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CALCULATING OF ENERGY CONSUMPTION OF THE SPORTS HALL

Bachelor's thesis
Degree program in building service engineering

December 2011

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Name of the bachelor's thesis

Calculating of energy consumption of the sports hall

Abstract

The subject of this thesis is energy consumption for the sports hall which is represented by air-supported structure. Such constructions are not common and have some features. In the thesis there is a description of the air dome especially such parameters as envelope, heating and cooling system.

One of the main points of the thesis is to compare energy consumption of the hall with different types of envelope. In this thesis there are calculations about heat losses and heat loads especially for air dome. As a result there is a table with energy consumption for different types of envelope and special settings for heating system. Finally, the most energy efficient envelope is selected and justified.

Also description and choosing the parameters of indoor climate is included in the thesis. Three different standards are compared to select the good indoor conditions. Beside description of the indoor climate there are recommendations for saving energy. These tips based on calculations and show the ways how to save energy in air supported structures. This information can be useful to both manufacturers and owners.

Subject headings (keywords)

Air supported structure, air dome, PVC membrane, envelope, heat losses, heat gain.

Pages	Language	URN
62, appendices 4	English	

Remarks, notes or appendices

Tutor	Bachelor's thesis assigned by
Aki Valkeapää	

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1 INTRODUCTION

Sports hall is a place where everyone can enjoy free time. Sportsmen can perform the best results and achieve success there. Audience can enjoy the performance. Everyone is satisfied. But do you know how much energy we utilize for this purpose? I think, no. But the amount of wasted energy is terribly big. Therefore, experts started to care of it. For this purpose, there are a lot of ways to reduce energy consumption and nowadays specialists are trying to follow these ways. So if assumption is justified we can significantly reduce the amount of energy consumption before year 2020.

My thesis covers the analysis of energy consumption for air-supported structure, which has not been built yet. Air dome is used for sports hall, especially for halls for professional football games. Such structures are not common now but very useful, and they don't required high investments in manufacturing and installation. The production costs of these air domes depend on many factors such as different types of shell, heating and cooling systems, base and lighting. And each of these factors impacts on operation cost and other different benefits.

The aim of this thesis is to find out the effect of the type of envelop on energy consumption. For this purpose, I have to detect dimensions and types of ventilation, heating, cooling and lighting of the sports hall. These parameters are considered to be constant and I will change only type of shell and operation time of the sports hall. Calculations are done for three main types of the envelope of air-supported structure. Results of these calculations have to be compared, and the best type of shell is selected then.

Another objective is to give recommendations for saving energy. Energy demand depends on many factors. Each of these factors is analyzed and recommendations for energy efficiency are given. Based on calculations, different operation times and settings of equipment are compared and analyzed for choosing the most energy efficient.

Beside the results of calculations this thesis helps manufactures and owners of air supported structures to save energy and develop indoor climate. It can help to choose suitable equipment for air domes. Also, it shows the way that is better for operating air supported sports facility.

Firstly, information about sports hall and indoor climate will be given here. Different inside conditions are possible. That is why different requirements are considered and compared for definition the best one. Then the envelope parts are described. Their parameters are compared, and some values for calculation are given as well. Next part is the main part of this thesis. It describes calculations and formulas used for definition energy consumption. Then based on these calculations I will give some recommendations and additions about equipment and settings for energy conservation. Certainly, one of significant factors affecting the energy consumption is the size of the sports facility. Therefore, I will start the description of the sports hall from the dimensions.

2 DESCRIPTION OF THE SPORT HALL

First of all, when designer is projecting and dimensioning any construction he has to know purpose, dimensions and type of structure. The sports hall is designed for conditions required for the southern city of Finland called Mikkeli. Inside this sports hall, there will be a football field that can be used for professional games and trainings. This playground can also be used for athletics and other different types of exercises.

2.1 Dimensions

For a good state of football ground with possibility to use it on high professional level, I should design the playground with dimensions required by FIFA World Cup™. This organization provides special ground for all professional football matches, and they set guidelines. “For all matches at the top professional level and where major international and domestic games are played, the playing field should have dimensions of 105m x 68m.”/1/. Also, it is necessary to have auxiliary area. “Additional flat areas are required beside the playing field, ideally behind each goal line, where players can warm up. This area should also allow for the circulation of assistant referees, ball boys and girls, medical staff, security staff and the media. It is recommended that this should be a minimum of 8.5m on the sides and 10m on the ends. This results in an overall playing field and auxiliary area dimension of length: 125m, width: 85m."/1/. On the following picture, you can notice dimensions of our ground.

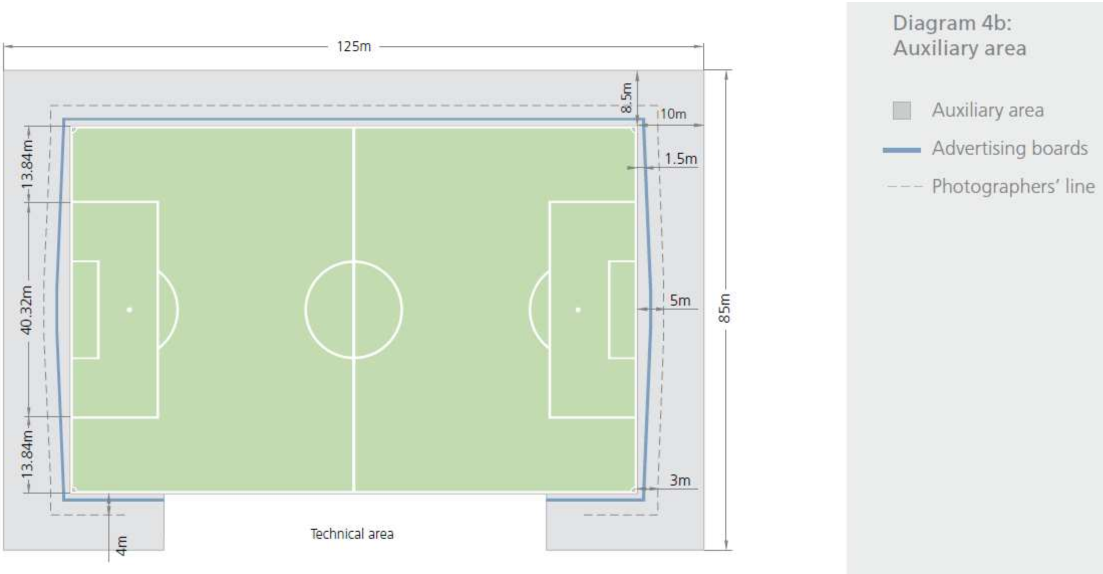


Figure 1. Dimensions and layout of a football ground /1/

In the sports arena it is necessary to take care of spectators as well. I will make a special area for audience. The capacity of the stands is 500 sitting places. It means that the total area for our air supported structure is 125 x 90m. So when I know dimensions for playground I can think about occupants.

2.2 Number of occupants

When sports facility is designed, perfect ventilation and thermal conditions must be designed too. Without them, there is high probability of getting some kind of injures, so sportsmen health can be at risk. To provide hall with good indoor air quality designer has to know a lot of things such as the number of occupants, dimensions, and type of building. This large sports arena is designed, so it means that there are a lot of conditions that can determines how many people are situated in our hall. For example, if there are only trainings in the facility it means that there will be about one hundred occupants, but if it is an official match between two teams there will be not more than seven hundred occupants.

This sports hall is a public building, so high quality of indoor air should be provided. Consequently, it is necessary to calculate the maximum amount of occupants that will be at sport hall at the same time. In our case, there are seats for 500 spectators and 50 service persons and place not more than for 100 sportsmen. It means that the total amount of people who situated inside the building is 650. And we should not forget that this is the maximum number of occupants that should be provided with indoor air conditions. It means that when I will calculate air flow change and thermal conditions it is necessary to remember the number of occupants in our structure.

3 INDOOR CLIMATE

First of all, when HVAC systems are designed, the organization in charge of it has to know all kinds of conditions that provide normal work of the construction and occupants. There are some significant parameters that help to achieve these conditions. Values of these parameters are possible to find in different standards and requirements. In this thesis work I will investigate recommendations given by National Building Code of Finland (D2), American Standard (ASHRAE), Russian National Building Code (31-112-2004). Of course, indoor conditions have to meet with the Finnish guidelines because the sports hall is situated in Finland. But it is possible to improve indoor climate if indoor conditions meet with other standards that give the regulations for the best state of indoor air. For this reason this comparison will be done.

3.1 Finnish national building code D2. Regulation and guidelines

In the following chapter, I will look closer at the regulations that are applied in Finland. These guidelines are the most essential for our structure because the sport hall will be situated in Mikkeli. It means, recommendations for this location has to be considered. In D2 Regulations and guidelines 2003 “Indoor climate and ventilation of building” /2/ there is general information about acceptable indoor climate in buildings and spaces. Also, there is “Guideline values for room temperatures for different room types during the heating season for premises where the room temperature design value is not 21 ^{0}C.” /2 p.8/. There are no special regulations for sport halls, but there is the guideline for gymnastics hall. According the National Building Code of Finland D2 temperature in sports facility hall has to be 18 ^{0}C.

At the same time, normal level of relative humidity must be ensured, but there is no exact value of it in D2. It is only written: “The humidity of indoor air shall not be harmfully high on a continual basis, nor shall humidity be allowed to concentrate on structures or their surfaces or in the ventilation system in such a way that it will cause moisture damage, growth of microbes or micro-organisms or any other health hazards.” /2, p.10/. It means, in each case, I have to produce moisture level based on the purpose of the facility.

Another important value is air change rate. This is one of omportant amounting of indoor air quality. In the Finish National Building Code D2, there is “guideline values for air flow rates, air movement and sound level.” /2, p.30/. This guideline gives us information that air velocity should not exceed 0.24 m/s for our temperature and air change rate have to be 2 $(dm^3/s)/m^2$. The value of air change is taken for large gym hall, because it is quite similar with our sport facility.

To meet the Finish National Building Code D2 I have to provide indoor climate of the sports hall with 18 ^{0}C degrees Celsius and relative humidity 40-70%.

3.2 Russian National Building Code 31-112-2004. Physical training and sport halls.

In this chapter I will investigate the regulations which Russian National Building Code gives us for physical training and sport halls. This document has a special chapter about engineering systems, heating and ventilation. There are guidelines for temperature and relative humidity.

“Designing parameters of air inside sports halls without an audience made temperature of 15 ° C with relative humidity 35 - 60% and air velocity not more than 0.3 m /s. In areas for health and fitness classes estimated temperature during the cold period is taken 18 ° C and relative humidity is 30 – 60%. At summertime temperature should not exceed 25 ^{0}C.” /3, p.34/.

In our case, there is the athletic hall with 500 people audience. It means that operative temperature is 18 ^{0}C and relative humidity is 30-60%. But when there are only trainings and other exercises, in other words when there is no audience it is possible to lower temperature to 15 ^{0}C for saving energy. But these changes are difficult to put into account because they are given just as a recommendation for staff.

3.3 ASHRAE

In this chapter, I will consider ANSI/ASHRAE Standard 55-2004 "Thermal environmental conditions for human occupancy." /4/. In this document, there is information about operative temperature, humidity limits, elevated air speed, radiant temperature, metabolic rate and clothing insulation. In this paper there is information about how to calculate these parameters and determine the number of dissatisfied occupants. Also, ASHRAE standard gives value for predicted percentage dissatisfied (PPD) and predicted mean vote (PMV). Categories A and B are acceptable by ASHRAE standard. To meet these categories PPD and PMV has to not exceed the values which are shown in table 1.

Table 1. Acceptable Thermal Environment for General Comfort /4, p.6/

Category	PPD, %	PMV Range
A	< 6	-0.2 < PMV < + 0.2
B	< 10	-0.5 < PMV < + 0.5
C	< 15	-0.7 < PMV < + 0.7

This standard does not give information about exact values of temperature and relative humidity in sports halls. But it is possible to use the document when the equipment will be adjusted.

3.4 Comparison

The conditions have to be designed in such way that temperature, relative humidity and air movement does not cause any dissatisfaction for occupants. Also, these conditions have to provide normal work of construction and equipment. Luckily, the envelope of air-supported structure is not exposed to corrosion, fungus, mold etc. This is one of the advantages of PVC membrane. Anyway, indoor air quality has to achieve to meet standards and guidelines. Table 2 has done to simplify the selection of the indoor conditions.

Looking in table 2, we can notice comparison guidelines of different countries for sport facilities

Table 2. Indoor air guidelines for sports halls

Standards Parameters of Indoor Climate	D2(Finish)	31-112-2004(Russian)	ASHRAE(American)
Temperature, C	18	15-18	Adjusting
Relative humidity, %	Adjusting(40-70)	30-60	Adjusting
Air velocity, m/s	≤0,24	≤0,3	≤0,8

Summarizing these standards, I suppose that it will be better to combine different parameters in order to provide perfect indoor air quality. But at the same time I will try to achieve conditions to meet with all of these requirements. Temperature has to be provided in such a way audience does not feel cold during their stay on places. I prefer 18 degrees of Celsius for our sports hall in winter time and 21 ^{0}C in summer time, and relative humidity has to be 40- 50%. It is necessary to avoid draft. That means that air velocity should not exceed 0,24 m/s according to D2.

Now I know dimensions and number of occupants in sports hall, and I know indoor climate conditions that are taken from different standards. On the next chapter, I can start to design envelopes and equipment.

4 FACTORS AFFECTING ENERGY CONSUMPTION

The amount of energy is measured in Joules (J) or kilowatt-hours (kWh). However, talking about energy consumption for whole building, unit usually is MWh. There are two laws of thermodynamics. The first of it states that neither energy nor matter can be destroyed. The second law of thermodynamics presents rules that guide in which way transformations are possible.

"Energy that has not been converted into any other form such as hydropower, coal and crude oil." /5/. However, we can decide what type of energy is possible to use for the air-supported structure. There are a lot of types of energy, for example renewable, hydropower, solar and geothermal energy.

All the time energy in a building has to be in balance. There are inlet and outlet flows of energy as it is shown in figure 2. Total heating energy consumption, which is required for building, is calculated based on these heat gains and heat losses.

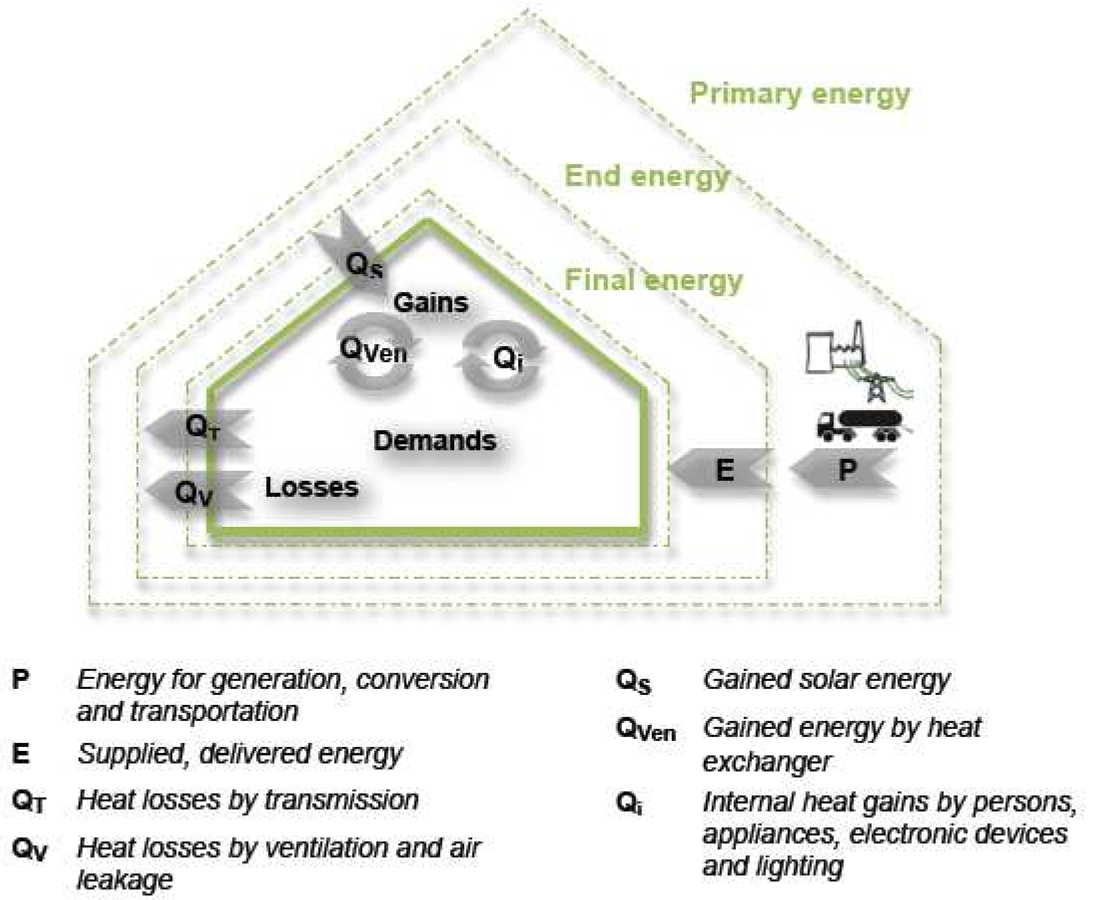


Figure 2. Buildings energy balance /6, p.14/

It is necessary to keep heat inside as much as possible for saving money and energy.

4.1 The envelope

One of the important parts of energy conservation strategy is envelope. In air supported structures the most of heat loss occurs through the envelope such as shell and floor. Heat losses through the floor are quite voluminous. These losses appear due to concrete structures under the building that have high U-value. In the common case, these structures can be insulated, but it takes specific materials and extra costs. However, it should be done for energy conservation. In this work, I calculate heat losses of air supported structures with constant structure of the floor and different types of envelope. There are 3 mainly different types of surrounding surfaces in air domes. These types will be clarified below.

4.1.1 Shell

In this work, I design sports hall, which is represented by air supported structure. Shells of air domes may have different shapes and ways of fastening to the ground such as untreated ground or uncommon foundation slab. The most popular shape of air domes is a cylinder. Shell also can be one-, two-, three-layer depending on the required values of insulation characteristics. Three baseline air-supported structures are analyzed in this thesis.

First of all, single-layer membranes without insulation and different types of heat emitters are used in summer time only. Usually this type of membrane has small weight and cheap fixing. It is impossible to warm this construction during the winter times because of huge heat losses. Sometimes air domes are insulated and then are set up individual equipment for heating. In such case, it is possible to use it during the whole year.

