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COMPARATIVE ANALYSIS of HEATING SYSTEMS of SHOPPING CENTER

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DESCRIPTION

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Comparative Analysis of Heating Systems of Shopping Center

Abstract

In this thesis is examined a shopping center located in St. Petersburg. The main purpose of this thesis is to compare heating systems and decide which one is more suitable for a shopping center.

The work consists of theoretical and practical parts. The theoretical part shows the features of the shopping center, two heating systems, their classifications and design features. The practical part consists of thermal and financial calculations which are necessary for comparing the systems. All the calculations were made according to the Russian building norms and regulations.

As a result of the comparison the individual heating system with a roof gas boiler plant was defined as a more effective and economical solution for heating a shopping center.

Subject headings, (keywords)

Heating system, district heating, boiler plant, heat load, operating costs

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CONTENT

LIST OF SYMBOLS

α_{ext}	heat transfer coefficient of the outer surface of the enclosing structure with the conditions of the cold period, W / $m^2 \cdot °C$
α_{int}	heat transfer coefficient of the inner surfaces of the enclosing structure, W / $m^2 \cdot °C$
A	area of the enclosing structure, m^2
d	thickness of material layer, m
D_d	degree-day value, °C*day
k	coefficient of heat transfer, W / $m^2 \cdot °C$
M_{DH}	annual cost of heat for district heating system, euro/year
M_{RB}	annual cost of heat for individual heating system, euro/year
N	annual operating time of the heating system, hour
Q	heat loss through the building envelope, kW
Q_h	total heat load of shopping center, kWh
Q_{TOT}	total heat load of building during the heating period, kW/year
R	thermal resistance of the building component, $m^2 \cdot °C/W$
$R_1, R_2, ..., R_n$	thermal resistances of the individual layers enclosing structure, $m^2 \cdot °C/W$
$R_{a.l}$	thermal resistance of an air cavity in the building component, $m^2 \cdot °C/W$
R_o	thermal resistance of the building component with serial homogeneous layers, $m^2 \cdot °C/W$
R_{reg}	normed thermal resistance of a building component, $m^2 \cdot °C/W$
R_T	thermal resistance of the enclosing structure, $m^2 \cdot °C/W$
T_B	design indoor air temperature, °C
T_H	design outdoor air temperature, °C
Tht	the average value of outdoor air temperature, ° C
Tint	the average value of indoor air temperature of the building, ° C
t_{out}	design winter outdoor temperature, °C
$t_{out.average}$	average temperature during the heating period, °C
$V_{gas,year}$	annual volume of gas, required for heating, m^3
Z_{ht}	duration of heating period, days
β	additional heat losses
λ	design thermal conductivity of material layer, W / $m^2 \cdot °C$

1 INTRODUCTION

Living in countries where the main part of the year is cold, it is necessary to provide heating for buildings: residential buildings, offices and other premises. Heat provides comfortable accommodation, if it is an apartment or a house, and productive work, if it is an office or warehouse. Heat supply of buildings has become one of the most pressing issues in the recent years. First of all, this situation is interesting for the owners of social facilities, office buildings and industrial plants. One of the objects of the social sphere in need of heat supply is shopping centers.

In Russia there are more and more shopping centers - high-rise buildings with big amounts of premises for shops and offices. The correct calculations and the correct design of all the systems are important parts in a successful opening of a shopping center. The design and the calculation of the heating system plays an important role for the construction of a shopping center. However, for the correct design it is necessary to understand the characteristics of a heating system. The heating system is the heat supply of residential, public and industrial buildings to provide the municipal and the technological needs of consumers.

Naturally, the question arises what kind of the heating system should be applied for shopping center buildings. Indeed, there are a number of technical solutions to this problem. The choice must be based on the specific conditions in order to offer the best solution both in technique and the cost of equipment and labor. In this case, typically the customer always wants to get the best option at an affordable cost.

However one shouldn’t forget that the system must be reliable. Such thing as a reliability of heat supply is particularly important. Shopping centers are facilities that serve people. It means that the failure in the operation of heating systems will cause changes in the indoor climate and the appearance of discomfort for humans. Therefore it is necessary to make correct calculations and properly design the entire system in order to subsequently save energy, time and money.

2 GENERAL

2.1 Aims

A thesis has several aims. The first aim is the familiarization with the heating systems of shopping centers. The second goal is to select two types of heating systems. The next aim is to compare the selected systems and to make a comparative table of the results. The resulting table will show the advantages and disadvantages of each system. The final or the main aim is to select the most efficient and economical heating system for a shopping center.

2.2 Methods

The following methods will be used to achieve the aims. The first method is to review the literature. The main sources are magazine articles, and information provided by companies operating in field of heat supply. The information describing the operating principles of heating systems will also be used. This method will show the characteristics of heating systems in more detail and will help to choose the most beneficial options for heating systems.

Two types of heating systems will be chosen. One of the shopping centers under construction in St. Petersburg will be selected for consideration of these systems. The second method is the design and the calculation of the heating systems. In this part the heat demand of the building and the approximate annual cost of heat will be calculated. The method of designing will help to become more familiar with the structure of systems. The next method is the financial calculation. This method will show the economic efficiency of the heating systems and will serve as one of the main criteria for selecting the more effective system.

The last method but also an important is comparison of these types of heating system and analyzing results. Advantages and disadvantages of one system relative to another will be shown. Result of the comparison will play a major role in selecting the most efficient and economical heating system. The result also shows in which situations we can use a particular system.

2.3 Background

Heating commercial premises is necessary for maintaining a certain temperature inside the building and doesn't depend on the time of year. The premises shouldn't be too hot or too cold. The premises must to have a good indoor climate. It's rather difficult to select the heat source. We must consider several important factors: the size of the areas, the required heat capacity, heat demands, the natural conditions (extreme cold or southern winters) and so on.

The heating systems can be devided into district or distributed systems. Distributed heating system or individual heating system serves one or more buildings, while the district heating system or the centralized system serves residential or industrial areas. These classifications of heating systems are based on the heat source used. CHP plant and boiler plant are the main sources of heat for rooms with a large area.

There are many different types of fuels. The main fuels are wood, gas, oil, coal. Each fuel used has benefits; cost, efficiency. The four main mediams for conveying heat are: air, water, steam and electricity. Heating systems can be classified into four types: hydronic heating systems, warm-air heating system, electric heating systems and steam heating systems

Hydronic systems

Hydronic systems use water as the medium for delivering the heat to the various rooms and spaces within a structure. In a typical hot-water heating system, water is heated in a boiler or water heater, and circulated through pipes to baseboard convectors or radiators located in various rooms. /1, p.149./

Warm-air systems

Warm-air system is advantageous to be used in commercial and industrial buildings with a large area and high ceilings. The advantage of this type of heating is the fact that you can adjust the temperature of the air flow, and in the warmer months, use it as a conditioner. In the recent years the presence of air heat curtains can be often observed at the entrance to the stores and shopping centers. Air curtains are installed at

the entrance to a store, and make a powerful warm shield, thus preventing the penetration of cold air inside. /2./

Electric system

The most simple, safe and convenient system for the installation is a system of electric heating. Such a system is totally dependent on an external source of electricity. Therefore, electric heating is most commonly used for offices and buildings that don't need to maintain the room temperature all year round and 24 hours a day.

2.4 District heating system

District heating is a heating system of large residential areas, cities, towns and industrial plants. District heating (DH) is a widely used form of heating for commercial building in such as shopping centers.

2.4.1 District heating system structure

The DH system consists of the following main parts: heat source, heat networks, substations and customer connection. Figure 1 shows the main component of district heating system in Russia. The source of heat in district heating is a combined heat and power plant (CHP) or a boiler plant. The thermal capacity of modern CHP reaches 2300-4600 MW, the district boiler 110-580 MW /3, p.6/.

Hot water and vapour serve as the main heat transfer media in the systems of district heat supply. The temperature of DH water depends on the design parameters of the whole DH system and the parameters of the boiler plant. District heating networks are mainly made two-piped. The system network consists of two kinds of pipelines: a pipeline for supplying hot water from the heat source to the system of heat consumption and a return pipeline. According to the Russian standards, the temperature in DHW network should not be less than +60 ^{0}C /4. p.13/. The selection of the temperature and pressure in heating systems is determined by the requirements of consumers and economic considerations.

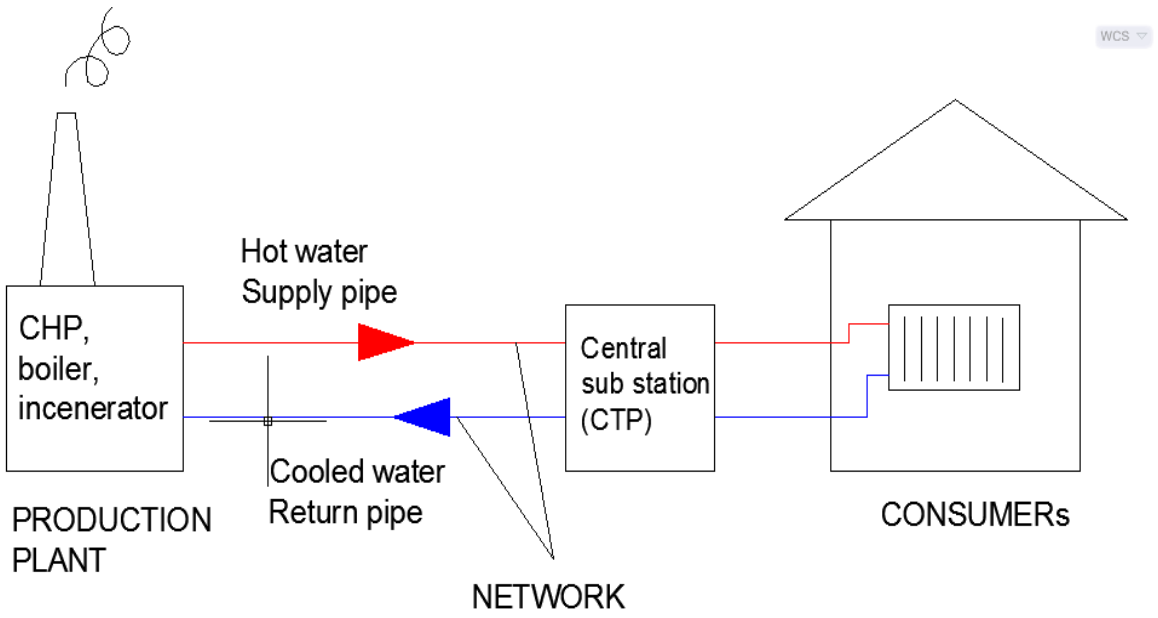

FIGURE 1. Main components of District Heating System in Russia

2.4.2 Direct and indirect scheme of district heating connection

There are two schemes of district heating network connection to buildings: direct and indirect. In the direct systems, hot water from the heat network goes directly to heat emitters of consumers. This type of connection is illustrated in Figure 2.

Direct system

Direct DH system has several advantages. There are neither heat exchangers, heat points nor hydraulic isolation. It's simple to operate a direct system and it doesn't require any additional equipment, such as circulation pumps, automatic regulation and control devices, heat exchangers, etc.

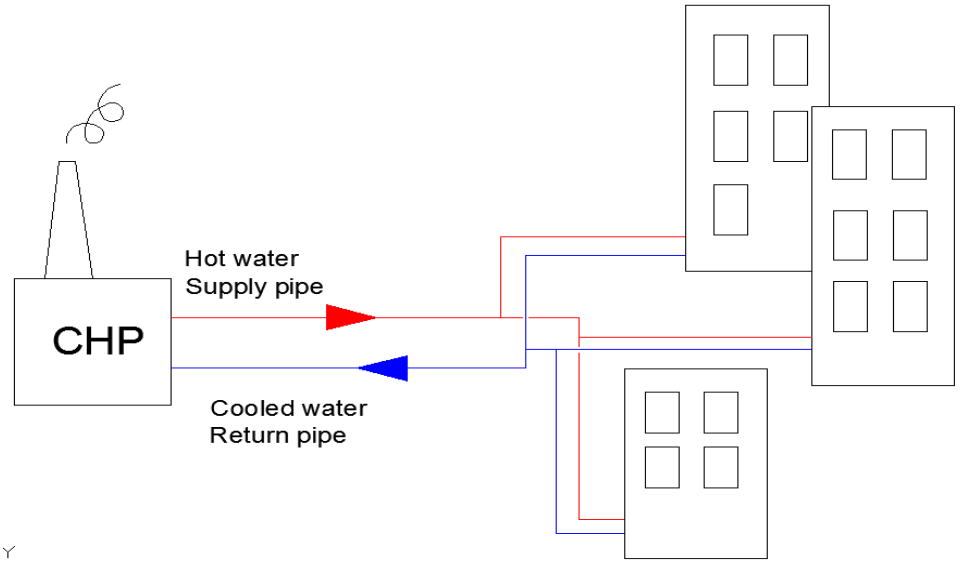

FIGURE 2. Direct DH system

Indirect system

In the indirect systems hot water goes initially to the heat exchanger, where this water heats and after that it goes to radiators. A heat exchanger is installed in the substations. In Figure 3 there is the scheme of indirect connection of DH system. Such systems as indirect DH systems are used mainly in large cities - in order to improve the reliability of heat.

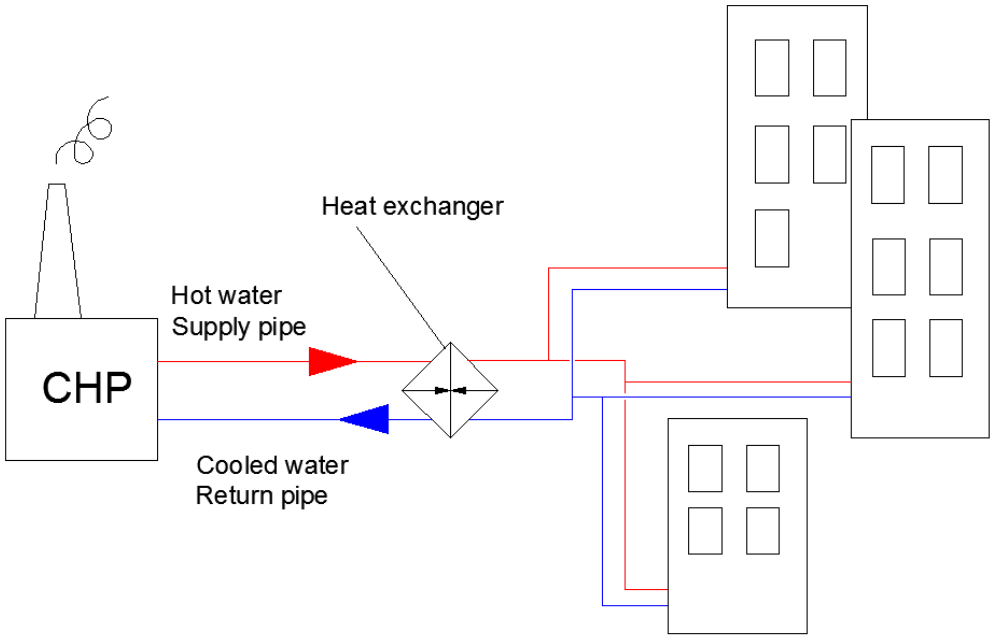

FIGURE 3. Indirect DH system

The indirect heating system has a number of advantages: the opportunity to control the amount of heat delivered to the consumer by adjusting the secondary fluid; its higher reliability and energy-saving effect, in such systems the heat savings is 10-40%. It is also possible to improve the operational and technical qualities of a heat transfer medium, which significantly improves the protection of boiler systems from contamination.

