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Research Paper

An Intelligent Facade System with Active Thermal Protection for Insulation Systems with Water or Air as Heat-Transfer Medium

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ABSTRACT
IFS - an intelligent façade system with active thermal protection (ATP) in an innovative way combines existing building and energy systems into one compact unit, thus creating combined building and energy systems. These are building structures with an internal energy source. They are applied as thermal insulation systems, large-area low-temperature heating/high-temperature cooling and active areas - collectors of solar energy and energy from the surrounding environment. They are designed for application in new buildings but also for comprehensive renovation of all types of buildings. The main benefit is the possibility of unified and prefabricated production.
KEYWORDS: *Building structures with an internal energy source, active thermal protection, thermal barrier, large-area radiant low-temperature heating and high-temperature cooling, thermal insulation panels with active heat transfer control*

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I. INTRODUCTION

An Intelligent Facade System (IFS) with active thermal protection (ATP) is currently in experimental verification phase. It consists of *thermal insulation panels for systems with active heat transfer control (ATP thermal insulation panels)*, which are applied in the same way as contact thermal insulation facade systems. These panels are protected by European patent EP 2 572 057 B1 of 15.10.2014 (author: Kalús, D.), [1].

II. ATP – ACTIVE THERMAL PROTECTION - DEFINITION

ATP are pipe systems embedded in envelope building structures, **FIG. 1B**, to which a heat-transfer medium (heating or cooling water or air) at regulated temperature is supplied. These are building structures with an internal energy source and they form a combined building and energy system.

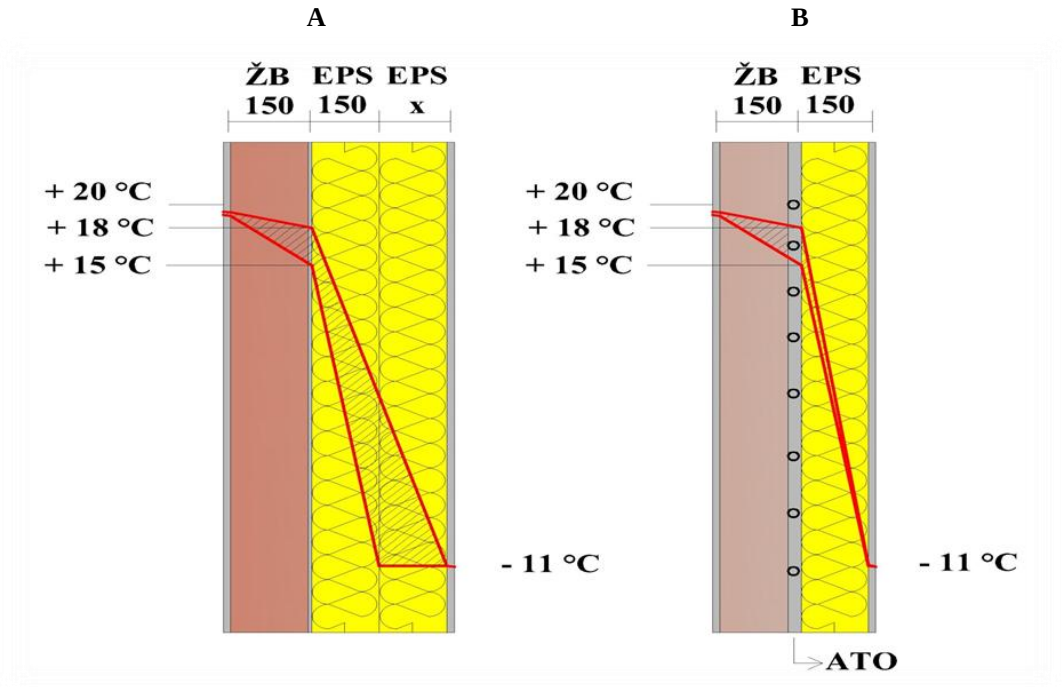

FIG. 1 Surface temperature between layers of the load-bearing and thermal insulation part of building structures with classic contact thermal insulation system "A" and a system with ATP "B",
ŽB - reinforced concrete, EPS - extruded polystyrene, x – increased thickness of thermal insulation, ATO = ATP – active thermal protection (author: Kalús)

From the point of view of thermal protection of buildings, it is important that thermally insulated building structures have the highest possible surface temperature between the layers of the load-bearing and the thermal insulation part. This can be achieved with greater thickness of thermal insulation, **FIG. 1A**, or the temperature of the heat- transfer medium in the ATO pipe systems in the building structure**, FIG. 1B**.

