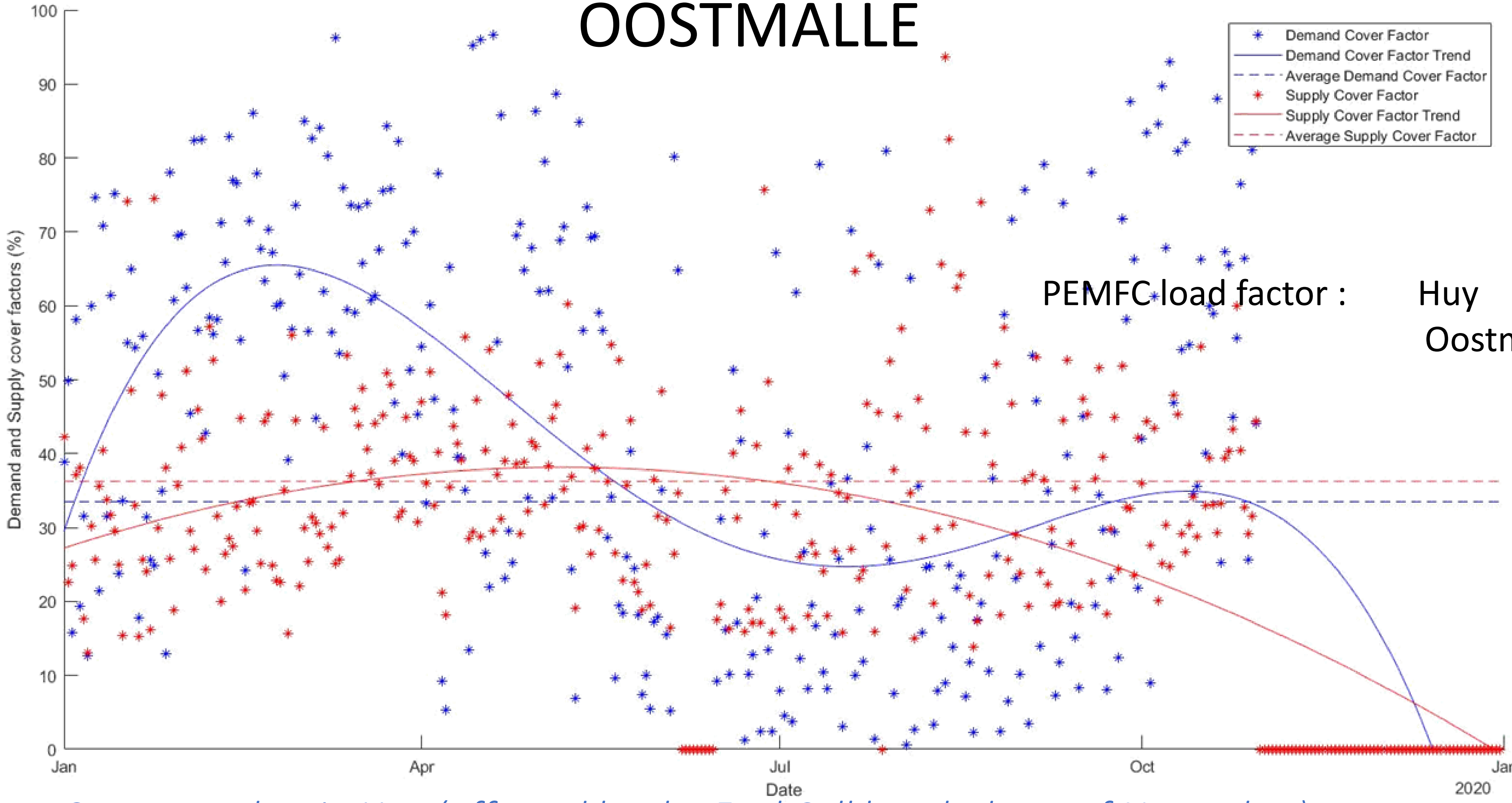
$\gamma_s = 34\%$

$\gamma_d = 25\%$

*Small seasonal effect : lower electrical production in summer leads to higher supply cover factor and lower demand cover factor*

*Results :*

# OOSTMALLE




PEMFC load factor : Huy ≈ 35%
Oostmalle ≈ 52%

$\gamma_s = 36\%$

$\gamma_d = 33\%$

*Same trend as in Huy (affected by the Fuel Cell break-down of November)*
*Higher demand cover factor linked to higher PEMFC load factor*

## *Conclusions :*

*The load factor has a stronger influence on the demand cover factor than on the supply cover factor (due to low and constant production)*

*Average supply cover factor about 35% → literature review at those latitudes shows that PV installations rarely actually reach 35% of supply cover factor (see paper)*

*Certainly less seasonal dependent than PV installations*

*BUT : - no flexible electrical production (no significant improvement of supply cover factors against PV installations)*
*- environmentally questionable as it currently burns (fossil) natural gas & lower electrical efficiency than combined-cycle gas turbines*