Optimal management and sizing of reversible heat pump/ORC Carnot batteries working in synergy with a district heating substation

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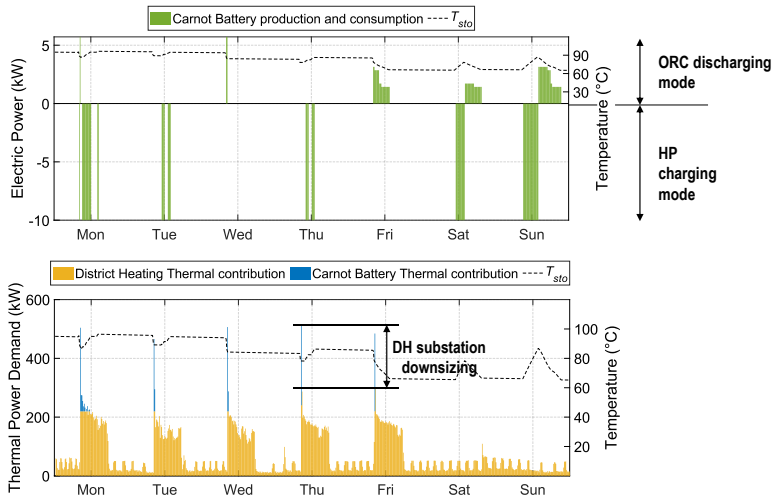
ABSTRACT

The use of Carnot Batteries, which can be realized by means of a reversible Organic Rankine Cycle (ORC)/heat pump (HP) [1], is a promising solution in the development of strategies for the flexible use of renewables. The Carnot battery allows to store electricity surplus by converting it into heat (heat pump mode), and then reuse this heat by converting it back in electric energy (ORC mode) when needed. This arrangement can become very interesting in many applications, involving both thermal and electrical energy flows [2].
In this study, the authors propose to analyze the optimal management of a 10 kW-size reversible HP/ORC Carnot battery (CB) when working in synergy with a district heating (DH) substation and a solar photovoltaic plant. The reversible HP/ORC prototype installed at the University of Liège [3], its DH substation and demand profile are used as case study. An off-design model of the system is employed to simulate its optimal management when the boundary conditions (i.e. building demand and ambient conditions) vary with the time. Choosing as reference a typical week in December, as shown in Fig. 1., the thermal energy storage (TES) allows to downsize the DH substation, partially satisfying the early morning peak of thermal demand. Then, the storage temperature is reincreased by the CB in HP working mode. The DH substation downsizing of 213 kW provides an economic gain of € 86 per week. Furthermore, the TES can be also discharged to produce electricity (ORC mode). The pay-back period of the CB is estimated to be of about 4 years.



[PERFORMANCE RESULTS] Fig. 1. CB optimal management and DH substation downsizing

References

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