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EFFECTIVE USE OF RENEWABLE ENERGY SOURCES IN THE LABORATORIES OF CIVIL ENGINEERING FACULTY

Abstract: Sustainable building technologies, designed to create an indoor environment that uses fewer resources and generates less waste, can also be used to retrofit existing buildings to be more efficient in terms of energy and water. This paper deals with renewable energy sources based on current technology system environments made of advanced materials with the use of modern terminal and distribution elements for smart buildings within smart cities. The synergy between these technologies in a specially made full-scale experimental laboratory aims to achieve a zero-net-energy balance and provide experimental data on energy storage, optimization and occupant behaviour. It proposes the application of computer and telematics tools with automation organized systems and passive bioclimatic strategies, to achieve a socio-technical management of smart buildings that are energy efficient and environmentally sustainable.

Keywords: laboratories, renewable energy, research and development

Introduction.

The word 'passive' is often associated with negative social conations and although passive homes are far better than conventional homes, the concept is still inferior to that of sustainable, active zero net energy homes. Contrary to widespread opinion, insulation and energy efficiency are not the only factors required to achieve a synergy between zero net energy buildings and renewable energy sources. Most of the overall energy use in residential buildings is for low temperature heat (cooking, bathing, washing etc.) which from a thermodynamic point of view is a degraded form of energy with low potential to be converted back into work. This residual energy, which is produced by appliances, people and the environment together with solar gains can either increase cooling loads for buildings or be harnessed by thermal mass and active storage devices to maintain thermal stability by delaying and attenuating peak temperatures.

The consumer model.

The purposely built 55 m2 consumer model is representative of a family residence and is built in what shall be a full-sized laboratory climate chamber. The project named VUKONZE is under development by the Technical University of Kosice. Half of the model features walls that are made from externally insulated rammed earth while the diametrically opposite walls are made of externally insulated fired brick, both with thermal transmittances of 0,15 $W/m^2.K$ fulfilling passive house requirements. The materials for the walls were selected as a source of heat sink for diurnal fluctuations of temperature. The typology of the building is near symmetrical so that the performance of the two envelopes may be compared to see if the hygrothermal and vapour diffusion properties of rammed earth are more capable of maintaining a stable environment than fired brick. The building envelope features triple glazing in the windows and doors 250 mm of mineral wool insulation in the walls. The internal floor is raised by 965 mm above ground level and is ventilated. The floor and lightweight flat roof are both insulated with 400 mm of thermal insulation. Figures 1 and 2 depict views and details of the consumer model.

Figure 1: The consumer model showing the heat pumps for the climate chamber (not-shown)

External shading devices can be adjusted by smart control systems, HVAC is solved using radiant wall, floor and ceiling systems, traditional hot water radiators, fan coils and split AC systems and a recuperation system that also humidifies or dehumidifies fresh air. The HVAC system must respond to a variety of conditions inside and outside the building (including weather, time of day, different heating zones in a building and occupancy), while simultaneously optimizing its operations and related energy usage.

Smart building control and climate chamber.

Smart building technology generally refers to the integration of four systems: a Building Automation System (BAS), a Telecommunications System (TS), an Office Automation System (OAS), and a Computer Aided Facility Management System (CAFMS). In smart building design, the building envelope constitutes the boundary, as opposed to the barrier, between the internal and external environments. The building envelope is therefore adjusting gains and losses to and from the interior either inherently, through static elements such as building mass or cohesively through automatic response or control.

Figure 2: Left: Floor/wall celing heating and cooling and fan coil; Right: hot water radiator experiment

The climate chamber currently under construction, is designed to operate within a temperature range of -15 to 50 °C; a relative humidity range of 10 to 95 %; a wind speed of 0,1 to 15 m/s and atmospheric pressure range of 700 to 1085 hPa simulating an altitude range of below sea-level to approximately 3000 m above sea level. With modifications, the chamber can function as a multi-zoned entity to emulate cardinal environments. As a result, the consumer model is transposable to a range of climates to provide a comprehensive study of building performance using a single test subject. The multivalent laboratory will constantly monitor the building envelope, building environment, storage devices and service systems using temperature, pressure and heat sensors. Currently, the next evolutionary step is being considered with the concept of smart materials which can be separated into two groups: passive smart materials which only perceive changes in the environment and active smart materials which exhibit the properties of passive ones and additionally react to stimuli and have also the actuator.

