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The thermomechanical study on central heating (thermal heating) versus local heating with apartment central heating

Doctoral thesis - Abstract

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In the first chapter, the heating of individual homes and administrative buildings, which is a problem for each society, is presented. Multiple systems have been used, with firewood or fossil fuels and a wide range of heat transfer agents (in the case of district heating systems). We mention among the first systems only the (central) heating with hot air practiced by the Romans, followed in time by hot water or steam as carrier agents.

The theme was established in 2017, and the current situation (starting from 2021) is fluctuating in terms of fuels and energy and has led to conclusions that cannot be considered definitive and correct.

Even in the current period, the choice of heating systems is often made difficult by the multitude of offers on the market.

All offered heating systems are organically linked to the generic notion of industrial engineering. All systems are designed by engineers (based on data received from the civilian environment) and made in various industries, connected.

They are heating systems that have been developed either based on the requirements of users or based on the ideas of designers who created a prototype.

The heating of living spaces is developing from year to year and is currently an important issue as more and more people decide to abandon the services of district heating and district heating providers.

The main reason is represented by the significantly high costs of the invoices, but also the uncertain or insolvent state of the local heating structures.

For the authenticity of the study, research on the costs of local heating systems of apartments, through purchase, installation, and maintenance, and an analysis of the costs of local heating systems of an apartment block through purchase, installation, and maintenance will be developed. These discussions will also extend to family or villa-type houses.

Insisting on the main objective of the thesis, we propose a critical analysis of the existing situation in several residential buildings (blocks and individual houses) in terms of ensuring heating, with a synthesis of the effects found for different heating systems.

The thermal comfort, the efficiency of the heating plant, the comfort, design, and connectivity options, and the creation of a pleasant environment in the home, are reasons why residents opt for plants both in apartments and in family homes.

Currently, the situation of SACET operators is decreasing, and heating systems (central) for apartments or family houses are constantly expanding.

In the second chapter, the heating systems for an apartment, a multi-apartment block, and a family house are presented and analyzed from an economic and thermal point of view.

First of all, the heating systems for an apartment are analyzed:

- + Centralized urban heating;
- + Gas plant;
- + Electric thermal power plant;
- + Heating system with air conditioner.

Secondly, the heating systems of a multi-apartment building are analyzed:

- + Own block power plant;
- + Heat pumps;
- + Photovoltaic panels.

Thirdly, the heating systems of a family house or villa located close to the city center are analyzed:

- + Gas plant;
- + Heating system with air conditioner;
- + Photovoltaic panel;
- + Central heating on wood or pellets.

In terms of heating systems, the municipal centralized system, Colterm, which is the company providing centralized heating services in the municipality of Timișoara, with over 60 years of experience in the field, will be highlighted. The company is responsible for providing heat and hot water throughout the city, and its services are used by more than 160,000 inhabitants and by several public and private institutions.

Heating systems are used for apartments in towns where there is no central heating network.

The heating systems we find on the market differ from each other according to price, installation, and maintenance costs or efficiency.

The apartments analyzed in the thesis are part of a building built 30 years ago, with brick and insulation inside. The building has 19 apartments, each with 2 rooms.

I mention the fact that of the 19 apartments, only the apartment on the ground floor is still connected to the city's heating system. In the current situation, we find one apartment heated with a heat pump, and 2 apartments with a heating system with air conditioners - the tenants are elderly and carry out their daily activities in one room, and the 15 apartments are heated with central heating gas and electric heating.

The study of heating systems is focused on a building - an apartment - in Timișoara, with a centralized heating system, gas heating systems, heat pumps, air conditioners, etc.

Although it is not the same apartment, each one's heating supply is different. The electric heating plant, as well as the gas plant, heats water in radiators, and the heat is shared in every room of the house, through radiators or in some cases through heat pumps.

The heating system with air conditioners uses the entire surface of the ceiling to radiate heat. Air conditioners are considered to be some of the most efficient products when it comes to energy consumption.

