# FINSTEAM TECHNOLOGY GUIDE

## *Finnish Sauna Reimagined*

### *Heat Transfer Physics, Scientific Research, and Next-Generation Sauna Technology*

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# 1

## Introduction: Purpose of This Guide

The Finnish sauna is one of the world's oldest wellness traditions still actively practiced today. Over the centuries, the Finnish sauna has evolved from the traditional smoke sauna to wood-fired, electric, and most recently gas-fired sauna heating systems. Although the heating technology has changed, the fundamental principle of the sauna has remained the same: to create a safe, stable, and comfortable sauna environment.

The performance of a sauna is often evaluated based on the heater's nominal power output, the quantity of sauna stones, or the maximum temperature achieved. However, these characteristics reveal only part of the overall picture. In practice, the quality of the sauna environment depends primarily on how heat is transferred from the heater into the sauna and how efficiently the generated thermal energy is utilized.

Sauna heaters with the same nominal power can heat a sauna at different rates, produce different temperature distributions, and create remarkably different sauna experiences. These differences arise from the method of heat transfer, air circulation, the thermal behavior of the stone mass, radiant heat, humidity, and the structural design of the heater.

The objective of this guide is to explain the operation of the Finnish sauna from a technical perspective and to describe how different sauna heater technologies utilize the fundamental principles of heat transfer. The content of this guide is based on the fundamental laws of thermodynamics and heat transfer, combustion engineering, international standards, independent laboratory testing, and published scientific research.

This guide is intended for FinSteam distributors, retailers, sauna designers, builders, and anyone seeking a deeper technical understanding of how the Finnish sauna functions.

The purpose of this guide is not to determine which type of sauna heater is the best or which heating method is suitable for everyone.

Instead, its objective is to provide readers with a solid understanding of how different sauna heaters operate and the physical principles on which their performance is based.

Once the fundamentals of heat transfer are understood, it becomes much easier to evaluate the characteristics of different heating solutions, compare them objectively, and select the option that best suits individual needs.

In the following chapters, we will first examine the fundamental principles of heat transfer and then explore how wood-fired, electric, and gas-fired sauna heaters apply the same laws of physics in different ways.

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# 2

# Fundamentals of Traditional Finnish Sauna Operation

**Key Engineering Principle**

> *"A Finnish sauna is a dynamic heat transfer system in which temperature, heat storage, airflow, thermal radiation, humidity, and löyly continuously interact to create the overall sauna environment."*

From a technical perspective, a sauna is a controlled thermal system in which temperature, air circulation, humidity, and radiant heat together create the sauna environment. Although the heat source may be wood, electricity, or liquefied petroleum gas (LPG), the operation of every sauna is governed by the same fundamental principles of physics and thermodynamics.

The primary function of a sauna heater is not merely to generate heat, but to transfer thermal energy efficiently into the sauna while maintaining stable conditions and enabling the production of high-quality löyly throughout the sauna session.

During the heating process, energy is first converted into thermal energy, after which heat is transferred from the heater to the sauna structure, the sauna stones, the air, and ultimately to the bather. At every stage, part of the energy is stored within materials while the remainder continues to move through the system.

**Understanding how a sauna operates therefore requires examining the entire heat transfer chain rather than focusing solely on the heater's nominal power output.**

In engineering practice, heat transfer rarely occurs through a single mechanism alone. In real thermal systems, conduction, convection, and thermal radiation occur simultaneously, while heat naturally flows from regions of higher temperature to regions of lower temperature. In general, the greater the temperature difference, the greater the potential rate of heat transfer.

These fundamental principles apply regardless of the heater technology used and provide the basis for understanding the operation of all Finnish sauna heaters.

The thermal environment of a sauna is governed by four fundamental physical phenomena.

- ***Heat conduction*** transfers thermal energy from one material to another through direct physical contact. In a sauna heater, this includes the transfer of heat from the heat source to the sauna stones and subsequently to the heater's metal components.

- ***Convection*** transfers heat through the movement of air. Air heated by the sauna heater rises naturally, while cooler air flows in to replace it. This natural circulation distributes thermal energy throughout the sauna and has a significant influence on temperature uniformity.

- ***Thermal radiation*** transfers energy directly from hot surfaces to their surroundings without requiring a physical medium. Sauna stones, metal surfaces, and other heated structures radiate heat toward the bather, making a major contribution to perceived thermal comfort.

- ***Water evaporation*** from the sauna stones creates the characteristic löyly of a Finnish sauna. When water comes into contact with sufficiently hot stones, it vaporizes rapidly, temporarily increases the humidity of the air, and significantly changes how heat is perceived by the human body.

Together, these four phenomena create the sauna's thermal environment, where temperature, humidity, air movement, thermal radiation, and thermal stratification continuously influence one another.

For this reason, air temperature alone is not sufficient to describe the quality of a sauna or the overall sauna experience. Two saunas heated to the same air temperature may feel completely different if their humidity, air circulation, level of radiant heat, or temperature distribution differ. In practice, these factors determine whether a sauna is experienced as soft and evenly heated or as dry, uneven, or heavily stratified.

Consequently, the objective of Finnish sauna design is not to achieve the highest possible temperature, but to create a controlled and balanced sauna environment in which heat, humidity, and air movement complement one another. This principle provides the foundation for comparing the different sauna heater technologies examined in the following chapters.

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# 3

# The Sauna Heater as a Heat Transfer System

**Key Engineering Principle**

> *"The primary function of a sauna heater is not simply to produce heat, but to control how thermal energy is generated, stored, transferred, and released throughout the sauna."*

A sauna heater can be viewed as a heat transfer system in which structural and functional design determine how efficiently thermal energy is transferred into the sauna. Its performance is influenced by the energy source, combustion or heating technology, airflow management, the quantity and arrangement of the sauna stones, material selection, and the heater's ability to store and release thermal energy in a controlled manner.

The performance of a sauna heater is therefore determined not only by the amount of energy it produces, but also by how effectively that energy is utilized. Part of the generated thermal energy is stored in the sauna stones and the surrounding structure, part heats the sauna air, and part is inevitably lost to the surroundings. The objective is to transfer as much of the available thermal energy as possible into useful heating of the sauna while minimizing unnecessary heat losses.

Two heaters may produce the same thermal power, yet the way in which that energy is transferred into the sauna can differ significantly. One heater may store a larger proportion of energy in the stone mass before releasing it gradually, while another may transfer more energy directly to the sauna air through convective airflow and heated surfaces. These differences strongly influence heat-up behavior, temperature distribution, löyly characteristics, and the overall sauna experience.

To create high-quality sauna conditions, a sauna heater must simultaneously fulfill five fundamental technical requirements.

The first requirement is to convert the available energy into thermal energy safely, efficiently, and in a controlled manner, regardless of whether the energy source is wood, electricity, or liquefied petroleum gas (LPG).

The second requirement is to heat the sauna stones to a sufficiently high temperature. Their role extends beyond producing löyly, as they also function as a thermal energy reservoir that moderates heat output and helps maintain stable sauna conditions.

The third requirement is to distribute thermal energy effectively throughout the occupied area of the sauna. Heat should not remain concentrated only around the heater or near the ceiling but should be distributed as evenly as possible to provide consistent thermal comfort.

The fourth requirement is to maintain stable operating conditions throughout both the heat-up phase and the sauna session. A well-designed heater must continuously compensate for heat losses while responding to changing operating conditions, such as door openings, ventilation, löyly events, and varying numbers of bathers.

During the initial heat-up phase, the sauna operates under transient thermal conditions, as the air, stones, heater structure, and surrounding surfaces are still warming. Once the desired operating temperature has been reached, the system approaches steady-state operation, where the heater primarily compensates for ongoing heat losses through the sauna structure, ventilation, and normal sauna use.

The fifth requirement is to store sufficient thermal energy for the production of high-quality löyly. The quality of löyly depends largely on the amount of thermal energy stored in the sauna stones and how rapidly they can transfer that energy to vaporize water. If the stone temperature becomes too low, water no longer vaporizes efficiently, resulting in heavier and more humid löyly.

