A heating System for small premises

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THESIS

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Abstract

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Abstract

There are a lot of different types of heating systems. They can be different from each other with type of tubes, boiler, the way of connection etc. The main aim of this thesis is to find out what is the most suitable heating system for a premise with total area of 158 m^2.

This work consists of the theoretical background and practical part. Most part of information for theoretical part is taken from books and websites. The practical part of the thesis was contributed by working experience of the writer.

Having considered the information about the types of boilers and tubes a conclusion that wall combined was made boiler is perfect for these premises. This system has a lot of advantages. Some of them are: low price, easy to install and maintain, suitable price.

Keywords
Heating system, Insulation, Types of boilers, Types of tubes.

CONTENTS

List of used symbols and terms

A = area

HV = heat value

Bp = power of heating system

L = heat loses

1 INTRODUCTION

Nowadays it is necessary to warm premises in the north climate. Air temperature should be maintained in the same level during cold winters. Moreover it helps to keep building and equipment save by adjusting air humidity.

The main requirements for heating systems are: steady air heating in the premises, possibility for heat control and combination of heating and ventilation of the room, lack of indoor air pollution, harmful emissions and odors, fire and explosive safety, operations and maintenance convenience.

The relevance of the current topic can be concluded when searching for the most effective solution for heating a premise, which has area of 158m^2. The price of the equipment delivery, installation and operation are also taken into account.

The objectives of the study are:

- to make an analysis of existing heating systems
- to make a comparison of these systems
- to calculate necessary heat for the premises heating
- based on the received data to make a combination of heating systems for the premises
- to have a contact with companies providing chosen heating system
- to implement the obtained results in the real project

2 THEORETICAL BACKGROUND

In this chapter the theoretical part of the thesis is presented.

2.1 Main information about heating

Heating in premises can be local or central. Local heating is arranged in one or more related areas of less than 500 m^2. In such systems usually heating generators and heat-transfer surface are structurally combined in one device.

Fuel used for heating systems:

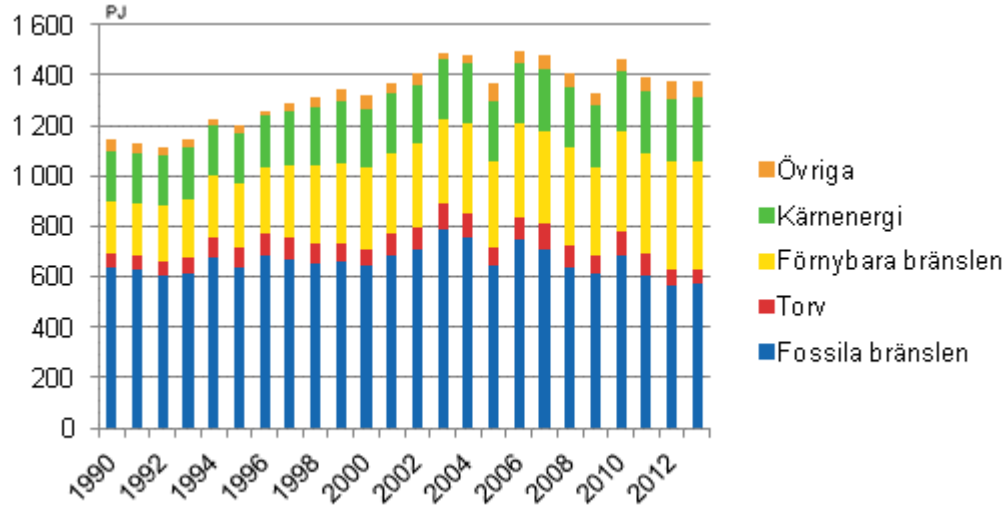

Figure 1. Use of fuels in electricity and heat production 1990–2013.[1]

[1] stat.fi/til/ehk/2013/ehk_2013_2014-12-10_tie_001_sv.html

According to this diagram the most popular type of fuel in Finland is black liquor fuel. Other fuels are:

Solid fuel (wood, coal, compressed sawdust). This type of fuel is more suitable for private houses. Advantages: cheapness of fuel and equipment, easy maintenance of system. Solid fuel, especially sawdust gives a lot of heat, as dust is the most environmentally friendly solid fuel. Disadvantages: plenty of storage space, burns too quickly, difficult to control temperature, require regular cleaning of equipment.

Electricity. Its principle of operation is simple - the electrical energy is converted into heat, which heats the heat carrier. Advantages: the system itself is cheap and easy to install, easy to control temperature, very reliable, silent and doesn't need a lot of space. Disadvantages: expensive, complete dependence of electricity.

Oil. Oil heating is quite popular because many people do not have access to the gas. Advantages: it gives a lot of heat, requiring little fuel; oil boilers consume a little electricity, cleanliness in use, doesn't need a lot of space for storaging. Disadvantages: price for oil is quite high in many places, obligatory presence of special room with fire regulations, diesel system needs constant supervision (maintain fuel level, filter cleaning).

Gas. Gas system is the most profitable and the most environmentally friendly. Advantages: keeps needed temperature in the room, retains heat for a long time; clean for using, can increase the heat immediately. Disadvantages: most unsafe type heating- gas explosive, expensive equipment can be installed only by experts. [2]

Hot water mains.

[2] A Treatise On Architecture And Building Construction. P. 134.

There are two types of heating, direct and indirect heating. The point of direct system is stoves or radiators inside of the room. In indirect heating, heat sources are outside the premises. For the better result a combination of this system can be used, it is named as the direct-indirect method. One example of the direct-indirect system is placing ventilation in the room with the heater. Ventilation is not the only system of combining direct and indirect methods. A heater or stuck can return warmed air through hot air flues and registers. (2)

Heating System classification:

Types of heating agents.

Steam

The idea of this method is heating premises with a steam radiator which can be a one-pipe system (condensate water comes back in the same pipe with steam) or a double-pipe system (first condensate flows into the condensate tank through the second pipe and from there it pumps to the boiler).

Water heating

The most popular way of water heating is using a boiler. One way of saving water in hot condition is using a storage water heater. It is a cylindrical vessel where water can stay hot for a long time. To keep water in hot condition these energy sources can be used: electricity, natural gas, propane, oil, solar etc. Another way is tankless water heating.[3]

[3] A Treatise On Architecture And Building Construction. P. 136.

