Evaluating Different Green School Building Designs for Albania: Indoor Thermal Comfort, Energy Use Analysis with Solar Systems.

by

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ABSTRACT

Improving the conditions of schools in many parts of the world is gradually acquiring importance. The Green School movement is an integral part of this effort since it aims at improving indoor environmental conditions. This would in turn, enhance student-learning while minimizing adverse environmental impact through energy efficiency of comfort-related HVAC and lighting systems. This research, which is a part of a larger research project, aims at evaluating different school building designs in Albania in terms of energy use and indoor thermal comfort, and identify energy efficient options of existing schools. We start by identifying three different climate zones in Albania; Coastal (Durres), Hill/Pre-mountainous (Tirana), mountainous (Korca). Next, two prototypical school building designs are identified from the existing stock. Numerous scenarios are then identified for analysis which consists of combinations of climate zone, building type, building orientation, building upgrade levels, presence of renewable energy systems (solar photovoltaic and solar water heater). The existing building layouts, initially outlined in CAD software and then imported into a detailed building energy software program (eQuest) to perform annual simulations for all scenarios. The research also predicted indoor thermal comfort conditions of the various scenarios on the premise that windows could be opened to provide natural ventilation cooling when appropriate. This study also estimated the energy generated from solar photovoltaic systems and solar water heater systems when placed on the available roof area to determine the extent to which they are able to meet the required electric loads (plug and lights) and building heating loads respectively.

The results showed that there is adequate indoor comfort without the need for mechanical cooling for the three climate zones, and that only heating is needed during the winter months.

ACKNOWLEDGMENTS

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CHAPTER 1

BACKGROUND AND OBJECTIVES

1.1 Background

The World Commission on Environment and Development defines *sustainability* as: "meeting the needs of today without compromising the ability of future generations to meet their own needs." Sustainable buildings approach is meant to be a complete solution for to the design, construction and operation of buildings of the future. Sustainable buildings, sometimes known as Green Buildings, not only aim to reduce operating costs and improve energy efficiency, but also aim to enhance productivity and improve the health and wellbeing of occupants.

In the context of Green Schools, the effect of the physical indoor environment on overall development of the students is becoming increasingly important. Studies have indicated that Green Schools can positively impact student learning in a variety of ways. Student academic achievement outcomes were measured in a number of Green Schools within the U.S. where it was found that the improvements led to a 15% decrease in absenteeism, a 19% increase in overall oral and reading scores, as well as a 12% decrease in missed work days for teachers (Ocku et al. ,2011). Research on school lighting provided evidence that improvements to this area can enhance visual and non-visual outcomes in students from healthy vision to higher achievements (Ocku et al. 2011). There was also evidence showing an inverse relationship between "productivity" and indoor thermal comfort. One experimental study found that a nearly 4^{o} Celsius decrease in temperature resulted in an increase in logical thinking, as well as an improved performance in maths and reading (Ocku et al. 2011). Higher temperatures also have the potential to increase the growth of some biological pollutants such as mold with adverse health consequences. (Ghodrati et al. 2012).

In short, Green Schools have the ability to enhance learning outcomes and improve productivity among students and teachers, but they can also serve as springboards to shape the behavior of students now while nurturing future sustainability leaders of their communities. Green Schools incorporate changes to facilities as well as interweaving "green teaching" into classrooms and the community.

1.2 Problem Statement

Data related to the construction practices and state of maintenance of typical Albanian school buildings and campuses prior to year 2000 were collected and documented. This collection covered a total of 18 schools across different climate zones. From the collected data, it was observed that most of the school buildings lacked modern lighting, mechanical, electrical systems and even amenities. Consistent with many pre-2000 construction, the school buildings have not received any significant upgrades or improvements in the last 20 years. The buildings are seriously deficient from architectural, mechanical, plumbing, electrical perspectives. The electrical service to the building and building electrical wiring systems are not adequate for any type of lighting or equipment loads. The classrooms typically have single incandescent lamps hung from the ceiling with an exposed wire. Many classrooms do not have working lightings. The electrical systems are not as per the current codes and standards. The school buildings do not have any kind of heating or cooling systems, making the indoors uncomfortable during extreme outdoor weather conditions, especially during the winter months. On a positive side, the building walls have high mass construction with ample daylighting. It is due to this high mass construction and daylighting design that many "schools" are able to continue in these older buildings.

1.3 Objective and overall approach

The objective of this research was to evaluate various school building retrofit designs in terms of energy use and thermal comfort in Albania, and to identify efficient options for transforming the portfolio of exiting schools into energy efficient Green Schools. The study focuses on comparing and analyzing upgrades to two different existing building prototypes, one located in rural and the other in urban areas of Albania. The climate of the country is studied, and classified into three different zones, namely Field Mediterranean Area (which is the coastal area), Hilly and Pre-mountainous Mediterranean Area and the Mountainous Mediterranean Area. Further, the building designs are categorized into different Tiers of upgrades. The existing building prototypes are then compared and analyzed for energy savings and thermal comfort with future possibilities of upgrade such as adding a baseboard heating system or a mere comfortable heating and cooling system along with solar photovoltaic system and solar water heater system options.

CHAPTER 2

LITERATURE REVIEW

2.1 Impact of Green School environment on learning outcomes.

Green School building designs aim at making use of maximum renewable energy and green materials. These designs are more energy and water efficient as well. Green buildings provide a healthy, comfortable and productive learning environment for students. Poorly maintained and outdated building, present health and productivity issues for occupants via poor indoor air quality, thermal comfort, ventilation, mold and moisture problems, as well as improper lighting levels. Research suggests that building deficiencies related to temperature, age, acoustics and lighting have a direct negative impact on student performance (Earthman, 2002).

Occupancy density (i.e. overcrowding), air filtration and ventilation, as well as indoor temperature and humidity can increase the chances of contracting infectious diseases such as the common cold, influenza, and other common respiratory illnesses, leading to higher costs of healthcare, increased absenteeism and loss of productivity (Fisk, 2000).

Thermal discomfort can impact productivity since temperatures outside certain desirable range of conditions, which also includes too cold and too hot, correlate with low levels of manual dexterity, headaches, lethargy, and can have a negative impact on mental performance (Wyon, 2004).

Studies have shown that high quality of indoor air improves health, which result in better attendance by students, teachers and staff and leads to better student achievement (Corb, 2008).

According to Willson & Giley (2008), a school facilities should have operable windows in classrooms to take advantage of natural outdoor airflow. The natural ventilation air contributes to healthy learning environment. Sustainable design helps to decrease the overall environmental impact which will help lower operating costs and create a more productive leaning environment.

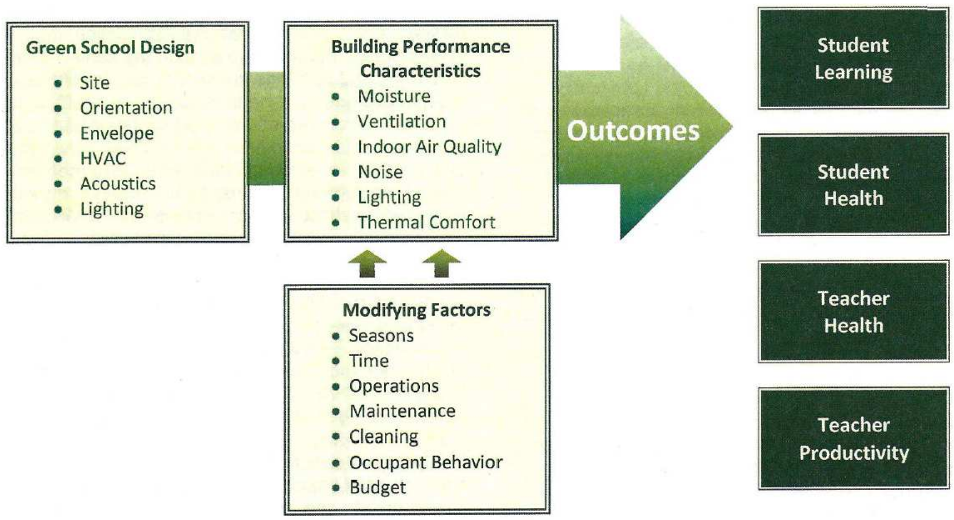

Figure 2.1 Link between Green School design and outcomes for learning, health and productivity. (Source: www.ncef.org)

An increasing amount of evidence suggests that green facilities can decrease absenteeism from common illnesses such as asthma, colds and flu. A study cited by Greening America's Schools put reductions in the 15 %range. Reviews of five national workplace studies by Carnegie Mellon University put green-building related asthma reduction at 38.5 percent. One of ten children in the U.S. suffers from asthma. A broader review of the 17 studies by Carnegie Mellon found an average occupant health improvement of 41% in the green buildings (Tobias, 2009).

Green facilities have been associated with increased teacher retention and improved attendance. The Green School designs which incorporate proper ventilation, acoustical quality and other environmental factors result in improved students and teacher's health along with higher attendance (Bardacke , 2009 ; Pennybacker,2005).Improved students test scored have been associated with Green Schools through improved learning environments. Adequate daylighting and improved site planning have shown increase in student performance by 25 %(Bardacke, 2009: Earthman 2002).

The impact of building construction on the environment is low due to Green School facilities (Bardacke, 2009). Green School facilities set an example for future generations, showing that environmental quality is crucial to long term well-being. A sustainable facility can become teaching tool, featuring concepts of science, math and environmental curriculum (Bardacke, 2009). Green school facility improvements directly related to student performance are additional daylight, improved indoor air quality, enhanced classroom acoustics, and comfortable and consistent indoor temperatures (USGBC, 2008).

2.2 Thermal comfort

An alternative to traditional comfort theory - termed the "adaptive model" of comfort - embraces the notion that people play an instrumental role in creating their own thermal preferences. This is achieved either through the way they interact with the environment, or modify their own behavior, or because contextual factors and past thermal history change their expectations and thermal preferences (de Dear et al, 1997)

Studies done by de Dear and Brager show that PMV model works well for buildings with HVAC systems. Studies have also indicated that in naturally ventilated buildings, people can accept higher indoor temperature (ASHRAE Standard -55, 2013).

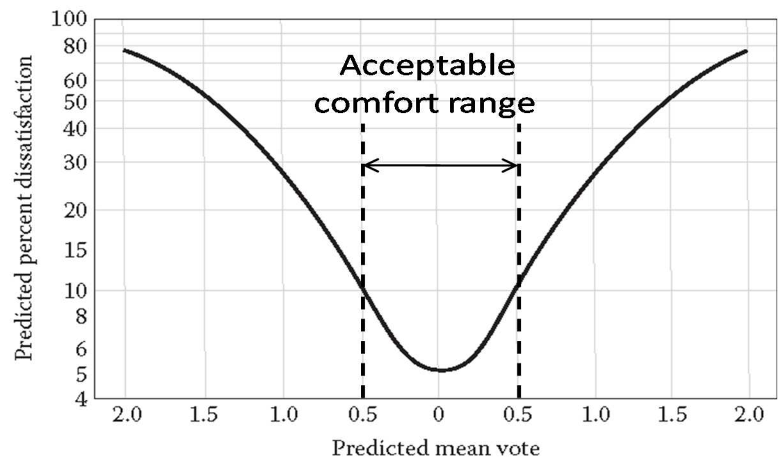

Figure 2.2, plotted PPD (predicted %of dissatisfaction) versus the PMV (predicted mean vote (ASHRAE Standard -55, 2013)).

The ASHRAE seven point comfort scale is for predicted mean vote (PMV) is given by -3 cold , -2 cool , -1 slightly cool , 0 neutral , 1 slightly warm , 2 warm and 3 hot. The PMV depends on two main factors Clothing insulation (clo) and Activity level (met), along with other secondary physical factors like air temperature, mean radiant temperature, air velocity and humidity (ASHRAE journal, Olesen Byarne,). Percent of People Dissatisfied (PPD) is the mean vote of the people voting outside the range of -1 to +1.

The comfort range of any given population differs based on the climate type. People usually tend to adapt to the changing environmental conditions. The results of field study conducted by Nicol and Humphreys (1973) in UK, India, Iraq and Singapore showed that temperatures above 30^{o} Celsius is not considered uncomfortable. One of the surveys conducted in an office building in Pakistan was to determine effectiveness of adaptive actions to achieve comfort by changing cloths and air movements (due to fans).The survey results showed that with changing indoor temperature and comfort the building was found to be comfortable between 20^{o} and 30^{o} C (Nicol et al 1999).

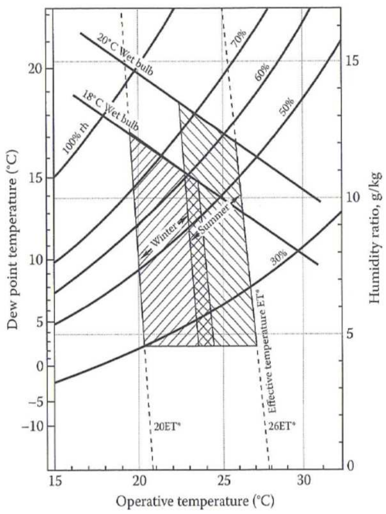

Figure 2.3, Acceptable range of operative temperature and humidity for typical summer and winter clothing. (Source ASHRAE, Standard 55-2013)

Figure 2.3 shows the acceptable range of operative temperature and humidity for people in typical summer and winter clothing during light and primarily sedentary activity. The ranges are based on 10 % dissatisfaction.

2.3 Daylighting

Katz (2006) showed that Green Schools use an average of 33 percent less energy compared to conventionally designed schools. He concluded that typical energy performance improvements must include more efficient lighting, greater use of day lighting and sensors, efficient heating and cooling systems and better insulated walls and roofs. Decrease in energy consumption in Green Schools has two main financial benefits: (i) Green Schools reduce the energy costs. (ii) They reduce overall market demand and which result in lower energy prices market-wide. (Katz, 2006)

Instead of relying on electric lights during the day, daylighting brings indirect natural light into the building. Daylighting has been shown to create calmer and productive environment because it connects people to the outdoors and also reduces the need for electric lights (Molinski, 2009). Sunshades and sunscreens are structures on the exterior of a building that reflect indirect lighting into a building. Molinsky concluded that by incorporating daylight harvesting into facility, a potential savings of 15%to 40%in energy costs could be achieved. According to Westfall (2003), effective daylighting can provide many benefits to schools including energy savings, increases in student test scored and attendance and a better learning environment for students.

Local climate condition must be considered as the seasons of the year and the angles of natural light. Several factors, such as surrounding mountains, trees and other buildings, affect the amount of daylight a facility receives (Gleed, 2009).

CHAPTER 3

CLIMATE AND BUILDING DESIGN SPECIFICATIONS

3.1 Climate Analysis

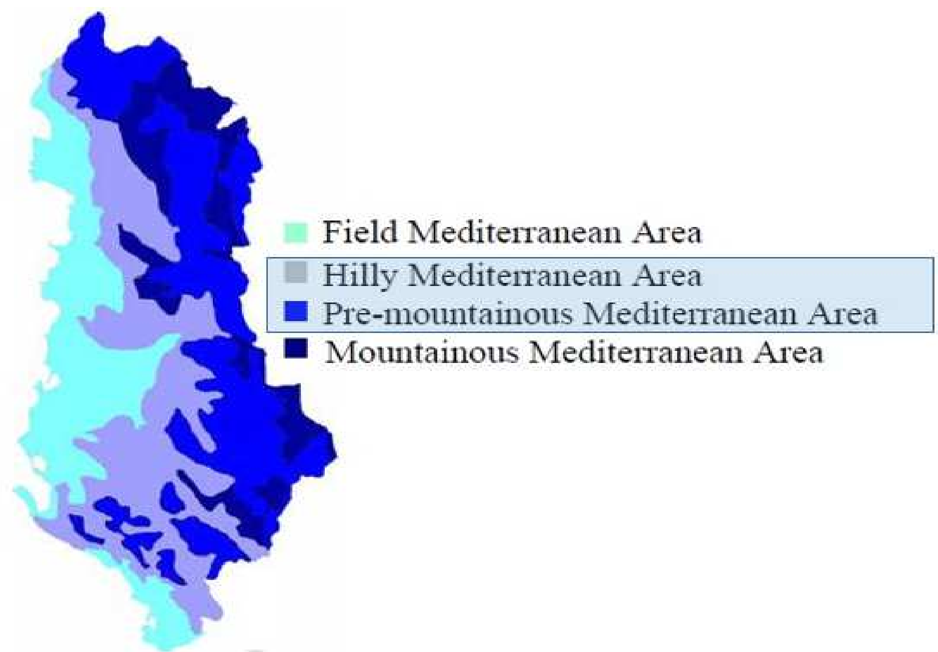

Figure 3.1 Climate divisions in Albania (Source: IHM 1978)

Albania is a Mediterranean country and lies between latitudes 39° and 43° N, and between longitudes 19° and 21° E. It is located on the western side of south east Europe surrounded by neighboring countries of Greece on the south and south eastern side, Macedonia and Kosovo to the East, and Montenegro to the north, with its western border being the Adriatic and Ionian Sea. The region has mostly mountainous topography and can be divided into three climatic zones namely, Field Mediterranean Area (which is the coastal area), Hilly and Pre-mountainous Mediterranean Area and the Mountainous Mediterranean Area (Figure 3.1). The weather data for each climate zone were not available online to download .Therefore they were acquired from White Box Technologies, Inc. The weather file for

Durres (Field Mediterranean Area), Tirana (Hilly and Pre-mountainous Mediterranean Area) and Korca (Mountainous Mediterranean Area) had the weather data for the following years

Durres is simply the historical weather file for 2013, since there was just 2 years of full data. Tirana is a "typical year" weather file created from data for 2001 through 2013.The selected years for the 12 months are as follows January (2010), February (2006), March (2005), April (2005), May (2005), ,June (2010), ,July (2010), August (2007), September (2010), October (2009), November (2005), December (2003). Korca is a "typical year" weather file created from data for October 2011 through September 2014, i.e., 3 years. The selected years for the 12 months are January (2013), February (2013),March (2014),April (2013),May (2012),June (2013),July (2013) ,August (2012), September (2013),October (2013),November (2012),December (2011).

3.1.1. Field Mediterranean/coastal climate: Durres

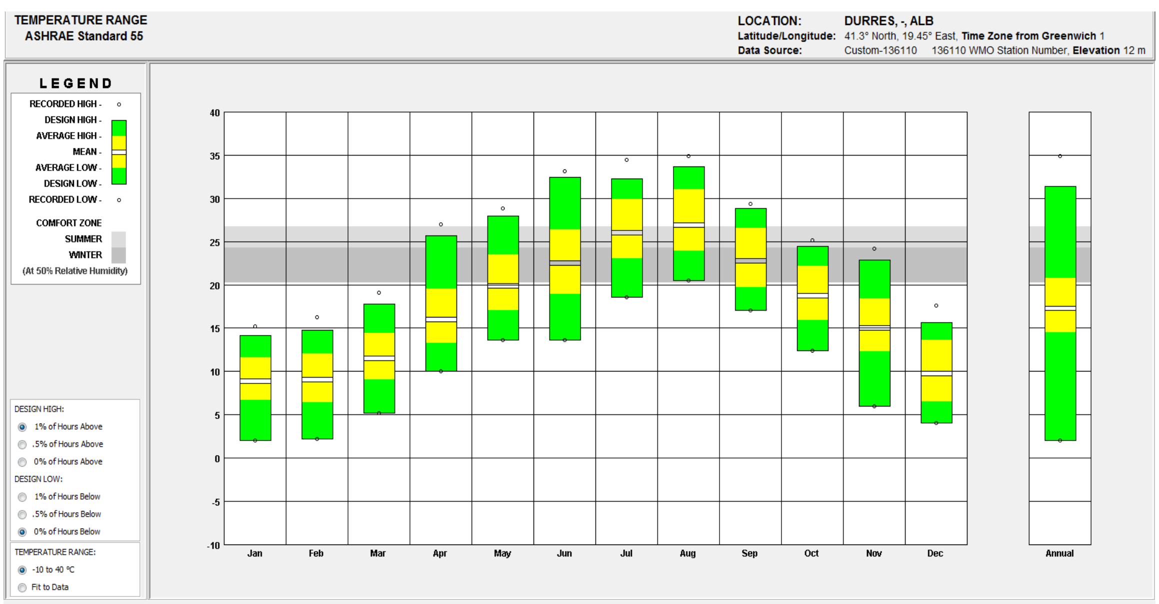

Figure 3.2 Average monthly temperature range in Durres (from Climate Consultant software)

Durres (41°19′N, 19°27′E) is located along the coastal belt of Albania at sea level. The temperature ranges between 22 – 33ºC in summer and between 2 – 13 ºC in winter. June, July and August are the hottest months. The winters are basically wet and cold. December through March are the winter months, during which the outdoor temperature is below comfort zone. In summer, (June to August) the outdoor temperatures are above comfort zone (see Figure 3.2). During the remaining months, the weather is moderate and pleasant. Figure 3.2 shows the monthly mean, maximum and minimum temperature for Durres, along with average outdoor comfort zone temperature range for the summer and winter months. Average relative humidity ranges from 63 percent to 72 percent. Figure 3.3 shows the annual prevailing wind direction in Durres. It is observed that the wind direction and speed in Durres changes throughout the year and are not from any particular direction.

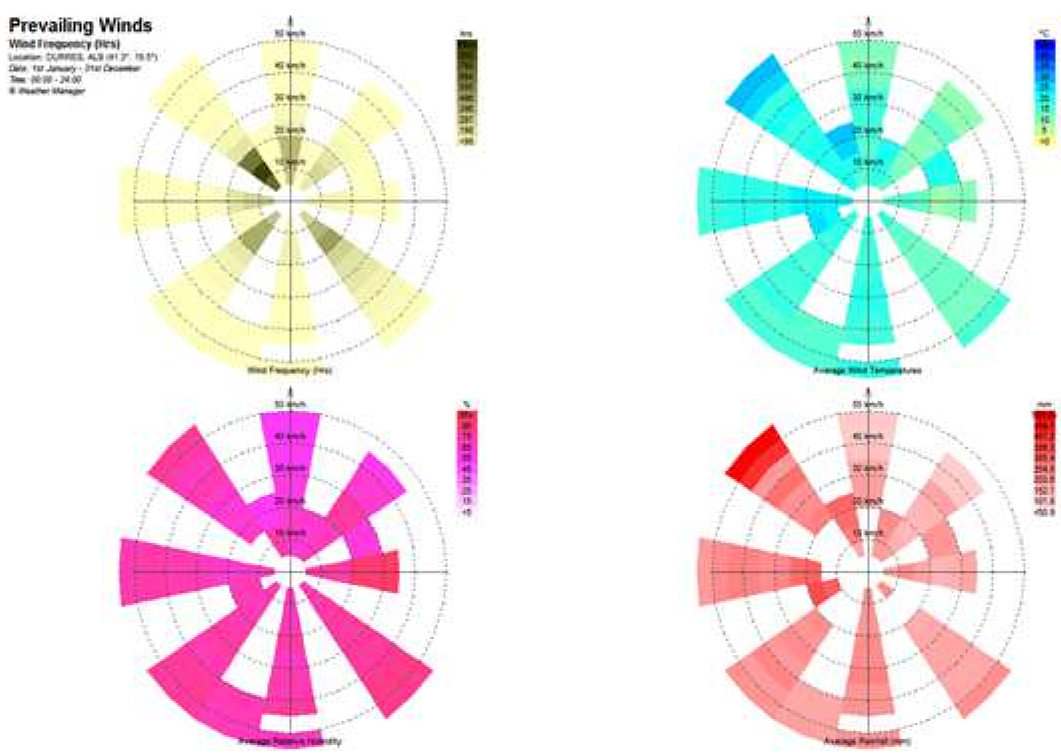

Figure 3.3 Annual prevailing winds in Durres (from Ecotect software)

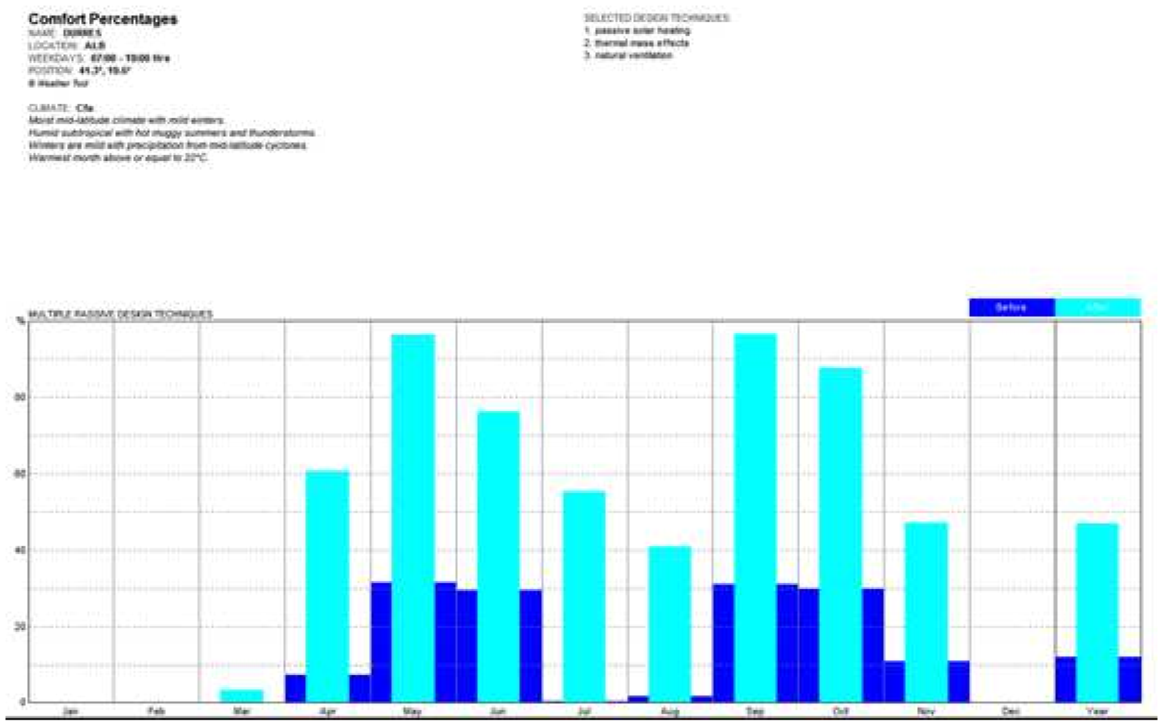

Figure 3.4 monthly comfort percentage achieved through passive design techniques in Durres (from Ecotect software)

Figure 3.4 shows the annual comfort percent that can be achieved using passive design techniques such as natural ventilation, thermal mass effect and solar heat gain in Durres. The analysis was done using Ecotect software which predicts such comfort percentages. The annual comfort percentages bar graph shows that overall it is possible to achieve up to 90% comfort in Durres using passive design techniques. Highest comfort percent above 80% are experienced in the months of May, September and October.

3.1.2. Hilly and pre-mountainous Mediterranean area: Tirana

Tirana (41°19′48″N 19°49′12″E) is the capital of Albania and lies in the Hilly/Pre mountainous area. The summers are very hot and reaches maximum temperature of 40 ^{o}C, and during winters the temperature drops down to – 7 ^{o}C. Figure 3.5 shows the monthly average temperature range. The outdoor temperature for winter is below comfort zone from November to March, while in summer the outdoor temperature is above comfort zone from May to September (see Figure 3.5). The average relative humidity is between 79 % to 94 %. There is some amount of rain throughout the year in Tirana.

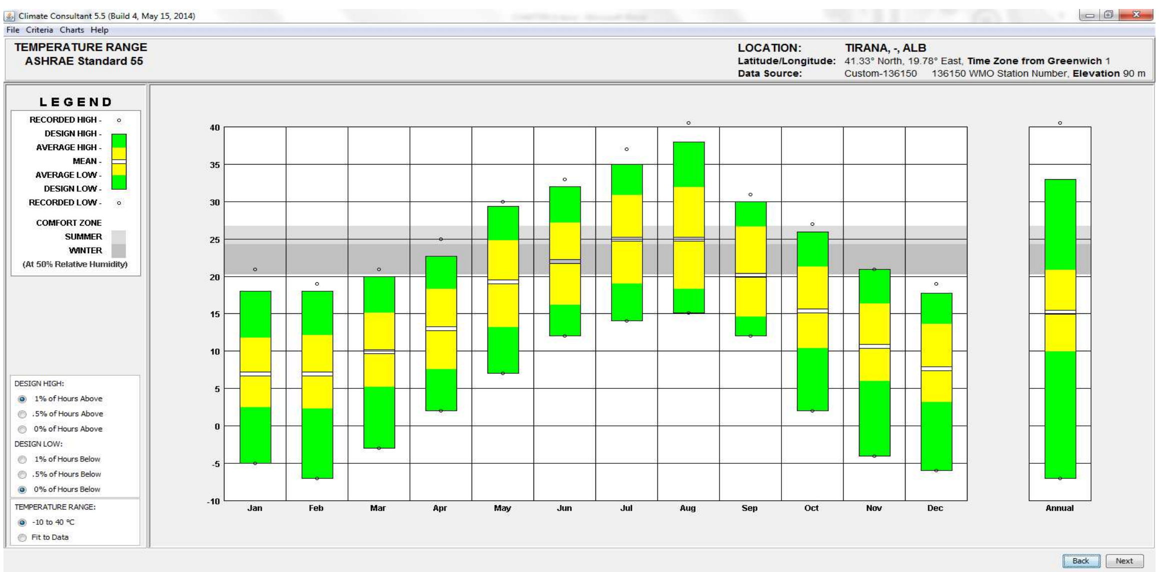

Figure 3.5 Average monthly temperature range in Tirana (from Climate Consultant software)

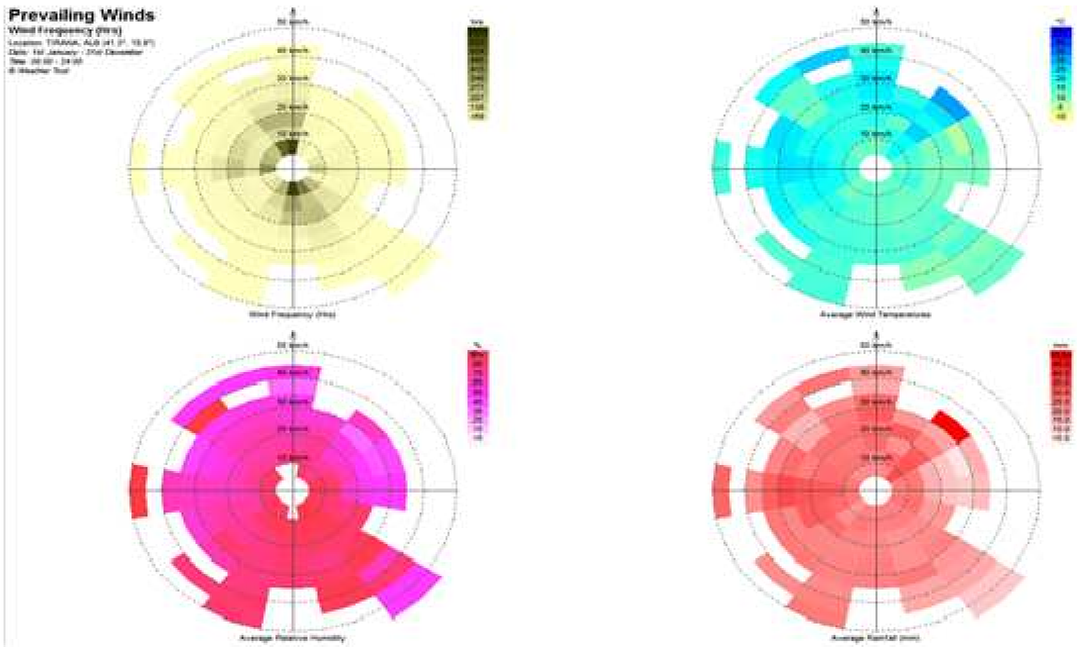

Figure 3.6 Annual prevailing winds in Tirana (from Ecotect software)

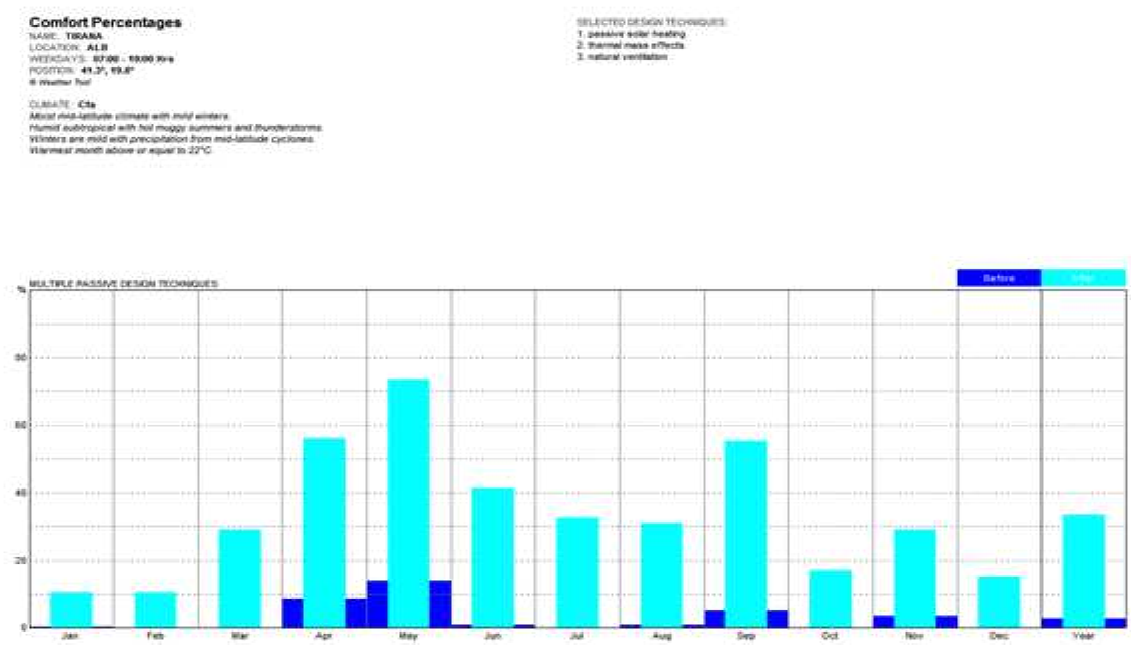

Figure 3.7 monthly comfort percentage achieved through passive design techniques in Korca in Tirana (from Ecotect software)

The prevailing wind direction in Tirana is from northwest and south east over the entire year (see Figure 3.6). The average annual wind speed is around 2m/s. Figure 3.6

summarizes the annual prevailing wind frequency, average wind temperature, relative humidity and average rainfall. Some amount of rainfall is seen throughout the year. Figure 3.7 shows the annual comfort percent that can be achieved in using passive design techniques in Tirana. The comfort percent that can be achieved using passive design techniques is low for Tirana (see Figure 3.7). Maximum comfort could be achieved using passive techniques in April (58 %), May (74 %) and September (58 %). For rest of the year, the comfort %would be an average of 23 %.

3.1.3 Mountainous Mediterranean Area: Korca

Korca (40°37′N, 20°46′E) is located in Mountainous Mediterranean area of Albania at 830 m elevation from sea level. The temperature is between 12 – 34^{o}C in summer and in winter between 10 – -7 ^{o}C. June to August are the warm months. December, January, February, March are the coldest months. Figure 3.8 shows the average monthly temperature

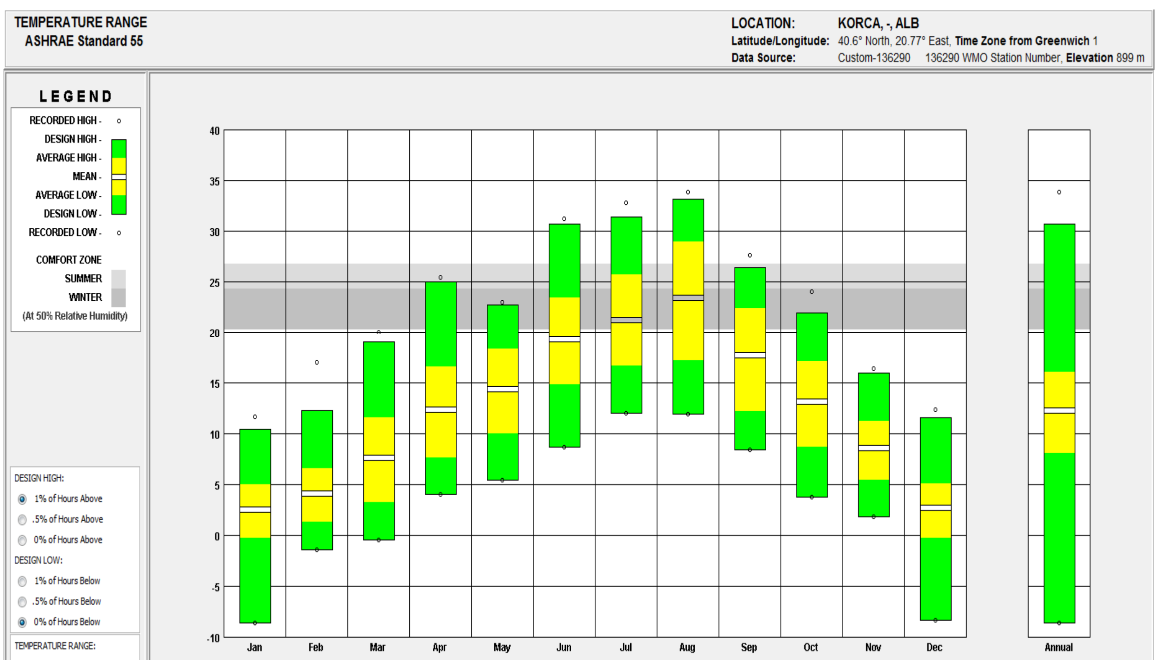

Figure 3.8 Average monthly temperature range in Korca (from Climate Consultant software)

range in Korca. The outdoor temperature in winter is mostly below the comfort zone from October to March. In summer, the maximum outdoor temperature is above comfort zone from June to August (see Figure 3.8).

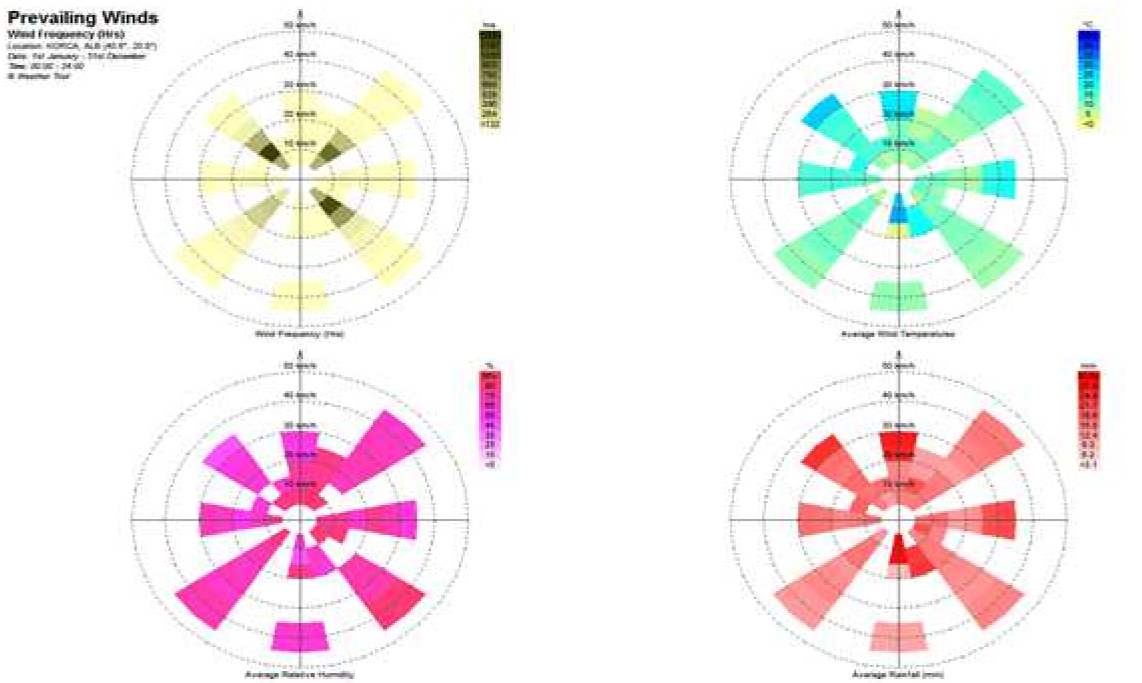

Figure 3.9 Annual prevailing winds in Korca (Ecotect)

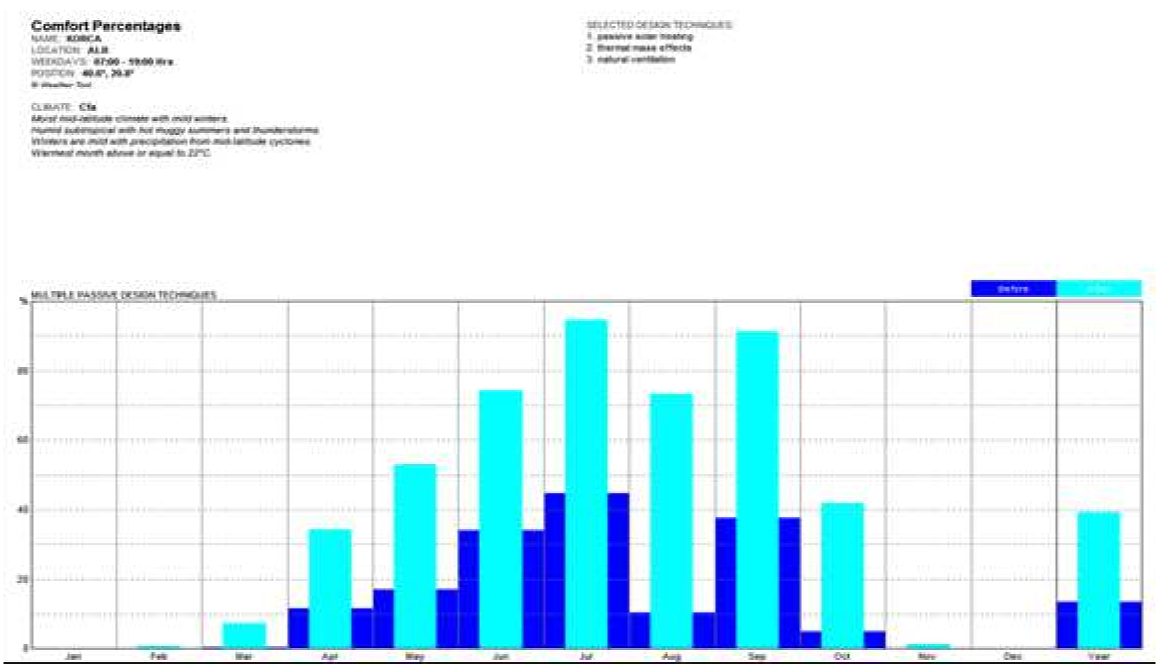

Figure 3.10 monthly comfort percentage achieved through passive design techniques in Korca (from Ecotect software)

The average relative humidity in Korca is 63 % to 83 %. The average annual wind speed is between 1 m/s to 4m/s Figure 3.9 shows the annual prevailing wind directions. It also shows the annual wind temperature, average relative humidity and average rainfall for Korca. Ecotect software suggests that in Korca, during the extreme winter months from November to March, comfort cannot be achieved using passive designs techniques. Maximum comfort could be achieved using passive design techniques during the warm summer months from June to September in Korca. Figure 3.10 shows the monthly comfort percentage that could be achieved from passive design techniques like natural ventilation, thermal mass effects and passive solar heating.