2.4.3 Open and closed schemes of DH connection

A domestic hot water connection is divided into open and closed. Figure 4 shows the difference between the open and close connection of DHW.

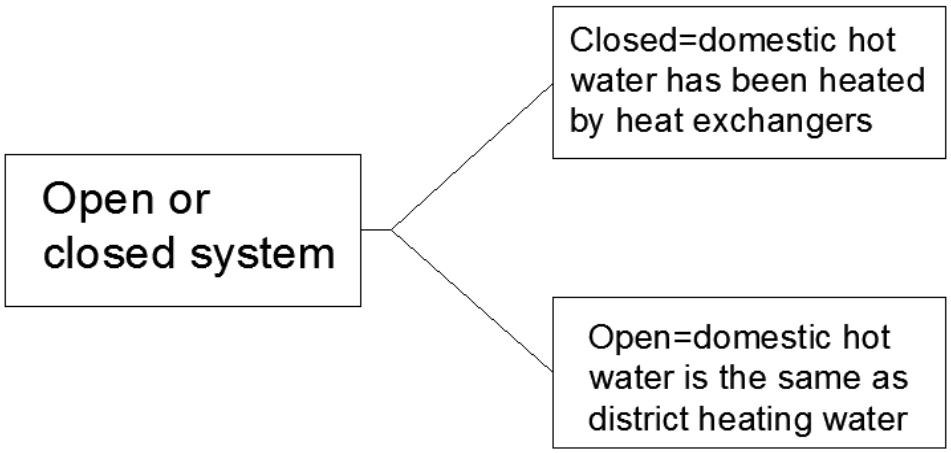

FIGURE 4. Open or closed DH system /5, p.25/

2.5 Individual heating system with a roof gas boiler plant

Currently individual heating systems, like a roof boilers, are becoming more popular. An autonomous (individual) boiler plant is a boiler room designed to heat a building or structure. So, the roof boiler of public buildings should provide reliable energy efficient and safe supply of the consumers with hot water and heat during operation, without a permanent staff.

Boiler plants as intended are divided into: boiler plants which provide heat to the heating, ventilation and hot water systems; boiler plants which provide heat to heating,

ventilation, hot water and technological systems and boiler plants for technological heat supply.

Figure 5 shows the main part of a roof gas boiler plant. Automated heat generators or boilers should be used as a source of heat in the roof boiler plant. The main fuel for the roof boiler plant is natural gas. It is also possible to use diesel, waste oil and masut. The heating capacity of such boiler should not exceed the heat demand of the building. In boiler plants there must be at least two boilers. The installation of one boiler is allowed in the industrial boiler plants of the second category. The automatic control unit is installed in the modern roof boiler plant. This control unit regulates the system in accordance with the temperature values. The main heat transfer media is water at a temperature up to 95 ° C, and pressure up to 1.0 MPa /6, p.2/.

The environmental safety is an important property, which a roof boiler plant has. It is an important advantage over other types of boilers. The fact is that being on the roof, gases have greater access to the open atmosphere, so that their removal is much easier compared to a conventional gas outlet. In the conventional gas outlet, the combustion gases are displaced upward along the pipe.

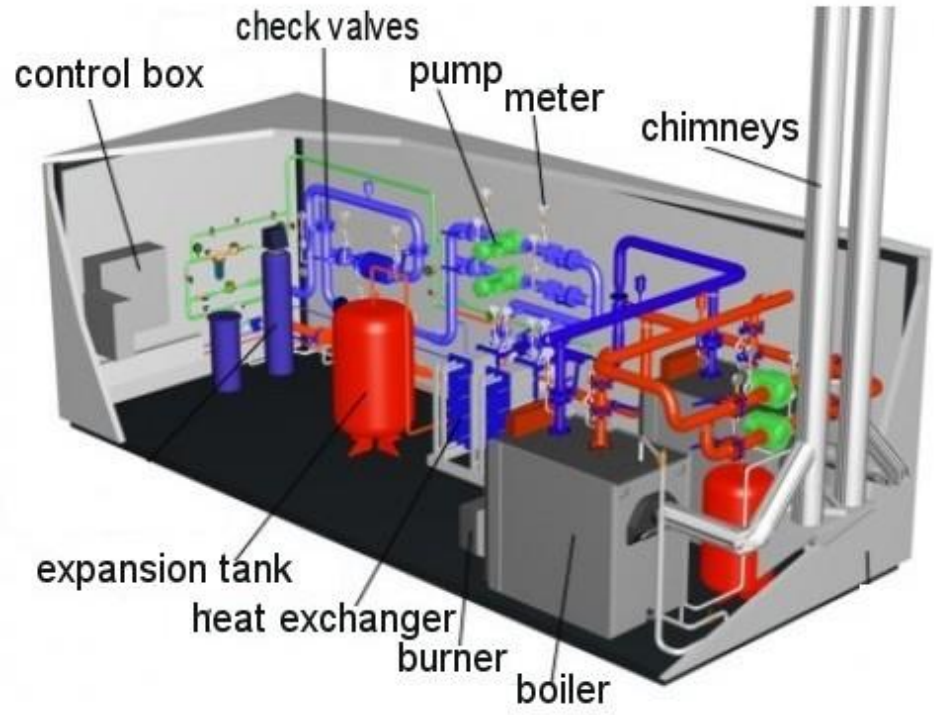

FIGURE 5. Gas boiler plant /7/

There are two main circuits of a connection between heat generators: parallel and serial. The parallel circuit is the inclusion of heat generators in parallel. Thus, each of them may be operating, and the backup heat source. In order to maintain a constant flow of water through the heat generator, each of them is equipped with a circulation pump. An entire chain of heat generators is equipped with a total recirculation line, check valve and pressure regulators. A series circuit is the inclusion of heat generators with their pump in series with each other. Each heat generator is equipped with recirculation line. /8, p.6./

The scheme of the roof boiler plant with a parallel circuit of connection between heat generators is illustrated in Figure 6. The scheme of the roof boiler plant with a serial circuit of connection is illustrated in Figure 7.

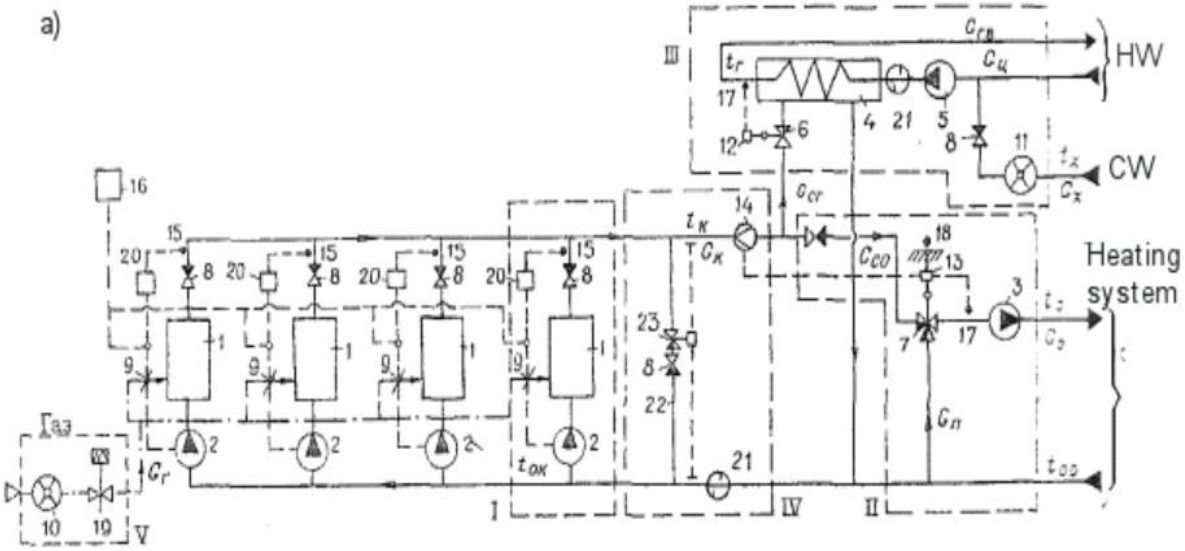

FIGURE 6. The scheme of a roof boiler plant with a parallel circuit of connection between heat generators /8, p.6/

The scheme with a parallel circuit consists of the following elements: 1 – heat generator; 2, 3, 5 - circulation pump; 4 - waterheater; 6 - two-way control valve; 7 – three-way control valve; 8 - check valve; 9 - gas control valve; 10 - gas meter; 11 – CW meter; 12 - HDW temperature regulator ; 13 – water temperature regulator for heating; 14 – the sensor of flow limiting device; 15, 17 - water temperature sensors; 16 –

control box; 18 – outdoor air temperature sensor; 19 – safety valve; 20 - regulator of water temperature after heat generator; 21 - mud trap; 22 - recirculation line; 23 - pressure drop regulator.

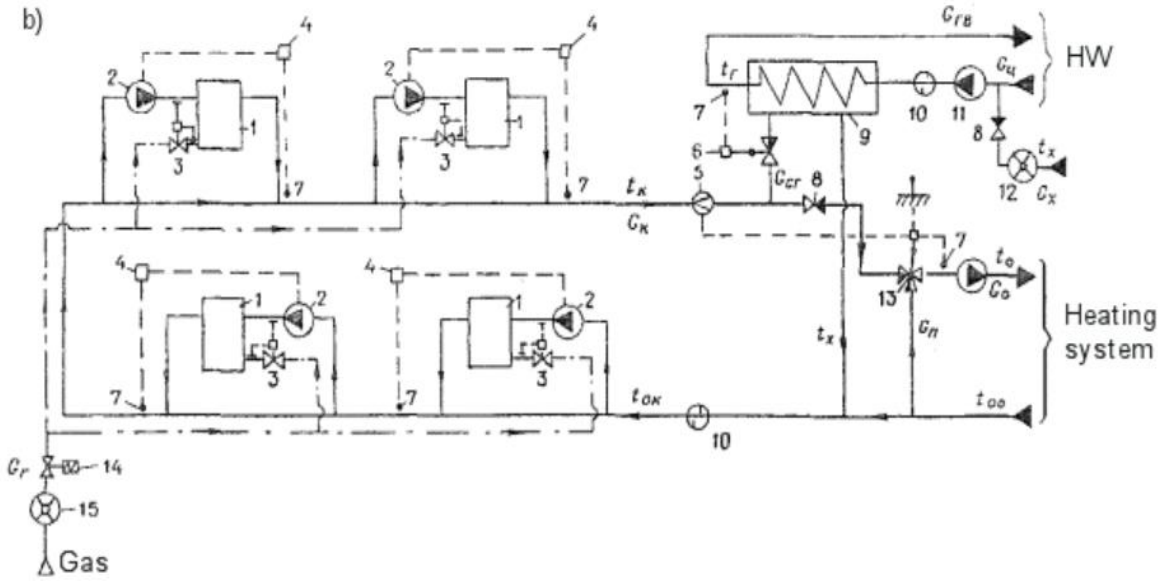

FIGURE 7. The scheme of a roof boiler plant with a serial circuit of connection between heat generators /8, p.6/

The scheme with a serial circuit consists of the following elements: 1 - heat generator; 2, 11 - circulation pump; 3 - gas flow regulator; 4 - regulator of water temperature after heat generator;; 5 - the sensor of flow limiting device; 6 - HDW temperature regulator; 7 - water temperature sensor; 8 - check valve; 9 - waterheater; 10 – mud trap; 12 - CW meter; 13 - three-way control valve; 14 - safety valve; 15 - gas meter

3 DESIGNING THE HEATING SYSTEMS

3.1 Description of the building

The multifunctional complex " U Krasnogo Mosta" has been chosen as the object of designing. The multifunctional complex is located on the Moika Embankment, in St. Petersburg. Figure 8 shows the facade of the shopping center. This complex is an object under restoration and reconstruction of the historic buildings in shopping destina-

tion in the city center. The multifunctional complex will be a seven-story building with the most modern solutions in the field of security and the latest automatic control of all the utilities. The roomy automated underground parking will be built in the complex. The building area is 12126.3 m^2. The building has similar floor plans. Figure 9 shows the floor plan.

FIGURE 8. Multifunctional complex " U Krasnogo Mosta" /9/

The current shopping center is located in the northern part of Russia. There are several estimated parameters of the outside air during the cold season:

- The design winter outdoor temperature t_{out}= -26 °C
- The average temperature during the heating period $t_{out.average}$= -1.8 °C
- The duration of the heating period: Z_{ht} = 220 days /13/.

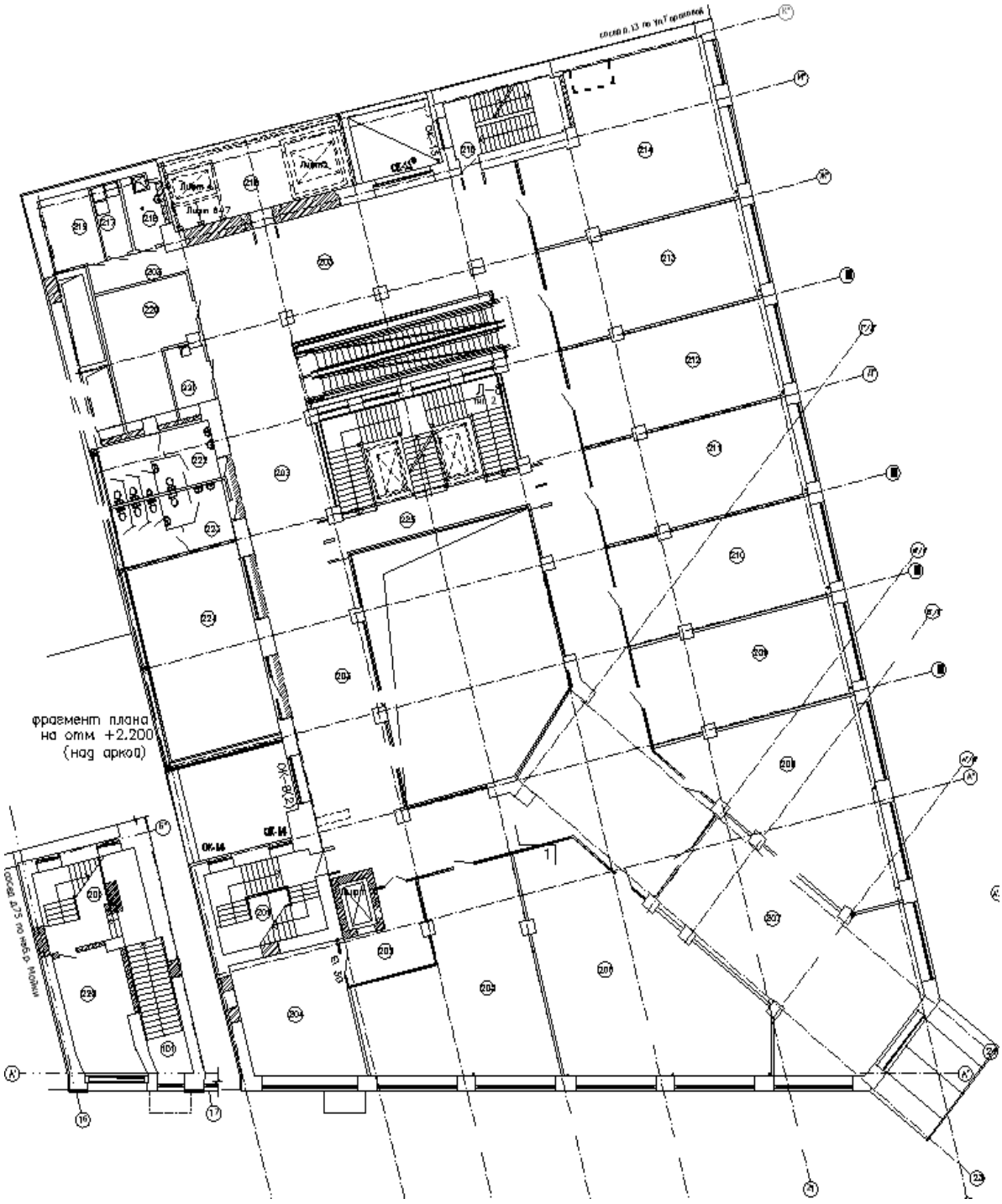

FIGURE 9. Example of a floor plan

3.2 Selection of heating systems for a shopping center

Today, there are many systems that can heat a room with a large area. For each object it is necessary to select the most beneficial heating system. For choosing a heating system it is necessary to study the external and internal factors: the location of the object, climatic conditions, the number of storeys of the building and internal climate.

