The performance evaluation of a grid-tied microgrid with hydrogen storage and a hydrogen fuel cell stack

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1. Introduction

In a heat-power system, the use of distribute energy generation and storage will improve system's efficiency, reliability, and emission. This work is focused on the comprehensive performance evaluation of a grid-tied microgrid, which consists of a PV system, a hydrogen fuel cell stack, a PEM electrolyzer, and a hydrogen tank. The performance indexes of this microgrid are compared with one without energy storage or a fuel cell stack. As a result, the environment effect and the service quality in the first system is higher than those in the second one. But they both have the same overall performance index.

2. Model of the microgrid

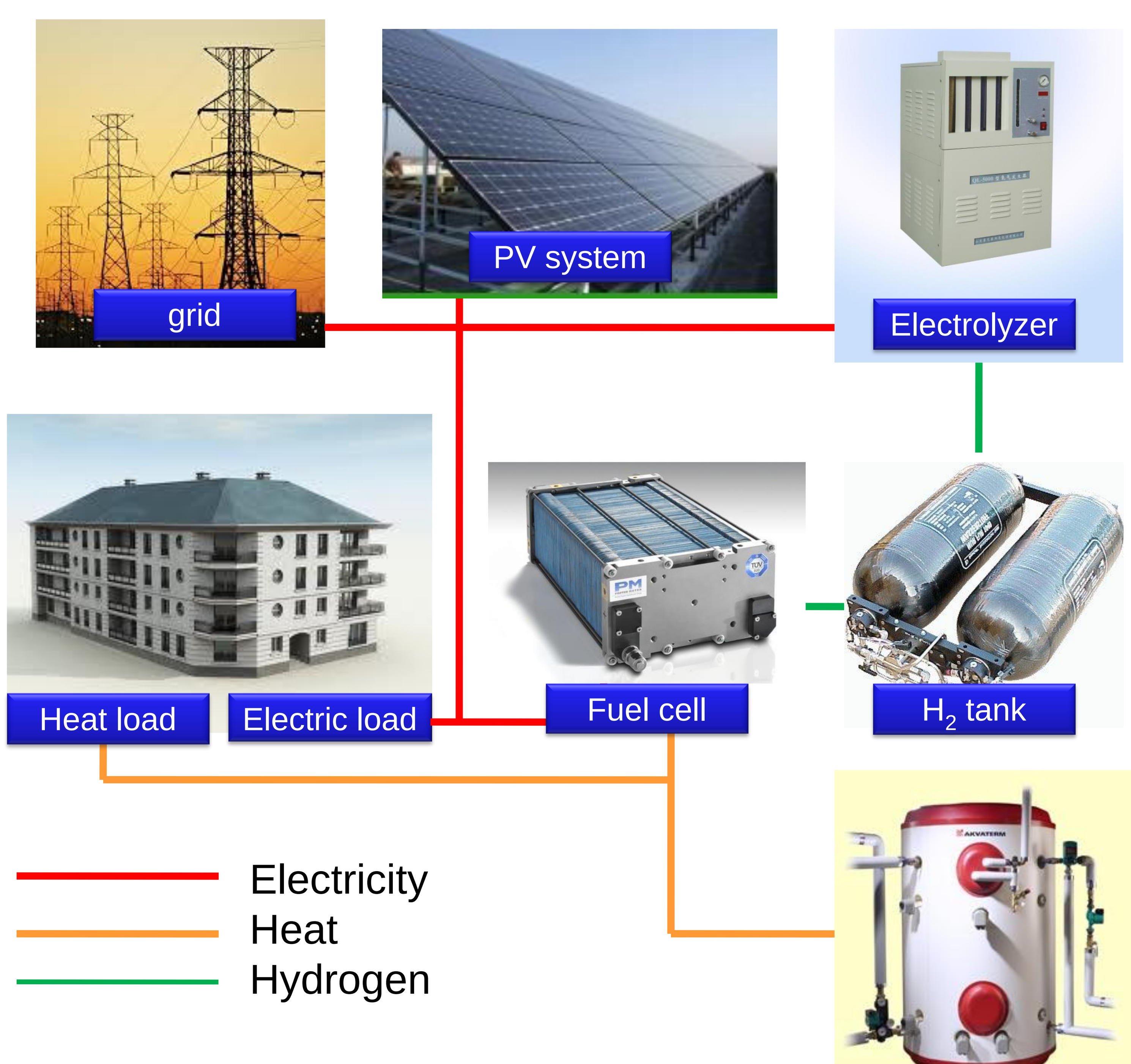
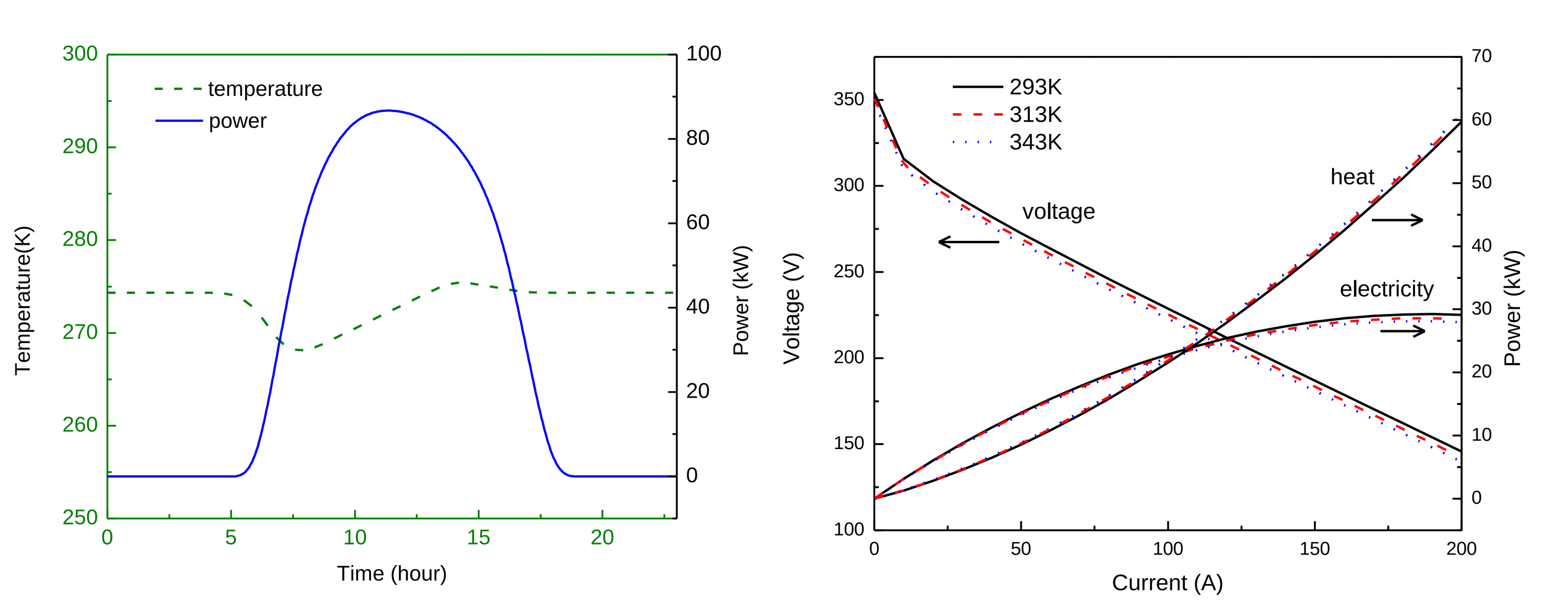


Figure 1 The structure of the microgrid



(a) (b)

Figure 2 The ambient temperature and the power output from the PV system in one day (a) and The voltage, electric power, and heat from the hydrogen FC stack at 0, 40, and 70 °C (b).

