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Influence of the optimal storage tank capacity on the economy of hybrid PV micro-CHP systems

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Abstract

Hybrid renewable systems, made up of a **PV unit and a micro-Combined Heat and Power** technology can help to cope with the intermittency of solar energy, **reducing the stress on the distribution electricity grid**, while **reducing the emissions** of the building sector [1]. However, the introduction of such technologies s**eeks an optimal dimensioning approach** in order to maximise their competitiveness with respect to fossil fuel generation.

Aim. The present paper focuses on the **use of water storage tanks** in the residential sector to **enhance the economy of hybrid renewable systems** through the analysis of the influence of the main design parameters on its optimal size. Results show as the **positive contribution of TES** is evident **in case of a higher operational flexibility**, such as with a Time of Use electricity Tariff. The outcome suggests as a **higher flexibility in the energy tariff system can help the economy of micro-generation.**

1. Conceptual layout of the hybrid system

The conceptual **layout of the proposed hybrid system** is reported below.

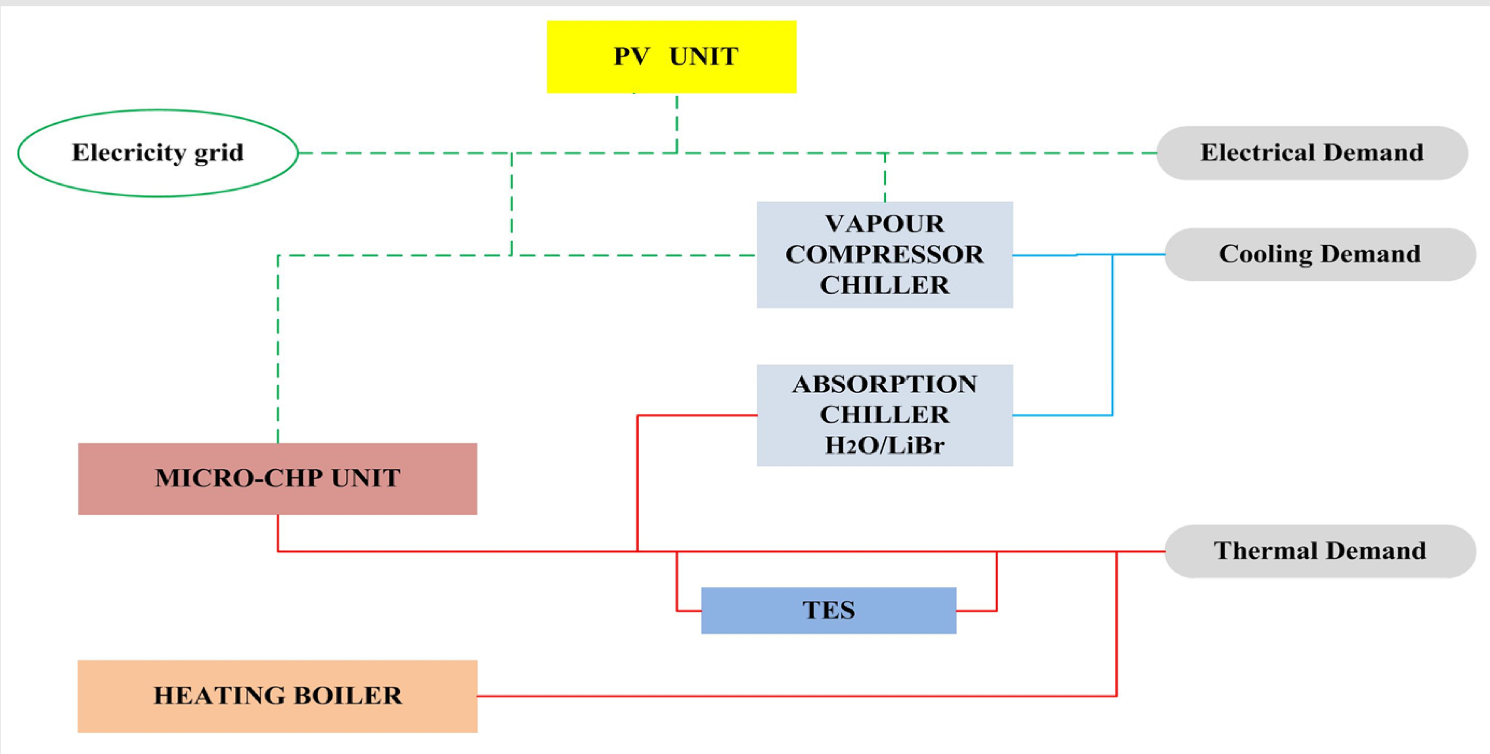

Figure 1 – Hybrid system layout

PV panel efficiency: calculated on the basis of the **panel temperature** and the **available irradiation** [2].

