Design and Optimization of a Zero Energy Building

By

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ABSTRACT

Izmir Institute of Technology (IZTECH), founded in 1992, is the third state university of Izmir. The campus area has the renewable energy sources of several kinds. The aim of this thesis is to design and optimize a building, which produce its own energy by using these sources.

Gülbahçe Zero Energy Building (GUZEB) is designed as a library and a gallery, and to be used for symposiums and special day meetings. 32^{o}C geothermal water that is from the ancient cave, which is located in campus area and close to the location of the building, will be used for heating and to meet the hot water requirement of the building.

Floor heating system considered being the best heating option with 32^{o}C water source. Necessary pipe length for floor heating system is found by using the software FLUENT.

Necessary cooling load is calculated in two different ways by with and without hourly load distribution. With hourly load distribution cooling load calculation is made by using Alarko-Carrier ‘s HVAC Design Hourly Analysis Program.

Additionally, energy storage method is recommended for the cooling plant, which will meet the cooling load. With this method, smaller cooling plant can be chosen instead of choosing cooling plant, which meets the load of symposium days or special day meetings that both are rare. Because of this, electrical load of the cooling plant considered to be lower.

Silica-aerogel and many different isolation materials are used in the design of the building’s isolation. Fiber lighting is recommended to decrease the lighting load of the building and with automatic controlled curtains and panels; daylight can be controlled during the summer days. So, electric consumption of the building can be tried to be decrease.

The wind speed of the location is 5-7 m/s. Electric demand can be met with the photovoltaic panels and wind turbine that will be located in suitable position.

ÖZ

1992 yılında kurulan İzmir Yüksek Teknoloji Enstitüsü, İzmir'in üçüncü devlet üniversitesidir. Kampus alanı yenilenebilir enerji kaynakları bakımından oldukça zengindir. Tezin ana amacı, bu kaynakları kullanarak, kendi enerjisini tamamiyle kendisi üretebilen, sıfır enerjili bina olarak tanımlanan bir binanın tasarımının ve, optimizasyonunun yapılmasıdır.

Gülbahçe Sıfır Enerjili Evi (GUZEB), bir kütüphane ve galeri olarak kullanılmak üzere tasarlanmıştır. Sempozyum ve toplantı gibi faaliyetlerde de kullanılabilecektir.

Kampüs alanında ve bina yerleşimi yakınında bulunan antik bir hamamdan, yaklaşık 32^{o}C de çıkan jeotermal su, binanın ısıtma sisteminde ve sıcak su karşılamasında kullanılacaktır. Bina ısıtmasında, bu sıcaklıktaki su için yerden ısıtma yöntemi en uygun ısıtma sistemi olarak belirlenmiştir. Bina ısıtması için gerekli boru uzunluğu FLUENT programında modellenerek bulunmuştur.

Bina için gerekli soğutma yükü saatlik yük dağılımı hesaba alınarak ve alınmayarak iki şekilde hesaplanmıştır. Saatlik yük dağılımı soğutma yükü hesabı, Alarko-Carrier'in HVAC Dizaynı Saatlik Analiz Programı kullanılarak yapılmıştır.

Ayrıca, soğutma yükünü karşılayacak soğutma grubu için, enerji depolama yöntemi önerilmiştir. Bu yöntemle, sempozyum, toplantı gibi ender günlerin soğutma yükü değerine göre soğutma grubu seçmek yerine, enerji depolayarak daha küçük bir soğutma grubu seçilmesi önerilmiştir. Bu sayede, soğutma grubunun elektrik yükünün düşürülmesi düşünülmüştür.

Bina tasarımında kullanılan silica-aerogel bazlı malzemeler ve çeşitli izolasyon malzemeleriyle, bina yalıtımı desteklenmiş, fiber aydınlatma önerisiyle, aydınlatma yükü azaltılmaya çalışılmış, otomatik kontrollü perde ve panellerle yaz aylarında güneş ışınının bina içerisine girişi kontrol altına alınmaya çalışılmıştır. Böylelikle, bina için gerekli elektrik ihtiyacı düşürülmeye çalışılmıştır.

Bölgenin rüzgar hızı 5-7 m/s arasındadır. Buna göre seçilecek rüzgar türbini ve uygun pozisyonda yerleştirilecek güneş panelleriyle tüm elektrik ihtiyacının karşılanabileceği düşünülmektedir.

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NOMENCLATURE

a	:Heat loss coefficient (m^3/mh)
C_{chrg}	:Capacity when charging storage
C_{Dconp}	:Capacity when direct cooling during on-peak period
CR_{chrg}	:Capacity ratio when charging storage
CR_{Dcoffp}	:Capacity ratio when direct cooling during off-peak period
CR_{Dconp}	:Capacity ratio when direct cooling during on-peak period
CLTD	:Cooling load temperature difference (^oC)
Fc	:Storage capacity
Fri	:The Froude Number
g	:Gravitaional acceleration constant (9.81 m/s^2)
h	:Convection coefficient (W/m^2K)
H	:Building localization coefficient ($W/m^3\ ^oC$)
h_i	:Minimum inlet opening height
H_{chrg}	:Hours charging storage
H_{Dconp}	:Hours direct cooling during on-peak period
H_{Dcoffp}	:Hours direct cooling during off-peak period
k	:Thermal conductivity (W/mK)
l	:Window or door collapsible length (m)
L	:Length (m)
m	:Mass flow rate (kg)
n	:Pressure drop coefficient
Nu_L	:Nusselt Number
Pr	:Prandtl Number
q	:Volume flow rate per unit diffuser length
Q	:Heat transfer rate (W)
Qm	:Maximum flow rate (m^3/s)
Qtotal	:Total heat loss (W)
R	:Room localization coefficient
Ra_L	:Rayleigh Number
toe	:Tons of oil equivalent (41.8 GJ)

TC_{Dcoffp}	:Total capacity when direct cooling off-peak
TC_{Dconp}	:Total capacity when direct cooling on-peak
TH_{DCchrg}	:Ton-hours direct cooling while simultaneously charging
T_s	:Ground temperature (^oC)
T_∞	:Inner air temperature (^oC)

Greek Letters

ρ_i	:Density of inlet water
ρ_a	:Density of ambient water
β	:Volumetric thermal expansion coefficient (K^{-1})
α	:Thermal diffusivity (m^2/s)
ν	:Kinematic viscosity (m^2/s)
ΔT	:Temperature difference

Subscripts

eq	:Eqıipment
r	:Roof
s	:Safety factor
ow	:Outer walls
w	:Windows
wc	:Window shading

Superscripts

· (dot)	:Quantity per unit time

Abbreviations

AC	:Air condition
FOM	: Figure of Merit
GUZEB	:Gulbahce Zero Energy House

HVAC	:Heating, ventilation, Air conditoning
IZTECH	:Izmir Institute of Technology
PMMA	:Polymethylmethacrylat
PV	:Photovoltaic
PVC	:Polyvinilclorur
TS	:Turkish Standards
TES	:Thermal Energy Storage
TPES	:Total primary energy supply
U.S	:The United States
UV	:Ultraviolet
WWF	:The World Wildlife Fund

Chapter 1

INTRODUCTION

In ancient times, the human being was using the natural energy sources in order to supply their daily needs, which were sufficient in those days, but through the technological advance, the industrial production starts to direct and generate the daily needs. Meanwhile this development leads people to be more dependent on different energy sources, which are unfortunately limited in the world. This limitation forced people to produce their energy. Also, these energy sources have to be natural; the importance of producing own energy by using natural energy sources has become more important. In addition, producing energy became such a ‘powerful gun’ that allowing countries not to be dependable on other countries. These energy sources have to be unlimited and friendly to human health. Therefore, increasing necessity for natural and healthy energy sources impress on importance of geothermal, wind and solar energy.

As known, energy is used to grow food, run the cars, warm and cool the houses, produce electricity for any kind of purpose from reading, to surfing on Internet, either using it for listening to radio or air conditioning the surroundings, briefly, in every phase of the daily life. Fuel is used in our furnaces or boilers for heating, and to heat water for baths and showers. Furthermore, energy is used to control heating and cooling system’s automatic control units or etc. These expenses designate energy consumption.

Houses as the basic living areas of human being are firstly subject to utilization of natural sources. So, these needs differ according to the type of building that is examined. As indicated in Table 1.1, if building’s usage function is different, their energy consumptions and expenditures will be different too.

Table 1.1: Different building activity energy consumptions [1].

PRINCIPAL BUILDING ACTIVITY	FUELOIL CONSUMPTION per building (m^3)	ELECTRICITY CONSUMPTION Total primary (trillion Wh)	NATURAL GAS CONSUMPTION (Billion m^3)
EDUCATION	69.43	227.7	6.23
HEALTH CARE	38.44	58.9	5.97
MERCANTILE	5.29	461	5.09
OFFICE	9.15	678.2	6.03
PUBLIC ASSEMBLY	14.12	169.1	2.66

Several notions and methodologies related with these values, which are shown in Table 1.1 are generated in order to reduce energy consumption. It would be impossible to stop using energy. But reduction of its use can be possible. It is listed below the methods, which should be applied to save energy:

i. Passive Heating Method: More glass window area can be added to the south side of the house to increase the passive heating system, and new designs are created to transfer this heated air to inner part of the houses.

ii. Shading Method: If the weather is hot, curtains can be placed to shade the volume and sunrise is tried to keep in control. In addition, plants can be used for shading.

iii. Insulation Method: Relevant isolation materials can be heavily utilized not only to isolate the building but also stabilize building energy.

iv. Window Types Method: Infiltration can be reduced with double or triple window designs, and using special window construction materials, like PVC, and PVC based materials.

Energy saving level is eventually increased with these methods and applications.

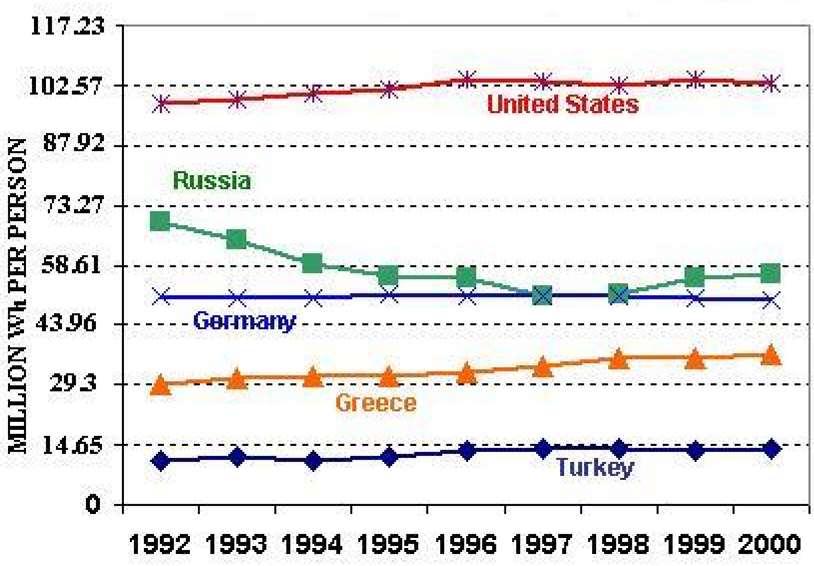


Figure 1.1: Energy Consumption per Capita, 1992-2000 [2].

*TOE (tons of oil equivalent)=41.8 GJ.

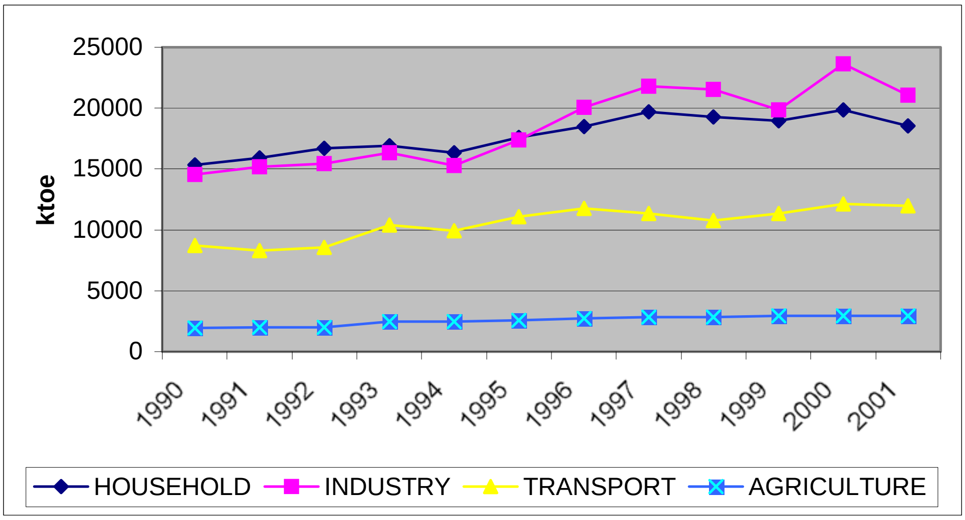


Figure 1.2: Total energy consumption in the sectors in Turkey during 1990–2001 [3,4].

As shown in Figure 1.1, total energy consumption per capita in Turkey is approximately 13.7% of the consumption of the United States [2]. Additionally, total energy use per capita is shared 10 kW by USA, 4 kW by Europe and 0.1 kW by Africa. The world population doubles in every 20-30 years, so the growth of the world supply should be between 4-8% per year [5].

From Figure 1.2, if all energy consumption values by different sectors are summed, without new energy supplies such growth cannot be maintained. So, renewable energy sources become very important. As the energy is such an important thing, renewable energy sources have to be everywhere in daily life. So, anticipated that these renewable energy sources have to be used to produce energy for houses named "Energy-Efficient Buildings". These houses produce most of its energy, but not all of them. These houses only reduce their energy consumption. In the course of time, house, which covers its energy is developed which is known as "Zero Energy House". The main goal of this idea is not to pay bill by generating its own energy.

The main goal of the Zero Energy House initiative is to bring the benefits of zero energy technology into the mainstream of both the residential and commercial building industries, but the initiative's near-term focus is on new home construction.

Advantages of Zero Energy Houses can be followed as:

- Zero Energy House control temperature changes; it has high comfort.
- Zero Energy House continues functioning even during blackouts.
- House protects its owner from changes in energy prices.
- Zero Energy House saves energy and reduces pollution.

Zero Energy Houses optimize:

- Passive solar heating and cooling
- Natural day-lighting
- Energy-efficient construction
- Energy-efficient appliances and lighting
- Solar thermal and solar electric systems [6].

Currently, many studies are conducted on energy-efficient buildings. A major aim during the design of these buildings is to reduce energy consumption. If some examples should be given from related studies around the world, the first one will be from Lakeland, Florida [7]:

The two houses were built in Lakeland, Florida, in the spring of 1998. They were constructed by the same builder and had identical compass orientations and floor plans (of 740 m^2). The energy use of both houses was monitored for more than a year.

Figure 1.3: A bird's eye view of both homes.

Both control and zero energy home features in Florida are listed below:

Control Home Features:

- Gray/brown asphalt shingle roof with 1.5-foot overhangs
- Attic insulation
- Wall insulation on interior of concrete block walls
- Single-glazed windows with aluminum frames
- Standard appliances (electric range, electric water heater, refrigerator, and electric dryer)
- Standard incandescent lighting (30 recessed-can lights)
- Standard-efficiency, 4-ton, seasonal energy efficiency ratio 10, heat pump, (a typical air conditioner in Florida).

Zero Energy Home Features:

- 2-kW solar water heater
- 4-kW utility-interactive PV system
- White-tile roof with 3-foot overhangs
- Attic insulation
- Exterior insulation over concrete block system
- Advanced solar control double-glazed windows
- Oversized, interior-mounted ducts
- High-efficiency refrigerator
- High-efficiency compact fluorescent lighting
- Programmable thermostat
- Downsized seasonal energy efficiency ratio 15, variable-speed, and 2-ton air conditioner with field-verified cooling-coil airflow.

Differences between control home and zero energy home are listed in Table 1.2 and can be clearly seen that, monthly cost of power for zero energy home is 80% less than the control home.

Table 1.2: Energy Bottom Line for June 1998.

Site Description	Power Use (kWh)	PV Array Output (AC kWh)	Net Power Use (kWh)	Monthly Cost of Power	PV Output % of Total Loads
Zero Energy Home	837	502	335	$27	60%
Control Home	1 839*	0	1 839*	$147	0%

* Air Conditioning Only

The second example of energy-efficient building is from Argentina [8].

Figure 1.4: North view of energy-efficient building in La Pampa, Argentina.

La Pampa Energy-Efficient Building Features can be followed as:

- The area is 315 m^2
- Low and small window design in north side
- The volumetric heat loss coefficient is 0.19 W/m^3K
- During winter, the building is heated by direct solar gain, with storage mass being provided in floors and walls.
- Passive cooling was provided by earth-coupled-ducts or earth-to-air heat exchangers.
- Energy saving is approximately 80%

Other example is from Netherlands. As indicated below, there are three different types of project in Netherlands. The World Wildlife Fund (WWF) supports these projects in Harderwijk, Zoetermeer and Etten Leur [9].

i. The project Harderwijk:

The project in the city of Harderwijk consists of 31 houses. To achieve the low energy consumption, the houses have a very high isolation standard and very low k value of windows. The houses also have a heat recovery system.

Figure 1.5: The one-family terrace houses in Harderwijk.

ii. The project Zoetermeer:

The project consists of 35 houses in five rows of one-family terrace houses. These houses are well insulated, and are supplied with energy-efficient systems. A conservatory gains passive solar energy. In the roofs of the conservatories of each house a solar collector for domestic hot water and a 12 square meters photo voltaic-system are integrated.

Figure 1.6: House view from Zoetermeer project.

iii. The project Etten Leur:

The project in the city of Etten Leur consists of 21 houses. To achieve the low energy consumption, the houses have a very high isolation standard and very low k value of windows same with the project in Harderwijk.

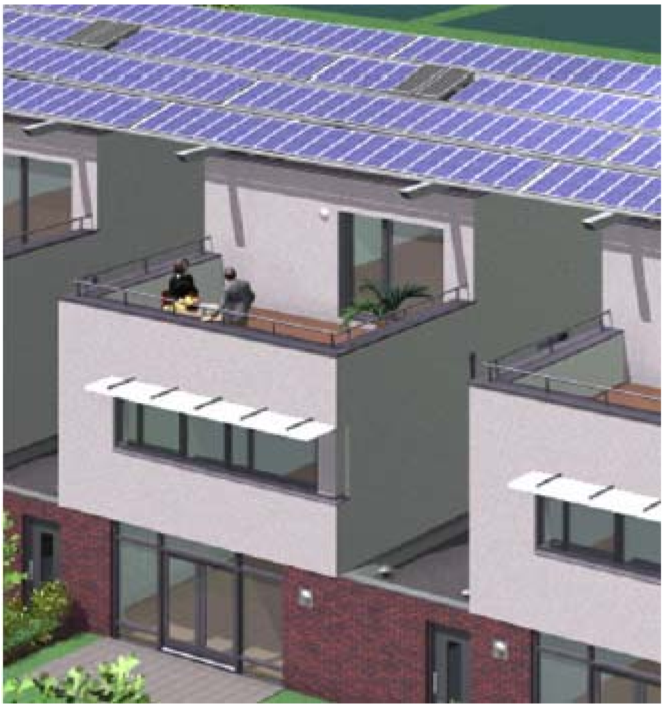


Figure 1.7: House view from Etten Leur project.

As a summary of these examples, all of the other related projects could be discussed in different building concepts. An example for one of these concepts is office building [10]. So, energy efficiency concept is not limited with house concepts. Energy saving is important for both houses and other energy used designs.

Energy is essential to economic and social development and energy supplies importance is increasing all around the world. The tables that are illustrated below show the energy potential of Turkey:

Table 1.3: Primary Energy Production and Consumption of Turkey in1998 and 2001 (ktoe) [4,11].

Primary Energy Production and Consumption of Turkey in1998 and 2001 (ktoe)				
	Energy Production		Energy Consumption	
	1998	*2001*	*1998*	*2001*
Hard Coal	1 678	1 255	8 160	6 972
Lignite	1 2514	1 2772	12 414	13 091
Oil	3 230	2679	32 083	30 721
Natural Gas	684	284	10 635	14 967
Total Fossil	18 106	16 990	63 292	65 751
Hydropower	3 632	2 072	3 632	2 072
Geothermal	256	310	256	310
Solar	98	130	98	130
Wood	5 512	5 060	5 512	5 060
Waste and Dung	1 492	1 372	1 492	1 372
Total renewable	10 878	8 945	10 878	8 945

*toe (tons of oil equivalent)=41.8 GJ.

Table 1.3 shows that Turkey’s total energy production is only 30% of its all consumption. This value clearly indicates that more energy sources are needed. In Turkey today, oil and natural gas still supply approximately 63% of our energy needs but these energy sources are expensive. In conclusion, Turkey has to tend to new energy sources, which include solar, hydropower, biomass, geothermal and wind energy.

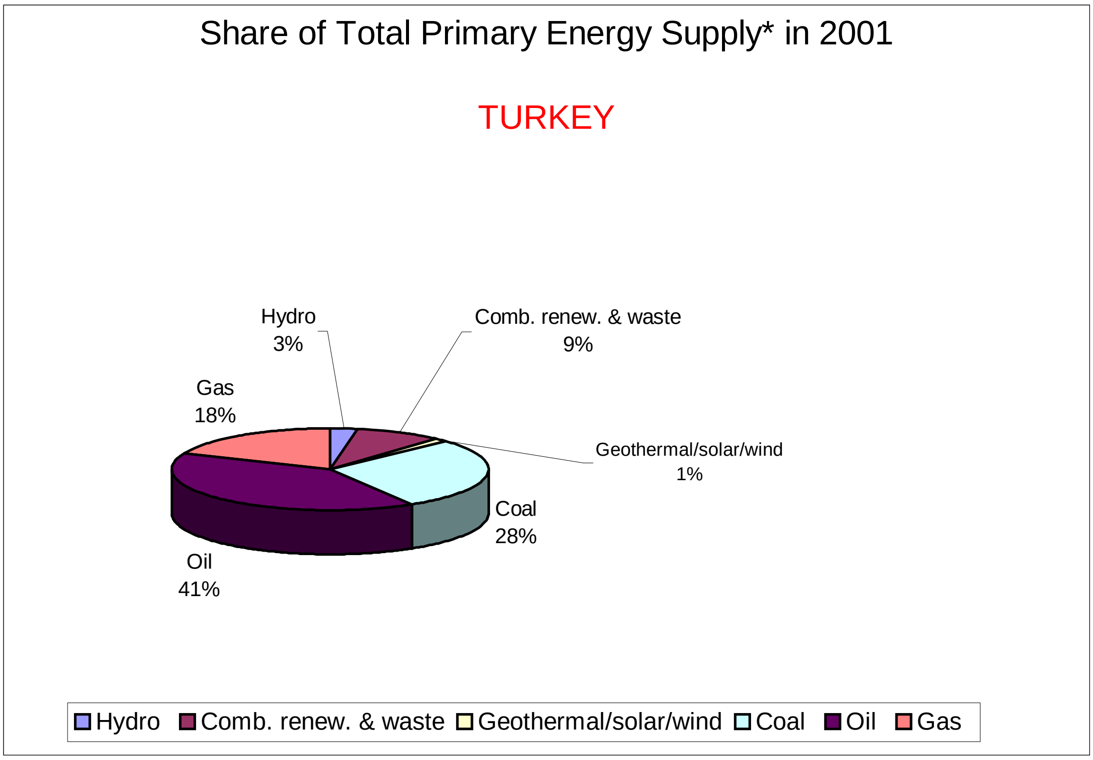
When examined the solar, wind and geothermal energy potential of Turkey, it can be clearly stated that Turkey has great renewable energy sources.

Table 1.4: Solar and Wind Energy Potential by Regions of Turkey [11,12].

Solar and Wind Energy Potential by Regions of Turkey			
	Annual Average Solar Radiation	**Sunshine Duration**	**Annual Average Wind Density**
	(kWh/m^2year)	**(h/year)**	**(W/m^2)**
Black Sea	1 120	1 971	21.31
Marmara	1 168	2 409	51.91
Aegean	1 304	2 738	23.47
Central Anatolia	1 314	2 628	20.14
East Anatolia	1 365	2 664	13.19
Mediterranean	1 390	2 956	21.36
Southeast Anatolia	1 460	2 993	29.33
Turkey Average	1 303	2 623	25.81

As known, Turkey is surrounded by the Black Sea in the North, the Marmara and the Aegean Sea on the West and the Mediterranean Sea in the South, give it very long seashores. So, the regions of Aegean, Marmara and East-Mediterranean have high wind energy potential. Turkey's total theoretically available potential for wind power is calculated to be around 90 000 MW annually. It is also estimated that Turkey has an economical wind power potential of about 10 000 MW [13].

Another energy source is geothermal energy. Turkey has rich geothermal energy capacity. Data accumulated since 1962 show that there may exist about 4 500 MW of geothermal energy, which can be used for electrical power generation in high enthalpy zones. Geothermal central heating, which is less costly than natural gas, could be feasible for many regions in the country. The total geothermal energy potential of Turkey is about 2 568 MW in 2000, but both for electrical and thermal uses of geothermal energy production are only 1 200 MW [11,14].



*Share of TPES excludes electricity trade.

Figure 1.8: Turkey's Share of Total Primary Energy Supply in 2001 [15].

As shown from Figure 1.8 Turkey still meets its energy needs from fossil fuels. But Turkey has good renewable energy sources compared with the world regarding to its location, and its very good solar radiation in average of 3 .6 kWh/m^2 per day. In Figure 1.9, can be easily seen that, Turkey has better solar radiation than European countries and many different areas of the world.

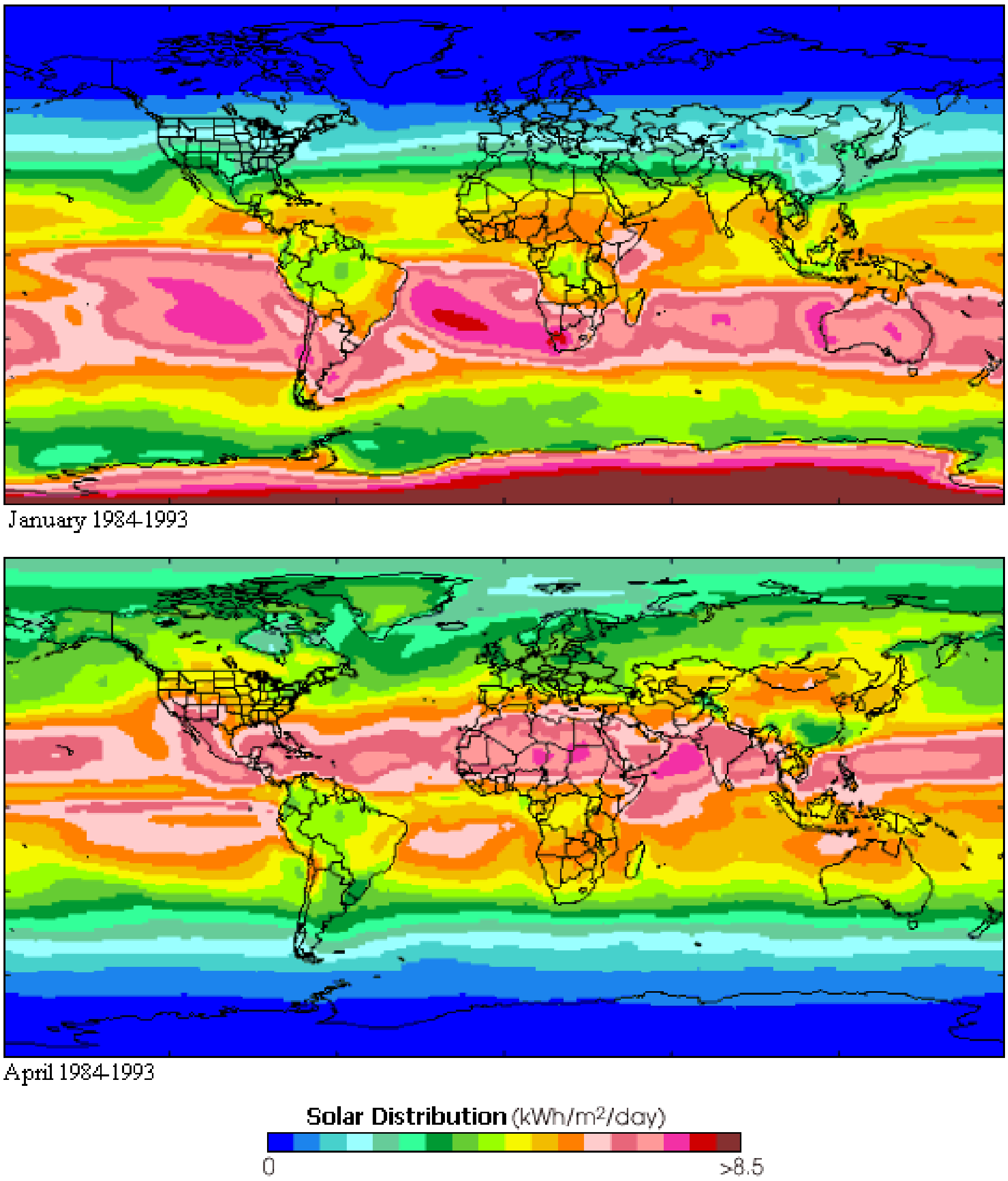


Figure 1.9: Measuring Solar Energy Distribution [16].

From Figure 1.10, it can easily be seen that Turkey is in the region of high temperature geothermal sources.

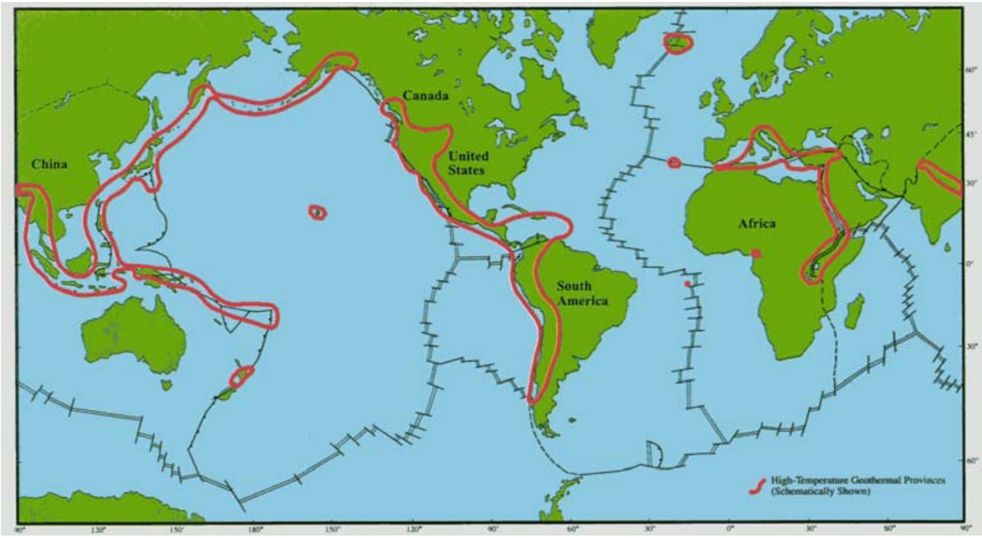


Figure 1.10: World High Temperature Geothermal Provinces [16].

On the other hand, the places on which the energy efficient or zero energy buildings are constructed, (eg. Argentina, Netherlands, U.S, etc.) do not have as rich renewable energy sources as Turkey has.

In conclusion, instead of fossil energy sources, to reduce energy by using these rich renewable energy sources that Turkey has, can be the start point. So, houses that obtain their energy from renewable sources are one of the important start points, which are used in daily life.

In this study, a zero energy building is designed and optimized. This building has many important differences compared with those in the similar studies on the same topic. These differences can be stated in three main points:

- All energy sources, used in this building, are from natural sources that are all of them are realistic.
- The entire task is constructed upon real examples of previous experimental studies.
- The electricity production method described in this study includes a hybrid system.

The roof system, new insulation materials, lighting proposals and many other functions that make this building special to save energy. Geothermal energy is used for heating purposes and for hot water production, wind and solar energy for producing electricity.

The main goal of this study is to heat, cool and ventilate, and to choose the construction materials and suggest other energy saving methods for the zero energy building. This study collects many ways, to save energy with many different energy saving methods, with a single compact example.

Chapter 2 describes the building design, architecture, and functions of the building: building's heating and cooling systems, lighting, energy storage and energy savers etc.

Heating and cooling load calculations results are given in Chapter 3.

In Chapter 4, considered floor-heating system is explained and the design procedures are given.

Chapter 5 describes the design of ventilation system of the building. Depending on this design, energy storage design procedures are explained in Chapter 6 and results are given in Chapter 7.

Chapter 2

GULBAHCE ZERO ENERGY BUILDING

2.1 General Information

Gulbahce Zero Energy Building (GUZEB) will be located in URLA, near the campus area of Izmir Institute of Technology, TURKEY.

Figure 2.1: Location of Gulbahce Zero Energy Building (GUZEB).

2.2 Gulbahce Zero Energy Building’s (GUZEB) Architectural Design

The Architecture Department of Izmir Institute of Technology (IZTECH) made the architectural project of GUZEB in coordination with the Mechanical Engineering Department of IZTECH. Its design is based on to save energy more efficiently with special, and functional designs. GUZEB’s position, architectural views and 3D view can be seen from Figure 2.2 to 2.9.

As shown in Figure 2.2, the location of the building is near the campus area of IZTECH, close to the seaside of Aegean Sea. Its location is planned based on the wind direction on the related location. In Figure 2.3, the roof style is designed as a function of the wind direction. This style helps to direct the wind into building for natural ventilation.

In general, this building is designed as a showroom. Additionally, the building will be functioned as a library in usual days. But in special days, this building will be functioned as a showroom and university’s special day meetings, for instance symposiums, etc. So, building’s architecture gets importance from that point.

Firstly, as shown in Figure 2.4, two huge triple reflective glasses, which have 80-cm. distances between them, stated in front of the building entrance. Between 80cm distance pebbles, which absorb the heat and functioned as heat storage system are spreaded out. From Figure 2.5, while entering the building, between these triple glasses, entrance is located. This entrance will be functioned as a temporary exhibition hall. This place can be used for presenting the special day’s related tables or other related materials, etc. On the other hand, it can be used for break time waiting.

Secondly, on the left side of the entrance, library is located. This library will include many books and materials about energy efficient buildings. Computers will be placed for searching data from Internet. Also, this library will be used for symposiums or other similar events. With removable and portable tables, library can be used for presentations. Thirdly, there will be two offices for staff in GUZEB.

Also, Canteen capacity will be enough for little coffee breaks, and only a mini refrigerator and little kitchen equipments will be placed.

There will be two toilets, one for handicapped person.

Lastly, installation room will be placed at the east side of the GUZEB, near the building. Each plant equipments will be placed in this installation room.

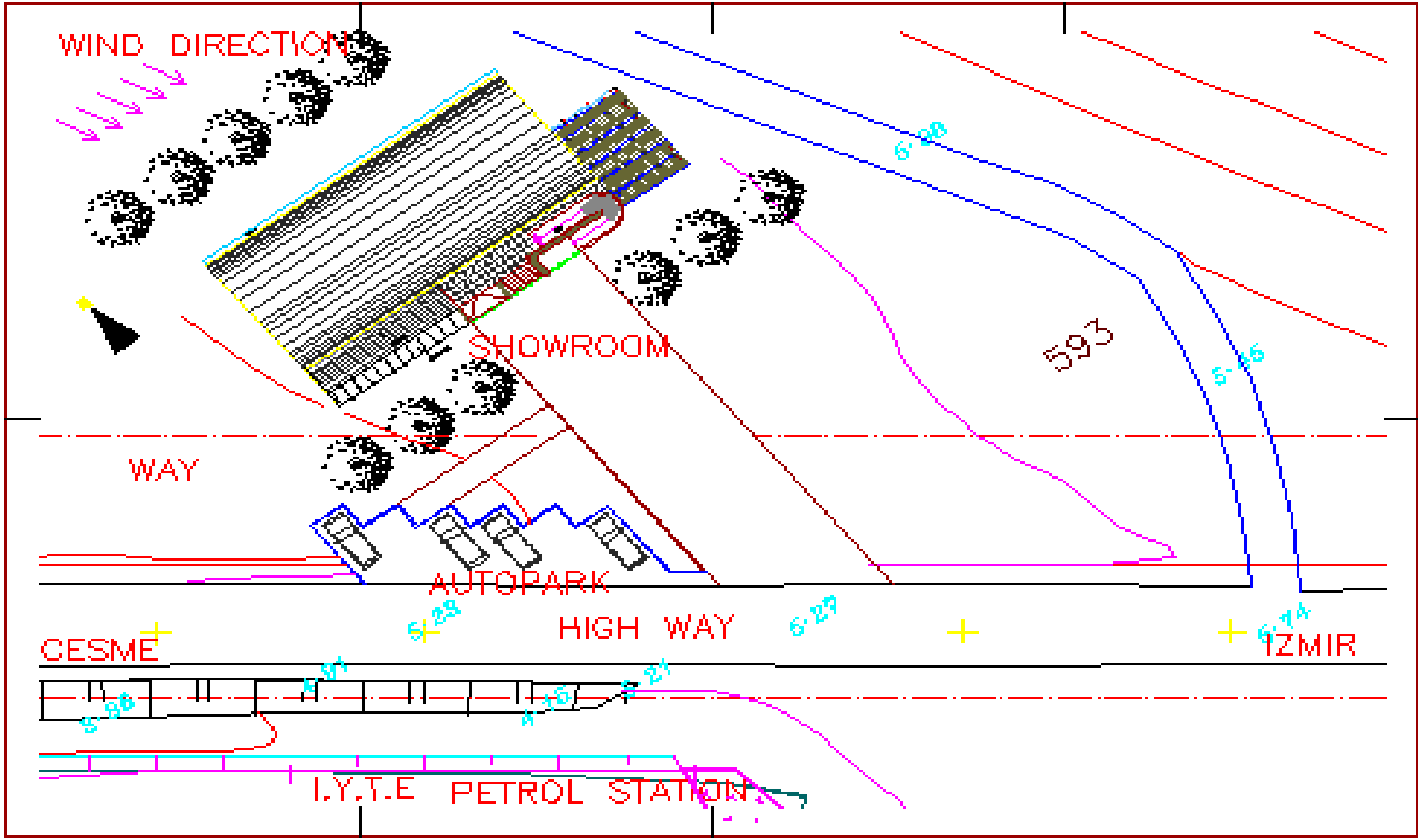


Figure 2.2: Location of GUZEB.

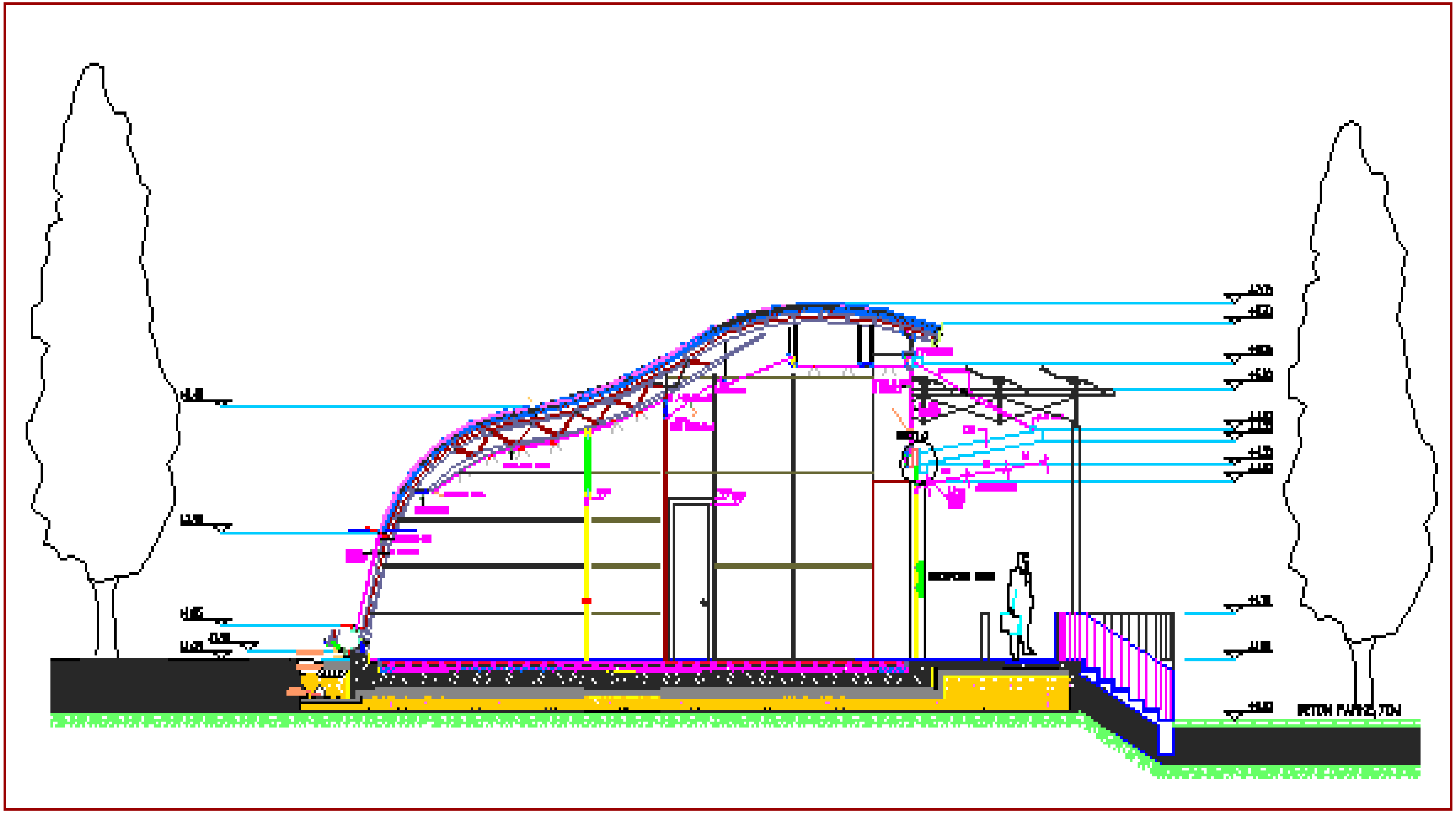


Figure 2.3: Side View of GUZEB.