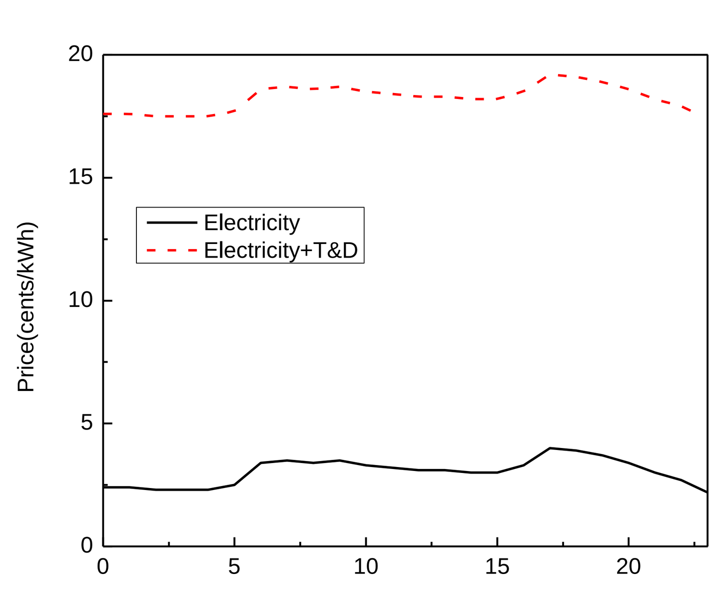


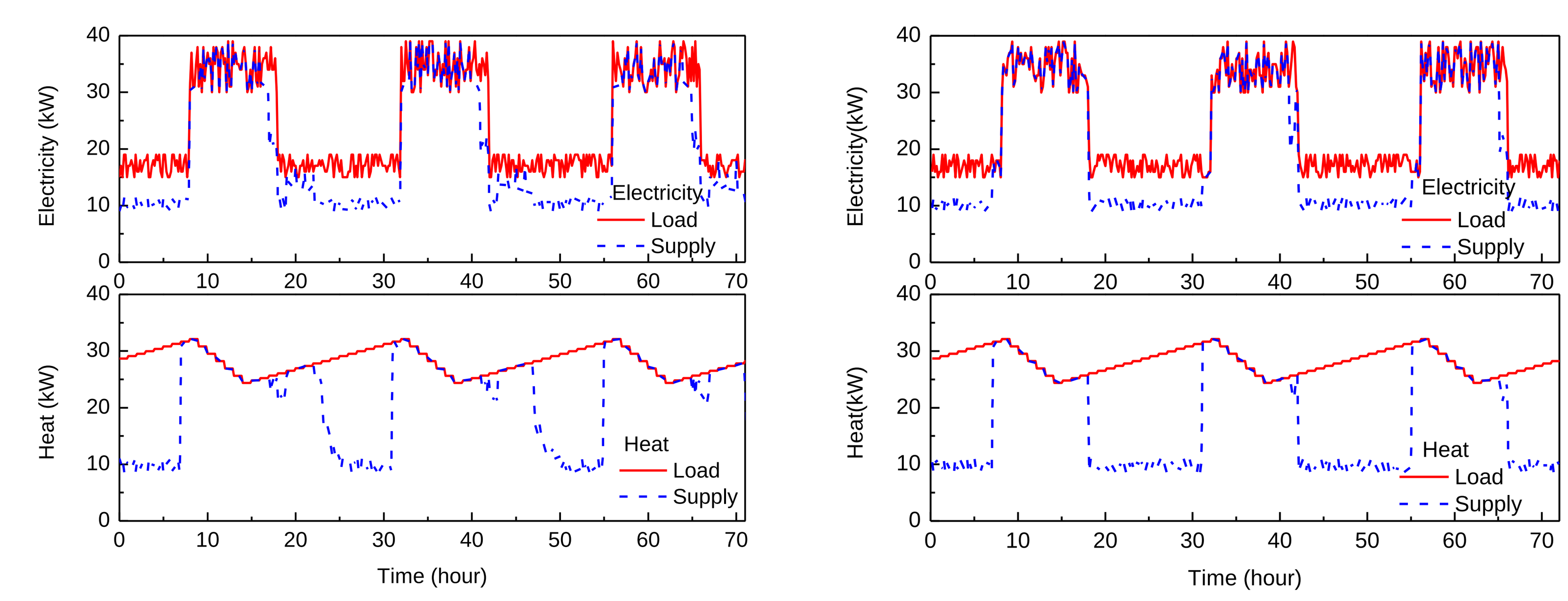
Figure 3 Residential electricity rate

The objective function for the operation of the system is:

$$\max\ Q = w_1F + w_2E + w_3S_1 + w_4S_2$$

Where: F is a price index of electricity, E is an environmental effect index due to atmospheric