GU J Sci 31(2): 328-340 (2018)

Gazi University

Journal of Science

http://dergipark.gov.tr/gujs

Zero Consumption Monotype Education Buildings

Filiz BAL KOÇYİĞİT[1,*]

[1]*Atilim University, Faculty of Arts, Design and Architecture, Department of Architecture, 06830 İncek Ankara, Turkey*

Article Info

Received: 14/11/2016
Accepted: 05/03/2018

Keywords

Education buildings
Energy efficiency
Transparent trombe walls
Type school buildings

Abstract

Turkey has mainly seven geographic zones but four climatic zones. Major influence on energy usage and educational buildings which perform well in energy terms will reap significant environmental and economic benefits for years to come. The lack of electric, heating-cooling and lighting comfort in the structure reduce the quality of education. Many village schools cannot provide training in enough conditions. Municipalities are preparing "Type School Project" for government schools, without thinking different zones conditions, directions and heights. At this stage, there arises importance of the Architectural Design Process for typical energy efficient design which can easily adapt to the location. The material must not only be transmits about 70-90% of solar radiation, but also its insulation quality. Additionally architectural form of building must be affected to take all solar energy, wind and water. In this study, architectural design method has been used for energy gain from transparent insulated trombe wall. And have been calculated in accordance with their manners in the middle, south, noth, east and west regions of Anatolia which are located in different degree-days regions on the basis of TS 825.

1. INTRODUCTION

Although the tuition allocation in Turkey is inadequate, the majority of the payment goes to preventable energy s in education structures not designed with energy efficient methods. There are several procedures for school buildings in worldwide. The problem is lack of standardization for education centers indoor quality for heating, lighting, and energy systems.

Municipalities spend too much money for education centers because of wrong prossesing of architectural design. If architectural design is not well conceived in the region it would be clear to remain in an unwanted direction in one another area. This can lead to energy loss. Additionally sun light can't reach inside and additional illumination energy has been need at daytime. Through insulation material applications in energy efficient buildings, it is possible both to prevent heating loss and to exploit solar energy in passive way. At this stage, there arises importance of the Architectural Design Process. The material must not only be transmits about 70-90% of solar radiation, but also its insulation quality [8]. Additionally architectural form of building must be affected to take all solar energy, wind and water. Outside surface temperature on the transparent insulated walls is higher than the inside temperature. If we can use this for trombe wall we can gain additionally not only heat but also light energy. Thus, those walls are not valued as the elements which cause to heat loss but as the elements providing comfort by transferring the deposited energy inside the building through radiation and convection. In this study, architectural design method has been used for energy gain from transparent insulated trombe wall. And have been calculated in accordance with their manners in the middle, south, north, east and west regions of Anatolia which are located in different degree-days regions on the basis of TS 825. The parameters effecting thermal manners of the transparent trombe walls were surveyed.

Energy efficiency for the school buildings have to be researched with two main parts. First part is the energy usage. Buildings are not use and the need energy. The right decisions, the right design and the

*Corresponding author, e-mail: filiz.kocyigit@atilim.edu.tr

right use of energy is a prerequisite for effective use. The location of the building has a direct influence energy consumption and production. Hence, energy production of building is the second important part of energy efficiency for the buildings. These conditions directly affect the control of the working environment in the classroom at school.

At the architectural design of education buildings need detailed investigation for user and usage needs. This is not only for the interior planning of building but also general form of building. Straight, one side effected buildings can be effected for one location but if this building design must be use at the different location versatile and multiple front-facing design must be produced. This project can be only used same regional zone also. When this Type School Project must be used for overall country energy efficiency have to be added to the design. Here versatile and multi front-facing design must be considered. Solar energy and wind energy another important effect for school buildings. At the primary and secondary schools which are working eight hours a day, energy consumption can be minimized through proper design for heating and lighting needs. Relative humidity and underground and surface waters are another important factors for Type School Design. Different geographical regions in Turkey are due to different climatic conditions, have different relative humidity, and surface and underground waters. Energy efficient buildings have to also use these natural energy sources. In some areas, snow and heavy rains can be used for energy purposes in the form of rain in some areas underground and surface water can be converted into energy.

Several countries like Germany, Sweden, USA are give importance of school environment control for education quality and also sustainability of school buildings' comfort with energy efficient building types. Especially USA creates LEED for schools. The LEED for school Rating System is designed to guide school district, designers, and constructors through the process of building high performance schools that have a low impact on the environment and are a healthy place for students and teachers to learn and work. The energy efficiency of completely air conditioned schools can be improved by passive means like geometry, thermal insulation, thermal capacity of room surfaces, orientation and solar control of windows as well as by advanced systems and components, but the new principles of climate control, which are shown in Table 1, allow for higher efficiency and performance [22]:

Table 1. *Disturbances and means of climate control of museum buildings [22]*

Disturbances of climate factor	**Effect**	**Means of stabilization/ passive control**	**Active**	**Disturbances of climate factor**	**Effect**	**Means of stabilization/ passive control**
Ambient temperature	Heat transmit.	Thermal Capacity	Surface Temp. Control	Ambient temperature	Heat transmit.	Thermal Capacity
Wind	Infiltration	Airtight Joints	Air Locks	Wind	Infiltration	Airtight Joints
Solar Radiation	Heat Gain	Solar Control (glass, shading device)	Surface Temp. Control	Solar Radiation	Heat Gain	Solar Control (glass, shading device)
Lighting	Heat Gain		Vent. + Sur face Temp. Control	Lighting	Heat Gain	

2. METHODOLOGY AND PRINCIPLES OF ZERO CONSUMPTION MONOTYPE SCHOOL BUILDINGS' EVALUATION

There is no standards about Zero consumption school building but municipalities have prepare school in eqality. So, government schools are designed "Monotype school building". Therefore, depending on the location differentiation cannot be adequately designed. In all cities one type school projects are produced to be ensure equality among students in public schools and to reduce the production cost. The requirements for the proposals created in a region seems incompatible to schools in other locations. With the aim of these projects is growing standardization and incompatibility are also sent to the urban environment. Turkey's educational equality by ensuring a minimum of comfort in rooms in raising the quality of education in every region of our country is one of the most important issues to achieve. According to the LEED all the school attributes include; sustainable site selection, low water use, both inside and outside, low energy use through the use of energy efficiency and renewable energy, reduce the use of virgin materials and transportation of materials from far away, re-use existing materials and structures, recycle existing materials, healthy indoor environment with improved air quality, comfort, daylighting, and views. At this point;

A school building is an energy system made of many interrelated components. Some of the components are obvious; walls (especially trombe walls are effective), roofs, lights, air vents, doors, and windows. The occupants "students, teachers, and other building users" are also an important part of the system. The energy use of the system affects everything from the school budget to the global environment. It is important to understand how all of the system components can work together to create an environment that is conducive to teaching and learning. A school building's energy system includes these components:

1. Occupants; Important point of schools that the buildings don't use energy, user do. The actions of the building occupants dictate how much energy is used by the other system components. The other four components all include points of human interface, and in the sections where they are described, suggestions are provided for how people can use energy more efficiently.
2. Building Envelope And Near Semi-Open Spaces: This component includes everything that creates barriers between indoors and outdoors; walls, floors, roofs, windows, doors and corridoors, entrance (windbreaker) etc.
3. Lighting and illumination: Lighting can be provide with natural and artificial methods. This component includes several types of fixtures that provide lighting for all of the areas and activities in the Turkish schools.
4. Heating, Ventilation, and Air Conditioning (HVAC) Systems: In Turkey ventilation and airconditioning confort providing with windows and HVAC systems. But in many countries this component, which named HVAC systems, includes the equipment that provides heating, cooling, hot water, and fresh air to the building. It also includes the devices that control the equipment, such as thermostats.
5. Electrical and Other Energy Devices: This component includes everything that is plugged into electrical outlets, such as refrigerators, copiers, and computers, as well as kitchen appliances that are wired directly into the school's electrical system, such as ovens and refrigeration units.

The amount of energy each of these components consumes varies according to where a school is located. When we compare with Turkey and USA some similarities can be seen according to energy consumption from sun. The U.S., Environmental Protection Agency has determined Climate Zones for all parts of the country. (Fig 2) In Turkey, Republıc Of Turkey Ministry Of Environment And Urbanization's National Climate Change Action Plan and deal with this subject [3]. Turkey can be research with regional zone (Fig 2). As seen in map Turkey have 7 zones namely 1. Central Anatolia, 2. Marmara, 3. Aegean, 4. Mediterranean, 5. Southeast Anatolia, 6. Eastern Anatolia, 7. Black Sea Zones. All of these geological zones have different natural environmental conditions. Table 1 shows the climate zone number for a wide variety of International locations. Locations meeting all four of the following criteria: 1. Mean temperature of coldest month between 27°F (-3°C) and 65°F (18°C) 2. Warmest month mean < 72°F (22°C) 3. At least four months with mean temperatures over 50°F (10°C) 4. Dry season in summer. The month with the heaviest precipitation in the cold season has at least three times as much precipitation as the month with the least precipitation in the rest of the year [14].

