

### **1. Research aim / research hypothesis.**

The aim of the research is to develop recommendations for the efficient use of combined energy sources and a significant reduction in energy consumption in public and residential buildings. Recommendations will be for new projects as well as modernization by examining and optimizing technical building systems for the needs of residents as well as the energy requirements of the building. Due to the purpose, the following tasks were defined:

- developing a methodology for determining the optimal level of energy efficiency in buildings and bringing it to near-zero energy consumption
- development of 'reference' energy and environmental models for public and residential buildings and the creation of models of it's user's habits;
- optimization of energy supply systems for buildings and development of optimal management strategies for complex combinations of technical building systems using traditional, non traditional and renewable energy sources. Compare the modeling results with field research data.
- developing recommendations for improving national approaches to the criteria for nearly zero-energy buildings.

**Main hypothesis.** The main assumption of the project is that solving the problems related to the approach to the requirements of nearly zero-energy buildings is the result of a comprehensive analysis of the building as a complex energy system, based on a combination of mathematical modeling and field research. Further focus on improving the thermal insulation properties of external partitions is no longer effective, so we want to focus on reducing energy consumption by using renewable energy sources. The joint correlation of associated energy sources with optimized and improved technical systems and the operating mode of the building will increase efficiency. The comfort of the residents remains one of the top priorities. First, the specificity of the project is the inclusion in the energy model of the user (as an entity called "client"), operating modes and comfort indicators. The comfort index depends on the energy condition of the building. Secondly, determining the economic feasibility of reducing energy consumption is ensured by integrating the operating modes in a dynamic model environment: the operation of various energy sources and technical systems of the building, the structure of the building envelope, the external environment, the activity and habits of the building users, subjective and objective comfort parameters.

**2. Research method / methodology used.** It is planned that the modelling of energy consumption in the building, current data and field studies will be used for comprehensive studies of the energy performance of buildings. The Department of Building Physics and Renewable Energy of the Kielce University of Technology has created a unique energy building, which is a testing ground for a set of modern RES control systems. The heat substation allows the use of water from the municipal heating network to heat rooms where it is not possible to use new heating methods, e.g. staircases. The main heat load falls on heat pumps, ensuring thermal comfort in rooms with underfloor heating. In addition, the building is equipped with solar installations with devices for storing thermal and electrical energy. All this together constitutes a hybrid energy substation, controlled by the BMS system. Energy flow management is easy to achieve. Modelling the entire system and data verification will be the basis for developing a methodology for regulating energy consumption with adaptation to various types of buildings, including residential buildings. In addition, we will use dynamic modeling methods to develop 3-D dynamic building models in the EnergyPlus software environment, CFD models of individual zones in Ansys/Fluent software combined with building envelope characteristics, climate and comfort conditions obtained during energy audits/surveys. Energy and exergy based thermal comfort models are used to integrate the needs of building occupants..

### **3. Influence of the expected effects on the development of science, civilization and society**

The implementation of research and the development of recommendations for the efficient use of renewable energy sources and a significant reduction in energy consumption in public and residential buildings in new construction and redevelopment projects is an important step towards achieving the SDGs and takes into account environmental, economic and social aspects. Environmental aspects are taken into account not only by optimizing final energy consumption, but also, more importantly, primary energy consumption and greenhouse gas emissions. The economic aspects is done through the use of modern methods of determining the optimal level of energy performance of buildings with the use of minimizing economic indicators throughout the life cycle of the building. In the case of existing buildings, thermal modernization creates additional benefits for the economy, such as the creation of additional jobs and the possibility of obtaining funds from international financial institutions, etc. The social importance of such research is to increase the level of thermal comfort and apply best practices to ensure good indoor air quality.