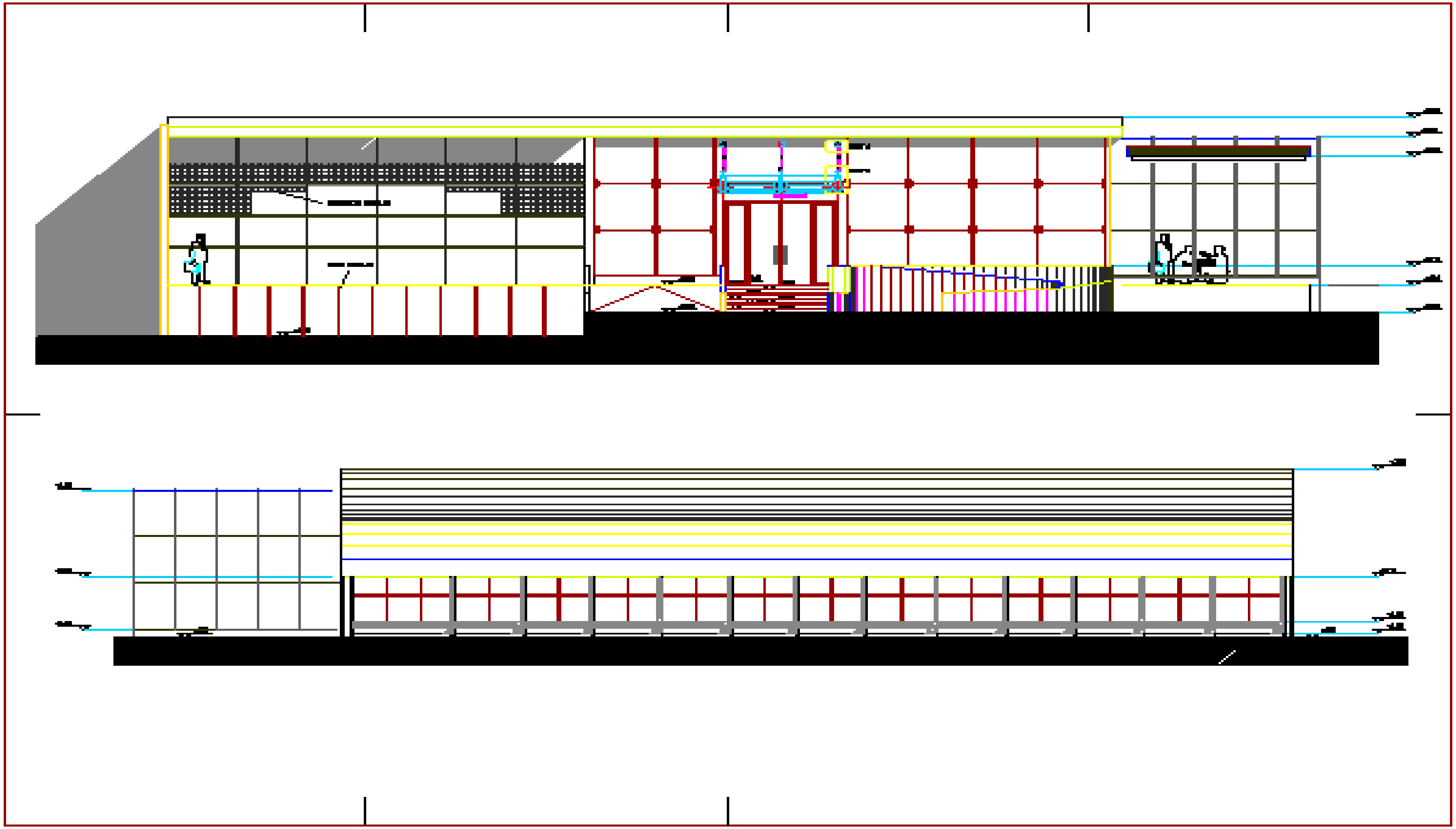


Figure 2.4: Front Side View of GUZEB.

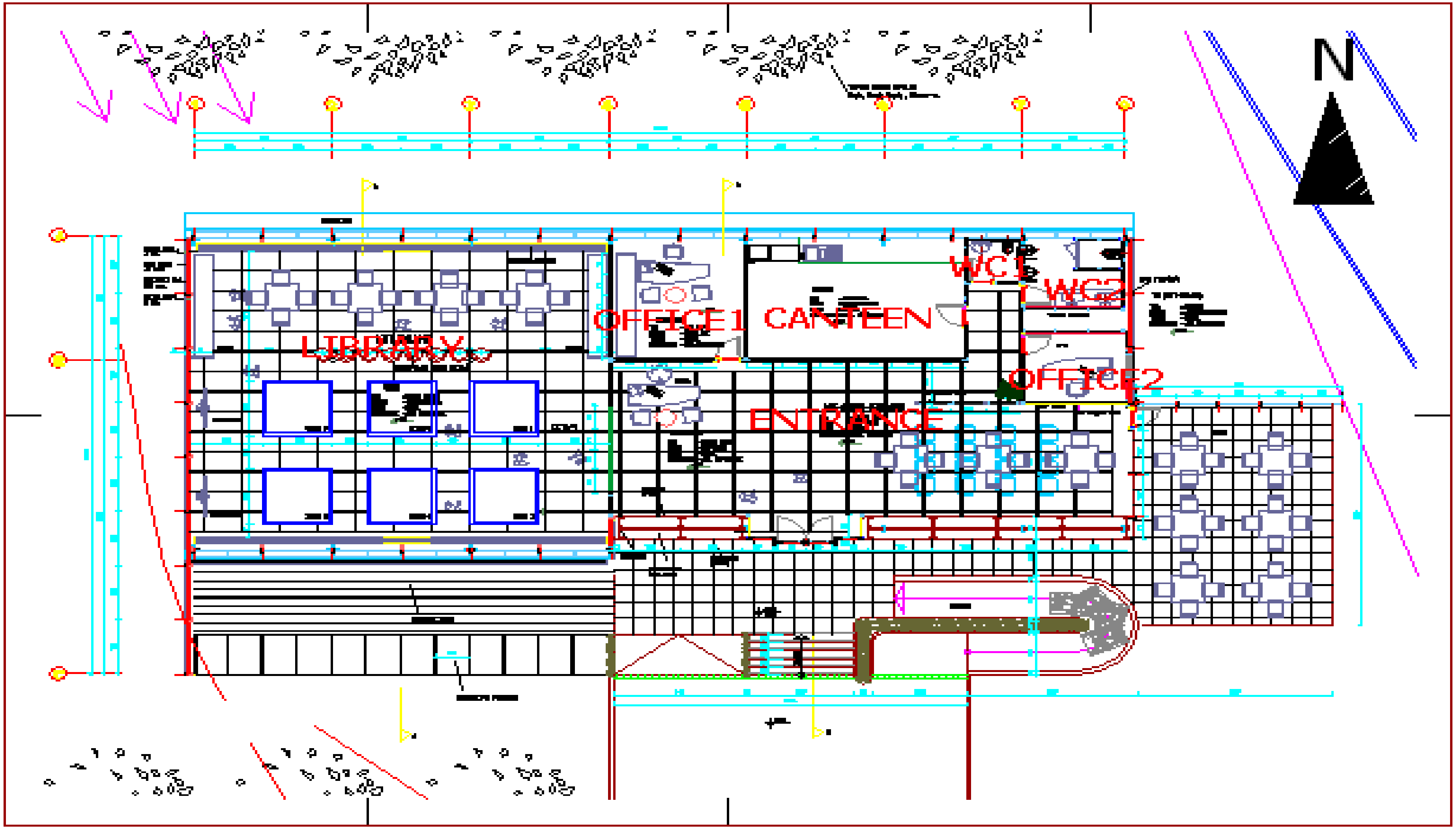


Figure 2.5: Plan of GUZEB.

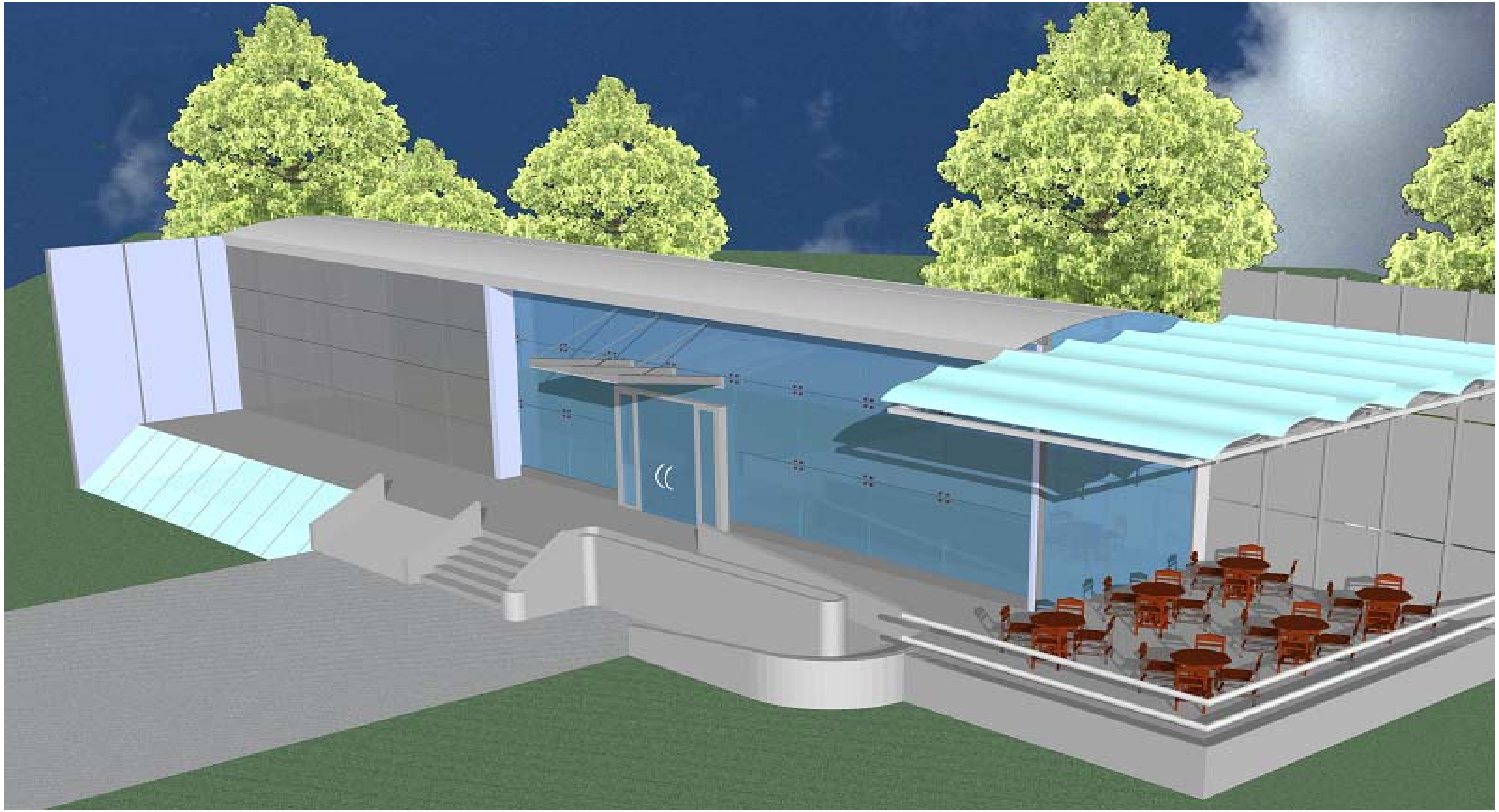


Figure 2.6: 3D View of GUZEB.

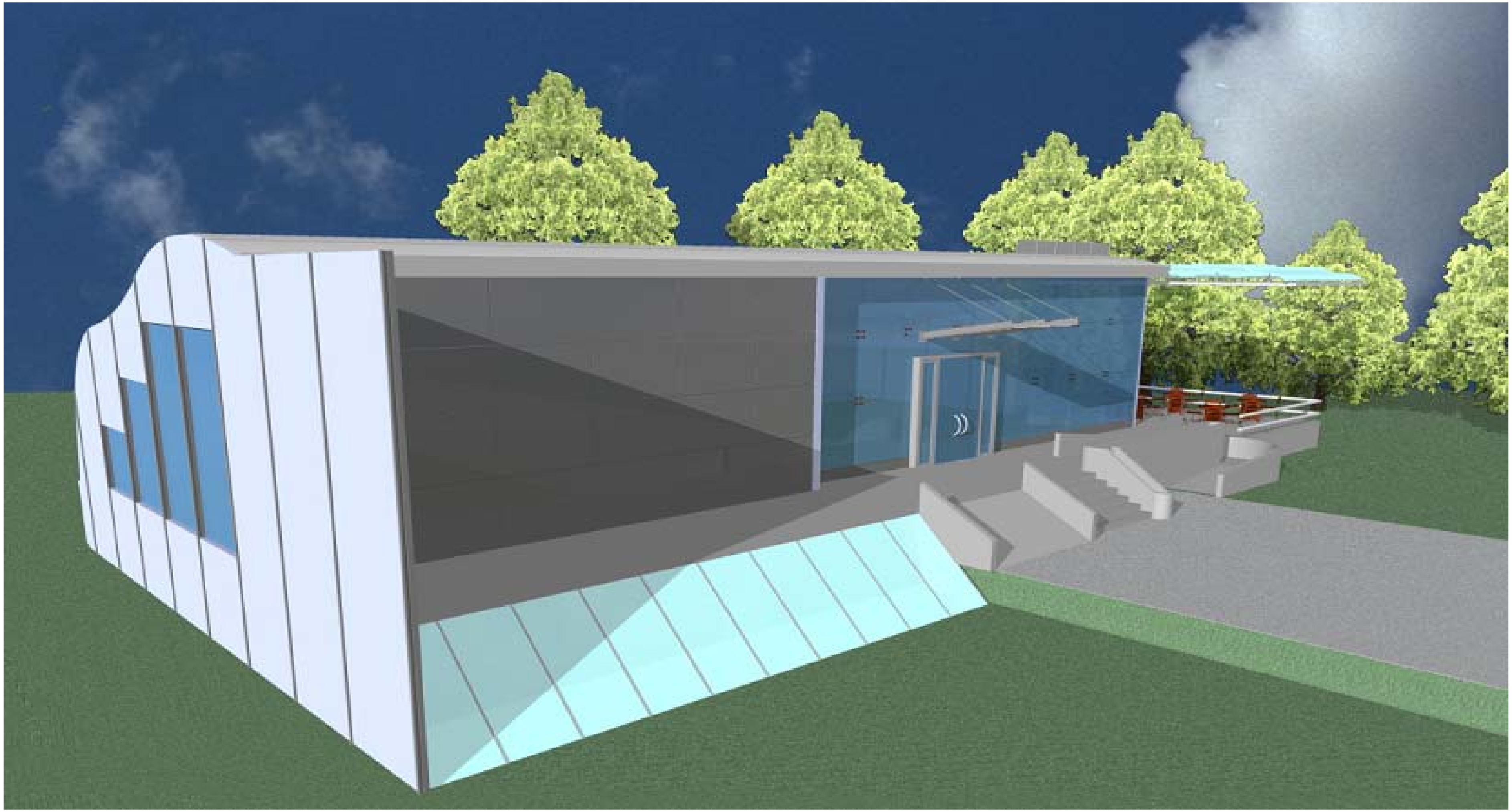


Figure 2.7: 3D View of GUZEB.

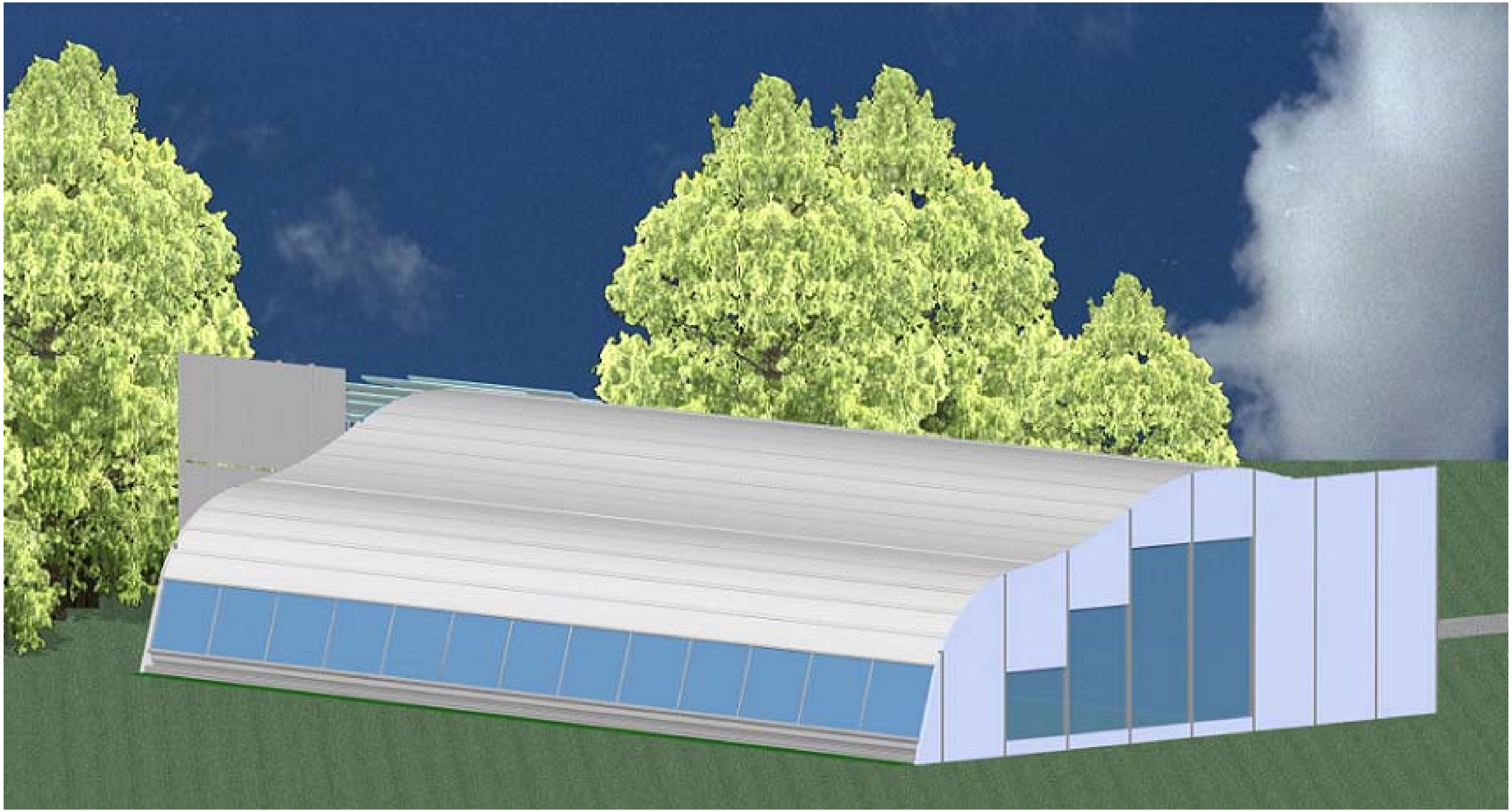


Figure 2.8: 3D View of GUZEB.

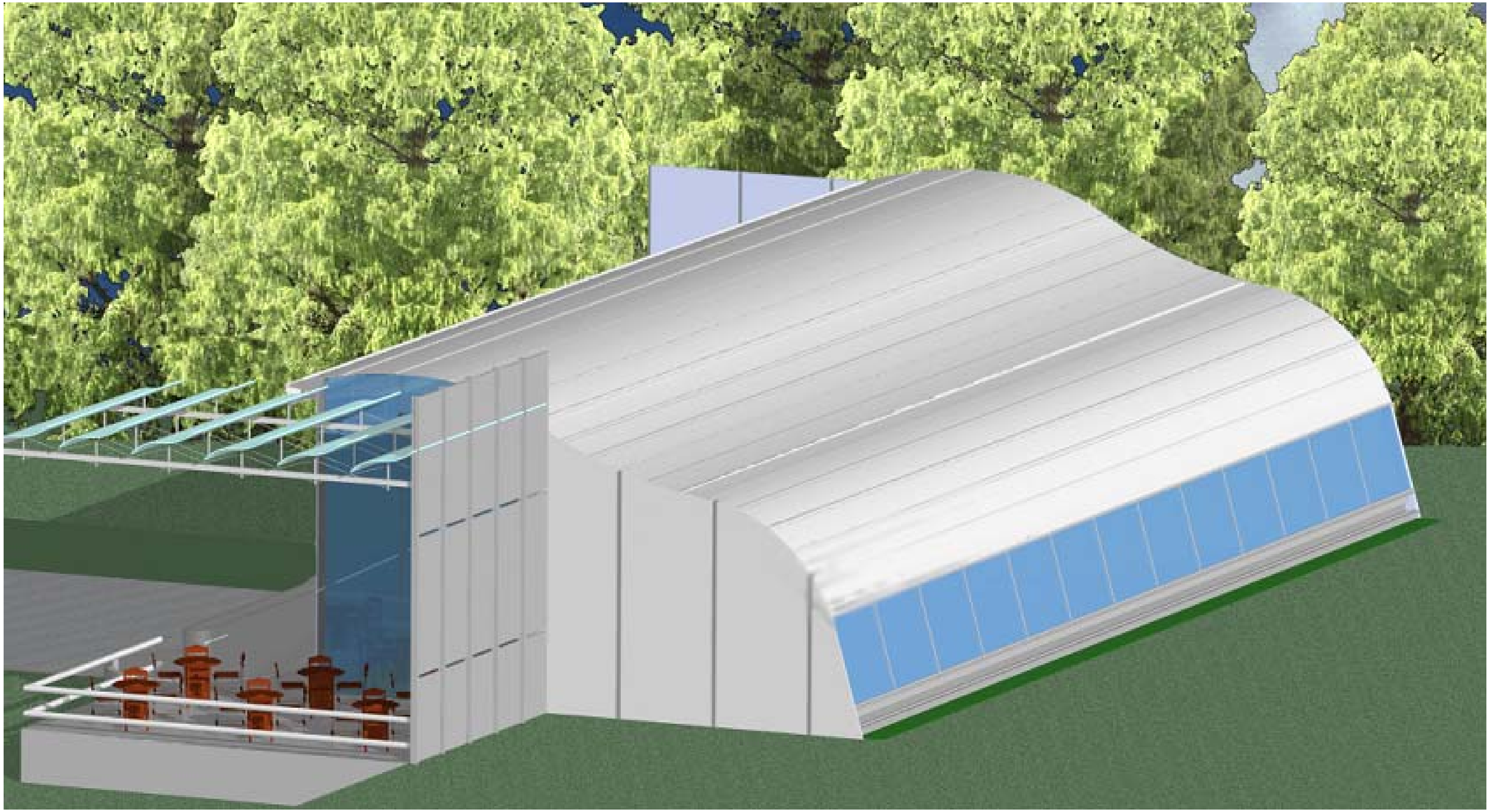


Figure 2.9: 3D View of GUZEB.

2.3 Selection of Construction Materials

Many construction materials are used in GUZEB's design. These materials are chosen for protecting energy, and for energy saving. These materials are listed below.

2.3.1 Windows

As mentioned before, all of the building's glasses will be triple glass and PVC. The air gaps between these three glasses are more helpful to protect energy than double glass windows (Figure 3.4). At the north side, backside of the building, windows cannot be collapsible. So, this functionality lowers infiltration. The south side of the building will be covered with this triple glass as mentioned.

Storing solar energy will not be a problem in winters with the help of the pebbles between two glasses. But in summer, heat load will cause problems. But these problems can be solved with curtains that not allow sunshine in.

2.3.2 Walls

Outer walls are made of metal sheet with 20cm. insulation material between them (Figure 3.3). Metal sheet is chosen because of the special roof style. Furthermore, some walls are supported by insulation with special insulation material. This insulation material will be discussed in Chapter 2.

2.3.3 Floor

The building will be single floored. Because of this, floor insulation gains more importance (Figure 3.1). Floor-heating system will be used for heating the building (Chapter 4). So, floor is the most important part of the building because of the special functionality of the building.

2.4 Heating System of the GUZEB

Heating system of GUZEB is designed based on the floor heating system. As mentioned, Turkey has great geothermal sources. Close to the building area, an ancient cave exists and this cave has approximately 32°C water source. Nevertheless, the temperature having that value will not be sufficient for floor heating system. Floor heating systems operate between 29-60ºC, compared to other hydronic heating systems' range of 54-71ºC. On the contrary, this source is continuous and limitless. So, this continuity helps us to use this source. More information will be studied in Chapter 4 with the design of floor heating system of GUZEB.

2.5 Cooling System of the GUZEB

GUZEB is designed for library function but on special days, for example on the symposium day, the building's cooling load will be maximum or 2-3 times greater than on usual days. If the cooling system is chosen for regular day cooling load, cooling system will not be enough on special days, while people load, equipment load or other loads are maximum.

For instance, churches have minimum cooling load on regular days. In contrast, on Sundays, churches have maximum heat load (Figure 2.10). But if the cooling system is chosen for Sundays, cooling system will not operate on other days with full capacity. This means that installation and operating cost will be meaningless. At this stage, stored energy will be more suitable and operable. This means that while operating on regular days, energy could be stored for special days (Chapter 6).

Cooling System will be controlled by automatic control systems.

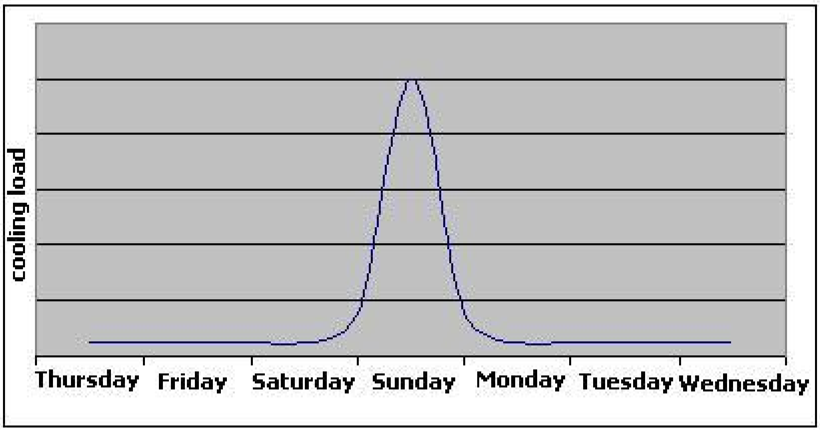


Figure 2.10: Projection of a Church Cooling Load on Sundays.

2.6 Clean and Wastewater System of the GUZEB

GUZEB has two toilets and a canteen. As a result, clean and wastewater design is related with these three spaces. Warm water will be used both in Canteen and in toilets. This water will be pumped from the ancient cave. Clean water can be taken from network or an artesian well.

2.7 Fire Protection System of the GUZEB

Fire protection system will be controlled automatically. Fire protection system will take its water from energy storage tank. In Chapter 6, design of energy storage tank will be discussed.

2.8 Lighting of the GUZEB

Lighting load of the GUZEB have to be minimum for energy saving. Because of this reason, window area is taken maximum to let the daylight lighting in. On the contrary, in summer, large window area will cause problem from the point of view of cooling load. Curtains simply will solve this problem.

At nights or more lighting is needed, especially for the areas which have not enough window area, energy efficient lighting sources will be used. These sources are 34W florescent lighting sources. For library lighting, 10 bulbs will be used, 4 bulbs for entrance, 2 bulbs for each place, canteen and office1, and 1 bulb for each place, office2 and toilets [17]. Fluorescents use up to 75% less energy, and should last approximately 10 000 hours.

Furthermore, other lighting options are suggested. These sources will be discussed in Chapter 2, Energy Saving Suggestions section. So with the light of these suggestions, lighting load of the library is taken less then the real calculation data.

2.9 Energy Saving Suggestions

2.9.1 Silica Aerogel

Aerogels are transparent, amazingly porous, low-density foams. Silica aerogel is a light form of silica that is 99.8% air [18,19]. Figure 2.11 shows the pore structure.

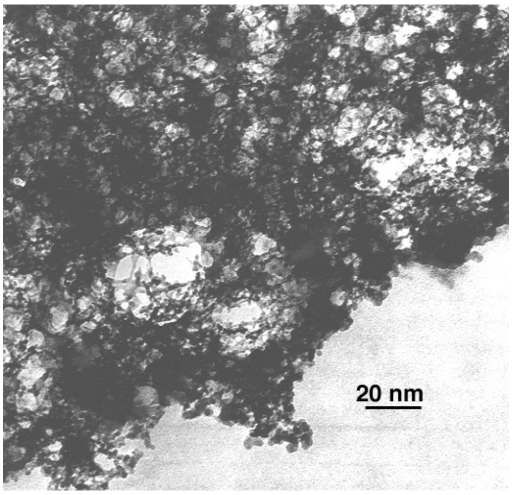


Figure 2.11: Pore Structure of Aerogel [20].

Silica aerogel has different pore diameter. Pores of less than 2 nm in diameter are called "micropores", diameters between 2 and 50 nm are termed "mesopores", and those greater than 50 nm in diameter are termed "macropores". The pore size distribution of a single-step silica aerogel is shown in Figure 2.12.

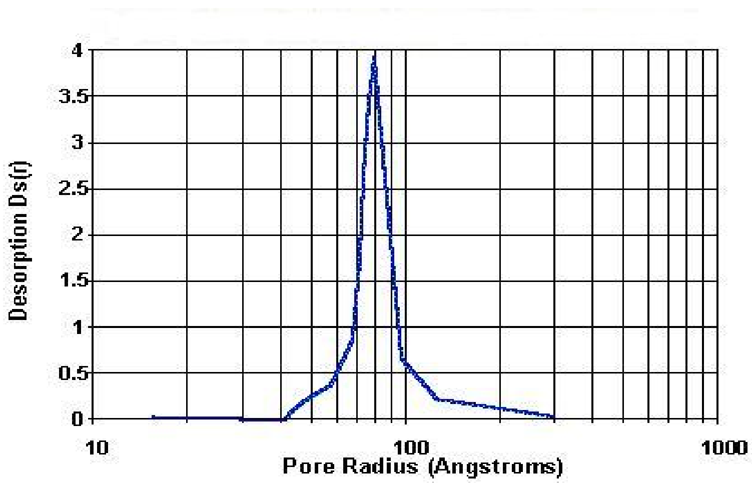


Figure 2.12: Pore Size Distribution of Silica Aerogel [20].

Furthermore, Figure 2.13 shows that aerogel has excellent insulating properties that aerogel never burn and never transport heat. Besides, Figure 2.14 illustrates the high technologic silica solid. Aerogel is very solid because of a ghostly appearance like an hologram. It feels like hard styrofoam when you touch.

Figure 2.13: Flower is Protected From Fire [18].

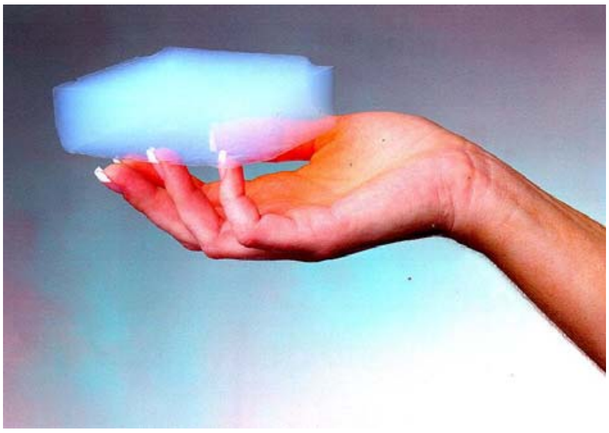


Figure 2.14: Aerogel in Hand [18].

With high technology, aerogels can be very transparent. This transparency is as same as a glass. So, aerogel can be used both an insulator and a window in architectural designs.

Figure 2.15: Transparency Example of Aerogel [20].

Silica aerogel are used for many applications. These applications are listed in Table 2.1 by the properties and features.

Table 2.1: Aerogel Properties and Features with Their Application [21].

Property	Features	Applications
Thermal Conductivity	*best insulating solid *transparent *high temperature *lightweight	**building insulation**, portable coolers,transport vehicles,pipes,cryogenic, skylightsspace vehicles and probes,casting molds
Density/Porosity	*lightest synthetic solid *homogeneous *high specific surface area *multiple composition	catalysts,sorbers,sensors,fuel storage, ion exchange ,X-ray lasers
Optical	*low refractive index solid *transparent *multiple composition	Cherenkov detectors, lightweight optics, lightguides,special effect optic
Acoustic	*lowest sound speed	impedance matchers for transducers,speakers
Mechanical	*elastic *lightweight	energy aborber,hypervelocity particle trap
Electrical	*lowest dielectric constant *high dielectric strength *high surface area	spacers for vacuum electrodes, vacuum display spacers,capacitors

As shown from the Table 2.1, silica has many applications areas and one of its most important applications is building insulation because aerogels are the best insulator that ever discovered. Aerogels provides 39 times more insulating than the best fiberglass insulation [18]. High technologic aerogel's thermal conductivity at $300^{o}K$ is 0.01-0.02 W/m^2K [19]. But, this value is changed depends on the types of silica aerogel, which are granular and monolithic. Because of this property, silica aerogel application is decided to use in GUZEB. Especially the biggest outer wall, west side of the building, aerogel application will be used. Approximately, 25-m^2 granular silica aerogel will be used between 6 mm glass panels. Thermal conductivity is taken 0.51 W/m^2K [22]. This kind of aerogel is used for GUZEB because of the investment cost of the building. As known, given examples above for instance high transparency and high insulation property, need high technology.

2.9.2 Composite Ceramic Roof Insulation

Composite ceramic insulation is designed for roofs, sidewalls, buildings and homes to help for insulation. This coating material will be used on roof of GUZEB.

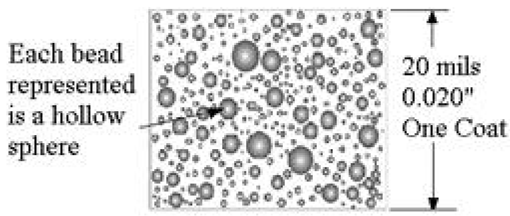


Figure 2.16: Pore Structure of Composite Ceramic Insulation Material [23].

As shown in Figure 2.16, this material is different from other applied coatings. More air between the particles increases the efficiency of heat transfer. With these kind of insulation materials energy savings average is 30-75% depending on geographic area. This coating material's coat thickness is approximately 0.5mm. It has low permeability, and reflectivity is 76%, has 100% UV reflection. The most important part for our design is thermal conductivity. Its thermal conductivity is 0.1 W/m^2K [23].

2.9.3 Fiber Lighting

Fiber cable lighting is a suggestion for lighting of the GUZEB. Because of its unique advantage in low energy consumption and low surface temperature, fiber lighting is one of the safest lighting products for lighting. This kind of lighting will take the place of neon border lighting. Its light source has a rated life of up to 100 000 hours. Illuminators are the light source of this fiber optic system. They do not use electrical power. With these illuminators, cables do not need electricity, and after use up time of the illuminators, illuminators are replaced with the new one.

The cable is flexible and can be bent around corners (Figure 2.17).

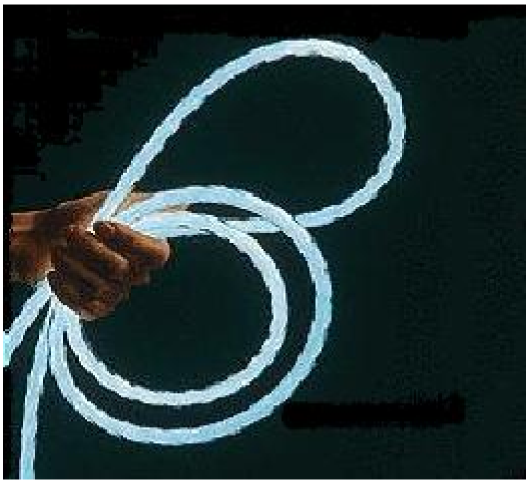


Figure 2.17: Flexibility of Fiber Cable.

Additionally, the cable is made of durable, UV protected PMMA plastic. There is nothing to break or burn out. There is no heat transmitted by the cable. It is safe because it carries no electricity, it can be used in water and there are no glass tubes or lamps to break. The cable is unbreakable, shockproof and waterproof [24,25].

The fiber lighting suggestion can be used in GUZEB to reduce energy consumption.

2.9.4 Curtains and Panels

Many different types of curtains or panels can be used to shade the areas. Specially, entrance has huge glass window area to let the sunshine in. On the other hand, in summer, this huge window is a handicap for cooling load. With the curtains or panels, sunshine will not be let in. For this reason, panels will be better to use outside of the glass, not in the space. This application can help not to store energy inside of the space that is 80cm. between two glasses.

Chapter 3

HEATING AND COOLING LOAD CALCULATIONS

3.1 General Information

In this chapter, GUZEB's heating and cooling load are calculated and the results are given.

Firstly, calculation details, which include material selection that will be used in construction and thermal conductivity of these selected materials against the thickness of the materials, are illustrated.

Secondly, for each part of the GUZEB, heating load is calculated according to TS 825 standard for determination of the heating load in buildings [26]. The results are given in Table 3.5.

Besides, cooling load is calculated in two different ways that both are based on ASHRAE standards [27]. Alarko-Carrier's HVAC Design Software, E20-II Hourly Analysis Program [28] calculates the cooling load values with hourly changing load distributions. This distribution is based on the loads that cause changing on cooling load hour by hour. Software values are compared with the second calculation method, which calculates the values not with hourly changing load distributions [29].

Finally, cooling load results are given in Table 3.9. Alarko-Carrier's HVAC Design Software printouts are given in Appendix A.

3.2 Heating Load Calculations

3.2.1 Construction Materials and Thermal Conductivity of the Materials

3.2.1.1 Floor

GUZEB's floor materials and their thickness are illustrated in Figure 3.1, and their thermal conductivity values are shown in Table 3.1.

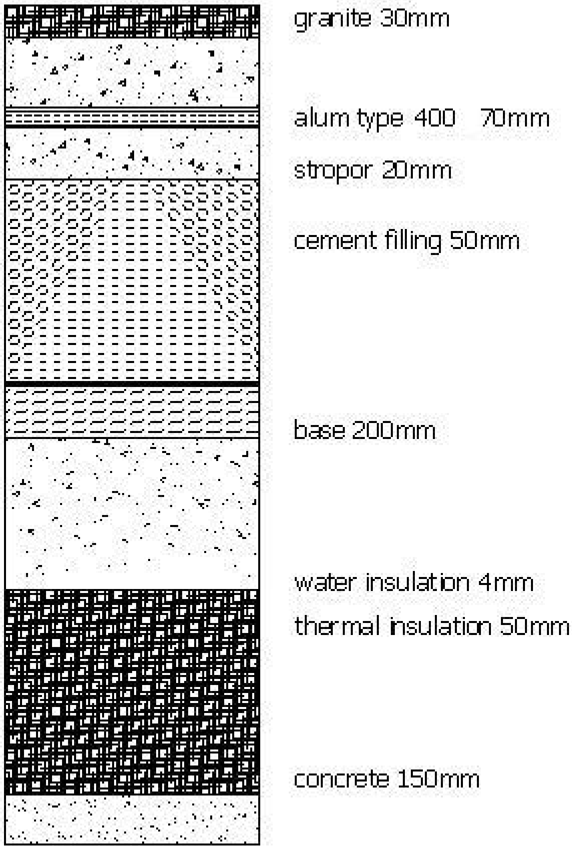


Figure 3.1: Floor Materials and Their Thickness.

Table 3.1: Thermal Conductivity Values of Floor Materials.

Material	Width	Thermal Conductivity
	(m)	(W/mK)
granite	0.03	3.5
alum type 400	0.07	0.72
stropor	0.02	0.04
cement filling	0.05	1.74
base	0.2	2.1
water insulation	0.004	0.7
thermal insulation	0.05	0.04
concrete	0.15	2
stone	0.2	1.4
sand	0.05	2.1

3.2.1.2 Roof

GUZEB's roof materials and their thickness are illustrated in Figure 3.2, and their thermal conductivity values are shown in Table 3.2.