Under certain conditions, ATP can serve as a heat recuperator or as an energy collector for an application with a heat pump. An ATP is made of pipe systems (usually plastic circuits) embedded in building structures, through which a working medium circulates heated by any heat source (CHP, natural gas or biomass boilers, heat pumps...). The main function of the system is to decrease or eliminate heat losses through non-transparent structures in winter and at the same time to decrease or eliminate heat gains in summer. It is in particular recommended to apply renewable energy sources with respect to low required temperatures of the heating medium, and thereby to shorten the heating period of the building. Application of ATP in combination with waste heat is recommended as well. Buildings where this system is applied have low energy consumption and therefore meet the requirements of Directive no. 2018/844 / EU, according to which, from 01.01.2021, all new buildings for housing and civic amenities should have energy demand close to zero. [6].

III. AN INTELLIGENT FACADE SYSTEM WITH ACTIVE HEAT TRANSFER CONTROL FOR THERMAL INSULATION OF BUILDINGS

ATP is applied on all non-transparent structures – floor, walls, and roof, **FIG. 2**. So far, ATP was realized by mechanical anchoring of distribution pipes on a wall, multiple rendering of the pipes and subsequent gluing on thermal insulation with finishing of the façade, [2], [3], [4], [5], [7], [8], [9], [10], [11], [12]. Thermal insulation panels with integrated active thermal protection in the form of pipes or canals represent an intelligent contact insulation system made by a standard procedure from the same materials and by the same technological procedure as a classic contact thermal insulation system.

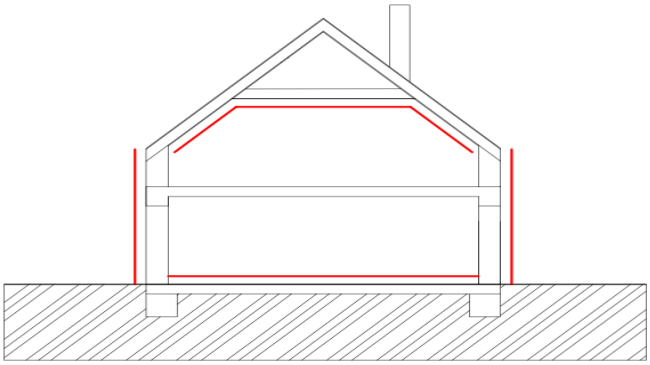

FIG.2 Principle of application of ATP on a building – ATP forms an active "envelope" of the building (author: Kalús)

The principle of contact thermal insulation systems with ATP is shown in **FIG. 3**, which depicts one of the possible variants of composition of thermal insulation panels with ATP. A contact thermal insulation system with ATP is formed by panels with standard dimensions (2000/1850/1600/1550x1000xthickness min. 100 mm) and non-standard panels tailor-made according to the laying plan, **FIG. 4**.

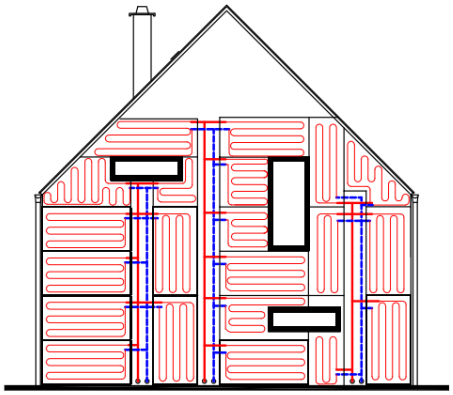

FIG. 3 Connection of panels with ATP (WATER as the heat-transfer medium) to the supply and return heating/cooling distribution pipes (author: Kalús)

FIG. 4 Principle of construction of a contact thermal insulation system using thermal insulation panels with ATP (WATER as the heat-transfer medium) (author: Kalús)

From technologic point of view, thermal insulation panels with ATP can be produced in two ways:
- By milling of grooves, **FIG. 5**,
- By embedding into a system board, **FIG. 6**.

