



# JUNIORSTAV 2020

22. ODBORNÁ KONFERENCE DOKTORSKÉHO STUDIA  
22<sup>ND</sup> INTERNATIONAL CONFERENCE OF DOCTORAL STUDENTS

## SBORNÍK PŘÍSPĚVKŮ PROCEEDINGS



# **JUNIORSTAV 2020**

22. odborná konference doktorského studia s mezinárodní účastí  
22<sup>nd</sup> International Conference of doctoral Students

## **PROCEEDINGS SBORNÍK PŘÍSPĚVKŮ**

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# HEATING IN A BURGHER HOUSE – INPUT PARAMETERS AND ASSUMPTIONS

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## Abstract

The topic of this paper is to define the input data for the design of a heating system in a historic town house. The paper is a follow-up to the elaborated research entitled "Contribution to the solution of non-invasive interventions in the field of technical equipment of buildings in listed buildings" (author: Ema Ruhigová), where the field of technical equipment of buildings is more specialized in heating. The main topic of the paper is to map historical heating systems in historic townhouses with respect to their typological type.

This knowledge is an important aspect that defines a range of options for how to approach a design of a heating system in a historic town house so as to minimize interference with the existing substance and at the same time (partly or fully) to ensure the required quality and temperature comfort in the interior. At the same time, this range of possibilities creates control lines for various architectural design of a restored cultural monument.

## Key words

Burgher house, authenticity, historical heating, historic town house, technical equipment of buildings

## 1 INTRODUCTION

The paper is a follow-up to the research in progress, the main topic of which is the cultural aspect of sustainability, which is the main tool for preserving cultural architectural diversity and authenticity of cities. Monument protection, in addition to those principles must also cope with the current normative requirements and regulations whose feasibility is often contrary to the fundamental ideas of monument protection. In practice, it is then often encountered with a negative moment that results from the mutual misunderstanding of the monument preserver and the civil engineer who are unable to achieve a result acceptable to both parties. This research is devoted to non-invasive interventions in the field of technical equipment of buildings in listed buildings. Its main task is to find possibilities how to carry out the monument restoration with an emphasis on preserving the authenticity of the building and at the same time to ensure a suitable indoor environment with the heating solution. This article discusses how to achieve these goals at a later finalization of research.

## 2 LITERARY OVERVIEW/DESCRIPTION OF THE CURRENT STATUS

V There are a number of publications on the theory of restoration of historical buildings. Developments are also progressing on the technical equipment of buildings and heating, but especially in relation to the solution of new buildings. The problem is that their mutual penetration is (to say) unpublished so far. This paper thus relies mainly on the findings of Jiří Škabrada in the publication "Construction of Historic Buildings", which describes the historical method of heating in folk architecture buildings. Understanding historical heating methods can lead to a better understanding of the design of a new heating system. With regard to the subject of study (burgher houses), the article is also based on theoretical knowledge and characteristics of the burgher house in the publication "Presentation of Architectural Heritage II" by Jana Gregorová and Pavel Gregor. To understand the historical development of the burgher house, literature by Peter Vodrážka – "The History of Building Cities" was also used.

The subject of the paper is a partial output of the research aimed at solving non-invasive interventions in the area of technical equipment of buildings at listed buildings. This paper will serve as a starting point for the definition of the subject matter of the case study as well as the basic starting conditions in the next phase of the research. The case study will be devoted to the design of a variant method of heating in a specific historical building, where the individual variants will represent three basic systems:

- Alternative 1: restoration of the original (historical) heating systém,
- Alternative 2: Application of one of the existing heating systems,
- Alternative 3: their combination.

### 3 METHODOLOGY

Based on the achieved results (either in terms of heritage, technical, or constructional-physical), the individual alternatives will be compared in terms of suitability, or unsuitability of individual solutions for the historical building. The key for realization is a detailed analysis of the development of historical heating systems that were present in the solved buildings. However, not only for the implementation of option 1, but knowledge of the chimney positions, the dimensions of the pipes, the way of flue gas exhaust or the supply of fresh air is equally important for options 2 and 3. Of course, if the purpose of the restoration is to maximize the authenticity of the materials and existing substance.

The paper therefore focuses on the basic starting points (Fig. 1), whose two primary parameters are:

- Development of historical heating systems,
- Development of a burgher house (as the subject of a subsequent case study).

Current methods of heating as another parameter for the realization of the case study are not the subject of this paper.

