Self-Learning Control Algorithms for Energy Systems Integration in the Residential Sector

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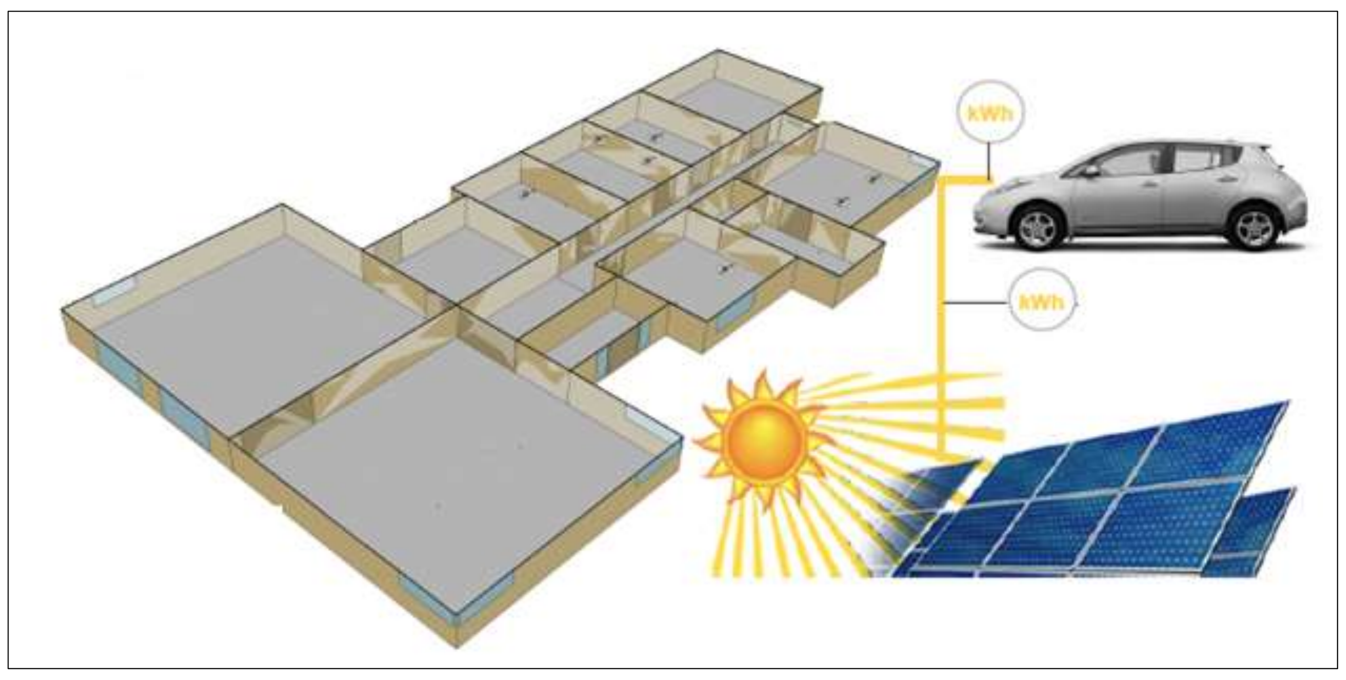
esipp Energy Systems Integration Partnership Programme

Research Hypothesis

A methodology can be developed:

- *to assess and enhance the Energy Flexibility (EF) of residential buildings*
- *to ensure their robustness and scalability through a self-learning control scheme*



