A Study for Energy Consumption patterns and Carbon Dioxide emissions for Residential Building in Dubai

دراسة عن أنماط استهلاك الطاقة ومعدل انبعاث ثاني أكسيد الكربون للمباني السكنية لإمارة دبي

by

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ABSTRACT

The climate is changing and recent years show that the earth is warming up, sea level is rising and carbon dioxide (CO2) increasing as well. Human activities are considered as part of climate change due to the amounts of greenhouse gases emitted by these activities to the atmosphere. The Environmental Protection Agency (EPA) concludes that "Since the beginning of the industrial revolution, atmospheric concentrations of carbon dioxide have increased nearly 30%...and nitrous oxide…risen by about 15%. These increases have enhanced the heat-trapping capability of the earth's atmosphere." Globally, energy consumption increased and as per IEA (2010), the total world energy used by sector is as follows: 28% for the industry sector, 27% for the transport sector, and 36% for the residential and service sector. Locally, as per the Annual Statistical Report for Electricity and Water (2010), the total gross generating capacity increased by 5967 MW from 2004 to 2009. Statistically, studies for The Dubai Statistics Center (2009) have indicated that most energy consumption is located in the Commercial sector. Mainly, it accounts for 43% of the overall Dubai energy consumption, being the rest divided between the Residential sector (30%), Industry (9%), and another type (18%). Moreover, research by The UAE Ecological Footprint Initiative Summary Report 2007-2010, 2011) shows that the household sector was the major contributor in the UAE's Footprint which is responsible for 57%.

The purpose of this research is to investigate energy consumption and carbon dioxide emissions from the residential sector in Dubai. Also, to find out the influence factors on the energy consumption for the residential buildings. The investigated residences were located in eight different locations along the Emirate of Dubai. Questionnaire survey methodology is to be used

for this investigation and the questionnaire survey is structured in a way that is to be used as data for the household profile in Dubai in particular and in UAE in general. It's revealed building characteristics and household characteristics in the energy use in addition to the influence of households' lifestyle on energy consumption. The questionnaire also covered white goods items, home entertainment items, computer and peripheral items, air-conditioners, and lighting. More than 200 hard copy questionnaires were distributed to the selected area, in addition to the electronic copy distributed to relatives, friends, Colleagues, and others. Questionnaire results were based on surveys of 95 households for different types of residences; villas, detached houses, Arabic houses, and apartments in different locations.

The research result outlines the key drivers that impacts on energy consumption. According to the results; Major electricity-consuming items were air-conditioners, lighting, and refrigerators. Furthermore, consumers' behavior is the most important issue of energy consumption. This impacts of that energy which is particularly fossil-fuel-generated electricity on carbon released to the atmosphere. The dissection report ends with a section for recommendation of efforts, such as detailed survey, policy and regulation, intended to influence building energy use.

Recommended courses of action from BUID to the residential leaders, students. The holistic and integrated approach to the research objective, guided by Systems thinking and ecological design, capacities actors at three different levels to pro-Actively implement end-use energy efficiency.

ملخص

المناخ يتغير وتظهر السنوات الأخيرة أن الأرض ترتفع درجة حرارتها ، ومستوى سطح البحر آخذ في الارتفاع ، وثاني أكسيد الكربون (CO2) يتزايد كذلك. تعتبر الأنشطة البشرية جزءًا من تغير المناخ بسبب كميات غازات المنبعثة للغلاف الجودي من هذه الأنشطة. حسب وكالة حماية البيئة (EPA) أنه "منذ بداية الثورة الصناعية ، زادت تركيزات ثاني أكسيد الكربون في الغلاف الجوي بما يقرب من 30٪ ... وارتفع أكسيد النيتروز ... بنحو 15٪ ". على الصعيد العالمي ، زاد استهلاك الطاقة ووفقًا لوكالة الطاقة الدولية (2010) ، فإن إجمالي الطاقة العالمية المستخدمة حسب القطاع هو كما يلي: 28٪ لقطاع الصناعة ، و 27٪ لقطاع النقل ، و 36٪ للقطاع السكني والخدمي. محليًا ، وفقًا للتقرير الإحصائي السنوي للكهرباء والمياه (2010) ، زاد إجمالي سعة التوليد بمقدار 5967 ميجاوات من 2004 إلى 2009. إحصائيًا يُظهر البحث الذي أجرته مبادرة البصمة البيئية لدولة الإمارات العربية المتحدة 2007-2010 ، 2011) أن قطاع الأسرة كان المساهم الرئيسي في البصمة البيئية لدولة الإمارات العربية المتحدة وهو مسؤول عن 57٪ .الغرض من هذا البحث هو دراسة استهلاك الطاقة وانبعاثات ثاني أكسيد الكربون من القطاع السكني في إمارة دبي. أيضا معرفة العوامل المؤثرة على هذا الإستهلاك. في هذا البحث تم اختيار ثمانية مواقع مختلفة على طول إمارة دبي لتغطية مناطق مختلفة جسب الإمكان. تم تصميم الاستبيان بطريقة تتضمن بيانات تفصيلية. لقد وضع الإستبيان خصائص نوع البناء والخصائص المنزلية في استخدام الطاقة بالإضافة إلى تأثير نمط حياة الأسرة على استهلاك الطاقة. شمل الاستبيان أيضًا السلع البيضاء ، وأجهزة الكمبيوتر ، ومكيفات الهواء ، والإضاءة وما إلى ذلك. تم توزيع أكثر من 200 استبيان على المناطق المختارة ، بالإضافة إلى توزيع النسخة الإلكترونية على الأقارب والأصدقاء والزملاء وغيرهم لتحديد العوامل الرئيسية في استهلاك الطاقة. وفقا للنتائج؛ كانت العناصر الرئيسية المستهلكة للكهرباء هي مكيفات الهواء والإضاءة والثلاجات. علاوة على ذلك ، يعتبر سلوك المستهلكين من أهم المسببات في استهلاك الطاقة. ينتهي البحث بفصل للتوصيات والجهود المقترحة تهدف إلى التأثير على استخدام الطاقة في القطاع السكني الذي يسترشد بالتفكير التنظيمي والتصميم البيئي ، وقدرات الجهات الفاعلة على مستويات مختلفة للتنفيذ الاستباقي لكفاءة استخدام الطاقة النهائية

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I wish to show my appreciation to Prof. Bassam Abu-Hijleh for his guidance, feedback, and patience.

A dissertation is not the outcome of the efforts of entirely one individual. Many people have contributed to the questionnaire. At this time, I take the opportunity to extend my special thanks to all those who contributed in answer the distributed questionnaire.

I also owe much gratitude to my parents, my son and daughter, and my relatives for their unwavering support and prayers.

Finally, and above all, I cannot begin to express my unfailing gratitude and love to my husband who has supported me throughout this process and has constantly encouraged me when the tasks seemed arduous and insurmountable.

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ABBREVIATION

ADWEA:	Abu Dhabi Water and Electricity Company
AMS:	The American Meteorological Society
CO_2:	Carbon dioxide
DEWA:	Dubai Electricity And Water Authority
EP:	Ecological Footprint
EPA:	Environmental Protection Agency
FEWA:	Federal Electricity And Water Authority
GFN	Global Footprint Network
IPCC:	The United Nations Intergovernmental Panel On Climate Change
NASA:	National Aeronautics and Space Administration
NOAA:	National Oceanic and Atmospheric Administration
SEI:	Sustainable Energy Ireland
UNFCCC:	United Nations Framework Convention on Climate Change
WWF:	World Wide Fund For Nature

CHAPTER ONE: INTRODUCTION

1.0 Global Warming and Climate Change

The climate is changing and recent years show that the earth is warming up, sea level is rising and carbon dioxide (CO_2) increasing as well. There is general scientific consensus about what is happening. Now, Climate change and global warming are well up on the current political agenda. It's raised as the hottest topic and the most serious environmental issue facing the planet during the 21st century. Several questions can be asked: are human activities altering the climate? Is energy consumption one of these causes? Is global warming a reality? How big are the changes likely to be? Will there be more serious disasters? Can we adapt to climate change or can we change the way we do things so that we can slow down the change or even prevent it from occurring? Are those changes having an impact on our life in the short or long term? Are human behaviors having a relation to what is happing? And what are the factors that lead to those changes? All those are samples of questions in mind which can be asked for climate change.

Simply being aware of the meaning of climate change and global warming and if there are any differences between both as well as, knowing the frequent things that can cause climate change and global warming is a great way to help people to modify their behaviors which have an impact on the environment and harm the atmosphere.

1.1 What is the meaning of Global Warming or Climate change?

Both terms of "global warming" and "climate change" are often used. (WWF) is used the more term of "climate change" as it more scientifically accurate term, while we often use "global warming" term as it more popular. The (NASA) definition may be the best way to approach both:

"...global warming refers to surface temperature increases, while climate change includes global warming and everything else that increasing greenhouse gas amounts will affect." But the term "global warming" became more dominant in June 1988, "when NASA scientist James E. Hansen had testified to Congress about climate, specifically referring to global warming. He said: "global warming has reached a level such that we can ascribe with a high degree of confidence a cause and effect relationship between the greenhouse effect and the observed warming" (Erik,2008).

1.2 The Climate changing

In the year 2050 my son will be reaching forty; what will happen after forty years? Currently, many things have been happened which not been happing last forty years ago. The climate changed more rapidly than before. But are human activities will keep affecting our environment more than todays? Before thinking about the future of climate change? The past of climate change has to be studied and the meaning shall be clarified as well. In addition to that, the main indicators of Climate shall be indicated.

1.2.1 What is climate change?

Climate change and global warming, those words increasing at those days! What does that's mean and what is the meaning of climate change? Currently, there is no single agreed or clear definition for "Climate change". The United Nations Intergovernmental Panel on Climate Change (IPCC, 2008) defined climate change as any change in climate over time due to human activity or natural variability. While according to the United Nations Framework Convention on Climate Change (UNFCCC, 2007) the change of climate is caused by human activity directly or indirectly which adapts the global atmosphere in addition to natural climate which has been changed over

comparable periods. While, The American Meteorological Society (AMS, 2007) defined it as any sustained long-term changes to the elements of the climate such as temperature, winds, and pressure due to natural forcing on climate system such as solar emission or due to humans forcing. For more explanation, as the temperature increase, the Earth sends back the infrared radiation (heat energy) into the atmosphere, and some of this heat is absorbed in the atmosphere by gases such as carbon dioxide (CO_2), nitrous oxide(NOx), water vapor (H_2O), ozone (O_3), methane(CH_4) and halocarbons.

1.2.2 Climate Change Timeline

Climate change is considered the biggest challenge that human face during this generation and to study climate changes we have to understand the history of climate change and how it was detected firstly. In the first instance was as early as (1753), the carbon dioxide gas was discovered by Joseph Black by treating limestone and magnesia with acids. He called the discovered gas "fixed as" and later he was found that the discovered gas present in the air by humans exhaled also, it's produced during the fermentation of beer (Stephan Harding, 2007). Moreover, the indicators of climate change were clear during Industrial Revolution were in the 18th & 19th centuries, due to human activities as they were started to use coal, oil, and natural gas as power sources. Those activities speed up the amount of green gas (carbon dioxide) emission. In 1827, Jean-Baptiste Fourier discovered that the greenhouse effect kept the earth warmer than it would be (Stephan Harding, 2007). In 1863 John Tyndall published a paper and was described that greenhouse gas could be created from water vapor and other gases (Michael Marshall, 2009). In 1896, Svante Arrhenius stated that the doubling amount of CO_2 in the air lead to raising global temperate gradually by 5 to 6 ^oC(Stephan Harding,2007).In 1896, Arrhenius published the first calculation

of CO_2 emission from human activity. In 1897, a model for carbon exchange was produced by Chamberlin (Spencer Weart, 2008). “Between” 1920-1925, the oil field was opened in Arab Gulf and Texas and was considered as the beginning of an era of cheap energy (Spencer Weart, 2008). In 1956, a realistic computer model was produced by Phillips for the global atmosphere. In the same year, Plass claimed as per his calculation that the additional amount of CO_2 to the atmosphere would affect radiation balance (Spencer Weart, 2008). In 1960, keeling accurate measurement for CO_2 in the atmosphere was detected the risen of CO_2 and global temperature by an average of five years and level equal to 315 ppm (Spencer Weart, 2008). In 1967, convinced calculation presented by Manabe and Wetherald showed the raise of atmospheres temperatures by doubling CO2. Evidence of climate change has continued to accumulate since the 1960s (Stephan Harding, 2007).

The Environmental Protection Agency (EPA) concludes that “Since the beginning of the industrial revolution, atmospheric concentrations of carbon dioxide have increased nearly 30%...and nitrous oxide…risen by about 15%. These increases have enhanced the heat-trapping capability of the earth’s atmosphere. Sulfate aerosols, a common air pollutant….”

1.2.3 The main indicators of Climate Change?

According to the US agency and National Oceanic and Atmospheric Administration (NOAA), seven indicators are expected to increase the earth’s temperature which are; Humidity, Tropospheric Temperature, Temperature over Oceans, Temperature over Land, Sea Surface Temperature, Sea level, and Ocean heat content. On other hand, three indicators are expected to decrease it which are; Glaciers, Sea Ice, and Snow Cover (Figure 1.1).

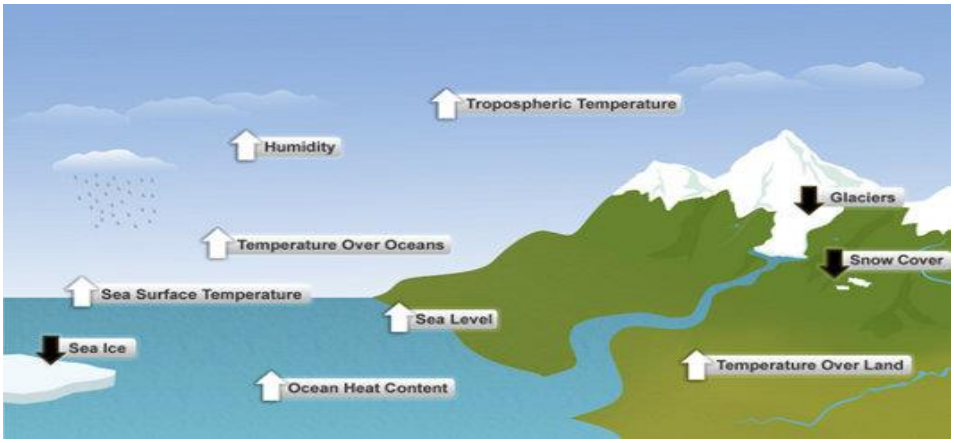

Figure 1.1: Ten indicators for a warming world according to scientists in 48 countries (NOAA, 2010**)**

1.3 A greenhouse gas emissions and carbon cycle

Greenhouse gases are those gases in an atmosphere which are varying in their ability to absorb and emit radiation within the thermal infrared ranges. This phenomenon is known among Scientists as the “greenhouse effect" (Figure 1.2). Some gases occurred and are emitted to the atmosphere through a natural process such as carbon dioxide. While others are created and emitted solely through human activities (EPA 2009). The most important gases because of human activities are water vapor (H_2O) which contributed 36 – 72 %, Carbon dioxide (CO_2) contributed by 9 – 26 %, Methane (CH_4) contributed by 4 – 9 %, and Ozone (O_3).

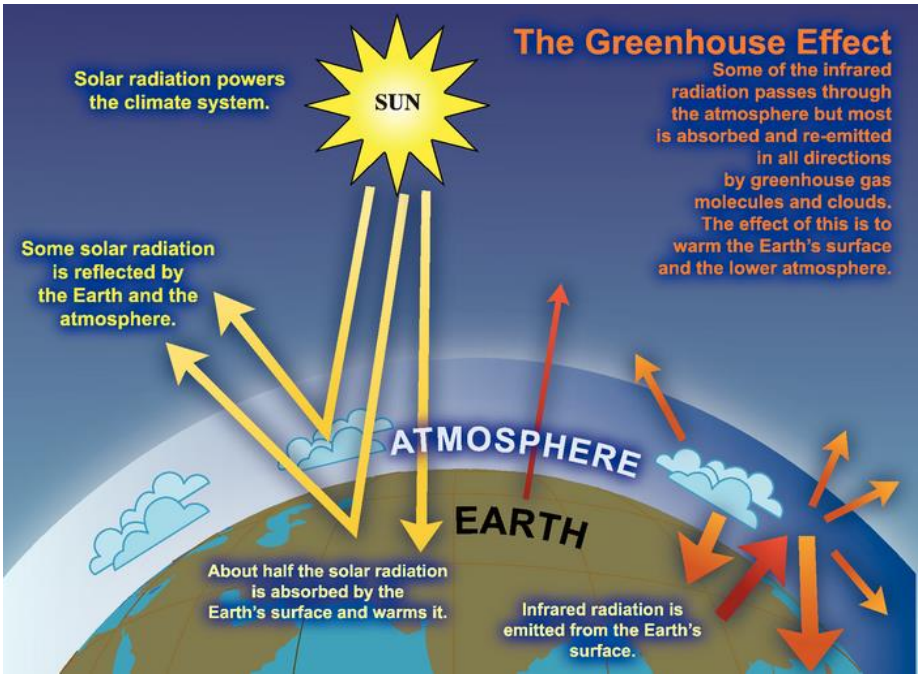

Figure 1.2: show an idealized model of the natural greenhouse IPCC Fourth (Assessment Report, 2007),

The most significant gas in the atmosphere is carbon dioxide (CO_2). The (IPCC Fourth Assessment Report, 2007) concluded that the Carbon dioxide (CO2)" has increased from a pre-industrial value of about 280 ppm to 379 ppm3 in 2005… CO_2 in 2005 exceeds by far the natural range over the last 650,000 years (180 to 300 ppm) …" On other hand, the (IPCC, 2007) conclude that the annual carbon dioxide emission grew by about 70% between 1970 and 2004, and the higher emission was during the period 1995- 2004. All those numbers mean the future will be warmer than in recent times with the accumulated amount of greenhouse gases in the atmosphere. (**Figure 1.3**)

The PCC Synthesis Report (2007) summarized that the concentration of carbon dioxide (CO_2), nitrous oxide (NOx), and methane (CH4) increased since 1750 as a result of human activity. And

as mentioned previously the Carbon dioxide (CO_2) has increased from a pre-industrial by far the natural range over the last 650,000 years. This increase in Carbon dioxide (CO_2) concentration is due to fossil fuel use and land-use change, while nitrous oxide (N_2O) and methane (CH_4) are due to agriculture (**Figure 1.4**).

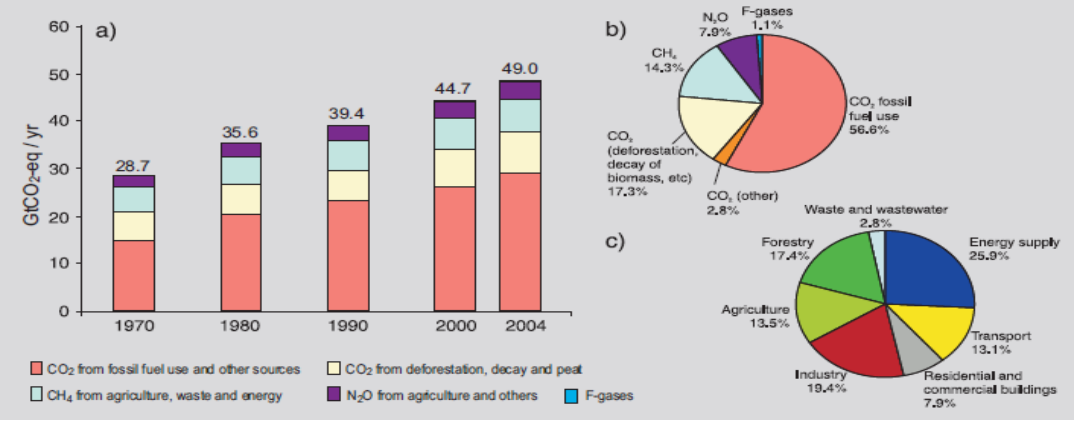

Figure 1.3: Show Global anthropogenic GHG emissions, where a) annual emissions of anthropogenic GHGs from 1970 to **2004, b**) Share of different anthropogenic GHGs in total emissions in 2004 in terms of CO2-**eq., c**) Share of different sectors in total anthropogenic GHG emissions in 2004 in terms of CO2-eq. **(IPCC, Synthesis** Report, (2007)

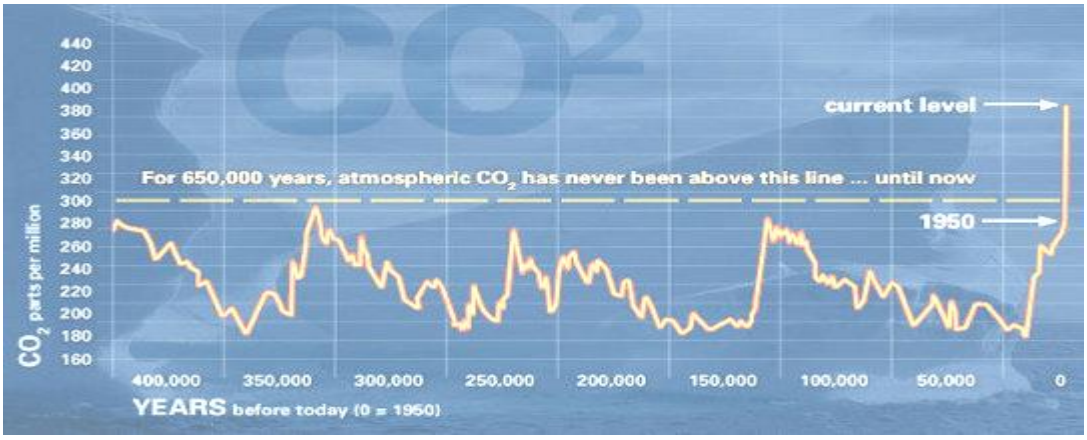

Figure 1.4: Climate change timeline for CO2 (NOAA, 2009)

1.3.1 The natural carbon dioxide cycle

In the natural carbon cycle, the earth maintains the carbon in balance, and when the concentrations of carbon dioxide (CO2) increase, the natural system returns to its natural state but this system works slowly compared to the increasing amount of Carbon dioxide (CO2) concentration in our atmospheres due to the fossil fuels burning. That's mean the removal of this concentration needs time. The natural carbon exchanges cycle is within a closed system containing four items; atmosphere, oceans, landmass and, biosphere. There are two cycles, short and long cycles.

In the short term cycle, the carbon is exchanged in the short period between the animals and plants through photosynthesis and respiration processes. Gas is exchanged between the atmosphere and the ocean. While, for the long-term cycle, the carbon is exchanged over millions of years. This is exchanged between rocks and the Earth's surface. According to (National Academy of Sciences, 2011)" carbon in the air is combined with water to form weak acids that very slowly dissolve rocks. This carbon is carried to the oceans where some form coral reefs and shells" (Figure 1.5).

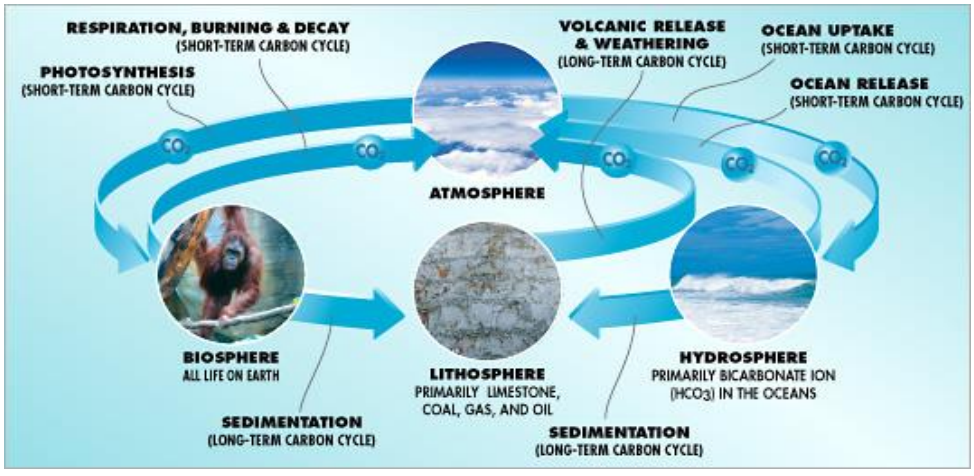

Figure 1.5: Shows the Earth's Carbon Cycle, including long and Short – Term Cycles (National Academy of Sciences, 2011).

1.3.2 Human Impact on the natural carbon cycle

Currently, human activities are considered as part of climate change due to the amounts of greenhouse gases emitted from these activities to the atmosphere. The largest contribution to the emissions is the burning of fossil fuels, which was started in the industrial era, about the year1750 (IPCC Synthesis Report, 2007). As a result of human activities, the main four greenhouse gases emitted to the atmosphere, which are, carbon dioxide (CO2), methane (CH4), nitrous oxide (NOx), and halocarbon. The CO2 has increased due to fossil fuel use in building, transportation, and manufacturing. The CH4 has increased due to human activities related to agriculture, natural gas distribution, and landfills. The N2O and Halocarbon gas are also emitted by human activities. As mentioned previously and as per the IPCC Synthesis Report (2007), the concentration of carbon dioxide (CO2) increased by 70% since 1750 as a result of human activities due to burning oil, natural gas, and coal to produce energy. The (UNFCCC) claimed that climate change refers to human activity directly or indirectly. Moreover, that's due to the high inflation in all sides of community, construction, residential, commercial, and industrial sectors. That’s why concentration growing up since the amount of the added carbon dioxide (CO2) by the human activity to the atmosphere is faster than the amount of carbon released by the natural system (Figure 1.6).

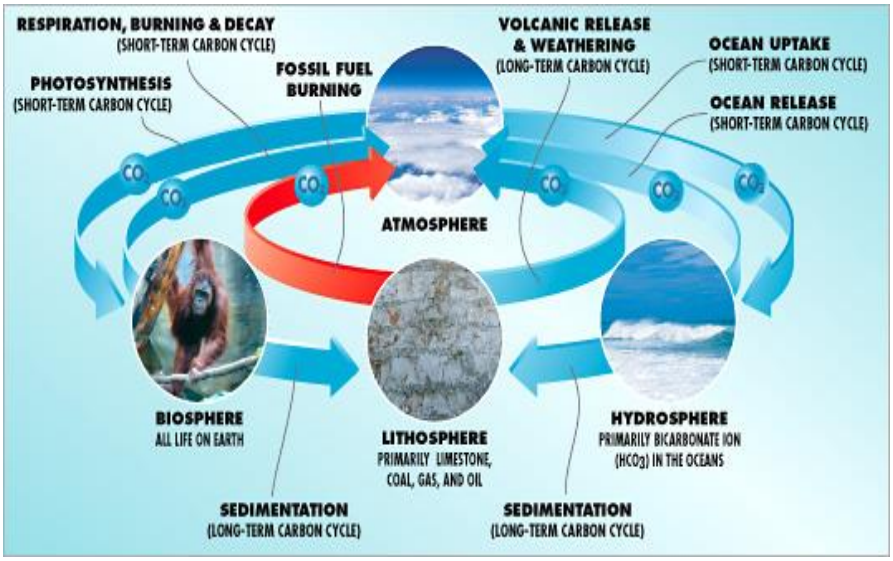

Figure 1.6: Shows Human Impact on the Carbon Cycle, the red arrow representing the increasing level of CO_2 in the atmosphere due to human activities (National Academy of Sciences, 2011)

These days, then activities affect to ecological Footprint and add more pressure on their resources. Currently, the term the Ecological Footprint (EF)" is widely used and, according to UAE Ecological Footprint Initiative (2010)"… The Ecological Footprint is a sustainability indicator that tells us about the relationship between human consumption and the earth's resources. It is an accounting tool that measures a nation's impact on planet earth… ".

Globally, as per Living Planet Report (2010), that in 2007 the humanity's Footprint was 2.7 global hectares (gha) per person, while the Earth's biocapacity was only 1.8 global hectares (gha) per person which mean that the ecological go beyond 50%. Moreover, the Earth needs 1.5 years to regenerate the resources used by people in 2007. By continuous consumption of the current population, we will need two and a half Earth by the 2030s to support us (Figure 1.7). The Ecological Footprint per person is differing from one country to other. By referring to (Figure 1.8) as an example, and if the Ecological Footprint for everyone on the Earth is equal to the average

of residents in the United Arab Emirates (UAE) or the United States (US), that means, we need fourth and a half (4.5) Earths to keep up with humanity's consumption and to absorb CO_2 waste.

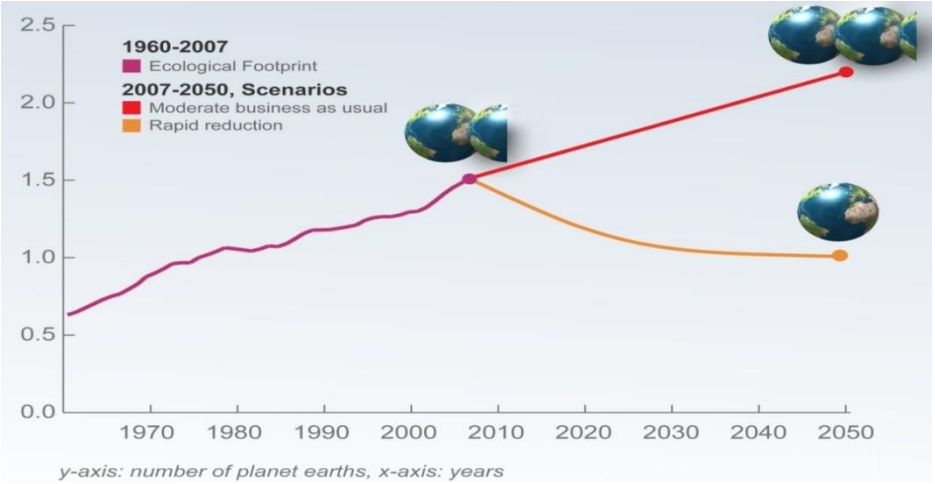

Figure 1.7: World Footprint (GFN, 2011)

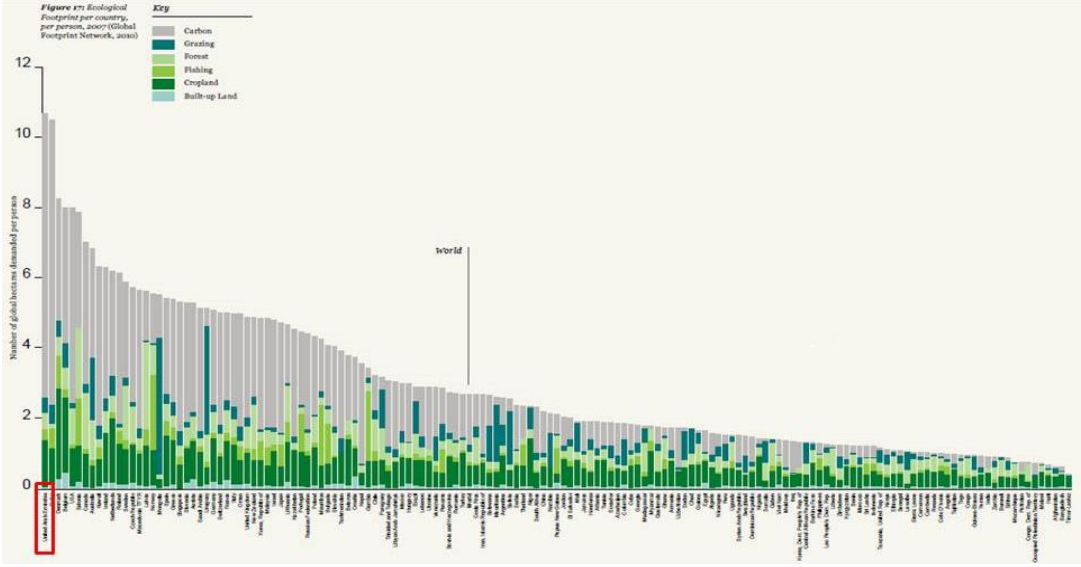

Figure 1.8: World Ecological Footprint, per person & UAE EF, highlighted by red, for 2007 (Global Footprint Network, 2010)

Locally, the UAE population growing with the growth of the economy. On the other hand, throwing increased the demand for natural resources as well as impacted our environment. The economic developments in all sides of the community are despite the economic crisis. The percentage of CO_2 continues to increase. According to the living plant report 2008, the carbon footprint from the use of fossil fuels was the fastest-growing component and the UAE has the highest amount of CO_2 which is near to 7.80 global hectares per person, in 2005. While in 2010 and referring to the Global Footprint Network (GFN) (2010), the carbon footprint exceeds 10 global hectares per person (Figure 1.9).

Research by The UAE Ecological Footprint Initiative (Summary Report 2007-2010, 2011) was carried to understand UAE's consumption patterns. The research shows that the households sector was the major contributor to UAE's Footprint which is responsible for 57%, followed by the business and industry sectors 30%. While the government sectors are considered as the fewer contributors which are responsible for only 12 % of total UAE's Footprint. But as stated by the mentioned report that the data required further research since there are some gaps in the provided local data that there are some gaps in locally generated UAE data which require further research. For that, this research will provide further research for the energy consumption by residential buildings and the amount of CO_2 emitted by this sector. The energy production and use will be clarified nationally and locally.

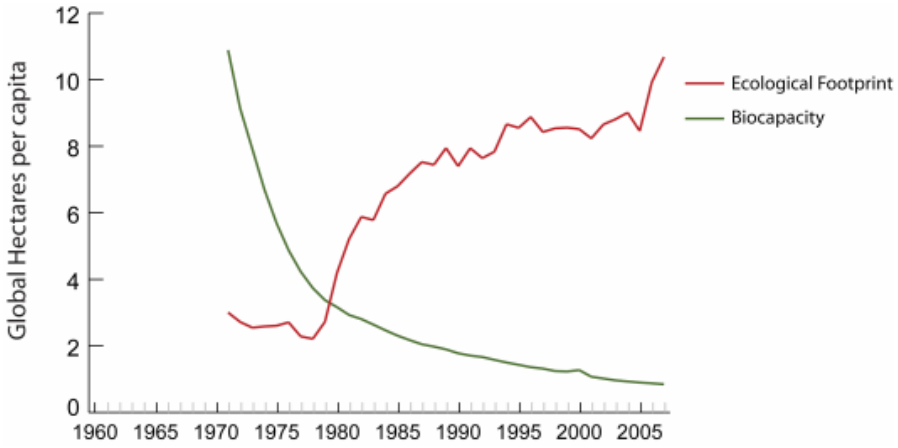

Figure 1.9: UAE Ecological Footprint since 1961 (GFN, 2010)

1.4 World Energy Production and Use:

In 2010, the world's primary energy production soared by 4% after a reduction of 0.6% in 2009. The continent of Asia accounted for 30% of total primary energy production, China was acquired about 18% of the total production. On the other hand, Russia was grown by 6%, North America by 2.5% (52 Mtoe), OECD countries by 2.3%, and the European Union by (20 Mtoe). In the Middle East, oil and gas producing were increased by 3.6%. (Enerdata, 2010)

The BP Statistical Review of World Energy (June 2011) reported that in 2010 the world's primary energy consumption was grown by 5.6%, which is considered the largest increase since 1973. This energy consumption was grown by 3.5% in OECD countries, which is considered the highest rate since 1984. While grown by 7.5% in Non-OECD countries. Oil continues to be the world's leading fuel with total global energy consumption of 33.6%.

Another report provided by Enerdata in (2010) in the Global Energy Statistical Yearbook (2011), stated that the world energy consumption rose by 5.5% and equal to 12,852 Mtoe after a slight decline of 1% in 2009, while it was 12,294 Mtoe with 4.5% above the pre-crisis level.

The re-soared growth was observed for all G20 countries due to the resume of energy consumption for OECD countries with the economic recovery after the sharp decrease in 2009. On the other hand, there was no slowdown in the consumption of energy both from China and India in 2009, and by 2010 the energy consumption increased in both countries by more than 6%, while in Japan increased by 6.7%, Europe increased by 4% and the United States increased by 3.7%. Now, China is considered as largest energy consumer in the world's and it's above the United States by 11%. And India ranked as the fourth energy consumer in the world (Figure 1.10).

