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HISTORICAL SOLUTIONS IN BUILDINGS IN THE CONTEXT OF CURRENT PROBLEMS OF GREEN ARCHITECTURE

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Abstract
The paper discusses the current problems of green architecture in Poland, yet, its main purpose is to search for historical architectural solutions in the area of broadly defined users' comfort, thermal comfort and ventilation. The aim of the work is to show an alternative development direction for energy-efficient architecture in relation to more and more strict thermal standards. The paper presents a number of interesting solutions, which, from the point of view of the current technological development, are examples of green architecture, where both energy-efficiency issues as well as thermal comfort and users' health issues are crucial. The presentation of historic architecture examples is a pretext for a broader look at architecture and for showing contemporary rules, which do not always lead to the most important goal, that is, the creation of sustainable architecture focused on users' health. The results of the studies cover the formulation of the most important, according to the author, solutions for the future of sustainable architecture. They can be used in the creation of new principles of truly green architecture, where energy efficiency will not conflict with users' comfort and health.

Keywords: **Sustainable Architecture; Green Building; History of Architecture; Ventilation; Indoor Air Quality; Health of Users.**

1. INTRODUCTION

Facing the necessity of verifying heating, cooling and ventilation systems related to greenhouse gases emission, changes in the way of thinking and innovative research methods are necessary in order to improve the current state of affairs. In order to do so, one must look back and return to the history and solutions used in the past. In the process of developing new technologies, not all of which lead to the improvement of the current state of affairs, we forget about old solutions, whose essence and objectives fulfil a number of conditions that must currently be met by building structures in order to ensure users' comfort and, most importantly, health. Applied and improved for years, passed from generation to generation, they were used intuitively before building physics phenomena started to be studied scientifically. The paper highlights the current problems of green architecture in Poland, yet, its main purpose is to search for historical architectural solutions in the area of broadly defined users' comfort, thermal comfort and ventilation.

The aim of the work is to show an alternative development direction for energy-efficient architecture in relation to more and more strict thermal standards. For this purpose, the study analyzes historical solutions related to thermal insulation, ventilation, protection against weather conditions, and the issues of user comfort.

The scope of discussed issues covers European architecture (mainly Polish lands), without excluding external influences and references that are important for the development of certain systems.

The research method involves: the revision and analysis of literature on a given issue, independent on-site architectural studies and case studies.

2. THE CURRENT PROBLEMS OF GREEN ARCHITECTURE IN POLAND – ECOLOGY VERSUS OSTENSIBLE EFFORTS

Ecology of the 21th century is not only a trend in the global world development, but a necessity that should be a common practice. “Sustainable architecture” is one of the environmental protection methods, where the project strategy involves:

- minimisation of energy loss in a building,
- maximisation of energy gains from renewable sources,
- optimisation of the building interior comfort [1].

The main principle of sustainable development is the fact that the needs of current and future generations should be met without reducing or destroying natural resources, the surroundings as well as cultural heritage and local tradition. The purpose of this trend is to keep both the world and an individual person healthy [2]. Obviously, these efforts affect the evolution of standards and regulatory acts related to architecture and civil engineering. They should become a true reflection of the idea of sustainable development in modern architectural projects. Thus contemporary designers have more detailed guidelines concerning individual building elements, which must be met for the benefit of the future user. However, is the current trend of the constant tightening of standards and related issues the only direction of sustainable architecture development? If so, does the theory translate into practice? There is controversy in architectural circles over the subsequent amendments of the document that regulates the principles of erecting buildings as well as designing ventilation and air-conditioning installations in Poland [3]. It is the Ordinance of the Minister of Infrastructure of 12 April 2002 (as amended): “On technical conditions that should be met by buildings and their locations”. It sets out, in whole or in part, the requirements covered by standards. The amendment of “technical conditions” of 1 January 2014 introduced the provision of the gradual tightening of the “thermal transmittance value” and the reduction of the annual consumption of “primary energy” in the years 2014, 2017 and 2021. Thus we are witnesses of the architectural landscape transformation process towards nearly zero energy building (NZEB). This situation leads to the common use of mechanical ventilation systems with “heat recovery”. Moreover, the new document introduces the “airtightness” parameter to ensure complete airtightness of designed and created building structures. However, it involves certain risk, as excessive airtightness of buildings is thought to pose a threat to the users’ well-being and health. The development of issues related to thermal comfort sometimes leads to erroneous solutions. Their consequences included the SBS (Sick Building Syndrome) and the BRI (Building Related Illness) defined in the second half of the 20th century [4]. Under the current standards, the indoor air quality (IAQ) is determined by the mechanical ventilation system. The total responsibility rests with the designer of an integrated system, whereas the proper functioning of an installation depends also on the correct calibration in the start-up phase as well as the programming and supervision during its use within an architectural structure.