3.2 Overview of existing building design and condition

Data was collected of typical school buildings and campus setting of pre-2000 construction era .Total of 18 schools were documented across different climate zones. The collected data provide an overview of building infrastructure and existing facilities. The collected data was then categorized into three different building types as follows:

a. Type 1 – This is a one-story freestanding buildings housing kindergarten or 1-3 or 1-9 grade schools. Construction of these schools is made up of plastered, masonry (brick) bearing walls with hipped, wood –framed roofs with clay file roofing; double-loaded corridor plan layout with some courtyard plans.
b. Type 2 – This is a two-story free standing, kindergarten + K-9, grades 10-12 schools, either with hipped-wood framed roofs or flat modern roofs. They were either plastered, masonry (brick) bearing walls or concrete frame with infill brick masonry for walls and

floors / roofs. They had double-loaded corridor plan with linear block, L-layout, or T_layout in plan view.

Figure 3.11, Documented school buildings classified into different types

c. Type 3 – Building are three to four story free standing grade 1-9 and grades 10-12 schools with concrete frame construction with infill brick masonry for walls and floors/roofs. They have typical flat, modern roof form with minimal overhang and have double-loaded corridor plan with linear block, L-layout, or T_layout plan form.

It was determined that there were not many differences between building Type 2 and Type3. Therefore to justify another building type it was decided that Type2 and Type 3 be clubbed together as Type 3 for further analysis. Figure 3.11 assembles photos of surveyed existing school buildings been classified into the two different building types.

a. Building Type 1: Rural School Building

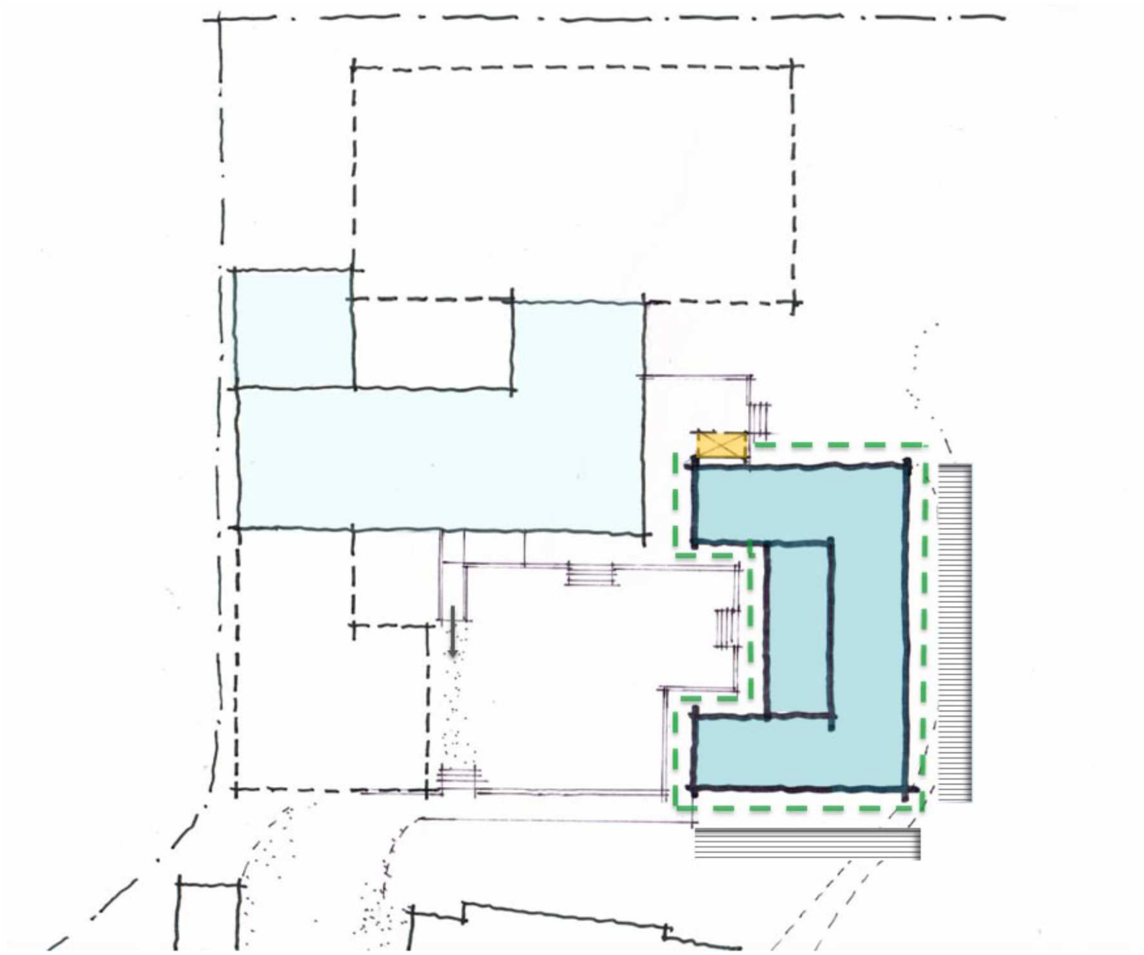

Figure 3.12: Building Type 1 – Rural School Building Site Plan

Architecture Overview

The School is a 33 years old (circa 1979) single story building having Mediterranean style architecture located in rural regions of Albania. The school has a U-shaped plan consisting of classrooms, corridor, computer lab, and office spaces. The exterior and interior walls are made of brick and finished with stucco on exterior and with cement plaster on interior walls. The classrooms have ample daylight coming through window openings with not much need for artificial lighting. The roof is supported by wooden battens and rafter with clay tiles on the exterior.

Existing Building Condition.

Consistent with pre-2000 Albanian schools, the building has not received any significant upgrades or improvements in the last 20 years. It lacks the basic amenities and modern HVAC systems. The building has no heating or cooling system to mitigate against extreme weather conditions. The existing roof construction results in high amount of heat loss

a. Existing School Building

b. Roof Exterior

c. Roof detail from inside

d. Classroom with wood stove

Figure 3.13 (a, b, c, d) show the exiting building Type 1 interiors and exteriors. (Refer Appendix A for architectural floor plans of building Type 1)

during the winters which compromises the interior space comfort. The building electrical wiring is not adequate for any kind of lighting and plug load requirement. Classrooms are typically lit through a single incandescent lamp hung from the ceiling on exposed wires.

b. Building Type 3 – Urban Building

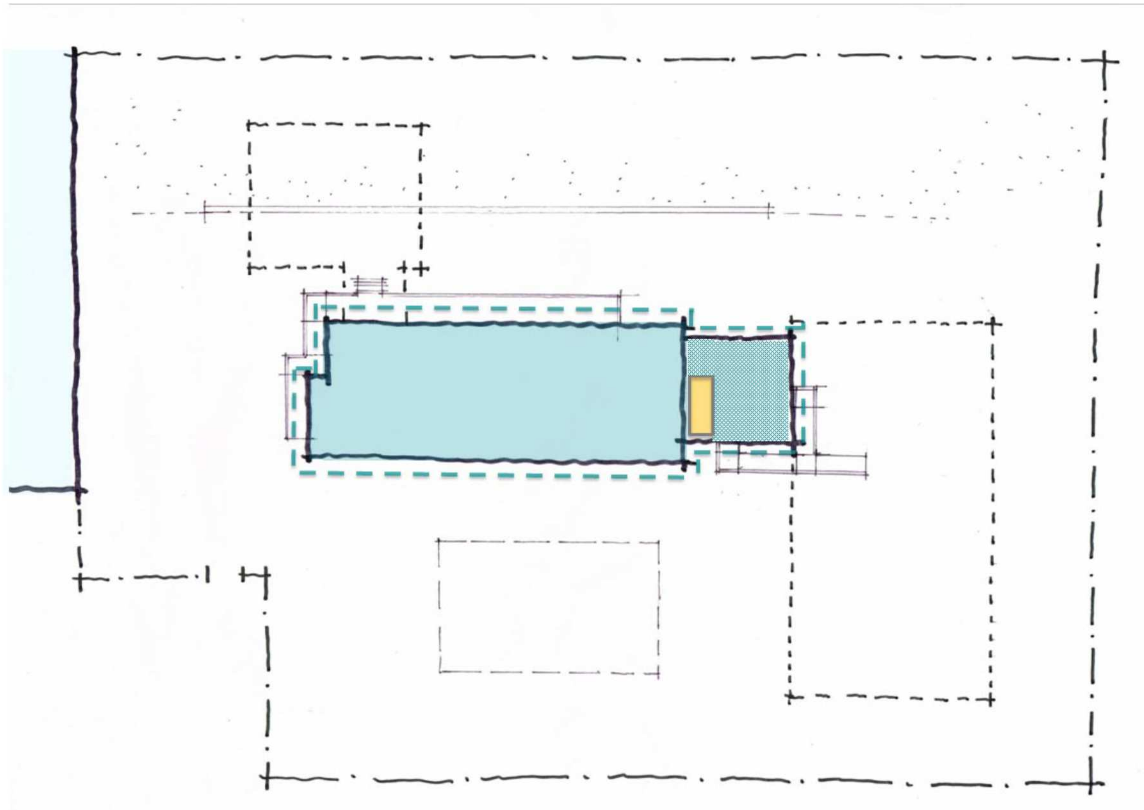

Figure 3.14: Building Type 3 – Urban School Building Site Plan

Architecture Overview

This 46 years old (Circa 1968) school building is a three story structure built in early modern era of school construction for the higher grades and located in urban locations. It is a framed structure with high mass construction and has significant amount of daylighting coming through window openings.

Existing Building Condition.

The school has not received any upgrades for last 20 years and lacks the basic modern amenities and facilities. Most of the window panes are broken which make the indoor space very uncomfortable during the cold winters and hot summer months.

a. Type3 Building Front

b. Type 3 Building Rear

c. Central Corridor

d. Wall detail

e. Typical Type 3 Classroom

Figure 3.15, (a, b, c, d, e,) show the exiting building Type 3 interiors and exteriors. (Refer to Appendix A for architectural floor plans of building Type 3)

The school is able to barely function for so long only due to high mass construction and ample of daylighting through windows. The school building does not have any kind of heating or cooling systems. The classrooms have typically single incandescent lamps hung from ceiling on exposed wires or two. 4 feet single florescent lamp fixtures. Electrical service to the building and the existing electrical wiring systems are not adequate for lighting and plug loads requirements.

3.3 Building design upgrades

It is decided that the building design be upgraded from their exiting condition and classified into three different retrofit Tiers for further comparison and analysis of the energy use and thermal comfort. The different cases mentioned below will be evaluated.

a. Tier 1: The existing building is upgraded by (Refer Appendix B for specification)
    1. Repairing /replacing the broken glass windows with clear glass with aluminum frame.
    2. Repairing / replacing existing broken fluorescent light fixtures with T8 lights.
    3. Installing new electrical system including wiring, panels, outlets, switches
    4. Installing new low voltage wiring for computer network systems and existing computer room internet, phone

b. Tier 2: building upgrades include the following
    1. Adding new exterior rigid insulation and stucco system to exterior building walls
    2. Adding insulation to building roof
    3. Replacing all windows with quality, operable, dual pane, low emissivity windows

4. Adding of exterior louvers on south and west sides of building for coastal climate zone only for building shading
5. Installing interior window shades
6. Installing in each class wall mounted ceiling fans in Coastal and Hilly/Pre mountainous regions and mountainous regions.

c. Tier 3: Upgrade work is aimed at improving the building sustainability by addition of passive and active energy systems. Three cases identified

1. Addition of Solar thermal system for radiant space heating
2. Solar thermal system for hot water
3. Solar photovoltaic system to take care of the electric load due to plug loads and lighting.

The above three Tier upgrades are evaluated against three scenarios to determine energy consumption and indoor comfort percentages for each case. (Refer Appendix B for detailed specification)

1. No Heating and Cooling (PLL)
2. Heating Energy with Baseboard (H+PLL)
3. Heating and Cooling System (HC+PLL)

3.4 Building Codes and standards

The following building codes and standard formed the basis of creating the building specification for each building upgrade Tiers (See Appendix B for Tier Specification)

a. Standards Adopted by Albania Ministry of Education, (December 2012, Guidance for Designing the School Building, Norms and Standards, Volume I, General Guidelines.)

The guide prepared for the ministry of education, science and technology (MEST) of Kosova describes the necessary educational building facilities by Type, size and specification as per the standards and requirements set by the ministry of education for public schools in urban and rural areas in Albania. The standard describes individual design concepts based on location, Building Type, school plan, size of the school capacity of teaching room. The norms for built spaces include the internal spaces, outdoor spaces, functionality and flexibility, design and aesthetics and cost and budget parameters. The standard also mentions various parameters for comfort, some of them are meant to improve climate comfort which can be achieved by passive design methods like building orientation, location and size of the opening, thermal insulation etc., or through artificial measures which includes mechanical and electrical methods like heating, ventilation and air-conditioning. For visual comfort, it specifies the standard that need to be complied with natural and artificial lighting. Other parameters which include heat, ventilation, hot water, and design safety, systems for fire protection, maintenance, furnishing and equipment are also addressed.

b. International Building Code 2012 (*Building Codes Illustrated, Volume 6: Building Codes Illustrated: A Guide to Understanding the 2012 International Building Code* (4th Edition ed.). (n.d.). John Wiley & Sons.)

This code is designed to meet the requirements of an up-to-date building code addressing the design and installation of building systems emphasizing performance. It also safeguards against public health and safety in all communities, large and small. This building code establishes minimum regulations for building systems using prescriptive and performance-related provisions. It is founded on broad-based principles that make possible use of new materials and new building designs. The International Building Code has many benefits. It provides a model code development process which offers an international forum for building professional to discuss performance and prescriptive code requirements. This model code also encourages international consistency in the application of provisions.

c. European (EU) Standards

The European standard are standards developed by European Committee of Standardization (CEN), which is a nonprofit organization whose mission is to foster the European economy in global trading, the welfare of European citizens and the environment by providing an efficient infrastructure to interested parties for the development, maintenance and distribution of coherent sets of standards and specifications. CEN has created a set of technical rules for structural design of construction works in European Union, these rules are called as Euro codes. The purpose of these codes is to provide European Union Law compliance with the requirements for mechanical strength and stability and safety; they also provide a basis for construction and engineering contract specifications and provide a framework for creating harmonized technical specifications for building products

d. Sustainability Standards

i. US LEED

Leadership in Energy and Environmental Design (LEED) is a set of rating systems for the design, construction, operation, and maintenance of green buildings, homes and neighborhoods. LEED has been designed by U.S Green Building Council (USGBC), and its intention is to provide help to building owners and operators to be environmentally responsible and use the resources efficiently.

ii. British BREEAM Rating Systems

Building Research Establishment Environmental Assessment Method (BREEAM), is a method of assessing, rating, and certifying the sustainability of buildings. It is one of the earliest environmental assessment methods and was developed in United Kingdom in 1990. BREEAM has been created to raise awareness amongst owners, occupiers, designers and operators of the benefits of sustainability. It helps adoption of sustainable solutions which are cost effective and also makes them environmentally friendly which provides a market recognition of their achievements.

e. ASHRAE 55 (Adaptive Comfort Standard)

The standard provides acceptable range of indoor conditions that are acceptable to accomplish thermal comfort for occupants. The ASHRAE adaptive model provides a relationship between operative temperature for indoor comfort and mean monthly outdoor temperature for naturally ventilated spaces.

3.5 Tools used for analysis

a. Climate Consultant

Climate Consultant was used to analyze the climate data for each location. It is an easy to use free graphic software which helps one to understand the required climate data. It uses EPW file format weather data to generate meaningful graphs. Based on the comfort model selected, the climate consultant produces monthly graphs showing temperatures range, radiation range, illumination range, sky cover and wind velocity range, sun shading charts, 2D and 3D graphs for solar radiation and psychometric charts. The program also suggests design strategies which can be adopted for the specified climate zone. Based on these factors one can analyze the impact of climate on the performance of the building.

b. Autodesk Ecotect

Ecotect is a 3D analysis program by Autodesk, which can be used to analyze various aspects of building performance. For this study, Ecotect was used to analyze the weather data and to determine the comfort %for using passive design techniques like natural ventilation, thermal mass effect and solar heating.

c. AutoCAD 2015

The existing building prototype drawings were drafted in AutoCAD which is a 2D and 3D design and drafting software developed by Autodesk.

d. eQuest

eQuest is one of the most popular and widely used energy modelling software for detailed building design analysis .It is built on the powerful DOE2.2 energy simulation engine. In this research, the eQuest simulation software was used to predict hourly energy use in conditioned spaces, and hourly indoor temperature for unconditioned spaces each zones for building Type 1 and Type 3.

e. PV Watts

PV Watts online software was used to determine the monthly energy generated from the photovoltaic system. It has been developed by the National Renewable Energy

Laboratory (NREL) which provides estimates of the electricity production and cost of energy of grid connected photovoltaic energy system for numerous locations worldwide.

CHAPTER 4

SIMULATION SCENARIOS OF ENERGY USE & INDOOR OCCUPANT COMFORT

This chapter describes various scenarios which were identified and then simulated to determine energy use and indoor occupant comfort. The simulations were performed on an hourly basis using actual climatic data from the Albanian locations which are then combined into monthly and annual estimates for reporting and analysis purposes.

4.1 Energy calculations

The numerous scenarios identified for simulation and analysis consist of are summarized in a flowchart depicted in Figure 4.1 and briefly described below:

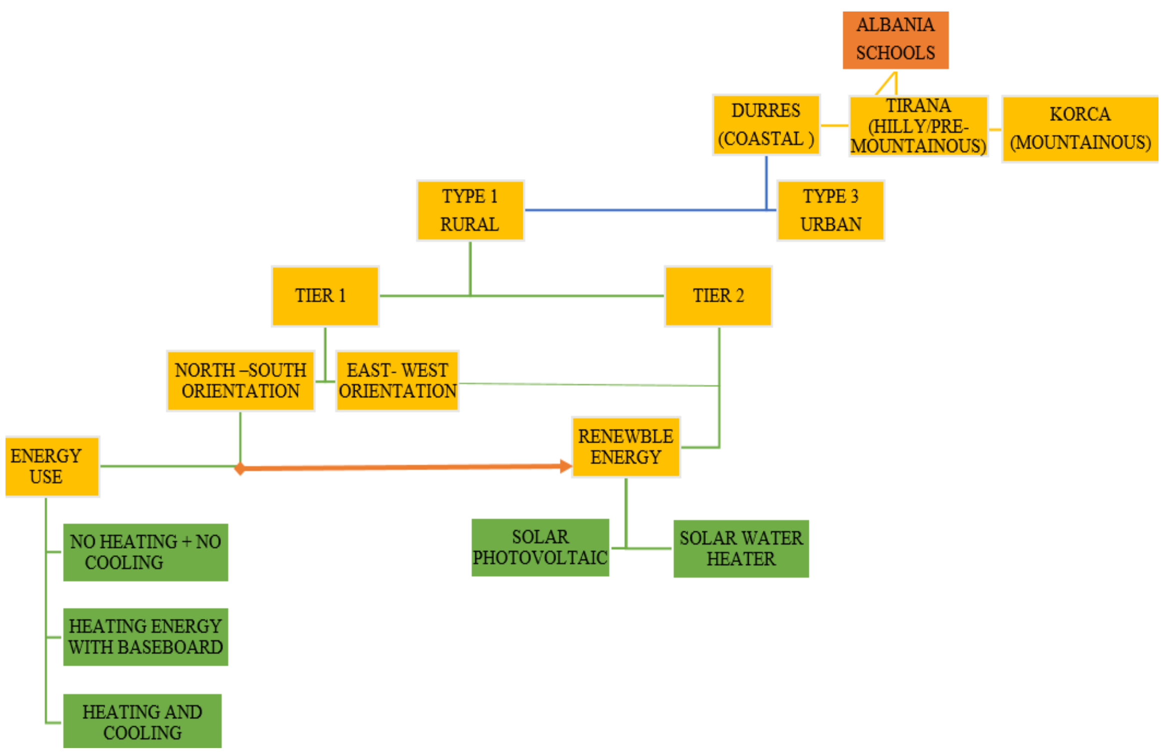

Figure 4.1 Overview of different scenarios considered for energy and comfort analysis.

1. Climate Zones: Three cities representative of the diversity of climate zones to be found in Albania were identified (Refer to Chapter 4: 4.1 Climate Analysis)

    a. Coastal Climate : Durres
    b. Hilly/Pre-mountainous climate : Tirana
    c. Mountainous climate: Korca
2. Building Type (refer to Chapters 4: 4.2 Building Design):
    a. Type 1: This represents a typical single story school building located in rural regions of Albania having a total floor area of 590.8 m^2.
    b. Type 3: This represents a typical three story school building in urban areas of Albania having total floor area of 2594.61m2.
3. Upgrade Levels: Two "Tiers" of building upgrades were identified (explained fully in Appendix B).
    a. Tier 1 : It includes the following upgrades to the conditions in the majority of the existing schools:
        i. Repair/replace current windows with aluminum frames with single glazing.
        ii. Repair/replace existing fluorescent light fixtures.
        iii. Install a new electrical system.
        iv. Install new low voltage wiring for computer network systems and existing computer room (which will include 1 new copier, 1 new printer ,6 new computers and 1 projector with 1 laptop)
    b. Tier 2: This would represent upgrades to Tier 1. It will include following upgrades:
        i. Addition of new exterior rigid insulation and exterior stucco to exterior building walls.

ii. Added insulation to roof
iii. Replace all existing windows to operable double low-e windows.
iv. Add exterior louvers on south and west sides of building (coastal climate zone only) for building shading.
v. Install wall mounted electric fans to provide ventilation and cross-flow to enhance indoor comfort.

4. Building Orientation: In order to evaluate the effect of building orientation, while limiting the number of scenarios, only two orientation were assumed north-south and East-west axis. Analyzing these two extreme cases would allow us to evaluate the importance of building orientation on our analysis results.
5. Energy use simulations for the following instances are to be done:
   a. No Heating & Cooling provided to the school building but includes electric plug loads and lights (PLL)
   b. Heating system provided to supply thermal energy with baseboard terminal devices plus electric plug loads and lights (H+PLL)
   c. Heating & Cooling system with split air-conditioner plus electric plug loads and lights (HC+PLL)

   Altogether, the various combinations result in 36 scenarios for which energy simulations were performed whose results are assembled in Appendices C and D.
6. Inclusion of Renewable Energy systems. Two different types of solar systems are to be evaluated:
   a. Solar photovoltaic system on building roof to meet the PLL loads

b. Solar water heater to meet the thermal heating and service hot water needs of the school

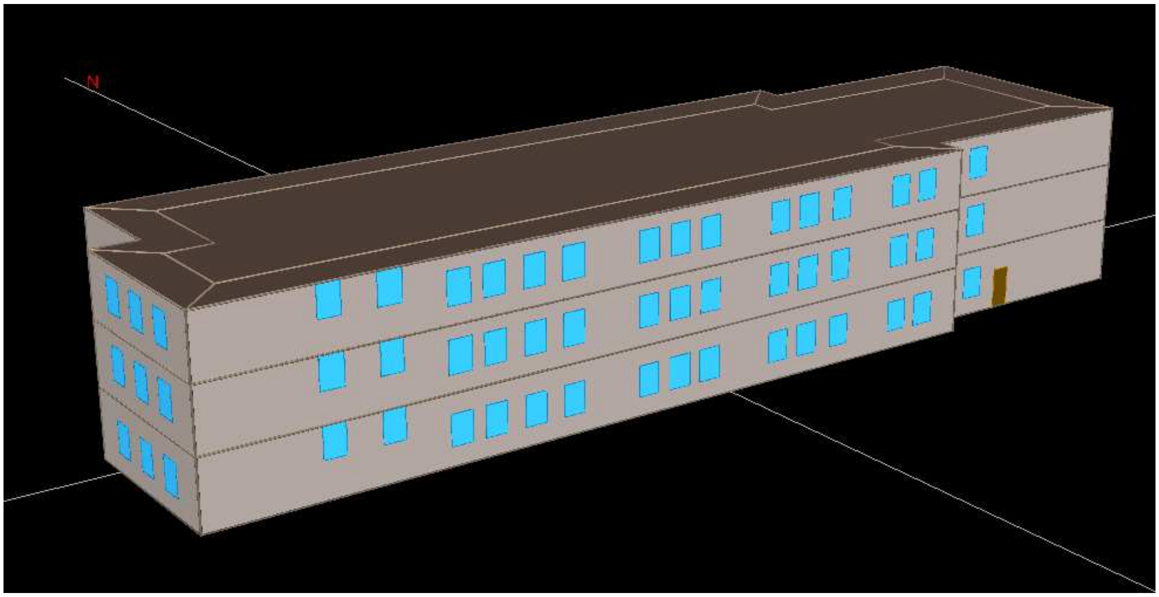

Figure 4.2 3D rendering of building Type 3 modeled in eQuest software.

The existing building layout is first sketched in Autocad 2014 software and then imported into the detailed building energy software program eQuest.The eQuest software was deemed most suitable to perform simulations to determine comfort energy needed in all the various scenarios shown in Figure 4.1. Some important considerations are described below:

(i) Daylight sensors are assumed to be present along each building periphery zone so as to allow eQuest to consider the control option that lights could be switched off when there is adequate daylight. Though in actuality such sensors are not to be installed, such an assumption would replicate the actual case where the switching off lights will be done manually by the occupants.

(ii) The glass Type for windows were seleted depending on the thermal heat loss coefficient (U-value) , solar heat gain coefficient (SHGC) and visible transmittance (VT) required for each climate.

(iii) Window overhangs were assumed on the south and west side of buildings located in coastal climate only.

(iv) Four separate zones long the four perimeter direction with no inner or core zone were considered for building Type 1 and Type 3.

(v) Occupied period for both building types is taken to be 7am to 7pm.The school is considered to be closed on Saturdays and Sundays.

(vi) The building set point temperature for heating is taken to be 64^{o}F for unoccupied hours and 70^{o}F for occupied hours. For cooling, the set point is taken to be 82^{o}F during unoccupied hours and 74^{o}F during occupied hours. The temperatures are assumed based on Adaptive model for 80 % acceptable range.

Further detailed specifications considered during the eQuest model development are described in Appendix B. The results generated from eQuest for each instance are then exported to a spreedsheet program for further analysis.

4.2 Indoor thermal comfort calculations

The analysis also requires that indoor thermal comfort conditions be predicted for the existing schools under two scenarios.

1. No heating and no cooling (PLL)
2. Heating energy with baseboard (H+PLL)

Existing software programs which could calculate the hourly indoor temperature for given climatic conditions, wind velocity, temperature and direction when the windows are open are far too complex and inappropriate for the scope and objective of the present study. The eQuest simulation tool used for energy analysis is also able to predict hourly indoor temperatures when the windows are closed and when no heating or cooling system is present. Consequently, the indoor hourly temperatures for the whole year and for each zone of the building were generated in eQuest, and then exported into a spreadsheet program for further analysis. The data is first sorted on an hourly basis to limit the analysis only to occupied hours (7am to 7pm), and the remaining data representative of unoccupied periods was discarded. Next, the temperatures for each zone were converted from degree Fahrenheit to degree Celsius for the above two conditions.

The ASHRAE adaptive model provides a relationship between operative temperature for indoor comfort and mean monthly outdoor temperature for naturally ventilated spaces. This model was deemed most appropriate for the types of conditions prevailing in Albanian schools. The Adaptive model is given by the following equation (also plotted in Figure 4.3)

$T_{op,comf} = 17.8 + 0.31 \times T_o$

where,

$T_{op,comf} =$ operative temperature for indoor comfort, and

$T_o =$ outdoor temperature.

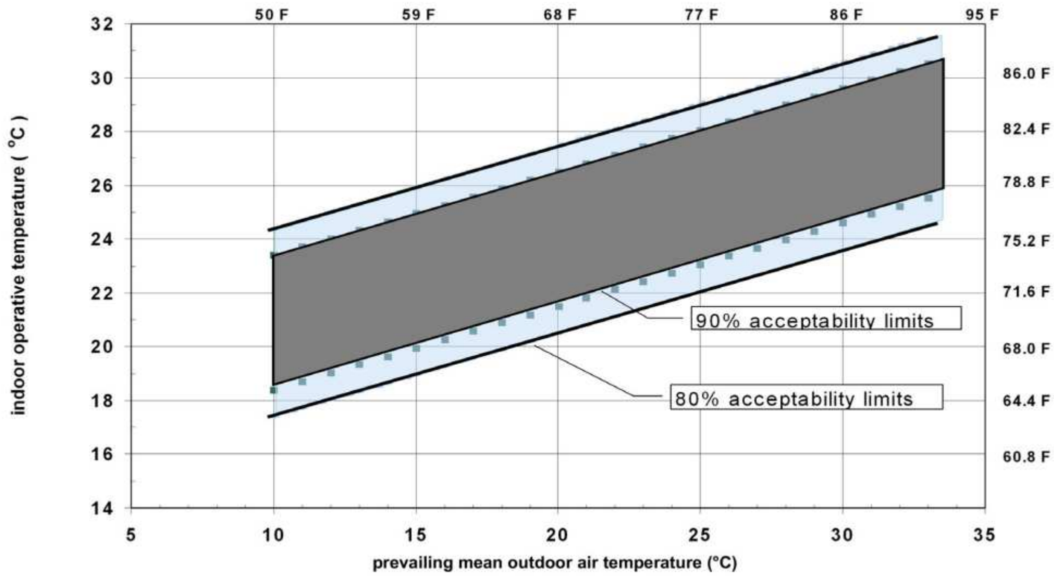

Figure 4.3 Acceptable operative temperature range for naturally conditioned spaces from ASHRAE standard 55, 2004

People in Albania have been acclimatized to indoor higher temperatures and higher humidity levels in summer than their counterparts in Europe or America. Therefore, thermal comfort in naturally ventilated spaces (i.e. which have openable windows which can be adjusted by the occupant as required) is assumed to conform to the 80 % acceptable limit shown in Figure 4.3 (ASHRAE standard 55, 2004).

Metabolic rate is taken to be 0.8 met (sitting / walking) and clothing level is assumed to be 0.4 clo in summer and 1.0 clo in winter. For the Albania climate, the 80%acceptable range for outdoor air temperature can be taken as: 17.4 ºC to 31.4 ºC (see Figure 4.3). Temperatures above and below this range will likely result in occupants being uncomfortable. Next, the total number of occupied hours during each month when occupants are likely to experience comfort can be determined from the outdoor air temperature and the indoor temperature for each zone predicted by eQuest. This information along with knowing the number of occupants in each of the zones allows monthly comfort percent for each zone to be is determined. Table 4.1 shows the total number of occupants in each zone per floor for building Type 1 and Type 3. Table 4.2 shows the monthly comfort percent values for each zone based on the 80% acceptable range and assumptions stated below.

Table 4.1 Total number of occupants per floor in each zone for building Type1 and Type3

Building Type	North -south orientation				East - west orientation				Total number of people per floor
	North	South	East	West	North	South	East	West	
Type 1	70	90	39	18	39	18	70	90	217
Type 3	98	98	25	16	25	16	98	98	237

Table 4.2 Monthly comfort percent values determined for each of the four zone for Building Type 3

	Outdoor	North		South		East		West	
No. of People		98		98		25		16	
Months	OD (%)	T1(%)	T2(%)	T1(%)	T2(%)	T1(%)	T2(%)	T1(%)	T2(%)
Jan	0	0	0	0	94	0	1	0	16
Feb	0	0	8	1	99	0	11	0	45
Mar	2	1	88	26	100	0	95	7	100
Apr	47	64	100	91	100	66	100	87	100
May	90	100	100	100	100	100	100	100	100
Jun	89	99	*89*	96	*89*	99	90	*86*	*89*
Jul	96	*95*	*96*	*89*	*96*	*92*	*96*	*77*	*96*
Aug	88	93	*88*	*60*	*88*	*81*	*88*	*54*	*88*
Sep	99	100	*99*	*96*	*99*	100	*99*	*97*	*99*
Oct	79	100	100	100	*79*	100	100	100	97
Nov	46	67	100	76	97	67	100	69	100
Dec	0	0	86	17	100	0	97	0	100
Annual	53	60	80	63	95	59	81	56	86

Further assumptions considered during the comfort analysis are stated below:

1. Windows will be assumed to be opened when outdoor air conditions are able to provide better comfort than indoor conditions with windows closed.
2. Tier 1 does not have any electric fans to draw outdoor air into the building. Natural ventilation during times when windows are open will be inadequate to

flush out the hotter indoor air. Consequently a simplified assumption was made that the indoor comfort percentage will be equal to the average of outdoor comfort and indoor comfort percentages.

3. For Tier 2, when the windows are open the indoor comfort percent is assumed to be equal to the outdoor comfort %since electric fans would adequately ventilate the indoor spaces.
4. 100 % comfort is assumed for interior spaces when the building is fully conditioned (HC+PLL).

4.3 Solar system calculations

4.3.1 PV System electric output

Renewable energy systems are a means for existing schools to be self-sustaining in energy and not rely on the electric grid which is intermittent. This would also reduce operational energy demand.

Electricity from solar photovoltaic systems can meet requirements for plug loads and lights including ventilation fans for the Tier 2 upgrade scenarios under (H+PLL) heating energy only. The PV calculations are performed assuming building to be orientated north- south which favors solar energy collection. To determine the energy generated from the photovoltaic system, an online software program called PV- Watts was used. PV- Watts has been developed by the National Renewable Energy Laboratory (NREL) and can provide estimates of the electricity production and cost of energy of grid connected photovoltaic energy system for numerous locations worldwide. Currently PV- Watts defaults to the location closest to the city under study which has a TMY 2 weather file. Since the weather data for Durres/Tirana/Korca are not available within PV-Watts, the closest location with TMY 2 data was Podgorica, Serbia and Montenegro for PV calculations. The PV system capacity is calculated based on the roof area available for PV system installation corrected for a ground cover ratio factor which is described further below.

Standard crystalline silicon module with a glass cover with approximate efficiency of 14 percent is assumed. This module has a temperature degradation coefficient of -0.47 percent per degree Celsius. PV module in this array is assumed to be fixed roof mount facing south direction. For Building Type 1, solar PV panels are assumed to be deployed only on the south elevation with a tilt of 34^o (roof area = 64 m^2), whereas for Building Type 3 the panel are assumed to be placed on the flat roof top (roof area = 864 $m^{2)}$, with a tilt of 20^o.The azimuth angle for the PV systems is taken to be due south. Ground coverage ratio which is the ratio of module surface area to the area of the ground or roof occupied by the array is taken to be 0.5.This is a realistic value suggested by PV-Watts itself for such PV systems. The system loss which include AC to DC conversion, power conditioning and wire losses as well as reduction in the incident solar radiation from shading (caused by the objects near the array due to surrounding buildings or trees) is taken to be 14% (which is a standard value assumed in numerous studies). Based on above specification PV- Watts calculates monthly solar radiation (kWh/m^2/day) and AC energy (kWh/month) generated by PV system. This data is then exported to the spreadsheet program for further investigation. The output results generated by PV-Watts are for Podgorica, Serbia and Montenegro weather file. The predicted monthly kWh values are corrected by considering the difference between average monthly solar radiation for Durres/Tirana/Korca and those of Podgorica, Serbia and Montenegro. This is simply done as follows:

$$E2 = E1 \times R2/R1$$

where

E2 = Monthly AC energy output by the PV system for of Durres/Tirana/Korca

E1= Monthly AC energy output by the PV system located in Podgorica, Serbia and Montenegro (Predicted by PV-Watts)

R2= Monthly mean horizontal global solar radiation at Durres/Tirana/Korca

R1= Monthly mean horizontal global solar radiation at solar radiation at Podgorica, Serbia and Montenegro

Table 4.2 assembles month-by-month values of the energy generated by a PV system for building Type 3 located in Durres/Tirana/Korca. The data is further used to estimate the monthly %load met by PV system for Durres /Tirana / Korca. The resulting values are tabulated and plotted in graphs in Appendix E. Table 4.3 presents the month-by-month values of the percentages of the total building load (which could be PLL or H+PLL) met by the PV system. These percentage ratios are often shown as ratio fractions and are referred to as monthly “solar fractions” in the solar energy literature.

Table 4.2: Building Type 3, Table showing monthly energy generated by PV system for Durres/Tirana/Korca.

	R1	E1	R2	E2	R3	E3	R4	E4
MONTHS	PV WATTS		DURRES WEATHER		TIRANA WEATHER		KORCA WEATHER	
	Solar Radiation	AC Energy	Solar Radiation	AC Energy	Solar Radiation	AC Energy	Solar Radiation	AC Energy
	(kWh / m2 / day)	KWH	(kWh / m2 / day)	KWH	(kWh / m2 / day)	KWH	(kWh / m2 / day)	KWH
Jan	2.58	3823	1.32	1956.0	1.31	1941.1	1.27	1881.9
Feb	3.83	5214	1.23	1674.5	1.24	1688.1	1.25	1701.7
Mar	4.6	6723	1.28	1870.7	1.28	1870.7	1.28	1870.7
Apr	5.57	7690	1.25	1725.8	1.24	1712.0	1.23	1698.2
May	6.75	9284	1.26	1733.0	1.26	1733.0	1.28	1760.5
Jun	7.35	9640	1.25	1639.5	1.25	1639.5	1.24	1626.3
Jul	7.72	10367	1.22	1638.3	1.22	1638.3	1.23	1651.7
Aug	7.33	9783	1.24	1655.0	1.24	1655.0	1.22	1628.3
Sep	6.05	7835	1.26	1631.8	1.26	1631.8	1.27	1644.7
Oct	4.23	5976	1.25	1766.0	1.25	1766.0	1.24	1751.8
Nov	3.01	4210	1.23	1720.4	1.23	1720.4	1.24	1734.4
Dec	2.55	3701	1.24	1799.7	1.23	1785.2	1.2	1741.6

Table 4.3: Building Type 3, showing the monthly energy load met by PV system.

PV	Durres			Tirana			Korca		
Months	PLL (kWh)	Energy from PV (kWh)	% Load met by PV	PLL (kWh)	Energy from PV (kWh)	% Load met by PV	PLL (kWh)	Energy from PV (kWh)	% Load met by PV
Jan	2954	4307	146	2823	4274	151	3095	4144	134
Feb	2698	3655	135	2631	3685	140	2858	3715	130
Mar	2478	4081	165	2821	4081	145	3020	4081	135
Apr	2421	3759	155	2428	3729	154	2623	3699	141
May	2219	3770	170	2226	3770	169	2227	3830	172
Jun	2412	3566	148	2418	3566	147	2420	3537	146
Jul	2417	3558	147	2424	3558	147	2426	3588	148
Aug	2321	3595	155	2326	3595	155	2328	3537	152
Sep	2326	3551	153	2334	3551	152	2334	3579	153
Oct	2350	3860	164	2357	3860	164	2356	3829	163
Nov	2164	3776	175	2320	3776	163	2623	3807	145
Dec	2796	3964	142	3019	3932	130	3256	3836	118

* PV calculations are done only for North-south Building Orientation

4.3.2 Solar water heater

Onsite solar water heater (SHW) option is analyzed for Tier 2 upgrade for Durres/Tirana/Korca to determine how much of the building heating load can be met using a SHW system which covers the entire roofs of the buildings. Calculation are done assuming the efficiency of SHW to be four times the efficiency of PV panel's i.e. around 45 % (which is realistic but simplified assumption). Table 4.4 assembles values of the monthly heating loads, the amount in kWh of thermal energy supplied by the SHW system, and the solar percentages for building Type 3 for Durres/Tiran/Korca.

Table 4.4 Building Type 3, Calculation showing loads met by SHW for Durres/Tirana/Korca.

SHW	Durres			Tirana			Korca		
Months	Heating Energy Required	Energy from SHW (kWh)	% Energy provided by SHW	Heating Energy Required	Energy from SHW	% Energy provided by SHW	Heating Energy Required	Energy from SHW	% Energy provided by SHW
Jan	20788	17228	83	21986	17097	78	34039	16575	49
Feb	19112	14621	77	20581	14740	72	28963	14859	51
Mar	14630	16323	112	16607	16323	98	23769	16323	69
Apr	4795	15038	314	7492	14917	199	12889	14797	115
May	86	15080	17495	247	15080	6115	4139	15320	370
Jun	105	14263	13597	88	14263	16153	1428	14149	991
Jul	93	14234	15338	98	14234	14569	95	14350	15121
Aug	88	14379	16322	101	14379	14294	109	14147	12967
Sep	89	14204	15888	111	14204	12819	533	14316	2688
Oct	95	15440	16184	2522	15440	612	5685	15316	269
Nov	4174	15105	362	10224	15105	148	16153	15228	94
Dec	17246	15856	92	21608	15729	73	32693	15345	47

Based on the above calculations the results are futher compared and analysed with graphs (Appendix F) to determine the monthly %of SHW loads for Durres/Tirana/Korca.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Evaluation of energy performance

5.1.1 Analysis for PLL scenario

a. Building Type1- Rural

The total annual energy consumption by end use is divided into two categories, namely, area lights and plug loads. The energy use results obtained from eQuest simulation software for all three climate zones (i.e. Durres, Tirana, and Korca) indicate that area lighting energy use is slightly higher (51%) compared to that for plug loads (49%).

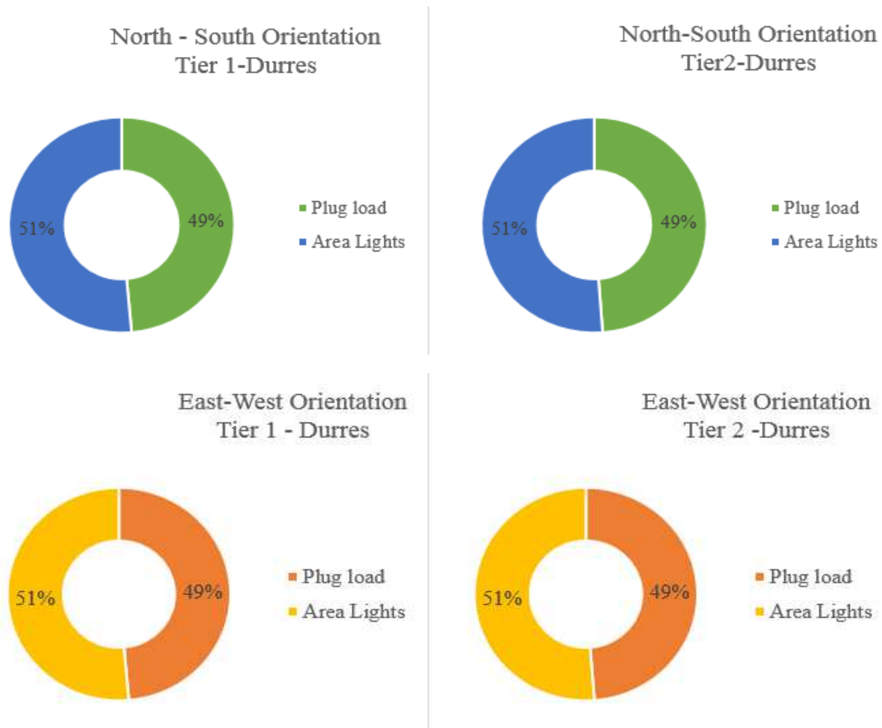

Figure 5.1 Annual energy consumption for Durres Tier 1 and Tier 2.