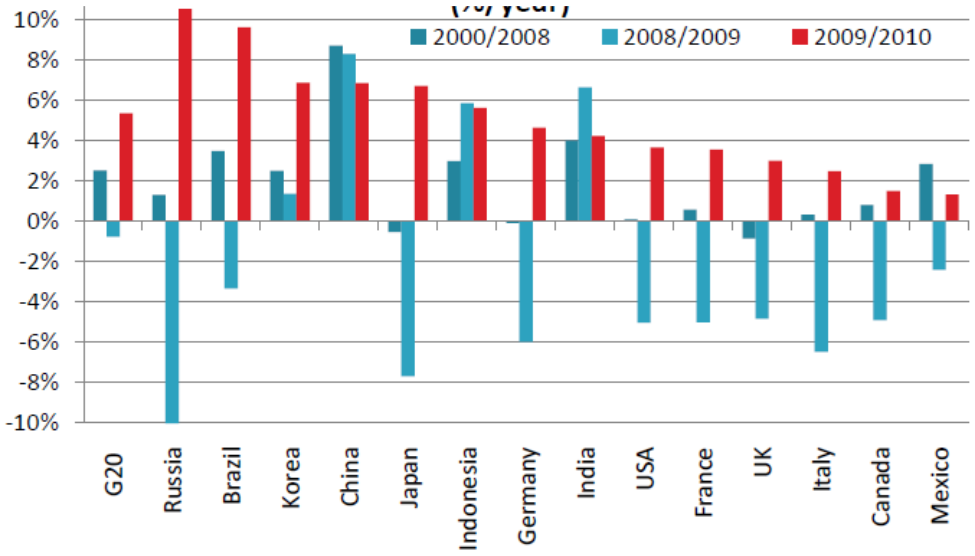

Figure 1.10: Energy consumption trends in major G20 consumers, y-axis: %, x-axis: country) (Enerdata, World energy use in 2010, 2010)

In 2009, world energy consumption decreased by (-1.1%). The first of energy consumption was before 30 years due to the economic crisis. Again, in 2009 the GDP drop by 0.6%. Energy

consumption remained vigorous in Asia and grew by +4%. Conversely, the energy consumption for the OECD countries was cut by 4.7% almost as what s in 2000. While, in North America, it was shrunk4.5%, in Europe by 5% and in CIS by 8.5%. But, China's energy consumption jumped in 2009 by 8% from 4% in 2008 it considers it the largest energy consumer in the worworld8% of the total energy consumed). Oil production remained the largest energy source by 33%. Coal is growing and accounted for 27% of the total energy consumptions (Enerdata, 2010).

As per (IEA,2009) data, The regional grew for energy use from 1990 to 2008 are as follows 170% for the Middle East, 146% for China, 91% for India, 70 % for Africa, 66% for Latin America, 20% for the UAS, 7% for EU-27 and 39% for rest of the world.

1.4.1 World Energy Use per Sector

The world energy uses mainly divided into four sectors: Industry sector, Transport sector, Residential & service sector, and Commercial sector. The industrial sector includes the manufacturing industries and nonmanufacturing industries. Examples of the manufacturing industries are paper, iron, steel, food, and others. And the nonmanufacturing industries include construction, agriculture, and mining.

In 2008, as per IEA (2010), the total world energy used by sector is as follows: 28% for the industry sector, 27% for the transport sector, and 36% for the residential and service sector. The sector division was almost the same as the year 2000 (Wikipedia, 2010). The below table (1.1) provides detailed data for the world energy for each sector between the years 2000 and 2008.

Table (1.1): World energy use per sector, (IEA,2010)

2008 %*	2000	2008 TWh	2000	
27.8%	26.5%	27,273	21,733	**Industry**
27.3%	27.5%	26,742	22,563	**Transport**
36.0%	37.3%	35,319	30,555	**Residential and service**
8.9%	8.7%	8,688	7,119	**Non-energy use**
100%	100%	98,022	81,970	**Total***

European Environment Agency (2007) has reported that the energy consumption for the EU-25 countries increased between 1990 and 2004 by 12.6%. As reported that the transport sector was the fastest-growing sector that increased by 28.6%, followed by the households' sector which increased by 17.5% as a result of rising income and higher living standards. Moreover, there was an increase in the number of owners of domestic appliances. On other hand, the final energy consumption for the services sector grew by 11.9 %. Lastly, the industrial sector decreased by -4.1% between 1990 and 2004 due to the shift to have less energy-intensive manufacturing. The below sector share chart shows that the largest energy consumer was transported, followed by industry, households, and services. While the largest growth rates between the year 2003 and 2004 was the households, followed by transport, industry, and services. The total grew rate was 1.1% (Figure 1.11).

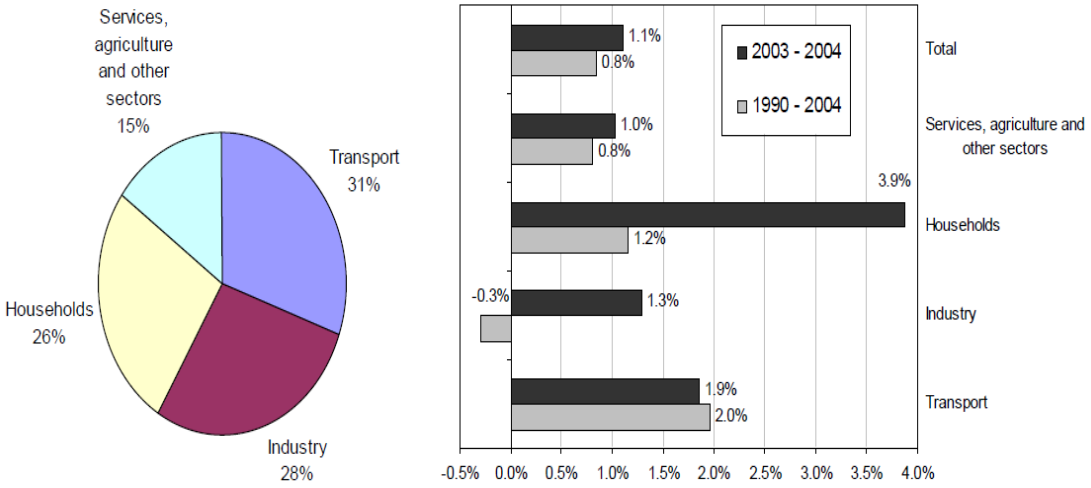

Figure 1.11: Sector Share: Final Energy Consumption and Growth Rates European Environment Agency (2007)

According to the EIA statistics reports, the US is considered the second-largest energy consumer. The consumption accounted per person as 335.9 million BTUs from 1980 to 2006. The consumption rate has increased faster than the production rate in the last fifty years. Moreover, as per the annual energy review (2009) by EIA that the percentage of U.S consumption for each sector is as follows: industrial (30%), residential (22%), commercial (19%), and transportation (29%) (Figure 1.12).Also The U.S ranks as seventh in the total energy consumption per capita with total consumption of 7,885.9 kgoe after Qatar (19,466.0 kgoe) , Iceland (12,209.4 kgoe), United Arab Emirates (10,354.0 kgoe), Bahrain (11,180.0 kgoe), Luxembourg(10,137.8 kgoe) and Canada (8,472.6 kgoe).(EIA,2011).

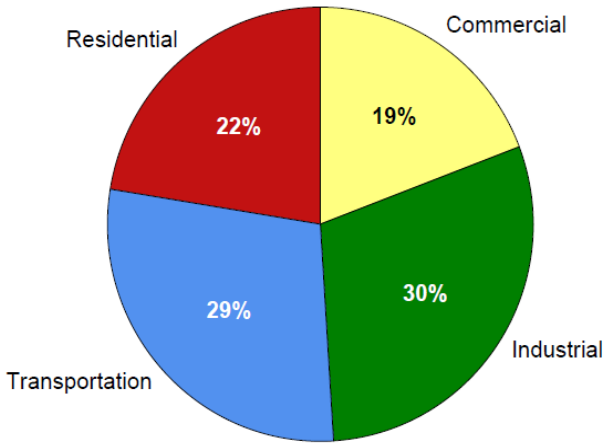

Figure 1.12: Pie Chart show the percentage of End-Use Sector Shares of Total consumption, 2009(EIA, 2011).

1.4.2 Energy consumption In the United Arab Emirates (UAE):

In recent years, the UAE has a significant development in all sides of the community. Although, with the current economic crisis, the UAE is continuing to grow. The real estate sector is ongoing to deliver more projects to the local market. As well as, the Electricity and Water sector is going to build up additional power plants to cover the additional demand and the population growth. According to UAE Year Book (2010), is UAE considered the “fourth-largest exporter of crude oil, after Saudi Arabia, Iran and Iraq" and” The UAE have world’s sixth-largest proven reserves of conventional crude oil and seventh-largest proven reserves of natural gas". The most generated electricity in the UAE is for natural gas.

Moreover, the Annual Statistical Report for Electricity and Water (2010), provides data that the total gross generation capacity increased by 5,967 MW from the year 2004 to 2009(Table 1.2) and (Figure1.13). As well, the annual energy demand grew from 52,066 GWh in 2004 to GWh 84,947 in 2009 (Table 1.3). For this increase in the electricity demand, the UAE continued to build up

more power capacity plants in 2009 to keep pace with consumption. UAE Year Book (2010) stated that according to Abu Dhabi Water and Electricity Company (ADWEC) statistical report issued in 2009 that the peak electricity consumption jumped for Emirates of Abu Dhabi to 11.3 percent and 6.3 percent for the Emirates of Dubai.

Table 1.2: Gross Generation Capacity (MW) 2004-2008 for ADWEA, DEWA, SEWA & FEWA (Annual Statistical Report for Electricity and Water, 2010)

الاجمالي Total	الهيئة الاتحادية للكهرباء والماء (FEWA)	هيئة كهرباء ومياه الشارقة (SEWA)	هيئة كهرباء ومياه دبي (DEWA)	هيئة مياه وكهرباء أبوظبي (ADWEA)	الأعوام
13,851	1,152	1,702	3,833	7,164	2004
14,769	1,152	1,902	3,833	7,882	2005
15,865	1,252	2,102	4,199	8,312	2006
17,369	1,252	2,302	5,448	8,367	2007
19,814	1,119	2,382	6,676	9,637	2008

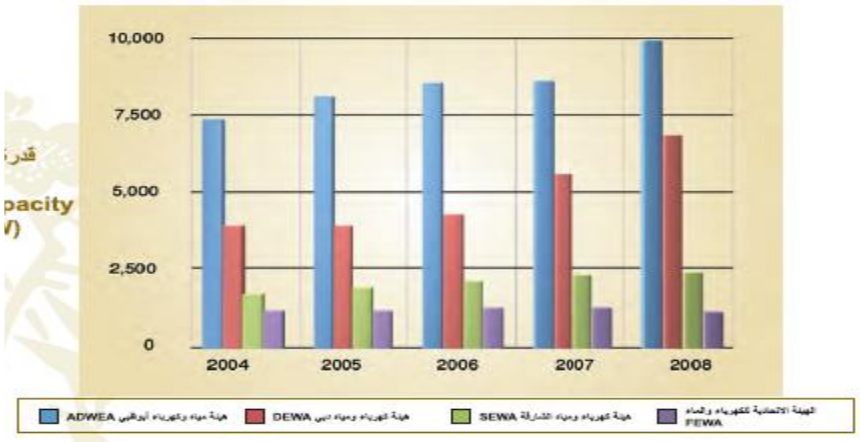

Figure 1.13: Chart show Gross Generation Capacity (MW)2004-2008 for ADWEA, DEWA, SEWA & FE, where x: years & y; energy generation capacity by MW(Annual Statistical Report for Electricity and Water 2010)

Table 1.3: Gross Annual Energy Demand (GWh) 2004-2008 for ADWEA, DEWA, SEWA & FEWA (Annual Statistical Report for Electricity and Wate, 010)

الأعوام	هيئة مياه وكهرباء أبوظبي (ADWEA)	هيئة كهرباء ومياه دبي (DEWA)	هيئة كهرباء ومياه الشارقة (SEWA)	الهيئة الاتحادية للكهرباء والماء (FEWA)	الاجمالي Total
2004	24,366	16,395	5,729	5,576	52,066
2005	25,424	16,572	6,323	5,745	54,064
2006	27,323	21,475	6,942	6,907	62,647
2007	34,143	24,756	7,684	8,134	74,717
2008	38,547	27,931	8,301	10,168	84,947

1.4.3 Energy consumption for The Emirate of Dubai:

At present, all households in Dubai connect with water and electricity. The Infrastructure indicators in the Dubai Statistical Yearbook (2009), show that the percentage of households connected with water and electricity is 100%. On the other hand, the estimated population in 2008 was 1,770,978 with an increased rate of around about 1.3%

Statistically, studies for Dubai Statistics Center (2009) have indicated that the electricity generation in Dubai increased from 22,272 GW per hour in 2006 to 29,089 GW per hour in 2008. Most energy consumptions are located in the Commercial sector. Mainly, it accounts for 43% of the overall Dubai energy consumption, being the rest divided between the Residential sector (30%), Industry (9%), and another type (18%).

Furthermore, the water production increased from 74,933 million gallons in 2006 to 91,260 million gallons in 2008. Also, water consumption increased from 64,961 million gallons in 2006 to 80,397 million gallons in 2008. Most water consumption is located in the residential sector. It

accounts for 60% of the overall water consumption in Dubai. And the rest divided in between commercial sector (25%), Industry (4%) and another type (11%).

Additional data provided by the World Energy Council (2007) that the energy consumption rate in Gulf countries is estimated as follows: 10 percent in the UAE, 7 percent in Saudi Arabia, and between 4 and 6 percent in other Gulf countries.

1.5 World CO2 Emissions from Energy Use:

Currently, Carbon Dioxide emissions are considered the most serious global environmental problem. The latest studies for EIA show that the most Carbon Dioxide I produced from energy consumption. In 2010, 41% of the world's emissions represented by OECD countries but it's increased slower than the world average which equals 3.8%. While In the United States the emissions increased by 4% which is considered faster than in Europe which is an average of 3%. In addition to that, the US emissions in 2010 are above their level in 1990 by 12%. In Japan and after a sharp decrease in 2009, the emissions re-increased in 2010 by 6.7%. China accounted for the largest CO_2 emitter in the world with an increase of 6% and in 2010, its share 25% of the world's emissions. China emissions are more than the US by 35%. On other hand, the CO_2 emissions increased sharply by 5% in India, and by 11% in Russia. Now, the CO_2 emissions in China, India, and Indonesia are above their levels in 1990 by more than three times (Figure 1.14) (Enerdata, 2010).

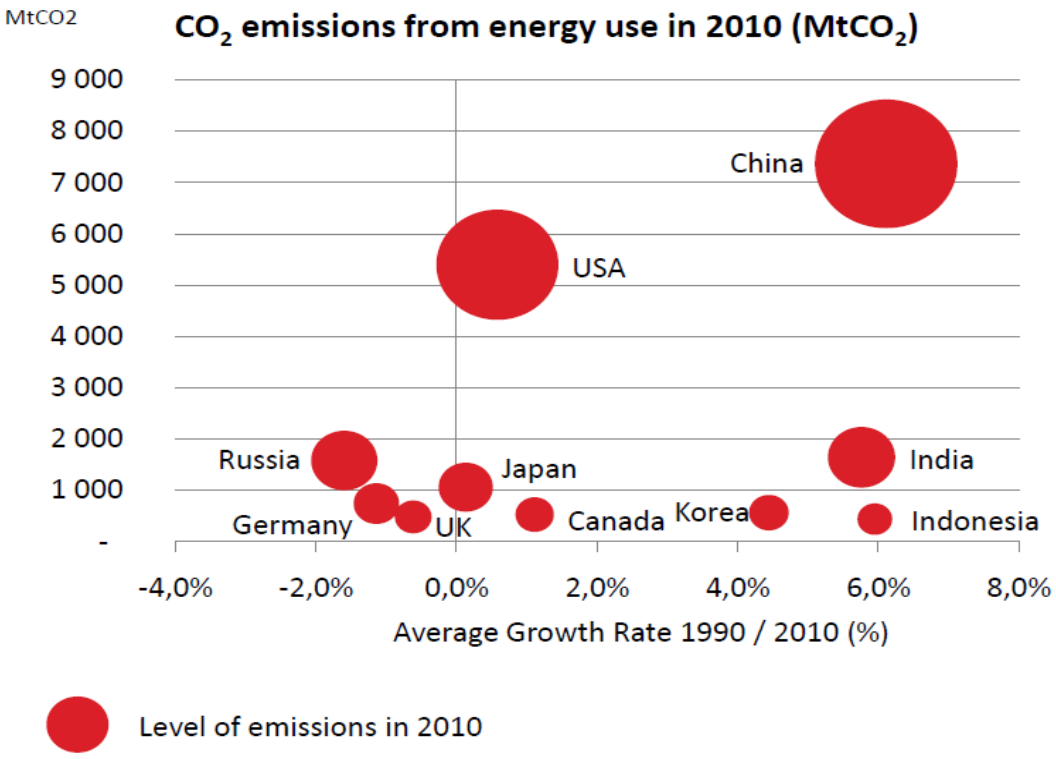

Figure 1.14: Shows level of CO_2 emissions from energy use in 2010 for the highest country emitting CO_2 (Enerdata, 2010)

On other hand, World Energy Council (WEC) (2007) stated in the Energy and Climate Change report the CO_2 emission for each region. Firstly, the OECD Europe show a small increase in CO_2 emission since 1971 which amounted to 3.7 Gigatonnes (Gt) and had risen to 4.1Gt in 2004 with an increase of 20%. Compared to world CO_2 emission the Europe's emission has fallen from 26% to 16% between 1971 and 2004. But Europe's emissions per head are nearly 8 tonnes of CO2 per capita which is considered high against the world average which is about 4 tonnes. Secondly, for North America and the Pacific OECD, the CO2 emissions amounted to around 50% since 1971 with a steady rise in the emissions. In addition to that, the emission per capita is about 14 tonnes which is higher than the world average. Thirdly, the Economies in transition countries in Eastern Europe and Asia and excluded those in the OECD. By 66% the CO2 emissions increase between

1970 and 1990 and fall by 31% between 1990 and 2004. Moreover, the emissions per capita are about 8 tonnes which are higher than the international standards. Lastly, the Developing countries had different trends for different regions. In Asia, the CO_2 emissions tripled between 1970 and 1990 due to economic growth and increased industrial production with heavy dependence on coal for China and India which are considered major economies in the region. While In Africa was shown a different range in CO_2 emissions due to slow growth economy. Though CO_2 emissions per capita were very low about 0.9 tonnes the emissions doubled by 50% between 1971 and 1990. The emissions have fallen in Zambia, Zimbabwe, and DR Congo since 1990 while it doubles in Ghana, Ethiopia, and Togo. But, a South Africa emission per capita was in line with the OECD countries which was over 7 tonnes. In the Middle East, the amount of CO2 emissions increased rapidly between 1971 and 1990. In some countries, emissions are influenced by the amount of oil production. The emissions per capita are different between those countries. In UAE or Kuwait, the emissions equal 25 tonnes although they are with low population. On the other hand, Syria and Jordan emissions equal 2.5 to 3 tonnes while they are with larger populations but they are with small oil and gas production. Latin America is located between OECD countries and Asian developing countries. The CO2 emissions increased by over 60% between 1971 and 1990 and 50% between 1990 and 2004. Although of this increased Latin America emits is the lowest in the world which is about 200g of CO2 per kWh, as in the example, OECD emit about 450g of CO2 per kWh and Asia emit about 730g of CO2 per kWh. Table (1.4) concludes the mentioned previously.

Table 1.4: Development of global CO2 emissions per region (Energy and Climate Change report, World Energy Council, 2007)

Region	% Increase in CO_2 emissions 1971-2004	Emissions per head 2004 (tonnes CO_2/capita)	Emissions intensity ($kgCO_2$/US$GDP using PPPs)
Europe	12	7.7	0.35
Other OECD	55	13.7	0.49
US	35	19.7	0.54
EITs	15	8.1	1.16
Asia	481	1.2	0.37
India	416	1.0	0.35
China	489	2.9	0.61
Africa	205	0.9	0.41
Latin America	147	2.0	0.29
Middle East	836	6.5	0.92
World	88	4.2	0.51

Source: CO_2 emissions from Fossil Fuel Combustion 2006. IEA Paris.

1.5.1 World sectoral CO2 emissions

The rapid rise of world energy use in the world raises environmental concerns regarding climate change and global warming. The global energy consumption has steadily increased for both residential and commercial sectors and reaching 20% to 40% in the developed countries and has exceeded the industrial and transportation sectors. IEA statistic studies show that between 1984 and 2004, the primary energy has grown by 49% with an annual increase of 2%, while the CO2 emissions have increased by 43% with an annual increase of 1.8% (Luis Pe´rez-Lombard, Jose´ Ortiz, Christine Pout, 2007).

Moreover, (IEA) provides individual analysis for CO2 emissions for each sector. In the time frame from 1990 to 2005, each sector of transportation, industrial, residential and commercial emit an amount of CO2 to the atmosphere. CO2 emissions from the industrial sector were the largest till 1997. On other hand, it was decreased gradually since 2000, while the transportation sector

emissions continued to increase since 1990 and be the greater emitter of CO2 in this time frame. Also, CO2 emissions show an increase in residential and commercial sectors (Figure 1.15) and (Table 1.4) (U.S Department of energy, 2007).

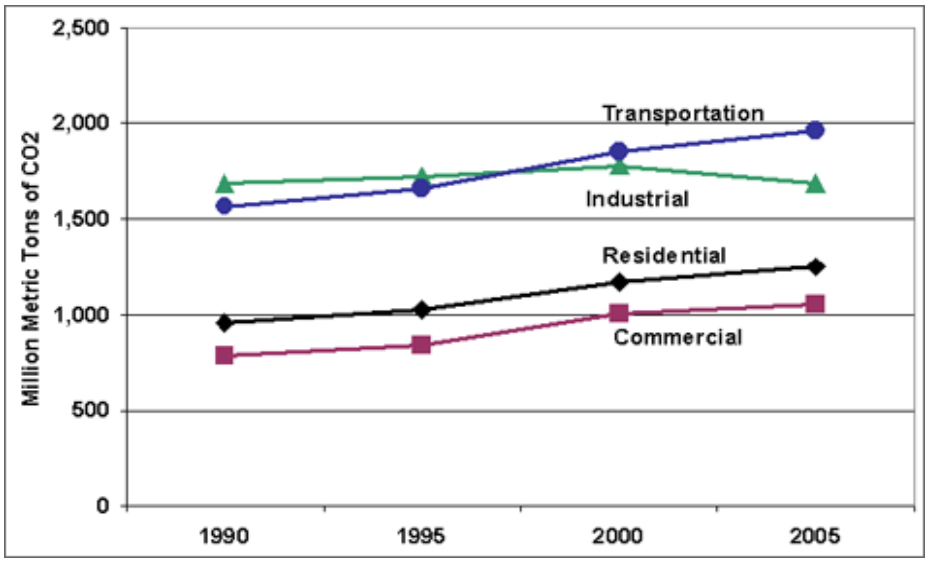

Figure 1.15: Carbon Dioxide Emissions by Sector, 1990-2005 (EIA, Emissions of Greenhouse Gases in the United States, 2005)

Table 1.5: Carbon Dioxide Emissions by Sector, 1990-2005 (EIA, Emissions of Greenhouse Gases in the United States, 2005)

Carbon Dioxide Emissions by Sector, 1990-2005 (million metric tons of carbon dioxide)				
2005	2000	1995	1990	
1,253.8	1,171.9	1,030.7	953.7	**Residential**
1,050.6	1,006.4	841.1	780.7	**Commercial**
1,682.3	1,778.0	1,728.6	1,683.6	**Industrial**
1,958.6	1,854.0	1,665.3	1,566.8	**Transportation**

Additional information was presented by World Energy Council (2007) in the Energy and Climate Change report that the building sector form 35% of total CO2 emissions from energy consumption due to continued population growth which increases the demand for the residential sector and service sector. In developed countries, the CO2 emissions have risen by 1% per year since 1970. In the economies in transition, the rapid increase was between 1971 and 1990, especially for commercial buildings. The growth in the developing countries was in both residential and commercial buildings. The emissions for both sectors were almost 5% and more. In general, there is a significant difference in emissions between countries due to the type and amount of energy used in the buildings.

The industrial sector is the largest signal source for emissions from final energy use which emit 35% of total CO2 emissions. But emissions also vary between countries and depend on the rate of the industrial sector. In the developed countries the emissions fall slowly by almost 1% a year. Also, in economies in transition countries emissions have been rapidly falling by 6% a year after 1990. While in developing countries emissions have been increasing around 6% since 1971.

The transport sector emits 25% of total CO2 emissions. This sector shows a significant growth in all-region and the emissions have been increased more than doubled since 1971 and 80% of total transport emissions for car use. In developed countries, CO2 emissions increased by 2% annually since 1971. While in developing countries, the annual increase is 5%.

1.6 Research Outline

This dissertation is divided into six chapters as follows:

Chapter one is an introduction and overview of climate change and global warming, including its definitions, timeline of climate change, and the main indicators for Climate Change. Also, will provide an overview look at greenhouse gas emissions with the impact of human activates on the natural carbon cycle. And provide a comprehensive discussion of energy consumption and carbon dioxide emissions globally and locally. In addition to the amount of carbon dioxide emissions in the Earths' atmosphere

Chapter two will be a literature review for residential sector energy use nationally and locally. In addition, is to investigate the effect of housing characteristics and household characteristics of energy use. And provide data for households' domestic energy use. Also, will present the effect of consumer lifestyle on energy use.

Chapter three is the methodology section which includes a review of different papers for the same topic and based on their methodologies. Those methodologies will be compared concerning their advantages and limitations. The chapter will also discuss the selected methodology with the appropriate selected site and software.

Chapter four will provide information on the questionnaire survey which will be used to collect data to create a database for the selected buildings. And will include information for the selected location for the survey and questionnaire set-up.

Chapter five will provide comprehensive analysis and discussion results for the questionnaire. The finding will be discussed in more detail and compare the different results for the surveyed areas.

Chapter six will provide a comprehensive conclusion based on the results and the main finding will be highlighted. Also, future research and recommendations will suggest for further research.

CHAPTER TWO: LITERATURE REVIEW

2 Background:

This chapter will highlight different sources, books, and scientific papers that addressed the profile of residential energy use. Furthermore, provides an overview of energy use in the residential sector and the amount of CO_2 emitted by sectors. Also, illustrate different methods used to identify the residential energy use and users' behavior factors that influence the energy consumption of the residential building.

2.1 National Residential Sector Energy Use

Recently, with population growth, the world energy demand is growing and the building energy consumption increased as well. That's to enhance better services and comfort levels with the rise of the time spent inside buildings. On other hand, that's growing in the residential sector adds more pressure on the environment and raises a concern about global climate change. Generally, direct emissions are related to the usage of oil, coal, natural gas, etc. While indirect emissions are by electronic appliances. Different countries had different energy consumption due to different conditions for each country. Nationally, the percentage of energy consumption ranges between 16 to 50% with an approximate average of 31% worldwide (Figure 2.1). Energy consumption is better understood for transportation, industrial and commercial sectors than the residential sector due to self-interest in reducing consumption. Also, they have almost more centralized ownership with a high level of documentation. While, the consumption of the residential sector was couldn't be defined correctly due to a wide variety of structure sizes, types, and envelopes. Moreover, are

there impacts of occupant behaviors on energy consumption? In addition to the privacy issues which limit the collection of energy consumption for the dwellings (Swan and Ugursal, 2008).

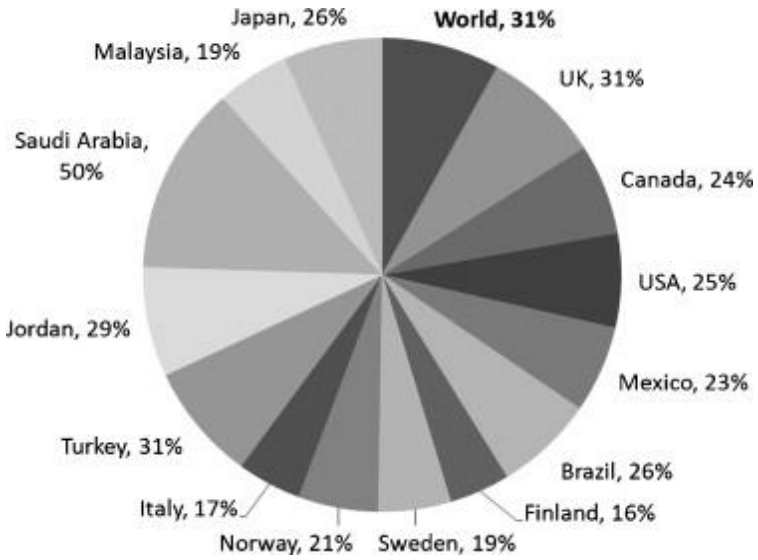

Figure 2.1: Pie chat shows the world residential energy consumption shown as a percentage of national energy consumption and in relative international form (Swan and Ugursal, 2008)

In the UK, the annual increase in building energy consumption is about 0.5% which was below the European rate of 1.5%. While in Spain the annual increasing rate was around 4.2% which was above the European rate due to economic growth as well as the spread of building services. In 2004, the building consumption in the European Union was about 37% of final energy and bigger than the other sectors.

The EIA Outlook (2006), analyses the energy use trends for the building over ten years, from 1994 to 2004 (Figure 2.2). In the next 20 years, energy use will grow by 34%, with an average rate of

1.5%. In 2030, the consumption will be approximately 67%. And in Southeast Asia, the growth in the residential sector will boost energy demand.

In 2010, the use of energy in dwellings was balanced for both developed and non-developed economies. But, by the next 25 years, the service sector in the non-developed countries will be growth by doubling with a rate about of 2.8% (Lombard, Ortiz and Pout, 2007).

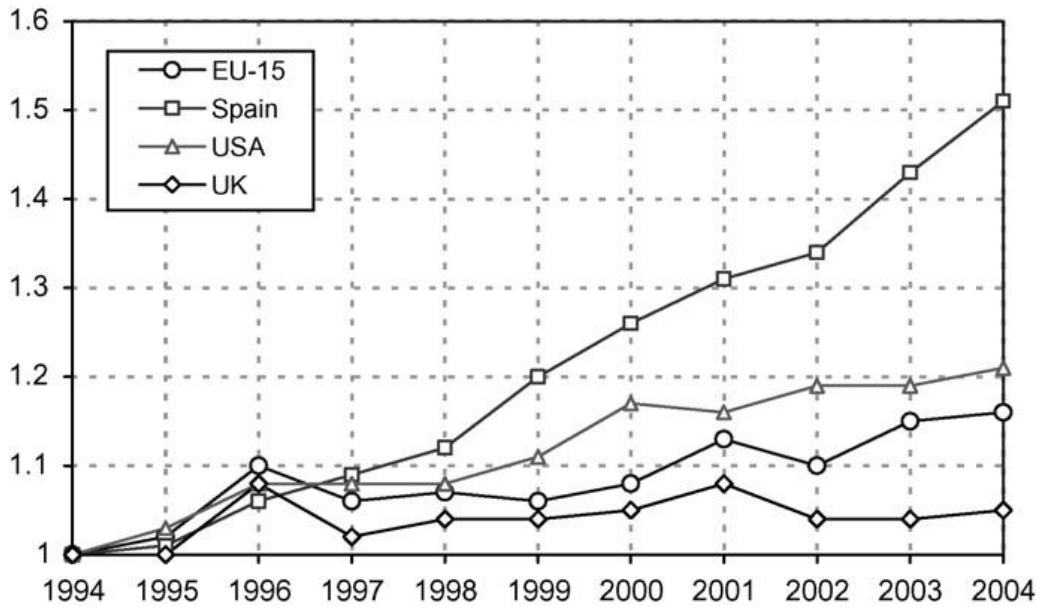

Figure 2.2: Chart shows the Energy consumption of buildings between 1994 and 2004 for EU-15, Spain, USA &UK, y-axis: energy consumption rate, x-axis: year (EIA, 2006)

Sustainable Energy Ireland (SEI) (2008) provided a report for energy in the residential sector, which provides an overview of energy trends and the total energy used in Ireland between 1990 and 2006. That's report stated that in 2006 the energy usage per dwelling in Ireland was 27% which is above the average for the UK. Moreover, in 2006 the residential sector consume 3,965

ktoe of primary energy, with an increase of 32% from 1990 and 2,990 ktoe of final energy, with an increase by 23 % from 1990. The residential sector was spending approximately €2.5 billion of total energy in 2006. The CO_2 emitted from the residential sector's decreased from 35% in 1990 to 25% in 2006. Also, approximately 8.1 tons of CO_2 are emitted by dwelling with a total of 4.8 tonnes of CO_2 from direct fuel use, equal to 59% (Sustainable Energy Ireland, 2008).

In India, as per Pachauri (2004) report that the households share about 40% of total direct energy. On another hand, and related to the indirect energy use the household sector presents about 70% of total energy use for all goods and the remaining 30% was for government consumption and investments.

Overview of residential energy use in Hong Kong by Joseph (1995) that during the 1960s and early 1970s the main fuel used domestic hot water and cooking was kerosene and electricity was not widespread at that's time. But recently, gas and electricity have been the major energy used in the residential sector. The electricity consumption rose from 2100GWh in 1979 to 6692 GWh in 1993 due to an increase in electrical appliances.

In China also the energy consumption for the residential sector increased sharply. In 2003, the consumption reached 192.684 million tons of standard, which is about 11.3% of national energy consumption and ranked as the second sector after the industry sector (Chen, Li, and Guan, 2007).

According to The Swedish Energy Agency (2009) the energy use in both sectors; service and residential sectors about 141 TWh in 2008, account for about 36% of total final energy use in

Sweden. And about 61% of the energy is used for domestic hot water and heating. And the energy use for domestic appliances increased from 2 TWh in 1970 to 19.5 TWh in 2008 due to increases in households numbers as well as ownership of electronic appliances.

2.2 Residential Energy Use in Dubai

In General, research by The UAE Ecological Footprint Initiative, Summary Report 2007-2010 (2011), to understand UAE's consumption patterns shows that the households sector are the major contributor to UAE's Footprint which is responsible for 57%, followed by the business and industry sectors 30%. While the government sectors are considered as the fewer contributors which are responsible for only 12 % of total UAE's Footprint. (Figure 2.3). But as stated by the mentioned report that the data required further research because there are some gaps in the provided local data that there are some gaps in locally generated UAE data that require further research.

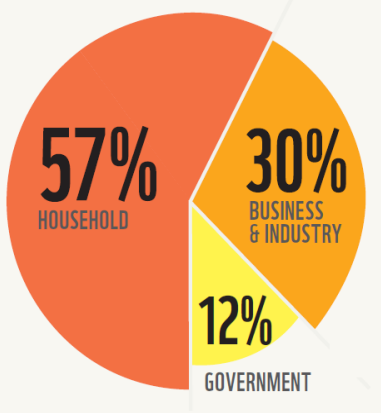

Figure 2.3: Pie chart shows UAE Footprint by demand sector (The UAE Ecological Footprint Initiative, Summary Report 2007-2010, 2011)

For Dubai in particular, all households in Dubai connect with water and electricity. The Infrastructure indicators in the Dubai Statistical Yearbook (2009), show that the percentage of households connected with water and electricity is 100%. On the other hand, the estimated population in 2008 was 1,770,978 with an increased rate of around about 1.3%

Statistically, studies for Dubai Statistics Center (2009) have indicated that the electricity generation in Dubai increased from 22,272 GW per hour in 2006 to 29,089 GW per hour in 2008. Most energy consumptions are located in the Commercial sector. Mainly, it accounts for 43% of the overall Dubai energy consumption, being the rest divided between the Residential sector (30%), Industry (9%), and another type (18%).

Furthermore, the water production increased from 74,933 million gallons in 2006 to 91,260 million gallons in 2008. Also, water consumption increased from 64,961 million gallons in 2006 to 80,397 million gallons in 2008. Most water consumption is located in the residential sector. It accounts for 60% of the overall water consumption in Dubai. And the rest divided in between commercial sector (25%), Industry (4%) and another type (11%).

2.3 Housing unit characteristics and household characteristics

Previously, the worldwide rate of energy consumption in the residential sector was covered. And now closer look for the housing unit characteristics, household characteristics, and energy usage within a household will be covered widely.

In the residential sector, building size and location play an important role in total energy consumption. The amount and type of energy used to depend on the architectural design, location, weather, energy system as well as economic level. The housing units in the developed countries consume more energy than the non-developed economies due to the use of new appliances such as air-conditioners, water heaters, computers, etc. In the USA, the dwellings consume around 22% of the total energy use, compared with 26% in the European Union (Lombard, Ortiz and Pout, 2007).

As per Yao and Steemers (2004), the used pattern depends on many factors, such as climate, building orientation, family level, income, number of occupants, and cultural background. The energy demands were classified into two types as follows:

- Behavioral factors: This type is related to the human factors and strongly related to people's habits and may influence by seasons, for example, water heater, air conditioning, television, etc. Moreover, it's influenced by the frequency of using those appliances and time scales like hourly, daily or weekly.

- Physical factors: This type is related to the climate, for example, lighting cooling, and heating has a direct relation with the climate and building design such as building orientation, size, and envelope

But sometimes may both factors affect the energy demand, for example, cooling has relation to the climate, as well as, to people’s habits by setting the internal comfort temperature as low or

high to fit the occupant comfort level. This means both behavioral and physical determinants are influenced by people's occupancy pattern (Runming Yao & Koen Steemers, 2004).