After examining the features of the location of the object, its structure was determined that for a given object can be used both district and distributed heating system. Two heating systems with different heat sources were chosen for the comparison:

- district heating system
- individual heating system with a roof gas boiler plant

Both of these systems are best suited for this shopping center. Each system has both its own requirements and characteristics, together with the advantages and disadvantages.

3.3 Designing DH system

A heat source for the district heating system of the current shopping center will be the a Central CHP plant. The Central CHP plant has certain technological facts: generated electric power - 75.5 MW, generated thermal capacity - 1600 MW /10/. Gas is used as a main fuel, masut- as a reserve fuel.

A hot water with parameters 90/70 ^{0}C will be the main heat transfer media in the system. The network of the system will be with indirect connection and two pipes with bottom distributing. Radiators and convectors of "PURMO" will be used as heat emitters. The building has similar floor plans. The scheme of a connection of the heat emitters is illustrated in Figure 10 and Figure 11.

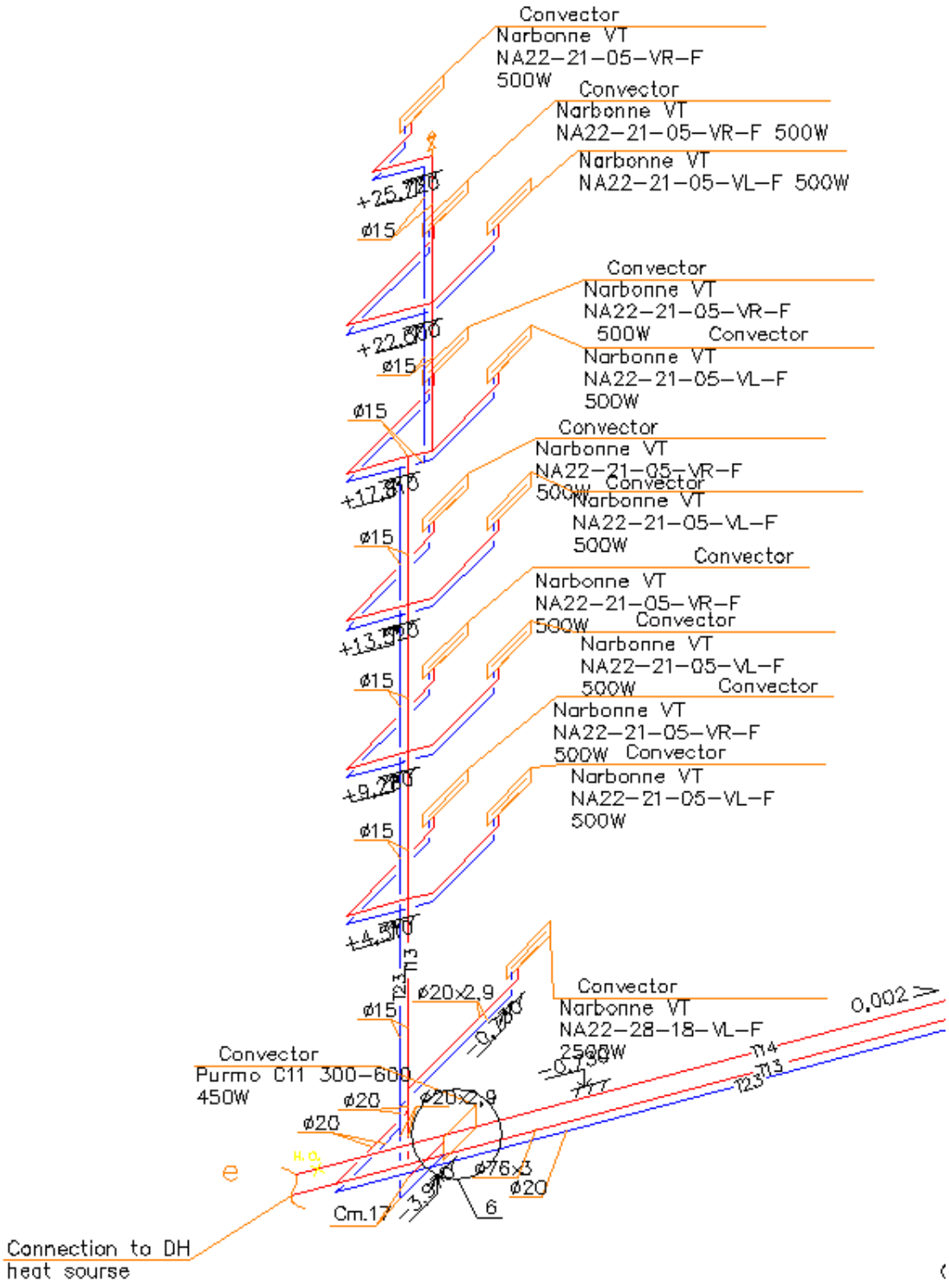

FIGURE 10. Scheme of a connection of the heat emitters to the heat riser

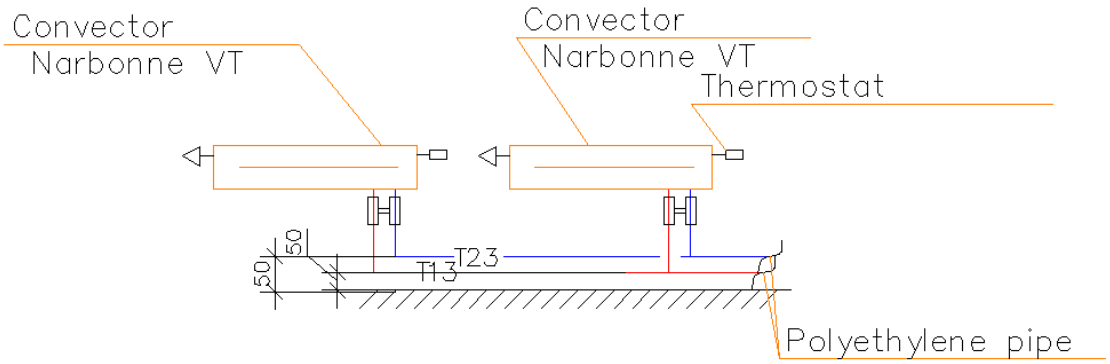

FIGURE 11. Scheme of a connection of the heat emitters

3.4 Designing a heating system with a roof gas boiler plant

Two boilers will be used as a main heat source: boiler « Viessmann Vitoplex-200-270" and boiler « Viessmann Vitoplex-200-200» with burners «Weishaupt» WM-G 20/2. Figure 12 illustrates the selected gas boiler and Figure 13 shows the roof gas boiler plant for the current shopping center. Table 1 shows the technical information of boilers.

TABLE 1. Technical information of boilers /11/

Technical information	Type of boiler	
	Vitoplex-200-200	Vitoplex-200-270
Nominal thermal capacity, kW	200	270
Max Permissible flow temperature	110 °C (120 °C)	
Operating temperature, °C	95	
Operating pressure, bar	4	
The volume of water in the boiler, l	300	400
Gas consumption per 1 kW , m3	0,105	
Standard efficiency η, %	89	

A hot water with a parameters 90/70 ^{0}C will be used as the main heat transfer media in the system. The network of the system will be with the indirect connection and two pipes with bottom distributing. Radiators and convectors of "PURMO" will be used as

heat emitters. The source of a gas for boiler plant is a medium pressure gas pipeline P = 98.1 kPa.

FIGURE 12. Gas boiler /11/

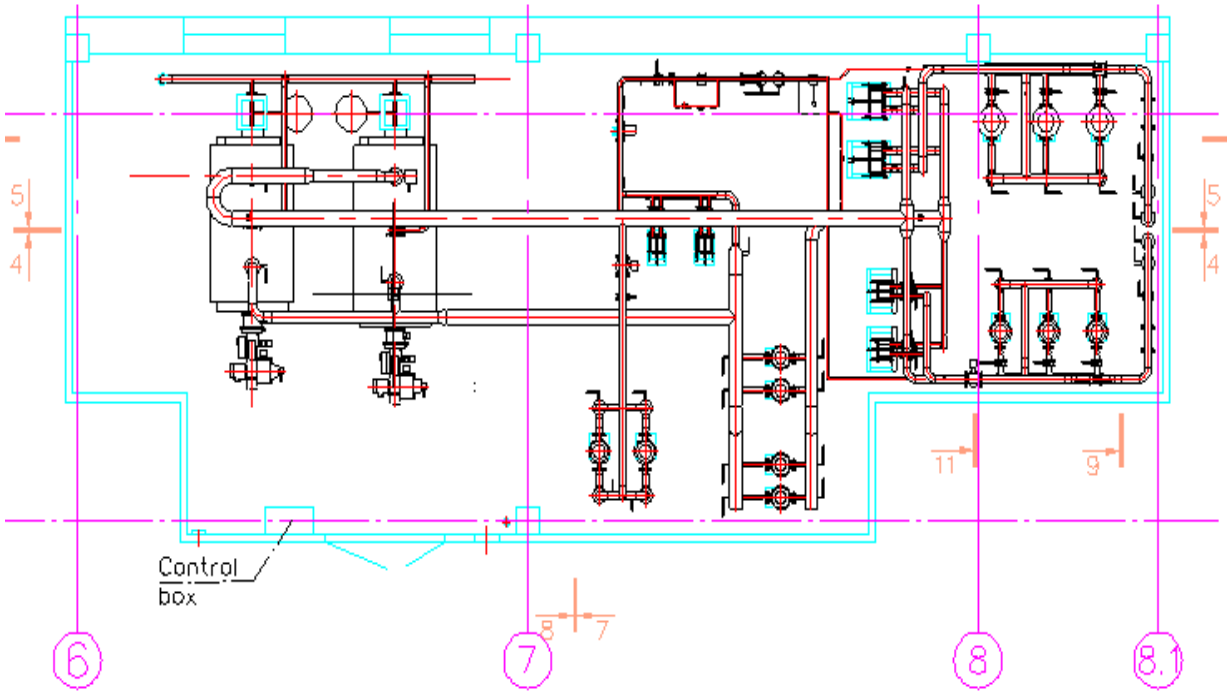

FIGURE 13. A roof gas boiler plant for the current shopping center

4 THERMAL CALCULATIONS OF BUILDING COMPONENTS

4.1 The calculation of normalized values of the thermal resistance of a building component

The calculations are based on the Russian building norms and regulations SNiP 23-02-2003 "Thermal protection of buildings". The thermal resistance of the building components R_o, $m^2 \cdot °C/W$, should not be less than normed thermal resistance Rreg, $m^2 \cdot °C/W$. The normed thermal resistance Rreg is defined in Table 4 of SNiP and depends on the degree-day value D_d, °C*day. /12, p.7./ The degree-day value D_d:

$$D_d = (T_{int} - T_{ht}) Z_{ht}, \quad (1)$$

where:

Tint - the average value of indoor air temperature of the building, ° C:

Tht - the average value of outdoor air temperature, ° C, to be considered for the period with an average daily temperature of the outside air is not more than 8 ° C:

Zht – duration of heating period, days.

The current shopping center has its own temperatures:

Tint = + 20 ° C.

Tint = + 5 ° C (for car parking)

Tht = -1,8 ° C;

Zht = 220 days

The degree-day value D_d:

$Dd=(20+1.8)*220=4796\ ^oC \cdot day$ (2)

$Dd=(5+1.8)*220=1496\ ^oC \cdot day$ /13/

Normalized values of thermal resistance of a building component are shown in Table 2.

TABLE 2. Normalized values of the thermal resistance of a building component /12/

Buildings and premises	The degree-day value D_d, $^{o}C \cdot day$	Normed thermal resistance Rreg, $m^2 \cdot °C/W$, of a building component			
		wall	floors and ceilings	Loft and basement ceilings	Window and door
Public, administrative and domestic buildings	4796	2,64	3,52	2,98	0,44
Car parking	1496	1,3	1,874	1,3	0,24

4.2 Calculation of actual values of thermal resistance of a building component

Calculations are based on the Russian building norms and regulations SNiP 23-101-2004 "Design of thermal protection of buildings". The thermal resistance R $m^2 \cdot °C/W$ of the building component is defined by the formula 3.

$R = d / \lambda$ (3)

where:

d- thickness of material layer 1, 2, ... m, m;

λ- design thermal conductivity of material layer 1, 2, ... m, e.g. normative thermal conductivity, W / $m^2 \cdot °C$.

The thermal resistance R_o $m^2 \cdot °C/W$ of the building component with serial homogeneous layers is determined by the formula 4:

$$R_o = \frac{1}{\alpha_{\text{int}}} + R_T + \frac{1}{\alpha_{ext}} \quad , \qquad (4)$$

where:

α_{int} - heat transfer coefficient of the inner surfaces of the enclosing structure, W / $m^2 \cdot °C$;

α_{ext} - heat transfer coefficient of the outer surface of the enclosing structure with the conditions of the cold period, W / $m^2 \cdot °C$;

R_T- the thermal resistance of the enclosing structure, $m^2 \cdot °C/W$.

The total thermal resistance R_T of the building components is calculated using the formula 5:

$$R_T = R_1 + R_2 + ... + R_n + R_{a.l.}, \quad (5)$$

where:

R_1, R_2, ..., R_n- thermal resistances of the individual layers enclosing structure, $m^2 \cdot °C/W$;

$R_{a.l.}$- thermal resistance of an air cavity in the building component, $m^2 \cdot °C/W$

A coefficient of heat transfer k of the enclosing structure is determined by the formula:

$$k = \frac{1}{R_0} \quad (6)$$

The results of the calculations of the thermal resistance of building component and heat transfer coefficients are given in Appendix 1.

