RESEARCH ARTICLE OPEN ACCESS

Research on Compact Heating/Cooling Units Using Renewable Sources of Energy

Assoc. Prof. Ing. Daniel Kalús, PhD.*, Ing. Matej Kubica*
* (Department of Building Services Faculty of Civil Engineering, STU in Bratislava, Slovak Republic,

ABSTRACT
Many ingenious inventions were developed during modern history, but their spreading failed due to inconvenient timing or weak propagation. In our work we processed our own survey and other researches about future constructions in European Union in order to indicate possible technological trend, which will be present in building constructions. In territory of EU can be seen great repulsion of investors and designers in usage of renewable sources of energy. However, according to research, this disinterest will gradually disappear and there will be suitable conditions for our developed device. The article contain chronologically described development, schemes of connection, method of measurement and regulation, possible process of production and future applications, direction in development of compact station is indicated. One of interesting novelties will be diagnostics of performance of whole system connected to compact station – that will bring better accuracy into controlling and it will be possible to integrate this invention into heating systems, which already exist.
***Keywords* –** compact heating/cooling units, combined construction and energy systems, mathematical and physical models, mobile laboratory, design models, renewable energy sources

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Date of Submission: 15-01-2021 Date of Acceptance: 31-01-2021

I. INTRODUCTION

Work with description, measurement and optimization of compact stations of the new S.M.A.R.T. type. Self-monitoring, analysis and reporting technology or S.M.A.R.T. is a technology monitoring system that detects and reports security reliability indicators in an attempt to predict failures.

The new smart-type compact heat station is a technological device with a control unit that can monitor, analyze, detect and predict failures, ensure the communication and collaboration of the technological components of the compact heat station with each other but also with external devices using software specially developed for this purpose remote control.

The technological development of technology in every field of science and technology is heading towards total networking. The reason is to use a huge amount of information to make decisions much faster and more accurate.

Tight connection of technological components of the compact station hot new smart type, heat sources, end elements energy systems, people like users to be achieved by reducing energy performance of buildings, increase the economic efficiency of technical building equipment, reduce operating costs and save the environment long term sustainable manner.

The compact heat station being developed also includes connections to heat sources and energy storage in addition to the connection and transfer nodes.

At present, efforts are being made to reduce operational and investment costs to a minimum by using renewable energy sources. Energy-efficient buildings no longer need traditional heating systems, but are increasingly being used to heat and cool large-area building structures. Unconventional energy systems, which are proposed as part of the construction, have been taking their lead and have been involved in building construction since the design itself.

Work is currently focused on market research and the assessment of potential future use of compact equipment and specification of its parts. The overall layout of a compact station from commonly used components adds new possibilities for its use, namely diagnostics of the heating system in renovations and buildings with incomplete factual design.