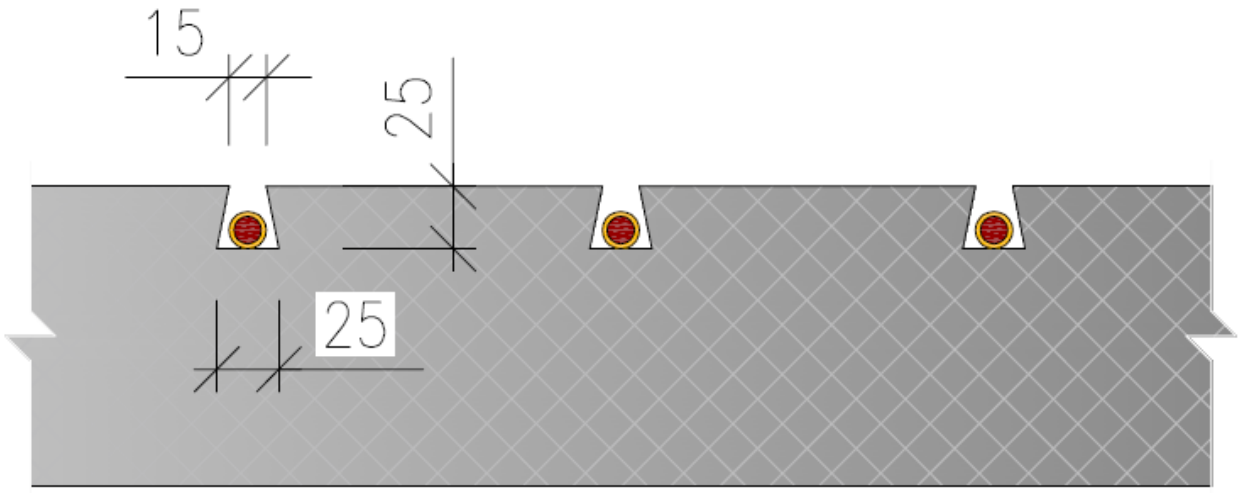

FIG. 5 Principle of a panel with ATP (WATER as the heat-transfer medium) – by milling of grooves (author: Kalús)

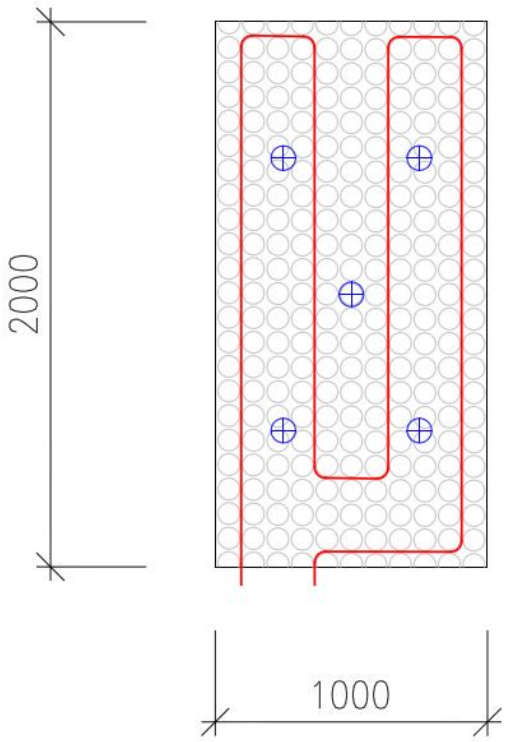

FIG. 6 Principle of a panel with ATP (WATER as the heat-transfer medium) – embedding into a system board (author: Kalús)

A contact thermal insulation system with ATP differs from classic thermal insulation systems because it contains distribution pipes. Connection of the panels to the supply and return pipes is realized in a way that none of the circuits created by the panels has an area bigger than 15 m^2. The supply and return distribution pipes are led in canals [in panels] with standard dimensions of 1000 x 500 x thickness of the panels (min. 100 mm), 1000 x 650 x thickness of the panels (min. 100 mm),1000 x 800 x thickness of the panels (min. 100 mm),1000 x 950 x thickness of the panels (min. 100 mm), **FIG. 7**. The principle of connection of the panels with ATP is shown in **FIG. 8**.