Research Gaps

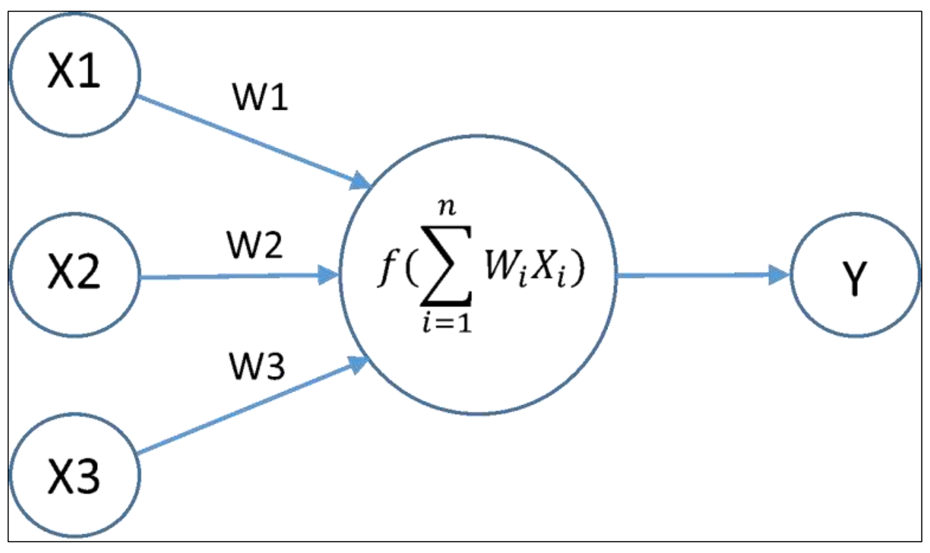
- Even though there is extensive research on EF concerning individual residential loads, *few studies develop baseline methodologies under various energy mixes*
- Although extensive research has been carried out concerning habitual behavior identification in residential electricity consumption, few studies in the literature explore the EF potential of residential scale buildings using data driven approaches
- Few studies explore the potentiality of a control scheme to learn and gain more experience in real-time operations under uncertain changes of the environment

Research Questions

1. Is it possible to develop a suitable methodology to quantify and assess EF in the residential sector?
2. Is there a methodology to enhance and evaluate EF in a household using data driven approaches?
3. How a self-learning-based Home EMS should be developed to optimally integrate demand response (DR) strategies?

Methodology

- Consideration of a calibrated white box model of a Smart Grid Ready Residential Building
- Analysis of the energy flexibility potential of the different energy vectors under various demand response strategies
- Selection of the most suitable data driven methods (e.g. Neural Networks, Genetic Algorithms etc.) to predict the EF potential of the residential loads.
- Integration of the data driven approaches in the optimization problem
- Application of different control schemes and DR scenarios