These five requirements are closely interconnected. Improving one characteristic often influences the others. For example, a larger stone mass increases thermal capacity and supports long-lasting löyly, but it also requires more energy and time to reach operating temperature. Likewise, stronger airflow may accelerate heat-up but can also increase thermal stratification and reduce the stones' ability to retain thermal energy.

For this reason, the overall performance of a sauna heater depends on far more than its nominal power output. Structural design, heat transfer mechanisms, stone mass, airflow management, and ventilation together determine how thermal energy is distributed throughout the sauna and, ultimately, the quality of the sauna environment.

The following chapters examine how wood-fired, electric, and gas-fired sauna heaters address these technical requirements in different ways, and how these design approaches influence heat-up performance, energy consumption, and the resulting sauna environment.

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# 4

## Traditional Sauna Heater Technologies

**Key Engineering Principle**

> *"Despite using different energy sources, traditional sauna heaters are based on the same indirect heating principle, in which a significant portion of the thermal energy is first stored before being released into the sauna room."*

The development of Finnish sauna culture has closely followed the evolution of available energy sources and heating technologies. For centuries, wood was virtually the only practical energy source for heating a sauna. The widespread adoption of electric sauna heaters during the second half of the twentieth century made it possible to build saunas in urban environments, making sauna bathing more accessible while simplifying and automating the heating process.


Today, wood-fired and electric sauna heaters remain the most widely used heater types in Finnish sauna culture. Although they use different energy sources, both are designed to heat the sauna stones to a sufficiently high temperature so that the stones can store heat, warm the sauna efficiently, and provide high-quality löyly.

From an engineering perspective, wood-fired and electric sauna heaters represent different implementations of the same heating concept. The primary difference lies in how heat is generated: a wood-fired heater releases energy through the combustion of wood, whereas an electric heater produces heat using electric heating elements. Once the stones have been heated, both heater types rely on essentially the same heat transfer mechanisms to warm the sauna.

Although their operating principles are similar, sauna heaters from different manufacturers may differ significantly in structural design, stone capacity, airflow characteristics, material selection, and thermal storage capability. These differences influence heat-up behavior, temperature distribution, energy efficiency, and the overall sauna environment.

The development of traditional sauna heater technologies has been driven primarily by three objectives: reducing heat-up time, improving energy efficiency, and achieving more consistent sauna conditions. To meet these objectives, manufacturers have continuously refined stone compartments, airflow management, heating element placement, and thermal storage solutions to improve overall heater performance.

Despite their different energy sources, wood-fired and electric sauna heaters share the same fundamental engineering concept and can therefore be evaluated using common engineering criteria.

The following chapters examine the operating principles and construction of wood-fired sauna heaters, followed by electric sauna heaters, before examining the gas-fired sauna heater. While all three technologies are designed to heat a sauna, the gas-fired heater introduces a fundamentally different engineering approach that distinguishes it from traditional sauna heater technologies.

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# 5

## Wood-Fired Sauna Heater

**Key Engineering Principle**

> *"A wood-fired sauna heater stores combustion heat primarily within the stone mass, from which thermal energy is gradually released to create traditional Finnish sauna conditions."*

The wood-fired sauna heater is the oldest and most iconic type of sauna heater in Finnish sauna culture. Its operating principle is based on the controlled combustion of wood, in which the chemical energy stored within the fuel is converted into heat. The released heat is transferred to the heater structure, the sauna stones, the sauna air, while a portion leaves the system with the flue gases through the chimney.

A wood-fired sauna heater is an **indirect heating system**. Its primary function is to heat the sauna stones and the heater structure, from which heat is subsequently transferred to the sauna through **natural convection, thermal radiation, and heat conduction.**

The combustion process begins when the wood reaches a sufficiently high temperature to release combustible gases. Most of the thermal energy is generated during the combustion of these gases, while the remaining charcoal burns more slowly and releases heat over a longer period. Consequently, the heating output naturally varies according to the amount, quality, and combustion stage of the firewood.

The hot flue gases produced during combustion flow through the firebox, the heater structure, and ultimately into the chimney. Before leaving the heater, they transfer a significant portion of their heat to the sauna stones and the heater structure. The more effectively this heat is recovered, the greater the proportion of the wood's energy that is utilized to heat the sauna.

Wood combustion is a complex multi-stage chemical process. Under ideal conditions, the carbon and hydrogen contained in the wood react with oxygen to produce primarily carbon dioxide ($CO_2$), water vapor ($H_2O$), and heat. In practice, however, combustion is never completely perfect. It is continuously influenced by factors such as the moisture content of the firewood, combustion air supply, combustion temperature, chimney draft, and the design of the firebox.

As a result, the flue gases contain not only carbon dioxide and water vapor, but also carbon monoxide (CO), particulate matter (PM), soot particles, volatile organic compounds (VOC), polycyclic aromatic hydrocarbons (PAH), tar compounds, nitrogen oxides ($NO_x$), and other products of incomplete combustion. The concentration of these compounds depends on the combustion conditions and the overall efficiency of the combustion process.

Because these flue gases contain compounds that are hazardous to human health and significant from a fire safety perspective, they must be discharged safely through a chimney. The chimney forms an essential part of the combustion system rather than serving only as an exhaust duct. Its natural draft creates the negative pressure required to supply combustion air to the firebox while simultaneously removing the flue gases from the sauna. Most of the water vapor generated during combustion is also discharged through the chimney and therefore contributes only minimally to the humidity inside the sauna.

The efficiency of a wood-fired sauna heater depends on factors such as firebox geometry, combustion air management, flue gas flow paths, stone compartment design, and the available heat exchange surface area. Modern heaters are designed to guide the flue gases along the longest practical flow path before they enter the chimney, allowing as much heat as possible to be recovered.

The characteristics of the firewood also have a significant influence on performance. Dry firewood ignites more easily, burns more cleanly, and produces more useful heat than wet wood. High moisture content increases energy consumption because part of the released heat is used to evaporate water instead of heating the sauna. For this reason, manufacturers generally recommend well-seasoned firewood with a moisture content below 20%.

During heating, the sauna stones function as the primary thermal energy reservoir. They absorb heat while the fire is burning and continue to release it gradually throughout the sauna session, providing the energy required for high-quality löyly. Increasing the stone mass increases thermal storage capacity but generally also extends the heat-up time. At the same time, heat is continuously transferred directly to the sauna through **natural convection and thermal radiation**, with the relative contribution of each mechanism depending on the heater design and operating conditions.

The performance of a wood-fired sauna heater is also influenced by the user. Adding firewood, adjusting the combustion air supply, and controlling the heating process continuously affect the combustion conditions and, consequently, the heating output. Unlike automatically controlled heating systems, the performance of a wood-fired sauna heater depends to some extent on the user's experience and operating technique.

Over decades of development, the wood-fired sauna heater has evolved into an effective and reliable heating system whose performance is based on controlled wood combustion, efficient heat recovery, thermal energy storage in the stone mass, and chimney-induced draft. Although individual designs differ, these engineering principles continue to form the foundation of modern wood-fired sauna technology.

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# 6

## Electric Sauna Heater

**Key Engineering Principle**

> *"An electric sauna heater converts electrical energy into stored thermal energy, with the sauna stones acting as the primary heat reservoir for the sauna."*

The electric sauna heater is currently the most common sauna heating system, particularly in residential buildings, apartment complexes, and public saunas. Its popularity is based on its simple construction, ease of use, and the ability to control the heating process precisely through automatic control systems.

Like a wood-fired sauna heater, an electric sauna heater is an indirect heating system. Its primary function is to heat the sauna stones and the heater structure, from which heat is subsequently transferred to the sauna.

The operation of an electric sauna heater is based on converting electrical energy into heat by means of electric heating elements. When an electric current passes through a heating element, its electrical resistance generates heat, converting almost all of the electrical energy into thermal energy. This phenomenon, known as resistive heating, forms the basis of all electric sauna heaters.

The heating elements are typically positioned in the center of the stone compartment or in close proximity to the sauna stones. This arrangement allows heat to be transferred efficiently into the stone mass, which serves as the primary thermal energy reservoir and the foundation for producing high-quality löyly. At the same time, heat is transferred to the heater structure and the surrounding air. The positioning of the heating elements has a significant influence on how evenly the stones are heated and how effectively heat is distributed throughout the stone compartment.