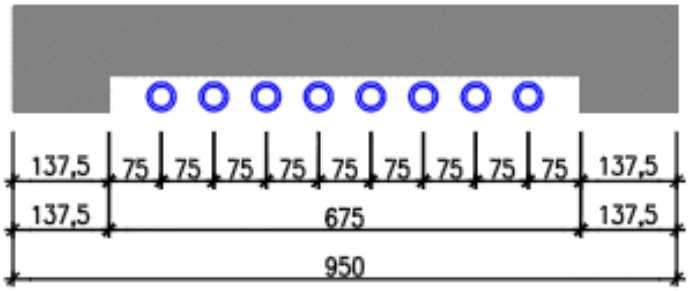

FIG. 7 Example of a thermal insulation panel to cover the supply and return pipes (author: Kalús)

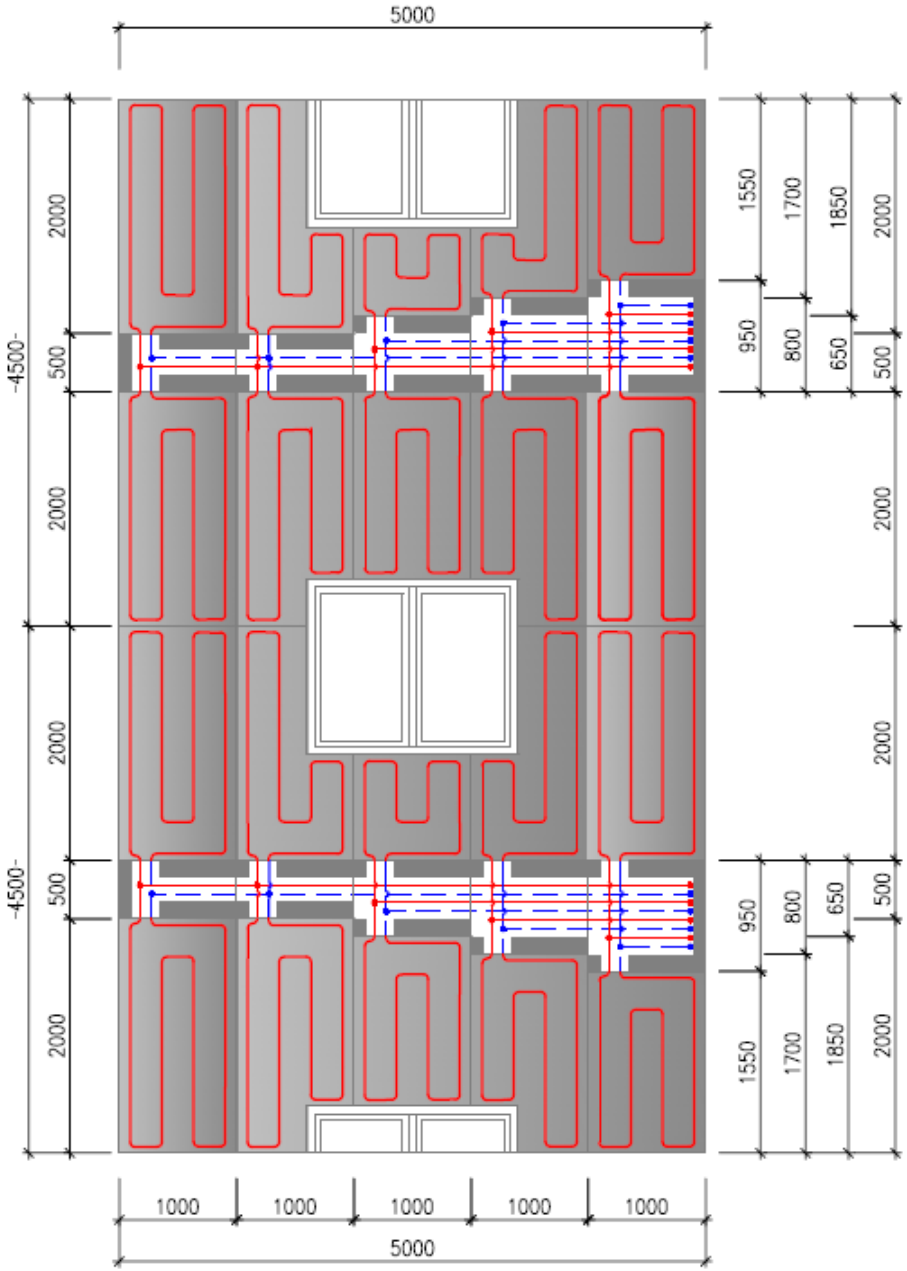

FIG. 8 Principle of connection of panels to heating circuits,supply and return distribution pipes led in canals (WATER as the heat-transfer medium) (author: Kalús)

4. TECHNOLOGICAL PROCEDURE FOR THE PRODUCTION OF THERMAL INSULATION PANELS WITH ACTIVE HEAT TRANSFER CONTROL FOR THERMAL INSULATION OF BUILDINGS

Production of thermal insulation panels with ATP (WATER as the heat-transfer medium) is possible in two ways:

a) Milling of grooves for the pipe register in three steps, **FIG. 9,**