Table 2. *International climatic zones (International Climate Zone Definition* [5])*

Zone Number	**Zone Name**	**Thermal Criteria (I-P Units)**	**Thermal Criteria (SI Units)**
1A and 1B	Very Hot-Humid (1A) Dry (1B)	9000 < CDD50 ^{0}F	5000 < CDD10 ^{0}C

2A and 2B	Hot-Humid (2A) Dry (2B)	6300 < CDD50 ^{0}F < 9000	3500 < CDD10 ^{0}C < 5000
3A and 3B	Varm-Humit (3A) Dry (3B)	4500 < CDD50 ^{0}F < 6300	2500 < CDD10 ^{0}C < 3500
3C	Warm – Marine (3C)	CDD50 ^{0}F <4500 and HDD65 ^{0}F <3600	CDD10 ^{0}C <2500 and HDD 18 ^{0}C < 2000
4A and 4B	Mixed – Humid (4A) Dry (4B)	CDD50 ^{0}F <4500 and 3600 < HDD65 ^{0}F < 5400	CDD10 ^{0}C <2500 and HDD 18 ^{0}C < 3000
4C	Mixed – Marine (4C)	3600 < HDD65 ^{0}F <5400	2000 < HDD 18 ^{0}C < 3000
5A 5B, and 5C	Cool Humid (5A) Dry (5B) Marine (5C)	5400 < HDD65 ^{0}F < 7200	3000 < HDD 18 ^{0}C < 4000
6A and 6B	Cold Humid (6A) Dry (6B)	7200 < HDD65 ^{0}F < 9000	4000 < HDD 18 ^{0}C <5000
7	Very cold	9000 < HDD65 ^{0}F < 12600	5000 < HDD 18 ^{0}C < 7000
8	Subarctic	12600 < HDD65 ^{0}F	7000 HDD 18 ^{0}C

**ANSI/ASHRAE/IESNA Standard 90.1- 2007 Normative Appendix B – Building Envelope Climate Criteria [5].*

Schools in the northern part of the Turkey namely Black Sea Zone and North-East Zone namely Eastern Anatolia use more energy for HVAC systems than other zones' use while schools in southern of the zones (Mediteranean and Southeast Anatolia) use more energy for cooling and lighting. During the Type School Building architects have to look at the map at Figure 1 and the chart at Table 3 to determine what are likely to be the large and small energy tasks in their school projects. Choosing appropriate data to cluster is an initial consideration in cluster analysis. In climate classification, the variability of long-term precipitation and temperature data are the most readily available variables (Fovell and Fovell, 1993). The seven climate zones over Turkey, shown in Figure 1(a,b), are those that have conventionally been accepted by Turkish climatologists since the beginning of the 20th century [27] (Figure 1a).

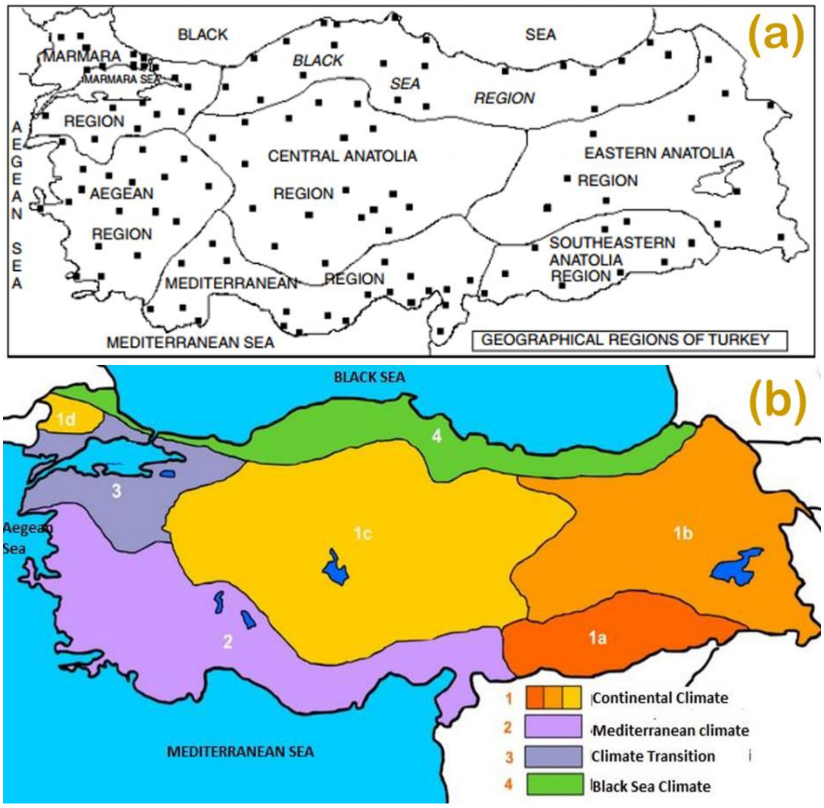


***Figure 1**. Turkey Climatic Zone Maps; a) Conventional classification of climate zones and distribution of data in Turkey [33] b) Turkey climatic zones map [27]*

Schools in the northern part of the USA and Alaska (Zones 6–8) use more energy for heating than any other use, while schools in southern areas of the country and Hawaii (Zones 1–2) use more energy for cooling and lighting. Figure 2 and the chart at Table 4 [34] to determine what are likely to be the large and small energy tasks in the region of school.