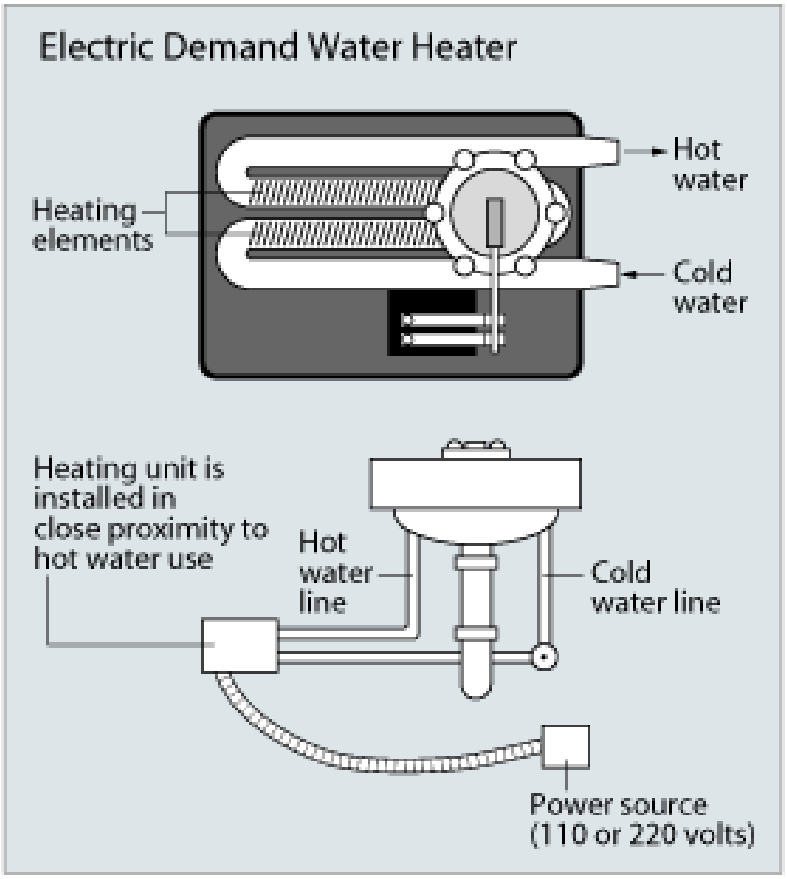

Figure 2. Principle of working Electric Demand water heater.[4]

Inside this tankless-heater, water is heated with burned gas or with electric element. This type of heater can provide only 7.6-15.2 liters per minute.

Air

Air heating systems (usually local) should be used for large room where air circulating is allowed. Preheated air at a high velocity (20 m/s) spreads to the room space.

Underfloor heating

[4] http://www.eia.gov/consumption/residential/

This system allows heat to rise in a room. For heating, there can be used pipes with hot air, tubes or heating cables under the floor. Experiences in operating room equipped with underfloor heating shows that in such premises where there is overheating, besides thermal discomfort for people, it results to heat loss. This type of heating is better used as combination with some other heating methods.

2.2 Types and principle of heating systems

There are four principles of heating system sources, which are going to be described in this chapter.

2.2.1 Ground source heating

Geothermal heating systems were begun to be used more than thirty years ago, in the time of the first “oil crisis”. Currently it is quite common in the US, Canada and Western Europe.

Principle of working geothermal heating system

Geothermal heating system comprises a heat pump and heat lines. Heat lines are laid under the ground (in the ground or wells) or at the bottom of pounds. The principle of its operation is similar to refrigerator. A pump, located in the house “takes” earth energy and converts it into heat. To do this, special liquid flowing on heat lines picks up heat from the ground (water) and then enters the evaporator heat exchanger where the heat is removed. This heat is used for heating the water

in the heat system. Then special liquid is cooled down and to repeat the cycle it should be reheated to 5 - 7 degrees. That is why the heat of the ground or water is needed. Even in the coldest winter the underground temperature does not fell below 4 degrees, and at the depth of 30 meters it is +8 -(+10) degrees. It is worth mentioning that in the summer the heat pump works in reverse: the warmth from the house goes the the ground and the coolness from there comes back. That is why the work of the geothermal pump is often compared with reversely type of condition.

Types of geothermal heating systems

Geothermal heating system pipes can be laid under the ground, the bottom of the pond or outside the well. Following from this there are three types of geothermal heating systems: horizontal, vertical or water.

In a horizontal Geothermal heating system the line laid is in the ground below the point where the soil freezes (it depends on the climatic characteristic of the region). This requires a sufficiently large area. For heating space of 200 m^2 it is needed land size is 500 m^2.

Figure 3. Horizontal type of geothermal heating system. [5]

In the surface water geothermal heating system, heatways lay along the bottom of the pond. It is considered to be the most economically profitable way of laying geothermal heating, because of less initial investment and greater efficiency. However, lakes and rivers deeper than two meters are not situated everywhere.

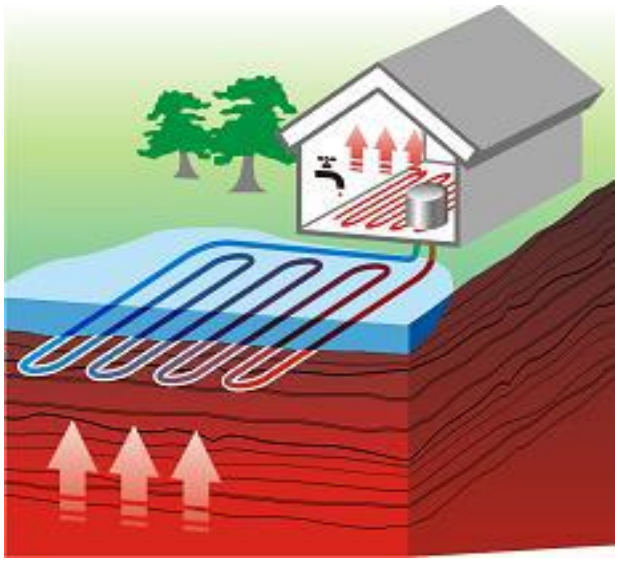

Figure 4. Surface water type of geothermal heating system. [6]

[5] http://www.energysolve.ie/

In the vertical type of geothermal heating system, on the other hand, is very expensive. It includes drilling, which requires special equipment and is not cheap. The depth of the hole needed to be drilled should be not less than 30 meters (depending on terrial). For example in Finland the most popular depth drill is 150 meters. However this type does not need a lot of space, which means that geothermal heating can be used also in the houses that are already built and for building in small plots.

Figure 5. Vertical type of geothermal heating system.[7]

Advantages and disadvantages of geothermal heating system

Geothermal energy is environmentally friendly. It is absolutely safe for humans. It does not emit harmful substances, nor unpleasant odors. There is no risk of fire, because no fuel is burning. In addition heat pumps are almost silent and almost do not require any maintenance. But most importantly, geothermal energy is free. The

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[6] http://www.energysolve.ie/

[7] http://www.energysolve.ie/

average cost of geothermal heating system (with all installation and activities) is around 10 000 euro. Experts says that investment pays off in about 5 years. There is no need to pay for central heating. The owner has only electricity costs for heat pump operation. This type of costs is the main disadvantage of this heating system.

Calculation for electricity costs

In this calculations, average values and “ideal condition” without heat losses will be used. For example, for heating space with the area of ten square meters it is needed 30 W heating power. Then, to warm the house with the area of 100 m^2 it is required to have 3 kW heating power. From one kilowatt of electricity consumed by the heat pump, it is possible to get 5 kilowatts of heat. Therefore to produce 3 kW of heat, it is needed 0.6 kW of electricity per hour. The energy needed per day is 14.1 kWh. In one month it is 432 kWh. If one kilowatt of electricity costs around 12 snt/kWh (Savon Voima 2014), geothermal heating will cost 51.8 euro in one month. It means that heat of the ground is cheaper energy source than any traditional source of energy.

2.2.2 Solar electricity system

Modern solar electricity system consists of chains of photocells - semiconductor devices that convert solar energy directly into electric current. The process of converting solar energy into electric current is called the photoelectric effect. Semiconductor is a material in which atoms have extra electrons (n-type), if they are not enough (p-type). Accordingly the semiconductor solar cell is composed of two layers with different conductivity. N-layer is used as cathode and p-layer as anid. Excess electrons from the n-layer can leave their atoms at the same time

when p-layer captures this electrons. Straight sunlight knocks out electrons from the atoms of n-layer and then moves to the p-layer to occupy the empty places. In this way electrons move through the circle from p-layer passing through the load (in this case accumulator) and returning to the n-layer.