b) By embedding of the pipes into a system board, **FIG. 10**.

a) **Milling of grooves for the pipe register in three steps**

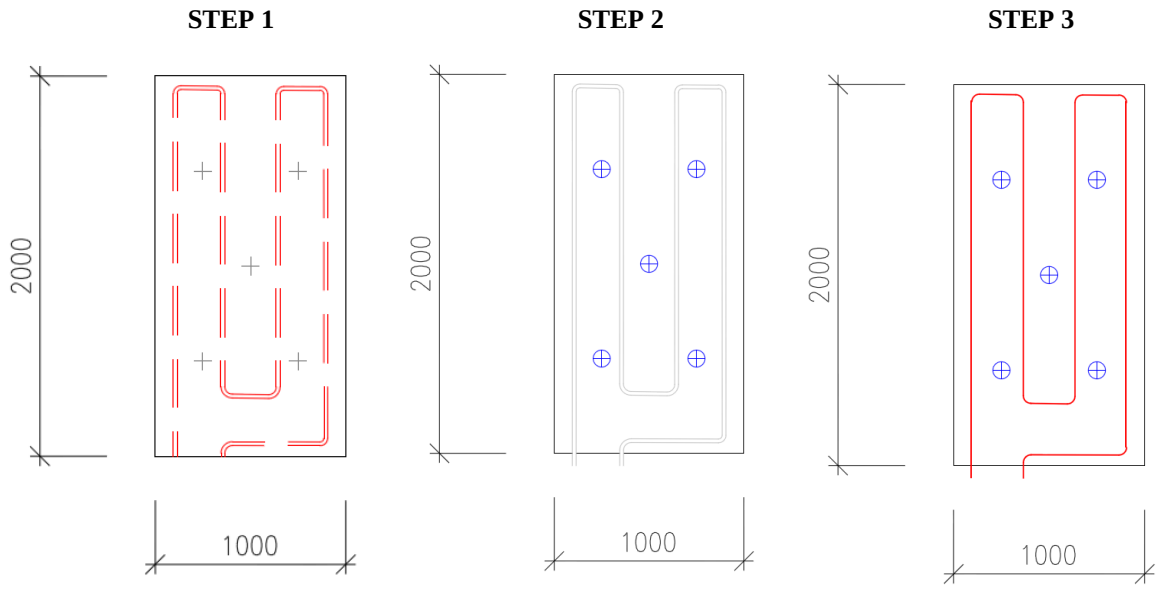

FIG. 9 Technologic process of production of the panels (WATER as the heat-transfer medium) - by milling. **STEP 1** – outline of the heating/cooling register and openings for mechanical anchoring (wall plugs) of the panels with ATP, **STEP 2** – milling of grooves for the heating/cooling register and drilling of openings for mechanical anchoring (wall plugs) of the panels with ATP, **STEP 3** – embedding of the heating/cooling pipes (author: Kalús)