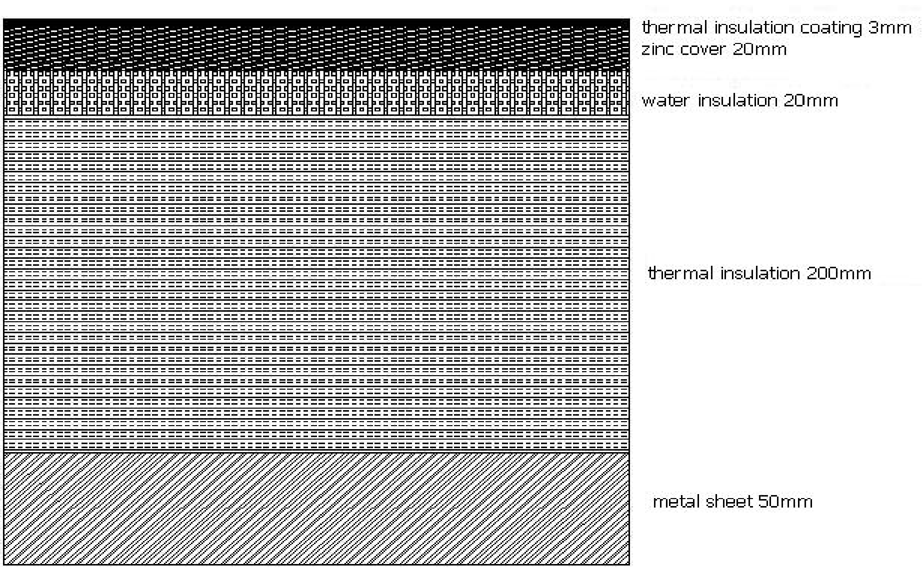


Figure 3.2: Roof Materials and Their Thickness.

Table 3.2: Thermal Conductivity Values of Roof Materials.

Material	Width	Thermal Conductivity
	(m)	(W/mK)
thermal insulation coating	0.003	0.1
zinc cover	0.02	116
water insulation	0.02	0.7
thermal insulation	0.2	0.04
metal sheet	0.05	15.1

3.2.1.3 Outer Walls

GUZEB's outer walls materials and their thickness are illustrated in Figure 3.3, and their thermal conductivity values are shown in Table 3.3.

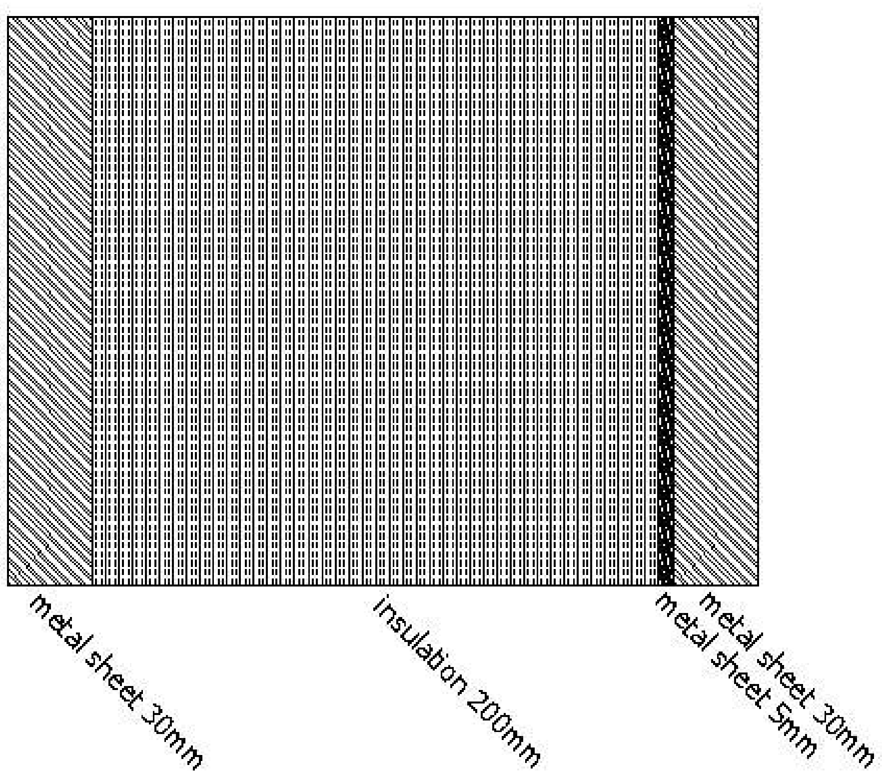


Figure 3.3: Outer Wall Materials and Their Thickness.

Table 3.3: **T**hermal Conductivity Values of Outer Walls Materials.

Material	Width	Thermal Conductivity
	(m)	(W/mK)
metal sheet	0.03	15.1
insulation	0.2	0.04
metal sheet	0.0005	15.1
metal sheet	0.03	15.1

3.2.1.4 Windows

GUZEB's window type is illustrated in Figure 3.4, and thermal conductivity values are shown in Table 3.4.

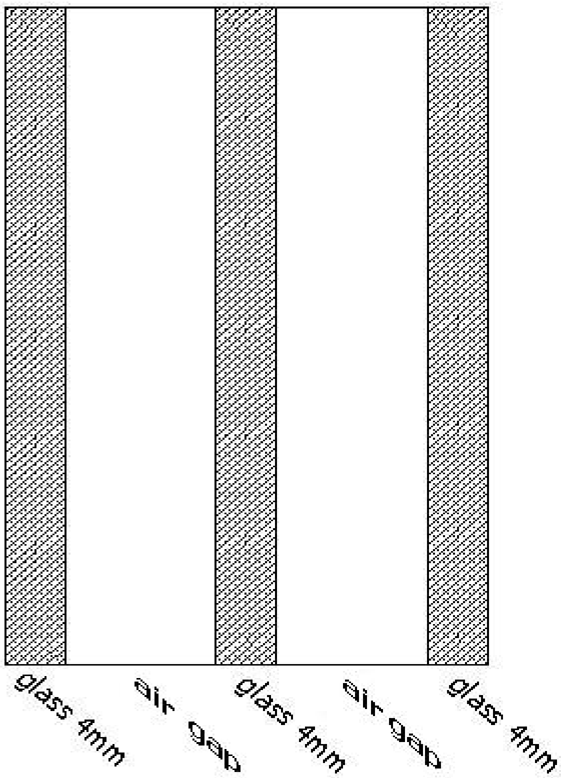


Figure 3.4: Window Materials and Their Thickness.

Table 3.4: Thermal Conductivity Values of Windows Materials

Material	Width	Thermal Conductivity
	(m)	(W/mK)
glass	0.04	5.23

3.2.1.5 Silica Wall

GUZEB's outer wall of silica aerogel is illustrated in Figure 3.5, and its thermal conductivity value is taken as 0.51 W/m^2K [22].

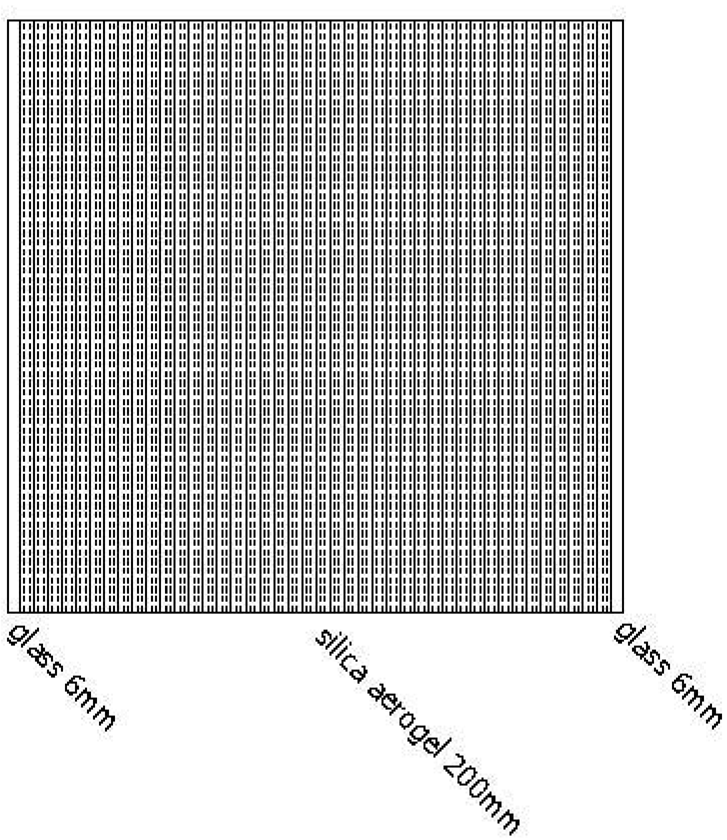


Figure 3.5: Silica Wall Materials and Their Thickness.

3.2.2 External Free Convection Flows Empirical Correlations

In this section, empirical correlations that have been calculated for floor heating system. The correlations are generally of the form of Nusselt Number. More convenient values are calculated below with the free convection flows empirical correlations for vertical and inclined plates [30]. Rayleigh Number is depends on the value of convection coefficient.

Where the Rayleigh Number is:

$$Ra_L = \frac{g\beta(T_s - T_\infty)L^3}{\nu\alpha} \tag{3.1}$$

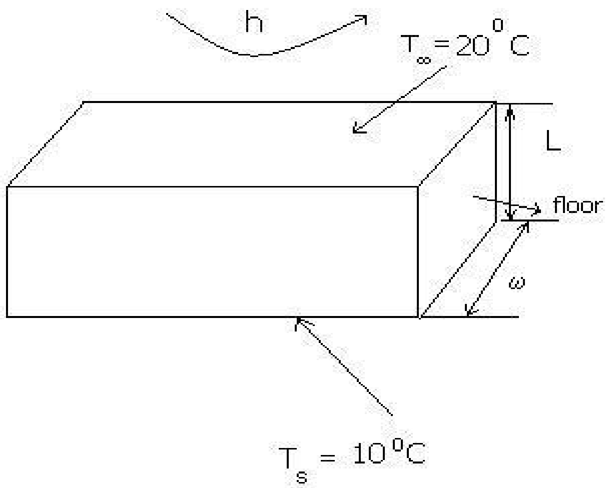


Figure 3.6: Floor Convection Schema.

Inner air temperature T_∞ is taken 20 ^oC and the ground temperature T_s is 10^oC for Izmir [26].

$T_\infty = 20^oC$; $T_s = 10^oC$

Air properties at 20^{o}C are;

$\nu = 15.445 \cdot 10^{-6}$ m^2/s

$\alpha = 21.81 \cdot 10^{-6}$ m^2/s

$\beta = 0.003389$ K^{-1}

k = $25.9 \cdot 10^{-3}$ W/mK

Pr = 0.7083

Then Rayleigh Number from Equation 4.1 for horizontal plates is:

$$Ra_L = \frac{9.81 \cdot 0.003389 \cdot (20-10) \cdot (0.824)^3}{15.445 \cdot 10^{-6} \cdot 21.81 \cdot 10^{-6}} = 5.522 \cdot 10^8$$

and Nusselt Number for horizontal plates is:

$$\overline{Nu}_L = 0.15 \cdot Ra_L^{1/3} \qquad \text{if} \qquad 10^7 \leq Ra_L \leq 10^{11} \qquad (3.2)$$

and Nusselt Number from Equation 3.2 is:

$$\overline{Nu}_L = 0.15 \cdot (5.22 \cdot 10^8)^{1/3} = 123.06$$

The convection coefficient associated with the sides is then

$$h = \frac{k}{L} \overline{Nu}_L \qquad (3.3)$$

For the top and the bottom, L = $A_S/P \cong \omega/2$ if $\omega \cong 1$ m. is taken,

$$h = \frac{25.9 \cdot 10^{-3}}{0.5} \cdot 123.06 = 6.375 \text{ W/m}^2\text{K}$$

For vertical plates;

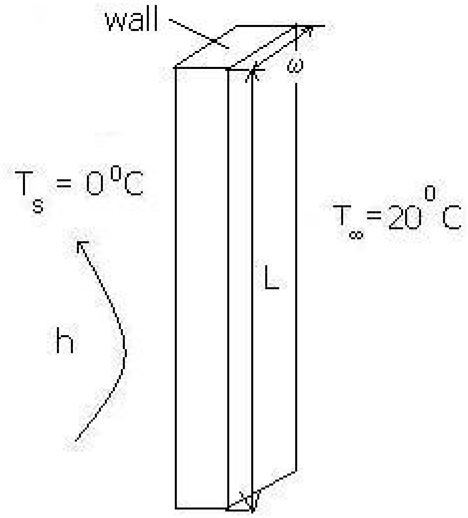


Figure 3.7: Wall Convection Schema.

From Equation 3.1 where L is approximately 2.5m:

$$Ra_L = \frac{9.81 \cdot 0.003389 \cdot (20-0) \cdot (2.5)^3}{15.445 \cdot 10^{-6} \cdot 21.81 \cdot 10^{-6}} = 3.084 \cdot 10^{10}$$

if $10^9 \leq Ra_L$ then;

$$\overline{Nu}_L = \left\{ 0.825 + \frac{0.387 \cdot Ra_L^{1/6}}{\left[1 + (0.492/\Pr)^{9/16}\right]^{8/27}} \right\}^2 \qquad (3.4)$$

$$\overline{Nu}_L = \left\{ 0.825 + \frac{0.387 \cdot (3.084 \cdot 10^{10})^{1/6}}{\left[1 + (0.492/0.7083)^{9/16}\right]^{8/27}} \right\}^2 = 360.5974$$

then ;

$$\bar{h} = \overline{Nu}_L \frac{k}{L} \qquad (3.5)$$

$$\bar{h} = 360.5974 \cdot \frac{0.193}{2.5} = 27.838$$

3.2.3 Heating Load Summary

In conclusion total heat losses of each space of the GUZEB's are given in Table 3.5.

Table 3.5: Total Heat Losses of Each Space of GUZEB's.

LIBRARY				
	AREA	ΔT	Thermal Conductivity	Q
	(m^2)		(W/mK)	(W)
FLOOR	125.6	10	0.419	526.26
ROOF	140	20	0.192	537.60
WINDOW	12.18	20	0.273	66.51
SILICA WALL	25	20	0.51	255
OUTER WALL	26.9	20	0.197	105.98
BACKWALL	14.62	20	0.197	57.61
FRONT WALL	68.4	20	0.197	269.50
			$Q_{Library}$ (W)=	**1 818.45**
ENTRANCE				
	AREA	ΔT	Thermal Conductivity	Q
	(m^2)		(W/mK)	(W)
FLOOR	87.4	8	0.419	292.97
ROOF	93	18	0.192	321.41
WINDOW	84.5	18	0.273	415.23
DOOR	3.9	18	0.273	19.16
OUTER WALL	15.9	18	0.197	56.38
			$Q_{entrance}$ (W)=	**1 105.15**
OFFICE 1				
	AREA	ΔT	Thermal Conductivity	Q
	(m^2)		(W/mK)	(W)
FLOOR	16.8	10	0.419	70.39
ROOF	17.5	20	0.192	67.20
WINDOW	3.85	20	0.273	21.02
OUTER WALL	4.62	20	0.197	18.20
			$Q_{office1}$ (W)=	**176.82**
OFFICE 2				
	AREA	ΔT	Thermal Conductivity	Q
	(m^2)		(W/mK)	(W)
FLOOR	9	10	0.419	37.71
ROOF	9.5	20	0.192	36.48
WINDOW	0.9	20	0.273	4.91
OUTER WALL	11	20	0.197	43.34
			$Q_{office2}$ (W)=	**122.44**

CANTEEN				
	AREA	ΔT	Thermal Conductivity	Q
	(m^2)		(W/mK)	(W)
FLOOR	27.5	8	0.419	92.18
ROOF	30	18	0.192	103.68
WINDOW	6.3	18	0.273	30.96
OUTER WALL	7.56	18	0.197	26.81
			$Q_{canteen}$ (W)=	**253.63**
WC 1				
	AREA	ΔT	Thermal Conductivity	Q
	(m^2)		(W/mK)	(W)
FLOOR	2.5	8	0.421	8.42
ROOF	2.7	18	0.192	9.33
WINDOW	1.6	18	0.273	7.86
OUTER WALL	1.92	18	0.197	6.81
			Q_{wc1} (W)=	**32.43**
WC 2				
	AREA	ΔT	Thermal Conductivity	Q
	(m^2)		(W/mK)	(W)
FLOOR	7.71	8	0.419	25.84
ROOF	8	18	0.192	27.65
WINDOW	3	18	0.273	14.74
OUTER WALL	23.8	18	0.197	84.39
			Q_{wc2} (W)=	**152.63**

Besides, considered that floor heating system will functioned nearly all day long. For this reason, safety factor can be taken approximately 7%. Furthermore heat loss from infiltration is calculated from Equation 3.6 [26]. From Table 3.5 total calculated heat loss is:

$$Q = Q_{library} + Q_{entrance} + Q_{office1} + Q_{office2} + Q_{canteen} + Q_{wc1} + Q_{wc2}$$

$$Q = 3661.54 \text{ W}$$

Safety total heat loss is:

$$Q = 3661.54 \cdot (1 + 0.07) = 3917.85 \text{ W}$$

$$Qs = \Sigma\, a \cdot l \cdot R \cdot H \cdot \Delta T \qquad (3.6)$$

where;

a: heat loss coefficient (m^3/mh)

l: window or door collapsible length (m)

R: room localization coefficient

H: building localization coefficient (W/m^3 ^oC)

ΔT: temperature difference (K)

Then total heat loss of the building is:

$$Q_{total} = \mathbf{4256.65}\ W$$

3.3 Cooling Load Calculations

3.3.1 Space Specifications

Cooling load is based on the space properties, which include the examination of window types, areas and directions, or other factors that contain the load of equipment or human load factors. These specifications are thought as a scenario if a symposium is organized in GUZEB in summer and specifications are stated in Table 3.6 for each space of the building. This kind of scenario is constituted for peak load values whether the system that will be installed can cover up the cooling load or not. Number of people and equipment loads are designated on a special day, symposium, which constitutes maximum peak cooling load. If the system can cover up the load on that kind of special days, it can easily come over the usual days, which has no special load values.

Table 3.6: Space and Equipment Specifications of GUZEB's.

LIBRARY			
	AREA (m2)	WALL TYPE	WINDOW TYPE
WALL DIRECTION*			
WNW	26.9	OUTER WALL	-
WNW	25	SILICA WALL	-
SSW	68.4	OUTER WALL	-
NNW	26.8	ROOF WALL	LIBRARY BACK WINDOW
FLOOR	125.6		
ROOF	140		
	QUANTITY		
PEOPLE	40	OFFICE WORK	
COMPUTER	4		
MONITOR	10		
PRINTER	2		
EQUIPMENT LOAD** (W)	1 390		
LIGHTING LOAD*** (W)	340		
ENTRANCE			
	AREA (m2)	WALL TYPE	WINDOW TYPE
WALL DIRECTION*			
SSW	85	OUTER WALL	-
SSE	15.9	OUTER WALL	DOOR
FLOOR	87.4		
ROOF	93		
	QUANTITY		
PEOPLE	10	OFFICE WORK	
COMPUTER	1		
MONITOR	1		
PRINTER	1		
EQUIPMENT LOAD** (W)	350		
LIGHTING LOAD*** (W)	136		
OFFICE 1			
	AREA (m2)	WALL TYPE	WINDOW TYPE
WALL DIRECTION*			
WNW	13.9	ROOF WALL	OFFICE 1 BACK WINDOW
FLOOR	16.8		
ROOF	17.5		
	QUANTITY		
PEOPLE	1	OFFICE WORK	
COMPUTER	1		
MONITOR	1		
PRINTER	1		
EQUIPMENT LOAD** (W)	350		
LIGHTING LOAD*** (W)	68		

OFFICE 2			
	AREA (m2)	WALL TYPE	WINDOW TYPE
WALL DIRECTION*			
SE	11.9	OUTER WALL	OFFICE 2 WINDOW
FLOOR	9		
	QUANTITY		
PEOPLE	1	OFFICE WORK	
COMPUTER	1		
MONITOR	1		
PRINTER	1		
EQUIPMENT LOAD** (W)	350		
LIGHTING LOAD*** (W)	34		

* N:NORTH, E:EAST, S:SOUTH, W:WEST
** MEDIUM LOAD DENSITY, ASHRAE 29.13 TABLE 12
*** WITH ENERGY SAVING LAMPS; LIGHTING LOAD: 2.7 W/m^2 for library, 1.55 W/m^2 for entrance, 4 W/m^2 for others.

3.3.2 Cooling Load Calculation Without Hourly Changing Load Distribution

3.3.2.1 General Information

Cooling load calculation determines total sensible cooling load due to heat gain through structural component for instance, walls, floors, ceilings, and windows. Equation 3.7 is the main formula for calculating the sensible cooling load using cooling load temperature differences, $(CLTD)_m$ [27].

$$Q_s = F_c \cdot k \cdot A \cdot (CLTD)_m \tag{3.7}$$

In Equation 3.7, F_c is the storage capacity of the space and calculated from Equation 3.8 and 3.9.

$$F_c = 1\text{-}0.0116\, K_T \tag{3.8}$$

$$K_T = \frac{1}{L_f}(\Sigma kA) \tag{3.9}$$

Other cooling load is related with the window-shading factor. Cooling load from the types of the windows is calculated generally with Equation 3.10.

$$Q_{ws} = F_c \cdot A_{ws} \cdot S_c \cdot SHGF \cdot CLF \quad (3.10)$$

And cooling load from people, lighting and other equipments, which are used in the spaces are calculated with the equations from 3.11 to 3.13.

$$Q_{light} = N \cdot CLF \cdot F_c \quad (3.11)$$

$$Q_{people} = S \cdot SHG \cdot CLF \cdot F_c + S \cdot LHG \quad (3.12)$$

$$Q_{eq} = P_s \cdot CLF \cdot F_c + P_l \quad (3.13)$$

where;

S_c: shading factor

SHGF: heat gain factor, [W/m^2]

CLF: load factor

N: wattage of lighting equipment

S: number of people

SHG: sensible heat gain factor, [W]

LHG: latent heat gain factor, [W]

P_s: sensible load, [W][31]

P_l: latent load, [W][31]

3.3.2.2 Cooling Load Calculation of Library

From Equation 3.8 and 3.9

$$K_T = \frac{1}{(12.18 \cdot 2 + 10.31)} \cdot (0.192 \cdot 140 + 0.197 \cdot 109.92 + 0.51 \cdot 25 + 0.273 \cdot 12.18)$$

$K_T = 1.8635$

$F_c = 1\text{-}0.0116\ K_T$

$F_c = 0.978$ $(CLTD)_m = 3.1$

Cooling load from the roof is calculated by using Equation 3.7:

$Q_r = F_c \cdot k_r \cdot A_r \cdot (CLTD)_m$

$Q_r = 0.978 \cdot 0.192 \cdot 140 \cdot 3.1$

$\mathbf{Q_r = 81.5\ W}$

Cooling load from outer walls is:

$Q_{ow} = F_c \cdot k_{ow} \cdot A_{ow} \cdot (CLTD)$

$Q_{ow} = 0.978 \cdot 0.197 \cdot (26 \cdot 9 \cdot 7 + 68 \cdot 4 \cdot 10) + 0.978 \cdot 0.51 \cdot 25 \cdot 7$

$\mathbf{Q_{ow} = 926.92\ W}$

Cooling load from windows is:

$Q_w = F_c \cdot k_w \cdot A_w \cdot (CLTD)$

$Q_w = 0.978 \cdot 0.273 \cdot 12.18 \cdot 8$

$\mathbf{Q_w = 26.02\ W}$

Cooling load from window shading is:

$Q_{ws} = F_c \cdot A_{ws} \cdot S_c \cdot SHGF \cdot CLF$

$Q_{ws} = 0.978 \cdot 12.18 \cdot 0.39 \cdot 624 \cdot 0.18$

$\mathbf{Q_{ws} = 521.8\ W}$

Cooling load from lighting is:

$Q_{light} = N \cdot CLF \cdot F_c$, 12 hours lighting period, lights opens at 8:00 am. B type furniture

$Q_{light} = 340 \cdot 0.8 \cdot 0.978$

$\mathbf{Q_{light} = 266W}$

Cooling load from people is:

$Q_{people} = S \cdot SHG \cdot CLF \cdot F_c + S \cdot LHG$, light working

$Q_{people} = 40 \cdot 65 \cdot 0.84 \cdot 0.978 + 40 \cdot 55$

$\mathbf{Q_{people} = 4\ 335.95\ W}$

Cooling load from equipments is:

$Q_{eq} = P_s \cdot CLF \cdot F_c + P_l$

$Q_{eq} = 1390 \cdot 0.78 \cdot 0.978$

$\mathbf{Q_{eq} = 1\ 060.34\ W}$

$\mathbf{Q_{LIBRARY} = 7\ 218.5\ W}$

3.3.2.3 Cooling Load Other Spaces

As indicated in Chapter 3.3.1.2, same calculations are made for the other spaces located in GUZEB, entrance, and offices.

$\mathbf{Q_{ENTRANCE} = 10\ 902.8\ W}$

$\mathbf{Q_{OFFICE\ 1} = 1\ 208.72\ W}$

$\mathbf{Q_{OFFICE\ 2} = 486.47\ W}$

3.3.2.4 Total Cooling Load Calculation of GUZEB

Table 3.7: Total Cooling Load of GUZEB Without Hourly Changing Load Distribution

	LIBRARY	ENTRANCE	OFFICE1	OFFICE2
Q (W)	7 218.5	10 902.8	1 208.72	486.47
QTOTAL (W)	**19 816.49**			

3.3.3 Cooling Load Calculation With Hourly Changing Load Distribution

3.3.3.1 Schedule Data

In this section, cooling load calculations are calculated by load distribution. These distributions include lighting or equipment and people daily load distribution. The load of these distributions designates daily load distributions. Distribution values describe the percentage of the loads in a day. These values are different in special days compared with the usual day loads. Schedule data is shown in Table 3.8.

Table 3.8: Schedule Data.

SCHEDULE DATA																								
Schedule Name: lighting library																								
Hour	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Design Day	0	0	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	20	0	0	0
Week Day	0	0	0	0	0	0	0	0	50	100	100	100	100	100	100	100	100	100	50	0	0	0	0	0
Schedule Name: lighting entrance																								
Hour	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Design Day	0	0	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	20	0	0	0
Week Day	0	0	0	0	0	0	0	0	50	50	0	0	0	0	0	0	50	50	50	0	0	0	0	0
Schedule Name: lighting office1																								
Hour	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Design Day	0	0	0	0	0	0	0	0	50	100	100	100	100	100	100	100	100	100	100	50	0	0	0	0
Week Day	0	0	0	0	0	0	0	0	50	100	100	100	100	50	100	100	100	100	50	0	0	0	0	0
Schedule Name: lighting office2																								
Hour	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Design Day	0	0	0	0	0	0	0	0	50	100	100	100	100	100	100	100	100	100	100	50	0	0	0	0
Week Day	0	0	0	0	0	0	0	0	50	100	100	100	100	50	100	100	100	100	50	0	0	0	0	0
Schedule Name: lighting toilets																								
Hour	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Design Day	0	0	0	0	0	0	0	0	50	100	100	100	100	100	100	100	100	100	100	50	0	0	0	0
Week Day	0	0	0	0	0	0	0	0	50	50	50	50	50	100	50	50	50	50	50	0	0	0	0	0
Schedule Name: people library																								
Hour	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Design Day	0	0	0	0	0	0	0	0	50	100	100	100	100	100	100	100	100	100	100	50	0	0	0	0
Week Day	0	0	0	0	0	0	0	0	25	25	50	50	50	25	50	50	50	25	25	0	0	0	0	0

Schedule Name: people entrance																								
Hour	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Design Day	0	0	0	0	0	0	0	0	50	100	100	100	100	100	100	100	100	100	100	50	0	0	0	0
Week Day	0	0	0	0	0	0	0	0	25	25	25	25	25	25	25	25	25	25	25	0	0	0	0	0

Schedule Name: people office1																								
Hour	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Design Day	0	0	0	0	0	0	0	0	50	100	100	100	100	100	100	100	100	100	50	0	0	0	0	0
Week Day	0	0	0	0	0	0	0	0	50	100	100	100	100	25	100	100	100	50	50	0	0	0	0	0

Schedule Name: people office2																								
Hour	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Design Day	0	0	0	0	0	0	0	0	50	100	100	100	100	100	100	100	100	100	50	0	0	0	0	0
Week Day	0	0	0	0	0	0	0	0	50	100	100	100	100	25	100	100	100	50	50	0	0	0	0	0

Schedule Name: equipment library																								
Hour	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Design Day	0	0	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	20	0	0	0
Week Day	0	0	0	0	0	0	0	0	25	50	50	50	50	25	50	50	50	50	25	0	0	0	0	0

Schedule Name: equipment entrance																								
Hour	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Design Day	0	0	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	20	0	0	0
Week Day	0	0	0	0	0	0	0	0	0	0	10	10	10	0	10	10	10	10	10	0	0	0	0	0

Schedule Name: equipment office1																								
Hour	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Design Day	0	0	0	0	0	0	0	0	50	100	100	100	100	100	100	100	100	100	100	50	0	0	0	0
Week Day	0	0	0	0	0	0	0	0	50	100	100	100	100	50	100	100	100	100	50	0	0	0	0	0

Schedule Name: equipment office2																								
Hour	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Design Day	0	0	0	0	0	0	0	0	50	100	100	100	100	100	100	100	100	100	100	50	0	0	0	0
Week Day	0	0	0	0	0	0	0	0	50	100	100	100	100	50	100	100	100	100	50	0	0	0	0	0

3.3.3.2 Total Cooling Load

The cooling peak load is found in July and the distribution of the total cooling load of GUZEB is shown in Table 3.9.

Table 3.9: Cooling Load Data in July.

Total Cooling Load in July																								
Hour	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Cooling Load (kW)	0	0	0	0	0	0	0	0	9.6	12	12.7	13.3	13.7	13.9	14.4	14.6	14.9	14.9	14.5	11.9	0	0	0	0

3.3.4 Summary of Cooling Load Calculations

Compared with the first calculation, total cooling load of GUZEB is found less than the calculated without scheduled data. This difference is because of the distribution of the loads in day hours. Cooling load calculations are summarized in Table 3.10.

Table 3.10: Summary of Cooling Load Calculations.

	Without Hourly Changing Load Distribution	With Hourly Changing Load Distribution
Q (kW)	19.8	14.9

Chapter 4

DESIGN OF HEATING SYSTEM OF GUZEB

4.1 General Information About Floor Heating Systems

Radiant floor heating has been used for centuries. The Romans channeled hot air under the floors of their villas. The Koreans channeled hot flue gases under their floors before venting them up the chimney. Radiant floor heating system’s basic idea depends on these ancient applications.

Radiant floor heating systems use a boiler to heat up hot water and a pump to circulate the hot water in pipes, which is installed in a concrete slab in a closed loop. The pipes, embedded in the floor, carry heated water that conducts warmth to the surface of the floor where it broadcasts energy to the space. While conventional heating systems rely on air circulation to distribute heat, radiant heating exploits the physical properties of warm air, which rises, to provide comfortable in houses and even garages. It’s the same principle as solar heating, which warms people and objects directly. Installed beneath a home’s flooring, it radiates heat upward and outward, spreading warmth and comfort with greater efficiency throughout any room in which it is installed.

Radiant heating systems are also used in ice and snow melt systems for walkways and streets.

4.1.1 Advantages of Floor Heating Systems

Listed here are some of the benefits of the radiant floor heating system [32]:

- Comfort – a radiant floor heating system "radiates" heat from the floor and delivers the heat evenly throughout the rooms. The room heats from the bottom up, warming the feet and body first.
- Lower boiler temperature – Radiant floors operate between 85-140ºF (29-60ºC), compared to other heating systems' range of 130-160ºF (54-71ºC).
- Silent operation – No hum or whistle of a forced air systems.
- Aesthetic- invisible vents or hear air blowing.

- Energy savings – Evenly distributed heat from a radiant floor heating system can allow the thermostat to be set 2-4 ^{o}C less than in a forced air heating system. Radiant floor heating proponents claim that fuel savings of 10% to 30% over forced air systems are possible.
- A healthier home – eliminates the draft and dust problems associated with forced-air heating systems.
- Quiet warmth – even with wood, tile, or uncovered concrete floors.

4.1.2 Components of a Radiant Floor Heating System

Many components are needed for radiant floor heating system. Heating source is one of the main components. This can be electricity, solar, natural gas, propane, oil, wood, or any other heating source. Boiler contains the water to be heated. Besides, pumps are necessary to circulate the water through tubing located under the floor. In addition, many radiant floor-heating projects are in slab-on-grade concrete. Tubing is one of the other components that installed in the slab. Temperature-controlled water then circulates though the tubing in the slabs. This process turns the slab into a radiant panel. Concrete presents the greatest thermal mass of any of the radiant floor heating methods, which can be a tremendous benefit in rooms or buildings with high ceilings.

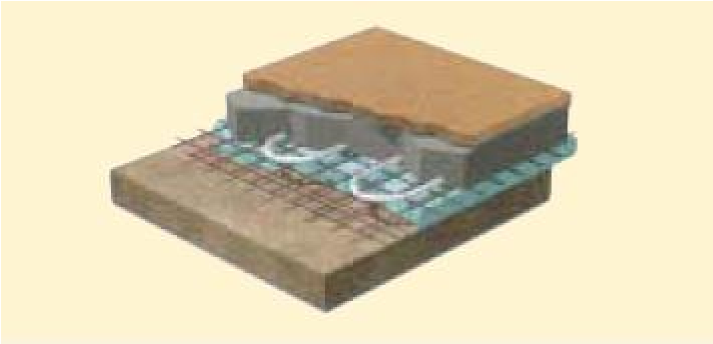


Figure 4.1: Installation Method of Floor Heating System.

4.1.3 Types of Radiant Floor Heating

There are three types of radiant floor heat: radiant air floors (air is the heat carrying medium); electric radiant floors; and hot water (hydronic) radiant floors. Besides, hydronic (liquid) systems are the most popular and cost-effective systems for heating-dominated climates. They have been in extensive use in Europe for decades. Hydronic radiant floor systems pump heated water from a boiler through tubing underneath the floor. A system of zoning valves or pumps and thermostats are done this flow.

4.2 Design Criteria of Floor Heating System in GUZEB

Floor heating system is required to meet the heating load of GUZEB. As indicated, an ancient cave is located near the GUZEB's location. This cave has approximately 32^{o}C water source but the temperature will not be enough for floor heating system operation temperature. Floor heating systems operate between 29-60ºC. On the contrary, this source is continuous and limitless. With a simple circulation pump, water will be pumped from the cave to the heating system of GUZEB. So, heating requirement of GUZEB will be solved.

The main problem is the calculation of heat gain from the tubes that lay in the concrete bottom block of the floor. The total heat flux calculation is calculated by using a program, which is named as Fluent [33]. Fluent is used for different structures, which are modeled by using a modeling program called Gambit.

By Gambit, floor is modeled by floor materials and thickness, which is illustrated in Figure 4.2 and 4.3. In this model, all construction materials are given in its real sizes with the area of 0.01 m^2. In the other meaning, the values that are found will be the values for 0.01 m^2. In this model, the tubing is 1 inch in diameter and the flow rate is taken 1 kg/s and 28^{o}C, less than the real values that will be from the ancient cave. Because, the real water temperature value, which is 32 ^{o}C, will reduce approximately to 28 ^{o}C when circulated in heat exchanger, and on the way from ancient cave to building. If these values meet the required value for heating, other values can be definitely enough for the heating requirement. The Fluent program printouts are given in Appendix B.

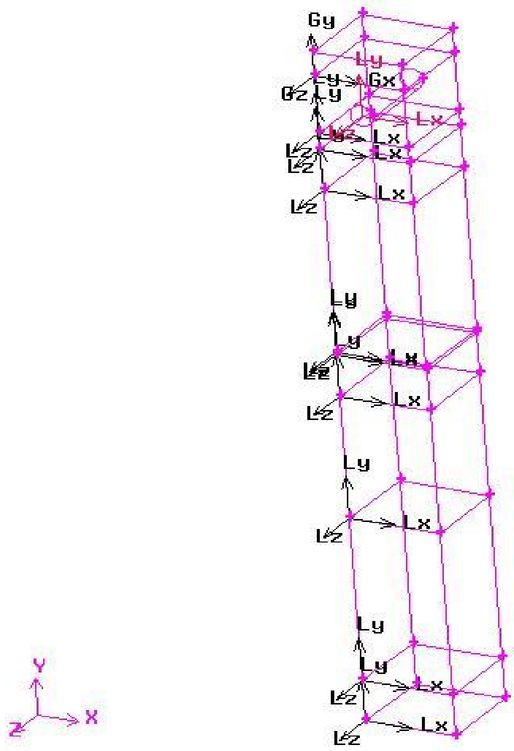


Figure 4.2: Modeled floor by Gambit.

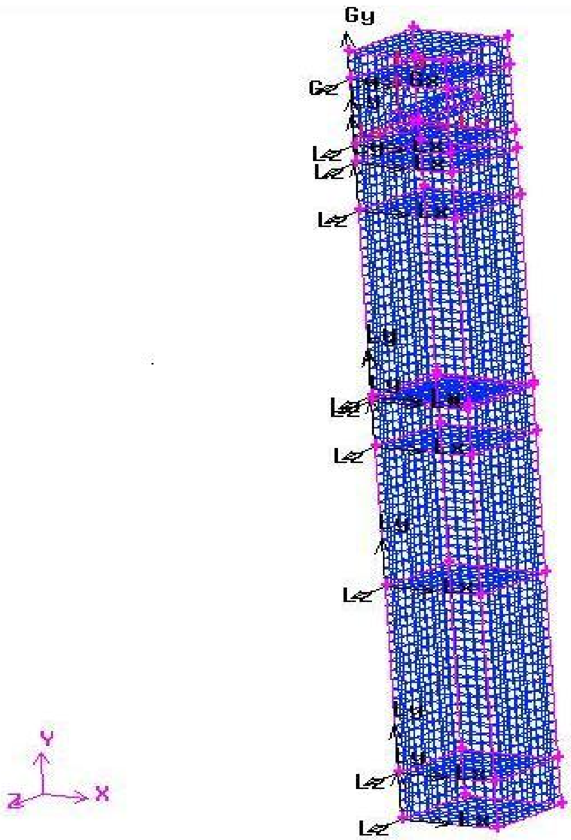


Figure 4.3: Meshed floor by Gambit.

4.3 Results of Floor Heating System in GUZEB

Table 4.1: Net Heat Transfer Rate per meter from Pipes.

	From Bottom	From Top
Net Heat Transfer Rate (W/m)	-0.738153	-2.62044

As calculated in Chapter 3.2.3, total heating load of GUZEB is

$$Q_{total} = \mathbf{4\,256.65}\ \text{W}$$

If Q_{total} is divided into net heat transfer rate from top, which means that the heat transfer rate from pipes to the spaces, 1624.4 m pipe is required to heat the spaces to the comfort temperature in winter.

Piping will be designed as illustrated in Figure 4.4 and details are given from Figure 4.6 to Figure 4.9. Although there are different types of piping methods, this type of piping is the best method for 1” pipes. From the calculations, 1624.4 m pipes for 276.5-m^2 spaces can be placed approximately 15 cm intervals between pipes. This is the best pipe placement for 1” pipe diameter [32].

The floor heating design project of GUZEB is illustrated in Figure 4.5.

Figure 4.5: Tubing Construction Style.

As illustrated in Figure 4.6 to 4.9, GUZEB's floor heating system pipe design is divided into 14 main parts. Each of these loops has approximately 110m pipe length. Each collector, which distributes the warm water to the pipes, has 7 loops. Number of these loops is chosen to protect the heat gain, temperature difference of the water from inlet to outlet, from the pipes in long distances and to decrease the pump power, which will be used to pump the warm water through the pipes. In other words, pump power can be decreased by this method.