Also, Hart (2002) stated in his research that residential energy use is influenced by different factors including climate, housing characteristics, appliances, consumer behavior, and demographics. And he set four steps for that; first to identify the household characteristics. The second is to analyze the used fuels. The third is to describe the appliance usage. Last, to outlines the efficiency improvements.

Housing specifications such as size, type, house envelope, and density affect the total energy consumption. It has been noted that in the low-density development the housing area increased while, in the higher density development the areas decreased and the energy consumption for the appliances increased which caused to raid increase in the energy consumption, even with the tightening in the energy-efficient appliances (Nikhil Kaza, 2010).

Same factors reported by Romero et.al (2001), that the geographic location, Socio-economic context, and Physical characteristics of households have an impact on energy use.

Feng et.al (2010) showed that the factors such as socio-economic context, family numbers, demographics, and geography affected energy use. And the greatest impact was by families' higher income levels. Green consumption helps to reduce energy consumption and CO_2 emissions. In the same report, they referred to Bin and Dowlatabadi (2005) studied and the relationship

between consumer behavior, energy use, and CO_2 emissions by using the consumer lifestyle approach (CLA) and showed that 80% of energy use and CO_2 emissions related to the consumer behavior and economic levels.

Yao and Steemers (2004) presented in their research paper the composition and occupancy pattern of the household. Between 1971 and 1991 the average size of household was from 2.91 to 2.48 people. But since 1998 it was continued to decline and reached 2.31. Also, the composition of households was changed and increased percentage of one person per household which was doubled from 17 to 31% between 1971 and 1998. And the percentage tripled from 5 to 15% for one-person aged "between" 16 – 59. Table (2.1) lists the UK household's composition in 2002.

Table 2.1: UK households composition in 2002 (Yao and Steemers, 2004)

Composition of households in the UK 2002						
Number of persons in the household	1	2	3	4	5	6 or more
Proportion of households with the specified number of people	31%	35%	16%	13%	4%	2%

For the occupancy pattern of the household, the cultural contexts shall be considered and the consumers' attitudes shall be identified as well to the explored link between energy use and consumers' behavior. Almost household usage pattern related to the occupied period. As an example, most of the appliances will not be used when the home is not occupied. Each household's

members have different lifestyle and the load profile depends on the occupancy pattern which is influenced by different factors as follows:

- Occupants number
- The period of the day that house unoccupied
- The time of the first person getting up at the morning and the last person going to sleep.

That's means to identify the usage patterns, the consumers' attitudes are to be identified firstly (Yao & Steemers, 2004).

Yas and Steemers, 2004 was summarized the occupied period for UK households as below. The appliances will not be used in an unoccupied period (Table2.2).

Table (2.2): UK Occupancy pattern for a three-person household (Yao and Steemers, 2004)

Scenarios	Type	Unoccupied period
1	Part-time working morning session 1/2	9:00–13:00
2	Full-time working	9:00–18:00
3	Part-time working 2/3	9:00–16:00
4	No working	N/A
5	Part-time working afternoon session 1/2	13:00–18:00

Yao and Steemers (2004) provided an example for appliance load profiles in the UK by the selected average size of household. The occupancy pattern for this example was dependent on Table 2.2. Further; modeling results were shown in figure (2.4) for the typical appliance load profiles which were presented by think line. From that, it was clear that during the time that homes were not occupied the appliance load was shown as constant between 9 to 12:30 at least. By taking

the unoccupied period "between" 9.00- 13:00 as an example, it was shown that appliances were almost used at morning time (7.00 -8:00) to prepare breakfast and after it was turned off till 13:00.

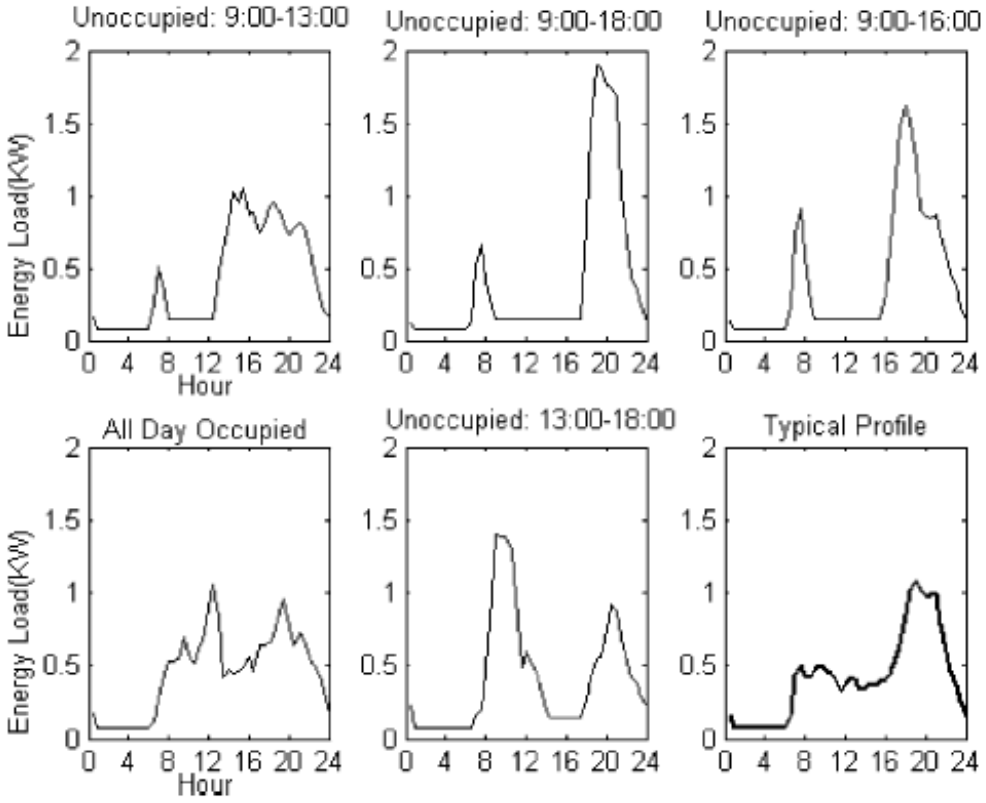

Figure 2.4: Typical appliance load profile of an average size of domestic household in UK (Yao and Steemers, 2004)

Chen and Yoshion (2010) claimed that housing unit characteristics and household characteristics are considered as influence factors for residential energy consumption. The main family type in China is family with three members as a percentage between 46 to 62% for cities, such as Shanghai, Beijing, and Kunming, while in Hong Kong families members were four persons or more. Figure 2.5 (a) shows the occupancy patterns during weekdays and Figure 2.5 (b) occupancy patterns during the weekdays for seven different cities in China. During the weekdays the morning and afternoon time occupancy relatively low but it was rose at noontime because some of the

family members back home for lunch. While during the weekend the occupancy rate was above 85% for all selected cities except Hong Kong which was about 65% at noon.

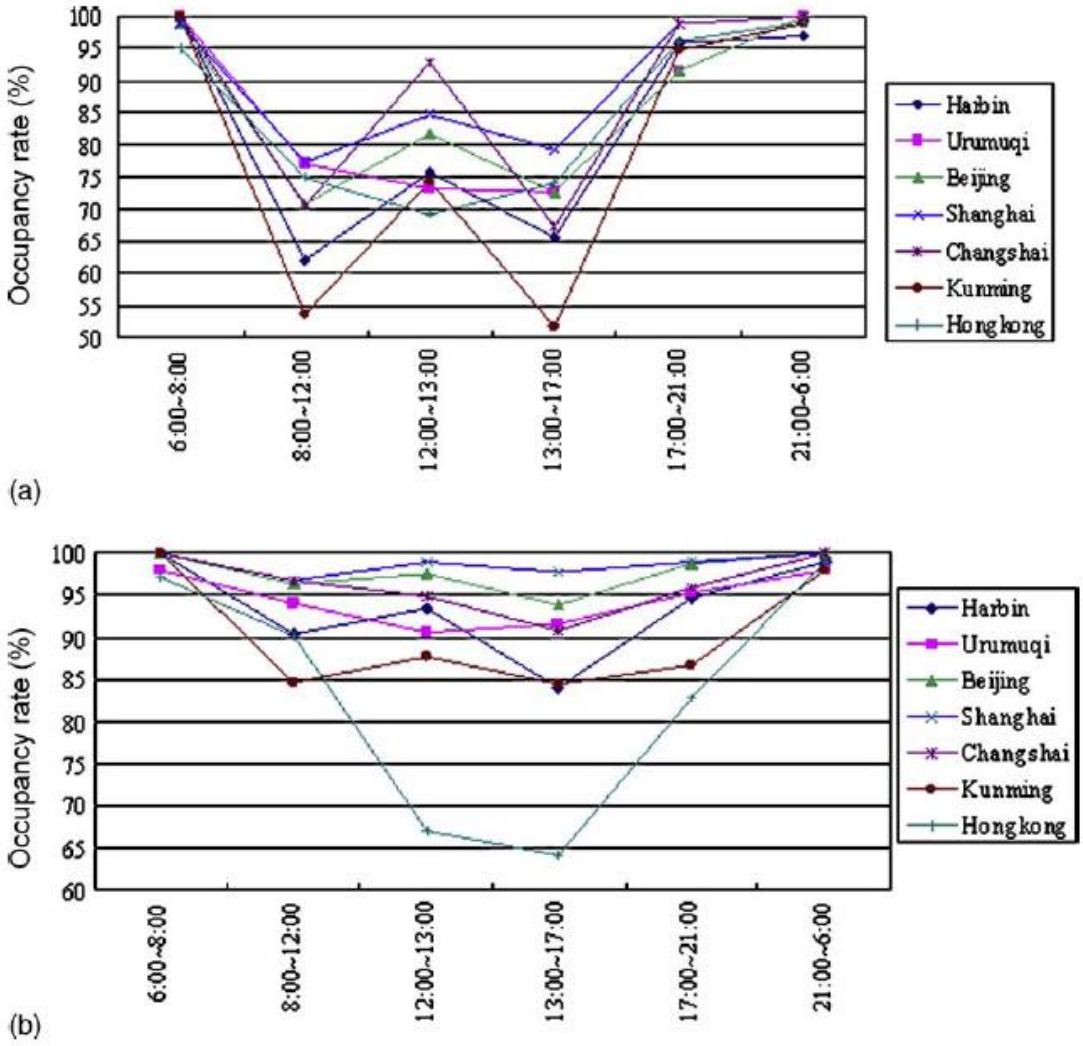

Figure 2.5: Shows occupancy patterns of residents for the seven cities in China, where (a) Occupancy patterns of residents during weekday, (b) occupancy patterns of residents during weekend (Chen and Yoshion, 2010).

Linde et.al (2005) reported several behaviors for their survey results which based on 600 Swedish households that the energy-efficient light bulb was not commonly used. In addition to that, the percentage of households which turned light off when they leaving a room was only about 17%.

This behavior to turn off lights was about saving money and energy. On other hand, 51% lowered room temperatures for comfort reasons while 27% for saving money or energy. For cleanliness, 50% of households are run washing machines four to five times per week. For the dishwasher, 50% rinsed dishes in running water. Also, 50% of households use Kettles and microwave ovens more frequently than before. The below table (Table 2.3) shows summered the inefficient behaviors.

Table 2.3: Inefficient behaviors and factors promoting for changing behavior (Linde, Kanyama and Eriksson, 2005)

Functional area	Behaviour	Grading/frequency	Policy instruments for change
Warm and light house	Use of energy efficient light bulbs	50% do not use them	Information, product development, rebates
	Turning lights off when leaving a room	Only 17% do it all the time	Rebates, information, product development
	Lowering indoor temperatures at night	38% of those who have the possibility do not use it, 23% can not lower temperatures at night	Information, product development, rebates
	Covering windows at night	Half of the households never do	Product development
	Airing during wintertime	40% air daily during this season	Product development, information
Cleanliness	The frequency of washing laundry	Half of the households run their washing machine 4 times per week or more	Changed norms for cleanliness, product development
	Removing stains instead of washing	70% never do	Product development, rebates, information
	Airing clothes instead of washing them	60% never or almost never do	Product development, rebates, information
Food provision	Using a kettle when boiling water	Only 39% do this	Information
	Rinsing dishes in running hot water before putting them in the dishwasher	37% do it often or always	Information, product development
	Rinsing dishes in running water when washing dishes by hand	50% use this practice	Information
Entertainment and information	Using the energy saving function on the computer	Half do not have it or don't know that it exists	Information, support
	Turning off the TV with the on/off button	34% never do it	Information about e.g. risk of fire

Note: All behaviours chosen in this analysis are significant at the *p*-level 0,05 (Carlsson-Kanyama et al., 2003).

2.4 Energy Consumption of Domestic Appliance

Swan and Ugursal (2008) stated that the residential sector mainly consumes secondary energy. The major end-use groups of this energy were broken down into:

- Space heating and cooling: required energy to support thermal losses of the building envelope
- Domestic hot water: required energy to heat water to a comfortable level
- Appliances and lighting: consumed energy to operate appliances

The mentioned three groups are depended on many factories such as climate, dwelling characteristics, appliance use, and occupant behavior (Swan and Ugursal, 2008)

Yao and Steemers (2004) classified domestic appliances into five groups as follows:

- Brown goods: includes electronic items, such as TVs, DVDs, etc.
- Cold appliances: includes refrigerators and freezers
- Cooking appliances: includes Electric Cooker (plates/Ovens), microwaves, kettles, etc.
- Wet appliances: includes washing machines and dishwashers
- Miscellaneous appliances: includes electronic irons, vacuum cleaners, PCs, etc

In 2000, the electricity consumption in the UK was accounted for 14.3% for brown goods, 22.2% for cold appliances, 16.5% for wet appliances, 18.8% for cooking appliances, 22.6% for lighting, and 5.6% for miscellaneous

Appliances. Table (2.4) shows the daily energy consumption per appliance in addition to ownership level (Yao and Steemers, 2004).

Table 2.4: Shows the average of energy consumption per appliances in the UK (Yao and Steemers, 2004).

Appliance	Average annual consumption per household (kWh/day)	Average annual consumption per capita (kWh/day)	Ownership level (%)
Electric hob	1.33	0.39	37
Electric oven	0.74	0.22	56
Microwave oven	0.23	0.07	74
Refrigerator	0.82	0.33	53
Fridge-freezer	1.9	0.56	58
Freezer	1.9	0.55	55
Colour-television set	0.91	0.27	97
Video recorder	0.3	0.09	76
Clothes-washing machine	0.8	0.20	88
Tumble-drier	0.78	0.28	49
Dishwasher	1.72	0.48	16
Electric kettle	0.78	0.28	5
Iron	0.3	0.09	100
Vacuum cleaner	0.15	0.04	100
Miscellaneous	1.1	0.33	100

Shimoda et.al (2004) claimed in their simulation result that the annual electricity consumption for lighting depends strongly on two factors the floor area and the number of occupied room .From the other hand, the annual electricity consumption for heating and cooling depends also on the floor area and several rooms. Also, they showed that the total energy consumption depends strongly on the household type than the floor area, such as; the energy consumption in the detached house is greater than the apartment house.

Chen et.al (2007) were listed in table (2.5) the number of equipment per Chinese household with the average power rating. In general, in terms of the running equipment schedule, the widely used are TV sets, cookers and water heaters, while the high-power equipment is electrical cookers, microwave and washing machines. Also, Figure (2.6) shows the peak time of cooling and heating during the year. Heaters were almost used between November to April while, air condition was used from June to October, and fans were used from May to the end of October. The peak time of using water heater was during February with a Percentage of 80%. The peak time for using air condition and fans was during August with the percentage of 58% and 90% respectively.

Table (2.5): Numbers and load densities of energy consuming equipment owned by the investigated households (Monthly utilization of space heating and cooling equipment (Chen, Li& Guan, 2007)

Categories of equipment	Average number of each equipment per household	Average power rating of each electrical equipment per household (W/household)
Air conditioning		
Local air conditioners	1	1198.4
Space heating		
Local space heaters	1.02	848
Lighting		
Incandescent lamp	1.34	83.15
Fluorescent lamp	4.39	81
Cooking and water heating		
Coal gas cooker	1	–
Water heater using coal gas	0.9	–
Microwave oven	0.37	351.9
Disinfection cupboard	0.27	83.3
Electrical cooker	0.58	464.8
Other domestic electrical equipment		
Exhaust fan	1.33	39.54
Water fountain	0.33	179.6
Color TV Set	1.4	187.87
Refrigerator	0.96	136.5
Electrical fan	3.08	169.6
Video compact disc	0.87	8.33
Computer	0.58	183
Amplifier	0.5	240.7
Washing machine	0.52	226.85
Bathroom heater	0.33	289.8
Total		
–	–	4772.34

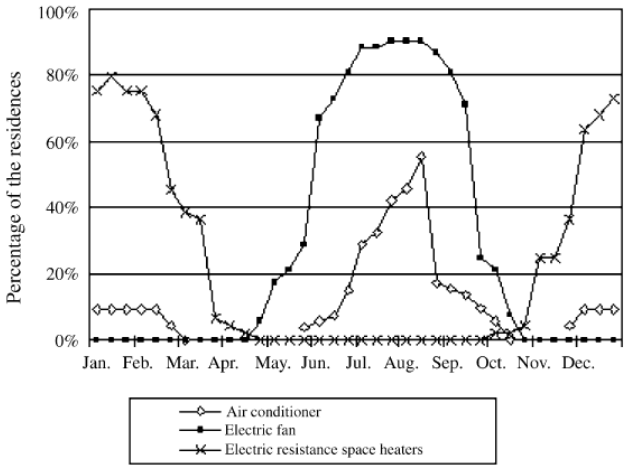

Figure (2.6): Monthly utilization of space heating and cooling equipment (Chen, Li& Guan, 2007)

Joseph (1995) has been stated in his report that energy consumption rise in the residential sector in Hong Kong. During the 15 years, the use of air-conditioning was grown by rate oa f 14% and considered as the greatest increase in electricity use, followed by the lighting which consumes about 10% of the total electricity use the household. The air-conditioning has been the largest electricity-consuming appliance due to the influence of weather conditions since the summer season in Hong Kong was long, hot, and humid (Figure2.7).

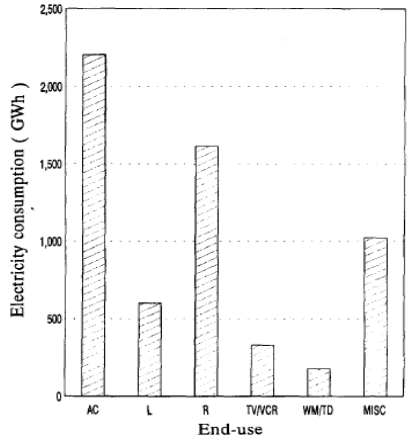

Figure (2.7): Column chart Estimated total annual household electricity consumption by end-use in 1993 (Joseph, 1995)

Figure 2.7, shows the estimated total annual household electricity consumption by end-use in 1993 in Hong Kong, where AC: Air-conditioning, L: Lighting, R: Refrigerators, TV/VCR: Televisions & Video-cassette recorders, WM/TD: Washing machines and tumble driers, MISC: Miscellaneous electrical appliances (Joseph, 1995)

In The US, the space heating consume 32% of total energy, water heating consume 13%, lighting consume 12%, air conditioning consume 11%, refrigeration consume 8%, electronics consume 5% and 5% wet-clean (Wikipedia,2011)

In 2000, the UK domestic building consume 56% for space heating, 24% for water heaters, and 20% for lighting and appliance (Runming Yao & Koen Steemers, 2004)

Shimoda et.al (2007) in their research linked living activities and energy consumption by households. And the appliance use calculated for each period during the day. Table (2.6) is shown the energy consumption of appliances per 100 households.

Table 2.6: Power consumption of home electric appliances used in this simulation (Shimoda et.al, 2007)

Appliances	Room	Number of holdings (per 100 households)	Power consumption (W)	
			Operating mode	Standby
Rice cooker	Kitchen	88.1	1250.0	35.0
Dishwasher	Kitchen	22.2	1000.0	3.0
Thermos	Kitchen	72.1	1000.0	45.0
Microwave	Kitchen	100.6	200.0	3.4
Toaster	Kitchen	79.0	500.0	2.8
TV	Living and bedroom	238.1	114.0	2.4
Refrigerator[a]	Kitchen	122.8	600.0	No standby
Fan	Kitchen	100.0	20.0	0.0
Washing Machine	Bathroom	109.3	126.0	0.7
Tumble dryer	Bathroom	26.4	1300.0	0.2
Hair dryer	Bathroom	133.9	450.0	0.0
Desk lamp	Bedroom	100.0	30.0	0.0
Vacuum	Living room	148.3	200.0	0.0
Iron	Living room	102.5	500.0	0.0
VCR	Living and bedroom	127.4	21.0	3.7
Radio	Living and bedroom	88.0	100.0	14.0
CD player	Bedroom	86.2	100.0	14.0
PC	Bedroom	47.6	62.7	3.3
PC accessories	Bedroom	47.6	20.0	34.8
BS tuner	Living and bedroom	43.1	[b]	13.9
Fax	Living room	39.1	[b]	20.0
Telephone	Living room	138.2	[b]	5.0
Shower toilet	Toilet	53.4	[b]	35.0
Kotatsu (foot warmer)	Living room	116.3	500.0	0.0
Electric carpet	Living room	116.1	580.0	0.1

[a]Power consumption of refrigerator is modeled as a function of outdoor air temperature.

[b]Operating mode is not considered since operation time is quite small.

2.5 Consumer lifestyle Approach (CLA)

Bin and Dowlatabadi (2005), proposed in their research an alternative paradigm called as Consumer Lifestyle Approach (CLA), this approach was used to study the relationship between consumer activities and the impacts of those activities on the environment. The results showed that 80% of the energy used and CO_2 emissions were due to consumer activities.

This concept of lifestyle started in the late 1980s. Schipper (2008) claimed that: ‘‘about 45–55% of total energy use is influenced by consumers’ activities for personal transportation, personal services, and homes.’’ Also, Schipper and Bartlett (1989) stated that the energy demand is driven by: ‘‘the mix of personal activities and their locations besides energy prices and incomes’’.

The proposed framework by Bin and Dowlatabadi (2005) for lifestyle approach was divided into five major groups as follows (Figure 2.8):

1) External environmental variables: includes influences of cultural and technology development

(2) Individual determinants: includes attitudes, beliefs, and psychological variables

3) Household characteristics: includes household size and type, location, orientation, and income.

(4) Consumer choices: includes ownerships, purchases, and use

(5) Consequences: includes environmental impacts related to the consumer activities

In CLA, the consumer activities were categorized into three levels. At the highest level, the consumer activities were categorized into direct and indirect influences. The direct influences

include home energy and personal travel. The indirect influences Include home and transport operation, Food and beverage consumption, Apparel, etc. (Table 2.7) Bin and Dowlatabadi (2005)

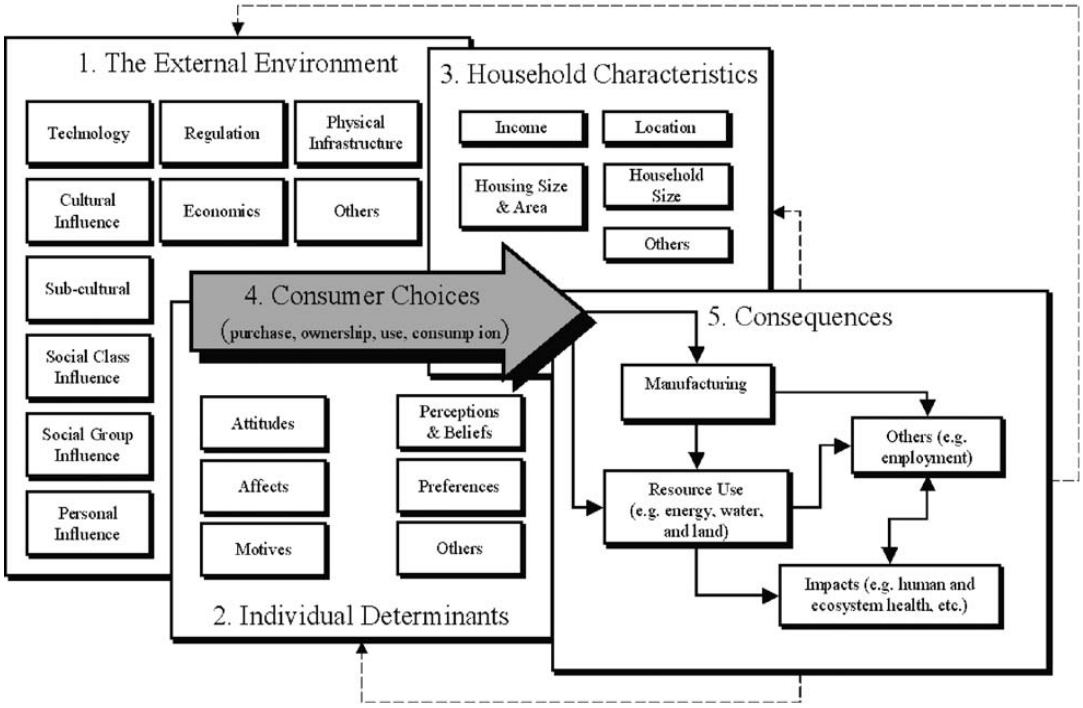

Figure 2.8: A framework for the proposed consumer lifestyle approach (Bin and Dowlatabadi, 2005)

Table 2.7: Consumer consumption activities categorization (Bin and Dowlatabadi, 2005)

Consumer activities categorization			Sources
Direct influences	Home energy	Space heating Air conditioning Water heating Refrigeration Other appliances and lighting	Residential Energy Consumption Survey (Department of Energy, 1999), or RECS
	Personal travel	Long distance by automobiles and trucks Long distance by air Long distance by others Short distance by automobiles and trucks Short distance by others	American Travel Survey (Department of Transportation, 1995), or ATS; Transportation Energy Data Book (Oak Ridge National Laboratory, 1999), or TEDB
Indirect influences	Housing operations	Shelter, utilities, etc.	Consumer Expenditure Survey (Department of Commerce, 1999), or CES
	Transportation operation	Vehicle purchase (net), gasoline and motor oil, other vehicle expenses, etc.	
	Food and beverage	Food at home, food away from home	
	Apparel and services	Men and boys, women and girls, etc.	
	Health care	Health insurance, drug, etc.	
	Entertainment	Fees and admissions, magazines, etc.	
	Personal Insurance	Personal insurance and pensions	
	Others	Education, tobacco, etc.	

According to Feng and Zou (2010), the external environmental factors have the greatest impact on consumer behavior which is mainly related to the accumulation of social factors including culture and history. The researcher analyzed the impact of household characteristics and consequences. Also, he was calculated energy use and CO_2 emissions for urban and rural households in China. In this research direct energy use of household including lighting; cooking, cooling, and heating were provided by China Energy Statistical Yearbooks, while CO_2 emissions from the direct energy use were calculated from below equation (1):

$$CO_2\_direct = F\_m \times CO_2\_coefficient$$

Where F_M is a matrix of energy consumption. F_m is a 1x 5 vector-matrix. CO_2 coefficient is a 1 x5 matrix of CO_2 coefficients for fuels.

Feng and Zou (2010) used the grey relational analysis to solve the problem, such as the effect of lifestyle on CO_2 emissions and economic development. Firstly, this theory was used to find the relations between indirect energy use for lifestyle and indirect CO_2 emissions. Secondary, to find relations between household consumer and indirect CO_2 emissions by determining the closeness of a link. As a result of this research, energy consumption for urban households was greater than rural households because house electrical device and AC were used in the urban household more than in rural households. Just for AC, the number in 2007 was increased three times than in 2000 for 100 urban households.

Indirect energy use and CO_2 emission were analyzed by Feng and Zou (2010) depending on the income level for urban and rural households in Chain and by referring to data provided by China

Statistical Yearbooks. It was found that CO_2 emissions for high-income levels are higher than at the low-income level. In rural high-income level, CO_2 emissions were an average of 3.1 times low-income level. While, in urban high-level income, CO_2 emissions were an average of 4.5 times low-income level (figure 2.9)

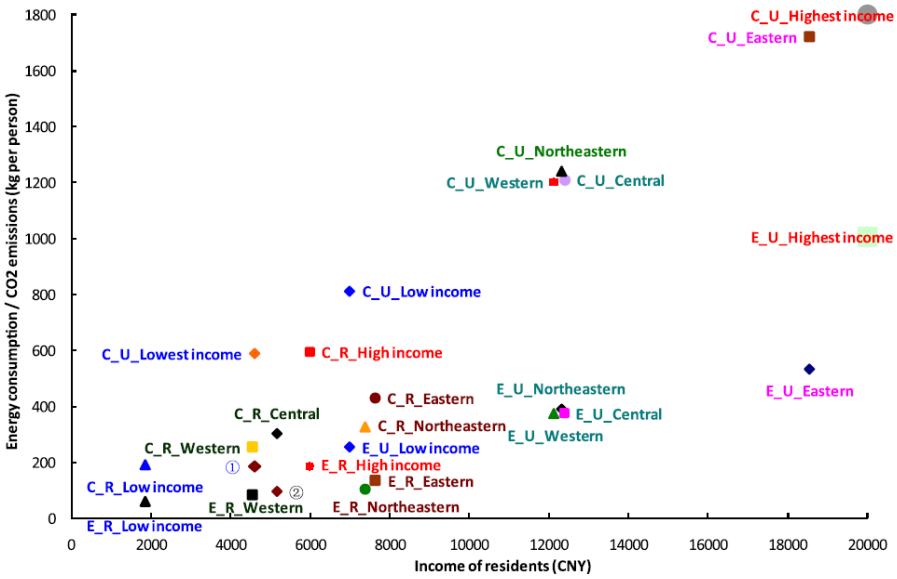

Figure 2.9: Indirect energy consumption and CO2 emissions by region and household income in china in 2007 (Feng and Zou, 2010)

Aydinalp et.al (200) summarized energy consumption by appliance, lighting, and AC per household as follows:

- Energy consumption per household has a direct relation with Income level and as income increase, the energy consumption increased.
- Detached household has higher energy consumption than attached household.
- Owner-occupied household has higher energy consumption than a rented occupied household.
- As the number of household number increased the energy consumption is increased.

CHAPTER THREE: METHODOLOGY

3 Background:

The previous chapter provides a closer look at the energy consumption and CO2 emissions for the residential sector nationally and locally. Also, it identifies the relationships between the occupants' behavior factors and energy use in the residential sectors in addition to the most appliances consumed energy within this sector.

Feng (2010) stated that the energy consumption of households is related to the consumer lifestyle approach (CLA) and according to Bin and Dowlatabadi it was classified into external environment factors like, individual factors, household characteristics, consumer choices, and the consequences which result from consumer behavior.

3.1 Methodology Literature Review:

This section aims to present a literature review of different researches methodologies related to the topic of reducing energy consumptions and CO2 emissions for the residential building and to find out what is the most sufficient way for this reduction which applied in the reviewed literature by using five different research methods which are:

- Simulation and modeling approach
- Filed measurement approach
- Case Studies, literature-review, and Historical Data approach
- Surveys approach
- Mathematical approach

Furthermore, this research will point out which of those methods is more applicable in the United Arab Emirates and why. Also, the advantages and limitations for each will be discussed.

3.1.1 Simulation and modeling approach:

The simulation approach is considered one of the most widely used approaches due to the high level of flexibility in controlling the variables. With the availability of required input data, the simulation will be easier to be used. The simulation models could be used for small areas like buildings or neighborhoods, or cloud is for bigger areas like cities, regions, or nations. The model result depends on the level of the input data and the more detailed the data the more comprehensive investigation of particulars and provides more suitable results. Some researchers rely on the simulation program to calculate energy use and CO_2 emissions.

Swan and Ugursal (2008) stated that the simulation model relies on the input data to calculate or simulate residential energy consumption. On other hand, the level of input data can differ dramatically which results in to use of different modeling techniques to take advantage of the available data. These different modeling techniques have different capabilities, strengths, weaknesses, and applicability.

Swan and Ugursal (2008) relied on their search three major modeling approaches, namely; top-down, bottom-up statistical, and bottom-up engineering. The top-down approach is used for analysis which is based on long-term projections by accounting historic response. The second approach used in their research the bottom-up statistical approaches which are used to determine the energy demand which results from the consumer's behaviors based on energy bills and simple

surveys. Lastly, the third approach bottom-up engineering approach is used to calculate the energy consumption of the user. The below table (3.1) provides the positive and negative attributes for the mentioned three approaches.

Table 3.1: Positive and negative attributes of the three major residential energy modeling approaches (Swan and Ugursal , 2008)

	Top-down	Bottom-up statistical	Bottom-up engineering
Positive attributes	• Long term forecasting in the absence of any discontinuity • Inclusion of macroeconomic and socioeconomic effects • Simple input information • Encompasses trends	• Encompasses occupant behaviour • Determination of typical end-use energy contribution • Inclusion of macroeconomic and socioeconomic effects • Uses billing data and simple survey information	• Model new technologies • "Ground-up" energy estimation • Determination of each end-use energy consumption by type, rating, etc. • Determination of end-use qualities based on simulation
Negative attributes	• Reliance on historical consumption information • No explicit representation of end-uses • Coarse analysis	• Multicollinearity • Reliance on historical consumption information • Large survey sample to exploit variety	• Assumption of occupant behaviour and unspecified end-uses • Detailed input information • Computationally intensive • No economic factors

Yao and Steemers (2004) used the thermal dynamic model to produce space load profiles for different types of households. This method can be used to produce daily load profiles from individual houses to urban communities. This model has been validated by simulation software Esp-r.

Shimoda et.al (2006) used a "virtual city " model to simulate the occupants' behavior and all appliances operation in all households in Osaka city. This model quantitatively estimates the effect of different types of energy conservation, such as appliances efficiency, building insulation, and occupant pattern. In general, the quantitative estimation for large scale was difficult to be measured, for that a standard household family was selected with four members; two adults and two children. Also, energy uses for each household differ because energy use depends on the

household type, occupants' activity, and appliances' efficiency. The used flow chart by researchers for the simulation model is shown in Figure (3.1). This model couldn't be used due to the limited time for this research and the model it's self-need more than one year. On the other hand, the model needs an enormous amount of input data, such as weather data, plans for the households and apartments, occupant behavior schedules.

The limitation of this type of methodology is the lack of required data that are used as input data to the program. Also, the simulation program required a plan of a model house or apartment. And it's a required pattern for the occupants, lighting, and appliance schedule.

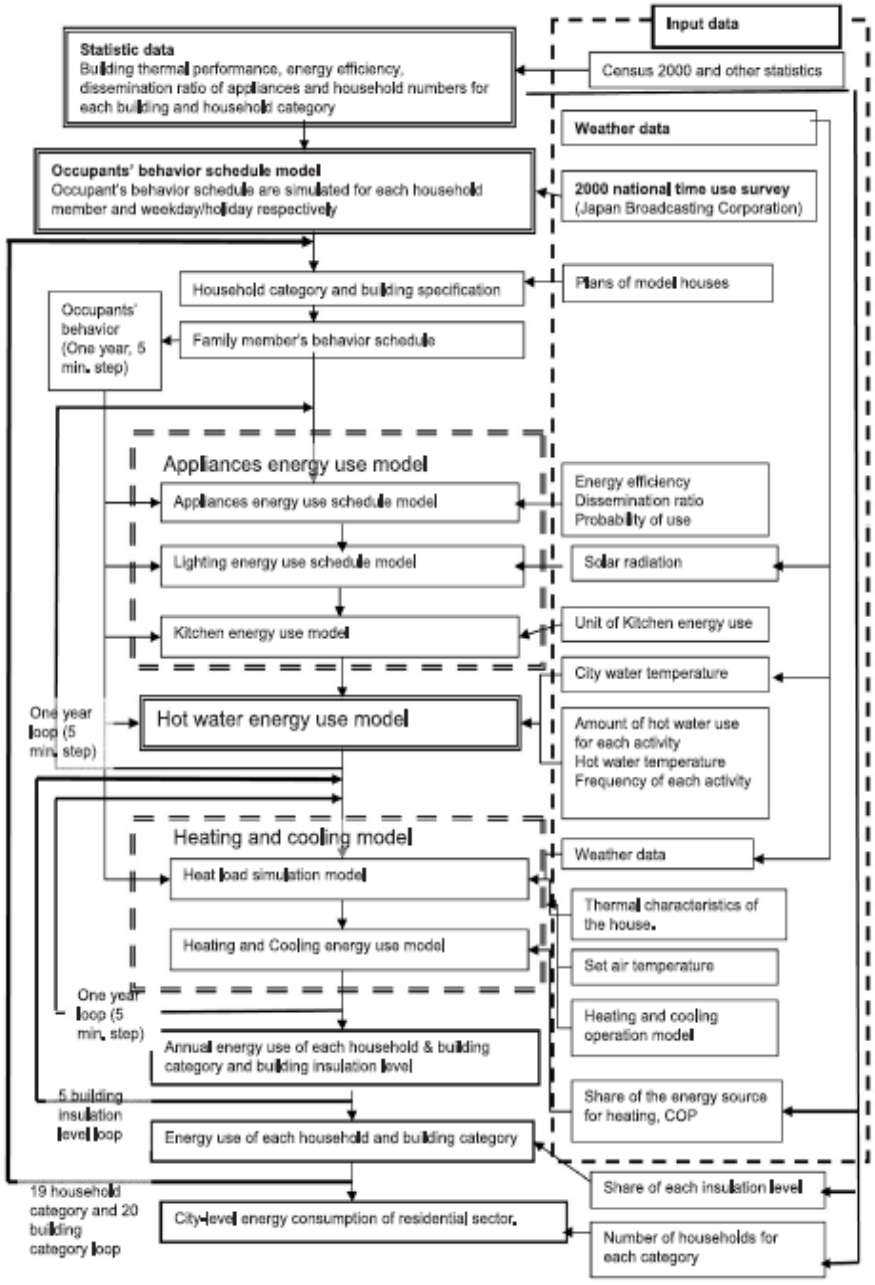

Figure 3.1: Flowchart of the "virtual city " model simulation (Asahi and Taniguchi, 2006)

3.1.2 A Filed Measurement approach:

One of the research methods that are widely known to the public is the field measurement approach. This type of approach is more stable for measurement related to the smaller area than the large scale area and related to microclimate measurements.