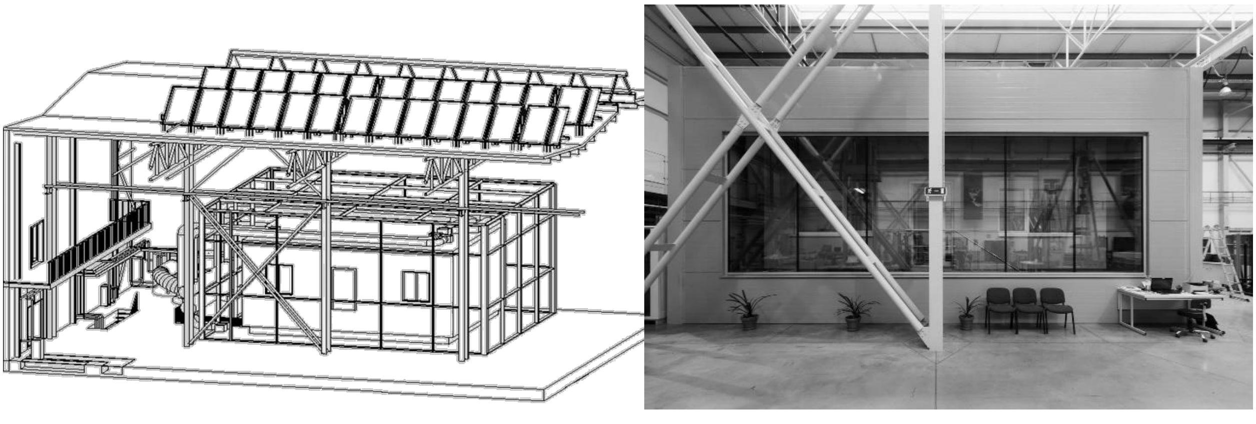

Figure 3: Partially transparent climate chamber that can regulate temperature, humidity, and pressure

The R&D of intelligent buildings service systems is focused on achieving a zero-net energy balance by implementing the strategy illustrated in Figure 4. The consumer model is situated in a climate chamber. At a later stage an identical reference building has been proposed for the external environment for verification of the research experiment. Eleven forms of renewable energy sources will provide a constant supply of energy to operate the module. The output and efficiency of each source will be monitored year-round to see which combination is the most effective and consistent for the Slovak climate. Energy derived from the renewable sources will be used to produce various forms of work. The entire system is over dimensioned so that there will always be excess energy which will be accumulated two short term storage tanks and three larger long term storage tanks. The heat sources provide heat for the administrative part of the building climate chamber hall and consumer model and electricity sources will provide energy for the consumer model.