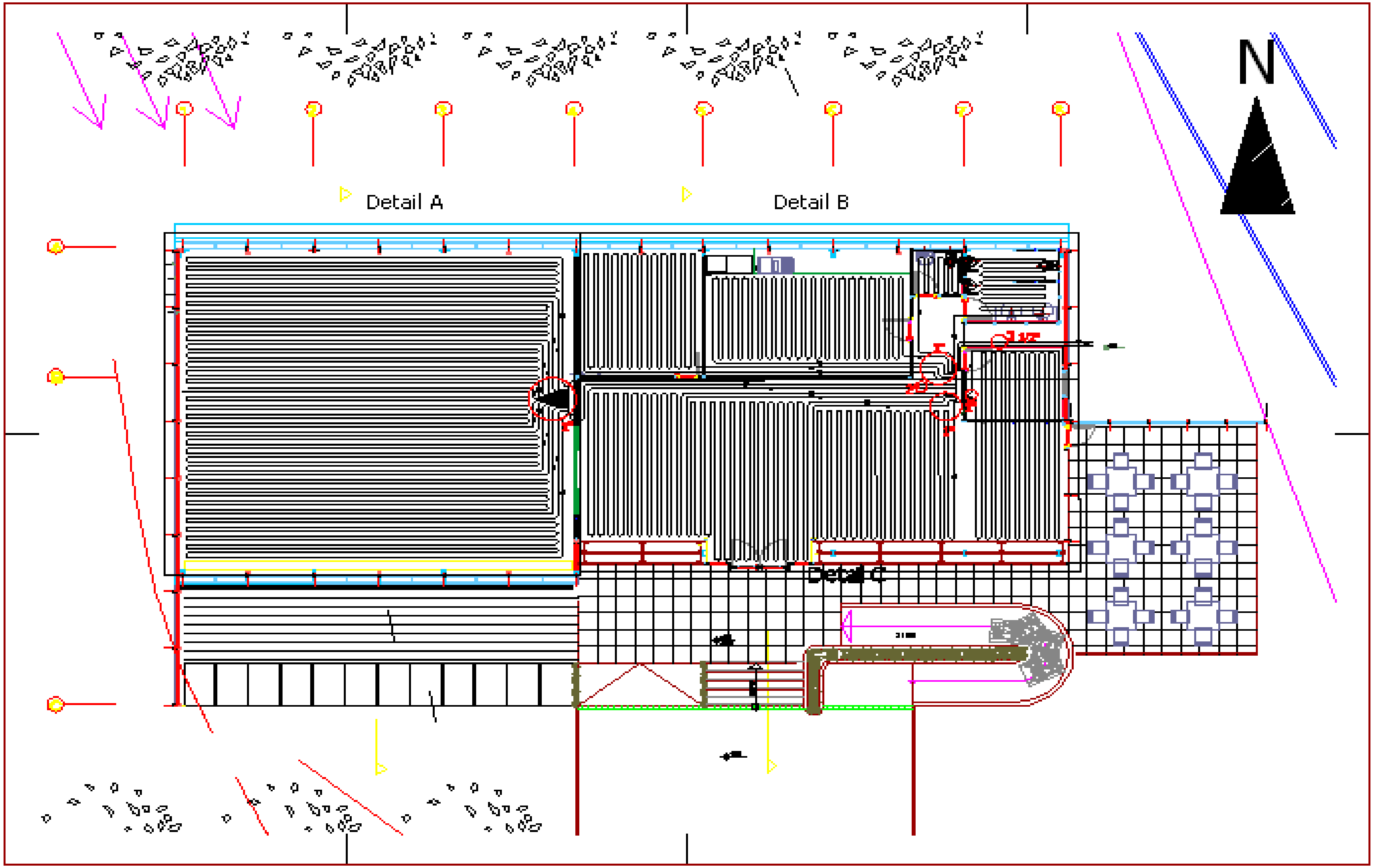


Figure 4.6: Floor Heating Design of GUZEB.

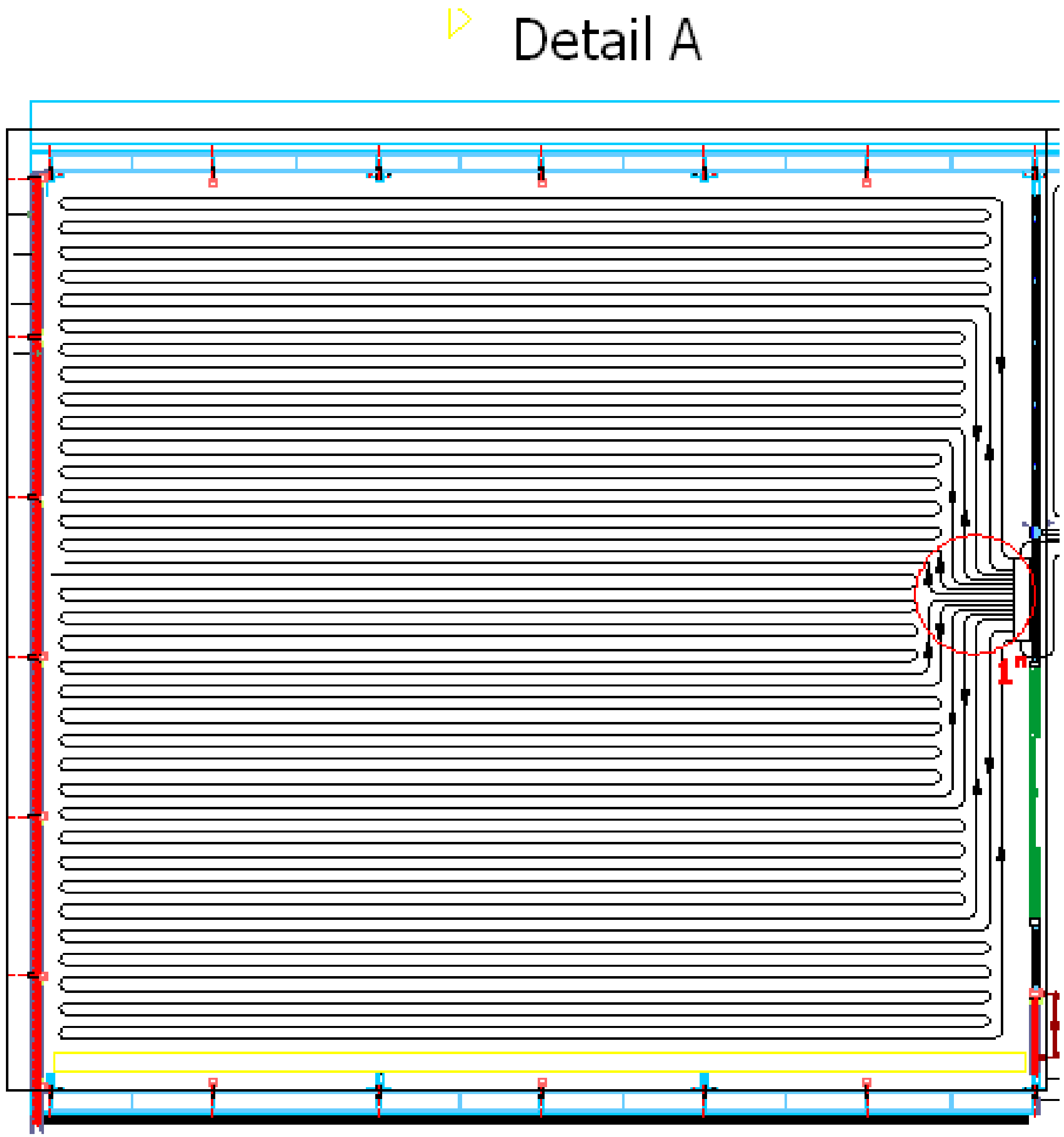


Figure 4.7: Floor Heating Design Detail A

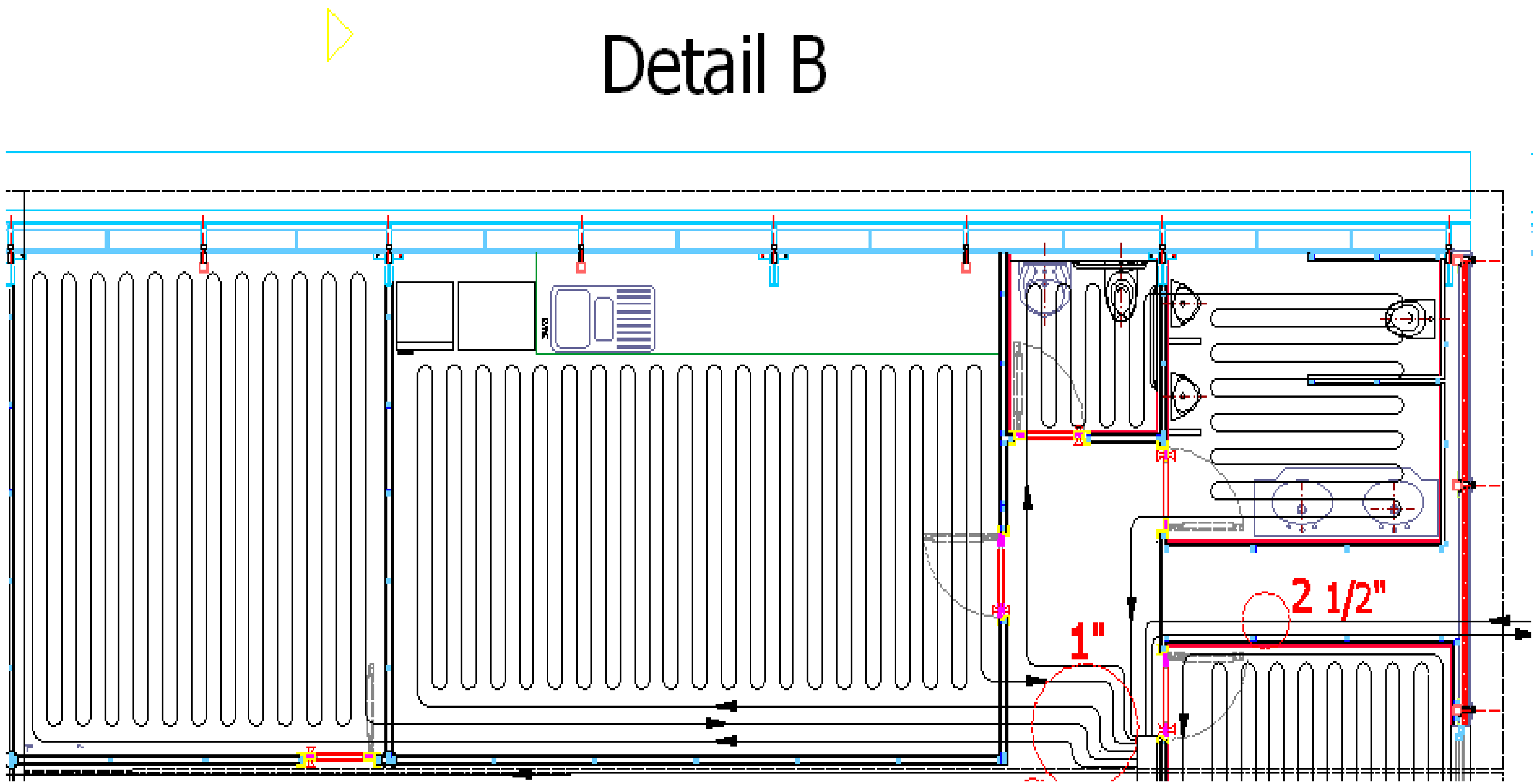


Figure 4.8: Floor Heating Design Detail B

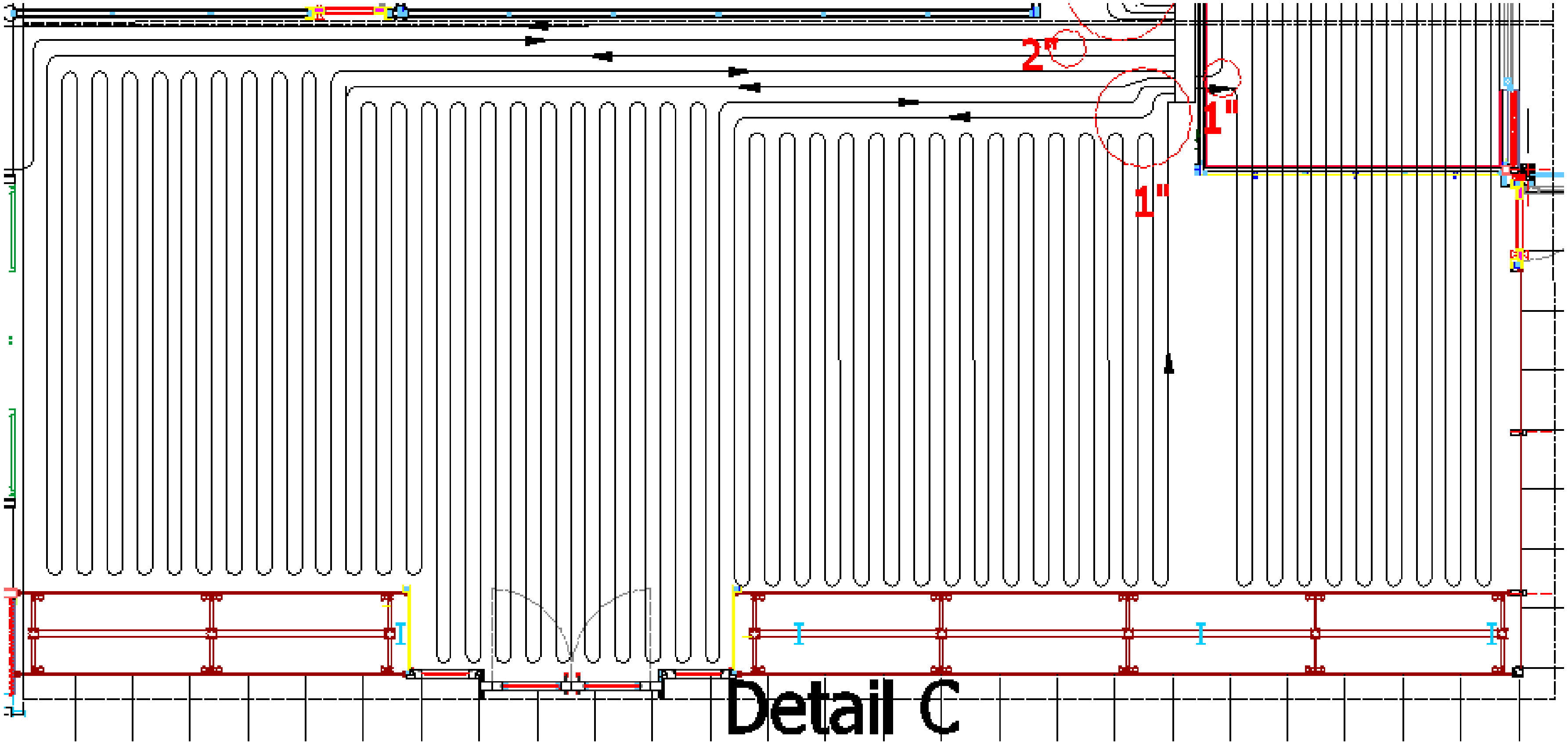


Figure 4.9: Floor Heating Design Detail C

Chapter 5

DESIGN OF VENTILATION SYSTEM OF GUZEB

5.1 General Information about Ventilation System in GUZEB

In both energy efficient buildings and zero energy houses, the main idea is to save energy and to reduce the energy consumption. One of the energy saving methods is natural ventilation and an effective ventilation design.

In GUZEB's ventilation design, natural energy is the main ventilation strategy. As known, the natural ventilation reduces energy consumption for fans and mechanical cooling and in most cases gives occupants to control over the spaces. Further benefits include no fan noise and in some cases elimination of the mechanical cooling system. GUZEB's special roof design especially in winter ensures the natural ventilation. As mentioned this special roof design helps to direct the outdoor air inside of the building with automatic controlled windows on the roof.

On the other hand, when ventilating a building using natural ventilation method, another distinct design strategy for the summer must be considered. During winter only small air flows are needed but there is the risk of cold air drafts. During the summer, the main challenge is providing enough airflow to give effective cooling. GUZEB's ventilation design uses mechanical systems to provide cool air for occupants in summer. But this system is used only for library and office ventilation systems in summer except for the entrance. The cooling load of the entrance is calculated in Chapter 3, and with hourly load distribution, as mentioned in Appendix A, total cooling load is approximately 4kW. This means that, ventilation system may not be necessary for the entrance. Because, the automatic controlled daylight sensible curtains, which cover the surface of the glass in front of the entrance, and the natural ventilation inlets and outlets can meet the cooling load of the entrance. In addition, in the special symposium days, the load from the people will be in the library. Mechanical ventilation and air-conditioning of buildings consume large amounts of energy in the world, especially in developed countries, where buildings are responsible for one-third of all energy consumption [34]. To reduce the energy consumption, mechanical system can be constructed only for library and offices. Besides, to save energy, energy storage system is anticipated. Detailed energy storage system design will be explained in Chapter 6.

For the ventilation system of the toilets and the canteen, exhaust system is anticipated. The exhaust system is designed based on the exhaust system criterian.

All duct types are chosen circular type because of the esthetic appearance.

5.2 Exhaust Ventilation System for Toilets and Canteen

The exhaust ventilation system is designed for the ventilation of the toilets and for the canteen, where cooking ventilation is necessary. Anticipated that the exhaust fan will be located top of the roof. The detailed drawing for the exhaust system is illustrated in Figure 5.1 and details are given in Figure 5.3. The pressure drop calculations and design sizes are calculated and illustrated in Table 5.1.

5.3 Ventilation System for Main Ventilation

As mentioned ventilation system is designed to meet the special symposium day cooling load. As the meeting room of the symposium, library will be used. Because of the peak load of that day, cooling load will be a difficult handicap for natural ventilation to achieve. With the illustration of the exhaust system of the toilets, mechanic ventilation system detailed drawing is illustrated in Figure 5.2. Pressure drop calculation results both inlet and outlet are shown in Table 5.2 and 5.3.

Table 5.1: Fan Sizes and Pressure Drop Tables of Toilet Exhaust Duct Design.

	Q	Duct	Velocity	Friction Loss	Length	Friction Loss	Pdyn	n	Pressure Drop	Total Loss
	m3/h	Diameter(mm)	m/s	mmH_2O/m	m	mmH_2O	mmH_2O		mmH_2O	mmH_2O
1	200	130	4.4	0.22	2.75	0.61	1.18	0.34	0.40	1.01
2	300	150	4.7	0.23	0.70	0.16	1.35	0.21	0.28	0.44
3	400	170	4.9	0.21	3.75	0.79	1.46	1.25	1.83	2.62
4	500	190	5	0.02	4.00	0.08	1.53	1.09	1.66	1.74
										5.81

	Quantity	Circular Type	Loss Coefficient (n)
1	1	Damper D/Do=1Q=0 CD9-1	0.19
	1	ElbowD=130 CD3-1	0.15
			0.34
2	1	Tee Qb/Qc=0,3 As/Ac=0,9 Ab/Ac=0,7	0.21
			0.21
3	1	ElbowD=100 CD3-1	0.21
	1	ElbowD=170 CD3-1	0.13
	1	Tee Qb/Qc=0,3 As/Ac=0,7 Ab/Ac=0,3	0.91
			1.25
4	1	Tee Qb/Qc=0,2 As/Ac=0,8 Ab/Ac=0,2	0.76
	3	ElbowD=190 CD3-1	0.33
	1	Transition Q=45 Ao/A1=1	0
	1	FanOutletAb/Ao=1 L/Le=1	0
			1.09

Table 5.2: Fan Sizes and Pressure Drop Tables of Library Main Inlet Duct Design.

	Q	Duct	Velocity	Friction Loss	Length	Friction Loss	Pdyn	n	Pressure Drop	Total Loss
	m3/h	Diameter(mm)	m/s	mmH_2O/m	m	mmH_2O	mmH_2O		mmH_2O	mmH_2O
1	750	240	4.8	0.130	1.75	0.23	1.41	0.30	0.42	0.65
2	1500	330	5	0.090	3.50	0.32	1.53	1.72	2.62	2.94
3	2250	400	5	0.075	5.25	0.39	1.53	0.31	0.47	0.87
4	3000	460	5	0.065	7.00	0.46	1.53	0.63	0.96	1.42
5	3750	500	5.2	0.065	6.25	0.41	1.65	1.89	3.12	3.52
6	7500	700	5.2	0.042	3.75	0.16	1.65	1.61	2.66	2.81
7	8150	720	5.3	0.042	10.80	0.45	1.71	1.75	3.00	3.45
8	8700	750	5.3	0.040	1.50	0.06	1.71	1.79	3.07	3.13
										18.79

	Quantity	Circular Type	Loss Coefficient (n)
1	1	Damper D/Do=1 Q=0 CD9-1	0.19
	1	Elbow D=240 CR3-1	0.11
			0.3
2	1	Tee As/Ac=0,7 Ab/Ac=0,7 Qb/Qc=0,5 ED5-3	1.72
			1.72
3	1	Tee As/Ac=0,8 Ab/Ac=0,6 Qb/Qc=0,3 ED5-3	0.31
			0.31
4	1	Tee As/Ac=0,9 Ab/Ac=0,5 Qb/Qc=0,3 ED5-3	0.63
			0.63
5	1	Tee As/Ac=0,9 Ab/Ac=0,5 Qb/Qc=0,2 ED5-3	1.74
	3	Elbow D=500 CR3-10	0.15
			1.89
6	1	Wye Ab1/Ac=0,7 Ab2/Ac=0,7 Qb1/Qc=0,5 ED5-9	1.61
			1.61
7	1	Tee As/Ac=0,9 Ab/Ac=0,2 Qb/Qc=0,1 ED5-3	1.67
	2	Elbow D=720 CR3-10	0.08
			1.75
8	1	Tee As/Ac=0,9 Ab/Ac=0,2 Qb/Qc=0,1 ED5-3	1.67
	3	Elbow D=750 CR3-10	0.12
			1.79

Table 5.3: Fan Sizes and Pressure Drop Tables of Library Main Outlet Duct Design.

	Q	Duct	Velocity	Friction Loss	Length	Friction Loss	Pdyn	n	Pressure Drop	Total Loss
	m3/h	Diameter(mm)	m/s	mmH_2O/m	m	mmH_2O	mmH_2O		mmH_2O	mmH_2O
1	650	220	4.7	0.140	1.75	0.25	1.35	0.30	0.40	0.65
2	1300	300	5	0.120	3.50	0.42	1.53	1.72	2.62	3.04
3	1950	360	5.2	0.950	5.25	4.99	1.65	0.31	0.51	5.50
4	2600	410	5.2	0.080	7.00	0.56	1.65	0.63	1.04	1.60
5	3250	460	5.3	0.080	8.25	0.66	1.71	2.19	3.75	4.41
6	6500	650	5.2	0.046	1.50	0.07	1.65	1.61	2.66	2.72
7	7100	700	5.1	0.038	14.50	0.55	1.59	1.75	2.78	3.33
8	7600	700	5.6	0.044	1.50	0.07	1.91	1.79	3.42	3.49
										24.75

	Quantity	Circular Type	Loss Coefficient (n)
1	1	Damper D/Do=1 Q=0 CD9-1	0.19
	1	Elbow D=220 CR3-1	0.11
			0.3
2	1	Tee As/Ac=0,7 Ab/Ac=0,7 Qb/Qc=0,5 ED5-3	1.72
			1.72
3	1	Tee As/Ac=0,8 Ab/Ac=0,6 Qb/Qc=0,3 ED5-3	0.31
			0.31
4	1	Tee As/Ac=0,9 Ab/Ac=0,5 Qb/Qc=0,3 ED5-3	0.63
			0.63
5	1	Tee As/Ac=0,9 Ab/Ac=0,5 Qb/Qc=0,2 ED5-3	1.74
	3	Elbow D=460 CR3-9	0.45
			2.19
6	1	Wye Ab1/Ac=0,7 Ab2/Ac=0,7 Qb1/Qc=0,5 ED5-9	1.61
			1.61
7	1	Tee As/Ac=0,9 Ab/Ac=0,2 Qb/Qc=0,1 ED5-3	1.67
	2	Elbow D=700 CR3-10	0.08
			1.75
8	1	Tee As/Ac=0,9 Ab/Ac=0,2 Qb/Qc=0,1 ED5-3	1.67
	3	Elbow D=700 CR3-10	0.12
			1.79

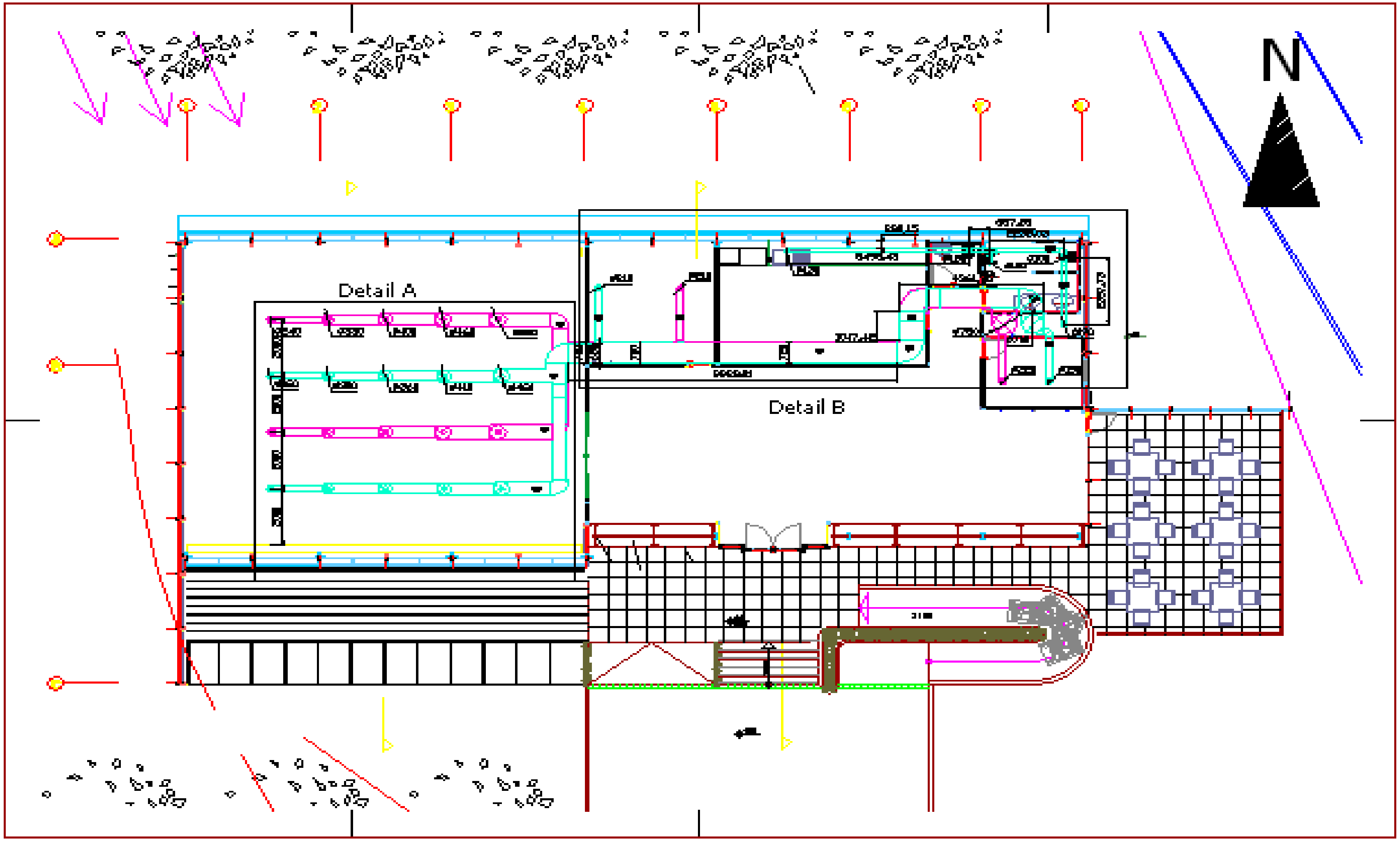


Figure 5.1: Duct Design of GUZEB.

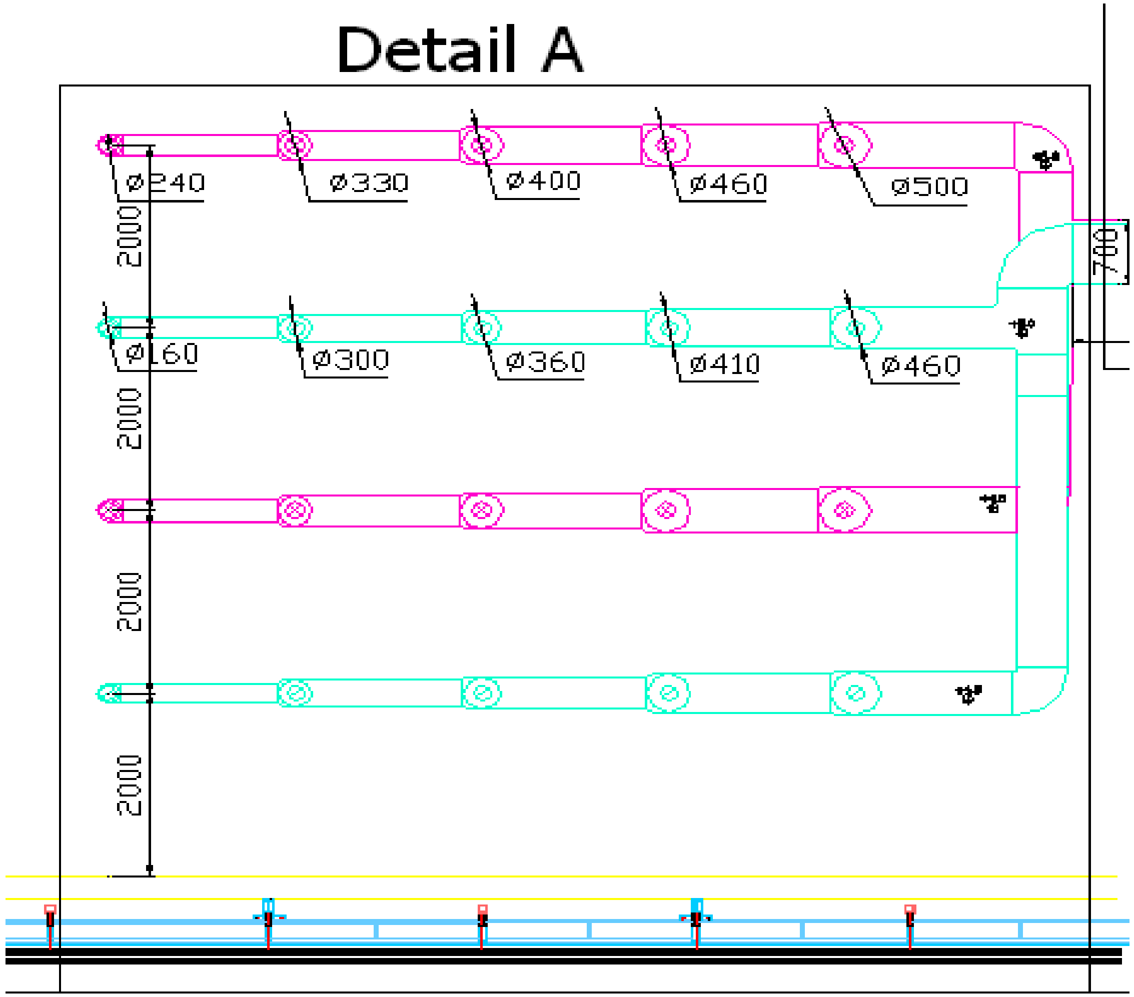


Figure 5.2: Duct Design Detail A.

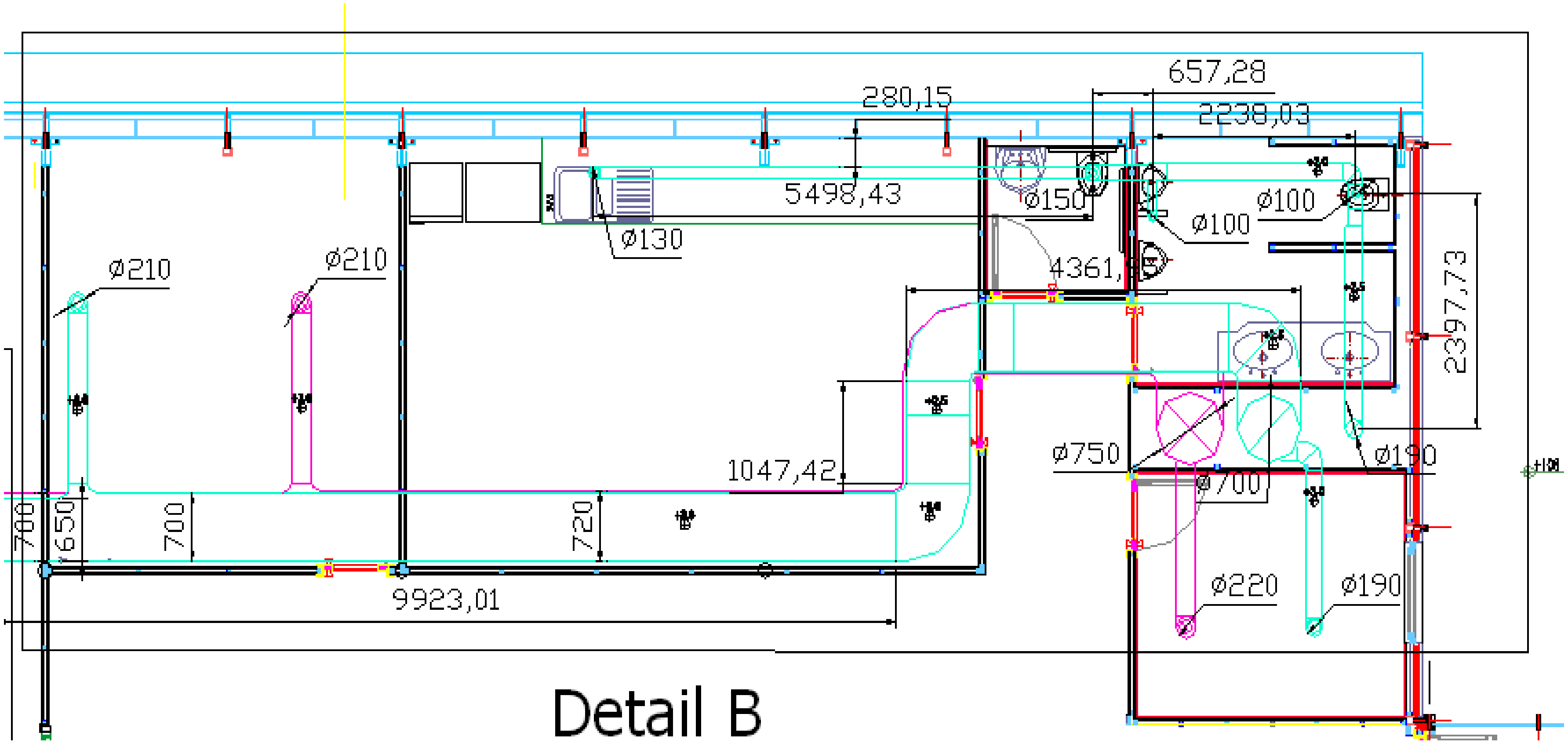


Figure 5.3: Duct Design Detail B.

Chapter 6

DESIGN OF THERMAL ENERGY STORAGE SYSTEM

6.1 General Information About Thermal Energy Storage Systems

Thermal energy storage has been used to shift on-peak loads to off-peak periods in order to reduce utility charges and minimize or avoid high, on-peak demand charges. Thermal energy storage systems provide energy savings when there are high loads of short duration, high electric power demand charges, or low electrical charges during off-peak hours. Thermal energy storage systems may be designed to produce and store ice or water during off-peak hours when utility rates are generally lower. This stored energy is used during on-peak hours, which is classified as a load-shift strategy.

In most cooling systems, there are two major components:

Firstly, chiller which make water or some other fluid cool and secondly the distribution system which take the cool water or fluid from the chiller to a place where it cools air for the building occupants. In systems, the chiller must be run only when the building occupants need cool air. In a storage cooling system, the chiller can be run at times other than only when the occupants want cooling.

Thermal Energy Storage (TES) systems typically involve the production of ice or chilled water during off-peak electrical usage periods using lower cost electricity. This stored energy is then used during on-peak electrical usage periods for air conditioning or process cooling. Thermal energy storage systems can be sized to operate in a load shifting, partial storage or load leveling, full storage strategy. Often, ice or water is produced 24 hours a day, a strategy called "full storage”. As shown in Figure 6.1 in a full storage strategy, equipment is allowed to operate 24 hours a day. In this method, chiller always runs with full capacity as long as it runs. Because of this discontinuous capacity, great capacities of chiller and storage tank are required. Automatic control is relatively simple in the full storage systems.

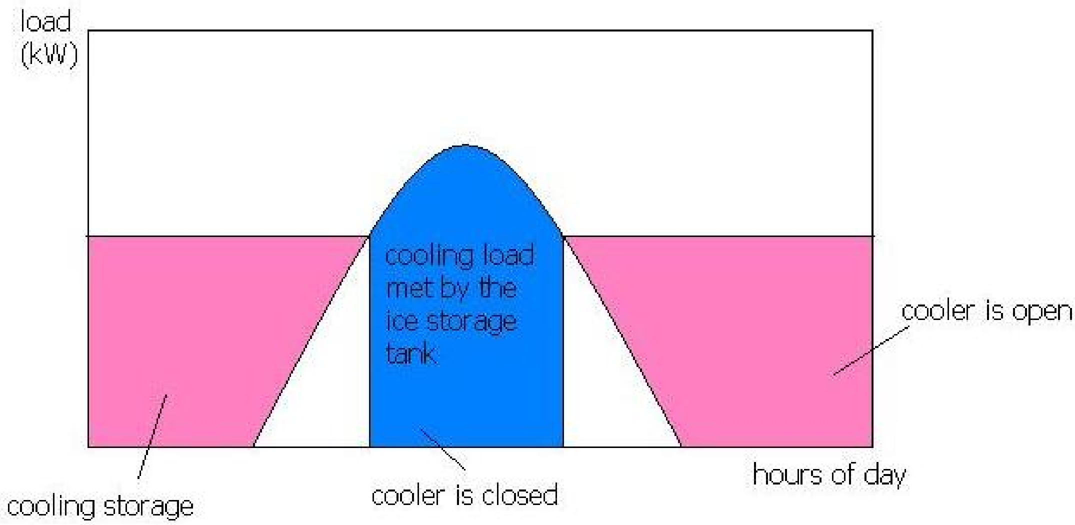


Figure 6.1: Full Storage.

In contrast, in a partial storage strategy, which is illustrated in Figure 6.2 and 6.3, the TES system runs during off-peak hours, eliminating electrical demand charges and reducing energy costs. There are two different applications for partial storage method:

i. Load Leveling Partial Storage:

Cooling system runs with full capacity during the whole day. It is used when the load is lower than its capacity. The required cooling capacity is provided by the tank, when the load is higher than cooling system capacity. This method is preferred when peak load is much higher than the average load.

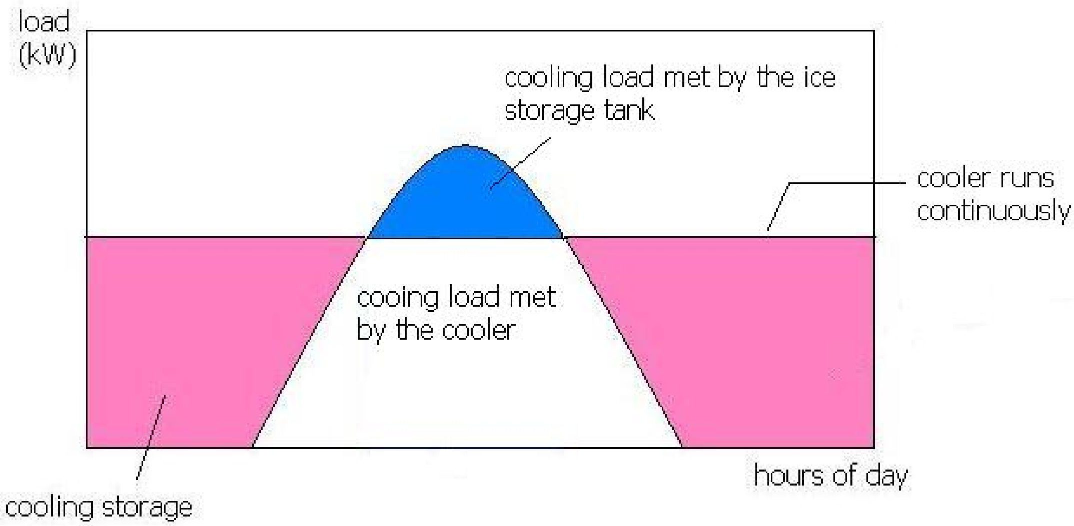


Figure 6.2: Load Leveling Partial Storage.

ii. Partial Storage Depending on Demand:

In this method, cooling system runs with low capacity, which is determined according to demand in the peak load.

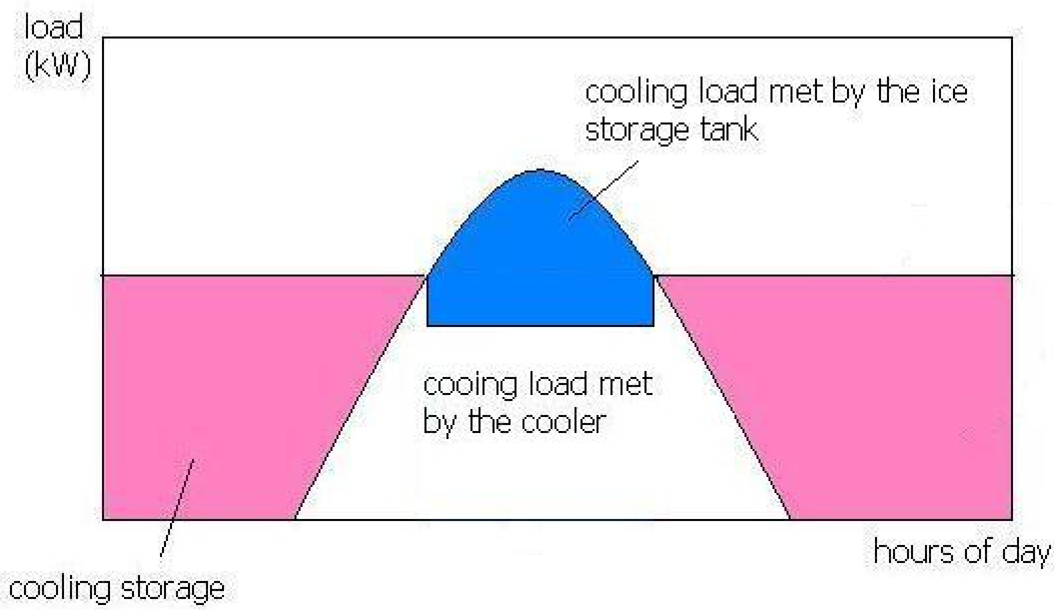


Figure 6.3: Partial Storage Dependent on Demand.

