Abstract

Masters in Computer Science

Minimising CO$_2$ Emissions Produced from Water Heater Usage

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The electricity supply is produced from renewable and non-renewable energy sources. Renewable sources, such as wind and solar produce no CO$_2$ emissions, but they are weather dependent. Non-renewable sources, such as coal and gas, are stable, but they do produce CO$_2$ emissions. European Union (EU) countries are required to reduce CO$_2$ emissions in order to comply with EU policy. This is achieved by increasing the use of renewable energy. The weather dependent nature of renewable sources means that the proportion of renewable and non-renewable energy in the electricity supply is constantly changing. This means that the CO$_2$ emissions produced by the electricity supply will vary over time.

The pattern of electricity consumption needs to dynamically adapt to enable the minimisation of CO$_2$ emissions. This dissertation focusses on water heaters, which have two sources of heat energy, an electrical element and a gas-fired space heating system. Existing research in this area has examined energy consumption of water heaters which only have a single source of heat energy; an electrical element. A water heater can store energy which gives it a flexible consumption pattern. This means that a water heater can consume energy during periods when a low CO$_2$ emission source becomes available.

This dissertation investigates the implementation of two different controllers which manage the operation of the water heater. The first controller, the expert, implements a known, good control policy. The second controller employs Q-learning. A set of experiments were carried out in order to determine if the Q-learning controller could achieve better performance than the expert controller. The results of the experiments show that the Q-learning controller could produce lower levels of CO$_2$ emissions. However this resulted in a loss of utility to the end user.