4.3 Heat loss calculation

Heat loss through the building envelope is calculated in accordance with Russian building norms and regulations SNiP 2.04.05-91 "Heating, Ventilation and Air Conditioning" by the formula:

$$Q = A \cdot (T_в - T_н) \cdot n \cdot (1 + \sum\beta) \cdot k \quad (7)$$

where:

A - area of the enclosing structure, m^2;

T_B – design indoor air temperature, °C;

T_H - design outdoor air temperature, °C;

β - additional heat losses;

k - coefficient of heat transfer, W / $m^2 \cdot °C$. /15./

The results of the calculation of heat loss are given in Appendix 2.

5 FINANCIAL CALCULATIONS

5.1 Initial date

Heating costs are determined depending on different factors: the area of the building, the type of heating medium and components of heating system. The most obvious factor affecting the price is the area of the building.

Appendix 2 shows that the total heat load of shopping center Q_h= 366.2 kW
Duration of the heating period: Z_{ht} = 220 days
The annual operating time of the heating system is calculated by the formula:
$N=24\cdot Z_{ht}=24\cdot 220=$ 5280 hours (8)

The total heat load of building during the heating period is calculated by formula:
$Q_{TOT}=N\cdot Q_h$ (9)
Q_{TOT} = 5280·366.2 kW= 1933536 kW/year=1933.54 MW/year

5.2 Calculation of the approximate annual cost of heating

District heating system
The price of district heating in Russia depends on the city in which the building is located. The price of the district heating for Saint-Petersburg consumers is 0.027 euro/ kWh. The heat tariffs are for 2013 /16/.
The annual cost of heating:
$M_{DH} = Q_{TOT} \cdot 0.027=$ 1933536 kW·0.027 euro/kW= 52205.47 euro/ year.

Individual heating system with a roof gas boiler plant
Natural gas is used as a fuel for a roof boiler plant of the shopping center. The price of natural gas in Russia depends on the city in which the building is located. The price of the natural gas for the Saint-Petersburg consumers is 0.112 euro/ m^3 /16/. The natural gas tariffs are 2013.

In accordance with the specifications of boilers, the required volume of natural gas for producing of 1 kW of heat is equal to 0,105 m^3 /11/. Thus, burning 1 m^3 of natural gas

produces 8,1 kW of heat taking into account efficiency. The annual volume of gas, required for heating, is calculated by formula:

$V_{gas,year} = Q_{TOT}/q_N$ (10)

$V_{gas,year}$=1933536 kW / 8,1 kW/m^3=238708,14 m^3

Annual cost of heat:

$M_{RB} = V_{gas,year} \cdot 0.112$= 238708,14 $m^3 \cdot 0.112$ euro/m^3= 26735.3 euro/ year

5.3 The calculation of a roof boiler plant cost

Boilers “Viessmann” are used as a main boiler plant equipment. The boilers are equipped with gas burners “WEISHAUPT”. The heating system includes a system of an automatic correction of heat transfer media temperature, which depends on the outside temperature changes. Table 3 shows the cost of the equipment. The cost of equipment was converted from rubles to euros. 1 euro equals 45.06 rubles, in accordance with the currency rate of the Central Bank of the Russian Federation on 9 January 2014.

TABLE 3. Cost of equipment

Name of equipment, types of work	Amount of equipment	Cost of equipment, euro
Boiler "Viessmann". "Vitoplex-200", 200 kW	1	4900,3
Boiler "Viessmann". "Vitoplex-200", 270 kW	1	6071,5
Accessories for boilers	1 set	7878
Antinoise prop under boilers	2	370
Gas burner "Weishaupt" WG30N/1 C	2 set	9320
Solenoid valve and filter "Termobrest", thermal closing valve	1 set	7301,4
Set of pump "Wilo"	1 set	11096,3
Heat exchanger of HDW, 567 kW "RIDAN"	2	2558,6
Heat exchanger of heating system, 817 kW "RIDAN"	2	7717,3
Heat exchanger of ventilation, 1160 kW "RIDAN"	2	9565,1
Taps and fittings, Tecofi	1 set	14425
Pipelines	1 set	6657,8
Thermal insulation	1 set	1220,6
Expendable materials	1 set	887,7
Expansion tank "Reflex"	1 set	2108,3
Gas contamination indicator	1	670,6

Boiler automation system, control box	1 set	9321
Control and measuring devices	1 set	2441,2
Cable products	1 set	1664,5
Dispatching and fire alarm system	1 set	2330,2
Triple tube with heat insulated 2 m.	set	10985,3
Heating and ventilation system of boiler plant	1 set	6080
Thermal energy metering units "VZLET"	1 set	8766,1
Lighting	1 set	887,7
Installation, adjustment of equipment, preparation for operation		71235,7
Designing boiler plant		17088,3

The total cost of the boiler plant is 223548,5 euros

6 COMPARISION OF THE SYSTEMS

As it is known, the main factors affecting the efficiency of the heating system is the length of heating pipes, the amount of useful heat energy, and the amount of heat loss. Both of the selected heating systems are effective and both of them have their own advantages and disadvantages. The result of a comparison of the heating systems is shown in Table 4.

Individual heating system with roof gas boiler plant

The relatively short length of individual heating system networks allows to constantly maintain the desired temperature in the premises. This advantage can significantly reduce energy in heating and for laying pipes. The natural gas, which is not so expensive in Russia is used as a main fuel. This is the economic advantage of the individual heating system.

Placing the boiler plant on the roof has its benefits: there is no need for land allotment or constructing a separate building for the boiler plant; permanent free access to communications allows easily make technical inspection of the pipelines and system components and there is no need to install a high chimneys

The system is also rather simple in operation. The whole system is autonomous. The amount of a heat produced by each boiler can be adjusted in the range of 10% to 100% of the nominal capacity. On average, as the statistics show, the boiler plant operates with 70-75% of the nominal capacity in the heating season, and about 25% in summer. It allows for maintenance and repair work with a partial shutdown of the thermal capacity in any period.

On the downside, the roof boiler plant has several disadvantages too. The most important of these is the need to use the newest, modern equipment for the installation of roof boiler plant elements. This equipment is rather expensive. Additional funds are spent for the installation of automated control systems and regulation systems which continuously monitor parameters in the entire heating system of the shopping center. There are requirements for installing the gas boiler plant. First of all, the limitation by weight of the boiler, since it is the main source of mass. The weight of the boiler must be evenly distributed to all the bearing elements of the roof. That's why the best material for the manufacture of the heat exchangers is copper.

District heating system

District heating is a type of heating, which provides to consumers a stable supply by using several different heat boiler plants and the multifunctional network. One of the advantages of the system is it ”flexible” manufacturing capabilities. District heating companies have many boilers plants with various technical and production capabilities. Thus, a district heating company may use different types of fuel to produce heat. This factor allows keeping a more flexible and stable price for heat than when one fuel is used for heating.

Nowadays in district heating modern technology is being increasingly used. For heat production, environmentally effective techniques are being increasingly used. The constant using of new technology reduces the harmful effects on the environment. The technical development also gives the opportunity to receive more heat from the combustion of fuel and improves the efficiency of the system. According to the requirements of the environment the district heating boiler plants have a high chimney. High chimneys improve the dissipation of emissions into the atmosphere. It helps to keep clean air in a city.

In addition, a district heating system is quite cost effective. There is the ability to use various cheap types of fuel, especially low-grade fuel. The total fuel consumption is also reduced through the use of heat produced as a waste of heat from electricity generation.

Currently, the main disadvantages of district heating are the high heat losses and a large percentage of the wearout of equipment. The high damageability of networks is the reason for accident situations. The most significant disadvantages of district heating are: large length of heat network, additional heat transfer losses, uncontrolled heat losses in the case of a pipeline break, complexity of the repairing and huge capital investments during the construction.

TABLE 4. The result of a comparison of the heating systems

	District heating system	**Individual heating system with roof boiler**
Heat source	CHP plant	Roof boiler plant
Condition of network	old pipe from the heat source to the consumer	new pipelines
Location of heat source	separate building in relative proximity to the shopping center	on the roof of the shopping center
Heat transfer losses	The high heat losses because of large length of heat network	insignificant losses
Annual cost of heating	52205.47 euros per year	26735.3 euros per year
Automation of heating system	partially automated system	fully automated system
Land allotment necessity	yes	no

7 CONCLUSION

The current bachelor thesis contains calculations, drawings and a results of the comparison of the systems. The heat sources for selected heating systems were picked up: CHP plant for a district heating system, and a roof gas boiler plant for an individual heating system. It was necessary to make the calculation of heat losses of the shopping

center. Using these results annual heating costs was calculated. The comparison has shown the efficiency of the selected heating systems and has identified goals for further development.

According to the results of the comparison, an individual heating system with roof gas boiler plant is a more cost-effective solution for heating the shopping center. This system is a widely used heating system which consists of the efficient modern heat source, automated control devices, and the pipeline from modern material. The individual heating system is also easy in installation and operation. This system is almost independent of urban heating networks, in order to avoid unnecessary interruptions of supply. However, this system depends on the gas supply of the city. Investigations of the Russian gas supply system in the recent years show that the system is working properly and without interruptions of gas supplies. Therefore the level of risk is reduced to a minimum due to the stability of the gas supply system. The individual heating system is much more economical than a district heating system. As a final conclusion it is possible to say an individual heating system is more suitable for the public building such in shopping center, and eventually will become one of the frequently used heating systems.

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APPENDIX 1(2).

The heat transfer coefficients

Layers of enclosing structure	Volumetric weight, kg/m3	thickness of layer, m	heat transfer coefficient, W / m2•°C	thermal resistance R, m2•°C/W
1	2	3	4	5
External wall				
wall along the axis A '(street facade - existing)				
Clay brick	1800	0,77	0,81	0,951
Plaster	1600	0,03	0,81	0,037
Heat emission of internal surface	-	1	8,7	0,115
Heat emission of external surface	-	1	23	0,043
				1,146
Coefficient of heat transfer			К=	0,87
wall along the axis 22 (street facade - existing)				
Clay brick	1800	0,77	0,81	0,951
Plaster	1600	0,03	0,81	0,037
Heat emission of internal surface	-	1	8,7	0,115
Heat emission of external surface	-	1	23	0,043
				1,146
Coefficient of heat transfer			К=	0,87
wall along the axis " Б*"				
Gazobeton	400	0,3	0,15	2
Insulation "Rockwool VENT BATS"	100	0,05	0,046	1,087
Heat emission of internal surface	-	1	8,7	0,115
Heat emission of external surface	-	1	23	0,043
				3,245
Coefficient of heat transfer			К=	0,31
wall along the axis 17 и "Б*"				
Clay brick	1800	0,77	0,81	0,951
Plaster	1600	0,03	0,81	0,037
Heat emission of internal surface	-	1	8,7	0,115
Heat emission of external surface	-	1	23	0,043
				1,146
Coefficient of heat transfer			К=	0,87
wall along the axis "И"(internal) и "К*"**				
Clay brick	1800	0,77	0,81	0,951
Plaster	1600	0,03	0,81	0,037
Heat emission of internal surface	-	1	8,7	0,115
Heat emission of external surface	-	1	23	0,043
				1,146
Coefficient of heat transfer			К=	0,87

APPENDIX 1(2).

The heat transfer coefficients

Window				
double-glass				0,58
		Coefficient of heat transfer	K=	1,72
Roof				
Insulation "Rockwool Roof BATS B"	190	0,04	0,048	0,833
Expanded polystyrene		0,05	0,06	0,833
Insulation "Rockwool Roof BATS B"	110	0,16	0,045	3,556
Reinforced concrete slab	2500	0,16	2,04	0,078
Heat emission of internal surface	-	1	8,7	0,115
Heat emission of external surface	-	1	23	0,043
				5,459
		Coefficient of heat transfer	K=	0,18
Roof (in the area of the roof boiler plant)				
Insulation "Rockwool Roof BATS B"	190	0,04	0,048	0,833
Expanded polystyrene		0,05	0,06	0,833
Insulation "Rockwool Roof BATS H"	110	0,04	0,045	0,889
Heat emission of internal surface	-	1	8,7	0,115
Heat emission of external surface	-	1	23	0,043
				2,714
		Coefficient of heat transfer	K=	0,37
Covering over parking				
Concrete paving slabs		0,08	1,86	0,043
Sand	1600	0,08	0,58	0,138
lightweight concrete	800	0,03	0,35	0,086
Insulation – Penopleks 45	45	0,05	0,032	1,563
Cement-sand grout	1800	0,05	0,93	0,054
Reinforced concrete slab		0,3	1,69	0,178
Heat emission of internal surface	-	1	8,7	0,115
Heat emission of external surface	-	1	23	0,043
				2,219
		Coefficient of heat transfer	K=	0,45
Overlapping				
Insulation		0,1	0,046	2,174
Reinforced concrete slab	2500	0,16	2,04	0,178
Heat emission of internal surface	-	1	8,7	0,115
Heat emission of external surface	-	1	23	0,043
				2,482
		Coefficient of heat transfer	K=	0,4

APPENDIX 2(1).

Heat loss calculation

Name and number of space	Surface of enclosure		Enclosure dimensions, m		area of the enclosing structure	Design indoor air temperature, °C	Design outdoor air temperature, °C	Temperature difference, °C	Coefficient of additional heat loss	heat transfer coefficient	The main heat loss, W	The total heat loss, W
	Designation	Orientation to the cardinal points	a	b	A = a × b, m^2					k, W / m2•°C		
1	2	3	4	5	6	7	8	9	10	11	12	13
Basement (point -3,970)												
001-Hall 1	sl1		4,70	2,00	9,40	16	-26	42	1	0,48	189,5	189,5
	sl2		4,70	2,00	9,40	16	-26	42	1	0,23	90,8	90,8
	sl3		4,70	2,00	9,40	16	-26	42	1	0,12	47,4	47,4
	sl4		4,70	8,85	41,60	16	-26	42	1	0,07	122,3	122,3
	EW	SE	4,70	1,70	7,99	16	-26	42	1,05	0,873	292,8	307,5
	WD1	SE			3,16	16	-26	42	1,05	0,852	113,0	118,7
	WD2	SE			2,44	16	-26	42	1,05	0,852	87,3	91,6
										SUM	943,1	967,7
										The total heat loss		**968**
003-The space of reserve fire extinguishing	sl1		5,61	2,00	11,22	16	-26	42	1	0,48	226,2	226,2
	sl2		5,61	2,00	11,22	16	-26	42	1	0,23	108,4	108,4
	sl3		5,61	2,00	11,22	16	-26	42	1	0,12	56,5	56,5
	sl4		5,61	3,72	20,87	16	-26	42	1	0,07	61,4	61,4
										SUM	452,5	452,5
										The total heat loss		**452**
with clockroo	sl4				20,95	16	-26	42	1	0,07	61,6	61,6
										SUM	61,6	61,6
										The total heat loss		**62**
for cleaning	sl4				2,19	16	-26	42	1	0,07	6,4	6,4
										SUM	6,4	6,4
										The total heat loss		**6**
006-WC	sl4				5,83	16	-26	42	1	0,07	17,1	17,1
										SUM	17,1	17,1
										The total heat loss		**17**
007-WC	sl4				6,00	16	-26	42	1	0,07	17,6	17,6
										SUM	17,6	17,6
										The total heat loss		**18**
008-Space for café	sl1				53,00	22	-26	48	1	0,48	1221,1	1221,1
	sl2				67,10	22	-26	48	1	0,23	740,8	740,8
	sl3				65,00	22	-26	48	1	0,12	374,4	374,4
	sl4				264,00	22	-26	48	1	0,07	887,0	887,0

APPENDIX 2(2).