The main advantage of the “full storage” system is that it minimizes electricity costs. The main advantage of the “partial storage” system is that a smaller chiller and smaller storage tank reduce the capital costs of the TES system [35].

Five main types of thermal storage systems are used to meet these strategies. The first type is “chilled water”, which has the advantage of being compatible with existing chillers and it is probably the most energy efficient storage system. In contrast, requiring much larger storage tanks than the other storage media is its disadvantage. The second type of TES system uses a “eutectic salt” water solution as the storage medium. Eutectic salt systems store cooling energy by freezing a solution at a temperature nearly at 8.5^{o}C. One of the advantages of these systems is, smaller tanks are required than for chilled water by storing cooling through a phase change. The next three storage systems have one thing in common is that ice as the storage material. Compact storage size is one of their main advantages. Ice tanks may be up to 50 percent of the size of comparable chilled water and eutectic salt tanks, respectively [36].

6.1.1 Chilled Water Storage

Chilled water storage systems store cooling with the help of the sensible heat capacity of water. Chiller is used to cool water and water, which is cooled by the chiller, is stored in a tank for later use in melting cooling needs. The temperature difference is between the chilled water in the tank and the return water from the load is the reason of the stored energy.

There are many advantages of chilled thermal storage systems:

- There is no need for any special equipment, for instance chiller.
- It is economical with the large storage tank sizes. Larger tanks have lower capital cost compared with chiller plants that are nonstorage.
- Storage tank can be used for fire protection water reservoir.
- Chilled thermal storage system store both warm and chilled water [35].

6.1.2 Ice Harvesting Systems

According to the chilled water system, ice harvesting refrigeration plant generates ice with a special designed evaporator section. Water is frozen where it is pumped to the storage tank. There are two modes for making the water chilled water or ice. Ice making or chiller mode is selected automatically related with the temperature of the water as it enters the evaporator. If the water is approximately near the freezing point, ice-making mode is selected. Otherwise chiller mode is chosen.

There are many advantages of ice harvesting systems:

- Ice harvesting systems meet the short term cooling needs, usually preferred in food productions.
- From ice generation to chilled-water generation change is done automatically with the load conditions.
- Ice harvesting systems produce high continuous discharge rates [35].

6.1.3 Advantages of Thermal Energy Storage Systems

Briefly, there are many advantages of thermal energy storage systems:

Compared with usual cooling systems, TES systems use smaller equipment capacity and typically operate during off-peak hours, reducing operating costs. Compared with the traditional cooling systems, TES systems occasionally provide savings in initial capital costs. Thermal energy storage systems provide energy savings when there are high electric power demand charges, or low electrical charges during off-peak hours.

6.2 Thermal Energy Storage in GUZEB

As mentioned in Chapter 2, GUZEB's cooling system design is different compared with the other traditional applications. Because the first main idea of both systems, especially the high load required systems, is to reduce the energy consumption. Cooling system is one of the high loaded energy systems. Related to this foresight, reducing energy from cooling system must be one of the main steps.

GUZEB is designed for library function except on special days that are symposium days. GUZEB's cooling load will be many times greater compared with the usual days. Anticipated that in cooling load calculations, these special symposium days will be organized only one or two days in a month. As given in church example, maximum load will be arising only on these special days. Cooling system will not operate on usual days with full capacity so, installation and operating cost will be meaningless if the cooling system is chosen upon the special day load. Additionally, this means that while operating on regular days, energy could be stored for special days.

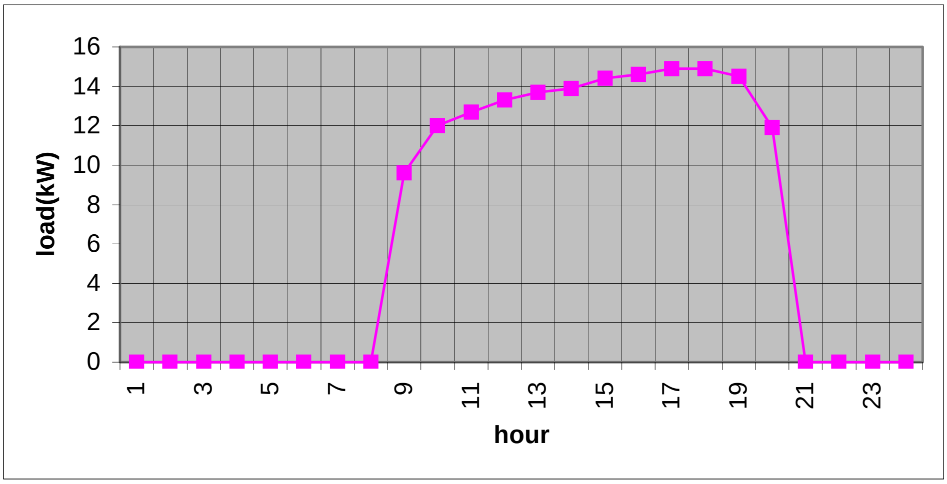
6.3 Design Procedure of Thermal Energy Storage in GUZEB

6.3.1 Load Calculation

As calculated in Chapter 3, the initial design for the GUZEB was completed based on a nonstorage cooling plant, and cool storage was being considered as an alternate because of the potential savings in the both first cost and operating cost.

In cooling load calculations, with hourly load calculation method is taken as a main calculation method in the design procedure of thermal energy storage. Cooling load distribution is shown in Table 6.1.

Table 6.1: Cooling Load Distribution of GUZEB.



6.3.2 Sizing of Chiller and Storage Capacity

The required chiller capacity and storage capacity for operating strategies are estimated using load profile.

The quick chiller and storage size and capacity based on the total cooling load requirement. The total cooling load can be approximated by the total chiller capacity by the number of hours available [35].

That is:

$$\text{Total Cooling Load} = \text{Total Chiller Capacity} \tag{6.1}$$

In many systems, the chiller capacity depends on whether it is charging storage or melting the load. The total capacity is the sum of the chiller capacity in each working load, times the operated hours.

$$\text{Total Chiller Capacity} = H_{chrg}*C_{chrg} + H_{DConp}*C_{DConp} + H_{DCoffp}*C_{Dcoffp} \tag{6.2}$$

where:

H_{chrg} = hours charging storage
C_{chrg} = capacity when charging storage
H_{Dconp} = hours direct cooling during on-peak period
C_{DConp} = capacity when direct cooling during on-peak period
H_{Dcoffp} = hours direct cooling during off-peak period
C_{Dcoffp} = capacity when direct cooling during off-peak period

If the nominal chiller capacity at ARI rating conditions (6-7^{o}C chilled water and 29,4^{o}C condenser water) is defined, the nominal chiller capacity is expressed as follows:

$$\text{Nominal Chiller Size} = \frac{TotalCoolingLoad}{H_{chrg} \cdot CR_{chrg} + H_{DConp} \cdot CR_{DCon}p + H_{DCoffp} \cdot CR_{Dcoffp}} \tag{6.3}$$

where:

H_{chrg} = hours charging storage
CR_{chrg} = capacity ratio when charging storage
H_{Dconp} = hours direct cooling during on-peak period
CR_{Dconp} = capacity ratio when direct cooling during on-peak period
H_{Dcoffp} = hours direct cooling during off-peak period
CR_{Dcoffp} = capacity ratio when direct cooling during off-peak period

The on-peak load capacity is zero for a full storage system. The direct cooling system is the same during on and off peak for load-leveling system.

The chilled water storage systems, the chiller capacity is assumed constant for quick chiller sizing ($CR_{chrg} = CR_{Dconp} = CR_{Dcoffp} = 1$). For ice harvesting systems, the ice making capacity is considered the nominal capacity and the direct cooling capacity ratio is taken between 1.2-1.3. For other ice harvesting systems, the ice making capacity is taken 0.6-0.7. For direct cooling capacity ratio changes depends on the chilled water temperature between 0.8 and 0.9.

The required storage capacity is equal to difference of the total cooling load and the cooling ton-hours supplied directly by the chiller, load that is met either directly or from storage while storage is being charged.

$$\text{Storage Capacity} = \text{Total Cooling Load} - (TC_{DConp} + TC_{DCoffp} + TH_{DCchrg}) \quad (6.4)$$

where:

TC_{Dconp} = total capacity when direct cooling on-peak

TC_{Dcoffp} = total capacity when direct cooling off-peak

TH_{DCchrg} = ton-hours direct cooling while simultaneously charging

From Table 6.1, Table 6.2 summarizes the information for the cooling load.

Table 6.2: Cooling Load Distribution Profile of GUZEB.

Total Cooling Load in July																								
Hour	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Cooling Load (kW)	0	0	0	0	0	0	0	0	9.6	12	12.7	13.3	13.7	13.9	14.4	14.6	14.9	14.9	14.5	11.9	0	0	0	0

On-peak period is chosen between 10:00-18:00 hours.

6.3.2.1 Full Storage

For daily full storage method, all on-peak cooling is supplied from storage. From Equation 6.3, for storage system with a charging capacity equal to the nominal capacity for a chilled water capacity is:

$$\text{Nominal Chiller Size}=\frac{160.4}{15}=10.7\,\text{kW}$$

This chiller capacity is less than the loads for hour 9. For this reason, loads during this hour will be met by direct cooling from the chiller and stored energy.

From Equation 6.4, storage capacity becomes:

$$\text{Storage Capacity}=160.4\text{-}(1\cdot 10.7+1\cdot 9.6)=140.1\ \text{kWh}$$

For a storage system with different capacities for charging and direct cooling, the charging capacity ratio is taken 0.7 and the direct cooling capacity is taken 0.9 from Equations 6.3 and 6.4, the nominal chiller size and storage capacity are calculate as follows:

$$\text{Nominal Chiller Size}=\frac{160.4}{13\cdot 0.7+2\cdot 0.9}=14.7156\,\text{kW}$$

$$\text{Storage Capacity}=160.4\text{-}(1\cdot 9.6+1\cdot 12+1\cdot 11.9)=126.9\ \text{kWh}$$

6.3.2.2 Daily Partial Storage, Load Leveling

For daily load-leveling system, the capacity ratios for direct cooling on and off peak are equal. For a storage system with a charging capacity equals to the nominal capacity, is calculated from Equation 6.3.

$$\text{Nominal Chiller Size}=\frac{160.4}{13\cdot 1+11\cdot 1}=6.69\,\text{kW}$$

And storage capacity is calculated as follows:

$$\text{Storage Capacity}=160.4-(11\cdot 6.69\cdot 1+1\cdot 9.6) = 77.21 \text{ kWh}$$

If the charging capacity ratio is taken 0.7 and the direct cooling capacity is taken 0.9, nominal chiller size and storage capacity is calculated as follows:

$$\text{Nominal Chiller Size}=\frac{160.4}{13\cdot 0.7+11\cdot 0.9}=8.442\,\text{kW}$$

$$\text{Storage Capacity}=160.4-(10\cdot 8.442\cdot 0.9+1\cdot 12\cdot 0.9+1\cdot 9.6)=64.022 \text{ kWh}$$

6.3.2.3 Daily Partial Storage, Demand Limiting

A demand limiting system operates similar with a load leveling system. However, the chiller capacity is limited during on-peak hours to allow additional demand savings. Using the same chiller capacity ratios used above for the load-leveling example, with a 50% on-peak load capacity limit, the nominal chiller size is from Equation 6.3 and the storage size from Equation 6.4 is:

$$\text{Nominal Chiller Size}=\frac{160.4}{13\cdot 0.7+(9\cdot 0.9\cdot 0.5)+(2\cdot 0.9)}=10.7291\,\text{kW}$$

$$\text{Storage Capacity}=160.4-[(9\cdot 10.7291\cdot 0.9\cdot 0.5)+(2\cdot 10.7291\cdot 0.9)+(1\cdot 9.6) = 83.035 \text{ kWh}$$

6.3.2.4 Summary of Operating Mode

The summary of operating modes is illustrated in Tables 6.3 to 6.7. These tables illustrate the relation between the cooling load distribution of the GUZEB and the different operating mode summary.

Table 6.3: Summary of Daily Full Storage Versus Daily Load Distribution.

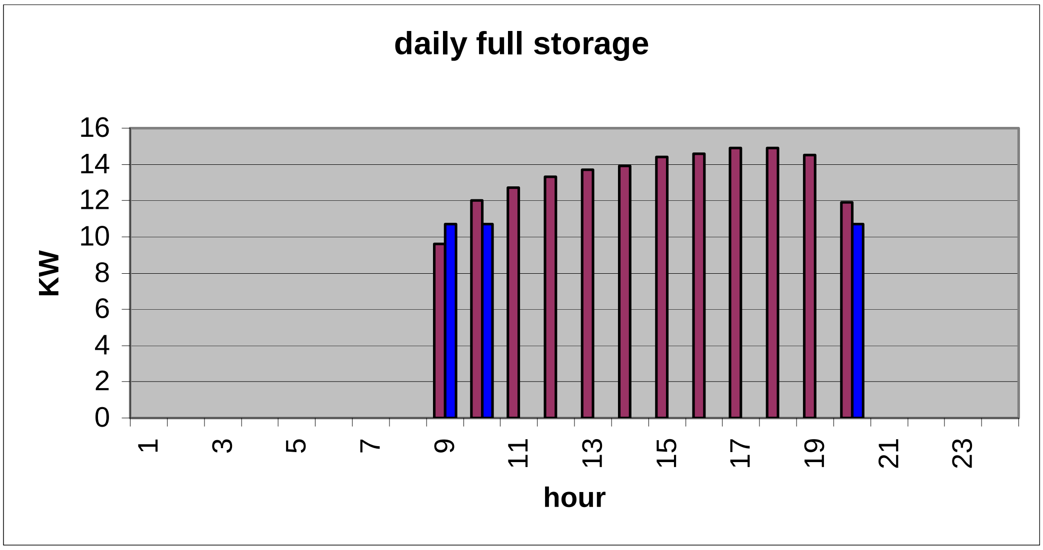


Table 6.4: Summary of Daily Full Storage with Glycol Versus Daily Load Distribution

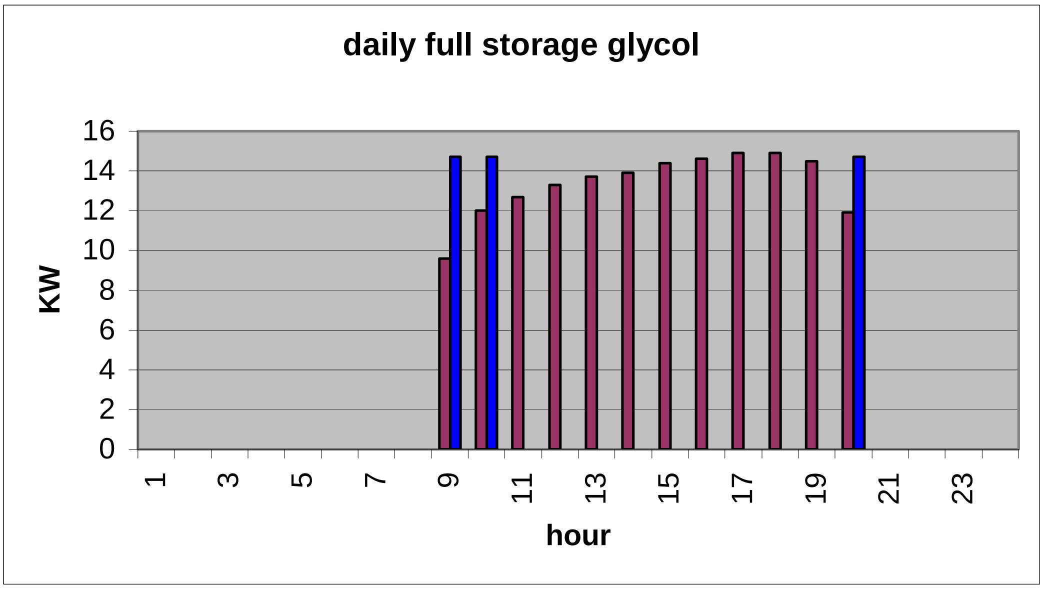


Table 6.5: Summary of Daily Load Leveling Versus Daily Load Distribution

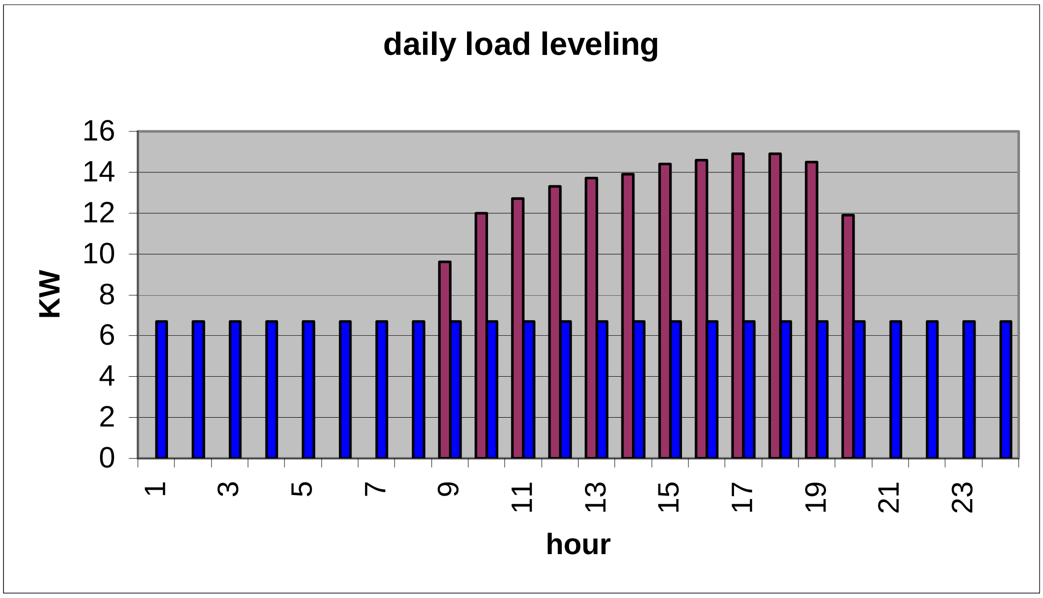


Table 6.6: Summary of Daily Load Leveling with Glycol Versus Daily Load Distribution

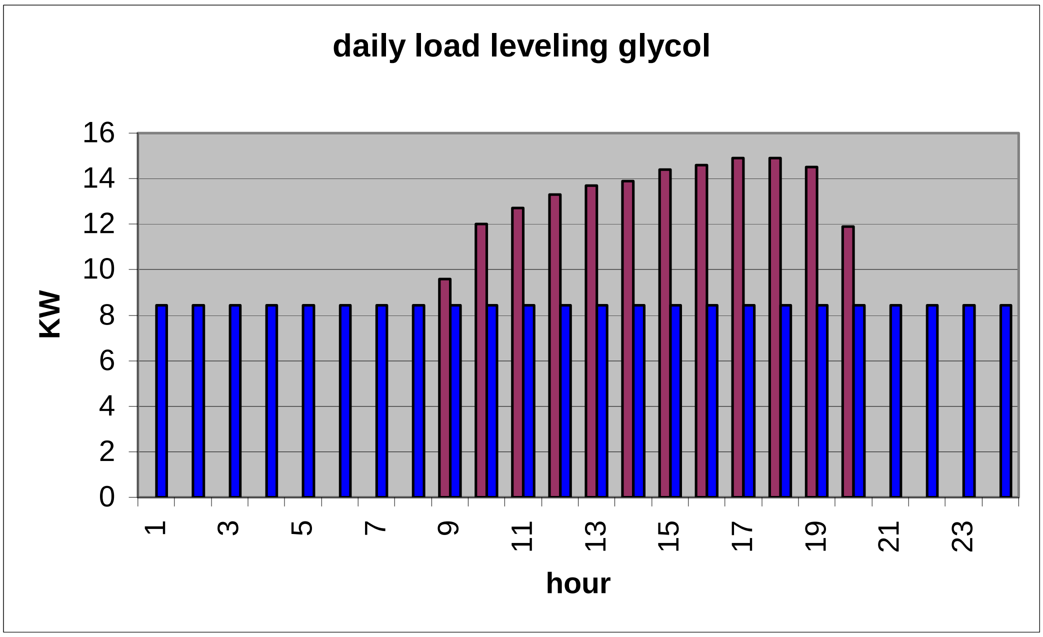
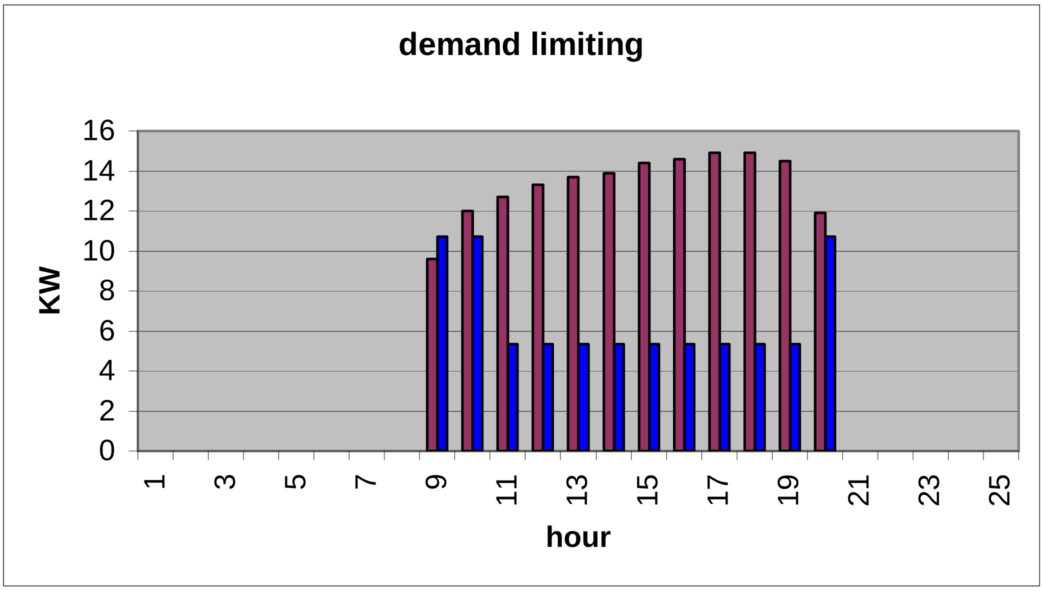


Table 6.7: Summary of Demand Limiting Versus Daily Load Distribution



6.3.2.5 Summary of Chiller and Storage Sizes

The chiller sizes and storage sizes determined and summarized in Table 6.8.

Table 6.8: Summary of Chiller and Storage Sizes

Operating Mode	Storage Type	Quick Chiller Size (kW)	Quick Storage Size (kWh)
Full Storage	Chilled Water	10.7	140.1
Full Storage	Glycol ice	14.72	126.9
Daily Load Leveling	Chilled Water	6.69	77.21
Daily Load Leveling	Glycol ice	8.44	64.02
Demand Limiting	Glycol ice	10.73	83.04

6.3.3 Economic Comparison

In Turkey, electricity consumption fees do not change during the day. For this reason, installation costs are estimated for each sizing options. These results are illustrated in Table 6.9. The chiller and storage cost prices are taken as followed [35].

Chiller Cost = $170/kW

Storage Cost:

Chilled water = $11.36/kWh

Glycol ice = $17.05/kWh

Table 6.9: Economic Comparison Summary

Operating Mode	Storage Type	Quick Chiller Size	Quick Storage Size	Chiller Cost	Storage Cost	Total Cost
		(kW)	(kWh)	$	$	$
Full Storage	Chilled Water	10.7	140.1	1819	1 591.54	3 410.54
Full Storage	Glycol ice	14.72	126.9	2 501.65	2 163.65	4 665 30
Daily Load Leveling	Chilled Water	6.69	77.21	1 137.3	877.11	2 014 41
Daily Load Leveling	Glycol ice	8.44	64.02	1 435.14	1 091.58	2 526.72
Demand Limiting	Glycol ice	10.73	83.04	1 823.95	1 415.75	3 239.69

As shown from Table 6.4, the most economical operating mode is daily load leveling, chilled water storage type. This operating mode is suitable for the fire protect system. Fire protect system can take the fire protect water from this storage tank, and another storage tank need can be removed with the water type of chilled water system.

6.3.4 Storage Tank Capacity

The storage capacity of chilled water tank increases with the temperature difference between the stored chilled water and the warm water returning from the load.

For the chilled water storage systems, the most favorite tank shape is flat-bottomed vertical cylinder. A cylindrical tank has lower surface to volume ratio than a rectangular tank of the same volume.

Concrete tanks are constructed with height to diameter ratios of 0.25 to 0.5. The best offer is generally 0.25 and 0.33. Concrete tanks are generally more economical below 14m heights. Besides, aboveground steel tanks are typically constructed with the ratio similarly with the concrete tanks of 0.5 to 1.2. Horizontal cylindrical tanks are not recommended for stratified chilled water storage. Welded steel, precast prestressed concrete, and cast-in-place concrete tanks are the most common chilled water storage tanks. Steel tanks are the best choice for the small sized tanks.

The tank volume depends on the temperature difference between the stored chilled water and the warm water returning. That effectiveness is expressed as the figure of merit (FOM) of the tank. The FOM is the ratio of the amount of cooling removed from storage to the amount of cooling available from fully charged storage. For well-designed water storage tanks FOM is 90% or better. If there is no data, a factor of 85 to 90 % is recommended.

The tank volume can be calculated from the following equation [35].

$$V(m^3) = \frac{TotaldailykWh \cdot 3600kJ / kWh}{\Delta K \cdot 998kg / m^3 \cdot 4.2kJ / kg^o K \cdot FOM} \tag{6.5}$$

Total daily load is 152.4 kWh for the cooling load of the GUZEB. If FOM is taken %85, and the system operates between 4 and 15°C, storage tank capacity will be:

$$V(m^3) = \frac{160.4 \cdot 3600}{11 \cdot 998 \cdot 4.2 \cdot 0.85} = 14.733m^3 \cong 15m^3$$

If the steel tank is cost is taken approximately 35 $/m^3$ [35], storage tank cost will be 535 $.

If the steel tanks height-to-diameter ratios is taken 0.95, and the storage tank size is decided to be cylindrical, length and the diameter of the storage tank is:

$$\frac{L}{D} = 0.95$$

$$15 = L \cdot \frac{\pi D^2}{4}$$

$$15 = 0.95 \cdot D \cdot \frac{\pi D^2}{4}$$

Diameter of the storage tank is found approximately 2.7 m., and the length is found 2.6 m.

6.3.5 Diffuser

Diffusers are needed in chilled storage water storage tanks to take the water gently into the tank in gravity current. The thermocline are, which means the warm and cold water transition area, is formed by designing diffusers with the Froude number and by the properly sizing diffuser openings. Degradation of the thermocline is minimized by the designing for an appropriate inlet Reynolds number and by the proper operation of the system. The Froude number is the dimensionless ratio of the inertial force to the buoyancy force that is acting on a fluid. The Froude number is [35]:

$$\text{Fri} = \frac{q}{\left(g h_i^{\,3}(\rho_i - \rho_a)/\rho_a\right)^{1/2}} \tag{6.6}$$

where:

q	=	volume flow rate per unit diffuser length
g	=	acceleration of gravity
h_i	=	minimum inlet opening height
ρ_i	=	density of inlet water
ρ_a	=	density of ambient water

and

$$q = Qm/L \tag{6.7}$$

where:

Qm = maximum flow rate

L = effective diffuser length. For a diffuser that discharges water in two directions 180^{o} apart, the effective diffuser lengths will be twice the actual physical length of the diffuser.

The Reynolds number in a flowing fluid is the dimensionless ratio of the internal to viscous forces. The inlet Reynolds number is calculated from [30]:

$$Re_i = q/\nu \qquad (6.8)$$

where:

q = flow rate per meter of diffuser length (m^2/s)
ν = kinematic viscosity of inlet water (m^2/s)

For very short tanks, Reynolds is recommended 200, for tank greater than about 5 m deep is between 400 and 850, for 12 m deep or more tanks, Reynolds is 2 000. In general, an upper limit of 850 is recommended so Reynolds should be used 200 [35].

From Equation 6.8 flow rate is found:

$$200 = q / 1.566 \cdot 10^{-6}(m^2/s) \quad \rightarrow \quad q = 3.132 \cdot 10^{-4}\ m^2/s$$

From Equation 6.6 Froude number can be calculate as followed where Froude number is equaled to 1. The density of inlet water and the density of ambient water are taken as:

$$\rho_i\left(4^o C\right) = 998.8234 kg / m^3$$

$$\rho_a\left(15^o C\right) = 997.9561 kg / m^3$$

Finally minimum inlet opening height is calculated that:

$$h_i = 0.02177\ m$$

As shown in Table 6.9 tank capacity is taken approximately 80 kWh. If the water making hours during 12 hours the required power is calculated as:

Required power = 80 / 12 = 6.67 kW

Mass flow rate can be calculated from Equation 6.9:

$$\overset{*}{Q} = m C_p \Delta T \qquad (6.9)$$

$$6.67kW = \overset{*}{m} \cdot 4.2 \cdot (\frac{kJ}{kgK}) \cdot 11(^{o}K)$$

$$\overset{*}{m} = 0.1443kg/s$$

Maximum Flow rate can be calculate:

$$Q_m = \frac{0.1443}{998.8234kg/m^3} = 1.4454 \cdot 10^{-4} m^3/s$$

and diffuser length can be calculate from Equation 6.7:

$$3.132 \cdot 10^{-4} = 1.4454 \cdot 10^{-4} / L \quad \rightarrow \quad L = 0.4615 \text{ m}$$

For radial disk diffuser, diameter of the diffuser is calculate from Equation 6.10:

$$D = L / \pi \qquad (6.10)$$

Finally diffuser length is found as:

$$D = 0.147 \text{ m}$$

Chapter 7

CONCLUSION

Turkey has great renewable energy sources when considered its solar, wind and geothermal energy potential.

Solar energy potential of Turkey is one of the best energy potential to gain its energy expenditure in average solar radiation of 3.6 kWh/m^2 per day. As shown in Figure 1.9, Turkey has better solar radiation compared with the both European countries and many different areas of the world.

On the other hand, as seas and long seashores surround it, wind energy is another energy potential. Turkey has an economical wind power potential of about 10 000 MW, which its total available potential for wind power is around 90 000 MW annually [13].

Another energy potential for Turkey is geothermal energy. Turkey has rich geothermal energy capacity about 4 500 MW which most of them can be used for electrical power generation in high enthalpy zones. Besides, geothermal central heating could be applicable for many regions in Turkey.

Summary of the average solar and wind potential is illustrated in Table 7.1. In summary, many regions around the world do not have rich energy sources that Turkey has.

Table 7.1: Average Solar and Wind Energy Potential of Turkey [11,12].

	Annual Average Solar Radiation	**Sunshine Duration**	**Annual Average Wind Density**
	(kWh/m^2year)	**(h/year)**	**(W/m^2)**
Turkey Average	1 303	2 623	25.81

As mentioned, more energy sources are needed if Turkey's total energy production is only 30% of its all consumption. Although oil and natural gas become very expensive, not only in Turkey but also in the world, these sources supply most of our energy needs. This means that, Turkey and the world have to tend to new energy sources, which include solar, hydropower, biomass, geothermal and wind energy, or have to control their energy expense with the help of many energy saving methods.

In the light of the renewable energy potential of Turkey, and energy reducing studies around the world, using renewable energy sources instead of fossil energy sources in life may start with the daily life, with the houses. So, house that produces its own energy, zero energy house idea, becomes the main point of this study.

Gulbahce Zero Energy Building's location is chosen near the campus area of IZTECH. This location is rich because of the natural energy sources. An ancient cave near the GUZEB has water source at 32^{o}C, which is used for heating the building in winter and used to meet hot water needs. Besides, the location of GUZEB has good wind energy potential, which its speed reaches up to 5-7 m/s at the sea level [37]. Additionally, solar energy potential of the location is better than the Turkey's solar radiation average when examined geographically.

In summary, the location of the GUZEB is special with the realistic renewable energy sources.

GUZEB is designed as a library and on special days, can be functioned as a showroom, where symposiums can be assembled. GUZEB is designed to use these renewable energy sources more productive that, for instance, roof is designed to help to take wind for ventilation inside of the building; in addition, floor insulation materials are chosen related with the floor heating method where geothermal energy can be used more efficiently. So, these kinds of design methods are chosen to help to store energy and to use these related renewable sources.

For example, geothermal energy is used to heat the building in winter. With low temperature geothermal sources, floor-heating system will be the best choice to use this real hot water reservoir. Although the reservoir has low water temperature for floor heating systems, the water will meet the heating load because of its continuity. While the system works continuously, the gain from the water used in the floor heating system will be enough to meet the heating load of the building.

Wind and solar energy is used to meet the electric consumption of the building. As mentioned, with good and efficient wind potential of the location; a wind turbine can be used to produce electricity together with the photovoltaic panels, which can be placed in front of the building. These panels and the wind turbine together, can be used to meet the electricity consumption including lighting equipments, cooling and ventilation group, automatic control equipments, pumps, etc.

On the other hand, the building is powered with many recommendations and many application materials to reduce energy consumption. Firstly, silica aerogel is one of these insulation materials, which help to reduce energy consumption. Because of its 99.8% is air, and related with this characteristic, its thermal conductivity is very low that aerogels are the best insulator that ever discovered. Aerogels can be produced, with high technology, transparent that is as same as a glass. So, aerogel can be used both an insulator and a window. This means that, wall, which silica aerogel is used, will help to let the sunshine in that help to reduce lighting consumption.

Secondly, fiber lighting is a lighting recommendation that do not need electricity. With the illuminators that do not use electrical power, but its electrical power can help to reduce electricity consumption, if it is used as a lighting option. With long life-span illuminators, fiber lighting can be a good energy saver.

Thirdly, easy applicable ceramic roof insulation material is another energy saving option. With these kind of insulation materials, the building can be protected and power instead of the energy losses.

Curtains and the panels, which is used for shading is other energy saving method that is recommended for the energy saving. These curtains can be controlled automatically concerned with the daylight.

Related with these curtains, cooling system is designed not for the entrance. Because, automatic controlled curtains and panels, the cooling system is designed for the library and the office spaces. Besides, toilets will have exhaust system. The main reason of choosing this kind of system is same with the other recommendations, to reduce energy consumption. If the cooling and ventilation system will be used on special days, selecting and constructing the full equipped and constructed duct design can be extravagant, while trying to reduce energy consumption.

In this study, thermal energy storage system is one of the other ways, which is recommended to produce and store ice or water during off-peak hours. This stored energy is used during on-peak hours. As mentioned in church example, GUZEB have less cooling load on regular days than on special symposium days, which will maximum cooling load where natural ventilation cannot be enough. On the other hand, if the cooling system is chosen for usual days, cooling system will not operate on special days when full capacity is needed. This means that installation and operating cost will be meaningless if the plant is chosen related with the special days, which may not be more than four or five days annually. While operating on regular days, energy could be stored for special days. So, stored energy can be more suitable and operable and more helpful on energy saving.

For thermal energy storage system, daily load leveling operating mode and chilled water storage type is the best operation type if both the chilled water can be used in fire protection system and its total cost are taken into consideration. Fire protect system can take the fire protect water from thermal energy storage tank, incase of fire and another storage tank need can be solved with only one tank.

Table 7.2 shows that, the cooling peak load on special symposium day and the load if the energy is stored. It is clearly shows that, the cooling system can be chosen 45% less than the peak load. With the light of these data, the first investment cost of the plant and the operation cost of the low loaded plant will be lower.

Table 7.2: Cooling Load Comparison on Regular and Special Days.

	Peak Load	**Daily Load Leveling Mode**
Cooling Load (kW)	14.9	6.69

Automatic control systems; for instance, how much water will be pumped for floor-heating system, how much fresh air will be let into the spaces from cooling and ventilation systems, how much intervals will be opened from natural ventilation intervals, how much sunshine will be let in from curtains, have to be set up to keep the building alive. Besides, monitoring systems will be used to monitor these control systems.

For many different examples and different designs, optimization of each system will be different from each other. Where the building will be settled, how efficient renewable sources that the location have, for which functions that the building will serve, and other qualifications of the building are designated the optimization of the related building.

In this study, the design recommendations are given related with the qualifications of the GUZEB that are followed above. Optimization of the GUZEB can be done in the light of these recommendations.

This study is a front study. After cost and performance analysis of each system, and recommendations, GUZEB can be constructed. But this never means that, zero energy houses including GUZEB, will be more feasible at the beginning. But, in the course of the time, these kinds of zero energy house systems can be feasible or profitable.

Additionally, zero energy house studies have the same main idea that the energy will be the most important subject which is going to be the most expensive to obtain and with renewable energy sources, the basic energy consumption for the usual life can be solved by these kinds of studies. In developed countries, the government supports this idea if people gain their energy from these renewable energy sources. So, zero energy houses will be one of the most important parts of the projects that are based on renewable energy sources where the energy is obtained from nature.

In this study, a zero energy building was designed and optimized. All energy sources, which are used in GUZEB, are from natural sources that are all of them are realistic. Geothermal energy, where is taken from an ancient cave near to the location of the GUZEB, is used for heating and for hot water demand; wind and solar energy, where both potential are high enough to produce electricity, are for producing electricity. In summary, GUZEB is constructed upon realistic examples, and with both of these natural energy sources, a hybrid system is created.

In addition, the building is designed with many different and specific systems, for instance, the roof design that for natural ventilation, and passive solar heating recommendations, and the building is powered by new insulation materials, lighting equipments and many other related functions, which are make GUZEB special to save energy.

In conclusion, GUZEB produces its own energy. And this study indicates that with a single compact hybrid example, a building can be designed to save energy and produce its own energy need with renewable energy sources and many different energy saving methods.