The Swedish energy agency (2008) used field measurement to analyze the Consumer behavior, routines, and habits of Swedish households. In this investigation measurements instrument were been used to measure the end-use of electricity & to study the occupants' behavior. This field measurement covered 200 detached houses and 200 apartments.

Another field measurement in Sweden and presented by Swedish Energy Agency (2008) as well. This field measurement coved 390 households. For this field measurement total of 46 pieces of measurement equipment were provided. The equipment's included serial watt meters, watt meters with ammeter pliers, lamp meters, and temperature sensors. The watt meters with ammeter pliers were used at the main switchboard and other equipment was connected to the appliance. These kinds of measurements provide an accurate measure. But it was taken more than five years from the pre-studying, filtering, preparation, and analyzing the measured data.

Chen et.al (2007) applied field measurement research for the residential building in China by equipping all-important home appliances with separated meters to measure the energy consumption for each appliance. Figure (3.2) shows the meter types and the spaces connected to them. The duration of this research was one month from December 1st till December 31st, 2006,

and coved 60 families' .Moreover; the collected data were transmitted by wireless to the data memorizer to analyze them. The temperature and relative humidity for indoor and outdoor were measured and recorded automatically every 30 min.

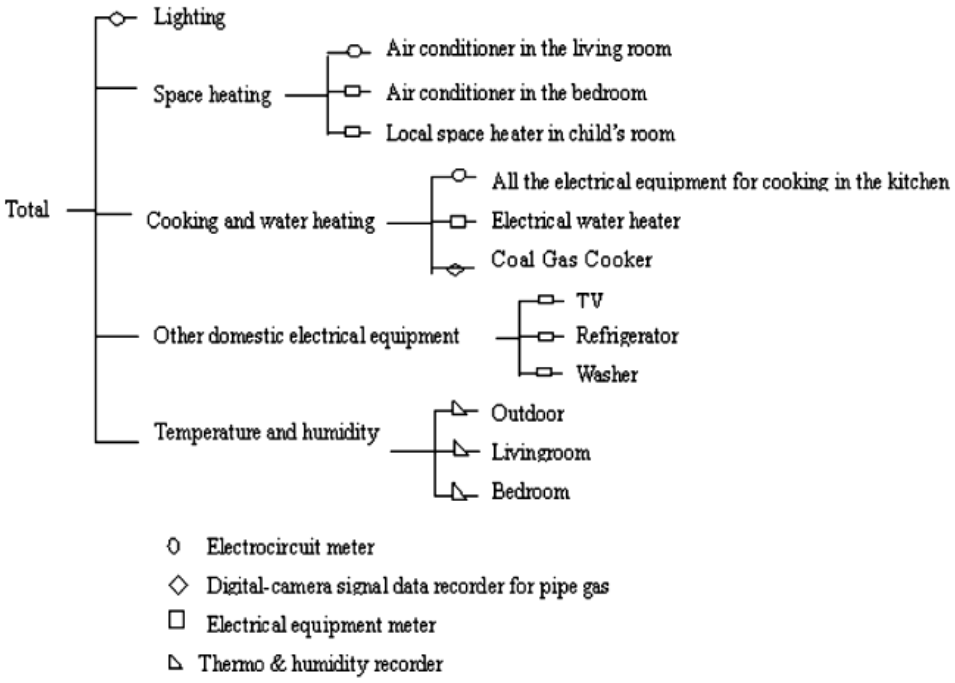

Figure 3.2: Household energy consumption metering system for China (Chen et.al, 2007)

The limitation of this type of methodology is the time factor, as it required a long time to collect, filter and analyze data. In addition to that, it's expensive to provide the required measurement instruments and data loggers for such several households and apartments.

3.1.3 Case Studies, literature-review and Historical Data approach

The advantage of those approaches is that provide a wide knowledge of data for the researchers. Also, the researcher has such an approach to compare the results and findings of the research. On, another hand, historical data consider as a good statistical resource since it's provided accumulated statistical data.

Romero (2001) selected case studies to approach states located in the arid zone in Mexicali, to analyze energy consumption behavior for the residential building. And he claimed that the summer season has higher energy consumption than winter due to the extremely hot climate for the selected area.

Li (2008) used a case studies approach to investigate energy consumption for the residential sector in China and to provide support data for the residential building in China. For his research, he was chosen eight uptowns and for each town, 75 families were chosen. Also, he showed that the statistical reports could be performed successfully.

3.1.4 Surveys approach

The surveying approach is considered one of the best research methods for the social research contexts. This approach is the best way to study the influence of consumers' lifestyle on the energy consumption. Due to the lack of published data, it is one of the best ways to provide a database for appliances' energy load profiles.

Shimoda et.al (2006) used the result of the questionnaire for the residents in Osaka city to cover the necessary parameters to run the simulation model. The required parameters are frequency of bathing, lighting, and ratio of the appliances. In addition to that, his research investigates the link between consumer activity and energy consumption.

Lucas (2001) used a survey approach in his research to investigate behavioral factors of householder occupants' on energy consumption. The surveys simple were distributed to 162 houses and the accuracy of the results was 95% and 6% was for error percentage. The factor that was considered by the researcher was the building location and orientation, number of a family member with their age. Also, he was surveyed income level in addition to the time they stay at home.

Yao and Steemers (2005) used this approach to study the appliance energy load profile for domestic buildings in the UK. As well as, to determine the impact of behavioral factors on the energy demands. The survey has covered the composition and occupancy pattern of households. Also, it’s covered energy use for domestic appliances and domestic water. The difficulty in this research was the accuracy of the information since the simulation need accurate data to have an accurate load profile for the households.

Pachauri (2004) used a micro-level survey to investigate the pattern of total household energy consumption in India. In addition to that, provide information about the occupancy pattern and dwelling size and the influence of each of them on the total energy use by the household.

Kaza (2010) used this approach to analyze the effect of various planning factors on the energy consumption of the household in the US, such as household density, housing type, and size because the effects of those factors are not well understood. In addition to that is to analyze the effect of multi-families and single families on energy consumption.

Aydinalp (2002) used this method to provide input data for the air conditioners by distributing a questionnaire to the householder occupant since not all occupants are aware of the capacity of their A/C units. The questionnaire was for the summer season only.

Aydinalp (2004) was used a database based on the survey to model the domestic hot water and energy consumption of the space. The data were collected by mail and the questionnaire included 376 questions, such as construction year, space heating and cooling equipment, domestic hot water, household appliances, etc. Moreover, actual energy billing was existed for around 2749 households (1993)

The limitation of this approach is the time factor, for that the number of survey households and items depends on the available time. Also, some factors are difficult to be surveyed, such as level income and resident age since some considered this item as a private issue and personal matter.

3.1.5 Mathematical Approach

This approach is purely based on calculation methods and depends on the availability of necessary information to calculate the required data.

Yao and Steemers (2005) used a mathematical approach along with the survey approach to calculate daily energy use for each appliance per household. The below equation (2) was used in this calculation, where " Ea is the daily delivered appliances energy-consumption of household; N the number of the occupants; A the appliance energy-consumption per capita.

$$E_a = N \times \sum A$$

Pachauri (2004) used this method to calculate direct and indirect energy use of households by using the below equation.

$$E_i = f(Y_i, H_i, F_i L_i), \quad (1)$$

where E_i refers to total per capita energy requirements of the ith individual, Y_i refers to total per capita household expenditure, H_i refers to a vector of various household dwelling attributes, F_i refers to a vector of the demographic or family type variables, and L_i refers to a vector of geographic location variables.

This approach can be consider as easiest ways, if required data are availabilities

3.2 Methodology Selection:

In this research, there are several factors have been considered in the selection of the methodology. Therefore and based on the available factors the survey methodologies approach was the more appreciated approach to be selected for this research. This methodology is selected to cover the lack of published detailed data on the amount of energy consumption for the residential buildings in Dubai because generally all published data were related to the energy consumption by this sector and were not providing illustrative data for the household's energy use. Also, the survey will provide statistical analysis for the households' energy profiles. In addition to that, breakdown

of household energy use in Dubai. Furthermore, is to illustrate the effect of household consumers' on energy consumption.

The other limitation is the time frame of this research. Field measurements need to at least cover two seasons; summer and winter. In addition to that, is to cover different locations with different building types and different nationalities. Moreover, the cost of the field measurement instruments is to be considered as those instruments need to be distributed among the selected sites and maintain it along different time and seasons which will be costly.

3.2.1 Selected Emirate (Emirate of Dubai):

The selected Emirate for this survey is the Emirate of Dubai. Dubai is the second largest emirate in the United Arab Emirates (UAE). It's located on the longitude 55.16 east and latitude 25.6 north. Also, it's overlooking the Arabian Gulf with a coast long of 72 km. It's bounded by Emirates of Abu-Dhabi from West and Emirates of Sharjah from East (Figure 3.3). Moreover, it's located in a strategic location as a gateway to Asia and Europe.

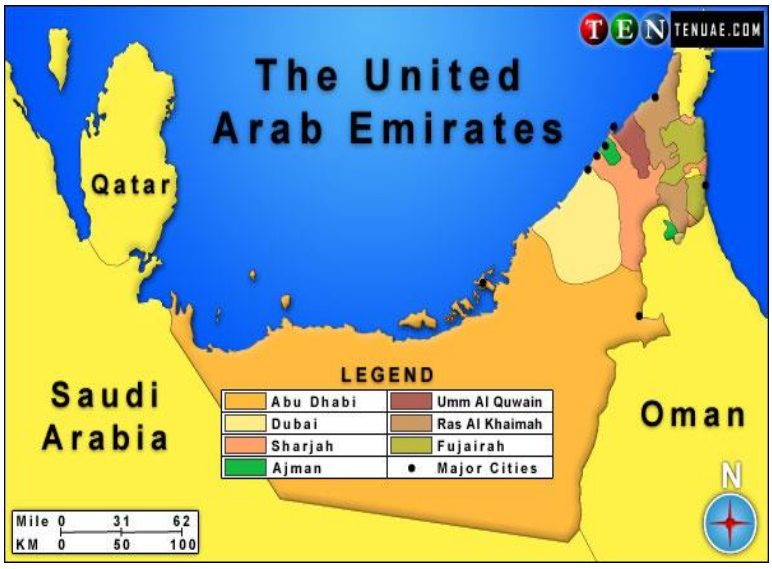

Figure 3.3: Map of the UAE, its neighbouring countries, and boundaries of each Emirate (Ten Guide, 2011)

Dubai has been chosen for the survey for many reasons, it is a good testing field to simulate the various compounds of energy profile because it includes different types of building with different nationalities it also, has high energy consumption due to high inflation in all sides of the community, construction, residential commercial and industrial comparing with the other Emirates. Today, it is considered one of the fastest-growing economies in the Middle East. According to the Dubai Land Department (2010) announcement that up to 45 thousand housing units are expected to enter the local real estate market by the end of 2011. With that vast number of housing units, the demand for both electricity and water will be increased as well. Other, related data are obtained from the Dubai Statistical Center report (2009) that the estimated population of Dubai was 1,770,978 with an increased rate of around 1.3%. This increase in population number will increase energy demand as well. In addition to that, the Dubai Chamber of Commerce and Industry (2008) indicated that for Dubai electricity sector alone needs around one billion dollars of investments annually to meet the growing energy demand over the next six to eight-year of 2008. In 2010 the required power generation capacity was around 9.5 GW.

Also, according to the Ministry of Labour (2006), 202 different nationalities exist in Dubai. By that survey will investigate the influence of different nationalities and consumer behavior on energy consumption.

3.2.2 Selected Residential Building Type:

The Residential Buildings Type is selected as an example for this survey. One of the major reasons was the growth in the number of residential buildings and housing units in the emirates of Dubai. Data on construction and housing units are obtained from Dubai Statistical Yearbook (2009) that

the highest percentage of the completed building and under-construction buildings in 2009 are the villas and residential complexes type with the respective percentages of 78.7% and 76.2%. Additional data from Dubai Statistical Yearbook (2009) are the percentage of private villas and Arabic Houses in 2005 are 26.8% and 14.7%. And the percentage of investment villas and apartment buildings in 2009 is 18.5% and 74.0%. Figure (3.4) shows building types for the emirates of Dubai for the years 2005 and 2009 and the growth in the residential sector in particular.

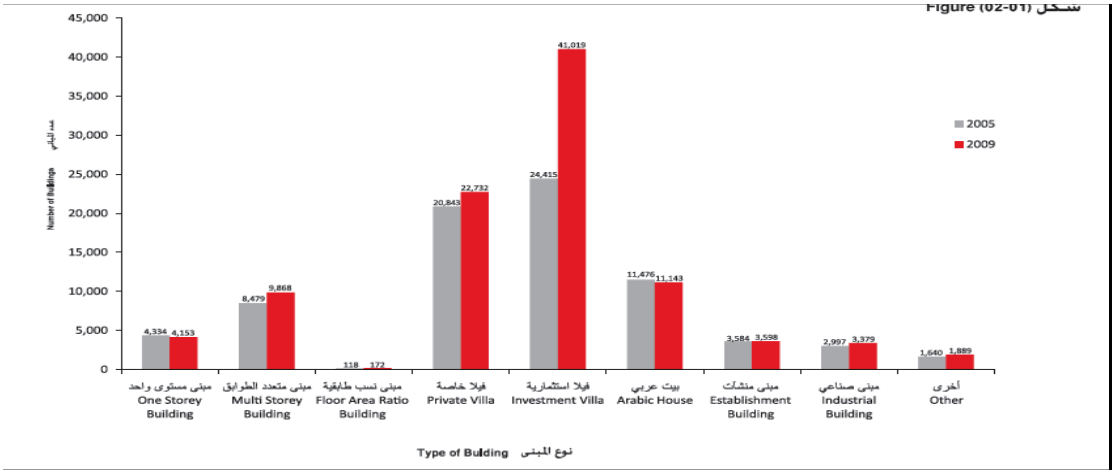

Figure 3.4: Chart of Building by type for emirates of Dubai for year 2005 2009,(Dubai Statistical Yearbook ,2009)

Furthermore, the total number of completed villas and residential complexes for emirates of Dubai in the years 2007 to 2009 was 1,907. While the under-construction buildings were 7,419 (Table 3.2) & (Figure 3.5). This increase in the number of residential buildings will add massive pressure on the electricity demand as well as increase the CO_2 emission.

Table (3.2): Under Construction and Completed Buildings by Type for Emirates of Dubai (2007-2009), (Dubai Statistical Yearbook,2009)

Years	2009	2008	2007	السنوات
Villas and Residential Complexes				**فلل ومجمعات سكنية**
Completed	1,907	2,163	1,673	منجزة
Under Construction	7,419	6,562	5,165	تحت الإنشاء
Multi- storey Commercial Buildings				**مباني استثمارية متعددة الطوابق**
Completed	290	395	349	منجزة
Under Construction	1,401	1,586	1,673	تحت الإنشاء
Industrial, Recreational and Services Buildings				**مباني صناعية وترفيهية وخدمات**
Completed	304	270	347	منجزة
Under Construction	607	521	505	تحت الإنشاء
Total				**المجموع**
Completed	**2,501**	**2,828**	**2,369**	**منجزة**
Under Construction	**9,427**	**8,669**	**7,343**	**تحت الإنشاء**
Number of Flats				**عدد الشقق**
Completed	19,684	17,074	11,291	منجزة
Under Construction	84,106	63,431	24,285	تحت الإنشاء
Number of shops				**عدد المحلات**
Completed	1,821	1,082	1,368	منجزة
Under Construction	6,817	3,533	1,515	تحت الإنشاء

* Dubai Municipality, Supervised Buildings
Source: Dubai Municipality

* المباني التي تحت إشراف بلدية دبي
المصدر: بلدية دبي

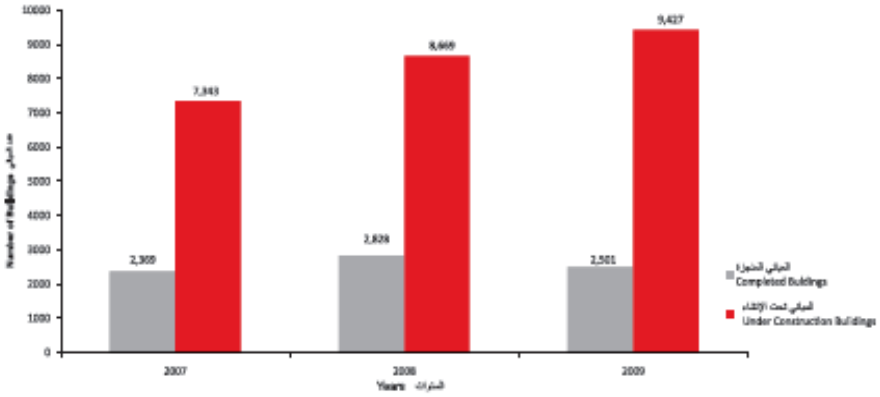

Figure 3.5: Chat of Under Construction and Completed Buildings by Type for Emirates of Dubai (2007-209), (Dubai Statistical Yearbook, 2009)

CHAPTER FOUR: QUESTIONNAIRE SETUP

4 Background:

As mentioned in the previous chapter, the surveying approach was the selected methodology for this research. Currently, the major appliances that consumed energy and the effect of householders' behavior on energy consumption are not well understood. This chapter describes the structure of the survey and the major appliance which were covered.

4.1 Survey Approach:

Currently, the published statistical reports were only for the proportion of energy consumed by the residential sector but no statistical data for the major appliance that consumed energy. On other hand, no official published reports for the relationship between the consumers' behavior and energy consumption. For that, the purpose of this survey is to create a database for the energy consumed by residential buildings. Further details for the questionnaire setup were covered as follows.

4.2 Questionnaire Setup

The questionnaire setup shall be structured in a way that to be used as data for the household profile in Dubai in particular and in UAE in general. Moreover, is to find the relation between consumers' behavior and energy use. For this, different kinds of literature based on the survey methodology were reviewed. According to Joseph's (1995) research "AN ANALYSIS OF RESIDENTIAL SECTOR ENERGY USE IN HONG KONG ", he covered the major appliances items which were; air-conditioners, lighting, refrigerators, washing machines, driers, Television,

and video set. As per Joseph (1995) the major appliance items to be covered in the survey were; air-conditioners, lighting, refrigerators, washing machines and driers, Television, and video set. While Lucas et.al (2001) surveyed used this to determine the relationship between consumers' behavior and energy consumption. For that, his survey almost related to the household occupants, such as the number of family members, ages of family members, and the time they spend at home during summer and winter seasons, type of work, income level. From another hand, Smith (2009) covered both items in his research. He was surveyed, many items, such as kitchen appliances, type of lighting, water heater, and TVs. Also, he surveyed the residents' behaviors, such as the type of lighting they use? Shower frequency, type of desktop screen, and what they were examined when they bought any appliance? Yoshino et.al (2006) questionnaire surveyed the building characteristics, such as the construction year of the building, the number of stories, and apartment's areas, and surveyed heating and cooling system in addition to the lifestyle. The previous addressed literature covered four different approaches. The first approach by Joseph (1995) was to find most appliances that consumed energy only. The second approach by Lucas et.al (2001), was surveyed the consumers' behaviors only. While for the third approach by Smith (2009) was surveyed both household energy use and consumers' behaviors. And the last approach by Yoshino et.al (2006) was surveyed building characteristics, heating, and cooling system, and lifestyle.

These research surveys are based on the third and fourth approaches, and the questionnaire was divided into eight sections to cover the required information as much as possible, to provide more accurate data for the residential building. Those sections were divided as follows:

1. Project Information, such as Building Type, Age of construction and Number of floors, rooms, and occupancy
2. Water heaters usage
3. White goods, such as clothes washers /Dryers, Clothes iron, Dishwashers, and Freezer
4. Kitchen & cooking appliances, such as Electric Cooker (plates/Ovens), Microwaves, Bread makers / Toasters /Espresso Machines / Juicer /rice cooker, etc.
5. Home entertainments, such as TV (LCD/Plasma/tube) and Sat/DVD/Video/Stereo
6. Computers and peripherals, such as Computers (CRT/ LCD), Laptop and Printer / Scanner /Fax /Others
7. Air condition (AC), such as AC Type
8. Lighting

In addition to the mentioned questionnaire sections, it covered questions related to the occupants' behaviors, such as bathing method and timing, if they were examined energy saving and power rating when they bought any electrical appliance or lamp if they were turned off desktop and laptop of they were kept them on standby mood? And if they are switched the lights and AC off when they are leave rooms. Below further questionnaire details.

4.3 Questionnaire Template:

The below table (4.1) is the format of the questionnaire which was distributed across the selected areas.

Kindly full the below survey to save our environment				
Building Location/Zone:		**Nationality:**		**Building Area:**
Building Type:				
Individual villa [ ]	Townhouse Villa [ ]	Arabic house [ ]	Apartment building [ ]	Comments:
Age Of Construction				
Before 1980 [ ]	Between 1980-1990 [ ]	Between 1990-2000 [ ]	Between 2000 to 2010 [ ]	No idea [ ]
No. Of Floors				
1 floor [ ]	2 floors [ ]	Low rise building (3-6 floor) [ ]	High rise building (more than 6) [ ]	Comments:
No. Of Rooms				
Total No. [ ]	No. of Bedrooms [ ]	Others [ ]	Comments:	
No. Of **Occupancy:**				
Total No. [ ]	During Morning : 6 am -12 pm[ ]	During Afternoon: 12pm -5pm [ ]	During Evening: 5pm -12am [ ]	During Midnight [ ]
Water Heaters Usage				
Hours per day	Morning : 6 am -12 pm	Afternoon: 12pm -5pm	Evening: 5pm -12am	Comments:
-Usage during Summer				
-Usage during Winter				
When bathing, do you usually:				
Shower? [ ]		Run a bath? [ ]	Comments:	
How many times a day do you shower or bath?				
Once [ ]	Twice [ ]	More than twice [ ]	Comments:	
How long do you usually shower for?				
5 minutes [ ]	10 minutes [ ]	15 minutes [ ]	30 minutes [ ]	More than 30 minutes [ ]
What time of the day do you usually shower or bath ?				
Morning : 6 am -2 pm [ ]	Afternoon: 2pm -12pm [ ]	Evening: 12pm -5 pm	Midnight [ ]	
White Goods				
Appliances Name	No.	Size (Big/Small)	used per week	Used primarily during Morning/Afternoon/Evening
Clothes washers				

Clothes dryers				
Clothes washers with dryers				
Cloths iron				
Dishwashers				
Refrigerators				
Freezers				
Others				
Kitchen & Cooking Appliances				
Appliances Name	No.	Size (Big/Small)	hours used per day	Used primarily during Morning/Afternoon/Evening
Cooking Appliances (electric plate)				
Ovens				
Microwaves				
Bread makers / Toasters /Espresso Machines /Juicer /rice cooker /others				
When you buy an electrical appliance, do you examine?				
Power rating [ ]	Voltage rating [ ]	None [ ]	Comments:	
Home Entertainment				
Appliances Name	No.	Size (Big/Small)	hours used per day	Used primarily during Morning/Afternoon/Evening
TV (LCD/Plasma) *				
TV (Tube) *				
Sat/DVD/Video/Stereo				
Others				
Computers and Peripherals				
	No.	hours per day		
Computer (CRT) *				
Computer (LCD) *				
Laptop				
printer / scanner /Fax /others				
When you are finished working on your computer/ laptop do you:				
Switch it off [ ]	Leave it on [ ]	Keep it on standby mode [ ]	Comments:	
Air Conditioners (AC)				
AC Type	Window Wall Air Conditioners	Split System Air Conditioners	Ducted Air Conditioners	Chiller	District cooling/ DC

No. of Units					
Power rating					
You turn A/C off when you go out for	More than 2hr	More than 4hr	More than 8hr (i.e. work)	Comments:	
- Usage during Summer					
- Usage during Winter					

Lighting (Power rating KW) *

No. of Types per Location	Living/dining room	TV/Family room	Bedrooms	kitchen	office/ study	Hallway & corridors	Toilets
Incandescent light bulb:							
• Low (10 to 40 watts)							
• Medium (41 to 149 watts)							
• High (150 watts or more)							
Fluorescent:							
• Short tube (less than 24 inches)							
• Long tube (24 inches or more)							
• Compact /CFLs							
Halogen /Spot light							

When you buy a lamp, do you examine?

type of bulb [ ]	energy saving [ ]	power rating of the bulb[ ]	lamp brightness [ ]	None [ ]

Do you switch the lights off when you leave your room?

Yes [ ]	No [ ]	Sometimes [ ]	Comments:

Swimming pool		Comments
Location		
Heated or cooled		
way of cooling/heating		

Appendix

Computers Types

TV Types

			
Computer (CRT)	Computer (LCD)	TV (Tube)	TV (LCD/Plasma)

Lighting Types

Incandescent

Fluorescent

Compact Fluorescents

Halogen /Spot light

Abbreviations : CFLs: Compact fluorescent lamp

4.4 Selected surveys locations

This questionnaire was based on a survey of 95 households for different types of residences; villas, detached houses, Arabic houses, and apartments for different locations. Those locations were selected to cover the Emirate of Dubai as much as possible (Figure 1.4). With taking into account the variety the selection of those places, with different nationalities and different building types. Moreover, some of the selected places were old and may back to pre-1980. The following table 4.2. Further details for each zone will be highlighted as well.

Figure 4.1: Overall Dubai map with the selected survey location (Google earth)

Table 4.2: The eight selected locations for the survey

No.	Zone Name	Nationality	Building Type	Age
1	Nad Al Hammar	local	Villas	New
2	Al Quoz	local	Arabichouse /Villas	Old
3	Arabian Branches	Arabian	Villas	Old
4	Al Nahda	Arabian	Apartments	New
5	Dubai Marina	Foreign	Apartments	New
6	International city	Multi Nationalities	Apartments	New
7	Mirdif	Multi Nationalities	Villas	New
8	Al Satwa	Asian	Arabic house	New

4.4.1 Zone 1: Nad Al-Hammer

Nad Al-Hammer area is considered a local area in Dubai. Its residential area is located in the east of Dubai Creek. All residence type in this area is villas which consist of ground floor or G+ 1 floor. In Nad Al-Hammer the questionnaires were conducted to interview 15 households (Figure 4.2).

Figure 4.2: Nad Al-Hammer Area, Dubai (Google earth)

4.4.2 Zone 2: Al Quoz

Al Quoz area is located in the western area of Dubai (Figure 4.3). Al Quoz area comprises residential and industrial areas. Residence types in this area are villas, Arabic houses, and apartments. In Al Quoz the questionnaires were conducted to interview 10 households.

Figure 4.3: Al Quoz Area, Dubai (Google earth)

4.4.3 Zone 3: Arabian Branch

Arabian Branch area is located within Dubai land area which is considered a new development area in Dubai. It's located near to Dubai motor city and along Emirates Road. It is a combination of attached and de-attached villas. The questionnaires were conducted to interview 10 households (Figure 4.4).

Figure 4.4: Arabian Branch Area, Dubai (Google earth)

4.4.4 Zone 4: Al Nahda

Al Nahda area is located in the eastern area in Dubai, which forms the eastern border of Dubai with Sharjah, (Figure 4.5). Al Nahda area comprises residential, commercial, and industrial areas. Residence types in this area are apartments. In Al Nahda the questionnaires were conducted to interview 10 households.

Figure 4.5: Al Nahda Area, Dubai (Google earth)

4.4.5 Zone 5: Dubai Marina

Dubai Marina is located in the heart of the "new Dubai" area. It's a canceled city stretched along two miles of the Arabic Gulf shoreline. Dubai Marina area comprises residential and commercial areas. The residence type in these areas is apartments. In Dubai Marina, the questionnaires were conducted to interview 10 households (Figure 4.6).

Figure 4.6: Dubai Marina Area, Dubai (Google earth)

4.4.6 Zone 6: Dubai International city

Dubai International city is an area comprised of residential and commercial buildings. It's spreading over an area of 8 million square meters. Residence types in this area are apartments. In the International city, the questionnaires were conducted to interview 15 households (Figure 4.7).

Figure 4.7: Dubai International City Area, Dubai (Google earth)

4.4.7 Zone 7: Mirdif

Mirdif area is located in the southwest of Bur Dubai. It is mainly considered a villa development. And recently apartment building community was added to this area called Quroob Community. Mirdif is known as multi nationalities area. The questionnaires were conducted to interview 15 households (Figure 4.8).

Figure 4.8: Mirif location, Dubai (Google earth)

4.4.8 Zone 8: Al Satwa

Al Satwa is located in the southwest of Bur Dubai and adjacent to Sheik Zayed Road. It's comprised of commercial and residential areas. It's known as an area for the Asian community. Residence types in Al Satwa are villas, attached villas, Arabic houses, and apartments. In Al Satwa the questionnaires were conducted to interview 10 households (Figure 4.9).

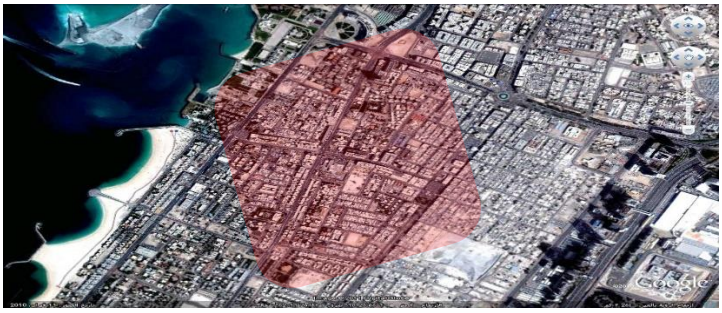

Figure 4.9: Al-Satwa location, Dubai (Google earth)

CHAPTER FIVE: RESULT AND DISCUSSION

5 Background:

This chapter will provide illustrative analysis for the households' energy use for the selected regions separately. Moreover, comparisons analysis will be provided between different regions and nationalities to investigate the actual habits and behavior of the occupants on energy consumption and CO_2 emissions by distributing questionnaires samples randomly to the selected locations. The sites analysis is structured the same as the distributed questionnaire.

It was difficult to predict the accuracy of the results because it only depends and the questionnaire results and no field measurements were taken. In addition to that, some of them were claimed that the questionnaire shall be from a governmental entity. Furthermore, consumers' behaviors are not a quantitative measurement.

5.1 Nad Al Hammar Analysis results:

Results of the questionnaire for Nad Al Hammar will be analysis the most important aspects as detailed follows:

5.1.1 Basic Buildings information

The first part of the questionnaire was provided basic information about their building, such as building type, age of construction, number of floors and rooms in addition to occupancy pattern. Regards to the construction year of those villas, 80% of the investigated building were constructed after the 2000s and 20% before the 2000s. It's horizontal development with individual private villas. Heights range between G+1 and G+2. As surveyed, the number of rooms was 57 % for

bedrooms, 24% for living rooms, and 19% for other rooms which could include the study room, office room, maid room, or stores (Figure 5.1a). Furthermore, the survey result categorized bedrooms as 30% for 4 bedrooms, 30% for 5 bedrooms, 20% for 6 bedrooms, 10% for 7 bedrooms, and 10% for 8 bedrooms (Figure 5.1b).

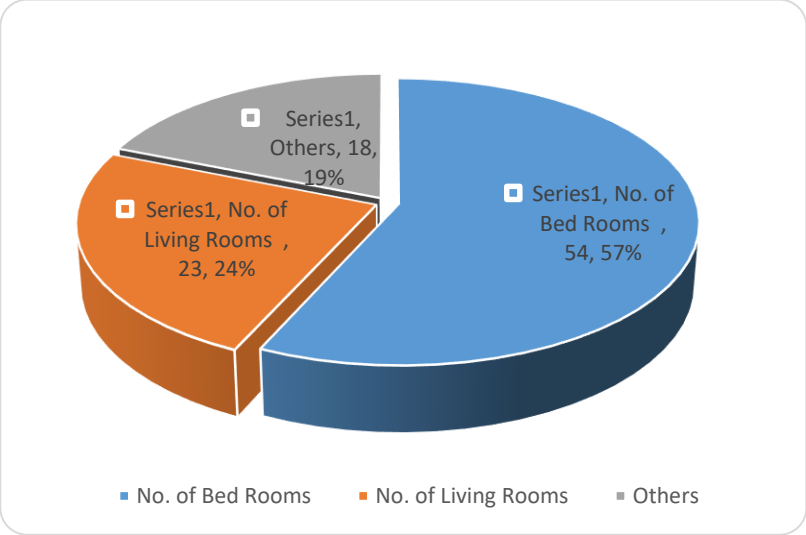

Figure 5.1a: Percentage of Rooms for all investigated households (Nad Al Hammar, Dubai)

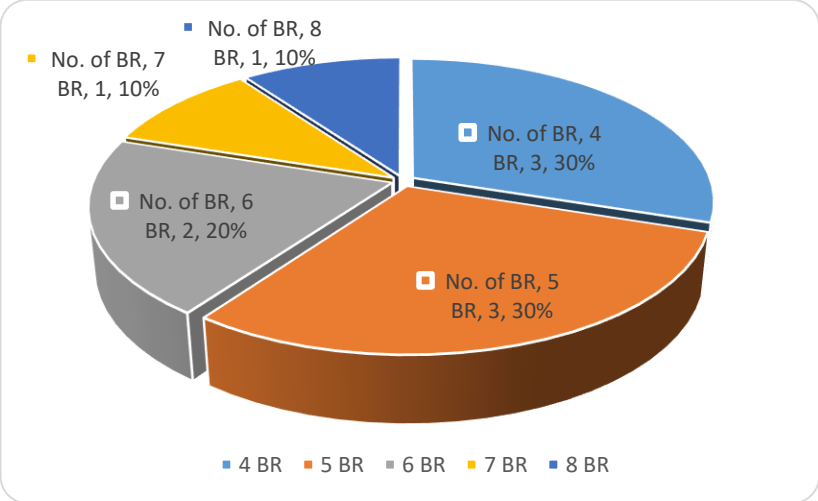

Figure 5.1b: Percentage of Bedrooms Number for all investigated households (Nad Al Hammar, Dubai)

It's very important to identify occupancy patterns to analyze load profiles. This survey provides data for the number of occupancy per household with the number of occupants that present in the house during the day. As investigated the number of residents per household for this area was an average of 7.2. Below table 5.1 shows the composition of households with the percentage of people per household. The dominant percentage for the residents per household was for families with eight members or more and followed by households with six members.

Table 5.1 Composition of households (Nad Al-Hammar, Dubai)

Number of persons in the household	3	4	5	6	7	8 or More
Percentage of households with the specified number of people	10%	10%	10%	20%	10%	40%

Figure 5.2 illustrates the occupancy patterns during the day. It clearly shows that most of the household residents would be away from home between 6:00 am to 2:00 pm and only about 10% of the household members would stay at home during that time which would be adult-like mothers and maids or would be children's, while other members would be at work or school and colleges. About 27% of household members would return to home from 2:00 pm to 6.00 pm. nearly, after 9.00 pm all the household members would return to home.

