SMART Solutions for Energy Saving and Better Indoor Environment

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This article contains partial results of a case study in the urban area of Brno - Nový Lískovec in the Czech Republic and partial results of a dynamic analysis of energy use in a case study setting in the Netherlands. Future research tasks, municipal visions and goals are discussed in order to fulfil the vision of the SMART Region concept in these locations. The article contains a brief presentation of some outputs and application of experiences from the National Centre of Competence project focused on energy flows in buildings, regions and distribution networks with a focus on heat/cooling supply, efficient use of RES, improvement of environmental quality and user comfort.

Keywords: Smart region, Buildings Refurbishment, Energy simulation, Indoor climate, Monitoring, Web map application

In Project [1], solved out from 2014 to 2019 in the Czech Republic, a multidisciplinary and interdisciplinary system of cooperation between companies and research organizations for the development of energy-efficient and environmentally friendly technological systems, equipment, components, methods and strategies for buildings in smart regions was analysed.

The outputs of the project have led to the establishment of a basis for a resilient approach in the pilot sites to address the energy and environmental situation of a set of buildings and the surrounding area/environment. A typical site is the urban district of Nový Lískovec with a detailed design of prefabricated residential, educational, office and civil buildings as well as a central and decentralized heat supply system and the use of renewable energy. Energy management was introduced in this area in 2000 and is still in operation today. Another example of smart solutions for the region is the analysis of energy flows and indoor environment and the solution of sub-issues in the Spa Piešťany site, which includes the efficient use of heat from the water of the healing springs and a study of natural lighting with a focus on the colours of interior wall surfaces and interior furnishings, leading to a reduction in energy consumption for lighting. A dynamic analysis of unused thermal energy sources in the region is a topic being worked on by a PhD student in the Netherlands. It deals with the usable energy flows between buildings that are in permanent cooling mode all year round (supermarkets, food warehouses, medicine stores) and other buildings that need heating in winter. The analysis also addresses the dynamics of the mismatch between energy supply and consumption (heat and cold) and the use of solar energy storage in the asphalt roads in the region.

The last sub-part of the smart region concept presented in this paper focuses on the possibility of using wind energy for power generation. It solves the CFD simulation of wind flow over the roofs of buildings. This issue has also been researched by a PhD student in recent years.

SMART city district BRNO – NOVÝ LÍSKOVEC

The Brno - Nový Lískovec district is located in the South Moravian Region of the Czech Republic. Currently, the area of this locality is 1.66 km² with 11 500 inhabitants. At the end of the 1990s, the Brno - Nový Lískovec municipal district launched an ambitious plan to revitalize the prefabricated apartment buildings in its ownership. Since the late 1990s, the municipality has introduced a building energy management system in its own housing stock to obtain valuable data on the energy behaviour of the buildings. Now, 22 years of intensive long-term monitoring of building energy consumption (heating and DHW) has provided and continues to provide decision-makers with valuable data and information when implementing renovation strategies and concepts and helps to facilitate important decisions in the future. Since 2014, indoor climate and indoor air quality (IAQ) has been monitored in selected apartments and municipal offices. Selected indoor climate and IAQ parameters such as air temperature, relative humidity and carbon dioxide (CO_2) concentration have been measured. A comparison of the energy performance of the pilot building type T06B before and after renovation is shown in **Figure 1**. The heating energy consumption in the selected years shows a significant decrease of 67% in 2004 and 78% in 2014 compared to the building energy consumption before retrofit. The energy consumption for hot water preparation shows only a gradual decrease in the selected measurement period.

The values of the heating system heat consumption obtained by implementing energy management with a weekly interval and related to the outdoor temperature plotted in the so-called E-T curve for the selected regenerated apartment building are shown in **Figure 2**. Research in this location in recent years has been focused on the use of IoT technologies for efficient energy use in controlling the operation of school buildings.

SMART region SPA PIEŠŤANY

The world-famous Piešťany Spa is located in the western part of the Slovak Republic, in the Trnava region, in the valley of the lower reaches of the longest Slovak river Váh. It is located on a spa island of 60 hectares at an altitude of 162 m. The spa island is one of the largest and most exceptional spa complexes in Europe. Its reputation is mainly due to its unique natural springs with thermal mineral water, which springing from cracks in the tectonic plates at a depth of 60 to 200 meters underground. The water on the surface reaches a very high temperature of 67–69°C, so it is first cooled before being used in the spa. Thermal mineral water is unique for its high sulphur and hydrogen sulphide content. The natural healing water pumped from the boreholes is piped into a storage station. Part of the natural healing water from the springs flows directly into the distributor, from where it flows into the balneotherapy department, the other part flows into the graphite heat exchanger