b) **By embedding of the pipe register into a system board in two steps**

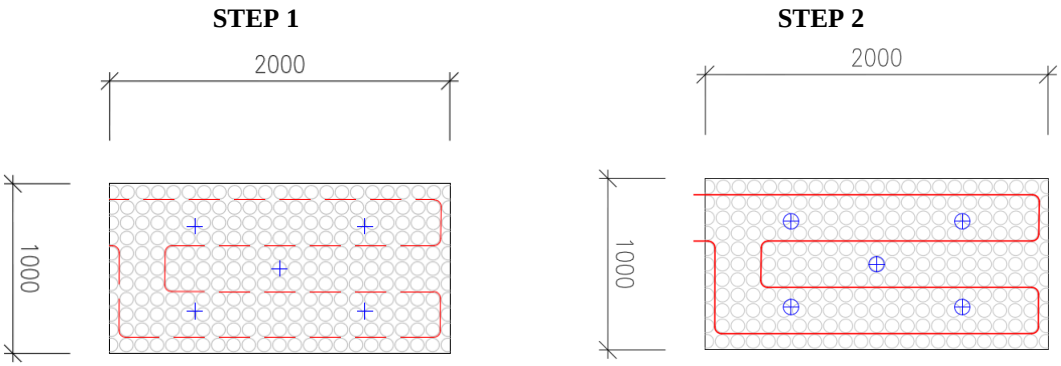

FIG. 10 Technologic process of production of the panels (WATER as the heat-transfer medium) – system board. **STEP 1** – outline of the heating/cooling register and drilling of openings for mechanical anchoring (wall plugs) of the panels with ATP, **STEP 2** – embedding of the heating/cooling pipes (author: Kalús)

Panels serving as warm-water canals and panels using AIR as the heat-transfer medium can be milled or pressed.

IV. AN INTELLIGENT FACADE SYSTEM WITH AN INTEGRATED ACTIVE SURFACE – A REGISTER FOR COLLECTING SOLAR ENERGY AND ENERGY FROM THE SURROUNDING ENVIRONMENT, WITH LIQUID OR GAS AS THE HEAT-TRANSFER MEDIUM

Thermally active panels with an integrated active surface – a register for collecting solar energy or energy of the surrounding environment – are applied as a standard contact thermal insulation system. The exterior surface is characterized by an active surface – a register formed by pipes for liquid or gaseous heat-transfer medium. These thermally active panels are applied in combination with renewable heat sources (RES), in particular with heat pumps. **FIG. 11**.