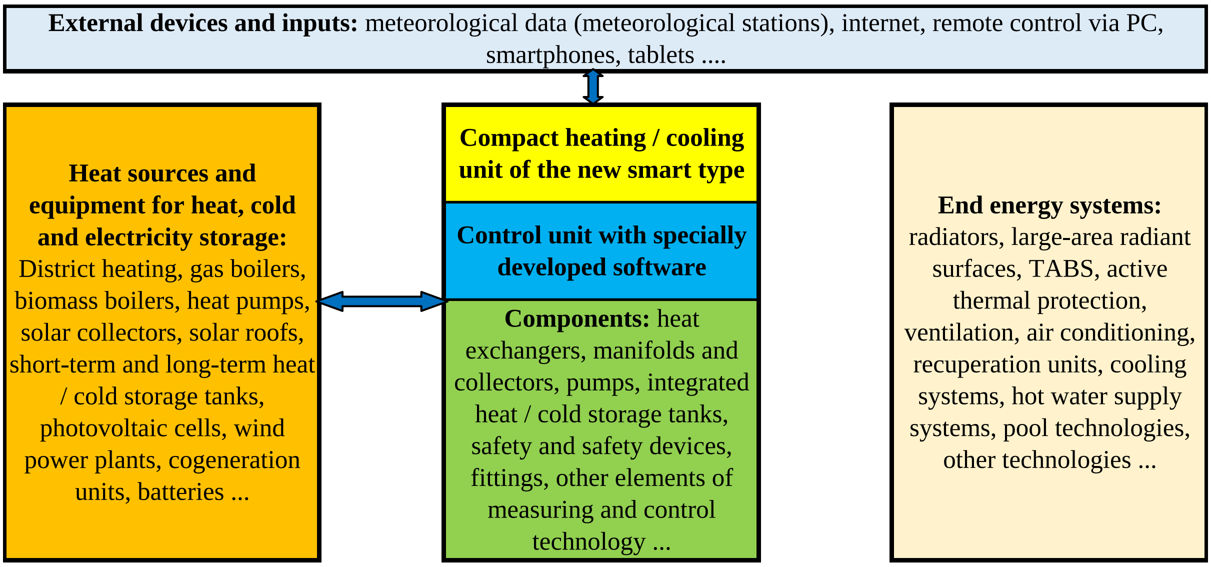

FIG. 1 Principle diagram of a compact heat station of a new smart type [Kalús]

II. CURRENT STATE OF THE MARKET AND TECHNOLOGY IN SOLVED PROBLEMS

Successful expansion and capture of the invention is directly related to the right timing of production and addressing future users. We have therefore decided to devote one chapter to our work of assessing the current state of the market for similar compact stations and new trends as well as the political situation affecting the near future in the field of construction and construction.

II.1 Survey of housing in EU countries

In most EU countries, the construction sector is growing. Surveys show an increased interest of people in solving the issue of their own housing. Due to migration policy in the Union as well as within individual countries, there will be considerable population shifts, and regions with enough jobs will expand. Surveys suggest that, for example, in Germany, up to 100,000 habitats will be missing in some regions by 2045 in some regions. In surveys, people prefer housing in family houses on the outskirts of cities and in the countryside before living in big cities.

A survey conducted between 9 April 2017 and 14 April 2017 with a sample of 558 respondents conducted on the territory of the Slovak Republic found that 79.8% of the interviewed wanted to live in a family home, and 71.3% of people wanted to influence the projection of their property. 27.8% of respondents in 5 years, 41.2% of those surveyed in 10 years, and 17.9% of respondents in 15 years want to realize their own housing plans.

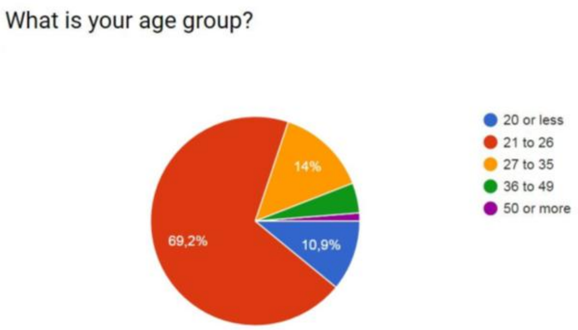

FIG. 2 Age composition of respondents in the survey [Kubica]

Solar water heaters would like to have 70.1% of the respondents on their property. Photovoltaic would like to have 55.9% of the respondents on their property and the Heat pump would prefer 34.6% of the respondents.

A survey conducted by ČSOB - bank with a sample of 4976 respondents carried out in the territory of the Slovak Republic in the period from 21.10.2013 to 14.10.2014 found that 49% of the interviewed wanted to live in a family home and 43% of people were living in their own property. The survey further found that 33% of the respondents were living with parents and 19% of people in the sublease. Up to 39% of Slovaks plan to implement their own housing plans at the 5-year horizon. [4]