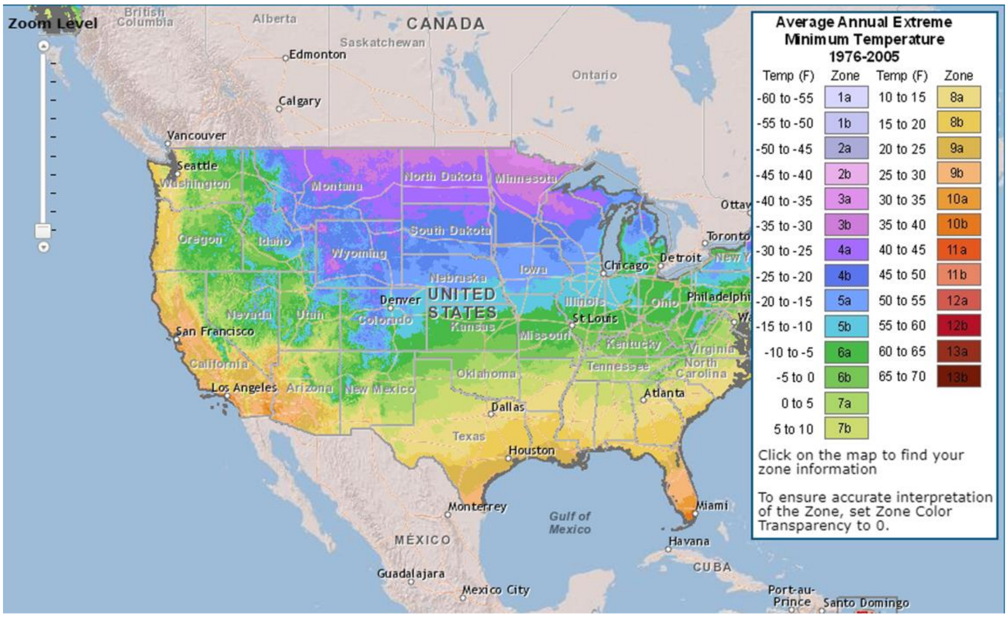


Figure 2. *USA Climatic Zone Map; http://planthardiness.ars.usda.gov/phzmweb/interactivemap.aspx)*

Table 3. *Energy consumption by climate zone in Turkey. This cities are sample from 1,2,3,4 Turkey Climatic Zone as seen from Figure 1 for the comparison between Turkey and USA*

CLIMATE ZONE	HEATING	COOLING	HEATING %	COOLING %
1A Ankara	560	14	27,59	6,8
1B Erzurum	770	8,5	37,93	4,1
1C Diyarbakır	290	62,5	14,29	30,3
3Antalya - İzmir	90	88	4,43	42,7
4 İstanbul	320	33	15,76	16,0
TOPLAM	2030	206	100	100,0

Table 4. *Table of energy consumption by climate zone in USA*

CLIMATE ZONE	HEATING %	COOLING %	LIGHTING %	WATER SYSTEMS %	ELECTRICAL DEVICES %	FANS %
1A	0,5	27,6	27,4	1	19,7	23,8
2A	4,6	19,8	28,9	1,4	20,8	24,4
2B	2	22,5	28,1	1,2	20,2	26,1
3A	7,2	14,3	30,9	1,7	22,2	23,7
3B	2,9	15	32,6	1,7	23,5	24,3
3C	3,7	6,1	34,4	2,2	24,7	28,9
4A	15,1	9,1	29,2	2	21	23,7
4B	7,1	10,3	31,7	2	22,8	26,1
4C	10,6	3,3	34,2	2,4	24,5	25,1
5A	23,8	6,5	26,1	1,9	18,8	23
5B	15,6	6,3	29,3	2,1	21	25,7
6A	32,8	3,9	23,8	1,9	17,1	20,5
7A	39,6	2	21,1	1,9	15,2	20,2
8A	58,7	0,6	15,4	1,5	11,1	12,7

Table 5. *Characteristics of scenarios for ERB (Energy Re-Building* [34]*

Scenario	**Assumption**
Sc_1	Adding insulation layers according to TS 825
Sc_2	Application of green roof on the existing flat roof areas
Sc_3	Changing the existing window type
Sc_4	Adding solar control devices on south, west and east facades.
Sc_5	Applying all the previous scenarios together.