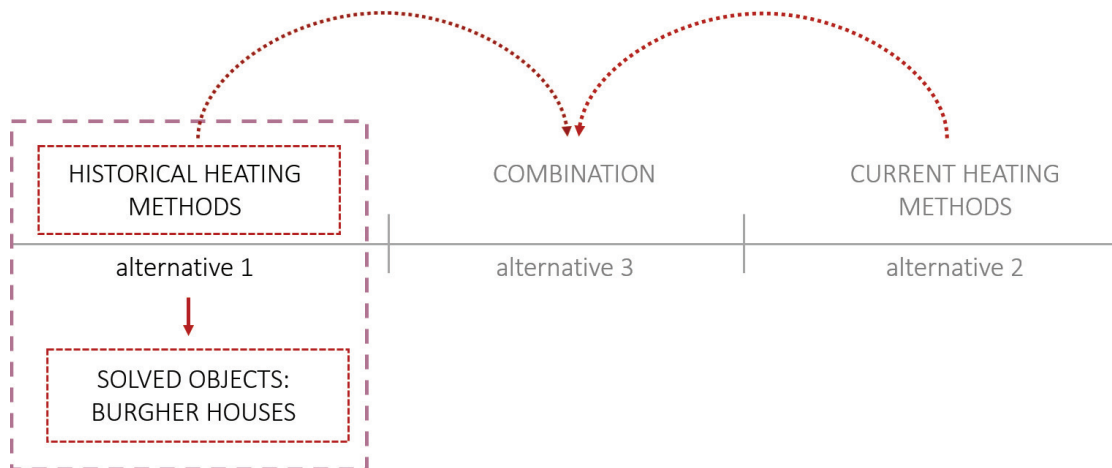


Fig. 1 Schematic representation of the main subject of the paper (Source: Ema Ruhigová).

### 4 RESULTS

#### Parameter of development of solved typology (burgher house) – disposition development

We can follow the development of the burgher house (Fig. 2) since the Middle Ages, when the so-called Tower Houses began to be built near lucrative locations (such as a trade route, market place, square). These houses were characterized by their verticality, where their residents (usually from higher social classes) had living rooms located on higher floors. The tower houses could be placed anywhere on the plot, but they were mostly part of the stone fence along the perimeter of the parcel. These houses together with high stone walls were an effective defense mechanism in times of frequent invasions and riots [1].

The chamber house begins to develop in the Gothic period. During this period, there is also pressure from the middle class of the population to keep their housing safe. This type of house did not differ significantly from the peasant house, which consisted of the so-called triple space. There is a bright room on the street side, a back room (chambers) on the side of the courtyard and a black kitchen between them. This position was particularly advantageous in that the black kitchen also served as a heat source for both rooms.

The passage house similarly begins to appear in the Gothic period. Its main feature is also a three-room, and an adjacent covered passage into the courtyard. The main advantage is the expansion of the floor area on the upper



(warmer and drier) floor. This typological species is the forerunner of the Hall House, which in terms of the predominant production and sales function on the ground floor can be considered the first "full-fledged" burgher house. The hall is created by connecting the passage and the bright room and opening towards the street.

"House with a height" - was a simpler type of passage house, the layout was enriched with a reduced attic = height, which was used to store grain or moisture-sensitive goods. On the facade, the "height" manifested itself in a series of small windows that axially linked to the windows of the residential floor. They had shutters on the outside or forged shutters from the inside with mechanical closing from the yard level [2].

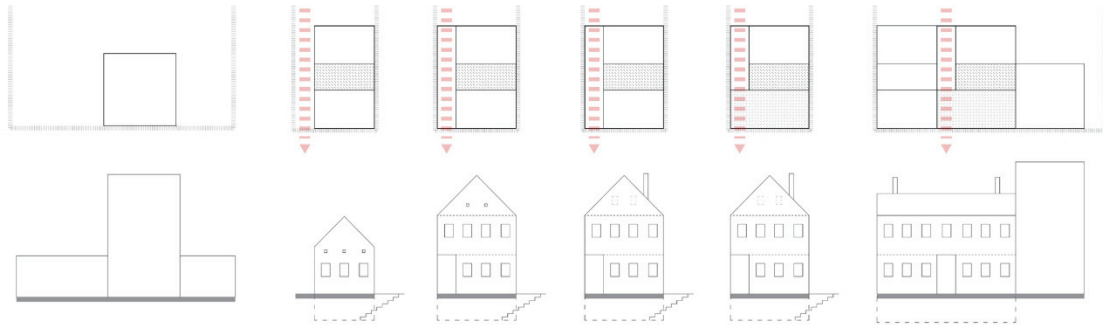


Fig. 2 Development stages of the burgherhouse in terms of disposition. From the left: Tower House, Chamber House, House with passage, House with passage with height, Hall House (with height) and mirroring the three-space by mutual interconnection (Source: Ema Ruhigová).