Very important is also the fact that this type of installations ensure that theoretical design parameters are in line with the specified objectives. First of all, windows must be closed, which guarantees the statutorily required airtightness of a facility. When we open windows, the system does not work in accordance with the designed principles, which results in energy loss. It affects, in fact, the entire annual thermal balance, that is, both heating and cooling costs. This implies that the possibility of opening windows should be available in periods when the temperature outside is similar to the temperature inside (the design temperature or the temperature selected by the user). The issues of thermal comfort are relative, but we can assume that an informed user of a modern building will choose an interior temperature close to the design temperature (i.e. statutory temperature for a given type of interiors). However, this is not all, as interior temperature is perceived by users differently in warm months and differently in cold months. For example, 20°C is assumed for rooms in which people stay permanently without outer garment and without performing continuous physical work. These rooms include: residential rooms, halls, individual kitchens, office rooms, conference rooms [3]. In practice, such temperature will be too low for most users during the summer heat, when the interior temperature exceeds 30°C if one wears light summer clothes. In the automotive industry, a good principle of the maximum temperature difference of 7°C in dual-zone air conditioning systems is applied. The same maximum value should be considered when setting the internal temperature, called “equivalent temperature”, in relation to the outside temperature. These parameters must be maintained for the purposes of not only energy saving, but also aspects related to users' health. It is particularly important for large format facilities, where the responsibility rests with the property manager. That is why one should conclude that there are no detailed arrangements which would have a significant influence on energy saving.

Other significant problems include the verification and control of mechanical ventilation and air-conditioning systems (HVAC). Financial savings of property managers may lead to a situation where the system is switched off or operates temporarily. Apparent energy savings as well as the reduction of costly inspections or filter replacement cause serious problems such as damp in the rooms, poorer insulation of partitions, not to mention a number of factors having negative impact on users' health. This problem also requires attention and improvement.

Taking into account these aspects, one can conclude that we are going to experience the next phase of SBS in Poland as a result of new technical conditions. It stems from excessive insulation and airtightness of buildings as well as the improper use of HVAC systems. It seems that users' health is not taken into account in the process of developing regulations to reduce energy consumption in buildings.

Multi-criteria certification systems used in Poland have a slightly different approach to this issue. As a result of PLGBC's (Polish Green Building Council) activity (the author is one of the founding members), we have currently access to five world systems (BREEAM, LEED, DGNB, HQE, WELL BUILDING STANDARD).

As opposed to legislative acts, multi-criteria certification systems are used throughout the entire life cycle of a building, not only in the design phase. They are addressed not only to specialists, but also to investors and persons that administer and manage building structures. It is a particularly important aspect, which is unfortunately often treated as less important in investment management. Although ventilation standards impose the requirement of periodic checks and inspections of the installation, they do not specify the verification and monitoring of the system parameters in the period when the building is used. The situation is different in the case of multi-criteria assessment systems.

However, it is proper and conscious facility management that guarantees the fulfilment of the design parameters for ventilation, heating and air-conditioning, which translates directly into the quality of internal space. These efforts have the greatest influence on the thermal comfort and health of the users. However, facility certification systems are not obligatory and their use in an investment project involves additional costs, which are often not covered by the investment budget.

Apart from undoubtedly positive efforts supporting green building in Poland, there are also apparent efforts made for PR reasons. In fact, they have negative consequences, as they often discourage the public from green activities. Funds allocated for ecology are usually wasted on actions that do not translate directly into the reduction of CO_2 emissions. Moreover, they do not have a significant impact on the improvement of users' health or thermal comfort. Neither do they achieve the intended green and economic effects. The thermal upgrading strategy followed in Poland (Poland's energy policy by 2030, adopted in 2009 [5]) influences the reduction of CO_2 emission only partially, as the users of upgraded facilities will probably feel higher temperature in their interiors, but they will not start saving energy without green awareness and education. They will probably use the entire heat energy excess, which will not have a significant influence on the intended primary energy saving. It will also have no impact on the users' health due to the unnaturally high temperature in the winter season as well as excessively airtight interiors, lack of oxygen and the increased level of pollutants such as volatile organic compounds (VOC), CO and CO_2.