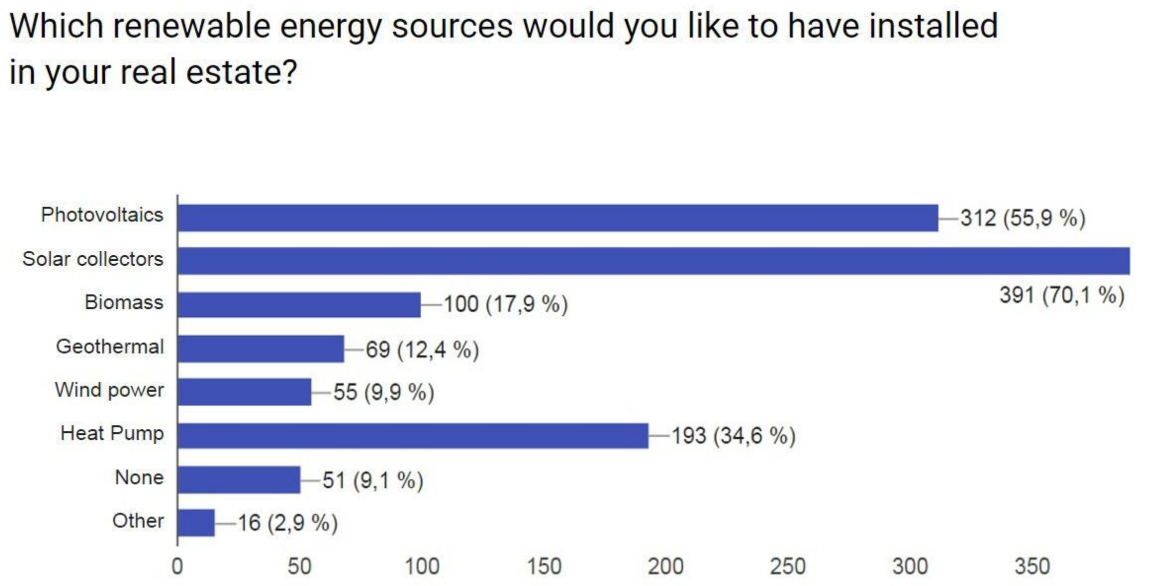

FIG. 3 Result of Preferential Renewable Resources Survey [Kubica]

A survey conducted by ELK with a sample of 1000 respondents conducted in the Czech Republic in April 2014 found that 84% of the interviewed wanted to live in their own family home. [5]

The Survey of the Integrated Market and the Opinion of the Research Institute in Austria published in December 2016 surprisingly showed that 75% of Austrians are looking for the home they will own. In the construction phase, 43% of respondents would manage their construction self-help, and 25% would welcome their own projection. [6]

Survey of the Institute of Management and Economic Research in Germany with a sample of 2100 respondents published in May 2016 that 67% of Germans would like to live in a family house or cottage. In Germany, 87.3% of the home is currently more than double rooms. [7]

II.2 Involvement of renewable resources in practice, attitudes of investors and specialists of the MEP

The current involvement of solar energy in the building system is inefficient, especially in smaller installations on family houses. In the case of photovoltaic engagement, three modes of connection are made. The first way is to connect to a network when overproduction of electricity is released into the divorce. This electricity can be redeemed, but in the event of a large number of installations being connected to the network, there will be major tension and flow problems in the future. In the future, therefore, it will not always be possible to buy electricity. The second way is to build an accumulator economy. Such solutions are expensive, unprofitable and non-eco- logical with regard to the lifetime of the currently used battery types. A third way is a combination of the aforementioned methods with the possibility of producing thermal energy from overproduction of electricity. Solar collectors are in hot water heating. In this connection, the use of solar collectors is half that of using solar collectors for heating in the transition period. The tray stack system forces the user to maintain such a stack permanently heated, which in the summer causes unnecessary losses from storage. ‘figure 3’shows the connection of solar collectors to a bivalent DHW cylinder. The solar circuit is inoperative, but the over-sized tank remains in the wiring, and therefore the user has to centrally prepare more water than would heat if the solar heating was not used at all.