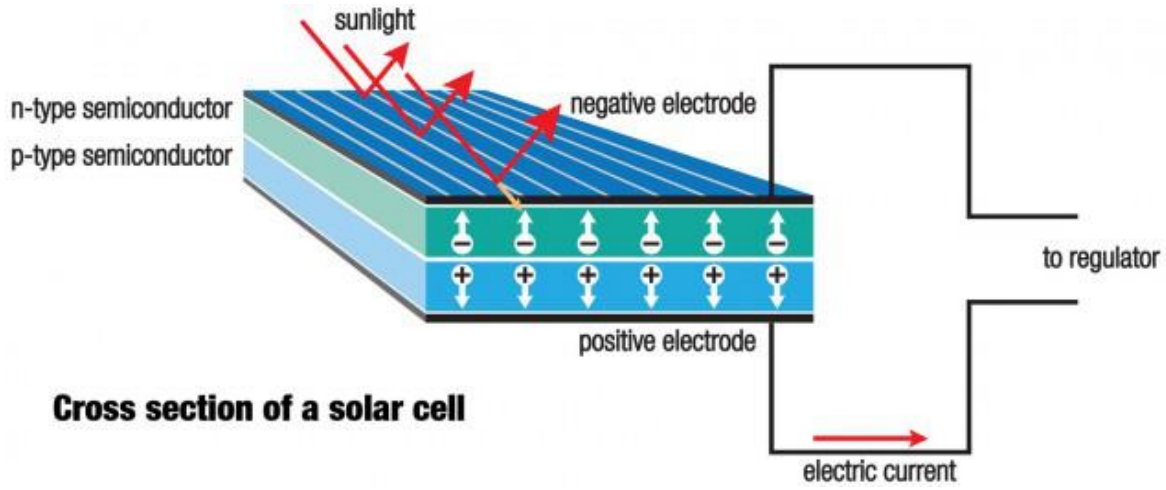

Figure 6. Scheme of photoelement.[8]

Home solar power plant should include solar panels, batteries (to provide storage for an excessive generated electricity), the controller (to control all elements of system) and the inverter (to convert low voltage DC generated by the solar panel or stored in batteries to AC voltage 220V). The solar panel is usually mounted on the roof. It must be constantly illuminated by the sun (not de in shadow). All other elements are installed anywhere in the house or out of the building. At the same time low-voltage consumers are connected directly to the controller and high-voltage to the inventor. The most important technical parameter of the solar cell, which has a major impact on the efficiency of the entire system is the net power. It is determined by the voltage and output current. These parameters depends on the intensivity of falling sunlight to the battery.

[8] http://www.posharp.com/

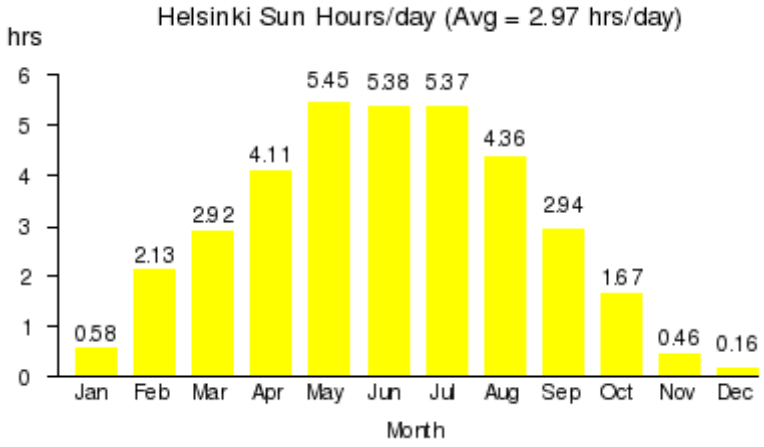

Figure 7. Sun hours in Helsinki.[9]

This diagram shows sun hours in Helsinki. Most profitable months for solar panels are May, June, July and August.

2.2.3 Boiler Heating system

There are a lot of different kind of heating boilers. The main difference between boiler systems is source of energy:

- electricity;
- gas;
- combined (gas and electricity).

These boilers can be both floor or pendant. A pendant boiler can be both vertical and horizontal. (3)

[9]http://ilmasto-opas.fi/en/datat/mennyt-ja-tuleva-ilmasto#DoubleMapTimelinePlace:vertailu

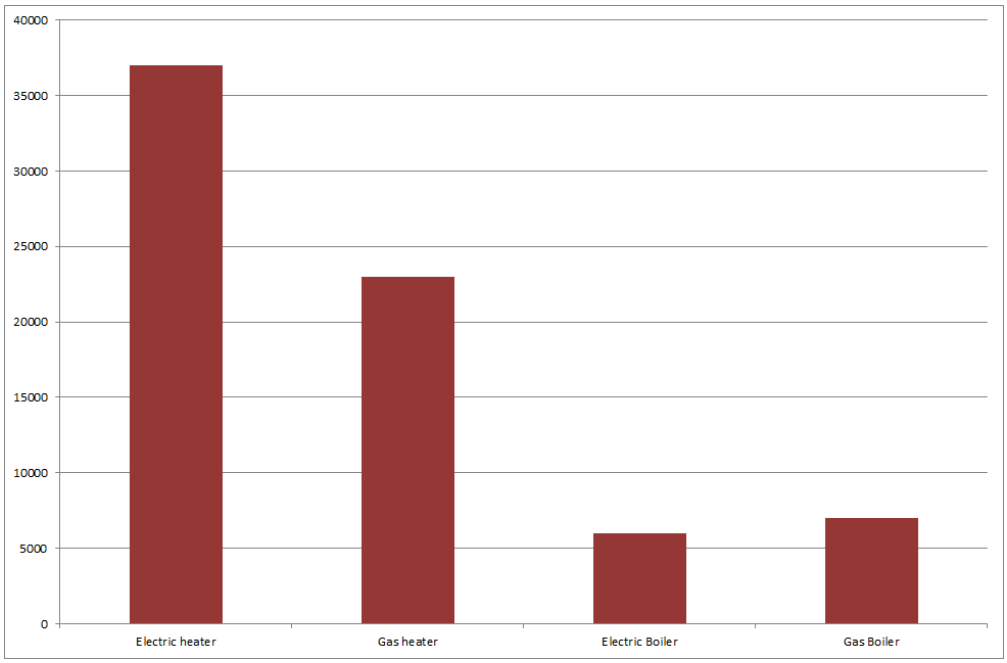

Figure 8. Using of heaters 2013.[10]

Figure 8 shows that about 37000 houses use electrical heaters. Compared to them, only 5500 houses use electric boilers.

All kinds of heating boilers inside the furnace room, except for the electric boiler, cause environmental pollution one way or another.

Conventional boiler

Conventional boilers are also known as regular boilers or open vent boilers. This type of boiler has two water tanks in the heating system. One is for storaging cold water and another is a feed and expansion tank. The point of the feed tank in this system is maintain the correct level of water in the whole system. The size of this

[10] http://www.eia.gov/consumption/residential/

tank is smaller compared to the size of the tank with cold water. Conventional boilers are suitable for homes which need hot water in several places at the same time.