Other negative elements include the fact that in the near future, heat and power plants, boiler houses or individual fired heaters will still use traditional energy sources, emitting greenhouse gases and particulate matter, that is, the so-called low emission. Thermal upgrading is therefore not a good solution to the current problems related to energy and the environment. A good alternative is, in this case, the replacement of outmoded heating systems based on fossil fuels with energy-efficient and resource-efficient heating and cooling systems.

The paper does not discuss the negative influence of the current thermal upgrading strategy on the quality and form of architecture, both the contemporary and historical one. Neither does it present the historical and cultural context. Some architectural forms or details cannot be implemented in the light of applicable regulations, but it will be studied by the author in greater detail in subsequent papers.

3. HISTORICAL GREEN SOLUTIONS

We are currently facing an important moment when the environmental pollution is no longer so intense to require immediate improvement measures. Renewable energy provides an opportunity to solve the problem. The environment pollution through heating and communication (combustion cars) must be quickly eliminated. It is necessary to go back to the times when the above-mentioned problems did not exist. It seems possible in the near future thanks to renewable energy sources. In this context, it is necessary to look at old green solutions again. The history of these issues shows that they rotate, whereas some of them recur and some go away. In the long history of the "art of building", there is a number of solutions having a positive influence on the users' health. Developed gradually, based on the observation of physical and natural phenomena, experiences of predecessors, creative thinking and intuition, they were used for ages. Some solutions formed the foundation for the solutions of contemporary architecture, some have been forgotten or eliminated by constantly increased normative requirements.

3.1. Thermal comfort in historic sites

The 19th century saw an important breakthrough in green thinking, when the issues of the thermal comfort and health of the users of architectural facilities started to be taken into account. However, the architecture was not devoid of green features before. The applied solutions were based on intuition, experience and creative thinking of the architects of those times [6]. Without modern technologies, they strived for the protection of a building interior against external environmental factors and for the preservation of relatively stable temperature, irrespective of weather conditions. The used heating systems were imperfect and not very efficient. Moreover, architects did not have an important tool that we use today: they erected their buildings without knowing the building physics, which was established in the 20th century. There were also no standards regulating thermal conditions in buildings. Only stylistic canons and experiences of architects passed from generation to generation were available. Architectural examples show that they were familiar with the problems of thermal comfort. Historical green solutions prove that they were treated as equally important to architectural styles or structures.

3.2. Protection against external environmental factors in historic buildings

From the standpoint of contemporary technical knowledge, very important was the favourable orientation of facilities towards the sun and wind direction. Churches are situated in such a way that the chancel faces the East. The use of massive bodies and architectural structures implies the intention to stabilize the temperature of the interior, which is currently referred to as thermal inertia or thermal stability of an object. The first church facilities on the Polish land – rotundas were central buildings, particularly favourable in terms of the protection against external environmental factors. A castle chapel of the 11th century – St. Nicolas rotunda in Cieszyn has a cylindrical nave and a semi-circular apse with massive stone walls (Fig. 1).

The walls, made of lime cut stones with the use of "opus emplectum" method, are 1.25 m thick and are characterised by high thermal capacity. Both in religious and secular facilities, buildings were "cut off" on the north by the proper distribution of functions, small windows, the use of buffering elements or relevant solutions for roofs and elevations. An interesting example is a type of wooden church used on the Polish land, which did not change from the Middle Ages to the 19th century. St. Michael the Archangel Church of the 15th century in Dębno, containing a number of architectural elements indicating a deliberate development of energy-efficient architecture (Fig. 2).