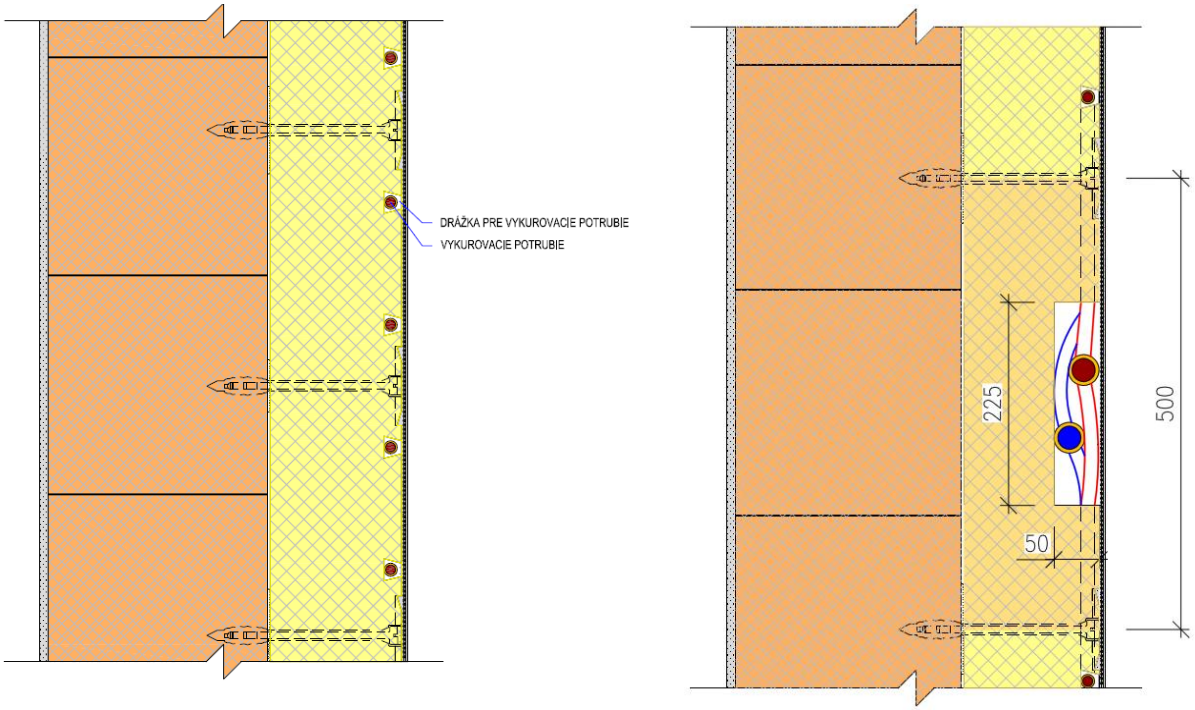

FIG. 11 Application of a contact thermal insulation system with a register collecting solar energy or energy of the surrounding environment in combination with a heat pump (author: Kalús)

V. AN INTELLIGENT FACADE SYSTEM WITH THE FUNCTION OF ATP AND AN ACTIVE SURFACE - REGISTER COLLECTING SOLAR ENERGY AND ENERGY OF THE SURROUNDING ENVIRONMENT, WITH LIQUID OR GAS AS THE HEAT-TRANSFER MEDIUM

A combination of a thermally active panel with ATP with an integrated active surface represents another possibility of creating a compact thermal insulation system, **FIG. 12**. This category includes thermal insulation panels with ATP (WATER or AIR as the heat-transfer medium with an additional function of absorber on the exterior side to collect energy of the surrounding environment). Thereby, the multiple functions of the construction and the contact thermal insulation system are expanded, and at the same time the number of operations is decreased in the process of construction of a building and realization of an energy system. Simplicity and technologic process of realization of a combined facade system remains unchanged, as it was before.

