Department	School of Computing
Supervisors	Simon Powers
Project Title	Using multi-agent systems to help households reduce peak electricity consumption in ways they perceive as fair

PROJECT DESCRIPTION

The UK and the EU have both recently updated their legislation to put net zero emissions targets in place for 2050. This requires moving away from using fossil fuels for energy generation, and moving towards renewable sources such as photovoltaic cells and wind turbines. Doing this on a national scale is difficult, because the amount of energy a renewable source generates depends on weather conditions, making it very challenging to balance supply of energy with the total demand for it. However, it is easier to solve this problem on a local scale. This has led to governments starting to advocate for community energy systems, where a community owns and manages its own renewable energy sources, and uses as much of its own locally generated energy as possible.

For a community energy system to work effectively, the community often needs to reduce its total peak electricity consumption, so that all of it can be met by its own renewable sources. This involves households adjusting the times at which they use high-powered appliances such as washing machines, dishwashers, and electric heating, so that they are not all using them at the same time. Traditional approaches to this have been based on time of use pricing – a utility company sets peak and off-peak hours, and charges households more to use their appliances in peak hours, with the aim of discouraging them from doing this. However, this approach has not been successful in the UK in widely shifting energy usage patterns (e.g. we are still facing the prospect of blackouts this winter because peak consumption is too high). And moreover, time of use pricing inheriently discriminates against households on lower incomes.

This project will develop alternative approaches, drawing on theory from social science to develop agent-based protocols for reducing peak electricity consumption in a way that people perceive as treating them fairly. These are based on the idea that each household can have an agent running on their smart meter, into which they can input their preferences for when they would like to run their appliances. Their agent then negotiates with the agents of other households to come up with an allocation of times that satisfies each household's preferences as far as possible, while reducing peak consumption. The project will develop and test several such protocols in simulation, and perform online user studies to test how fair people find them.

Prospective applicants are encouraged to contact the Supervisor before submitting their applications. Applications should make it clear the project you are applying for and the name of the supervisor(s).

Academic qualifications

A first degree (at least a 2.1) ideally in computer science with a good fundamental knowledge of artificial intelligence.

English language requirement

IELTS score must be at least 6.5 (with not less than 6.0 in each of the four components). Other, equivalent qualifications will be accepted. Full details of the University's policy are available online.

Essential attributes:

- Experience of fundamental techniques of algorithm design and analysis.
- Competent in software development.

- Knowledge of human computer interaction, or data visualisation, or games development.
- Good written and oral communication skills
- Strong motivation, with evidence of independent research skills relevant to the project
- Good time management

Desirable attributes:
Interest in interdisciplinary work, with enthusiasm for working at the interface of computing, engineering and social science.

Indicative Bibliography	Brooks, N. A., Powers, S. T., & Borg, J. M. (2020). A mechanism to promote social behaviour in household load balancing. In *Proceedings of the Artificial Life Conference 2020 (ALIFE 2020)*. , (95-103). https://doi.org/10.1162/isal_a_00290 Gruber, L., Bachhiesl, U., & Wogrin, S. (2021). The current state of research on energy communities. *E & i Elektrotechnik Und Informationstechnik*, *138*(8), 515–524. https://doi.org/10.1007/s00502-021-00943-9 Powers, S. T., Meanwell, O., & Cai, Z. (2019). Finding Fair Negotiation Algorithms to Reduce Peak Electricity Consumption in Micro Grids. In *PAAMS 2019: Advances in Practical Applications of Survivable Agents and Multi-Agent Systems: The PAAMS Collection*, 269-272. https://doi.org/10.1007/978-3-030-24209-1_28
Enquiries	For informal enquiries about this PhD project, please contact Dr. Simon T. Powers (S.Powers@napier.ac.uk)
Web page	https://www.napier.ac.uk/research-and-innovation/research-degrees/application-process