### Parameter of development of solved typology (burgher house) — signs on the facade of the heating system

The visual elements on the facade of the town houses from individual periods do not play a fundamental role in terms of the topic under consideration, so this aspect will not be devoted to a large extent in the paper. At this level it is necessary to realize the vertical disposition of the townhouse, which, with the presence of the characteristic feature of the townhouse (commercial / production function on the ground floor), shifts the function of housing to higher floors. In terms of external features on the facade of individual periods, it will be necessary to examine in particular the absence of the chimney (smoke openings on the facade are present), the position and height of the chimney, the number of chimneys, its materiality and form (Fig. 3). It will also be necessary to verify the presence of heating in commercial and production rooms, as well as the forms of its operation (presence of solid fuel storage etc.).



Fig. 3 Development stages of the appearance of a townhouse. From the left: Gothic tower house (Křížany, first half of 14th century), Gothic burgher house (Bardejov), Renaissance burgher house with attic (Banská Bystrica, Thurz house), baroque burgher house (Nitra, Štefániková street) (Source: Ema Ruhigová).

### Parameter of historical development of heating

Efforts to create and maintain warmth in living rooms have been current since time immemorial. Open fire under a shelter in prehistoric times can also be considered as primary heating systems. The aim of this paper, however, is not a detailed mapping of heating systems in the cross-section of history, but a narrowing of the examination of the period of presence of townhouses - from the Middle Ages, through Gothic, Renaissance, Baroque, to Classicism (Fig. 4).

As burgher houses belong to the group of professional architecture, the schemes do not take into account all the heating methods used at that time, also used in folk architecture. Although heating methods represented a wide range in individual periods, only their "most developed forms" will be mentioned for the purposes of this paper.

The fundamental division of heating systems is determined by the method of operation – so that the addition of solid fuel to the fire, depending on the relationship between the operator's location and the heated space. Thus, the heating can be: direct (with a fireplace and service directly in the heated room); and indirect (with the operation of the fireplace from the adjacent area, where also the cold air for combustion and where the smoke goes) [3].

### **Parameter of historical development of heating – Gothic period**

The Gothic period brings with it the heating of the open fire in the room into the fireplace, so that the flue gases are discharged through the chimney directly above the roof plane. Unlike folk architecture, where the presence of flue gases persists in the upper part of the room or in the roof space). Although the chimney increases comfort and hygiene standards of living rooms, but escapes up to 80% of heat. Therefore, the company began to realize in this period the need to make the heating element more efficient - open fire began to build bricks and stones, so that even after the fire has burned out the heat radiates. Within the territory of Slovakia it can be stated that the fireplace was brought from the Balkans and the Mediterranean during the Gothic period.

Later on, the first stoves began to emerge, evolving from a gradual increase in the "wall-accumulation" volume around the fireplace and an effort to eliminate flue gases from open fire into the room.

Stoves are coming to our regions as a great innovation from the West. This happened (according to findings and previous knowledge) during the 14th century [4].

It must be said, however, that in the Gothic period there are still systems that we can define as "absent" chimney bodies. These systems are heating methods that have also been used in simpler forms of housing. On the facade we can observe the smoke openings through which the flue gases from the open fire were led to the exterior. One of the ways is also to exhaust the flue gases into the roof space by means of the so-called smoke hood [5].

### **Parameter of historical development of heating – Renaissance period**

In this period, there is already a fully established indirect method of heating stoves with brick chimneys (in buildings of higher social layers). There are also new places of stoking. Until this time, the method of stoking on the fire was realized from a side black kitchen. During the Renaissance, new stoking places were also created – in the position of corridors, for example. Renaissance tiles, as a rule with sgraffito decoration and ornately finished heads, are our oldest surviving upper end chimneys. The renaissance “column stoves” served as an end element along the entire height of the room, ensuring maximum storage volume and ample space for flue gas tracing in the horizontal direction.

### **Parameter of historical development of heating – Baroque period**

The system established in 1710-1714 at the Peter the Great Summer Residence in St. Petersburg can be considered as a forerunner of steam heating systems. This system was not as effective, but the main progress was to enable multiple rooms to be heated from one heat source.

The heat transfer medium – water vapor - allowed a simple construction comprising a sealed water tank connected to the wiring. The source of heat becomes the central boiler, which distributes heat through the distribution. In this case, the wiring also becomes the terminal element.

### **Parameter of historical development of heating – period of Classicism**

The expansion of central heating has been closely linked to changes in fuel use. In households it was not common to use central heating with solid fuel because of the need for intensive operation. Joseph Nason (USA) created a primitive radiator in 1841, which was patented as a water vapor radiator. In 1855, San Galli basically created today's radiators [6].