Heat loss calculation

	EW1	SE	4,70	1,30	6,11	22	-26	48	1,05	0,873	255,9	268,7
	EW2	NE	4,70	1,30	6,11	22	-26	48	1,15	0,873	255,9	294,3
	WD1	SE			7,32	22	-26	48	1,05	0,852	299,2	314,2
	WD2	NE			3,16	22	-26	48	1,15	0,852	129,2	148,5
										SUM	4163,5	4249,1
										The total heat loss		**4249**
009/1-Staircase JI-11	sl4				13,28	16	-26	42	1	0,07	39,0	39,0
										SUM	39,0	39,0
										The total heat loss		**39**
009/2-Tambour 4	sl4				5,09	16	-26	42	1	0,07	15,0	15,0
										SUM	15,0	15,0
										The total heat loss		**15**
010-Space for café	sl4				12,10	16	-26	42	1	0,07	35,6	35,6
										SUM	35,6	35,6
										The total heat loss		**36**
011-Hot shop café	sl4				33,29	16	-26	42	1	0,07	97,9	97,9
										SUM	97,9	97,9
										The total heat loss		**98**
012-Cold shop café	sl4				15,44	16	-26	42	1	0,07	45,4	45,4
										SUM	45,4	45,4
										The total heat loss		**45**
013-Space for café	sl4				12,52	16	-26	42	1	0,07	36,8	36,8
										SUM	36,8	36,8
										The total heat loss		**37**
Washing room of	sl4				17,26	16	-26	42	1	0,07	50,7	50,7
										SUM	50,7	50,7
										The total heat loss		**51**
015-storage room	sl4				6,96	16	-26	42	1	0,07	20,5	20,5
										SUM	20,5	20,5
										The total heat loss		**20**
016-Café staff room	sl4				4,31	16	-26	42	1	0,07	12,7	12,7
										SUM	12,7	12,7
										The total heat loss		**13**
017-storage room	sl4				11,88	16	-26	42	1	0,07	34,9	34,9
										SUM	34,9	34,9
										The total heat loss		**35**
018-storage room	sl4				11,88	16	-26	42	1	0,07	34,9	34,9
										SUM	34,9	34,9
										The total heat loss		**35**
019-Hall (1)	sl1			23,32	23,32	16	-26	42	1	0,48	470,1	470,1
	sl2			32,28	32,28	16	-26	42	1	0,23	311,8	311,8
	sl3			17,45	13,88	16	-26	42	1	0,12	70,0	70,0
	sl4			69,86	72,73	16	-26	42	1	0,07	213,8	213,8

APPENDIX 2(3).

Heat loss calculation

											SUM	1065,7	1065,7
											The total heat loss		**1066**
Storage room of	sl4				13,96	16	-26	42	1	0,07		41,0	41,0
											SUM	41,0	41,0
											The total heat loss		**41**
021- Storage room	sl4				14,70	16	-26	42	1	0,07		43,2	43,2
											SUM	43,2	43,2
											The total heat loss		**43**
022- Storage room	sl4				11,88	16	-26	42	1	0,07		34,9	34,9
											SUM	34,9	34,9
											The total heat loss		**35**
Storage room of	sl4				34,68	16	-26	42	1	0,07		102,0	102,0
											SUM	102,0	102,0
											The total heat loss		**102**
Storage room of	sl4				45,65	16	-26	42	1	0,07		134,2	134,2
											SUM	134,2	134,2
											The total heat loss		**134**
Washing room of	sl4				15,54	16	-26	42	1	0,07		45,7	45,7
											SUM	45,7	45,7
											The total heat loss		**46**
025- Storage room	sl4				20,90	16	-26	42	1	0,07		61,4	61,4
											SUM	61,4	61,4
											The total heat loss		**61**
026-Hall (2)	sl1				27,62	16	-26	42	1	0,48		556,8	556,8
	sl2				6,56	16	-26	42	1	0,23		63,4	63,4
	sl3				2,24	16	-26	42	1	0,12		11,3	11,3
	sl4				0,00	16	-26	42	1	0,07		0,0	0,0
	EW	SW			31,89	16	-26	42	1	0,873		1168,7	1168,7
	WD1	SW			2,30	16	-26	42	1	0,852		82,3	82,3
	D	SW			2,28	16	-26	42	1	0		0,0	0,0
											SUM	1882,5	1882,5
											The total heat loss		**1882**
027- Tambour 1	sl4				4,80	16	-26	42	1	0,07		14,1	14,1
											SUM	14,1	14,1
											The total heat loss		**14**
028- Tambour 2	sl4				8,05	16	-26	42	1	0,07		23,7	23,7
											SUM	23,7	23,7
											The total heat loss		**24**
029- Staircase JI-8	sl4				13,05	16	-26	42	1	0,07		38,4	38,4
											SUM	38,4	38,4
											The total heat loss		**38**
030- Staff room	sl4				13,10	16	-26	42	1	0,07		38,5	38,5
											SUM	38,5	38,5

APPENDIX 2(4).

Heat loss calculation

										The total heat loss		**39**
031-Staff room	sl4				62,36	16	-26	42	1	0,07	183,3	183,3
										SUM	183,3	183,3
										The total heat loss		**183**
032-Staff room	sl4				99,46	16	-26	42	1	0,07	292,4	292,4
										SUM	292,4	292,4
										The total heat loss		**292**
033-Hall (3)	sl1				44,42	16	-26	42	1	0,48	895,5	895,5
	sl2				40,52	16	-26	42	1	0,23	391,4	391,4
	sl3				36,14	16	-26	42	1	0,12	182,1	182,1
	sl4				142,17	16	-26	42	1	0,07	418,0	418,0
	EW1	NE			14,10	16	-26	42	1,15	0,873	516,8	594,3
	WD1	NE			6,72	16	-26	42	1,15	0,852	240,3	276,4
	WD2	NE			3,16	16	-26	42	1,15	0,852	113,0	130,0
	EW2	SW	4,89	3,24	15,84	16	-26	42	1	0,873	580,7	580,7
	D	SW			2,28	16	-26	42	1	1,553	148,7	148,7
										SUM	3486,5	3617,1
										The total heat loss		**3617**
034-Security room	sl1				3,70	18	-26	44	1	0,48	78,1	78,1
	sl2				0,79	18	-26	44	1	0,23	8,0	8,0
	sl3				0,00	18	-26	44	1	0,12	0,0	0,0
	sl4				0,00	18	-26	44	1	0,07	0,0	0,0
	EW	SW	1,00	3,24	3,24	18	-26	44	1	0,873	124,4	124,4
										SUM	210,5	210,5
										The total heat loss		**211**
035-WC	sl4				7,20	16	-26	42	1	0,07	21,2	21,2
										SUM	21,2	21,2
										The total heat loss		**21**
036-WC	sl4				7,20	16	-26	42	1	0,07	21,2	21,2
										SUM	21,2	21,2
										The total heat loss		**21**
037-Utility room	sl4				5,10	16	-26	42	1	0,07	15,0	15,0
										SUM	15,0	15,0
										The total heat loss		**15**
038-Utility room	sl1				3,40	16	-26	42	1	0,48	68,5	68,5
	sl2				1,87	16	-26	42	1	0,23	18,1	18,1
	sl3				0,00	16	-26	42	1	0,12	0,0	0,0
	sl4				0,00	16	-26	42	1	0,07	0,0	0,0
	EW	SW			3,24	16	-26	42	1,05	0,873	118,7	124,7
										SUM	205,4	211,3
										The total heat loss		**211**
039-Hall (3)	sl1				19,83	16	-26	42	1	0,48	399,8	399,8
	EW	SW	5,70	3,24	18,47	16	-26	42	1,05	0,873	676,8	710,7

APPENDIX 2(5).

Heat loss calculation

	D				6,26	16	-26	42	1,05	1,553	408,3	428,7
										SUM	1484,9	1539,2
										The total heat loss		**1539**
040-Utility room	sl4				11,36	16	-26	42	1	0,07	33,4	33,4
										SUM	33,4	33,4
										The total heat loss		**33**
041-Hall (4)	sl1				4,00	15	-26	41	1	0,48	78,7	78,7
	sl2				4,00	15	-26	41	1	0,23	37,7	37,7
	sl3				4,00	15	-26	41	1	0,12	19,7	19,7
	sl4				7,88	15	-26	41	1	0,07	22,6	22,6
										SUM	158,7	158,7
										The total heat loss		**159**
042-Utility room	sl1				19,94	15	-26	41	1	0,48	392,4	392,4
	sl2				20,21	15	-26	41	1	0,23	190,6	190,6
	sl3				12,90	15	-26	41	1	0,12	63,5	63,5
	sl4				4,85	15	-26	41	1	0,07	13,9	13,9
										SUM	660,4	660,4
										The total heat loss		**660**
043-Room for cleaning equinment	sl1				5,28	16	-26	42	1	0,48	106,4	106,4
	sl2				5,28	16	-26	42	1	0,23	51,0	51,0
	sl3				5,28	16	-26	42	1	0,12	26,6	26,6
	sl4				3,75	16	-26	42	1	0,07	11,0	11,0
										SUM	195,1	195,1
										The total heat loss		**195**
044-Elevator tambour	sl4				5,12	16	-26	42	1	0,07	15,1	15,1
										SUM	15,1	15,1
										The total heat loss		**15**
045-Elevator tambour	sl1		10,68	2,00	21,36	16	-26	42	1	0,48	430,6	430,6
	sl2		10,68	2,00	21,36	16	-26	42	1	0,23	206,3	206,3
	sl3		10,68	2,00	21,36	16	-26	42	1	0,12	107,7	107,7
	sl4		10,86	1,52	16,51	16	-26	42	1	0,07	48,5	48,5
										SUM	793,1	793,1
										The total heat loss		**793**
046-storage	sl4				25,00	16	-26	42	1	0,07	73,5	73,5
										SUM	73,5	73,5
										The total heat loss		**74**
047-Storage	sl4				10,70	16	-26	42	1	0,07	31,5	31,5
										SUM	31,5	31,5
										The total heat loss		**31**
048-staff room	sl4				14,50	16	-26	42	1	0,07	42,6	42,6
										SUM	42,6	42,6
										The total heat loss		**43**
staff ro	sl4				9,90	16	-26	42	1	0,07	29,1	29,1

APPENDIX 2(6).

Heat loss calculation

											SUM	29,1	29,1
											The total heat loss		**29**
050-staff room	sl4				15,39	16	-26	42	1	0,07	45,2	45,2
											SUM	45,2	45,2
											The total heat loss		**45**
051-WC	sl4				1,65	16	-26	42	1	0,07	4,9	4,9
											SUM	4,9	4,9
											The total heat loss		**5**
052-WC	sl4				1,65	16	-26	42	1	0,07	4,9	4,9
											SUM	4,9	4,9
											The total heat loss		**5**
053-clock room	sl4				15,50	16	-26	42	1	0,07	45,6	45,6
											SUM	45,6	45,6
											The total heat loss		**46**
054-clock room	sl4				11,63	16	-26	42	1	0,07	34,2	34,2
											SUM	34,2	34,2
											The total heat loss		**34**
055-staff room	sl4				11,62	16	-26	42	1	0,07	34,2	34,2
											SUM	34,2	34,2
											The total heat loss		**34**
056-Tambour 3	sl4				7,22	16	-26	42	1	0,07	21,2	21,2
											SUM	21,2	21,2
											The total heat loss		**21**
057-Staircase Л9А	sl4				11,96	16	-26	42	1	0,07	35,2	35,2
											Сумма	35,2	35,2
											Общие теплопотери		**35**
058-Staircase	sl4				11,46	16	-26	42	1	0,07	33,7	33,7
											SUM	33,7	33,7
											The total heat loss		**34**
059-Utility room	sl1		2,95	2,00	5,90	16	-26	42	1	0,48	118,9	118,9
	sl2		2,95	2,00	5,90	16	-26	42	1	0,23	57,0	57,0
	sl3		2,95	2,00	5,90	16	-26	42	1	0,12	29,7	29,7
	sl4		2,95	0,48	1,42	16	-26	42	1	0,07	4,2	4,2
											SUM	209,8	209,8
											The total heat loss		**210**
060-Utility room	sl1				20,00	16	-26	42	1	0,48	403,2	403,2
	sl2				19,42	16	-26	42	1	0,23	187,6	187,6
	sl3				13,88	16	-26	42	1	0,12	70,0	70,0
	sl4				0,00	16	-26	42	1	0,07	0,0	0,0
											SUM	660,8	660,8
											The total heat loss		**661**
Technical room	sl1		12,71	2,00	25,42	16	-26	42	1	0,48	512,5	512,5
	sl2		12,71	2,00	25,42	16	-26	42	1	0,23	245,6	245,6

APPENDIX 2(7).

Heat loss calculation

	sl3		12,71	2,00	25,42	16	-26	42	1	0,12	128,1	128,1
	sl4		12,71	3,14	39,91	16	-26	42	1	0,07	117,3	117,3
										SUM	1003,5	1003,5
										The total heat loss		**1003**
											The sum of heat loss of basement =	**20340 W**
First floor												
102	EW	SE	2,26	4,71	10,64	16	-26	42	1,05	0,873	390,1	409,6
	WD	SE	2,26	4,03	9,11	16	-26	42	1,05	0,852	325,7	342,0
										SUM	715,9	751,6
										The total heat loss		**752**
103	EW	SE	2,90	4,78	13,86	16	-26	42	1,05	0,873	508,0	533,4
	WD	SE	2,90	4,03	11,69	16	-26	42	1,05	0,852	418,0	438,9
										SUM	926,0	972,3
										The total heat loss		**972**
105	EW1	NE	5,40	4,78	25,81	16	-26	42	1,1	0,873	946,0	1040,6
	EW2	SW	4,57	4,78	21,84	16	-26	42	1	0,873	800,6	800,6
	EW3	SW	5,40	4,78	25,81	16	-26	42	1	0,873	946,0	946,0
	EW4	SW	4,97	4,78	23,76	16	-26	42	1	0,873	870,7	870,7
	EW5	NE	2,68	4,78	12,81	16	-26	42	1,1	0,873	469,5	516,4
	WD1	NE	4,35	3,98	17,32	16	-26	42	1,1	0,852	619,4	681,4
	WD2	SW	3,40	3,98	13,53	16	-26	42	1	0,852	484,0	484,0
	WD3	SW	2,68	3,98	10,67	16	-26	42	1	0,852	381,5	381,5
	WD4	NE	2,08	3,43	7,13	16	-26	42	1,1	0,852	255,2	280,7
										SUM	5772,8	6001,8
										The total heat loss		**6002**
106	EW	SE	19,42	4,78	92,83	20	-26	46	1,05	0,873	3726,1	3912,4
	WD1	SE	4,50	3,98	53,73	20	-26	46	1,05	0,852	2104,6	2209,9
	WD2	SE	2,24	3,98	8,92	20	-26	46	1,05	0,852	349,2	366,7
										SUM	6179,9	6488,9
										The total heat loss		**6489**
109	EW	SE	2,27	4,78	10,85	16	-26	42	1,05	0,873	397,7	417,5
	WD	SE	2,27	3,98	9,03	16	-26	42	1,05	0,852	323,1	339,3
										SUM	720,8	756,8
										The total heat loss		**757**
110	EW1	E	6,06	4,78	28,97	16	-26	42	1,15	0,873	1061,6	1220,9
	EW2	SE	0,80	4,78	3,82	16	-26	42	1,15	0,873	140,1	161,2
	EW3	NE	0,80	5,24	4,19	16	-26	42	1,15	0,873	153,6	176,7
	WD				38,78	16	-26	42	1	0,852	1387,0	1387,0
										SUM	2742,3	2945,6

APPENDIX 2(8).