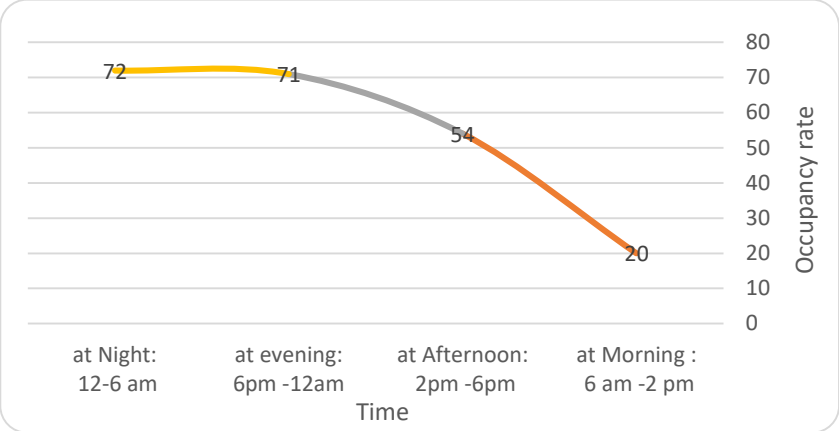

Figure 5.2: Number of occupants that present in the house during the day , y-axis: Occupancy rate, x-axis: time (Nad Al-Hammar, Dubai)

5.1.2 Water Heaters usage

This part of the research illustrates the water heater usage per household. Figure 5.3a shows that more consumption of the water heater was during the winter which was up to 83%, while water heater usage did not exceed 17 % in the summer. It's found from figure 5.3b the different timing usage for water heater during winter and summer. The demand for water heaters reached a maximum during the winter season in the evening time followed by the morning and afternoon. But during the summer season, it was almost used during evening and morning, while it's not used during afternoon time.

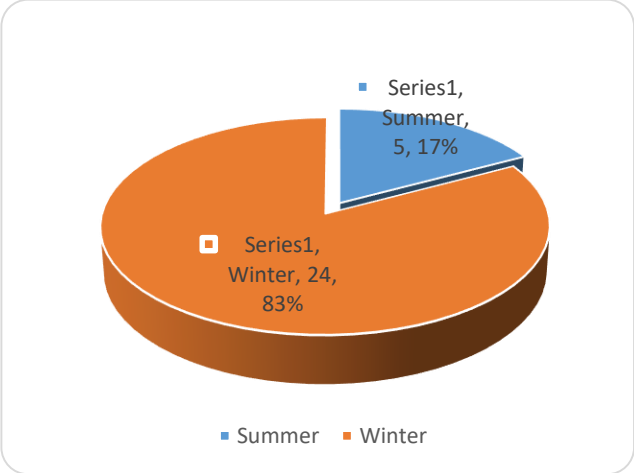

Figure 5.3a: Water heater profile for summer and winter seasons (Nad Al-Hammar, Dubai)

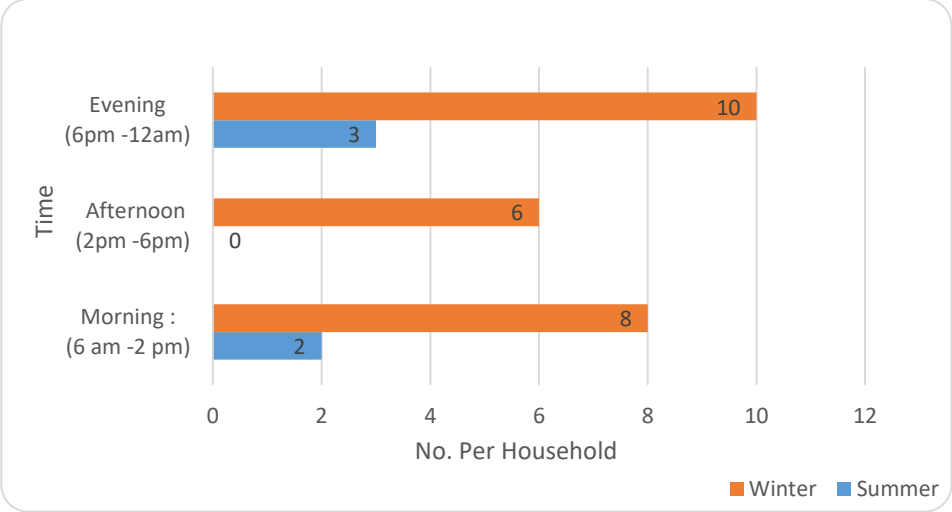

Figure 5.3b: Demand for water heater during the day for summer and winter seasons (Nad Al-Hammar, Dubai)

The approximate energy load required for a water heater is around 1000-2000 watts per hr. The water heater demand for the winter season was range "between" 18 to 24 hr, while during summer season demand was almost during the evening and follows by morning with maximum approximate usage of 6 hr.

From the survey, 83 % were stated that they were used a shower compared to 17 % using the run bath. The majority were claimed that they are showering twice a day and were about 50%, compared to 40% are showering once a day and 10% are showering more than twice a day. The below figure 5.4 shows the shower/ bath demand during the day and reached peak times during morning and evening (figure 5.4).

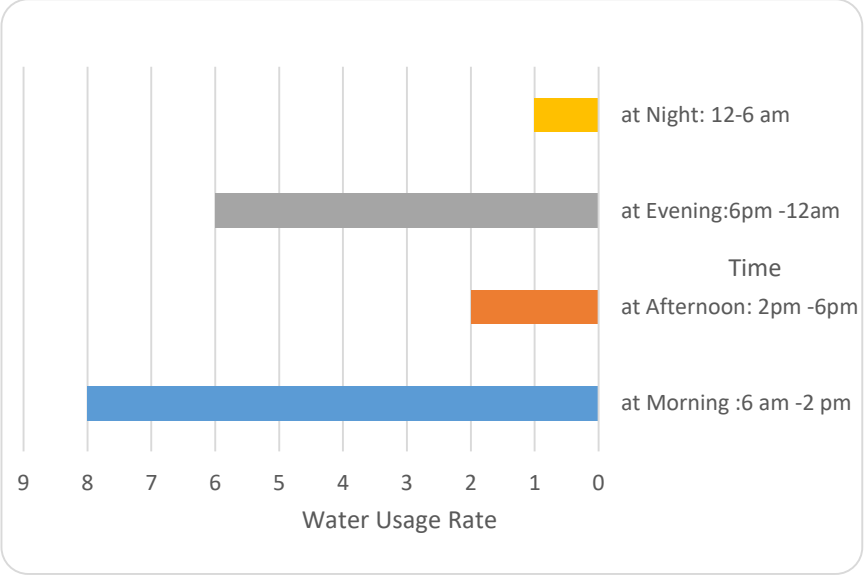

Figure 5.4: Water demand during Day (Nad Al-Hammar, Dubai)

The majority, with 37% were claimed that they need 10 minutes for showing, while 27 % need 15 minutes, 18% need only five minutes, 10% need 30 minutes and 10% need more than 30 minutes. Accuracy was difficult to be predicted since it is not a quantitative measurement and is affected by residents' behavior. Many were claimed that shower length depends on different times and would be longer when washing their hair (figure 5.5).

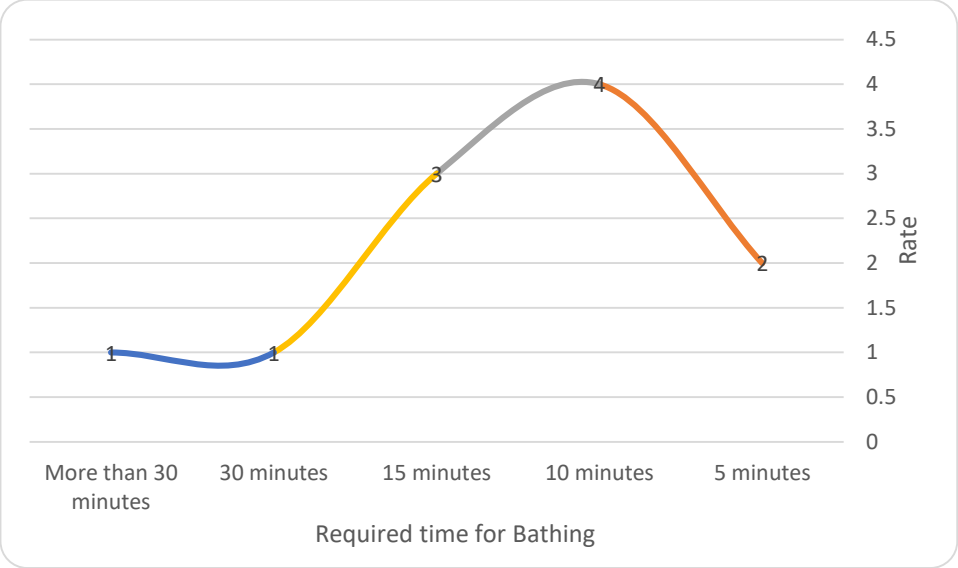

Figure 5.5: Residents' bathing length (Nad Al-Hammar, Dubai)

5.1.3 White Goods

The surveyed white goods include clothes washers /dryers, cloths iron, dishwashers, refrigerators, and freezers. All households were provided with the mentioned white goods except dishwashers and freezers of which only 10% of households provided with dishwashers and 70% with freezers. Below the figure, 5.6a shows the using frequency for different white goods items as all items use daily. Except for cloth washers, that 10% claimed that they used cloth washers 4 to 5 times per week. On other hand, the peak time for those items vary. Figure 5.6b shows using time for different white goods. Refrigerators and freezers were working 24 hr, while other items using time are varying.

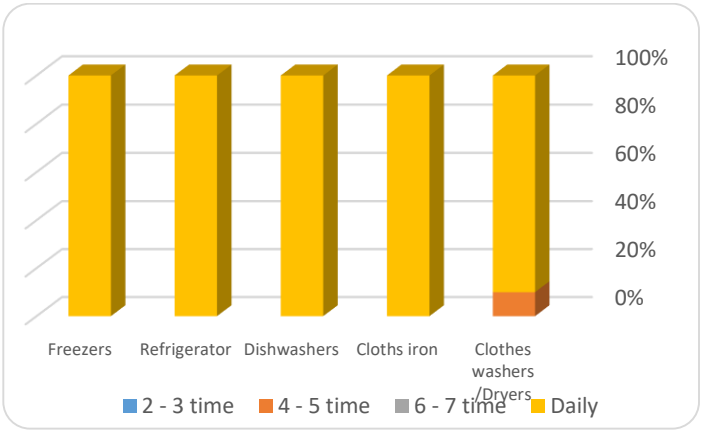

Figure 5.6a: Frequency for different white goods items, where; y-axis: frequency usage percentage, x-axis: white good items (Nad Al-Hammar, Dubai)

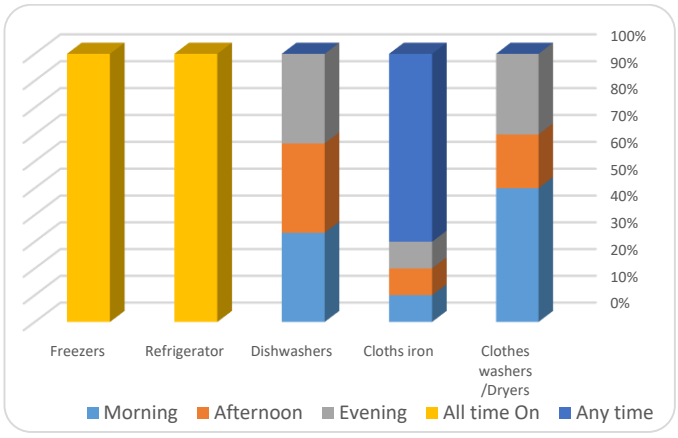

Figure 5.6b: Pattern of white goods using time where; y-axis: usage time percentage, x-axis: white good items (Nad Al-Hammar, Dubai)

The consumed energy for each item has a linear relation with the quantity and the approximate used time. Below table 5.2 provides illustrative data for the amount of consumed energy per day and per month for different white goods items. The refrigerators were the largest white goods items that consume energy, consuming 6732KW monthly, while clothes washers were the least energy-consuming by calculating energy consumption as one quantity (21KW).

Table 5.2: Total Units Consumed per white good items (Nad Al-Hammar, Dubai)

White Goods Name	Appx Average Load (W)	Quantity	Total Appx used time (hr)	Total Units Consumed / per Day	Total Units Consumed / per month
Clothes washers /Dryers	700	13	1	9.100	273.000
Electric iron	800	14	3	33.600	1008.000
Dishwashers	1300	01	1	1.300	39.000
Refrigerator	550	17	24	224.400	6732.000
Freezers	550	7	24	92.400	2772.000
Total				195.200	5856.000

Consumption is based on 1 Unit = 1000 Watts per hour

5.1.4 Kitchen & Cooking Appliances

The surveyed kitchen & cooking appliances include electric cooker, microwaves, bread makers/toasters/espresso machines/juicer/rice cooker /others. The consumed energy for each item depends on quantity and the approximate used time. Table 5.3 Provide illustrative data for the amount of consumed energy per day and month. The total energy consumed for items, such as bread makers/ toasters /espresso machines/juicer/rice cooker was 1462KW per month, while by refereeing to table 5.3. And by assuming that each item was used for 15 minutes daily, the microwaves consumed energy more than other items (7.500 KW On Month). On the other hand, the consumed energy of those items has a linear relation with the used items and time (Table 5.4).

Table 5.3: Total Units Consumed per Kitchen & Cooking Appliances (Nad Al-Hammar, Dubai)

Kitchen & Cooking Appliances	Appx Average Load (W)	Quantity	Total Appx used time (hr)	Total Units Consumed / per Day	Total Units Consumed / per month
electric cooker	1000	03	12	36.000	1080.000
microwaves	1000	10	4.5	40.833	1225.000
Bread makers / Toasters /Espresso Machines / Juicer /rice cooker /others	650*	15	5	48.750	1462.500
Consumption is based on 1 Unit = 1000 Watts per hour					
*Bread makers / Toasters /Espresso Machines / Juicer /rice cooker has different loads & 650 is calculated as an average load for mentioned appliances					

Table 5.4: Total Units Consumed per Kitchen & Cooking Appliances for 15 minutes long (energy calculator,FEWA)

Kitchen						
Hand Blender	75-500	287.5	1	0	15	2.156
Roti Maker	875	875	1	0	15	6.562
Toaster	750	650	1	0	15	4.875
Mixer-cum-grinder	600	600	1	0	15	4.500
Microwave Oven	800-1200	1000	1	0	15	7.500
Water Purifier	15-60	37.5	1	0	15	0.281

The questionnaire also was contained a question of whether the users were examined power and voltage ratings when they buy an electrical appliance. 50% claimed that they checked power rating and 50% bought appliance without checking power and voltage rating (Figure 5.7)

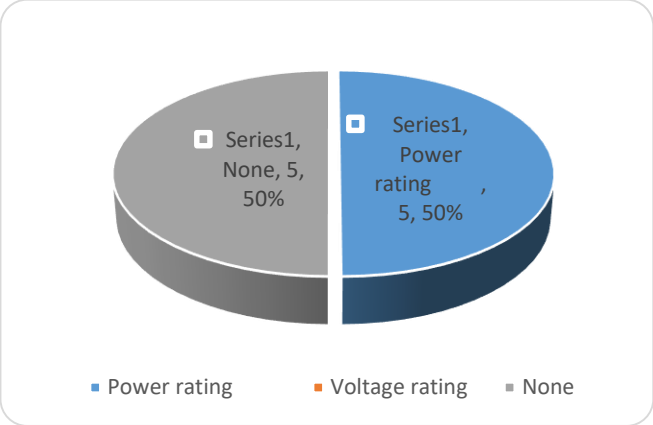

Figure 5.7: Percentage of what was examined when buying electrical appliance (Nad Al-Hammar, Dubai)

5.1.5 Home Entertainment

The surveyed home entertainment items include TV, Sat, DVD, Video, and Stereo. The consumed energy for each item depends on quantity and the approximate used time. 47% of households stated they have LCD/Plasma TV compared to 16% for tube TV and 36% for items such as Sat, DVD, Video, and Stereo. Table 5.5 Provide illustrative data for the amount of consumed energy per day and month. TV consumed more energy than others entertainment items because it was used by all household members and used between 4 to 8 hr daily (Figure 5.8a). The peak time for the used entertainment items is during the evening time (Figure 5.8b).

Table 5.5: Total Units Consumed per home entertainment for each 1hr per day and month (Nad Al-Hammar, Dubai)

home entertainment	Appx Average Load (W)	Quantity	Total Units Consumed / per Day	Total Units Consumed / per month
TV (LCD/Plasma)	300	15	4.500	135.000
TV (Tube)	200	05	1.000	30.000
Sat/DVD/Video/Stereo	118*	12	1.416	42.480
Consumption is based on 1 Unit = 1000 Watts per hour				
* Sat/DVD/Video/Stereo have different load & 118 is calculated as an average load for mentioned appliances				

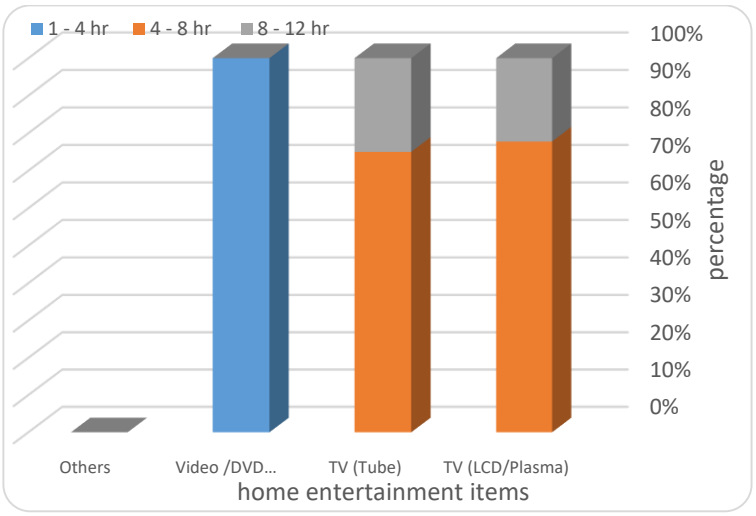

Figure 5.8a: Chart shows the frequency of using home entertainment items per day (Nad Al-Hammar, Dubai)

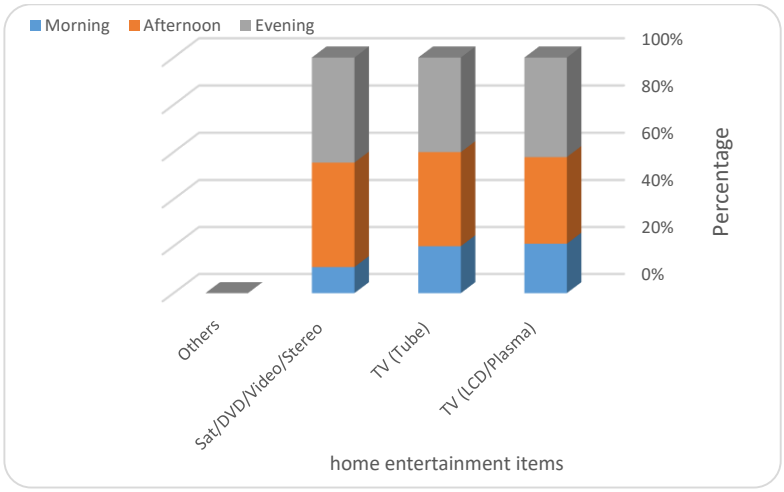

Figure5.8b: Chart shows home entertainment items pattern per day (Nad Al-Hammar, Dubai)

5.1.6 Computers and Peripherals

The surveyed computers and peripherals include Computers, laptops, Printers, Scanner, and Fax. The consumed energy for each item depends on quantity and the approximate used time. Table

5.6 provides illustrative data for the amount of consumed energy per day per month. Laptops consumed more energy than others entertainment items because almost all houses have one laptop or more (47%). But on the other hand, fax consumed more energy in case if it is used as 24 hr (2.880 KW). Computers and Laptops are used by all household members for 4 to 8 hr daily (Figure 5.9).

Table 5.6: Total Units Consumed per Computers and Peripherals for each 1hr per day and month

Computers and Peripherals	Appx Average Load (W)	Quanti ty	Total Units Consumed / per Day	Total Units Consumed / per month
Desk Top	200	06	1.200	36.000
Laptop	150	17	2.250	76.500
Printer / Scanner /Fax /Others	135*	13	1.755	52.650
Consumption is based on 1 Unit = 1000 Watts per hour				

* Printer / Scanner /Fax /have different load & 135 is calculated as an average load for mentioned appliances

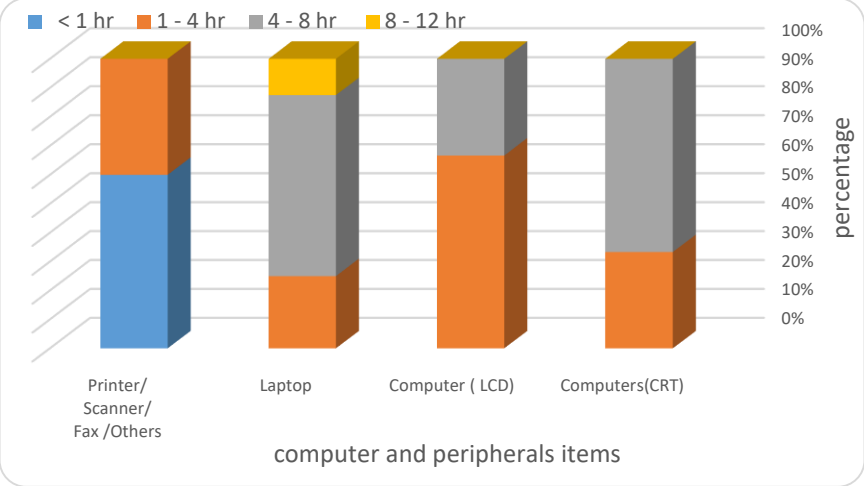

Figure 5.9: Chart shows the frequency house of using the computer and peripherals items per day (Nad Al-Hammar, Dubai)

By asking household members if they were switched the computer and laptop off, leave it on, or kept it on standby mode. 64% of them claimed that they were switched it off compared to 36% they have kept it on standby mood (Figure 5.10).

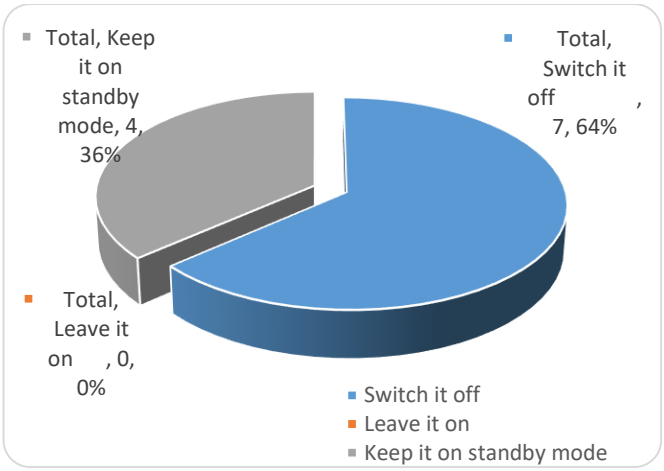

Figure 5.10: Pie Chart shows Computer & laptop mood with percentage (Nad Al-Hammar, Dubai)

5.1.7 Air Conditioning (AC)

According to the surveyed results that not all household occupants were aware of the AC power and some of them answered about the type of used A/C, but without mentioning the number of units per area. For that, the below table 5.7 provides overall data for the AC required load according to different assumed times. The bigger houses hold need more AC units than smaller which means the required load and energy use are almost related to the house area and the number of rooms per house.

Table 5.7: Approximately required load for AC during one month for one A/C unit only (Nad Al-Hammar, Dubai)

Hour	24 hr	18 hr	12 hr	6 hr
Required Load (watts)	1224.000	917.999	612.000	306.000

** The used Appx Average Load (W) 1700 for window/spilled A/C
** Consumption is based on 1 Unit = 1000 Watts per hour

By calculating the total numbers of bedrooms, living rooms, and kitchens for Nad Al-Hammar. The total approximated required load of A/C as below table (5.8)

Table 5.8: Approximate required load for A/C during one month for Nad Al-Hammar.

Hour	24 hr	18 hr	12 hr	6 hr
Required Load	106487.999	79866.000	53243.999	26621.999

** The used Appx Average Load (W) 1700 for window/spilled A/C
** Consumption is based on 1 Unit = 1000 Watts per hour

Energy consumption by A/C is considered as one of the items that are related to the occupants' behavior. For that, the questionnaire included questions about whether they turn A/C off when they leave the house or the room. The figure illustrates the questionnaire result (Figure 5.11).

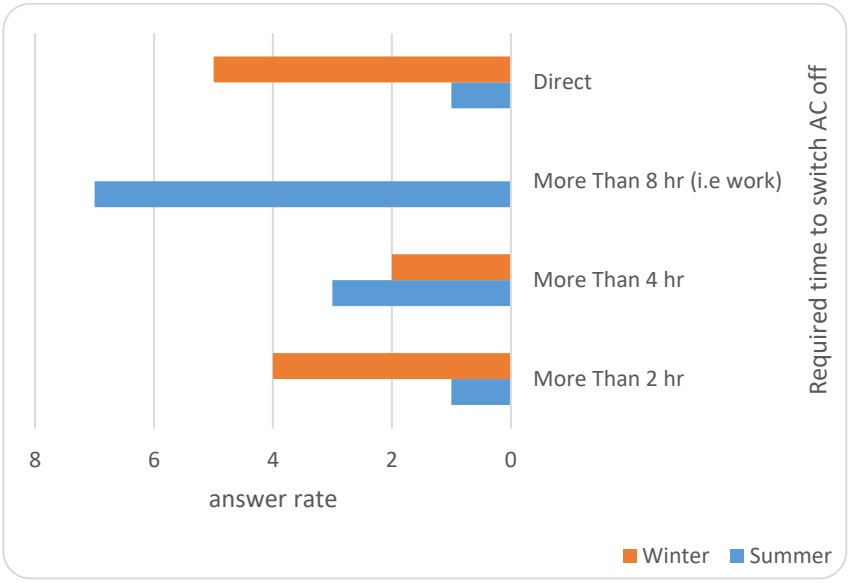

Figure 5.11: Chart shows questionnaire result if they turn AC off when they left house or room (Nad Al-Hammar, Dubai)

5.2 Al Qouz Analysis results:

Results of a questionnaire for Al Qouz will be analysis the most important aspects as follows:

5.2.1 Basic Buildings information

As mentioned previously this part provide basic information about the surveyed building, such as building type, age of construction, number of floor and room in addition to occupancy pattern. Regards to the construction year of the surveyed buildings, 46% of the investigated building were constructed “between” 1980 – 1990, 36% were constructed “between” 1990 – 2000 and 18% were constructed before 1980. The building types were villas and Arabic houses which were about 40% and 60% respectively. In this area number of bedrooms was about 62%, living rooms were about 26%, and 12% were for others rooms (Figure 5.12a).

Furthermore, the survey result categorized bedrooms as 30% for 3 bedrooms, 50% for 4 bedrooms, and 20% for 5 bedrooms (Figure 5.12b).

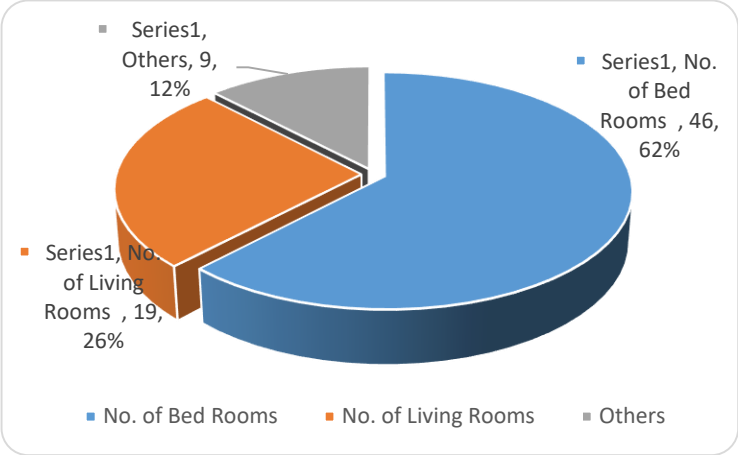

Figure 5.12a: Percentage of Rooms for all investigated households (Al-Quoz, Dubai)

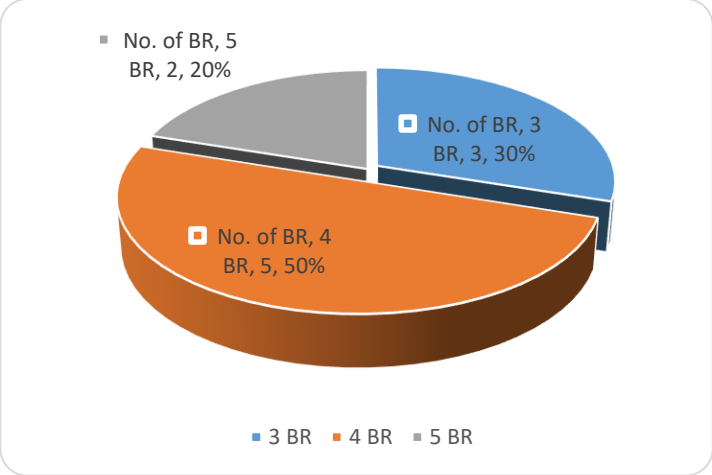

Figure 5.12b: Percentage of Bedrooms Number for all investigated households (Al-Quoz, Dubai)

As surveyed the number of residents per household for this area was an average of 6.8. Below table 5.8 shows the composition of households with the percentage of people household. The

dominant percentage for the residents per household was for families with eight members or more and followed by households with six members.

Table 5.8 Composition of households (Al Quos, Dubai)

Number of persons in the household	5	6	7	8	9 or More
Percentage of households with the specified number of people	9%	27%	37%	18%	9%

Figure 5.13 illustrates the occupancy patterns during the day. It clearly shows that most of the household residents would be away from home between 6:00 am to 2:00 pm and only about 11% of the household members would stay at home during that's time which would be adults or children's, while other members would be at work or school and colleges. About 25% of household members would return to home from 2:00 pm to 6.00 pm. nearly, after 09.00 pm all the household members would return to home.

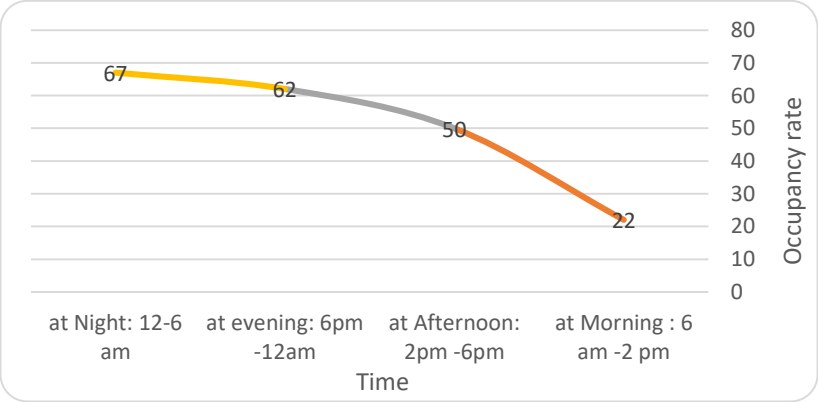

Figure 5.13: Number of occupants that present in the house during the day (Al Qouz, Dubai)

5.2.2 Water Heater Usage

This part of the research illustrates the water heater usage per household. Figure 5.14a shows that more consumption of the water heater was during the winter which was up to 77% and 23 % in the summer. It's found from figure 5.14b the different timing usage for water heater during winter and summer. The Demand for water heaters has reached a maximum during the winter season in the morning time followed by the evening and afternoon. But during the summer season, it was almost used during evening and morning, while it's not used during afternoon time.

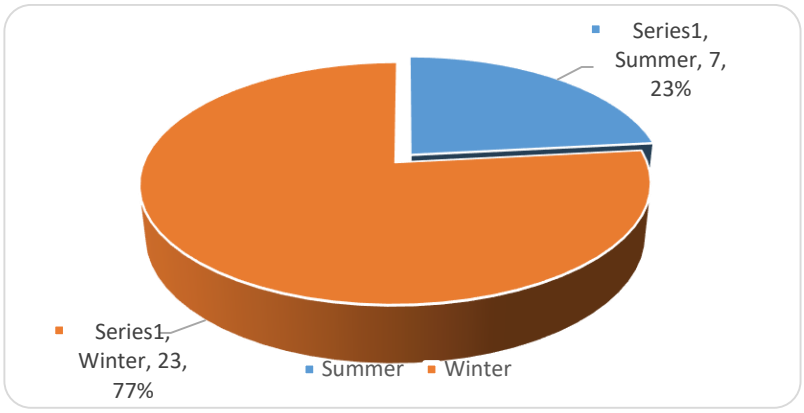

Figure 5.14a: Water heater profile for summer and winter seasons (Al-Quoz, Dubai)

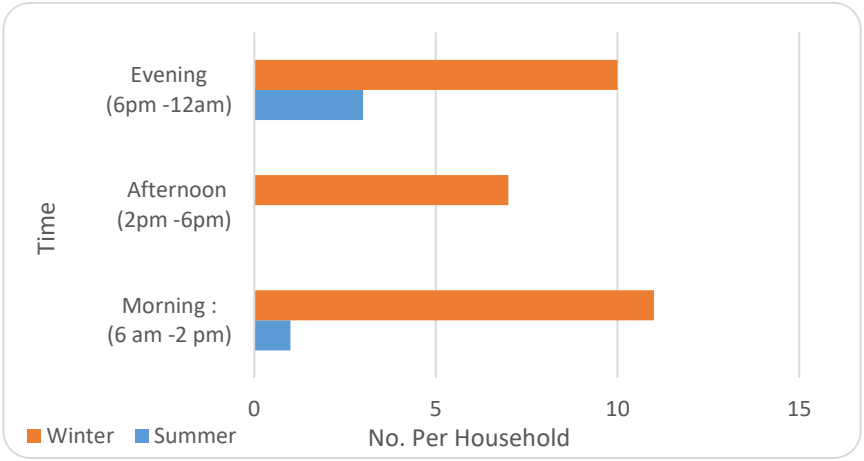

Figure 5.14b: Demand of water heater during the day for summer and winter seasons (Al-Quoz, Dubai)

The approximate energy load required for a water heater is around 1000-2000 watts per hr. The water heater demand for the winter season was a range between 18 to 24 hr, while during the summer season demand was almost during the evening and follows by morning with maximum approximate usage of 6 hr.

From the survey, 83 % were stated that they were used a shower compared to 17 % using the run bath. The majority were claimed that they are showering once a day and were about 82%, compared to 18% are showering twice a day. The below figure 5.15 shows the shower/ bath demand during the day and reached peak times during morning and evening (figure 5.15).

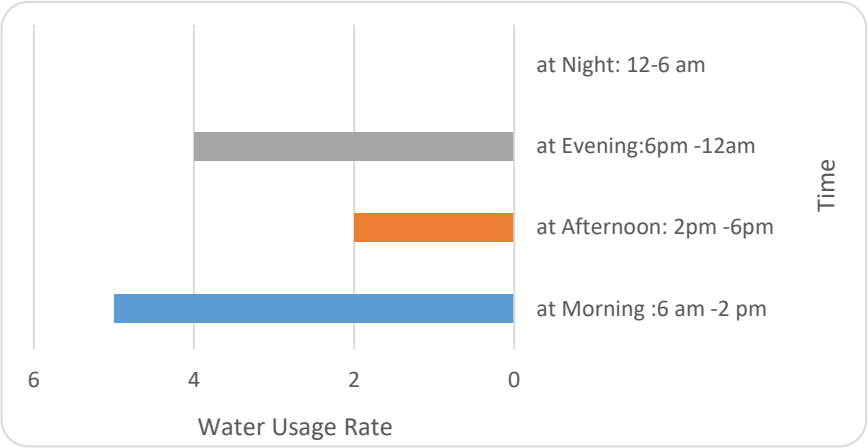

Figure 5.15: Water demand during Day (Al-Quoz, Dubai)

The majority, with 50% was claimed that they need 10 minutes for showering, while 22 % need 5 minutes, 21% need 15 minutes and 7% need 30 minutes, and 10% need more than 30 minutes. Accuracy was difficult to be predicted since it is not a quantitative measurement and is affected by residents' behavior. Many were claimed that shower length depends on different times and would be longer when washing their hair (figure 5.16).