Unlike a wood-fired sauna heater, the heat output of an electric sauna heater is highly consistent. The heating elements operate at essentially constant power whenever electricity is supplied, allowing the heating process to be controlled precisely without the natural fluctuations associated with combustion. This enables stable sauna conditions to be maintained even during extended sauna sessions.

During operation, natural air circulation transfers heat from the heater to the sauna. The effectiveness of this process depends on the heater design, the quantity and arrangement of the sauna stones, and the available airflow through the stone compartment. Thermal radiation provides an additional contribution, particularly in the immediate vicinity of the heater.

Over the past decades, the design of electric sauna heaters has evolved considerably. Alongside traditional enclosed metal-casing heaters, open mesh heaters and large-stone pillar heaters have become increasingly common, with stone capacities that may be several times greater than those of conventional wall-mounted heaters. A larger stone mass increases thermal storage capacity and enables longer-lasting löyly, although it generally also increases both the heat-up time and the amount of energy required.

In addition to the quantity of sauna stones, their arrangement is equally important. If air flows too freely through the stone compartment, part of the heat is transferred rapidly to the sauna air before sufficient energy can be stored in the stones. Conversely, if the stones are packed too tightly, airflow may be restricted, increasing the operating temperature of the heating elements and potentially reducing their service life. For this reason, correct stone stacking is an essential part of the safe and efficient operation of an electric sauna heater.

The operation of an electric sauna heater is typically controlled by a thermostat. The thermostat monitors the sauna temperature and switches the heating elements on and off as required to maintain the selected temperature automatically. Modern control systems may also incorporate timers, remote-control functions, energy-saving features, and various safety systems that improve both user convenience and energy efficiency.

Because no combustion takes place in an electric sauna heater, it requires neither a chimney nor the removal of flue gases. The heating process also produces no combustion-generated water vapor or other combustion by-products. Consequently, the humidity level inside the sauna is determined primarily by the ventilation system and the amount of water poured onto the sauna stones.

In practice, the performance of an electric sauna heater depends on the combined effect of heater power, stone quantity and quality, structural design, the control system, and ventilation. Together, these factors determine heat-up performance, temperature stability, energy efficiency, and the quality of the löyly produced.

The development of electric sauna heaters has focused primarily on improving energy efficiency, safety, user convenience, and sauna performance. Although structural solutions vary between manufacturers, all electric sauna heaters operate according to the same engineering principle: electrical energy is converted into heat, stored primarily in the stone mass, and gradually transferred to the sauna. This indirect heating principle continues to form the foundation of modern electric sauna heater technology.

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# 7

# Shared Operating Principles of Wood-Fired and Electric Sauna Heaters

**Key Engineering Principle**

> *"Wood-fired and electric sauna heaters differ in their energy source but share the same fundamental indirect heating principle."*

Although wood-fired and electric sauna heaters use different energy sources, they are based on the same fundamental engineering concept. In both systems, heat is generated within the heater, stored primarily in the sauna stones and the heater structure, and gradually transferred to the sauna. The differences between the two technologies lie mainly in how heat is generated and controlled rather than in the fundamental method of heating the sauna.

In an indirect heating system, the sauna room is heated primarily by natural convection. As the air surrounding the sauna heater is heated, its density decreases, causing it to rise toward the ceiling of the sauna. At the same time, cooler air continuously flows from floor level toward the heater to be heated, creating a continuous natural air circulation. This airflow gradually transfers thermal energy throughout the sauna room and subsequently into the sauna walls, ceiling, benches, and other structural components. In addition, the sauna stones and the hot surfaces of the heater transfer heat by thermal radiation and conduction. However, in traditional wood-fired and electric sauna heaters, convection is the primary heat transfer mechanism responsible for heating the sauna room.

For this reason, both wood-fired and electric sauna heaters are classified as **indirect heating systems**. In both technologies, the primary purpose of the heater is to heat the sauna stones and the heater structure, which together form the system's principal thermal energy reservoir. The stored heat is then gradually released into the sauna, while simultaneously supporting the production of high-quality löyly.

The overall performance of both heater types depends on the combined effect of several closely related design factors, including stone mass, stone arrangement, airflow through the heater, structural design, and thermal storage capacity. Together, these determine heat-up performance, temperature stability, energy efficiency, and the characteristics of the löyly produced. Consequently, two heaters using different energy sources, or even two heaters of the same type, may create noticeably different sauna conditions despite operating according to the same engineering principles.

The development of both wood-fired and electric sauna heaters has therefore focused on optimizing the balance between thermal storage, heat-up time, air circulation, energy efficiency, and user experience. While the structural solutions vary between manufacturers, the underlying engineering objective remains the same: to store heat efficiently and release it in a controlled manner throughout the sauna session.

Because wood-fired and electric sauna heaters share the same operating principles, they can be regarded as a single category of **traditional indirect heating technologies**. This common engineering foundation provides a clear reference point for evaluating alternative sauna heating concepts. The following chapters introduce the FinSteam gas-fired sauna heater, whose operating principle differs fundamentally from traditional indirect heating systems and therefore represents a distinctly different approach to sauna heating.

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# 8

# Operating Principle of the FinSteam Gas Sauna Heater

### Key Engineering Principle

> *"The FinSteam heating system distributes heat and moisture simultaneously through multiple coordinated processes rather than relying primarily on stored heat within the sauna stones."*

The FinSteam gas sauna heater is based on the controlled combustion of liquefied petroleum gas (LPG). Unlike traditional indirect heating systems, the thermal energy generated during combustion is utilized through multiple simultaneous heat transfer pathways rather than relying primarily on the gradual heating of the sauna stones. The objective is not merely to achieve the desired sauna temperature, but to create a stable and uniform thermal and humidity environment throughout the entire sauna.

In conventional wood-fired and electric sauna heaters, heat is transferred primarily through the heated stone mass and the heater structure. In the FinSteam system, the sauna stones continue to function as an important thermal energy reservoir, while a portion of the generated heat is simultaneously transferred directly into the sauna by the hot combustion gas and air stream. As a result, several heat transfer mechanisms contribute to heating the sauna from the very beginning of the heating process.

The sauna stones continue to moderate temperature fluctuations, store thermal energy, and provide the foundation for producing traditional Finnish löyly. At the same time, thermal radiation from the heater structure warms the surrounding surfaces, while the hot combustion gas and air stream transfers heat directly into the sauna air. These parallel heat transfer pathways are designed to promote a more even distribution of heat throughout the sauna. The resulting temperature profile ultimately depends on factors such as sauna geometry, insulation, ventilation, bench layout, and operating conditions.

Another important characteristic of the combustion process is the continuous production of water vapor. During properly adjusted LPG combustion, the primary combustion products are carbon dioxide ($CO_2$) and water vapor ($H_2O$). In the FinSteam Type A flueless gas appliance, these combustion products are intentionally released into the sauna, making correct ventilation in accordance with the manufacturer's installation instructions an essential part of the system design. As a result, water vapor is continuously introduced into the sauna atmosphere during burner operation without the need for separate steam generators or water injection systems. The final humidity level remains dependent on the combined effects of ventilation, sauna volume, operating temperature, and the amount of water poured onto the sauna stones.

Because heat transfer, moisture generation, thermal storage, and ventilation operate simultaneously, the sauna environment develops as one coordinated thermal system. Rather than maximizing any single parameter, the objective is to maintain stable and comfortable sauna conditions throughout both the heating phase and the sauna session.

The operating principle of the FinSteam gas sauna heater can be described through three complementary engineering concepts that together define the behavior of the system.

## Direct Thermal Flow™

Direct Thermal Flow™ describes FinSteam's multi-path heat transfer concept, in which heat is transferred simultaneously to the sauna stones, surrounding structures, and directly into the sauna air by the hot combustion gas and air stream. This allows the available heat to contribute to warming the sauna immediately from the beginning of operation.

## Humidity Balance™

Humidity Balance™ describes the continuous production of water vapor during properly adjusted LPG combustion and its contribution to maintaining the sauna's natural base humidity throughout burner operation. This moisture is generated as an integral part of the combustion process without requiring additional humidity-generating equipment.