Figure 5.1 shows energy consumption due to building plug loads and area lights for Durres for both tiers and for two building orientations considered. None of these factors have any effect on relative split between plug and light loads. A closer inspection of Table 5.1 reveals that there is slight increase in plug loads for Tier 2 compared to Tier 1 which is due to the additional fan load in Tier 2. The annual energy consumption due to plug loads is constant for Tier 1 and Tier 2 for north-south and East-west building orientations for the three climate zones. Area lighting, however, varies with each climate and building orientation.

Table 5.1 Annual energy use (kWh) for building Type 1

Type 1	Tier 1		Tier 2	
North -South Orientation	Lighting	Plug load	Lighting	Plug load
Durres	1,921	1,816	1,924	1,834
Tirana	1,928	1,816	1,931	1,834
Korca	1,929	1,816	1,933	1,834
East-West Orientation				
Durres	1,922	1,816	1,925	1,834
Tirana	1,930	1,816	1,933	1,834
Korca	1,930	1,816	1,934	1,834

b. Building Type 3 – Urban

For this building type, we observe for all three climate zones that the energy consumption from plug load is 59 % whereas for area lighting it is 41 % (see Figure 5.2). As seen in Table 5.2, the plug loads are identical for north-south and East-west building orientation. On the other hand, the lighting loads vary due to variation in daylighting levels for each climate and building orientation.

Table 5.2 Annual energy use (kWh) for building Type 3

Type 3	Tier 1		Tier 2	
North-South Orientation	Lighting	Plug load	Lighting	Plug load
Durres	7175	10381	7244	10396
Tirana	7255	10381	7305	10396
Korca	7266	10381	7329	10396
East-West Orientation				
Durres	7190	10381	7263	10396
Tirana	7278	10381	7342	10396
Korca	7292	10381	7373	10396

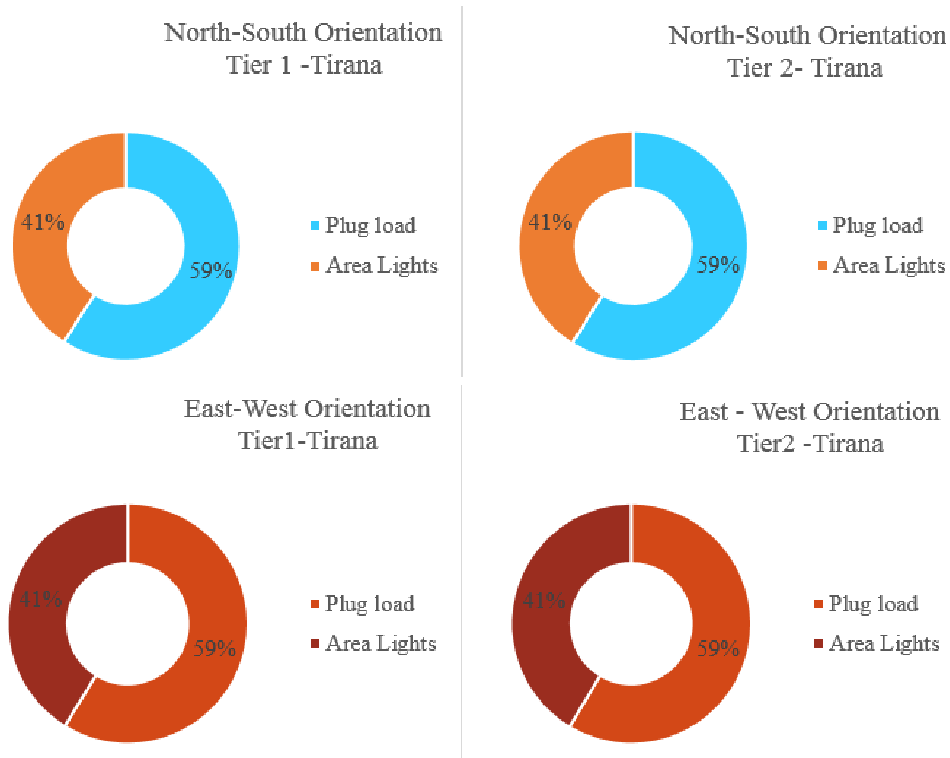

Figure 5.2 Annual energy consumption for Tirana

5.1.2 Analysis for H+PLL scenario

a. Building Type1- Rural

Heating energy with baseboard has been calculated for retrofit types Tier 1 and Tier 2 and assembled in Table 5.3. In Durres, heating is required from November to April (see

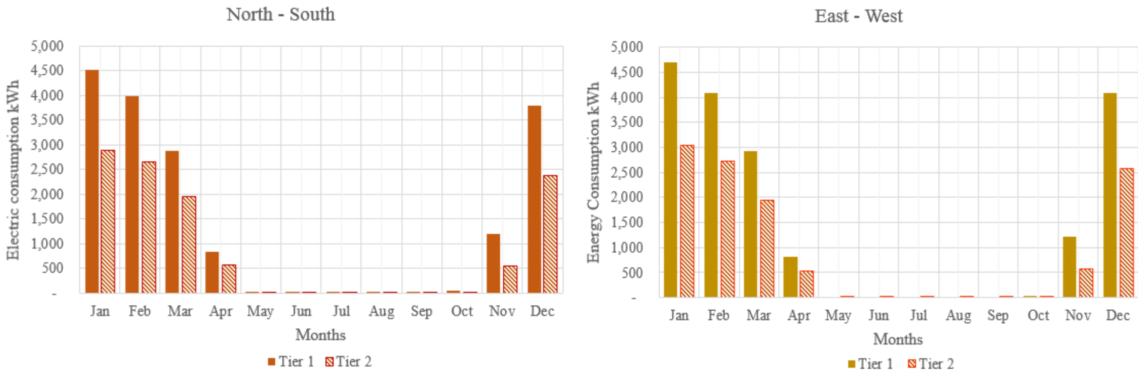

Figure 5.3 Graphs of monthly heating energy with baseboard (Tier 1 and 2) for North-south and East-west orientations (Durres).

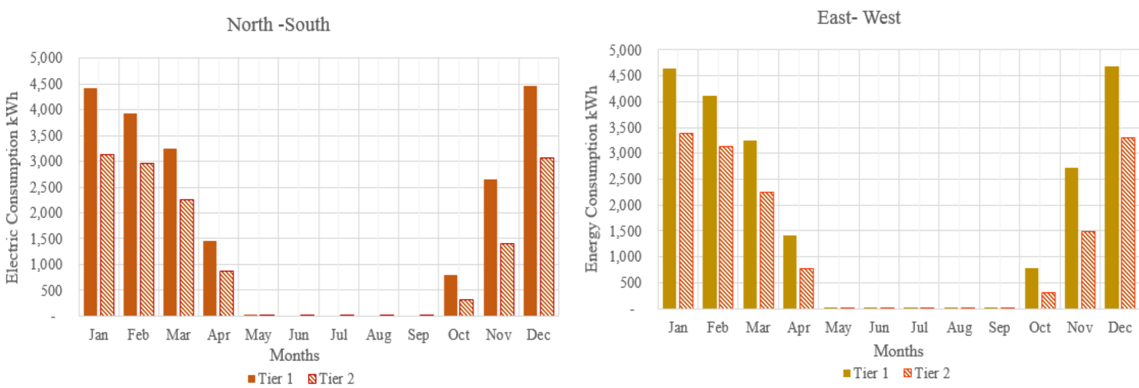

Figure 5.4 Graphs of monthly heating energy with baseboard (Tier 1 and 2) for North-south and East-west orientations (Tirana)

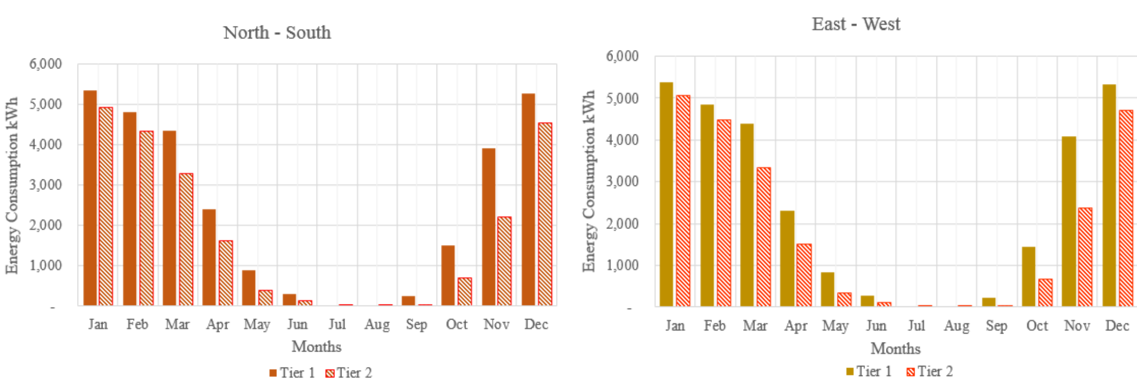

Figure 5.5 Graphs of monthly heating energy with baseboard (Tier 1 and 2) for North-south and East-west orientations (Korca)

Figure 5.3), for Tirana heating is required from October to April (see Figure 5.4) and for Korca, which is located at a higher altitude, heating is required from September to June

(See Figure 5.5). Refer to Figures 5.3, 5.4, 5.5 for monthly heating loads for Durres, Tirana and Korca respectively for north-south and east –west orientations.

Table 5.3 H+PLL building Type1, Annual energy consumption (kWh)

Type 1	Tier 1			Tier 2		
North-South	Durres	Tirana	Korca	Durres	Tirana	Korca
Space Heat	17,299	21,054	29,065	11,058	14,057	22,188
Vent. Fans	4,646	4,869	5,711	3,898	4,180	4,933
Misc. Equip.	2,324	2,324	2,324	2,343	2,343	2,324
Area Lights	1,973	1,980	1,981	1,976	1,983	1,985
East-west						
Space Heat	17,898	21,699	29,155	11,455	14,711	22,616
Vent. Fans	4,650	4,918	5,724	4,014	4,216	4,953
Misc. Equip.	2,324	2,324	2,324	2,343	2,343	1,984
Area Lights	1,974	1,982	1,982	1,977	2,324	1,986

The annual energy consumption results assembled in Table 5.3 reveal that a building oriented East-west consumes more energy as compared to one with north-south orientation. The energy load from miscellaneous equipment is constant while lighting loads vary slightly throughout the year. Refer to Appendix C for detailed monthly energy load consumption for all three climate zones. The heating loads for all three locations are higher for Tier 1 building configuration as compared to Tier 2 by about 22 percent.

Table 5.4 H+PLL building Type 1, Annual energy use percent and saving between Tier 1 & Tier 2

Climate : Durres				
North-South	Heating	Total	Energy Use %	Saving %
Tier 1	17,299	17,299	66	
Tier 2	11,058	11,058	57	8
East-West				
Tier 1	17,898	17,898	67	
Tier 2	11,455	11,455	58	9
Climate : Tirana				
North-South	Heating	Total	Energy Use %	Saving %
Tier 1	21,054	21,054	70	
Tier 2	14,057	14,057	62	7
East-West				
Tier 1	21,699	21,699	70	
Tier 2	14,711	14,711	63	7
Climate : Korca				
North-South	Heating	Total	Energy Use %	Saving %
Tier 1	29,065	29,065	74	
Tier 2	22,188	22,188	71	4
East-West				
Tier 1	29,155	29,155	74	
Tier 2	22,616	22,616	71	3

Table 5.4 shows energy consumption and savings due to space heating between Tier 1 and Tier 2 for all three locations. Note that savings range from 3% to 9 % with them being higher for Durres than Korca. Also, building orientation has very little effect. For example, the savings for Durres drop from 9 % for an East-west orientated building to 8% for one oriented north-south. However this trend is reversed for Korca.

b. Building Type3- Urban

The energy consumption due to space heating is highest in January for all three locations. Heating is required for Durres from November to April (see Figure 5.6), for Tirana from October to April (see Figure 5.7), while for Korca heating energy is required from October to June (see Figure 5.8).

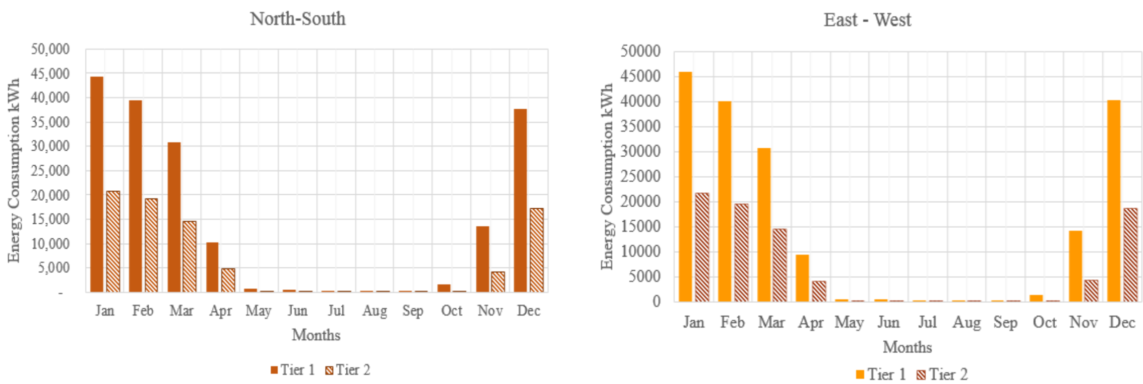

Figure 5.6 Graphs for monthly heating and cooling (Tier 1 and 2) for North-south and East-west orientations (Durres)

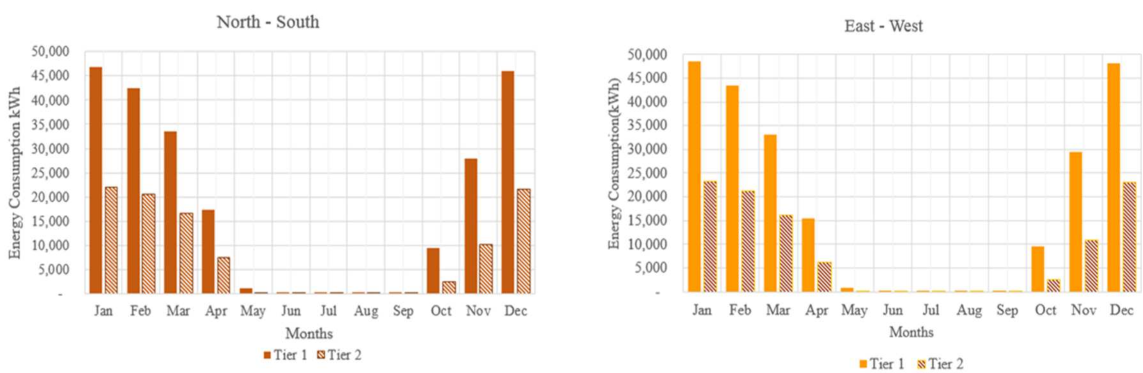

Figure 5.7 Graphs of monthly heating energy with baseboard (Tier 1 and 2) for North-south and East-west orientations (Tirana)

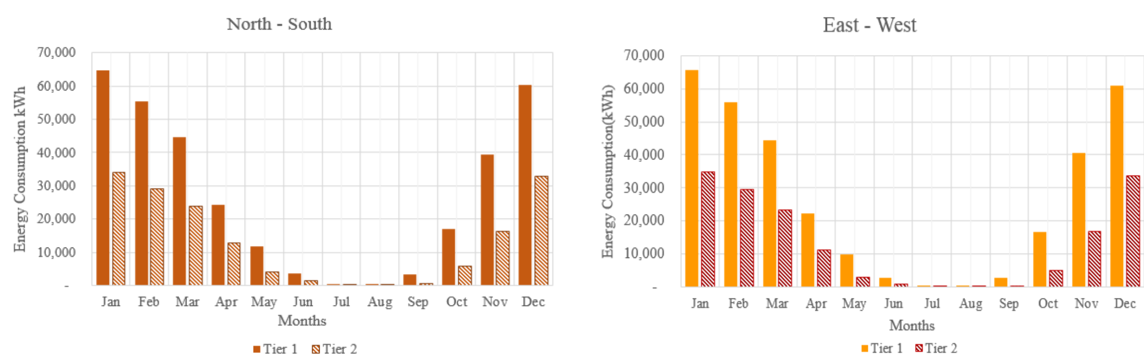

Figure 5.8 Graphs of monthly heating energy with baseboard (Tier 1 and 2) for North-south and East-west orientations (Korca).

The energy consumption in a building oriented East-west (except Tirana) is greater than one with north-south building orientation. Table 5.5 assembles the values of annual energy consumption due to heating energy with baseboard.

Table 5.5 H+PLL building Type 3, Annual energy consumption.

Type 3	Tier 1			Tier 2		
North-South	Durres	Tirana	Korca	Durres	Tirana	Korca
Space Heat	179,707	225,243	325,141	81,303	101,665	160,496
Vent. Fans	13,765	14,768	16,050	11,646	12,136	13,567
Misc. Equip.	10,381	10,381	10,381	10,396	10,396	10,381
Area Lights	7,446	7,544	7,556	7,514	7,593	7,618
East-West						
Space Heat	183,323	228,838	322,216	83,574	103,830	158,619
Vent. Fans	13,760	14,756	16,019	11,782	12,234	13,585
Misc. Equip.	10,381	10,381	10,381	10,396	10,396	10,381
Area Lights	7,459	7,566	7,581	7,534	7,629	7,661

Table 5.6 Annual energy use and saving for building Type 3

Climate : Durres			
North-South	Heating	Energy Use %	Saving %
Tier 1	179,707	85	
Tier 2	81,303	73	12
East-West			
Tier 1	183,323	85	
Tier 2	83,574	74	12
Climate : Tirana			
North-South	Heating	Energy Use %	Saving %
Tier 1	225,243	87	
Tier 2	101,665	77	10
East-West			
Tier 1	228,838	87	
Tier 2	103,830	77	10
Climate : Korca			
North-South	Heating	Energy Use %	Saving %
Tier 1	325,141	91	
Tier 2	160,496	84	7
East-West			
Tier 1	322,216	90	
Tier 2	158,619	83	7

Table 5.6 summarizes the annual space heating energy consumption between Tier 1 and Tier 2. It reveals that Tier 2 upgrades would result in greater energy savings as compared to Tier 1 for all climates. This was expected, but the numerical values of the savings (see

Table 5.6) which range from 7%to 12 %could only be determined by careful building energy simulation using eQuest software. Building orientation did not have any effect on energy savings.

5.1.3 Analysis for HC+PLL

a. Building Type1- Rural

The energy consumption due to space cooling is higher than space heating for Durres and Tirana; while for Korca, space heating is higher than space cooling. For Durres and Tirana, July and August are the peak months where energy consumption due to cooling is found to be very high (Appendix C assembles graphs and monthly table for energy consumption for building Type 1).

Table 5.7 HC+PLL, Annual energy consumption for building Type 1

Type 1	Tier 1			Tier 2		
North-South	Durres	Tirana	Korca	Durres	Tirana	Korca
Space Cool	19,745	23,188	9,935	19,594	17,287	7,748
Space Heat	18,256	21,880	29,024	7,160	9,031	13,347
Vent. Fans	8,924	9,413	8,849	6,269	6,342	6,261
Pumps & Aux.	836	1,209	1,710	836	1,209	1,710
Misc. Equip.	2,324	2,324	2,324	2,324	2,324	2,324
Area Lights	1,973	1,981	1,981	1,975	1,983	1,985
East-West.						
Space Cool	20,042	23,752	10,191	20,129	20,064	8,413
Space Heat	18,443	22,051	29,137	7,308	9,242	13,644
Vent. Fans	9,063	9,578	8,981	6,582	6,597	6,572
Pumps & Aux.	836	1,209	1,710	836	1,209	1,710
Misc. Equip.	2,324	2,324	2,324	2,324	2,324	2,324
Area Lights	1,973	1,982	1,982	1,976	1,984	1,986

For building Type 1, Table 5.7 summarizes the annual energy consumption for Tier 1 and Tier 2 for Durres, Tirana and Korca. Table 5.8 summarizes the annual energy use and savings for Tier 1 and Tier 2 for north-south and east-west oriented building. The savings from Tier 2 to Tier 1 ranges from 13 percent to 16 percent. The effect of orientation is negligible.

Table 5.8 building Type 1, Annual energy use and saving

Climate : Durres					
North-South	Heating	Cooling	Total	Energy Use %	Saving %
Tier 1	18,310	19,745	38,055	35	
Tier 2	7,196	19,594	26,790	19	16
East-West					
Tier 1	18,497	20,042	38,539	35	
Tier 2	7,344	20,129	27,473	19	16
Climate : Tirana					
North-South	Heating	Cooling	Total	Energy Use %	Saving %
Tier 1	21,948	23,188	45,136	37	
Tier 2	9,077	17,287	26,364	24	13
East-West					
Tier 1	22,119	23,752	45,871	36	
Tier 2	9,289	20,064	29,353	22	14
Climate : Korca					
North-South	Heating	Cooling	Total	Energy Use %	Saving %
Tier 1	29,129	9,935	39,064	54	
Tier 2	13,420	7,748	21,168	40	14
East-West					
Tier 1	29,242	10,191	39,433	54	
Tier 2	13,717	8,413	22,131	40	14

b. Building Type3 – Urban

For building Type 3, the energy consumption due to space heating is greater than space cooling for all three locations. Figures 5.9, 5.10 and 5.11 summarize the monthly heating and cooling energy consumption needed for the school buildings in Durres, Tirana and Korca respectively. The plug loads are constant throughout the year for Tier1 and Tier 2, while lighting load varies slightly. Energy consumption due to space heating is highest for Korca Tier 1 (81 %) and Tier 2 (55 %). The energy consumption and savings due to space heating and cooling for Tier 1 and Tier 2(shown in Table 5.9) are in the range of 9% to 11 %

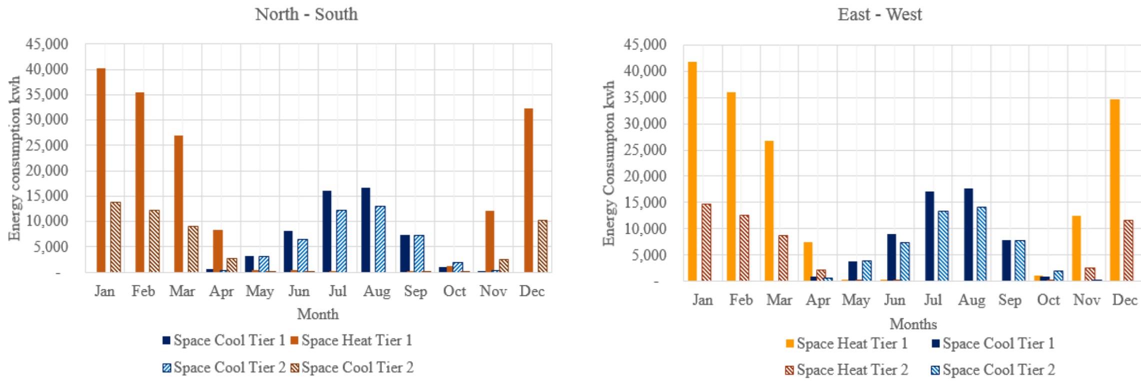

Figure 5.9 Graphs for monthly heating and cooling (Tier 1 and 2) for North-south and East-west orientations (Durres)

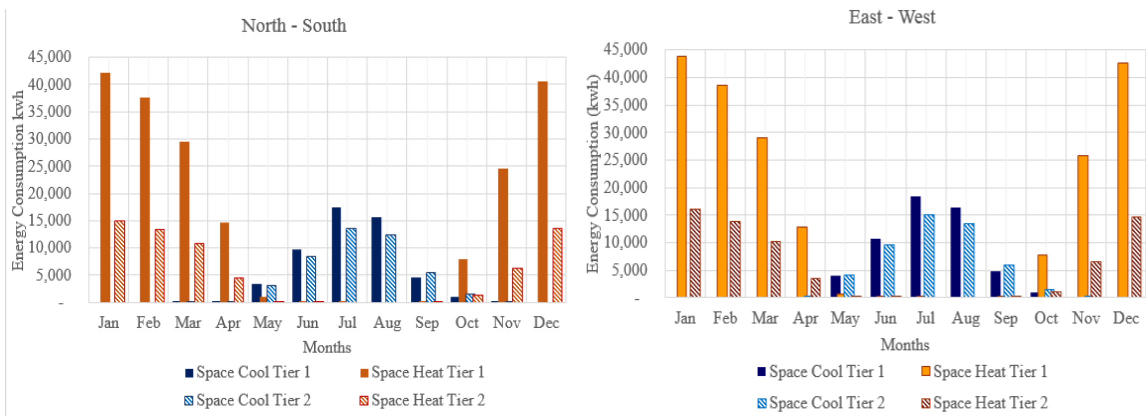

Figure 5.10 Graphs for monthly heating and cooling with (Tier 1 and 2) for North-south and East-west orientations (Tirana)

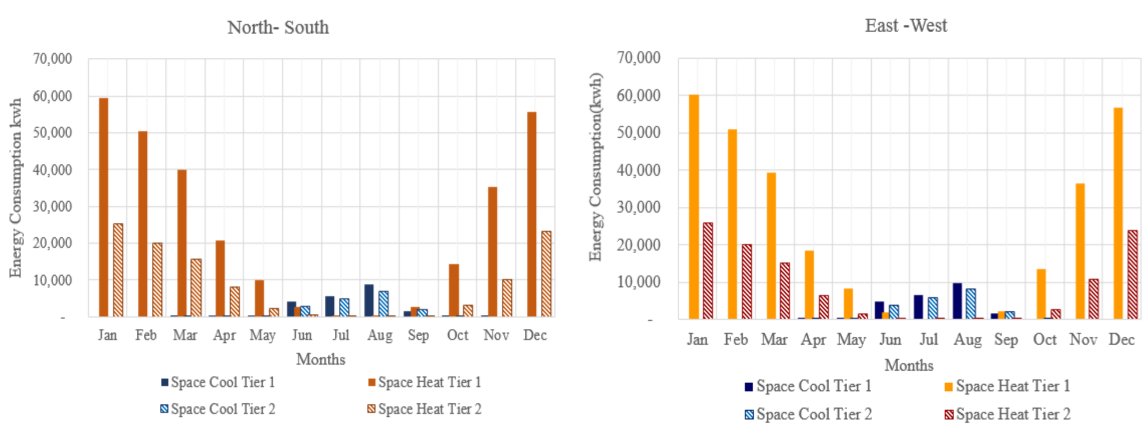

Figure 5.11 Graphs for monthly heating and cooling with (Tier 1 and 2) for North-south and East-west orientations (Korca)

Table 5.9 HC+PLL building Type 3, Annual energy use and saving between Tier 1 and Tier 2

Climate : Durres					
North-South	Heating	Cooling	Total	Energy Use %	Saving %
Tier 1	157,681	53,381	211,062	82	
Tier 2	50,465	44,998	95,463	72	10
East-West					
Tier 1	160,979	57,233	218,212	82	
Tier 2	52,268	49,288	101,556	72	9
Climate : Tirana					
North-South	Heating	Cooling	Total	Energy Use %	Saving %
Tier 1	198,245	51,730	249,975	84	
Tier 2	65,188	44,685	109,873	74	9
East-West					
Tier 1	201,770	55,298	257,069	84	
Tier 2	66,130	49,875	116,004	74	9
Climate : Korca					
North-South	Heating	Cooling	Total	Energy Use %	Saving %
Tier 1	291,939	21,156	313,095	86	
Tier 2	108,640	16,801	125,441	76	10
East-West					
Tier 1	289,177	23,791	312,968	86	
Tier 2	106,834	20,797	127,631	75	11

5.1.4 Analysis for Solar Photovoltaic System

a. Building Type1- Rural

Installing a solar photovoltaic system provides onsite electricity which could satisfy the building lighting and plug loads for Tier 2 upgrade. The month by month electricity generation and the percent of load are assembled in Table 5.10. From Chapter 4, recall that a standard polycrystalline silicon solar photovoltaic system with about 14 % efficiency has been assumed with the PV panels placed on the south side of the sloping roof for building Type 1 with a tilt of 34^{o}. The PV system would be able to meet 45 % of annual average load for Durres, 44 % for Tirana and 41 % for Korca. For Durres, the highest electric load demand (844 kWh/month) is in January and the PV system is able to meets 46 % of this amount. The lowest electric load required is in the month of November for Durres and the PV system is able to meet 58 % of this need. The solar load fraction from PV is highest in November (58 %) and least in February (38 %) for Durres.

Table 5.10 Building Type 1, Monthly loads met by PV system for Durres, Tirana, Korca

PV	Durres			Tirana			Korca		
Months	PLL (kWh)	Energy Provided by PV (kWh)	% Load met by PV	PLL (kWh)	Energy Provided by PV (kWh)	% Load met by PV	PLL (kWh)	Energy Provided by PV (kWh)	% Load met by PV
Jan	844	386	46	852	383	45	1012	372	37
Feb	830	317	38	794	319	40	923	322	35
Mar	686	334	49	810	334	41	923	334	36
Apr	659	293	45	660	291	44	735	289	39
May	605	284	47	606	284	47	604	289	48
Jun	659	263	40	659	263	40	659	261	40
Jul	660	265	40	661	265	40	659	268	41
Aug	633	279	44	634	279	44	632	274	43
Sep	632	289	46	633	289	46	631	291	46
Oct	635	330	52	636	330	52	634	327	52
Nov	583	340	58	665	340	51	794	343	43
Dec	794	367	46	902	364	40	1037	355	34

The highest electric load for Tirana is in December (902 kWh) and PV meets 40%of the load, while the lowest solar fraction is in May (47percent). For Korca, 34%is the highest solar fraction for PV which occurs in December while PV fraction is lowest in May (48 percent).

b. Building Type 3- Urban with entire roof covered with PV

The PV system is located on the flat roof covering an area of 864 m^2. For a Type 3 building, the total energy generated by PV would exceed the total building energy load required if the PV system were to cover the entire roof area (corrected of course for the ground cover ratio assumed). Table 5.11 shows that for Durres in the month of

November, the solar percentage would reach a maximum value of 175 %, while for Tirana it is 159 % in May and 172 % in May for Korca. For Durres, PV generates an excess of 45 % electric energy in January which has the highest electric load. For Tirana, the surplus is 30 % and for Korca 18 % in December when the electric load is maximum.

Table 5.11 Building Type 3, Monthly loads met by PV system for Durres, Tirana, Korca

PV	Durres			Tirana			Korca		
Months	PLL (kWh)	Energy Provided by PV (kWh)	% Load met by PV	PLL (kWh)	Energy Provided by PV (kWh)	% Load met by PV	PLL (kWh)	Energy Provided by PV (kWh)	% Load met by PV
Jan	2954	4307	146	2823	4274	151	3095	4144	134
Feb	2698	3655	135	2631	3685	140	2858	3715	130
Mar	2478	4081	165	2821	4081	145	3020	4081	135
Apr	2421	3759	155	2428	3729	154	2623	3699	141
May	2219	3770	170	2226	3770	169	2227	3830	172
Jun	2412	3566	148	2418	3566	147	2420	3537	146
Jul	2417	3558	147	2424	3558	147	2426	3588	148
Aug	2321	3595	155	2326	3595	155	2328	3537	152
Sep	2326	3551	153	2334	3551	152	2334	3579	153
Oct	2350	3860	164	2357	3860	164	2356	3829	163
Nov	2164	3776	175	2320	3776	163	2623	3807	145
Dec	2796	3964	142	3019	3932	130	3256	3836	118

Building Type 3- Urban with no net electric sell back by the PV system

Since the PV system assumed to cover the entire roof area of a Type 3 building is able to generate electricity in excess to its needs, this would require net sell-back to the grid at the monthly levels. We have considered another case which is likely to be more cost effective. This scenario does not involve selling excess electricity generated back to the grid but sizing the PV system so that there is no net sell-back even for the most critical month (of course, for the other months, electricity must be purchased). For example, in Durres, the minimum electric load is during November with 2,164 kWh requirement. The PV system is sized such that it generates just this amount of electricity in November. Consequently, the school will have to purchase electricity during the other months of the year as shown. The PV system sizes required are shown in Table 5.12. We note, for example, that for Durres, the PV module area will be 248 sq.m (down from 432 sq.m had the entire roof been used). Similar PV module areas for Tirana and Korca can also be found in Table 5.12.

Table 5.12 PV system sizing to avoid electric sell-back to grid

	Durres	Tirana	Korca
Area of roof (sq.m)	864	864	864
Ground cover ratio	0.5	0.5	0.5
PV module area if all roof covered (sq.m)	432	432	432
Highest electric load (kWh)	2954 (Jan)	3019 (Dec)	3255 (Dec)
Lowest electric load (kWh)	2164 (Nov)	2226 (May)	2227 (May)
PV module for month with highest load (sq.m)	296	332	367
PV module for month with lowest load (sq.m)	248	255	251
Annual electric energy purchased from grid for PV sized for lowest load (kWh)	3469	3340	5315
Annual solar fraction (%) for PV sized to meet the lowest electric load	88	89	83

If PV system were sized to meet the electric load of highest month see Table 5.12 then in this case there will be net electric sell back during certain months. With a PV system sized to meet the lowest electric load an annual electric energy that needs to be purchased from the grid is 3469 kWh for Durres, 3340 kWh for Tirana and 5315 kWh for Korca. The solar PV system is able to meet 88 % of the annual electric load for Durres, 89 % in Tirana and 83 % for Korca (see Table 5.12).

5.1.5 Analysis for solar water heater

a. Building Type1- Rural

The solar water heating system is meant to meet the space heating loads of the buildings. Table 5.13 assembles the monthly values of the heating energy required, along with the SHW output and solar load fraction for all three locations. For example, the SHW systems meets 53 % of the heating energy load in January when demand for heating energy is maximum. For Tirana the solar fraction are 49 %, and 30 % for Korca. Energy provided by SHW greatly exceeds the heating load of the building for more than 5 months of the year; from April to November for Durres, April to October for Tirana and May to October for Korca. This is not surprising since the heating loads during the summer months and for some of the swing months is very low.

Table 5.13 Building Type 1, Monthly heating energy load met by SHW for Durres, Tirana and Korca.

SHW	Durres			Tirana			Korca		
Months	Heating Energy Required (kWh)	load met by SHW	% Energy provided by SHW	Heating Energy Required (kWh)	load met by SHW	% Energy provided by SHW	Heating Energy Required (kWh)	load met by SHW	%Energy provided by SHW
Jan	2892	1545	53	3132	1533	49	4908	1487	30
Feb	2654	1267	48	2953	1277	43	4319	1287	30
Mar	1947	1338	69	2256	1338	59	3292	1338	41
Apr	576	1173	204	870	1164	134	1626	1154	71
May	9	1136	12627	13	1136	8742	389	1154	297
Jun	10	1052	10517	9	1052	11686	134	1043	779
Jul	10	1062	10620	10	1062	10620	9	1071	11896
Aug	10	1114	11145	11	1114	10132	11	1097	9968
Sep	10	1156	11563	12	1156	9636	43	1165	2710
Oct	10	1320	13203	320	1320	413	709	1310	185
Nov	548	1360	248	1411	1360	96	2216	1371	62
Dec	2383	1469	62	3060	1457	48	4532	1421	31

Figure 5.12 is a histogram of monthly heating load required and the solar load fractions met by the SHW system for Korca. The heating energy demand is from November to April and SHW meets an average of 44 % of the heating energy requirement. (Refer to Appendix C for graphs showing monthly heating load met by SHW for Durres and Tirana)

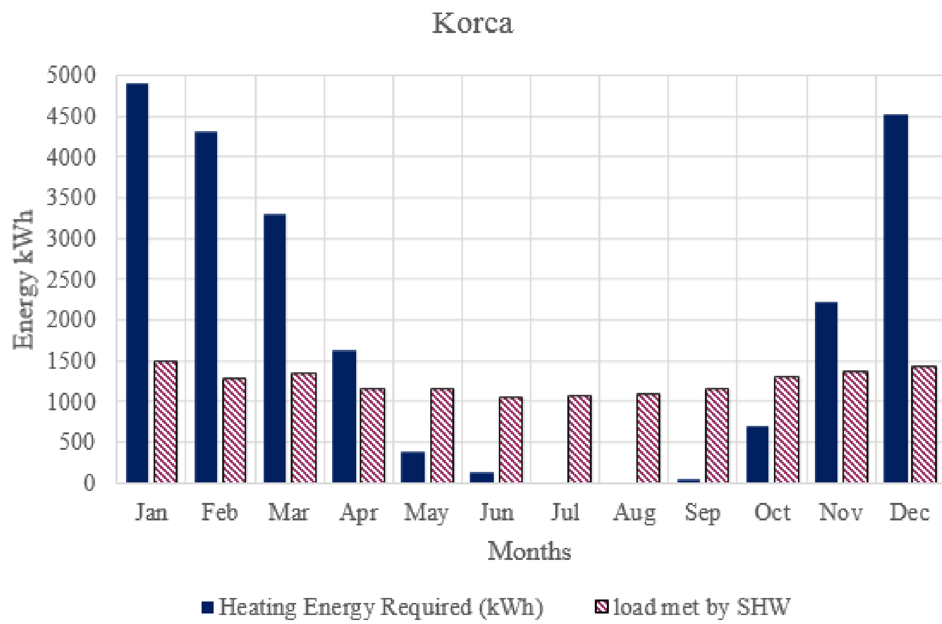

Figure 5.12 Building Type 1, Monthly heating energy load met by SHW for Korca.

b. Building Type3- Urban

From Table 5.14 we observe that SHW meets 83 % of highest heating energy load in January for Durres, 78 % for Tirana and 49 % for Korca. The SHW system produces energy greatly in excess during the summer months when there is little or no heating energy load for all three climate zones. The highest amount of energy produced from SHW is in the month of May for Durres, June for Tirana and July for Korca. Figure 5.13 shows graph of monthly heating load of the building required and the energy delivered by SHW for Korca. The heating load is maximum during winters from December to March and lowest from May to October.

Table 5.14 Type 3, Monthly heating energy load met by SHW for Durres, Tirana and Korca

SHW	Durres			Tirana			Korca		
Months	Heating Energy Required (kWh)	load met by SHW	% Energy provided by SHW	Heating Energy Required (kWh)	load met by SHW	% Energy provided by SHW	Heating Energy Required (kWh)	load met by SHW	% Energy provided by SHW
Jan	20788	17228	83	21986	17097	78	34039	16575	49
Feb	19112	14621	77	20581	14740	72	28963	14859	51
Mar	14630	16323	112	16607	16323	98	23769	16323	69
Apr	4795	15038	314	7492	14917	199	12889	14797	115
May	86	15080	17495	247	15080	6115	4139	15320	370
Jun	105	14263	13597	88	14263	16153	1428	14149	991
Jul	93	14234	15338	98	14234	14569	95	14350	15121
Aug	88	14379	16322	101	14379	14294	109	14147	12967
Sep	89	14204	15888	111	14204	12819	533	14316	2688
Oct	95	15440	16184	2522	15440	612	5685	15316	269
Nov	4174	15105	362	10224	15105	148	16153	15228	94
Dec	17246	15856	92	21608	15729	73	32693	15345	47

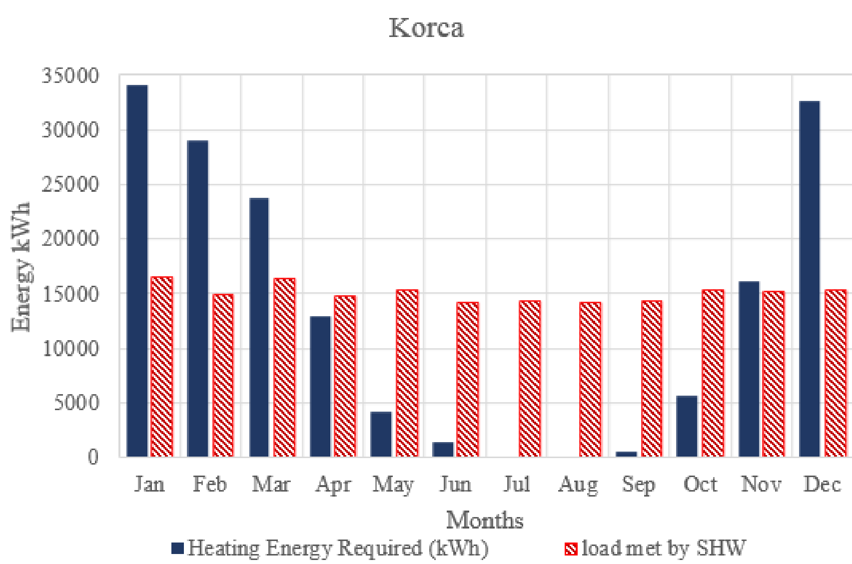

Figure 5.13 Building Type 3 monthly heating energy load met by SHW for Korca.

5.2 Thermal Comfort Analysis

5.2.1 Analysis for PLL

a. Building Type1- Rural

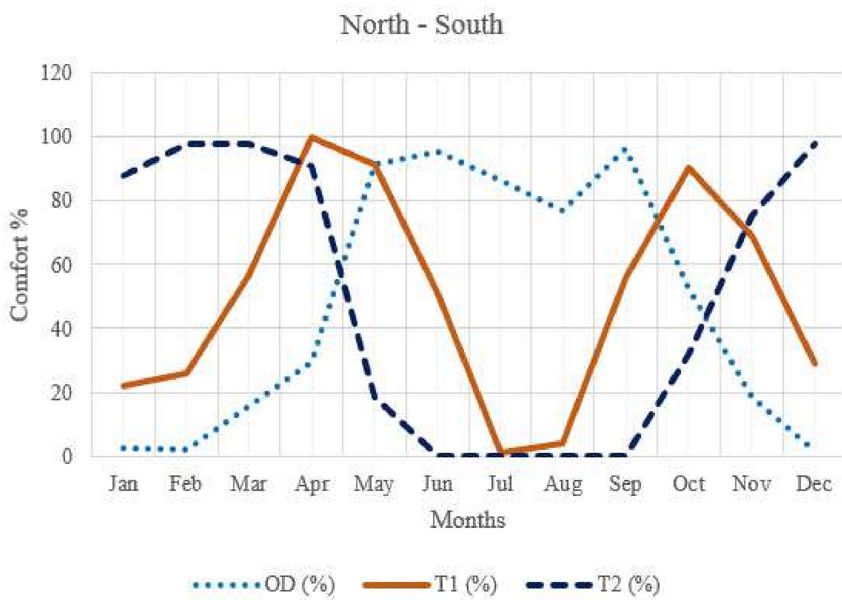

Figure 5.14 PLL: Monthly comfort percentages for Tirana when windows are closed

Figure 5.14 assembles plots of occupant comfort percentages for each month of the year at Tirana with windows closed. During the summer months, the discomfort percent for indoor spaces is greater for Tier 2 than Tier 1 since the windows are assumed closed and the improved insulation results in over-heating the interior spaces. On the other hand, during the winter months, indoor conditions in Tier 2 are more comfortable than those of Tier 1. It is also observed that when the outdoor comfort is very low, Tier 2 allows an average acceptable comfort of 91% to be achieved while Tier 1 has an acceptable comfort of only 50 %. Indoor comfort in Tier 1 is greater than Tier 2 when the outdoor comfort percent is higher than indoor comfort percent.

