

Brief information about the project

Name of the project	Intelligent control system for building energy consumption and occupant comfort using multiagent reinforcement learning.
Relevance	Modern buildings consume up to 60% of a city's electricity, and reducing their energy consumption is a pressing issue. Reducing a building's energy consumption will inevitably impact occupant comfort. Ensuring occupant comfort while reducing energy consumption is also a pressing issue.
Purpose	The goal of the project is to create an intelligent control system for building energy consumption and maintaining occupant comfort using multi-agent reinforcement learning with a new asynchronous energy consumption algorithm and a system for determining the state of people using thermography.
Objectives	To achieve the set goal, the following tasks will be solved: 1. Development of a monitoring and control system for building energy consumption to create a thermodynamic model of the environment. As a result of solving this problem, a system for monitoring temperature, humidity, carbon dioxide levels, and the occupant number in the room will be created. 2. Development of a thermodynamic model of the environment for the purpose of training agents. As a result of completing this task, a premises thermodynamic model will be created based on experimental data on monitoring premises. 3. Development of an occupant's state recognition system based on images from CCTV cameras and infrared cameras. As a result of completing this task, a neural network will be created to recognize an occupant's state at any mutual arrangement of the camera and the person's face. 4. Analysis of the correlation of input and output data in order to determine the key parameters of the multi-agent system. As a result of the task, correlation matrices of input and output data will be obtained, based on which the agents will be adjusted. 5. Study of the methods efficiency for optimizing decision-making of a multi-agent system within the framework of the task of increasing the building energy efficiency and maintaining occupant's comfort. As a result of this task, the most optimal hyperparameters for neural networks will be selected. 6. Training a multi-agent system in a virtual thermodynamic environment to optimize energy consumption in a building using asynchronous energy consumption. As a result of this task, the agents will be trained using the multi-agent reinforcement learning method in the developed thermodynamic model of

	premises using the asynchronous energy consumption algorithm. 7. Verification of the flexibility and accuracy of the model by scaling the system to a larger number of rooms. As a result of scaling the multi-agent system to a larger number of rooms, the capabilities of the developed multi-agent system for adaptation and stability in changing environments will be investigated. 8. Development of a photovoltaic system and collection of energy generation data. As a result of completing this task, a system for monitoring and forecasting solar radiation and generation of a solar power plant will be created, which will be installed on the roof of the building under study. 9. Training a neural network to forecast energy generation by a photovoltaic system. During the task, a neural network will be developed and trained based on historical data on electricity generation by a photovoltaic system, forecasting the output power of the system, taking into account weather station data, time of day and time of year. 10. Testing the multi-agent system in practice. As a result of completing this task, the developed intelligent control system for building energy consumption and maintaining occupant comfort will be applied in practice in the building under study.
Expected and achieved results	The main result of the project is an intelligent energy consumption and comfort management system for buildings based on artificial intelligence methods, reducing peak loads and increasing energy efficiency through an asynchronous energy consumption algorithm. Comfort monitoring is implemented using video and infrared cameras. To date, the following results have been achieved: An IoT system for monitoring indoor environmental parameters (temperature, humidity, CO₂, occupancy) has been developed. A data collection and storage system (video stream, thermography, sensor data) has been implemented. A mobile application for collecting subjective user assessments has been developed. A building model has been built in EnergyPlus. A human state recognition system (CNN+GRU) with an accuracy of 95.58% has been developed. A correlation analysis of the multi-agent system parameters has been conducted. Optimization of the reinforcement learning algorithms and hyperparameters is underway. The system is expected to have high commercialization potential and will reduce peak loads in power systems. The results obtained form the basis for the development of Smart Grid and Microgrid.
Research team members with	Dosymbetova Gulbakhar, PhD (Индекс Хирша: Scopus

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Usage	The primary potential buyers of the proposed system could be large enterprises, individuals, and legal entities responsible for the operation of office building services. The results obtained can be used by undergraduate, master's, and PhD students in their education and research in this field.
Priority compared to real-world alternatives	Unlike solutions based on fixed sensors, a combination of computer vision and facial thermal data is used for more accurate comfort assessment. Instead of rules and centralized algorithms, multi-agent reinforcement learning is used, providing adaptive, decentralized control. Asynchronous energy management is implemented to smooth out load peaks and improve energy efficiency. Comfort management is integrated with photovoltaic systems for the efficient use of renewable energy.

	Joint optimization of comfort and energy consumption is ensured.
List of publications with links to them	Kapparova A., Zholamanov B., Bolatbek A., Kuttybay N., Dosymbetova G., Zhumagaliyev Y. Implementation of the multi-agent framework of IMPALA for a single-zone temperature control of a simulated thermal zone // Herald of the Kazakh-British Technical University, (status: peer-review) Kapparova A., Nurgaliyev M., Saymbetov A., Orynbassar S., Dosymbetova G., Zhumagaliyev Y. Multi-agent proximal policy optimization for zone temperature and humidity control // Bulletin of KazATC, (status: peer-review)
Patents	-