## Sauna Climate Engineering™

Sauna Climate Engineering™ integrates heat transfer, moisture generation, thermal storage, and ventilation into one coordinated thermal management system. The objective is to support stable temperature distribution, comfortable humidity, and consistent sauna conditions throughout heating and normal operation.

These three engineering concepts are not independent functions but complementary components of the same operating principle. Direct Thermal Flow™ defines how heat is distributed, Humidity Balance™ describes the continuous generation of moisture, and Sauna Climate Engineering™ integrates these processes into a coordinated thermal management system. Together, they define the operating principle of the FinSteam gas sauna heater and distinguish it fundamentally from traditional indirect sauna heating technologies.

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# 9

# Direct Thermal Flow™


**Key Engineering Principle**

> *"Thermal energy is distributed simultaneously through multiple parallel heat transfer pathways from the beginning of the heating process."*

**Direct Thermal Flow™** is FinSteam's proprietary heat transfer concept in which the thermal energy generated during the combustion of liquefied petroleum gas (LPG) is distributed simultaneously through multiple parallel heat transfer pathways. Unlike traditional wood-fired and electric sauna heaters, where most of the thermal energy is first stored in the sauna stones before being gradually released into the sauna room, Direct Thermal Flow™ transfers heat from the very beginning of the heating process simultaneously to both the sauna air and the sauna stone mass.

During combustion, the hot combustion products and the accompanying airflow carry a significant amount of thermal energy. In the FinSteam design, this energy is utilized so that part of it heats the sauna air immediately, while the remaining energy is stored in the sauna stones and the heater structure. As a result, the sauna room begins to heat up immediately, while the sauna stones simultaneously accumulate thermal energy for the continued production of high-quality löyly.

Direct Thermal Flow™ is not based on a new physical phenomenon or a new heat transfer mechanism. Instead, it utilizes the well-established principles of heat transfer—conduction, natural convection, and thermal radiation—but applies them in an engineering configuration that differs fundamentally from conventional sauna heater technologies. The innovation lies in the way the thermal energy generated during combustion is simultaneously directed through multiple parallel heat transfer pathways.

This operating principle combines rapid sauna heating with high thermal storage capacity within the same heating system. The sauna air reaches the desired temperature quickly, while the sauna stones store sufficient thermal energy to produce high-quality traditional Finnish löyly throughout the entire sauna session.

Direct Thermal Flow™ defines the primary heat distribution principle of the FinSteam heating system. Together with **Humidity Balance™** and **Sauna Climate Engineering™**, it forms one of the three complementary engineering concepts that define the operating principle of the FinSteam gas sauna heater.

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# 10

## Humidity Balance™


**Key Engineering Principle**

> *"Water vapor generated naturally during properly adjusted LPG combustion provides a continuous source of humidity throughout heater operation."*

**Humidity Balance™** is FinSteam's proprietary engineering concept that utilizes the water vapour naturally produced during the properly adjusted combustion of liquefied petroleum gas (LPG) as a continuous source of humidity within the sauna environment. Unlike traditional sauna heaters, where humidity is generated primarily by pouring water onto the sauna stones, the FinSteam system continuously produces moisture throughout both the heating phase and the entire sauna session.

During properly adjusted LPG combustion, the primary combustion products are carbon dioxide ($CO_2$) and water vapour ($H_2O$). In FinSteam's flueless Type A gas appliance, these combustion products are intentionally discharged into the sauna room as part of the appliance's approved and tested operating principle. As a result, water vapour is continuously released into the sauna air for as long as the burner remains in operation. Safe operation of the system always requires ventilation to be installed in accordance with the manufacturer's installation instructions.

In a wood-fired sauna heater, most of the moisture generated during combustion is discharged through the chimney, while an electric sauna heater produces no moisture during heating. In contrast, the water vapour generated by the FinSteam system remains in the sauna room, making moisture generation a continuous process rather than one that depends solely on individual applications of löyly water.

Humidity Balance™ is not intended to replace the traditional Finnish practice of producing **löyly**. Water can be poured onto the sauna stones in exactly the same way as with any traditional Finnish sauna heater. Instead, the purpose of the concept is to establish a higher natural baseline humidity before the first **löyly** and to maintain that humidity continuously throughout burner operation.

Because moisture is generated continuously during heating, the humidity level develops more gradually than in systems where humidity is created only when water is poured onto the stones. The final relative humidity nevertheless depends on the combined effects of sauna volume, ventilation, operating temperature, heating time, the number of bathers, and the amount of water poured onto the sauna stones. Humidity Balance™ therefore does not regulate the humidity to a predetermined value; rather, it provides a continuous source of moisture that becomes a natural part of the normal sauna environment.

Humidity Balance™ defines the principle of continuous moisture generation within the FinSteam heating system. Together with **Direct Thermal Flow™** and **Sauna Climate Engineering™**, it forms one of the three complementary engineering concepts that define the operating principle of the FinSteam gas sauna heater.

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# 11

## Sauna Climate Engineering™

Sauna Climate Engineering™

**Key Engineering Principle**

> *"A high-quality sauna environment is achieved by managing heat transfer, moisture generation, airflow, thermal storage, and ventilation as one coordinated engineering system."*

**Sauna Climate Engineering™** is the overarching engineering concept of the FinSteam heating system. It integrates heat transfer, moisture generation, thermal storage, natural air movement, thermal radiation, and ventilation into one coordinated operating system. Rather than optimizing individual performance parameters, the objective is to manage the entire sauna environment as a unified thermal system.

The quality of a Finnish sauna cannot be evaluated solely by measuring air temperature. Although temperature is one of the most easily measured parameters, the overall sauna experience results from the combined interaction of several physical factors, including temperature distribution, relative humidity, natural air circulation, thermal radiation, the temperature of the sauna stones, and the production of löyly. These factors continuously influence one another throughout both the heating phase and the sauna session.

In traditional sauna heaters, the heater functions primarily as a source of heat, while the final sauna conditions develop largely through the interaction between the heater, the sauna structure, and natural physical processes. The resulting sauna environment can be excellent, but its characteristics depend heavily on factors such as the structural design of the sauna, ventilation, stone mass, and the natural evolution of heat and humidity.

**Sauna Climate Engineering™** approaches the heating process from a system-level perspective. Instead of treating heat transfer, humidity, airflow, and thermal storage as separate phenomena, the FinSteam system is designed so that these processes operate simultaneously and continuously support one another throughout heater operation.

Within this engineering concept, **Direct Thermal Flow™** provides the mechanism for heat distribution, while **Humidity Balance™** provides continuous moisture generation. **Sauna Climate Engineering™** coordinates these processes together with thermal storage, natural air circulation, thermal radiation, and ventilation into one integrated operating system that governs the overall behavior of the sauna environment.

The objective of this approach is to achieve both temporal and spatial uniformity within the sauna. Temporal uniformity means that temperature and humidity develop gradually and predictably throughout both the heating phase and the sauna session without unnecessary fluctuations. Spatial uniformity means supporting the most even practical distribution of heat throughout the sauna while minimizing unnecessary temperature differences between the upper and lower areas of the room. The final conditions naturally remain dependent on factors such as sauna geometry, insulation, ventilation, and bench layout.

**Sauna Climate Engineering™** is therefore not an individual technical component but a system-level engineering concept describing how the complete heating system functions as an integrated whole. Rather than evaluating performance solely by heater output or heat-up time, the concept considers how effectively the entire system manages heat distribution, humidity development, airflow, thermal storage, and löyly conditions throughout normal operation.

**Sauna Climate Engineering™** therefore represents the highest level of the FinSteam engineering architecture. Together with **Direct Thermal Flow™** and **Humidity Balance™**, it defines the operating principle of the FinSteam gas sauna heater and distinguishes it fundamentally from traditional sauna heating technologies. Instead of functioning merely as a heat source, the heater becomes an integral part of managing the complete sauna environment, with the objective of creating stable, balanced, and comfortable sauna conditions throughout the entire heating cycle and sauna session.