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APPENDIX A

SCHEDULE DATA

Prepared By: IYTE 07-05-04

HAP v3.23

Schedule Name: lighting library Hourly Percentages

Hour ----->	00	01	02	03	04	05	06	07	08	09	10	11
DESIGN DAY	0	0	0	0	0	0	0	0	100	100	100	100
Weekday	0	0	0	0	0	0	0	0	50	100	100	100
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

Hour ----->	12	13	14	15	16	17	18	19	20	21	22	23
DESIGN DAY	100	100	100	100	100	100	100	100	20	0	0	0
Weekday	100	100	100	100	100	100	50	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

Schedule Name: lighting entrance Hourly Percentages

Hour ----->	00	01	02	03	04	05	06	07	08	09	10	11
DESIGN DAY	0	0	0	0	0	0	0	0	100	100	100	100
Weekday	0	0	0	0	0	0	0	0	50	50	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

Hour ----->	12	13	14	15	16	17	18	19	20	21	22	23
DESIGN DAY	100	100	100	100	100	100	100	100	20	0	0	0
Weekday	0	0	0	0	50	50	50	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

Schedule Name: lighting office1 Hourly Percentages

Hour ----->	00	01	02	03	04	05	06	07	08	09	10	11
DESIGN DAY	0	0	0	0	0	0	0	0	50	100	100	100
Weekday	0	0	0	0	0	0	0	0	50	100	100	100
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

Hour ----->	12	13	14	15	16	17	18	19	20	21	22	23
DESIGN DAY	100	100	100	100	100	100	100	50	0	0	0	0
Weekday	100	50	100	100	100	100	50	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

SCHEDULE DATA

Prepared By: IYTE 07-05-04

HAP v3.23

Schedule Name: lighting office2 — Hourly Percentages

Hour ----->	00	01	02	03	04	05	06	07	08	09	10	11
DESIGN DAY	0	0	0	0	0	0	0	0	50	100	100	100
Weekday	0	0	0	0	0	0	0	0	50	100	100	100
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

Hour ----->	12	13	14	15	16	17	18	19	20	21	22	23
DESIGN DAY	100	100	100	100	100	100	100	50	0	0	0	0
Weekday	100	50	100	100	100	100	50	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

Schedule Name: lighting toilets — Hourly Percentages

Hour ----->	00	01	02	03	04	05	06	07	08	09	10	11
DESIGN DAY	0	0	0	0	0	0	0	0	50	100	100	100
Weekday	0	0	0	0	0	0	0	0	50	50	50	50
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

Hour ----->	12	13	14	15	16	17	18	19	20	21	22	23
DESIGN DAY	100	100	100	100	100	100	100	50	0	0	0	0
Weekday	50	100	50	50	50	50	50	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

Schedule Name: people library — Hourly Percentages

Hour ----->	00	01	02	03	04	05	06	07	08	09	10	11
DESIGN DAY	0	0	0	0	0	0	0	0	50	100	100	100
Weekday	0	0	0	0	0	0	0	0	25	25	50	50
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

Hour ----->	12	13	14	15	16	17	18	19	20	21	22	23
DESIGN DAY	100	100	100	100	100	100	100	50	0	0	0	0
Weekday	50	25	50	50	50	25	25	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

Schedule Name: people entrance Hourly Percentages

Hour ----->	00	01	02	03	04	05	06	07	08	09	10	11
DESIGN DAY	0	0	0	0	0	0	0	0	50	100	100	100
Weekday	0	0	0	0	0	0	0	0	25	25	25	25
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

Hour ----->	12	13	14	15	16	17	18	19	20	21	22	23
DESIGN DAY	100	100	100	100	100	100	100	50	0	0	0	0
Weekday	25	25	25	25	25	25	25	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

Schedule Name: people office1 Hourly Percentages

Hour ----->	00	01	02	03	04	05	06	07	08	09	10	11
DESIGN DAY	0	0	0	0	0	0	0	0	50	100	100	100
Weekday	0	0	0	0	0	0	0	0	50	100	100	100
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

Hour ----->	12	13	14	15	16	17	18	19	20	21	22	23
DESIGN DAY	100	100	100	100	100	100	50	0	0	0	0	0
Weekday	100	25	100	100	100	50	50	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

Schedule Name: people office2 Hourly Percentages

Hour ----->	00	01	02	03	04	05	06	07	08	09	10	11
DESIGN DAY	0	0	0	0	0	0	0	0	50	100	100	100
Weekday	0	0	0	0	0	0	0	0	50	100	100	100
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

Hour ----->	12	13	14	15	16	17	18	19	20	21	22	23
DESIGN DAY	100	100	100	100	100	100	50	0	0	0	0	0
Weekday	100	25	100	100	100	50	50	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

Schedule Name: equipment library Hourly Percentages

Hour ----->	00	01	02	03	04	05	06	07	08	09	10	11
DESIGN DAY	0	0	0	0	0	0	0	0	100	100	100	100
Weekday	0	0	0	0	0	0	0	0	25	50	50	50
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

Hour ----->	12	13	14	15	16	17	18	19	20	21	22	23
DESIGN DAY	100	100	100	100	100	100	100	100	20	0	0	0
Weekday	50	25	50	50	50	50	25	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

Schedule Name: equipment entrance Hourly Percentages

Hour ----->	00	01	02	03	04	05	06	07	08	09	10	11
DESIGN DAY	0	0	0	0	0	0	0	0	100	100	100	100
Weekday	0	0	0	0	0	0	0	0	0	0	10	10
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

Hour ----->	12	13	14	15	16	17	18	19	20	21	22	23
DESIGN DAY	100	100	100	100	100	100	100	100	20	0	0	0
Weekday	10	0	10	10	10	10	10	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

Schedule Name: equipment office1 Hourly Percentages

Hour ----->	00	01	02	03	04	05	06	07	08	09	10	11
DESIGN DAY	0	0	0	0	0	0	0	0	50	100	100	100
Weekday	0	0	0	0	0	0	0	0	50	100	100	100
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

Hour ----->	12	13	14	15	16	17	18	19	20	21	22	23
DESIGN DAY	100	100	100	100	100	100	100	50	0	0	0	0
Weekday	100	50	100	100	100	100	50	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

SCHEDULE DATA

Schedule Name: equipment office2 Hourly Percentages

Hour ----->	00	01	02	03	04	05	06	07	08	09	10	11
DESIGN DAY	0	0	0	0	0	0	0	0	50	100	100	100
Weekday	0	0	0	0	0	0	0	0	50	100	100	100
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

Hour ----->	12	13	14	15	16	17	18	19	20	21	22	23
DESIGN DAY	100	100	100	100	100	100	100	50	0	0	0	0
Weekday	100	50	100	100	100	100	50	0	0	0	0	0
Saturday	0	0	0	0	0	0	0	0	0	0	0	0
Sunday	0	0	0	0	0	0	0	0	0	0	0	0

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DESIGN PARAMETERS

City Name	IZMIR
Location	Turkey
Latitude	38.2 degrees
Longitude	-27.1 degrees
Elevation	58.0 m
Summer Design Dry-Bulb	33.9 C
Summer Coincident Wet-Bulb	22.7 C
Summer Daily Range	8.4 K
Winter Design Dry-bulb	1.6 C
Atmospheric Clearness Number	1.00
Average Ground Reflectance	0.20
Soil Conductivity	1.385 W/m/K
Local Time Zone (GMT +/- N hours)	-3.0 hours
Consider Daylight Savings Time?	Y
First Month for Daylight Savings	April
Last Month for Daylight Savings	November
Simulation Weather Data	Athens (TRY)
Current data is	User Defined

DESIGN DAY MAXIMUM SOLAR HEAT GAINS (W/SQM)

Month	N	NNE	NE	ENE	E	ESE	SE	SSE	S
January	31.0	31.0	31.0	128.1	239.2	322.8	368.0	381.0	384.0
February	40.2	40.2	83.7	217.6	309.1	382.5	401.6	393.2	384.4
March	56.6	57.0	196.7	326.4	424.7	457.2	452.2	409.7	384.7
April	79.0	155.4	333.2	450.6	512.2	519.6	460.3	381.1	335.7
May	102.6	279.8	455.8	570.0	598.3	567.5	462.4	343.9	282.8
June	155.0	363.6	562.1	677.5	691.8	640.1	502.7	351.9	281.1
July	120.5	318.6	518.9	637.2	673.8	636.9	521.5	384.5	316.4
August	95.9	185.6	374.2	497.4	576.1	578.5	515.3	426.1	376.3
September	72.1	72.1	232.7	369.1	493.9	543.2	534.2	488.9	457.4
October	47.5	47.5	102.2	229.5	351.8	418.0	450.8	440.9	426.4
November	30.0	30.0	30.0	127.7	221.8	303.9	347.9	364.1	360.9
December	27.1	27.1	27.1	99.7	204.8	292.5	343.4	364.6	370.6

Month	SSW	SW	WSW	W	WNW	NW	NNW	HOR	Mult.
January	383.7	370.4	317.2	242.1	123.7	31.0	31.0	216.2	0.48
February	391.7	400.5	383.8	309.7	215.3	88.7	40.2	305.5	0.51
March	405.6	448.0	461.8	418.3	333.1	192.2	57.9	441.2	0.61
April	376.5	458.9	515.7	516.6	455.0	323.7	170.2	591.4	0.73
May	340.0	466.5	561.7	606.6	568.3	445.4	289.7	734.7	0.87
June	349.3	507.9	630.4	703.8	672.3	553.0	379.2	875.0	1.03
July	382.0	523.7	627.4	682.7	635.7	507.9	331.9	834.7	1.00
August	420.8	513.2	574.8	576.6	508.3	363.7	194.4	672.5	0.85
September	488.0	532.3	545.4	490.1	377.2	233.0	72.1	522.4	0.75
October	441.1	450.8	415.0	351.1	235.3	96.8	47.5	341.9	0.59
November	363.6	346.9	304.7	219.3	128.0	30.0	30.0	204.2	0.46
December	368.4	344.0	290.8	201.6	102.9	27.1	27.1	179.0	0.46

Mult. = User-defined solar multiplier factor.

COOLING DESIGN TEMPERATURE PROFILES

Location: IZMIR, Turkey 07-05-04

HAP v3.23

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(Format is Dry-Bulb/Wet-Bulb C)

Hr	January	February	March	April	May	June
0000	7.6/ 5.5	7.8/ 5.5	9.8/ 7.3	13.6/ 10.2	18.0/ 13.8	22.7/ 16.8
0100	7.5/ 5.4	7.5/ 5.3	9.3/ 6.9	13.2/ 9.9	17.3/ 13.3	21.9/ 16.2
0200	7.3/ 5.3	7.3/ 5.2	9.1/ 6.7	12.9/ 9.7	16.9/ 12.9	21.5/ 15.9
0300	7.2/ 5.3	7.2/ 5.0	8.9/ 6.6	12.6/ 9.6	16.6/ 12.7	21.0/ 15.6
0400	7.0/ 5.2	7.0/ 5.0	8.7/ 6.5	12.4/ 9.5	16.2/ 12.5	20.6/ 15.4
0500	6.9/ 5.1	6.9/ 4.9	8.5/ 6.5	12.1/ 9.3	16.0/ 12.4	20.4/ 15.4
0600	6.9/ 5.1	6.8/ 4.8	8.3/ 6.4	12.1/ 9.4	16.3/ 12.9	20.9/ 16.0
0700	6.8/ 5.0	6.8/ 4.8	8.5/ 6.6	13.1/ 10.4	18.0/ 14.6	22.9/ 18.1
0800	6.9/ 5.1	7.1/ 5.1	9.4/ 7.4	14.3/ 11.6	19.3/ 15.9	24.1/ 19.3
0900	7.7/ 5.6	8.1/ 5.7	10.7/ 8.2	15.6/ 12.3	20.6/ 16.5	25.6/ 19.8
1000	8.7/ 6.3	9.2/ 6.5	11.9/ 8.9	16.8/ 12.8	21.9/ 16.9	26.9/ 20.2
1100	9.7/ 6.9	10.2/ 7.1	13.0/ 9.4	18.0/ 13.2	23.0/ 17.2	28.1/ 20.4
1200	10.4/ 7.3	10.9/ 7.5	13.9/ 9.7	18.8/ 13.3	23.9/ 17.2	28.9/ 20.3
1300	10.9/ 7.6	11.5/ 7.7	14.6/ 10.0	19.5/ 13.3	24.4/ 16.9	29.5/ 19.9
1400	11.3/ 7.9	12.0/ 8.2	15.1/ 10.3	19.9/ 13.7	24.7/ 17.2	29.9/ 20.3
1500	11.3/ 7.9	12.0/ 8.2	15.0/ 10.4	19.7/ 13.5	24.6/ 17.1	29.7/ 20.1
1600	11.0/ 7.9	11.8/ 8.2	14.7/ 10.5	19.3/ 13.7	24.2/ 17.3	29.3/ 20.4
1700	10.2/ 7.3	11.1/ 7.8	14.1/ 10.2	18.7/ 13.5	23.6/ 17.2	28.6/ 20.4
1800	9.5/ 6.8	10.2/ 7.2	13.1/ 9.6	17.7/ 13.0	22.5/ 16.7	27.6/ 20.0
1900	9.0/ 6.6	9.5/ 6.8	12.2/ 9.0	16.6/ 12.5	21.4/ 16.1	26.4/ 19.5
2000	8.7/ 6.5	9.1/ 6.7	11.6/ 8.8	15.9/ 12.2	20.6/ 15.9	25.5/ 19.2
2100	8.4/ 6.2	8.7/ 6.3	11.1/ 8.3	15.1/ 11.5	19.8/ 15.1	24.6/ 18.3
2200	8.0/ 5.9	8.3/ 5.9	10.6/ 7.8	14.5/ 10.9	19.1/ 14.4	24.0/ 17.7
2300	7.8/ 5.7	8.1/ 5.7	10.2/ 7.5	14.0/ 10.5	18.5/ 14.1	23.3/ 17.2

Hr	July	August	September	October	November	December
0000	25.2/ 18.6	24.9/ 18.7	21.3/ 15.6	16.8/ 13.3	11.9/ 9.1	9.1/ 6.8
0100	24.5/ 18.1	24.4/ 18.4	20.8/ 15.5	16.6/ 13.2	11.9/ 9.1	9.0/ 6.7
0200	24.0/ 17.9	23.9/ 18.2	20.4/ 15.4	16.3/ 13.0	11.7/ 9.0	8.9/ 6.7
0300	23.5/ 17.6	23.4/ 17.9	20.0/ 15.3	16.0/ 12.9	11.6/ 8.8	8.8/ 6.6
0400	23.1/ 17.5	23.0/ 17.8	19.6/ 15.3	15.8/ 12.8	11.4/ 8.7	8.7/ 6.5
0500	22.7/ 17.3	22.7/ 17.7	19.3/ 15.3	15.5/ 12.7	11.3/ 8.6	8.6/ 6.5
0600	22.9/ 17.7	22.6/ 17.9	19.2/ 15.5	15.4/ 12.7	11.1/ 8.6	8.4/ 6.4
0700	24.5/ 19.4	23.7/ 19.0	19.9/ 16.2	15.6/ 12.9	11.1/ 8.5	8.4/ 6.4
0800	25.6/ 20.5	25.0/ 20.3	21.5/ 17.8	16.9/ 14.2	11.7/ 9.2	8.5/ 6.5
0900	27.2/ 21.1	26.6/ 20.9	23.3/ 18.6	18.6/ 15.1	12.9/ 9.8	9.4/ 7.0
1000	28.7/ 21.7	28.1/ 21.5	24.8/ 19.1	19.9/ 15.7	14.1/ 10.5	10.4/ 7.7
1100	30.0/ 22.0	29.5/ 21.9	26.3/ 19.6	21.2/ 16.1	15.1/ 11.0	11.3/ 8.2
1200	30.9/ 21.9	30.5/ 21.9	27.3/ 19.7	22.1/ 16.3	15.8/ 11.2	11.9/ 8.5
1300	31.5/ 21.5	31.1/ 21.6	28.0/ 19.4	22.8/ 16.3	16.4/ 11.3	12.5/ 8.7
1400	31.8/ 21.9	31.5/ 21.9	28.3/ 19.7	23.1/ 16.5	16.7/ 11.6	12.7/ 9.0
1500	31.7/ 21.8	31.4/ 21.8	28.1/ 19.4	22.9/ 16.3	16.5/ 11.4	12.6/ 8.8
1600	31.4/ 22.1	31.0/ 22.0	27.5/ 19.3	22.2/ 16.2	16.0/ 11.3	12.1/ 8.6
1700	30.8/ 22.0	30.3/ 21.9	26.5/ 18.8	21.1/ 15.6	14.9/ 10.7	11.3/ 8.1
1800	29.9/ 21.6	29.2/ 21.3	25.2/ 18.0	20.1/ 15.1	14.1/ 10.3	10.7/ 7.7
1900	28.7/ 21.0	28.1/ 20.7	24.2/ 17.4	19.2/ 14.9	13.5/ 10.1	10.3/ 7.5
2000	27.8/ 20.7	27.3/ 20.5	23.6/ 17.3	18.7/ 14.8	13.1/ 10.1	10.0/ 7.5
2100	27.0/ 19.9	26.7/ 19.8	22.9/ 16.6	18.2/ 14.3	12.8/ 9.8	9.8/ 7.3
2200	26.4/ 19.3	26.0/ 19.2	22.3/ 16.0	17.6/ 13.7	12.3/ 9.3	9.5/ 7.0
2300	25.8/ 18.9	25.5/ 18.9	21.8/ 15.8	17.2/ 13.5	12.1/ 9.2	9.3/ 6.9

```
                          AIR SYSTEM INPUT DATA
Name: AIR SYSTEM                                                  03-06-04
Type: VARIABLE VOLUME - VAV                                      HAP v3.23
Prepared by: IYTE                                                  Page  1
**************************************************************************

1. SYSTEM NAME AND TYPE
--------------------------------------------------------------------------
  Name............: AIR SYSTEM
  Type............: VARIABLE VOLUME - VAV
  Number of Zones.:  1
==========================================================================

2. SYSTEM DESCRIPTION
--------------------------------------------------------------------------
COOLING SYSTEM DATA
 Supply Air....................:          12.8 C
 Coil Bypass Factor............:         0.100
 Supply Air Reset..............:    Outdoor Air
 Maximum Reset Temperature.....:          18.3 C
 OA Temp For Min Supply........:          35.0 C
 OA Temp For Max Supply........:          -1.1 C
OUTDOOR VENTILATION DATA
 Type of Control...............:    Proportional to Supply Air
 Design Ventilation Airflow....:            20 %
 Minimum Ventilation Rate......:             0 %
 Dampers Open During Unocc Per.:             Y
SUPPLY DUCT DATA
 Duct Heat Gain................:             0 %
 Duct Leakage Rate.............:             0 %
RETURN PLENUM DATA
 Is a Return Plenum Used.......?             N
SUPPLY FAN DATA
 Fan Type......................:    FC w/ Variable Speed Drive
 Configuration.................:    Draw-Thru
 Fan kW........................:           0.0 kW
RETURN FAN DATA
 Fan Type......................:    None
OUTDOOR AIR ECONOMIZER
 Outdoor Economizer Type.......:    None
PREHEAT COIL
 Preheat Coil Used.............?             N
PRECOOL COIL
 Precool Coil Used.............?             N
HUMIDIFICATION
 Humidification System Used....?             N
DEHUMIDIFICATION
 Dehumidification System Used..?             N
VENTILATION HEAT RECLAIM
 Reclaim Unit Type.............:    None
SAFETY FACTORS
 Sensible Cooling Factor.......:             0 %
 Latent Cooling Factor.........:             0 %
 Heating Factor................:             0 %
==========================================================================
```

AIR SYSTEM INPUT DATA

Name: AIR SYSTEM 03-06-04
Type: VARIABLE VOLUME - VAV HAP v3.23
Prepared by: IYTE Page 2

3. ZONE DATA

ZONE	1 (All Zones the Same)
T-Stat Occupied Cooling....(C):	23.9
Unoccupied Cooling..(C):	29.4
Occupied Heating....(C):	21.1
Unoccupied Heating..(C):	15.6
Throttling Range....(K):	1.7
Zone Heating Unit Type........:	None
Trip Temperature.........(C):	-
Design Supply Temperature(C):	-
Fan Total Static....(Pa.):	-
Fan Efficiency...........(%):	-
Zone Terminal Type...........:	VAV Box
Minimum Damper Position...(%)	10
Reheat Coil.................?	N
Fan Total Static....(Pa.):	-
Fan Efficiency...........(%):	-
Heating Supply Temp......(C):	-
Diversity Factor...........(%):	100
Direct Exhaust Airflow...(L/s):	0.0
Direct Exhaust Fan kW.....(kW):	0.0

4. SCHEDULE DATA

HOURLY TSTAT SCHEDULES	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Design Day............									X	X	X	X	X	X	X	X	X	X	X	X				
Weekday................										X	X	X	X	X	X	X	X	X	X					
Saturday...............																								
Sunday.................																								

Cooling Available During Unoccupied Period ? N

MONTHLY SCHEDULES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Central Cooling........					XXX	XXX	XXX	XXX	XXX			

AIR SYSTEM INPUT DATA

Name: AIR SYSTEM 03-06-04
Type: VARIABLE VOLUME - VAV HAP v3.23
Prepared by: IYTE Page 1

1. SPACE SELECTION

Space Name	Qty	Space Name	Qty
SPACES IN ZONE 1 (Zone 1)			
1. LIBRARY	1	2. ENTRANCE	1
3. OFFICE1	1	4. OFFICE2	1

SPACE DESCRIPTION

Prepared by: IYTE 03-06-04
HAP v3.23 Page 1

GENERAL
- Name......: LIBRARY
- Floor Area......: 125.6 sqm
- Building Weight.: 146.5 kg/sqm
- Windows Shaded..? Y
- Partitions Used.? N

LIGHTING
- Overhead Fixture: Free-Hanging
- Lamp Wattage....: 2.70 W/sqm
- Ballast Mult....: 2.00
- Task Lighting...: 0.0 W

PEOPLE
- Occupancy.......: 40 People
- Activity Level..: Office Work
- Sensible........: 71.8 W
- Latent..........: 60.1 W

OTHER LOADS
- Equipment.......: 1390.0 W
- Misc. Sensible..: 0.0 W
- Misc. Latent....: 0.0 W

SCHEDULES
- Lighting....: lighting library
- Task Lights.: lighting library
- People......: people library
- Equipment...: equipment library
- Misc. Sens..: misc.sensible
- Misc. Latent: misc. latent

INFILTRATION
- Cooling.....: 0.0 L/s
- Heating.....: 0.0 L/s
- Typical.....: 0.0 L/s
- When Fan On.? N

FLOOR
- Type........:Slab On Grade
- Perimeter.............: 45.0 m
- Slab Floor Area.......: 125.6 sqm
- Floor R-Value.........: 2.37
- Insulation R-value....: 1.75

EXTERNAL SHADING	Type 1	Type 2	Type 3
Reveal Depth....................(mm)	0.0	0.0	0.0
Overhang			
Projection From Building Surface.(mm)	0.0	0.0	0.0
Height Above Window.............(mm)	0.0	0.0	0.0
Extension Past RH Side Of Window.(mm)	0.0	0.0	0.0
Extension Past LH Side Of Window.(mm)	0.0	0.0	0.0
Right Fin			
Distance From Edge Of Window.....(mm)	0.0	0.0	0.0
Projection From Building Surface.(mm)	0.0	0.0	0.0
Height Above Window.............(mm)	0.0	0.0	0.0
Left Fin			
Distance From Edge Of Window.....(mm)	0.0	0.0	0.0
Projection From Building Surface.(mm)	0.0	0.0	0.0
Height Above Window.............(mm)	0.0	0.0	0.0

WALL Exp	Gross Area (sqm)	WALL Type	WINDOW Type	WINDOW Qty	WINDOW Shade	WINDOW Type	WINDOW Qty	WINDOW Shade	Any Doors?
WNW	26.9	1	1	0	0	1	0	0	N
WNW	25.0	3	1	0	0	1	0	0	N
SSW	68.4	1	1	0	0	1	0	0	N
NNW	26.8	4	2	1	0	1	0	0	N

ROOF Exp	Slope (deg)	Gross Area (sqm)	ROOF Type	SKYLIGHT Type	SKYLIGHT Qty
HOR	-	140.0	1	1	0

No partition data for this space.

SPACE DESCRIPTION

Prepared by: IYTE 03-06-04

HAP v3.23 Page 1

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GENERAL
- Name......: ENTRANCE
- Floor Area......: 87.4 sqm
- Building Weight.: 146.5 kg/sqm
- Windows Shaded..? Y
- Partitions Used.? N

LIGHTING
- Overhead Fixture: Free-Hanging
- Lamp Wattage....: 1.55 W/sqm
- Ballast Mult....: 2.00
- Task Lighting...: 0.0 W

PEOPLE
- Occupancy.......: 10 People
- Activity Level..: Office Work
- Sensible........: 71.8 W
- Latent..........: 60.1 W

OTHER LOADS
- Equipment.......: 350.0 W
- Misc. Sensible..: 0.0 W
- Misc. Latent....: 0.0 W

SCHEDULES
- Lighting....: lighting entrance
- Task Lights.: lighting entrance
- People......: people entrance
- Equipment...: equipment entrance
- Misc. Sens..: misc.sensible
- Misc. Latent: misc. latent

INFILTRATION
- Cooling.....: 0.0 L/s
- Heating.....: 0.0 L/s
- Typical.....: 0.0 L/s
- When Fan On.? N

FLOOR
- Type........:Slab On Grade
- Perimeter.............: 48.8 m
- Slab Floor Area.......: 87.4 sqm
- Floor R-Value.........: 2.37
- Insulation R-value....: 1.75

EXTERNAL SHADING	Type 1	Type 2	Type 3
Reveal Depth....................(mm)	80.0	0.0	0.0
Overhang			
Projection From Building Surface.(mm)	0.0	0.0	0.0
Height Above Window.............(mm)	0.0	0.0	0.0
Extension Past RH Side Of Window.(mm)	0.0	0.0	0.0
Extension Past LH Side Of Window.(mm)	0.0	0.0	0.0
Right Fin			
Distance From Edge Of Window.....(mm)	0.0	0.0	0.0
Projection From Building Surface.(mm)	0.0	0.0	0.0
Height Above Window.............(mm)	0.0	0.0	0.0
Left Fin			
Distance From Edge Of Window.....(mm)	0.0	0.0	0.0
Projection From Building Surface.(mm)	0.0	0.0	0.0
Height Above Window.............(mm)	0.0	0.0	0.0

WALL Exp	Gross Area (sqm)	WALL Type	WINDOW Type	WINDOW Qty	WINDOW Shade	WINDOW Type	WINDOW Qty	WINDOW Shade	Any Doors?
SSW	85.0	1	1	1	0	1	0	0	N
SSE	15.9	1	1	0	0	1	0	0	Y

ROOF Exp	Slope (deg)	Gross Area (sqm)	ROOF Type	SKYLIGHT Type	SKYLIGHT Qty
HOR	-	93.0	1	1	0
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-

DOOR
- Gross Area..: 3.9 sqm
- Uvalue......: 0.273
- Glass Area..: 2.2 sqm
- Glass U-val.: 0.273
- Shade Coeff.: 1.00
- Glass Shaded? Y

No partition data for this space.

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GENERAL                                      SCHEDULES
 Name......: OFFICE1                          Lighting....: lighting office1
 Floor Area......:      16.8 sqm              Task Lights.: lighting office1
 Building Weight.:     146.5 kg/sqm           People......: people office1
 Windows Shaded..?         Y                  Equipment...: equipment office1
 Partitions Used.?         N                  Misc. Sens..: misc.sensible
LIGHTING                                      Misc. Latent: misc. latent
 Overhead Fixture: Free-Hanging              INFILTRATION
 Lamp Wattage....:      4.05 W/sqm            Cooling.....:       0.0 L/s
 Ballast Mult....:      2.00                  Heating.....:       0.0 L/s
 Task Lighting...:       0.0 W                Typical.....:       0.0 L/s
PEOPLE                                        When Fan On.?         N
 Occupancy.......:         1 People          FLOOR
 Activity Level..: Office Work                Type........:Slab On Grade
 Sensible........:      71.8 W                Perimeter.............:      14.1 m
 Latent..........:      60.1 W                Slab Floor Area.......:      16.8 sqm
OTHER LOADS                                   Floor R-Value.........:      2.37
 Equipment.......:     350.0 W                Insulation R-value....:      1.75
 Misc. Sensible..:       0.0 W
 Misc. Latent....:       0.0 W
```

EXTERNAL SHADING	Type 1	Type 2	Type 3
Reveal Depth....................(mm)	0.0	0.0	0.0
Overhang			
Projection From Building Surface.(mm)	0.0	0.0	0.0
Height Above Window.............(mm)	0.0	0.0	0.0
Extension Past RH Side Of Window.(mm)	0.0	0.0	0.0
Extension Past LH Side Of Window.(mm)	0.0	0.0	0.0
Right Fin			
Distance From Edge Of Window.....(mm)	0.0	0.0	0.0
Projection From Building Surface.(mm)	0.0	0.0	0.0
Height Above Window.............(mm)	0.0	0.0	0.0
Left Fin			
Distance From Edge Of Window.....(mm)	0.0	0.0	0.0
Projection From Building Surface.(mm)	0.0	0.0	0.0
Height Above Window.............(mm)	0.0	0.0	0.0

WALL Exp	Gross Area (sqm)	WALL Type	WINDOW Type	WINDOW Qty	WINDOW Shade	WINDOW Type	WINDOW Qty	WINDOW Shade	Any Doors?
WNW	13.9	4	3	1	0	1	0	0	N

ROOF Exp	Slope (deg)	Gross Area (sqm)	ROOF Type	SKYLIGHT Type	SKYLIGHT Qty
HOR	-	17.5	1	1	0

No partition data for this space.

SPACE DESCRIPTION

```
Prepared by: IYTE                                                    03-06-04
HAP v3.23                                                            Page  1
*****************************************************************************
GENERAL                                     SCHEDULES
 Name......: OFFICE2                         Lighting....: lighting office2
 Floor Area......:       9.0 sqm             Task Lights.: lighting office2
 Building Weight.:     146.5 kg/sqm          People......: people office2
 Windows Shaded..?         Y                 Equipment...: equipment office2
 Partitions Used.?         N                 Misc. Sens..: misc.sensible
LIGHTING                                     Misc. Latent: misc. latent
 Overhead Fixture: Free-Hanging             INFILTRATION
 Lamp Wattage....:      3.77 W/sqm           Cooling.....:       0.0 L/s
 Ballast Mult....:      2.00                 Heating.....:       0.0 L/s
 Task Lighting...:       0.0 W               Typical.....:       0.0 L/s
PEOPLE                                       When Fan On.?         N
 Occupancy.......:         1 People         FLOOR
 Activity Level..: Office Work               Type........:Slab On Grade
 Sensible........:      71.8 W               Perimeter.............:      12.0 m
 Latent..........:      60.1 W               Slab Floor Area.......:       9.0 sqm
OTHER LOADS                                  Floor R-Value.........:      2.37
 Equipment.......:     350.0 W               Insulation R-value....:      1.75
 Misc. Sensible..:       0.0 W
 Misc. Latent....:       0.0 W
```

EXTERNAL SHADING	Type 1	Type 2	Type 3
Reveal Depth....................(mm)	0.0	0.0	0.0
Overhang			
Projection From Building Surface.(mm)	0.0	0.0	0.0
Height Above Window.............(mm)	0.0	0.0	0.0
Extension Past RH Side Of Window.(mm)	0.0	0.0	0.0
Extension Past LH Side Of Window.(mm)	0.0	0.0	0.0
Right Fin			
Distance From Edge Of Window.....(mm)	0.0	0.0	0.0
Projection From Building Surface.(mm)	0.0	0.0	0.0
Height Above Window.............(mm)	0.0	0.0	0.0
Left Fin			
Distance From Edge Of Window.....(mm)	0.0	0.0	0.0
Projection From Building Surface.(mm)	0.0	0.0	0.0
Height Above Window.............(mm)	0.0	0.0	0.0

WALL Exp	Gross Area (sqm)	WALL Type	WINDOW Type	WINDOW Qty	WINDOW Shade	WINDOW Type	WINDOW Qty	WINDOW Shade	Any Doors?
SE	11.9	1	4	1	0	1	0	0	N

ROOF Exp	Slope (deg)	Gross Area (sqm)	ROOF Type	SKYLIGHT Type	SKYLIGHT Qty
HOR	-	9.5	1	1	0

No partition data for this space.

```
                        AIR SYSTEM SIZING SUMMARY
Air System.: AIR SYSTEM                                              03-06-04
Weather....:  IZMIR, Turkey                                         HAP v3.23
Prepared By: IYTE                                                      Page 1
*****************************************************************************