Electric boilers

The main idea of using an electric boiler is to simplify its structure, and thereby reducing the cost of purchasing components, connection and operation. The size of electric boilers is from 5 to 120 liters. There are two types of electric boilers: cumulative and flowing. Electric boiler has no tank. It starts working only if the tap is opened. Flowing boilers are not used for room heating but cumulative boiler has a special tank where the water is heated gradually with electricity. The principle of operation storage water heaters is this: The operating mode is set and the water is heated. When the water cools down or is consumed, the sensor is activated and the water starts to heat up. Typically, the power storage heater is no more than two kilowatts.

Combination Boilers

More popular name for combination boiler is Combi boilers. This type of boilers differs from others by the lack of water tank or hot water cylinder, and also the size is smaller than the others have. Combi boilers make water hot very fast but not in very big volume. That is the reason why it is used for small houses, which need constant hot water. There are different kinds of combi boilers but they work in the same way. Water is taken directly from the mains and heated. The disadvantage of these boilers is that pressure is not so high as in the mains. The advantages of

these systems are connected with the lack of the tank: it saves a lot of space in property and also there is no heat loss in comparison to other boilers.

Condensing boilers

These types of water heaters are fuelled with gas or oil. The principle of working for condensing boilers is that natural gases or oil is heated inside the boiler. During the process of burning natural gases, water vapours and carbon dioxide is produced. These gases are thrown to the atmosphere through a flue, while this process is going on, some warmth of these gases is transferred to cold water making it hotter.[11]

The efficiency of these boilers is around 70-80%. [1]

[11] How Your House Works: A Visual Guide to Understanding & Maintaining Your Home. P. 3

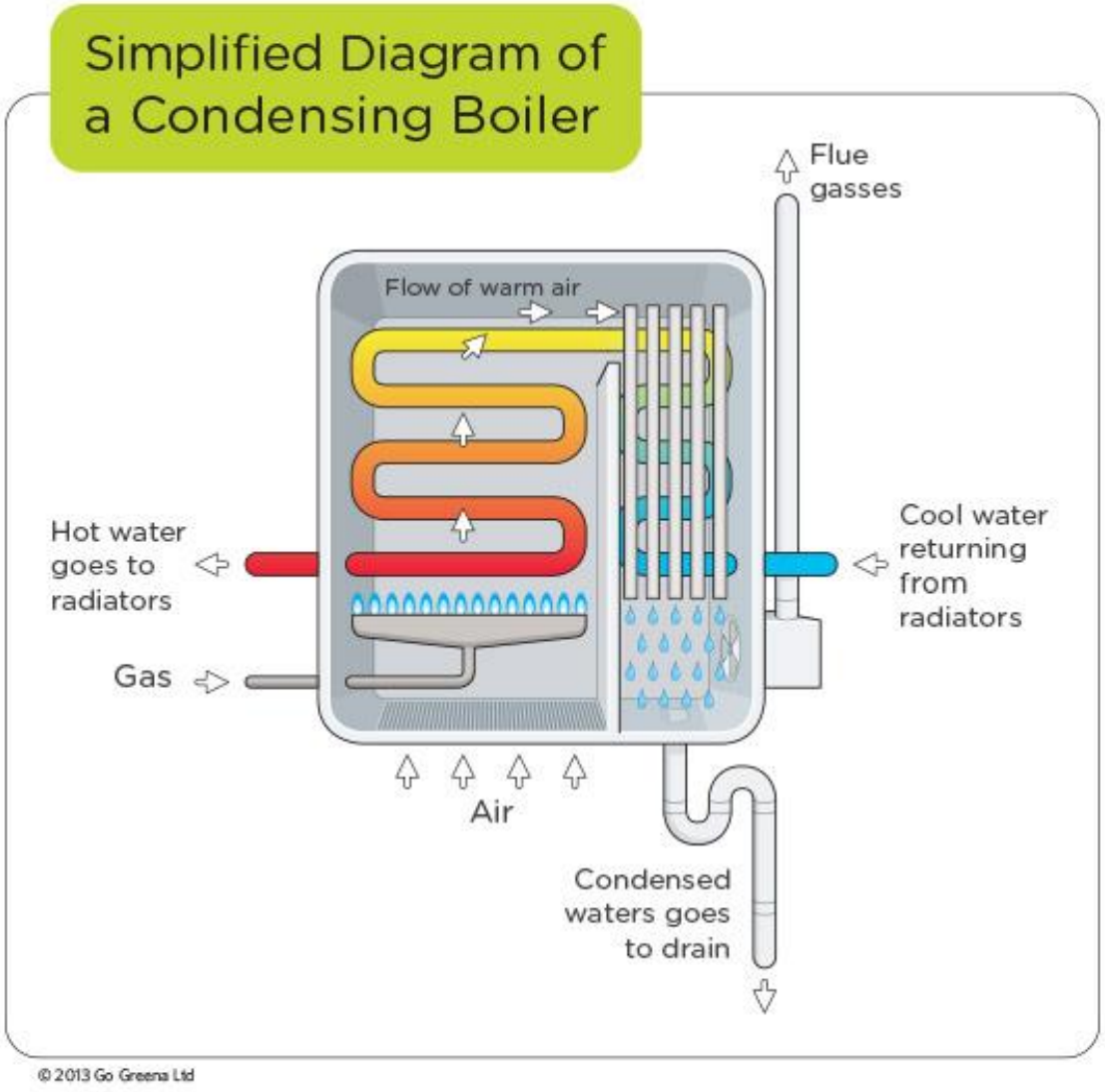

Figure 9. The process of condensing boiler operation.[12]

2.2.4 Electric Heating

Electric heaters can be divided in fixed and non-fixed heaters. Main type of non-fixed electric heaters are:

- radiators filled with oil

[12] http://www.gogreenexpo.co.nz/about/2015-auck-photos/

- convector heaters
- fan heaters
- halogen heaters

Oil radiators

Oil radiators are heaters made for space heating and having a mineral oil as a heat transfer fluid. The temperature of the outer surface of the radiator through which they transfer heat, should not exceed 100-110 °C. The average temperature is usually 85-95 °C. Heating time is about 25-35 minutes. Oil-filled radiators can have different power, designs, sizes, options and accessories.

Convector heater

The principle of working for convector heaters is that the heat from the heating element is transferred by convection in a heated room. Natural convection, where warm air is already heated by contact with the heating element rises to the top, and its place is taken by colder air space, enhanced design of the convector. Dividing heaters on the type of installation: There are convectors that can be installed to the wall, and heaters that can be placed on the floor with special brackets.

Fan heaters

Fan heaters operates as follows: The flow of cold air is created by a fan which is supplied to the heating element, and the temperature rises in the room and these comes pre-heated air stream. Stationary model heaters are usually equipped with a special rotary device (another fan) that allows to distribute more efficiently the heated air around the room. The main advantage of a fan heater is possibility to quickly warm the air in the room and the creation of comfortable conditions in some areas of the room. When the heating element is turned off, many models are able to perform the function of a usual fan.