# 12

# Nominal Power and Actual Heating Performance

***Key Engineering Principle***

> *"The nominal power rating of a sauna heater indicates its maximum heat output, but not how effectively that energy is converted into useful heating of the sauna."*

Nominal power is one of the most commonly quoted specifications of a sauna heater. Expressed in kilowatts (kW), it indicates the maximum rate at which the heater can generate thermal energy under defined operating conditions. It is an important engineering parameter because it is used for heater sizing, estimating energy consumption, and determining the recommended sauna volume.

However, **heat generation is not the same as heat transfer**.

A sauna heater may produce a certain amount of heat, but the quality and performance of the sauna depend on how effectively that heat is transferred into the sauna, stored where appropriate, distributed throughout the room, and ultimately experienced by the user. For this reason, nominal power alone cannot fully describe the actual heating performance of a sauna heater.

Actual heating performance depends on the combined behavior of the established heat transfer mechanisms together with thermal storage, airflow, ventilation, insulation, sauna geometry, and heat losses. Consequently, two sauna heaters with identical nominal power ratings may produce significantly different sauna conditions depending on how their heating systems are engineered.

## Wood-Fired Sauna Heaters

In a wood-fired sauna heater, the nominal power is based on the thermal energy released during the combustion of firewood. In practice, however, the heat output varies continuously throughout the combustion cycle and does not remain constant during heating. Furthermore, a portion of the generated heat inevitably leaves the sauna through the chimney together with the flue gases instead of contributing to heating the sauna.

### Independent Laboratory Evidence

This phenomenon has been demonstrated in independent laboratory testing. In a comparative study conducted by **TM Rakennusmaailma** and the **FINAS-accredited laboratory of Kymenlaakso University of Applied Sciences**, seven wood-fired sauna heaters with nominal power ratings of approximately 20 kW were evaluated.

The tested heaters had nominal power ratings ranging from **17.5 to 26.1 kW**, while their measured heating outputs ranged from only **10.0 to 16.6 kW**. In practice, the measured heating output corresponded to only **57–72%** of the declared nominal power. Approximately **28–43%** of the heat released during combustion was discharged through the chimney with the flue gases rather than contributing to heating the sauna.

TM Rakennusmaailma and the FINAS-accredited laboratory of Kymenlaakso University of Applied Sciences

| Measurements | Aito 20 | Harvia Pro 20 | Helo 20 PK | Kastor Karhu 20 PK | Misa 11206 | Narvi NC 20 | Sydänkiuas 10 |
|---|---|---|---|---|---|---|---|
| Nominal Power, kW | 26,11 | 25,48 | 21,01 | 17,58 | 20,21 | 17,52 | 18,51 |
| Heat Output, kW | 15,53 | 16,61 | 14,26 | 11,62 | 13,06 | 10,03 | 13,39 |
| Efficiency, % | 59,47 | 65,19 | 67,87 | 66,12 | 64,61 | 57,23 | 72,34 |
| Flue Gas Mass Flow Rate, g/s | 23,58 | 19,22 | 18,31 | 19,63 | 19,27 | 16,38 | 18,02 |
| Average Flue Gas Temperature, °C | 392,0 | 392,0 | 323,0 | 268,0 | 324,0 | 404,0 | 250,0 |
| Maximum Flue Gas Temperature at the Flue Connection, °C | 657,4 | 608,46 | 529,5 | 432,7 | 498,6 | 679,6 | 384,8 |
| Sauna Heating Time to 80 °C, min | 48,0 | 38,45 | 50,30 | 59,0 | 51,0 | 66,0 | 64,0 |
| Maximum Sauna Floor Temperature, °C | 37,9 | 43,1 | 46,4 | 49,6 | 47,3 | 46,5 | 37,4 |
| Carbon Monoxide Emission (red 13% $O_2$), % | 0,13 | 0,13 | 0,07 | 0,14 | 0,13 | 0,08 | 0,09 |

The study also demonstrated that the differences between the heaters were primarily explained by their ability to recover heat from the flue gases before they exited through the chimney. Lower flue gas temperatures indicated more effective heat recovery and higher thermal efficiency, while higher chimney temperatures indicated greater heat losses to the environment.

# Electric Sauna Heaters

Electric sauna heaters convert electrical energy into heat with very high efficiency. Nevertheless, this does not mean that all generated heat immediately contributes to warming the sauna. A substantial proportion is first absorbed by the sauna stones and the heater structure before being gradually transferred to the sauna. Consequently, the actual heating behavior of an electric sauna heater depends not only on its nominal power but also on factors such as stone mass, heater design, airflow, and the control system.

# FinSteam Gas Sauna Heater

The FinSteam gas sauna heater follows the same fundamental laws of heat transfer as every other heating system, but its operating principle differs from traditional indirect heating technologies. Rather than relying primarily on stored heat within the sauna stones, the system distributes heat simultaneously through multiple parallel heat transfer pathways. Part of the generated heat is transferred directly into the sauna air while thermal energy is simultaneously stored within the sauna stones and transferred to surrounding structures.

The performance of the FinSteam system has also been verified through independent laboratory testing as part of the EU Type Examination and conformity assessment process for gas appliances. Laboratory measurements confirmed the declared heat input of both the **BOTNIA 8.1 kW** and **AURORA 8.1 kW** models: approximately **8.1 kW** using G31 propane at 37 mbar and approximately **8.3 kW** using G30 at 29 mbar.

Because the FinSteam heater is a certified **Type A flueless gas appliance**, the heat released during combustion is not discharged through a chimney. Instead, heat and water vapor become part of the designed heating process within the sauna. From an engineering perspective, however, this alone does not determine sauna performance. The decisive factor remains how effectively the generated heat interacts with the sauna air, the stone mass, ventilation, humidity, insulation, sauna geometry, and user operation to create the desired sauna environment.

Two sauna heaters with identical nominal power ratings may therefore produce markedly different heating characteristics. If one heater loses a substantial proportion of its energy through the chimney or stores most of its heat before the sauna air begins to warm, while another distributes heat simultaneously through multiple pathways, differences may become evident in heat-up time, temperature distribution, humidity development, energy consumption, and the overall sauna environment experienced by the user.

Nominal power also does not account for numerous installation-specific factors, including sauna size, insulation quality, ventilation, interior surface materials, outdoor temperature, stone quantity and arrangement, or operating practices. Consequently, the same heater may perform differently in different sauna installations.

From an engineering perspective, the performance of a sauna heater should therefore be evaluated as a complete thermal system rather than solely by its nominal power rating. Nominal power indicates **how much heat a heater can generate**, but actual heating performance is determined by **how effectively that heat is transferred, distributed, stored, and utilized throughout the sauna environment**. Ultimately, the engineering objective is not simply to maximize heat generation, but to create the desired sauna conditions in the most effective and predictable manner.

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# 13

## Safety, Certification, and Regulatory Compliance

**Key Engineering Principle**

> *“A certified gas appliance is approved as a complete engineered system. Its safety depends on the interaction of all certified components and operating conditions rather than on any individual safety device.”*

The FinSteam gas sauna heater has undergone **EU Type Examination** in accordance with **Regulation (EU) 2016/426 (Gas Appliances Regulation)**. Its conformity has been verified by a notified body and documented through the manufacturer's **EU Declaration of Conformity**. The EU Type Examination and the EU Declaration of Conformity support conformity with the applicable essential requirements when the appliance is used in its approved configuration.

Gas appliance safety is based on the performance of the complete engineered system rather than on any single component. The heater structure, combustion system, burner adjustment, combustion air supply, ventilation, construction materials, thermal loads, safety clearances, automatic safety devices, and installation instructions together form the certified operating configuration. Each element contributes to the safe and intended operation of the appliance and cannot be evaluated independently.

Before certification, the complete appliance undergoes extensive laboratory testing to verify combustion stability, gas tightness, ignition characteristics, structural integrity, material durability, surface temperatures, emissions, the operation of safety devices, and performance under defined operating conditions. Certification therefore applies to the complete appliance as tested, not merely to individual components or the burner itself.

A fundamental principle of gas appliance certification is that the appliance must always be installed and operated exactly as approved during testing. Any modification that changes the combustion process, airflow, structural configuration, or operating conditions falls outside the scope of the original certification. Once these conditions change, the appliance can no longer be considered to operate within its certified design.