In practice, we often meet with investors who oversee the obligation to deal with heating and heating systems. Installed power from renewable sources is negligible and, as a result, increases investment costs without lowering operating costs. Most designers do not like to propose technically more complex solutions, preferring pre-prepared schemes from previous projects.

FIG. 4 Connecting a non-functional solar circuit to a bivalent hot water tank [source: authors]

II.3 Requirements for construction in the European Union, Directive No. 2018/844 (2010/31)

The objectives of the Energy Performance of Buildings Directive impose new obligations on the state. Member States are committed to increasing energy efficiency by 20% and reducing energy consumption by 2020, which in practice means designing all new buildings with nearly zero energy consumption. The second main point of the directive is to cover 20% of the consumption of renewable energy by 2020. The third major point is to reduce greenhouse gas emissions by 20% by 2020. A further point on the developed plant is the mandatory assessment of the possibilities of using the system of energy supply from renewable resources for new buildings. [8]

II.4 Current Compact Heating Stations

At present, a whole range of compact heating stations are offered on the market. Some stations are able to use a renewable energy source, but none can solve the complexity of multiple sources using maximum efficiency. In addition to compact stations for family and apartment homes, compact compact stations and special compact stations for industrial use are also on the market. These stations with high transmission power are out of reach of the station being developed. The following compact devices are the most important devices for the new device.

- Compact stations with one function that do not address the complexity of residential unit heating but serve to simplify the installation of heating technology. These include, for example, compact stations for the preparation of hot water, solar compact units and others. [9]
- Distribution and measurement compact stations designed for installation in family houses and apartment buildings. Such compact stations are in power ranges from 2 kW to 50 kW.

FIG. 5 Domestic compact station for measuring hot and cold water consumption with integrated plate heat exchanger for connection to source [9]

II.5 Utility model of a compact device

Based on utility model no. 5749 A working laboratory and a series of mathematical and physical models have been developed for the operation of the combined building and energy system of buildings and equipment registered in Banská Bystrica, Slovak Republic in April 2011. [3]

The nature of the operation of the combined building and energy system of buildings based on the exchange and / or conversion of energy according to the invention consists in the fact that the complex creation of the indoor environment of the buildings with regard to the seasonal or immediate requirements is accomplished by a combination of controlled processes. These processes include heat absorption, heat production, cold, heat accumulation, use of active heat protection, low temperature, hot air heating, cooling,