Halogen heaters

Halogen heater give off heat to the environment by the infrared radiation. Radiant energy is absorbed by the surrounding surfaces, in developing thermal energy heats them, which in turn transfers the heat to the air. This gives a substantial economic effect compared with convection heating, where the heat is spent on heating of the area that is not used. In addition, by means of infrared heaters it is possible to locate heating only in those areas of the room in which it is needed without heating the entire volume of space; the thermal effect of infrared heater is felt immediately after turned on which avoids preheating space. These factors reduce the costs of energy.

So, heaters can be:

- electric
- gas
- diesel

Their method of installation can be:

- mobile (Portable)
- stationary - floor, wall, ceiling, suspended.
- fixed electric heaters

2.3 Preparation for installation of heating system

Before installing the heat system, a premises should be well prepared. Taking in to account the nordic climate, the main preparation is warming the premises. Construction can be maintained both inside and outside. Each method has its advantages and disadvantages. The main problem of the internal insulation of walls is the fact that the wall itself is not getting warmer, and even begins to freeze over. This leads to the fact that the dew point, which is the place where the moisture from the warm indoor air starts to condense, transfers closer to the inner edge of the wall or on its surface. This condensation will inevitably lead to destruction and moisture of the wall of the finishing layer, the deterioration of thermal insulation and heat insulation properties of the material. As a result, the heat loss will be high again and further high humidity. Brick walls will have most damage from moisture. Based on this finding it is better insulate the building from the outside than the inside if it is possible.

Insulating construction from outside

A thick layer of insulation reduces the need for power boilers and radiators heating system, so one can save a little on the initial investment in the heating system.

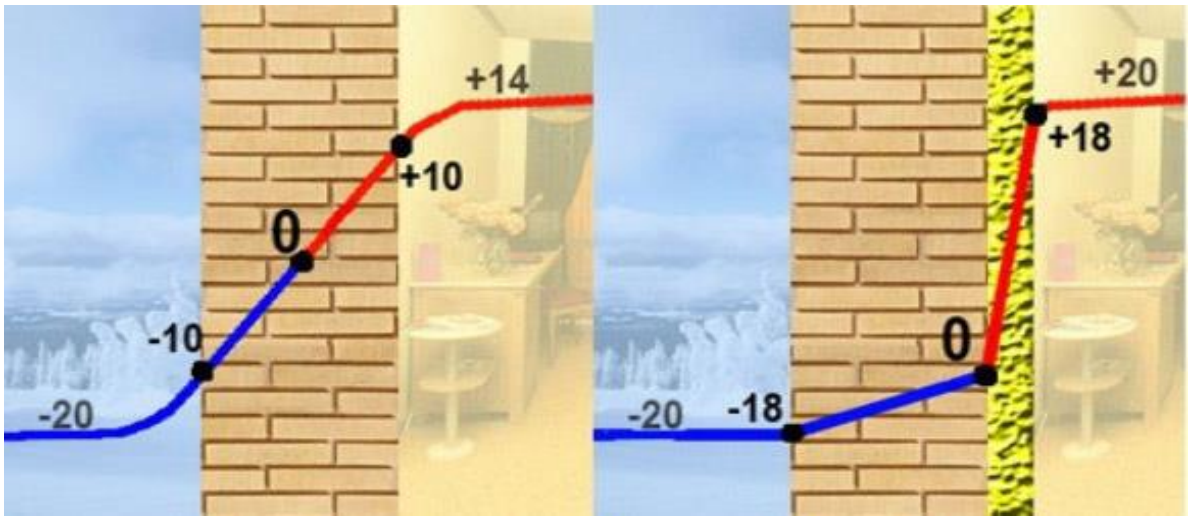

Figure 9. Comparison of insulated and not insulated wall.[13]

Heating room

The heating room is the place where the heating equipment is situated.

Requirements for the heating room if it is placed in a separate room located on any floor of a residential building, with a total capacity of up to 150 W are:

- height of the room should be not less than 2.5 meters.
- volume and area of the room depends on service condition and additional equipment, but should not be less than 15 m^3.
- the room should be separated from other rooms enclosing walls with a fire-resistance rating of 0.75 hours.
- day lighting from the calculation of 0.03 m^2 per 1 m^3 of space.
- the room must be provided at the rate of ventilation: it should be ventilated three times more than normal room in one hour.

[13] "Cyclopedia Of Architecture, Carpentry And Building; A General Reference Work - Vol I"

- if heating room is in the separate building it should be placed in a solid part of the wall of the building. The horizontal distance from the window or door is not less than 4 meters for residential buildings and 2 m for industrial buildings. The heating room wall should not be connected with the residential building.

2.4 Installation of heating system

In this chapter the installation of heating systems is going to be described, as well as certain pipe tube needs to be chosen for the chosen heating system.

2.4.1 Steel pipes

Steel pipes are installed in most urban apartments, and in many country houses where is water heating. The material for the production of steel pipes is a high-quality carbon steel.

Figure 10. Steel pipes.[14]

Table 1. *Advantages and disadvantages of steel pipes.*

Advantages:	Disadvantages:
Durability	Susceptibility to corrosion, which can be a reason of leakage and put tubes out of action
Resistance to high pressure, hydroblow, pressure surges in the system	Inner surface quickly block different sedimentation, reducing the capacity of the pipes
Steel has a low temperature coefficient of linear expansion, which makes it possible to use steel pipes in hot water and heating	High cost of installation works: for welding it is needed appropriate skills

[14] http://heatonplumbing.com/tank-type-water-heater/

Relatively low cost	

2.4.2 Plastic Pipes (PPR pipes)

Polypropylene pipes are good for the drinking water supply. Reinforced plastic pipes have proven themselves in heating systems, where it is necessary to transport the hot water or steam. PPR pipes are suitable for almost any kind of pipelines. Their only limitation is the coolant temperature (from 65 to 95 degrees). On average, polypropylene pipes have a working temperature up to 75 degrees at a pressure of 7.5 atm. In this case, the guaranteed service life is 25 years. The maximum temperature that can be used in this kind of pipes is 95 degrees. However, with such "extreme" mode of operation pipe lifetime is reduced.

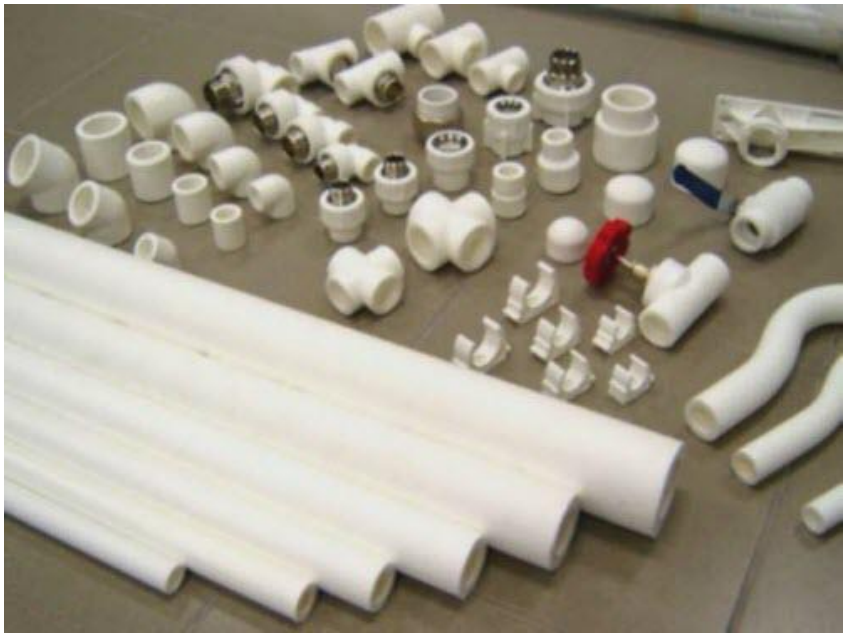

Figure 11. PPR pipes.[15]