Second structure is the most common. Double membrane is often used in air-supported halls designed for different types of sport facilities. Nowadays it is an acceptable variant for countries without extreme climate. This type has a quite adept thermal resistance and durability properties. With this structure, there is a possibility to use both cooling and heating systems. It means that owner can use the air dome during the whole year. On the figure 3, we can notice scheme of double membrane.

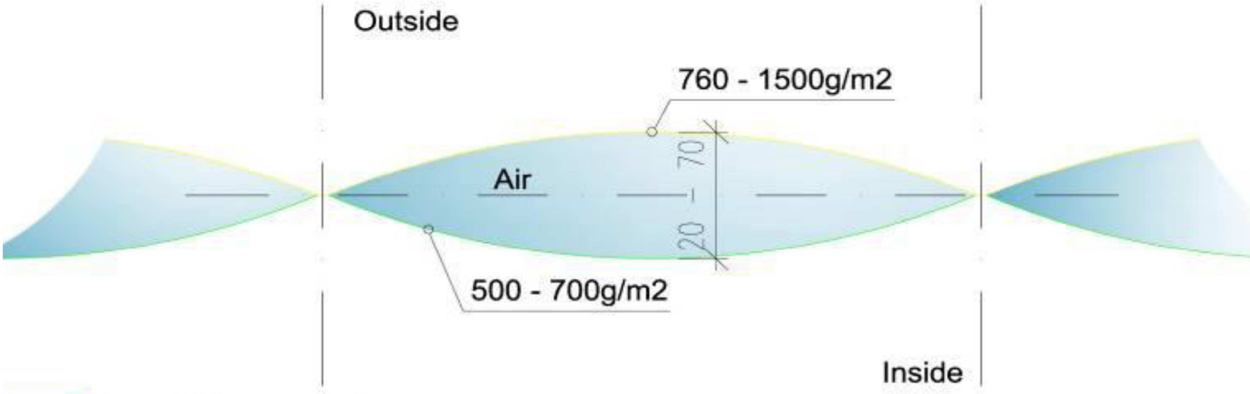


Figure 3. Double membrane scheme /7 p.7/

The last type is a triple-layer membrane that is not common now. There are a lot of benefits of this type of envelope. This membrane has small U-value; it means that heat losses through the shell are the smallest in comparison with other membranes. Insulation of thin parts of double membrane or third layer of the envelope provides the value of heat conductivity with air gap between these layers.

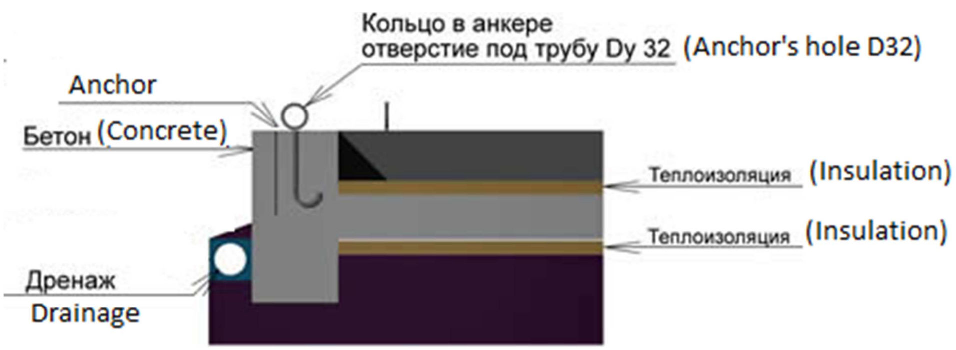
"Experiences from built houses and detailed building simulations call for a careful and integrated approach when designing heating and cooling systems for nearly zero energy buildings is clearly a need to adapt our current systems in such a way that they optimize both energy use and comfort requirements in low energy construction." /6/. In the way of energy conservation strategy, this type of envelope for air supported structure is the best one. At first, it requires more investments but with using heating and cooling systems it can provide a short period of payback and long period of work. It can save a lot of money for air dome's owner if they will use the sports hall regularly.

Membranes for air supported structures have a lot of benefits and meet with all regulations of civil structures. As well, this type of envelope is easy to maintain and it has a long period of life, excellent resistance from weather, fire, fungus and mildew.

Pressure inside the structure depends on weight of the envelope of air dome and the pressure on the surface caused by wind and snow. For example, for light single membrane inside pressure is more than 150 Pa according the Russian Building Code CH 497-77. Of course, these values depend on dimensions of air dome. There is formula where pressure is a function of wind pressure and dimensions of air supported structure. Inside pressure affects on leakage air of the building. That is why it should be taken into account in calculations. Moreover, amount of leak air depends on fixing shell to base. Different types of fastening will consider further.

4.1.2 Base

Another kind of the envelope is a floor. One of advantages of air domes is a small weight of its constructions comparing with other building. It means that the cost of the foundation is much less than in standard sports facilities. Inside the air dome, there is overpressure. It means the building tends to break away from the ground. Foundation prevents it and it can be of two types: the anchor and the ballast. Anchor type of foundation is a concrete (steel) piles that are hammered into the ground (concrete slab), or metal screw piles that are screwed into the ground. Their number and size depends on the size of air dome. In figure 4 you can see the standard construction of the anchor type of foundation.



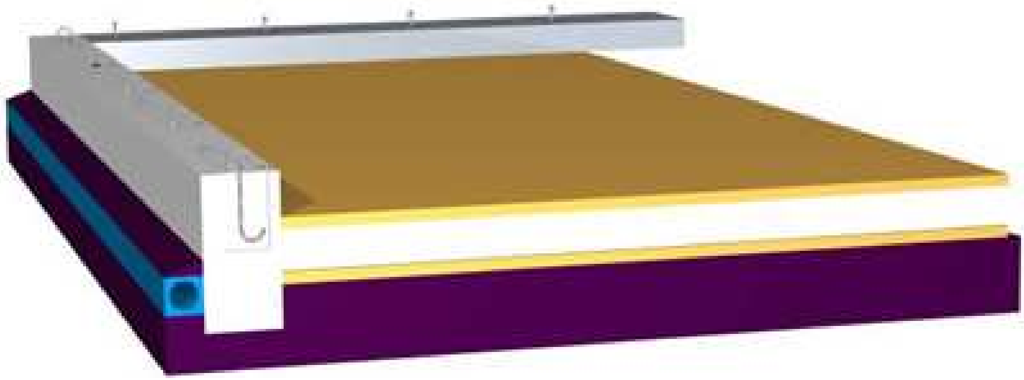


Figure 4. Foundation for anchor's fastening /8/

In this picture, strip foundation is shown with foundation slab under the building. Most common height of concrete layer is about 15 cm. This concrete slab is situated between two layers of insulation. Thickness of each insulation layer is 10 cm. During the insulation football ground should be installed as well.

Ballast foundation pier is made from monolithic concrete or precast concrete blocks, located along the contour of the shell. The minimum lateral dimensions of the foundation are 400 mm in width and 600 in height. Slope has to be not less than 4% from outside the foundation, to organize the flow of rainwater and melt water.

Steel angles and anchor bolts provide the junction of the shell and foundation by pressing the edge of air dome to the foundation slab. Water-filled bottles, bags of sand or other loose materials also can be used as ballast how it is shown on figure 5.

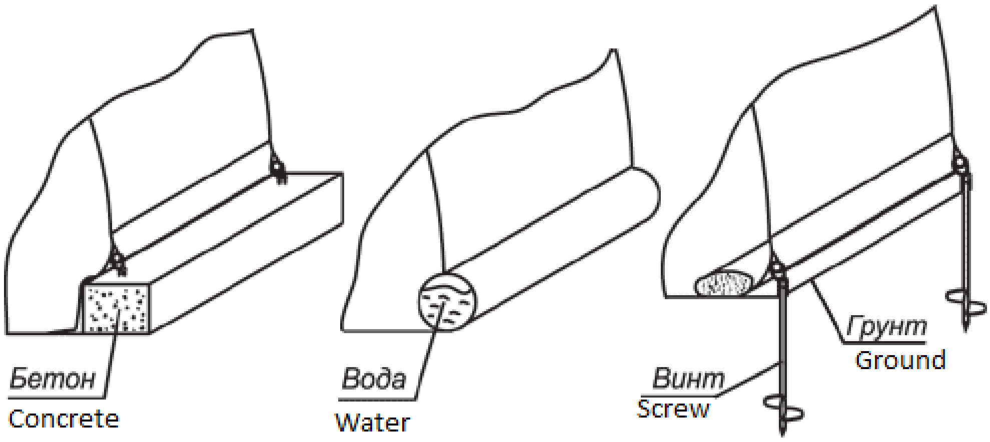


Figure 5. Ballast foundation /9/

This type of foundation has some disadvantages. For example, amount of leakage air is much bigger with this construction than with anchor’s foundation. For energy conservation, it is necessary to provide the best air-tightness. Taken all these disadvantages into consideration we can see that this type of foundation is not suitable.

4.2 The ventilation

Ventilation has to provide acceptable indoor air quality and prevent health hazards or any other pollutants. However, in air supported structures the purpose of ventilation is not to provide indoor climate only. In air domes ventilation is used for heating in winter time and cooling during the summer. What is more, ventilation is a system guaranteeing the stability of the dome. In air supported structures shell is based on air, which is blowing inside with particular oversized fans. Next, I will look closer on this system.

4.2.1 Heating by the ventilation system

Air heater depends on available source of heat. Heating coils or fire heaters are most common for air supported structures. In rare cases, electric heating is used but only for small areas because of high electricity price. Water or glycol heaters are very easy to use, and there are no disadvantages of it beside of the risk of thawing. When water heaters are using they should have strict link parameters of heat source and the load in the form of graphs and flow rate.

Also when warm air passes it is important to remember about durability of material. The material itself is very strength under normal temperature in the range -50 ... +50 ° C. But in excess of 60-70 ° C the material loss the durability and structure of material can be deformed. So when air dome is heated with air which temperature is above 60 ° C, it can cause deformation of the material and welds the individual bands of the shell.

For heating so large sports facility, I can use unique idea of designers from DUOL's company. They suggested using condensing heating unit with high thermal efficiency. This efficiency is achieved with condensing stainless steel boiler in combination with premix gas burner. The idea is quite understandable: "During combustion of the gas, water vapor is produces, which in traditional heaters leaves the unit through the chimney. In condensing boilers this water vapor is utilized and converted to heat energy for maximum efficiency. In premix burners air and gas are mixed in special air tight chamber, what ensures maximum gas efficiency. Burners are fully modulating, controlled by sensitive probe of outlet air temperature. With the unit running 40% of its working time on minimum and average of 40°C constant outlet air temperature, the low stratification effect is achieved. In overall the energy savings with the heating unit is 45-50%. "/10/. This system looks like it shown on figure 6.

Figure 6. Condensing ventilation/heating unit /10/

This equipment connects with fan that is situated inside the air dome and flows warm air. Special fans are used to prevent uneven distribution of warm air inside and provide recirculate air.

4.2.2 Recirculation system

Amount of recirculated air is 80% of all air flow. It means that it is very important to provide quality work of this system. The main purposes of fans are to circulate air and support the pressure in air supported structure.

Choosing the fan for air supported structure is very important task and it is necessary to pay attention to two main factors. The first factor is the value of the fan efficiency. This fan will operate 24 hours per day. Consequently, energy consumption for it will be very high. So efficiency of equipment plays very important role for energy saving strategy. It is possible to conserve 80 MWh annual with using higher efficiency fans.

The second factor in choosing a fan is a noise. Unfortunately, it is not always that the quietest fan has a maximum efficiency. The value of the ventilator pressure recirculation system usually is not more than 600-700 Pa. Airflows within 5.5-11 m^3/s is a standard. The use of silencers creates additional problems with the size and in most cases is not practical. In order to create pressure in the dome additional fan or a fan of the recirculating air heating can be used. When the leakage air flow increases rapidly, fan's flow increases without increasing power consumption. Overlapping of all leaks pressure is created by a fan. It is desirable to choose a fan with top limits of the pressure for example 1000 Pa. In this case, there is no risk of rupture of the shell.

4.2.3 Cooling system

Cooling system in air supported structures is used only in well insulated types of these structures and allows using the sports facility during all the year. Cooling usually is a large air-cooled condensing units having efficiencies ranging from EER = 10.0 to EER = 9.6. This efficiency range is indicative of currently available air-cooled units available from all commercial cooling suppliers.

DUOL Company offers a good idea of how to supply cold air inside the building and in the same time prevent vertical disparity in the distribution of cold air. One of the physic's low state is that hot air rises up and cold air moves down. So it is more useful to flow cold air under the top of the building. In this case warm air will rise up and will mix with cold air. Such distribution prevents irregular temperature inside the sports hall. Also occupants will not feel cold because of mixing cold and warm air. For this process DUOL made a special pipe with holes through which cold air flows. In figure 7 process of supply cold air is shown.

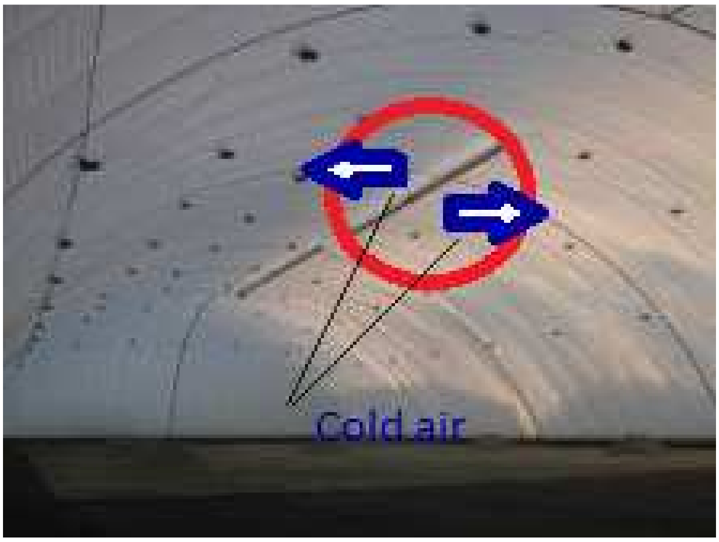


Figure 7. Distribution the cold air by special DUOL's pipe /10/

Amount of energy needed for cooling is calculated further. We take outside temperature and cool it to 17 ^{0}C and then distribute it to the fan. Usually in fan temperature rises on 1 ^{0}C. So then temperature of supply air will be 18 ^{0}C. All values of energy consumption for cooling are shown in APPENDIX 2.3.

In this chapter all ventilation processes was described. Further, some recommendations and advice of how to save energy will be given.

4.3 Heat gain factors

There are a lot of factors affecting energy consumption of building. Some factors influence heat losses, while others heat loads. Designer has to put heat gain's factors into account to prevent producing extra energy. Also, it helps to keep good thermal indoor conditions. Solar radiation, number of occupants, lighting and heat gain from electrical equipment are the factors affecting the energy consumption. Value of solar radiation is too small and difficult to calculate for air supports structure because there is no window in such buildings. But let us look closer on calculated heat gain factors.

4.3.1 Number of occupant

One of heat load factors is the number of occupants. People are in the sport hall for particularly in the daytime. Occupants generate heat which should be taken into account in calculations. However, there is a problem. Number of occupants varies. In our case, maximum amount of people who can be inside is 650. Indoor climate should be design in such way to provide comfort conditions for as maximum people as it is possible. At the same time, each person generates warm, and if the number of people is increasing, consequently account of heat will increase too. It can cause discomfort. Therefore, it should be put into calculations to prevent dissatisfaction of occupants. In National Building Code of Finland D3, there are peculiar values for heat gains for people for different types of buildings. For sports hall, this value is 200 W/person. Further in calculations you will see that during all year account of stored energy is quite large.

4.3.2 Lighting

Lighting also plays an important role in building's energy balance. There are different types of lamps which provide visible inside. D2 states: "Buildings shall should be designed and constructed in such a way that it is possible to maintain such lighting conditions in the occupied zone as it is necessary for achieving the level of visibility required by the tasks that should be performed during periods of occupancy so that energy will not be used unnecessarily" /2 p.11/.

There are some ideas of how to save energy with lighting. For example, REHVA European HVAC Journal gives some values. " For luminaires, energy-efficiency regulations are fairly pointless as the energy use of a luminaire is determined by the lighting design and the way the product is deployed in the application. When these products are put into existing schemes, they can deliver some 15% improvement in energy efficiency. All too often, however, they are put into service in poorly designed and operated lighting installations, resulting in poor lighting conditions and wasted energy. When lighting schemes are properly designed, the improved effectiveness of the lighting – in terms of both quality and quantity – can reduce energy usage by up to 55%." /11/. Of course, it is extremely high values for our sports facility, but at the same time it shows that it is important to remember about lighting. It is one more point in energy conservation strategy, which must be taken into account.

There are some objectives for lighting in sports halls. In each sport facility, there is playing area and auxiliary area. These areas should be illuminated. Lighting levels are described in particular rules and requirement. It depends on the playing area, elevation of the sports hall, elevation of lamps and type of it. Usually it is necessary to use lamps for long periods of time and at the same time provide normal visibility for a large area. And the main task is to keep low energy demand with high efficiency of lighting system. In our sports hall system that is providing illumination emits heat. Heat load from this system is 15 W/ m^2.

To conclude, light impacts on the total energy demand for the buildings because lamps burn up heat.

4.3.3 Electrical equipment

Another system, which has the most strong influence on heating demand of the sports hall, is ventilation. In air supported structures ventilation is used as heating system. Despite the fact that heating by ventilation is the best engineering solution for the air supported sports arena, this system requires fairly high volume of electrical energy. However, there is a side effect of this type of heating system. Fan requires high value of energy, but at the same time, it emits large amounts of heat inside. Volume of heat gained from fan depends on SFP-factor. The specific fan power is measured for the ventilation systems efficiency. It is calculated as a sum of electrical power demand for all fans of the ventilation system, divided with the highest supply or exhaust air flow rate. The SFP-factor is could be measured in kW/ (m^3/s). For ventilation systems with constant air flow rate, this is a best way to describe how much electricity is required for fans. In Finland, there are some guidelines for specific fan power in low energy houses and passive houses. For such buildings SFP-factor has to be less than 2.0 kW/(m^3/s). In some countries, this value reduced to 1.5 kW/(m^3/s).

To summarize all these factors, it is worth noting that each element of building affects on energy consumption. If I want to calculate the total energy demand for the sports hall, I have to design initial data. In the next chapter, this task will be shown.