It mainly consists of a firm body surrounded by buffering elements – timbered arcades, called in Poland "Szalowane soboty", which served as a kind of a waiting room for the faithful waiting for religious ceremonies. Wooden churches had a uniform functional arrangement, in which the entrance was placed to the west and north, the sacristy was available only from the chancel, without the possibility of entering the northern part. There were no window openings in the northern wall, the interiors were lit by windows cut exclusively to the south and in the closure to the east. It was associated with a belief, common in the Middle Ages, that the northern side is a zone of evil and its power [7]. In medieval wooden churches, people consciously protected structural elements against damp by means of appropriate materials and design solutions, such as the above-mentioned arcades. In wooden churches, they were one-storey, low column structures covered with a mono-pitched roof, surrounding the church around the entire perimeter or a part of it. They formed an external structure typical

Figure 1.
Cieszyn, Poland, castle chapel – St. Nicolas rotunda, 11th century Central, firm body with thick stone walls and small windows: South-eastern view. The author's photograph of 2012

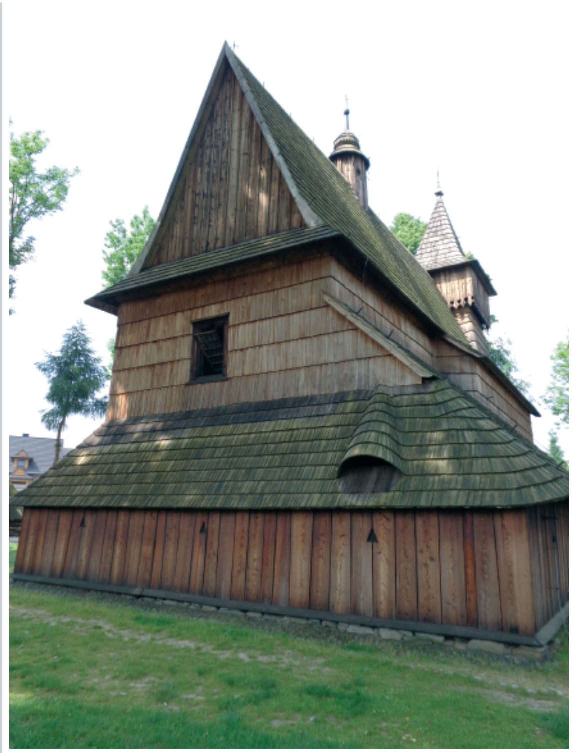

Figure 2.
Dębno, Poland, St. Michael the Archangel Church, 2nd half of the 15th century: Timbered arcades surrounded all church walls, forming a thermal buffer. The author's photograph of 2015

for Poland, whose main purpose was to protect the lower parts of the walls against damp, whereas a shelter for the faithful was their secondary function [8]. In the closed (timbered) form, they provided protection not only against the rain, but also against low temperatures or heat. Wooden facilities were erected on Polish lands mainly with the use of a log structure. Corner beam connections prevented the lengthwise movement of beams and served as a kind of a "freeze barrier", using the physical properties of wood. As we know, cold penetration along wood fibres is twice higher than crosswise. Churches erected with the use of this technique provided, apart from considerable durability, sufficient protection against cold, heat and precipitation [9]. This aspect is particularly interesting in the context of contemporary principles of sustainable construction. It should therefore be pointed out that the use and arrangement of construction materials in partitions used their best qualities and physical properties. In brick architecture, one can observe a tendency to improve the insulation of partitions by the use of layered partitions and buffering spaces in walls and roof finials. Even in the Roman times walls were built in such a way that wall faces were carefully made of cut stones or bricks, whereas the interior was filled with debris or crushed stone and poured with lime mortar. The porous structure of the internal side of the wall provided good thermal insulation. A similar principle was applied for domes, and sometimes the structural layers were separated by an air gap. In order to protect interiors against external environmental factors, parts of the facility were often hidden under the ground. Storied arrangements were also used in buildings or their parts. Some medieval churches had all these elements. Saint Cross Church in Wrocław has two sacred storeys, both of which are used for the purposes of liturgy (Fig. 3).

The lower church is partially sunk into the ground, and the sacristy has two storeys. The body of the church is firm, with beautiful Gothic forms, showing energy-efficiency properties. Location was an important element of historic architecture. Apart from the orientation, the location of churches in microclimatic conditions, favourable in terms of energy-efficiency, was also important. Cistercians built their monasteries in the vicinity of water: rivers and water bodies.