[15] http://heatonplumbing.com/tank-type-water-heater/

Table 2. *Advantages and disadvantages of PPR pipes.*

Advantages:	Disadvantages:
long lifetime of pipelines (up to fifty years)	quality of installation depends on the material
PPR pipes do not corrode, it can make the inner diameter smaller because of sedimentation blocking.	sensitive to high temperatures. These pipes are not suitable for fire risk room
high chemical resistance: does not rust, and therefore do not change the taste, color, water content	with the purchase of polypropylene pipes it is needed to consider their products, as the shortcomings of such pipes may be associated with impaired their production technology
low noise level (as compared with metal) fluid flow monolithic pipe connection, with this connection, PPR pipes can be hidden in walls, plaster, or floor	
for welding of polypropylene pipes welding machine is used, it is work which can be studied by any person for a couple of minutes, and welding takes only few seconds	

PPR pipes are two times cheaper than metal pipes, especially the connections (fittings)	
high mechanical strength	
by freezing water in the pipe, almost certainly it is not necessary to worry about the integrity of the pipe - polypropylene expand and after thawing will take its original shape	
environmentally friendly	

2.4.3 Metal-plastic pipes

Metal plastic pipes are reliable, because of five-layer structure (polyethylene, glue and aluminum foil). In the line of plastic pipes very great importance is the connection technology of pipes with fittings.

Figure 12. Metal plastic pipes.[16]

Table 3. *Advantages and disadvantages of metal plastic pipes.*

Advantages:	Disadvantages:
Long life period (at least fifty years)	Intolerant to ultraviolet radiation (direct sunlight)
The oxygen doesn't go inside, whereby the metal parts of the system are not subject to corrosion	Intolerant to mechanical loads and thermal effects (open fire)
Length of tubes. Large coiled tubing (50-500 m) that enables the pipe to be laid without the use of large areas compounds for which eliminates the possibility of leakage;	Installation of fittings require caution: can stress the pipe which can cause tube damages.

[16] http://heatonplumbing.com/tank-type-water-heater/

Metal pipes is convenient to use in rooms with complex geometry, The reason is the pipe is plastic, it is easy to bend, change a shape.	
When the tube is heated it has small linear stretch	

2.4.4 Corrugated stainless steel pipe

A corrugated stainless steel pipe is suitable for the installation of all types of pipelines for transporting liquid. These tubes are easy to bend - it is very convenient for installation of water heating in confined spaces.

Figure 13. Corrugated stainless steel pipe.[17]

[17] http://heatonplumbing.com/tank-type-water-heater/

Table 4. *Advantages and disadvantages of corrugated stainless steel pipe.*

Advantages:	Disadvantages:
intolerant to hydroblows as well as external mechanical forces;	high price
bends easily without any tools, without reducing the inner diameter	
intolerant to defrost	
the drinking water supply does not require special cleaning	
high heat transfer, making corrugated stainless steel pipe is very advantageous for the manufacture of floor heating and warm walls	
possibility of using tubes as radiators, doing without actually installing radiators	
intolerant to rodents, moldand mildew	
because of tube flexibility, installation of complex paths with a minimal number of connecting nodes	

2.4.5 Copper pipes

The main requirement is to apply uniform origin materials such as copper and its alloys. But if the mixing materials can not be avoided, it is necessary to observe the following rules:

- forbid joint copper with non-alloy steel. In this case, there will be a rate of corrosion of steel.
- steel pipes can only be installed before copper tubes, if we consider how to install pipes in the direction of water movement;
- If copper pipes are laid inside the wall, they need to be wrapped by the entire length of polyethylene coating to prevent thermal movement. Copper pipes and fittings are durable. Their life is comparable with the operation life of the building.

Figure 14. Copper pipes.[18]

Table 5. *Advantages and disadvantages of copper pipes.*

[18] http://heatonplumbing.com/tank-type-water-heater/

Advantages:	Disadvantages:
Thinner wall pipes significantly reduce the internal diameter without reducing the strength characteristics and qualities of the pipeline crossing.	reaction of copper with other metals (aluminium, zink steel) leads to electro-chemical corrosion formation which leads to destruction of steel and zink.
The inner walls of the pipe are not exposed to overgrowing	
Pipes are highly flexible, which makes it possible to use them in underfloor heating systems.	
Durability	

2.4.6 PEX-pipes (XLPE)

PEX-pipes are wildly used in underfloor heating and also in water pipes and sewerage systems.

Figure 15. PEX-pipes. [19]

Table 6. *Advantages and disadvantages of PEX-pipes.*

Advantages	Disadvantages
Chemical and electrical inertia, resistance to aggressive environments	High coefficient of linear thermal expansion (0.15-0.20 mm / m × ° C)
Low surface roughness of the inner part of the tube	Sensitivity to sunlight
Small weight of the tubes, the possibility of acquisition of long bays.	Inability to retain the shape of the bend, imparted during installation
Ease of manufacturability and assembly	
Hygiene (pipe material does not emit harmful substances into the water flow of the operating temperature range)	

[19] http://heatonplumbing.com/tank-type-water-heater/

3 HEATING SYSTEM APPLICATION

This chapter is devoted to implementing theory into practice.

3.1 Heating system plan of the building

The building for which this project is done consists of two floors.

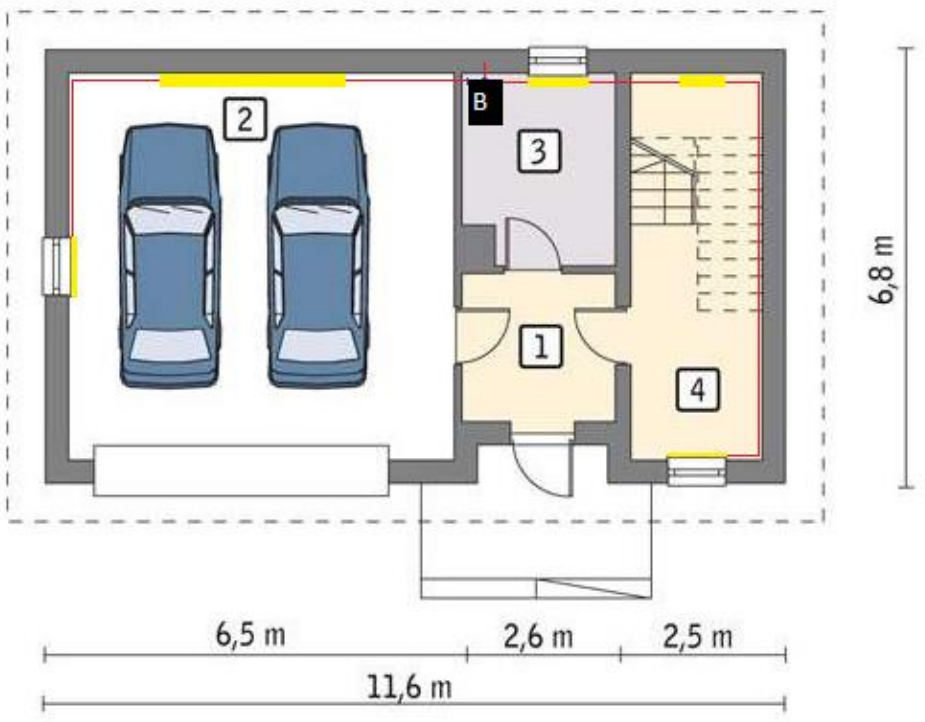

Figure 16. The plan for the first floor with pipeline, radiators and boiler.