5 CALCULATION MODEL

Calculation of heat losses and heat gains is a significant step in the design of heating energy consumption of buildings. When heating energy consumption is calculated it is necessary to take into account the issue of energy saving. Heat loss can not be calculated without the data about heat transfer coefficients on surfaces, the calculated internal and external conditions.

There are different ways to select calculated values for the thermal conductivity coefficients of building materials. The issue of the selection of these coefficients is extremely serious. For determining the heat losses of the building, it is necessary to correctly estimate coefficients of heat transfer.

Also, calculation of heat loads plays a key role in determining the energy consumption of buildings. So, it is one more way to save energy.

Following chapter shows the calculations about energy consumption of the sports hall. Calculations were made based on national building codes of Finland.

5.1 Heat losses

Heat losses according National Building Code of Finland D3 defined as the sum of the calculated heat loss through all envelopes and ventilation system. Calculations of heat losses can be divided on some parts. Firstly, I have to define outside and inside conditions for making calculation related to heat losses through the shell and heat losses due to infiltration. Then I have to determine ventilation system in order to calculate losses due to this system.

5.1.1 Weather conditions

Coldest weather conditions within the heating period are described with calculations of climatic parameters that are not absolute extremes for the construction area. Point is that these extremely cold conditions appear very rarely. It occurs once during every hundred years. If we focus on these values, it will lead to a significant increase in the cost of construction. Therefore, the calculated values are taken with the certain probability. Outdoor temperature is the most significant parameter of the cold period of the year to select heat-protective qualities of the external barriers and determine the power of heating system.

In Finland, there are three areas for which significant curves are done. These curves describes how much time each temperature appears during the year. Figure 6 shows these curves.

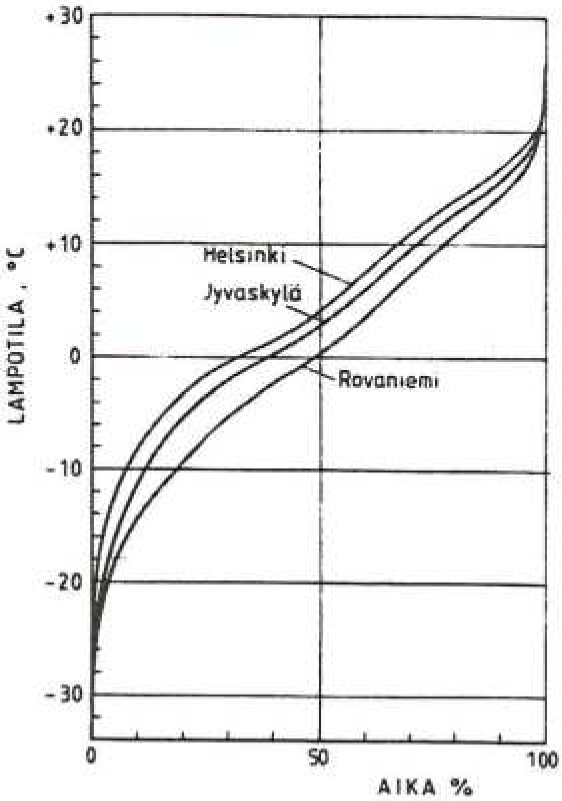


Figure 8. Average outside temperature as a percentage for Helsinki, Jyvaskylä and Rovaniemi.

In this thesis the curve for Jyväskylä city is used because it is the nearest city to Mikkeli. For example, temperature that is less than -34 ^{0}C usually occurs about 5 hours per year. These curves help to calculate the difference of temperature between outside and inside air. Based on these temperature differences I can calculate quite exactly heat losses and energy demand for building. In APPENDIX 1, there are all values of temperature given from the middle curve.

5.1.2 Heat losses through envelope

Heat goes from higher to lower temperature. The process of transferring heat from one point in space to another due to the difference temperature is called heat transfer. It consists of three basic types of heat transfer: conduction, convection and radiation. All kinds of heat transfer take part in heat losses of structure. Conduction is a type of heat transfer between the stationary particles solid, liquid or gaseous substance. Thus, the thermal conductivity is the heat transfer between particles or elements of the structure with indirect contact with each other. Convection is the heat transfer by moving particles in substance. Convection observes only in liquid and gaseous phase. Radiation is the heat transfer from the surface to surface by electromagnetic waves transforming into heat.

All of these types of heat transfer take part in thermal conductivity of structures. In heat losses calculations, the following initial data that is represented in table 3 is needed at least. Areas in this table were calculated by individual formulas, and temperatures are taken from National Building Codes and designing decisions considering in chapter 3.

Table 3. Initial data for heat losses calculations

Envelope area	17584 m^2
Floor area	11957 m^2
Inside temperature	18 ^0C
Ground temperature	5 ^0C

Also, U-values related with initial data. U-value of the shell in our air supported structure given by manufactory. In this thesis work three types of shell are examined and then all needed calculation are done. Soil temperature is taken from research note of agriculture research center of Finland: “The mean annual soil temperature measured at 50 cm below the soil surface, ranged from 6,4 ^0C at the warmest site to 1,9 ^0C at the coldest one. ”/12/.

U-value of the floor can be calculated if the structure of it is determined. On figure 9 the structure of the floor is shown with U-values of each material.

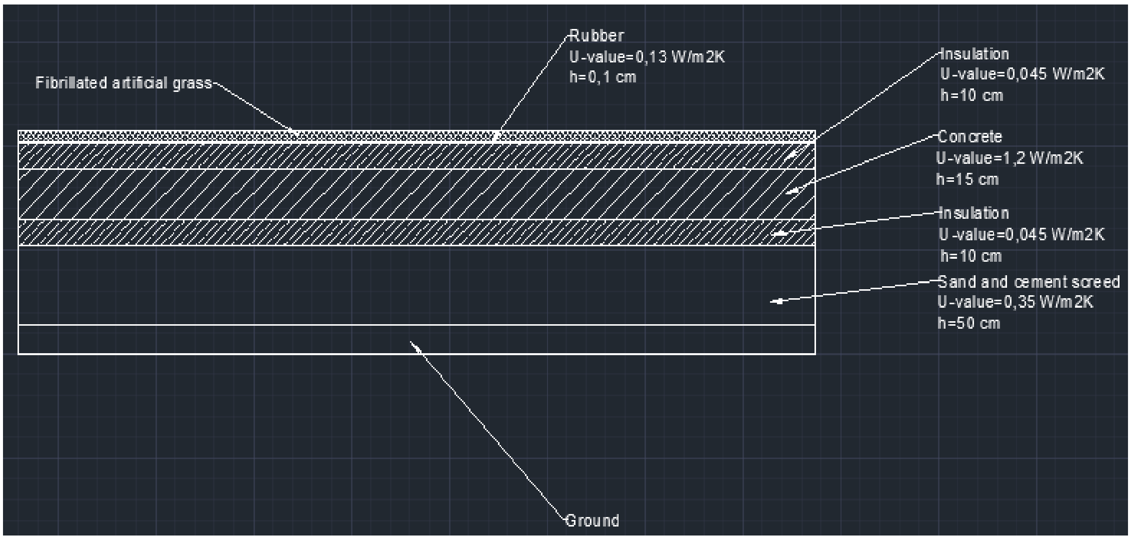


Figure 9. Structure of the floor with dimensions and U-values

Thermal resistance (m^2K/W) is calculated using the equation /1/

$$R_t = R_{si} + R_1 + R_2 + ... + R_n + R_{se} \tag{1}$$

and thermal resistance of the material layer is calculated by equation /2/

$$R = \frac{\delta}{\lambda} \tag{2}$$

where

δ	is the thickness of material, m
λ	is heat conductivity of material, W/mK
R_t	is the total thermal resistance, m^2K/W
R_{si},R_{se}	is the internal and external thermal resistance, m^2K/W
R_1, R_2, ..., R_n	is the thermal resistance of each material, m^2K/W.

Thermal resistance of each material can be calculated from the equation 2 and total thermal resistance of the floor from the equation 1.

Table 4. Thermal resistance of the floor

Material	δ, m	λ, W/mK	R, m^2K/W
Rubber	0,01	0,13	0,08
Insulation	0,2	0,045	4,44
Concrete	0,15	1,2	0,125
Sand	0,5	1,4	0,36
Internal surface	-	-	0,13
		Total	5,105

Heat transfer coefficient of the construction is calculated by equation /3/

$$U = \frac{1}{R_t} \tag{3}$$

where

U is U-value, W/m^2K.

When the R_t of the floor is 5,1 m^2K/W, U-value is 0,196 W/m^2K.

Heat losses (W) through the envelope are /4/

$$E = U \cdot A \cdot \Delta t \tag{4}$$

where

E is heat losses through the envelope, W

U is U-value of building envelope, W/m^2K

A is the area of building envelope, m^2

Δt is the temperature difference between indoor and outdoor, K.

Energy losses (Wh) can be calculated using the equation /5/

$$Q = E \cdot \Delta\tau = U \cdot A \cdot \Delta t \cdot \Delta\tau \tag{5}$$

where

Q	is energy losses, Wh
$\Delta\tau$	is time period when temperature difference is constant, h.

Formula 4 allows calculating energy losses through the shell and floor. In APPENDIX 2, there is a table in which all values of energy demand for the sports hall are calculated. Here, I would like to put only first line as an example. If U-value of a single membrane shell is 2,37 W/m^{2}K, then heat losses through the floor are

$$Q= 2{,}37\ W/m^2K \cdot 17584m^2 \cdot 52\ ^0C \cdot 5h=10835kWh= 10{,}84\ MWh$$

As well, in the same way I can calculate heat losses through the floor. U-value of the floor is 0,2 W/m^{2}K as it was calculated earlier. Floor area is 11957 m^2. Temperature difference is 13^{0}C (ground temperature +5 ^{0}C, inside temperature +18 ^{0}C). Heat losses through the floor are ($\Delta\tau$=5h)

$$Q=0{,}196\ W/m^2K \cdot 11957\ m^2 \cdot 13^0C \cdot 5h=152{,}3\ kWh = 0{,}20\ MWh.$$

Total heat losses through the envelope and the floor with outdoor temperature -34 ^{0}C are 11 MWh. Energy losses with other temperature differences are calculated in the same way.

5.1.3 Heat losses by air leakage

Air leakage also called infiltration (penetration of outside air into the building) describes the amount of air flowing through the building envelope, usually presented in l/s or m^3/h.

Tightness of the building envelope is described with air leakage rate. Infiltration can cause many different problems. For example, draught or moisture and heat losses by warm room air with high vapor content penetrate to the construction. For energy efficient buildings, heat losses play a pivotal role. With small infiltration value buildings have lower energy consumption. Except the benefits of saving energy, air tightness reduces problems with draught and moisture risks.

However, in our case firstly I have to think about energy losses related with air leakages. In National Building Code of Finland, there are guidelines on how to calculate air leakage. Energy losses (Wh) with infiltration is calculated using the equation /6/

$$Q_{inf} = \rho \cdot c_p \cdot q_{v.l.a.} \cdot (t_i - t_u) \cdot \Delta\tau \quad (6)$$

where

Q_{inf}	is the energy losses by leakage air, Wh
ρ	is the density of air, 1,2 kg/m^3
c_p	is the specific heat capacity of air, 1 kJ/kg$\cdot$K
$q_{v.l.a.}$	is leakage air flow rate, m^3/s
(t_i-t_u)	is the temperature difference between inside and outside, K
$\Delta\tau$	is the time period lenght, h.

According to D5 leakage air flow rate (m^3/h) is calculated using the equation /7/

$$q_{v.l.a.} = \frac{q_{50}}{3600 \cdot x} \cdot A \quad (7)$$

where

q_{50}	is leak air coefficient of building envelope, m^3/h$\cdot$m^2
x	is storey coefficient
A	is the area of envelope, m^2
3600	is transmittance coefficient.

Leakage air coefficient q_{50} (m^3/h) is

$$q_{50} = \frac{n_{50}}{A} \cdot V \quad (8)$$

where

n_{50}	is tightness of the building with pressure difference 50 Pa, 1/h
A	is the area of building envelope, m^2
V	is volume of the building, m^3

For tight envelope structures according National Building Code of Finland, n_{50} is in range 0,5-1,5. If n_{50} is 1 $^1/_h$, leakage air coefficient q_{50} is

$$q_{50.} = \frac{n_{50}}{A} \cdot V = \frac{1}{17584} \cdot 191980 = 10{,}92 \ \text{m}^3/\text{h} \cdot \text{m}^2$$

and leakage air flow rate is

$$q_{\text{v.l.a.}} = \frac{q_{50}}{3600 \cdot x} \cdot A = \frac{10{,}92}{3600 \cdot 35} \cdot 17584 = 1{,}52\,\text{m}^3/\text{s}.$$

Consequently energy consumption by leakage air is calculated using the formula 5. For example for temperatures less than -34 ^{0}C energy demand calculated in a such way:

Q_{inf}= 1,2 kg/m^3$\cdot$ 1 kJ/kgK $\cdot$ 1,52 m^3/s $\cdot$ [18-(-34)]^{0}C $\cdot$ 5h=474,2 kWh =0,47 MWh

Other values for energy losses by leak air are given in APPENDIX 2.

5.1.4 Heat losses by ventilation

Ventilation is needed to achieve an acceptable indoor air quality and prevent air pollution and any health hazards in buildings. In many cases, ventilation is also used for heating and cooling. There are different ways to ventilate inside area. Ventilation can be natural and mechanical. Mechanical ventilation system is better because it can have the function of providing supply air. Air is cleaned and filtered from dust and other pollen or spores. People with allergies prefer this type of ventilation.

In our case according to National Building Code of Finland D2 outdoor air flow has to be 6 l/s per person. It means that in our case outdoor air flow (q_v) is

q_v= 6 l/s · 650=3900 l/s =3,9 m^3/s

But the amount of outdoor air floor is not enough for large sport facility. Consequently I will use recirculation air. Also, there are some requirements for recirculation air: “Only air that is from rooms with equal or better air cleanliness and that does not contain harmful quantities of impurities may be re-used as recirculation air or transferred air. The use of recirculation air or transferred air shall not cause harmful distribution of impurities, and odours in particular”/2 p.17/

Moreover, some part of the energy is wasted on recirculation air. Amount of outdoor air flow is 20% of the all air flow rate. It means that the amount of recirculation air ($q_{v.r.a.}$) is

$$q_{\mathrm{v.r.a.}} = \frac{3{,}9\,\mathrm{m^3/s}}{0{,}2} - 3{,}9\,\mathrm{m^3/s} = 15{,}6\ \mathrm{m^3/s}$$

National Building Code of Finland D3 gives formulas for calculation energy losses (kWh) caused by ventilation

$$Q_{s.a.} = \rho \cdot c_p \cdot q_{v.s.a.} \cdot (t_s - t_i) \cdot t_d \cdot t_w \cdot \Delta\tau \qquad (9)$$

where

$Q_{s.a.}$	is energy consumption by ventilation, kWh
ρ	is the density of air, 1,2 kg/m^3
c_p	is the specific heat capacity of air, 1 kJ/kg·K
$q_{v.s.a.}$	is outdoor air flow, m^3/s

t_s-t_i is the temperature difference between supply air temperature and inside air temperature, K.

t_d is the ratio of duration per day, h/24h

t_w is the ratio of duration per week, day/7 days

$\Delta\tau$ is the time period lenght, h.

Supply air temperature depends on outside conditions. So, when outside temperature is less than 17 ^{0}C it should be heated. But when the outside temperature is over than 17 ^{0}C we have to cool supply air to the temperature that is required for the sports hall. Cooling system will be mentioned in the next chapter.

Total energy consumption on heat losses calculated as a sum of energy demands on each factor: conduction, leakage air and ventilation. In APPENDIX 2 shown total energy consumption needed on heat losses per one year. Heat loads particularly significant part of energy demand of the building as well and it has to be included in calculations. This process is shown in the next chapter.

5.2 Heat loads

The difference of heat generation and heat losses is called the extra heat of the room in the case when the difference is positive. The difference between heat generation and heat losses is called heat deficiencies if it is negative. Heat load mainly consist from the solar radiation, lighting, heating systems, electrical equipment, people and other sources of heat (hot food, hot surfaces, etc.).

In 2000, the Department of Heating and Ventilation in Moscow determined the energy consumption of buildings. The scientists wanted to compare heat loads and heat losses of buildings. The calculations were determined heat gains from solar radiation, people, equipment, and heat in the monthly average temperature and mean seasonal wind speed directed on broad facade of the building. The results of these calculations are shown in figure 10

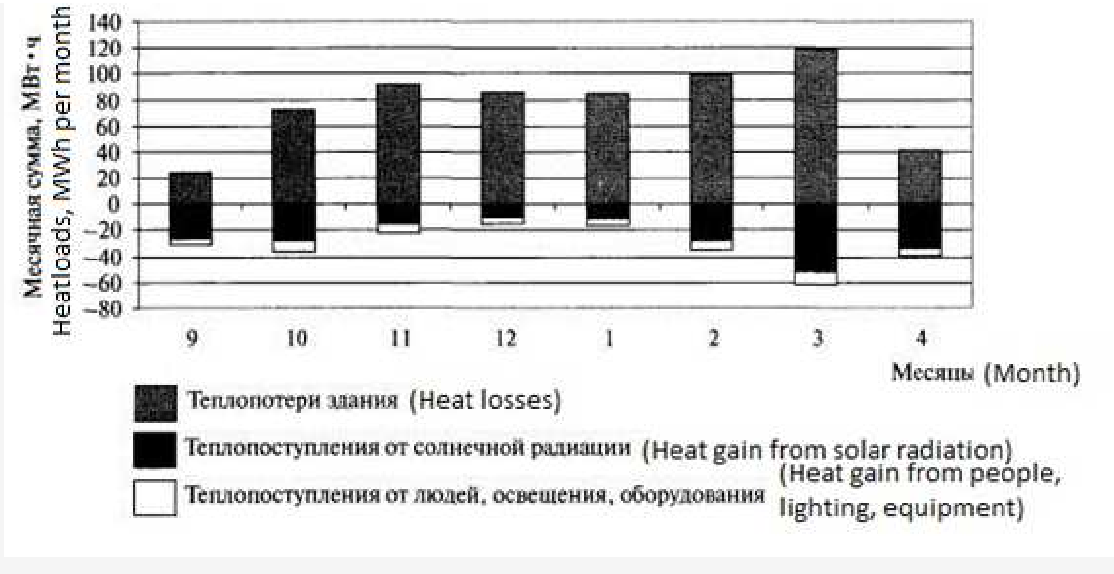


Figure 10. Comparison of heat loads and heat losses /13/

This comparison is given for educational building with quite large area of glass material. Reader can notice that amount of gains per 12 months is about 20 % included the solar radiation. In air supported structures, there are no windows. Nevertheless, heat loads should be put into the calculations of energy consumption. According to the National Building Code of Finland D3 heat loads from different factors are represented in table 5.

