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INNOVATIVE TECHNOLOGY, OPERATION AND ENERGY MANAGEMENT OF BUILDING: SCIENCE & TECHNOLOGY PARK, TUKE

The current goal of increasing the energy efficiency of buildings should be implemented holistically, considering multidisciplinary measures during the design phase. For the application of innovative technologies it is crucial to know the building's function, operational requirements, the investor's financial scope and environmental conditions or limitations. This concept is a continuous process to attain suitable architectural and construction solutions, technical systems and efficiently manage the operation of the building. The result of this process must be a construction of high quality from the perspective of systemic connections between building-climate-energy, which should function as a catalyst for a sustainable society. By adhering to these criteria, real conditions are evaluated in economic terms. This aspect defines the design of the system and correlates to feasible applications of systems with real returns on investment. The building which is the subject of this paper went through this design process and is an example of the system functioning at the operation and management level of intelligent buildings.

Key words: Intelligent buildings, renewable energy sources, recuperation, passive cooling, heat pump, radiant heating, climate façade.

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ІННОВАЦІЙНА ТЕХНОЛОГІЯ, ЕКСПЛУАТАЦІЯ ТА ЕНЕРГЕТИЧНИЙ МЕНЕДЖМЕНТ БУДІВНИЦТВА: НАУКОВИЙ ТА ТЕХНОЛОГІЧНИЙ ПАРК, ТУК

Нинішня мета підвищення енергоефективності будівель повинна бути реалізована цілісно, з урахуванням міждисциплінарних заходів на етапі проектування. Для застосування інноваційних технологій важливо знати функцію будівлі, оперативні вимоги, обсяг фінансування інвестора та умови або обмеження навколишнього середовища. Ця концепція є безперервним процесом для досягнення відповідних архітектурно-будівельних рішень, технічних систем та ефективного управління роботою будівлі. Результатом цього процесу має бути високоякісна конструкція з погляду системних зв'язків між будівлею, кліматом та енергією, яка повинна функціонувати як каталізатор стійкого суспільства. Дотримуючись цих критеріїв, реальні умови оцінюються в економічному плані. Цей аспект визначає дизайн системи та корелює з можливими застосуваннями систем із реальною віддачею інвестицій. Будівля, яка є предметом цієї статті, пройшла через цей процес розробки та є прикладом системи функціонування на рівні експлуатації та управління розумних будівель.

Ключові слова: інтелектуальні будівлі, відновлювані джерела енергії, рекуперація, пасивне охолодження, тепловий насос, променеве опалення, кліматичний фасад.

Introduction. The present building functions as an office, conference and exhibition centre with 5 floors and 1 sub-level. The structure is enclosed by an atrium over 4 floors with a courtyard balcony which provides access to the offices situated on the peripheral wall. The building is designed to be intelligent with the use of renewable energy sources and a passive climate façade. It also serves as a scientific and technological base for research on the designed and implemented service systems to optimize their operations. The object is known as TECHNIKOM (Science & Technology Park), at the Technical University of Kosice.

Fig. 1. Front view (WEST) of TECHNIKOM (Science & Technology Park) building

Process of creating the energy concept. During the proposal stage of the energy concept for the building, various systems were considered to manage indoor environmental parameters with the aid of renewable energy sources.

The following technologies were considered during the conceptual process:

- Energy buffer zone within the climate façade: it is designed to shield the building from the direct influence of the external environment. Facade with active shading incorporates (directional louvers) in the space between the double façade. Air is supplied to the cavity and is subsequently used for internal ventilation at various stages throughout the year. Summer mode, transition period, winter mode.
- Earth air collector: a natural air collector consisting of tubes that are placed into the ground at a depth of 2-3 meters. The air passing through the collector is heated / cooled under the conditions of use for ventilation and is augmented by the climate facade or as inlet air for ventilation in air conditioners.
- Drilled wells for energy use: a well with water depth of about eight meters will be used in the summer for passive cooling. In winter, it serves as a heat source for a water/water heat pump. At the same time, water is used in the operation of the object as grey water (toilet flushing, watering exterior, ...)
- Solar hot water collectors on the roof: for hot water and central heating in winter
- Photovoltaic panels incorporated into the facade: production of electricity for the operation of the object.
- Underground heat accumulator: underground storage tank for long-term storage of energy in water during the summer months when there is a surplus of heat energy from the heat pump.
- Heat pump water/water: used for heating, supplied by the wells, in an underground storage tank. The heat pump has the potential to provide cooling and hot water for heating and operation of the facilities.
- Ventilated atrium: the atrium facilitates ventilation to other spaces and in collaboration with the climate façade, ventilation and air-conditioning units with heat recovery systems, maintains thermal comfort hygiene and other required parameters.
- Heat transfer station: serves as a state of the art source of heat and for equipment requiring a hot water heating temperature of 60 °C. The system is connected to the municipal hot water supply.

The assessment process included energy and economic balances, which determine the profitability of individual systems when in service. According to these criteria, several proposed systems were excluded as they were deemed ineffective.

Realization of the energy concept. Heating and cooling systems were implemented as result of a feasibility assessment. Systems that produce (heating/cooling) were implemented based on the results of an assessment. The system's consumption and distribution of heating/cooling relied on low-temperature heating and high temperature cooling. These systems can make effective use of renewable resources.

- **Ventilation of the atrium and office space**

The atrium is tempered via air conditioning (E HVAC) augmented by ventilation air. Under favourable conditions, the ventilation due to gravity is managed by automatically controlled and autonomous skylights. The air from the atrium is circulated to the office space via the management of automatic flaps, which regulate the intensity of CO_2, or humidity. On the roof, heat pumps (1) provide (preheated/precooled) air from exhaust air and part of the climate façade are recovered by means of recuperation. The resulting energy is fed through a water system located in the basement (E HVAC) and is used to preheat the air. Ventilation of offices on the west side is supplied via the climate façade controlled buffer system.