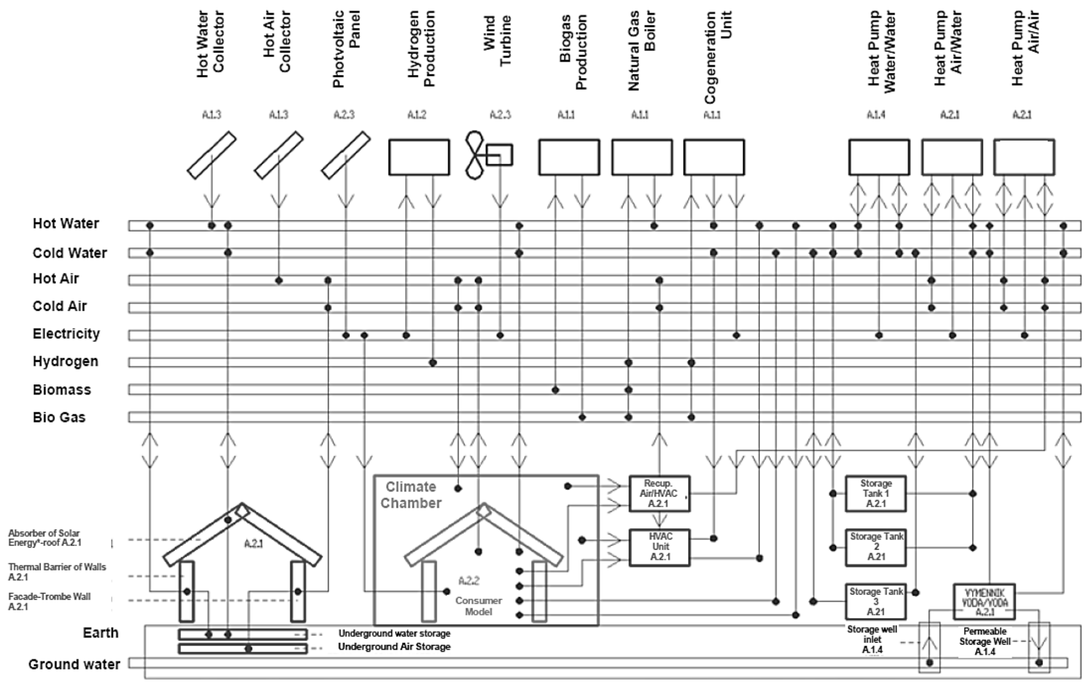

Figure 4: Schematic diagram depicting the symbiosis between renewable energy sources

Results.

The total annual thermal capacity of the permanent storage tanks is 290 GJ or 87 MWh. The peak performances of the individual renewable sources of energy are presented in the table below. Manipulation of these energy resources will be accessible via a cloud computing network so that registered institutions may conduct experiments for their desired climatic conditions remotely.

Table 1: Peak output of the renewable energy sources

Source	Heat [kW]	Electricity [kW]
Solar Collector 128m2	90	0
Hot Air Collector	3	0
Photovoltaic	0	5
Hydrogen	3	3
Wind turbine	0	1.5
Bio gas	90	0
Natural gas	25	0
cogeneration	37	30
Heat pump water/water	43	0
Heat pump air/water	15	0
Heat pump air/air	3.5	0
Total	312.5	39.5

Conclusion.

The practical implications of the applied research and development of intelligent building service systems is the creation of a platform to research the efficiency and interoperability of components and renewable energy technologies which will be based on experimental analysis. It will involve:

(1). The management, distribution and consumption of all multivalent sources used in the system, auxiliary pumps regulatory nodes etc.

(2). The optimum use of energy produced in relation to its potential temperature, and researching principles of short and long term storage of energy

(3) Examining the principles of temperature stratification in the tank (soil characteristics, depth, the influence of humidity and temperature gradient at different timescales)

(4). In situ simulation and testing conditions of energy and process controls subjected to dynamic environmental conditions

(5). The creation of a computer cloud where it is possible with remote supervision to simulate and test the interoperability of physical connections with heat sink surfaces such as rammed and fired brick walls.

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Анотація:

Стійкі будівельні технології, призначені для створення внутрішнього середовища, яке використовує менше ресурсів і створює менше відходів, а також може бути використана для модернізації існуючих будівель, щоб бути більш енергоефективними з точки зору енергії і води. Ця стаття стосується поновлюваних джерел енергії, заснованих на сучасних матеріалах з використанням терміналів і розподільних елементів для інтелектуальних будівель в межах розумних міст, що забезпечують експериментальні дані по зберіганню енергії, оптимізації. Система пропонує застосування комп'ютерних засобів з автоматизацією організованих систем і пасивних біокліматичних стратегій для досягнення соціально-технічного управління інтелектуальними будівелями, які є енергоефективними і екологічно стійкими.

Ключові слова: лабораторії, поновлювані джерела енергії, дослідження і розробки

Аннотация:

Устойчивые строительные технологии, предназначенные для создания внутренней среды, которое использует меньше ресурсов и создает меньше отходов, а также может быть использована для модернизации зданий, чтобы быть более энергоэффективными с точки зрения энергии и воды. Эта статья касается возобновляемых источников энергии, основанных на современных материалах с использованием терминалов и распределительных элементов для интеллектуальных зданий в пределах разумных городов, обеспечивающих экспериментальные данные по хранению энергии, оптимизации. Система предлагает применение компьютерных средств с автоматизацией организованных систем и пассивных биоклиматических стратегий для достижения социально-технического управления интеллектуальных зданий, которые являются энергоэффективными и экологически устойчивыми.

Ключевые слова: лаборатории, возобновляемые источники энергии, исследования и разработки