Table 5. Standard for calculation internal heat loads from different factors in different types of building /14/

Type of building	Period of use		Degree of use	Lighting, W/m^2	Electrical equipment, W/m^2	Persons, W/m^2
	h/24h	d/7d				
Sports hall	14	7	0,58	15	0	5

In the following chapter, these calculations are presented.

5.2.1 Heat gain from lighting

For light industrial buildings three types of lighting are used such as natural, artificial and mixed illumination. Mixed light is common for most types of room. Mixed light means a combination of artificial and natural lighting. In case of air supported structure PVC-membrane transmit only a part of natural light but at the same time normal level of lighting has to be ensured. It means lamps should be used to add deficiency of light in sports hall. The number of lamps for lighting detected based on space dimensions and purpose.

According to the table 5 heat load from lighting is 15 W/m^2. Formula /10/ shows how to calculate heat gain from lighting. In D3, there is regulation for functional time of sport facilities. Amount of using time is 14 hours. Consequently amount of generated energy (kWh) is:

$$Q_{s.a.} = P_l \cdot A \cdot t_d \cdot t_w \cdot \Delta\tau \qquad (10)$$

where

$Q_{s.a.}$	is the energy generated by lighting, Wh
P_l	is heat generated from lighting, W/m^2
A	is the area of the sports hall, m^2
t_d	is the ratio of duration per day, h/24h
t_w	is the ratio of duration per week, day/7 days

In APPENDIX 2 values of generated energy are given.
At the same time while our air dome is working there are occupants inside. And each of them is generating heat and moisture. Amount of this energy is calculated further.

5.2.2 Heat gain from occupants

The human body generates heat. The amount of heat released by a person depends on the thermal conditions and the nature of its work. The heat is occurred mainly from the body surface by convection, radiation and evaporation. In table 4, there are values of heat generated from the human body. These values change depends on activity of people in different types of building. D3 gives value 5 W/m^2 for sports hall. It means that the amount of energy generated (kWh) from the human body is calculated using the equation /11/

$$Q_{s.a.}=P_h \cdot A \cdot t_d \cdot t_w \cdot \Delta\tau \qquad (11)$$

where

$Q_{s.a.}$	is the energy generated from the persons
P_h	is heat generated from people, W/m^2
A	is the area of the sports hall, m^2
t_d	is the ratio of dwelling per day, h/24h
t_w	is the ratio of dwelling per week, day/7 days
$\Delta\tau$	is time period, h.

In APPENDIX 2 values of energy generated by occupants is shown.

5.2.3 Heat gain from electrical equipment

In our sports hall, electrical equipment consist only of lighting and fans that supply and recirculate air. Heat gain from lighting was described earlier. Heat load from electrical equipment for standard sports halls is zero according the Finland National Building Code D3. But the sports hall is represented by air supported structure, and there is equipment inside the building. This equipment is a different fan, which needs energy for ensure pressure and air exchange.

As I state earlier, heat from equipment depends on SFP-number. SFP-number usually is tried to reduce because it is cheaper to heat space with air or water and surely it is much better for control heat demand. That is why designers use small SFP-number. In Finland value has to be not bigger than 2,5 kW/ (m^3/s). If there is only one fan in the sports hall, SFP-number is 1 kW/ (m^3/s).

All power that fans take from the grid converts to the heat that is gained inside the air dome. To calculate heat load I have to know SFP-number and amount of air that goes through fans. The formula is

$$Q_{fan}=SFP \cdot q_v \cdot \Delta\tau \qquad (12)$$

where

Q_{fan}	is heat gain from electrical equipment, kWh
SFP	is SFP-number of fan, kW/ (m^3/s)
q_v	is air flow through fans, m^3/s
$\Delta\tau$	is time period, h.

Total amount of gained energy is shown in APPENDIX 2.

5.3 Energy consumption for cooling

For the sports hall, cooling is necessary, when the outdoor temperature exceeds the 18 ^{0}C. It is explained by the fact: while the temperature is above 18 ^{0}C there are no leakages of warm air. In this case, heat conduct through the shell increase inside temperature. In this chapter, I will write only about the amount of energy required for cooling. Principles and equipment have been written already.

Amount of energy consumption for cooling depends on cooling system and its efficiency. This amount is possible to calculate basing on values of heat load and U-values, envelope area and outside conditions. To get this value we have to assume values of affecting factors:

$$Q_{cool}=Q_{ce} - Q_{cf} + Q_{totload} \qquad (13)$$

where

Q_{cool}	is cooling demand, MWh
Q_{ce}	is energy demand through the shell, MWh
Q_{cf}	is energy demand through the floor, MWh
$Q_{totload}$	is energy of heat loads, MWh.

When the outside temperature is above the 18 ^{0}C, heat goes from outside to inside according to thermodynamic low. However, ground does not heat much during the summer time that is why there are heat losses through the floor and heat loads through the shell. Amount of cooling demand is very difficult to calculate, because there are many factors affecting on heat load. As I said earlier number of occupants and solar radiation affects on heat gain. It is the most difficult factors which have to be put into account. To provide normal indoor temperature, it is necessary to know heat load from occupants and solar radiation in any time. The most difficult is to calculate solar radiation heat load for building especially for air supported structure, because in such type there is no window. Therefore, cooling will be used only for triple membrane layer because with this type of envelope solar radiation effect will be not so big. The results are shown in APPENDIX 3.3 and 4.3.

6 RECCOMENDATIONS FOR SAVING ENERGY

Nowadays all European counties are following the path of minimizing energy consumption by buildings. There are individual programs for each country with a specific ways of managing this and a deadline of transfer to the next lower-level of consumption. According to the nowadays this technical improvement should take a lot of time, in spite of it first steps already done. For instance, a lot of countries are using or start to use recovered energy. Majority of the countries made a long-time track with detailed targets. Adhering to this way many countries will try to reduce primary energy consumption as much as possible. However year this program should be done until 2020./15/.

In this chapter different opportunities of saving energy are described and analyzed for the air supported sports hall. These methods can be used for a new or existing air domes. It is possible to conserve energy by reducing energy demand of different systems, such as lighting, heating or cooling. Another way of managing this is to improve insulation or to use night setback. In the following chapter I will look closer to those methods.

6.1 Insulation

Earlier different types of shell with different U-values were considered. In order to get the best values for heat losses through the envelope the triple membrane is the best option. In comparison with other membranes, triple membrane has better U-value. So in a way of energy conservation it is better to use more insulated envelope, in spite of higher price. In APPENDIX 3.1, 3.2, 3.3 energy demands with different membranes are shown. But besides the high cost of the triple membrane more energy will be utilized on lighting. The more thick is the shell is more opaque it becomes. Consequently more lighting energy is required.

6.2 Heating and cooling

Energy consumption of the heating takes the majority of the wasted energy, because the sports hall will be situates in a such climate, where the amount of heating hours are about 80-90 % through the whole year. It is shown on the figure 7. Different types of heating systems can be used in the air supported structures and each of them has a different operating costs and investments. In our case I decide to use condensing heating unit with high thermal efficiency, cause this unit has got not very high operating costs and first costs.

Other types of ventilation heating with better efficiency can be considered, but it will take much more investments. For example, high efficiency boiler system will work with hot water coils instead of a gas furnace. Also hot water can be taken from district heating and this can reduce operation cost. Another one system is heat pump. This equipment has many advantages, but very big first cost. As well heat pump is using ground sources it can provide cooling of the building which means that it’s applicable for insulated air supported structures. But the biggest disadvantages of this system are high installation price and maintain costs.

Different cooling systems can be possible as well. In chapter 4 I discussed about outlet unit only, but energy demand of the cooling will depends on type of the system mostly. Energy efficient condenser unit and evaporative cooled condenser units applicable for cooling air domes. For saving energy with the first one we can increase its efficiency and as a result we’ll get cost savings. Evaporative cooled condensing units have better efficiency than condenser unit and this equipment has integral supply fans.

6.3 Night setback

During the occupied and unoccupied time period normal temperature in the sport hall is 18 ^{0}C. Usage of a night setback can reduce energy demand needed for heating and ventilation. Unoccupied time period is 10 hours per day. Progress doesn’t stop and now there are special systems which can control and adjust space temperatures manually and can switch off the heating.

DUOL Company is famous for their control systems. With those systems you can check and manage the ventilation processes in your laptop or mobile phone, using the internet or GSM network. The amount of setback can depend on many factors. It gives possibility to turn down temperatures while sports facility is not using.

Different manufacturers recommend different setback. Some of them consider that turning the heat off at night helps to save much energy, but in Finnish climate it is not helpful for the envelopes and internal surfaces. I believe that 8 ^{0}C is good temperature for unoccupied time period. Remember, that recovery times are quite short: about 30-45 minutes, because of the capacity of the makeup air units and large air flows.

In APPENDIX 4.1, 4.2, 4.3 is shown energy consumption needed for air supported sports hall during the all year around with using night setback. These tables are given for sports hall with different types of shell. If you compare these values with values in APPENDIX 3.1, 3.2, 3.3 you will notice how much energy consumption depends on night setback.

6.4 Weekdays setting

Generally official games happen on the weekends. In these days amount of occupants inside the facility is maximum, but on the weekdays at the sports halls usually trainings are taking place. During these days amount of occupants significantly reduced due to the absence of spectators and press. Therefore there is no point to supply maximum amount of outdoor air, because it is reasonable to save energy and money. Consequently it is necessary to reduce supply air for saving energy. But firstly, I have to calculate amount of persons during the weekdays. Usually during the training days there are not more than 100 sportsmen. But at the same time amount of heat gains from people is reduced too.

Using the formulas and equations from chapter 5, I calculated required volume of supply air and heat load from people for weekdays when amount of occupants is much lower. Other components will be not changed, but ventilation strongly effects on energy consumption. Also amount of weekdays is much bigger than weekends. It means that by these settings, amount of energy demand can be significantly reduced.

Calculations are represented in APPENDIX 5.1, 5.2, 5.3. Using next table you can compare how this setting will effect on energy consumption**.**

7 DISCUSSION OF THE RESULTS

There are some requirements for energy efficiency for buildings. To design energy efficient building, it is necessary to determine the building type according to its purpose. Then based on it, I determined the indoor climate factors affecting total energy consumption. Annual energy consumption is calculated for facility with different types of the envelope. Many factors have influence on the final results, such as type of envelope and, air-tightness of envelope, ventilation and heat gain factors.

In my thesis all of these factors are considered and I, as a result, made the following tables, which represent how each factor effect on annual energy demand. Analyzing these tables, I can state that better energy efficiency and low period of simple payback we can achieve with using a combination of energy conservation strategy. Calculations have been done for three different types of the envelope and four types of settings. In table 6 the main results of the calculations are shown:

Table 6. Energy consumption for different envelopes and settings

Type of air supported structure	Simple annual energy consumption, MWh	Annual energy consumption using night setback, MWh	Annual energy consumption without occupants, MWh	Annual energy consumption using weekdays setting, MWh	Annual cooling demand, MWh
Single layer envelope	5826	5719	2907	5589	0

Double layer envelope	4310	4207	2166	4038	0
Triple layer envelope	2902	2799	1491	2626	142

Firstly, I've calculated energy demand for the sports hall without any energy conservation strategies. It means ventilation, heating and lighting systems operate permanently (24 hours per day). In table 5, annual energy consumption for different envelopes is presented**.** Interesting fact is that energy demand with triple-layer membrane is half of energy demand with single-layer membrane.

Secondly, I've calculated energy consumption in the way that about ten hours per day there are no occupants inside the sports hall. Consequently, it is not effective to use all equipment during all day. Therefore, value of operate time have been reduced. Lighting doesn't work without occupants and ventilation keeps the temperature on such a level to prevent freezing in the winter time. As well, amount of annual energy demand was decreased. Comparing first and the second column, it is obvious that night setback is superiorly to use.

The third column of table 5 shows how much energy wasted on supporting the structure and conserving the correct temperature during the cold season. In this case, there is no light and occupants in the sports hall. Amount of supply air is very small. In this case, the amount of supply air equal with the amount of leakage air. It is clear, that this column has the smallest energy demand.

The fourth column is the most useful in my opinion. It was calculated for weekdays when amount of occupants is less than 650. In calculations, two energy conservation strategies were combined: night setback and setting for weekdays. In this case, there is optimal energy usage.

In addition in the fifth column, there is amount of energy needed for cooling. The cooling energy was calculated only for air dome with three-layer's envelope, because it is not effective to use cooling for other types of envelope.

In this table there are results of all calculations which have been done in this thesis. By this table, easy to compare how each of this factors effect on energy consumption**.** According by calculations it is possible to choose the suitable settings and envelope.

8 CONCLUSION

The point of designing HVAC systems by engineers is to ensure functional ventilation and heating systems with the less energy consumption. Majority of countries have achieved the first part, but the second is what each of them are trying to aspire. For design buildings guidelines and requirements are used. It changes every time, because of the new materials and new lows provided by the government for better energy conservation. For example in Finland, these guidelines are represented by National Building Codes D3 and D5. According to these regulations and guidelines most of the calculations in my thesis have been done.

One of the aims of the thesis is to compare different types of envelope. According the results of the calculations, which is represented in table 5 I can state that triple membrane has the best efficiency with using night setback and setting for weekdays. Manufactures have to pay attention on this type envelope with those settings. As you can see in table 5 the envelope plays a key role in energy conservation strategy for the domes. Basically shell strongly effects on energy consumption, but other strategies should be used for saving energy: configure of operation time and different kinds of equipment.

In this thesis there are recommendations for saving energy. These tips can help manufactures and owners to reduce amount of heating energy consumption. Using energy effective envelope and equipment it is possible to save significant amount of energy without missing of comfort and reduce such big amount of wasted energy.

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	Time period	Time in hours		Time period	Time in hours
Temperature, C	of the year, %	per 1 year	Temperature, C	of the year, %	per 1 year
-34	0,057	5	-3	26,290	296
-33	0,080	2	-2	29,100	246
-32	0,091	1	-1	32,930	336
-31	0,171	7	0	38,180	460
-30	0,263	8	1	45,470	639
-29	0,377	10	2	50,210	415
-28	0,548	15	3	54,030	335
-27	0,753	18	4	56,950	256
-26	0,902	13	5	59,390	214
-25	1,210	27	6	62,070	235
-24	1,553	30	7	63,950	165
-23	1,975	37	8	65,960	176
-22	2,432	40	9	68,370	211
-21	2,911	42	10	70,880	220
-20	3,368	40	11	73,740	251
-19	3,984	54	12	76,390	232
-18	4,749	67	13	79,260	251
-17	5,731	86	14	82,740	305
-16	6,963	108	15	85,790	267
-15	7,740	68	16	88,690	254
-14	8,402	58	17	91,070	208
-13	9,064	58	18	93,240	190
-12	9,680	54	19	94,900	145
-11	10,450	67	20	96,350	127
-10	11,950	131	21	97,520	102
-9	13,320	120	22	98,390	76
-8	14,510	104	23	99,000	53
-7	15,960	127	24	99,350	31
-6	17,710	153	25	99,690	30
-5	19,900	192	26	99,860	15
-4	22,910	264	27	99,950	8
-3	26,290	296	28	100,000	4

INITIAL DATA	
U-value	2,37
Envelope area, m2	17584
Floor area, m2	11957
Inside Temp, C	18
Working time, h/24h	0,58
Light heatload, W/m2	12
Number of occupants	650
Occupant, W/person	200
Ground temp, C	1
Floor U-value	0,2
Volume, m3	191980
qv leakage m3/s	1,52

Fan	
qv, m3/s	3,9
qv, m3/h	14040
SFP	2
qv, m3/s	19,5

Temperature,C	Time ,h	Qce, MWh	Qcf, MWh	Qv.s.a., MWh	Qv.r.a., MWh	Qleak, MWh	Qtotlost, MWh	Qlight, MWh	Qfan, MWh	Qpeople, MWh	Qtotload, MWh	Qtot(with people), MWh
-34	5	10,82	0,20	1,22	0,28	0,47	12,99	0,42	0,19	0,17	0,78	12,21
-33	2	4,28	0,08	0,48	0,11	0,19	5,15	0,17	0,08	0,07	0,32	4,83
-32	1	2,01	0,04	0,23	0,05	0,09	2,41	0,08	0,04	0,03	0,15	2,26
-31	7	14,31	0,28	1,61	0,39	0,63	17,22	0,58	0,27	0,24	1,10	16,12
-30	8	16,12	0,33	1,81	0,45	0,71	19,42	0,67	0,31	0,28	1,26	18,15
-29	10	19,56	0,41	2,20	0,56	0,86	23,58	0,83	0,39	0,35	1,57	22,01
-28	15	28,72	0,61	3,22	0,84	1,26	34,65	1,25	0,58	0,52	2,35	32,30
-27	18	33,68	0,73	3,78	1,01	1,47	40,67	1,49	0,70	0,62	2,82	37,85
-26	13	23,93	0,53	2,69	0,73	1,05	28,93	1,09	0,51	0,45	2,05	26,88
-25	27	48,35	1,10	5,43	1,52	2,12	58,51	2,25	1,05	0,94	4,23	54,27
-24	30	52,59	1,22	5,91	1,69	2,30	63,71	2,50	1,17	1,04	4,71	58,99
-23	37	63,16	1,50	7,09	2,08	2,76	76,60	3,08	1,44	1,28	5,80	70,80
-22	40	66,73	1,63	7,49	2,25	2,92	81,02	3,33	1,56	1,39	6,28	74,74
-21	42	68,20	1,71	7,66	2,36	2,98	82,90	3,49	1,64	1,45	6,58	76,32
-20	40	63,40	1,63	7,12	2,25	2,77	77,17	3,33	1,56	1,39	6,28	70,89
-19	54	83,21	2,19	9,34	3,03	3,64	101,42	4,49	2,10	1,87	8,47	92,95
-18	67	100,54	2,72	11,29	3,76	4,40	122,72	5,58	2,61	2,32	10,51	112,20
-17	86	125,47	3,50	14,09	4,83	5,49	153,38	7,16	3,35	2,98	13,50	139,89
-16	108	152,92	4,39	17,17	6,06	6,69	187,23	8,98	4,21	3,74	16,93	170,30
-15	68	93,61	2,77	10,51	3,82	4,10	114,80	5,66	2,65	2,36	10,68	104,13
-14	58	77,34	2,36	8,68	3,26	3,38	95,02	4,83	2,26	2,01	9,10	85,92
-13	58	74,92	2,36	8,41	3,26	3,28	92,23	4,83	2,26	2,01	9,10	83,13
-12	54	67,46	2,19	7,58	3,03	2,95	83,22	4,49	2,10	1,87	8,47	74,75
-11	67	81,52	2,74	9,15	3,79	3,57	100,77	5,61	2,63	2,34	10,58	90,19
-10	131	153,33	5,34	17,22	7,38	6,71	189,98	10,94	5,12	4,56	20,62	169,36
-9	120	135,04	4,88	15,16	6,74	5,91	167,73	9,99	4,68	4,16	18,83	148,90