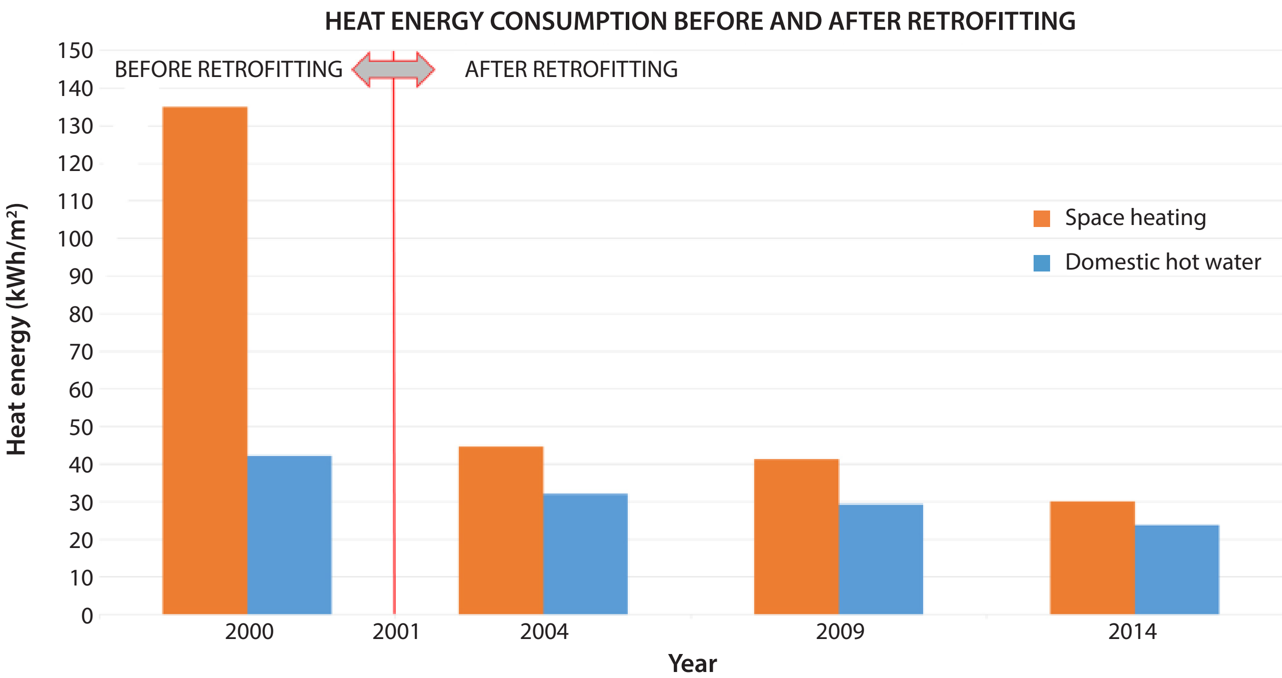


Figure 1. Comparison of the pre- and post-retrofitting results.

block, where it is cooled to a temperature of about 24°C and flows into the cooled water distributor, from where it flows into the balneotherapy department. The hot natural healing water distributor separates a partial quantity of this water into hot natural healing water storage tanks, where it is stored at a temperature of approximately 67°C and a pressure of 180 kPa. The cold natural medicinal water distributor separates a partial quantity of the cooled natural medicinal water into storage tanks of cooled natural medicinal water, where it is stored at a temperature of about 24°C and a pressure of 240 kPa. The pressure in the tanks is maintained by air compressors. In the event of greater water demand, this stored water can be used in the distribution system. The idea of implementing the SMART region principle in the Piešťany Spa was based on a detailed dynamic analysis of the temperature conditions of natural healing water in the distribution system and in the source wells with relation to the requirements of the healing processes and the management of the used healing water. The following measures have been developed and implemented: extension and improvement of the monitoring system of energy flows and water temperature parameters, systematic evaluation of information and data on the operation and use of natural medicinal water, efficient use of warm natural medicinal water in swimming pools, optimization of the technology of the accumulation station, dynamic analysis of the generation of natural medicinal water from the source and the requirements and utilization of natural healing water for therapeutic processes, design and implementation of a new heat exchanger for cooling of natural medicinal water based on experimental measurements and simulation model, and analysis of interior daylighting as a function of interior colour and with impact on electricity consumption for artificial lighting.