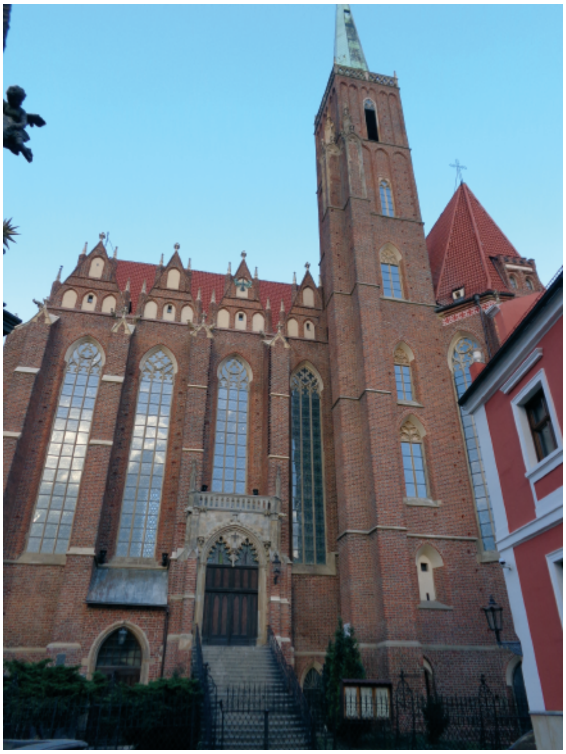

Figure 3.
Wrocław, Poland, Saint Cross and Saint Bartholomew Church, 14th century: The main entrance to the upper church. The author's photograph of 2015

The proximity of water areas is an important factor influencing the stability of the ambient temperature [10]. Water bodies are kinds of heat accumulators and they reduce temperature fluctuation in adjacent areas [11]. In the history of architecture there are also consciously used architectural and natural elements that protect against the wind. This function was provided in churches by wooden towers. They covered the nave to the west, that is, the dominant wind direction in Poland, and protected it against the rain. Greenery was also an important accompanying element. It is hard to prove that it was used deliberately in order to reduce energy loss in buildings, but it must be mentioned that there existed a number of palace and park complexes, where deliberately shaped plants formed urban and landscape arrangements and contributed to the creation of specific microclimatic conditions. Groups of trees served as windbreaks, as they are currently used for this purpose [11].

3.3. Heat energy acquisition in historic buildings

External environmental factors have a considerable influence on the development of the microclimate of interiors in historic buildings. The structure of historic buildings usually includes partitions with poor thermal insulation, which sometimes causes that the conditions inside them are tightly related to external environmental factors. External environmental factors are understood as environmental and natural issues associated with the location, season or even time of the day. They have a direct influence on the temperature inside buildings as well as other physical qualities related to the properties of a building [6]. Most of the above-mentioned phenomena are induced by sunlight. Solar absorption makes it possible to acquire energy through the appropriate shaping of bodies and elevations of buildings, architectural details and urban interiors as well as the use of appropriate construction materials. The lack of thermal insulation, understood as a layer made of an insulation material of very low thermal conductivity, causes that the thermal circulation in partitions is not reduced drastically. This, in turn, enables the acquisition of external heat to construction elements as well as its storage and distribution in the building interior. It also provides the possibility of acquiring heat from the atmosphere by means of appropriate construction materials and partition structures. Materials of high thermal capacity fulfilled, in this case, the role of heat stores. Other important heat sources in historic buildings include the use of heat emitted by people present in a building. It is particularly useful for religious buildings, which can house a large number of people. Heating systems have existed since the ancient times. As Palladio writes: "even the ancients placed fireplaces with columns and brackets supporting the architrave and the eaves through which smoke was discharged in the middle of their rooms. When they did not want to build a fireplace, they made channels in the walls through which the heat of the fire set under habitable rooms got inside" [12]. They were gradually modified and improved, sometimes taking the form of very complex heating systems. They were based on the principle of acquiring, storing (thermal capacity) and distributing heat energy. Interesting examples include the central heating system built before 1340 in a medieval castle in Malbork (Fig. 4).

Figure 4.
Malbork, Poland, Middle Castle. Heating stove built to heat the Great Refectory, 14th century: A visible furnace opening at the bottom, an accumulation chamber filled with huge stones at the top. The author's photograph of 2018

Here smoke conducts are separated from channels distributing hot air. The fire from heaters warmed up huge stones, which served as heat stores. Once they were warmed up, the chimney draught was blocked and, after extinguishing the fire, the second hot air cycle was opened and the hot air was let into the rooms through special openings (Fig. 5). The system heated the Great Refectory in the Middle Castle in Malbork, but the entire concept included more than ten heaters [13, 14].