-8	104	112,95	4,24	12,68	5,85	4,94	140,67	8,68	4,07	3,61	16,36	124,32
-7	127	132,34	5,16	14,86	7,13	5,79	165,29	10,57	4,95	4,40	19,93	145,36
-6	153	153,33	6,23	17,22	8,61	6,71	192,10	12,76	5,98	5,32	24,05	168,05
-5	192	183,88	7,80	20,65	10,77	8,05	231,15	15,97	7,48	6,65	30,10	201,06
-4	264	241,75	10,72	27,15	14,81	10,58	305,00	21,94	10,28	9,14	41,37	263,63
-3	296	259,12	12,04	29,10	16,63	11,34	328,23	24,64	11,55	10,27	46,46	281,77
-2	246	205,17	10,01	23,04	13,82	8,98	261,02	20,49	9,60	8,54	38,62	222,40
-1	336	265,66	13,64	29,83	18,84	11,63	339,60	27,92	13,08	11,63	52,64	286,96
0	460	344,99	18,70	38,74	25,83	15,10	443,35	38,27	17,94	15,95	72,16	371,20
1	639	452,42	25,96	50,81	35,86	19,80	584,86	53,15	24,91	22,14	100,19	484,67
2	415	276,87	16,88	31,09	23,32	12,12	360,27	34,56	16,19	14,40	65,15	295,13
3	335	209,18	13,60	23,49	18,79	9,16	274,23	27,85	13,05	11,60	52,50	221,72
4	256	149,24	10,40	16,76	14,37	6,53	197,29	21,29	9,98	8,87	40,13	157,16
5	214	115,80	8,69	13,00	12,00	5,07	154,56	17,79	8,34	7,41	33,54	121,03
6	235	117,40	9,54	13,18	13,18	5,14	158,46	19,54	9,16	8,14	36,83	121,62
7	165	75,50	6,70	8,48	9,25	3,30	103,22	13,71	6,42	5,71	25,84	77,38
8	176	73,38	7,16	8,24	9,89	3,21	101,88	14,65	6,87	6,11	27,63	74,25
9	211	79,18	8,58	8,89	11,86	3,47	111,98	17,57	8,23	7,32	33,12	78,86
10	220	73,31	8,94	8,23	12,35	3,21	106,03	18,30	8,58	7,62	34,50	71,53
11	251	73,09	10,19	8,21	14,07	3,20	108,75	20,85	9,77	8,69	39,31	69,44
12	232	58,05	9,44	6,52	13,04	2,54	89,58	19,32	9,05	8,05	36,42	53,16
13	251	52,39	10,22	5,88	14,12	2,29	84,90	20,92	9,81	8,72	39,45	45,46
14	305	50,82	12,39	5,71	17,12	2,22	88,26	25,37	11,89	10,57	47,83	40,43
15	267	33,40	10,22	3,75	15,00	1,46	63,84	22,23	10,42	9,26	41,92	0,00
16	254	21,17	9,72	2,38	14,27	0,93	48,47	21,14	9,91	8,81	39,86	0,00
17	208	8,69	7,98	0,98	11,71	0,38	29,73	17,35	8,13	7,23	32,71	0,00
18	190	0,00	7,27	0,00	10,68	0,00	17,95	15,82	7,41	6,59	29,82	0,00
19	145	0,00	5,56	0,00	8,17	0,00	13,73	12,10	5,67	5,04	22,82	0,00
20	127	0,00	4,86	0,00	7,13	0,00	11,99	10,57	4,95	4,40	19,93	0,00
21	102	0,00	3,92	0,00	5,76	0,00	9,68	8,53	4,00	3,55	16,08	0,00
22	76	0,00	2,92	0,00	4,28	0,00	7,20	6,34	2,97	2,64	11,96	0,00
23	53	0,00	2,04	0,00	3,00	0,00	5,05	4,45	2,08	1,85	8,38	0,00
24	31	0,00	1,17	0,00	1,72	0,00	2,89	2,55	1,20	1,06	4,81	0,00
25	30	0,00	1,14	0,00	1,67	0,00	2,81	2,48	1,16	1,03	4,67	0,00
26	15	0,00	0,57	0,00	0,84	0,00	1,41	1,24	0,58	0,52	2,34	0,00
27	8	0,00	0,30	0,00	0,44	0,00	0,74	0,66	0,31	0,27	1,24	0,00
28	4	0,00	0,17	0,00	0,25	0,00	0,41	0,36	0,17	0,15	0,69	0,00
	8760											5826,94

INITIAL DATA	
U-value	1,7
Envelope area, m2	17584
Floor area, m2	11957
Inside Temp, C	18
Working time, h/24h	0,58
Light heatload, W/m2	12
Number of occupants	650
Occupant, W/person	200
Ground temp, C	1
Floor U-value	0,2
Volume, m3	191980
qv leakage m3/s	1,52

Fan	
qv, m3/s	3,9
qv, m3/h	14040
SFP	2
qv, m3/s	19,5

Temperature, C	Time ,h	Qce, MWh	Qcf, MWh	Qv.s.a., MWh	Qv.r.a., MWh	Qleak, MWh	Qtotlost, MWh	Qlight, MWh	Qfan, MWh	Qpeople, MWh	Qtotload, MWh	Qtot(with people), MWh
-34	5	7,76	0,20	1,22	0,28	0,47	9,93	0,42	0,19	0,17	0,78	9,15
-33	2	3,07	0,08	0,48	0,11	0,19	3,94	0,17	0,08	0,07	0,32	3,62
-32	1	1,44	0,04	0,23	0,05	0,09	1,85	0,08	0,04	0,03	0,15	1,70
-31	7	10,26	0,28	1,61	0,39	0,63	13,18	0,58	0,27	0,24	1,10	12,08
-30	8	11,56	0,33	1,81	0,45	0,71	14,86	0,67	0,31	0,28	1,26	13,60
-29	10	14,03	0,41	2,20	0,56	0,86	18,05	0,83	0,39	0,35	1,57	16,48
-28	15	20,60	0,61	3,22	0,84	1,26	26,53	1,25	0,58	0,52	2,35	24,18
-27	18	24,16	0,73	3,78	1,01	1,47	31,15	1,49	0,70	0,62	2,82	28,33
-26	13	17,17	0,53	2,69	0,73	1,05	22,17	1,09	0,51	0,45	2,05	20,12
-25	27	34,68	1,10	5,43	1,52	2,12	44,84	2,25	1,05	0,94	4,23	40,61
-24	30	37,72	1,22	5,91	1,69	2,30	48,84	2,50	1,17	1,04	4,71	44,13
-23	37	45,31	1,50	7,09	2,08	2,76	58,74	3,08	1,44	1,28	5,80	52,94
-22	40	47,87	1,63	7,49	2,25	2,92	62,16	3,33	1,56	1,39	6,28	55,88
-21	42	48,92	1,71	7,66	2,36	2,98	63,62	3,49	1,64	1,45	6,58	57,04
-20	40	45,47	1,63	7,12	2,25	2,77	59,24	3,33	1,56	1,39	6,28	52,96
-19	54	59,68	2,19	9,34	3,03	3,64	77,89	4,49	2,10	1,87	8,47	69,43
-18	67	72,12	2,72	11,29	3,76	4,40	94,30	5,58	2,61	2,32	10,51	83,78
-17	86	90,00	3,50	14,09	4,83	5,49	117,91	7,16	3,35	2,98	13,50	104,42
-16	108	109,69	4,39	17,17	6,06	6,69	144,00	8,98	4,21	3,74	16,93	127,07
-15	68	67,14	2,77	10,51	3,82	4,10	88,34	5,66	2,65	2,36	10,68	77,66
-14	58	55,47	2,36	8,68	3,26	3,38	73,16	4,83	2,26	2,01	9,10	64,06
-13	58	53,74	2,36	8,41	3,26	3,28	71,05	4,83	2,26	2,01	9,10	61,95
-12	54	48,39	2,19	7,58	3,03	2,95	64,15	4,49	2,10	1,87	8,47	55,68
-11	67	58,47	2,74	9,15	3,79	3,57	77,73	5,61	2,63	2,34	10,58	67,14
-10	131	109,98	5,34	17,22	7,38	6,71	146,63	10,94	5,12	4,56	20,62	126,02

-9	120	96,86	4,88	15,16	6,74	5,91	129,56	9,99	4,68	4,16	18,83	110,73
-8	104	81,02	4,24	12,68	5,85	4,94	108,74	8,68	4,07	3,61	16,36	92,38
-7	127	94,92	5,16	14,86	7,13	5,79	127,88	10,57	4,95	4,40	19,93	107,95
-6	153	109,98	6,23	17,22	8,61	6,71	148,75	12,76	5,98	5,32	24,05	124,70
-5	192	131,90	7,80	20,65	10,77	8,05	179,17	15,97	7,48	6,65	30,10	149,07
-4	264	173,40	10,72	27,15	14,81	10,58	236,66	21,94	10,28	9,14	41,37	195,29
-3	296	185,87	12,04	29,10	16,63	11,34	254,98	24,64	11,55	10,27	46,46	208,52
-2	246	147,17	10,01	23,04	13,82	8,98	203,02	20,49	9,60	8,54	38,62	164,40
-1	336	190,56	13,64	29,83	18,84	11,63	264,50	27,92	13,08	11,63	52,64	211,86
0	460	247,46	18,70	38,74	25,83	15,10	345,82	38,27	17,94	15,95	72,16	273,67
1	639	324,52	25,96	50,81	35,86	19,80	456,96	53,15	24,91	22,14	100,19	356,76
2	415	198,60	16,88	31,09	23,32	12,12	282,00	34,56	16,19	14,40	65,15	216,86
3	335	150,05	13,60	23,49	18,79	9,16	215,09	27,85	13,05	11,60	52,50	162,59
4	256	107,05	10,40	16,76	14,37	6,53	155,10	21,29	9,98	8,87	40,13	114,97
5	214	83,06	8,69	13,00	12,00	5,07	121,83	17,79	8,34	7,41	33,54	88,29
6	235	84,21	9,54	13,18	13,18	5,14	125,27	19,54	9,16	8,14	36,83	88,43
7	165	54,15	6,70	8,48	9,25	3,30	81,88	13,71	6,42	5,71	25,84	56,04
8	176	52,63	7,16	8,24	9,89	3,21	81,13	14,65	6,87	6,11	27,63	53,51
9	211	56,80	8,58	8,89	11,86	3,47	89,59	17,57	8,23	7,32	33,12	56,47
10	220	52,58	8,94	8,23	12,35	3,21	85,31	18,30	8,58	7,62	34,50	50,81
11	251	52,42	10,19	8,21	14,07	3,20	88,09	20,85	9,77	8,69	39,31	48,78
12	232	41,64	9,44	6,52	13,04	2,54	73,17	19,32	9,05	8,05	36,42	36,75
13	251	37,58	10,22	5,88	14,12	2,29	70,09	20,92	9,81	8,72	39,45	30,65
14	305	36,45	12,39	5,71	17,12	2,22	73,90	25,37	11,89	10,57	47,83	26,07
15	267	23,96	10,22	3,75	15,00	1,46	54,40	22,23	10,42	9,26	41,92	12,48
16	254	15,19	9,72	2,38	14,27	0,93	42,48	21,14	9,91	8,81	39,86	2,62
17	208	6,23	7,98	0,98	11,71	0,38	27,27	17,35	8,13	7,23	32,71	0,00
18	190	0,00	7,27	0,00	10,68	0,00	17,95	15,82	7,41	6,59	29,82	0,00
19	145	0,00	5,56	0,00	8,17	0,00	13,73	12,10	5,67	5,04	22,82	0,00
20	127	0,00	4,86	0,00	7,13	0,00	11,99	10,57	4,95	4,40	19,93	0,00
21	102	0,00	3,92	0,00	5,76	0,00	9,68	8,53	4,00	3,55	16,08	0,00
22	76	0,00	2,92	0,00	4,28	0,00	7,20	6,34	2,97	2,64	11,96	0,00
23	53	0,00	2,04	0,00	3,00	0,00	5,05	4,45	2,08	1,85	8,38	0,00
24	31	0,00	1,17	0,00	1,72	0,00	2,89	2,55	1,20	1,06	4,81	0,00
25	30	0,00	1,14	0,00	1,67	0,00	2,81	2,48	1,16	1,03	4,67	0,00
26	15	0,00	0,57	0,00	0,84	0,00	1,41	1,24	0,58	0,52	2,34	0,00
27	8	0,00	0,30	0,00	0,44	0,00	0,74	0,66	0,31	0,27	1,24	0,00
28	4	0,00	0,17	0,00	0,25	0,00	0,41	0,36	0,17	0,15	0,69	0,00
	8760											4310,65

INITIAL DATA	
U-value	1,09
Envelope area, m2	17584
Floor area, m2	11957
Inside Temp, C	18
Working time, h/24h	0,58
Light heatload, W/m2	12
Number of occupants	650
Occupant, W/person	200
Ground temp, C	1
Floor U-value	0,2
Volume, m3	191980
qv leakage m3/s	1,52

Fan	
qv, m3/s	3,9
qv, m3/h	14040
SFP	2
qv, m3/s	19,5

Temperature, C	Time ,h	Qce, MWh	Qcf, MWh	Qv.s.a., MWh	Qv.r.a., MWh	Qleak, MWh	Qtotlost, MWh	Qlight, MWh	Qfan, MWh	Qpeople, MWh	Qtotload, MWh	Qtot(with people), MWh	Qcool, MWh
-34	5	4,98	0,20	1,22	0,28	0,47	7,15	0,42	0,19	0,17	0,78	6,37	0,00
-33	2	1,97	0,08	0,48	0,11	0,19	2,83	0,17	0,08	0,07	0,32	2,52	0,00
-32	1	0,92	0,04	0,23	0,05	0,09	1,33	0,08	0,04	0,03	0,15	1,18	0,00
-31	7	6,58	0,28	1,61	0,39	0,63	9,49	0,58	0,27	0,24	1,10	8,39	0,00
-30	8	7,41	0,33	1,81	0,45	0,71	10,71	0,67	0,31	0,28	1,26	9,45	0,00
-29	10	9,00	0,41	2,20	0,56	0,86	13,02	0,83	0,39	0,35	1,57	11,45	0,00
-28	15	13,21	0,61	3,22	0,84	1,26	19,14	1,25	0,58	0,52	2,35	16,79	0,00
-27	18	15,49	0,73	3,78	1,01	1,47	22,48	1,49	0,70	0,62	2,82	19,67	0,00
-26	13	11,01	0,53	2,69	0,73	1,05	16,01	1,09	0,51	0,45	2,05	13,96	0,00
-25	27	22,24	1,10	5,43	1,52	2,12	32,39	2,25	1,05	0,94	4,23	28,16	0,00
-24	30	24,19	1,22	5,91	1,69	2,30	35,30	2,50	1,17	1,04	4,71	30,59	0,00
-23	37	29,05	1,50	7,09	2,08	2,76	42,49	3,08	1,44	1,28	5,80	36,69	0,00
-22	40	30,69	1,63	7,49	2,25	2,92	44,98	3,33	1,56	1,39	6,28	38,70	0,00
-21	42	31,37	1,71	7,66	2,36	2,98	46,07	3,49	1,64	1,45	6,58	39,49	0,00
-20	40	29,16	1,63	7,12	2,25	2,77	42,93	3,33	1,56	1,39	6,28	36,65	0,00
-19	54	38,27	2,19	9,34	3,03	3,64	56,48	4,49	2,10	1,87	8,47	48,01	0,00
-18	67	46,24	2,72	11,29	3,76	4,40	68,42	5,58	2,61	2,32	10,51	57,90	0,00
-17	86	57,71	3,50	14,09	4,83	5,49	85,62	7,16	3,35	2,98	13,50	72,12	0,00
-16	108	70,33	4,39	17,17	6,06	6,69	104,64	8,98	4,21	3,74	16,93	87,71	0,00
-15	68	43,05	2,77	10,51	3,82	4,10	64,25	5,66	2,65	2,36	10,68	53,57	0,00
-14	58	35,57	2,36	8,68	3,26	3,38	53,25	4,83	2,26	2,01	9,10	44,15	0,00
-13	58	34,46	2,36	8,41	3,26	3,28	51,76	4,83	2,26	2,01	9,10	42,66	0,00
-12	54	31,03	2,19	7,58	3,03	2,95	46,78	4,49	2,10	1,87	8,47	38,31	0,00
-11	67	37,49	2,74	9,15	3,79	3,57	56,74	5,61	2,63	2,34	10,58	46,16	0,00
-10	131	70,52	5,34	17,22	7,38	6,71	107,17	10,94	5,12	4,56	20,62	86,55	0,00

APPENDIX 2.3(2).