The above observations pertain to the case when windows are always kept closed. As described in the previous chapter, it is logical to assume instead that windows will be (manually) opened when the outdoor conditions are more comfortable than those indoors. Such a control has been assumed in this analysis as well. From Figure 5.14 for Tirana,

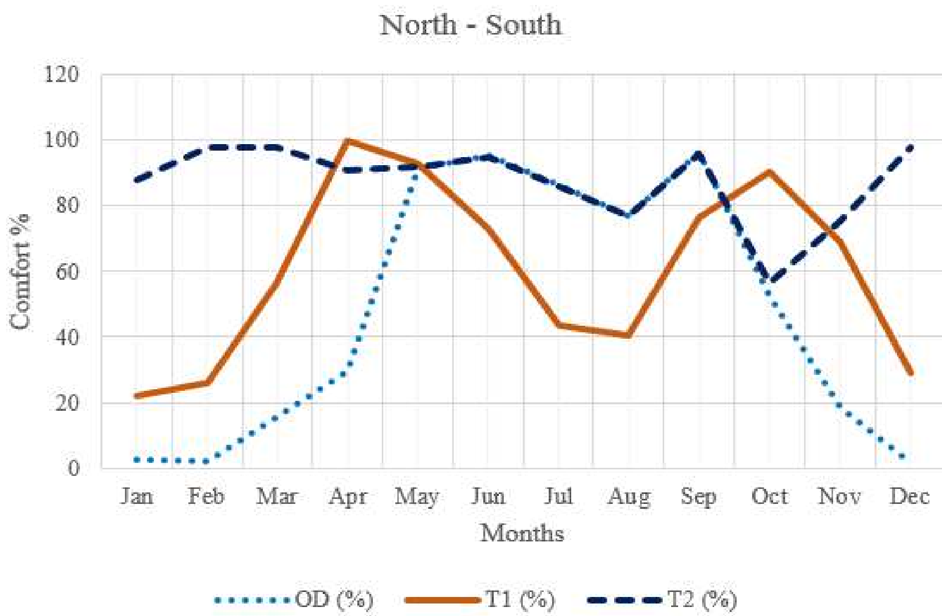

Figure 5.15 PLL: Monthly comfort percentages for Tirana when windows are open for outdoor and two retrofit Tier types.

opening the windows from May to September greatly enhances indoor comfort conditions. The occupant comfort percentages increase drastically for both Tier 1 and Tier 2 compared to when windows are closed especially in the summer months. From Table 5.15, we note for example with north-south building orientation, that for Durres when the windows are open during the summer, the comfort percentage for T1 are about 61% and for T2 is 89 % For Tirana the comfort percent for T1 is 60 % and for T2 it is 87 %, for Korca the indoor comfort percent for T1 is 53 % and for T2 it is 75 %.

Table 5.15 Building Type 1 summary of Annual thermal comfort with openable windows for PLL scenario

TYPE 1			
Climate : Durres			
North- South	OD (%)	T1(%)	T2(%)
PLL	53	61	89
East-West			
PLL	53	59	90
Climate : Tirana			
North- South	OD (%)	T1(%)	T2(%)
PLL	47	60	87
East-West			
PLL	47	57	89
Climate : Korca			
North- South	OD (%)	T1(%)	T2(%)
PLL	34	53	75
East-West			
PLL	34	52	74

b. Building Type3- Urban

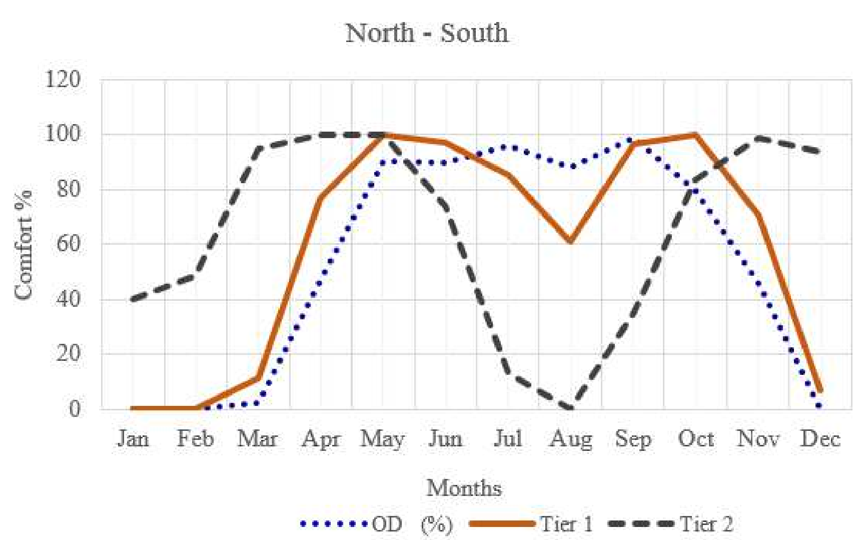

Figure 5.16 PLL: Monthly Comfort percentages for Durres when windows are closed

The same effect of openable windows in summer is also noted for the other two locations. Figure 5.16 indicates that for Durres when the windows are closed, the comfort percentage for Tier 2 from November to May is higher compared to those for Tier 1 and for outdoor conditions. However Tier 1 comfort percentage is greater during the summer months as compared to Tier 2. The comfort percentage of Tier 2 is lower than the outdoor comfort from May to August. On the other hand, the comfort for Tier 1 is lower than outdoors from June to September. We note that in August, Tier 2 has 0 % comfort when the windows are closed while Tier 1 has a comfort of 50 %. Generally, when the outdoor comfort percentage is better than indoor the drop in comfort percentage is higher for Tier 2 during the summer months compared to Tier 1.

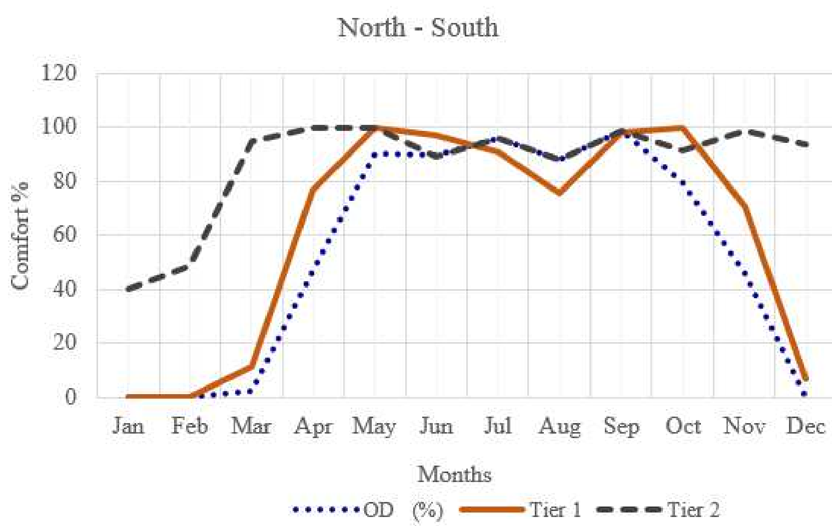

Figure 5.17 Monthly Comfort percentage for Durres when windows are open in summer for outdoor and two retrofit Tier types.

When the windows are opened, the comfort percentage for Tier 2 are assumed to be same as outdoor comfort, while for Tier 1 the comfort percentage drops slightly. From Figure 5.17 which shows monthly comfort percentage for Durres, it can be noted that the comfort percentage for Tier 1 is 78 % in august when the outdoor comfort is 95 % .From

July to September the indoor comfort percentage is lower than the outdoor comfort percentage for Tier1.

Table 5.16 Building Type 3 summary of annual thermal comfort for PLL scenario

TYPE 3			
Climate : Durres			
North- South	OD (%)	T1(%)	T2(%)
PLL	53	61	87
East-West			
PLL	53	59	82
Climate : Tirana			
North- South	OD (%)	T1(%)	T2(%)
PLL	47	53	79
East-West			
PLL	47	51	71
Climate : Korca			
North- South	OD (%)	T1(%)	T2(%)
PLL	34	44	64
East-West			
PLL	34	43	60

Table 5.16 Summarizes the acceptable comfort percentages achieved for north-south, east –west building orientation for Durres, Tirana, and Korca for Tier 1 and Tier 2 upgrades (Refer Appendix D for detailed monthly thermal comfort for each building zones).We notice that retrofit type T2, even without a heating or cooling system would provide the best indoor comfort ranging from about 64 % (for Korca) to about 87 % (for Durres) and 79 % (for Tirana).The effect of building orientation is small, about 2 – 5 percentage points, the north-south orientation yielding higher comfort. The improvement in comfort from T1 to T2 is substantial; about a 20 % absolute point increase. Even T1 improves indoor comfort compared to outdoor by about 5 – 6 % absolute points.

5.2.2 Analysis for H+PLL

a. Building Type1- Rural

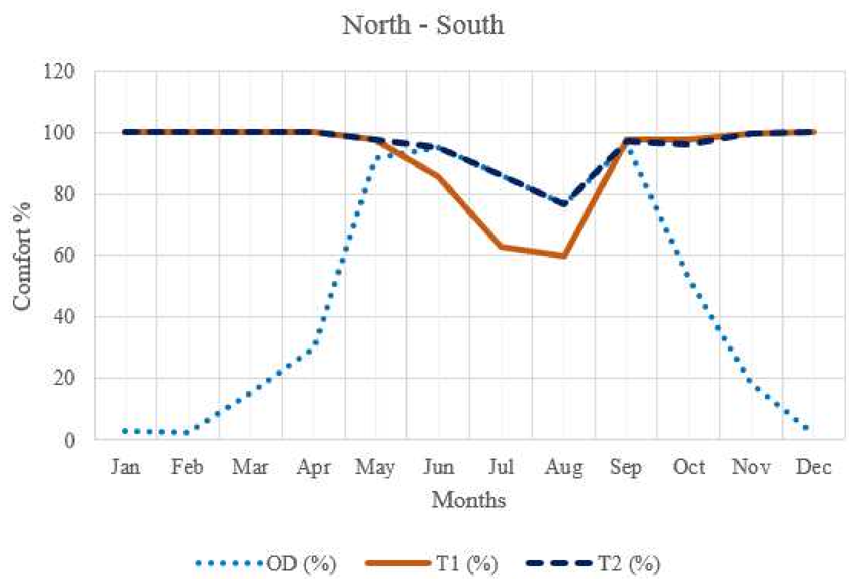

Figure 5.18 H+PLL: Monthly Comfort percentage with heating for Tirana when windows are open in summer for outdoor and two retrofit Tier types.

If space heat is available, Tier 1 and Tier 2 retrofits in buildings are able to achieve 100 % comfort even when the outdoor comfort is very low. In Figure 5.18, the monthly comfort with heating for Tirana shows 100 % comfort from September to May when outdoor comfort is low. From May to September when the windows are assumed to be open, the indoor comfort for Tier 2 is identical to that for outdoor conditions while Tier 1 comfort increases compared to when the windows were closed.

Table 5.17 Building Type 1 summary of annual thermal comfort for H+PLL scenario

TYPE 1			
Climate : Durres			
North- South	OD (%)	T1(%)	T2(%)
H+PLL	53	88	96
East-West			
H+PLL	53	86	97
Climate : Tirana			
North- South	OD (%)	T1(%)	T2(%)
H+PLL	47	92	96
East-West			
H+PLL	47	93	96
Climate : Korca			
North- South	OD (%)	T1(%)	T2(%)
H+PLL	34	96	97
East-West			
H+PLL	34	97	97

Table 5.17 assembles the annual comfort percentage for the H+PLL Building Type 1 scenario for all three locations. Even when average annual outdoor comfort is low, Tier 1 is able to attain 87 % average annual comfort, while Tier 2 can achieve up to 96 % in Durres. For Tirana and Korca, Tier 1 is able to achieve above 90 % comfort however Tier 2 achieves 97 % comfort.

b. Building Type 3 - Urban

Figure 5.19 assembles the monthly comfort %with heating for Durres when windows are closed. The comfort percentage for Tier 2 drop more than those of Tier1 when the windows are closed. Figure 5.19 indicates that for Durres, the comfort percentage for Tier 2 is 50 % in August whereas for Tier 1 the indoor comfort is 80 %. From October to June, 100 % comfort is achieved due to heating for Tier 1 and Tier 2 buildings.

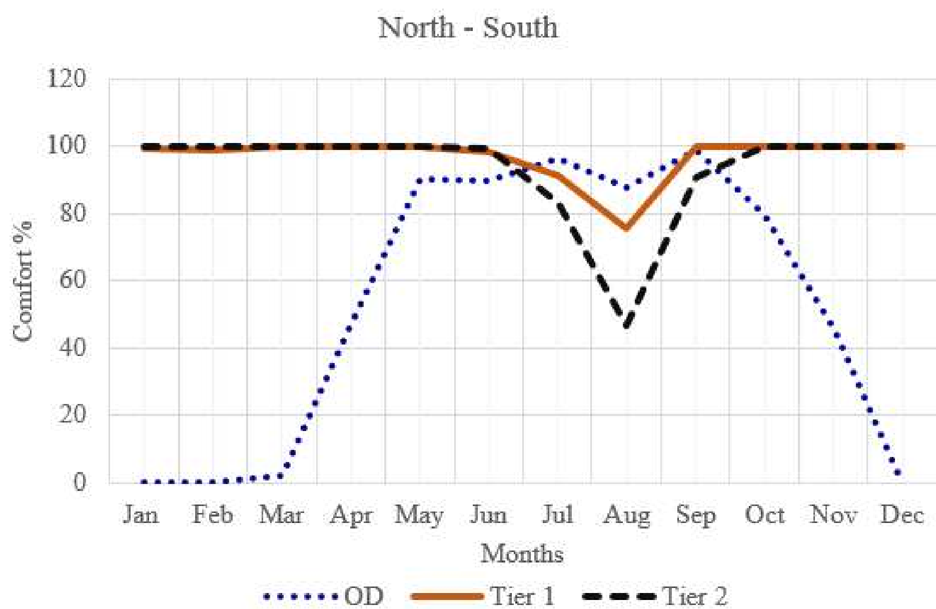

Figure 5.19 H+PLL: Monthly Comfort percentage with heating for Durres when windows are closed in summer.

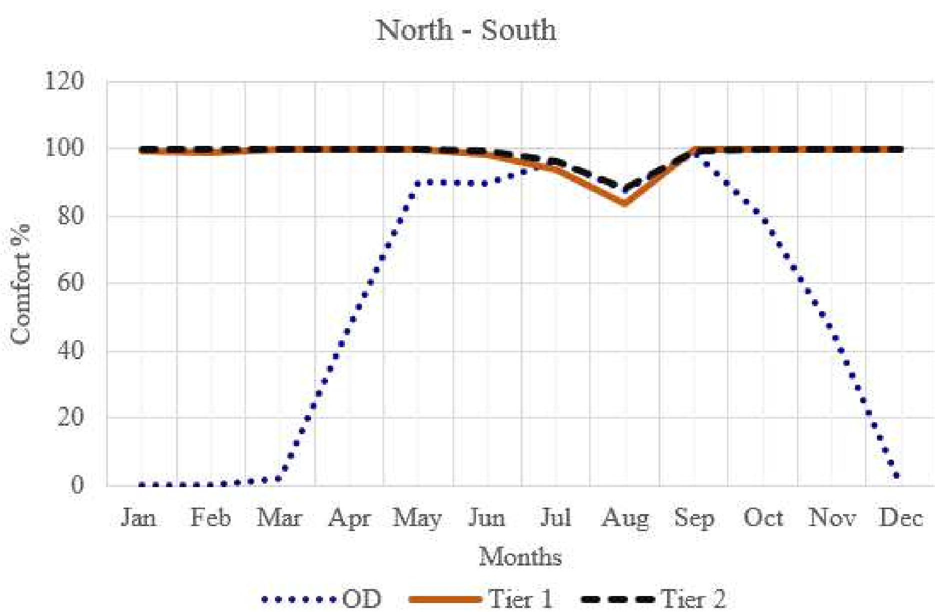

Figure 5.20 H+PLL: Monthly Comfort percentage with heating for Durres when windows are open in summer.

Figure 5.20 indicates the monthly comfort percentage with heating for Durres when the windows are opened in summer. From Figure 5.20 it is seen that the indoor comfort of Tier 1 and Tier 2 are greater when the windows are open compared to comfort percentage in

Figure 5.19 when the windows are closed. For example in the month August when the windows are closed (see Figure 5.19) the comfort percentage for Tier 1 is 79 % and Tier 2 is 48 % ,However when windows are opened (see figure 5.20) the indoor comfort for Tier 1 is 83 % and Tier 2 is 88 %.

Table 5.18 Building Type 3 summary of Annual thermal comfort for H+PLL scenario

TYPE 3			
Climate : Durres			
North- South	OD (%)	T1(%)	T2(%)
H+PLL	53	98	99
East-West			
H+PLL	53	98	98
Climate : Tirana			
North- South	OD (%)	T1(%)	T2(%)
H+PLL	47	97	97
East-West			
H+PLL	47	96	98
Climate : Korca			
North- South	OD (%)	T1(%)	T2(%)
H+PLL	34	99	99
East-West			
H+PLL	34	100	100

From building Type 3 summary of Annual thermal comfort (Table 5.18), we note that for H+PLL scenario, Tier 1 and Tier 2 buildings can both achieve more than 95 % comfort in all three locations (Refer Appendix D for detail monthly acceptable comfort for each building zones.)

CHAPTER 6

CLOSURE

6.1 Summary and Conclusions

The objective of this research was to evaluate different retrofit strategies done to existing school building designs in terms of energy use and thermal comfort in Albania and identify energy efficient options for transforming the portfolio of exiting schools into energy efficient Green Schools. It involves evaluating five discrete scenarios for each of the three climatic zones selected. AutoCAD 2015 was used as a design tool for creating existing building prototypes, eQuest software for energy performance simulation and to predict the hourly indoor temperature of each zones of the building designs, PV Watts to determine the monthly energy generated from the photovoltaic system, and Spreadsheet programs for comparative energy analysis, to evaluate thermal comfort percentages, and to perform solar photovoltaic and solar water heater calculations.

The following are a succinct list of critical observations and inferences derived from the analysis

a) Energy use related

1. Overall we can conclude in all scenarios that the building orientation did not have any major impact on energy consumption for all three locations. The east-west building orientation was found to consume slightly more energy compared to north-south building orientation

2. The results for PLL energy consumption shows a slight increase in plug loads and area lights in Tier 2 type of building retrofit compared to Tier 1 for both building Type 1 and Type 3 in all three locations.
3. From the energy analysis table and graphs we can conclude that the heating demand is mainly from November to April for all three locations for building Type 1 and Type 3.
4. Comparing the three climate zones, we observed that energy consumption due to heating is highest for Korca (building Type 1: Tier 1 (74 %), Tier 2 (71%), building Type 3: Tier 1 (91%), Tier 2 (84%)) while energy consumption due to space heating is least for Durres (building Type 1: Tier 1 (66 %), Tier 2 (57 %), building Type 3 Tier 1 (85 % , Tier 2 (73 %)) in both Tier 1 and Tier 2 upgrade for building Type 1 and Type 3.
5. For HC+PLL scenario, energy consumption in building Type 3 (see Table 5.9) due to space heating is highest for Korca and least for Durres. The energy consumption due to space cooling is least for Korca and highest for Tirana. In building Type 1 (see Table 5.8) the energy consumption due to space heating is highest in Korca while for space cooling the energy consumption is highest in Durres.
6. Energy use analysis for HC+PLL for Building Type 1 shows that energy consumption due to space cooling is greater than space heating in Durres and Tirana, whereas for Korca the energy use due to space heat is higher than space cooling. Therefore for building Type 1 cooling is required during the summer months for Durres and Tirana while heating is needed for Korca.

7. From the overall analysis results for HC+PLL for building Type 3, we can conclude that space heating is required for all three climate zones during the winter months while space cooling is required only for Durres and Tirana in summer months.

8. Table 6.1(H+PLL) and Table 6.2 (HC+PLL) shows the annual energy savings for Tier 2 compared to Tier 1. For H+PLL and HC+PLL we can conclude that Tier 2 has higher energy savings therefore it is more efficient than Tier 1 for Durres, Tirana and Korca for building Type 1 and Type 3 for both north - south and east-west building orientation.

Table 6.1 H+PLL: Annual energy savings for Tier 2 compared to Tier 1.

HC+PLL	North-south orientation		East-west orientation	
Building Type	Type 1	Type 3	Type 1	Type 3
Durres	16%	10%	16%	9%
Tirana	13%	9%	14%	9%
Korca	14%	10%	14%	11%

Table 6.2 HC+PLL: Annual energy savings for Tier 2 compared to Tier 1.

H+PLL	North-south orientation		East-west orientation	
Building Type	Type 1	Type 3	Type 1	Type 3
Durres	8%	12%	9%	12%
Tirana	7%	10%	7%	10%
Korca	4%	7%	3%	7%

b) Thermal comfort related

The indoor thermal comfort was analyzed for PLL and H+PLL based on following assumptions .Windows will be assumed to be opened when outdoor air conditions are able to provide better comfort than indoor conditions with windows closed. Tier 1 does not have any electric fans to draw outdoor air into the building. Natural ventilation during times when windows are open will be inadequate to flush out the hotter indoor air. Consequently a simplified assumption was made that the indoor comfort percentage will be equal to the average of outdoor comfort and indoor comfort percentages. For Tier 2, when the windows are open the indoor comfort percentage is assumed to be equal to the outdoor comfort percentage since electric fans would adequately ventilate the indoor spaces.100 % comfort is assumed for interior spaces when the building is fully conditioned (HC+PLL). For HC+PLL it is obvious that 100 % indoor comfort is achieved throughout the year since the school building has both heating and cooling equipment, and so this case is of no particular interest.

1. For PLL the indoor comfort percentage for north-south building orientation and east-west building orientation are almost same for Tier 1 and Tier 2 for building Type 1(see Table 5.15) and building Type 3 (see Table 5.16).
2. In Building Type 1 (see Table 6.3) and Type 3(see Table 6.3), Tier 1 and Tier 2 are able to achieve greater indoor comfort percentages compared to outdoor.
3. Comparing the indoor comfort percentages for Tier 1 and Tier 2 for building Type 1(see Appendix C) and Type 3 (see Appendix D) we can conclude that Tier 2 has higher indoor comfort percent during the winter months. In summer, if the windows

are closed the indoor comfort in Tier 1(see Figure 5.14) is greater than Tier 2 (see Figure 5.16) and vice versa if the windows are opened.

4. In case of H+PLL, Tier 1 and Tier 2 are both able to achieve almost 100 % indoor comfort for building Type 1 and Type 3 in all three locations (see Table 6.3).

Table 6.3, Annual comfort percentage for building Type 1 and Type 3

TYPE 1			
Climate : Durres			
North- South	OD (%)	T1(%)	T2(%)
PLL	53	61	89
H+PLL	53	88	96
East-West			
PLL	53	59	90
H+PLL	53	86	97
Climate : Tirana			
North- South	OD (%)	T1(%)	T2(%)
PLL	47	60	87
H+PLL	47	92	96
East-West			
PLL	47	57	89
H+PLL	47	93	96
Climate : Korca			
North- South	OD (%)	T1(%)	T2(%)
PLL	34	53	75
H+PLL	34	96	97
East-West			
PLL	34	52	74
H+PLL	34	97	97

TYPE 3			
Climate : Durres			
North- South	OD (%)	T1(%)	T2(%)
PLL	53	61	87
H+PLL	53	98	99
East-West			
PLL	53	59	82
H+PLL	53	98	98
Climate : Tirana			
North- South	OD (%)	T1(%)	T2(%)
PLL	47	53	79
H+PLL	47	97	97
East-West			
PLL	47	51	71
H+PLL	47	96	98
Climate : Korca			
North- South	OD (%)	T1(%)	T2(%)
PLL	34	44	64
H+PLL	34	99	99
East-West			
PLL	34	43	60
H+PLL	34	100	100

Table 6.3 summarizes the annual comfort percent for building Type 1 and Type 3 for all three climate zones.

c) Effects of Solar photovoltaic and solar water heater addition

1. For building Type 1, PV panels were assumed to be placed only on the south roof. They are able to meet an average building load of 46%for Durres, 44%for Tirana and 41%for Korca, the rest of the energy needs has to be purchased from the grid. However, for building Type 3, if the entire roof is covered with PV panels then excess electric energy is produced throughout the year in all three locations. Hence,

it is mere economical to only cover approximately 30 %of the roof with PV panels (see Table 5.12).

2. Solar hot water (SHW) system produces thermal energy greatly in excess than needed during the summer months for both building Type 1 and Type 3 in all three locations. For winter months, SHW can meet heating load of 58 % for Durres, 59 % for Tirana and 44 % for Korca for Building Type 1 .For building Type 3, SHW can meet an average heating load of 84 % for Durres, 80 % for Tirana and 62 % for Korca. Hence designing a SHW system may not be cost effective, it would essentially not be used (or used very little) during the summer months unless a specific and proper use can be made of this hot water in summer, installing a SHW system is likely to be uneconomical and hence undesirable.

d.) Summary of energy needs normalized by floor area for various scenarios.

Table 6.4, Energy use per meter square (kWh/m^2) for building Type 1 and Type 3

North- South Building Orientation									
			PLL		**H+PLL**			**HC+PLL**	
Bldg Type	**Area m^2**	**Climate**	**Tier 1**	**Tier 2**	**Tier 1**	**Tier 2 w/o solar**	**Tier 2 w/ solar**	**Tier 1**	**Tier 2**
3	2594.61	Durres	6.77	6.80	81.44	42.73	32.67	99.45	51.10
		Tirana	6.80	6.82	99.41	50.79	40.47	115.37	57.17
		Korca	6.80	6.83	138.41	74.03	63.91	139.58	63.63
1	590.85	Durres	6.32	6.36	44.41	32.62	26.28	88.20	64.64
		Tirana	6.34	6.37	51.16	38.19	31.85	101.65	64.69
		Korca	6.34	6.35	66.14	53.23	46.92	91.27	56.61
East - West Building Orientation									
			PLL		**H+PLL**			**HC+PLL**	
Bldg Type	**Area m^2**	**Climate**	**Tier 1**	**Tier 2**	**Tier 1**	**Tier 2 w/o solar**	**Tier 2 w/ solar**	**Tier 1**	**Tier 2**
3	2594.61	Durres	6.77	6.81	82.83	43.66	33.61	102.88	54.05
		Tirana	6.81	6.84	100.80	51.68	41.36	118.63	60.36
		Korca	6.81	6.85	137.28	73.33	63.21	140.32	65.42
1	590.85	Durres	6.33	6.36	45.43	33.49	27.15	89.25	66.33
		Tirana	6.34	6.38	52.34	39.36	33.02	103.18	70.18
		Korca	6.34	6.35	66.32	53.99	47.68	92.12	58.77

Key:

*PLL: Plug loads + lights (kWh/sq./yr)with daylighting

H+PLL: Heating + lights (kWh/sq./yr)with daylighting

HC+PLL: Heating + Cooling + Heating + lights (kWh/sq./yr) with daylighting

Solar PV calculations based on following module area

PV module area for building Type 1 = 34m^2

PV module area for building Type 3 are as follows

Durres = 245 m^2, Tirana = 255 m^2, Korca = 251 m^2

6.2 Future works

Future work may include the following

1. Further investigation in a more quantitative manner to analyze how energy efficient and green features in schools would impact learning outcomes and improve students and teacher's health.
2. The research can also include to look at different system types such as ground source heat pump driven by solar water heater, where the heat from the ground can be used for heating the interior spaces in winter and in summer the ground can be used as heat sink to remove heat from the building.
3. Use thermal mass of the building to determine the fluctuation of indoor temperature over the day.
4. Future research could evaluate the thermal comfort models i.e. compare Predicted mean vote (PMV) – Predicted Percentage of Dissatisfied (PPD) which is depend on the momentary air and radiant temperatures, air velocity, relative humidity,

metabolism and clothing insulation value with adaptive model which relate the indoor comfort temperature to mean outside temperatures.

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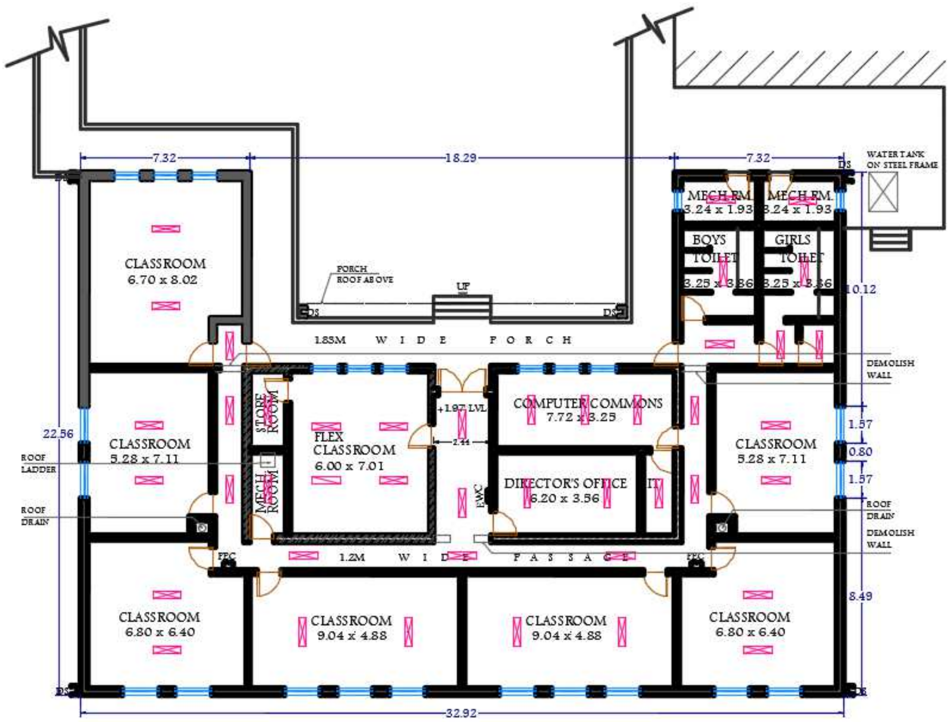
APPENDIX A

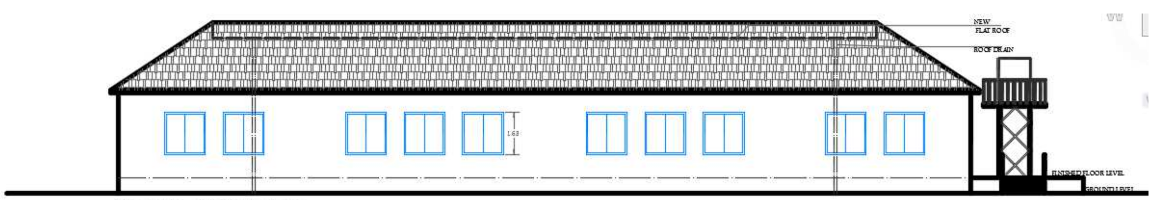
ARCHITECTURE DRAWINGS

Appendix A1: Building Type 1 - Rural

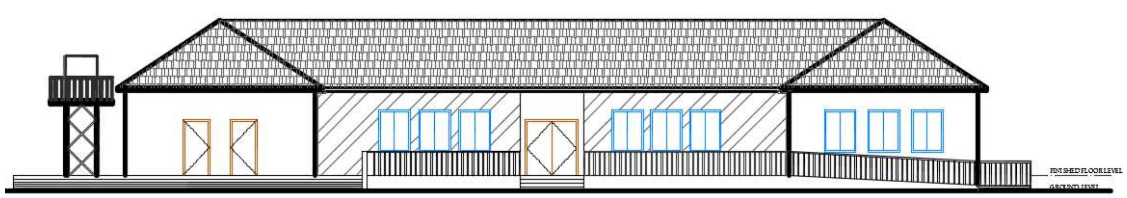
Area: 590.85 m^2



FLOOR PLAN



SOUTH ELEVATION



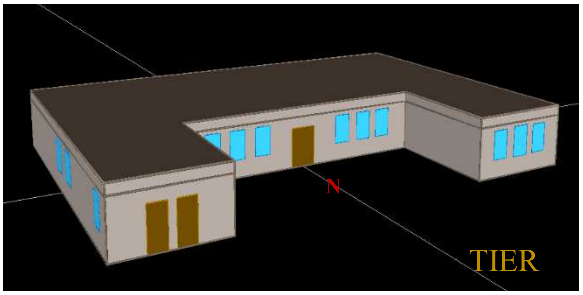
NORTH ELEVATION

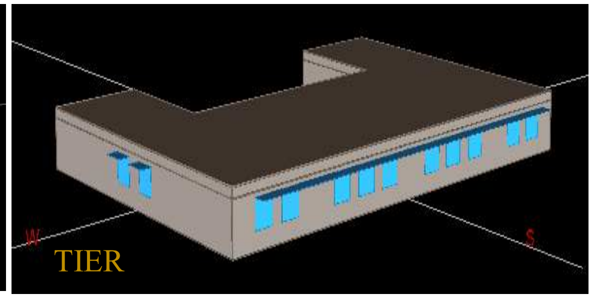
Appendix A2: Building Type 3 - Urban

Area: 2594.61 m^2

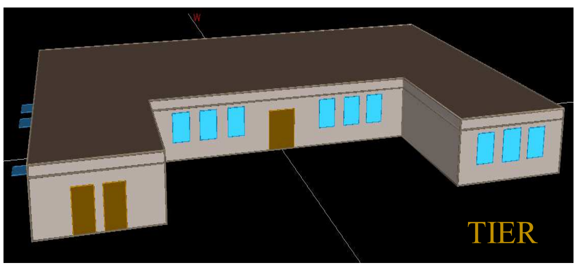
Appendix A3:eQuest Models

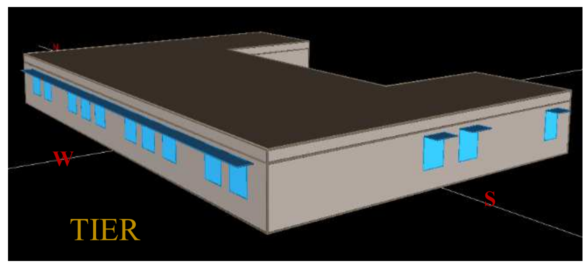
Type 1: Orientation: North – South



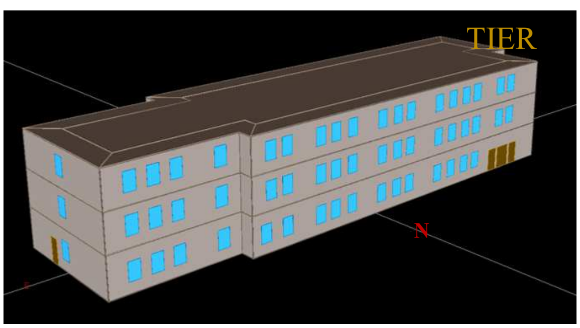


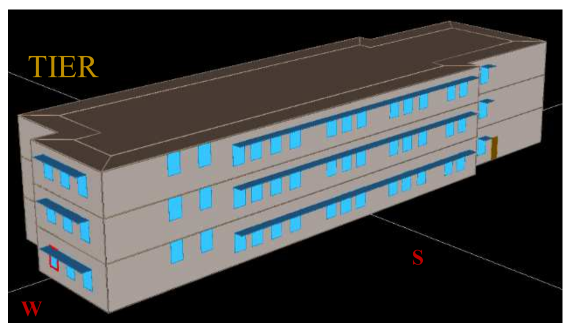
Orientation: East- West

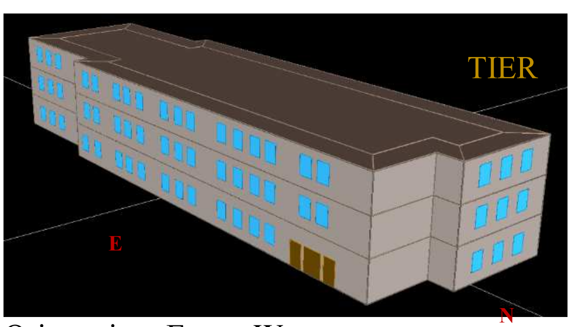


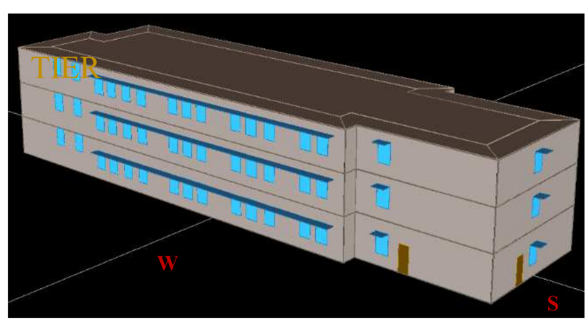


Type 3 Orientation: North – South









Orientation: East – West

APPENDIX B

BUILDING SPECIFICATION

Architecture Features	**Tier 1**	**Tier 2**
Orientation		
Option One	Long Axis Faces North / South	
Option Two	Long Axis faces East / West	
Exterior Wall Type	Solid Double Brick Masonary 30cms thick finished with Cement Plaster. R- 3.48	polystyrene insulation mechanically fastened to existing exterior masonry wall with exterior stucco finish. R 16.12
Interior Wall Type	Solid Double Brick Masonary 25cms thick finished with Cement Plaster. R- 3.48	Solid Double Brick Masonary 25cms thick finished with Cement Plaster. R- 3.48
Exterior main door	Steel door frame with single glazed glass	Steel door frame with single glazed glass
Interior Doors	Panelized wood	Panelized wood
Roof Construction	TYPE 1 Building : Pitched, hipped roof with 8 in 12 slope with clay tile roofing, hung directly on roofing laths and battens nailed to wooden rafters;vented air space between upper clay tile roof and inner plaster ceilings. R - 5.78	TYPE 1 : 2 layers 3.81 cm polystyrene rigid insulation on top of existing ceiling structure.R30 batt insulation on top of rigid insulation .R-45
	TYPE 3 , 6 " Concrete Slab R-1.34	2 layers 3.81 cm polystyrene rigid insulation on top of existing roof structure . R - 13.88
False ceiling	R- 1.24	
Floor Construction	6" Slab on grade with ceramic tiles	6" Slab on grade with ceramic tiles
Window Type	Single Pane clear glass	Double Low e
Durres (U-value/SHGF/Visible Transmittance)	single Clear Glass (1.11 / 0.86 /0.9)	Double Low- e (0.26 / 0.56 / 0.75)
Tirana (U-value/SHGF/Visible Transmittance)	single Clear Glass (1.11 / 0.86 /0.9)	Double Low- e (0.26/0.65/0.77)

Korea (U-value/SHGF/Visible Transmittance)	single Clear Glass (1.11 / 0.86 /0.9)	Double Low- e (0.29/0.68/0.72)
Window Frame Type	Aluminum frames	Aluminum frames
Wall mounted fan in classrooms	None	14"Diameter High Velocity Fan, 3 Blade GalvAlum (37 Degree) ,2 each per class room
Interior Lighting	Two 1.2 meter long T-8 fixtures per room, ceiling mounted, standard for both classrooms and corridors	Two 1.2 meter long T-8 fixtures per room, ceiling mounted, standard for both classrooms and corridors
Window Shading		
Interior	Fabric Curtains	commercial window shades at all windows, fabric roller shades with manual operation
Exterior	None	aluminum sunscreen louvers at south and west facing windows (Only for coastal climate zone Durres)
Daylighting	Yes	Yes
Building Operation and Internal Load		
Occupancy Schedule	7am - 7 pm , M-Fri	
Holidays	Sat - Sun	
Lighting and Equipment	7am - 7 pm , M-Fri	
Lighting power density	0.1 w /sq.ft	
Equipment Plug Load	0.1 w /sq.ft	
Occupancy	217 (~2.7 m2/person)	
Case 1		
Heating	BaseBoard Heating	
Heating Set Point (Unocc.)	70 F (64F)	

Case 2		
Heating and Cooling	DX Coil with Furnace	
Cooling EER	10.8	
Cooling /Heating Set Point (Unocc)	74F/70F(82F/64F)	

APPENDIX C

RESULTS OF BUILDING TYPE 1: RURAL

Appendix C1: Analysis Results for Durres - Type 1, Rural Building

C1.1 Graphs of Monthly Heating Energy Use with Baseboard (Tier 1 and 2) for North-south and East-west Building Orientations

C1. 2 Graphs for Monthly Heating and Cooling Energy Use (Tier 1 and 2) for North-south and East-west Building Orientations

C1.3 Graphs for Monthly Thermal Comfort Percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations for PLL and H+PLL scenario.