A later, but also interesting heating system was used in the Cistercian monastery in Lubiąż. During the reconstruction of the facility in the 17th century, a central heating system made of air channels distributing heat to the rooms of the building was established. It forms a system connected to numerous chimneys and smoke channels leading to them, which is difficult to figure out nowadays due to its present condition [6, 15].

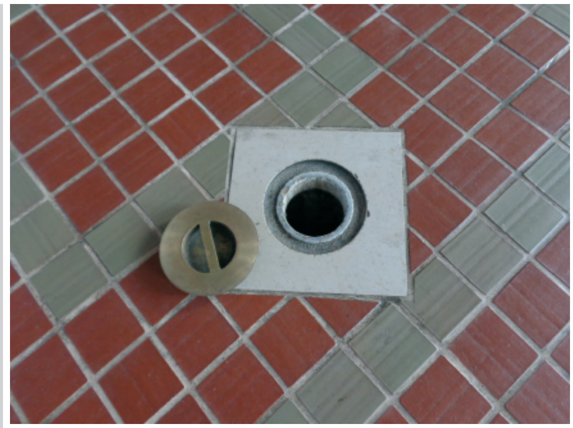

Figure 5.
Malbork, Poland, Middle Castle. Great Refectory, 14th century: One of the 36 openings supplying hot air from the accumulation chamber of the stove located below. The author's photograph of 2018

3.4. Interior ventilation and cooling in historic buildings

In the past, ventilation was used in two ways, both for air exchange in interiors and for cooling. The appearance of ventilation using the phenomenon of chimney draught is most probably related to the development of heating systems, as the use of smoke conduits forced air exchange even outside the heating season. Apart from the basic ventilation function, that is, ensuring air supply and exchange, it had also a positive influence on the condition of building structures. The lack of air exchange caused the occurrence of damp on the foundations, walls or vaults. We currently know that damp on construction partitions is caused by the worsening of their insulation parameters. It was also related to other issues, such as the microclimate of interiors, that is, broadly defined users' comfort. There are interesting historical solutions implying that these issues have been important since the ancient times. Interesting examples include openings in vaults, which have existed since the ancient times, through the Middle Ages, to the modern times. They are present in vaults of some Gothic churches in Silesia. Churches in Wrocław have open keystones in the form of oculi. Their main function is to support the structure and to distribute the load of the vault to the ribs. However, very characteristic is the fact that only 2 or 3 out of tens of ogival vaults have the open form, enabling gravitational airflow. Other vaults have traditional keystones. The oculi are distributed intentionally in a way to ensure the possibility of ventilating the most important area of a building. They usually include: the nave, the chancel

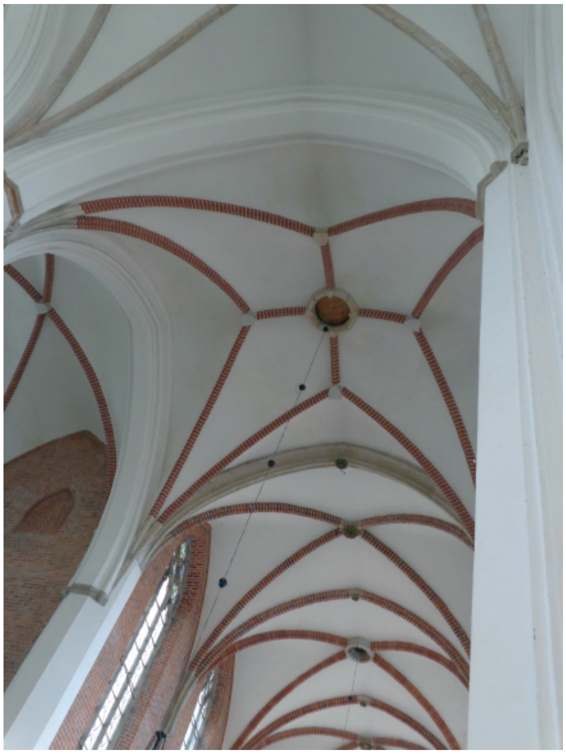

Figure 6.
Wrocław, Poland, Saint Cross and Saint Bartholomew Church, 14th century: A view of the open keystones (oculi) of transept and chancel vaults. The author's photograph of 2017