The first floor of the building is done for a car parking place (number 2 in the plan) and three small rooms (numbers 1,3 and 4). The height of the walls is 3 meters. In the parking area there is planned one big door (400cm x 280cm) and

one window (60cm x 100cm). One outside door will be in Room 1 and two windows of the same size (60cm x 100 cm) in Rooms 3 and 4. The total area of the first floor is 79 m^2.

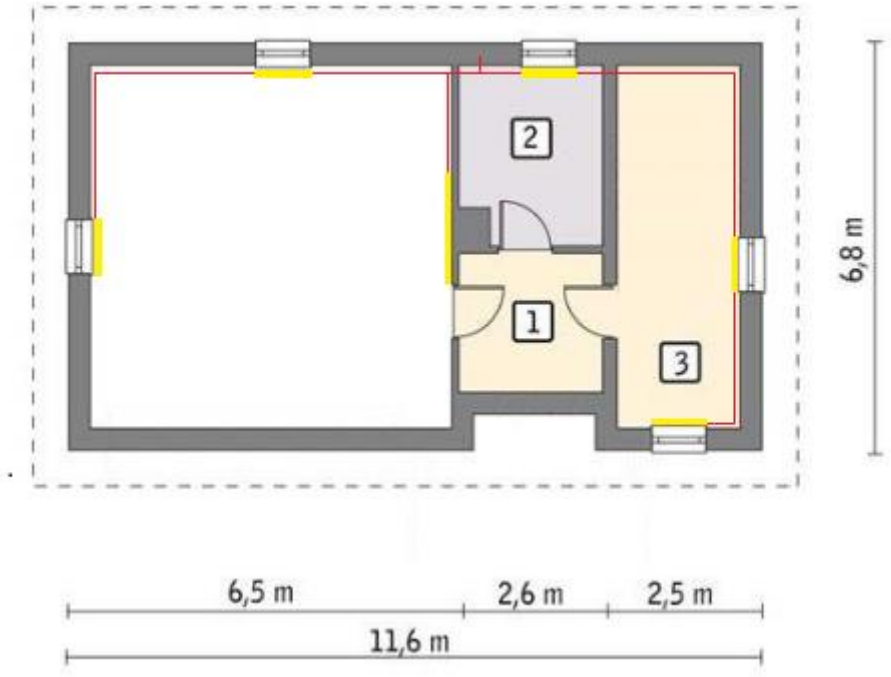

Figure 17. The plan for the second floor with pipelines and radiators.

In figures 17 and 18 is shown plans of the first and second floors. Figures include: pipelines (red line), radiators (yellow rectangle) and boiler (black rectangle with “B” letter). There are 11 radiators and 90.6 meters of pipelines altogether. Every radiator has it’s own switch. First and second floors can be heated independently with corresponding boiler settings that located on the first floor.

In the second floor there will be one big living room (area is 44 m^2) and three small rooms. The total area is the same like in the first floor (79 m^2). The height of walls in the second floor is 2.5 m.

3.2 Heaters Planning

In this thesis a two-pipe heating system is used as the base of the project. It is better to make two loops of heating pipes than one very long one around the perimeter of the house. The tube with hot water is marked with a red line, the tube which goes after heating is marked with blue. Black dots are on the tubes with hot water and in its return. This valves are: radiator valves, thermostatic switches, and so on. Stop valves are marked on the flow and return of each radiator. Shut-off valves should be placed in every radiator - in case the radiator for any reason stops working, and it should be disconnected from the system for repair or replacement without stopping the entire system. In addition to the stop valves, on each radiator valves there are the same on the pitch for each loop, right after the boiler.

As it can be seen on the chart, the length of the loop system is not the same, "wing" comes from the boiler down (see the diagram), in short order, which goes up. This means that the resistance of the shorter pipeline will be less. Therefore, the coolant can no longer go on a shorter "wings", while longer "wing" will be colder. Due to cranes in the supply pipe, one can adjust the uniform supply.

3.3 Choosing of the tube type

For this project PPR pipes were chosen.

Installation of PPR heating pipes is quite cheap and it does not require drilling additional holes in the walls, and the service life span of these pipes is much longer than for metal pipes. Very important advantage of this tube type is that it’s

made of polypropylene and can be used not only for the installation of heating and water supply, but also for the floor heating.

Principe of installation:

Pipe joints should be heated soldering around the diameter. The inner surface of the pipe coupling is heated. Thermal exposure is performed about thirty seconds. The time depends on the diameter of the pipe. Thereafter pipes are connected. The result of this welding is a strong connection.

3.4 Calculation of heating boiler power

Table 4. *Necessary data for the calculation of heating power*

1. Internal dimensions of each room.	Check Plan 1
2. The external dimensions of the building.	According to the project the size of the house 11.6 m length and 6.8 m width (in the drawing all dimensions in cm).
3. Dimensions of window and doors. Blue lines show windows, green shows door. The dimensions of window and door openings on the plan are also pointed out.	Check Plan 1
4. Each room should have own name	Check Plan 1

5. Location of the house in the cardinal point.	It is shown in the upper right corner of the drawing.
6. Construction area - an area or region where your home is located (climatic conditions in different areas can be very different).	Finland
7. The height of the outer wall.	3 m.
8. Composition of the exterior walls (if the wall is made of various materials, then all of them needed to be listed); floor material (transferred from the ground and to the premises); part of the ceiling (it is inside the building).	

The power of the boiler should be calculated the most accurately during calculating of the heating system of small premises. This indicator is very important to make comfortable temperature in the room. If the power is not enough, the house will be cold. With a large capacity of the boiler, it will spend the extra fuel that, of course, is wasteful. For an accurate calculation the optimal value of the power of the boiler should be taken into account.

Calculating formulas:

The calculation of the thermal load on the heating involves determining the thermal losses (L) and the boiler power (Bp). The boiler power is calculated by this formula:

$$Bp = 1.2 * L \quad (1)$$

Bp = thermal performance of the heating system (kW);

L = thermal loss at home (kW/ h);

1.2 = the safety factor (20%).

20% coefficient is a safety factor that takes into account a possible drop of pressure in the pipeline during the cold season and unexpected loss of heat (such as broken window, poor-quality thermal insulation of entrance doors or unprecedented cold). It allows to protect yourself from a number of troubles and allows wide regulations of temperature.

As it can be seen from this formula, the boiler capacity depends on the heat losses. Heat losses are spread in the home unevenly: on the exterior walls losses are about 40% of the total, at the windows 20%. 10% is taken by floor, the roof is 10%. The remaining 20% goes through doors and ventilation.

The materials of which the house is built have a direct impact on the amount of heat lost. Therefore, in the calculations it is necessary to analyse what constitutes the walls and floor and everything else.

