

# Increasing Thermal Efficiency by Optimizing Radiator Connection Schemes in Building Heating Systems

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**Abstract:** This article examines the connection schemes of radiators widely used in building heating systems and their influence on thermal efficiency. The side, diagonal, and bottom connection schemes of radiators are analyzed, and their heat transfer efficiency as well as their impact on heat distribution within buildings are compared. The results of the study show that the radiator connection method has a significant effect on heat distribution. It was determined that the diagonal connection scheme is one of the most efficient methods in terms of heat transfer performance. The findings also indicate that selecting an appropriate radiator connection scheme is important in the design of building heating systems.

**Keywords:** Radiator, heating system, heat transfer, connection scheme, energy efficiency, heat distribution.

**Introduction:** Nowadays, the efficient use of energy resources in buildings is considered one of the most pressing issues. Particularly in regions with cold climatic conditions, heating systems in buildings account for a significant share of total energy consumption. Therefore, improving the efficiency of heating systems is of great importance.

One of the most widely used systems for heating buildings is the radiator-based water heating system. In this system, hot water or another heat carrier passes through the radiator and releases heat into the surrounding environment. The efficiency of radiator operation depends on many factors, one of which is how the radiator is connected to the piping system.

The radiator connection scheme determines the movement of the heat carrier inside the radiator. This, in turn, affects the distribution of heat across the radiator surface and the overall heat transfer process. Therefore, studying radiator connection schemes and analyzing their impact on thermal efficiency has important scientific and practical significance.

The aim of this study is to analyze the radiator

connection schemes used in building heating systems and to determine their effect on heat transfer efficiency.

## METHODS

Radiator heating systems are based on the transfer of thermal energy to the indoor environment of a building using hot water as a heat carrier. Heat transfer from the radiator mainly occurs through two processes:

- Convection
- Thermal radiation

The general equation of heat transfer can be expressed as:

$$Q = k \cdot A \cdot (t_1 - t_2)$$

Where:

$Q$  – heat flow (W),  $k$  – heat transfer coefficient,  $A$  – heat transfer surface area ( $m^2$ )

$t_1$  – temperature of the radiator surface,  $t_2$  – temperature of the room air

Proper connection of radiators in buildings plays an important role in ensuring the efficient operation of heating systems and the rational use of thermal energy.

Radiators transfer heat to the indoor environment by circulating a heat carrier, usually hot water, through their internal channels. The connection scheme of a radiator determines how the heat carrier is distributed along the radiator surface, which directly affects the efficiency of heat transfer. In practice, radiators are mainly connected through three basic schemes: side connection, diagonal connection, and bottom connection.

The diagonal connection scheme ensures a more uniform movement of the heat carrier across the radiator, allowing the entire heating surface to operate effectively. For this reason, this type of connection is considered one of the most efficient in terms of heat transfer performance. The side connection scheme is widely used due to its simplicity and ease of installation; however, in the case of long radiators, uneven heat distribution may occur. The bottom connection scheme is often preferred for aesthetic

reasons because the pipes can be hidden, but the heat transfer efficiency may be slightly lower due to incomplete circulation of the heat carrier within the radiator.

Therefore, selecting an appropriate radiator connection scheme is an important factor in designing building heating systems. An optimal connection improves heat transfer efficiency, reduces energy consumption, and helps maintain a comfortable indoor thermal environment.

In practice, radiators are connected to heating systems using three main connection methods.

### Side connection

In the side connection scheme, the heat carrier enters the radiator from the top and exits from the bottom. This scheme is widely used in practice due to its ease of installation. However, in cases where the radiator is long, uneven heat distribution may occur.