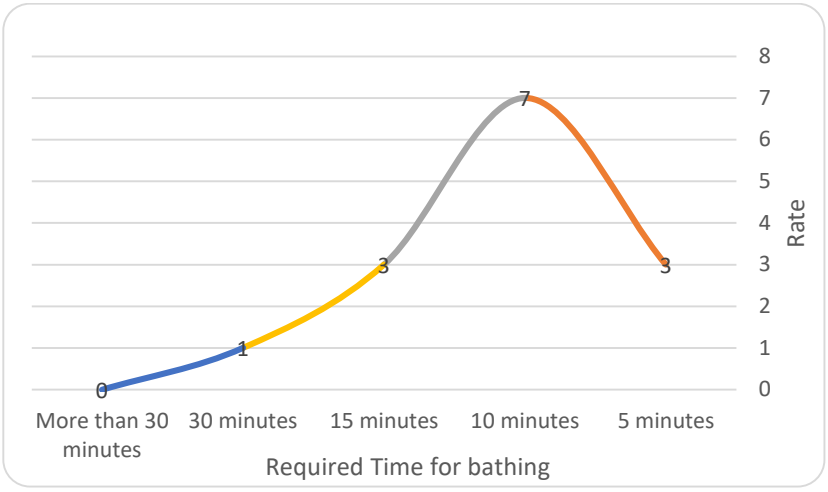

Figure 5.16: Residents' bathing length (Al-Quoz, Dubai)

5.2.3 White Goods

All Al-Quoz households were provided with the mentioned before white goods except dishwashers and freezers, of which only 5% of households were provided with freezers and no house was provided with a dishwasher. Below the figure, 5.17a shows the using frequency for different white goods items as the dominant use was daily. While 40% stated that they used cloth washers 4 to 5 times per week and 20% stated that they used cloth iron 6-7 times per week. On other hand, the peak time for those items varies as shown in Figure 5.17b and only refrigerators and freezers are working 24 hr.

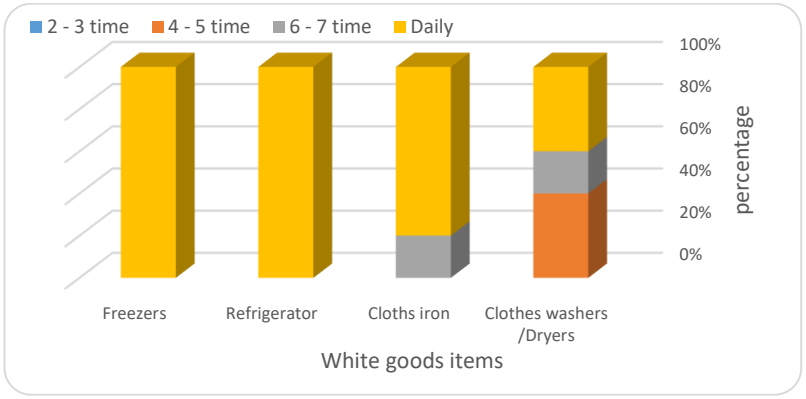

Figure 5.17a: Frequency for different white goods items (Al-Quoz, Dubai)

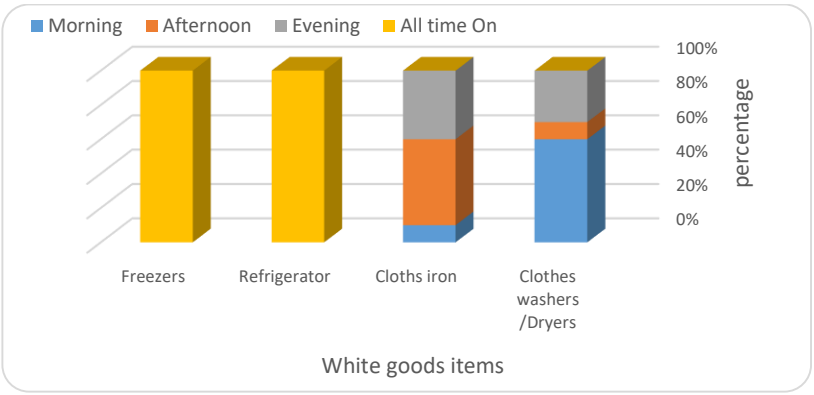

Figure 5.17b: Pattern of white goods using time (Al-Quoz, Dubai)

The consumed energy for each item has a linear relation with the quantity and the approximate used time. Below table 5.9 provides illustrative data for the amount of consumed energy per day and per month for different white goods items in the Alqouz area. The refrigerators were the largest white goods items that consume energy, consuming 5544.000 KW monthly, while clothes washers were the least energy-consuming by calculating energy consumption as one quantity (936KW).

Table 5.9: Total Units Consumed per white good items (Al-Quoz, Dubai)

White Goods Name	Appx Average Load (W)	Quantity	Total App. used time (hr)	Total Units Consumed / per Day	Total Units Consumed / per month
Clothes washers /Dryers	700	12	1	8.399	251.999
Electric iron	800	13	3	31.200	936.000
Refrigerator	550	14	24	184.800	5544.000
Freezers	550	2	24	81.600	2448.000
Total				305.999	9180
Consumption is based on 1 Unit = 1000 Watts per hour					

5.2.4 Kitchen & Cooking Appliances

The surveyed kitchen & cooking appliances include electric cooker, microwaves, bread makers/toasters/espresso machines/juicer/rice cooker /others. The consumed energy for each item depends on quantity and the approximate used time. Table 5.10 Provide illustrative data for the amount of consumed energy per day and month. The total energy consumed for items, such as bread makers/toasters/espresso machines/juicer/rice cooker was 1462.500 KW per month.

Table 5.10: Total Units Consumed per Kitchen & Cooking Appliances (Al-Quoz, Dubai)

Kitchen & Cooking Appliances	App. Average Load (W)	Quantity	Total App. used time (hr)	Total Units Consumed / per Day	Total Units Consumed / per month
Electric cooker	1000	03	12	36.000	1080.000
Microwaves	1000	10	4.5	40.833	1225.000
Bread makers / Toasters /Espresso Machines / Juicer /rice cooker /others	650*	15	5	48.750	1462.500
Consumption is based on 1 Unit = 1000 Watts per hour					

The questionnaire also was contained a question of whether the users were examined power and voltage ratings when they buy an electrical appliance. 50% claimed that they checked power rating and 50% bought appliance without checking power and voltage rating (Figure 5.18)

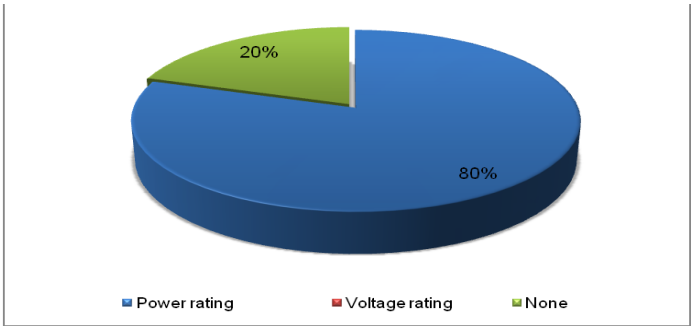

Figure 5.18: percentage of what was examined when buying electrical appliance (Al-Quoz, Dubai)

5.2.5 Home Entertainment

As surveyed 23% of households stated they have LCD/Plasma TV compared to 31% for tube TV and 46% for items such as Sat, DVD, Video, and Stereo. Table 5.11 provides illustrative data for the amount of consumed energy per day per month. TVs consumed more energy than others entertainment items because it was used by all household member and used between 4 to 8 hr daily (Figure 5.19a). The peak time for the used entertainment items during the evening time (Figure 5.19b)

Table 5.11: Total Units Consumed per home entertainment for each 1hr per day and month (Al-Quoz, Dubai)

home entertainment	App. Average Load (W)	Quantity	Total Units Consumed / per Day	Total Units Consumed / per month
TV (LCD/Plasma)	300	06	1.799	54.000
TV (Tube)	200	08	1.600	48.000
Sat/DVD/Video/Stereo	118*	12	1.416	42.480
Consumption is based on 1 Unit = 1000 Watts per hour				
* Sat/DVD/Video/Stereo have different load & 118 is calculated as an average load for mentioned appliances				

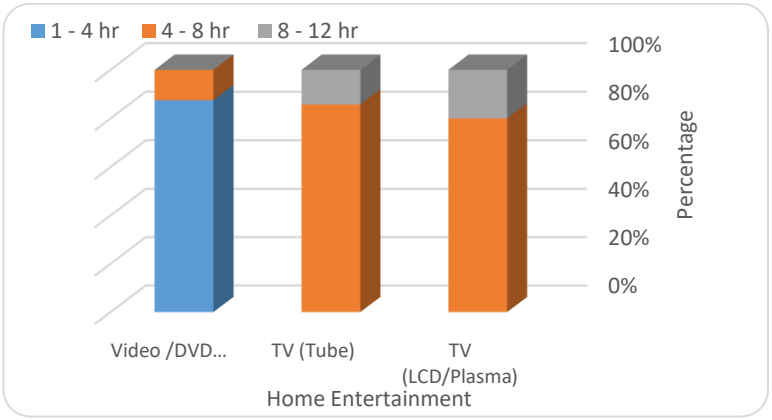

Figure 5.19a: Chart shows frequency of using home entertainment items per day (Al-Quoz, Dubai)

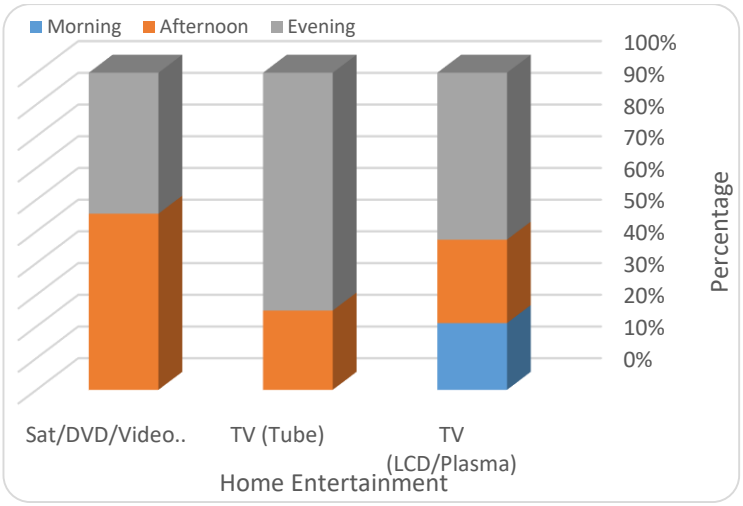

Figure5.19b: Chart shows home entertainment items pattern per day (Al-Quoz, Dubai)

5.2.6 Computers and Peripherals

The surveyed computers and peripherals include Computers, laptops, Printers, Scanner, and Fax. The consumed energy for each item depends on quantity and the approximate used time. Table 5.12 provides illustrative data for the amount of consumed energy per day and month. Laptops consumed more energy than others entertainment items because almost all houses have one laptop or more (46%). Figure 5.20 shows the using period.

Table 5.12: Total Units Consumed per Computers and Peripherals for each 1hr per day and month (Al-Quoz, Dubai)

Computers and Peripherals	App. Average Load (W)	Quanti ty	Total Units Consumed / per Day	Total Units Consumed / per month
Desk Top	200	06	1.200	36.000
Laptop	150	10	1.500	45.000
Printer / Scanner /Fax /Others	135*	06	0.810	24.300
Consumption is based on 1 Unit = 1000 Watts per hour				

* Printer / Scanner /Fax /have different load & 135 is calculated as an average load for mentioned appliances

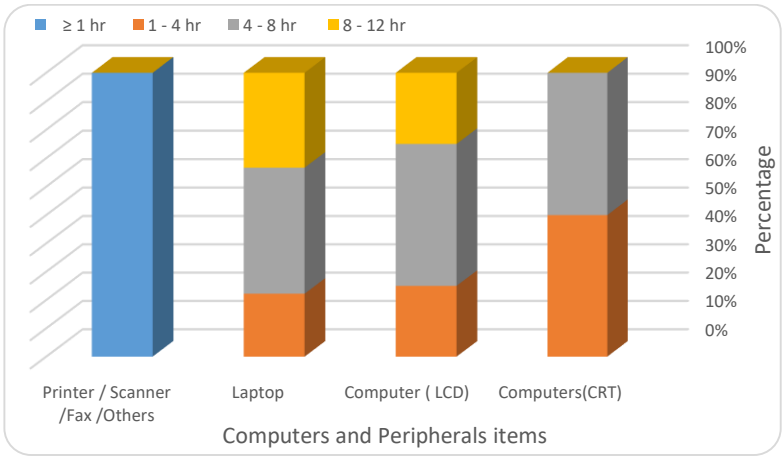

Figure 5.20: Chart shows frequency of using computer and peripherals items per day (Al-Quoz, Dubai)

By asking household members if they were switched the computer and laptop off, leave it on, or kept it on standby mode. 62% of them claimed that they were switched it off compared to 38% they have kept it on standby mood (Figure 5.21).

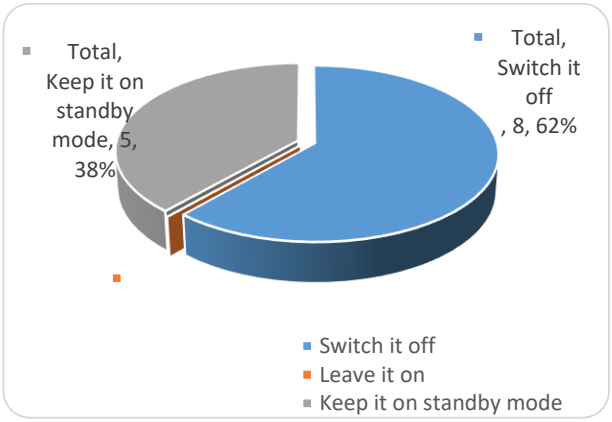

Figure 5.21: Pie Chart shows Computer & laptop mood (Al-Quoz, Dubai)

5.2.7 Air Conditioning (AC)

Table 5.13 provide overall data for the AC required load according to different assumed time. The bigger households need more AC units than a smaller house which means the required load and energy use are almost related to the house area and number of rooms per house. By calculating the total number of bedrooms, living rooms, and kitchen the total approximated required load of A/C will as below table (5.13)

Table 5.13 : Approximate required load for A/C during one month for (Al-Quoz, Dubai)

Hour	24 hr	18 hr	12 hr	6 hr
Required Load	91800.000	68850.000	45900.000	22950.000

** The used Appx Average Load (W) 1700 for window/spilt A/C
** Consumption is based on 1 Unit = 1000 Watts per hour

AC energy use is considered one of the items related to the occupants' behavior. For that, the questionnaire included questions if they are turn AC off when they left the house or the room. The figure illustrates the questionnaire result.

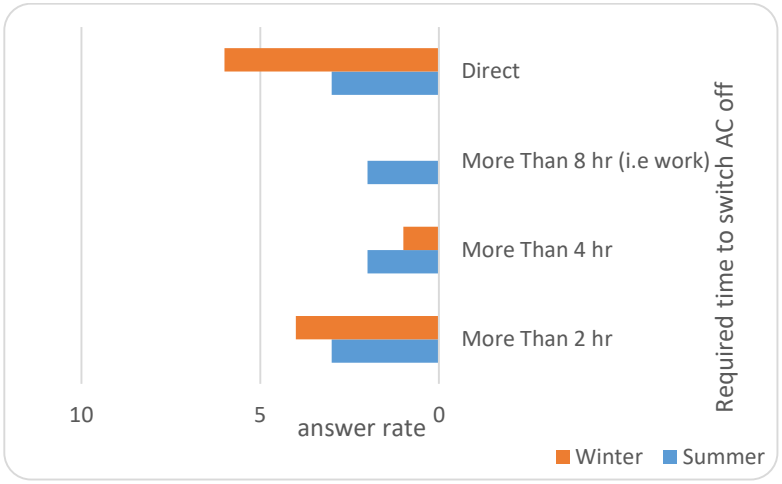

Figure 5.22: Chart shows questionnaire result, if they turn AC off when they left house or room (Al-Quoz, Dubai)

5.3 Arabian Ranches Analysis results:

Results of questionnaire investigation for Arabian Ranches will be analysis the most important aspects as detailed below:

5.3.1 Basic Buildings information

First part of the questionnaire provide basic information about their building ,such as, building type ,age of construction, number of floor and room in addition to occupancy pattern. Regards to the construction year of those villas in this area, all investigated building were constructed after 2000. It's horizontal development with individual and townhouses villas with heights range between G+1 and G+2. The questionnaire was distributed to 7 individual villas and 4 townhouse villas and equal to 64% and 36% respectively. In this survey, number of rooms was as 48 % for bedrooms, 27% for living rooms and 25% for others rooms which could include study room, office room or maid room. Furthermore, the survey result categorized rooms as 48 % for bedrooms, 27%

for living rooms and 25% for others rooms (Figure 5.23a). From other hand, The number of bed room per household ranges between 30% and 40%, 2 bedrooms and 3 bedrooms about 30%, while 4 bedrooms was about 40 %(Figure 5.23b).

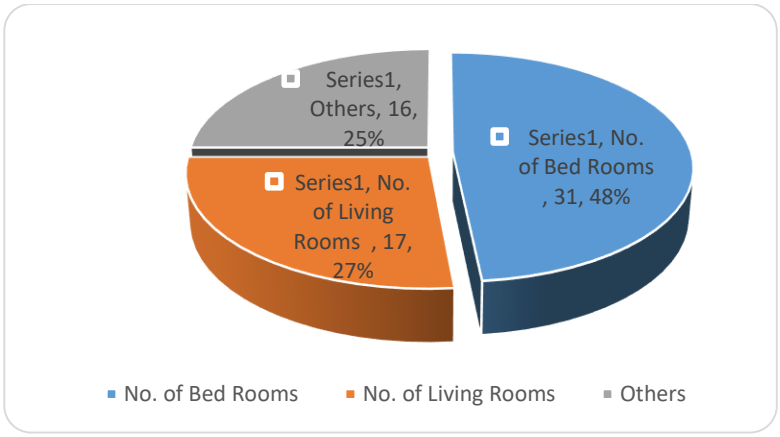

Figure 5.23a: Percentage of Rooms for all investigated household (Arabian Ranches, Dubai)

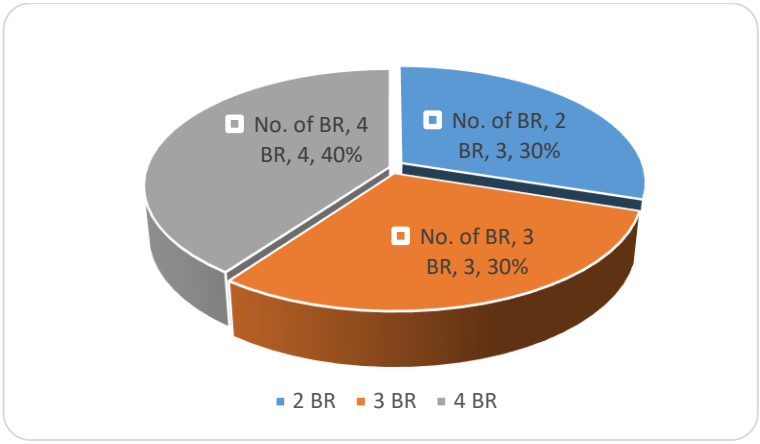

Figure 5.23b: Percentage of Bedrooms Number for all investigated (Arabian Ranches, Dubai)

It's very important to identify occupancy pattern in order to analyze load profile. This survey provides data for the number of occupancy per household with the number of occupants that present in the house during the day. As investigated the number of residents per household for this

area was an average of 4.2 .Below table 5.13. shows the composition of households with percentage of people per households. The dominated percentage for the residents per household was for families with four members and follows by three, five and 6 or more families' members with same percentage of 20%.

Table 5.13. Composition of households (Arabian Ranches)

Number of persons in the household	1	2	3	4	5	6 or More
Percentage of households with the specified number of people	0%	10%	20%	30%	20%	20%

Figure 5.24 illustrates the occupancy patterns during the day. It clearly shows that most of the household residents would be away from home between 6:00 am to 2:00 pm and only about 9% of the household members would stay at home during that's time which would be adult-like mother and maid or would be children's, while other members would be at work or school and colleges. About 24% of household members would return home from 2:00 pm to 6.00 pm. Nearly, after 9.00 pm all the household members would return home.

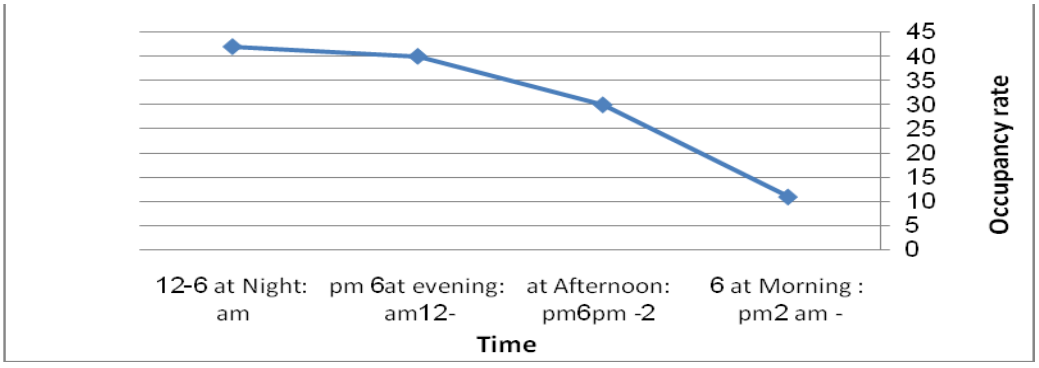

Figure 5.24: Number of occupants that present in the house during the day (Arabian Ranches, Dubai)

5.3.2 Water Heaters usage

This part of the research illustrates the water heater usage per household. Figure 5.25 shows that more consumption of the water heater during the winter was up to 87%, while water heater usage does not exceed 13 % in the summer. Figure 5.26. Shows the different timing usage for water heater during winter and summer. The water heater demand reached a maximum during the winter season in the morning followed by the evening and afternoon. But during the summer season, it's almost used during the evening and rarely used during the morning, while it's not used during the afternoon time.

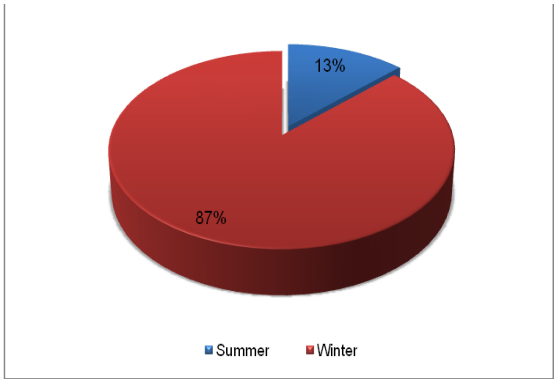

Figure 5.25: Water heater profile for summer and winter seasons (Arabian Ranches, Dubai)

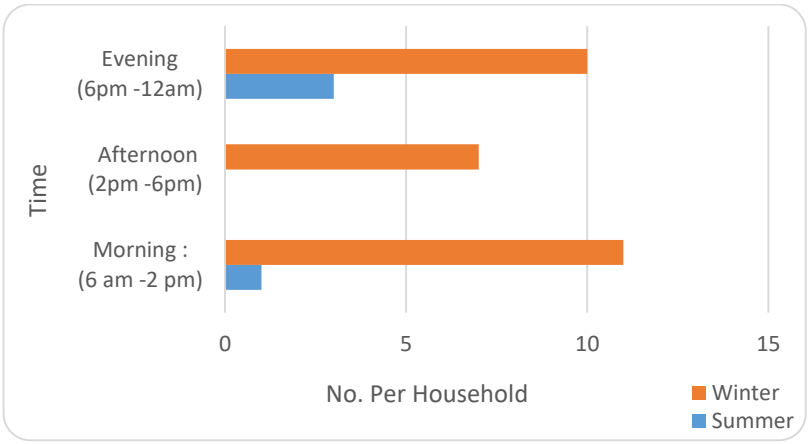

Figure 5.26: Demand of water heater during the day for summer and winter seasons (Arabian Ranches, Dubai)

The approximate energy load required for a water heater is around 1000-2000 watts. And by assuming that all bedrooms and living rooms were provided with a water heater. The water heater demand for the winter season range between 18 to 24 hr, while during the summer season demand is almost during the evening and follows by morning with maximum approximate usage of 6 hr.

80 percent stated they used a shower compared to 20 using the run bath. The majority claim that they only showered once a day and about 67% compared to 25% showered twice a day and 8% showered more than twice a day. Figure 5.27 Shows the shower/ bath demand during the day and reached peak times during morning and evening.

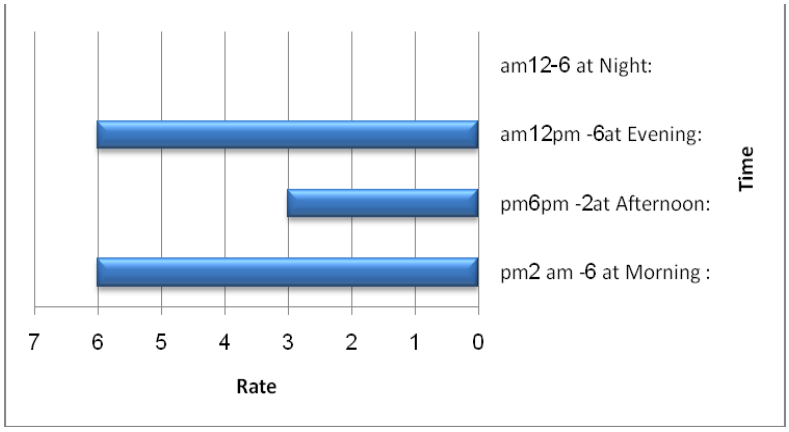

Figure 5.27: Water demand during Day (Arabian Ranches, Dubai)

The majority percentage (50%) claimed that they need 10 minutes for showing, while 30 % need 15 minutes and 20% were for 30 minutes or more. Accuracy was difficult to be predicted since it is not a quantitative measurement and is affected by residents' behavior. Many claimed that shower length depends on different times and would be longer when washing their hair.

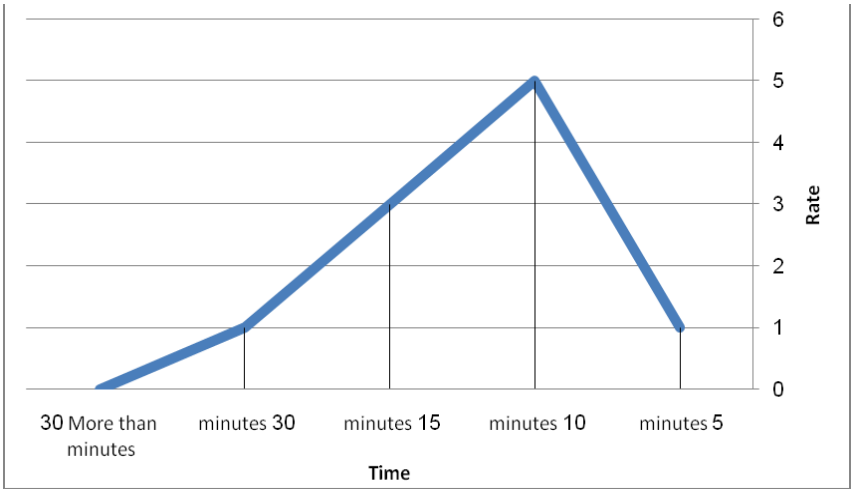

Figure 5.28: Residents' bathing length (Arabian Ranches, Dubai)

5.3.3 White Goods

The surveyed white goods include clothes washers /dryers, cloths iron, dishwashers, refrigerators, and freezers. All households provided with the mentioned white goods except dishwashers and freezers, that 60% with dishwashers and only 30% with freezers. Using frequency for those devices vary from house to house, which affects the rate of energy consumption. Below figure 5.29a shows the using frequency for different white goods, refrigerators, and freezers were used daily as 24hr, the dishwashers used daily between two to three times, while clothes iron and clothes washers different from house to house, some claimed that they used them daily and others between 4 to 5 times weekly or 6 to 7 time weekly. On other hand, the peak time for those items vary and depends on the number of household members and working times. Figure 5.29b shows using time for different white goods.

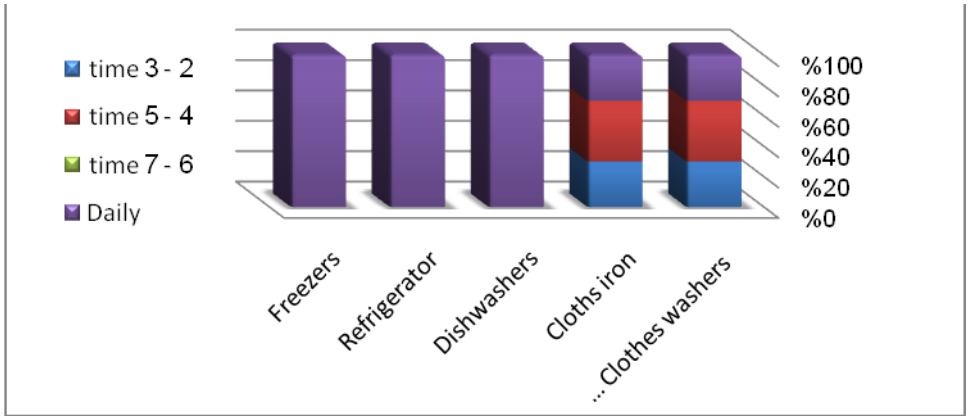

Figure 5.29a: Frequency for different white goods items (Arabian Ranches, Dubai)

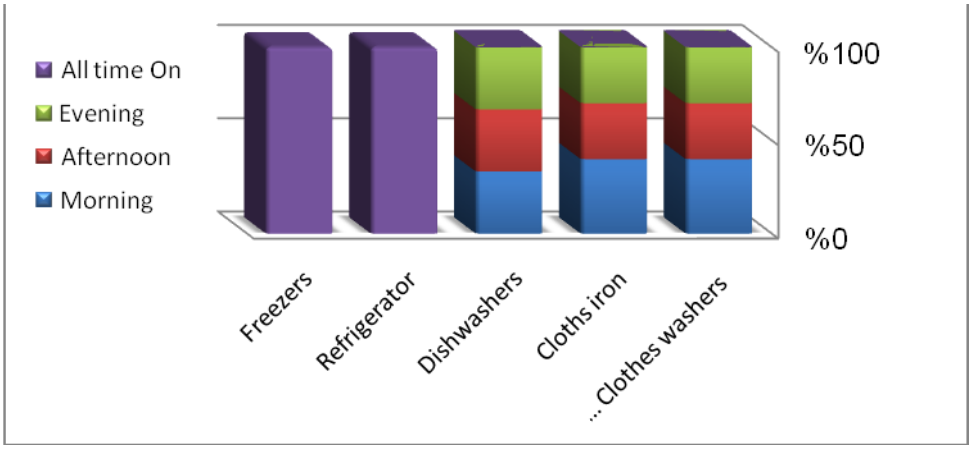

Figure 5.29b: Pattern of white goods using time (Arabian Ranches, Dubai)

The consumed energy for each item has a linear relation with the quantity and the approximate used time. Below table 5.14 Provide illustrative data for the amount of consumed energy per day per month. The refrigerators were the largest white goods items that consume energy, consuming 3960 KW monthly, while clothes washers were the least energy-consuming.

Table 5.14: Total Units Consumed per white good items (Arabian Ranches, Dubai)

White Goods Name	Appx Average Load (W)	Quantity	Total Appx used time (hr)	Total Units Consumed / per Day	Total Units Consumed / per month
Clothes washers /Dryers	700	10	1	7.000	210.000
Electric iron	800	11	1	8.800	264.000
Dishwashers	1300	06	1	7.800	234.000
Refrigerator	550	10	24	132.000	3960.000
Freezers	550	3	24	39.600	1188.000
Total				195.200	5856.000

Consumption is based on 1 Unit = 1000 Watts per hour

5.3.4 Kitchen & Cooking Appliances

The surveyed kitchen & cooking appliances include electric cooker, microwaves, bread makers/toasters/espresso machines/juicer/rice cooker /others. The consumed energy for each item depends on quantity and the approximate used time. Table 5.15 Provide illustrative data for the amount of consumed energy per day and month. The total energy consumed for items, such as bread makers/toasters/espresso machines/juicer/rice cooker consuming 1365.000 KW monthly.

Table 5.15: Total Units Consumed per Kitchen & Cooking Appliances (Arabian Ranches, Dubai)

Kitchen & Cooking Appliances	App. Average Load (W)	Quantity	Total App. used time (hr)	Total Units Consumed / per Day	Total Units Consumed / per month
Electric cooker	1000	02	11	22.000	660.000
Microwaves	1000	10	4.5	45.500	1350.000
Bread makers / Toasters /Espresso Machines / Juicer /rice cooker /others	650*	14	5	45.500	1365.000
Consumption is based on 1 Unit = 1000 Watts per hour					
*Bread makers / Toasters /Espresso Machines / Juicer /rice cooker have different load & 650 is calculated as an average load for mentioned appliances					

The questionnaire also contained a question of whether the users were examined power and voltage ratings when they buy an electrical appliance. 60% claimed that they checked power rating and 40% bought appliance without checking and nobody check the voltage rating (Figure 5.30)

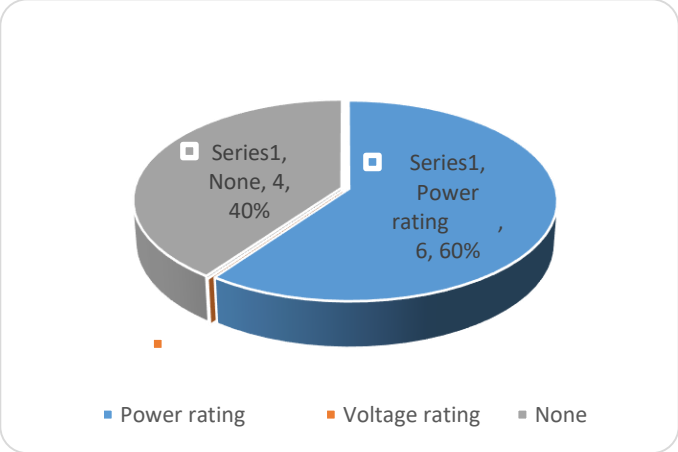

Figure 5.30: Percentage of what was examined when buying electrical appliance (Arabian Ranches, Dubai)

5.3.5 Home Entertainment

The surveyed home entertainment items include TV, Sat, DVD, Video, and Stereo. The consumed energy for each item depends on quantity and the approximate used time. 52% of households stated they have LCD/Plasma TV compared to 12% for tube TV and 36% for items such as Sat, DVD, Video, and Stereo. Table 5.16 provides illustrative data for the amount of consumed energy per day and month. TV consumed more energy than others entertainment items because it was used by all household members and used between 4 to 8 hr daily (Figure 5.31a). The peak time for the used entertainment items during the evening time (Figure 5.31b)

Table 5.16: Total Units Consumed per home entertainment for each 1hr per day and month (Arabian Ranches, Dubai)

home entertainment	App. Average Load (W)	Quantity	Total Units Consumed / per Day	Total Units Consumed / per month
TV (LCD/Plasma)	300	13	3.900	117.000
TV (Tube)	200	03	0.600	18.000
Sat/DVD/Video/Stereo	118*	09	1.061	31.860
Consumption is based on 1 Unit = 1000 Watts per hour				
* Sat/DVD/Video/Stereo have different load & 118 is calculated as an average load for mentioned appliances				

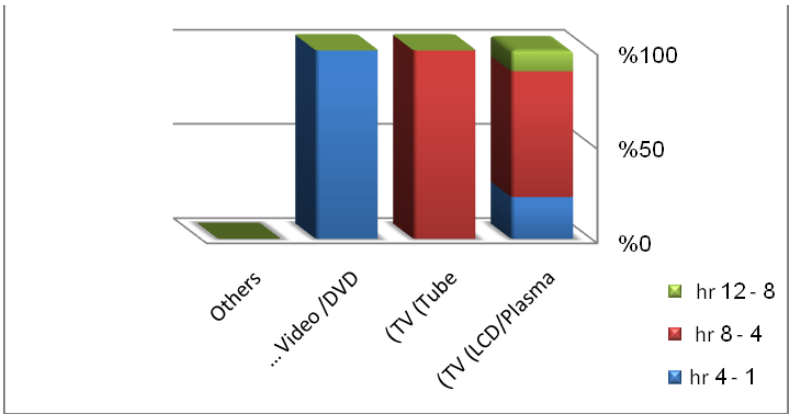

Figure 5.31a: Chart shows frequency of using home entertainment items per day (Arabian Ranches, Dubai)

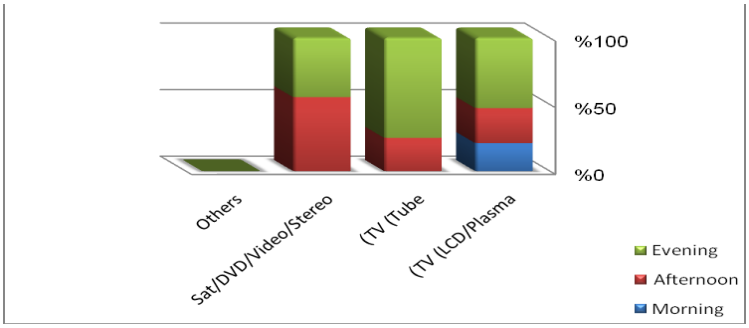

Figure 5.31b: Chart shows home entertainment items pattern per day (Arabian Ranches, Dubai)

5.3.6 Computers and Peripherals

The surveyed computers and peripherals include Computers, laptops, Printers, Scanner, and Fax. The consumed energy for each item depends on quantity and the approximate used time. Table 5.17 Provide illustrative data for the amount of consumed energy per day and month. Laptops consumed more energy than others entertainment items because almost all houses have one laptop or more (46%). Computers and Laptops are used by all household members for 4 to 8 hr daily (Figure 5.32).