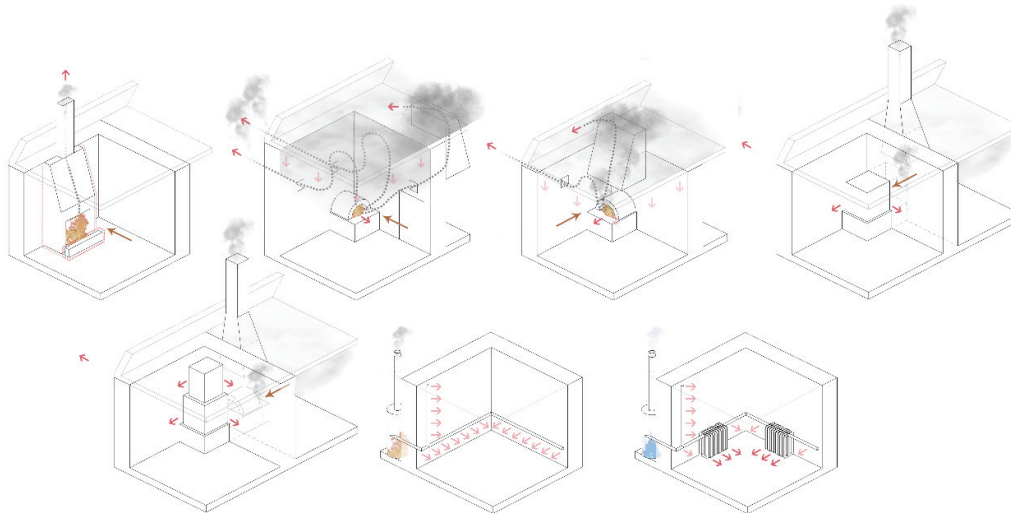


Fig. 4 Developmental stages of heating. Top left: Gothic period – fireplace with chimney, late Gothic period – flue gas exhaust through smoke vents, flue gas exhaust to the roof space, tiles. Bottom left: renaissance period – two-piece stove, baroque period – first distribution of heat transfer medium, classicism period – first radiators, gas (Source: Ema Ruhigová).

## 5 DISCUSSION

The following figure links the two initial parameters (development of the burgher house and the development of heating) and thus creates a starting point for further examination of the topic in the form of a case study of individual periods. From the period of High Gothic to Classicism, we can clearly read the principle of heating, as well as the layout and operating form of the house itself, which opens up possibilities for further deepening the theme. Such a summary of the typological development and its characteristic features compared to the present heating system and its signs on the facade can be seen as the main contribution of this paper.

CENTURY	12-13th	13th	14th	15th	14-16th	17-18th	19th
HEATING							
SIGNS ON FACADE							
DEVELOPMENT OF DISPOSITION							
HEAT INTERMEDIATE	OPEN FIRE, FIREPLACE	OPEN FIRE, FIREPLACE, STOVE			STOVE	STOVE, HEAT DISTRIBUTION	METAL STOVE, RADIATORS, KITCHEN STOVE
FLUE GAS REMOVAL	HOOD, VENTS	VENTS	HOOD	BRICK CHIMNEY	BRICK CHIMNEY	BRICK CHIMNEY, STEEL CHIMNEY	BRICK CHIMNEY, STEEL CHIMNEY

Fig. 5 Summary of developmental stages from the Middle Ages (Top Middle Age Gothic in 12th century, Late Middle Age Gothic in 13th, 14th, 15th century) to Modern Age (Renaissance in 14–16th century, Baroque in 17–18th century, Classicism in 19th century) of heating and development of a burgher house (Source: Ema Ruhigová).

## 6 CONCLUSION

The contribution can be perceived as an overview article on the topic of designing new heating systems for existing historical buildings. The acquired knowledge maps the historical principle of heating in burgher houses in individual construction periods. It is obvious that the layout development of the townhouse is very closely related to the heating system used in the house. This system can also be read on the façade of the house, for example by the presence of end elements for exhausting flue gases into the air.

This knowledge will be applied in the next stage of research in the design of new heating systems. They will be particularly important in terms of placing new wiring into existing cavities (eg no longer functioning chimneys). It is also possible to investigate their re-commissioning as well as applications in combination with new heating technologies.

### References

- [1] VODRÁŽKA, Peter. Dejiny stavby miest. Bratislava: Meritum, 2001. ISBN ISBN 80-227-1310-4.
- [2] GREGOROVÁ, Jana, Pavel GREGOR a kolektív. Prezentácia architektonického dedičstva II. Bratislava: Perfekt, 2008. ISBN ISBN 978-80-8046-394-6.
- [3] ŠKABRADA, Jiří. Konstrukce historických staveb. Praha: Argo, 2003. ISBN 80-7203-548-7., str. 118
- [4] ŠKABRADA, Jiří. Konstrukce historických staveb. Praha: Argo, 2003. ISBN 80-7203-548-7., str. 121
- [5] ŠKABRADA, Jiří. Lidové stavby: Architektura českého venkova. Praha: Argo, 2005. ISBN 80-7203-082-5.
- [6] MUNIAK, Damian Pjotr. Radiators in Hydronic Heating Installations. Springer, 2017. ISBN 978-3-319-55242-2.

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