C1.4 Tables of Monthly Energy Use when no Heating & no Cooling (Tier 1 and 2) for North-south and East-west Building Orientations

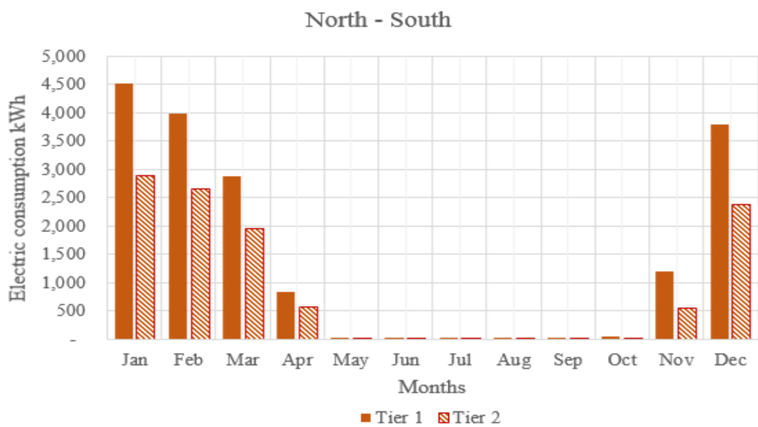
C1.5 Tables of Monthly Heating Energy Use with Baseboard (Tier 1 and 2) for North-south and East-west Building Orientations

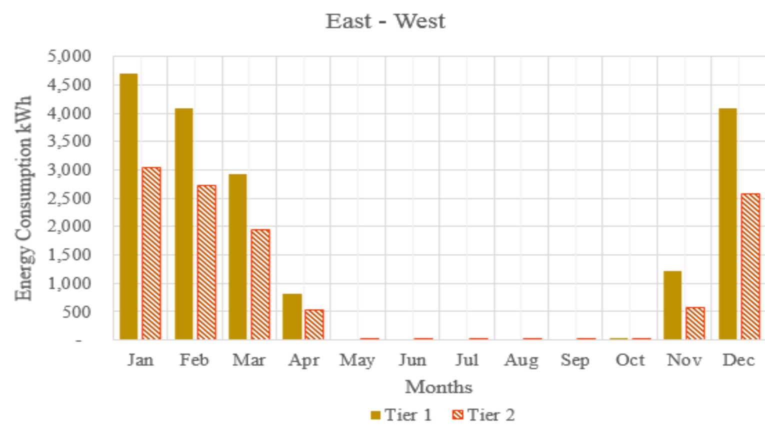
C1.6 Tables of Monthly Heating and Cooling Energy Use (Tier 1 and 2) for North-south and East-west Building Orientations

C1.7 Tables for Monthly Thermal Comfort Percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations

C1.1 Graphs of Monthly Heating Energy Use with Baseboard (Tier 1 and 2) for North-south and East-west Building Orientations

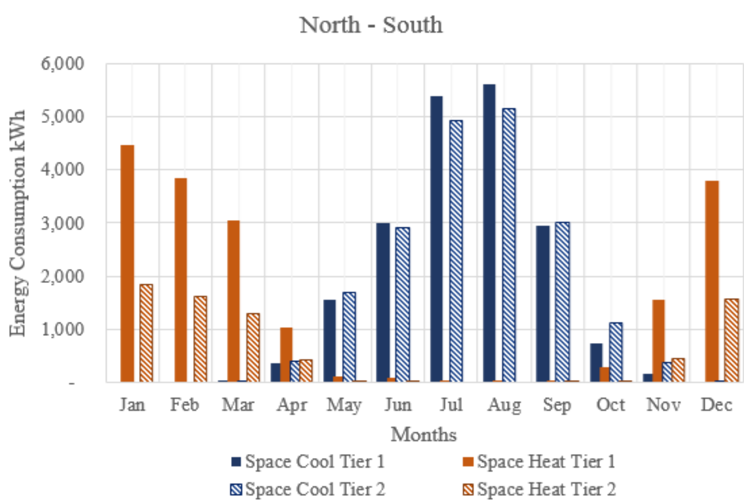
- H+PLL

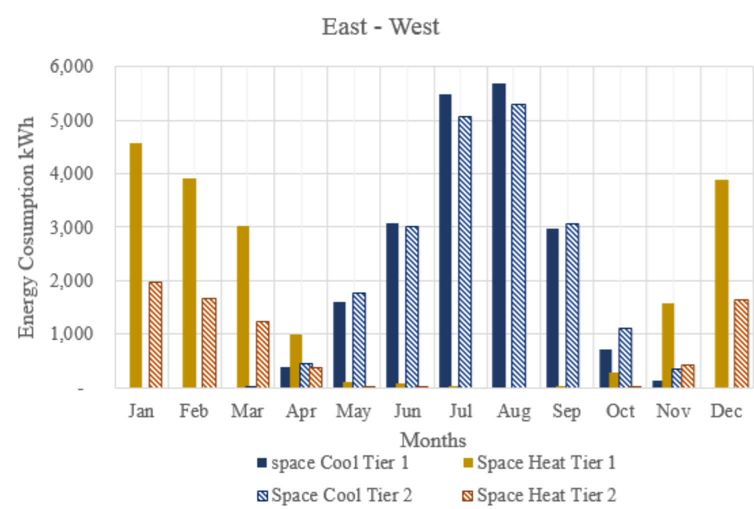




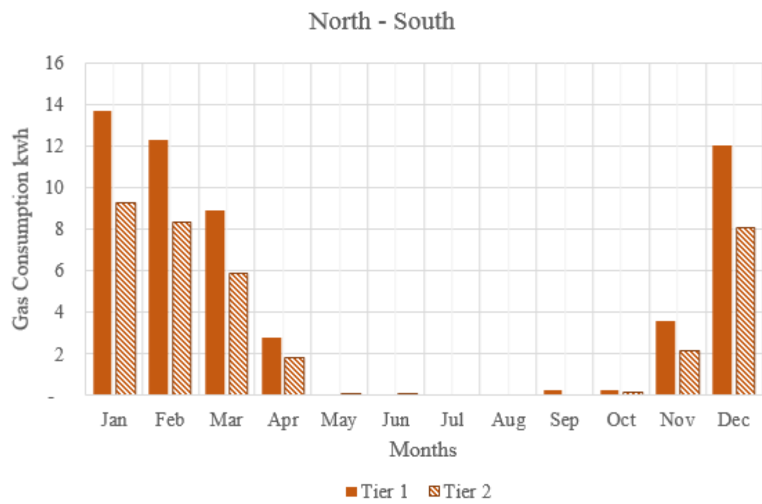
C1. 2 Graphs for Monthly Heating and Cooling Energy Use (Tier 1 and 2) for North-south and East-west Building Orientations Electric consumption

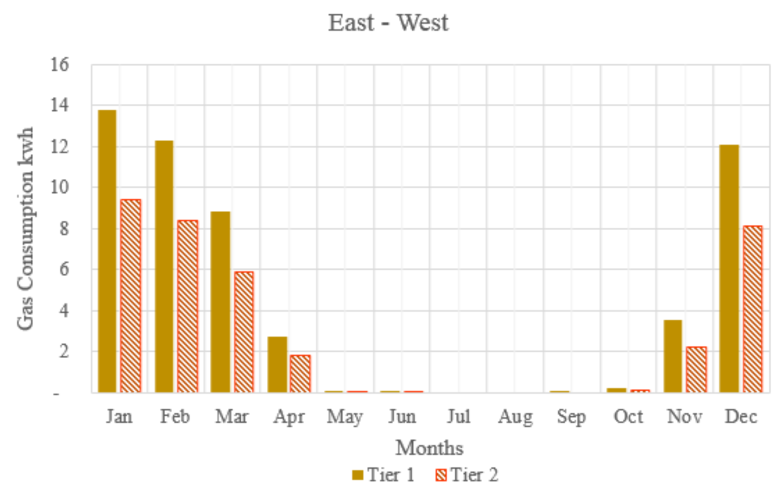
- HC+PLL





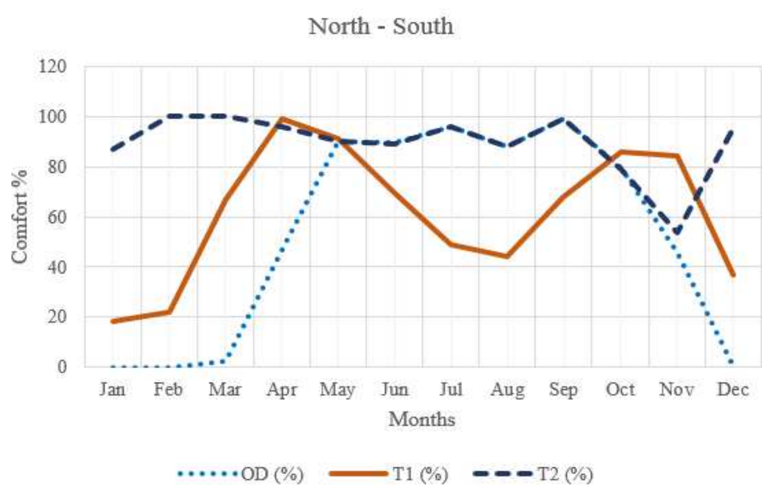
Gas Consumption

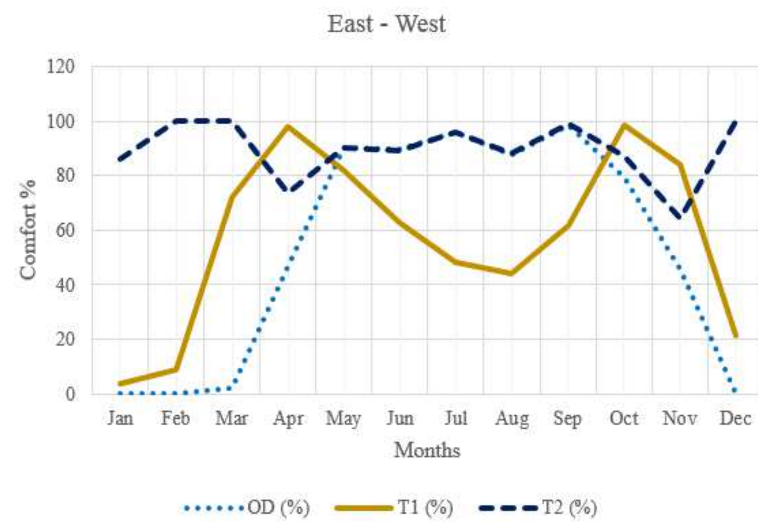




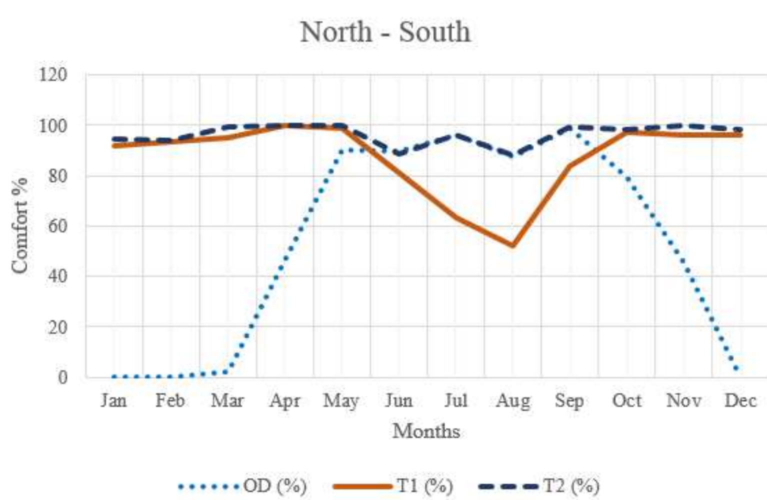
C1.3 Graphs for Monthly Thermal Comfort Percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations.

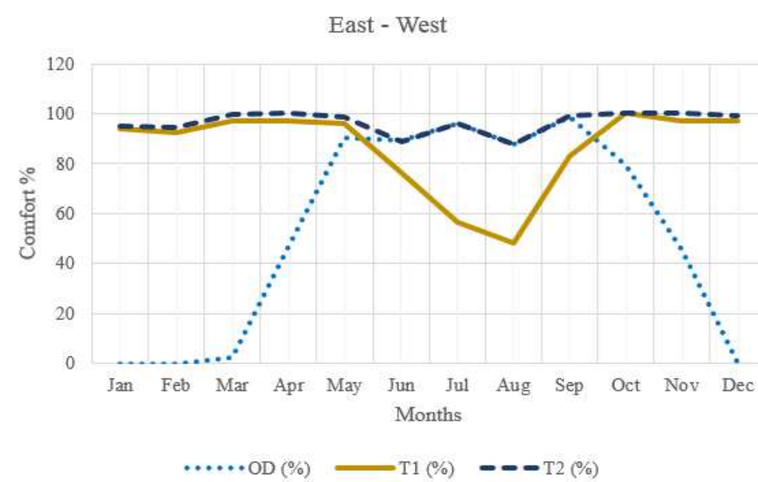
- PLL





- H+PLL





C1.4 Tables of Monthly Energy Use when no Heating & no Cooling (Tier 1 and 2) for North-south and East-west Building Orientations

- PLL

Orientation: North –south

Durres_Electric Consumption (kWh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	145	137	159	159	145	159	159	152	152	152	137	159	1,816
Area Lights	156	147	168	167	152	166	166	159	160	162	148	171	1,921
Total	300	284	327	326	297	325	325	311	312	314	286	330	3,737

Durres_Electric Consumption (kWh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	147	139	161	161	147	161	161	154	154	154	139	161	1,834
Area Lights	156	147	168	167	152	166	166	160	160	162	148	171	1,924
Total	303	286	329	328	299	327	327	314	314	316	287	332	3,758

Orientation: East-west

Durres_Electric Consumption (kWh)													
TIER01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	145	137	159	159	145	159	159	152	152	152	137	159	1,816
Area Lights	156	147	168	167	152	166	166	159	160	162	148	171	1,922
Total	301	284	327	326	297	325	325	311	312	314	286	330	3,738

Durres_Electric Consumption (kWh)													
TIER02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	147	139	161	161	147	161	161	154	154	154	139	161	1,834
Area Lights	156	147	169	167	152	166	166	160	160	162	149	171	1,925
Total	303	286	330	328	299	327	327	314	314	316	288	332	3,759

C1.5 Tables of Monthly Heating Energy Use with Baseboard (Tier 1 and 2) for North-south and East-west Building Orientations

- H+PLL

Orientation: North –south

Durres_ Electric Consumption (kWh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	4,506	3,981	2,879	845	12	14	11	11	12	48	1,189	3,792	17,299
Vent. Fans	662	594	458	289	262	289	289	276	276	276	329	648	4,646
Misc. Equip.	187	176	203	202	187	202	203	195	194	195	178	203	2,324
Area Lights	161	151	172	170	157	169	170	164	164	166	153	175	1,973
Total	5,515	4,902	3,712	1,506	618	674	673	645	646	684	1,848	4,818	26,241

Durres _ Electric Consumption (kWh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	2,892	2,654	1,947	576	9	10	10	10	10	10	548	2,383	11,058
Vent. Fans	494	501	309	285	259	285	285	272	272	272	250	414	3,898
Misc. Equip.	188	178	205	204	188	204	204	196	196	196	179	205	2,343
Area Lights	161	151	172	170	157	170	170	164	164	166	153	175	1,976
Total	3,735	3,484	2,633	1,235	614	668	670	642	642	645	1,130	3,176	19,275

Orientation: East -west

Durres_Electric Consumption (kWh)													
TIER01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	4,697	4,086	2,918	806	12	14	12	13	13	34	1,214	4,080	17,898
Vent. Fans	662	592	464	289	263	289	289	276	276	276	328	643	4,650
Misc. Equip.	187	176	203	202	187	202	203	195	194	195	178	203	2,324
Area Lights	161	151	172	170	157	169	170	164	164	166	153	175	1,974
Total	5,706	5,005	3,757	1,468	619	675	675	648	647	671	1,873	5,102	26,845

Durres_Electric Consumption (kWh)													
TIER02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	3,048	2,723	1,943	528	10	11	11	11	10	9	571	2,582	11,455
Vent. Fans	531	510	310	285	259	285	285	272	272	272	258	474	4,014
Misc. Equip.	188	178	205	204	188	204	204	196	196	196	179	205	2,343
Area Lights	161	151	173	171	157	169	170	164	165	167	154	175	1,977
Total	3,929	3,562	2,630	1,187	614	669	670	643	643	644	1,162	3,436	19,789

C1.6 Tables of Monthly Heating and Cooling Energy Use (Tier 1 and 2) for North-south and East-west Building Orientations

•HC+PLL

Orientation: North –south

Durres_Electric Consumption (kWh)													
TIER1	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	0	367	1,541	3,007	5,398	5,607	2,961	718	146	-	19,745
Space Heat	4,474	3,849	3,048	1,033	112	85	0	0	15	287	1,554	3,797	18,256
Vent. Fans	711	676	782	782	711	782	782	747	747	747	676	782	8,924
Pumps & Aux.	249	212	119	2	-	-	-	-	-	-	55	198	836
Misc. Equip.	187	176	203	202	187	202	203	195	194	195	178	203	2,324
Area Lights	161	151	172	170	157	169	170	164	164	166	153	175	1,973
Total	5,782	5,064	4,325	2,557	2,708	4,246	6,553	6,713	4,081	2,112	2,762	5,155	52,058

Gas Consumption (kwh)													
TIER1	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	14	12	9	3	0	0	-	-	0	0	4	12	54
Total	14	12	9	3	0	0	-	-	0	0	4	12	54

Durres_Electric Consumption (kWh)													
TIER 2	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	1	404	1,699	2,901	4,931	5,159	3,021	1,116	361	1	19,594
Space Heat	1,828	1,613	1,288	410	3	3	-	-	0	13	433	1,568	7,160
Vent. Fans	500	475	549	549	500	549	549	525	525	525	475	549	6,269
Pumps & Aux.	249	212	119	2	-	-	-	-	-	-	55	198	836
Misc. Equip.	187	176	203	202	187	202	203	195	194	195	178	203	2,324
Area Lights	161	151	172	170	157	170	170	164	164	166	153	175	1,975
Total	2,924	2,627	2,333	1,739	2,546	3,825	5,854	6,042	3,904	2,014	1,655	2,695	38,158

Gas Consumption (kwh)													
TIER 2	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	9	8	6	2	0	0	-	-	-	0	2	8	36
Total	9	8	6	2	0	0	-	-	-	0	2	8	36

Orientation: East –west

Durres_ Electric Consumption (kWh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	383	1,592	3,078	5,482	5,682	2,985	710	129	-	20,042
Space Heat	4,584	3,903	3,022	1,005	104	80	0	-	16	275	1,573	3,883	18,443
Vent. Fans	722	686	794	794	722	794	794	758	758	758	686	794	9,063
Pumps & Aux.	249	212	119	2	-	-	-	-	-	-	55	198	836
Misc. Equip.	187	176	203	202	187	202	203	195	194	195	178	203	2,324
Area Lights	161	151	172	170	157	169	170	164	164	166	153	175	1,973
Total	5,903	5,129	4,310	2,557	2,762	4,324	6,650	6,799	4,117	2,104	2,774	5,253	52,682

Gas Consumption (kwh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	14	12	9	3	0	0	-	-	0	0	4	12	54
Total	14	12	9	3	0	0	-	-	0	0	4	12	54

Durres _ Electric Consumption (kWh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	0	436	1,780	3,023	5,078	5,289	3,070	1,107	346	-	20,129
Space Heat	1,959	1,675	1,223	365	2	2	-	-	-	6	432	1,644	7,308
Vent. Fans	524	498	577	577	524	577	577	551	551	551	498	577	6,582
Pumps & Aux.	249	212	119	2	-	-	-	-	-	-	55	198	836
Misc. Equip.	187	176	203	202	187	202	203	195	194	195	178	203	2,324
Area Lights	161	151	173	170	157	169	170	164	164	167	154	175	1,976
Total	3,081	2,713	2,295	1,753	2,650	3,974	6,028	6,199	3,979	2,025	1,662	2,797	39,155

Gas Consumption (kwh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	9	8	6	2	0	0	-	-	-	0	2	8	36
Total	9	8	6	2	0	0	-	-	-	0	2	8	36

C1.7 Tables for Monthly Thermal Comfort Percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations

Total Number of people: 711 nos. , Each floor: 237 nos.

T1: Tier 1, T2: Tier 2, OD: Outdoor

* Cells in italics corresponds to months when windows will be opened

- PLL

Orientation: North – south

Durres	Outdoor	North		South		East		West	
No. of People		70		90		39		18	
Months	OD (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)
Jan	0	0	72	44	100	0	83	0	82
Feb	0	0	100	52	100	4	100	1	100
Mar	2	39	100	93	100	61	100	54	100
Apr	47	100	98	97	*97*	100	91	100	94
May	90	100	90	*81*	*90*	93	*90*	100	90
Jun	89	*74*	*89*	*68*	*89*	*69*	*89*	*70*	*89*
Jul	96	*52*	*96*	*48*	*96*	*48*	*96*	*48*	*96*
Aug	88	*45*	*88*	*44*	*88*	*44*	*88*	*44*	*88*
Sep	99	*85*	*99*	*51*	*99*	*73*	*99*	*78*	*99*
Oct	79	100	*79*	*66*	*79*	100	*79*	100	*79*
Nov	46	82	83	88	29	83	58	83	54
Dec	0	0	100	88	89	0	100	0	100
Annual	53	56	91	68	88	56	89	57	89

North - South	Annual Comfort %		
No. of People		217	
Months	OD (%)	T1 (%)	T2 (%)
Jan	0	18	86
Feb	0	22	100
Mar	2	67	100
Apr	47	99	96
May	90	91	90
Jun	89	70	89
Jul	96	49	96
Aug	88	44	88
Sep	99	68	99
Oct	79	86	79
Nov	46	85	54
Dec	0	37	96
Annual	**53**	**61**	**89**

Orientation: East – west

Durres	Outdoor	North		South		East		West	
No. of People		39		18		70		90	
Months	OD (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)
Jan	0	0	80	2	87	16	96	0	80
Feb	0	6	100	9	100	17	100	0	100
Mar	2	70	100	77	100	81	100	30	100
Apr	47	99	78	96	63	100	89	100	97
May	90	*78*	*90*	*76*	*90*	99	*90*	100	*90*
Jun	89	*62*	*89*	*58*	*89*	*71*	*89*	*74*	*89*
Jul	96	*48*	*96*	*48*	*96*	*49*	*96*	*53*	*96*
Aug	88	*44*	*88*	*44*	*88*	*44*	*88*	*45*	*88*
Sep	99	*62*	*99*	*60*	*99*	*56*	*99*	*87*	*99*
Oct	79	100	*79*	98	*99*	98	*79*	100	*79*
Nov	46	83	73	83	65	89	43	83	78
Dec	0	2	100	13	100	80	100	0	100
Annual	53	55	89	55	90	67	89	56	91

East-West	Annual Comfort %		
No. of People		217	
Months	OD (%)	T1 (%)	T2 (%)
Jan	0	5	86
Feb	0	7	100
Mar	2	58	100
Apr	47	100	88
May	90	94	90
Jun	89	70	89
Jul	96	50	96
Aug	88	44	88
Sep	99	71	99
Oct	79	99	81
Nov	46	85	65
Dec	0	27	100
Annual	**53**	**59**	**90**

- H+PLL

Orientation: North – south

Durres	Outdoor	North		South		East		West	
No. of People		70		90		39		18	
Months	OD (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)
Jan	0	82	84	99	100	94	98	82	96
Feb	0	82	84	104	99	96	97	82	94
Mar	2	89	98	99	100	94	100	96	100
Apr	47	100	100	100	100	100	100	100	100
May	90	100	100	98	100	100	100	100	100
Jun	89	*88*	89	*78*	*89*	*77*	*89*	*82*	*89*
Jul	96	*79*	*96*	*57*	*96*	*57*	*96*	*63*	*96*
Aug	88	*63*	*88*	*46*	*88*	*51*	*88*	*51*	*88*
Sep	99	100	100	*67*	*99*	*87*	*99*	*95*	*99*
Oct	79	100	100	94	97	100	100	100	100
Nov	46	93	99	98	100	96	100	97	100
Dec	0	92	94	100	100	94	100	98	100
Annual	53	89	94	87	97	87	97	87	97

North - South	Annual Comfort %		
No. of People		217	
Months	OD (%)	T1 (%)	T2 (%)
Jan	0	91	94
Feb	0	93	93
Mar	2	95	99
Apr	47	100	100
May	90	99	100
Jun	89	81	89
Jul	96	65	96
Aug	88	53	88
Sep	99	84	99
Oct	79	98	99
Nov	46	96	100
Dec	0	96	98
Annual	53	88	96

Orientation: East – west

HEATING ONLY									
Durres	Outdoor	North		South		East		West	
No. of People		48		90		39		18	
Months	OD (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)
Jan	0	87	92	95	95	100	100	93	93
Feb	0	82	93	94	94	98	98	92	92
Mar	2	87	100	100	100	100	100	100	100
Apr	47	87	100	100	100	100	100	100	100
May	90	*95*	100	95	97	100	100	100	100
Jun	89	*75*	*89*	*72*	*89*	*86*	*85*	*89*	95
Jul	96	*51*	*96*	*51*	*96*	*65*	*96*	*88*	*96*
Aug	88	*47*	*88*	*46*	*88*	*49*	*88*	*65*	*88*
Sep	99	*83*	*99*	*80*	*99*	*84*	*99*	100	100
Oct	79	100	100	100	100	100	100	100	100
Nov	46	96	100	97	100	99	100	95	100
Dec	0	94	99	97	99	100	100	99	99
Annual	53	82	96	86	96	90	97	93	97

East-West	Annual Comfort %		
No. of People		217	
Months	OD (%)	T1 (%)	T2 (%)
Jan	0	94	95
Feb	0	92	95
Mar	2	97	100
Apr	47	97	100
May	90	96	99
Jun	89	77	89
Jul	96	56	96
Aug	88	48	88
Sep	99	83	99
Oct	79	100	100
Nov	46	97	100
Dec	0	97	99
Annual	53	86	97

Appendix C2: Analysis Results for Tirana - Type 1, Rural Building

C2.1 Graphs of Monthly Heating Energy Use with Baseboard (Tier 1 and 2) for North-south and East-west Building Orientations

C2. 2 Graphs for Monthly Heating and Cooling Energy Use (Tier 1 and 2) for North-south and East-west Building Orientations

C2.3 Graphs for Monthly Thermal Comfort Percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations for PLL and H+PLL scenario.

C2.4 Tables of Monthly Energy Use when no Heating & no Cooling (Tier 1 and 2) for North-south and East-west Building Orientations

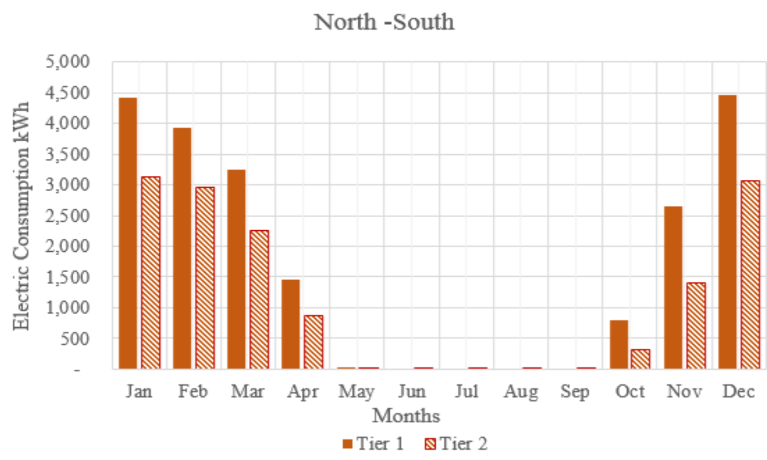
C2.5 Tables of Monthly Heating Energy Use with Baseboard (Tier 1 and 2) for North-south and East-west Building Orientations

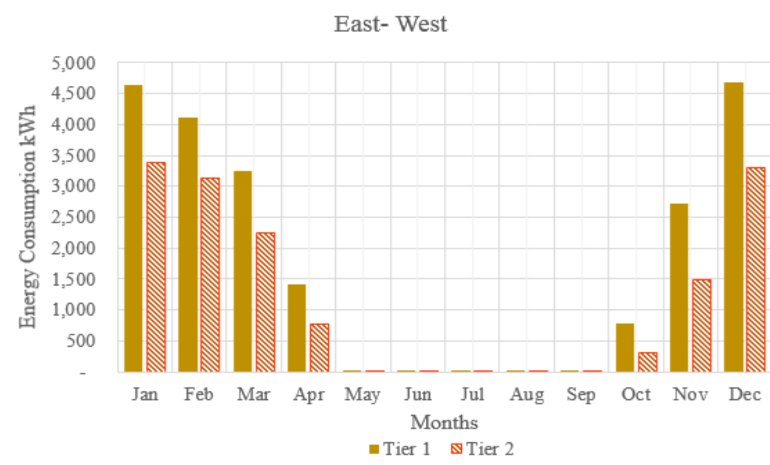
C2.6 Tables of Monthly Heating and Cooling Energy Use (Tier 1 and 2) for North-south and East-west Building Orientations

C2.7 Tables for Monthly Thermal Comfort Percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations.

C2.1 Graphs of Monthly Heating Energy Use with baseboard (Tier 1 and 2) for North-south and East-west Building Orientations

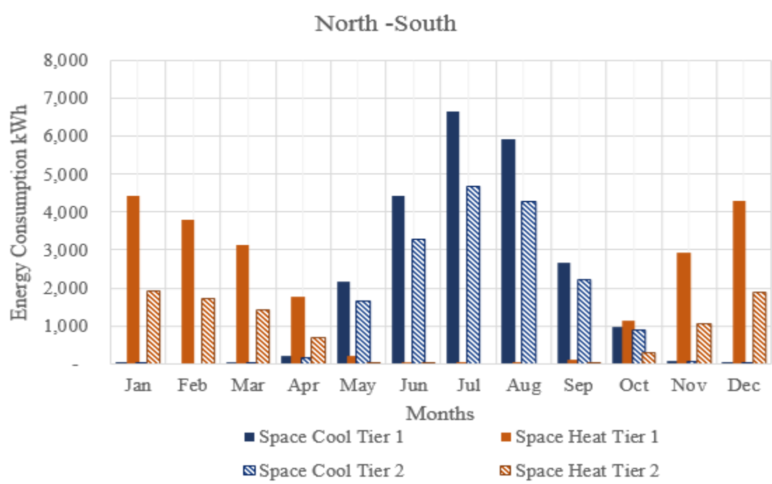
- H+PLL

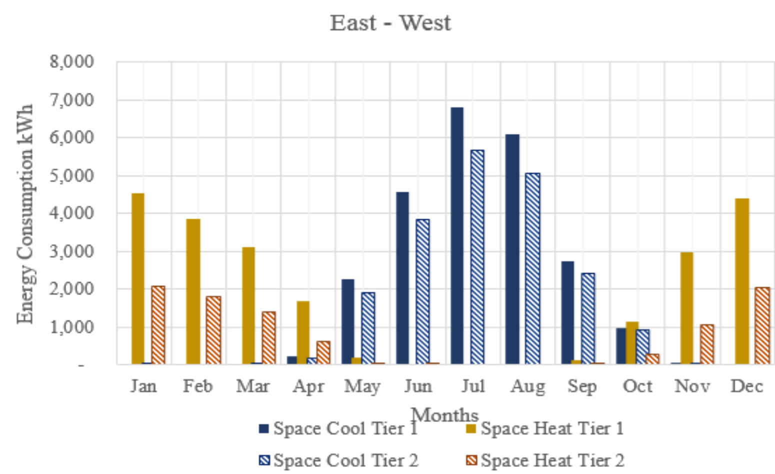




C2. 2 Graphs for Monthly Heating and Cooling Energy Use with (Tier 1 and 2) for North-south and East-west Building Orientations

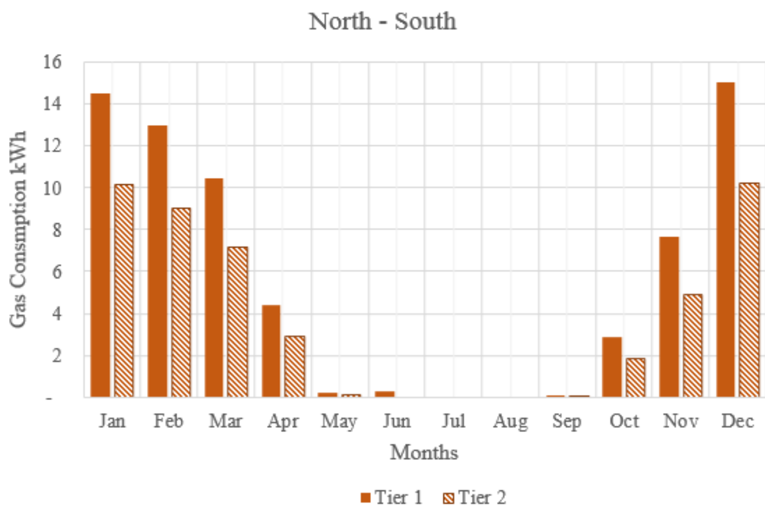
HC+PLL: Electric consumption

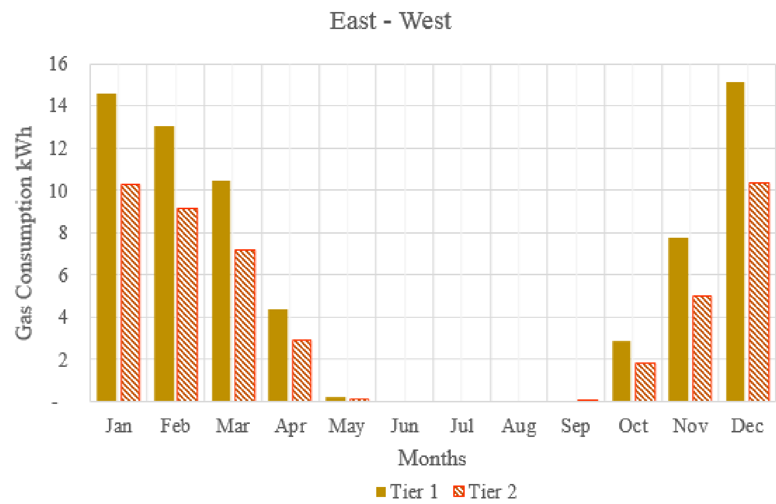




Gas Consumption

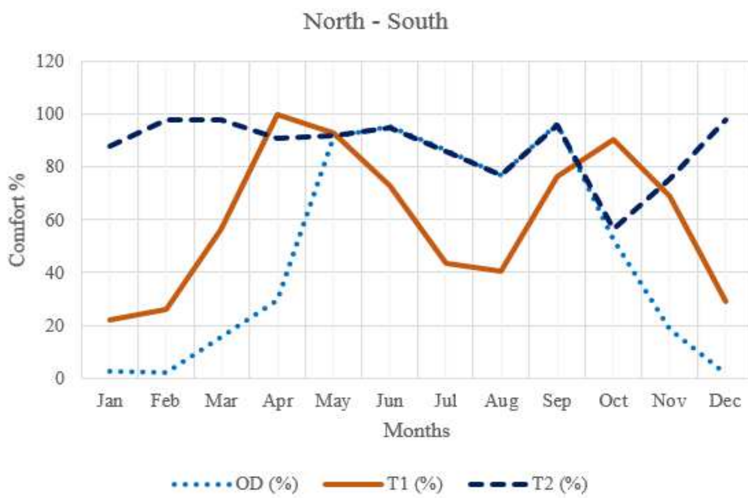
- HC+PLL

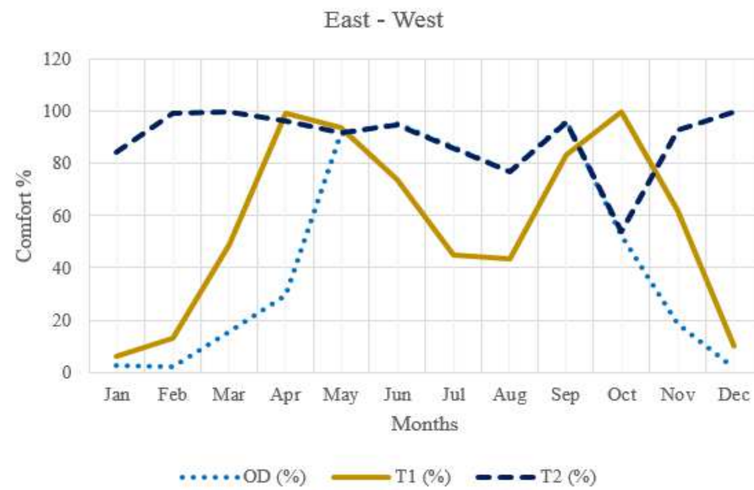




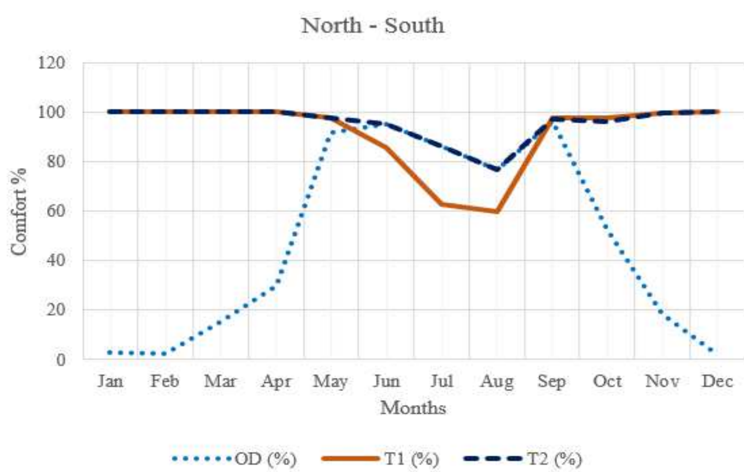
C2.3 Graphs for Monthly Thermal Comfort Percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations for PLL and H+PLL scenario.

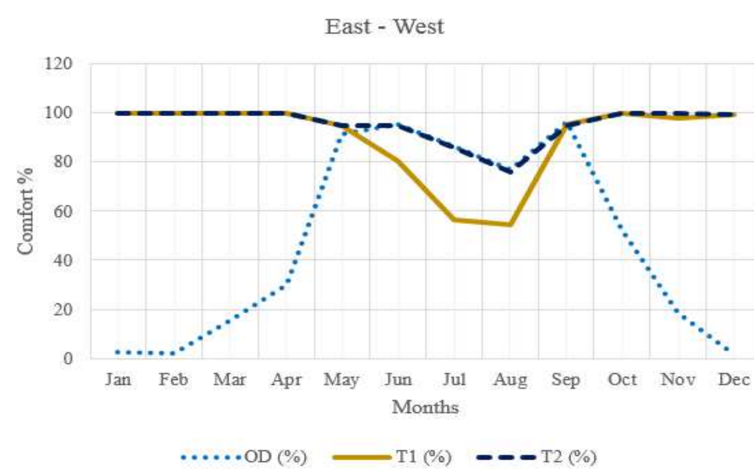
- PLL





H+PLL





C2.4 Tables of Monthly Energy Use when no Heating & no Cooling (Tier 1 and 2) for North-south and East-west Building Orientations

PLL

Orientation: North –south

Tirana_Electric Consumption (kWh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	145	137	159	159	145	159	159	152	152	152	137	159	1,816
Area Lights	156	147	169	167	153	166	167	160	161	162	149	172	1,928
Total	301	285	328	327	297	326	326	312	313	314	286	331	3,745

Tirana_Electric Consumption (kWh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	147	139	161	161	147	161	161	154	154	154	139	161	1,834
Area Lights	157	148	169	167	153	166	167	160	161	162	149	172	1,931
Total	304	287	330	328	300	327	328	314	315	316	288	333	3,765

Orientation: East-west

Tirana_Electric Consumption (kWh)													
TIER01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	145	137	159	159	145	159	159	152	152	152	137	159	1,816
Area Lights	157	147	169	167	153	166	167	160	161	162	149	172	1,930
Total	301	285	328	327	297	326	326	312	313	314	286	331	3,746

Tirana_Electric Consumption (kWh)													
TIER02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	147	139	161	161	147	161	161	154	154	154	139	161	1,834
Area Lights	157	148	169	168	153	167	167	160	161	163	149	172	1,933
Total	304	287	330	329	300	328	328	314	315	317	288	333	3,767

C2.5 Tables of Monthly Heating Energy Use with Baseboard (Tier 1 and 2) for North-south and East-west Building Orientations.

- H+PLL

Orientation: North –south

Tirana _ Electric Consumption (kWh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	4,418	3,935	3,246	1,460	41	14	15	16	21	793	2,642	4,457	21,054
Vent. Fans	640	590	503	300	273	300	300	287	287	287	417	685	4,869
Misc. Equip.	187	176	203	202	187	202	203	195	194	195	178	203	2,324
Area Lights	162	151	173	171	158	170	171	165	165	167	154	176	1,980
Total	5,406	4,853	4,125	2,133	658	686	689	662	666	1,441	3,390	5,520	30,228

Tirana _ Electric Consumption (kWh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	3,132	2,953	2,256	870	13	9	10	11	12	320	1,411	3,060	14,057
Vent. Fans	501	464	432	285	259	285	285	272	272	272	331	521	4,180
Misc. Equip.	188	178	205	204	188	204	204	196	196	196	179	205	2,343
Area Lights	162	152	173	171	158	170	171	165	165	167	154	176	1,983
Total	3,983	3,747	3,065	1,530	618	668	671	644	644	955	2,076	3,962	22,563

Orientation: East -west

Tirana _Electric Consumption (kWh)													
TIER01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	4,635	4,108	3,246	1,405	33	16	18	19	20	793	2,718	4,688	21,699
Vent. Fans	648	599	507	303	275	303	303	289	289	289	422	691	4,918
Misc. Equip.	187	176	203	202	187	202	203	195	194	195	178	203	2,324
Area Lights	162	152	173	171	158	170	171	165	165	167	154	176	1,982
Total	5,632	5,035	4,129	2,081	653	691	694	667	668	1,443	3,472	5,757	30,923

Tirana _Electric Consumption (kWh)													
TIER02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	3,394	3,131	2,252	780	11	10	11	12	12	304	1,491	3,303	14,711
Vent. Fans	512	464	436	285	259	285	285	272	272	272	336	538	4,216
Misc. Equip.	188	178	205	204	188	204	205	196	196	196	179	205	2,343
Area Lights	162	152	173	171	158	170	171	165	165	167	154	176	1,984
Total	4,256	3,925	3,065	1,440	617	669	672	645	645	940	2,160	4,222	23,255

C2.6 Tables of Monthly Heating and Cooling Energy Use (Tier 1 and 2) for North-south and East-west Building Orientations

- HC+PLL

Orientation: North –south

Tirana_Electric Consumption (kWh)													
TIER1	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	4	-	36	205	2,181	4,437	6,644	5,932	2,671	984	82	11	23,188
Space Heat	4,429	3,809	3,116	1,769	194	44	2	1	115	1,146	2,944	4,312	21,880
Vent. Fans	750	713	825	825	750	825	825	788	788	788	713	825	9,413
Pumps & Aux.	256	222	166	97	6	-	-	-	-	54	161	248	1,209
Misc. Equip.	187	176	203	202	187	202	203	195	194	195	178	203	2,324
Area Lights	161	151	173	171	158	170	171	165	165	167	154	176	1,981
Total	5,787	5,071	4,518	3,270	3,476	5,678	7,845	7,080	3,932	3,334	4,230	5,774	59,994

Gas Consumption (kwh)													
TIER1	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	15	13	10	4	0	0	-	-	0	3	8	15	68
Total	15	13	10	4	0	0	-	-	0	3	8	15	68

Tirana_Electric Consumption (kWh)													
TIER 2	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	3	-	21	156	1,664	3,293	4,673	4,278	2,227	899	68	5	17,287
Space Heat	1,928	1,735	1,418	699	20	0	-	-	1	306	1,038	1,886	9,031
Vent. Fans	505	480	556	556	505	556	556	531	531	531	480	556	6,342
Pumps & Aux.	256	222	166	97	6	-	-	-	-	54	161	248	1,209
Misc. Equip.	187	176	203	202	187	202	203	195	194	195	178	203	2,324
Area Lights	162	152	173	171	158	170	171	165	165	167	154	176	1,983
Total	3,040	2,765	2,536	1,881	2,540	4,221	5,603	5,168	3,118	2,152	2,079	3,073	38,176

Gas Consumption (kwh)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	10	9	7	3	0	-	-	-	0	2	5	10	46
Total	10	9	7	3	0	-	-	-	0	2	5	10	46

Orientation: East –west

Tirana_ Electric Consumption (kWh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	2	-	30	214	2,275	4,570	6,803	6,073	2,736	984	63	2	23,752
Space Heat	4,530	3,858	3,111	1,695	183	40	2	2	111	1,127	2,986	4,406	22,051
Vent. Fans	763	725	840	840	763	840	840	801	801	801	725	840	9,578
Pumps & Aux.	256	222	166	97	6	-	-	-	-	54	161	248	1,209
Misc. Equip.	187	176	203	202	187	202	203	195	194	195	178	203	2,324
Area Lights	162	152	173	171	158	170	171	164	165	167	154	176	1,982
Total	5,898	5,133	4,522	3,219	3,573	5,821	8,019	7,235	4,007	3,328	4,267	5,874	60,896

Gas Consumption (kwh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	15	13	10	4	0	-	-	-	0	3	8	15	68
Total	15	13	10	4	0	-	-	-	0	3	8	15	68

Tirana_ Electric Consumption (kWh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	1	-	8	184	1,921	3,823	5,673	5,065	2,416	939	36	-	20,064
Space Heat	2,079	1,802	1,388	614	15	0	-	-	0	263	1,044	2,037	9,242
Vent. Fans	526	499	578	578	526	578	578	552	552	552	499	578	6,597
Pumps & Aux.	256	222	166	97	6	-	-	-	-	54	161	248	1,209
Misc. Equip.	187	176	203	202	187	202	203	195	194	195	178	203	2,324
Area Lights	162	152	173	171	158	170	171	165	165	167	154	176	1,984
Total	3,209	2,851	2,516	1,846	2,812	4,774	6,626	5,977	3,327	2,170	2,071	3,242	41,421

Gas Consumption (kwh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	10	9	7	3	0	-	-	-	0	2	5	10	47
Total	10	9	7	3	0	-	-	-	0	2	5	10	47

C 2.7 Tables for Monthly Thermal Comfort Percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations.