Table 5.17: Total Units Consumed per Computers and Peripherals for each 1hr per day and month(Arabian Ranches, Dubai)

Computers and Peripherals	App. Average Load (W)	Quantity	Total Units Consumed / per Day	Total Units Consumed / per month
Desk Top	200	05	1.000	30.000
Laptop	150	10	1.500	45.000
Printer / Scanner /Fax /Others	135*	06	0.810	24.300

Consumption is based on 1 Unit = 1000 Watts per hour

* Printer / Scanner /Fax /have different load & 135 is calculated as an average load for mentioned appliances

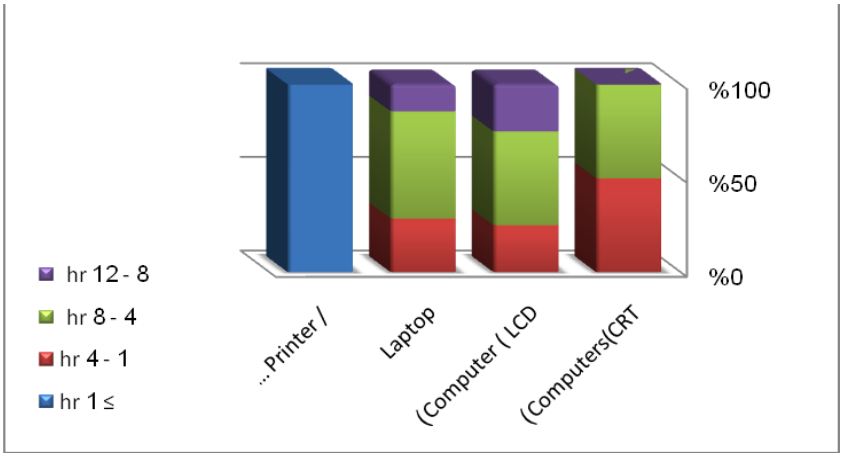

Figure 5.32: Chart shows frequency of using computer and peripherals items per day (Arabian Ranches, Dubai)

By Asked household members if they were switched computer and laptop off, leave it on or keep it on standby mode. 62% of them claimed that they were switched it off compared to 38% they have kept it on standby mood (Figure 33).

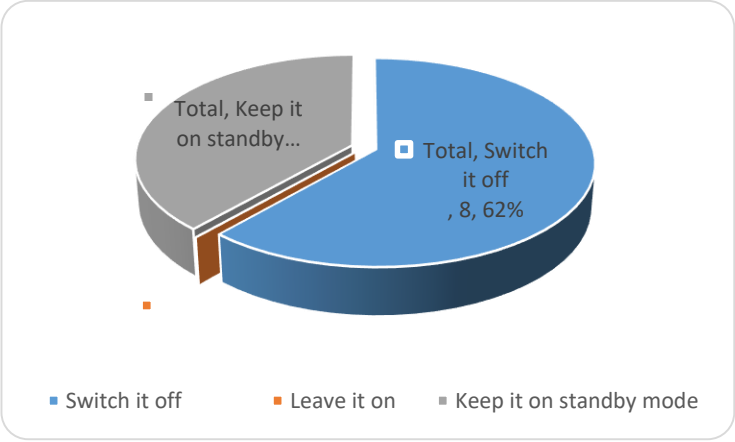

Figure 5.33: Pie Chart shows Computer & laptop mood (Arabian Ranches, Dubai)

5.3.7 Air Conditioning (AC)

The bigger households need more AC units than a smaller house which means the required load and energy use are almost related to the house area and number of rooms per house. By calculating the total number of bedrooms, living rooms, and kitchen the total approximated required load of A/C will as below table (5.18).

Table 5.18 : Approximate required load for A/C during one month for (Arabian Ranches, Dubai)

Hour	24 hr	18 hr	12 hr	6 hr
Required Load (watts)	70992.000	53243.999	35496.000	17748.000

** The used Appx Average Load (W) 1700 for window/spilt A/C
** Consumption is based on 1 Unit = 1000 Watts per hour

AC energy use is considered one of the items related to the occupants' behavior. For that, the questionnaire included questions if they are turn AC off when they left the house or the room. The figure illustrates the questionnaire result

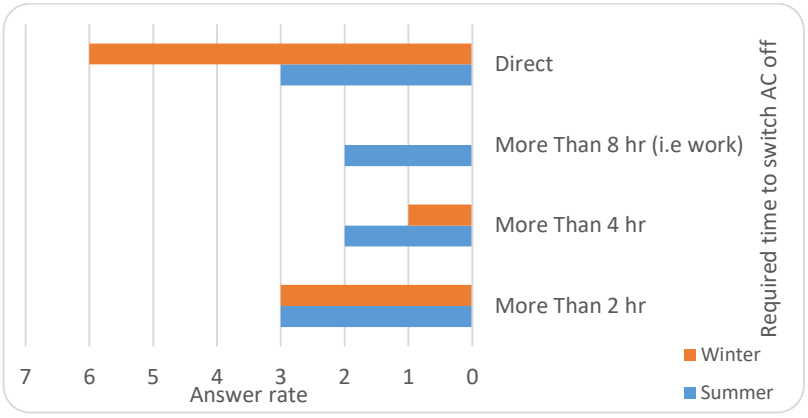

Figure 5.34: Chart shows questionnaire result, if they turn AC off when they left house or room (Arabian Ranches, Dubai)

5.4 Al Nahda Analysis results:

Results of questionnaire investigation for Al Nahda will be analysis the most important aspects as detailed below:

5.4.1 Basic Buildings information

Its vertical development area which a combination of low-rise (3-6 floors) and high–rise (above 6 floors) buildings, this area was constructed after 2000. As surveyed, the number of rooms was 68 % for bedrooms, 29% for living rooms, and 3% for others rooms which could include the study room, office room, maid room, or stores (Figure 5.35). Furthermore, the survey result categorized bedrooms as 70% for 2 bedrooms and 30% for 3 bedrooms.

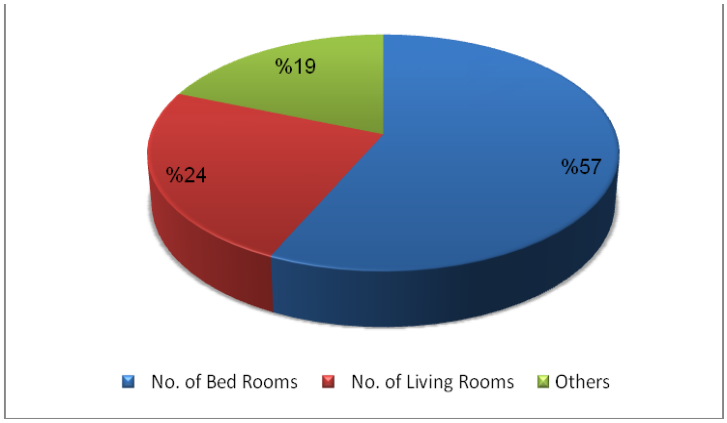

Figure 5.35: Percentage of Rooms for all investigated household (Al Nahda, Dubai)

As investigated the number of residents per household for this area was an average of 4.3. Below table 5.19 shows the composition of households with the percentage of people per household. The dominant percentage for the residents per household was for families with four members or more and followed by households with six members.

Table 5.19: Composition of households (Al Nahda, Dubai)

Number of persons in the household	3	4	5	6 or More
Percentage of households with the specified number of people	20%	40%	27%	13%

Figure 5.36 illustrates the occupancy patterns during the day. It clearly shows that most of the household residents would be away from home between 6:00 am to 2:00 pm and only about 10% of the household members would stay at home during that's time which would be adult-like mother and maid or would be children's, while other members would be at work or school and colleges. About 23% of household members would return home from 2:00 pm to 6.00 pm. Nearly, after 9.00 pm all the household members would return home.

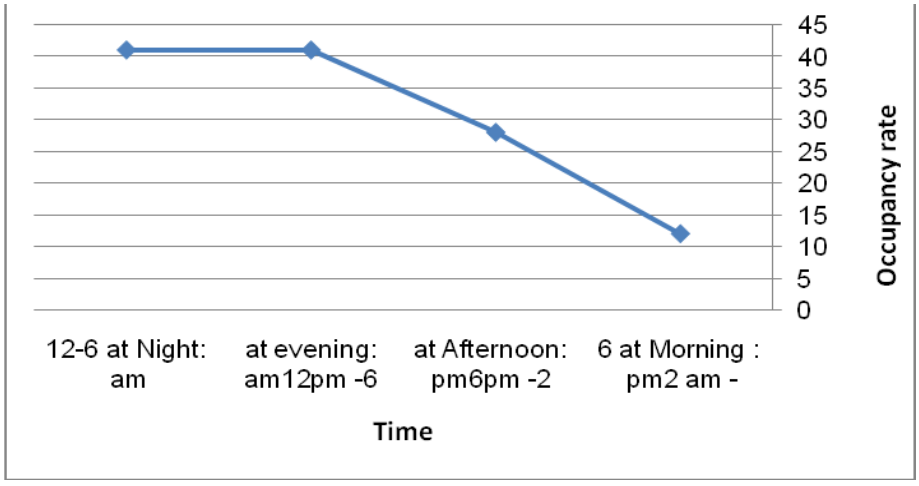

Figure 5.36 : Number of occupants that present in the house during the day (Al-Nahda, Dubai)

5.4.2 Water Heaters usage

This part of the research illustrates the water heater usage per household. Figure 5.37 shows that more consumption of the water heater was during the winter which was up to 77%, while water heater usage does not exceed 23 % in the summer. It's found from figure 5.38 the different timing usage for water heater during winter and summer. The water heater demand reached a maximum during the winter season in the evening followed by the morning and afternoon. But during the summer season, it’s almost used during evening and morning, while it's not used during afternoon time.

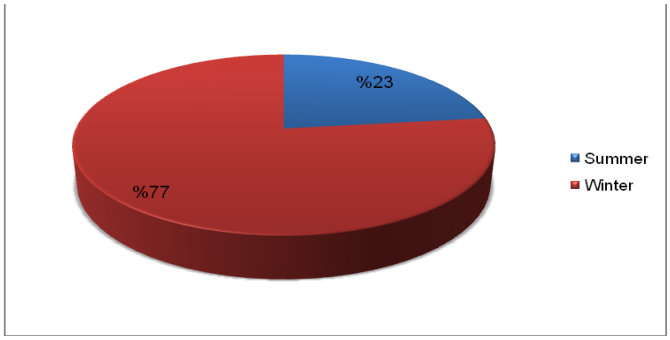

Figure 5.37: Water heater profile for summer and winter seasons (Al-Nahda, Dubai)

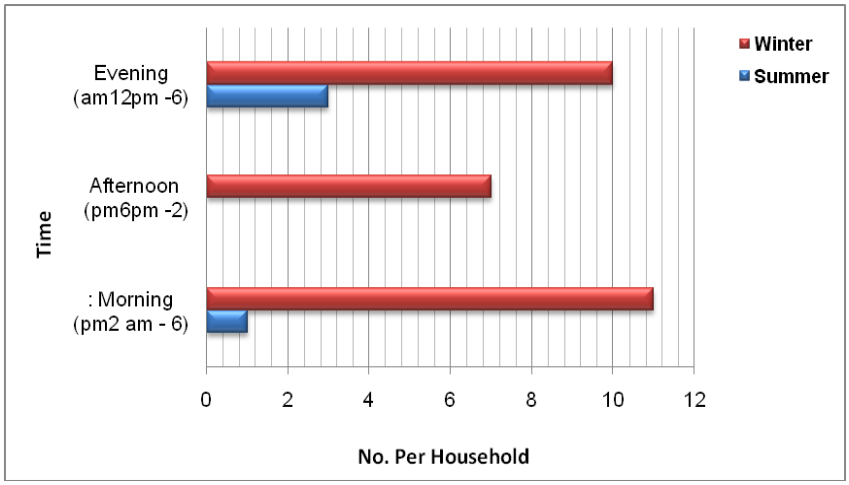

Figure 5.38: Demand of water heater during the day for summer and winter seasons (Al-Nahda, Dubai)

By assuming that all bedrooms and living rooms are provided with a water heater. The water heater demand for the winter season range between 18 to 24 hr, while during the summer season demand is during the evening time.

77% stated they used a shower compared to 23% using the run bath. The majority claim that they showered once a day which was about 60% compared to 40% showered twice a day. Figure 5.39 shows the shower/ bath demand during the day and reached peak times during morning followed by evening. On the other hand, 40% of household members claimed that they needed 10 minutes for showing, also 40% need 15 minutes, and 5% of them need only five (figure 5.40).

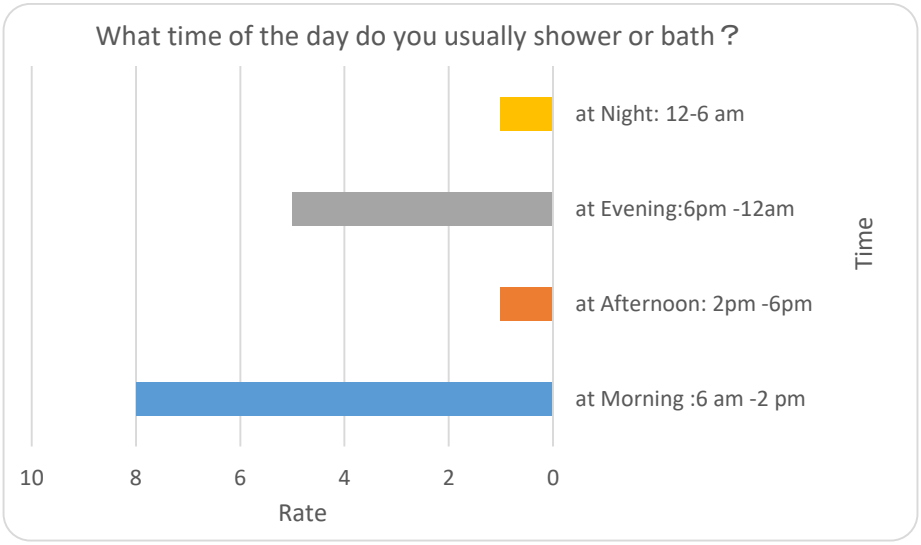

Figure 5.39: Water demand during Day Al-Nahda, Dubai)

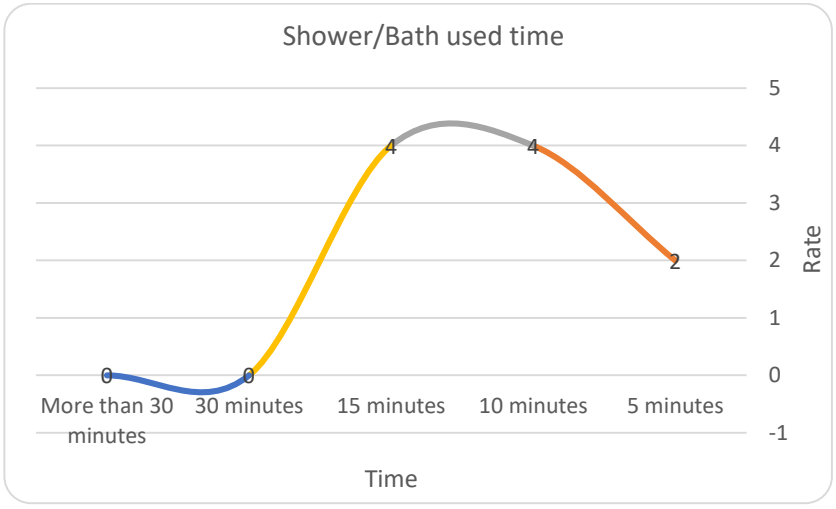

Figure 5.40: Residents' bathing length (Al-Nahda, Dubai)

5.4.3 White Goods

In Al-Nahda, all households are provided with clothes washers /dryers, cloths iron, dishwashers, refrigerators, and freezers. But only 5% of households were provided with dishwashers and 11% with freezers. Below the figure, 5.41a shows the using frequency for different white goods items with a range between daily uses, 2-3 times and 4-5 times. From another hand, the peak time for those items vary. Figure 5.41b shows using time for different white goods. Refrigerators and freezers were working 24 hr, while other items vary.

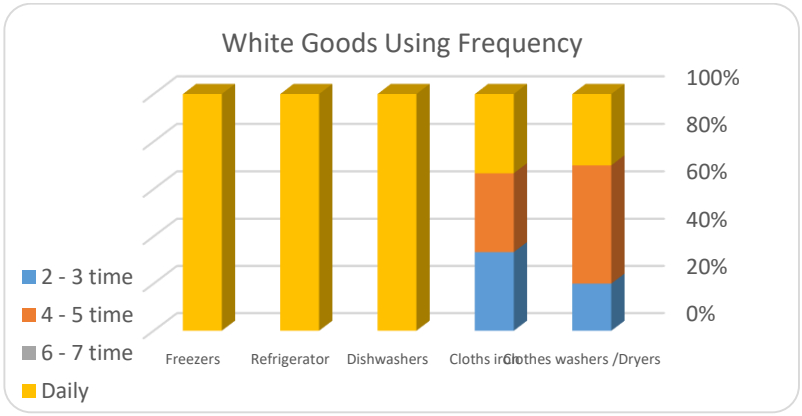

Figure 5.41a: Frequency for different white goods items (Al-Nahda, Dubai)

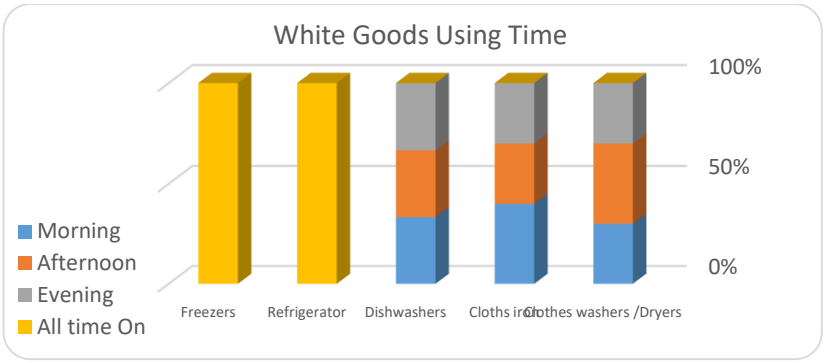

Figure 5.41b: Pattern of white goods using time (Al-Nahda, Dubai)

Below table 5.20 Provide illustrative data for the amount of consumed energy per day and month. The refrigerator was the largest white good item that consume energy, consuming 3960 KW monthly, while Dishwashers were the least energy-consuming by calculating energy consumption as one quantity (78 KW).

Table 5.20: Total Units Consumed per white good items (Al-Nahda, Dubai)

White Goods Name	Appx Average Load (W)	Quantity	Total Appx used time (hr)	Total Units Consumed / per Day	Total Units Consumed / per month
Clothes washers /Dryers	700	10	1	7.000	210.000
Electric iron	800	10	3	24.000	720.000
Dishwashers	1300	02	1	2.600	78.000
Refrigerator	550	10	24	132.000	3960.000
Freezers	550	4	24	52.800	1584.000
Total				164.200	5342.000

Consumption is based on 1 Unit = 1000 Watts per hour

5.4.4 Kitchen & Cooking Appliances

The surveyed kitchen & cooking appliances include electric cooker, microwaves, bread makers/toasters/espresso machines/juicer/rice cooker /others. Table 5.21 Provide illustrative data for the amount of consumed energy per day and per month for mentioned items. The total energy consumed for items, such as bread makers/toasters/espresso machines/juicer/rice cooker consuming 1485.000 KW monthly.

Table 5.21: Total Units Consumed per Kitchen & Cooking Appliances (Al-Nahda, Dubai)

Kitchen & Cooking Appliances	Appx Average Load (W)	Quantity	Total Appx used time (hr)	Total Units Consumed / per Day	Total Units Consumed / per month
electric cooker	1000	02	8	16.000	480.000
microwaves	1000	09	3.5	49.500	1485.000
Bread makers / Toasters /Espresso Machines / Juicer /rice cooker /others	650*	11	4	28.600	858.000
Consumption is based on 1 Unit = 1000 Watts per hour					

*Bread makers / Toasters /Espresso Machines / Juicer /rice cooker have different load & 650 is calculated as an average load for mentioned appliances

The questionnaire also contained a question of whether the users were examined power and voltage ratings when they buy an electrical appliance. Just 27% claimed that they checked power rating and 9% checked voltage rating compared to 64% they bought appliance without checking power and voltage rating (Figure 5.42)

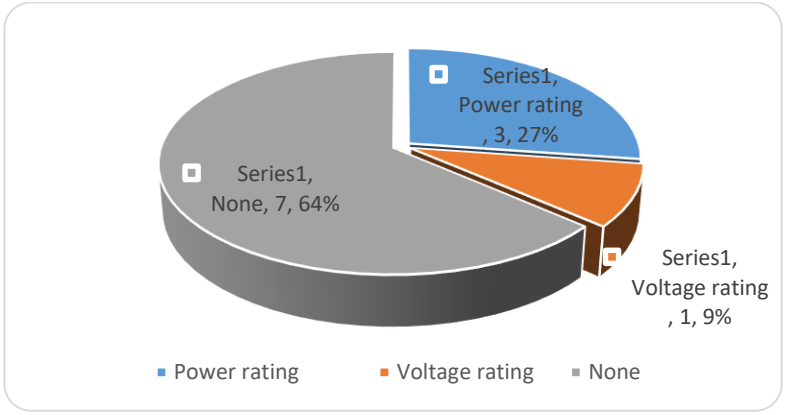

Figure 5.42: Pie Chart shows Computer & laptop mood with percentage (Al-Nahda, Dubai)

5.4.5 Home Entertainment

Of the surveyed, 52% of households stated they have LCD/Plasma TV compared to 12% for tube TV and 36% for items such as Sat, DVD, Video, and Stereo. Table 5. Provide illustrative data for the amount of consumed energy per day and month. TV consumed more energy than others entertainment items because it was used by all household members and used between 4 to 8 hr daily (Figure 5.43a). The peak time for the use of entertainment items range between evening and afternoon time (Figure 5.43b).

Table 5.22: Total Units Consumed per home entertainment for each 1hr per day and month(Al-Nahda, Dubai)

home entertainment	Appx Average Load (W)	Quanti ty	Total Units Consumed / per Day	Total Units Consumed / per month
TV (LCD/Plasma)	300	12	3.599	108.000
TV (Tube)	200	05	1.000	30.000
Sat/DVD/Video/Stereo	118*	12	1.416	42.480
Consumption is based on 1 Unit = 1000 Watts per hour				
* Sat/DVD/Video/Stereo have different load & 118 is calculated as an average load for mentioned appliances				

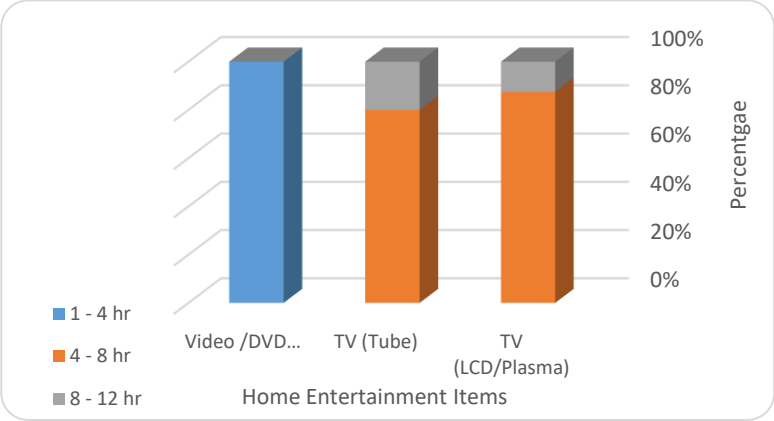

Figure 5.43a: Chart shows frequency of using home entertainment items per day (Al-Nahda, Dubai)

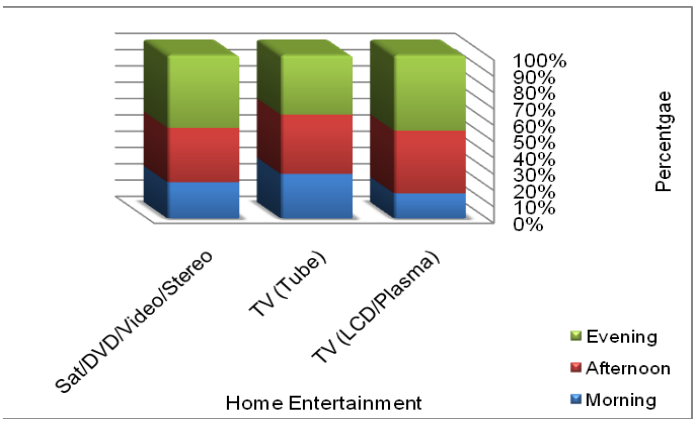

Figure 5.43b: Chart shows home entertainment items pattern per day (Al-Nahda, Dubai)

5.4.6 Computers and Peripherals

The consumed energy for computers, laptops, printers, scanners, and fax items depends on quantity and the approximate used time. Table 5.23 Provide illustrative data for the amount of consumed energy per day and month. Laptops and computers consumed more energy than others peripherals. But on the other hand, fax consumed more energy in case if it is used as 24 hr (2.880 KW). Computers and Laptops are used by all household members for 4 to 8 hr daily (Figure 5.44).

Table 5.23: Total Units Consumed per Computers and Peripherals for each 1hr per day and month

Computers and Peripherals	Appx Average Load (W)	Quanti ty	Total Units Consumed / per Day	Total Units Consumed / per month
Desk Top	200	09	1.800	54.000
Laptop	150	08	1.200	36.000
Printer / Scanner /Fax /Others	135*	09	1.215	36.450
Consumption is based on 1 Unit = 1000 Watts per hour				

* Printer / Scanner /Fax /have different load & 135 is calculated as an average load for mentioned appliances

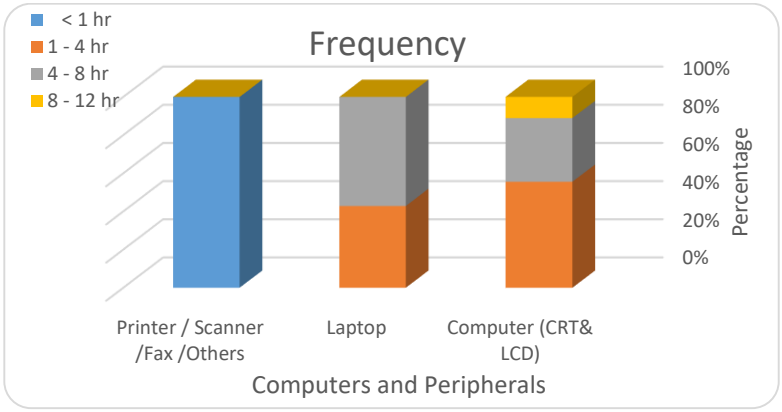

Figure 5.44: Chart shows frequency of using computer and peripherals items per day (Al-Nahda, Dubai)

By Asked household members if they were switched computer and laptop off, leave it on, or kept it on standby mode. 46% of them claimed that they were switched it off compared to 9% they were left it on and 45% kept it on standby mood (Figure 5.45).

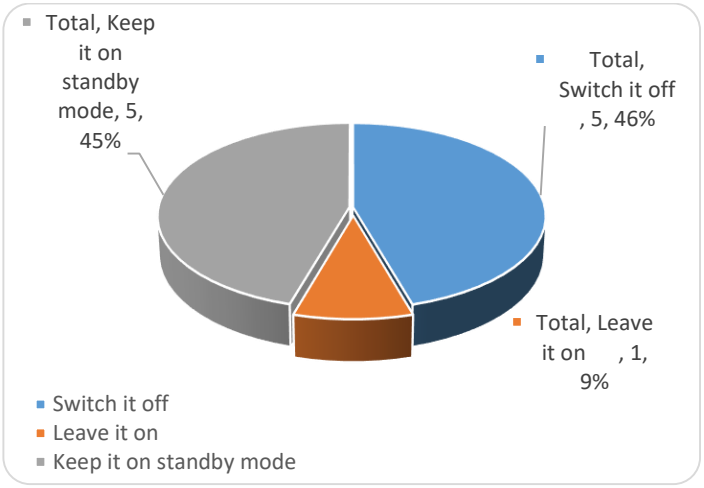

Figure 5.45: Pie Chart shows Computer & laptop mood with percentage (Al-Nahda, Dubai)

5.4.7 Air Conditioning (AC)

Table 5.24 provide overall data for the AC required load according to different assumed time. The calculated load and energy use are almost related to the house area and the number of rooms per house.

Table 5.24 : Approximate required load for A/C during one month for (Al-Nahda, Dubai)

Hour	24 hr	18 hr	12 hr	6 hr
Required Load	41616.000	31211.999	20808.000	10404.000

** The used Appx Average Load (W) 1700 for window/spilt A/C
** Consumption is based on 1 Unit = 1000 Watts per hour

Energy consumption by A/C is considered as one of the items that are related to the occupants' behavior. For that, the questionnaire included questions if they turn A/C off when they leave the house or the room. The figure illustrates the questionnaire result (Figure 5.46).

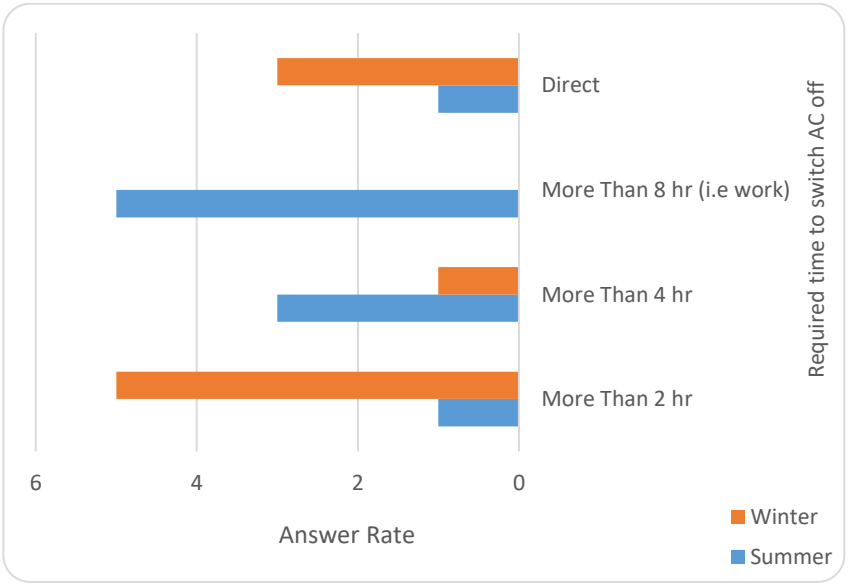

Figure 5.46: Chart shows questionnaire result, if they turn AC off when they left house or room (Al-Nahda, Dubai)

5.5 Dubai Marina Analysis results:

Results of questionnaire investigation for Dubai Marina will be analysis the most important aspects as detailed below:

5.5.1 Basic Buildings information

As mentioned previously, the first part of the questionnaire provides basic information about their building, such as building type, age of construction, number of floors, and room in addition to occupancy pattern. With regard to the construction year of this area. Dubai Marina is considered as the new Dubai area and all buildings were constructed after 2000. It's a vertical development area with high-rise buildings; all buildings were above seven stories. As surveyed, the number of rooms was as 60 % for bedrooms, 29% for living rooms and 11% for others rooms (Figure 5.46). Furthermore, the survey result categorized bedrooms as 50% for 2 bedrooms, 30% for 3 bedrooms and 20% for 1 bedroom.

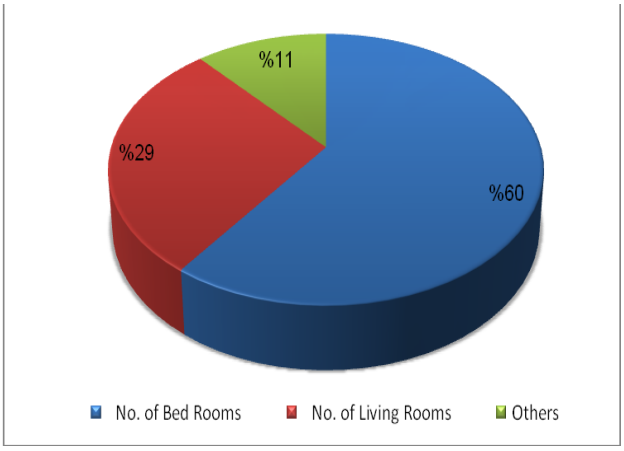

Figure 5.46: Percentage of Rooms for all investigated household (Dubai Marina, Dubai)

As surveyed, the total occupancy numbers per household were summarized in table 5.25. As investigated the number of residents per household for this area was an average of 3.1. The dominant percentage for the residents per household was for families with three members and followed by a household with four members.

Table 5.25 Composition of households (Dubai Marina, Dubai)

Number of persons in the household	2	3	4	5 or More
Percentage of households with the specified number of people	20%	50%	30%	0%

Figure 5.47 illustrates the occupancy patterns during the day. It clearly shows that most of the household residents would be away from home between 6:00 am to 2:00 pm and only about 9% of the household members would stay at home during that's time. About 24% of household members would return home from 2:00 pm to 6.00 pm. nearly, after 21.00 pm all the household members would return to home.

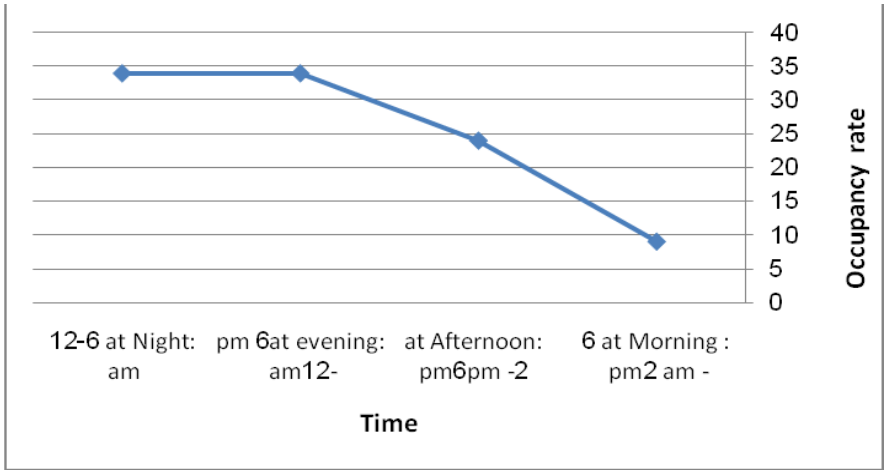

Figure 5.47: Number of occupants that present in the house during the day (Dubai Marina, Dubai)

5.5.2 Water Heaters usage

This part of the research illustrates the water heater usage per household. Figure 5.48a shows that the more consumption of the water heater was during the winter which was up to 82%, while water heater usage does not exceed 18 % in the summer. It's found from figure 5.48b the different timing usage for water heater during winter and summer. The water heater demand reached a maximum during the winter season in the evening followed by the morning and afternoon. But during the summer season, it's almost used during evening and morning, while it's not used during afternoon time.

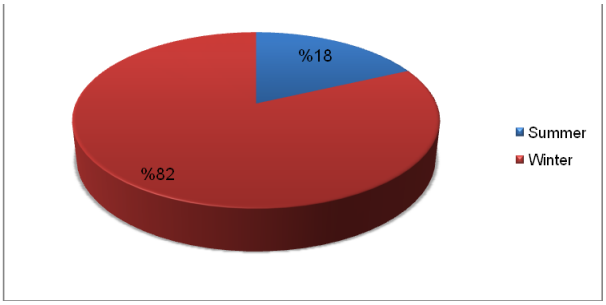

Figure 5.48a: Water heater profile for summer and winter seasons (Dubai Marina, Dubai)

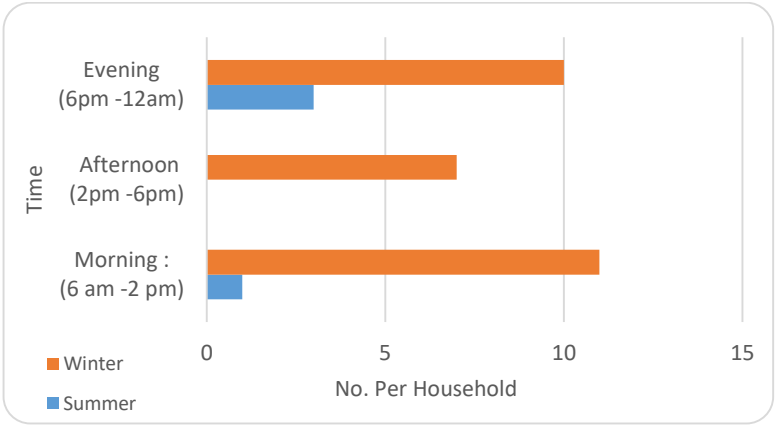

Figure 5.48b: Demand of water heater during the day for summer and winter seasons (Dubai Marina, Dubai)

For Dubai Marina, 91% stated they used a shower compared to 9% using the run bath. The majority claim that they showered once a day which was about 58% compared to 42% showered twice a day. Figure 5.49 shows the shower/ bath demand during the day and reached peak times during morning followed by evening. On the other hand, 46% of households' members claimed that they needed 10 minutes for show, 36% need only 5 minutes and 36% of them need 5 minutes (figure 5.50).