**Data US Environmental Protection Agency*

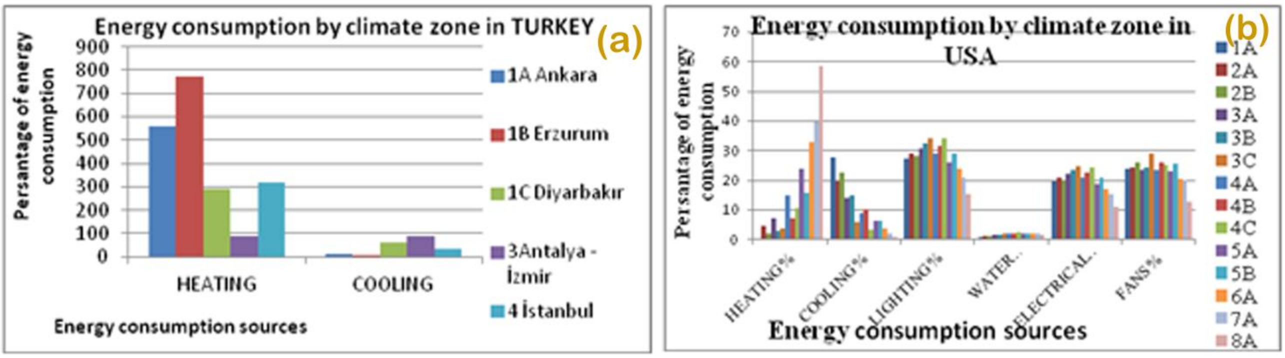


Figure 3. *Energy consumption by climate zone in USA and Turkey; a) Energy consumption by climate zone in Turkey b) Energy consumption by climate zone in USA*

3. SCHOOL BUILDING DESIGN; BASIC PRINCIPLES

There are several school buildings which need renovation in villages and there are many villages which need education buildings in Turkey. When rebuilding or renovating a school, several basic energy efficiency measures, including architecture, electrical systems, energy modeling, heating, cooling, air conditioning and ventilating systems (or HVAC) mechanical design, should be addressed in the pre-design and design phases. Beginning with the selection of a type of school project to be built as a village school, the impact of environmental energy in architectural design necessitates adaptation to child ergonomics, close cultural values and environmental natural resource data. For this reason, the design should have the elasticity to match the variables. At this research two parameters were processed namely environmental analysis and reflection of environmental factors in architectural design.

3.1. Role of Architecture

It can be constructed by architectural design that the school can have a design that can easily adapt to environmental variability. The renovation of old buildings, albeit in new building begins with energy efficient architectural design, though. Firstly architecture have to have general decision about energy efficient systems and design with depend of this knowledge. Also at the design process level architects and related engineers have to work with correlation. With these knowledge at design level designer should make the best use of the space available and account for opportunities to minimize (or, depending on the climate, maximize) heat gain and incorporate day lighting. The building design and layout should also allow for efficient placement of mechanical systems, which will require input from engineers and maintenance personnel early in conceptual design.

3.2. Site Layout and Orientation

To give students and teachers the greatest access to natural light, classrooms should be located on wings with a long east-west axis. This allows the classrooms to use north- or south-facing glazing. As a rule for the entire building, minimize east- and west-facing glazing. At this point it is advised the trombe wall which composed with aquarium walls instead of brick or adobe walls. According to calculations seem that the water is double more effected than bricks for thermal efficiency. Because water conductivity raios is (Thermal conductivity W/(m·K)=0,6) change with temperature [35].

4. ANALYZING OF TURKEY'S ENERGY SOURCES FOR SCHOOL BUILDING GAIN

Turkey is one of the most important country because of energy gain including solar, wind and water energy. In Turkey there are 4 main part of geographic zone. (Figure 4a, 4b)