Following the economic and thermal analysis of apartment heating systems, a multi-apartment building, or a family house, the most important advantages and disadvantages could be highlighted. It can be seen that through centralized heating we can efficiently ensure the simultaneous heating, from a single source, of several homes in one or more buildings, using a thermal agent for this purpose.

In this case, there is the possibility of disconnecting several apartments from the heating network thanks to modern heating systems, and the high costs in terms of the monthly administrative expenses of the tenants connected to the city heating system are very high.

Gas plants are some of the most efficient, especially when it comes to gas-condensing thermal plants. Unlike other types of heating plants that cannot reach the maximum efficiency percentage of 100%, gas heating plants can exceed it, most of the time. In this case, the gas plant is not a green energy source and produces carbon dioxide when burned, and the prices of this fuel depend on worldwide demand and natural gas suppliers.

Power plants are designed to be reliable and safe in operation, ensuring a constant supply of electricity. This is important for maintaining the electricity supply to communities and economies.

Although the initial costs of building a power plant can be high, long-term costs can be reduced by using renewable energy sources that do not require the purchase and transportation of fossil fuels. In addition, electricity produced from renewable sources is free and inexhaustible. Power plants are an efficient and convenient option for generating electricity, providing a constant and reliable source of electricity that is clean and environmentally friendly. The most minor disadvantage is their operation and construction.

Heating with an air conditioner is the cheapest way to heat compared to other heating methods such as power plants, gas, coal, wood, pellets, or central heating. Air-conditioned heating offers the ability to control the temperature in a room or area according to individual preferences. This can be useful, especially if different areas of the house are used differently. Air conditioners are known for being energy efficient, and heating with this type of appliance is less efficient than other heating systems. They use a lot of electricity, which can lead to high bills at the end of the month.

In Romania, the concept of individual heating based on natural gas experienced an important increase with the development of the natural gas distribution network. In this sub-chapter, I will list the most important local heating systems for a multi-apartment block, such as the block's boilers, heat pumps, and photovoltaic panels.

A block thermal power plant supplies heat to a large number of homes that are part of the same complex.

Air/water split heat pumps or even the smaller, mono-bloc versions are the ideal systems for block apartments.

With heat pumps, it is possible to waive everything that means the part of the gas authorization project, the costs regarding the realization of the gas route and the connection, the operating authorization, or the periodic technical check every 2 years.

Systems with photovoltaic panels, which contribute to the production of electric current used for electric heating, are complete solar installations that produce domestic hot water but also contribute to heating the house.

Heat pumps are a very good solution to heat several apartments in a building and can be implemented (with costs comparable to those required to install a heating plant - because most of them have an individual heating plant for each apartment).

However, the thermal efficiency of own block plants can vary significantly depending on the type of fuel used, the technology used, and the size of the plant.

In general, own block power plants using fossil fuels such as natural gas can have high thermal efficiencies of up to 90%.

In comparison, own block plants using renewable energy sources such as photovoltaics or wind energy can have lower thermal efficiency because these energy sources can be less constant and less predictable.

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Heat pumps use renewable energy such as solar, geothermal, or air energy to produce heat. This means that they are much more energy efficient than other heating systems such as boilers or stoves.

Because heat pumps use renewable energy, running costs are much lower than conventional heating systems. They also have a longer lifespan, so maintenance costs are lower in the long run.

Heat pumps are designed to be durable and run for the long term with little maintenance. This means they can offer a higher level of safety and don't need to be replaced as often as other heating systems.

The initial costs of installing a heat pump system can be higher than the installation costs of other heating systems such as central heating or wood boilers. Heat pump systems require regular maintenance to function optimally and maintain their energy efficiency.

Of all the benefits of photovoltaic panels, the most important thing is that solar energy is a truly renewable energy source. For one year, the photovoltaic panels must ensure, on average, the consumption of homes. But the more the amount of kWh produced will be different from the average annual housing consumption, the longer the investment will recover.

The heating systems of a family house or villa are similar to the case of an apartment, only the area is larger than m², so the heating power is also higher, in this case, we also point out the higher costs.