emissions, S_1 is the service quality of electricity, and S_2 is the service quality of heat.

3. Results and discussion



(a) (b)

Figure 4 The electricity and heat power for the system with a FC stack (a) and without a FC stack (b)

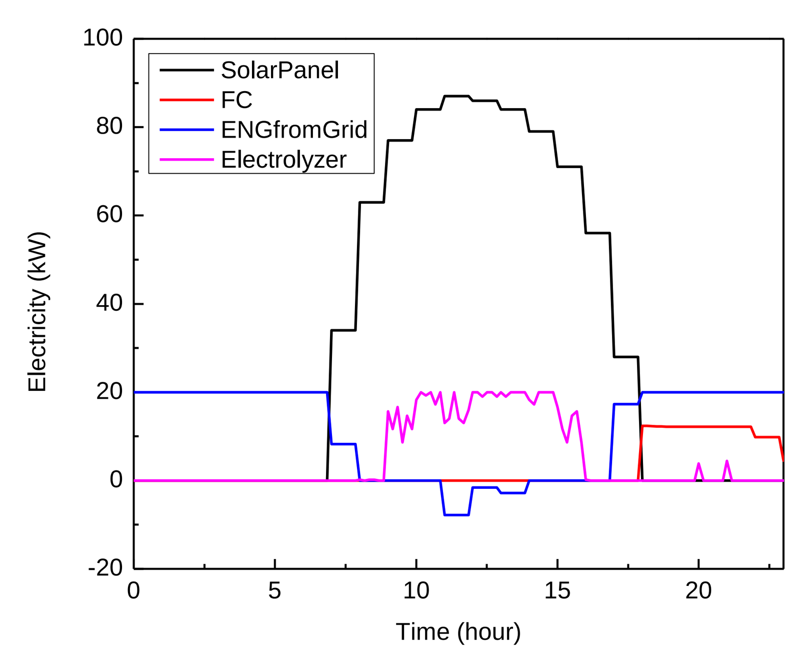
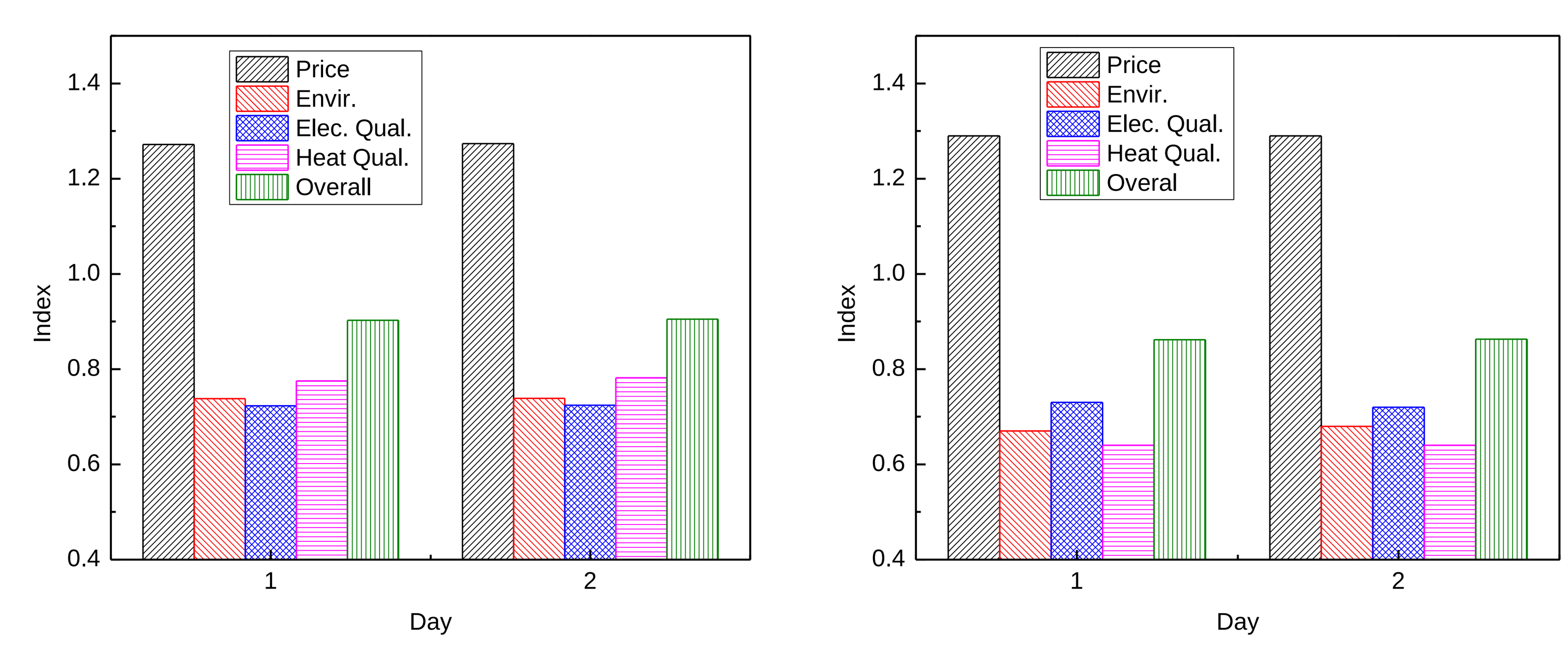