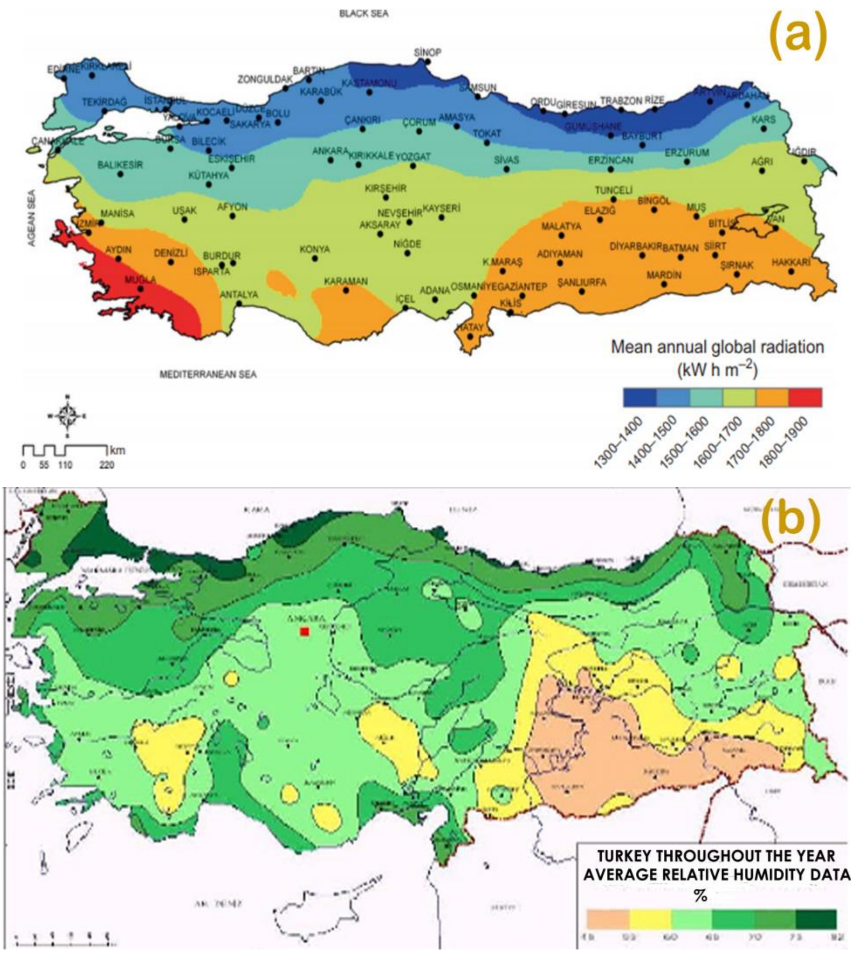


***Figure 4**. Geographical distribution of Turkey's solar, wind and relative humidity; a) Geographical distribution of 22-year average of annual global solar irradiation based on NASA /SSE b) The spatial distribution of mean annual relative humidity in Turkey (Climatology Branch, 2004) (Source EIE)[29]*

4.1. Analyzing of School Building Energy Consumption

There are several school which need rebuilt or renovation. In both cases it can be made in energy efficient buildings. But as a cheap and effective, which is to design energy-efficient buildings in the first design. For this reason architect firstly prepare enough research about building layout and environment condition. (Table 6)

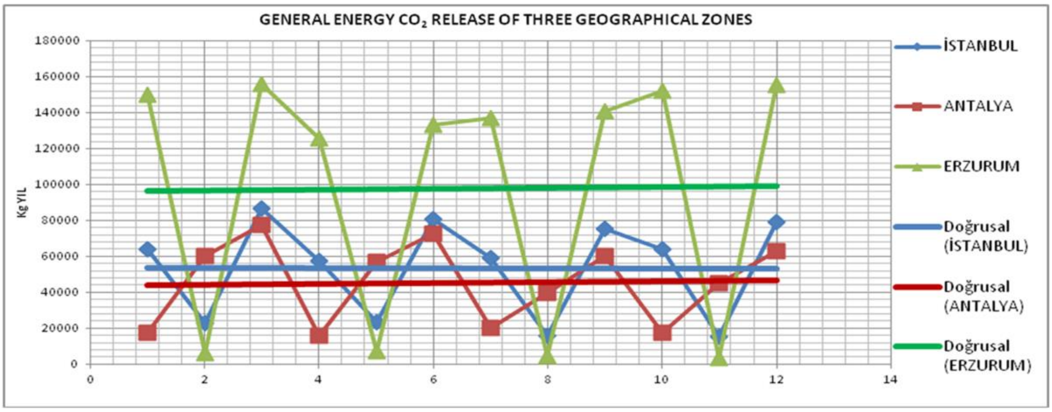


Figure 5. *General CO_2 release of three geographic zones*

Table 6. *General energy CO_2 release of three samples from three geographic zones*

Sample cities	HMD	CMD	Total MD	HS1	CS1	Total S1	HS2	CS2	Total S2	HS3	CS3	Total S3
İST.	63711	22888	86599	57423	23215	80638	59323	15807	75130	63801	15069	78870
ANT.	17304	60066	77370	15710	56658	72368	20287	39713	60000	17524	45243	62767
ERZ.	149943	6203	156146	125794	7327	133121	136786	4252	141038	152059	3224	155283

5. EFFECT OF ARCHITECTURAL DESIGN ON ENERGY EFFICIENCY WITH SOLAR ENERGY, WIND ENERGY AND WATER ENERGY

As seen in the fourth section Turkey can use different natural energy in different zones. At the Figure of 4a, 4b, and 4c solar, wind and water energy types are shown which can are usable for energy efficiency. Architectural designer have to know theese condition and have to use for their projects.

5.1. Daylighting effect and energy efficiency for heating also from the daylight at school projects

Education buildings for primary, secondary and highschools are using generally from 08:00 am. to 16:00 pm. This means that usage time in the spring and fall period under the daylight, only winter period after 16:00 darkness begin. Because of this condition daylight is very important energy for illumination for school projects. Daylighting reduces electricity costs by reducing the use of artificial lights and the amount of air conditioning by providing natural light from the sun. Daylighting analysis should begin early in the design process to determine which spaces will benefit the most from daylighting and to optimize glazing size and location. Denote the target average illuminance level at the m^{th} on the student table in classroom, when the mth zone is occupied (respectively, unoccupied), as W_m^0 (respectively, W_m^u).The average net illuminance at the mth zone in the classrooms, given dimming vector d and under daylight may be written as;