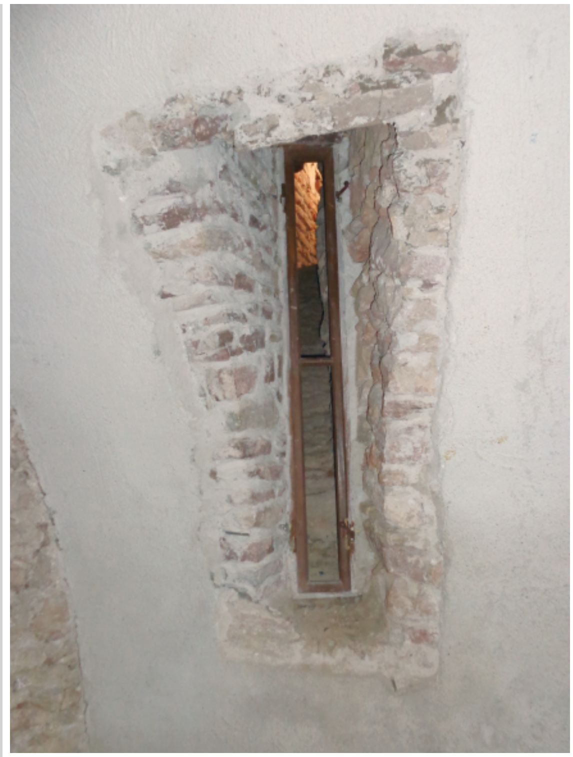

Figure 7.
Czorsztyn, Poland, Upper Castle. A ventilation opening in the form of a slot window in the cellar of the Upper Castle, 14th century. The author's photograph of 2015

and sometimes the transept. As it was not possible to open windows in these facilities, ventilation through keystones was the only air exchange measure. What is important, it could be adjusted seasonally by covering the opening with boards. The above-mentioned Saint Cross Church in Wrocław is a perfect example (Fig. 6).

We do not know whether the solutions of the Middle Ages were modelled on the example of ancient Rome. The temple of the Pantheon is described by Andrea Palladio in his "Four Books on Architecture". The inspiration is visible in "Villa Rotonda" near Vicenza, where such oculus modelled on the one from the Pantheon was used, but it was closed with a lantern. Many years later, in 18th century, this ventilation method started to be used mainly for the sake of users, in order to ensure quick air exchange in auditoria in theatres and operas.

However, the renaissance architecture developed ventilation systems with air-conditioning systems. Palladio, in "The Four Books on Architecture", mentions an outstanding solution, probably being one of the first air-conditioning systems for interiors. He writes about "Villa Costoza", in which cool air from the underground caves located within the estate was used. Several facilities were cooled this way, by supplying them with cool air through vaulted conduits. They could be freely closed and opened in order to cool the rooms more or less, depending on the season [12, 16].

In the medieval and modern times, various solutions based on the thermal stability of the ground and building structures, building so-called ice houses, used to store food. Due to the well thought out location, they maintained a stable, within certain limits, temperature. The ice house in Wawel is one of the examples. It is located under the south-eastern corner of the Renaissance arcaded courtyard. Ice houses and cellars used for food storage usually had proper ventilation, as did the 14th century castle in Czorsztyn. A ventilation opening is provided in the very thick wall in such a way that the intense sunlight does not reach here (Fig. 7).

Methods used in the past were improved, developed, but employed intuitively. Physical and chemical started to be taken as late as in the 19th century. Learning the chemical composition of the air and the development of building physics made it possible to determine the influence of external environmental factors on human health.

3.5. Users' health in historic buildings

In 19th century England, air pollution issues started to be analysed in terms of human health. It was decided that the quality, or rather the chemical composition of the air polluted by the industry, is the source of numerous diseases. They were even called the "bad air ailments". The recommended solution to these problems provided in the literature of the time was to intensively ventilate habitable rooms. It was believed that a properly dressed and nourished person does not have to be afraid of large amounts of cool or even cold air [17]. Today we know that this method was not entirely right due to the atmospheric pollution caused by the industry of that time. The problem was probably caused by particulate matter and other harmful substances, against which we are currently able to protect ourselves by using filters, ionizers etc. The 20th century, in turn, saw the problem of excessive insulation of buildings. In 1980's, glass elevations without the possibility of opening windows started to be used in office buildings. It caused totally new, previously unknown problems like SBS and BRI. It was a very important moment, as scientists realised a number of negative consequences of such a strategy of designing, erecting and using buildings. It made it possible to draw conclusions and adapt certain solutions [18]. Unfortunately, nowadays the problem of excessive insulation of external walls is still present due to the installation of modern, airtight windows valued for energy efficiency and acoustic reasons and by insulating buildings with polystyrene [1, 19]. It seems that the strategy requires looking back and modifying its paradigms as soon as possible.