Heat loss calculation

										The total heat loss		**2946**
111	EW	NE	2,20	4,78	10,52	16	-26	42	1,1	0,873	385,4	423,9
	WD	NE	2,20	3,98	8,76	16	-26	42	1,1	0,852	313,2	344,5
										SUM	698,6	768,4
										The total heat loss		**768**
113	EW	NE	32,61	4,78	155,88	18	-26	44	1,1	0,873	5984,8	6583,2
	WD	NE			103,92	18	-26	44	1,1	0,852	3893,6	4283,0
										SUM	9878,4	10866,2
										The total heat loss		**10866**
116	EW	SW	5,38	4,78	25,72	16	-26	42	1	0,873	942,5	942,5
	WD	SW			12,19	16	-26	42	1	0,852	436,0	436,0
										SUM	1378,5	1378,5
										The total heat loss		**1378**
117	EW1	SW	3,54	4,78	16,92	16	-26	42	1,1	0,873	620,1	682,2
	EW2	SE	7,42	4,78	35,47	16	-26	42	1,15	0,873	1299,9	1494,8
										SUM	1920,0	2177,0
										The total heat loss		**2177**
118	EW1	SW	4,00	4,78	19,12	16	-26	42	1	0,873	700,7	700,7
	EW2		1,67	4,78	7,98	16	5	11	1	3,57	313,5	313,5
										SUM	1014,2	1014,2
										The total heat loss		**1014**
120	EW		3,40	4,78	16,25	16	5	11	1	3,570	638,2	638,2
										SUM	638,2	638,2
										The total heat loss		**638**
121	EW1	NW	3,36	4,78	16,06	16	-26	42	1,15	0,873	588,6	676,9
	EW2	SW	4,40	4,78	21,03	16	-26	42	1,1	0,873	770,8	847,9
										SUM	1359,4	1524,8
										The total heat loss		**1525**
121	EW	NW	1,76	4,78	8,41	16	-26	42	1,1	0,873	308,3	339,2
										SUM	308,3	339,2
										The total heat loss		**339**
124	EW	NW	2,73	4,78	13,05	16	-26	42	1,1	0,873	478,3	526,1

APPENDIX 2(9).

Heat loss calculation

										SUM	478,3	526,1
										The total heat loss		**526**
125	EW	NW	10,60	4,78	50,67	16	-26	42	1,1	0,873	1856,9	2042,6
										SUM	1856,9	2042,6
										The total heat loss		**2043**
126	EW	NW	5,40	4,78	25,81	16	-26	42	1,1	0,873	946,0	1040,6
	KP				21,60	16	-26	42	1	0,209	189,6	189,6
										SUM	1135,6	1230,2
										The total heat loss		**1230**
128	EW	NW	6,70	4,71	31,56	16	-26	42	1,1	0,873	1156,5	1272,2
										SUM	1156,5	1272,2
										The total heat loss		**1272**
131	EW1	NW	2,70	4,67	12,61	5	-26	31	1,15	0,873	341,1	392,2
	EW2	NE	4,30	4,67	11,66	5	-26	31	1,15	0,873	315,3	362,6
	WD	NE			2,00	5	-26	31	1,15	0,852	52,8	60,7
	D	NE	3,51	2,40	8,42	5	-26	31	2,41	2,105	549,7	1324,8
										SUM	1258,9	2140,4
										The total heat loss		**2140**
										The sum of heat loss of first floor		**=43930 W**
										Second floor		
203-hall	EW1	SW	5,42	4,24	22,98	18	-26	44	1,05	0,873	882,3	926,5
	EW2	NW	5,40	4,24	22,90	18	-26	44	1,1	0,873	879,1	967,0
	WD1	SW			6,36	18	-26	44	1,05	0,852	238,3	250,2
	WD2	NW			7,75	18	-26	44	1,1	0,852	290,4	319,4
										SUM	2290,1	2463,1
										The total heat loss		**2463**
204	EW	SE	6,84	4,77	32,63	18	-26	44	1,05	0,873	1252,7	1315,3
	WD	SE			18,26	18	-26	44	1,05	0,852	684,2	718,4
										SUM	1936,8	2033,7
										The total heat loss		**2034**
205	EW	SE	6,84	4,77	32,63	18	-26	44	1,05	0,873	1252,7	1315,3
	WD	SE			29,80	18	-26	44	1,05	0,852	1116,5	1172,4
										SUM	2369,2	2487,7
										The total heat loss		**2488**
206	EW	SE	11,82	4,77	56,38	18	-26	44	1,05	0,873	2164,7	2273,0
	WD	SE			29,80	18	-26	44	1,05	0,852	1116,5	1172,4
										SUM	3281,3	3445,3
										The total heat loss		**3445**

APPENDIX 2(10).

Heat loss calculation

207	EW1	SE	5,92	4,77	28,24	18	-26	44	1,15	0,873	1084,2	1246,8
	EW2	E	6,00	4,77	28,62	18	-26	44	1,15	0,873	1098,8	1263,7
	EW3	NE	5,35	4,77	25,52	18	-26	44	1,15	0,873	979,8	1126,8
	WD1	SE			14,90	18	-26	44	1,15	0,852	558,3	642,0
	WD2	E			13,20	18	-26	44	1,15	0,852	494,6	568,8
	WD3	NE			14,15	18	-26	44	1,15	0,852	530,2	609,7
										SUM	4745,9	5457,7
										The total heat loss		**5458**
208	EW	NE	11,50	4,77	54,86	18	-26	44	1,1	0,873	2106,1	2316,7
	WD	NE			28,30	18	-26	44	1,1	0,852	1060,3	1166,4
										SUM	3166,5	3483,1
										The total heat loss		**3483**
206	EW	NE	5,40	4,77	25,76	18	-26	44	1,1	0,873	989,0	1087,9
	WD	NE			14,15	18	-26	44	1,1	0,852	530,2	583,2
										SUM	1519,1	1671,0
										The total heat loss		**1671**
210	EW	NE	5,40	4,77	25,76	18	-26	44	1,1	0,873	989,0	1087,9
	WD	NE			14,15	18	-26	44	1,1	0,852	530,2	583,2
										SUM	1519,1	1671,0
										The total heat loss		**1671**
211	EW	NE	5,40	4,77	25,76	18	-26	44	1,1	0,873	989,0	1087,9
	WD	NE			14,15	18	-26	44	1,1	0,852	530,2	583,2
										SUM	1519,1	1671,0
										The total heat loss		**1671**
212	EW	NE	5,40	4,77	25,76	18	-26	44	1,1	0,873	989,0	1087,9
	WD	NE			14,15	18	-26	44	1,1	0,852	530,2	583,2
										SUM	1519,1	1671,0
										The total heat loss		**1671**
213	EW	CB	5,40	4,77	25,76	18	-26	44	1,1	0,873	989,0	1087,9
	WD	CB			14,15	18	-26	44	1,1	0,852	530,2	583,2
										SUM	1519,1	1671,0
										The total heat loss		**1671**
214	EW1	NE	9,65	4,77	46,03	20	-26	46	1,15	0,873	1847,6	2124,8
	EW2	NW	9,43	4,77	44,98	20	-26	46	1,15	0,873	1805,5	2076,4
	WD1	NE			14,15	20	-26	46	1,15	0,852	554,3	637,4
	WD2	NW			6,88	20	-26	46	1,15	0,873	276,2	317,6
	CR				9,51	20	5	15	1	1,103	157,3	157,3
										SUM	4640,9	5313,5
										The total heat loss		**5313**
216-tambour	EW1	NW	10,54	4,77	50,28	16	-26	42	1,15	0,873	1842,6	2119,0
	EW2	NE	3,89	4,77	18,56	16	-26	42	1,15	0,873	680,0	782,0
										SUM	2522,6	2901,0
										The total heat loss		**2901**

APPENDIX 2(11).

Heat loss calculation

218	EW	NW	3,35	4,77	15,98	16	-26	42	1,1	0,873	585,6	644,2
										SUM	585,6	644,2
										The total heat loss		**644**
219-staff room	EW1	NW	4,48	4,77	21,37	22	-26	48	1,15	0,873	895,1	1029,3
	EW2	SW	4,13	4,77	19,70	22	-26	48	1,1	0,873	825,1	907,6
	IW		4,17	4,77	19,89	22	-26	48	1	2,303	2198,8	2198,8
										SUM	3919,0	4135,8
										The total heat loss		**4136**
220-technical room	IW		6,30	4,77	30,05	16	-26	42	1	2,303	2906,7	2906,7
										SUM	2906,7	2906,7
										The total heat loss		**2907**
220-technical room	EW		6,30	2,50	15,75	16	-26	42	1	0,873	577,2	577,2
	WD				4,21	16	-26	42	1	0,852	150,6	150,6
										SUM	727,8	727,8
										The total heat loss		**728**
222-WC	EW	SW	4,12	4,77	19,65	16	-26	42	1	0,873	720,2	720,2
										SUM	720,2	720,2
										The total heat loss		**720**
223-WC	EW	SW	3,36	4,77	16,03	16	-26	42	1	0,873	587,4	587,4
										SUM	587,4	587,4
										The total heat loss		**587**
224	EW1	SW	10,88	4,77	51,90	20	-26	46	1	0,873	2083,1	2083,1
	EW2	SE	6,76	4,77	32,25	20	-26	46	1	0,873	1294,3	1294,3
	CR				77,94	20	-26	46	1	0,230	824,6	824,6
										SUM	4202,1	4202,1
										The total heat loss		**4202**
The sum of heat loss of second floor =49990 W												
Third floor												
303-hall	EW1	SW	5,42	4,24	22,98	18	-26	44	1,05	0,873	882,3	926,5
	EW2	NW	5,40	4,24	6,36	18	-26	44	1,1	0,873	244,2	268,6
	WD1	SW			6,36	18	-26	44	1,05	0,852	238,3	250,2
	WD2	NW			7,75	18	-26	44	1,1	0,852	290,4	319,4
										SUM	1655,2	1764,7
										The total heat loss		**1765**
304	EW	SE	6,84	4,24	29,00	18	-26	44	1	0,873	1113,5	1113,5
	WD	SE			15,27	18	-26	44	1	0,852	572,1	572,1
										SUM	1685,6	1685,6
										The total heat loss		**1686**
305	EW	SE	6,84	4,24	29,00	18	-26	44	1,05	0,873	1113,5	1169,2
	WD	SE			24,84	18	-26	44	1,05	0,852	930,7	977,2
										SUM	2044,2	2146,4
										The total heat loss		**2146**
306	EW	SE	11,82	4,24	50,12	18	-26	44	1,05	0,873	1924,2	2020,4

APPENDIX 2(12).

Heat loss calculation

	WD	SE			24,84	18	-26	44	1,05	0,852	930,7	977,2
										SUM	2854,9	2997,6
										The total heat loss		**2998**
307	EW1	SE	5,92	4,24	25,10	20	-26	46	1,15	0,873	1007,5	1158,7
	EW2	E	6,00	4,24	25,44	20	-26	46	1,15	0,873	1021,2	1174,3
	EW3	NE	5,35	4,24	22,68	20	-26	46	1,15	0,873	910,5	1047,1
	WD1	SE			12,42	20	-26	46	1,15	0,852	486,5	559,5
	WD2	E			11,06	20	-26	46	1,15	0,852	433,2	498,2
	WD3	NE			11,84	20	-26	46	1,15	0,852	463,8	533,3
										SUM	4322,7	4971,1
										The total heat loss		**4971**
308	EW	NE	11,50	4,24	48,76	18	-26	44	1,1	0,873	1872,1	2059,3
	WD	NE			28,30	18	-26	44	1,1	0,852	1060,3	1166,4
										SUM	2932,4	3225,7
										The total heat loss		**3226**
309	EW	NE	5,40	4,24	22,90	18	-26	44	1,1	0,873	879,1	967,0
	WD	NE			11,84	18	-26	44	1,1	0,852	443,6	488,0
										SUM	1322,7	1455,0
										The total heat loss		**1455**
310	EW	NE	5,40	4,24	22,90	18	-26	44	1,1	0,873	879,1	967,0
	WD	NE			11,84	18	-26	44	1,1	0,852	443,6	488,0
										SUM	1322,7	1455,0
										The total heat loss		**1455**
311	EW	NE	5,40	4,24	22,90	18	-26	44	1,1	0,873	879,1	967,0
	WD	NE			11,84	18	-26	44	1,1	0,852	443,6	488,0
										SUM	1322,7	1455,0
										The total heat loss		**1455**
312	EW	NE	5,40	4,24	22,90	18	-26	44	1,1	0,87	879,1	967,0
	WD	NE			11,84	18	-26	44	1,1	0,852	443,6	488,0
										SUM	1322,7	1455,0
										The total heat loss		**1455**
313	EW	NE	5,40	4,24	22,90	18	-26	44	1,1	0,87	879,1	967,0
	WD	NE			11,84	18	-26	44	1,1	0,852	443,6	488,0
										SUM	1322,7	1455,0
										The total heat loss		**1455**
314	EW1	NE	9,65	4,24	40,92	20	-26	46	1,15	0,873	1642,4	1888,7
	EW2	NW	5,87	4,24	24,89	20	-26	46	1,15	0,873	999,0	1148,9
	IW3		1,55	4,24	6,57	20	5	15	1	2,610	257,3	257,3
	IW4		2,98	4,24	12,64	20	5	15	1	2,610	494,7	494,7
	WD1	NE			11,84	20	-26	46	1,15	0,852	463,8	533,3
	WD2	NW			11,84	20	-26	46	1,15	0,852	463,8	533,3
										SUM	4320,9	4856,2
										The total heat loss		**4856**

APPENDIX 2(13).