In the calculations it is taken into account that each of these factors use next coefficient:

- K1 is window type
- K2 is wall insulation
- K3 is the ratio of floor area to windows
- K4 is minimal outside temperature
- K5 is quantity of outside walls
- K6 is quantity of floors

- K7 is high of the room

Main coefficients values are the following.

Window heat loss coefficients are:

- ordinary glazing - 1.27
- double-glass - 1
- three-chambered glazed - 0.85.

Depending on the wall material the coefficient of wall insulation are:

- concrete panels, blocks - 1.25-1.5
- logs, lumber - 1.25
- brick (brick 1.5) - 1.5
- brick (brick 2.5) - 1.1
- foam with high insulation - 1

If there is larger window area ratio to the floor, then heat losses becomes bigger.

Table 5. *Heating loss coefficient*

Ratio of the windows area to the floor	Coefficient
10%	0,8
11-19%	0,9
20%	1
21-29%	1,1
30%	1,2
31-39%	1,3

40%	1,4
50%	1,5

Outside temperature is a very important coefficient:

- More than -10C° – 0,7;
- -10C° – 0,8
- -15C° — 0,90
- -20C° — 1,00
- -25C° — 1,10
- -30C° — 1,20
- -35C° — 1,30

The ratio of the heat losses to outside walls:

- four walls - 1.33
- three walls - 1.22
- two walls - 1.2
- one wall – 1

The number of floors or type of premises, which is above the room's coefficient K6 is as follows: if the house has over two or more floors, than the value of 0.82 is taken for calculation, but if the upper store is warm then coefficient is 0.91 and 1 for the cold room.

The coefficient values for the high of walls

- 4,5 m – 1,2
- 4,0 m – 1,15

- 3,5 m – 1,1
- 3,0 m – 1,05
- 2,5 m – 1

In addition to these factors Area (A) and the specific heat value (HVs) are also calculated. Hvs coefficient is 100 W / m^2.

The final formula for the calculation of the coefficient of thermal losses:

$$L = A*HVs * K1 * K2 * K3 * K4 * K5 * K6 * K7 \quad (2)$$

Calculating the heating boiler power for the project premise.

To calculate total heating power it is easier to calculate power for the first and for the second floor separately.

First floor of the house, for which we will determine the load on the heating system has:

- double glazing (K1 = 1)
- foam concrete walls with high insulation (R2 = 1)
- window area is 23% of the floor area (K3 = 1.1)
- outside temperature is -25C (K4 = 1.1)
- four walls of the first floor are located outside (K5 = 1.33)
- house has two floors (K6 = 0.82)
- the height of walls are 3 meters (K7 = 1.05)
- total area is 52m^2.

L= 78.9*100*1*1*1.1*1.1*1.33*0.82*1.05

L=10932 Wt = 11 kW

Calculating of the power of heating system:

Bp (1) = 1.2 * 7.205 = 13.118 kW

Second floor calculations:

- double glazing (K1 = 1)
- foam concrete walls with high insulation (R2 = 1)
- window area is 30% of the floor area (K3 = 1.2)
- outside temperature is -25C (K4 = 1.1)
- four walls of the first floor are located outside (K5 = 1.33)
- there are no warm room above second floor(K6 = 1)
- the height of walls are 2.5 meters (K7 = 1)
- total area is 78.88m^2.

L= 78.9*100*1*1*1.2*1.1*1.33*1*1.

L=13852 Wt = 13 kW

Calculating of the power of heating system:

Bp (2) = 1.2 * 9.129 = 16.622 kW

The total power for this house should be not less than:

$$Bp(1) + Bp(2) = 13.118 + 16.622 = 29.740 \text{ kW} \quad (3)$$

3.5 Installation of the heating system

The best way of making a heating system in the project house is to use two loop system. The point of this system is that one loop of tubes goes to the first floor and another one goes to the second. The advantage of this system is that temperature on the floors can be easily controlled and it can be different.

Boiler room:

First step on the installation of the heating system is to make a boiler room. A boiler room can be inside of the house and also in special room outside the house. In this project it was decided to build it inside of the house in the second floor. Inside of this room a boiler will be installed and also other equipment for house heating. [3]

Connection types:

To connect pipes having small diameter (63 millimetres), two main technologies are used:

- fusion welding, in which one end of the pipe is part of the other. One end of the tube is wider than another. Tubes are connected one inside another.
- coupling welding, in which both ends are connected to each other with additional part consisting of the coupling.

For pipes connections with diameters greater than 63 millimetres a butt welding technology is used. When no coupling is required, the connection is extremely high.

Welding of plastic pipes on the socketed technology.

When connecting pipes up to 40 mm are used for the installation, manual welding machine can be used. For the installation of wider pipes, a stationary device is required that performs pre-centering. A heating element transmitting heat initiating polymer is a special sleeve, which melts the outer surface, creating conditions. With the help of border mutual diffusion, molecules of plastic parts can be joined. The purpose of this process is to heat both inner surface of the socket and outer surface.

Figure 18. Boiler room.[20]

[20] http://www.teplorai.ru/sec2.php?s_uid=185

Typically, the heating system consists of the following components:

- A different heating device, such as a boiler.
- Heat-transfer elements, radiators.
- A pipeline to circulate the water from the heater to the radiators and back again.
- An expansion tank for water, increasing in volume when heated, to avoid damages in the system

According to the writer's opinion, the best heating system type is PPR. It has high corrosion and chemical resistance which makes it even more popular on the market. Considerable environmental properties like (polypropylene does not react with the water and the elements contained therein) and economy (low system cost, delivery, and maintenance costs) are also a big advantage. This heating system is simple and quick to install: the material is light and convenient, does not require any hazard welding equipment, tools for installation are cheap and durable. A wide range of compounds and a range of diameters allows one to assemble the heating system of any complexity.

The heat source chosen for this project is electricity.

The main reasons why this heat source has been chosen for this project:

- low cost;
- the ability to install in any room without special permits and approvals;
- an opportunity to leave the boiler without constant supervision;
- small dimensions at high power;
- quiet operation;

- environmental friendliness.

Together with this pipe type, in writer’s opinion, it is better to use mixed boiler (combined boiler) which can use different sources of energy. Combining fuels may be, for example, solid and electricity, gas and solid fuels, etc.

One of the main advantages of this boiler - its reliable operation, in the absence of any of the fuels is possible to switch to another type of fuel resources. The main disadvantage of mixed boiler is the cost of maintenance.

4 CONCLUSION

In this thesis different types of heating systems were considered. As a result it can be said that there are a lot of different kind of heating systems. Nowadays there are still a lot of new ways to get comfortable temperature in the house.

While projecting new house it is very important to remember about hot water and heat in the house. A boiler, tubes, the way of connecting tubes, connectors and housewarming should be selected in the right way. Each of these components has own properties and different advantages and disadvantages. It is essential to take them into the consideration.

During the project the Gebwell company was contacted to. They could not provide a lot of information but gave some advice where the attention needs to be paid while making this project.

Having considered the information about the types of boilers and tubes it was made a conclusion, that for Finland, a wall combined boiler is perfect for such premises. This system has a lot of advantages, such as low price, easy to install and maintain as well as suitable price. In my opinion, the best choice for a heating system connection is using a two loops system.

During this thesis a big amount of research was made which led to the necessary calculations. Writer hopes that the information gathered during my thesis process can be used in future for building the project premises.

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