Domestic Heating Control with Adaptive Thermal Modelling and Probabilistic Occupancy Estimates

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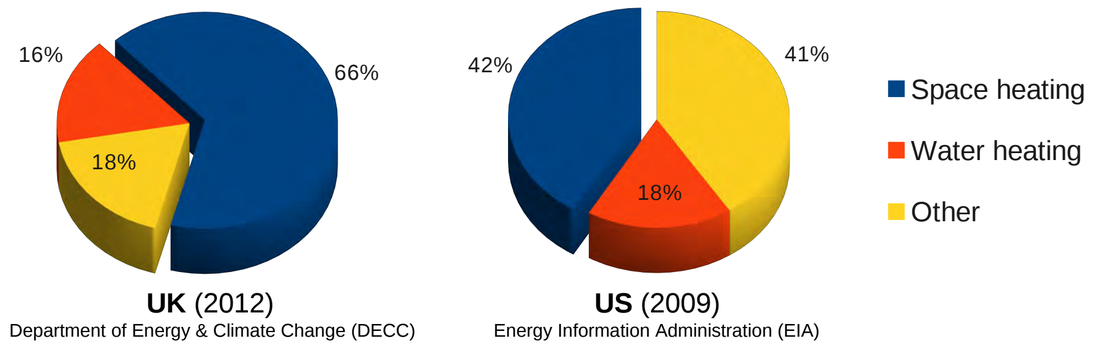
Motivation

Improving the energy efficiency of domestic heating systems can lead to a major reduction in energy consumption and the corresponding CO2 emissions.

In many countries, such as the UK and the US, the domestic sector accounts for more than 20% of the total energy consumption, and over 40% of this share is related to space heating.

Domestic energy consumption by end use



UK (2012)
Department of Energy & Climate Change (DECC)

US (2009)
Energy Information Administration (EIA)

Domestic Heating Automation Systems (DHAS)

Domestic heating automation systems (DHAS) aim to operate domestic heating systems more efficiently (i.e., optimize the heating control process) with minimum user-input.

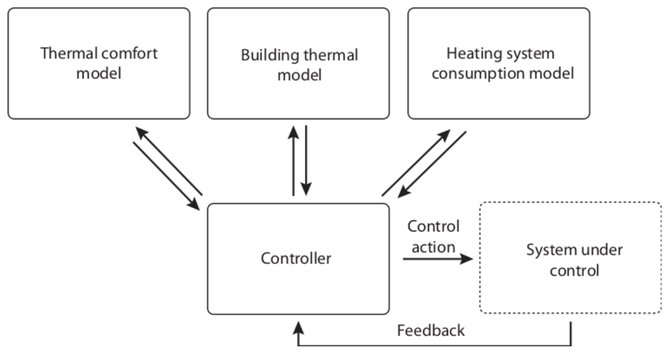
What are the **main challenges** for developing an efficient DHAS?

- Occupancy schedule is uncertain.
- Occupants' activity affects the thermal condition of houses.
- Instrumentation is generally poor in domestic settings.
- A diverse range of heating systems is employed.
- The user preferences, in balancing heating cost and thermal discomfort, are diverse and time-varying.

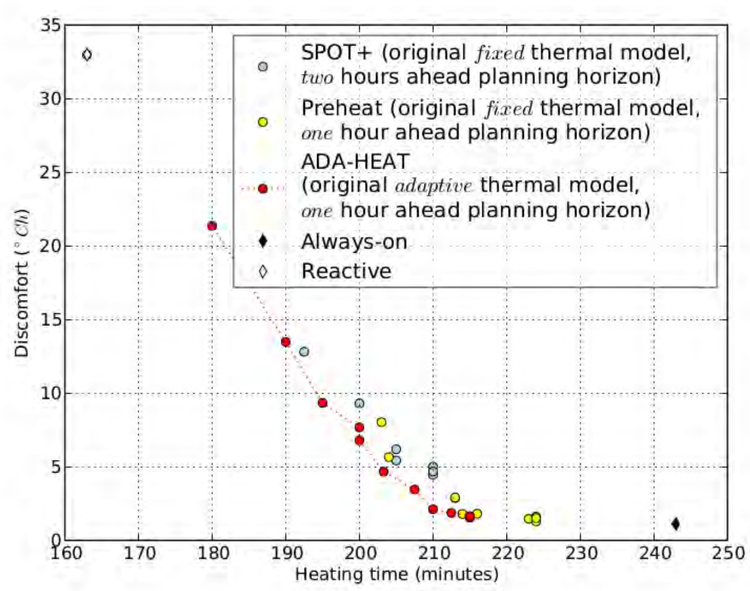
ADA-HEAT: a new general adaptive DHAS

...that balances heating cost and thermal discomfort in an **infinite horizon optimization** manner, learns an **adaptive thermal model** on-line, and plans a heating schedule **fully exploiting the probabilistic occupancy estimates**.

Adaptive MPC - DP planning algorithm - scalarized optimization objective

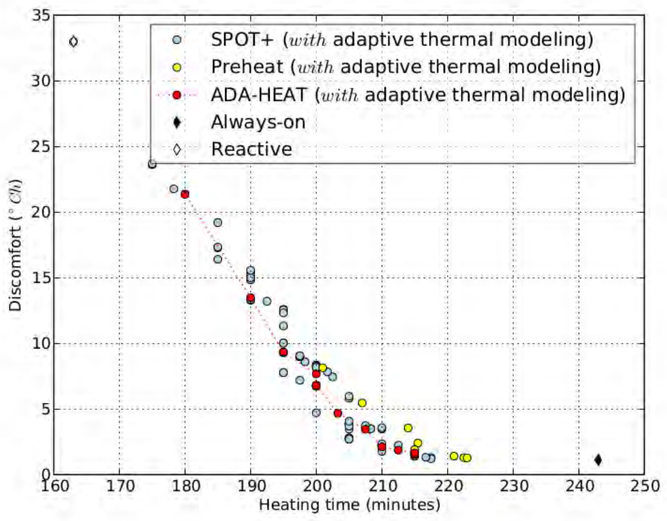


Initial Evaluation of ADA-HEAT

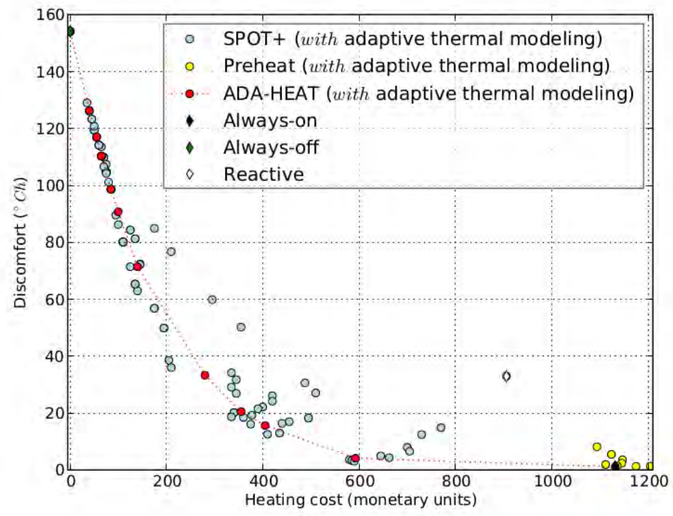


Characterization of the considered DHASs

Without energy cost variability



With energy cost variability



Meet the user Preferences

ADA-HEAT adapts to the user preferences in balancing cost and discomfort as it relies on only one parametrization factor that can be learned on-line.