For this reason, the installation of a chimney, flue, or any other exhaust duct on a FinSteam gas sauna heater is strictly prohibited. The appliance has been specifically designed and certified as a **Type A flueless gas appliance**, in which combustion, airflow, heat transfer, ventilation, and automatic safety functions operate as one coordinated system. Introducing a chimney would alter the combustion conditions, burner air-to-gas ratio, airflow characteristics, and heat transfer behavior in ways that were not evaluated during certification testing. Such a modification would invalidate the appliance's certified operating configuration and its CE conformity.

The heater is equipped with an **Oxygen Depletion System (ODS)** that continuously monitors the combustion process through changes in the pilot flame. If the oxygen concentration of the combustion air falls below the designed operating threshold, for example, due to insufficient ventilation, the ODS safety system is designed to shut off the gas supply if oxygen depletion affects the pilot flame/combustion conditions, preventing continued operation under unsafe combustion conditions.

The ODS safety system is an important element of the overall safety concept, but it does not replace correctly designed ventilation. The sauna must always be provided with combustion air and exhaust ventilation in accordance with the manufacturer's installation instructions. Proper ventilation is essential not only for safe combustion, but also for maintaining the intended temperature distribution, humidity conditions, and natural air circulation within the sauna.

From the user's perspective, safe operation is based on a simple engineering principle: the appliance must be installed, connected, maintained, and operated exactly as specified by the manufacturer. No modifications may be made to the appliance or its approved operating conditions, all prescribed safety clearances must be maintained, and the ventilation system must be implemented as instructed. When these requirements are fulfilled, the heater operates under the same conditions in which its safety, performance, and regulatory compliance were evaluated during conformity assessment.

Safety is therefore not an individual feature but a property of the complete FinSteam engineering system. The appliance achieves its certified level of safety because combustion, heat transfer, ventilation, automatic safety functions, and structural design have been engineered, tested, and approved to operate together as one coordinated system.

**Engineering Note**

**EU type examination and CE conformity apply only to the appliance in its approved configuration. Any structural modification - including the installation of a chimney or flue - changes the approved operating conditions and falls outside the scope of the original conformity assessment.**

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# 14

## Practical Benefits for the User

**Key Engineering Principle**

> *"The value of engineering is ultimately measured by the quality, consistency, predictability, and comfort of the sauna experience it creates."*

Every engineering solution incorporated into a sauna heater ultimately serves the same purpose: to create a comfortable, consistent, safe, and authentic Finnish sauna experience.
From the user's perspective, the most important consideration is not how much heat the heater generates, but how the sauna performs throughout both the heating phase and the sauna session.

The engineering concepts described in the previous chapters - including **Direct Thermal Flow™**, **Humidity Balance™**, and **Sauna Climate Engineering™ -** work together to influence the practical characteristics of the sauna environment. Rather than functioning as isolated technologies, they contribute collectively to the way heat, humidity, and airflow develop throughout normal operation.

One practical benefit is a heating process in which the sauna gradually reaches comfortable operating conditions while maintaining sufficient thermal energy within the sauna stones for consistent löyly. At the same time, the distribution of heat throughout the sauna helps support a more uniform thermal environment, reducing unnecessary temperature differences between different areas of the room and improving comfort for users sitting on different bench levels.

Another characteristic of the FinSteam system is the continuous generation of water vapor as a natural consequence of LPG combustion. This contributes to the sauna's base humidity throughout heater operation. The overall effect depends on factors such as ventilation, temperature, sauna size, and heating duration, but it can help reduce the sensation of excessively dry air, particularly during extended heating periods.

This continuous base humidity does not replace traditional Finnish löyly. Water is poured onto the heated sauna stones in exactly the same manner as with traditional sauna heaters. The continuously generated water vapor establishes the background humidity of the sauna, while löyly allows users to create temporary increases in humidity and perceived heat according to their personal preferences.

The combined effect of these engineering principles allows the heater to maintain stable sauna conditions during continuous operation while preserving sufficient stored heat within the sauna stones for repeated and consistent löyly throughout the sauna session.

Predictability is another important practical benefit. When the heater is installed correctly and the sauna ventilation is designed in accordance with the manufacturer's installation instructions, the sauna reaches its operating conditions gradually and consistently without unnecessary fluctuations. This makes the sauna comfortable to use for both experienced sauna users and those with limited sauna experience.

It is important to recognize, however, that the heater represents only one part of the complete sauna system. The overall sauna environment is also influenced by factors including sauna size, insulation, ventilation, interior surface materials, stone quantity and arrangement, bench design, outdoor conditions, and user operation. Consequently, the same heater may produce somewhat different results in different sauna installations.

Individual preferences also influence what is considered an ideal sauna environment. Some users prefer higher temperatures with lower humidity, while others favor slightly lower temperatures combined with more frequent löyly. The FinSteam system accommodates both approaches by allowing users to adjust the sauna temperature and the intensity of löyly according to their own preferences.

Ultimately, the user's experience is created by the interaction of the complete sauna system rather than by any individual technical feature. Heat distribution, humidity development, thermal storage, ventilation, sauna design, and user operation work together to create the final sauna environment. The objective of the FinSteam engineering system is therefore not simply to generate heat, but to provide a predictable, balanced, and authentic Finnish sauna experience in which the technology supports the experience without drawing attention to itself.

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# 15

## The Future of Sauna Design

**Key Engineering Principle**

> *“The future of sauna engineering lies not in maximizing individual performance parameters, but in optimizing the complete sauna environment as an integrated thermal system.”*

For decades, sauna design has focused primarily on temperature. Heater selection, heating capacity, stone quantity, sauna size, and heat-up time have traditionally been evaluated according to how quickly the desired temperature can be achieved and maintained throughout the sauna session.

Contemporary sauna research, however, increasingly indicates that temperature alone does not fully describe the sauna environment. Studies involving healthy adults have demonstrated that both **sauna air temperature** and **relative humidity** independently influence physiological responses during Finnish sauna bathing. These findings support the importance of evaluating the sauna environment as a complete system, although they do not by themselves validate the performance or health effects of any particular heater technology.

The interaction between temperature and humidity is explained by fundamental heat transfer physics. As the water vapor content of the air increases, the evaporation of sweat from the skin becomes less effective. Because evaporative cooling is one of the body's primary mechanisms for dissipating heat, physiological heat stress may increase even when the air temperature remains unchanged. Consequently, two saunas operating at the same temperature may produce noticeably different thermal sensations and physiological responses because of differences in relative humidity.

Current research does not suggest that higher humidity or higher temperature is inherently preferable. Instead, it increasingly emphasizes that sauna conditions should be evaluated as an integrated environment in which temperature, humidity, ventilation, heat distribution, airflow, and löyly interact continuously throughout the sauna session.

This perspective represents a gradual shift in sauna engineering. Rather than optimizing individual technical parameters in isolation, future sauna design is increasingly concerned with managing the complete thermal environment. The objective is not to maximize any single variable, but to establish stable, balanced, and predictable sauna conditions through the coordinated interaction of all relevant engineering factors.

Within this approach, the sauna heater becomes more than a source of heat. Together with the sauna structure, ventilation system, sauna stones, and user operation, it forms part of an integrated engineering system responsible for creating and maintaining the overall sauna environment. The quality of the sauna is therefore determined not by one technical specification, but by the combined performance of the complete system.

This system-oriented perspective is consistent with the engineering principles presented throughout this guide. Heat generation, heat transfer, humidity development, thermal storage, ventilation, and user interaction should not be considered as separate functions, but as interconnected processes that collectively determine sauna performance.

The future of sauna engineering is therefore likely to place increasing emphasis on holistic environmental control rather than on individual heater specifications alone. As scientific understanding of sauna physiology and thermal engineering continues to evolve, future heater development is expected to focus increasingly on creating controlled, predictable, and well-balanced sauna environments that support both user comfort and authentic Finnish sauna bathing traditions.

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# 16

# Frequently Asked Questions

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## Why doesn't the FinSteam gas sauna heater require a chimney?