4. FINDINGS AND THE MOST IMPORTANT SOLUTIONS FOR THE FUTURE

The current problems related to heating, cooling, ventilation and greenhouse gas emissions make us change systems based on fossil fuels into energy-efficient and resource-efficient heating and cooling systems. The purposes of this publication include the highlighting of selected solutions that, according to the author, should be mainly developed in order to improve the comfort and health of users.

4.1. The analysis and implementation of solutions used in historic architecture

The historic architecture has numerous interesting solutions that may be analysed, developed and reimplemented in contemporary buildings. Exploring the rich resources of historic facilities may provide an opportunity for the implementation and development of certain solutions. One can use Sustainable Construction Certification Systems for this purpose, in order to implement selected aspects into legislative and normative acts.

4.2. Use of greenery

Greenery has always been present in architecture, especially as an element of composition, but also served as protection against the wind. Growing freely on elevations, it provided protection against external environmental factors, as does contemporary thermal insulation, yet, it changed with seasons. These properties are used for elevations of currently designed buildings. It prevents interiors from warming up in the summer and provides access to the sunlight in the winter. Greenery used on façades is also a symbol of a return to nature, respect for the environment and a promise of users' physical health [20, 21]. But it is not all that we can achieve by the use of various types of plants. Greenery is, most of all, a kind of a catalyst reducing CO_2, purifying the atmosphere and generating oxygen. The presence of selected plants in city centres improves the users' living conditions and health.

4.3. Ensuring the possibility of gravitational ventilation (on demand) in public utility buildings (concert halls, hypermarkets)

Just like in medieval churches, it is not possible to open windows in facilities such as concert halls or hypermarkets, or they sometimes do not have any windows. Ventilation is limited exclusively to mechanical systems. One should, at least partially, reapply old solutions and enable temporary gravitational air exchange, switching off HVAC systems in these periods. It is related to the creation of an adequate, smart control system, which would enable complete air exchange inside, depending on the season, external and internal temperature, humidity or air quality. It had a positive influence on the comfort and health of the users.

4.4. The creation of an equivalent (adequate) temperature system helpful for the management of public utility and large facilities

In public utility or large format facilities, it would be advisable to create smart, automated internal temperature management systems, which enable the manager to individually control the thermal comfort, but only to a certain, very narrow extent. Such a solution will eliminate situations in which the system is managed by an incompetent person, without even the general knowledge on human thermal comfort. In practice, unfortunately, temperature is managed in the entire facility by a randomly appointed person, selecting an unnaturally low, harmful for user's temperature. In the proposed solution, it will not be possible, as the system will automatically suggest appropriate temperature, matching external environmental conditions, season (users' clothing) and other detailed parameters. Facility manager will be able to adjust the internal (equivalent) temperature adequately, but in a very narrow scope.

4.5. Creating the possibility of the external control of HVAC systems

The last issue that needs attention is related to financial savings of facility managers, which involve temporary switching off of HVAC systems. This leads to situations that are dangerous from the point of view of users' health and humidity of the building structure. Creating the possibility of the external control of the functioning of HVAC systems would prevent such situations and every user of a building would be sure that the quality of air in the building meets normative parameters. It is possible thanks to the installation of controlling panels connected with external IT systems. Legal and statutory solutions should also be a significant supporting element.

5. CONCLUSION

The issues described in the paper cover a wide variety of phenomena, therefore they cover certain generalisations. However, the main idea is the conviction that, in the following years, we can witness a significant change of applicable energy paradigms, as the cheaper and cheaper energy from renewable resources will lead to the changes in building strategies. Excessive insulation and airtightness of buildings will no longer be a priority, and will be replaced by improved health conditions of users as a result of the access to fresh air and proper ventilation of interiors. This will cause the return of natural materials, whose structure guarantees that a building "breathes". Vapour permeability of walls, combined with smart facility management systems, provide a chance for a solution to today's problems. One should believe that, in the near future, the unlimited access to fresh air will also be ensured, as the car transport will be based on electricity. That is why we are facing a great opportunity of creating new principles of truly green architecture, where energy efficiency will not conflict with users' comfort and health.

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