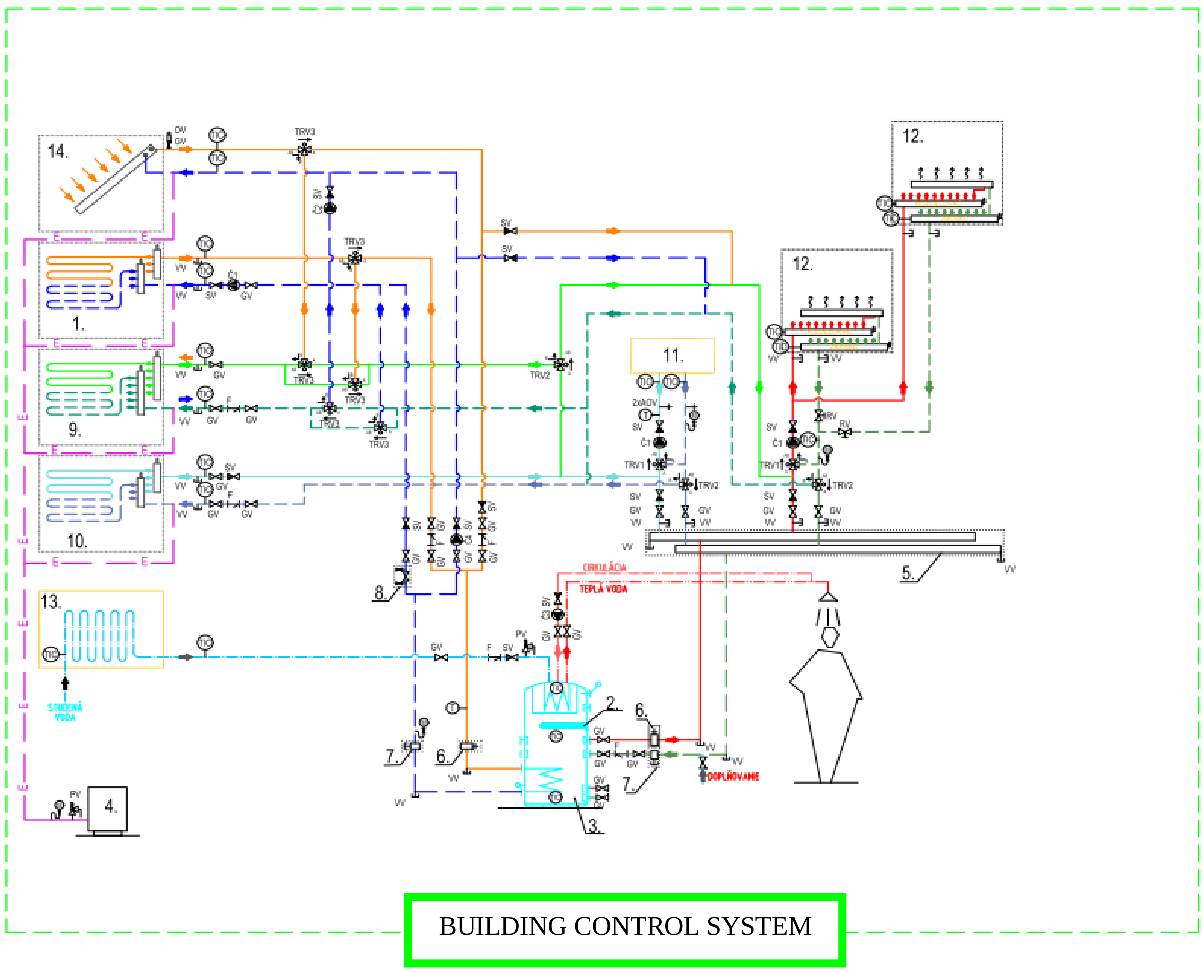

FIG. 6 Mathematical-physical model - variant 21.01.02 [Kubica, Kalús, 3]

VARIANT 21.01.02: ENERGY SYSTEM OF THE BUILDING IN MODIFICATION WITH SOLAR ROOF AND SOLAR COLLECTORS, THE TOP SOURCE IS AN ELECTRIC SPIRAL IN THE COMBINED STORAGE TANK, HEATING IS CARRIED OUT BY UNDERFLOOR HEATING, LONG-TERM STORAGE IS A GROUND STORAGE TANK BELOW THE BUILDING

water heating. With the help of a building control system that actively regulates the temperature of the heating medium and with the help of a heat source, a cold source and a short-term heat reservoir and a short-term cold storage tank, we create the appropriate properties of the indoor environment.

III. RESULTS

Experimental measurements were performed in a mobile laboratory. On the basis of the measurements, a method of operation and connection of the future compact device was proposed. An important step towards improving the operation was to separate heat or cold from a part of the distribution. At a time when free energy is produced, this energy is often unused and accumulated in short-term storage. So the building can use the energy collected during the day to use at night. Such a measure can reduce the heating period by up to 60 days.

III.1 Suggested procedure for operating a compact device

From the observation of the behavior of the system, the following conclusion was reached. The control of the laboratory and the compact device will take place on two levels. The first level will be controlling distribution, accumulation and production according to six seasons. Periods are alternated according to average daily temperatures similar to those found in a residential building where the start and end of the heating season are controlled by an average daily temperature of 13 ° C for more than three days. The second level of control will be the equithermal regulation of the curves on the heating systems. The intent of regulating equilibrium is that if the heating water temperature rises, the direct path of the 3-way valve closes and vice versa. If the outside air temperature rises, the setpoint of the heating water supply temperature is dropped according to the equithermal curve. The following chapters describe a step algorithm for creating a control program for each period.