AIR SYSTEM INFORMATION
-----------------------------------------------------------------------------
  System Type...............: (VAV)       Floor Area........:    239 sqm
  Number of Zones...........:         1
-----------------------------------------------------------------------------
SIZING CALCULATION INFORMATION
-----------------------------------------------------------------------------
  Zone and Space Sizing Method:          Calculation Months: JFMAMJJASOND
    Zone L/s: Peak Zone Load             Sizing Data.......:   Calculated
    Space L/s: Coincident Space Loads
-----------------------------------------------------------------------------
CENTRAL COOLING COIL SIZING DATA
-----------------------------------------------------------------------------
  Total coil load (kW)......:    14.9    Load occurs at....:   Jul 1600
  Sensible coil load (kW)...:    10.8    OA DB/RH (C/%)....: 31.4/ 44.9
  Coil L/s at Jul 1600......:     673    Entering Db/Wb....: 26.7/ 19.3 C
  Max possible L/s..........:     681    Leaving Db/Wb.....: 13.3/ 12.7 C
  Design supply temp (C)....:    12.8    Coil ADP..........:       11.8 C
  sqm/kW....................:    16.0    Bypass factor.....:      0.100
  W/sqm.....................:    62.4    Resulting RH......:         51 %
  Water L/s @  6K rise......:    0.59    Zone T-stat Check.: 1 of  1 OK
-----------------------------------------------------------------------------
SUPPLY FAN SIZING DATA
-----------------------------------------------------------------------------
  Actual max L/s @ Jul 1800.:     681    Fan motor BHP.....:       0.00
  Standard L/s..............:     676    Fan motor kW......:       0.00
  Actual max L/s/sqm .......:    2.85
-----------------------------------------------------------------------------
OUTDOOR VENTILATION AIR DATA
-----------------------------------------------------------------------------
  Design airflow (L/s)......:     136    L/s/person........:       2.62
  L/s/sqm ..................:    0.57
-----------------------------------------------------------------------------
```

ZONE SIZING SUMMARY

Air System.: AIR SYSTEM 03-06-04
Weather....: IZMIR, Turkey HAP v3.23
Prepared By: IYTE Page 1

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TABLE 1. SIZING CALCULATION INFORMATION

Zone and Space Sizing Method:	Calculation Months: JFMAMJJASOND
Zone L/s: Peak Zone Load	Sizing Data.......: Calculated
Space L/s: Coincident Space Loads	

TABLE 2. ZONE SIZING DATA

Zone Name	Cooling Sensible (kW)	Air Flow (L/s)	Design Mon Hour	Heating Load (kW)
Zone 1.................	9.1	681	Jul 1800	3.0

Note: Zone loads calculated at occupied thermostat setpoint.

TABLE 3. ADDITIONAL ZONE TERMINAL SIZING DATA

(Not Applicable for this System)

TABLE 4. SPACE LOADS AND AIRFLOWS

Zone Name / Space Name	Mult	Cooling Sensible (kW)	Time of Load	Air Flow (L/s)	Heating Load (kW)
Zone 1.................					
LIBRARY.................	x 1	5.7	Jul 1800	427	1.6
ENTRANCE................	x 1	2.3	Jul 1800	170	1.1
OFFICE1.................	x 1	0.6	Jul 1800	46	0.2
OFFICE2.................	x 1	0.5	Jul 1800	38	0.1

Note: Space loads and airflows do not include multipliers.

AIR SYSTEM DESIGN LOAD SUMMARY

Air System.: AIR SYSTEM 03-06-04
Weather....: IZMIR, Turkey HAP v3.23
Prepared By: IYTE Page 1 of 1

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COOLING AT........: Jul @ 1600 HEATING AT......: Winter Design
COOLING OA DB/RH..: 31.4 C / 45 % HEATING OA DB...: 1.6 C

ZONE LOADS	Details	COOLING Sensible (W)	COOLING Latent (W)	HEATING Sensible (W)
Solar Loads	104 sqm	394	-	-
Wall Transmission	168 sqm	436	-	798
Roof Transmission	260 sqm	1658	-	973
Glass Transmission	104 sqm	187	-	552
Skylight Transmission	0 sqm	0	-	0
Door Transmission	2 sqm	3	-	9
Floor Transmission	239 sqm	0	-	659
Partitions	0 sqm	0	-	0
Ceiling	0 sqm	0	-	0
Overhead Lighting	1153 W	1067	-	-
Task Lighting	0 W	0	-	-
Electric Equipment	2440 W	2038	-	-
People	52 people	3071	3124	-
Infiltration		0	0	0
Miscellaneous		0	0	-
Safety Factor	0/ 0/ 0 %	0	0	0
>>Total Zone Loads (1)		8855	3124	2991
Zone Conditioning (2)		9844	3124	-271
Plenum Wall Load	0 %	0	-	-
Plenum Roof Load	0 %	0	-	-
Plenum Lighting Load	0 %	0	-	-
Return Fan Load		0	-	0
Ventilation Load	135 L/s	945	981	271
Supply Fan Load	673 L/s	0	-	0
Space Fan Coil Fans		0	-	0
Duct Heat Gain/Loss	0 %	0	-	0
>>Total System Loads		10790	4105	0
Central Cooling Coil		10790	4101	0
Central Heating Coil		0	-	0
Precool Coil		0	0	0
Preheat Coil		0	-	0
Central Reheat Coil		0	-	-
Humidification Load		0	0	-
Terminal Reheat Coils		0	-	0
Space/Skin Heat Coils		0	-	0
>>Total Conditioning		10790	4101	0

Notes: (1) Zone loads calculated at occupied thermostat setpoint.
(2) Zone conditioning based on heat extraction analysis.
(3) In the COOLING column, positive loads indicate heat gains, while positive coil loads indicate system heat removal.
(4) In the HEATING column, positive loads indicate heat loss, while positive coil loads indicate system heat addition.

ZONE DESIGN LOAD SUMMARY

Air System.: AIR SYSTEM 03-06-04
Weather....: IZMIR, Turkey HAP v3.23
Prepared By: IYTE Page 1 of 1

ZONE...: Zone 1

COOLING AT.........: Jul @ 1800
COOLING OA DB/RH...: 29.9 C / 48 %
HEATING OA DB......: 1.6 C

Load Component	Details	COOLING Sensible (W)	COOLING Latent (W)	HEATING Sensible (W)
Solar Loads	104 sqm	398	-	-
Wall Transmission	168 sqm	592	-	798
Roof Transmission	260 sqm	1511	-	973
Glass Transmission	104 sqm	163	-	552
Skylight Transmission	0 sqm	0	-	0
Door Transmission	2 sqm	3	-	9
Floor Transmission	239 sqm	0	-	659
Partitions	0 sqm	0	-	0
Ceiling	0 sqm	0	-	0
Overhead Lights	1153 W	1086	-	-
Task Lights	0 W	0	-	-
Electric Equipment	2440 W	2129	-	-
People	51 people	3188	3064	-
Infiltration		0	0	0
Miscellaneous		0	0	-
Safety Factor	0/ 0/ 0 %	0	0	0
>>Total Zone Loads (1)		9069	3064	2991

Note: (1) Zone loads calculated at 23.9 C cooling, 21.1 C heating.

SPACE DESIGN LOAD SUMMARY

Air System.: AIR SYSTEM 03-06-04
Weather....: IZMIR, Turkey HAP v3.23
Prepared By: IYTE Page 1

TABLE 1A. SPACE AND ZONE NAME

SPACE..: LIBRARY	COOLING AT........: Jul @ 1800
IN ZONE: Zone 1	COOLING OA DB/RH..: 29.9 C / 48 %
	HEATING OA DB.....: 1.6 C

TABLE 1B. SPACE COMPONENT LOADS

Load Component	Details	COOLING Sensible (W)	COOLING Latent (W)	HEATING Sensible (W)
Solar Loads	12 sqm	17	-	-
Wall Transmission	135 sqm	502	-	670
Roof Transmission	140 sqm	814	-	524
Glass Transmission	12 sqm	19	-	65
Skylight Transmission	0 sqm	0	-	0
Door Transmission	0 sqm	0	-	0
Floor Transmission	126 sqm	0	-	321
Partitions	0 sqm	0	-	0
Ceiling	0 sqm	0	-	0
Overhead Lights	678 W	640	-	-
Task Lights	0 W	0	-	-
Electric Equipment	1390 W	1218	-	-
People	40 people	2478	2403	-
Infiltration		0	0	0
Miscellaneous		0	0	-
Safety Factor	0/ 0/ 0 %	0	0	0
>>Total Space Loads (1)		5687	2403	1580

Note: (1) Zone loads calculated at 23.9 C cooling, 21.1 C heating.

TABLE 1C. WALL, WINDOW, DOOR, ROOF

	Area (sqm)	Type	U-val	Shade Coeff	COOLING TRANS. (W)	COOLING SOLAR (W)	HEATING TRANS. (W)
WNW EXPOSURE							
WALL.........	26.9	1	0.197	-	55	-	103
WNW EXPOSURE							
WALL.........	25.0	3	0.510	-	255	-	249
SSW EXPOSURE							
WALL.........	68.4	1	0.197	-	168	-	263
NNW EXPOSURE							
WALL.........	14.6	4	0.192	-	24	-	55
WINDOW.......	12.2	2	0.273	0.010	19	17	65
H EXPOSURE (0 degree slope)							
ROOF.........	140.0	1	0.192	-	814	-	524

SPACE DESIGN LOAD SUMMARY

Air System.: AIR SYSTEM 03-06-04
Weather....: IZMIR, Turkey HAP v3.23
Prepared By: IYTE Page 2

TABLE 2A. SPACE AND ZONE NAME

SPACE..: ENTRANCE	COOLING AT........: Jul @ 1700
IN ZONE: Zone 1	COOLING OA DB/RH..: 30.8 C / 47 %
	HEATING OA DB.....: 1.6 C

TABLE 2B. SPACE COMPONENT LOADS

Load Component	Details	COOLING Sensible (W)	COOLING Latent (W)	HEATING Sensible (W)
Solar Loads	87 sqm	382	-	-
Wall Transmission	12 sqm	34	-	48
Roof Transmission	93 sqm	582	-	348
Glass Transmission	87 sqm	149	-	462
Skylight Transmission	0 sqm	0	-	0
Door Transmission	2 sqm	3	-	9
Floor Transmission	87 sqm	0	-	254
Partitions	0 sqm	0	-	0
Ceiling	0 sqm	0	-	0
Overhead Lights	271 W	253	-	-
Task Lights	0 W	0	-	-
Electric Equipment	350 W	301	-	-
People	10 people	606	601	-
Infiltration		0	0	0
Miscellaneous		0	0	-
Safety Factor	0/ 0/ 0 %	0	0	0
>>Total Space Loads (1)		2311	601	1121

Note: (1) Zone loads calculated at 23.9 C cooling, 21.1 C heating.

TABLE 2C. WALL, WINDOW, DOOR, ROOF

	Area (sqm)	Type	U-val	Shade Coeff	COOLING TRANS. (W)	COOLING SOLAR (W)	HEATING TRANS. (W)
SSW EXPOSURE							
WALL.........	0.5	1	0.197	-	1	-	2
WINDOW.......	84.5	1	0.273	0.010	145	178	450
SSE EXPOSURE							
WALL.........	12.0	1	0.197	-	33	-	46
DOOR.........	1.7	-	0.273	-	3	-	9
DOOR GLASS...	2.2	-	0.273	1.000	4	204	12
H EXPOSURE (0 degree slope)							
ROOF.........	93.0	1	0.192	-	582	-	348

TABLE 3A. SPACE AND ZONE NAME

SPACE..: OFFICE1	COOLING AT........: Jul @ 1700
IN ZONE: Zone 1	COOLING OA DB/RH..: 30.8 C / 47 %
	HEATING OA DB.....: 1.6 C

TABLE 3B. SPACE COMPONENT LOADS

Load Component	Details	COOLING Sensible (W)	COOLING Latent (W)	HEATING Sensible (W)
Solar Loads	4 sqm	9	-	-
Wall Transmission	10 sqm	17	-	37
Roof Transmission	18 sqm	110	-	65
Glass Transmission	4 sqm	7	-	21
Skylight Transmission	0 sqm	0	-	0
Door Transmission	0 sqm	0	-	0
Floor Transmission	17 sqm	0	-	53
Partitions	0 sqm	0	-	0
Ceiling	0 sqm	0	-	0
Overhead Lights	136 W	127	-	-
Task Lights	0 W	0	-	-
Electric Equipment	350 W	295	-	-
People	1 people	60	60	-
Infiltration		0	0	0
Miscellaneous		0	0	-
Safety Factor	0/ 0/ 0 %	0	0	0
>>Total Space Loads (1)		624	60	177

Note: (1) Zone loads calculated at 23.9 C cooling, 21.1 C heating.

TABLE 3C. WALL, WINDOW, DOOR, ROOF

	Area (sqm)	Type	U-val	Shade Coeff	COOLING TRANS. (W)	COOLING SOLAR (W)	HEATING TRANS. (W)
WNW EXPOSURE							
WALL.........	10.0	4	0.192	-	17	-	37
WINDOW.......	3.8	3	0.273	0.010	7	9	21
H EXPOSURE (0 degree slope)							
ROOF.........	17.5	1	0.192	-	110	-	65

TABLE 4A. SPACE AND ZONE NAME

SPACE..: OFFICE2	COOLING AT........: Jul @ 1700
IN ZONE: Zone 1	COOLING OA DB/RH..: 30.8 C / 47 %
	HEATING OA DB.....: 1.6 C

SPACE DESIGN LOAD SUMMARY

Air System.: AIR SYSTEM 03-06-04
Weather....: IZMIR, Turkey HAP v3.23
Prepared By: IYTE Page 4

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TABLE 4B. SPACE COMPONENT LOADS

Load Component	Details	COOLING Sensible (W)	COOLING Latent (W)	HEATING Sensible (W)
Solar Loads	1 sqm	2	-	-
Wall Transmission	11 sqm	35	-	42
Roof Transmission	10 sqm	59	-	36
Glass Transmission	1 sqm	2	-	5
Skylight Transmission	0 sqm	0	-	0
Door Transmission	0 sqm	0	-	0
Floor Transmission	9 sqm	0	-	31
Partitions	0 sqm	0	-	0
Ceiling	0 sqm	0	-	0
Overhead Lights	68 W	63	-	-
Task Lights	0 W	0	-	-
Electric Equipment	350 W	295	-	-
People	1 people	60	60	-
Infiltration		0	0	0
Miscellaneous		0	0	-
Safety Factor	0/ 0/ 0 %	0	0	0
>>Total Space Loads (1)		516	60	113

Note: (1) Zone loads calculated at 23.9 C cooling, 21.1 C heating.

TABLE 4C. WALL, WINDOW, DOOR, ROOF

	Area (sqm)	Type	U-val	Shade Coeff	COOLING TRANS. (W)	COOLING SOLAR (W)	HEATING TRANS. (W)
SE EXPOSURE							
WALL.........	11.0	1	0.197	-	35	-	42
WINDOW.......	0.9	4	0.273	0.010	2	2	5
H EXPOSURE (0 degree slope)							
ROOF.........	9.5	1	0.192	-	59	-	36

HOURLY AIR SYSTEM DESIGN DAY LOADS

Air System.: AIR SYSTEM 03-06-04
Weather....: IZMIR, Turkey HAP v3.23
Prepared By: IYTE Page 1 of 12

MONTH: JANUARY

Hour	OA TEMP (C)	CENTRAL COOLING Sens. (kW)	CENTRAL COOLING Total (kW)	CENTRAL HEATING (kW)	PREHEAT COIL (kW)	TERMINAL HEATING COIL (kW)	SPACE & SKIN HEATING (kW)	SUPPLY AIRFLOW (L/s)
0000	7.6	0.0	0.0	0.0	0.0	0.0	0.0	0
0100	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0
0200	7.3	0.0	0.0	0.0	0.0	0.0	0.0	0
0300	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0
0400	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0
0500	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0
0600	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0
0700	6.8	0.0	0.0	0.0	0.0	0.0	0.0	0
0800	6.9	0.0	0.0	0.0	0.0	0.0	0.0	68
0900	7.7	0.0	0.0	0.0	0.0	0.0	0.0	68
1000	8.7	0.0	0.0	0.0	0.0	0.0	0.0	68
1100	9.7	0.0	0.0	0.0	0.0	0.0	0.0	68
1200	10.4	0.0	0.0	0.0	0.0	0.0	0.0	68
1300	10.9	0.0	0.0	0.0	0.0	0.0	0.0	68
1400	11.3	0.0	0.0	0.0	0.0	0.0	0.0	68
1500	11.3	0.0	0.0	0.0	0.0	0.0	0.0	68
1600	11.0	0.0	0.0	0.0	0.0	0.0	0.0	68
1700	10.2	0.0	0.0	0.0	0.0	0.0	0.0	68
1800	9.5	0.0	0.0	0.0	0.0	0.0	0.0	68
1900	9.0	0.0	0.0	0.0	0.0	0.0	0.0	68
2000	8.7	0.0	0.0	0.0	0.0	0.0	0.0	0
2100	8.4	0.0	0.0	0.0	0.0	0.0	0.0	0
2200	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0
2300	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0

HOURLY AIR SYSTEM DESIGN DAY LOADS

Air System.: AIR SYSTEM 03-06-04
Weather....: IZMIR, Turkey HAP v3.23
Prepared By: IYTE Page 2 of 12

MONTH: FEBRUARY

Hour	OA TEMP (C)	CENTRAL COOLING Sens. (kW)	CENTRAL COOLING Total (kW)	CENTRAL HEATING (kW)	PREHEAT COIL (kW)	TERMINAL HEATING COIL (kW)	SPACE & SKIN HEATING (kW)	SUPPLY AIRFLOW (L/s)
0000	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0
0100	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0
0200	7.3	0.0	0.0	0.0	0.0	0.0	0.0	0
0300	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0
0400	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0
0500	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0
0600	6.8	0.0	0.0	0.0	0.0	0.0	0.0	0
0700	6.8	0.0	0.0	0.0	0.0	0.0	0.0	0
0800	7.1	0.0	0.0	0.0	0.0	0.0	0.0	68
0900	8.1	0.0	0.0	0.0	0.0	0.0	0.0	68
1000	9.2	0.0	0.0	0.0	0.0	0.0	0.0	68
1100	10.2	0.0	0.0	0.0	0.0	0.0	0.0	68
1200	10.9	0.0	0.0	0.0	0.0	0.0	0.0	68
1300	11.5	0.0	0.0	0.0	0.0	0.0	0.0	68
1400	12.0	0.0	0.0	0.0	0.0	0.0	0.0	68
1500	12.0	0.0	0.0	0.0	0.0	0.0	0.0	68
1600	11.8	0.0	0.0	0.0	0.0	0.0	0.0	68
1700	11.1	0.0	0.0	0.0	0.0	0.0	0.0	68
1800	10.2	0.0	0.0	0.0	0.0	0.0	0.0	68
1900	9.5	0.0	0.0	0.0	0.0	0.0	0.0	68
2000	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0
2100	8.7	0.0	0.0	0.0	0.0	0.0	0.0	0
2200	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0
2300	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0

HOURLY AIR SYSTEM DESIGN DAY LOADS

Air System.: AIR SYSTEM 03-06-04
Weather....: IZMIR, Turkey HAP v3.23
Prepared By: IYTE Page 3 of 12

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MONTH: MARCH

Hour	OA TEMP (C)	CENTRAL COOLING Sens. (kW)	CENTRAL COOLING Total (kW)	CENTRAL HEATING (kW)	PREHEAT COIL (kW)	TERMINAL HEATING COIL (kW)	SPACE & SKIN HEATING (kW)	SUPPLY AIRFLOW (L/s)
0000	9.8	0.0	0.0	0.0	0.0	0.0	0.0	0
0100	9.3	0.0	0.0	0.0	0.0	0.0	0.0	0
0200	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0
0300	8.9	0.0	0.0	0.0	0.0	0.0	0.0	0
0400	8.7	0.0	0.0	0.0	0.0	0.0	0.0	0
0500	8.5	0.0	0.0	0.0	0.0	0.0	0.0	0
0600	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0
0700	8.5	0.0	0.0	0.0	0.0	0.0	0.0	0
0800	9.4	0.0	0.0	0.0	0.0	0.0	0.0	68
0900	10.7	0.0	0.0	0.0	0.0	0.0	0.0	68
1000	11.9	0.0	0.0	0.0	0.0	0.0	0.0	68
1100	13.0	0.0	0.0	0.0	0.0	0.0	0.0	68
1200	13.9	0.0	0.0	0.0	0.0	0.0	0.0	68
1300	14.6	0.0	0.0	0.0	0.0	0.0	0.0	68
1400	15.1	0.0	0.0	0.0	0.0	0.0	0.0	68
1500	15.0	0.0	0.0	0.0	0.0	0.0	0.0	68
1600	14.7	0.0	0.0	0.0	0.0	0.0	0.0	68
1700	14.1	0.0	0.0	0.0	0.0	0.0	0.0	68
1800	13.1	0.0	0.0	0.0	0.0	0.0	0.0	68
1900	12.2	0.0	0.0	0.0	0.0	0.0	0.0	68
2000	11.6	0.0	0.0	0.0	0.0	0.0	0.0	0
2100	11.1	0.0	0.0	0.0	0.0	0.0	0.0	0
2200	10.6	0.0	0.0	0.0	0.0	0.0	0.0	0
2300	10.2	0.0	0.0	0.0	0.0	0.0	0.0	0

HOURLY AIR SYSTEM DESIGN DAY LOADS

Air System.: AIR SYSTEM 03-06-04
Weather....: IZMIR, Turkey HAP v3.23
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MONTH: APRIL

Hour	OA TEMP (C)	CENTRAL COOLING Sens. (kW)	CENTRAL COOLING Total (kW)	CENTRAL HEATING (kW)	PREHEAT COIL (kW)	TERMINAL HEATING COIL (kW)	SPACE & SKIN HEATING (kW)	SUPPLY AIRFLOW (L/s)
0000	13.6	0.0	0.0	0.0	0.0	0.0	0.0	0
0100	13.2	0.0	0.0	0.0	0.0	0.0	0.0	0
0200	12.9	0.0	0.0	0.0	0.0	0.0	0.0	0
0300	12.6	0.0	0.0	0.0	0.0	0.0	0.0	0
0400	12.4	0.0	0.0	0.0	0.0	0.0	0.0	0
0500	12.1	0.0	0.0	0.0	0.0	0.0	0.0	0
0600	12.1	0.0	0.0	0.0	0.0	0.0	0.0	0
0700	13.1	0.0	0.0	0.0	0.0	0.0	0.0	0
0800	14.3	0.0	0.0	0.0	0.0	0.0	0.0	68
0900	15.6	0.0	0.0	0.0	0.0	0.0	0.0	68
1000	16.8	0.0	0.0	0.0	0.0	0.0	0.0	68
1100	18.0	0.0	0.0	0.0	0.0	0.0	0.0	68
1200	18.8	0.0	0.0	0.0	0.0	0.0	0.0	68
1300	19.5	0.0	0.0	0.0	0.0	0.0	0.0	68
1400	19.9	0.0	0.0	0.0	0.0	0.0	0.0	68
1500	19.7	0.0	0.0	0.0	0.0	0.0	0.0	68
1600	19.3	0.0	0.0	0.0	0.0	0.0	0.0	68
1700	18.7	0.0	0.0	0.0	0.0	0.0	0.0	68
1800	17.7	0.0	0.0	0.0	0.0	0.0	0.0	68
1900	16.6	0.0	0.0	0.0	0.0	0.0	0.0	68
2000	15.9	0.0	0.0	0.0	0.0	0.0	0.0	0
2100	15.1	0.0	0.0	0.0	0.0	0.0	0.0	0
2200	14.5	0.0	0.0	0.0	0.0	0.0	0.0	0
2300	14.0	0.0	0.0	0.0	0.0	0.0	0.0	0

HOURLY AIR SYSTEM DESIGN DAY LOADS

Air System.: AIR SYSTEM 03-06-04
Weather....: IZMIR, Turkey HAP v3.23
Prepared By: IYTE Page 5 of 12

MONTH: MAY

Hour	OA TEMP (C)	CENTRAL COOLING Sens. (kW)	CENTRAL COOLING Total (kW)	CENTRAL HEATING (kW)	PREHEAT COIL (kW)	TERMINAL HEATING COIL (kW)	SPACE & SKIN HEATING (kW)	SUPPLY AIRFLOW (L/s)
0000	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0
0100	17.3	0.0	0.0	0.0	0.0	0.0	0.0	0
0200	16.9	0.0	0.0	0.0	0.0	0.0	0.0	0
0300	16.6	0.0	0.0	0.0	0.0	0.0	0.0	0
0400	16.2	0.0	0.0	0.0	0.0	0.0	0.0	0
0500	16.0	0.0	0.0	0.0	0.0	0.0	0.0	0
0600	16.3	0.0	0.0	0.0	0.0	0.0	0.0	0
0700	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0
0800	19.3	4.6	5.8	0.0	0.0	0.0	0.0	451
0900	20.6	5.5	7.9	0.0	0.0	0.0	0.0	501
1000	21.9	6.0	8.5	0.0	0.0	0.0	0.0	518
1100	23.0	6.5	9.0	0.0	0.0	0.0	0.0	537
1200	23.9	6.9	9.4	0.0	0.0	0.0	0.0	556
1300	24.4	7.3	9.6	0.0	0.0	0.0	0.0	574
1400	24.7	7.6	10.0	0.0	0.0	0.0	0.0	590
1500	24.6	7.8	10.2	0.0	0.0	0.0	0.0	604
1600	24.2	7.9	10.4	0.0	0.0	0.0	0.0	616
1700	23.6	7.9	10.3	0.0	0.0	0.0	0.0	625
1800	22.5	7.6	10.0	0.0	0.0	0.0	0.0	630
1900	21.4	6.7	7.7	0.0	0.0	0.0	0.0	583
2000	20.6	0.0	0.0	0.0	0.0	0.0	0.0	0
2100	19.8	0.0	0.0	0.0	0.0	0.0	0.0	0
2200	19.1	0.0	0.0	0.0	0.0	0.0	0.0	0
2300	18.5	0.0	0.0	0.0	0.0	0.0	0.0	0

HOURLY AIR SYSTEM DESIGN DAY LOADS

Air System.: AIR SYSTEM 03-06-04
Weather....: IZMIR, Turkey HAP v3.23
Prepared By: IYTE Page 6 of 12

MONTH: JUNE

Hour	OA TEMP (C)	CENTRAL COOLING Sens. (kW)	CENTRAL COOLING Total (kW)	CENTRAL HEATING (kW)	PREHEAT COIL (kW)	TERMINAL HEATING COIL (kW)	SPACE & SKIN HEATING (kW)	SUPPLY AIRFLOW (L/s)
0000	22.7	0.0	0.0	0.0	0.0	0.0	0.0	0
0100	21.9	0.0	0.0	0.0	0.0	0.0	0.0	0
0200	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0
0300	21.0	0.0	0.0	0.0	0.0	0.0	0.0	0
0400	20.6	0.0	0.0	0.0	0.0	0.0	0.0	0
0500	20.4	0.0	0.0	0.0	0.0	0.0	0.0	0
0600	20.9	0.0	0.0	0.0	0.0	0.0	0.0	0
0700	22.9	0.0	0.0	0.0	0.0	0.0	0.0	0
0800	24.1	6.6	8.6	0.0	0.0	0.0	0.0	526
0900	25.6	7.5	10.9	0.0	0.0	0.0	0.0	566
1000	26.9	8.1	11.5	0.0	0.0	0.0	0.0	582
1100	28.1	8.6	12.0	0.0	0.0	0.0	0.0	597
1200	28.9	9.1	12.4	0.0	0.0	0.0	0.0	614
1300	29.5	9.5	12.6	0.0	0.0	0.0	0.0	630
1400	29.9	9.9	13.1	0.0	0.0	0.0	0.0	644
1500	29.7	10.0	13.2	0.0	0.0	0.0	0.0	657
1600	29.3	10.1	13.5	0.0	0.0	0.0	0.0	668
1700	28.6	10.0	13.5	0.0	0.0	0.0	0.0	676
1800	27.6	9.8	13.1	0.0	0.0	0.0	0.0	678
1900	26.4	8.7	10.7	0.0	0.0	0.0	0.0	633
2000	25.5	0.0	0.0	0.0	0.0	0.0	0.0	0
2100	24.6	0.0	0.0	0.0	0.0	0.0	0.0	0
2200	24.0	0.0	0.0	0.0	0.0	0.0	0.0	0
2300	23.3	0.0	0.0	0.0	0.0	0.0	0.0	0

HOURLY AIR SYSTEM DESIGN DAY LOADS

Air System.: AIR SYSTEM 03-06-04
Weather....: IZMIR, Turkey HAP v3.23
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MONTH: JULY

Hour	OA TEMP (C)	CENTRAL COOLING Sens. (kW)	CENTRAL COOLING Total (kW)	CENTRAL HEATING (kW)	PREHEAT COIL (kW)	TERMINAL HEATING COIL (kW)	SPACE & SKIN HEATING (kW)	SUPPLY AIRFLOW (L/s)
0000	25.2	0.0	0.0	0.0	0.0	0.0	0.0	0
0100	24.5	0.0	0.0	0.0	0.0	0.0	0.0	0
0200	24.0	0.0	0.0	0.0	0.0	0.0	0.0	0
0300	23.5	0.0	0.0	0.0	0.0	0.0	0.0	0
0400	23.1	0.0	0.0	0.0	0.0	0.0	0.0	0
0500	22.7	0.0	0.0	0.0	0.0	0.0	0.0	0
0600	22.9	0.0	0.0	0.0	0.0	0.0	0.0	0
0700	24.5	0.0	0.0	0.0	0.0	0.0	0.0	0
0800	25.6	7.2	9.6	0.0	0.0	0.0	0.0	547
0900	27.2	8.1	12.0	0.0	0.0	0.0	0.0	582
1000	28.7	8.7	12.7	0.0	0.0	0.0	0.0	594
1100	30.0	9.3	13.3	0.0	0.0	0.0	0.0	608
1200	30.9	9.8	13.7	0.0	0.0	0.0	0.0	623
1300	31.5	10.2	13.9	0.0	0.0	0.0	0.0	638
1400	31.8	10.5	14.4	0.0	0.0	0.0	0.0	651
1500	31.7	10.7	14.6	0.0	0.0	0.0	0.0	663
1600	31.4	10.8	14.9	0.0	0.0	0.0	0.0	673
1700	30.8	10.7	14.9	0.0	0.0	0.0	0.0	680
1800	29.9	10.5	14.5	0.0	0.0	0.0	0.0	681
1900	28.7	9.4	11.9	0.0	0.0	0.0	0.0	637
2000	27.8	0.0	0.0	0.0	0.0	0.0	0.0	0
2100	27.0	0.0	0.0	0.0	0.0	0.0	0.0	0
2200	26.4	0.0	0.0	0.0	0.0	0.0	0.0	0
2300	25.8	0.0	0.0	0.0	0.0	0.0	0.0	0

HOURLY AIR SYSTEM DESIGN DAY LOADS

Air System.: AIR SYSTEM 03-06-04
Weather....: IZMIR, Turkey HAP v3.23
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MONTH: AUGUST

Hour	OA TEMP (C)	CENTRAL COOLING Sens. (kW)	CENTRAL COOLING Total (kW)	CENTRAL HEATING (kW)	PREHEAT COIL (kW)	TERMINAL HEATING COIL (kW)	SPACE & SKIN HEATING (kW)	SUPPLY AIRFLOW (L/s)
0000	24.9	0.0	0.0	0.0	0.0	0.0	0.0	0
0100	24.4	0.0	0.0	0.0	0.0	0.0	0.0	0
0200	23.9	0.0	0.0	0.0	0.0	0.0	0.0	0
0300	23.4	0.0	0.0	0.0	0.0	0.0	0.0	0
0400	23.0	0.0	0.0	0.0	0.0	0.0	0.0	0
0500	22.7	0.0	0.0	0.0	0.0	0.0	0.0	0
0600	22.6	0.0	0.0	0.0	0.0	0.0	0.0	0
0700	23.7	0.0	0.0	0.0	0.0	0.0	0.0	0
0800	25.0	6.7	9.1	0.0	0.0	0.0	0.0	524
0900	26.6	7.6	11.4	0.0	0.0	0.0	0.0	559
1000	28.1	8.2	12.0	0.0	0.0	0.0	0.0	569
1100	29.5	8.7	12.7	0.0	0.0	0.0	0.0	582
1200	30.5	9.2	13.1	0.0	0.0	0.0	0.0	596
1300	31.1	9.6	13.3	0.0	0.0	0.0	0.0	611
1400	31.5	9.9	13.8	0.0	0.0	0.0	0.0	624
1500	31.4	10.1	14.0	0.0	0.0	0.0	0.0	636
1600	31.0	10.2	14.2	0.0	0.0	0.0	0.0	646
1700	30.3	10.1	14.2	0.0	0.0	0.0	0.0	653
1800	29.2	9.9	13.7	0.0	0.0	0.0	0.0	656
1900	28.1	8.8	11.1	0.0	0.0	0.0	0.0	610
2000	27.3	0.0	0.0	0.0	0.0	0.0	0.0	0
2100	26.7	0.0	0.0	0.0	0.0	0.0	0.0	0
2200	26.0	0.0	0.0	0.0	0.0	0.0	0.0	0
2300	25.5	0.0	0.0	0.0	0.0	0.0	0.0	0

HOURLY AIR SYSTEM DESIGN DAY LOADS

Air System.: AIR SYSTEM 03-06-04
Weather....: IZMIR, Turkey HAP v3.23
Prepared By: IYTE Page 9 of 12

MONTH: SEPTEMBER

Hour	OA TEMP (C)	CENTRAL COOLING Sens. (kW)	CENTRAL COOLING Total (kW)	CENTRAL HEATING (kW)	PREHEAT COIL (kW)	TERMINAL HEATING COIL (kW)	SPACE & SKIN HEATING (kW)	SUPPLY AIRFLOW (L/s)
0000	21.3	0.0	0.0	0.0	0.0	0.0	0.0	0
0100	20.8	0.0	0.0	0.0	0.0	0.0	0.0	0
0200	20.4	0.0	0.0	0.0	0.0	0.0	0.0	0
0300	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0
0400	19.6	0.0	0.0	0.0	0.0	0.0	0.0	0
0500	19.3	0.0	0.0	0.0	0.0	0.0	0.0	0
0600	19.2	0.0	0.0	0.0	0.0	0.0	0.0	0
0700	19.9	0.0	0.0	0.0	0.0	0.0	0.0	0
0800	21.5	5.2	6.8	0.0	0.0	0.0	0.0	465
0900	23.3	6.1	9.1	0.0	0.0	0.0	0.0	505
1000	24.8	6.6	9.7	0.0	0.0	0.0	0.0	517
1100	26.3	7.1	10.3	0.0	0.0	0.0	0.0	531
1200	27.3	7.6	10.7	0.0	0.0	0.0	0.0	547
1300	28.0	8.0	11.0	0.0	0.0	0.0	0.0	564
1400	28.3	8.4	11.4	0.0	0.0	0.0	0.0	579
1500	28.1	8.5	11.5	0.0	0.0	0.0	0.0	593
1600	27.5	8.6	11.5	0.0	0.0	0.0	0.0	604
1700	26.5	8.4	11.3	0.0	0.0	0.0	0.0	613
1800	25.2	8.2	10.7	0.0	0.0	0.0	0.0	617
1900	24.2	7.2	8.4	0.0	0.0	0.0	0.0	566
2000	23.6	0.0	0.0	0.0	0.0	0.0	0.0	0
2100	22.9	0.0	0.0	0.0	0.0	0.0	0.0	0
2200	22.3	0.0	0.0	0.0	0.0	0.0	0.0	0
2300	21.8	0.0	0.0	0.0	0.0	0.0	0.0	0

HOURLY AIR SYSTEM DESIGN DAY LOADS

Air System.: AIR SYSTEM 03-06-04
Weather....: IZMIR, Turkey HAP v3.23
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MONTH: OCTOBER

Hour	OA TEMP (C)	CENTRAL COOLING Sens. (kW)	CENTRAL COOLING Total (kW)	CENTRAL HEATING (kW)	PREHEAT COIL (kW)	TERMINAL HEATING COIL (kW)	SPACE & SKIN HEATING (kW)	SUPPLY AIRFLOW (L/s)
0000	16.8	0.0	0.0	0.0	0.0	0.0	0.0	0
0100	16.6	0.0	0.0	0.0	0.0	0.0	0.0	0
0200	16.3	0.0	0.0	0.0	0.0	0.0	0.0	0
0300	16.0	0.0	0.0	0.0	0.0	0.0	0.0	0
0400	15.8	0.0	0.0	0.0	0.0	0.0	0.0	0
0500	15.5	0.0	0.0	0.0	0.0	0.0	0.0	0
0600	15.4	0.0	0.0	0.0	0.0	0.0	0.0	0
0700	15.6	0.0	0.0	0.0	0.0	0.0	0.0	0
0800	16.9	0.0	0.0	0.0	0.0	0.0	0.0	68
0900	18.6	0.0	0.0	0.0	0.0	0.0	0.0	68
1000	19.9	0.0	0.0	0.0	0.0	0.0	0.0	68
1100	21.2	0.0	0.0	0.0	0.0	0.0	0.0	68
1200	22.1	0.0	0.0	0.0	0.0	0.0	0.0	68
1300	22.8	0.0	0.0	0.0	0.0	0.0	0.0	68
1400	23.1	0.0	0.0	0.0	0.0	0.0	0.0	68
1500	22.9	0.0	0.0	0.0	0.0	0.0	0.0	68
1600	22.2	0.0	0.0	0.0	0.0	0.0	0.0	68
1700	21.1	0.0	0.0	0.0	0.0	0.0	0.0	68
1800	20.1	0.0	0.0	0.0	0.0	0.0	0.0	68
1900	19.2	0.0	0.0	0.0	0.0	0.0	0.0	68
2000	18.7	0.0	0.0	0.0	0.0	0.0	0.0	0
2100	18.2	0.0	0.0	0.0	0.0	0.0	0.0	0
2200	17.6	0.0	0.0	0.0	0.0	0.0	0.0	0
2300	17.2	0.0	0.0	0.0	0.0	0.0	0.0	0

HOURLY AIR SYSTEM DESIGN DAY LOADS

Air System.: AIR SYSTEM 03-06-04
Weather....: IZMIR, Turkey HAP v3.23
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MONTH: NOVEMBER

Hour	OA TEMP (C)	CENTRAL COOLING Sens. (kW)	CENTRAL COOLING Total (kW)	CENTRAL HEATING (kW)	PREHEAT COIL (kW)	TERMINAL HEATING COIL (kW)	SPACE & SKIN HEATING (kW)	SUPPLY AIRFLOW (L/s)
0000	11.9	0.0	0.0	0.0	0.0	0.0	0.0	0
0100	11.9	0.0	0.0	0.0	0.0	0.0	0.0	0
0200	11.7	0.0	0.0	0.0	0.0	0.0	0.0	0
0300	11.6	0.0	0.0	0.0	0.0	0.0	0.0	0
0400	11.4	0.0	0.0	0.0	0.0	0.0	0.0	0
0500	11.3	0.0	0.0	0.0	0.0	0.0	0.0	0
0600	11.1	0.0	0.0	0.0	0.0	0.0	0.0	0
0700	11.1	0.0	0.0	0.0	0.0	0.0	0.0	0
0800	11.7	0.0	0.0	0.0	0.0	0.0	0.0	68
0900	12.9	0.0	0.0	0.0	0.0	0.0	0.0	68
1000	14.1	0.0	0.0	0.0	0.0	0.0	0.0	68
1100	15.1	0.0	0.0	0.0	0.0	0.0	0.0	68
1200	15.8	0.0	0.0	0.0	0.0	0.0	0.0	68
1300	16.4	0.0	0.0	0.0	0.0	0.0	0.0	68
1400	16.7	0.0	0.0	0.0	0.0	0.0	0.0	68
1500	16.5	0.0	0.0	0.0	0.0	0.0	0.0	68
1600	16.0	0.0	0.0	0.0	0.0	0.0	0.0	68
1700	14.9	0.0	0.0	0.0	0.0	0.0	0.0	68
1800	14.1	0.0	0.0	0.0	0.0	0.0	0.0	68
1900	13.5	0.0	0.0	0.0	0.0	0.0	0.0	68
2000	13.1	0.0	0.0	0.0	0.0	0.0	0.0	0
2100	12.8	0.0	0.0	0.0	0.0	0.0	0.0	0
2200	12.3	0.0	0.0	0.0	0.0	0.0	0.0	0
2300	12.1	0.0	0.0	0.0	0.0	0.0	0.0	0

HOURLY AIR SYSTEM DESIGN DAY LOADS

Air System.: AIR SYSTEM 03-06-04
Weather....: IZMIR, Turkey HAP v3.23
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MONTH: DECEMBER

Hour	OA TEMP (C)	CENTRAL COOLING Sens. (kW)	CENTRAL COOLING Total (kW)	CENTRAL HEATING (kW)	PREHEAT COIL (kW)	TERMINAL HEATING COIL (kW)	SPACE & SKIN HEATING (kW)	SUPPLY AIRFLOW (L/s)
0000	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0
0100	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0
0200	8.9	0.0	0.0	0.0	0.0	0.0	0.0	0
0300	8.8	0.0	0.0	0.0	0.0	0.0	0.0	0
0400	8.7	0.0	0.0	0.0	0.0	0.0	0.0	0
0500	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0
0600	8.4	0.0	0.0	0.0	0.0	0.0	0.0	0
0700	8.4	0.0	0.0	0.0	0.0	0.0	0.0	0
0800	8.5	0.0	0.0	0.0	0.0	0.0	0.0	68
0900	9.4	0.0	0.0	0.0	0.0	0.0	0.0	68
1000	10.4	0.0	0.0	0.0	0.0	0.0	0.0	68
1100	11.3	0.0	0.0	0.0	0.0	0.0	0.0	68
1200	11.9	0.0	0.0	0.0	0.0	0.0	0.0	68
1300	12.5	0.0	0.0	0.0	0.0	0.0	0.0	68
1400	12.7	0.0	0.0	0.0	0.0	0.0	0.0	68
1500	12.6	0.0	0.0	0.0	0.0	0.0	0.0	68
1600	12.1	0.0	0.0	0.0	0.0	0.0	0.0	68
1700	11.3	0.0	0.0	0.0	0.0	0.0	0.0	68
1800	10.7	0.0	0.0	0.0	0.0	0.0	0.0	68
1900	10.3	0.0	0.0	0.0	0.0	0.0	0.0	68
2000	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0
2100	9.8	0.0	0.0	0.0	0.0	0.0	0.0	0
2200	9.5	0.0	0.0	0.0	0.0	0.0	0.0	0
2300	9.3	0.0	0.0	0.0	0.0	0.0	0.0	0

HOURLY ZONE DESIGN DAY LOADS

Air System.: AIR SYSTEM 03-06-04
Weather....: IZMIR, Turkey HAP v3.23
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ZONE: ZONE 1
MONTH: JANUARY

Hour	OA TEMP (C)	ZONE TEMP (C)	RH (%)	ZONE SENSIBLE (W)	ZONE REHEAT (W)	SPACE & SKIN HTG (W)	ZONE AIRFLOW (L/s)	ZONE COND (W)
0000	7.6	29.3	-	-106	0	0	0	0
0100	7.5	29.1	-	-356	0	0	0	0
0200	7.3	29.0	-	-580	0	0	0	0
0300	7.2	28.9	-	-777	0	0	0	0
0400	7.0	28.8	-	-953	0	0	0	0
0500	6.9	28.7	-	-1110	0	0	0	0
0600	6.9	28.6	-	-1246	0	0	0	0
0700	6.8	28.4	-	-1367	0	0	0	0
0800	6.9	29.2	100	1127	0	0	68	364
0900	7.7	29.8	100	2463	0	0	68	359
1000	8.7	30.0	100	2910	0	0	68	347
1100	9.7	30.3	100	3385	0	0	68	335
1200	10.4	30.5	100	3848	0	0	68	328
1300	10.9	30.8	100	4266	0	0	68	324
1400	11.3	31.0	100	4620	0	0	68	322
1500	11.3	31.2	100	4897	0	0	68	326
1600	11.0	31.4	100	5091	0	0	68	333
1700	10.2	31.6	100	5166	0	0	68	348
1800	9.5	31.7	100	5102	0	0	68	362
1900	9.0	31.4	100	3974	0	0	68	365
2000	8.7	30.7	-	1557	0	0	0	0
2100	8.4	30.4	-	872	0	0	0	0
2200	8.0	30.2	-	505	0	0	0	0
2300	7.8	30.1	-	180	0	0	0	0

Notes: (1) ZONE SENSIBLE calculated at occ. t-stat setpoint (23.9 C).
(2) ZONE COND = CONDITIONING SUPPLIED which is based on heat extraction analysis.

HOURLY ZONE DESIGN DAY LOADS

Air System.: AIR SYSTEM 03-06-04
Weather....: IZMIR, Turkey HAP v3.23
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ZONE: ZONE 1
MONTH: FEBRUARY

Hour	OA TEMP (C)	ZONE TEMP (C)	RH (%)	ZONE SENSIBLE (W)	ZONE REHEAT (W)	SPACE & SKIN HTG (W)	ZONE AIRFLOW (L/s)	ZONE COND (W)
0000	7.8	29.7	-	-6	0	0	0	0
0100	7.5	29.6	-	-272	0	0	0	0
0200	7.3	29.5	-	-509	0	0	0	0
0300	7.2	29.3	-	-715	0	0	0	0
0400	7.0	29.2	-	-900	0	0	0	0
0500	6.9	29.1	-	-1063	0	0	0	0
0600	6.8	29.0	-	-1208	0	0	0	0
0700	6.8	28.9	-	-1333	0	0	0	0
0800	7.1	29.6	100	1170	0	0	68	367
0900	8.1	30.2	100	2530	0	0	68	360
1000	9.2	30.5	100	3019	0	0	68	346
1100	10.2	30.7	100	3535	0	0	68	335
1200	10.9	31.0	100	4028	0	0	68	328
1300	11.5	31.3	100	4471	0	0	68	323
1400	12.0	31.5	100	4847	0	0	68	319
1500	12.0	31.8	100	5143	0	0	68	323
1600	11.8	32.0	100	5358	0	0	68	330
1700	11.1	32.1	100	5461	0	0	68	343
1800	10.2	32.2	100	5389	0	0	68	359
1900	9.5	31.9	100	4200	0	0	68	366
2000	9.1	31.2	-	1730	0	0	0	0
2100	8.7	30.9	-	1016	0	0	0	0
2200	8.3	30.7	-	630	0	0	0	0
2300	8.1	30.6	-	294	0	0	0	0

Notes: (1) ZONE SENSIBLE calculated at occ. t-stat setpoint (23.9 C).
(2) ZONE COND = CONDITIONING SUPPLIED which is based on heat extraction analysis.

ZONE: ZONE 1
MONTH: MARCH

Hour	OA TEMP (C)	ZONE TEMP (C)	RH (%)	ZONE SENSIBLE (W)	ZONE REHEAT (W)	SPACE & SKIN HTG (W)	ZONE AIRFLOW (L/s)	ZONE COND (W)
0000	9.8	31.2	-	362	0	0	0	0
0100	9.3	31.0	-	71	0	0	0	0
0200	9.1	30.9	-	-184	0	0	0	0
0300	8.9	30.8	-	-409	0	0	0	0
0400	8.7	30.7	-	-607	0	0	0	0
0500	8.5	30.5	-	-785	0	0	0	0
0600	8.3	30.4	-	-944	0	0	0	0
0700	8.5	30.3	-	-1075	0	0	0	0
0800	9.4	31.1	100	1461	0	0	68	354
0900	10.7	31.7	100	2896	0	0	68	342
1000	11.9	32.0	100	3460	0	0	68	328
1100	13.0	32.3	100	4035	0	0	68	315
1200	13.9	32.6	100	4577	0	0	68	305
1300	14.6	32.9	100	5059	0	0	68	299
1400	15.1	33.2	100	5462	0	0	68	295
1500	15.0	33.4	100	5776	0	0	68	301
1600	14.7	33.7	100	5996	0	0	68	309
1700	14.1	33.9	100	6098	0	0	68	322
1800	13.1	34.0	100	6030	0	0	68	340
1900	12.2	33.6	100	4785	0	0	68	349
2000	11.6	32.9	-	2228	0	0	0	0
2100	11.1	32.6	-	1464	0	0	0	0
2200	10.6	32.4	-	1047	0	0	0	0
2300	10.2	32.3	-	684	0	0	0	0

Notes: (1) ZONE SENSIBLE calculated at occ. t-stat setpoint (23.9 C).
(2) ZONE COND = CONDITIONING SUPPLIED which is based on heat extraction analysis.

ZONE: ZONE 1
MONTH: APRIL

Hour	OA TEMP (C)	ZONE TEMP (C)	RH (%)	ZONE SENSIBLE (W)	ZONE REHEAT (W)	SPACE & SKIN HTG (W)	ZONE AIRFLOW (L/s)	ZONE COND (W)
0000	13.6	33.5	-	997	0	0	0	0
0100	13.2	33.4	-	685	0	0	0	0
0200	12.9	33.2	-	409	0	0	0	0
0300	12.6	33.1	-	164	0	0	0	0
0400	12.4	33.0	-	-53	0	0	0	0
0500	12.1	32.9	-	-247	0	0	0	0
0600	12.1	32.8	-	-415	0	0	0	0
0700	13.1	32.7	-	-534	0	0	0	0
0800	14.3	33.5	100	2014	0	0	68	313
0900	15.6	34.1	100	3456	0	0	68	302
1000	16.8	34.4	100	4032	0	0	68	288
1100	18.0	34.7	100	4631	0	0	68	273
1200	18.8	35.1	100	5212	0	0	68	266
1300	19.5	35.4	100	5747	0	0	68	259
1400	19.9	35.7	100	6207	0	0	68	258
1500	19.7	36.0	100	6575	0	0	68	266
1600	19.3	36.3	100	6851	0	0	68	277
1700	18.7	36.5	100	7022	0	0	68	290
1800	17.7	36.7	100	7035	0	0	68	309
1900	16.6	36.4	100	5859	0	0	68	323
2000	15.9	35.6	-	3231	0	0	0	0
2100	15.1	35.3	-	2294	0	0	0	0
2200	14.5	35.1	-	1772	0	0	0	0
2300	14.0	34.9	-	1353	0	0	0	0

Notes: (1) ZONE SENSIBLE calculated at occ. t-stat setpoint (23.9 C).
(2) ZONE COND = CONDITIONING SUPPLIED which is based on heat extraction analysis.

HOURLY ZONE DESIGN DAY LOADS

Air System.: AIR SYSTEM 03-06-04
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ZONE: ZONE 1
MONTH: MAY

Hour	OA TEMP (C)	ZONE TEMP (C)	RH (%)	ZONE SENSIBLE (W)	ZONE REHEAT (W)	SPACE & SKIN HTG (W)	ZONE AIRFLOW (L/s)	ZONE COND (W)
0000	18.0	26.4	-	1661	0	0	0	0
0100	17.3	26.3	-	1319	0	0	0	0
0200	16.9	26.2	-	1019	0	0	0	0
0300	16.6	26.1	-	754	0	0	0	0
0400	16.2	26.1	-	518	0	0	0	0
0500	16.0	26.0	-	310	0	0	0	0
0600	16.3	25.9	-	137	0	0	0	0
0700	18.0	25.9	-	40	0	0	0	0
0800	19.3	24.9	58	2635	0	0	451	5219
0900	20.6	25.0	62	4152	0	0	501	6009
1000	21.9	25.1	60	4801	0	0	518	6378
1100	23.0	25.1	59	5452	0	0	537	6753
1200	23.9	25.2	58	6067	0	0	556	7114
1300	24.4	25.2	57	6622	0	0	574	7437
1400	24.7	25.3	57	7096	0	0	590	7713
1500	24.6	25.3	56	7476	0	0	604	7922
1600	24.2	25.4	56	7764	0	0	616	8068
1700	23.6	25.4	56	7935	0	0	625	8134
1800	22.5	25.4	57	7941	0	0	630	8076
1900	21.4	25.2	54	6754	0	0	583	7249
2000	20.6	27.0	-	4120	0	0	0	0
2100	19.8	26.8	-	3129	0	0	0	0
2200	19.1	26.6	-	2517	0	0	0	0
2300	18.5	26.5	-	2048	0	0	0	0

Notes: (1) ZONE SENSIBLE calculated at occ. t-stat setpoint (23.9 C).
(2) ZONE COND = CONDITIONING SUPPLIED which is based on heat extraction analysis.

HOURLY ZONE DESIGN DAY LOADS

Air System.: AIR SYSTEM 03-06-04
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ZONE: ZONE 1
MONTH: JUNE

Hour	OA TEMP (C)	ZONE TEMP (C)	RH (%)	ZONE SENSIBLE (W)	ZONE REHEAT (W)	SPACE & SKIN HTG (W)	ZONE AIRFLOW (L/s)	ZONE COND (W)
0000	22.7	27.1	-	2366	0	0	0	0
0100	21.9	27.0	-	2001	0	0	0	0
0200	21.5	26.9	-	1682	0	0	0	0
0300	21.0	26.8	-	1397	0	0	0	0
0400	20.6	26.8	-	1144	0	0	0	0
0500	20.4	26.7	-	921	0	0	0	0
0600	20.9	26.7	-	743	0	0	0	0
0700	22.9	26.6	-	655	0	0	0	0
0800	24.1	25.1	54	3272	0	0	526	6705
0900	25.6	25.2	57	4829	0	0	566	7457
1000	26.9	25.2	56	5524	0	0	582	7824
1100	28.1	25.3	55	6225	0	0	597	8207
1200	28.9	25.3	54	6882	0	0	614	8564
1300	29.5	25.4	53	7478	0	0	630	8891
1400	29.9	25.4	52	7987	0	0	644	9166
1500	29.7	25.5	52	8396	0	0	657	9365
1600	29.3	25.5	52	8704	0	0	668	9495
1700	28.6	25.5	52	8884	0	0	676	9539
1800	27.6	25.5	53	8894	0	0	678	9461
1900	26.4	25.4	50	7698	0	0	633	8578
2000	25.5	27.6	-	5048	0	0	0	0
2100	24.6	27.5	-	4001	0	0	0	0
2200	24.0	27.3	-	3305	0	0	0	0
2300	23.3	27.2	-	2784	0	0	0	0

Notes: (1) ZONE SENSIBLE calculated at occ. t-stat setpoint (23.9 C).
(2) ZONE COND = CONDITIONING SUPPLIED which is based on heat extraction analysis.

ZONE: ZONE 1
MONTH: JULY

Hour	OA TEMP (C)	ZONE TEMP (C)	RH (%)	ZONE SENSIBLE (W)	ZONE REHEAT (W)	SPACE & SKIN HTG (W)	ZONE AIRFLOW (L/s)	ZONE COND (W)
0000	25.2	27.3	-	2623	0	0	0	0
0100	24.5	27.2	-	2267	0	0	0	0
0200	24.0	27.1	-	1952	0	0	0	0
0300	23.5	27.1	-	1671	0	0	0	0
0400	23.1	27.0	-	1420	0	0	0	0
0500	22.7	27.0	-	1196	0	0	0	0
0600	22.9	26.9	-	1008	0	0	0	0
0700	24.5	26.9	-	891	0	0	0	0
0800	25.6	25.1	52	3468	0	0	547	7163
0900	27.2	25.3	56	4987	0	0	582	7870
1000	28.7	25.3	55	5663	0	0	594	8220
1100	30.0	25.3	54	6356	0	0	608	8588
1200	30.9	25.4	53	7014	0	0	623	8937
1300	31.5	25.4	52	7614	0	0	638	9256
1400	31.8	25.5	51	8127	0	0	651	9519
1500	31.7	25.5	51	8540	0	0	663	9715
1600	31.4	25.5	51	8855	0	0	673	9844
1700	30.8	25.6	51	9048	0	0	680	9888
1800	29.9	25.6	52	9069	0	0	681	9797
1900	28.7	25.4	49	7884	0	0	637	8923
2000	27.8	27.8	-	5237	0	0	0	0
2100	27.0	27.6	-	4204	0	0	0	0
2200	26.4	27.5	-	3533	0	0	0	0
2300	25.8	27.4	-	3030	0	0	0	0

Notes: (1) ZONE SENSIBLE calculated at occ. t-stat setpoint (23.9 C).
(2) ZONE COND = CONDITIONING SUPPLIED which is based on heat extraction analysis.

ZONE: ZONE 1
MONTH: AUGUST

Hour	OA TEMP (C)	ZONE TEMP (C)	RH (%)	ZONE SENSIBLE (W)	ZONE REHEAT (W)	SPACE & SKIN HTG (W)	ZONE AIRFLOW (L/s)	ZONE COND (W)
0000	24.9	27.1	-	2442	0	0	0	0
0100	24.4	27.0	-	2112	0	0	0	0
0200	23.9	26.9	-	1818	0	0	0	0
0300	23.4	26.9	-	1553	0	0	0	0
0400	23.0	26.8	-	1316	0	0	0	0
0500	22.7	26.8	-	1106	0	0	0	0
0600	22.6	26.7	-	923	0	0	0	0
0700	23.7	26.7	-	794	0	0	0	0
0800	25.0	25.1	53	3341	0	0	524	6754
0900	26.6	25.2	57	4797	0	0	559	7443
1000	28.1	25.2	56	5409	0	0	569	7761
1100	29.5	25.3	54	6053	0	0	582	8108
1200	30.5	25.3	54	6682	0	0	596	8450
1300	31.1	25.3	53	7259	0	0	611	8760
1400	31.5	25.4	52	7754	0	0	624	9022
1500	31.4	25.4	52	8150	0	0	636	9211
1600	31.0	25.4	52	8447	0	0	646	9333
1700	30.3	25.5	52	8627	0	0	653	9371
1800	29.2	25.5	53	8636	0	0	656	9288
1900	28.1	25.3	50	7443	0	0	610	8403
2000	27.3	27.5	-	4784	0	0	0	0
2100	26.7	27.4	-	3811	0	0	0	0
2200	26.0	27.2	-	3255	0	0	0	0
2300	25.5	27.2	-	2816	0	0	0	0

Notes: (1) ZONE SENSIBLE calculated at occ. t-stat setpoint (23.9 C).
(2) ZONE COND = CONDITIONING SUPPLIED which is based on heat extraction analysis.

HOURLY ZONE DESIGN DAY LOADS

Air System.: AIR SYSTEM 03-06-04
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ZONE: ZONE 1
MONTH: SEPTEMBER

Hour	OA TEMP (C)	ZONE TEMP (C)	RH (%)	ZONE SENSIBLE (W)	ZONE REHEAT (W)	SPACE & SKIN HTG (W)	ZONE AIRFLOW (L/s)	ZONE COND (W)
0000	21.3	26.5	-	1900	0	0	0	0
0100	20.8	26.4	-	1587	0	0	0	0
0200	20.4	26.4	-	1308	0	0	0	0
0300	20.0	26.3	-	1059	0	0	0	0
0400	19.6	26.2	-	834	0	0	0	0
0500	19.3	26.2	-	633	0	0	0	0
0600	19.2	26.1	-	459	0	0	0	0
0700	19.9	26.1	-	327	0	0	0	0
0800	21.5	24.9	56	2857	0	0	465	5596
0900	23.3	25.0	60	4271	0	0	505	6319
1000	24.8	25.1	59	4832	0	0	517	6630
1100	26.3	25.1	58	5451	0	0	531	6986
1200	27.3	25.1	56	6064	0	0	547	7339
1300	28.0	25.2	56	6626	0	0	564	7666
1400	28.3	25.2	55	7104	0	0	579	7935
1500	28.1	25.3	55	7480	0	0	593	8131
1600	27.5	25.3	55	7751	0	0	604	8250
1700	26.5	25.3	55	7900	0	0	613	8279
1800	25.2	25.4	55	7871	0	0	617	8184
1900	24.2	25.2	52	6626	0	0	566	7305
2000	23.6	26.9	-	3986	0	0	0	0
2100	22.9	26.8	-	3123	0	0	0	0
2200	22.3	26.7	-	2650	0	0	0	0
2300	21.8	26.6	-	2251	0	0	0	0

Notes: (1) ZONE SENSIBLE calculated at occ. t-stat setpoint (23.9 C).
(2) ZONE COND = CONDITIONING SUPPLIED which is based on heat extraction analysis.

HOURLY ZONE DESIGN DAY LOADS

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****

ZONE: ZONE 1
MONTH: OCTOBER

Hour	OA TEMP (C)	ZONE TEMP (C)	RH (%)	ZONE SENSIBLE (W)	ZONE REHEAT (W)	SPACE & SKIN HTG (W)	ZONE AIRFLOW (L/s)	ZONE COND (W)
0000	16.8	33.8	-	1192	0	0	0	0
0100	16.6	33.7	-	911	0	0	0	0
0200	16.3	33.6	-	659	0	0	0	0
0300	16.0	33.5	-	435	0	0	0	0
0400	15.8	33.4	-	235	0	0	0	0
0500	15.5	33.3	-	55	0	0	0	0
0600	15.4	33.2	-	-103	0	0	0	0
0700	15.6	33.1	-	-233	0	0	0	0
0800	16.9	33.9	100	2282	0	0	68	277
0900	18.6	34.5	100	3658	0	0	68	259
1000	19.9	34.8	100	4154	0	0	68	243
1100	21.2	35.1	100	4696	0	0	68	226
1200	22.1	35.4	100	5236	0	0	68	217
1300	22.8	35.7	100	5733	0	0	68	211
1400	23.1	36.0	100	6158	0	0	68	211
1500	22.9	36.3	100	6491	0	0	68	219
1600	22.2	36.5	100	6725	0	0	68	234
1700	21.1	36.8	100	6846	0	0	68	255
1800	20.1	36.9	100	6803	0	0	68	274
1900	19.2	36.6	100	5580	0	0	68	283
2000	18.7	35.8	-	3047	0	0	0	0
2100	18.2	35.5	-	2292	0	0	0	0
2200	17.6	35.4	-	1877	0	0	0	0
2300	17.2	35.3	-	1515	0	0	0	0

Notes: (1) ZONE SENSIBLE calculated at occ. t-stat setpoint (23.9 C).
(2) ZONE COND = CONDITIONING SUPPLIED which is based on heat extraction analysis.

HOURLY ZONE DESIGN DAY LOADS

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ZONE: ZONE 1
MONTH: NOVEMBER

Hour	OA TEMP (C)	ZONE TEMP (C)	RH (%)	ZONE SENSIBLE (W)	ZONE REHEAT (W)	SPACE & SKIN HTG (W)	ZONE AIRFLOW (L/s)	ZONE COND (W)
0000	11.9	31.1	-	436	0	0	0	0
0100	11.9	31.0	-	184	0	0	0	0
0200	11.7	30.9	-	-40	0	0	0	0
0300	11.6	30.7	-	-237	0	0	0	0
0400	11.4	30.6	-	-416	0	0	0	0
0500	11.3	30.5	-	-574	0	0	0	0
0600	11.1	30.4	-	-716	0	0	0	0
0700	11.1	30.3	-	-839	0	0	0	0
0800	11.7	31.1	100	1666	0	0	68	317
0900	12.9	31.7	100	3000	0	0	68	307
1000	14.1	31.9	100	3428	0	0	68	291
1100	15.1	32.2	100	3885	0	0	68	279
1200	15.8	32.5	100	4345	0	0	68	272
1300	16.4	32.7	100	4775	0	0	68	267
1400	16.7	33.0	100	5150	0	0	68	266
1500	16.5	33.2	100	5446	0	0	68	273
1600	16.0	33.5	100	5659	0	0	68	285
1700	14.9	33.6	100	5770	0	0	68	306
1800	14.1	33.7	100	5726	0	0	68	320
1900	13.5	33.4	100	4577	0	0	68	325
2000	13.1	32.7	-	2133	0	0	0	0
2100	12.8	32.4	-	1435	0	0	0	0
2200	12.3	32.3	-	1058	0	0	0	0
2300	12.1	32.2	-	728	0	0	0	0

Notes: (1) ZONE SENSIBLE calculated at occ. t-stat setpoint (23.9 C).
(2) ZONE COND = CONDITIONING SUPPLIED which is based on heat extraction analysis.

HOURLY ZONE DESIGN DAY LOADS

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ZONE: ZONE 1
MONTH: DECEMBER

Hour	OA TEMP (C)	ZONE TEMP (C)	RH (%)	ZONE SENSIBLE (W)	ZONE REHEAT (W)	SPACE & SKIN HTG (W)	ZONE AIRFLOW (L/s)	ZONE COND (W)
0000	9.1	29.7	-	32	0	0	0	0
0100	9.0	29.6	-	-214	0	0	0	0
0200	8.9	29.5	-	-430	0	0	0	0
0300	8.8	29.3	-	-622	0	0	0	0
0400	8.7	29.2	-	-790	0	0	0	0
0500	8.6	29.1	-	-940	0	0	0	0
0600	8.4	29.0	-	-1076	0	0	0	0
0700	8.4	28.9	-	-1195	0	0	0	0
0800	8.5	29.7	100	1301	0	0	68	346
0900	9.4	30.2	100	2642	0	0	68	340
1000	10.4	30.5	100	3087	0	0	68	328
1100	11.3	30.7	100	3551	0	0	68	318
1200	11.9	31.0	100	3999	0	0	68	312
1300	12.5	31.3	100	4403	0	0	68	306
1400	12.7	31.5	100	4740	0	0	68	306
1500	12.6	31.7	100	4997	0	0	68	312
1600	12.1	31.9	100	5162	0	0	68	323
1700	11.3	32.0	100	5195	0	0	68	339
1800	10.7	32.1	100	5147	0	0	68	349
1900	10.3	31.8	100	4052	0	0	68	352
2000	10.0	31.1	-	1654	0	0	0	0
2100	9.8	30.9	-	982	0	0	0	0
2200	9.5	30.7	-	626	0	0	0	0
2300	9.3	30.6	-	310	0	0	0	0

Notes: (1) ZONE SENSIBLE calculated at occ. t-stat setpoint (23.9 C).
(2) ZONE COND = CONDITIONING SUPPLIED which is based on heat extraction analysis.

TABLE 1: CHILLER LOADS

MONTH: JANUARY					
Hour	OA TEMP (C)	CENTRAL COOLING (kW)	TERMINAL COOLING (kW)	PRECOOL COIL (kW)	TOTAL COOLING (kW)
0000	7.6	0.0	0.0	0.0	0.0
0100	7.5	0.0	0.0	0.0	0.0
0200	7.3	0.0	0.0	0.0	0.0
0300	7.2	0.0	0.0	0.0	0.0
0400	7.0	0.0	0.0	0.0	0.0
0500	6.9	0.0	0.0	0.0	0.0
0600	6.9	0.0	0.0	0.0	0.0
0700	6.8	0.0	0.0	0.0	0.0
0800	6.9	0.0	0.0	0.0	0.0
0900	7.7	0.0	0.0	0.0	0.0
1000	8.7	0.0	0.0	0.0	0.0
1100	9.7	0.0	0.0	0.0	0.0
1200	10.4	0.0	0.0	0.0	0.0
1300	10.9	0.0	0.0	0.0	0.0
1400	11.3	0.0	0.0	0.0	0.0
1500	11.3	0.0	0.0	0.0	0.0
1600	11.0	0.0	0.0	0.0	0.0
1700	10.2	0.0	0.0	0.0	0.0
1800	9.5	0.0	0.0	0.0	0.0
1900	9.0	0.0	0.0	0.0	0.0
2000	8.7	0.0	0.0	0.0	0.0
2100	8.4	0.0	0.0	0.0	0.0
2200	8.0	0.0	0.0	0.0	0.0
2300	7.8	0.0	0.0	0.0	0.0
Total kWh		0.0	0.0	0.0	0.0

TABLE 2: CHILLER LOADS

MONTH: FEBRUARY					
Hour	OA TEMP (C)	CENTRAL COOLING (kW)	TERMINAL COOLING (kW)	PRECOOL COIL (kW)	TOTAL COOLING (kW)
0000	7.8	0.0	0.0	0.0	0.0
0100	7.5	0.0	0.0	0.0	0.0
0200	7.3	0.0	0.0	0.0	0.0
0300	7.2	0.0	0.0	0.0	0.0
0400	7.0	0.0	0.0	0.0	0.0
0500	6.9	0.0	0.0	0.0	0.0
0600	6.8	0.0	0.0	0.0	0.0
0700	6.8	0.0	0.0	0.0	0.0
0800	7.1	0.0	0.0	0.0	0.0
0900	8.1	0.0	0.0	0.0	0.0
1000	9.2	0.0	0.0	0.0	0.0
1100	10.2	0.0	0.0	0.0	0.0
1200	10.9	0.0	0.0	0.0	0.0
1300	11.5	0.0	0.0	0.0	0.0
1400	12.0	0.0	0.0	0.0	0.0
1500	12.0	0.0	0.0	0.0	0.0
1600	11.8	0.0	0.0	0.0	0.0
1700	11.1	0.0	0.0	0.0	0.0
1800	10.2	0.0	0.0	0.0	0.0
1900	9.5	0.0	0.0	0.0	0.0
2000	9.1	0.0	0.0	0.0	0.0
2100	8.7	0.0	0.0	0.0	0.0
2200	8.3	0.0	0.0	0.0	0.0
2300	8.1	0.0	0.0	0.0	0.0
Total kWh		0.0	0.0	0.0	0.0

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TABLE 3: CHILLER LOADS

MONTH: MARCH					
Hour	OA TEMP (C)	CENTRAL COOLING (kW)	TERMINAL COOLING (kW)	PRECOOL COIL (kW)	TOTAL COOLING (kW)
0000	9.8	0.0	0.0	0.0	0.0
0100	9.3	0.0	0.0	0.0	0.0
0200	9.1	0.0	0.0	0.0	0.0
0300	8.9	0.0	0.0	0.0	0.0
0400	8.7	0.0	0.0	0.0	0.0
0500	8.5	0.0	0.0	0.0	0.0
0600	8.3	0.0	0.0	0.0	0.0
0700	8.5	0.0	0.0	0.0	0.0
0800	9.4	0.0	0.0	0.0	0.0
0900	10.7	0.0	0.0	0.0	0.0
1000	11.9	0.0	0.0	0.0	0.0
1100	13.0	0.0	0.0	0.0	0.0
1200	13.9	0.0	0.0	0.0	0.0
1300	14.6	0.0	0.0	0.0	0.0
1400	15.1	0.0	0.0	0.0	0.0
1500	15.0	0.0	0.0	0.0	0.0
1600	14.7	0.0	0.0	0.0	0.0
1700	14.1	0.0	0.0	0.0	0.0
1800	13.1	0.0	0.0	0.0	0.0
1900	12.2	0.0	0.0	0.0	0.0
2000	11.6	0.0	0.0	0.0	0.0
2100	11.1	0.0	0.0	0.0	0.0
2200	10.6	0.0	0.0	0.0	0.0
2300	10.2	0.0	0.0	0.0	0.0
Total kWh		0.0	0.0	0.0	0.0

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TABLE 4: CHILLER LOADS

MONTH: APRIL					
Hour	OA TEMP (C)	CENTRAL COOLING (kW)	TERMINAL COOLING (kW)	PRECOOL COIL (kW)	TOTAL COOLING (kW)
0000	13.6	0.0	0.0	0.0	0.0
0100	13.2	0.0	0.0	0.0	0.0
0200	12.9	0.0	0.0	0.0	0.0
0300	12.6	0.0	0.0	0.0	0.0
0400	12.4	0.0	0.0	0.0	0.0
0500	12.1	0.0	0.0	0.0	0.0
0600	12.1	0.0	0.0	0.0	0.0
0700	13.1	0.0	0.0	0.0	0.0
0800	14.3	0.0	0.0	0.0	0.0
0900	15.6	0.0	0.0	0.0	0.0
1000	16.8	0.0	0.0	0.0	0.0
1100	18.0	0.0	0.0	0.0	0.0
1200	18.8	0.0	0.0	0.0	0.0
1300	19.5	0.0	0.0	0.0	0.0
1400	19.9	0.0	0.0	0.0	0.0
1500	19.7	0.0	0.0	0.0	0.0
1600	19.3	0.0	0.0	0.0	0.0
1700	18.7	0.0	0.0	0.0	0.0
1800	17.7	0.0	0.0	0.0	0.0
1900	16.6	0.0	0.0	0.0	0.0
2000	15.9	0.0	0.0	0.0	0.0
2100	15.1	0.0	0.0	0.0	0.0
2200	14.5	0.0	0.0	0.0	0.0
2300	14.0	0.0	0.0	0.0	0.0
Total kWh		0.0	0.0	0.0	0.0

TABLE 5: CHILLER LOADS

MONTH: MAY					
Hour	OA TEMP (C)	CENTRAL COOLING (kW)	TERMINAL COOLING (kW)	PRECOOL COIL (kW)	TOTAL COOLING (kW)
0000	18.0	0.0	0.0	0.0	0.0
0100	17.3	0.0	0.0	0.0	0.0
0200	16.9	0.0	0.0	0.0	0.0
0300	16.6	0.0	0.0	0.0	0.0
0400	16.2	0.0	0.0	0.0	0.0
0500	16.0	0.0	0.0	0.0	0.0
0600	16.3	0.0	0.0	0.0	0.0
0700	18.0	0.0	0.0	0.0	0.0
0800	19.3	5.8	0.0	0.0	5.8
0900	20.6	7.9	0.0	0.0	7.9
1000	21.9	8.5	0.0	0.0	8.5
1100	23.0	9.0	0.0	0.0	9.0
1200	23.9	9.4	0.0	0.0	9.4
1300	24.4	9.6	0.0	0.0	9.6
1400	24.7	10.0	0.0	0.0	10.0
1500	24.6	10.2	0.0	0.0	10.2
1600	24.2	10.4	0.0	0.0	10.4
1700	23.6	10.3	0.0	0.0	10.3
1800	22.5	10.0	0.0	0.0	10.0
1900	21.4	7.7	0.0	0.0	7.7
2000	20.6	0.0	0.0	0.0	0.0
2100	19.8	0.0	0.0	0.0	0.0
2200	19.1	0.0	0.0	0.0	0.0
2300	18.5	0.0	0.0	0.0	0.0
Total kWh		108.7	0.0	0.0	108.7

TABLE 6: CHILLER LOADS

MONTH: JUNE					
Hour	OA TEMP (C)	CENTRAL COOLING (kW)	TERMINAL COOLING (kW)	PRECOOL COIL (kW)	TOTAL COOLING (kW)
0000	22.7	0.0	0.0	0.0	0.0
0100	21.9	0.0	0.0	0.0	0.0
0200	21.5	0.0	0.0	0.0	0.0
0300	21.0	0.0	0.0	0.0	0.0
0400	20.6	0.0	0.0	0.0	0.0
0500	20.4	0.0	0.0	0.0	0.0
0600	20.9	0.0	0.0	0.0	0.0
0700	22.9	0.0	0.0	0.0	0.0
0800	24.1	8.6	0.0	0.0	8.6
0900	25.6	10.9	0.0	0.0	10.9
1000	26.9	11.5	0.0	0.0	11.5
1100	28.1	12.0	0.0	0.0	12.0
1200	28.9	12.4	0.0	0.0	12.4
1300	29.5	12.6	0.0	0.0	12.6
1400	29.9	13.1	0.0	0.0	13.1
1500	29.7	13.2	0.0	0.0	13.2
1600	29.3	13.5	0.0	0.0	13.5
1700	28.6	13.5	0.0	0.0	13.5
1800	27.6	13.1	0.0	0.0	13.1
1900	26.4	10.7	0.0	0.0	10.7
2000	25.5	0.0	0.0	0.0	0.0
2100	24.6	0.0	0.0	0.0	0.0
2200	24.0	0.0	0.0	0.0	0.0
2300	23.3	0.0	0.0	0.0	0.0
Total kWh		145.2	0.0	0.0	145.2

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TABLE 7: CHILLER LOADS

MONTH: JULY					
Hour	OA TEMP (C)	CENTRAL COOLING (kW)	TERMINAL COOLING (kW)	PRECOOL COIL (kW)	TOTAL COOLING (kW)
0000	25.2	0.0	0.0	0.0	0.0
0100	24.5	0.0	0.0	0.0	0.0
0200	24.0	0.0	0.0	0.0	0.0
0300	23.5	0.0	0.0	0.0	0.0
0400	23.1	0.0	0.0	0.0	0.0
0500	22.7	0.0	0.0	0.0	0.0
0600	22.9	0.0	0.0	0.0	0.0
0700	24.5	0.0	0.0	0.0	0.0
0800	25.6	9.6	0.0	0.0	9.6
0900	27.2	12.0	0.0	0.0	12.0
1000	28.7	12.7	0.0	0.0	12.7
1100	30.0	13.3	0.0	0.0	13.3
1200	30.9	13.7	0.0	0.0	13.7
1300	31.5	13.9	0.0	0.0	13.9
1400	31.8	14.4	0.0	0.0	14.4
1500	31.7	14.6	0.0	0.0	14.6
1600	31.4	14.9	0.0	0.0	14.9
1700	30.8	14.9	0.0	0.0	14.9
1800	29.9	14.5	0.0	0.0	14.5
1900	28.7	11.9	0.0	0.0	11.9
2000	27.8	0.0	0.0	0.0	0.0
2100	27.0	0.0	0.0	0.0	0.0
2200	26.4	0.0	0.0	0.0	0.0
2300	25.8	0.0	0.0	0.0	0.0
Total kWh		160.2	0.0	0.0	160.2

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TABLE 8: CHILLER LOADS

MONTH: AUGUST					
Hour	OA TEMP (C)	CENTRAL COOLING (kW)	TERMINAL COOLING (kW)	PRECOOL COIL (kW)	TOTAL COOLING (kW)
0000	24.9	0.0	0.0	0.0	0.0
0100	24.4	0.0	0.0	0.0	0.0
0200	23.9	0.0	0.0	0.0	0.0
0300	23.4	0.0	0.0	0.0	0.0
0400	23.0	0.0	0.0	0.0	0.0
0500	22.7	0.0	0.0	0.0	0.0
0600	22.6	0.0	0.0	0.0	0.0
0700	23.7	0.0	0.0	0.0	0.0
0800	25.0	9.1	0.0	0.0	9.1
0900	26.6	11.4	0.0	0.0	11.4
1000	28.1	12.0	0.0	0.0	12.0
1100	29.5	12.7	0.0	0.0	12.7
1200	30.5	13.1	0.0	0.0	13.1
1300	31.1	13.3	0.0	0.0	13.3
1400	31.5	13.8	0.0	0.0	13.8
1500	31.4	14.0	0.0	0.0	14.0
1600	31.0	14.2	0.0	0.0	14.2
1700	30.3	14.2	0.0	0.0	14.2
1800	29.2	13.7	0.0	0.0	13.7
1900	28.1	11.1	0.0	0.0	11.1
2000	27.3	0.0	0.0	0.0	0.0
2100	26.7	0.0	0.0	0.0	0.0
2200	26.0	0.0	0.0	0.0	0.0
2300	25.5	0.0	0.0	0.0	0.0
Total kWh		152.5	0.0	0.0	152.5

TABLE 9: CHILLER LOADS

MONTH: SEPTEMBER					
Hour	OA TEMP (C)	CENTRAL COOLING (kW)	TERMINAL COOLING (kW)	PRECOOL COIL (kW)	TOTAL COOLING (kW)
0000	21.3	0.0	0.0	0.0	0.0
0100	20.8	0.0	0.0	0.0	0.0
0200	20.4	0.0	0.0	0.0	0.0
0300	20.0	0.0	0.0	0.0	0.0
0400	19.6	0.0	0.0	0.0	0.0
0500	19.3	0.0	0.0	0.0	0.0
0600	19.2	0.0	0.0	0.0	0.0
0700	19.9	0.0	0.0	0.0	0.0
0800	21.5	6.8	0.0	0.0	6.8
0900	23.3	9.1	0.0	0.0	9.1
1000	24.8	9.7	0.0	0.0	9.7
1100	26.3	10.3	0.0	0.0	10.3
1200	27.3	10.7	0.0	0.0	10.7
1300	28.0	11.0	0.0	0.0	11.0
1400	28.3	11.4	0.0	0.0	11.4
1500	28.1	11.5	0.0	0.0	11.5
1600	27.5	11.5	0.0	0.0	11.5
1700	26.5	11.3	0.0	0.0	11.3
1800	25.2	10.7	0.0	0.0	10.7
1900	24.2	8.4	0.0	0.0	8.4
2000	23.6	0.0	0.0	0.0	0.0
2100	22.9	0.0	0.0	0.0	0.0
2200	22.3	0.0	0.0	0.0	0.0
2300	21.8	0.0	0.0	0.0	0.0
Total kWh		122.4	0.0	0.0	122.4

TABLE 10: CHILLER LOADS

MONTH: OCTOBER					
Hour	OA TEMP (C)	CENTRAL COOLING (kW)	TERMINAL COOLING (kW)	PRECOOL COIL (kW)	TOTAL COOLING (kW)
0000	16.8	0.0	0.0	0.0	0.0
0100	16.6	0.0	0.0	0.0	0.0
0200	16.3	0.0	0.0	0.0	0.0
0300	16.0	0.0	0.0	0.0	0.0
0400	15.8	0.0	0.0	0.0	0.0
0500	15.5	0.0	0.0	0.0	0.0
0600	15.4	0.0	0.0	0.0	0.0
0700	15.6	0.0	0.0	0.0	0.0
0800	16.9	0.0	0.0	0.0	0.0
0900	18.6	0.0	0.0	0.0	0.0
1000	19.9	0.0	0.0	0.0	0.0
1100	21.2	0.0	0.0	0.0	0.0
1200	22.1	0.0	0.0	0.0	0.0
1300	22.8	0.0	0.0	0.0	0.0
1400	23.1	0.0	0.0	0.0	0.0
1500	22.9	0.0	0.0	0.0	0.0
1600	22.2	0.0	0.0	0.0	0.0
1700	21.1	0.0	0.0	0.0	0.0
1800	20.1	0.0	0.0	0.0	0.0
1900	19.2	0.0	0.0	0.0	0.0
2000	18.7	0.0	0.0	0.0	0.0
2100	18.2	0.0	0.0	0.0	0.0
2200	17.6	0.0	0.0	0.0	0.0
2300	17.2	0.0	0.0	0.0	0.0
Total kWh		0.0	0.0	0.0	0.0

TABLE 11: CHILLER LOADS

MONTH: NOVEMBER					
Hour	OA TEMP (C)	CENTRAL COOLING (kW)	TERMINAL COOLING (kW)	PRECOOL COIL (kW)	TOTAL COOLING (kW)
0000	11.9	0.0	0.0	0.0	0.0
0100	11.9	0.0	0.0	0.0	0.0
0200	11.7	0.0	0.0	0.0	0.0
0300	11.6	0.0	0.0	0.0	0.0
0400	11.4	0.0	0.0	0.0	0.0
0500	11.3	0.0	0.0	0.0	0.0
0600	11.1	0.0	0.0	0.0	0.0
0700	11.1	0.0	0.0	0.0	0.0
0800	11.7	0.0	0.0	0.0	0.0
0900	12.9	0.0	0.0	0.0	0.0
1000	14.1	0.0	0.0	0.0	0.0
1100	15.1	0.0	0.0	0.0	0.0
1200	15.8	0.0	0.0	0.0	0.0
1300	16.4	0.0	0.0	0.0	0.0
1400	16.7	0.0	0.0	0.0	0.0
1500	16.5	0.0	0.0	0.0	0.0
1600	16.0	0.0	0.0	0.0	0.0
1700	14.9	0.0	0.0	0.0	0.0
1800	14.1	0.0	0.0	0.0	0.0
1900	13.5	0.0	0.0	0.0	0.0
2000	13.1	0.0	0.0	0.0	0.0
2100	12.8	0.0	0.0	0.0	0.0
2200	12.3	0.0	0.0	0.0	0.0
2300	12.1	0.0	0.0	0.0	0.0
Total kWh		0.0	0.0	0.0	0.0

TABLE 12: CHILLER LOADS

MONTH: DECEMBER					
Hour	OA TEMP (C)	CENTRAL COOLING (kW)	TERMINAL COOLING (kW)	PRECOOL COIL (kW)	TOTAL COOLING (kW)
0000	9.1	0.0	0.0	0.0	0.0
0100	9.0	0.0	0.0	0.0	0.0
0200	8.9	0.0	0.0	0.0	0.0
0300	8.8	0.0	0.0	0.0	0.0
0400	8.7	0.0	0.0	0.0	0.0
0500	8.6	0.0	0.0	0.0	0.0
0600	8.4	0.0	0.0	0.0	0.0
0700	8.4	0.0	0.0	0.0	0.0
0800	8.5	0.0	0.0	0.0	0.0
0900	9.4	0.0	0.0	0.0	0.0
1000	10.4	0.0	0.0	0.0	0.0
1100	11.3	0.0	0.0	0.0	0.0
1200	11.9	0.0	0.0	0.0	0.0
1300	12.5	0.0	0.0	0.0	0.0
1400	12.7	0.0	0.0	0.0	0.0
1500	12.6	0.0	0.0	0.0	0.0
1600	12.1	0.0	0.0	0.0	0.0
1700	11.3	0.0	0.0	0.0	0.0
1800	10.7	0.0	0.0	0.0	0.0
1900	10.3	0.0	0.0	0.0	0.0
2000	10.0	0.0	0.0	0.0	0.0
2100	9.8	0.0	0.0	0.0	0.0
2200	9.5	0.0	0.0	0.0	0.0
2300	9.3	0.0	0.0	0.0	0.0
Total kWh		0.0	0.0	0.0	0.0

****

TABLE 1: MAXIMUM COOLING AND HEATING PLANT LOADS

Maximum Cooling Plant Load.....:	14.9 kW	@	Jul 1600
Maximum Heating Plant Load.....:	0.0 kW	@	Winter Design

TABLE 2: COINCIDENT COOLING LOADS FOR JUL 1600 AND DESIGN HEATING LOADS

AIR SYSTEM NAME	AIR SYSTEM MULTIPLIER	TOTAL COOLING (kW)	TOTAL HEATING (kW)
AIR SYSTEM......................	1	14.9	0.0

APPENDIX B