-9	120	62,11	4,88	15,16	6,74	5,91	94,80	9,99	4,68	4,16	18,83	75,97	0,00
-8	104	51,95	4,24	12,68	5,85	4,94	79,67	8,68	4,07	3,61	16,36	63,31	0,00
-7	127	60,86	5,16	14,86	7,13	5,79	93,81	10,57	4,95	4,40	19,93	73,89	0,00
-6	153	70,52	6,23	17,22	8,61	6,71	109,29	12,76	5,98	5,32	24,05	85,24	0,00
-5	192	84,57	7,80	20,65	10,77	8,05	131,84	15,97	7,48	6,65	30,10	101,74	0,00
-4	264	111,18	10,72	27,15	14,81	10,58	174,44	21,94	10,28	9,14	41,37	133,07	0,00
-3	296	119,17	12,04	29,10	16,63	11,34	188,28	24,64	11,55	10,27	46,46	141,83	0,00
-2	246	94,36	10,01	23,04	13,82	8,98	150,21	20,49	9,60	8,54	38,62	111,59	0,00
-1	336	122,18	13,64	29,83	18,84	11,63	196,12	27,92	13,08	11,63	52,64	143,48	0,00
0	460	158,66	18,70	38,74	25,83	15,10	257,03	38,27	17,94	15,95	72,16	184,87	0,00
1	639	208,08	25,96	50,81	35,86	19,80	340,51	53,15	24,91	22,14	100,19	240,32	0,00
2	415	127,33	16,88	31,09	23,32	12,12	210,74	34,56	16,19	14,40	65,15	145,60	0,00
3	335	96,21	13,60	23,49	18,79	9,16	161,25	27,85	13,05	11,60	52,50	108,75	0,00
4	256	68,64	10,40	16,76	14,37	6,53	116,69	21,29	9,98	8,87	40,13	76,56	0,00
5	214	53,26	8,69	13,00	12,00	5,07	92,02	17,79	8,34	7,41	33,54	58,49	0,00
6	235	54,00	9,54	13,18	13,18	5,14	95,05	19,54	9,16	8,14	36,83	58,21	0,00
7	165	34,72	6,70	8,48	9,25	3,30	62,45	13,71	6,42	5,71	25,84	36,61	0,00
8	176	33,75	7,16	8,24	9,89	3,21	62,25	14,65	6,87	6,11	27,63	34,62	0,00
9	211	36,42	8,58	8,89	11,86	3,47	69,21	17,57	8,23	7,32	33,12	36,09	0,00
10	220	33,71	8,94	8,23	12,35	3,21	66,44	18,30	8,58	7,62	34,50	31,94	0,00
11	251	33,61	10,19	8,21	14,07	3,20	69,28	20,85	9,77	8,69	39,31	29,97	0,00
12	232	26,70	9,44	6,52	13,04	2,54	58,23	19,32	9,05	8,05	36,42	21,81	0,00
13	251	24,09	10,22	5,88	14,12	2,29	56,61	20,92	9,81	8,72	39,45	17,16	0,00
14	305	23,37	12,39	5,71	17,12	2,22	60,82	25,37	11,89	10,57	47,83	12,99	0,00
15	267	15,36	10,22	3,75	15,00	1,46	45,80	22,23	10,42	9,26	41,92	3,88	0,00
16	254	9,74	9,72	2,38	14,27	0,93	37,03	21,14	9,91	8,81	39,86	-2,83	0,00
17	208	4,00	7,98	0,98	11,71	0,38	25,04	17,35	8,13	7,23	32,71	0,00	21,49
18	190	0,00	7,27	0,00	10,68	0,00	17,95	15,82	7,41	6,59	29,82	0,00	23,23
19	145	2,79	5,56	0,68	8,17	0,00	17,20	12,10	5,67	5,04	22,82	0,00	13,29
20	127	4,87	4,86	1,19	7,13	0,00	18,05	10,57	4,95	4,40	19,93	0,00	14,83
21	102	5,89	3,92	1,44	5,76	0,00	17,01	8,53	4,00	3,55	16,08	0,00	13,56
22	76	5,84	2,92	1,43	4,28	0,00	14,47	6,34	2,97	2,64	11,96	0,00	11,24
23	53	5,12	2,04	1,25	3,00	0,00	11,42	4,45	2,08	1,85	8,38	0,00	8,74
24	31	3,53	1,17	0,86	1,72	0,00	7,28	2,55	1,20	1,06	4,81	0,00	5,23
25	30	4,00	1,14	0,98	1,67	0,00	7,78	2,48	1,16	1,03	4,67	0,00	6,46
26	15	2,28	0,57	0,56	0,84	0,00	4,25	1,24	0,58	0,52	2,34	0,00	2,96
27	8	1,36	0,30	0,33	0,44	0,00	2,44	0,66	0,31	0,27	1,24	0,00	1,75
28	4	0,84	0,17	0,20	0,25	0,00	1,46	0,36	0,17	0,15	0,69	0,00	1,07
	8760											2902,3	123,85

INITIAL DATA	
U-value	2,37
Envelope area, m2	17584
Floor area, m2	11957
Inside Temp, C	18
Working time, h/24h	0,58
Light heatload, W/m2	12
Number of occupants	650
Occupant, W/person	200
Ground temp, C	1
Floor U-value	0,2
Volume, m3	191980
qv leakage m3/s	1,52

Fan	
qv, m3/s	3,9
qv, m3/h	14040
SFP	2
qv, m3/s	19,5

Temperature,C	Time ,h	Qce, MWh	Qcf, MWh	Qv.s.a., MWh	Qv.r.a., MWh	Qleak, MWh	Qtotlost, MWh	Qlight, MWh	Qfan, MWh	Qpeople, MWh	Qtotload, MWh	Qtot(with people), MWh
-34	5	10,82	0,20	0,81	0,28	0,47	12,59	0,42	0,13	0,17	0,72	11,87
-33	2	4,28	0,08	0,32	0,11	0,19	4,99	0,17	0,05	0,07	0,29	4,70
-32	1	2,01	0,04	0,15	0,05	0,09	2,34	0,08	0,03	0,03	0,14	2,20
-31	7	14,31	0,28	1,08	0,39	0,63	16,69	0,58	0,18	0,24	1,01	15,68
-30	8	16,12	0,33	1,21	0,45	0,71	18,82	0,67	0,21	0,28	1,16	17,66
-29	10	19,56	0,41	1,47	0,56	0,86	22,85	0,83	0,26	0,35	1,44	21,42
-28	15	28,72	0,61	2,16	0,84	1,26	33,58	1,25	0,39	0,52	2,16	31,43
-27	18	33,68	0,73	2,53	1,01	1,47	39,42	1,49	0,47	0,62	2,59	36,84
-26	13	23,93	0,53	1,80	0,73	1,05	28,05	1,09	0,34	0,45	1,88	26,17
-25	27	48,35	1,10	3,64	1,52	2,12	56,72	2,25	0,71	0,94	3,89	52,83
-24	30	52,59	1,22	3,96	1,69	2,30	61,76	2,50	0,79	1,04	4,33	57,43
-23	37	63,16	1,50	4,75	2,08	2,76	74,26	3,08	0,97	1,28	5,32	68,94
-22	40	66,73	1,63	5,02	2,25	2,92	78,55	3,33	1,05	1,39	5,77	72,79
-21	42	68,20	1,71	5,13	2,36	2,98	80,38	3,49	1,10	1,45	6,04	74,33
-20	40	63,40	1,63	4,77	2,25	2,77	74,82	3,33	1,05	1,39	5,77	69,05
-19	54	83,21	2,19	6,26	3,03	3,64	98,33	4,49	1,41	1,87	7,77	90,56
-18	67	100,54	2,72	7,56	3,76	4,40	118,99	5,58	1,75	2,32	9,65	109,34
-17	86	125,47	3,50	9,44	4,83	5,49	148,73	7,16	2,25	2,98	12,39	136,34
-16	108	152,92	4,39	11,51	6,06	6,69	181,57	8,98	2,82	3,74	15,54	166,02
-15	68	93,61	2,77	7,04	3,82	4,10	111,34	5,66	1,78	2,36	9,80	101,53
-14	58	77,34	2,36	5,82	3,26	3,38	92,15	4,83	1,52	2,01	8,35	83,80
-13	58	74,92	2,36	5,64	3,26	3,28	89,45	4,83	1,52	2,01	8,35	81,10
-12	54	67,46	2,19	5,08	3,03	2,95	80,72	4,49	1,41	1,87	7,77	72,95
-11	67	81,52	2,74	6,13	3,79	3,57	97,75	5,61	1,76	2,34	9,71	88,04
-10	131	153,33	5,34	11,54	7,38	6,71	184,30	10,94	3,43	4,56	18,93	165,37
-9	120	135,04	4,88	10,16	6,74	5,91	162,73	9,99	3,14	4,16	17,28	145,44

-8	104	112,95	4,24	8,50	5,85	4,94	136,49	8,68	2,72	3,61	15,01	121,47
-7	127	132,34	5,16	9,96	7,13	5,79	160,38	10,57	3,32	4,40	18,29	142,09
-6	153	153,33	6,23	11,54	8,61	6,71	186,42	12,76	4,01	5,32	22,08	164,34
-5	192	183,88	7,80	13,84	10,77	8,05	224,34	15,97	5,01	6,65	27,63	196,71
-4	264	241,75	10,72	18,19	14,81	10,58	296,04	21,94	6,89	9,14	37,98	258,07
-3	296	259,12	12,04	19,50	16,63	11,34	318,63	24,64	7,74	10,27	42,64	275,98
-2	246	205,17	10,01	15,44	13,82	8,98	253,41	20,49	6,43	8,54	35,45	217,96
-1	336	265,66	13,64	19,99	18,84	11,63	329,76	27,92	8,77	11,63	48,32	281,43
0	460	344,99	18,70	25,96	25,83	15,10	430,57	38,27	12,02	15,95	66,24	364,33
1	639	452,42	25,96	34,04	35,86	19,80	568,09	53,15	16,69	22,14	91,98	476,12
2	415	276,87	16,88	20,83	23,32	12,12	350,01	34,56	10,85	14,40	59,80	290,21
3	335	209,18	13,60	15,74	18,79	9,16	266,47	27,85	8,74	11,60	48,20	218,28
4	256	149,24	10,40	11,23	14,37	6,53	191,76	21,29	6,68	8,87	36,84	154,92
5	214	115,80	8,69	8,71	12,00	5,07	150,27	17,79	5,59	7,41	30,78	119,49
6	235	117,40	9,54	8,83	13,18	5,14	154,11	19,54	6,13	8,14	33,81	120,29
7	165	75,50	6,70	5,68	9,25	3,30	100,42	13,71	4,30	5,71	23,72	76,70
8	176	73,38	7,16	5,52	9,89	3,21	99,16	14,65	4,60	6,11	25,36	73,80
9	211	79,18	8,58	5,96	11,86	3,47	109,04	17,57	5,52	7,32	30,41	78,64
10	220	73,31	8,94	5,52	12,35	3,21	103,32	18,30	5,75	7,62	31,67	71,65
11	251	73,09	10,19	5,50	14,07	3,20	106,04	20,85	6,55	8,69	36,08	69,96
12	232	58,05	9,44	4,37	13,04	2,54	87,43	19,32	6,07	8,05	33,43	53,99
13	251	52,39	10,22	3,94	14,12	2,29	82,96	20,92	6,57	8,72	36,21	46,75
14	305	50,82	12,39	3,82	17,12	2,22	86,38	25,37	7,97	10,57	43,91	42,47
15	267	33,40	10,22	2,51	15,00	1,46	62,61	22,23	6,98	9,26	38,48	0,00
16	254	21,17	9,72	1,59	14,27	0,93	47,68	21,14	6,64	8,81	36,59	0,00
17	208	8,69	7,98	0,65	11,71	0,38	29,41	17,35	5,45	7,23	30,03	0,00
18	190	0,00	7,27	0,00	10,68	0,00	17,95	15,82	4,97	6,59	27,38	0,00
19	145	0,00	5,56	0,00	8,17	0,00	13,73	12,10	3,80	5,04	20,94	0,00
20	127	0,00	4,86	0,00	7,13	0,00	11,99	10,57	3,32	4,40	18,29	0,00
21	102	0,00	3,92	0,00	5,76	0,00	9,68	8,53	2,68	3,55	14,76	0,00
22	76	0,00	2,92	0,00	4,28	0,00	7,20	6,34	1,99	2,64	10,98	0,00
23	53	0,00	2,04	0,00	3,00	0,00	5,05	4,45	1,40	1,85	7,70	0,00
24	31	0,00	1,17	0,00	1,72	0,00	2,89	2,55	0,80	1,06	4,42	0,00
25	30	0,00	1,14	0,00	1,67	0,00	2,81	2,48	0,78	1,03	4,29	0,00
26	15	0,00	0,57	0,00	0,84	0,00	1,41	1,24	0,39	0,52	2,14	0,00
27	8	0,00	0,30	0,00	0,44	0,00	0,74	0,66	0,21	0,27	1,14	0,00
28	4	0,00	0,17	0,00	0,25	0,00	0,41	0,36	0,11	0,15	0,63	0,00
	8760											5719,47

INITIAL DATA	
U-value	1,7
Envelope area, m2	17584
Floor area, m2	11957
Inside Temp, C	18
Working time, h/24h	0,58
Light heatload, W/m2	12
Number of occupants	650
Occupant, W/person	200
Ground temp, C	1
Floor U-value	0,2
Volume, m3	191980
qv leakage m3/s	1,52

Fan	
qv, m3/s	3,9
qv, m3/h	14040
SFP	2
qv, m3/s	19,5

Temperature,C	Time,h	Qce, MWh	Qcf, MWh	Qv.s.a., MWh	Qv.r.a., MWh	Qleak, MWh	Qtotlost, MWh	Qlight, MWh	Qfan, MWh	Qpeople, MWh	Qtotload, MWh	Qtot(with people), MWh
-34	5	7,76	0,20	0,81	0,28	0,47	9,53	0,42	0,13	0,17	0,72	8,81
-33	2	3,07	0,08	0,32	0,11	0,19	3,78	0,17	0,05	0,07	0,29	3,49
-32	1	1,44	0,04	0,15	0,05	0,09	1,77	0,08	0,03	0,03	0,14	1,63
-31	7	10,26	0,28	1,08	0,39	0,63	12,65	0,58	0,18	0,24	1,01	11,64
-30	8	11,56	0,33	1,21	0,45	0,71	14,26	0,67	0,21	0,28	1,16	13,10
-29	10	14,03	0,41	1,47	0,56	0,86	17,33	0,83	0,26	0,35	1,44	15,89
-28	15	20,60	0,61	2,16	0,84	1,26	25,47	1,25	0,39	0,52	2,16	23,31
-27	18	24,16	0,73	2,53	1,01	1,47	29,90	1,49	0,47	0,62	2,59	27,32
-26	13	17,17	0,53	1,80	0,73	1,05	21,28	1,09	0,34	0,45	1,88	19,40
-25	27	34,68	1,10	3,64	1,52	2,12	43,05	2,25	0,71	0,94	3,89	39,16
-24	30	37,72	1,22	3,96	1,69	2,30	46,89	2,50	0,79	1,04	4,33	42,56
-23	37	45,31	1,50	4,75	2,08	2,76	56,40	3,08	0,97	1,28	5,32	51,08
-22	40	47,87	1,63	5,02	2,25	2,92	59,69	3,33	1,05	1,39	5,77	53,92
-21	42	48,92	1,71	5,13	2,36	2,98	61,10	3,49	1,10	1,45	6,04	55,05
-20	40	45,47	1,63	4,77	2,25	2,77	56,90	3,33	1,05	1,39	5,77	51,13
-19	54	59,68	2,19	6,26	3,03	3,64	74,81	4,49	1,41	1,87	7,77	67,04
-18	67	72,12	2,72	7,56	3,76	4,40	90,57	5,58	1,75	2,32	9,65	80,92
-17	86	90,00	3,50	9,44	4,83	5,49	113,26	7,16	2,25	2,98	12,39	100,87
-16	108	109,69	4,39	11,51	6,06	6,69	138,34	8,98	2,82	3,74	15,54	122,79
-15	68	67,14	2,77	7,04	3,82	4,10	84,87	5,66	1,78	2,36	9,80	75,07
-14	58	55,47	2,36	5,82	3,26	3,38	70,29	4,83	1,52	2,01	8,35	61,94
-13	58	53,74	2,36	5,64	3,26	3,28	68,27	4,83	1,52	2,01	8,35	59,92
-12	54	48,39	2,19	5,08	3,03	2,95	61,64	4,49	1,41	1,87	7,77	53,87

APPENDIX 3.2(2).