## Two-pipe Heating system

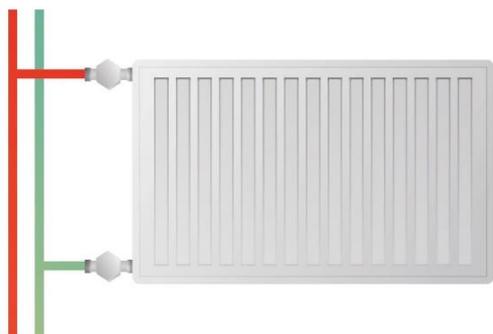


Figure 1. Radiator connection diagram from the side

### Diagonal connection

Diagonal connection of a radiator is considered one of the most efficient methods in heating systems. In this configuration, the hot water enters the radiator through the upper inlet on one side and exits through the lower outlet on the opposite side. This

arrangement allows the heat carrier to flow uniformly across the entire radiator surface, ensuring an even temperature distribution. As a result, the effective heat transfer area increases and thermal efficiency improves, making diagonal connection particularly suitable for long radiators and large heated spaces.

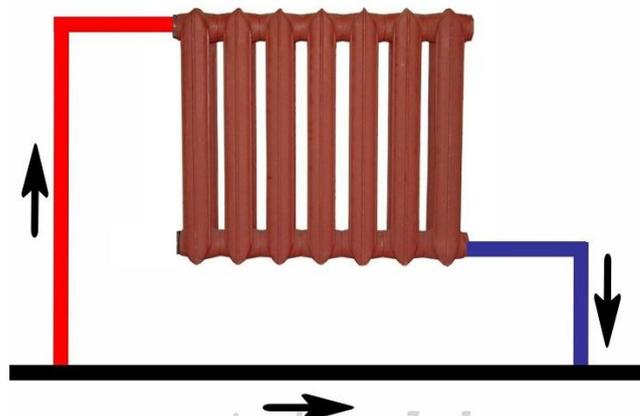
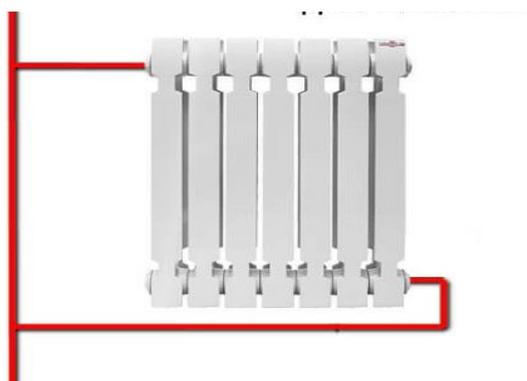


Figure 2. Diagonal radiator connection diagram

**Bottom connection** is a radiator installation method in which both the inlet and outlet pipes are connected to the lower part of the radiator. In this configuration, the heat carrier enters and exits from the bottom section,

allowing the pipes to be concealed within the floor or wall structure. Although this method provides aesthetic and installation advantages, the heat transfer efficiency may be slightly lower compared to diagonal connections.



**Figure 3. Radiator connection diagram from below**

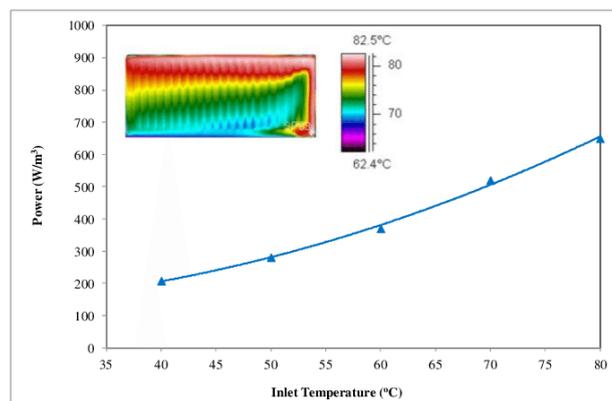
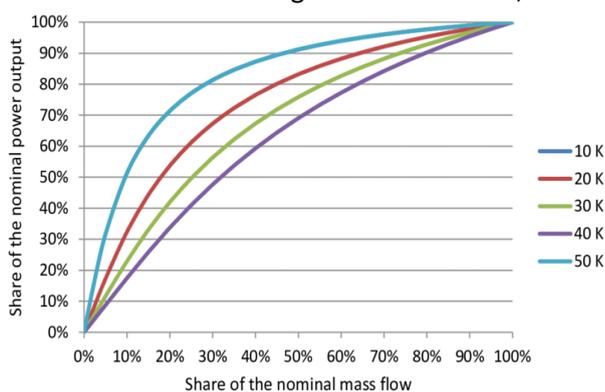
**RESULTS**