Heat loss calculation

315	EW1	NW	10,54	4,24	44,69	16	-26	42	1,15	0,873	1637,8	1883,5
	EW2	NE	3,86	4,24	16,37	16	-26	42	1,15	0,873	599,8	689,8
										SUM	2237,7	2573,3
										The total heat loss		**2573**
318	EW	NW	3,35	4,24	14,20	16	-26	42	1,1	0,873	520,6	572,6
										SUM	520,6	572,6
										The total heat loss		**573**
319-staff room	EW1	NW	4,48	4,24	19,00	22	-26	48	1,15	0,873	795,6	915,0
	EW2	SW	4,13	4,24	17,51	22	-26	48	1,1	0,873	733,5	806,8
	IW3		4,17	4,24	17,68	22	-26	48	1	2,303	1954,5	1954,5
										SUM	3483,6	3676,3
										The total heat loss		**3676**
320-technical room	IW		6,30	4,24	26,71	16	-26	42	1	2,303	2583,7	2583,7
										SUM	2583,7	2583,7
										The total heat loss		**2584**
322-WC	EW	SW	4,12	4,24	17,47	16	-26	42	1	0,873	640,2	640,2
										SUM	640,2	640,2
										The total heat loss		**640**
323-WC	EW	SW	3,36	4,24	14,25	16	-26	42	1	0,873	522,1	522,1
										SUM	522,1	522,1
										The total heat loss		**522**
324	EW1	SW	10,88	4,24	46,13	20	-26	46	1	0,873	1851,7	1851,7
	EW2	SE	6,76	4,24	28,66	20	-26	46	1	0,873	1150,5	1150,5
										SUM	3002,2	3002,2
										The total heat loss		**3002**
												The sum of heat loss of third floor = 42600 W
						Fourth floor						
403	EW	SE	6,84	4,29	29,34	22	-26	48	1	0,873	1229,1	1229,1
	WD	SE			14,34	22	-26	48	1	0,852	586,1	586,1
										SUM	1815,2	1815,2
										The total heat loss		**1815**
406	EW	SE	16,70	4,29	71,64	22	-26	48	1	0,873	3000,8	3000,8
	WD	SE			34,20	22	-26	48	1	0,852	1397,9	1397,9
	IW1		2,31	4,29	9,91	22	16	6	1	6,525	388,0	388,0
	IW2		2,50	4,29	10,73	22	16	6	1	6,525	419,9	419,9
										SUM	5206,5	5206,5
										The total heat loss		**5206**
407	EW	NE	22,40	4,29	96,10	22	-26	48	1,1	0,873	4025,0	4427,5
	WD	NE			43,52	22	-26	48	1,1	0,852	1778,8	1956,7
										SUM	5803,8	6384,2
										The total heat loss		**6384**
408-hall	EW1	NE	10,78	4,29	46,25	22	-26	48	1,15	0,873	1937,0	2227,6
	EW2	E	6,34	4,29	27,20	22	-26	48	1,15	0,873	1139,2	1310,1

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Heat loss calculation

	EW3	SE	11,67	4,29	50,06	22	-26	48	1,15	0,873	2096,9	2411,5
	EW4	SW	5,42	4,29	23,25	22	-26	48	1,15	0,873	973,9	1120,0
	WD1	NE			21,76	22	-26	48	1,15	0,852	889,4	1022,8
	WD2	E			9,32	22	-26	48	1,15	0,852	380,9	438,1
	WD3	SE			22,80	22	-26	48	1,15	0,852	931,9	1071,7
	WD4	SW			6,94	22	-26	48	1,15	0,852	283,7	326,2
										SUM	8633,0	9927,9
										The total heat loss		**9928**
409	EW	NE	16,20	4,29	69,50	22	-26	48	1,15	0,873	2910,9	3347,5
	WD	NE			32,64	22	-26	48	1,15	0,852	1334,1	1534,2
										SUM	4245,0	4881,8
										The total heat loss		**4882**
411	EW1	NE	4,24	4,29	18,19	24	-26	50	1,15	0,873	793,6	912,7
	EW2	NW	5,60	4,29	24,02	24	-26	50	1,15	0,873	1048,2	1205,4
	IW3		1,50	4,29	6,44	24	5	19	1	2,060	251,9	251,9
	WD1	NE			5,30	24	-26	50	1,15	0,852	225,7	259,5
										SUM	2319,3	2629,4
										The total heat loss		**2629**
412-staff room	IW		2,98	4,29	12,78	16	5	11	1	3,559	500,5	500,5
										SUM	500,5	500,5
										The total heat loss		**500**
422-staff room	EW	NW	2,58	4,29	11,07	16	-26	42	1,1	0,873	405,6	446,2
										SUM	405,6	446,2
										The total heat loss		**446**
423-cloak room	EW1	NW	5,30	4,29	22,74	18	-26	44	1,15	0,873	873,0	1003,9
	EW2	SW	4,55	4,29	19,52	18	-26	44	1,15	0,873	749,4	861,9
	IW		1,66	4,29	7,12	18	5	13	1	3,012	278,8	278,8
										SUM	1901,3	2144,6
										The total heat loss		**2145**
425-staff room	IW		1,76	4,29	7,55	16	5	11	1	3,559	295,6	295,6
										SUM	295,6	295,6
										The total heat loss		**296**
426-technical room	IW		2,67	4,29	11,45	16	5	11	1	3,559	448,4	448,4
										SUM	448,4	448,4
										The total heat loss		**448**
426-technical room	IW		3,50	4,29	15,02	16	5	11	1	3,559	587,8	587,8
										SUM	587,8	587,8
										The total heat loss		**588**
429-hall (2)	IW		1,36	4,29	5,83	16	5	11	1	3,559	228,4	228,4
	EW2		5,40	4,29	23,17	16	5	11	1	0,873	222,4	222,4
	WD				7,75	16	5	11	1	0,852	72,6	72,6
										SUM	523,4	523,4
										The total heat loss		**523**

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Heat loss calculation

431-tambour	EW1	NW	10,54	4,29	45,22	16	-26	42	1,15	0,873	1657,2	1905,7
	EW2	NE	3,86	4,29	16,56	16	-26	42	1,15	0,873	606,9	697,9
										SUM	2264,0	2603,6
										The total heat loss		**2604**
435-WC	EW	SW	4,12	4,29	17,67	16	-26	42	1	0,873	647,8	647,8
										SUM	647,8	647,8
										The total heat loss		**648**
436-WC	EW	SW	3,36	4,29	14,41	16	-26	42	1	0,873	528,3	528,3
										SUM	528,3	528,3
										The total heat loss		**528**
437-Utility room	EW		1,00	4,29	4,29	16	-26	42	1	0,873	157,2	157,2
										SUM	157,2	157,2
										The total heat loss		**157**
438-administration	W	SE	7,50	4,29	32,18	20	-26	46	1,1	0,873	1291,5	1420,6
	WD				6,38	20	-26	46	1,1	0,852	249,9	274,9
										SUM	1541,4	1695,5
										The total heat loss		**1696**
										The sum of heat loss of fourth floor =		**35850 W**
						Fifth floor						
503-hall	EW1	NE	5,40	4,19	22,63	18	-26	44	1,1	0,873	868,7	955,6
	EW2	SW		4,19	4,19	18	-26	44	1	0,873	160,9	160,9
	WD1	NE			5,15	18	-26	44	1,1	0,852	193,0	212,3
	WD2	SW			6,25	18	-26	44	1	0,852	234,2	234,2
										SUM	1456,7	1562,9
										The total heat loss		**1563**
504	EW	SE	6,68	4,19	27,99	18	-26	44	1,05	0,873	1074,6	1128,4
	WD	SE			6,15	18	-26	44	1,05	0,852	230,4	241,9
										SUM	1305,1	1370,3
										The total heat loss		**1370**
505	EW	SE	11,33	4,19	47,47	18	-26	44	1,05	0,873	1822,7	1913,8
	WD	SE			10,20	18	-26	44	1,05	0,852	382,2	401,3
										SUM	2204,9	2315,1
										The total heat loss		**2315**
506	EW	SE	12,00	4,19	50,28	18	-26	44	1,05	0,873	1930,5	2027,0
	WD	SE			10,20	18	-26	44	1,05	0,852	382,2	401,3
										SUM	2312,6	2428,3
										The total heat loss		**2428**
507	EW1	SE	5,46	4,19	22,88	20	-26	46	1,15	0,873	918,3	1056,0

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Heat loss calculation

	EW2	E	5,71	4,19	23,92	20	-26	46	1,15	0,873	960,3	1104,4
	EW3	NE	5,70	4,19	23,88	20	-26	46	1,15	0,873	958,7	1102,5
	WD1	SE			5,10	20	-26	46	1,15	0,852	199,8	229,7
	D	E			9,17	20	-26	46	1,15	1,103	465,3	535,1
	WD3	NE			5,10	20	-26	46	1,15	0,852	199,8	229,7
										SUM	3702,1	4257,4
										The total heat loss		**4257**
508	EW	NE	11,50	4,19	48,19	18	-26	44	1,1	0,873	1850,0	2035,0
	WD	NE			10,20	18	-26	44	1,1	0,852	382,2	420,4
										SUM	2232,2	2455,4
										The total heat loss		**2455**
509	EW	NE	5,40	4,19	22,63	18	-26	44	1,1	0,873	868,7	955,6
	WD	NE			5,10	18	-26	44	1,1	0,852	191,1	210,2
										SUM	1059,8	1165,8
										The total heat loss		**1166**
510	EW	NE	5,40	4,19	22,63	18	-26	44	1,1	0,873	868,7	955,6
	WD	NE			5,10	18	-26	44	1,1	0,852	191,1	210,2
										SUM	1059,8	1165,8
										The total heat loss		**1166**
511	EW	NE	5,40	4,19	22,63	18	-26	44	1,1	0,873	868,7	955,6
	WD	NE			5,10	18	-26	44	1,1	0,852	191,1	210,2
										SUM	1059,8	1165,8
										The total heat loss		**1166**
512	EW	NE	5,40	4,19	22,63	18	-26	44	1,1	0,873	868,7	955,6
	WD	NE			5,10	18	-26	44	1,1	0,852	191,1	210,2
										SUM	1059,8	1165,8
										The total heat loss		**1166**
513	EW	NE	5,40	4,19	22,63	18	-26	44	1,1	0,873	868,7	955,6
	WD	NE			5,10	18	-26	44	1,1	0,852	191,1	210,2
										SUM	1059,8	1165,8
										The total heat loss		**1166**
514	EW1	NE	9,64	4,19	40,39	20	-26	46	1,15	0,873	1621,3	1864,5
	EW2	NW	5,96	4,19	24,97	20	-26	46	1,15	0,873	1002,4	1152,7
	IW3		1,55	4,19	6,49	20	5	15	1	2,610	254,3	254,3
	IW4		2,98	4,19	12,49	20	5	15	1	2,610	488,8	488,8
	WD	NE			7,65	20	-26	46	1,15	0,852	299,7	344,6
										SUM	3666,4	4104,9
										The total heat loss		**4105**
516-tambour	EW1	NW	10,54	4,19	44,16	16	-26	42	1,15	0,873	1618,5	1861,3
	EW2	NE	3,86	4,19	16,17	16	-26	42	1,15	0,873	592,7	681,7
										SUM	2211,3	2543,0
										The total heat loss		**2543**
ility	EW	NW	3,31	4,19	13,87	16	-26	42	1,1	0,873	508,3	559,1

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Heat loss calculation

										SUM	508,3	559,1
										The total heat loss		**559**
519-staff room	EW1	NW	5,30	4,19	22,21	22	-26	48	1,15	0,873	930,1	1069,7
	EW2	SW	4,55	4,19	19,06	22	-26	48	1,15	0,873	798,5	918,3
	IW3		1,66	4,19	6,96	22	5	17	1	2,303	272,3	272,3
	IW4		1,95	4,19	8,17	22	5	17	1	2,30	319,9	319,9
										SUM	2320,8	2580,1
										The total heat loss		**2580**
520-technical room	EW		6,70	4,19	28,07	16	5	11	1	3,559	1099,0	1099,0
										SUM	1099,0	1099,0
										The total heat loss		**1099**
522-WC	EW	SW	4,12	4,19	17,26	16	-26	42	1	0,873	632,7	632,7
	KP				33,60	16	-26	42	1	0,209	294,9	294,9
										SUM	927,6	927,6
										The total heat loss		**928**
523-WC	EW	SW	3,36	4,19	14,08	16	-26	42	1	0,873	516,0	516,0
	KP				34,03	16	-26	42	2	0,209	298,7	597,4
										SUM	814,7	1113,4
										The total heat loss		**1113**
524	EW1	SE	7,50	4,19	31,43	20	-26	46	1,1	0,873	1261,4	1387,5
	EW2	SW	1	4,19	4,19	20	-26	46	1,1	0,873	168,2	185,0
	WD				6,38	20	-26	46	1,1	0,852	249,9	274,9
	KP				59,52	20	-26	46	2,1	0,209	572,2	1201,7
										SUM	2251,7	3049,1
										The total heat loss		**3049**
The sum of heat loss of fifth floor = 36280 W												
Sixth floor												
603-hall	EW1	NW	5,40	3,86	20,84	18	-26	44	1,1	0,873	800,3	880,3
	EW2	SW	23,16	3,86	89,40	18	-26	44	1	0,873	3432,4	3432,4
	WD1	NW			2,62	18	-26	44	1,1	0,852	98,2	108,0
	WD2	SW			26,40	18	-26	44	1	0,852	989,1	989,1
	WD3	SW			5,84	18	-26	44	1	0,873	224,2	224,2
										SUM	5544,2	5634,0
										The total heat loss		**5634**
604	EW	SE	6,68	3,86	25,78	18	-26	44	1,05	0,873	990,0	1039,5
	WD	SE			2,85	18	-26	44	1,05	0,852	106,8	112,1
	KP				24,30	18	-26	44	1	0,209	223,5	223,5
										SUM	1320,2	1375,1
										The total heat loss		**1375**
605	EW	SE	11,30	3,86	43,62	18	-26	44	1,05	0,873	1674,7	1758,4
	WD	SE			2,85	18	-26	44	1,05	0,852	106,8	112,1
	KP				33,97	18	-26	44	1	0,209	312,4	312,4
										SUM	2093,9	2182,9

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Heat loss calculation

										The total heat loss		**2183**
606	EW	SE	11,93	3,86	46,05	18	-26	44	1,05	0,873	1768,1	1856,5
	WD	SE			2,85	18	-26	44	1,05	0,852	106,8	112,1
	KP				40,96	18	-26	44	1	0,209	376,7	376,7
										SUM	2251,5	2345,2
										The total heat loss		**2345**
607	EW1	SE	5,46	3,86	21,08	20	-26	46	1,15	0,873	846,0	972,9
	EW2	E	5,71	3,86	22,04	20	-26	46	1,15	0,873	884,7	1017,4
	EW3	NE	5,70	3,86	22,00	20	-26	46	1,15	0,873	883,2	1015,6
	WD1	SE			2,85	20	-26	46	1,15	0,852	111,6	128,4
	WD2	E			2,32	20	-26	46	1,15	0,852	90,9	104,5
	WD3	NE			2,85	20	-26	46	1,15	0,852	111,6	128,4
	KP				15,81	18	-26	44	1	0,209	145,4	145,4
	KP				15,81	18	-26	44	1	0,209	145,4	145,4
										SUM	3218,7	3657,9
										The total heat loss		**3658**
608	EW	NE	11,02	3,86	42,54	18	-26	44	1,05	0,873	1633,2	1714,9
	WD	NE			5,70	18	-26	44	1,05	0,852	213,6	224,2
	KP				27,63	18	-26	44	1	0,216	262,6	262,6
										SUM	2109,4	2201,7
										The total heat loss		**2202**
609	EW	NE	5,40	3,86	20,84	18	-26	44	1,1	0,873	800,3	880,3
	KP				13,50	18	-26	44	1	0,209	124,1	124,1
										SUM	924,4	1004,5
										The total heat loss		**1004**
610	EW	NE	5,40	3,86	20,84	18	-26	44	1,1	0,873	800,3	880,3
	KP				13,50	18	-26	44	1	0,209	124,1	124,1
										SUM	924,4	1004,5
										The total heat loss		**1004**
611	EW	NE	5,40	3,86	20,84	18	-26	44	1,1	0,873	800,3	880,3
	KP				13,50	18	-26	44	1	0,209	124,1	124,1
										SUM	924,4	1004,5
										The total heat loss		**1004**
612	EW	NE	5,40	3,86	20,84	18	-26	44	1,1	0,873	800,3	880,3
	WD	NE			2,55	18	-26	44	1,1	0,852	95,5	105,1
	KP				13,50	18	-26	44	1	0,209	124,1	124,1
										SUM	1020,0	1109,6
										The total heat loss		**1110**
613	EW	NE	5,40	3,86	20,84	18	-26	44	1,1	0,873	800,3	880,3
	WD	NE			2,55	18	-26	44	1,1	0,852	95,5	105,1
	KP				13,50	18	-26	44	1	0,209	124,1	124,1
										SUM	1020,0	1109,6
										The total heat loss		**1110**

APPENDIX 2(19).