Currently, gas is cheaper than electricity, so it is a more economical solution. Gas central is suitable in a house because they do not take up much space and can be easily integrated into the furniture.

From a financial point of view, connecting to the grid is more expensive. But over time, the investment will pay off. The costs are much higher compared to an apartment because the family home has more rooms.

The heating system through an air conditioner, from the point of view of purchase, is a much cheaper way of heating compared to other heating methods - and here we are talking about power plants, gas, coal, wood, or pellets, but also central heating. The air conditioner, as in the case of an apartment, begins to heat immediately after it is turned on - there is no need to wait or accumulate energy overnight.

In the case of a family house, the photovoltaic panels work in the temperature range of -40°C to 85°C, and have a warranty of over 10 years. At the same time, photovoltaic panels offer stability and predictability in terms of energy consumption bills.

When it comes to wood-fired boilers for a family home, they are very fuel-efficient. The wood-fired boiler consumes less wood fuel and generates more heat compared to traditional wood-burning stoves.

First of all, wood supply is manual and inconvenient, and secondly, we can talk about cleanliness, they have to be cut and carried. The small capacity of most wood-burning plants forces people to add wood several times throughout the day and night to maintain a constant level of heat.

In the third chapter, the district heating system in the Municipality of Timisoara is presented. Heating in Timisoara is provided by the Colterm company, which has been providing centralized heating services in the city for over 60 years. The central heating system in Timisoara consists of a network of underground pipes and several thermal plants that produce heat and hot water for end consumers. Currently, Colterm manages over 160,000 heating and hot water meters and provides services to residents, but also public and private institutions.

In recent years, Colterm has invested considerably in the modernization and efficiency of the central heating system, intending to reduce costs and improve the quality of the services offered. Among the investments made is the replacement of old pipes with new ones, the introduction of more efficient thermal plants, as well as the development of an intelligent heat and hot water distribution network.

Also, Colterm implemented a series of projects that had a positive impact on the environment. These include the replacement of coal used as an energy source in the past with natural gas, which has led to a significant reduction in carbon dioxide emissions and air pollution in the area.

In the fourth chapter, the case studies will be presented - the case of an apartment and the case of a family house. The case of an apartment in an apartment block is the first case we will analyze from a technical and economic point of view. The block of flats is located in the Bucovina area of the Municipality of Timisoara and is a block built in 1988 with brick and has four floors and 19 apartments. The apartment we will analyze is located on the 4th floor (apartment 18) and we propose three situations in which we find heating systems - an electric heating plant, a gas heating plant, and heating with an air conditioner. The proposed heat requirement for each month of the year is 22°C, the proposed requirement for all 3 heating systems proposed for analysis.

Through the technical and economic analysis we will track the costs of the proposed heating installations for each month of the year, which is the investment for each heating system, we will also present the financial and technical situation for two years - 2022 and 2023.

To carry out the economic analysis, we chose a one-story villa located on the outskirts of Timisoara. The house was built at the beginning of 2020 and completed at the end of 2020. The family house has 3 bedrooms, a terrace, and a hall upstairs, and on the ground floor, there is a bathroom, a kitchen, a living room, a hall, and a garage heated with its sources.

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Also, improper maintenance can lead to high emissions of greenhouse gases and pollutants into the atmosphere, affecting the environment and human health.

The issue of increasing the energy performance of buildings, blocks, and houses is still at a modest stage of implementation, the centralization and verification of the increase in energy performance among tenants are not developed with sufficient accuracy and there is no transparent legislation on the calculation of the heat requirement for heating a room and presentation of the best heating system.

The emphasis was placed on the presentation of the most suitable local heating systems, such as solar panels, and electric and gas plants, for houses and villas we find fireplaces and mobile or fixed stoves.

Thermal energy was relatively cheap, and currently, the costs are high, but analyzing the situation, we can come to the conclusion that by choosing a heating system suitable for the home, over time, the investment will be minimal.