```
FLUENT
Version: 3d, segregated, lam (3d, segregated, laminar)
Release: 6.0.12
Title:

Models
------

   Model                         Settings
   -------------------------------------
   Space                         3D
   Time                          Steady
   Viscous                       Laminar
   Heat Transfer                 Enabled
   Solidification and Melting    Disabled
   Radiation                     None
   Species Transport             Disabled
   Coupled Dispersed Phase       Disabled
   Pollutants                    Disabled
   Soot                          Disabled

Boundary Conditions
-------------------

   Zones

      name                    id   type
      -------------------------------------------
      fluid                   2    fluid
      sand                    3    solid
      stone                   4    solid
      concrete                5    solid
      thermal insulation      6    solid
      water insulation        7    solid
      base                    8    solid
      cement filling          9    solid
      stropor                 10   solid
      alum type 400           11   solid
      granite                 12   solid
      waterflow-shadow        77   wall
      waterflow               13   wall
      waterout                14   outflow
      waterinlet              15   mass-flow-inlet
      back                    16   wall
      front                   17   wall
      right                   18   wall
      left                    19   wall
      bottom                  20   wall
      top                     21   wall
      default-interior        23   interior
      back:001                1    wall
      back:022                22   wall
      back:024                24   wall
      back:025                25   wall
      back:026                26   wall
      back:027                27   wall
      back:028                28   wall
      back:029                29   wall
      back:030                30   wall
      front:031               31   wall
      front:032               32   wall
```

```
   front:033               33   wall
   front:034               34   wall
   front:035               35   wall
   front:036               36   wall
   front:037               37   wall
   front:038               38   wall
   front:039               39   wall
   right:040               40   wall
   right:041               41   wall
   right:042               42   wall
   right:043               43   wall
   right:044               44   wall
   right:045               45   wall
   right:046               46   wall
   right:047               47   wall
   right:048               48   wall
   left:049                49   wall
   left:050                50   wall
   left:051                51   wall
   left:052                52   wall
   left:053                53   wall
   left:054                54   wall
   left:055                55   wall
   left:056                56   wall
   left:057                57   wall
   default-interior:058    58   interior
   default-interior:059    59   interior
   default-interior:060    60   interior
   default-interior:061    61   interior
   default-interior:062    62   interior
   default-interior:063    63   interior
   default-interior:064    64   interior
   default-interior:065    65   interior
   default-interior:066    66   interior
   default-interior:067    67   interior
   default-interior:068    68   interior
   default-interior:069    69   interior
   default-interior:070    70   interior
   default-interior:071    71   interior
   default-interior:072    72   interior
   default-interior:073    73   interior
   default-interior:074    74   interior
   default-interior:075    75   interior
   default-interior:076    76   interior

Boundary Conditions

   fluid

      Condition                                              Value
      -------------------------------------------------------------
      Material Name                                          water-liquid
```

```
sand

   Condition                      Value
   -------------------------------------------------------------
   Material Name                  sand


stone

   Condition                      Value
   -------------------------------------------------------------
   Material Name                  stone


concrete

   Condition                      Value
   -------------------------------------------------------------
   Material Name                  concrete


thermal insulation

   Condition                      Value
   -------------------------------------------------------------
   Material Name                  thermal insulation


water insulation

   Condition                      Value
   -------------------------------------------------------------
   Material Name                  water insulation


base

   Condition                      Value
   -------------------------------------------------------------
   Material Name                  base


cement filling

   Condition                      Value
   -------------------------------------------------------------
   Material Name                  cement filling


stropor

   Condition                      Value
   -------------------------------------------------------------
   Material Name                  stropor

alum type 400

   Condition                      Value
   -------------------------------------------------------------
   Material Name                  alum type 400
(profile  )))
```

granite

Condition	Value
Material Name	granite

waterflow-shadow

Condition	Value
Wall Thickness	0
Heat Generation Rate	0
Material Name	alum type 400
Thermal BC Type	3
Temperature	300
Heat Flux	0
Convective Heat Transfer Coefficient	0
Free Stream Temperature	300
External Radiation Temperature	300

waterflow

Condition	Value
Wall Thickness	0
Heat Generation Rate	0
Material Name	alum type 400
Thermal BC Type	3
Temperature	300
Heat Flux	0
Convective Heat Transfer Coefficient	0
Free Stream Temperature	300
External Radiation Temperature	300

waterout

Condition	Value
Flow rate weighting	1

waterinlet

Condition	Value
Mass Flow Specification Method	0
Mass Flow-Rate	1
Mass Flux	1
Average Mass Flux	1
Upstream Torque Integral	1
Total Temperature	301

back

Condition	Value
Temperature	300
Heat Flux	0
Convective Heat Transfer Coefficient	0
External Emissivity	1
External Radiation Temperature	300

front

Condition	Value
Temperature	300
Heat Flux	0
Convective Heat Transfer Coefficient	0
Free Stream Temperature	300
External Radiation Temperature	300

right

Condition	Value
Temperature	300
Heat Flux	0
Convective Heat Transfer Coefficient	0
Free Stream Temperature	300
External Radiation Temperature	300

left

Condition	Value
Temperature	300
Heat Flux	0
Convective Heat Transfer Coefficient	0
Free Stream Temperature	300

bottom

Condition	Value
Material Name	sand
Thermal BC Type	0
Temperature	283
Heat Flux	0
Convective Heat Transfer Coefficient	0
Free Stream Temperature	300
External Radiation Temperature	300

top

Condition	Value
Material Name	granite
Thermal BC Type	2
Temperature	300
Heat Flux	0
Convective Heat Transfer Coefficient	6.77
Free Stream Temperature	295
External Radiation Temperature	300

Solver Controls

Equations

Equation	Solved
Flow	yes
Energy	yes

Numerics

Numeric	Enabled
Absolute Velocity Formulation	yes

Relaxation

Variable	Relaxation Factor
Pressure	0.3
Density	1
Body Forces	1
Momentum	0.7
Energy	1

Linear Solver

Variable	Solver Type	Termination Criterion	Residual Reduction Tolerance
Pressure	V-Cycle	0.1	
X-Momentum	Flexible	0.1	0.7
Y-Momentum	Flexible	0.1	0.7
Z-Momentum	Flexible	0.1	0.7
Energy	Flexible	0.1	0.7

Solution Limits

Quantity	Limit
Minimum Absolute Pressure	1
Maximum Absolute Pressure	5000000
Minimum Temperature	1
Maximum Temperature	5000

Material Properties

Material: water-liquid (fluid)

Property	Units	Method	Value(s)
Density	kg/m3	constant	998.2
Cp (Specific Heat)	j/kg-k	constant	4182
Thermal Conductivity	w/m-k	constant	0.6
Viscosity	kg/m-s	constant	0.001003
Molecular Weight	kg/kgmol	constant	18.0152
L-J Characteristic Length	angstrom	constant	0
L-J Energy Parameter	k	constant	0
Thermal Expansion Coefficient	1/k	constant	0
Degrees of Freedom		constant	0

Material: sand (solid)

Property	Units	Method	Value(s)
Density	kg/m3	constant	2000
Cp (Specific Heat)	j/kg-k	constant	800
Thermal Conductivity	w/m-k	constant	2.0999999

Material: stone (solid)

Property	Units	Method	Value(s)
Density	kg/m3	constant	1800
Cp (Specific Heat)	j/kg-k	constant	800
Thermal Conductivity	w/m-k	constant	1.4

Material: concrete (solid)

Property	Units	Method	Value(s)
Density	kg/m3	constant	2400
Cp (Specific Heat)	j/kg-k	constant	780
Thermal Conductivity	w/m-k	constant	2

Material: thermal insulation (solid)

Property	Units	Method	Value(s)
Density	kg/m3	constant	15
Cp (Specific Heat)	j/kg-k	constant	0
Thermal Conductivity	w/m-k	constant	0.039999999

Material: water insulation (solid)

Property	Units	Method	Value(s)
Density	kg/m3	constant	2000
Cp (Specific Heat)	j/kg-k	constant	0
Thermal Conductivity	w/m-k	constant	0.69999999

Material: base (solid)

Property	Units	Method	Value(s)
Density	kg/m3	constant	2400
Cp (Specific Heat)	j/kg-k	constant	780
Thermal Conductivity	w/m-k	constant	2.0999999

Material: cement filling (solid)

Property	Units	Method	Value(s)
Density	kg/m3	constant	2200
Cp (Specific Heat)	j/kg-k	constant	0
Thermal Conductivity	w/m-k	constant	1.74

Material: stropor (solid)

Property	Units	Method	Value(s)
Density	kg/m3	constant	15
Cp (Specific Heat)	j/kg-k	constant	0
Thermal Conductivity	w/m-k	constant	0.039999999

Material: alum type 400 (solid)

Property	Units	Method	Value(s)
Density	kg/m3	constant	1860
Cp (Specific Heat)	j/kg-k	constant	780
Thermal Conductivity	w/m-k	constant	0.72000003

Material: granite (solid)

Property	Units	Method	Value(s)
Density	kg/m3	constant	2800
Cp (Specific Heat)	j/kg-k	constant	101.7
Thermal Conductivity	w/m-k	constant	3.5