The FinSteam heater has been engineered and certified as a **Type A flueless gas sauna heater**. During correctly adjusted LPG combustion, the primary combustion products are carbon dioxide and water vapor, which are released directly into the sauna as part of the appliance's approved Type A flueless operating configuration.

Because the heater has been specifically designed and tested to operate without a chimney, it must always be installed with ventilation that complies with the manufacturer's installation instructions. A chimney or flue must never be connected to the appliance.

---

## Can a chimney or flue be installed later?

No.

The heater has been tested and certified exactly in the configuration in which it is supplied. Installing a chimney, flue, or any other exhaust duct would alter the combustion process, airflow, and heat transfer characteristics in ways that were not evaluated during certification. Such a modification would invalidate the appliance's certified operating configuration.

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## Can the heater remain operating during sauna bathing?

Yes.

The FinSteam heater is designed for continuous operation throughout normal sauna bathing. It may remain in operation during the entire sauna session, continuously maintaining the sauna temperature while heating the sauna stones and generating water vapor.

Safe operation always requires installation and ventilation in accordance with the manufacturer's instructions.

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## Can water be poured onto the sauna stones?

Yes.

The sauna stones are heated in the same manner as those of a traditional Finnish sauna heater, and water may be poured onto them normally to produce löyly while the heater remains in operation.

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## Does the heater generate humidity even without pouring water onto the stones?

Yes.

The combustion of LPG naturally produces water vapor, which becomes part of the sauna atmosphere during normal operation. This increases the sauna's base humidity throughout the heating process.

This continuously generated humidity does not replace traditional löyly. Instead, it complements löyly by providing a stable background humidity while allowing users to create additional humidity by pouring water onto the sauna stones.

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## Can the heating output be adjusted?

Yes.

The heating output can be adjusted continuously within the appliance's approved operating range using the control knob.

Higher output shortens the heat-up time, while lower output helps maintain the desired sauna temperature with reduced gas consumption. Users can therefore adjust the sauna conditions according to their personal preferences.

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## How much LPG does the heater consume?

The maximum LPG consumption of the FinSteam 8.1 kW model is approximately **0.6 kg per hour** at full output.

Actual consumption depends on factors including the selected heating output, sauna size, insulation, outdoor temperature, ventilation, and whether the heater is warming a cold sauna or maintaining an existing operating temperature.

Based on maximum consumption, an **11 kg LPG cylinder** provides approximately **18 hours** of continuous full-power operation. In normal use, operating time is typically longer because full output is primarily required during the initial heating phase.

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## Why is ventilation important?

Proper ventilation provides the oxygen required for clean combustion while maintaining safe operating conditions within the sauna.

Correctly designed supply and exhaust ventilation also supports uniform heat distribution, appropriate humidity levels, and comfortable air circulation. Ventilation is an essential part of the heater's approved Type A flueless operating configuration and must always comply with the manufacturer's installation instructions.

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## Is FinSteam safe?

Yes, provided that the sauna heater is installed, connected to the gas supply system, operated, and maintained in accordance with FinSteam's instructions and all applicable local gas regulations.

The FinSteam gas sauna heater has undergone **EU Type Examination** in accordance with **Regulation (EU) 2016/426 (Gas Appliances Regulation)** and is supported by notified-body assessment and the manufacturer's **EU Declaration of Conformity**.

The heater has been certified as a complete engineering system, including its construction, combustion system, materials, safety devices, and specified operating conditions. The appliance is also equipped with an **Oxygen Depletion System (ODS)** that is designed to shut off the gas supply if oxygen depletion affects the pilot flame/combustion conditions

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## Does the heater produce carbon monoxide inside the sauna?

Like every gas appliance, combustion can produce carbon monoxide if combustion conditions become unsafe.

When the FinSteam heater is correctly installed, properly ventilated, and operated in accordance with the manufacturer's instructions, it operates within its certified combustion conditions. The integrated **Oxygen Depletion System (ODS)** and the specified ventilation requirements form essential parts of this certified safety concept.

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## Is FinSteam completely electricity-free?

Yes.

The heater operates entirely without mains electricity, electrical heating elements, or electronic controls. Ignition is provided by the integrated piezo ignition system, and the appliance uses LPG as its only energy source.

This allows the heater to be used wherever mains electricity is unavailable.

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## Can FinSteam be used in both indoor and outdoor saunas?

Yes.

The sauna heater may be installed in indoor or outdoor saunas that comply with the manufacturer's installation, ventilation, gas installation, and safety clearance requirements.

It must not be installed in living spaces or in rooms not specifically intended for sauna use.

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## What fuel does the heater use?

FinSteam is available in versions approved for different gas categories.

Depending on the heater model and local gas regulations, the approved fuel is G31 propane, G30 butane, or approved LPG mixtures, as permitted by the appliance category and the data plate.

**Only the gas type specified on the appliance's data plate may be used.**

## Can any type of sauna stones be used?

No.

Only heat-resistant sauna stones specifically intended for sauna heater use should be installed.

The recommended stone size is **5–10 cm**. Ordinary natural stones should not be used because they may fracture at high temperatures or contain minerals unsuitable for repeated heating.

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## Does FinSteam require regular maintenance?

Yes.

Like all gas appliances, FinSteam should be inspected regularly to support safe and reliable operation.

Routine maintenance includes keeping the heater clean, inspecting the gas hose, regulator, and connections, ensuring that air inlet openings remain unobstructed, and replacing worn components when necessary.

An inspection is recommended before each heating season and whenever abnormal operation is observed.

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## Does FinSteam replace the traditional Finnish sauna?

No.

FinSteam is not designed to replace traditional wood-fired or electric sauna heaters. Its purpose is to provide a new alternative in the sauna heater market and to expand the availability of authentic Finnish sauna experiences to locations where electricity is unavailable or where a wood-fired sauna heater is impractical or cannot be used.

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## How does FinSteam differ from an ordinary gas heater?

FinSteam is a purpose-designed and **EU type-examined and CE-marked gas sauna heater**, not a conventional gas space heater.

Its combustion system, heat transfer concept, sauna stone arrangement, safety systems, and operating characteristics have all been engineered specifically for Finnish sauna bathing. The appliance has been developed to create authentic Finnish sauna conditions while operating safely within its certified design.

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# 17

# Conclusion

**Key Engineering Principle**

> *"The performance of a sauna heater is determined not only by how much heat it generates, but by how effectively the complete sauna system creates and maintains the desired sauna environment."*

The Finnish sauna is far more than a heated room or a heating appliance. A high-quality sauna is created through the interaction of multiple physical processes in which heat transfer, humidity, airflow, thermal radiation, thermal storage, ventilation, and user operation together determine the overall sauna environment.

For many years, sauna performance has been evaluated primarily by air temperature and the nominal power rating of the sauna heater. Although both remain important engineering parameters, they describe only part of the heater's overall performance. The quality of a sauna ultimately depends on how effectively thermal energy is transferred, distributed, stored, and utilized throughout the complete sauna system.

Throughout this guide, the sauna heater has been examined as a heat transfer system rather than simply as a source of heat. This perspective emphasizes that the engineering objective is not merely to generate thermal energy, but to manage how that energy interacts with the sauna stones, the sauna air, the surrounding structures, ventilation, and humidity to create stable and predictable sauna conditions.

Traditional wood-fired and electric sauna heaters, together with the FinSteam gas sauna heater, are all governed by the same fundamental laws of thermodynamics and heat transfer. Their differences arise not from different physical laws, but from the engineering solutions used to apply those laws within the sauna environment.

The FinSteam heating system has been presented as one example of this engineering approach. Its operating principles - **Direct Thermal Flow™**, **Humidity Balance™**, and **Sauna Climate Engineering™** - illustrate how heat transfer, moisture generation, thermal storage, and ventilation can be coordinated as one integrated heating system while preserving the essential characteristics of authentic Finnish sauna bathing.

Current scientific research further supports the importance of evaluating sauna conditions as a complete thermal environment rather than through individual parameters alone. Temperature, relative humidity, ventilation, heat distribution, and user interaction all contribute to the physiological responses experienced during sauna bathing. Continued research will undoubtedly improve our understanding of these relationships and contribute to the future development of sauna engineering.