Figure 5 The profile of the MGs with a FC stack

In Figure 4, most electricity load is met in both systems in the day time. After sunset, these two systems obtain limited electricity from the grid. In addition to this, the FC stack in the first system can generate electricity and heat till its hydrogen tank becomes empty. Thus, more electricity is supplied to the load. Figure 5 shows that electrolyzer runs in the day time and the spare electricity flows to the grid. In the night, the fuel cell stars to work.



(a) (b)

Figure 6 The performance indices of the systems with a FC stack (a) and without a FC stack (b)

The price indexes in both systems are higher than 1 due to the significant credits for electricity transfer from the system to the grid. The service qualities of electricity and heat are higher in the first system than in the second system. Finally, the overall indexes for both systems are close.

4. Conclusions

With the dynamic electricity price and the constraint on electricity from the grid, the performance is evaluated on a grid-tied MG with DES and a hydrogen FC stack and it is also compared with that of a similar MG but without DES or a hydrogen FC stack. With the assumed weighting factors, both MGs show almost the same overall performance index. Except the price index, the environmental and service quality indexes are higher in the MG with DES and a FC stack.

References

Linfeng Zhang, Nicolae Gari, Lawrence Hmurcik, Energy management in a microgrid with renewable energy resources", Energy Conversion and Management, 2014, 78, P. 297-305