$$W_m \ (d, U_m = \sum_{n=1}^{p} H_{m,n}\, d_n$$

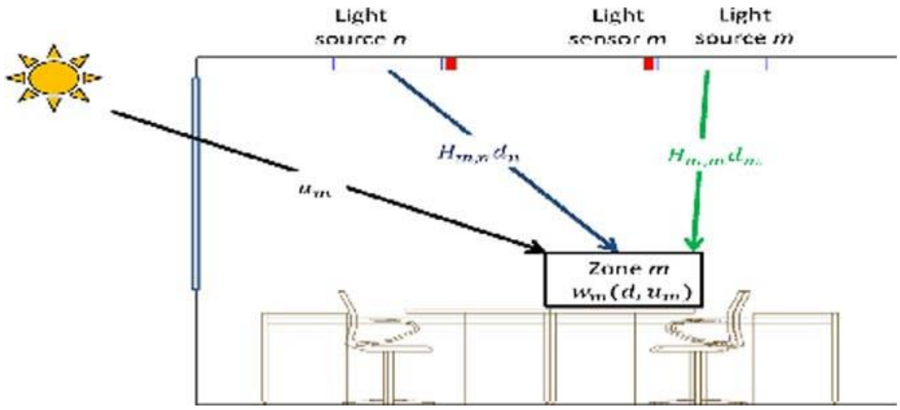


Figure 6. *Average illuminance at zone m at the classroom table due to contribution from artificial light and daylight*

Where $\sum_{n=1}^{p} H_{m,n}\, d_n$ and U_m are the illuminance contributions due to lighting system and daylight at the **m**th zone, respectively, as seen in Fig. 6. Here, Hm,n≥ 0 is the unknown illuminance contribution to the average in the mth zone when the nth light source is at maximum intensity, with all other light sources turned off. Inpractice, illuminance values at the workspace place cannot be measured; instead, only illuminance measurements at light sensors areavailable. For south-facing classrooms, light shelves and exterior shading devices should be designed to minimize glare and maximize daylight penetration into the classroom. The optimum height for ceilings is at least 10^0, but if daylighting is provided through the roof, the height can be less than 10^0. Ceilings can slope back to 8^0 at the interior wall if necessary to accommodate ductwork. Appropriate photosensor controls must be installed and maintained to ensure lights are turned off when natural daylight provides ample light for a space. North-facing classrooms can benefit greatly from daylighting without the need for light shelves and shading devices since the sun will not shine directly into these classrooms. For interior spaces, such as corridors and cafeterias, schools should consider top-lighting with tubular daylight devices. For gymnasiums, top-lighting or very high clerestory glazing should be considered. Additionally, filtered light coming from water mass, can create illumination comfort inside. Here not only for filtered light but also for heating energy thrombe wall can be used which interior wall is built by transparent water tank.

5.2. Architectural form of the school building

One another important factor is architectural design form of school. Curvative walls, roliefic face, solid-void ratio, escarpment walls, opac-transparent cavities etc. These are directly effect to gain natural energy gain. Especially curvative face directly effect wind energy gain. If wind energy is effective fot the location curvative forms which can directly effect to wind velocity and related wind speed an efficiency gain. Consequently energy gain for electricity. Or if, solar energy effected at that zone solar cells and trombe walls must thing at design and angles of walls, roof etc. Have to design with these respect. The acquisition of hydropower can e divide active and passive way. Trombe wall can be product with water tanks instead of brick wall. Trombe walls of the water tank as the most important problem in the making, the high pressure of the water in the glass wall and the fracture risk. But the wall made with the water tank in front of thrombin will benefit both indoors as well as to receive light to be higher than the amount of heat gain because it increases the conductivity. Furthermore, it is now left for the heat that gets into a certain amount of salt added will leave in the night longer receives heat gain during the day. Thermal conductivity is a material property describing the ability to conduct heat. Thermal conductivity can be defined as “The quantity of heat transmitted through a unit thickness of a material - in a direction normal to a surface of unit area - due to a unit temperature gradient under steady state conditions" (Table 7, Figure 7, 8a and 8b). Thermal conductivity units is W/(m K**)** in the SI system and Btu/(hr ft °F**)** in the Imperial systems.

Table 7. *Thermal conductivity of water and brick [36]*

Thermal Conductivity – k – W/(m K)			
Material/Substance	**Temperature – ^oC**		
	25	**125**	**225**
Brick dense	1,31		
Brick, insulating	0.15		
Brickwork, common (Building Brick)	0.6 -1.0		
Concrete, stone	1,7		
Water	0.58		
Water, vapor (steam)		0.016	