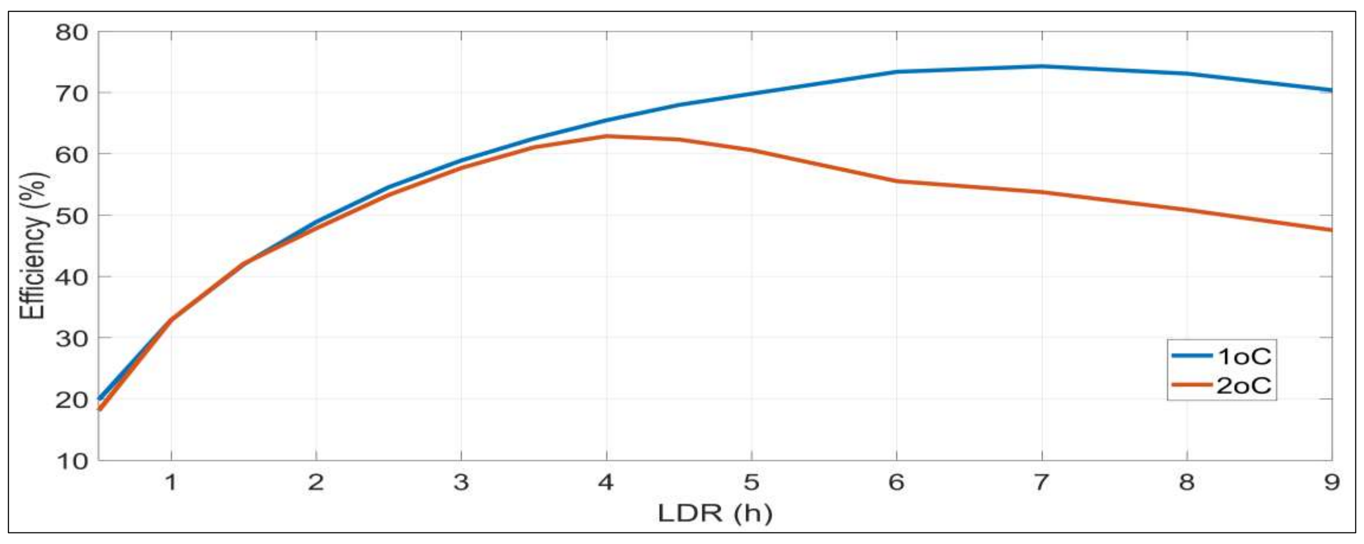
Contributions

- Development of a suitable methodology to quantify and characterize the EF for different residential energy mixes
- Enhancement of the predictability of residential loads and the awareness of the EF potential for all stakeholders
- More optimal use of demand EF under climate, price and behavioral uncertainties
- An optimal control strategy can be obtained for different consumers as well as changing pricing policies climate and dwelling type, based on the demand and system configuration

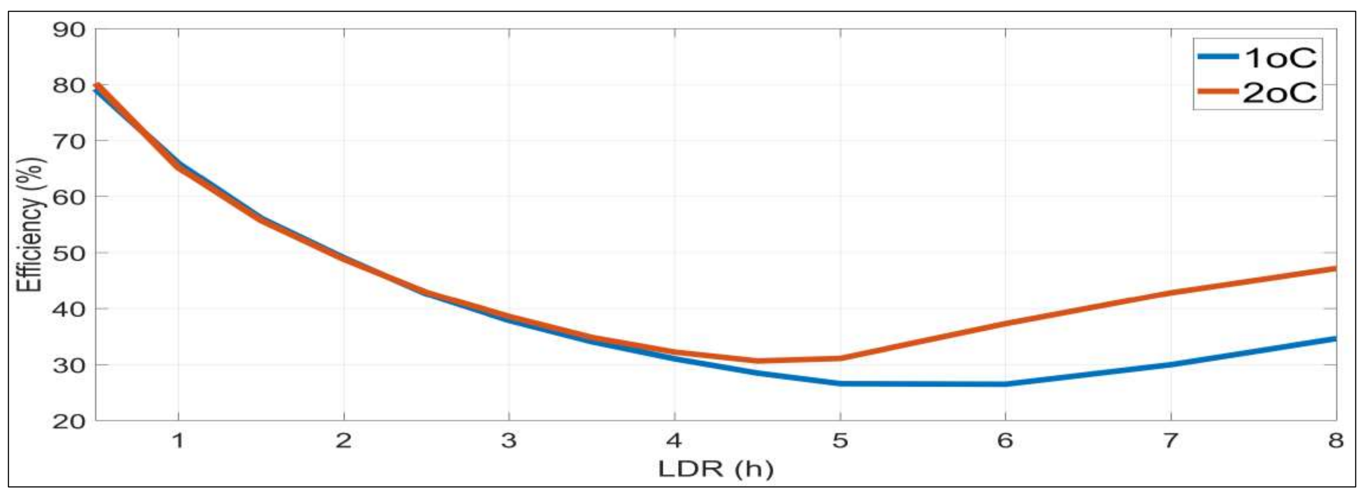
Preliminary Results

- A sensitivity analysis of two case studies for a dwelling was considered with a flat tariff step increase (down-flex) and a flat tariff step decrease (up-flex) for different DR durations.
- Consideration of full heating with a constant temperature setpoint at 22°C
- Both figures illustrate DR efficiency as a function of the DR duration for 1°C and 2°C of temperature decrease (down-flex) or increase (up-flex)

Down-Flex



Up-Flex



Conclusions

- In both cases, the DR events efficiency depends both on the temperature setpoint change and the DR duration (LDR)
- In regulation down/up, a decrease/increase of 1°C/2°C is more efficient comparing to temperature decrease/increase of 2°C/1°C
- The obtained results will lead to the suitable categorization of the residential consumption permitting the controllable demand quantification
- This research forms a foundation to develop optimal DR strategies and integrate them in holistic manner in an Energy Management System

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