Heat loss calculation

614	EW1	NE	9,64	3,86	37,21	20	-26	46	1,15	0,873	1493,6	1717,7
	EW2	NW	5,96	3,86	23,01	20	-26	46	1,15	0,873	923,4	1062,0
	IW3		1,55	3,86	5,98	20	5	15	1	2,610	234,2	234,2
	IW4		2,98	3,86	11,50	20	5	15	1	2,610	450,3	450,3
	WD1	NE			7,65	20	-26	46	1,15	0,852	299,7	344,6
	WD2	NE			7,65	20	-26	46	1,15	0,852	299,7	344,6
	KP				22,50	18	-26	44	1	0,209	206,9	206,9
										SUM	3907,8	4360,3
										The total heat loss		**4360**
616-tambour	EW1	NW	10,54	3,86	40,68	16	-26	42	1,15	0,873	1491,1	1714,7
	EW2	NE	3,86	3,86	14,90	16	-26	42	1,15	0,873	546,1	628,0
										SUM	2037,1	2342,7
										The total heat loss		**2343**
618-utility room	EW	NW	3,31	3,86	12,78	16	-26	42	1,1	0,873	468,3	515,1
										SUM	468,3	515,1
										The total heat loss		**515**
619-staff room	EW1	NW	5,30	3,86	20,46	22	-26	48	1,15	0,873	856,9	985,4
	EW2	SW	4,55	3,86	17,56	22	-26	48	1,15	0,873	735,6	846,0
	IW3		1,66	3,86	6,41	22	5	17	1	2,303	250,9	250,9
	IW4		1,95	3,86	7,53	22	5	17	1	2,30	294,7	294,7
										SUM	2138,1	2376,9
										The total heat loss		**2377**
620-technical room	IW1		3,17	3,86	12,24	16	5	11	1	3,559	479,0	479,0
	IW1		0,82	3,86	3,17	16	5	11	1	3,559	123,9	123,9
										SUM	602,9	602,9
										The total heat loss		**603**
621	IW1		3,60	3,86	13,90	16	5	11	1	3,559	544,0	544,0
										SUM	544,0	544,0
										The total heat loss		**544**
										The sum of heat loss of sixth floor =		**33460 W**
						Mansard						
702-hall	KP				5,88	16	-26	42	1	0,216	53,3	53,3
										SUM	53,3	53,3
										The total heat loss		**53**
703-Technical room	KP				16,30	16	-26	42	1	0,230	157,5	157,5
										SUM	157,5	157,5
										The total heat loss		**157**
704-cloakroom	EW		3,60	1,50	5,40	18	12	6	1	6,525	211,4	211,4
	KP1				20,50	18	-26	44	1	0,216	194,8	194,8
										SUM	406,2	406,2
										The total heat loss		**406**
restor an	EW1	SW	23,25	3,33	77,31	22	-26	48	1,15	0,873	3238,0	3723,7
	WD1	SW			2,55	22	-26	48	1,15	0,852	104,2	119,9

APPENDIX 2(20).

Heat loss calculation

	IW2		16,63	1,50	24,95	22	12	10	1	6,525	1627,7	1627,7
	WD2	SE			26,67	22	-26	48	1,05	1,724	2207,2	2317,5
	IW3	SE	1,44	1,50	2,16	22	12	10	1,05	6,525	140,9	148,0
	IW4		28,18	1,50	42,27	22	12	10	1	6,525	2758,1	2758,1
	WD2	NE			57,33	22	-26	48	1,15	1,724	4744,6	5456,2
	KP				400,00	22	-26	48	1	0,209	4012,8	4012,8
	D1		1,80	0,70	1,26	22	16	6	1	0,000	0,0	0,0
	D2		1,80	0,70	1,26	22	16	6	1	0,000	0,0	0,0
										SUM	#####	20163,8
										The total heat loss		**20164**
706-hall	EW1		1,20	1,10	1,32	18	12	6	1	6,525	51,7	51,7
	EW2		3,25	1,10	3,58	18	12	6	1	6,525	140,0	140,0
	EW3		3,22	1,10	3,54	18	12	6	1	6,525	138,7	138,7
	EW4		3,22	1,10	3,54	18	12	6	1	6,525	138,7	138,7
	WD1	SW			8,30	18	-26	44	1	1,724	629,7	629,7
	WD2	N			8,30	18	-26	44	1,1	1,724	629,7	692,6
	KP				5,00	18	-26	44	1	0,216	47,5	47,5
										SUM	1775,8	1838,8
										The total heat loss		**1839**
707-Tower 1 floor	EW1	SW	5,44	3,93	21,38	18	-26	44	1,15	0,267	251,2	288,8
	EW2	S	1,21	3,93	4,76	18	-26	44	1,15	0,267	55,9	64,2
	EW3	SE	5,27	3,93	20,71	18	-26	44	1,15	0,267	243,3	279,8
	EW4	E	0,97	3,93	3,81	18	-26	44	1,15	0,267	44,8	51,5
	EW5	NE	5,70	3,93	22,40	18	-26	44	1,15	0,267	263,2	302,6
										SUM	858,3	987,0
										The total heat loss		**987**
738-tower doom	DO		132,00	1,00	132,00	22	-26	48	1,25	1,724	#####	13655,2
										SUM	#####	13655,2
										The total heat loss		**13655**
708-WC	KP1				2,80	16	-26	42	1	0,216	25,4	25,4
	KP2				3,00	16	-26	42	1	0,216	27,2	27,2
										SUM	52,6	52,6
										The total heat loss		**53**
709-smoking-room	EW1	NW	7,23	3,26	23,57	16	-26	42	1	0,873	863,8	863,8
	EW2	NE	3,77	3,26	12,29	16	-26	42	1	0,873	450,4	450,4
	WD1	NE			2,61	16	-26	42	1	0,852	93,3	93,3
	WD2	NE			2,61	16	-26	42	1	0,852	93,3	93,3
	KP				37,47	16	-26	42	1	0,209	328,9	328,9
										SUM	1829,8	1829,8
										The total heat loss		**1830**
710-WC	EW1	SW	3,84	2,89	11,10	16	-26	42	1	0,873	406,7	406,7
	KP				17,93	16	-26	42	1	0,209	157,4	157,4
										SUM	564,1	564,1

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Heat loss calculation

										The total heat loss		**564**
711-WC	KP				12,20	16	-26	42	1	0,209	107,1	107,1
										SUM	107,1	107,1
										The total heat loss		**107**
712-Utility room	KP				4,12	16	-26	42	1	0,209	36,2	36,2
										SUM	36,2	36,2
										The total heat loss		**36**
713-WC	KP				2,00	16	-26	42	1	0,209	17,6	17,6
										SUM	17,6	17,6
										The total heat loss		**18**
714-Utility room	KP				2,00	16	-26	42	1	0,209	17,6	17,6
										SUM	17,6	17,6
										The total heat loss		**18**
715-hall	EW1	NW	5,40	4,11	22,19	16	-26	42	1,1	0,873	813,4	894,7
	WD1	NW			2,61	16	-26	42	1,1	0,852	93,3	102,7
	KP1				61,59	16	-26	42	1	0,209	540,6	540,6
										SUM	1447,4	1538,0
										The total heat loss		**1538**
716-Technical room	EW1	NW	2,00	3,26	6,52	5	-26	31	1	0,873	176,4	176,4
	KP				14,21	5	-26	31	1	0,209	92,1	92,1
										SUM	268,4	268,4
										The total heat loss		**268**
717-Cloakroom and WC	EW1	SW	4,30	3,26	14,02	22	-26	48	1,1	0,873	587,1	645,9
	EW2	NW	7,98	3,26	26,01	22	-26	48	1,15	0,873	1089,6	1253,1
	KP				30,42	22	-26	48	1	0,209	305,2	305,2
										SUM	1981,9	2204,1
										The total heat loss		**2204**
718-Utility room	KP				2,87	16	-26	42	1	0,209	25,2	25,2
										SUM	25,2	25,2
										The total heat loss		**25**
719-Hall	EW1	NW	10,71	3,26	34,91	16	-26	42	1,15	0,873	1279,6	1471,5
	EW2	NE	3,91	3,26	12,75	16	-26	42	1,15	0,873	467,2	537,2
	KP				42,2	16	-26	42	1	0,209	370,4	370,4
										SUM	2117,2	2379,2
										The total heat loss		**2379**
720-storage room	KP				7,12	16	-26	42	1	0,209	62,5	62,5
										SUM	62,5	62,5
										The total heat loss		**62**
721-storage room	KP				6,77	16	-26	42	1	0,209	59,4	59,4
										SUM	59,4	59,4
										The total heat loss		**59**
722	KP				10,00	16	-26	42	1	0,209	87,8	87,8
										SUM	87,8	87,8

APPENDIX 2(22).

Heat loss calculation

										The total heat loss		**88**
723-staff room	KP				9,50	16	-26	42	1	0,209	83,4	83,4
										SUM	83,4	83,4
										The total heat loss		**83**
724-staff room	KP				7,00	16	-26	42	1	0,209	61,4	61,4
										SUM	61,4	61,4
										The total heat loss		**61**
725-Hot shop	KP				18,48	16	-26	42	1	0,209	162,2	162,2
										SUM	162,2	162,2
										The total heat loss		**162**
726-Cold shop	KP				14,20	16	-26	42	1	0,209	124,6	124,6
										SUM	124,6	124,6
										The total heat loss		**125**
727-staff room	KP				18,84	16	-26	42	1	0,209	165,4	165,4
										SUM	165,4	165,4
										The total heat loss		**165**
728	KP				2,22	16	-26	42	1	0,209	19,5	19,5
										SUM	19,5	19,5
										The total heat loss		**19**
729	KP				11,67	16	-26	42	1	0,209	102,4	102,4
										SUM	102,4	102,4
										The total heat loss		**102**
730-staff room	KP				9,63	16	-26	42	1	0,216	87,4	87,4
										SUM	87,4	87,4
										The total heat loss		**87**
731-Utility room	KP1				6,50	16	-26	42	1	0,216	59,0	59,0
										SUM	59,0	59,0
										The total heat loss		**59**
732-Technical room	EW	NE			1,76	16	-26	42	1,15	0,873	64,5	74,2
	KP1		3,07	4,56	14,00	16	-26	42	1	0,209	122,9	122,9
	KP2		4,53	4,88	22,11	16	-26	42	1	0,216	200,5	200,5
										SUM	387,9	397,6
										The total heat loss		**398**
733-Utility room	EW1	NW			19,69	16	-26	42	1,15	0,873	721,6	829,9
	KP		4,27	2,81	12,00	16	-26	42	1	0,216	108,9	108,9
	IW2		1,55	2,50	3,88	16	5	11	1	3,559	151,7	151,7
	IW3		2,73	2,50	6,83	16	5	11	1	3,559	267,2	267,2
										SUM	1249,4	1357,6
										The total heat loss		**1358**
Tech 1	KP				46,30	16	-26	42	1	0,216	420,0	420,0
										SUM	420,0	420,0
										The total heat loss		**420**
Tech 2	KP				100,50	16	-26	42	1	0,216	911,7	911,7

APPENDIX 2(23).

Heat loss calculation

										SUM	911,7	911,7
										The total heat loss		**912**
Tech 3	KP				16,31	16	-26	42	1	0,216	148,0	148,0
										SUM	148,0	148,0
										The total heat loss		**148**
Tech 4	KP				42,50	16	-26	42	1	0,216	385,6	385,6
										SUM	385,6	385,6
										The total heat loss		**386**
										The sum of heat loss of mansard = 51150 W		
						Staircase						
Staircase 1	EW1	SE	2,94	2,82	8,29	16	-26	42	1,15	0,873	303,9	349,4
	EW2	SW	8,75	2,82	24,68	16	-26	42	1,15	0,873	904,3	1040,0
	WD1	SE			3,55	16	-26	42	2,105	1,553	231,6	487,4
	WD2	SW			1,60	16	-26	42	1	1,553	104,4	104,4
	CR				31,50	16	-26	42	1	1,103	1459,3	1459,3
	KP				36,68	16	-26	42	1,15	0,216	332,8	382,7
										SUM	3336,1	3823,1
										The total heat loss		**3823**
Staircase 2	EW1	NW	7,20	29,58	212,98	16	-26	42	1,1	0,308	2756,5	3032,2
	WD1	NW			1,30	16	-26	42	1,1	1,416	77,3	85,0
	WD2	NW			24,40	16	-26	42	1,1	1,416	1451,1	1596,2
	WD3	NW			2,06	16	-26	42	1,1	1,416	122,5	134,8
	WD4	NW			6,78	16	-26	42	1,1	1,416	403,2	443,5
	KP				42,85	16	-26	42	1	0,216	388,7	388,7
	sl1		6,98	2,00	13,96	16	-26	42	1	0,48	281,4	281,4
	sl2		6,98	2,00	13,96	16	-26	42	1	0,23	134,9	134,9
	sl3		6,98	2,00	13,96	16	-26	42	1	0,12	70,4	70,4
	sl4		6,98	1,52	10,61	16	-26	42	1	0,07	31,2	31,2
										SUM	5717,2	6198,3
										The total heat loss		**6198**
Staircase 3 (near cafe)	EW	NE	5,48	4,70	25,76	16	-26	42	1,1	0,873	943,9	1038,3
	WD1	NE			17,80	16	-26	42	1,1	0,852	636,6	700,3
	WD2	NE			4,48	16	-26	42	1,1	1,724	324,4	356,9
	KP				13,34	16	-26	42	1	0,216	121,0	121,0
	sl1				13,60	16	-26	42	1	0,48	274,2	274,2
	sl2				9,99	16	-26	42	1	0,23	96,5	96,5
	sl3				0,00	16	-26	42	1	0,12	0,0	0,0
	sl4				0,00	16	-26	42	1	0,07	0,0	0,0
										SUM	2396,7	2587,2
										The total heat loss		**2587**
Staircase 4	EW1		7,00	33,15	232,02	16	-26	42	1,1	0,873	8503,2	9353,5
	EW2		4,37	24,66	107,76	16	-26	42	1,15	0,873	3949,5	4541,9
	WD	SW	1,50	1,50	13,50	16	-26	42	1,15	0,852	482,8	555,2

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Heat loss calculation

	KP				28,27	16	-26	42	1	0,216	256,5	256,5
	CR				28,27	16	-26	42	1	1,103	1309,6	1309,6
										SUM	#####	16016,7
										The total heat loss		**16017**
											The sum of heat loss of staircase = 28640 W	
											The sum of heat loss of building = 342240 W	
											The total heat load (with losses in the pipes - 7%) = 366197 W	

APPENDIX 2(1).

Heat loss calculation