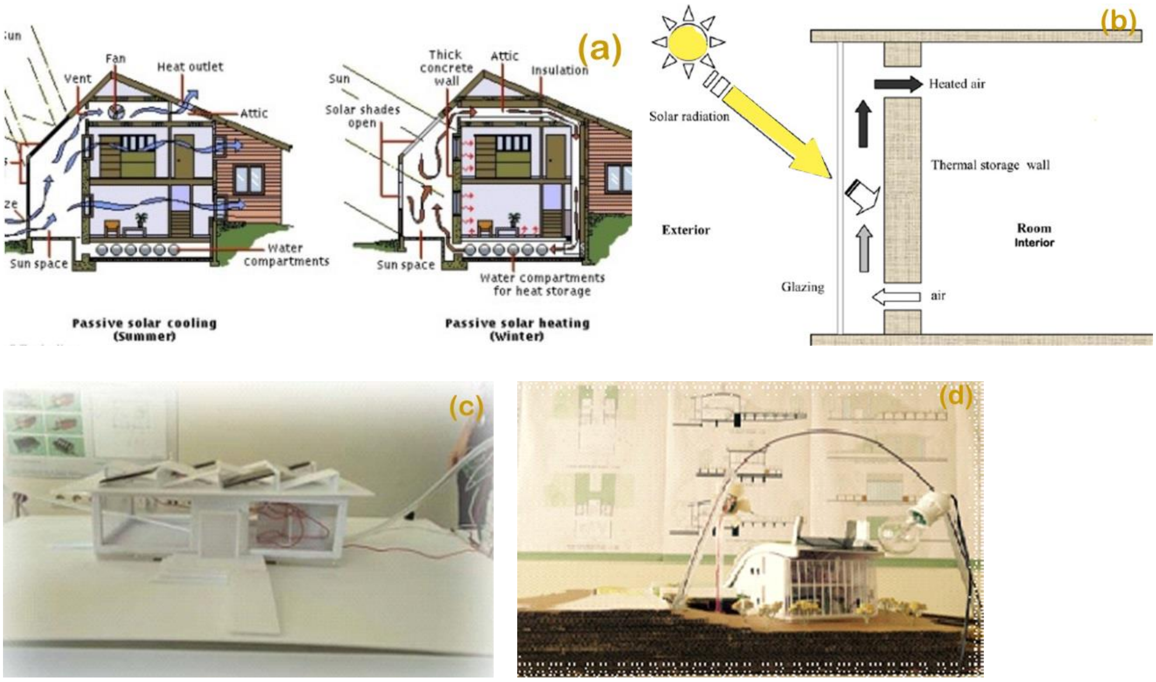
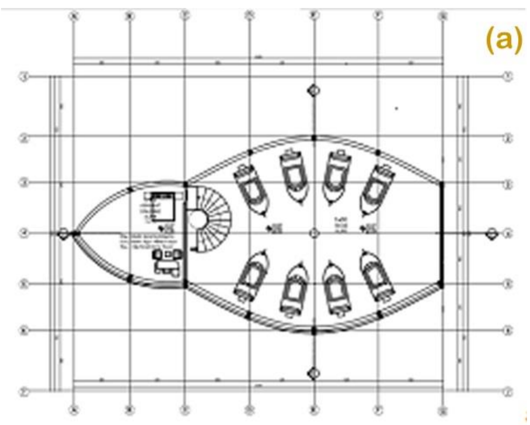


Figure 7. *Some research examples about energy efficient buildings designworks from Atilim University Environmental Control lecture teamwork ; a) Passive solar heating and cooling systems[29] b) trombe wall c) Example about energy efficient buildings 1 from Environmental Control Lecture Projects at Atilim University [30, 31] d) Example about energy efficient buildings 2 from Environmental Control Lecture Projects at Atilim University [30, 31]*



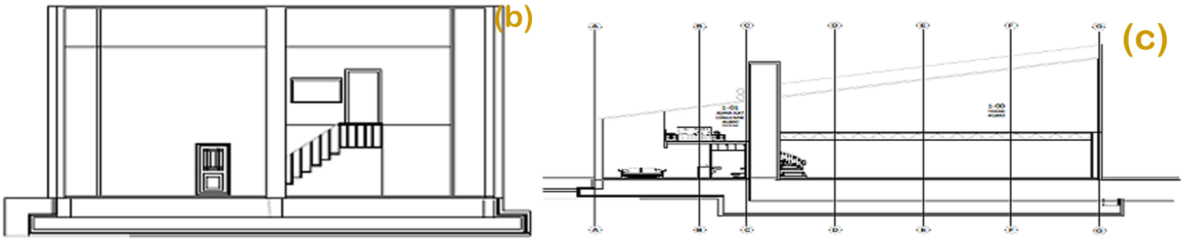


Figure 8. *Ankara sailing club project in Gölbaşı (longitudinal section and cross section plan) [30, 31,32]; a) ground flor plan b) section South-North c)section East – West*

6. CONCLUSIONS

Nowadays, energy gain and consumption rate is one of the most important problems in the world and in our country. Energy engineers and some other disciplines are working on this subject. Problem is the correlation between engineers and architecture research. Generally architects are trying to stand a little far from science wing and the engineers are from architectural design. These condition create lack of correlation between them. One of the most problem this design decisions need to be given from the start. Public school buildings need cheap energy for creating comfort condition for education. It should get benefited from architectural design methods to increase the efficiency of the energy that exists in the environment. This is also needs much architectural design research. We want to renovate some school buildings to make energy efficient buildings in villages, which need new school or create better education condition in them.

CONFLICTS OF INTEREST

No conflict of interest was declared by the authors.

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