Using Domestic Hot Water Cylinders as an Energy Storage System to increase Variable Renewable Electricity Supply in Microgrids

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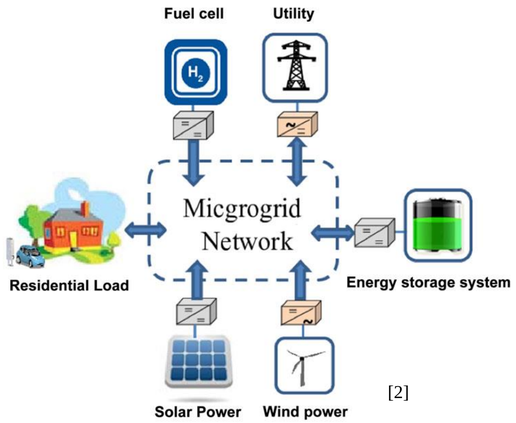
Introduction

- Due to the need for energy security, increasing demand for renewable electricity and mitigation of the effects of natural disasters, microgrids are being deployed for a decarbonized and decentralized energy grid[1].



[2]

Figure 1. A microgrid network

- The variability of both renewable energy sources and electricity demand creates a significant supply-demand mismatch in microgrids. This is normally dealt with dispatchable fossil sources which increase emissions.

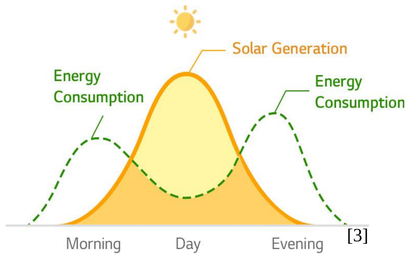


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Figure 2. Mismatch between energy demand and solar energy supply in a typical household

- In this project, we explore the opportunity for residential hot water cylinders to be used as an energy storage system to address this supply-demand mismatch.
- Depending on the cylinder size, around 10kWh energy can be stored in a cylinder per house[4].
- Often, hot water flow is not monitored but we need this to simulate the hot water control.
- We propose a novel approach to develop hot water usage on reverse engineering measured electricity data to find hot water flow.

System and Simulation

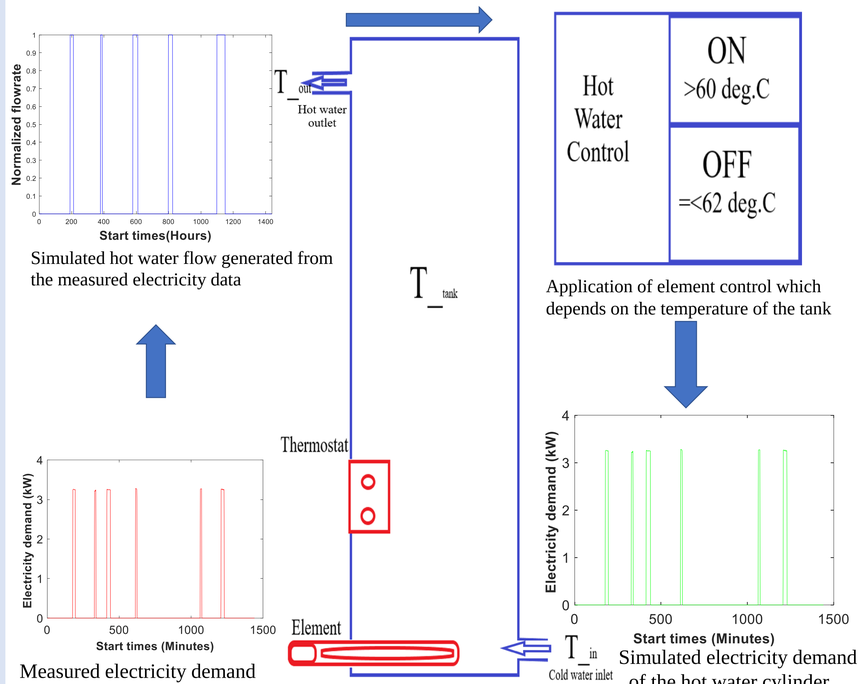

Figure 3. Simulation of a simple hot water cylinder

- The measured electricity data and a simple physical model of the cylinder were used to calculate the start times and durations of hot water flow.
- The hot water flow was utilized as an input in the hot water control to produce a simulated electricity demand data of the cylinder
- This simulated electricity data would be compared with the real measured electricity data to validate this method.