-11	67	58,47	2,74	6,13	3,79	3,57	74,71	5,61	1,76	2,34	9,71	64,99
-10	131	109,98	5,34	11,54	7,38	6,71	140,95	10,94	3,43	4,56	18,93	122,03
-9	120	96,86	4,88	10,16	6,74	5,91	124,55	9,99	3,14	4,16	17,28	107,27
-8	104	81,02	4,24	8,50	5,85	4,94	104,55	8,68	2,72	3,61	15,01	89,54
-7	127	94,92	5,16	9,96	7,13	5,79	122,97	10,57	3,32	4,40	18,29	104,68
-6	153	109,98	6,23	11,54	8,61	6,71	143,07	12,76	4,01	5,32	22,08	120,99
-5	192	131,90	7,80	13,84	10,77	8,05	172,36	15,97	5,01	6,65	27,63	144,73
-4	264	173,40	10,72	18,19	14,81	10,58	227,70	21,94	6,89	9,14	37,98	189,73
-3	296	185,87	12,04	19,50	16,63	11,34	245,37	24,64	7,74	10,27	42,64	202,73
-2	246	147,17	10,01	15,44	13,82	8,98	195,41	20,49	6,43	8,54	35,45	159,96
-1	336	190,56	13,64	19,99	18,84	11,63	254,65	27,92	8,77	11,63	48,32	206,33
0	460	247,46	18,70	25,96	25,83	15,10	333,04	38,27	12,02	15,95	66,24	266,80
1	639	324,52	25,96	34,04	35,86	19,80	440,19	53,15	16,69	22,14	91,98	348,22
2	415	198,60	16,88	20,83	23,32	12,12	271,74	34,56	10,85	14,40	59,80	211,94
3	335	150,05	13,60	15,74	18,79	9,16	207,34	27,85	8,74	11,60	48,20	159,14
4	256	107,05	10,40	11,23	14,37	6,53	149,57	21,29	6,68	8,87	36,84	112,73
5	214	83,06	8,69	8,71	12,00	5,07	117,54	17,79	5,59	7,41	30,78	86,75
6	235	84,21	9,54	8,83	13,18	5,14	120,92	19,54	6,13	8,14	33,81	87,10
7	165	54,15	6,70	5,68	9,25	3,30	79,08	13,71	4,30	5,71	23,72	55,36
8	176	52,63	7,16	5,52	9,89	3,21	78,41	14,65	4,60	6,11	25,36	53,05
9	211	56,80	8,58	5,96	11,86	3,47	86,66	17,57	5,52	7,32	30,41	56,25
10	220	52,58	8,94	5,52	12,35	3,21	82,59	18,30	5,75	7,62	31,67	50,92
11	251	52,42	10,19	5,50	14,07	3,20	85,38	20,85	6,55	8,69	36,08	49,29
12	232	41,64	9,44	4,37	13,04	2,54	71,02	19,32	6,07	8,05	33,43	37,58
13	251	37,58	10,22	3,94	14,12	2,29	68,15	20,92	6,57	8,72	36,21	31,94
14	305	36,45	12,39	3,82	17,12	2,22	72,01	25,37	7,97	10,57	43,91	28,11
15	267	23,96	10,22	2,51	15,00	1,46	53,16	22,23	6,98	9,26	38,48	14,68
16	254	15,19	9,72	1,59	14,27	0,93	41,69	21,14	6,64	8,81	36,59	5,11
17	208	6,23	7,98	0,65	11,71	0,38	26,95	17,35	5,45	7,23	30,03	0,00
18	190	0,00	7,27	0,00	10,68	0,00	17,95	15,82	4,97	6,59	27,38	0,00
19	145	0,00	5,56	0,00	8,17	0,00	13,73	12,10	3,80	5,04	20,94	0,00
20	127	0,00	4,86	0,00	7,13	0,00	11,99	10,57	3,32	4,40	18,29	0,00
21	102	0,00	3,92	0,00	5,76	0,00	9,68	8,53	2,68	3,55	14,76	0,00
22	76	0,00	2,92	0,00	4,28	0,00	7,20	6,34	1,99	2,64	10,98	0,00
23	53	0,00	2,04	0,00	3,00	0,00	5,05	4,45	1,40	1,85	7,70	0,00
24	31	0,00	1,17	0,00	1,72	0,00	2,89	2,55	0,80	1,06	4,42	0,00
25	30	0,00	1,14	0,00	1,67	0,00	2,81	2,48	0,78	1,03	4,29	0,00
26	15	0,00	0,57	0,00	0,84	0,00	1,41	1,24	0,39	0,52	2,14	0,00
27	8	0,00	0,30	0,00	0,44	0,00	0,74	0,66	0,21	0,27	1,14	0,00
28	4	0,00	0,17	0,00	0,25	0,00	0,41	0,36	0,11	0,15	0,63	0,00
	8760											4207,87

INITIAL DATA	
U-value	1,09
Envelope area, m2	17584
Floor area, m2	11957
Inside Temp, C	18
Working time, h/24h	0,58
Light heatload, W/m2	12
Number of occupants	650
Occupant, W/person	200
Ground temp, C	1
Floor U-value	0,2
Volume, m3	191980
qv leakage m3/s	1,52

Fan	
qv, m3/s	3,9
qv, m3/h	14040
SFP	2
qv, m3/s	19,5

Temperature,C	Time,h	Qce, MWh	Qcf, MWh	Qv.s.a., MWh	Qv.r.a., MWh	Qleak, MWh	Qtotlost, MWh	Qlight, MWh	Qfan, MWh	Qpeople, MWh	Qtotload, MWh	Qtot(with people), MWh	Qcool, MWh
-34	5	4,98	0,20	0,81	0,28	0,47	6,75	0,42	0,13	0,17	0,72	6,03	0,00
-33	2	1,97	0,08	0,32	0,11	0,19	2,67	0,17	0,05	0,07	0,29	2,38	0,00
-32	1	0,92	0,04	0,15	0,05	0,09	1,26	0,08	0,03	0,03	0,14	1,12	0,00
-31	7	6,58	0,28	1,08	0,39	0,63	8,96	0,58	0,18	0,24	1,01	7,95	0,00
-30	8	7,41	0,33	1,21	0,45	0,71	10,11	0,67	0,21	0,28	1,16	8,95	0,00
-29	10	9,00	0,41	1,47	0,56	0,86	12,29	0,83	0,26	0,35	1,44	10,85	0,00
-28	15	13,21	0,61	2,16	0,84	1,26	18,07	1,25	0,39	0,52	2,16	15,92	0,00
-27	18	15,49	0,73	2,53	1,01	1,47	21,24	1,49	0,47	0,62	2,59	18,65	0,00
-26	13	11,01	0,53	1,80	0,73	1,05	15,12	1,09	0,34	0,45	1,88	13,24	0,00
-25	27	22,24	1,10	3,64	1,52	2,12	30,60	2,25	0,71	0,94	3,89	26,72	0,00
-24	30	24,19	1,22	3,96	1,69	2,30	33,36	2,50	0,79	1,04	4,33	29,03	0,00
-23	37	29,05	1,50	4,75	2,08	2,76	40,15	3,08	0,97	1,28	5,32	34,82	0,00
-22	40	30,69	1,63	5,02	2,25	2,92	42,51	3,33	1,05	1,39	5,77	36,74	0,00
-21	42	31,37	1,71	5,13	2,36	2,98	43,54	3,49	1,10	1,45	6,04	37,50	0,00
-20	40	29,16	1,63	4,77	2,25	2,77	40,58	3,33	1,05	1,39	5,77	34,81	0,00
-19	54	38,27	2,19	6,26	3,03	3,64	53,39	4,49	1,41	1,87	7,77	45,62	0,00
-18	67	46,24	2,72	7,56	3,76	4,40	64,69	5,58	1,75	2,32	9,65	55,04	0,00
-17	86	57,71	3,50	9,44	4,83	5,49	80,97	7,16	2,25	2,98	12,39	68,58	0,00
-16	108	70,33	4,39	11,51	6,06	6,69	98,98	8,98	2,82	3,74	15,54	83,43	0,00
-15	68	43,05	2,77	7,04	3,82	4,10	60,78	5,66	1,78	2,36	9,80	50,98	0,00
-14	58	35,57	2,36	5,82	3,26	3,38	50,39	4,83	1,52	2,01	8,35	42,03	0,00
-13	58	34,46	2,36	5,64	3,26	3,28	48,99	4,83	1,52	2,01	8,35	40,63	0,00
-12	54	31,03	2,19	5,08	3,03	2,95	44,28	4,49	1,41	1,87	7,77	36,51	0,00
-11	67	37,49	2,74	6,13	3,79	3,57	53,72	5,61	1,76	2,34	9,71	44,01	0,00
-10	131	70,52	5,34	11,54	7,38	6,71	101,49	10,94	3,43	4,56	18,93	82,56	0,00

APPENDIX 3.3(2).

-9	120	62,11	4,88	10,16	6,74	5,91	89,80	9,99	3,14	4,16	17,28	72,51	0,00
-8	104	51,95	4,24	8,50	5,85	4,94	75,48	8,68	2,72	3,61	15,01	60,47	0,00
-7	127	60,86	5,16	9,96	7,13	5,79	88,91	10,57	3,32	4,40	18,29	70,62	0,00
-6	153	70,52	6,23	11,54	8,61	6,71	103,61	12,76	4,01	5,32	22,08	81,53	0,00
-5	192	84,57	7,80	13,84	10,77	8,05	125,03	15,97	5,01	6,65	27,63	97,40	0,00
-4	264	111,18	10,72	18,19	14,81	10,58	165,48	21,94	6,89	9,14	37,98	127,50	0,00
-3	296	119,17	12,04	19,50	16,63	11,34	178,68	24,64	7,74	10,27	42,64	136,03	0,00
-2	246	94,36	10,01	15,44	13,82	8,98	142,61	20,49	6,43	8,54	35,45	107,15	0,00
-1	336	122,18	13,64	19,99	18,84	11,63	186,28	27,92	8,77	11,63	48,32	137,96	0,00
0	460	158,66	18,70	25,96	25,83	15,10	244,25	38,27	12,02	15,95	66,24	178,01	0,00
1	639	208,08	25,96	34,04	35,86	19,80	323,75	53,15	16,69	22,14	91,98	231,77	0,00
2	415	127,33	16,88	20,83	23,32	12,12	200,48	34,56	10,85	14,40	59,80	140,68	0,00
3	335	96,21	13,60	15,74	18,79	9,16	153,50	27,85	8,74	11,60	48,20	105,30	0,00
4	256	68,64	10,40	11,23	14,37	6,53	111,16	21,29	6,68	8,87	36,84	74,32	0,00
5	214	53,26	8,69	8,71	12,00	5,07	87,73	17,79	5,59	7,41	30,78	56,95	0,00
6	235	54,00	9,54	8,83	13,18	5,14	90,70	19,54	6,13	8,14	33,81	56,88	0,00
7	165	34,72	6,70	5,68	9,25	3,30	59,65	13,71	4,30	5,71	23,72	35,93	0,00
8	176	33,75	7,16	5,52	9,89	3,21	59,53	14,65	4,60	6,11	25,36	34,17	0,00
9	211	36,42	8,58	5,96	11,86	3,47	66,28	17,57	5,52	7,32	30,41	35,87	0,00
10	220	33,71	8,94	5,52	12,35	3,21	63,73	18,30	5,75	7,62	31,67	32,06	0,00
11	251	33,61	10,19	5,50	14,07	3,20	66,57	20,85	6,55	8,69	36,08	30,48	0,00
12	232	26,70	9,44	4,37	13,04	2,54	56,08	19,32	6,07	8,05	33,43	22,64	0,00
13	251	24,09	10,22	3,94	14,12	2,29	54,67	20,92	6,57	8,72	36,21	18,46	0,00
14	305	23,37	12,39	3,82	17,12	2,22	58,93	25,37	7,97	10,57	43,91	15,03	0,00
15	267	15,36	10,22	2,51	15,00	1,46	44,57	22,23	6,98	9,26	38,48	6,08	0,00
16	254	9,74	9,72	1,59	14,27	0,93	36,25	21,14	6,64	8,81	36,59	0,00	0,00
17	208	4,00	7,98	0,65	11,71	0,38	24,72	17,35	5,45	7,23	30,03	0,00	18,80
18	190	0,00	7,27	0,00	10,68	0,00	17,95	15,82	4,97	6,59	27,38	0,00	20,79
19	145	2,79	5,56	0,46	8,17	0,00	16,97	12,10	3,80	5,04	20,94	0,00	18,69
20	127	4,87	4,86	0,80	7,13	0,00	17,66	10,57	3,32	4,40	18,29	0,00	18,76
21	102	5,89	3,92	0,96	5,76	0,00	16,53	8,53	2,68	3,55	14,76	0,00	17,10
22	76	5,84	2,92	0,96	4,28	0,00	13,99	6,34	1,99	2,64	10,98	0,00	14,18
23	53	5,12	2,04	0,84	3,00	0,00	11,00	4,45	1,40	1,85	7,70	0,00	10,96
24	31	3,53	1,17	0,58	1,72	0,00	7,00	2,55	0,80	1,06	4,42	0,00	6,88
25	30	4,00	1,14	0,65	1,67	0,00	7,46	2,48	0,78	1,03	4,29	0,00	7,25
26	15	2,28	0,57	0,37	0,84	0,00	4,06	1,24	0,39	0,52	2,14	0,00	3,91
27	8	1,36	0,30	0,22	0,44	0,00	2,33	0,66	0,21	0,27	1,14	0,00	2,22
28	4	0,84	0,17	0,14	0,25	0,00	1,39	0,36	0,11	0,15	0,63	0,00	1,32
	8760											2799,9	140,86

INITIAL DATA	
U-value	2,37
Envelope area, m2	17584
Floor area, m2	11957
Inside Temp, C	18
Working time, h/24h	0,58
Light heatload, W/m2	12
Number of occupants	650
Occupant, W/person	200
Ground temp, C	1
Floor U-value	0,2
Volume, m3	191980
qv leakage m3/s	1,52

Fan	
qv, m3/s	3,9
qv, m3/h	14040
SFP	2
qv, m3/s	19,5

Temperature,C	Time ,h	Qce, MWh	Qcf, MWh	Qv.s.a. , MWh	Qv.r.a. , MWh	Qleak, MWh	Qtotlost, MWh	Qlight, MWh	Qfan, MWh	Qpeople, MWh	Qtotload, MWh	Qtot(with people), MWh
-34	5	10,82	0,20	0,13	0,28	0,47	11,90	0,42	0,13	0,06	0,60	11,30
-33	2	4,28	0,08	0,05	0,11	0,19	4,71	0,17	0,05	0,02	0,24	4,47
-32	1	2,01	0,04	0,02	0,05	0,09	2,21	0,08	0,03	0,01	0,12	2,10
-31	7	14,31	0,28	0,17	0,39	0,63	15,78	0,58	0,18	0,08	0,85	14,93
-30	8	16,12	0,33	0,19	0,45	0,71	17,79	0,67	0,21	0,09	0,97	16,82
-29	10	19,56	0,41	0,23	0,56	0,86	21,61	0,83	0,26	0,12	1,21	20,40
-28	15	28,72	0,61	0,33	0,84	1,26	31,76	1,25	0,39	0,17	1,81	29,94
-27	18	33,68	0,73	0,39	1,01	1,47	37,28	1,49	0,47	0,21	2,17	35,11
-26	13	23,93	0,53	0,28	0,73	1,05	26,52	1,09	0,34	0,15	1,58	24,94
-25	27	48,35	1,10	0,56	1,52	2,12	53,64	2,25	0,71	0,31	3,26	50,37
-24	30	52,59	1,22	0,61	1,69	2,30	58,41	2,50	0,79	0,35	3,63	54,78
-23	37	63,16	1,50	0,73	2,08	2,76	70,24	3,08	0,97	0,43	4,47	65,77
-22	40	66,73	1,63	0,77	2,25	2,92	74,30	3,33	1,05	0,46	4,84	69,46
-21	42	68,20	1,71	0,79	2,36	2,98	76,03	3,49	1,10	0,49	5,08	70,96
-20	40	63,40	1,63	0,73	2,25	2,77	70,78	3,33	1,05	0,46	4,84	65,94
-19	54	83,21	2,19	0,96	3,03	3,64	93,03	4,49	1,41	0,63	6,53	86,51
-18	67	100,54	2,72	1,16	3,76	4,40	112,59	5,58	1,75	0,78	8,11	104,49
-17	86	125,47	3,50	1,45	4,83	5,49	140,75	7,16	2,25	1,00	10,40	130,34
-16	108	152,92	4,39	1,77	6,06	6,69	171,83	8,98	2,82	1,25	13,05	158,78
-15	68	93,61	2,77	1,08	3,82	4,10	105,38	5,66	1,78	0,79	8,23	97,14
-14	58	77,34	2,36	0,90	3,26	3,38	87,23	4,83	1,52	0,67	7,01	80,22
-13	58	74,92	2,36	0,87	3,26	3,28	84,68	4,83	1,52	0,67	7,01	77,67
-12	54	67,46	2,19	0,78	3,03	2,95	76,42	4,49	1,41	0,63	6,53	69,90
-11	67	81,52	2,74	0,94	3,79	3,57	92,56	5,61	1,76	0,78	8,16	84,40
-10	131	153,33	5,34	1,77	7,38	6,71	174,53	10,94	3,43	1,52	15,89	158,64

-9	120	135,04	4,88	1,56	6,74	5,91	154,13	9,99	3,14	1,39	14,52	139,61
-8	104	112,95	4,24	1,31	5,85	4,94	129,29	8,68	2,72	1,21	12,61	116,69
-7	127	132,34	5,16	1,53	7,13	5,79	151,96	10,57	3,32	1,47	15,36	136,59
-6	153	153,33	6,23	1,77	8,61	6,71	176,65	12,76	4,01	1,78	18,54	158,11
-5	192	183,88	7,80	2,13	10,77	8,05	212,63	15,97	5,01	2,23	23,20	189,43
-4	264	241,75	10,72	2,80	14,81	10,58	280,65	21,94	6,89	3,06	31,89	248,76
-3	296	259,12	12,04	3,00	16,63	11,34	302,13	24,64	7,74	3,43	35,81	266,32
-2	246	205,17	10,01	2,37	13,82	8,98	240,35	20,49	6,43	2,86	29,77	210,58
-1	336	265,66	13,64	3,08	18,84	11,63	312,84	27,92	8,77	3,89	40,58	272,26
0	460	344,99	18,70	3,99	25,83	15,10	408,60	38,27	12,02	5,33	55,63	352,98
1	639	452,42	25,96	5,24	35,86	19,80	539,29	53,15	16,69	7,41	77,24	462,05
2	415	276,87	16,88	3,20	23,32	12,12	332,39	34,56	10,85	4,82	50,22	282,17
3	335	209,18	13,60	2,42	18,79	9,16	253,16	27,85	8,74	3,88	40,47	212,68
4	256	149,24	10,40	1,73	14,37	6,53	182,26	21,29	6,68	2,97	30,94	151,32
5	214	115,80	8,69	1,34	12,00	5,07	142,90	17,79	5,59	2,48	25,85	117,05
6	235	117,40	9,54	1,36	13,18	5,14	146,63	19,54	6,13	2,72	28,40	118,24
7	165	75,50	6,70	0,87	9,25	3,30	95,62	13,71	4,30	1,91	19,92	75,70
8	176	73,38	7,16	0,85	9,89	3,21	94,49	14,65	4,60	2,04	21,30	73,19
9	211	79,18	8,58	0,92	11,86	3,47	104,00	17,57	5,52	2,45	25,53	78,47
10	220	73,31	8,94	0,85	12,35	3,21	98,65	18,30	5,75	2,55	26,59	72,05
11	251	73,09	10,19	0,85	14,07	3,20	101,39	20,85	6,55	2,91	30,30	71,08
12	232	58,05	9,44	0,67	13,04	2,54	83,73	19,32	6,07	2,69	28,08	55,65
13	251	52,39	10,22	0,61	14,12	2,29	79,63	20,92	6,57	2,92	30,41	49,22
14	305	50,82	12,39	0,59	17,12	2,22	83,14	25,37	7,97	3,54	36,87	46,27
15	267	33,40	10,22	0,39	15,00	1,46	60,48	22,23	6,98	3,10	32,32	28,16
16	254	21,17	9,72	0,25	14,27	0,93	46,33	21,14	6,64	2,95	30,73	15,61
17	208	8,69	7,98	0,10	11,71	0,38	28,86	17,35	5,45	2,42	25,22	3,64
18	190	0,00	7,27	0,00	10,68	0,00	17,95	15,82	4,97	2,21	22,99	0,00
19	145	0,00	5,56	0,00	8,17	0,00	13,73	12,10	3,80	1,69	17,59	0,00
20	127	0,00	4,86	0,00	7,13	0,00	11,99	10,57	3,32	1,47	15,36	0,00
21	102	0,00	3,92	0,00	5,76	0,00	9,68	8,53	2,68	1,19	12,40	0,00
22	76	0,00	2,92	0,00	4,28	0,00	7,20	6,34	1,99	0,88	9,22	0,00
23	53	0,00	2,04	0,00	3,00	0,00	5,05	4,45	1,40	0,62	6,46	0,00
24	31	0,00	1,17	0,00	1,72	0,00	2,89	2,55	0,80	0,36	3,71	0,00
25	30	0,00	1,14	0,00	1,67	0,00	2,81	2,48	0,78	0,35	3,60	0,00
26	15	0,00	0,57	0,00	0,84	0,00	1,41	1,24	0,39	0,17	1,80	0,00
27	8	0,00	0,30	0,00	0,44	0,00	0,74	0,66	0,21	0,09	0,95	0,00
28	4	0,00	0,17	0,00	0,25	0,00	0,41	0,36	0,11	0,05	0,53	0,00
	8760											5589,26