Table 1. Periods based on average daily temperatures

Average daily temperatures	Heating period
4°C - 8°C	1/2 spring
8°C - 15°C	2/2 spring
15°C and more	summer
8°C - 15°C	1/2 fall
4°C - 8°C	2/2 fall
4°C and less	winter

FIG. 7 View of a mobile laboratory equipped with solar collectors and photovoltaic cells [Photo source: authors]

III.2 Diagnostics of Installed Outputs

Pre-installed and pre-programmed ultrasonic heat meters allow you to create new ways to get data and compare the projected and actual state. In the compact station are installed two sets of ultrasonic heat meters. The resource set can detect the immediate power output and the amount of energy stored in the heat and cold storage. The set of heat distribution meters can detect the installed power of the heating systems. The procedure for calculating the power of the source according to the ultrasonic heat meter is shown in Example 1. [1] [2]

Example 1

Obtain immediate power on the source side and the inlet pipe temperature is t_1 = 50 °C and the return pipe temperature is t_2 = 30 °C. The volume flow of the heating water in the pipeline is V= 1 m³/h. The specific heat capacity of the water is c = 4180 J/(kg.K) and the water density at medium temperature t_{str} = 40 °C is ρ = 992.2 kg/m^3.

Conversion: 1 m³/h = 1/3600 m³/s

Qz = m. c. $(t_2 - t_1)$ = V. ρ. c. $(t_2 - t_1)$ =

1/3600. 992.2. 4180. (50-30) = 23 041 W

Conversion: 23 041 W = 23.04 kW

Instantaneous power on the side of the sources at a flow rate of 1 m³/h at a temperature drop of 20K with a mean temperature of tstr = 40 ° C is Qz = 23.04 kW.

III.3 Designing a production program solution

For the future manufacturer, it is important to create a clear production program. The consumer can thus choose the device according to performance from two power alternatives from 10kW to 45kW and from 45kW to 150kW. The user or designer chooses an alternative to heat and cold or heat only.

FIG. 8 View of a mobile laboratory - heat source - heat pump [Photo source: authors]

At present, reversible heat pumps are used for the production of cold when heat or cold is prepared with one device. In the final step, the manufacturer offers additional packages such as solar collectors, photovoltaic panels, biomass boilers, hot water heating, and the like. The design software calculates the storage tank volumes according to the floor area of the heated building and also suggests the volume of the expansion vessel.

FIG. 9 View of the the possibility of connecting a mobile laboratory to an external heat source [Photo source: authors]

FIG. 10 View at the equipment of technical and measuring micromobility of a mobile laboratory [Photo source: authors]

FIG. 11 Distributor and collector with measuring instruments on the heat transfer side [Photo source: authors]

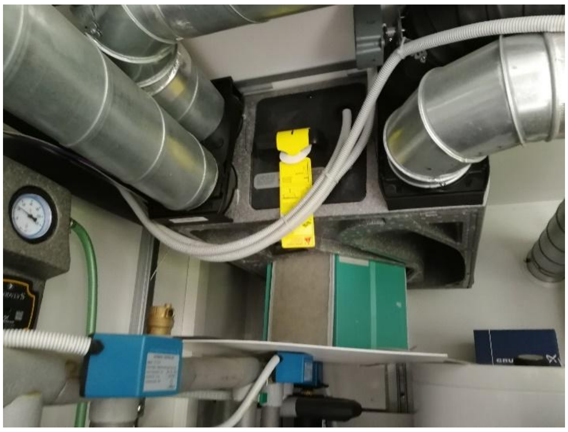

FIG. 12 View of the recuperation ventilation unit [Photo source: authors]

FIG. 13 View of the air ductwork in the measuring room [Photo source: authors]