Total Number of people: 711 nos. , Each floor: 237 nos.

T1: Tier 1, T2: Tier 2, OD: Outdoor

* Cells in italics corresponds to months when windows will be opened

•PLL

Orientation: North – south

Tirana	Outdoor	North M		South		East		West	
No.of People		70		90		39		18	
Months	OD (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)
Jan	3	0	75	51	100	2	86	2	83
Feb	2	0	92	61	100	6	100	0	100
Mar	16	43	100	70	94	52	100	47	100
Apr	30	99	100	100	79	100	97	100	100
May	92	100	*92*	*89*	*92*	*88*	*92*	100	*92*
Jun	95	*80*	*95*	*72*	*95*	*60*	*95*	*80*	*95*
Jul	86	*45*	*86*	*43*	*86*	*43*	*86*	*44*	*86*
Aug	77	*46*	*77*	*38*	*77*	*38*	*77*	*38*	*77*
Sep	96	97	*96*	*58*	*96*	*72*	*96*	*95*	*96*
Oct	53	100	64	76	*53*	100	*53*	100	*53*
Nov	18	53	100	85	42	65	98	61	100
Dec	2	0	100	67	95	7	100	0	100
Annual	47	55	90	68	84	53	90	56	90

North - South	Annual Comfort %		
No. of People		217	
Months	OD (%)	T1 (%)	T2 (%)
Jan	3	22	88
Feb	2	26	98
Mar	16	56	98
Apr	30	100	91
May	92	93	92
Jun	95	73	95
Jul	86	44	86
Aug	77	41	77
Sep	96	76	96
Oct	53	90	57
Nov	18	69	75
Dec	2	29	98
Annual	**47**	**60**	**87**

Orientation: East – west

Tirana	Outdoor	North		South		East		West	
No. of People		39		18		70		90	
Months	OD (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)
Jan	3	3	83	4	83	16	92	0	80
Feb	2	13	99	6	100	32	100	0	99
Mar	16	55	100	52	100	55	100	41	100
Apr	30	100	81	100	96	100	100	98	100
May	92	*76*	*92*	*87*	*92*	98	*92*	100	*92*
Jun	95	*52*	*95*	*62*	*95*	*79*	*95*	*81*	*95*
Jul	86	*43*	*86*	*43*	*86*	*43*	*86*	*48*	*86*
Aug	77	*38*	*77*	*38*	*77*	*38*	*77*	*51*	*77*
Sep	96	*63*	*96*	*87*	*96*	*77*	*96*	97	*96*
Oct	53	99	*53*	100	42	100	*53*	100	57
Nov	18	65	98	62	100	71	79	54	100
Dec	2	7	100	1	100	26	100	0	100
Annual	47	51	88	53	89	61	89	56	90

East-West	Annual Comfort %		
No. of People		217	
Months	OD (%)	T1 (%)	T2 (%)
Jan	3	6	85
Feb	2	13	99
Mar	16	49	100
Apr	30	99	96
May	92	94	92
Jun	95	74	95
Jul	86	45	86
Aug	77	44	77
Sep	96	83	96
Oct	53	100	54
Nov	18	62	93
Dec	2	10	100
Annual	47	57	89

Orientation: North – south

Tirana	Outdoor	North		South		East		West	
No.of People		48		90		39		18	
Months	OD (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)
Jan	3	100	100	100	100	100	100	100	100
Feb	2	100	100	100	100	100	100	100	100
Mar	16	100	100	100	100	100	100	100	100
Apr	30	100	100	100	100	100	100	100	100
May	92	100	100	98	95	93	99	100	100
Jun	95	*93*	*95*	*83*	*95*	*79*	*95*	*92*	*95*
Jul	86	*76*	*86*	*58*	*86*	*50*	*86*	*73*	*86*
Aug	77	78	*77*	*49*	*77*	*50*	*77*	*68*	*77*
Sep	96	100	100	*96*	*96*	98	95	100	100
Oct	53	100	100	95	91	100	100	100	100
Nov	18	99	99	100	100	100	100	100	100
Dec	2	100	100	100	100	100	100	100	100
Annual	47	95	96	90	95	89	96	94	96

North - South	Annual Comfort %		
No. of People		217	
Months	OD (%)	T1 (%)	T2 (%)
Jan	3	100	100
Feb	2	100	100
Mar	16	100	100
Apr	30	100	100
May	92	98	98
Jun	95	86	95
Jul	86	63	86
Aug	77	60	77
Sep	96	98	97
Oct	53	98	96
Nov	18	100	100
Dec	2	100	100
Annual	47	92	96

Orientation: East- west

Tirana	Outdoor	North		South		East		West	
No. of People		39		18		70		90	
Months	OD (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)
Jan	3	100	100	100	100	100	100	100	100
Feb	2	100	100	100	100	100	100	100	100
Mar	16	100	100	100	100	100	100	100	100
Apr	30	100	100	100	100	100	100	100	100
May	92	*88*	*92*	98	94	100	100	100	100
Jun	95	*72*	*95*	*81*	*95*	*91*	*95*	*94*	91
Jul	86	*47*	*86*	*53*	*86*	*72*	*86*	*77*	*86*
Aug	77	*45*	*77*	*51*	*77*	*65*	*77*	87	*77*
Sep	96	*89*	*96*	100	92	98	96	100	100
Oct	53	100	100	100	100	100	100	100	100
Nov	18	98	99	97	100	97	100	97	100
Dec	2	99	99	99	99	99	99	99	99
Annual	47	87	95	90	95	94	96	96	96

East-West	Annual Comfort %		
No. of People		217	
Months	OD (%)	T1 (%)	T2 (%)
Jan	3	100	100
Feb	2	100	100
Mar	16	100	100
Apr	30	100	100
May	92	98	98
Jun	95	88	93
Jul	86	68	86
Aug	77	69	77
Sep	96	98	97
Oct	53	100	100
Nov	18	98	100
Dec	2	99	99
Annual	47	93	96

Appendix C3: Analysis Results for Korca - Type 1, Rural Building

C3.1 Graphs of Monthly Heating Energy Use with Baseboard (Tier 1 and 2) for North-south and East-west Building Orientations

C3. 2 Graphs for Monthly Heating and Cooling Energy Use (Tier 1 and 2) for North-south and East-west Building Orientations

C3.3 Graphs for Monthly Thermal Comfort Percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations for PLL and H+PLL scenario.

C3.4 Tables of Monthly Energy Use when no Heating & no Cooling (Tier 1 and 2) for North-south and East-west Building Orientations

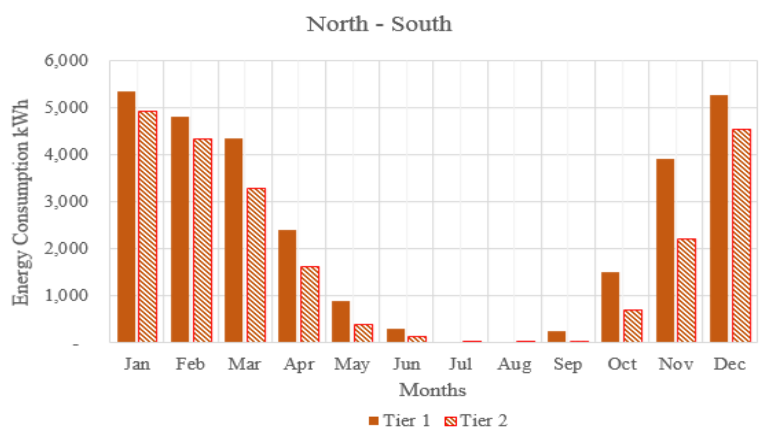
C3.5 Tables of Monthly Heating Energy Use with Baseboard (Tier 1 and 2) for North-south and East-west Building Orientations

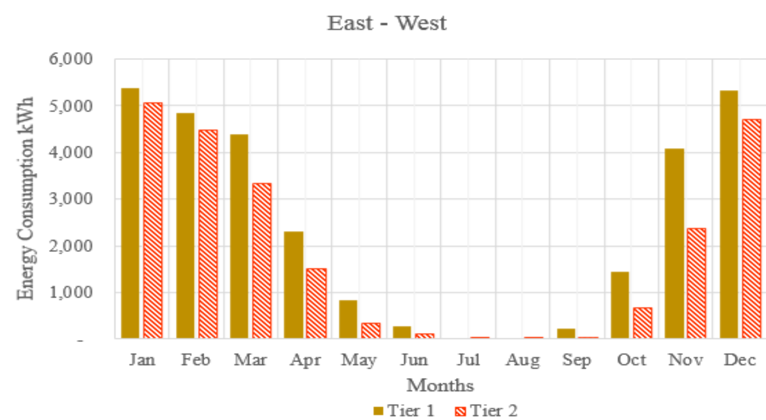
C3.6 Tables of Monthly Heating and Cooling Energy Use (Tier 1 and 2) for North-south and East-west Building Orientations

C3.7 Tables for Monthly Thermal Comfort Percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations

C3.1 Graphs of Monthly Heating Energy Use with Baseboard (Tier 1 and 2) for North-south and East-west Building Orientations

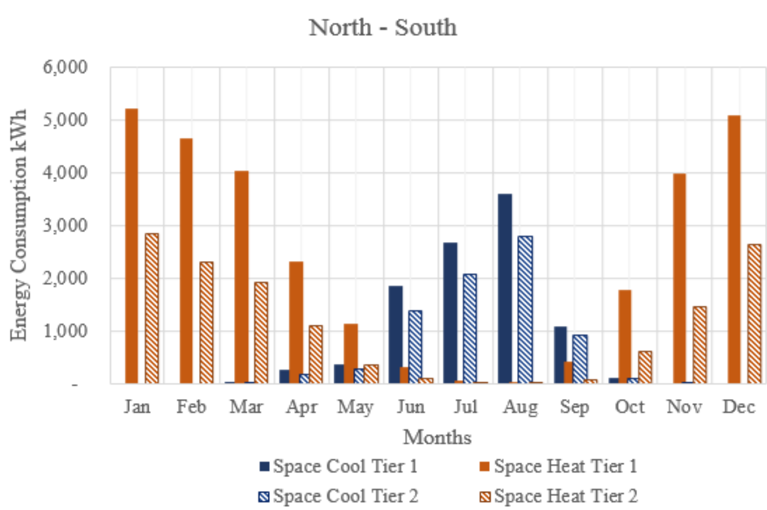
H+PLL

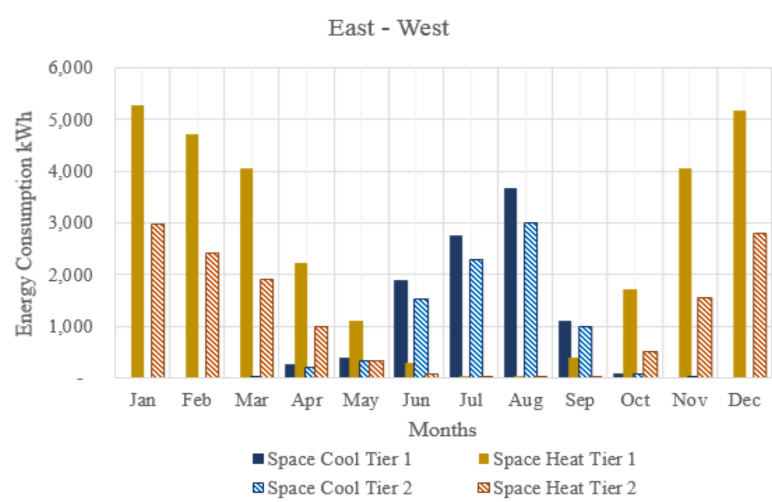




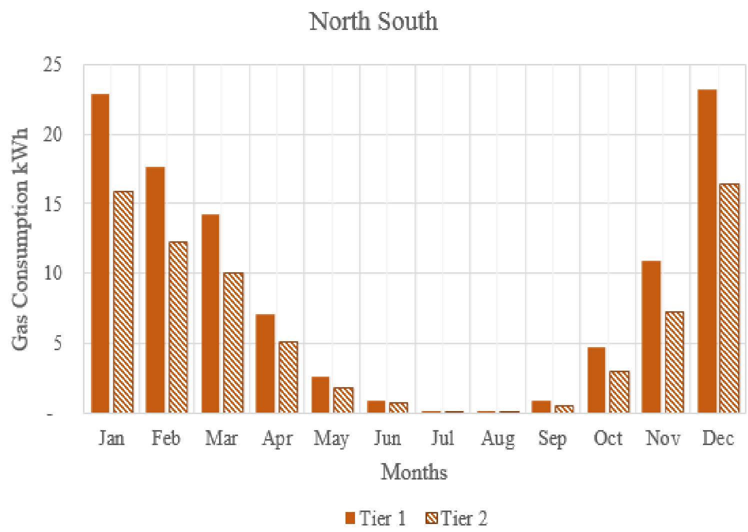
C3.2 Graphs for Monthly Heating and Cooling Energy Use with (Tier 1 and 2) for North-south and East-west Building Orientations

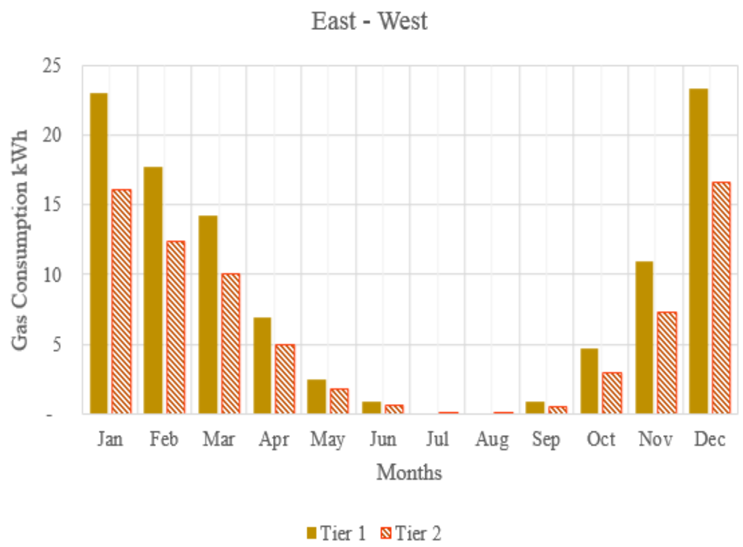
HC+PLL: Electric consumption





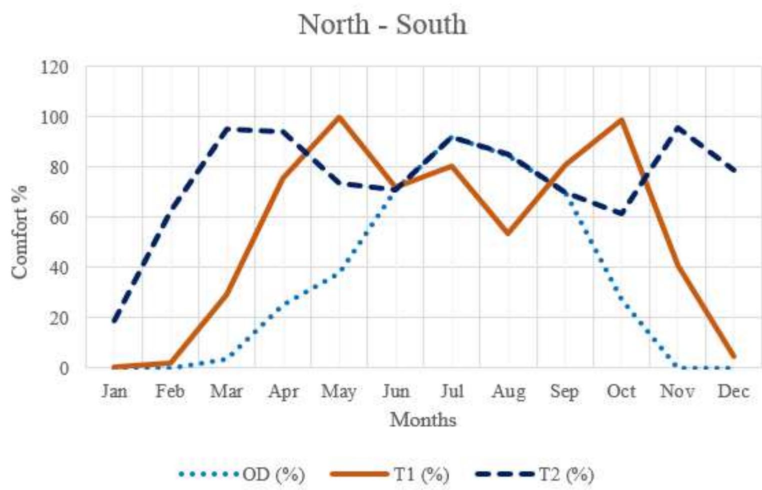
Gas Consumption

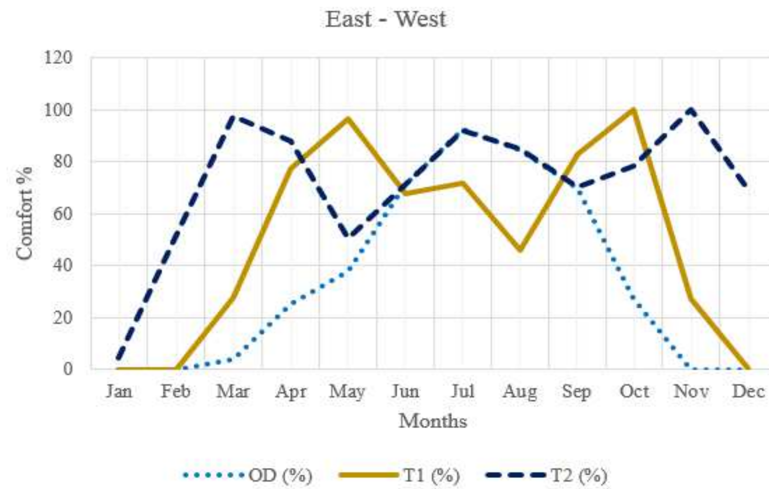




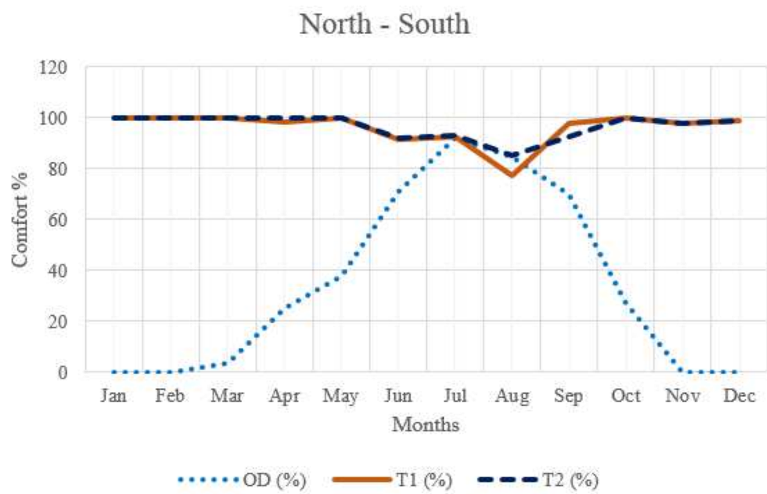
C3.3 Graphs for Monthly Thermal Comfort Percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations for PLL and H+PLL Scenario.

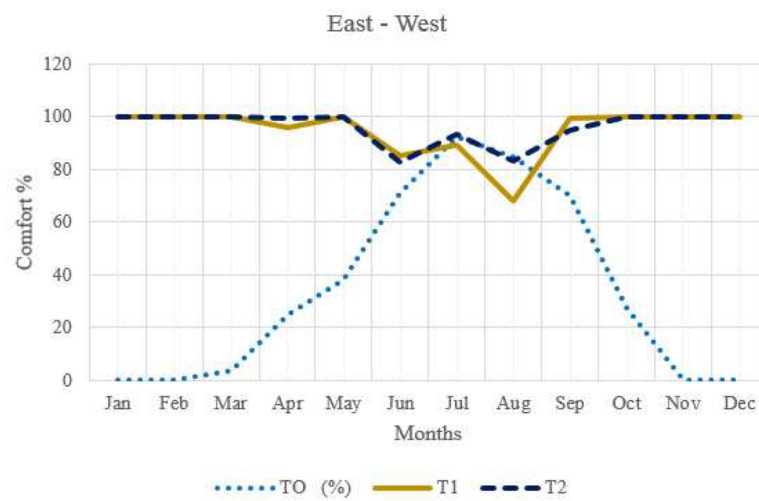
- PLL





- H+PLL





C3.4 Tables of Monthly Energy Use when no Heating & no Cooling (Tier 1 and 2) for North-south and East-west Building Orientations

PLL

Orientation: North –south

Korca Electric Consumption (kWh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	145	137	159	159	145	159	159	152	152	152	137	159	1,816
Area Lights	156	147	169	167	153	166	167	160	161	162	149	172	1,929
Total	301	285	328	327	297	326	326	312	313	314	286	331	3,745

Korca Electric Consumption (kWh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	147	139	161	161	147	161	161	154	154	154	139	161	1,834
Area Lights	157	148	169	168	153	167	167	160	161	162	149	172	1,933
Total	304	287	330	329	300	328	328	314	315	316	288	333	3,767

Orientation: East-west

Korca_Electric Consumption (kWh)													
TIER01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	145	137	159	159	145	159	159	152	152	152	137	159	1,816
Area Lights	156	147	169	167	153	167	167	160	161	162	149	172	1,930
Total	301	285	328	327	297	326	326	312	313	314	286	331	3,747

Korca_Electric Consumption (kWh)													
TIER02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	147	139	161	161	147	161	161	154	154	154	139	161	1,834
Area Lights	157	148	169	168	153	167	167	160	161	163	149	172	1,934
Total	304	287	330	329	300	328	328	314	315	317	288	333	3,768

C3.5 Tables of Monthly Heating Energy Use with Baseboard (Tier 1 and 2) for North-south and East-west Building Orientations

- H+PLL

Orientation: North –south

Korca _ Electric Consumption (kWh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	5,345	4,804	4,345	2,390	897	310	23	26	246	1,501	3,906	5,273	29,065
Vent. Fans	761	685	646	458	288	317	317	303	303	303	576	755	5,711
Misc. Equip.	187	176	203	202	187	202	203	195	194	195	178	203	2,324
Area Lights	161	151	173	171	158	170	171	165	165	167	154	176	1,981
Total	6,455	5,816	5,366	3,221	1,530	999	714	688	908	2,166	4,813	6,406	39,081

Korca _ Electric Consumption (kWh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	4,908	4,319	3,292	1,626	389	134	9	11	43	709	2,216	4,532	22,188
Vent. Fans	663	595	547	362	259	285	285	272	272	272	462	658	4,933
Misc. Equip.	188	178	205	204	188	204	204	196	196	196	179	205	2,343
Area Lights	162	152	173	171	158	170	171	165	165	167	154	176	1,985
Total	5,921	5,243	4,216	2,363	995	793	671	645	676	1,345	3,011	5,570	31,449

Orientation: East - west

Korca _Electric Consumption (kWh)													
TIER01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	5,372	4,848	4,394	2,307	834	285	23	25	215	1,443	4,081	5,328	29,155
Vent. Fans	764	689	647	455	288	317	317	303	303	303	581	758	5,724
Misc. Equip.	187	176	203	202	187	202	203	195	194	195	178	203	2,324
Area Lights	162	152	173	171	158	170	171	165	165	167	154	176	1,982
Total	6,484	5,864	5,417	3,136	1,467	974	714	688	877	2,107	4,993	6,465	39,185

Korca _Electric Consumption (kWh)													
TIER02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	5,054	4,483	3,334	1,503	335	115	10	12	26	671	2,373	4,700	22,616
Vent. Fans	665	595	546	359	259	285	285	272	272	272	485	658	4,953
Misc. Equip.	188	178	205	204	188	204	205	196	196	196	179	205	2,343
Area Lights	162	152	174	171	158	170	171	165	165	167	154	176	1,986
Total	6,069	5,407	4,258	2,237	940	775	672	646	659	1,307	3,191	5,738	31,898

C3.6 Tables of Monthly Heating and Cooling Energy Use (Tier 1 and 2) for North-south and East-west Building Orientations

- HC+PLL

Orientation: North –south

Korca_Electric Consumption (kWh)													
TIER1	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	16	259	368	1,842	2,672	3,593	1,083	102	-	-	9,935
Space Heat	5,222	4,650	4,045	2,310	1,135	312	50	41	414	1,774	3,975	5,097	29,024
Vent. Fans	705	670	776	776	705	776	776	740	740	740	670	776	8,849
Pumps & Aux.	332	297	248	129	43	9	-	-	7	83	234	327	1,710
Misc. Equip.	187	176	203	202	187	202	203	195	194	195	178	203	2,324
Area Lights	161	151	173	171	158	170	171	165	165	167	154	176	1,981
Total	6,607	5,945	5,461	3,847	2,595	3,310	3,871	4,734	2,603	3,061	5,210	6,578	53,823

Gas Consumption (kwh)													
TIER1	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	23	18	14	7	3	1	0	0	1	5	11	23	105
Total	23	18	14	7	3	1	0	0	1	5	11	23	105

Korca_Electric Consumption (kWh)													
TIER 2	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	9	173	275	1,390	2,076	2,801	923	101	0	-	7,748
Space Heat	2,834	2,296	1,924	1,093	359	102	1	0	69	596	1,448	2,625	13,347
Vent. Fans	499	474	549	549	499	549	549	524	524	524	474	549	6,261
Pumps & Aux.	332	297	248	129	43	9	-	-	7	83	234	327	1,710
Misc. Equip.	187	176	203	202	187	202	203	195	194	195	178	203	2,324
Area Lights	162	152	173	171	158	170	171	165	165	167	154	176	1,985
Total	4,013	3,395	3,106	2,318	1,521	2,422	3,000	3,685	1,882	1,666	2,489	3,879	33,375

Gas Consumption (kwh)													
TIER 2	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	16	12	10	5	2	1	0	0	0	3	7	16	73
Total	16	12	10	5	2	1	0	0	0	3	7	16	73

Orientation: East –west

Korca_ Electric Consumption (kWh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	13	272	389	1,905	2,755	3,673	1,101	84	-	-	10,191
Space Heat	5,285	4,724	4,047	2,235	1,097	301	47	39	398	1,719	4,067	5,178	29,137
Vent. Fans	716	680	787	787	716	787	787	751	751	751	680	787	8,981
Pumps & Aux.	332	297	248	129	43	9	-	-	7	83	234	327	1,710
Misc. Equip.	187	176	203	202	187	202	203	195	194	195	178	203	2,324
Area Lights	162	151	173	171	158	170	171	165	165	167	154	176	1,982
Total	6,680	6,028	5,472	3,796	2,589	3,375	3,964	4,823	2,616	2,999	5,313	6,671	54,326

Gas Consumption (kwh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	23	18	14	7	3	1	0	0	1	5	11	23	105
Total	23	18	14	7	3	1	0	0	1	5	11	23	105

Korca_ Electric Consumption (kWh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	4	207	332	1,531	2,282	2,996	989	72	0	-	8,413
Space Heat	2,980	2,411	1,920	1,005	325	94	1	0	42	520	1,552	2,796	13,644
Vent. Fans	524	498	576	576	524	576	576	550	550	550	498	576	6,572
Pumps & Aux.	332	297	248	129	43	9	-	-	7	83	234	327	1,710
Misc. Equip.	187	176	203	202	187	202	203	195	194	195	178	203	2,324
Area Lights	162	152	173	171	158	170	171	165	165	167	154	176	1,986
Total	4,184	3,534	3,124	2,290	1,569	2,583	3,233	3,906	1,948	1,587	2,616	4,077	34,650

Gas Consumption (kwh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	16	12	10	5	2	1	0	0	0	3	7	17	73
Total	16	12	10	5	2	1	0	0	0	3	7	17	73

C3.7 Tables for Monthly Thermal Comfort Percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations

Total Number of people: 711 nos. , Each floor: 237 nos.

T1: Tier 1, T2: Tier 2, OD: Outdoor

*Cells in italics corresponds to months when windows will be open

•PLL

Orientation: North – south

Korca	Outdoor	North		South		East		West	
No.Of People		70		90		39		18	
Monthis	OD (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)
Jan	0	0	0	1	43	0	7	0	1
Feb	0	0	13	5	96	0	75	0	50
Mar	4	8	87	48	99	32	100	12	98
Apr	25	56	100	89	89	88	94	60	100
May	38	100	100	100	59	100	55	100	93
Jun	71	78	*71*	*71*	*71*	*68*	*71*	*73*	*71*
Jul	92	*90*	*92*	*78*	*92*	*67*	*92*	*89*	*92*
Aug	85	*72*	*85*	*44*	*85*	*42*	*85*	*58*	*85*
Sep	70	100	*70*	*64*	*70*	78	*70*	98	*70*
Oct	27	98	97	99	19	100	84	100	92
Nov	0	18	100	70	90	24	100	23	100
Dec	0	0	61	11	94	0	77	0	77
Annual	34	52	73	57	75	50	76	51	77

North - South	Annual Comfort %		
No. of People		217	
Months	OD (%)	T1 (%)	T2 (%)
Jan	0	1	19
Feb	0	2	62
Mar	4	29	95
Apr	25	76	94
May	38	100	74
Jun	71	73	71
Jul	92	81	92
Aug	85	54	85
Sep	70	81	70
Oct	27	99	62
Nov	0	41	96
Dec	0	5	79
Annual	34	53	75

Orientation: East – west

Korca	Outdoor	North		South		East		West	
No. Of People		39		18		70		90	
Months	OD (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)
Jan	0	0	2	0	2	0	12	0	0
Feb	0	0	50	0	38	0	80	0	25
Mar	4	38	99	21	96	34	100	2	95
Apr	25	89	81	73	91	76	98	55	100
May	38	95	38	100	48	100	71	100	93
Jun	71	*61*	*71*	*69*	*71*	*75*	*71*	81	*71*
Jul	92	*52*	*92*	*78*	*92*	*87*	*92*	*91*	*92*
Aug	85	*42*	*85*	*46*	*85*	*47*	*85*	*71*	*85*
Sep	70	*68*	*70*	90	*70*	88	*70*	100	*70*
Oct	27	100	82	100	89	100	57	100	94
Nov	0	25	100	21	100	46	100	19	100
Dec	0	0	65	0	64	1	82	0	75
Annual	34	47	70	50	70	55	77	52	75

East-West	Annual Comfort %		
No. of People		217	
Months	OD (%)	T1 (%)	T2 (%)
Jan	0	0	5
Feb	0	0	48
Mar	4	20	97
Apr	25	69	95
May	38	99	72
Jun	71	74	71
Jul	92	81	92
Aug	85	56	85
Sep	70	89	70
Oct	27	100	79
Nov	0	29	100
Dec	0	0	75
Annual	34	52	74

- H+PLL

Orientation: North – south

Korca	Outdoor	North		South		East		West	
No. of People		70		90		39		18	
Months	OD (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)
Jan	0	100	100	100	100	100	100	100	100
Feb	0	100	100	100	100	100	100	100	100
Mar	4	100	100	100	100	100	100	100	100
Apr	25	100	99	98	100	100	100	91	100
May	38	100	100	100	100	100	100	100	100
Jun	71	100	100	89	88	79	85	100	100
Jul	92	98	98	*90*	*92*	*87*	87	96	97
Aug	85	90	85	*64*	*85*	*85*	*85*	84	*85*
Sep	70	100	100	95	83	100	100	100	100
Oct	27	99	100	100	100	100	100	100	100
Nov	0	94	94	100	100	100	100	98	98
Dec	0	96	96	100	100	100	100	100	100
Annual	34	98	98	95	96	96	96	97	98

North - South	Annual Comfort %		
No. of People		217	
Months	OD (%)	T1 (%)	T2 (%)
Jan	0	100	100
Feb	0	100	100
Mar	4	100	100
Apr	25	98	100
May	38	100	100
Jun	71	92	92
Jul	92	93	93
Aug	85	78	85
Sep	70	98	93
Oct	27	100	100
Nov	0	98	98
Dec	0	99	99
Annual	34	96	97

Orientation: East- west

Korca	Outdoor	North		South		East		West	
No. Of People		39		18		70		90	
Months	OD (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)
Jan	0	100	100	100	100	100	100	100	100
Feb	0	100	100	100	100	100	100	100	100
Mar	4	100	100	100	100	100	100	100	100
Apr	25	100	100	100	100	100	100	100	100
May	38	100	100	100	100	100	100	100	100
Jun	71	*73*	71	86	81	100	100	100	100
Jul	92	*84*	*92*	*91*	*92*	94	94	100	99
Aug	85	*53*	*85*	*71*	*85*	*79*	73	92	87
Sep	70	100	94	100	98	100	100	100	100
Oct	27	100	100	100	100	100	100	100	100
Nov	0	100	100	100	100	100	100	100	100
Dec	0	100	100	100	100	100	100	100	100
Annual	34	92	95	96	96	98	97	99	99

East-West	Annual Comfort %		
No. of People		217	
Months	T_O (%)	T_1	T_2
Jan	0	100	100
Feb	0	100	100
Mar	4	100	100
Apr	25	100	100
May	38	100	100
Jun	71	94	93
Jul	92	95	96
Aug	85	79	82
Sep	70	100	99
Oct	27	100	100
Nov	0	100	100
Dec	0	100	100
Annual	34	97	97

APPENDIX D

RESULTS OF BUILDING TYPE 3 : URBAN

Appendix D1: Analysis Results for Durres - Type 3, Urban Building

D1.1 Graphs of Monthly Heating Energy Use with Baseboard (Tier 1 and 2) for North-south and East-west Building Orientations

D1. 2 Graphs for Monthly Heating and Cooling Energy Use (Tier 1 and 2) for North-south and East-west Building Orientations

D1.3 Graphs for Monthly Thermal Comfort Percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations

D1.4 Tables of Monthly Energy Use when no Heating & no Cooling (Tier 1 and 2) for North-south and East-west Building Orientations

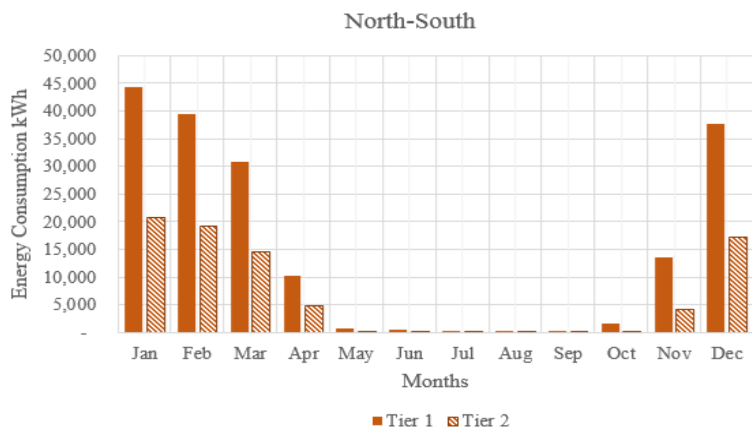
D1.5 Tables of Monthly Heating Energy Use with Baseboard (Tier 1 and 2) for North-south and East-west Building Orientations

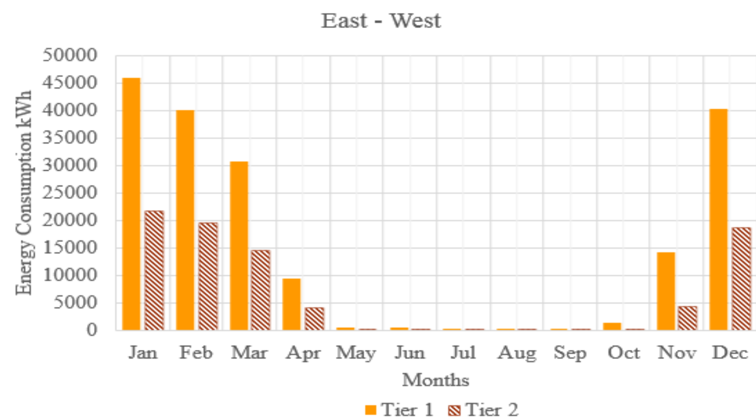
D1.6 Tables of Monthly Heating and Cooling Energy Use (Tier 1 and 2) for North-south and East-west Building Orientations

D1.7 Tables for monthly thermal comfort percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations

D1.1 Graphs of Monthly Heating Energy Use with Baseboard (Tier 1 and 2) for North-south and East-west Building Orientations

- H+PLL

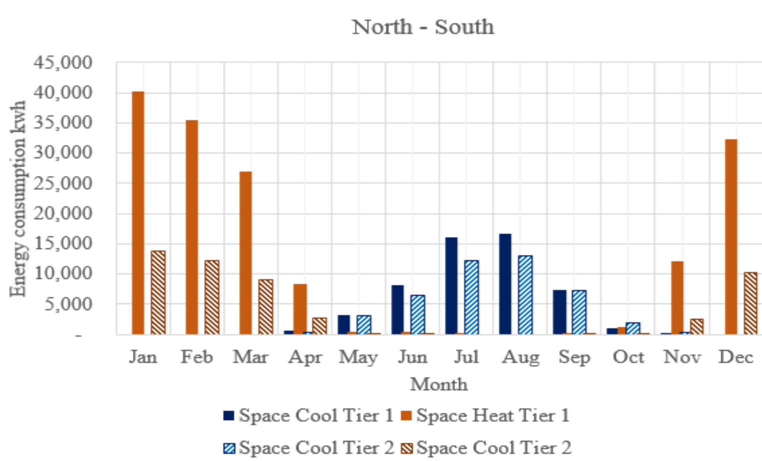


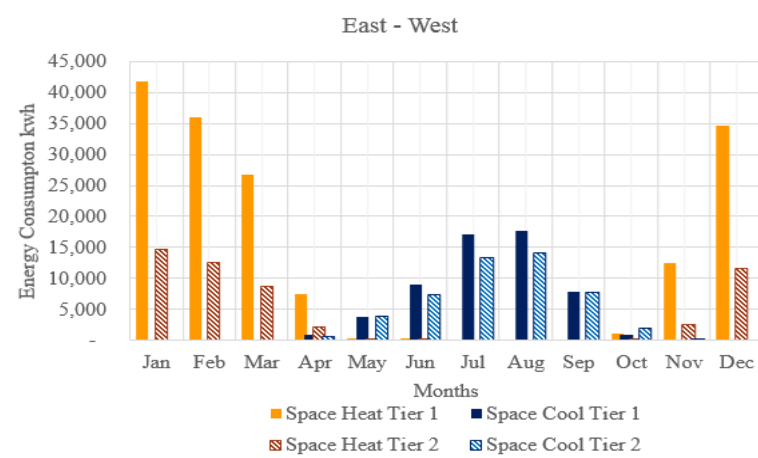


D1. 2 Graphs for Monthly Heating and Cooling Energy Use (Tier 1 and 2) for North-south and East-west Building Orientations

Electric consumption

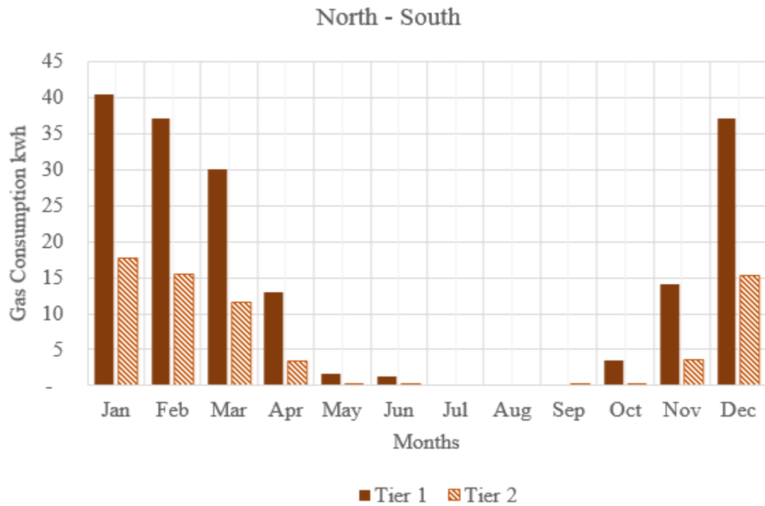
- HC + PLL

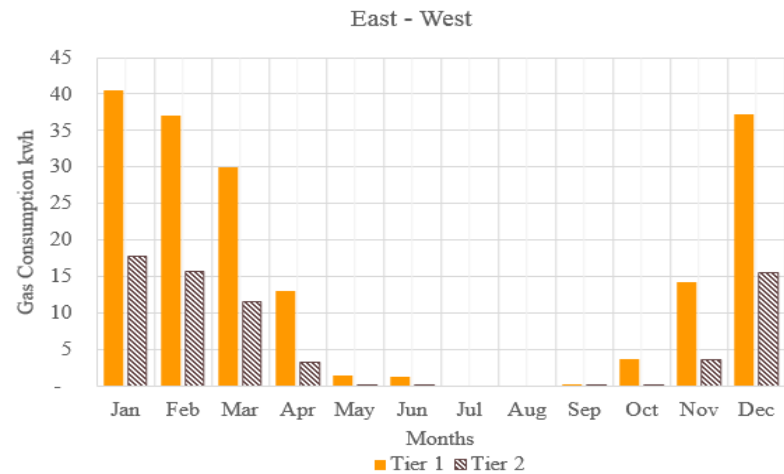




Gas Consumption

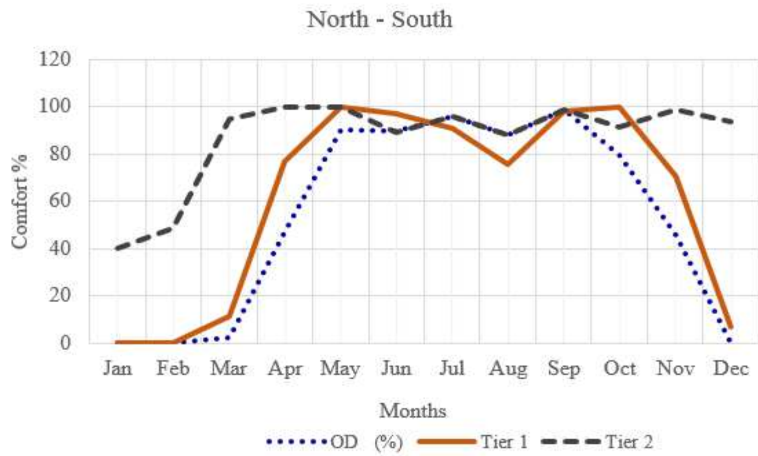
- HC + PLL

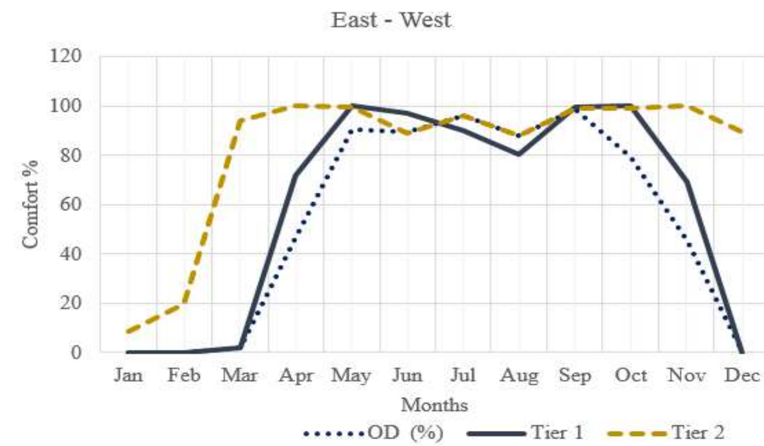




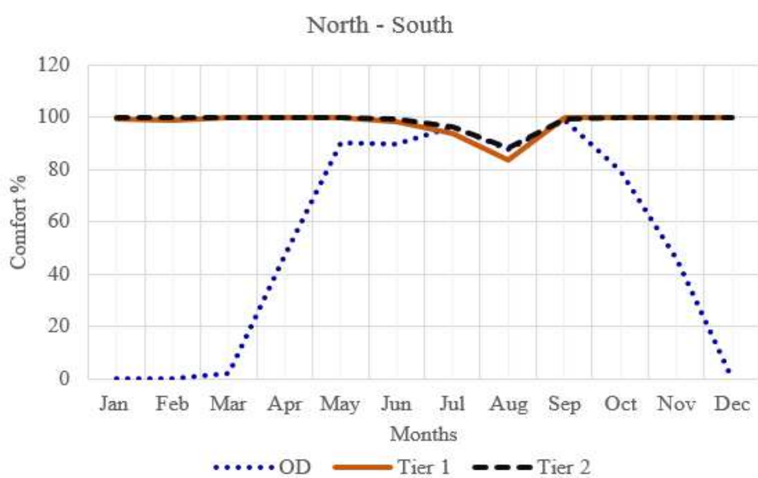
D1.3 Graphs for Monthly Thermal Comfort Percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations

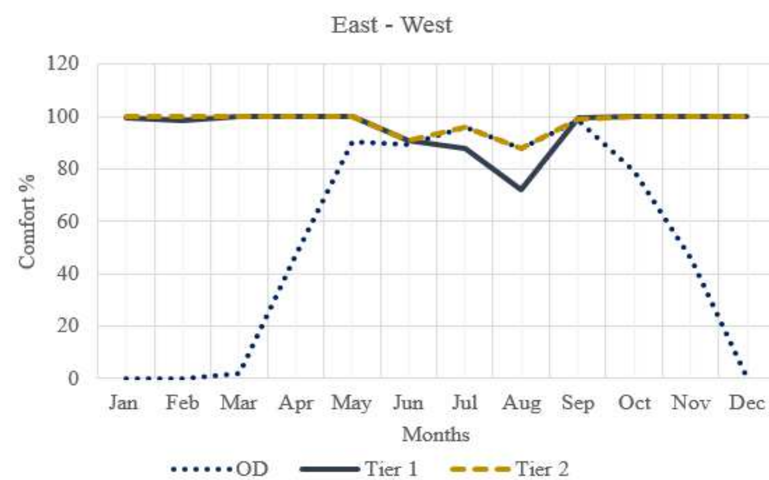
- PLL





- H+PLL





D1.4 Tables of Monthly Energy Use when no Heating & no Cooling (Tier 1 and 2) for North-south and East-west Building Orientations

- PLL

Orientation: North –South

Durres_Electric Consumption (kWh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	608	560	626	606	556	598	601	580	589	611	576	662	7,175
Total	1,441	1,348	1,533	1,509	1,390	1,501	1,507	1,451	1,456	1,481	1,370	1,569	17,556

Durres_Electric Consumption (kWh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	835	788	908	904	835	904	907	871	868	871	795	907	10,396
Area Lights	612	565	632	613	563	606	608	586	595	616	580	668	7,244
Total	1,447	1,353	1,540	1,517	1,398	1,510	1,515	1,457	1,463	1,487	1,375	1,575	17,640

Orientation: East-west

Durres_ Electric Consumption (kWh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	609	562	628	607	556	599	602	581	591	613	578	664	7,190
Total	1,443	1,349	1,534	1,510	1,390	1,502	1,508	1,451	1,458	1,483	1,372	1,571	17,571

Durres_ Electric Consumption (kWh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	835	788	908	904	835	904	907	871	868	871	795	907	10,396
Area Lights	615	568	634	613	562	605	608	587	597	619	584	671	7,263
Total	1,450	1,356	1,542	1,517	1,397	1,509	1,515	1,458	1,465	1,490	1,379	1,578	17,659

D1.5 Tables of Monthly Heating Energy Use with Baseboard (Tier 1 and 2) for North-south and East-west Building Orientations

- H+PLL

Orientation: North –south

Durres_Electric Consumption (kWh)													
Tier 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	44,394	39,379	30,920	10,277	699	587	129	123	131	1,632	13,674	37,764	179,707
Vent. Fans	1,619	1,477	1,638	1,183	800	880	880	840	840	843	1,117	1,650	13,765
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	629	581	650	631	577	620	622	603	613	634	597	687	7,446
Total	47,476	42,224	34,115	12,994	2,910	2,990	2,538	2,436	2,450	3,978	16,182	41,007	211,299

Durres_Electric Consumption (kWh)													
Tier 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	20,788	19,112	14,630	4,795	86	105	93	88	89	95	4,174	17,246	81,303
Vent. Fans	1,485	1,324	915	880	800	880	880	840	840	840	767	1,197	11,646
Misc. Equip.	835	788	908	904	835	904	907	872	868	871	795	908	10,396
Area Lights	634	586	656	637	584	628	630	610	618	639	602	692	7,514
Total	23,743	21,810	17,109	7,216	2,305	2,516	2,510	2,409	2,415	2,445	6,338	20,042	110,859

Orientation: East-west

Durres_Electric Consumption (kWh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	45,957	40,059	30,826	9,344	499	445	132	128	131	1,391	14,146	40,264	183,323
Vent. Fans	1,619	1,477	1,638	1,175	800	880	880	840	840	843	1,119	1,650	13,760
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	631	583	652	632	578	619	622	604	615	636	599	688	7,459
Total	49,042	42,906	34,023	12,054	2,711	2,847	2,541	2,443	2,452	3,739	16,659	43,508	214,923

Durres_Electric Consumption (kWh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	21,823	19,540	14,524	4,144	87	99	94	91	89	80	4,351	18,653	83,574
Vent. Fans	1,521	1,334	917	880	800	880	880	840	840	840	776	1,276	11,782
Misc. Equip.	835	788	908	904	835	904	907	872	868	871	795	908	10,396
Area Lights	637	589	659	638	584	626	629	610	621	642	605	695	7,534
Total	24,816	22,251	17,007	6,566	2,306	2,509	2,510	2,413	2,417	2,433	6,527	21,531	113,285

D1.6 Tables of Monthly Heating and Cooling Energy Use (Tier 1 and 2) for North-south and East-west Building Orientations

•HC+PLL

Orientation: North –south

Durres_Electric Consumption (kWh)													
Tier 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	683	3,231	8,118	16,051	16,760	7,398	1,029	110	-	53,381
Space Heat	40,199	35,370	26,965	8,376	542	382	0	-	19	1,286	12,096	32,266	157,502
Vent. Fans	2,141	2,034	2,355	2,355	2,141	2,355	2,355	2,248	2,248	2,248	2,034	2,355	26,870
Pumps & Aux.	665	566	318	6	-	-	-	-	-	-	146	528	2,230
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	633	585	654	635	581	624	626	607	616	637	600	690	7,488
Total	44,472	39,342	31,199	12,957	7,329	12,382	19,939	20,486	11,148	6,071	15,781	36,746	257,851

Gas Consumption (kwh)													
Tier 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	40	37	30	13	2	1	-	-	0	4	14	37	179
Total	40	37	30	13	2	1	-	-	0	4	14	37	179

Durres_Electric Consumption (kWh)													
Tier 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	419	3,153	6,501	12,217	13,088	7,249	1,947	424	-	44,998
Space Heat	13,700	12,195	8,996	2,646	18	13	-	-	0	25	2,480	10,325	50,398
Vent. Fans	1,352	1,284	1,487	1,487	1,352	1,487	1,487	1,419	1,419	1,419	1,284	1,487	16,962
Pumps & Aux.	665	566	318	6	-	-	-	-	-	-	146	528	2,230
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	638	589	660	641	587	631	633	613	621	642	605	695	7,556
Total	17,188	15,422	12,367	6,101	5,944	9,534	15,243	15,991	10,156	4,902	5,734	13,942	132,524

Gas Consumption (kwh)													
Tier 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	18	16	12	3	0	0	-	-	0	0	4	15	67
Total	18	16	12	3	0	0	-	-	0	0	4	15	67

Orientation: East –west

Durres_Electric Consumption (kWh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	814	3,782	8,937	17,150	17,770	7,882	885	12	-	57,233
Space Heat	41,826	36,041	26,753	7,447	367	262	0	-	11	1,055	12,455	34,583	160,801
Vent. Fans	2,280	2,166	2,508	2,508	2,280	2,508	2,508	2,394	2,394	2,394	2,166	2,508	28,613
Pumps & Aux.	665	566	318	6	-	-	-	-	-	-	146	528	2,230
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	634	587	656	635	581	623	626	608	618	639	603	692	7,501
Total	46,239	40,147	31,141	12,313	7,844	13,233	21,190	21,642	11,772	5,843	16,176	39,217	266,759

Gas Consumption (kwh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	40	37	30	13	1	1	-	-	0	4	14	37	178
Total	40	37	30	13	1	1	-	-	0	4	14	37	178

Durres_Electric Consumption (kWh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	578	3,826	7,406	13,300	14,084	7,727	2,061	304	-	49,288
Space Heat	14,630	12,512	8,797	2,109	11	9	-	-	-	21	2,560	11,551	52,201
Vent. Fans	1,474	1,401	1,622	1,622	1,474	1,622	1,622	1,548	1,548	1,548	1,401	1,622	18,501
Pumps & Aux.	665	566	318	6	-	-	-	-	-	-	146	528	2,230
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	640	592	662	642	587	629	633	614	624	645	608	699	7,576
Total	18,243	15,859	12,306	5,860	6,732	10,569	16,461	17,116	10,766	5,146	5,814	15,305	140,177

Gas Consumption (kwh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	18	16	12	3	0	0	-	-	0	0	4	16	67
Total	18	16	12	3	0	0	-	-	0	0	4	16	67

D1.7 Tables for Monthly Thermal Comfort Percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations

Total Number of people: 711 nos. , Each floor: 237 nos.

T1: Tier 1, T2: Tier 2, OD: Outdoor

* Cells in italics corresponds to months when windows will be opened

- PLL

Orientation: North – south

	Outdoor	North		South		East		West	
No. of People		98		98		25		16	
Months	OD (%)	T1(%)	T2(%)	T1(%)	T2(%)	T1(%)	T2(%)	T1(%)	T2(%)
Jan	0	0	0	0	94	0	1	0	16
Feb	0	0	8	1	99	0	11	0	45
Mar	2	1	88	26	100	0	95	7	100
Apr	47	64	100	91	100	66	100	87	100
May	90	100	100	100	100	100	100	100	100
Jun	89	99	*89*	96	*89*	99	90	*86*	*89*
Jul	96	*95*	*96*	*89*	*96*	*92*	*96*	*77*	*96*
Aug	88	93	*88*	*60*	*88*	*81*	*88*	*54*	*88*
Sep	99	100	*99*	*96*	*99*	100	*99*	*97*	*99*
Oct	79	100	100	100	*79*	100	100	100	97
Nov	46	67	100	76	97	67	100	69	100
Dec	0	0	86	17	100	0	97	0	100
Annual	53	60	80	63	95	59	81	56	86

North-South	Annual Comfort %		
No. of People		237	
Months	OD (%)	T1(%)	T2(%)
Jan	0	0	40
Feb	0	0	48
Mar	2	12	95
Apr	47	77	100
May	90	100	100
Jun	89	97	89
Jul	96	91	96
Aug	88	76	88
Sep	99	98	99
Oct	79	100	91
Nov	46	71	99
Dec	0	7	94
Annual	**53**	**61**	**87**

Orientation: East – west

	Outdoor	North		South		East		West	
No.of People		25		16		98		98	
Months	OD (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)
Jan	0	0	8	0	18	0	16	0	0
Feb	0	0	30	0	54	0	28	0	4
Mar	2	5	100	8	100	1	99	1	86
Apr	47	85	100	87	100	72	100	66	100
May	90	100	100	100	98	100	100	100	100
Jun	89	*85*	*89*	*86*	*89*	100	*89*	99	*89*
Jul	96	*71*	*96*	*76*	*96*	*93*	*96*	*94*	*96*
Aug	88	*53*	*88*	*55*	*88*	*81*	*88*	91	*88*
Sep	99	99	*99*	*97*	*99*	100	99	100	*99*
Oct	79	100	94	100	94	100	100	100	100
Nov	46	67	100	67	100	73	100	67	100
Dec	0	0	96	0	98	0	100	0	76
Annual	53	55	83	56	86	60	85	60	78

East-West	Annual Comfort %		
No. of People		237	
Months	OD (%)	T1 (%)	T2 (%)
Jan	0	0	9
Feb	0	0	20
Mar	2	2	94
Apr	47	72	100
May	90	100	100
Jun	89	97	89
Jul	96	90	96
Aug	88	80	88
Sep	99	100	99
Oct	79	100	99
Nov	46	69	100
Dec	0	0	90
Annual	**53**	**59**	**82**

- H+PLL

Orientation: North – south

	Outdoor	North		South		East		West	
No. of People		98		98		25		16	
Months	OD (%)	T1(%)	T2(%)	T1(%)	T2(%)	T1(%)	T2(%)	T1(%)	T2(%)
Jan	0	99	100	100	100	100	100	100	100
Feb	0	98	100	99	100	99	100	98	100
Mar	2	100	100	100	100	100	100	100	100
Apr	47	100	100	100	100	100	100	100	100
May	90	100	100	100	100	100	100	100	100
Jun	89	99	100	98	100	99	100	90	94
Jul	96	96	*96*	*93*	*96*	*94*	*96*	*85*	*96*
Aug	88	96	*88*	*73*	*88*	90	*88*	*65*	*88*
Sep	99	100	100	100	99	100	100	99	*99*
Oct	79	100	100	100	100	100	100	100	100
Nov	46	100	100	100	100	100	100	100	100
Dec	0	100	100	100	100	100	100	100	100
Annual	53	99	99	97	99	98	99	95	98

North- South	Annual Comfort %		
No. of People		237	
Months	OD (%)	T1(%)	T2(%)
Jan	0	99	100
Feb	0	99	100
Mar	2	100	100
Apr	47	100	100
May	90	100	100
Jun	89	98	99
Jul	96	94	96
Aug	88	83	88
Sep	99	100	100
Oct	79	100	100
Nov	46	100	100
Dec	0	100	100
Annual	53	98	99

Orientation: East- west

	Outdoor	North		South		East		West	
No.of People		25		16		98		98	
Months	OD (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)
Jan	0	100	100	100	100	100	100	98	100
Feb	0	99	100	98	100	99	100	97	100
Mar	2	100	100	100	100	100	100	100	100
Apr	47	100	100	100	100	100	100	100	100
May	90	100	100	100	100	100	100	100	100
Jun	89	*88*	*89*	90	*89*	100	100	99	100
Jul	96	*87*	*96*	*86*	*96*	*95*	*96*	*96*	96
Aug	88	*67*	*88*	*69*	*88*	92	*88*	95	*88*
Sep	99	100	*99*	99	*99*	100	100	100	100
Oct	79	100	100	100	100	100	100	100	100
Nov	46	100	100	100	100	100	100	100	100
Dec	0	100	100	100	100	100	100	100	100
Annual	53	95	98	95	98	99	99	99	99

East-West	Annual Comfort %		
No. of People		237	
Months	OD (%)	T1 (%)	T2 (%)
Jan	0	99	100
Feb	0	98	100
Mar	2	100	100
Apr	47	100	100
May	90	100	100
Jun	89	98	98
Jul	96	94	96
Aug	88	89	88
Sep	99	100	100
Oct	79	100	100
Nov	46	100	100
Dec	0	100	100
Annual	53	98	98

Appendix D2: Analysis Results for Tirana - Type 3, Urban Building

D2.1 Graphs of Monthly Heating Energy Use with Baseboard (Tier 1 and 2) for North-south and East-west Building Orientations

D2. 2 Graphs for Monthly Heating and Cooling Energy Use (Tier 1 and 2) for North-south and East-west Building Orientations

D2.3 Graphs for Monthly Thermal Comfort Percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations

D2.4 Tables of Monthly Energy Use when no Heating & no Cooling (Tier 1 and 2) for North-south and East-west Building Orientations

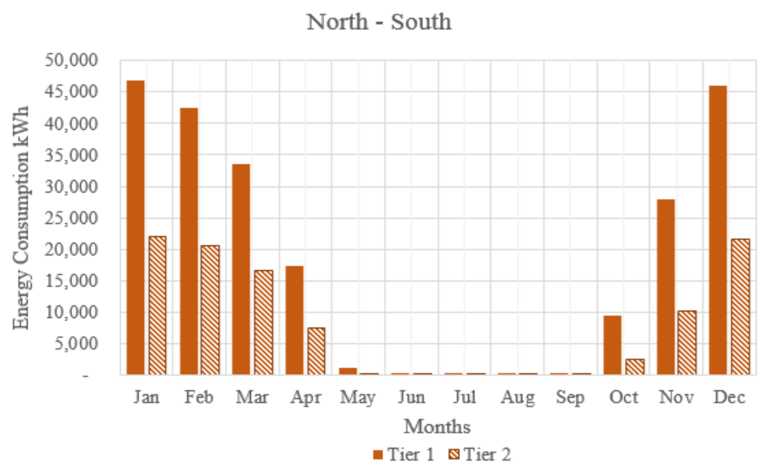
D2.5 Tables of Monthly Heating Energy Use with Baseboard (Tier 1 and 2) for North-south and East-west Building Orientations

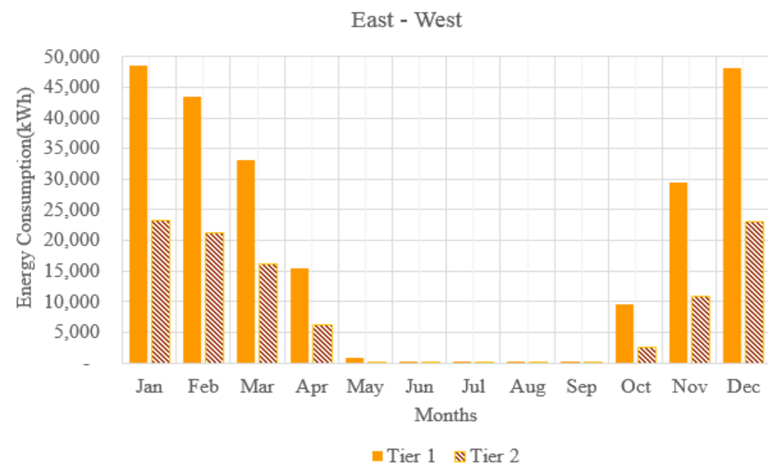
D2.6 Tables of Monthly Heating and Cooling Energy Use (Tier 1 and 2) for North-south and East-west Building Orientations

D2.7 Tables for Monthly Thermal Comfort Percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations

D2.1 Graphs of Monthly Heating Energy Use with Baseboard (Tier 1 and 2) for North-south and East-west Building Orientations

- H+PLL

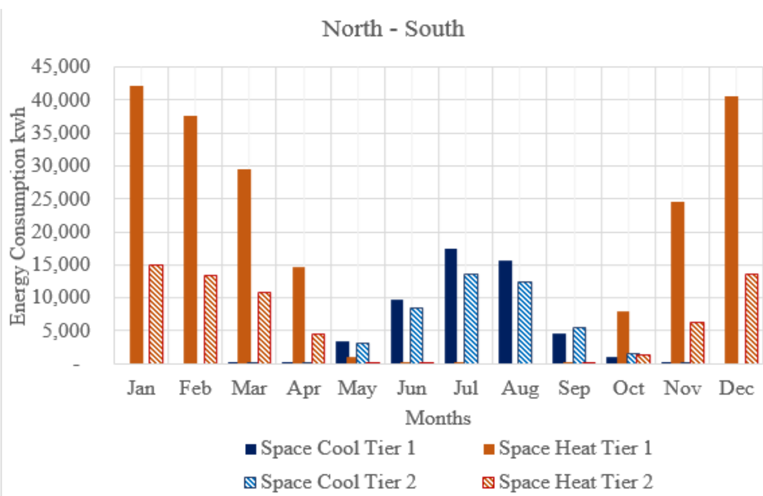


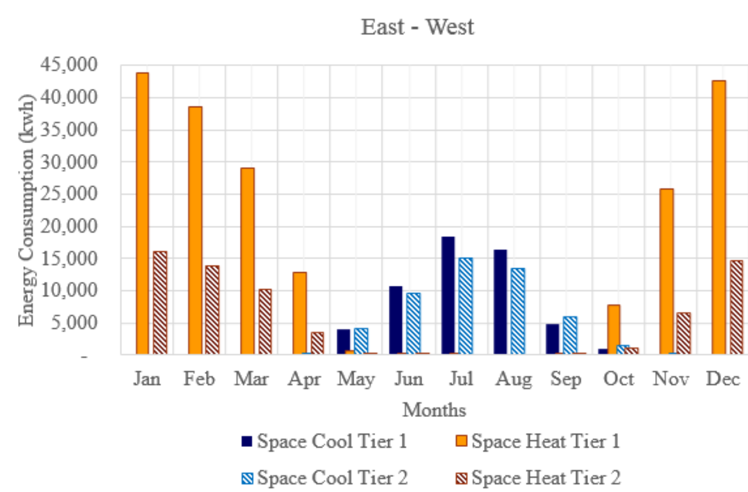


D2. 2 Graphs for Monthly Heating and Cooling Energy Use (Tier 1 and 2) for North-south and East-west Building Orientations

Electric consumption

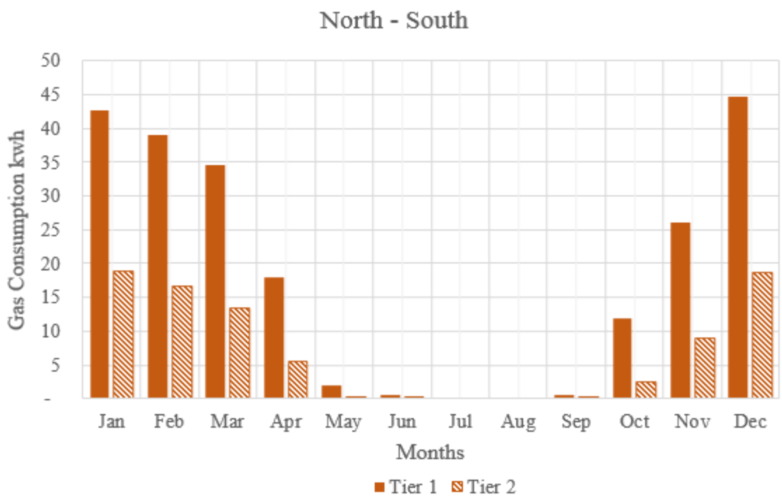
- HC+PLL

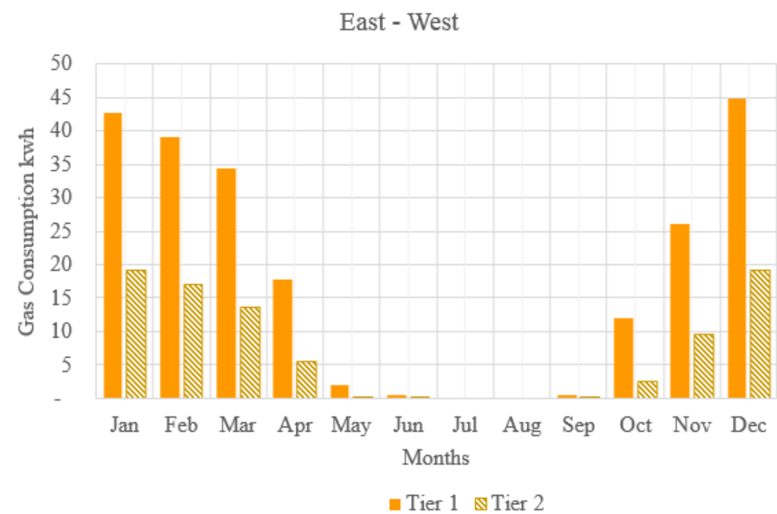




Gas Consumption

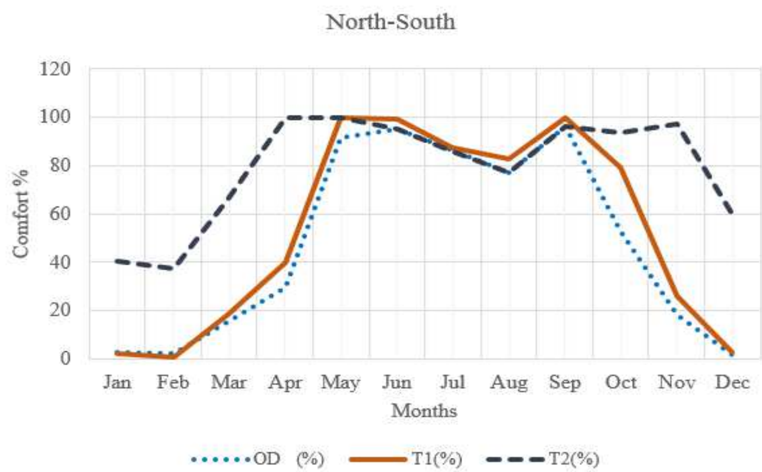
- HC+PLL

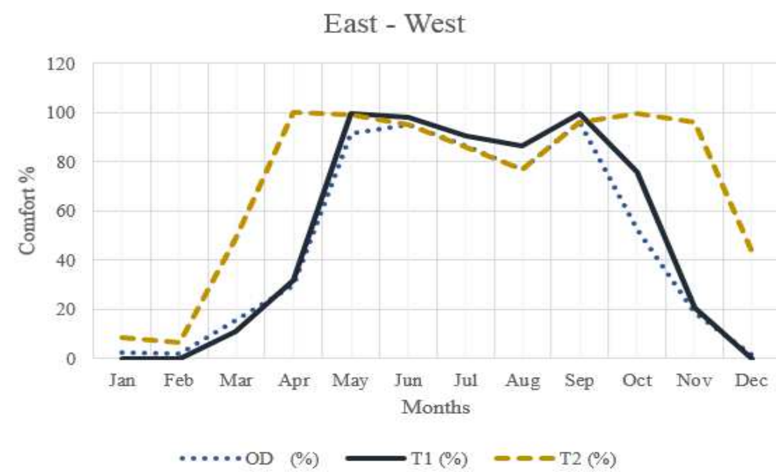




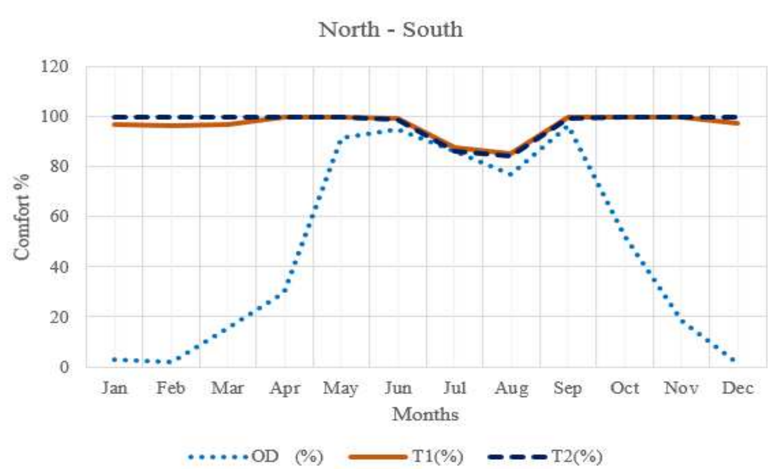
D2.3 Graphs for Monthly Thermal Comfort Percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations

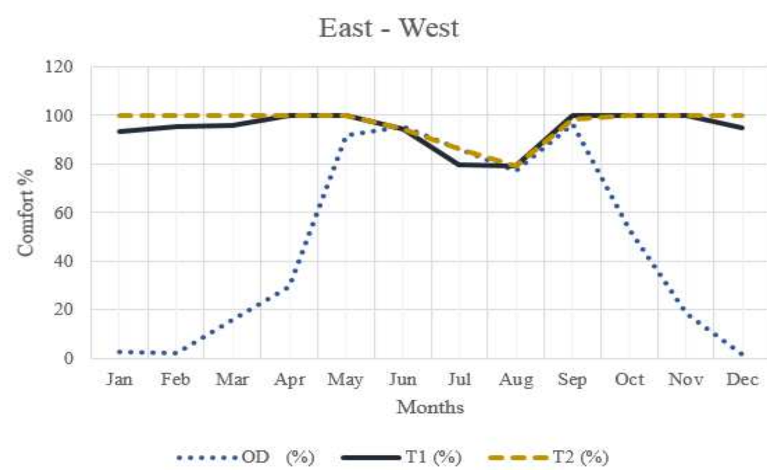
- PLL





- H+PLL





D2.4 Tables of Monthly Energy Use when no Heating & no Cooling (Tier 1 and 2) for North-south and East-west Building Orientations

- PLL

Orientation: North –south

Tirana_Electric Consumption (kWh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	616	568	632	613	562	602	605	585	598	618	583	672	7,255
Total	1,450	1,355	1,539	1,516	1,396	1,505	1,511	1,456	1,465	1,488	1,377	1,579	17,636

Tirana_Electric Consumption (kWh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	835	788	908	904	835	904	907	871	868	871	795	907	10,396
Area Lights	619	571	636	618	567	607	610	590	602	622	587	676	7,305
Total	1,454	1,359	1,544	1,522	1,402	1,511	1,517	1,461	1,470	1,493	1,382	1,583	17,701

Orientation: East-west

Tirana_ Electric Consumption (kWh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	619	570	635	615	562	601	605	586	601	622	586	677	7,278
Total	1,453	1,357	1,542	1,517	1,396	1,504	1,511	1,456	1,467	1,492	1,380	1,583	17,659

Tirana_ Electric Consumption (kWh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	835	788	908	904	835	904	907	871	868	871	795	907	10,396
Area Lights	624	575	641	621	567	607	611	592	606	627	591	682	7,342
Total	1,459	1,363	1,549	1,525	1,402	1,511	1,518	1,463	1,474	1,498	1,386	1,589	17,738

D2.5 Tables of Monthly Heating Energy Use with Baseboard (Tier 1 and 2) for North-south and East-west Building Orientations

- H+PLL

Orientation: North –south

Tirana_Electric Consumption (kWh)													
Tier 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	46,777	42,433	33,589	17,244	1,070	174	149	142	246	9,458	27,999	45,962	225,243
Vent. Fans	1,630	1,510	1,603	1,426	811	880	880	840	840	1,125	1,559	1,663	14,768
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	638	589	657	639	586	628	631	610	622	642	605	696	7,544
Total	49,879	45,319	36,755	20,212	3,301	2,585	2,566	2,462	2,575	12,095	30,958	49,227	257,935

Tirana_Electric Consumption (kWh)													
Tier 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	21,986	20,581	16,607	7,492	247	88	98	101	111	2,522	10,224	21,608	101,665
Vent. Fans	1,347	1,250	1,253	880	800	880	880	840	840	840	916	1,412	12,136
Misc. Equip.	835	788	908	904	835	904	907	872	868	871	795	908	10,396
Area Lights	641	592	661	644	591	634	637	615	626	645	608	700	7,593
Total	24,809	23,212	19,429	9,920	2,472	2,506	2,522	2,427	2,445	4,878	12,543	24,627	131,790

Orientation: East-west

Tirana_Electric Consumption (kWh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	48,479	43,430	33,121	15,341	786	156	151	142	200	9,547	29,414	48,070	228,838
Vent. Fans	1,628	1,505	1,602	1,422	806	880	880	840	840	1,131	1,560	1,661	14,756
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	641	592	660	640	586	627	631	611	625	645	608	701	7,566
Total	51,582	46,313	36,289	18,306	3,012	2,566	2,569	2,464	2,532	12,193	32,376	51,338	261,540

Tirana_Electric Consumption (kWh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	23,183	21,295	16,206	6,230	175	90	100	101	108	2,455	10,868	23,020	103,830
Vent. Fans	1,358	1,256	1,255	880	800	880	880	840	840	840	954	1,453	12,234
Misc. Equip.	835	788	908	904	835	904	907	872	868	871	795	908	10,396
Area Lights	646	596	665	647	591	633	638	617	630	650	612	706	7,629
Total	26,021	23,935	19,034	8,660	2,401	2,507	2,525	2,429	2,445	4,816	13,230	26,086	134,089

D2.6 Tables of Monthly Heating and Cooling Energy Use (Tier 1 and 2) for North-south and East-west Building Orientations

- HC+PLL

Orientation: North –south

Tirana_Electric Consumption (kWh)													
Tier 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	1	88	3,348	9,766	17,352	15,666	4,499	1,002	7	-	51,730
Space Heat	42,095	37,598	29,489	14,627	928	106	1	0	170	7,857	24,602	40,552	198,025
Vent. Fans	2,245	2,133	2,470	2,470	2,245	2,470	2,470	2,358	2,358	2,358	2,133	2,470	28,179
Pumps & Aux.	682	592	442	259	17	-	-	-	-	144	428	661	3,224
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	641	592	661	643	589	632	635	614	626	645	608	700	7,586
Total	46,496	41,702	33,969	18,991	7,961	13,876	21,363	19,508	8,519	12,876	28,573	45,290	299,125

Gas Consumption (kwh)													
Tier 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	43	39	35	18	2	0	-	-	1	12	26	45	220
Total	43	39	35	18	2	0	-	-	1	12	26	45	220

Tirana_Electric Consumption (kWh)													
Tier 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	1	13	3,128	8,389	13,599	12,408	5,465	1,600	83	-	44,685
Space Heat	15,042	13,396	10,777	4,540	68	1	-	-	3	1,325	6,320	13,631	65,103
Vent. Fans	1,373	1,304	1,510	1,510	1,373	1,510	1,510	1,441	1,441	1,441	1,304	1,510	17,228
Pumps & Aux.	682	592	442	259	17	-	-	-	-	144	428	661	3,224
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	644	596	665	647	594	637	640	618	630	649	611	703	7,635
Total	18,574	16,674	14,301	7,873	6,013	11,440	16,655	15,338	8,405	6,028	9,542	17,412	148,256

Gas Consumption (kwh)													
Tier 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	19	17	13	6	0	0	-	-	0	2	9	19	85
Total	19	17	13	6	0	0	-	-	0	2	9	19	85

Orientation: East –west

TIRANA_TIER 01													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	126	3,973	10,710	18,334	16,342	4,864	949	-	-	55,298
Space Heat	43,884	38,588	29,019	12,823	664	67	0	-	115	7,841	25,879	42,670	201,550
Vent. Fans	2,352	2,235	2,588	2,588	2,352	2,588	2,588	2,470	2,470	2,470	2,235	2,588	29,524
Pumps & Aux.	682	592	442	259	17	-	-	-	-	144	428	661	3,224
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	645	595	663	644	589	631	635	614	628	648	611	705	7,608
Total	48,397	42,797	33,619	17,343	8,429	14,898	22,463	20,296	8,943	12,923	29,948	47,529	307,585

Gas Consumption (kwh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	43	39	34	18	2	0	-	-	0	12	26	45	220
Total	43	39	34	18	2	0	-	-	0	12	26	45	220

TIRANA_TIER 02													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	88	4,067	9,633	15,015	13,480	6,018	1,572	0	-	49,875
Space Heat	16,016	13,851	10,235	3,463	40	1	-	-	1	1,117	6,556	14,764	66,044
Vent. Fans	1,540	1,463	1,694	1,694	1,540	1,694	1,694	1,617	1,617	1,617	1,463	1,694	19,326
Pumps & Aux.	682	592	442	259	17	-	-	-	-	144	428	661	3,224
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	649	599	669	650	594	637	641	620	633	653	615	710	7,671
Total	19,720	17,292	13,946	7,058	7,092	12,868	18,257	16,588	9,136	5,974	9,857	18,735	156,521

Gas Consumption (kwh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	19	17	14	5	0	0	-	-	0	3	9	19	86
Total	19	17	14	5	0	0	-	-	0	3	9	19	86

D 2.7 Tables for Monthly Thermal Comfort Percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations

Total Number of people: 711 nos. , Each floor: 237 nos.

T1: Tier 1, T2: Tier 2, OD: Outdoor

* Cells in italics corresponds to months when windows will be opened

- PLL

Orientation: North – south

Tirana	Outdoor	North		South		East		West	
No. of People		98		98		25		16	
Months	OD (%)	T1(%)	T2(%)	T1(%)	T2(%)	T1(%)	T2(%)	T1(%)	T2(%)
Jan	3	0	3	6	93	0	3	0	7
Feb	2	0	2	1	86	0	3	0	11
Mar	16	0	44	42	96	8	48	10	53
Apr	30	21	100	61	100	35	100	39	100
May	92	100	100	100	100	100	100	100	100
Jun	95	100	*95*	100	*95*	99	*95*	96	*95*
Jul	86	94	*86*	*83*	*86*	*80*	*86*	*83*	*86*
Aug	77	94	*77*	*72*	*77*	83	*77*	77	*77*
Sep	96	100	*96*	100	*96*	100	96	100	*96*
Oct	53	66	100	95	85	73	100	77	100
Nov	18	0	93	59	100	6	100	12	100
Dec	2	0	23	7	100	0	52	0	54
Annual	**47**	**48**	**68**	**61**	**93**	**49**	**72**	**50**	**73**

North-South	Annual Comfort %		
No. of People		237	
Months	OD (%)	T1(%)	T2(%)
Jan	3	2	40
Feb	2	1	37
Mar	16	19	67
Apr	30	40	100
May	92	100	100
Jun	95	99	95
Jul	86	87	86
Aug	77	83	77
Sep	96	100	96
Oct	53	79	94
Nov	18	26	97
Dec	2	3	60
Annual	**47**	**53**	**79**

Orientation: East – west

	Outdoor	North		South		East		West	
No.of People		25		16		98		98	
Months	OD (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)
Jan	3	0	17	0	7	0	15	0	0
Feb	2	0	24	0	13	0	8	0	0
Mar	16	39	62	10	56	15	50	0	43
Apr	30	81	100	39	100	30	100	19	100
May	92	100	*92*	100	100	100	100	100	100
Jun	95	*86*	*95*	95	*95*	100	95	100	*95*
Jul	86	*64*	*86*	*82*	*86*	96	*86*	93	*86*
Aug	77	*64*	*77*	77	*77*	86	*77*	95	*77*
Sep	96	99	*96*	100	*96*	100	*96*	100	*96*
Oct	53	80	99	75	100	84	100	67	100
Nov	18	24	100	6	100	44	100	0	90
Dec	2	0	58	0	49	0	68	0	14
Annual	47	53	75	49	73	55	75	48	67

East-West	Annual Comfort %		
No. of People		237	
Months	OD (%)	T1 (%)	T2 (%)
Jan	3	0	9
Feb	2	0	7
Mar	16	11	49
Apr	30	32	100
May	92	100	99
Jun	95	98	95
Jul	86	90	86
Aug	77	87	77
Sep	96	100	96
Oct	53	76	100
Nov	18	21	96
Dec	2	0	43
Annual	47	51	71

- H+PLL

Orientation: North – south

Tirana	Outdoor	North		South		East		West	
No. of People		98		98		25		16	
Months	OD (%)	T1(%)	T2(%)	T1(%)	T2(%)	T1(%)	T2(%)	T1(%)	T2(%)
Jan	3	97	100	99	100	95	100	88	100
Feb	2	93	100	99	100	99	100	93	100
Mar	16	97	100	98	100	96	100	95	100
Apr	30	100	100	100	100	100	100	100	100
May	92	100	100	100	100	100	100	100	100
Jun	95	100	99	99	98	99	100	97	96
Jul	86	93	*86*	*84*	*86*	*82*	*86*	*84*	*86*
Aug	77	95	92	*75*	*77*	87	87	84	*77*
Sep	96	100	100	100	98	100	100	100	100
Oct	53	100	100	100	100	100	100	100	100
Nov	18	99	100	100	100	100	100	99	100
Dec	2	97	100	99	100	96	100	94	100
Annual	47	98	98	96	97	96	98	95	97

North-South	Annual Comfort %		
No. of People		237	
Months	OD (%)	T1(%)	T2(%)
Jan	3	97	100
Feb	2	96	100
Mar	16	97	100
Apr	30	100	100
May	92	100	100
Jun	95	99	99
Jul	86	88	86
Aug	77	85	84
Sep	96	100	99
Oct	53	100	100
Nov	18	100	100
Dec	2	97	100
Annual	47	97	97

Orientation: East- west

	Outdoor	North		South		East		West	
No.of People		25		16		98		98	
Months	OD (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)
Jan	3	96	100	92	100	98	100	81	100
Feb	2	95	100	96	100	97	100	96	100
Mar	16	97	100	96	100	97	100	91	100
Apr	30	100	100	100	100	100	100	100	100
May	92	100	100	100	100	100	100	100	100
Jun	95	*90*	*95*	96	91	100	100	100	100
Jul	86	*70*	*86*	*83*	*86*	94	88	92	*86*
Aug	77	*68*	*77*	84	*77*	90	88	95	92
Sep	96	100	96	100	100	100	100	100	100
Oct	53	100	100	100	100	100	100	100	100
Nov	18	100	100	99	100	100	100	99	100
Dec	2	96	100	94	100	98	100	88	100
Annual	47	93	96	95	96	98	98	95	98

East-West	Annual Comfort %		
No. of People		237	
Months	OD (%)	T1 (%)	T2 (%)
Jan	3	90	100
Feb	2	96	100
Mar	16	94	100
Apr	30	100	100
May	92	100	100
Jun	95	99	99
Jul	86	90	87
Aug	77	89	88
Sep	96	100	100
Oct	53	100	100
Nov	18	100	100
Dec	2	93	100
Annual	47	96	98

Appendix D3: Analysis Results for Korca - Type 3, Urban Building

D3.1 Graphs of Monthly Heating Energy Use with Baseboard (Tier 1 and 2) for North-south and East-west Building Orientations

D3. 2 Graphs for Monthly Heating and Cooling Energy Use with (Tier 1 and 2) for North-south and East-west Building Orientations

D3.3 Graphs for Monthly Thermal Comfort Percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations

D3.4 Tables of monthly energy use when no Heating & no Cooling (Tier 1 and 2) for North-south and East-west Building Orientations

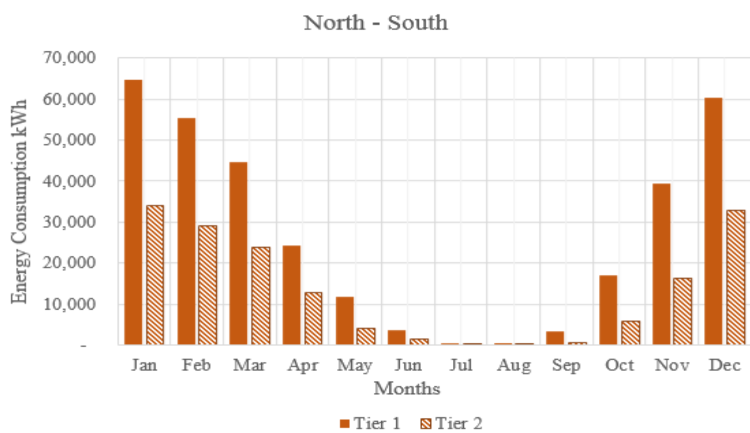
D3.5 Tables of Monthly Heating Energy Use with Baseboard (Tier 1 and 2) for North-south and East-west Building Orientations

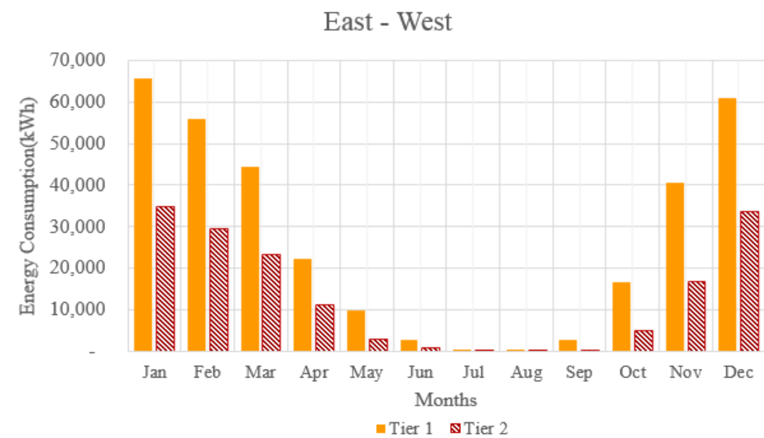
D3.6 Tables of Monthly Heating and Cooling Energy Use (Tier 1 and 2) for North-south and East-west Building Orientations

D3.7 Tables for Monthly Thermal Comfort Percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations

D3.1 Graphs of monthly Heating Energy Use with Baseboard (Tier 1 and 2) for North-south and East-west Building Orientations

H+PLL

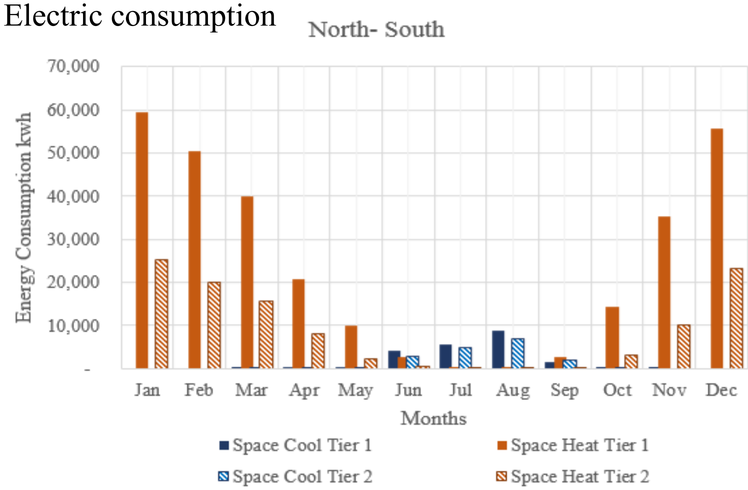


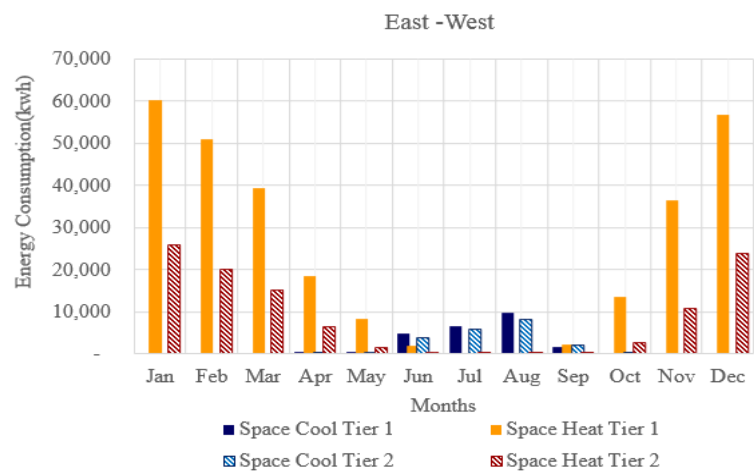


D3.2 Graphs for Monthly Heating and Cooling Energy Use with (Tier 1 and 2) for North-south and East-west Building Orientations.