Preliminary Results

- Simulated start times and duration of hot water usage

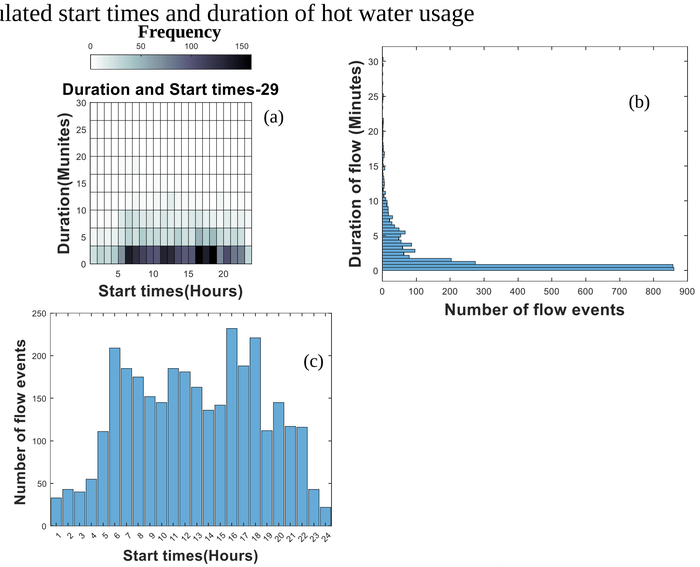

Figure 4. The start times and durations of hot water usage of House 29-(a) and group distribution of durations and start times for a year are displayed in (b) and (c) respectively.

The start times and duration of hot water flow were obtained using the novel approach. Most of the flow events are short and occasionally there are long flow events.

- Comparison with measured electricity data

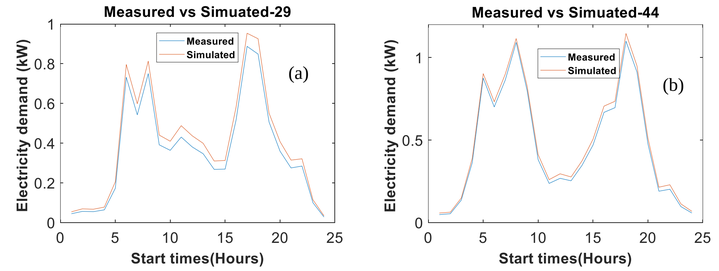

Figure 5. Comparison between daily measured and simulated electricity demand data for House 29 and House 44 averaged over a year are shown in (a) and (b) respectively

References

[1] Soshinskaya, M., Crijns-Graus, W.J., Guerrero, J.M., & Vasquez, J.C. (2014). Microgrids: Experiences, barriers and success factors. *Renewable and Sustainable Energy Reviews*, 40, 659-672. http://dx.doi.org/10.1016/j.rser.2014.07.198

[2] Opium Power, (2018). *Microgrids: Hybrid Renewable Energy Systems*. Retrieved from https://www.opiumpower.com/microgrids/.

[3] LGChem, (2019). *About home batteries*. Retrieved from https://www.lgessbattery.com/us/home-battery/intro.lg

[4] M. W. Jack, K. Suomalainen, J. J. W. Dew, and D. Eyers, "A minimal simulation of the electricity demand of a domestic hot water cylinder for smart control," Applied Energy, vol. 211, pp. 104–112, 2018.

Conclusions

- We have developed a method of simulation for hot water usage from a real electricity data to get hot water flow.
- Comparison between measured and simulated electricity data was used to demonstrate the validity of our method.
- In future work, we will use this simulation to balance variable solar photovoltaic supply in a 20 house microgrid by using hot water cylinders as storage systems.