

## Article

# Evaluating Reinforcement Learning Algorithms in Residential Energy Saving and Comfort Management

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**Abstract:** The challenge of maintaining optimal comfort in residents while minimizing energy consumption has long been a focal point for researchers and practitioners. As technology advances, reinforcement learning (RL)—a branch of machine learning where algorithms learn by interacting with the environment—has emerged as a prominent solution to this challenge. However, the modern literature exhibits a plethora of RL methodologies, rendering the selection of the most suitable one a significant challenge. This work focuses on evaluating various RL methodologies for saving energy while maintaining adequate comfort levels in a residential setting. Five prominent RL algorithms—Proximal Policy Optimization (PPO), Deep Deterministic Policy Gradient (DDPG), Deep Q-Network (DQN), Advantage Actor-Critic (A2C), and Soft Actor-Critic (SAC)—are being thoroughly compared towards a baseline conventional control approach, exhibiting their potential to improve energy use while ensuring a comfortable living environment. The integrated comparison between the different RL methodologies emphasizes the subtle strengths and weaknesses of each algorithm, indicating that the best selection relies heavily on particular energy and comfort objectives.

**Keywords:** reinforcement learning; energy efficiency; thermal comfort; buildings; residents; Energym



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## 1. Introduction

### 1.1. Motivation

Contrary to the outdated standpoint considering residents as static constructions, the modern perspective identifies them as multifunctional cyber-physical entities able to provide efficient thermal comfort and promote occupants' quality of life [1–5]. However, to provide adequate comfort to residents—using the potential integrated heating, ventilation, and air conditioning (HVAC) equipment—a specific amount of energy needs to be consumed. Such an amount portrays a significant portion of the overall energy consumption, rendering residential buildings as energy-intensive consumers and a significant contributor to the surge in greenhouse gas (GHG) emissions [6–8]. To this end, to maintain residential comfort in a viable way, the need to harmonize energy conservation while maintaining comfort levels has become an essential objective [9–12].

For many years, residents relied on manual approaches to control HVAC by adjusting thermostats, opening windows, or turning on fans based on their immediate comfort needs. While these actions provided quick adjustments to the indoor environment, the lack of real-time adaptability often resulted in energy wastage during unoccupied or temperate periods [12,13]. Recognizing this gap, scheduling devices emerged, facilitating pre-configured temperature preferences and timed functions, granting a level of autonomous management while ensuring a stable comfortable environment. However, their static configurations often

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