Due to the high costs of thermal energy, more and more Romanians choose to disconnect from the heating network and install apartment or staircase central heating systems.

Nowadays, many buildings are heated with boilers or apartment boilers, and the residents of the houses choose an ecological system, such as solar panels.

The current situation of apartment heating varies by region and country, but in general, several issues need to be addressed to achieve an efficient and environmentally friendly system.

In many areas of the world, apartment heating is done by district heating systems that use fossil fuels such as natural gas or coal, which means that emissions of carbon dioxide and other greenhouse gases are significant. In addition, these systems can have low efficiency, leading to heat loss and high costs for end consumers.

For this reason, more and more people are choosing to install individual heating systems, such as heat pumps or underfloor heating systems, which are more efficient and environmentally friendly.

The current situation of heating a house varies by region and country, but in general, there are several options to achieve an efficient and environmentally friendly system.

In many areas of the world, home heating is done by district heating systems that use fossil fuels such as natural gas or coal, which means that emissions of carbon dioxide and other greenhouse gases are significant. In addition, these systems can have low efficiency, leading to heat loss and high costs for end consumers.

For this reason, more and more people are choosing to install individual heating systems, such as heat pumps or underfloor heating systems, which are more efficient and environmentally friendly. In addition, there is also the option of using renewable energy sources such as photovoltaic panels or wind turbines to power the heating system.

In this thesis, three situations are proposed, which are present in everyday life.

The issue of water losses and their recovery is raised in the maintenance lists.

The city heating network continuously heats the 19 apartments. Most of the time, we find tenants who do not have a water meter, and the question arises of water losses, to whom they belong, or if they are shared correctly.

We propose 3 solutions adopted by the owners' associations to recover the difference, to cover the counter value of the invoice, namely:

- ✚ The difference is distributed proportionally to the individual share of each apartment; - be the most suitable solution?
- ✚ The difference is distributed proportionally to the number of people present; - is this the most appropriate solution?
- ✚ The difference is apportioned in proportion to consumption – and are we talking about price here? – or is this the most correct solution?
- ✚ The difference is distributed equally to all apartments.

It can be emphasized that the most correct and transparent solution to divide the water losses is one according to the number of people living in the apartment because all the inhabitants living in the apartment consume water and in this case, a compromise solution is found.

But if we were to compare this city heating system with a gas plant, the heating system with its gas plant will certainly be chosen, because each owner will be responsible for his consumption, and the losses will no longer exist.

We are currently seeing a desirable situation in terms of the city heating system, as many owners are filing the disconnection file to choose their heating solutions, no longer depending on other suppliers.

Most of the time we think about which system is more suitable and which system brings us comfort in our own homes without any discomfort.

A gas plant has the advantage that - gas - is one of the cheapest conventional fuels, while an electric plant consumes a lot of electricity, but the district heating system offers low costs. The question arises: What is the best heating system?

Out of the 19 apartments, in 2021, we found 8 apartments with central city heating. The costs exceeded the amount of 500 lei per month in the cold period with a consumption of over 230 kWh, to which were added the losses of hot water, while the other 11 apartments (9 with a gas plant and 2 with an electric thermal plant) had an own heating system.

In the case of the family house, a comparison is presented between 5 heating systems, for the first 3 months of 2022 and 2023:

- ✚ Centralized urban system - the family house is located in the center of the city where we find an urban heating network;
- ✚ Gas plant;
- ✚ The power plant on pellets;
- ✚ Electric thermal power plant;
- ✚ Heat pump.

Heating systems have a significant impact on people's thermal comfort, health, and energy bills. Choosing the right heating system can be an important and difficult decision for home and apartment owners. Energy-efficient and environmentally friendly heating systems can reduce greenhouse gas emissions and heating costs but can be more expensive to purchase and install. At the same time, older or energy-inefficient heating systems can produce high pollutant emissions, thus increasing health risks and contributing to climate change.

In conclusion, home and apartment owners need to choose the right heating system, taking into account factors such as energy efficiency, environmental impact, installation, and operating costs, as well as their personal preferences.

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