Three technologies of m-CHP: **ICE, Stirling engine** and **fuel cell** [3].

	ICE	Stirling	Fuel cell
Electrical efficiency [%]	24	15.8	40
Thermal efficiency [%]	64	75	40
Specific cost [€/kWe]	3,400	4,500	6,700
O&M COST	0.021	0.017	0.019
Lifetime		10 years	
	Compr. chiller	Absorp. chiller	
COP	3	0.7	
Specific cost [€/kW]	250	300	

2. Optimization procedure

Main aim of the optimization algorithm: 1) **satisfy the thermal and electric demand; 2)** achieve **minimum total annual cost criterion** [3].

Loads: a typical day for each season with a time step of one hour.

Tariffs: 1) **a flat electricity tariff of 0.16 €/kWh 2) a variable tariff, following a daily market trend**, have been chosen (costs of distribution and dispatch have been added in order to reach the **same average value of the flat tariff**).

3. Results and discussion

Size of the micro-CHP unit and TES, yearly savings of the hybrid renewable energy system defined by the **optimal sizing procedure**.

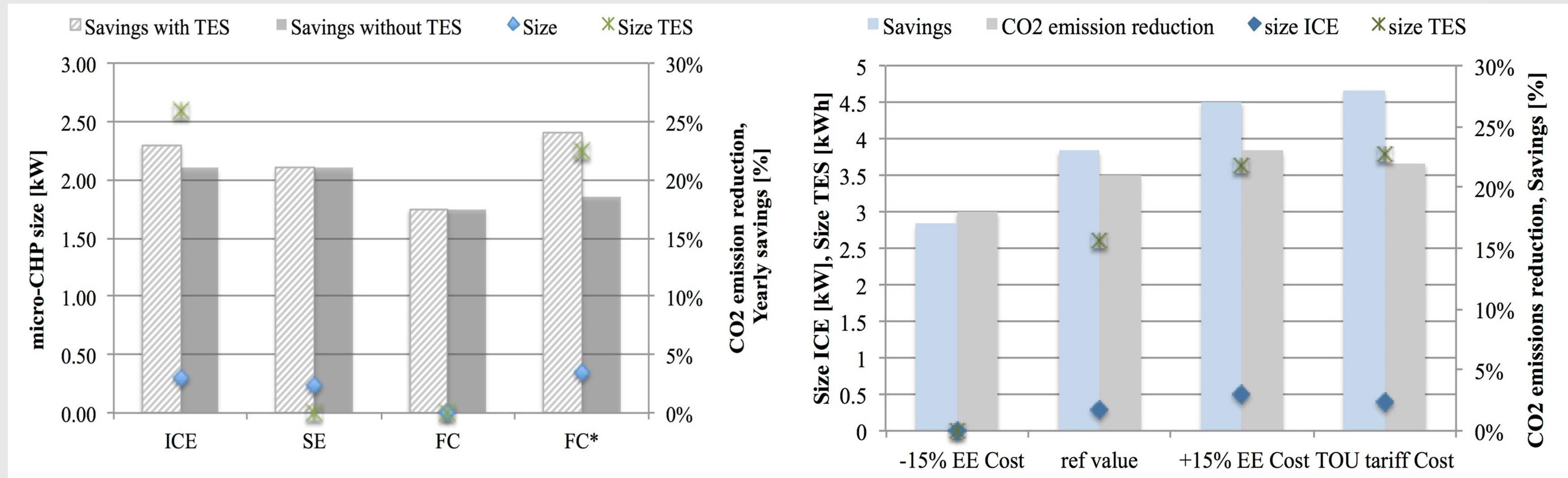

Figure 2 – Size of the CHP and TES (a); variable electricity price for ICE case (b)

ICE is recognised to be the **most advantageous micro-CHP technology** in residential applications [4]. **Fuel cell is too expensive.**

Higher electricity tariff → **increased attraction of TES**

Effect of different NG tariffs on **savings, CO_2 emission reduction** and **sizes of micro-CHP and the TES: ICE** (Figure 3a) and **SE** (Figure 4b) case