Design with heat generation is also the cheapest version of a compact station without a reversible heat pump and without the ability to produce cold. The compact station has three outputs for the source, two with the exchanger and one without the exchanger. Due to the lack of cooling

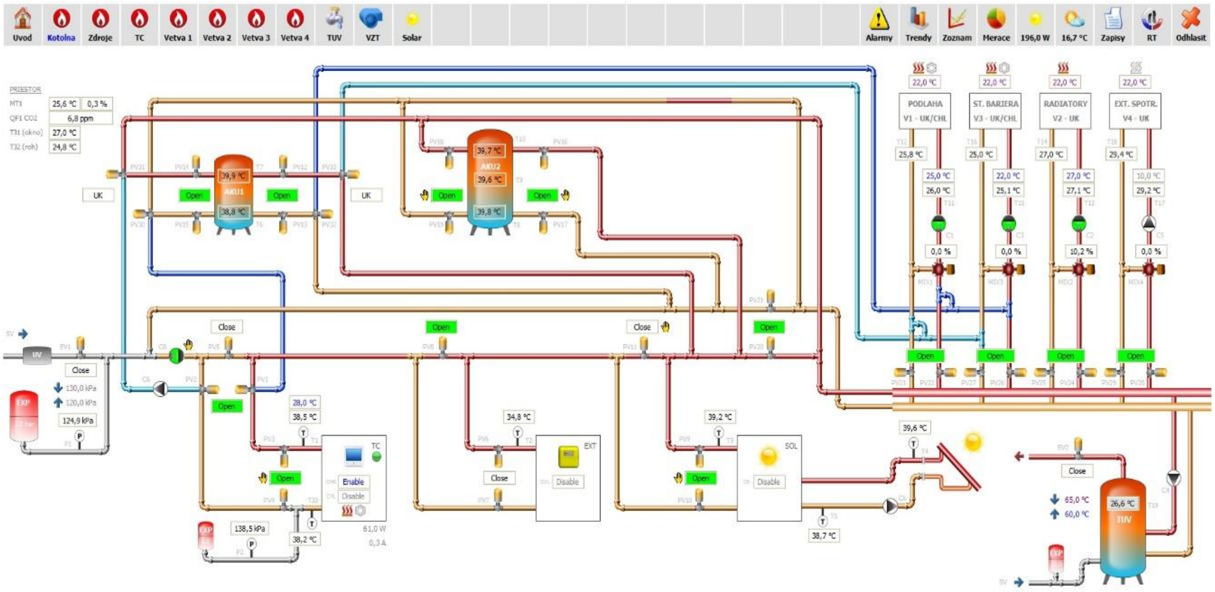

FIG. 13 Visualization of a mobile laboratory in software [Kubica]

circuit, the compact station has only one short-term storage tank. In addition to this type of compact station, it is also possible to connect a heat pump with the production of cold, but which will have its own cooling circuit and will not be controlled by a compact station.

Design with heat and cold production has two alternatives. In the first alternative, is the heat produced and passed through one heat exchanger and the cold through the second heat exchanger. Connection via a three-way valve system is not necessary and the whole system is more efficient than the other alternative. The second option is producing heat and cold in two regimes. Most low power heat pumps have the capability of reversible heat production with switching between heat generation and cold production. In this case, the compact station has a three-way valve system that divides cold and heat production into two circuits, allowing the heating system to use both cold and heat.

IV. CONCLUSION

As a result, we can evaluate the very favorable conditions for developing and selling a new renewable energy facility and addressing the complex production, preparation and distribution of heat for family houses and small apartment buildings. There are currently technically simpler devices on the market that make good sense of compact stations due to their current advantages, such as fast and high quality assembly, pre-production and calibration in the production, control and flushing of the finest parts. The European Union's ecological focus also contributes to increasing sympathy for the prepared facility. Last but not least, the end of the economic crisis in the European Union and the high number of users of the target group will also be beneficial.

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