the connection scheme of radiators is an important factor that directly influences the thermal efficiency of building heating systems. In water-based heating systems, radiators transfer heat from the circulating heat carrier, usually hot water, to the indoor air through convection and thermal radiation. The way a radiator is connected to the supply and return pipes determines the distribution of the heat carrier inside the radiator and consequently affects the overall heat transfer process.

Different connection schemes, such as side, diagonal, and bottom connections, lead to different patterns of heat carrier flow and temperature distribution along the radiator surface. Among these methods, the

diagonal connection is generally considered the most efficient because the hot water enters from the upper inlet on one side and exits from the lower outlet on the opposite side. This configuration allows the heat carrier to pass through the entire radiator volume, ensuring uniform heating of the radiator surface and maximizing heat transfer to the surrounding air.

In contrast, side connections may cause partial temperature reduction in the far sections of long radiators due to uneven flow distribution. Bottom connections, although aesthetically advantageous and commonly used in modern building installations, may result in lower thermal performance because the heat carrier may not circulate evenly throughout the radiator.



**Figure 4. Radiator connection diagram and temperature distribution on the surface**

The graphical analysis indicates that in the diagonal connection scheme the heat carrier is distributed more uniformly across the entire surface of the radiator. In this configuration, hot water enters from the upper inlet on one side and exits from the lower outlet on the opposite side, allowing the heat flow to pass through the whole radiator length. As a result, a larger portion of the radiator surface actively participates in the heat

transfer process, and the overall thermal efficiency reaches its maximum level. In the case of side connection, the heat carrier tends to circulate more intensively near the inlet section, which may lead to a slight temperature decrease in the distant parts of long radiators. For bottom connection, the heat carrier may not circulate uniformly throughout the radiator, which can result in comparatively lower heat transfer efficiency and reduced thermal performance.

## DISCUSSION

The obtained results demonstrate that the radiator connection scheme plays a significant role in the thermal performance of building heating systems. The graphical and analytical evaluation indicates that the diagonal connection provides a more uniform distribution of the heat carrier across the entire radiator surface. When hot water enters the radiator from the upper inlet on one side and leaves through the lower outlet on the opposite side, the heat carrier flows through the whole radiator volume. This configuration ensures that most parts of the radiator participate actively in the heat transfer process, which leads to higher thermal efficiency and more stable indoor temperature conditions.

In comparison, the side connection scheme may lead to uneven heat distribution, especially in long radiators. In such cases, the sections located farther from the inlet may receive a smaller amount of heat carrier, which can reduce the effective heat transfer area. Similarly, bottom connection, although widely used for aesthetic and installation purposes, may result in a less efficient circulation of the heat carrier inside the radiator. This may cause a reduction in the overall heat transfer performance.

From the perspective of building heating system efficiency, the use of diagonal or uniformly distributed connection schemes is more advantageous. These configurations improve the uniformity of temperature distribution on the radiator surface and enhance the overall heat transfer process. Therefore, during the design and installation of heating systems in buildings, special attention should be given to the selection of an optimal radiator connection scheme. Properly designed radiator connections contribute to improved thermal comfort in indoor environments and support more energy-efficient operation of heating systems.

## CONCLUSION

The results of the study indicate that the radiator connection scheme significantly influences the thermal efficiency of building heating systems. Among the existing methods, the diagonal connection ensures a more uniform distribution of the heat carrier across the radiator surface. This configuration allows more effective heat transfer and improves overall heating performance. Therefore, selecting an appropriate radiator connection scheme during the design stage of heating systems is essential for ensuring efficient heat distribution and reducing energy consumption in buildings.

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