SMART region in Netherland

A pilot analysis of energy flows was carried out on a case study in the Netherlands. In the selected location, the combination of energy systems in a supermarket, an adjacent asphalt road, single-family and apartment buildings and truck traffic to supply the supermarket was analysed. To reduce the carbon footprint from truck traffic, the location of the greenhouse adjacent to the supermarket was chosen. The location of the collector in the road was investigated in terms of solar energy use. For residential and single-family homes, the option of ground energy accumulation was investigated, and for the supermarket, the objective was to analyse mainly the residual heat from refrigeration. The role of the four partners in the thermal energy exchange network was defined from dynamic simulations and the evolution of the time dependence of the energy flows. The **Figure 4** show the cooperation schemes in energy use between the partners.

WIND in SMART region

One of the scientific papers related to the SMART region concept deals with the use of wind flow over a building to provide information to determine the energy potential for a small wind power plant. A detailed 3D CFD simulation model including the surrounding terrain in two variants was used to analyse the wind flow over the roof of the FAST BUT science centre building. The variants differed in the use of boundary conditions for the building surroundings. The resulting findings, in particular the processed images of the wind flow fields, can be used to optimize the location of the wind turbine on the roof of the building and contribute to expanding the use of renewable energy potential in the region and in the building.

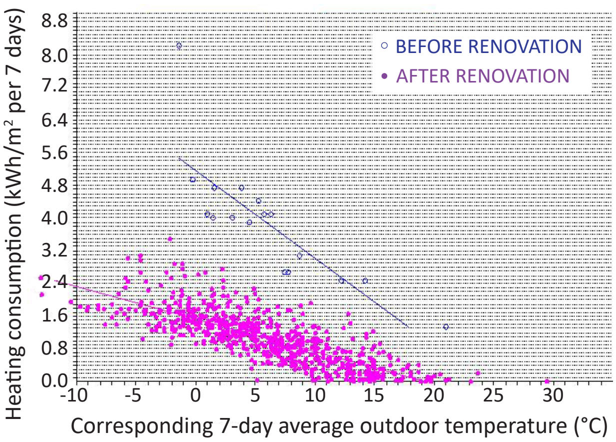
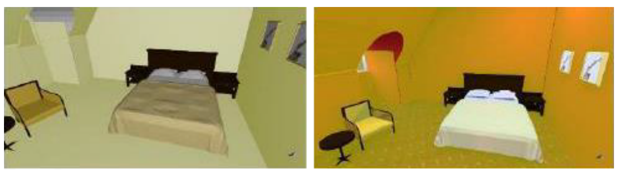


Figure 2. E-T curve for heating of prefabricated apartment building T06B (from 2000 year).



Variation A	Variation B
Surface reflectance -walls and soffit = 0.86 -carpet and upholstery 0.74	Surface reflectance -walls and soffit = 0.33 -carpet and upholstery 0.13

Figure 3. Room interior, in variation A and B (DIALux simulations).

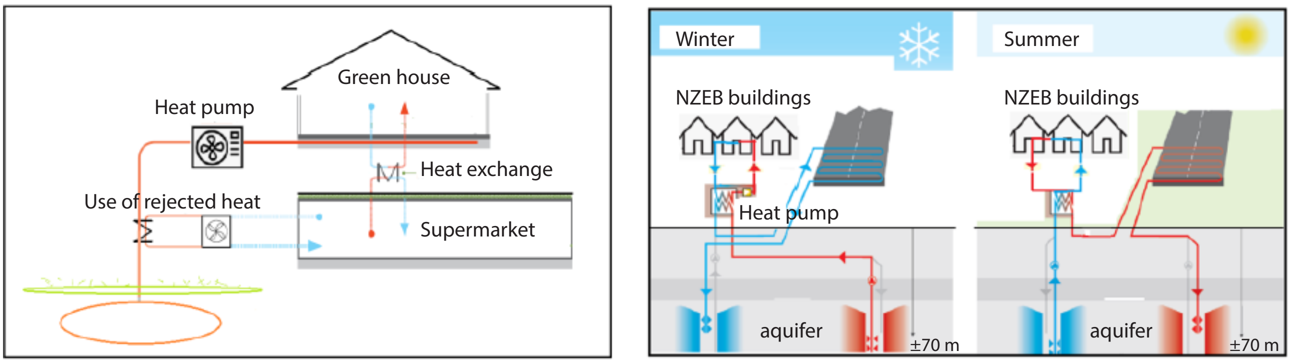


Figure 4. Collaboration between road and dwellings and between supermarket – greenhouse.

Conclusion

Creating a model and implementing the vision of a SMART region is a long-term activity that, thanks to modern technologies, enables efficient operation not only of energy systems, but also the use of data and information for further decision-making processes. The concept of the SMART Region can be built gradually, by developing partial solutions that build on each other and are compatible with each other. In the paper some solutions in recent years in several locations have been presented. The methodology and the form of the elaboration allows to repeat the application in other regions. ■

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