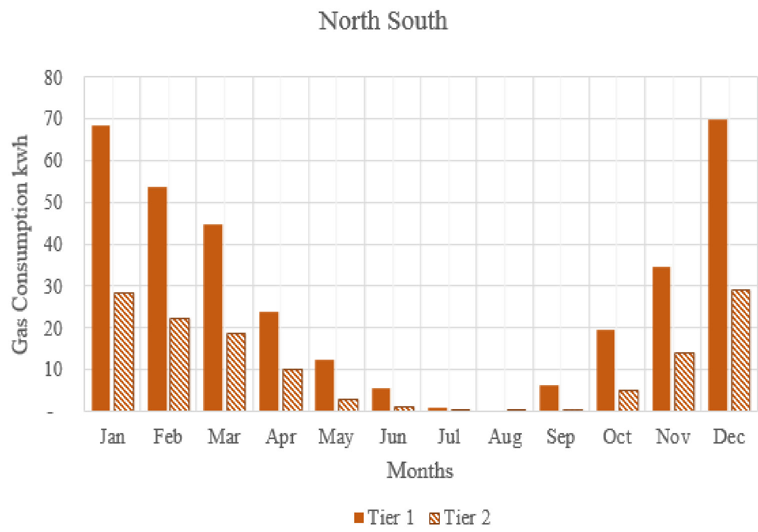
HC+PLL

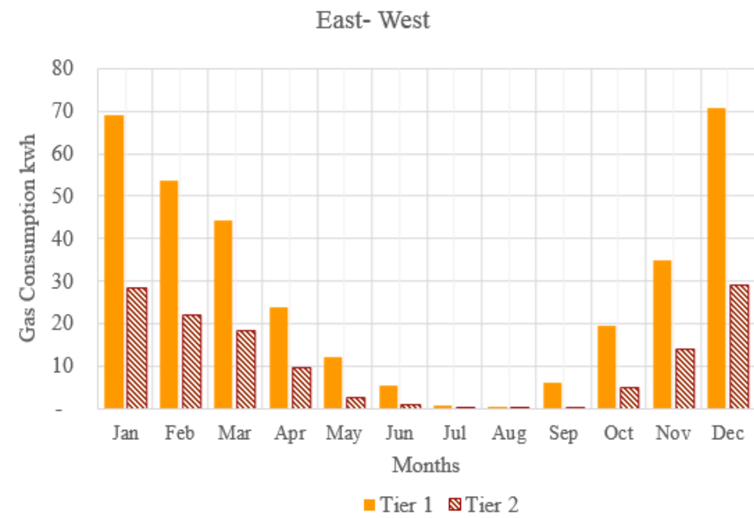
Electric consumption





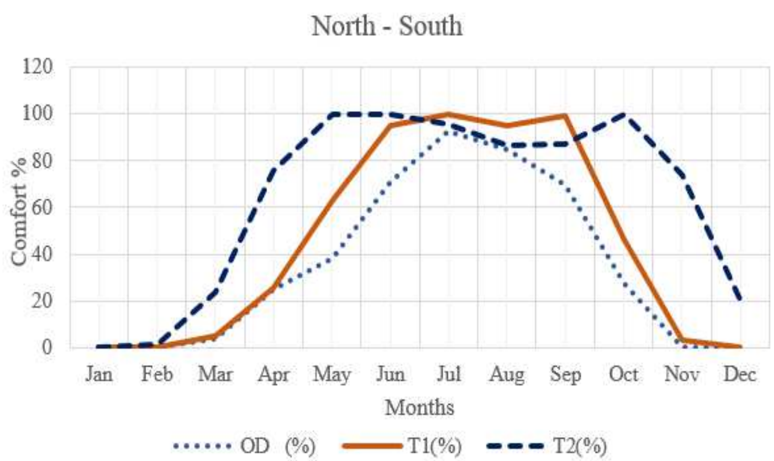
Gas Consumption

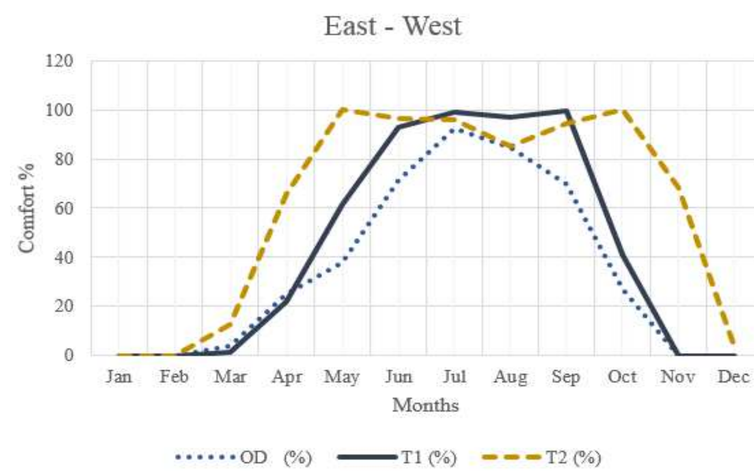




D3.3 Graphs for Monthly Thermal Comfort Percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations.

- PLL





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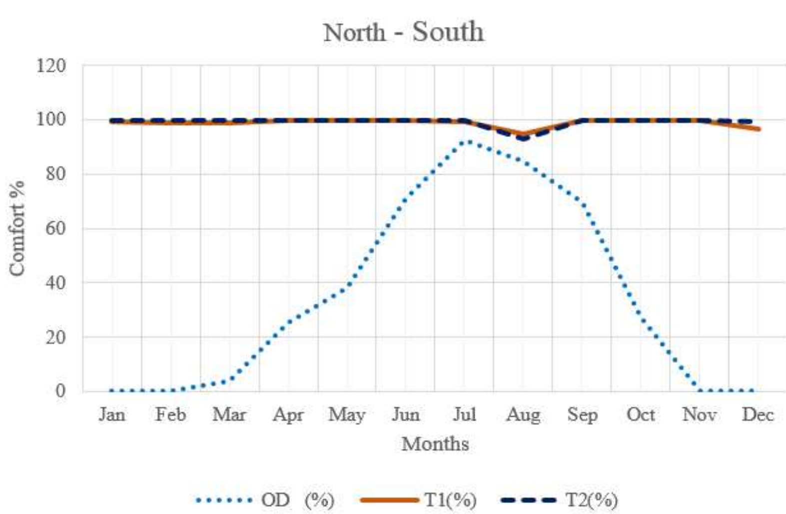
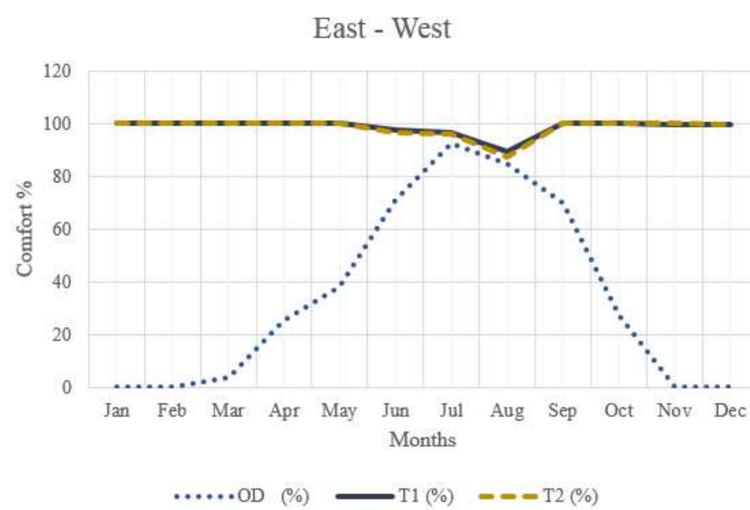




D3.4 Tables of Monthly Energy Use when no Heating & no Cooling (Tier 1 and 2) for North-south and East-west Building Orientations

- PLL

Orientation: North –south

Korca_Electric Consumption (kWh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	615	568	636	614	563	604	607	587	598	619	583	672	7,266
Total	1,449	1,355	1,543	1,517	1,397	1,507	1,513	1,457	1,465	1,489	1,377	1,578	17,647

Korca_Electric Consumption (kWh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	835	788	908	904	835	904	907	871	868	871	795	907	10,396
Area Lights	619	572	641	620	570	611	614	593	603	623	587	676	7,329
Total	1,454	1,360	1,549	1,524	1,405	1,515	1,521	1,464	1,471	1,494	1,382	1,583	17,725

Orientation: East-west

Korca_ Electric Consumption (kWh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	618	570	639	616	564	605	608	589	601	622	586	676	7,292
Total	1,452	1,358	1,546	1,519	1,398	1,507	1,514	1,459	1,468	1,492	1,380	1,582	17,673

Korca_ Electric Consumption (kWh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Misc. Equip.	835	788	908	904	835	904	907	871	868	871	795	907	10,396
Area Lights	625	576	645	623	571	612	615	596	608	628	591	682	7,373
Total	1,460	1,364	1,553	1,527	1,406	1,516	1,522	1,467	1,476	1,499	1,386	1,589	17,769

D3.5 Tables of Monthly Heating Energy Use with Baseboard (Tier 1 and 2) for North-south and East-west Building Orientations

- H+PLL

Orientation: North –South

Korca_Electric Consumption (kWh)													
Tier 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	64,748	55,391	44,692	24,331	11,624	3,647	337	190	3,412	16,873	39,515	60,381	325,141
Vent. Fans	1,796	1,536	1,639	1,416	1,216	976	884	844	889	1,470	1,565	1,819	16,050
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	637	589	661	640	587	630	633	612	623	642	605	696	7,556
Total	68,015	58,304	47,899	27,290	14,261	6,156	2,760	2,516	5,791	19,855	42,479	63,802	359,128

Korca_Electric Consumption (kWh)													
Tier 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	34,039	28,963	23,769	12,889	4,139	1,428	95	109	533	5,685	16,153	32,693	160,496
Vent. Fans	1,619	1,477	1,448	1,074	800	880	880	840	840	840	1,220	1,650	13,567
Misc. Equip.	835	788	908	904	835	904	907	872	868	871	795	908	10,396
Area Lights	641	594	666	646	594	637	640	618	627	646	609	700	7,618
Total	37,135	31,822	26,791	15,514	6,367	3,849	2,522	2,438	2,868	8,042	18,777	35,951	192,077

Orientation: East - west

Korca_Electric Consumption (kWh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	65,604	55,799	44,377	22,275	9,852	2,854	281	171	2,798	16,526	40,639	61,042	322,216
Vent. Fans	1,810	1,531	1,638	1,409	1,196	959	884	844	886	1,474	1,565	1,823	16,019
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	640	592	664	642	587	631	634	614	625	645	607	700	7,581
Total	68,888	58,709	47,585	25,228	12,469	5,347	2,706	2,499	5,175	19,515	43,605	64,471	356,197

Korca_Electric Consumption (kWh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	34,791	29,356	23,361	11,072	2,970	948	92	104	326	5,128	16,844	33,627	158,619
Vent. Fans	1,619	1,477	1,447	1,059	800	880	880	840	840	840	1,254	1,650	13,585
Misc. Equip.	835	788	908	904	835	904	907	872	868	871	795	908	10,396
Area Lights	647	598	670	649	594	638	641	621	632	651	613	707	7,661
Total	37,892	32,218	26,386	13,684	5,199	3,370	2,521	2,436	2,666	7,490	19,506	36,891	190,260

D3.6 Tables of Monthly Heating and Cooling Energy Use (Tier 1 and 2) for North-south and East-west Building Orientations

- HC+PLL

Orientation: North –south

Korca_Electric Consumption (kWh)													
Tier 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	2	389	435	4,172	5,662	8,890	1,581	21	3	-	21,156
Space Heat	59,514	50,394	39,845	20,751	10,121	2,776	194	55	2,697	14,216	35,259	55,776	291,599
Vent. Fans	2,113	2,007	2,324	2,324	2,113	2,324	2,324	2,219	2,219	2,219	2,007	2,324	26,519
Pumps & Aux.	884	792	662	344	115	24	-	-	19	222	625	871	4,560
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	640	593	665	644	590	634	637	616	626	645	608	700	7,597
Total	63,986	54,573	44,405	25,356	14,209	10,833	9,723	12,650	8,008	18,194	39,297	60,578	361,813

Gas Consumption (kwh)													
Tier 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	68	54	45	24	12	6	1	0	6	19	35	70	340
Total	68	54	45	24	12	6	1	0	6	19	35	70	340

Korca_Electric Consumption (kWh)													
Tier 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	1	144	163	2,885	4,751	6,949	1,843	66	-	-	16,801
Space Heat	25,122	19,912	15,760	7,972	2,352	654	6	1	206	3,185	10,219	23,119	108,508
Vent. Fans	1,358	1,290	1,494	1,494	1,358	1,494	1,494	1,426	1,426	1,426	1,290	1,494	17,042
Pumps & Aux.	884	792	662	344	115	24	-	-	19	222	625	871	4,560
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	645	597	669	649	597	641	644	621	631	650	612	704	7,660
Total	28,843	23,378	19,493	11,506	5,419	6,600	7,801	9,868	4,991	6,419	13,541	27,094	164,953

Gas Consumption (kwh)													
Tier 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	29	22	19	10	3	1	0	0	0	5	14	29	132
Total	29	22	19	10	3	1	0	0	0	5	14	29	132

Orientation: East –west

Korca_Electric Consumption (kWh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	484	549	4,777	6,463	9,764	1,744	6	4	-	23,791
Space Heat	60,342	50,858	39,428	18,612	8,444	2,067	145	34	2,123	13,666	36,339	56,778	288,836
Vent. Fans	2,275	2,162	2,503	2,503	2,275	2,503	2,503	2,389	2,389	2,389	2,162	2,503	28,556
Pumps & Aux.	884	792	662	344	115	24	-	-	19	222	625	871	4,560
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	644	595	668	645	591	634	637	617	629	649	611	703	7,623
Total	64,980	55,193	44,167	23,491	12,809	10,908	10,655	13,675	7,771	17,801	40,534	61,762	363,747

Gas Consumption (kwh)													
TIER 01	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	69	54	44	24	12	6	1	0	6	20	35	71	341
Total	69	54	44	24	12	6	1	0	6	20	35	71	341

Korca_Electric Consumption (kWh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	276	432	3,746	5,929	8,198	2,214	2	-	-	20,797
Space Heat	25,814	20,108	15,113	6,362	1,579	416	5	0	94	2,552	10,678	23,982	106,703
Vent. Fans	1,551	1,474	1,707	1,707	1,551	1,707	1,707	1,629	1,629	1,629	1,474	1,707	19,471
Pumps & Aux.	884	792	662	344	115	24	-	-	19	222	625	871	4,560
Misc. Equip.	834	787	907	903	834	903	906	870	867	870	794	906	10,381
Area Lights	650	601	674	653	598	642	645	625	635	655	616	710	7,703
Total	29,734	23,762	19,062	10,246	5,110	7,437	9,191	11,323	5,458	5,929	14,187	28,177	169,615

Gas Consumption (kwh)													
TIER 02	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Heat	29	22	19	10	3	1	0	0	0	5	14	29	131
Total	29	22	19	10	3	1	0	0	0	5	14	29	131

D3.7 Tables for Monthly Thermal Comfort Percentages (Outdoors/indoors for Tier1 and Tier 2) for North-south and East-west Building Orientations.

Total Number of people: 711 nos. , Each floor: 237 nos.

T1: Tier 1, T2: Tier 2, OD: Outdoor

*Cells in italics corresponds to months when windows will be open

- PLL

Orientation: North – south

Korca	Outdoor	North		South		East		West	
No. of People		98		98		25		16	
Months	OD (%)	T1(%)	T2(%)	T1(%)	T2(%)	T1(%)	T2(%)	T1(%)	T2(%)
Jan	0	0	0	0	0	0	0	0	0
Feb	0	0	0	0	4	0	0	0	0
Mar	4	0	0	12	53	0	8	0	13
Apr	25	17	56	35	99	23	63	24	70
May	38	57	100	67	100	65	100	67	100
Jun	71	93	100	96	100	99	100	97	100
Jul	92	100	100	100	*92*	100	97	99	92
Aug	85	100	89	91	*85*	93	*85*	94	*85*
Sep	70	98	100	100	*70*	100	100	100	95
Oct	27	19	100	73	100	49	100	42	100
Nov	0	0	48	8	100	0	75	0	75
Dec	0	0	0	0	50	0	0	0	0
Annual	34	40	58	49	71	44	61	44	61

North-South	Annual Comfort %		
No. of People		237	
Months	OD (%)	T1(%)	T2(%)
Jan	0	0	0
Feb	0	0	1
Mar	4	5	24
Apr	25	25	75
May	38	63	100
Jun	71	95	100
Jul	92	100	96
Aug	85	95	87
Sep	70	99	87
Oct	27	46	100
Nov	0	3	74
Dec	0	0	21
Annual	**34**	**44**	**64**

Orientation: East – west

Korca	Outdoor	North		South		East		West	
No.of People		25		16		98		98	
Months	OD (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)
Jan	0	0	0	0	0	0	0	0	0
Feb	0	0	0	0	0	0	0	0	0
Mar	4	7	44	0	22	1	16	0	0
Apr	25	52	100	24	88	19	61	17	58
May	38	84	100	68	100	56	100	61	100
Jun	71	87	*71*	96	93	91	100	96	100
Jul	92	*90*	*92*	99	*92*	100	97	100	96
Aug	85	*76*	*85*	94	*85*	100	*85*	100	*85*
Sep	70	100	*70*	100	84	100	96	99	100
Oct	27	61	100	36	100	59	100	19	100
Nov	0	0	88	0	73	0	87	0	44
Dec	0	0	6	0	0	0	7	0	0
Annual	34	46	63	43	61	44	62	41	57

East-West	Annual Comfort %		
No. of People		237	
Months	OD (%)	T1 (%)	T2 (%)
Jan	0	0	0
Feb	0	0	0
Mar	4	1	13
Apr	25	22	66
May	38	62	100
Jun	71	93	96
Jul	92	99	96
Aug	85	97	85
Sep	70	100	94
Oct	27	41	100
Nov	0	0	68
Dec	0	0	3
Annual	34	43	60

- H+PLL

Orientation: North – south

Korca	Outdoor	North		South		East		West	
No. of People		98		98		25		16	
Months	OD (%)	T1(%)	T2(%)	T1(%)	T2(%)	T1(%)	T2(%)	T1(%)	T2(%)
Jan	0	100	100	100	100	100	100	100	100
Feb	0	99	100	99	100	99	100	99	100
Mar	4	99	100	99	100	99	100	99	100
Apr	25	100	100	100	100	100	100	100	100
May	38	100	100	100	100	100	100	100	100
Jun	71	100	100	100	100	100	100	100	100
Jul	92	100	100	99	100	99	100	99	99
Aug	85	100	100	89	84	94	99	94	92
Sep	70	100	100	100	100	100	100	100	100
Oct	27	100	100	100	100	100	100	100	100
Nov	0	99	100	100	100	100	100	99	100
Dec	0	97	99	97	100	97	100	97	99
Annual	34	99	100	99	99	99	100	99	99

North-South	Annual Comfort %		
No. of People		237	
Months	OD (%)	T1(%)	T2(%)
Jan	0	100	100
Feb	0	99	100
Mar	4	99	100
Apr	25	100	100
May	38	100	100
Jun	71	100	100
Jul	92	99	100
Aug	85	95	93
Sep	70	100	100
Oct	27	100	100
Nov	0	100	100
Dec	0	97	99
Annual	34	99	99

Orientation: East- west

Korca	Outdoor	North		South		East		West	
No.of People		25		16		98		98	
Months	OD (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)	T1 (%)	T2 (%)
Jan	0	100	100	100	100	100	100	100	100
Feb	0	100	100	100	100	100	100	100	100
Mar	4	100	100	100	100	100	100	100	100
Apr	25	100	100	100	100	100	100	100	100
May	38	100	100	100	100	100	100	100	100
Jun	71	95	92	100	100	100	100	100	100
Jul	92	93	*92*	99	99	100	100	100	100
Aug	85	81	*85*	94	*85*	99	100	100	100
Sep	70	100	100	100	100	100	100	100	100
Oct	27	100	100	100	100	100	100	100	100
Nov	0	100	100	99	100	100	100	99	100
Dec	0	100	100	100	100	99	100	99	99
Annual	34	97	97	99	99	100	100	100	100

East-West	Annual Comfort %		
No. of People		237	
Months	OD (%)	T1 (%)	T2 (%)
Jan	0	100	100
Feb	0	100	100
Mar	4	100	100
Apr	25	100	100
May	38	100	100
Jun	71	99	99
Jul	92	99	99
Aug	85	97	97
Sep	70	100	100
Oct	27	100	100
Nov	0	99	100
Dec	0	99	100
Annual	34	100	100

APPENDIX E

RESULTS WITH SOLAR PHOTOVOLTAIC SYSTEMS

Appendix E1: Analysis Results for Solar Photovoltaic System, Building TYPE 1

E1.1 Table of Monthly Percent Load met by Solar Photovoltaic System (Tier 2) for North-south Building Orientation.

E1. 2 Graphs of Monthly Percent Load met by Photovoltaic System (Tier 2) for North-south Building Orientation.

Appendix E2: Analysis Results for Solar Photovoltaic System, TYPE 3

E2.1 Table of Monthly Percent Load met by Solar Photovoltaic System (Tier 2) for North-south Building Orientation.

E2.2 Graphs of Monthly Percent Load met by Photovoltaic System (Tier 2) for North-south Building Orientation.

E1.1 Table of Monthly Percent Load met by Solar Photovoltaic System (Tier 2) for North-south Building Orientation.

Type: Standard (crystalline Silicon)

Approximate Efficiency: 15 %

Model Cover: Glass

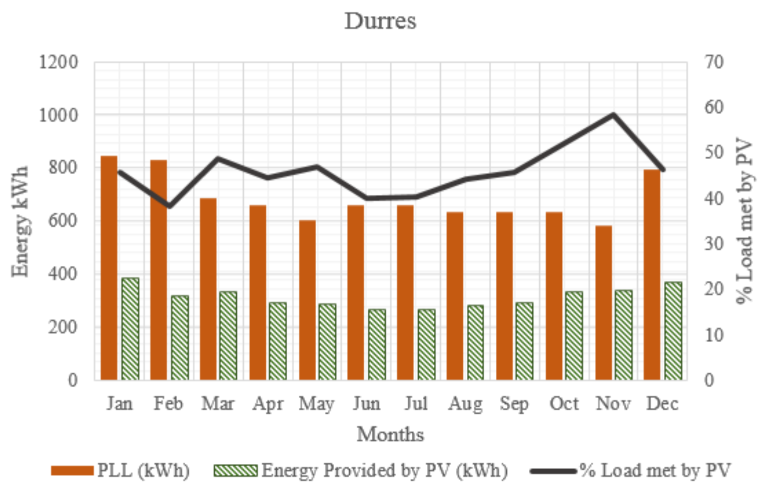
Tilt degree: 34°

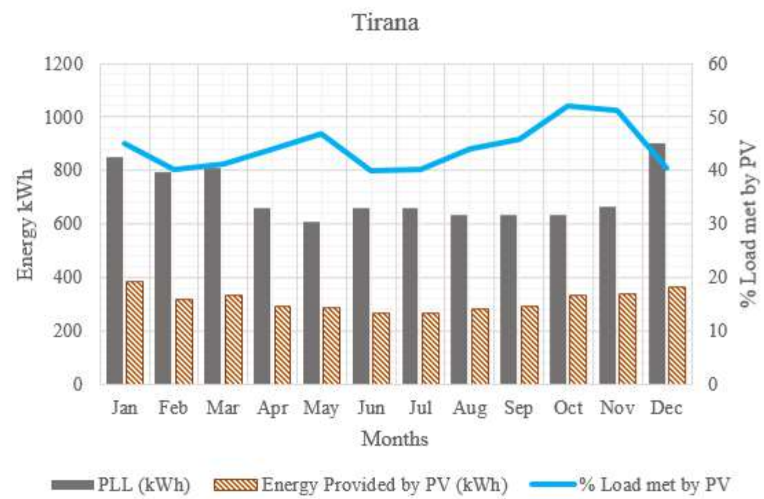
Array Type: Fixed Roof Mount

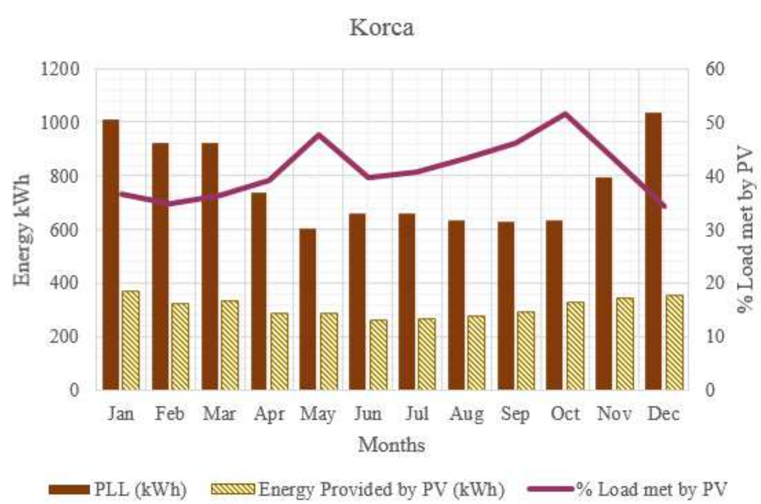
Ground coverage = 0.5

PV	Durres			Tirana			Korca		
Months	PLL (kWh)	Energy Provided by PV (kWh)	% Load met by PV	PLL (kWh)	Energy Provided by PV (kWh)	% Load met by PV	PLL (kWh)	Energy Provided by PV (kWh)	% Load met by PV
Jan	844	386	46	852	383	45	1012	372	37
Feb	830	317	38	794	319	40	923	322	35
Mar	686	334	49	810	334	41	923	334	36
Apr	659	293	45	660	291	44	735	289	39
May	605	284	47	606	284	47	604	289	48
Jun	659	263	40	659	263	40	659	261	40
Jul	660	265	40	661	265	40	659	268	41
Aug	633	279	44	634	279	44	632	274	43
Sep	632	289	46	633	289	46	631	291	46
Oct	635	330	52	636	330	52	634	327	52
Nov	583	340	58	665	340	51	794	343	43
Dec	794	367	46	902	364	40	1037	355	34

E 1.2 Graphs of Monthly Percent Load met by photovoltaic (Tier 2) for North-south Building Orientation.







E2.1 Table of Monthly Percent Load met by Solar Photovoltaic System (Tier 2) for North-south Building Orientation.

Type: Standard (crystalline Silicon)

Approximate Efficiency: 15 %

Model Cover: Glass

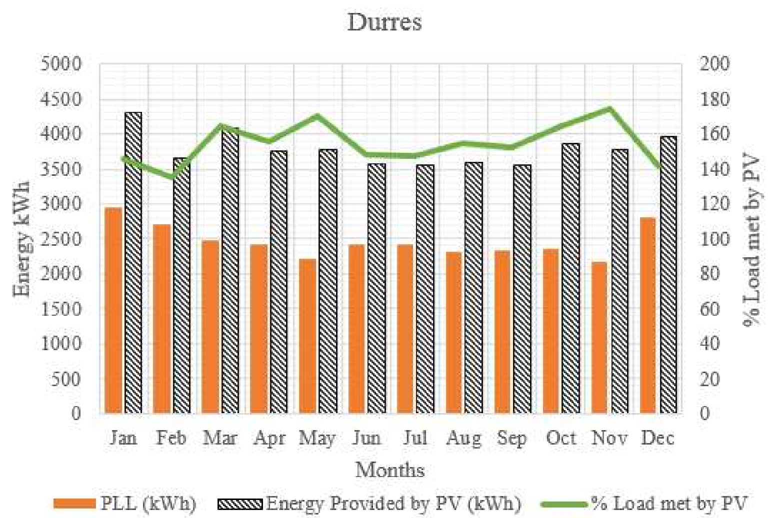
Tilt degree: 20°

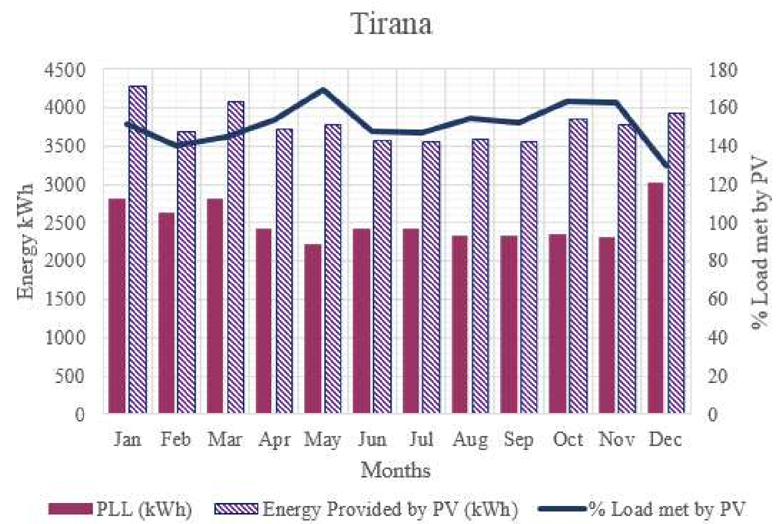
Array Type: Fixed Roof Mount

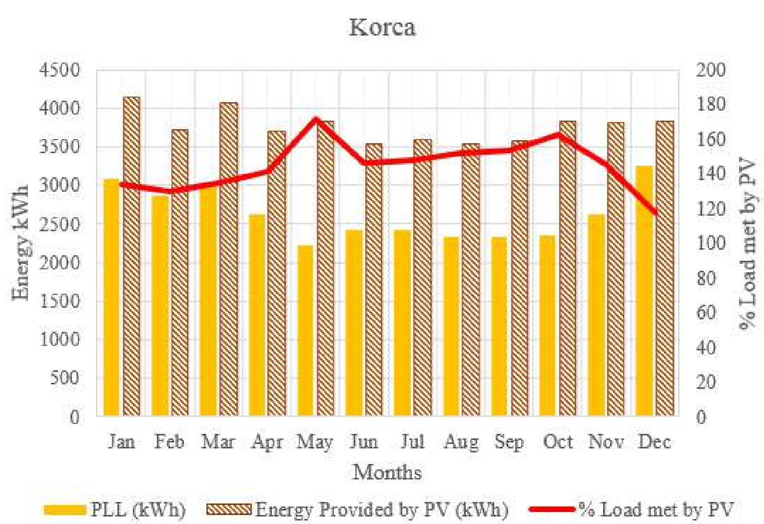
Ground coverage = 0.5

PV	Durres			Tirana			Korca		
Months	PLL (kWh)	Energy Provided by PV (kWh)	% Load met by PV	PLL (kWh)	Energy Provided by PV (kWh)	% Load met by PV	PLL (kWh)	Energy Provided by PV (kWh)	% Load met by PV
Jan	2954	4307	146	2823	4274	151	3095	4144	134
Feb	2698	3655	135	2631	3685	140	2858	3715	130
Mar	2478	4081	165	2821	4081	145	3020	4081	135
Apr	2421	3759	155	2428	3729	154	2623	3699	141
May	2219	3770	170	2226	3770	169	2227	3830	172
Jun	2412	3566	148	2418	3566	147	2420	3537	146
Jul	2417	3558	147	2424	3558	147	2426	3588	148
Aug	2321	3595	155	2326	3595	155	2328	3537	152
Sep	2326	3551	153	2334	3551	152	2334	3579	153
Oct	2350	3860	164	2357	3860	164	2356	3829	163
Nov	2164	3776	175	2320	3776	163	2623	3807	145
Dec	2796	3964	142	3019	3932	130	3256	3836	118

E2.2 Graphs of Monthly Percent Load met by Photovoltaic (Tier 2) for North-south Building Orientation.







APPENDIX F

RESULTS WITH SOLAR WATER HEATER

Appendix F1: Analysis Results for Solar Water Heater, Building TYPE 1

F 1.1 Table of Monthly Percent load met by Solar Water Heater System (Tier 2) for North-south Building Orientation.

F 1.2. Graphs of Monthly Load met by Solar Water Heater System (Tier 2) for North-south Building Orientation

Appendix F2: Analysis Results for Solar Water Heater, Building TYPE 3

F 2.1 Table of Monthly Percent load met by Solar Water Heater System (Tier 2) for North-south Building Orientation.

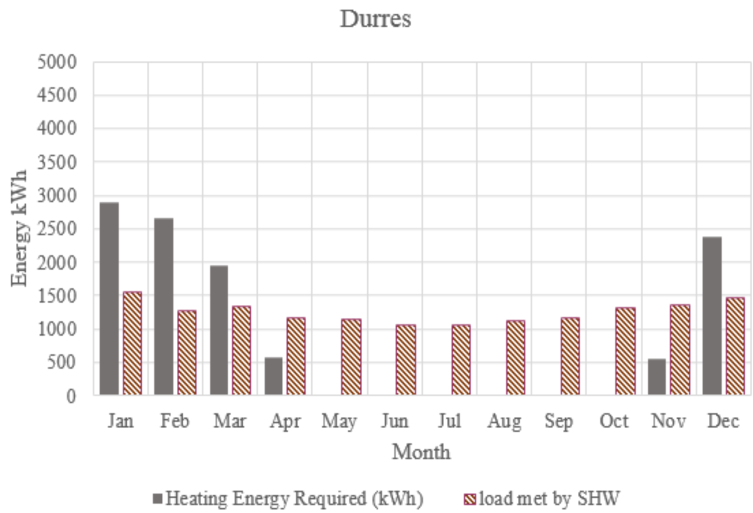
F 2.2. Graphs of Monthly Load met by Solar Water Heater System (Tier 2) for North-south Building Orientation

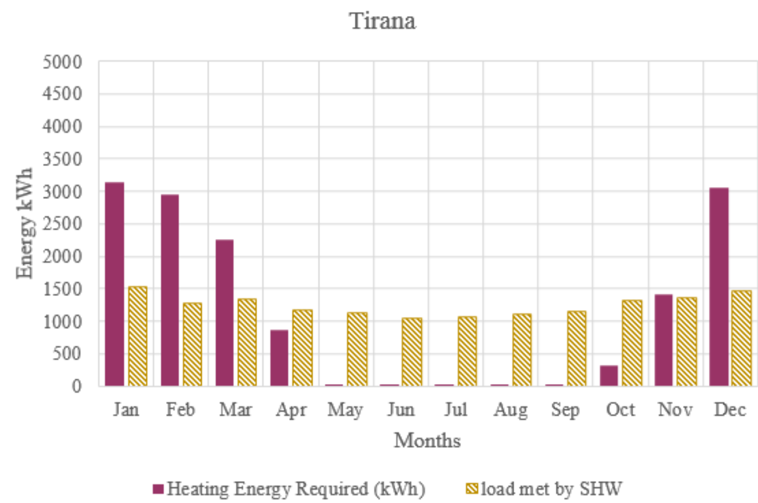
F1.1 Table of Monthly Percent load met by Solar Water Heater System (Tier 2) for North-south Building Orientation.

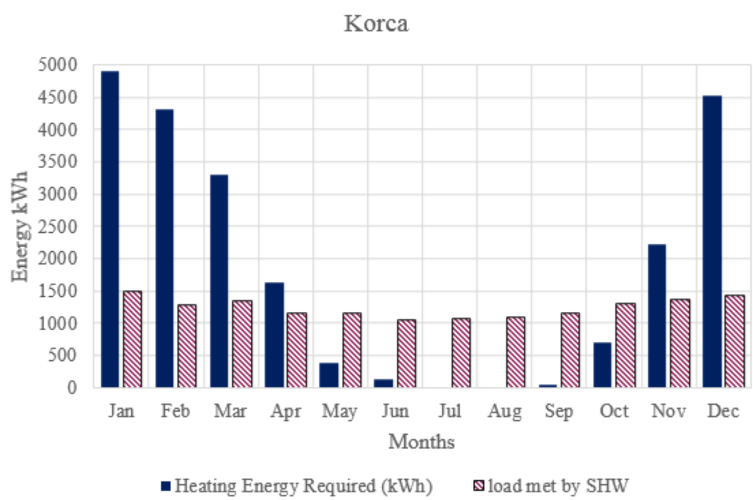
Efficiency: 60 %

SHW	Durres			Tirana			Korca		
Months	Heating Energy Required (kWh)	load met by SHW	% Energy provided by SHW	Heating Energy Required (kWh)	load met by SHW	% Energy provided by SHW	Heating Energy Required (kWh)	load met by SHW	%Energy provided by SHW
Jan	2892	1545	53	3132	1533	49	4908	1487	30
Feb	2654	1267	48	2953	1277	43	4319	1287	30
Mar	1947	1338	69	2256	1338	59	3292	1338	41
Apr	576	1173	204	870	1164	134	1626	1154	71
May	9	1136	12627	13	1136	8742	389	1154	297
Jun	10	1052	10517	9	1052	11686	134	1043	779
Jul	10	1062	10620	10	1062	10620	9	1071	11896
Aug	10	1114	11145	11	1114	10132	11	1097	9968
Sep	10	1156	11563	12	1156	9636	43	1165	2710
Oct	10	1320	13203	320	1320	413	709	1310	185
Nov	548	1360	248	1411	1360	96	2216	1371	62
Dec	2383	1469	62	3060	1457	48	4532	1421	31

F 1.2. Graphs of Monthly load met by Solar Water Heater System (Tier 2) for North-south Building Orientation







F2.1 Table of Monthly Percent load met by Solar Water Heater System (Tier 2) for North-south Building Orientation.

Efficiency: 60 %

SHW	Durres			Tirana			Korca		
Months	Heating Energy Required (kWh)	load met by SHW	% Energy provided by SHW	Heating Energy Required (kWh)	load met by SHW	% Energy provided by SHW	Heating Energy Required (kWh)	load met by SHW	% Energy provided by SHW
Jan	20788	17228	83	21986	17097	78	34039	16575	49
Feb	19112	14621	77	20581	14740	72	28963	14859	51
Mar	14630	16323	112	16607	16323	98	23769	16323	69
Apr	4795	15038	314	7492	14917	199	12889	14797	115
May	86	15080	17495	247	15080	6115	4139	15320	370
Jun	105	14263	13597	88	14263	16153	1428	14149	991
Jul	93	14234	15338	98	14234	14569	95	14350	15121
Aug	88	14379	16322	101	14379	14294	109	14147	12967
Sep	89	14204	15888	111	14204	12819	533	14316	2688
Oct	95	15440	16184	2522	15440	612	5685	15316	269
Nov	4174	15105	362	10224	15105	148	16153	15228	94
Dec	17246	15856	92	21608	15729	73	32693	15345	47

F 2.2. Graphs of Monthly Load met by Solar Water Heater System (Tier 2) for North-south Building Orientation