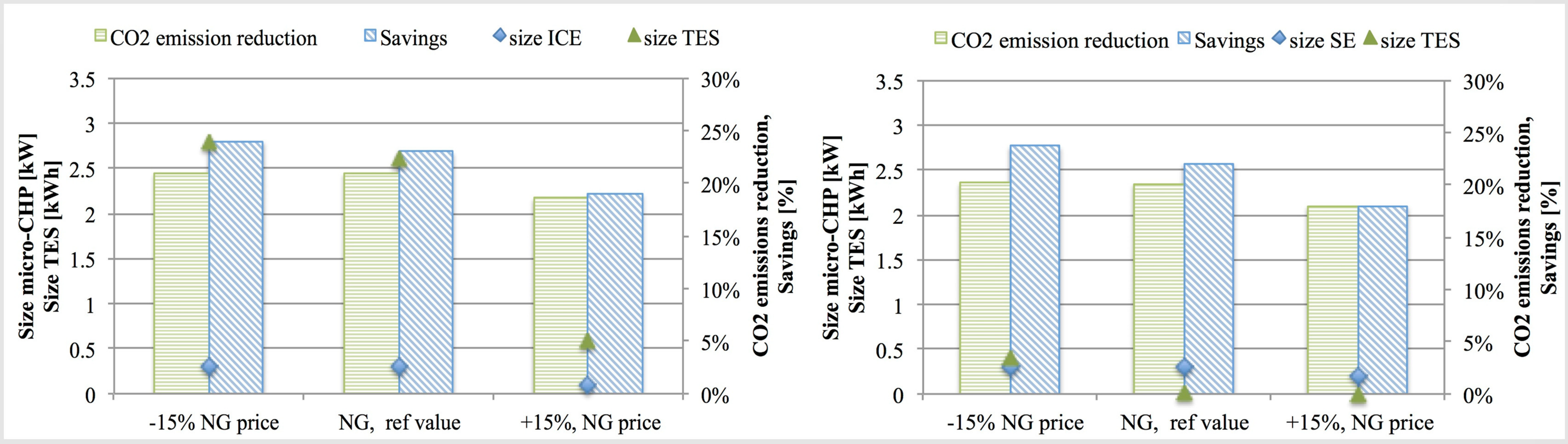

Figure 3 – Effect of variable NG price for ICE case (a) and SE case (b)

Lower NG tariff → **improved economy**

ICE case: **operating hours** ↑ **TES capacity** ↑

SE case: **operating hours** ↓ **TES capacity** ↑

Influence of reducing the capital cost of micro-CHP and TES: **ICE and SE** cases.

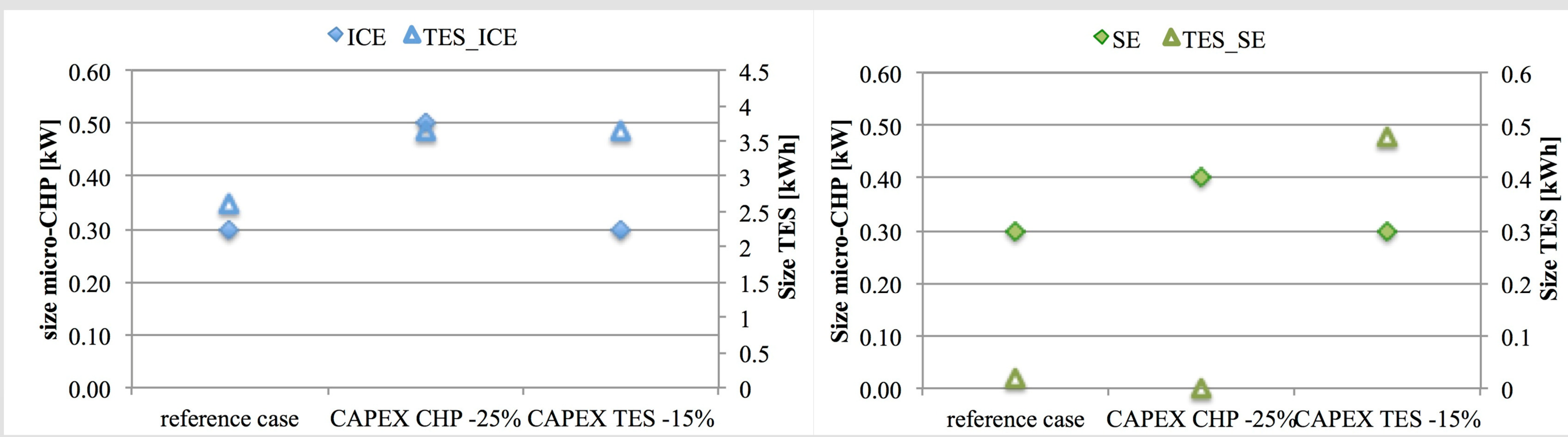

Figure 4 – Influence of CAPEX for ICE case (a) and SE case (b)

Reduction in the cost of the **TES** → **limited savings (2-4%)**

Reduction in the cost of the **m-CHP** → **higher savings (SE)**

4. Conclusions

ICEs represent the most suitable technology for residential applications. **Higher savings can be achieved with a water storage unit**, in particular in case of: i) a higher **flexibility of the electricity tariff**, ii) **lower NG tariff** (reduced taxation), and iii) a **reduction in the cost of storage tanks**, that could be provided as grant scheme.

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