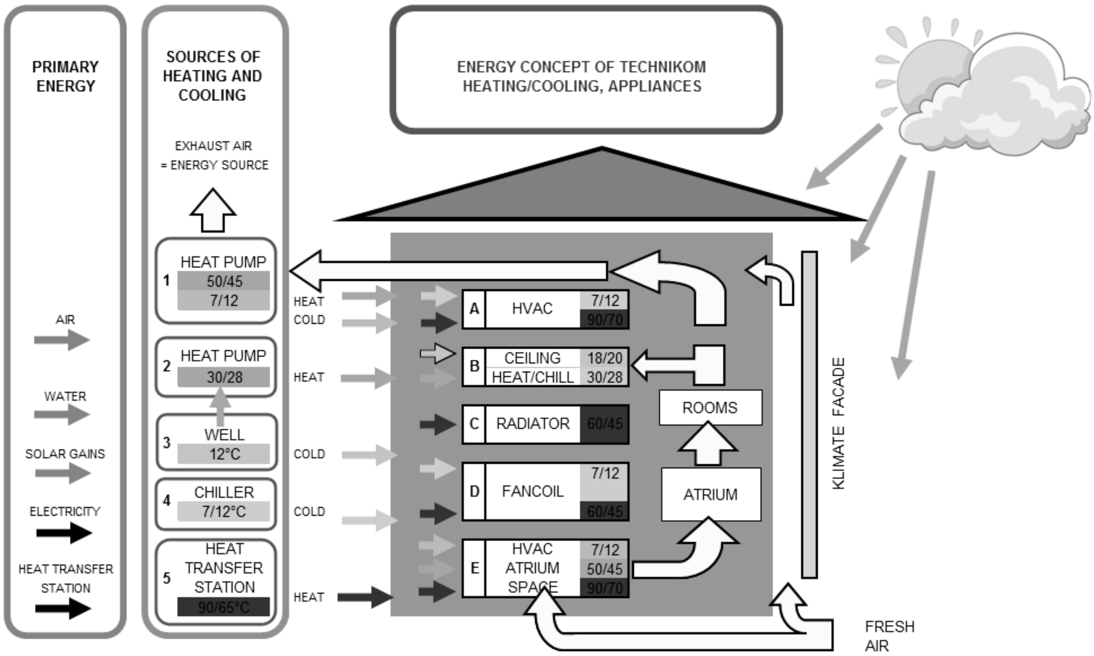

Fig. 2. Energy supply concept heating – cooling – ventilation

- **Ventilation and air conditioning of conference rooms**

Internal environment temperature with a higher occupancy level (conference, lecture) is solved using HVAC air handling units (A AHU). It provides cooling via a chiller (4), while heating is supplied by the heat transfer station (5).

Heating and cooling are secured by radiant systems (B ceiling) low-temperature heating and high temperature cooling. The source of heating is a heat pump (2) water/water from wells' (3) which is a source of passive cooling. Depending on the operating requirements the use of the overhead system is prioritized. An HVAC air handling unit is activated if the occupancy level is higher with increased ventilation demands, or elimination of higher heat loads is necessary.

- **Heating office and conference spaces**

Offices and other spaces are heated by means of a radiator circuit (C radiators) and a fan coil (D) (east, west, fan coil strand) for which the heat source is a heat transfer station (5). The source of cooling for the fan coil strand is the chiller (4). Offices on the fifth level are exposed to high heat loads and low ventilation demands are supplemented with ceiling heating/cooling (B ceiling) forming a separate strand. Heating and cooling is the same as in the case of ceilings in conference rooms (2), (3).

- **Hot water heating**

It is supplied by the heat transfer station (5). Drinking water is preheated.

- **Bore Wells (3 Wells)**

Bore wells are a source of heat for the heat pump (2) low-temperature radiant heating and passive cooling (B ceiling). At the same time they provide potable water for independent distribution in the building. Part of the rain runoff water is ducted to one of the wells – well infiltration. The capacity of the wells extraction and absorption rate determine the maximum possible performance for low temperature heating and high temperature cooling (B ceiling).

- **Climate facade**

Automatic controlled blind system serves as a screening device for reducing the heat load in the west facing office spaces. The air in the climate façade is integrated into the ventilation system.

- **Management system**

The management system incorporates elements of intelligent building management. It provides:

  - Monitoring of operating parameters and conditions, quality of the environment,
  - Energy flows, metering and evaluating individual energy systems as required by the operational energy demands and parameters of external and internal changes.
  - Access system, monitoring outputs and movement around the site/occupancy level
  - Real time control of blinds in order to manage the intensity and reduce the heat load from solar radiation
  - Opening the windows and skylight for natural ventilation in energy-efficient mode,
  - Cycling and management of appliances and heating/cooling sources

Controlled blind system serves as a screening device for reducing the thermal load on the premises. After drawing up the energy performance certificate the Building achieved the following ratings:

Results of the Building Energy Efficiency Assessment

floor area of the building 5 698 m^2	Emissions CO2 12,64 kg/(m^2.a)	
place of energy consumption	the need for energy	Category
Energy demand for heating	16,2 kWh/(m^2.a)	A
Energy demand for the preparation of hot water	11,3 kWh/(m^2.a)	C
Energy demand for cooling / ventilation	15,8 kWh/(m^2.a)	A
Energy demand for lighting	11,3 kWh/(m^2.a)	A
Total energy demand	**55 kWh/(m^2.a)**	**A**
Primary energy	**70 kWh/(m^2.a)**	**A1**

Conclusion. At present, the object is at the stage of a gradual start-up of operations and fine tuning software applications for efficient management. Ongoing measurements and the evaluation of systems in different operating modes are underway to calibrate the system and improve energy efficiency. The outputs of the measurement balances are reviewed for various sources of energy distribution and consumption to evaluate the impact on environmental indicators. They are compared with balances that have been created in the design process of project activity. The results will be published on a partial basis and will serve for the processing of energy models for drafting and designing similar facilities.

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