At the same time, no sauna heater alone determines the quality of a sauna. The overall performance of the sauna is always influenced by its construction, insulation, ventilation, bench arrangement, sauna stones, operating conditions, and the preferences of its users. The highest-quality sauna environments are achieved when all of these elements function together as one integrated system.

Safety remains the foundation of every engineering solution. The FinSteam heater has been designed, tested, and certified in accordance with the requirements of the **European Union Gas Appliances Regulation (EU) 2016/426**, and its certified performance depends on installation and operation exactly as specified by the manufacturer. Maintaining the approved operating configuration is therefore essential for preserving both safety and regulatory compliance.

Finnish sauna culture has continuously evolved through advances in construction methods, materials, and heating technologies. The future of sauna engineering is likely to continue this development by placing increasing emphasis on the design of complete sauna environments rather than on individual technical specifications. Within this broader evolution, FinSteam represents one engineering solution developed to expand the availability of authentic Finnish sauna bathing to environments where conventional solutions are not always practical.

Ultimately, the purpose of every sauna heater remains unchanged: to create an authentic, comfortable, safe, and enjoyable Finnish sauna experience. Engineering provides the means to achieve this objective, but it is the complete interaction between the heater, the sauna, and its users that defines the quality of the final sauna environment.

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# 18

# Glossary

## Conduction

**The transfer of thermal energy through direct contact between solid materials.** In a sauna heater, conduction transfers heat from heated components to the heater structure and sauna stones.

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## Convection

**The transfer of thermal energy by the movement of air.** In a sauna, warm air rises while cooler air moves to replace it, creating natural air circulation.

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## Thermal Radiation

**The transfer of thermal energy by electromagnetic radiation without physical contact or air movement.** In a sauna, thermal radiation is emitted primarily by the heated sauna stones and other hot surfaces.

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## Heat Transfer

**The movement of thermal energy from one location to another.** In sauna engineering, heat transfer occurs through the combined effects of conduction, convection, and thermal radiation.

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## Thermal Energy Storage

**The ability of a material to absorb, store, and gradually release thermal energy.** In a sauna heater, the sauna stones provide the primary thermal storage.

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## Relative Humidity

**The amount of water vapor in the air relative to the maximum amount the air can contain at the same temperature.** It is expressed as **percentage relative humidity (% RH).**

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## Sauna Environment (Sauna Microclimate)

**The combined thermal conditions within a sauna, including temperature, humidity, airflow, thermal radiation, and thermal stratification.** These factors together determine the overall sauna experience.

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## Thermal Stratification

**The variation of air temperature with height inside the sauna.** Warm air naturally accumulates near the ceiling, while cooler air remains closer to the floor.

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## Thermal Efficiency

**The proportion of generated energy that is usefully transferred to heating the sauna.** Higher thermal efficiency generally means lower heat losses.

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## Nominal Power

**The maximum heating capacity specified by the manufacturer under standardized operating conditions.** Nominal power describes the heater's heat generation capability but does not, by itself, determine actual sauna performance.

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## Combustion

**A chemical reaction in which fuel reacts with oxygen, releasing thermal energy.** During properly adjusted LPG combustion in the FinSteam heater, the primary combustion products are carbon dioxide and water vapor.

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### Oxygen Depletion System (ODS)

**An automatic safety system that monitors combustion conditions through the pilot flame.** If the oxygen concentration falls below the designed operating threshold, the gas supply is automatically shut off.

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## FinSteam Engineering Concepts

## Direct Thermal Flow™

**A FinSteam engineering concept describing the simultaneous distribution of thermal energy through multiple heat transfer pathways.** Heat is transferred simultaneously to the sauna air, sauna stones, and surrounding sauna environment throughout normal heater operation.

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## Humidity Balance™

**A FinSteam engineering concept describing the continuous generation of water vapor during properly adjusted LPG combustion.** This naturally generated water vapor contributes to the sauna's base humidity while complementing traditional löyly.

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## Sauna Climate Engineering™

**A FinSteam system-level engineering concept describing the coordinated interaction of heat transfer, humidity generation, thermal storage, ventilation, and airflow.** The objective is to create a stable, balanced, and predictable sauna environment through the integrated operation of the complete heating system.

#### Terminology Note

*Throughout this guide, standard engineering terminology has been used wherever possible. The terms **Direct Thermal Flow™**, **Humidity Balance™**, and **Sauna Climate Engineering™** are proprietary engineering concepts developed by FinSteam to describe specific characteristics of its heating system.*

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# 19

# References

The content of this guide is based on European Union legislation, harmonized European standards, the certification and technical documentation of the FinSteam gas sauna heater, and relevant scientific research. The references listed below constitute the technical and regulatory framework upon which this guide is based.

## European Union Legislation

European Parliament and Council. (2016). *Regulation (EU) 2016/426 of the European Parliament and of the Council of 9 March 2016 on appliances burning gaseous fuels and repealing Directive 2009/142/EC (Gas Appliances Regulation, GAR).*

European Commission. *Gas Appliances Regulation (EU) 2016/426 – Legal Framework and Harmonized Standards.* Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs.

## European Standards

European Committee for Standardization (CEN). (2002). *EN 449:2002+A1:2007 – Specification for Dedicated Liquefied Petroleum Gas Appliances – Domestic Flueless Space Heaters.*

European Committee for Standardization (CEN). *Harmonized European Standards Supporting* Regulation (EU) 2016/426.

European Committee for Standardization (CEN). EN 16510 – *Residential solid fuel burning appliances.*

## Certification and Conformity Documentation

AENOR CONFÍA S.A.U. *EU Type Examination Certificate No. A01/002220.*

AENOR CONFÍA S.A.U. *EU Type Examination Assessment Documentation.*

FinSteam. *EU Declaration of Conformity (DoC).*

## FinSteam Technical Documentation

FinSteam. *TS A01-01 – Technical Specification – Sauna Heater.* Revision 6. Technical specification supporting EU Type Examination.

FinSteam. *Installation & Safety Guide.*

FinSteam. *Technical Datasheet.*

## Independent Laboratory and Test Reports

Applus+ Laboratories. *Final Test Report – Gas Sauna Heater.*

AENOR CONFÍA S.A.U. *Technical Assessment and Certification Documentation.*

Independent laboratory testing and performance measurements conducted as part of the CE certification process for the **BOTNIA 8.1 kW** and **AURORA 8.1 kW** gas sauna heaters.

## Scientific Literature

*Temperature and Humidity Independently Influence Thermoregulatory Responses During Finnish Sauna Bathing.* Iida Laatikainen-Raussi, Tom Mikkola, Johanna K. Ihalainen, Essi Ahokas 2026.

*Fundamentals of Heat and Mass Transfer.* Incropera, DeWitt, Bergman and Lavine.

*Heat Transfer: A Practical Approach.* Yunus A. Cengel

## Comparative Studies

**TM Rakennusmaailma.** Comparison of Continuously Heated Wood-Fired Sauna Heaters (Approx. 20 kW). Measurements were conducted at the Energy Technology Laboratory of Kymenlaakso University of Applied Sciences, a FINAS-accredited testing laboratory.

## Technical Concepts and Terminology

The technical concepts relating to thermal engineering, heat transfer, combustion, ventilation, and sauna environments used throughout this guide are based on established terminology in the fields of thermodynamics, combustion engineering, building physics, and gas appliance engineering, together with the European legislation, harmonized standards, and technical documentation referenced above.

The terms **Direct Thermal Flow™**, **Humidity Balance™**, and **Sauna Climate Engineering™** are proprietary technical concepts developed by FinSteam to describe the operating principles of the FinSteam gas sauna heater. These concepts are specific to FinSteam and are distinct from internationally standardized engineering terminology.

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## Intellectual Property Rights



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This guide does not replace the applicable installation instructions, operating instructions, safety instructions, maintenance instructions, EU conformity documentation, or any other official product documentation supplied by the manufacturer. The installation, commissioning, operation, and maintenance of the product must always be carried out in accordance with the current instructions supplied with the specific product model, together with all applicable national legislation, regulatory requirements, and local installation regulations.

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