INITIAL DATA	
U-value	1,7
Envelope area, m2	17584
Floor area, m2	11957
Inside Temp, C	18
Working time, h/24h	0,58
Light heatload, W/m2	12
Number of occupants	650
Occupant, W/person	200
Ground temp, C	1
Floor U-value	0,2
Volume, m3	191980
qv leakage m3/s	1,52

Fan	
qv, m3/s	3,9
qv, m3/h	14040
SFP	2
qv, m3/s	19,5

Temperature,C	Time,h	Qce, MWh	Qcf, MWh	Qv.s.a., MWh	Qv.r.a., MWh	Qleak, MWh	Qtotlost, MWh	Qlight, MWh	Qfan, MWh	Qpeople, MWh	Qtotload, MWh	Qtot(with people), MWh
-34	5	7,76	0,20	0,13	0,28	0,47	8,84	0,42	0,13	0,06	0,60	8,24
-33	2	3,07	0,08	0,05	0,11	0,19	3,50	0,17	0,05	0,02	0,24	3,26
-32	1	1,44	0,04	0,02	0,05	0,09	1,64	0,08	0,03	0,01	0,12	1,53
-31	7	10,26	0,28	0,17	0,39	0,63	11,74	0,58	0,18	0,08	0,85	10,89
-30	8	11,56	0,33	0,19	0,45	0,71	13,24	0,67	0,21	0,09	0,97	12,26
-29	10	14,03	0,41	0,23	0,56	0,86	16,08	0,83	0,26	0,12	1,21	14,87
-28	15	20,60	0,61	0,33	0,84	1,26	23,64	1,25	0,39	0,17	1,81	21,83
-27	18	24,16	0,73	0,39	1,01	1,47	27,76	1,49	0,47	0,21	2,17	25,59
-26	13	17,17	0,53	0,28	0,73	1,05	19,76	1,09	0,34	0,15	1,58	18,18
-25	27	34,68	1,10	0,56	1,52	2,12	39,97	2,25	0,71	0,31	3,26	36,71
-24	30	37,72	1,22	0,61	1,69	2,30	43,54	2,50	0,79	0,35	3,63	39,91
-23	37	45,31	1,50	0,73	2,08	2,76	52,38	3,08	0,97	0,43	4,47	47,91
-22	40	47,87	1,63	0,77	2,25	2,92	55,44	3,33	1,05	0,46	4,84	50,60
-21	42	48,92	1,71	0,79	2,36	2,98	56,75	3,49	1,10	0,49	5,08	51,68
-20	40	45,47	1,63	0,73	2,25	2,77	52,86	3,33	1,05	0,46	4,84	48,02
-19	54	59,68	2,19	0,96	3,03	3,64	69,51	4,49	1,41	0,63	6,53	62,99
-18	67	72,12	2,72	1,16	3,76	4,40	84,17	5,58	1,75	0,78	8,11	76,06
-17	86	90,00	3,50	1,45	4,83	5,49	105,27	7,16	2,25	1,00	10,40	94,87
-16	108	109,69	4,39	1,77	6,06	6,69	128,60	8,98	2,82	1,25	13,05	115,55
-15	68	67,14	2,77	1,08	3,82	4,10	78,91	5,66	1,78	0,79	8,23	70,68
-14	58	55,47	2,36	0,90	3,26	3,38	65,37	4,83	1,52	0,67	7,01	58,35
-13	58	53,74	2,36	0,87	3,26	3,28	63,50	4,83	1,52	0,67	7,01	56,49
-12	54	48,39	2,19	0,78	3,03	2,95	57,35	4,49	1,41	0,63	6,53	50,82

APPENDIX 4.2(2).

-11	67	58,47	2,74	0,94	3,79	3,57	69,52	5,61	1,76	0,78	8,16	61,36
-10	131	109,98	5,34	1,77	7,38	6,71	131,19	10,94	3,43	1,52	15,89	115,30
-9	120	96,86	4,88	1,56	6,74	5,91	115,95	9,99	3,14	1,39	14,52	101,44
-8	104	81,02	4,24	1,31	5,85	4,94	97,36	8,68	2,72	1,21	12,61	84,75
-7	127	94,92	5,16	1,53	7,13	5,79	114,55	10,57	3,32	1,47	15,36	99,18
-6	153	109,98	6,23	1,77	8,61	6,71	133,31	12,76	4,01	1,78	18,54	114,77
-5	192	131,90	7,80	2,13	10,77	8,05	160,65	15,97	5,01	2,23	23,20	137,45
-4	264	173,40	10,72	2,80	14,81	10,58	212,31	21,94	6,89	3,06	31,89	180,42
-3	296	185,87	12,04	3,00	16,63	11,34	228,88	24,64	7,74	3,43	35,81	193,06
-2	246	147,17	10,01	2,37	13,82	8,98	182,35	20,49	6,43	2,86	29,77	152,58
-1	336	190,56	13,64	3,08	18,84	11,63	237,74	27,92	8,77	3,89	40,58	197,16
0	460	247,46	18,70	3,99	25,83	15,10	311,08	38,27	12,02	5,33	55,63	255,45
1	639	324,52	25,96	5,24	35,86	19,80	411,39	53,15	16,69	7,41	77,24	334,15
2	415	198,60	16,88	3,20	23,32	12,12	254,12	34,56	10,85	4,82	50,22	203,90
3	335	150,05	13,60	2,42	18,79	9,16	194,02	27,85	8,74	3,88	40,47	153,55
4	256	107,05	10,40	1,73	14,37	6,53	140,07	21,29	6,68	2,97	30,94	109,13
5	214	83,06	8,69	1,34	12,00	5,07	110,16	17,79	5,59	2,48	25,85	84,31
6	235	84,21	9,54	1,36	13,18	5,14	113,44	19,54	6,13	2,72	28,40	85,05
7	165	54,15	6,70	0,87	9,25	3,30	74,28	13,71	4,30	1,91	19,92	54,36
8	176	52,63	7,16	0,85	9,89	3,21	73,74	14,65	4,60	2,04	21,30	52,45
9	211	56,80	8,58	0,92	11,86	3,47	81,62	17,57	5,52	2,45	25,53	56,08
10	220	52,58	8,94	0,85	12,35	3,21	77,93	18,30	5,75	2,55	26,59	51,33
11	251	52,42	10,19	0,85	14,07	3,20	80,72	20,85	6,55	2,91	30,30	50,42
12	232	41,64	9,44	0,67	13,04	2,54	67,32	19,32	6,07	2,69	28,08	39,25
13	251	37,58	10,22	0,61	14,12	2,29	64,82	20,92	6,57	2,92	30,41	34,41
14	305	36,45	12,39	0,59	17,12	2,22	68,78	25,37	7,97	3,54	36,87	31,91
15	267	23,96	10,22	0,39	15,00	1,46	51,04	22,23	6,98	3,10	32,32	18,72
16	254	15,19	9,72	0,25	14,27	0,93	40,35	21,14	6,64	2,95	30,73	9,62
17	208	6,23	7,98	0,10	11,71	0,38	26,40	17,35	5,45	2,42	25,22	0,00
18	190	0,00	7,27	0,00	10,68	0,00	17,95	15,82	4,97	2,21	22,99	0,00
19	145	0,00	5,56	0,00	8,17	0,00	13,73	12,10	3,80	1,69	17,59	0,00
20	127	0,00	4,86	0,00	7,13	0,00	11,99	10,57	3,32	1,47	15,36	0,00
21	102	0,00	3,92	0,00	5,76	0,00	9,68	8,53	2,68	1,19	12,40	0,00
22	76	0,00	2,92	0,00	4,28	0,00	7,20	6,34	1,99	0,88	9,22	0,00
23	53	0,00	2,04	0,00	3,00	0,00	5,05	4,45	1,40	0,62	6,46	0,00
24	31	0,00	1,17	0,00	1,72	0,00	2,89	2,55	0,80	0,36	3,71	0,00
25	30	0,00	1,14	0,00	1,67	0,00	2,81	2,48	0,78	0,35	3,60	0,00
26	15	0,00	0,57	0,00	0,84	0,00	1,41	1,24	0,39	0,17	1,80	0,00
27	8	0,00	0,30	0,00	0,44	0,00	0,74	0,66	0,21	0,09	0,95	0,00
28	4	0,00	0,17	0,00	0,25	0,00	0,41	0,36	0,11	0,05	0,53	0,00
	8760											4038,80

APPENDIX 4.3(1).

INITIAL DATA	
U-value	1,09
Envelope area, m2	17584
Floor area, m2	11957
Inside Temp, C	18
Working time, h/24h	0,58
Light heatload, W/m2	12
Number of occupants	650
Occupant, W/person	200
Ground temp, C	1
Floor U-value	0,2
Volume, m3	191980
qv leakage m3/s	1,52

Fan	
qv, m3/s	3,9
qv, m3/h	14040
SFP	2
qv, m3/s	19,5

Temperature,C	Time,h	Qce, MWh	Qcf, MWh	Qv.s.a., MWh	Qv.r.a., MWh	Qleak, MWh	Qtotlost, MWh	Qlight, MWh	Qfan, MWh	Qpeople, MWh	Qtotload, MWh	Qtot(without people), MWh	Qtot(with people), MWh	Qcool, MWh
-34	5	4,98	0,20	0,13	0,28	0,47	6,06	0,42	0,13	0,06	0,60	5,51	5,45	0,00
-33	2	1,97	0,08	0,05	0,11	0,19	2,40	0,17	0,05	0,02	0,24	2,18	2,16	0,00
-32	1	0,92	0,04	0,02	0,05	0,09	1,13	0,08	0,03	0,01	0,12	1,02	1,01	0,00
-31	7	6,58	0,28	0,17	0,39	0,63	8,05	0,58	0,18	0,08	0,85	7,29	7,20	0,00
-30	8	7,41	0,33	0,19	0,45	0,71	9,09	0,67	0,21	0,09	0,97	8,21	8,11	0,00
-29	10	9,00	0,41	0,23	0,56	0,86	11,05	0,83	0,26	0,12	1,21	9,95	9,84	0,00
-28	15	13,21	0,61	0,33	0,84	1,26	16,25	1,25	0,39	0,17	1,81	14,61	14,43	0,00
-27	18	15,49	0,73	0,39	1,01	1,47	19,09	1,49	0,47	0,21	2,17	17,13	16,92	0,00
-26	13	11,01	0,53	0,28	0,73	1,05	13,60	1,09	0,34	0,15	1,58	12,17	12,02	0,00
-25	27	22,24	1,10	0,56	1,52	2,12	27,52	2,25	0,71	0,31	3,26	24,57	24,26	0,00
-24	30	24,19	1,22	0,61	1,69	2,30	30,01	2,50	0,79	0,35	3,63	26,72	26,37	0,00
-23	37	29,05	1,50	0,73	2,08	2,76	36,12	3,08	0,97	0,43	4,47	32,08	31,65	0,00
-22	40	30,69	1,63	0,77	2,25	2,92	38,26	3,33	1,05	0,46	4,84	33,88	33,42	0,00
-21	42	31,37	1,71	0,79	2,36	2,98	39,20	3,49	1,10	0,49	5,08	34,61	34,13	0,00
-20	40	29,16	1,63	0,73	2,25	2,77	36,54	3,33	1,05	0,46	4,84	32,16	31,70	0,00
-19	54	38,27	2,19	0,96	3,03	3,64	48,10	4,49	1,41	0,63	6,53	42,20	41,57	0,00
-18	67	46,24	2,72	1,16	3,76	4,40	58,29	5,58	1,75	0,78	8,11	50,96	50,19	0,00
-17	86	57,71	3,50	1,45	4,83	5,49	72,98	7,16	2,25	1,00	10,40	63,57	62,57	0,00
-16	108	70,33	4,39	1,77	6,06	6,69	89,24	8,98	2,82	1,25	13,05	77,44	76,19	0,00
-15	68	43,05	2,77	1,08	3,82	4,10	54,82	5,66	1,78	0,79	8,23	47,38	46,59	0,00
-14	58	35,57	2,36	0,90	3,26	3,38	45,46	4,83	1,52	0,67	7,01	39,12	38,45	0,00

-13	58	34,46	2,36	0,87	3,26	3,28	44,22	4,83	1,52	0,67	7,01	37,88	37,20	0,00
-12	54	31,03	2,19	0,78	3,03	2,95	39,99	4,49	1,41	0,63	6,53	34,08	33,46	0,00
-11	67	37,49	2,74	0,94	3,79	3,57	48,53	5,61	1,76	0,78	8,16	41,16	40,38	0,00
-10	131	70,52	5,34	1,77	7,38	6,71	91,72	10,94	3,43	1,52	15,89	77,36	75,83	0,00
-9	120	62,11	4,88	1,56	6,74	5,91	81,20	9,99	3,14	1,39	14,52	68,07	66,68	0,00
-8	104	51,95	4,24	1,31	5,85	4,94	68,29	8,68	2,72	1,21	12,61	56,89	55,68	0,00
-7	127	60,86	5,16	1,53	7,13	5,79	80,48	10,57	3,32	1,47	15,36	66,59	65,12	0,00
-6	153	70,52	6,23	1,77	8,61	6,71	93,84	12,76	4,01	1,78	18,54	77,08	75,30	0,00
-5	192	84,57	7,80	2,13	10,77	8,05	113,32	15,97	5,01	2,23	23,20	92,34	90,12	0,00
-4	264	111,18	10,72	2,80	14,81	10,58	150,09	21,94	6,89	3,06	31,89	121,26	118,20	0,00
-3	296	119,17	12,04	3,00	16,63	11,34	162,18	24,64	7,74	3,43	35,81	129,80	126,37	0,00
-2	246	94,36	10,01	2,37	13,82	8,98	129,55	20,49	6,43	2,86	29,77	102,63	99,77	0,00
-1	336	122,18	13,64	3,08	18,84	11,63	169,36	27,92	8,77	3,89	40,58	132,68	128,78	0,00
0	460	158,66	18,70	3,99	25,83	15,10	222,28	38,27	12,02	5,33	55,63	171,99	166,66	0,00
1	639	208,08	25,96	5,24	35,86	19,80	294,94	53,15	16,69	7,41	77,24	225,11	217,70	0,00
2	415	127,33	16,88	3,20	23,32	12,12	182,86	34,56	10,85	4,82	50,22	137,45	132,64	0,00
3	335	96,21	13,60	2,42	18,79	9,16	140,18	27,85	8,74	3,88	40,47	103,59	99,71	0,00
4	256	68,64	10,40	1,73	14,37	6,53	101,66	21,29	6,68	2,97	30,94	73,69	70,72	0,00
5	214	53,26	8,69	1,34	12,00	5,07	80,36	17,79	5,59	2,48	25,85	56,99	54,51	0,00
6	235	54,00	9,54	1,36	13,18	5,14	83,22	19,54	6,13	2,72	28,40	57,55	54,83	0,00
7	165	34,72	6,70	0,87	9,25	3,30	54,84	13,71	4,30	1,91	19,92	36,84	34,92	0,00
8	176	33,75	7,16	0,85	9,89	3,21	54,86	14,65	4,60	2,04	21,30	35,60	33,56	0,00
9	211	36,42	8,58	0,92	11,86	3,47	61,24	17,57	5,52	2,45	25,53	38,15	35,70	0,00
10	220	33,71	8,94	0,85	12,35	3,21	59,06	18,30	5,75	2,55	26,59	35,01	32,46	0,00
11	251	33,61	10,19	0,85	14,07	3,20	61,91	20,85	6,55	2,91	30,30	34,52	31,61	0,00
12	232	26,70	9,44	0,67	13,04	2,54	52,38	19,32	6,07	2,69	28,08	27,00	24,31	0,00
13	251	24,09	10,22	0,61	14,12	2,29	51,33	20,92	6,57	2,92	30,41	23,84	20,92	0,00
14	305	23,37	12,39	0,59	17,12	2,22	55,70	25,37	7,97	3,54	36,87	22,36	18,83	0,00
15	267	15,36	10,22	0,39	15,00	1,46	42,44	22,23	6,98	3,10	32,32	13,22	10,12	0,00
16	254	9,74	9,72	0,25	14,27	0,93	34,90	21,14	6,64	2,95	30,73	7,12	0,00	0,00
17	208	4,00	7,98	0,10	11,71	0,38	24,16	17,35	5,45	2,42	25,22	0,00	0,00	18,80
18	190	0,00	7,27	0,00	10,68	0,00	17,95	15,82	4,97	2,21	22,99	0,00	0,00	20,79
19	145	2,79	5,56	0,07	8,17	0,00	16,59	12,10	3,80	1,69	17,59	0,00	0,00	18,76
20	127	4,87	4,86	0,12	7,13	0,00	16,99	10,57	3,32	1,47	15,36	0,00	0,00	18,88
21	102	5,89	3,92	0,15	5,76	0,00	15,72	8,53	2,68	1,19	12,40	0,00	0,00	17,25
22	76	5,84	2,92	0,15	4,28	0,00	13,19	6,34	1,99	0,88	9,22	0,00	0,00	14,32
23	53	5,12	2,04	0,13	3,00	0,00	10,30	4,45	1,40	0,62	6,46	0,00	0,00	11,09
24	31	3,53	1,17	0,09	1,72	0,00	6,51	2,55	0,80	0,36	3,71	0,00	0,00	6,97
25	30	4,00	1,14	0,10	1,67	0,00	6,91	2,48	0,78	0,35	3,60	0,00	0,00	7,35
26	15	2,28	0,57	0,06	0,84	0,00	3,75	1,24	0,39	0,17	1,80	0,00	0,00	3,97
27	8	1,36	0,30	0,03	0,44	0,00	2,14	0,66	0,21	0,09	0,95	0,00	0,00	2,26
28	4	0,84	0,17	0,02	0,25	0,00	1,27	0,36	0,11	0,05	0,53	0,00	0,00	1,34
	8760											2720,6	2626,3	141,7