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Demand modelling of horizontal electric water heaters

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Abstract

The thesis presented extends and contributes to research in demand-side management for the purpose of power utility planning and load forcasting applications and addresses the challenge of predicting the cummulative effects of Electric Water Heater (EWH) load due to transient heat recovery processes experienced by the thermal storage. Although previous work in this area has produced models that estimate water heating load through various abstractions of the thermal energy storage, there has not been an investigation into the transient response of the heat recovery process evident in the horizontal EWH typical to South African installations, which is computationally inexpensive for scaling to simulations with large populations. In the research presented, a multi-node model for a typical 150 ℓ, 3 kW EWH with 24 layers at fixed heights and variable volumes, and the mixing processes due to circular convection and inlet turbulence are modelled through different heat transfer coefficients affecting specified layers in relation to the element position. Measurement obtained over a range of draw scenarios (varying volumes and flow rates) are used to validate the multi-node model. Single-draw events are considered for ideal case validation and a double-draw event is considered to indicate a realistic usage profile. It is shown that the cummulative effects of the load profiles for a large range of population and demand intervals produce a predicted peak demand within 20%, time to peak of 5% and total energy within 15%. In addition, the multi-node model is shown to produce better peak demand predictions than a binodal model with a simple thermal abstraction.

This model and approach therefore represents a novel and valuable contribution to the development of load models for EWHs with transient characteristics, which enables low computational modelling of variable water heating load to produce a more accurate prediction of cummulative peak parameters for grid loading simulations.