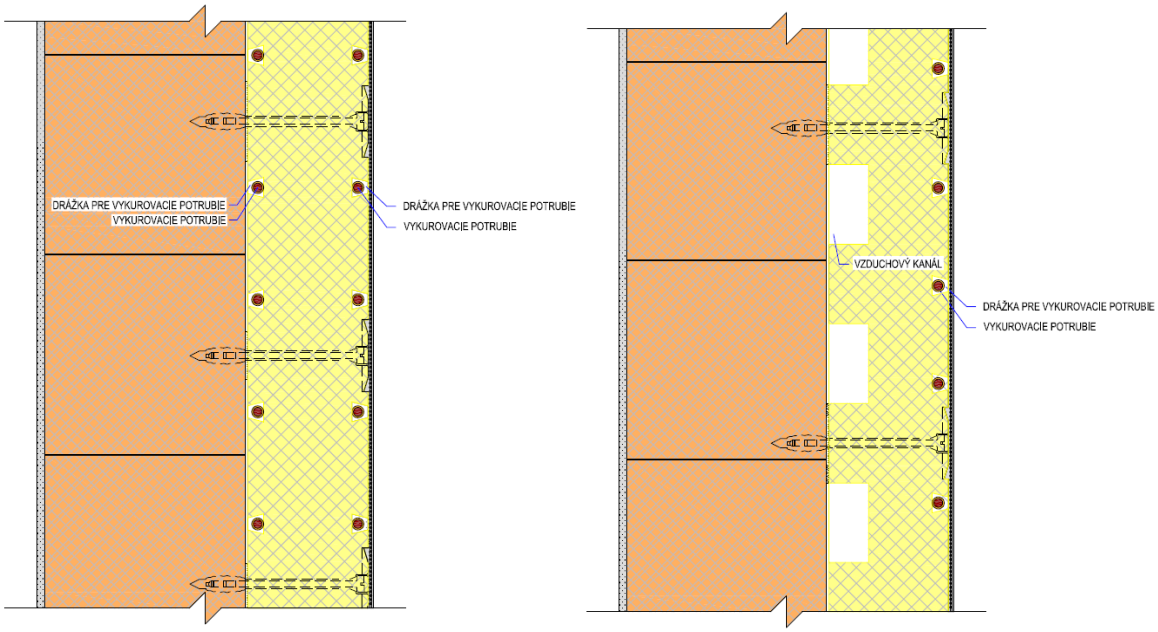

FIG. 12 Application of a contact thermal insulation system using thermally active panels, with a combined function of ATP and register collecting solar energy or energy of the surrounding environment (author: Kalús)

VI. CONCLUSION

An intelligent façade system with thermal insulation panels with ATP has a wide range of applications. Not only in new buildings, but also in reconstructions. Unification of production is supported by the fact that a majority of residential houses in Slovakia, as well as in Central and Eastern Europe are not yet thermally insulated. Elaboration of prototypal documentation with laying plans for the individual types of panel residential buildings could significantly contribute to mass production of panels with ATP. The character of low temperature heating applied to constructions with ATP predestines this system also for application in industrial buildings, commercial premises, and other civic amenities, where, besides the traditional heat sources, it is possible to use renewable energy sources and waste heat, e.g. from cooling and freezing installations. Versatility of use in all types of buildings or premises is supported by the possibility to use ATP panels also with AIR as the heat-transfer medium. Panels with AIR as the heat-transfer medium can be manufactured with plastic (metal) ventilation ducts with a circular cross-section with diameters of 50 to 100 mm, integrated in the thermal insulation board.

LITERATURE

[1]. KALÚS, D.: EUROPEAN PATENT EP 2 572 057 B1: *Heat insulating panel with active regulation of heat transition.* Date of publication and mention of the grant of the patent: 15.10.2014 In: Bulletin 2014/42 European Patent Office, international application number: PCT/SK2011/000004, international publication number: WO 2011/146025 (24.11.2011 Gazette 2011/47), 67 p.

[2]. CVÍČELA, M.: Analysis of wall energy systems. Dissertation work. Slovak University of Technology in Bratislava, Faculty of Civil Engineering, Slovak Republic 2011, 119 pp., SvF-13422-17675.

[3]. JANÍK, P .: Optimization of energy systems with long-term heat accumulation. Dissertation work. Slovak University of Technology in Bratislava, Faculty of Civil Engineering, Slovak Republic 2013, 185 pp., SvF-13422-16657.

[4]. Q Zhu, X Xu, J Gao, F Xiao: A semi - Dynamic simplified therm model of active pipe embedded building envelope based on frequency finite difference method. In: International Journal of Thermal Sciences, 2015 – Elsevier, Vol. 88, pg. 170-179, 2015.

[5]. KRZACZEKA, M., KOWALCZUK, Z.: Thermal Barrier as a technique of indirect heating and cooling for residential buildings. In: An international journal devoted to investigations of energy use and efficiency in buildings - Energy and Buildings, 2011 – Elsevier, Vol. 43, pg. 823-837, 2011.

[6]. Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency

[7]. www.isomax-terrasol.eu

[8]. www.rieder.at

[9]. www.po.opole.pl. TU v Opole (2013)

[10]. http://www.eng.pw.edu.pl. TU vo Varšave (2013)

[11]. http://www.stavebne-forum.sk/sk/article/18284/

[12]. ISOMAX. http://www.isomax.sk.