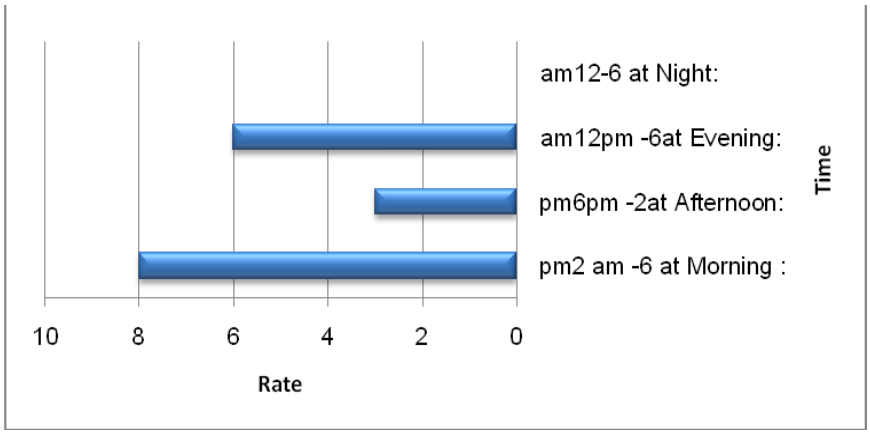

Figure 5.49: Water demand during Day (Dubai Marina, Dubai)

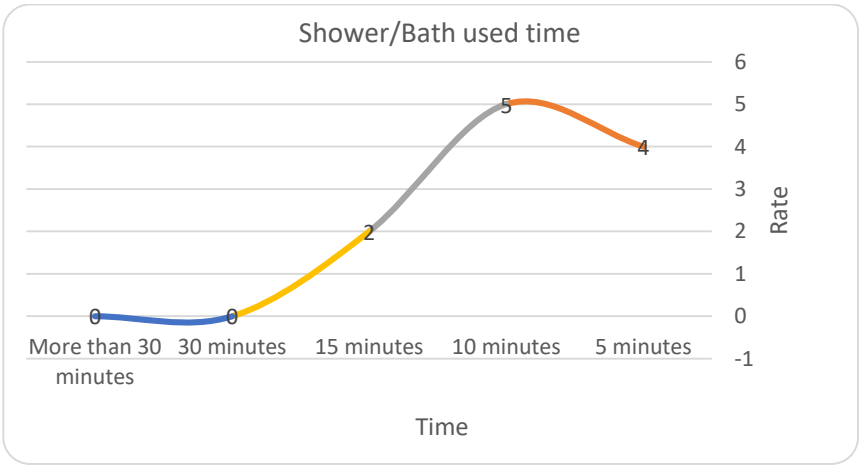

Figure 5.50: Residents' bathing length (Dubai Marina, Dubai)

5.5.3 White Goods

The surveyed household in this area was provided with clothes washers /dryers, cloths iron, dishwashers, and refrigerators. Below the figure, 5.51a shows the using frequency for different white goods items with a range between daily uses, 2-3 times and 4-5 times. Figure 5.51b shows frequency using time for different white goods.

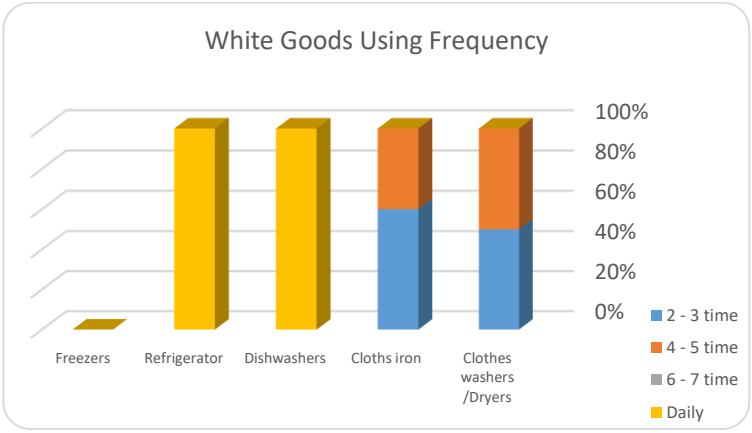

Figure 5.51a: Frequency for different white goods items (Dubai Marina, Dubai)

Figure 5.51b: Pattern of white goods using time (Dubai Marina, Dubai)

Below table 5.26 Provide illustrative data for the amount of consumed energy per day per month. The refrigerators were the largest white goods items that consume energy, consuming 3960 KW monthly.

Table 5.26: Total Units Consumed per white good items (Dubai Marina, Dubai)

White Goods Name	Appx Average Load (W)	Quantity	Total Appx used time (hr)	Total Units Consumed / per Day	Total Units Consumed / per month
Clothes washers /Dryers	700	10	1	7.000	210.000
Electric iron	800	10	3	24.000	720.000
Dishwashers	1300	09	1	11.700	351.000
Refrigerator	550	10	24	132.000	3960.000
Total				174.000	5241.000

Consumption is based on 1 Unit = 1000 Watts per hour

5.5.4 Kitchen & Cooking Appliances

The surveyed kitchen & cooking appliances include electric cooker, microwaves, bread makers/toasters/espresso machines/juicer/rice cooker /others. Table 5.27 Provide illustrative data for amount unit of consumed energy per day and per month for mentioned items. The electric cooker was consumed more energy and accounted for 2160.000 KW per month.

Table 5.27: Total Units Consumed per Kitchen & Cooking Appliances (Dubai Marina, Dubai)

Kitchen & Cooking Appliances	Appx Average Load (W)	Quantity	Total Appx used time (hr)	Total Units Consumed / per Day	Total Units Consumed / per month
electric cooker	1000	06	12	72.000	2160.000
microwaves	1000	10	3.5	50.000	1500.000

Bread makers / Toasters /Espresso Machines / Juicer /rice cooker /others	650*	18	5	58.500	1755.000
Consumption is based on 1 Unit = 1000 Watts per hour					
*Bread makers / Toasters /Espresso Machines / Juicer /rice cooker have different load & 650 is calculated as an average load for mentioned appliances					

The questionnaire also contained a question of whether the users were examined power and voltage ratings when they buy an electrical appliance. 80% claimed that they checked power rating compared to 20% they checked nothings (Figure 5.52)

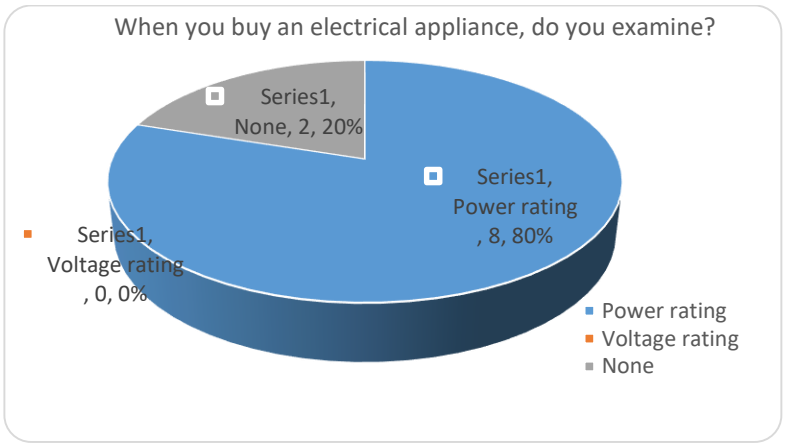

Figure 5.52: Percentage of what was examined when buying electrical appliance (Dubai Marina, Dubai)

5.5.5 Home Entertainment

The surveyed, all households stated that they have LCD/Plasma TV and 45% have items such as Sat, DVD, Video, and Stereo. Table 5.28 Provide illustrative data for the amount of consumed energy per day and per month. TV consumed more energy than others entertainment items because

it was used by all household members and used between 8 to 12 hr daily (Figure 5.53a). The peak time for the use of entertainment items range between evening and afternoon time (Figure 5.53b)

Table 5.28: Total Units Consumed per home entertainment for each 1hr per day and month (Dubai Marina, Dubai)

home entertainment	Appx Average Load (W)	Quantity	Total Units Consumed / per Day	Total Units Consumed / per month
TV (LCD/Plasma)	300	15	4.500	135.000
Sat/DVD/Video/Stereo	118*	12	1.416	42.480

Consumption is based on 1 Unit = 1000 Watts per hour

* Sat/DVD/Video/Stereo have different load & 118 is calculated as an average load for mentioned appliances

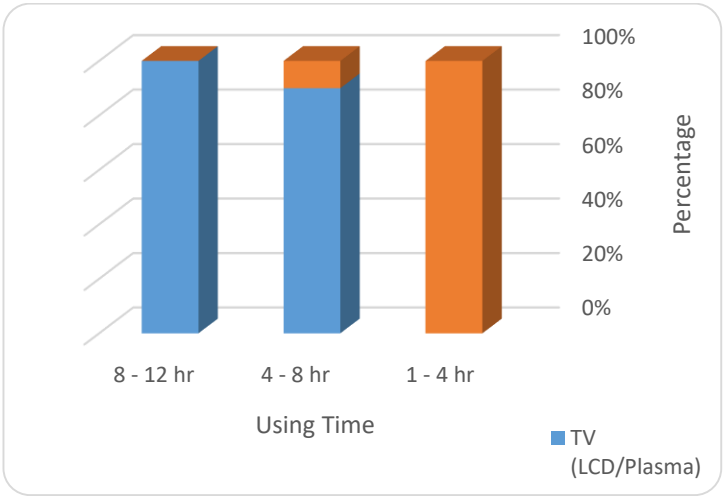

Figure 5.53a: Chart shows frequency of using home entertainment items per day (Dubai Marina, Dubai)

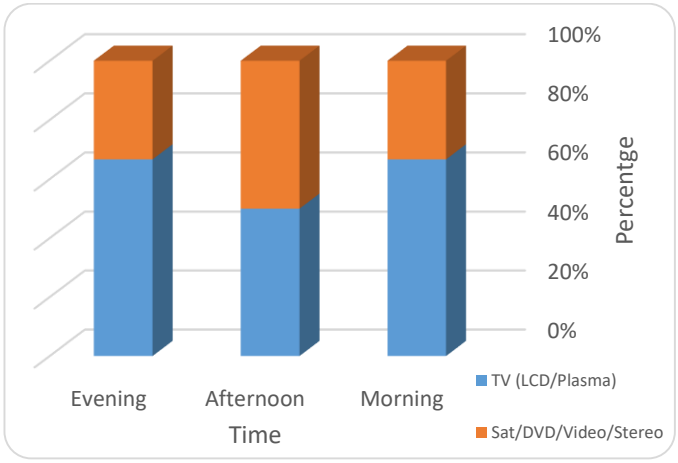

Figure 5.53b: Chart shows home entertainment items pattern per day (Dubai Marina, Dubai)

5.5.6 Computers and Peripherals

The consumed energy for computers, laptops, printers, scanners, and fax item depends on quantity and the approximate used time. Table 5.28 Provide illustrative data for the amount of consumed energy per day and per month. Laptops are considered as more energy consumption.

Table 5.28: Total Units Consumed per Computers and Peripherals for each 1hr per day and month (Dubai Marina, Dubai)

Computers and Peripherals	Appx Average Load (W)	Quanti ty	Total Units Consumed / per Day	Total Units Consumed / per month
Desk Top	200	03	0.600	18.000
Laptop	150	11	1.650	49.500
Printer / Scanner /Fax /Others	135*	10	1.350	40.500
Consumption is based on 1 Unit = 1000 Watts per hour				

* Printer / Scanner /Fax /have different load & 135 is calculated as an average load for mentioned appliances

By Asked household members if they were switched computer and laptop off, leave it on, or kept it on standby mode. The majority (62%) claimed that they were switched it off and 38% were kept it on standby mood (Figure 5.54).

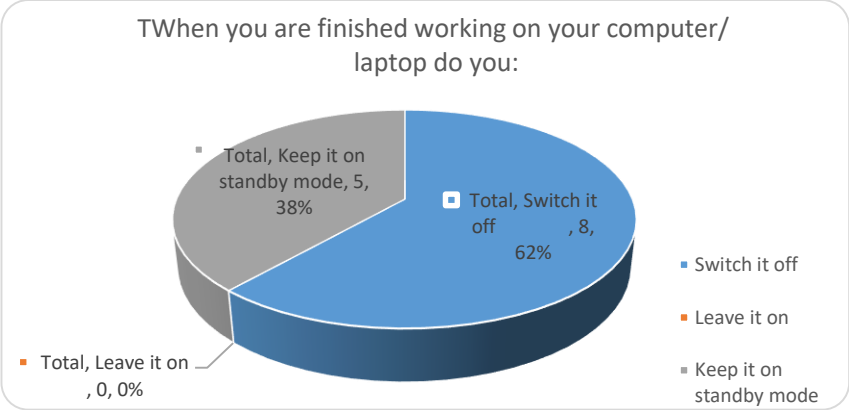

Figure 5.54: Pie Chart shows Computer & laptop mood with percentage (Dubai Marina, Dubai)

5.5.7 Air Conditioning (AC)

A/C is calculated by calculating the total number of bedrooms, living rooms, and kitchens for Dubai Marina. The total approximated required load of A/C as below table (5.8)

Table 5.29 : Approximate required load for A/C during one month for Total Units (Dubai Marina, Dubai)

Hour	24 hr	18 hr	12 hr	6 hr
Required Load	50184.000	37638.000	25092.000	12546.000

** The used Appx Average Load (W) 1700 for window/spilt A/C
** Consumption is based on 1 Unit = 1000 Watts per hour

Energy consumption by A/C is considered as one of the items that are related to the occupants' behavior. For that, the questionnaire included a question about whether they turn A/C off when they leave the house or the room. The figure illustrates the questionnaire result (Figure 5.11).

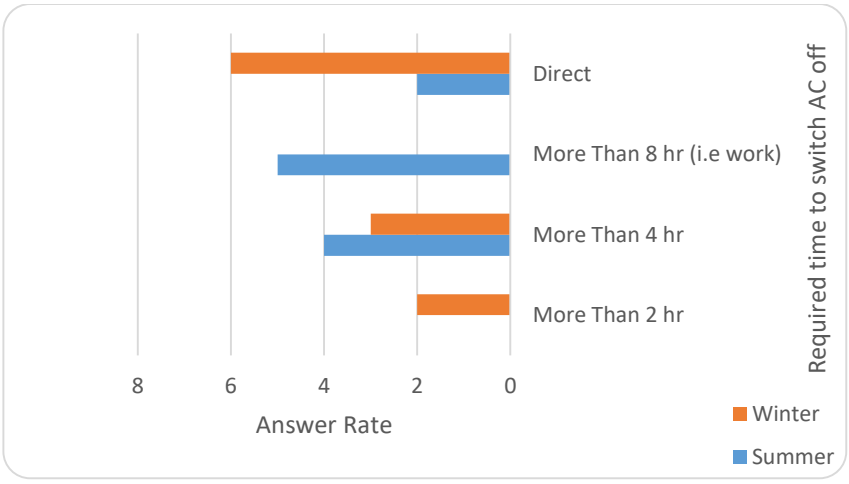

Figure 5.55: Chart shows questionnaire result, if they turn AC off when they left house or room (Dubai Marina, Dubai)

5.6 International city Analysis results:

Results of questionnaire investigation for the International city will be analysis the most important aspects as detailed below:

5.6.1 Basic Buildings information

The international city is a new development area in Dubai which constructed after 2000. The survey building rang between low-rise buildings and high-rise buildings. As surveyed, the number of rooms was 61 % for bedrooms, 32% for living rooms, and 7% for other rooms (Figure 5.56).

Furthermore, the survey result categorized bedrooms as 50% for 2 bedrooms, 30% for 3 bedrooms, and 20% for 1 bedroom.

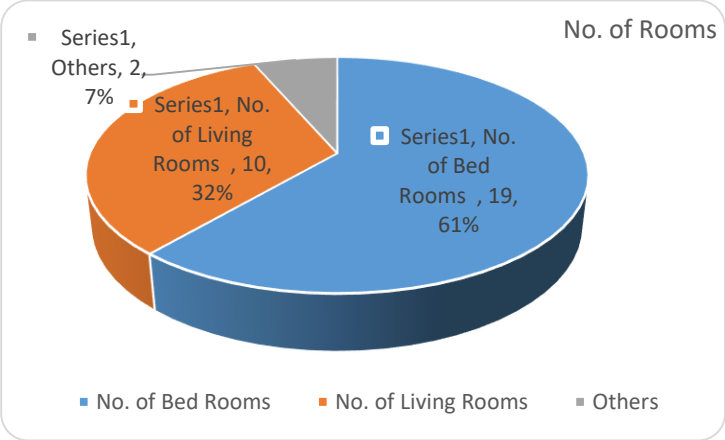

Figure 5.56: Percentage of Rooms for all investigated household (International city, Dubai)

As surveyed, the total occupancy numbers per household were summarized in table 5.30. As investigated the number of residents per household for this area was an average of 3.2. The dominant percentage for the residents per household was ranged between families with three members and four members.

Table 5.30 Composition of households (International city, Dubai)

Number of persons in the household	2	3	4	5 or More
Percentage of households with the specified number of people	20%	40%	40%	0%

Figure 5.57 illustrates the occupancy patterns during the day. It clearly shows that most of the household residents would be away from home between 6:00 am to 2:00 pm and only about 8% of the household members would stay at home during that's time. About 37% of household

members would return home from 6:00 pm. Nearly, after 10.00 pm all the household members would return to home.

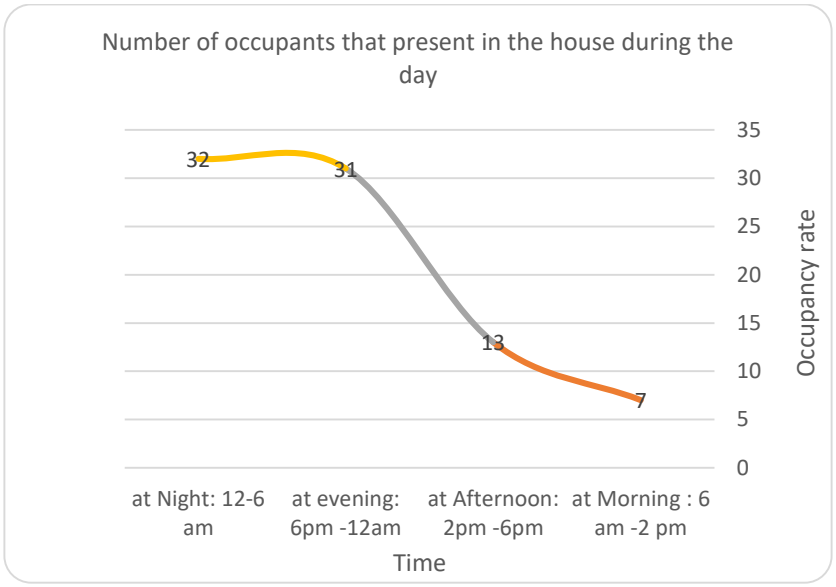

Figure 5.57: Number of occupants that present in the house during the day (International city, Dubai)

5.6.2 Water Heaters usage

This part of the research illustrates the water heater usage per household. Figure 5.58a shows that the more consumption of the water heater was during the winter which was up to 84%, while water heater usage does not exceed 16 % in the summer. It's found from figure 5.58b the different timing usage for water heater during winter and summer. The water heater demand reached a maximum during the winter season in the evening followed by the morning and afternoon. But during the summer season, it’s almost used during evening and morning, while it's not used during afternoon time.

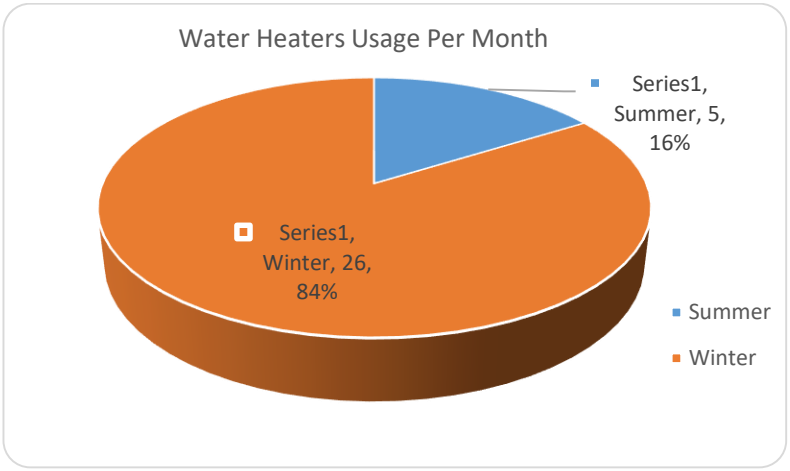

Figure 5.58a: Water heater profile for summer and winter seasons (International city, Dubai)

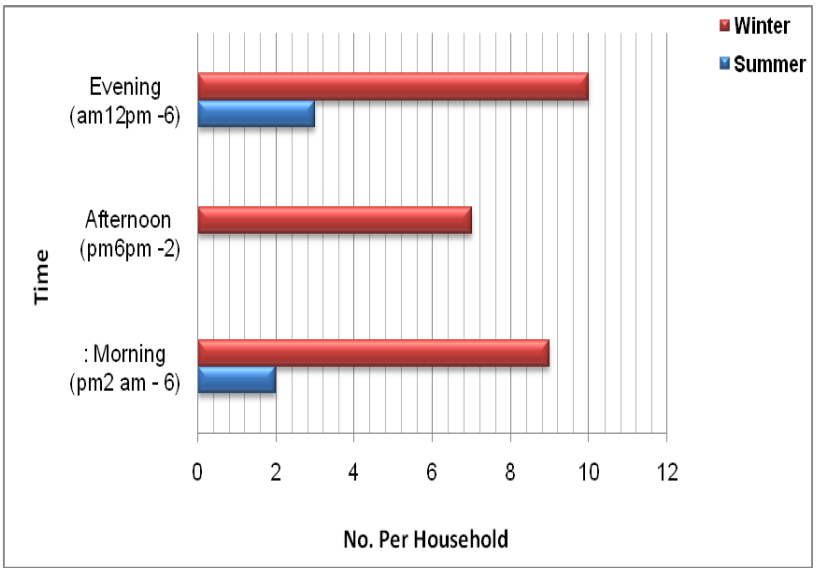

Figure 5.58b: Demand of water heater during the day for summer and winter seasons (International city, Dubai)

In an international city, 83% stated they used a shower compared to 17% using the run bath. The majority claim that they showered once a day which was about 50% compared to 42% showered twice a day. The below figure 5.59a Shows the shower/ bath demand during the day and reached peak times during morning followed by evening. On the other hand, 50% of households' members

claimed that they needed 10 minutes for the show, 20% need10 minutes, 20% need 5 minutes, and 10% need 30 minutes (figure 5.59b).

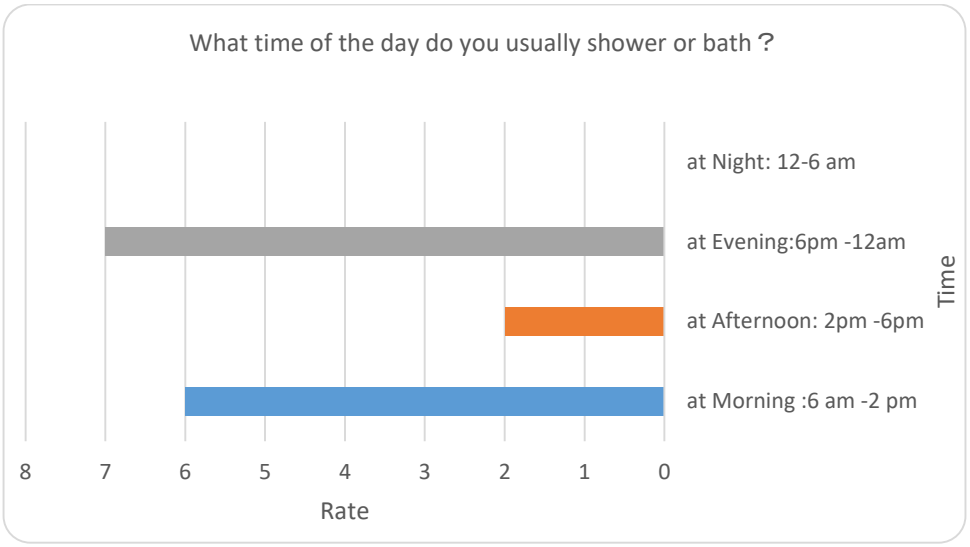

Figure 5.59a: Water demand during Day (International city, Dubai)

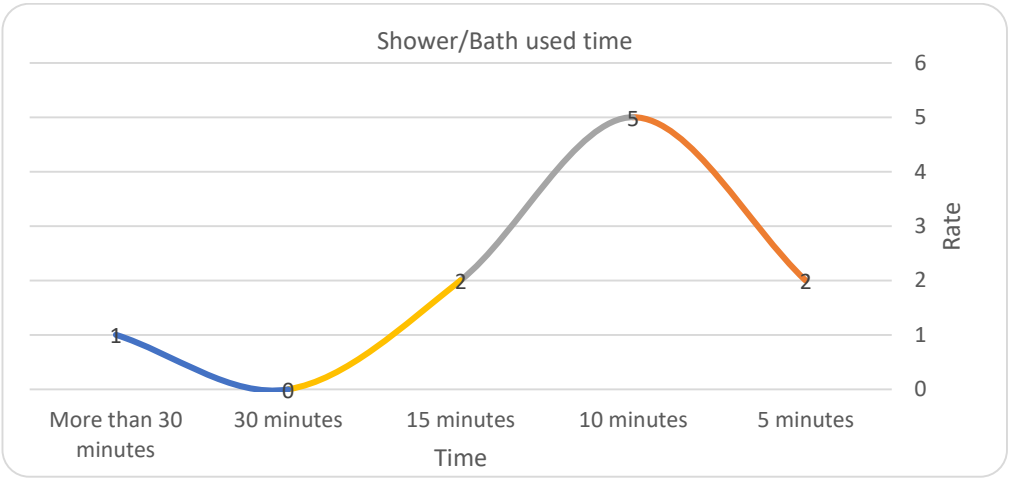

Figure 5.59b: Residents' bathing length (International city, Dubai)

5.6.3 White Goods

The surveyed household in this area was provided with clothes washers /dryers, cloths iron, dishwashers, and refrigerators. Below the figure, 5.60a shows the using frequency for different

white goods items with a range between daily uses, 2-3 times and 4-5 times. Figure 5.60b shows frequency using time for different white goods.

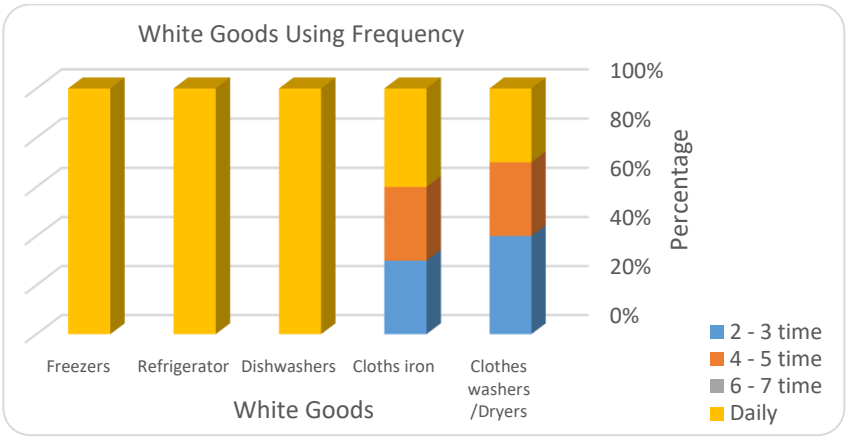

Figure 5.60a: Frequency for different white goods items (International city, Dubai)

Figure 5.60b: Pattern of white goods using time (International city, Dubai)

Below table 5.31 Provide illustrative data for the amount of consumed energy per day and month. The refrigerators were the largest white goods items that consume energy, consuming 3960.000 KW monthly.

Table 5.31: Total Units Consumed per white good items (International city, Dubai)

White Goods Name	Appx Average Load (W)	Quantity	Total Appx used time (hr)	Total Units Consumed / per Day	Total Units Consumed / per month
Clothes washers /Dryers	700	11	1	7.699	230.999
Electric iron	800	12	3	28.800	864.000
Dishwashers	1300	03	1	3.900	117.000
Refrigerator	550	10	24	132.000	3960.000
Freezers	550	1	24	13.200	396.000

- Consumption is based on 1 Unit = 1000 Watts per hour

5.6.4 Kitchen & Cooking Appliances

The surveyed kitchen & cooking appliances include electric cooker, microwaves, bread makers/toasters/espresso machines/juicer/rice cooker /others. Table 5.32 Provide illustrative data for the amount of consumed energy per day and per month for mentioned items. The total energy consumed for items, such as bread makers/toasters/espresso machines/juicer/rice cooker consuming 1072.500 KW monthly.

Table 5.32: Total Units Consumed per Kitchen & Cooking Appliances (International city, Dubai)

Kitchen & Cooking Appliances	Appx Average Load (W)	Quantity	Total Appx used time (hr)	Total Units Consumed / per Day	Total Units Consumed / per month
electric cooker	1000	03	12	36.000	1080.000
microwaves	1000	9	3.5	31.500	945.000
Bread makers / Toasters /Espresso Machines / Juicer /rice cooker /others	650*	11	5	35.750	1072.500
Consumption is based on 1 Unit = 1000 Watts per hour					

*Bread makers / Toasters /Espresso Machines / Juicer /rice cooker have different load & 650 is calculated as an average load for mentioned appliances

The questionnaire also contained a question of whether the users were examined power and voltage ratings when they buy an electrical appliance. 64% claimed that they checked power rating compared to 36% they checked nothings (Figure 5.61)

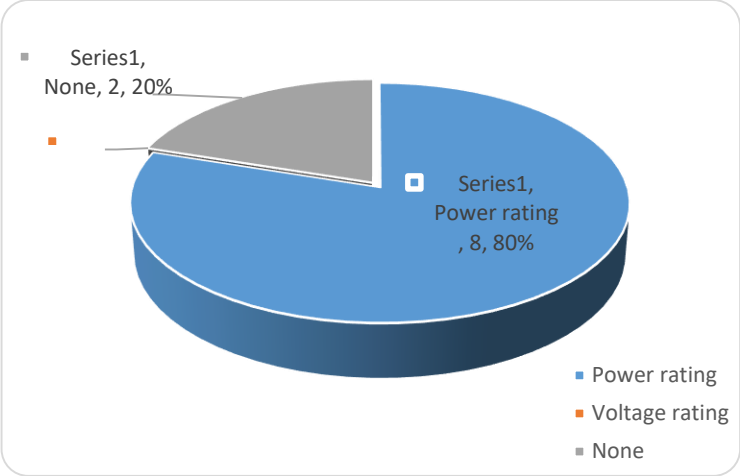

Figure 5.61: Pie Chart shows Computer & laptop mood (International city, Dubai)

5.6.5 Home Entertainment

The surveyed, 48% stated that they have LCD/Plasma TV compared to 35% has tube TV and 17% for items such as Sat, DVD, Video, and Stereo. Table 5.33 Provide illustrative data for the amount of consumed energy per day and month. TV consumed more energy than others entertainment items because it was used by all household members and used between 4 to 8 hr daily (Figure 5.62a). The peak time for the use of entertainment items ranges between evening and afternoon time (Figure 5.62b).

Table 5.33: Total Units Consumed per home entertainment for each 1hr per day and month (International city, Dubai)

home entertainment	App. Average Load (W)	Quantity	Total Units Consumed / per Day	Total Units Consumed / per month
TV (LCD/Plasma)	300	12	3.599	108.000
TV (Tube)	200	04	0.800	24.000
Sat/DVD/Video/Stereo	118*	12	1.416	42.480
Consumption is based on 1 Unit = 1000 Watts per hour				

* Sat/DVD/Video/Stereo have different load & 118 is calculated as an average load for mentioned appliances

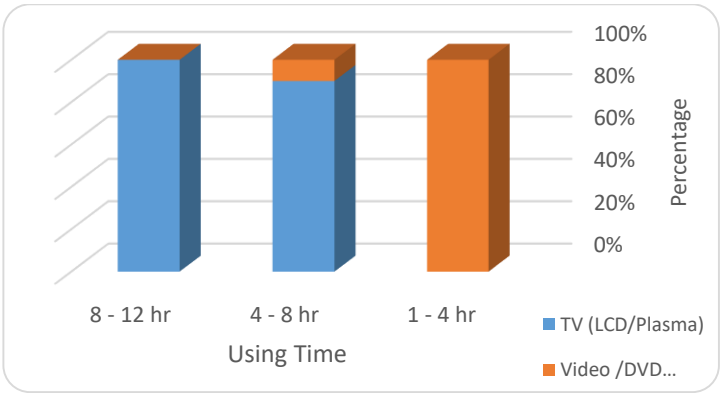

Figure 5.62a: Chart shows frequency of using home entertainment items per day (International city, Dubai)

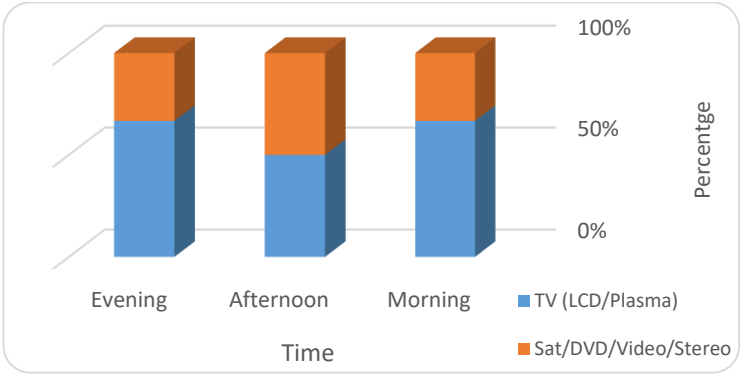

Figure 5.62b: Chart shows frequency of using home entertainment items per day (International city, Dubai)

5.6.6 Computers and Peripherals

Table 5.34 provides illustrative data for the amount of consumed energy per day and month. Laptops and computers consumed more energy than others peripherals since the percent of the laptop was 38%, desktop computers, and 29% and 33% for the other for the printer, fax, etc.

Table 5.34: Total Units Consumed per Computers and Peripherals for each 1hr per day and month (International city, Dubai)

Computers and Peripherals	App. Average Load (W)	Quanti ty	Total Units Consumed / per Day	Total Units Consumed / per month
Desk Top	200	07	1.400	42.000
Laptop	150	19	2.850	85.500
Printer / Scanner /Fax /Others	135*	08	1.080	32.400
Consumption is based on 1 Unit = 1000 Watts per hour				
* Printer / Scanner /Fax /have different load & 135 is calculated as an average load for mentioned appliances				

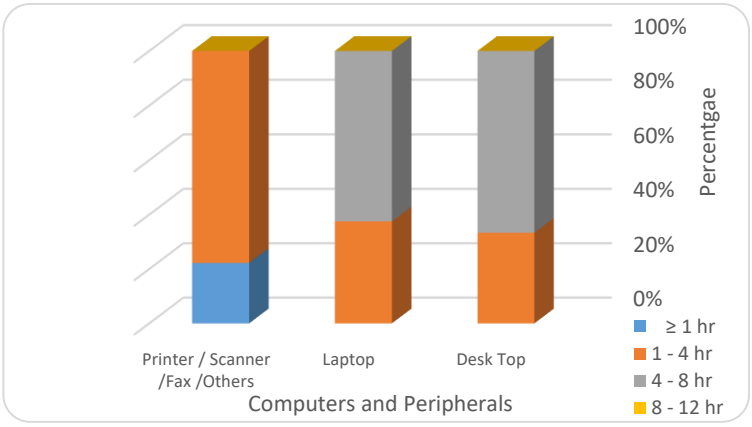

Figure 5.63: Chart shows frequency of using computer and peripherals items per day (International city, Dubai)

By Asked household members if they were switched computer and laptop off, leave it on, or kept it on standby mode. The majority (62%) claimed that they were switched it off and 38% were kept it on standby mood (Figure 5.64).

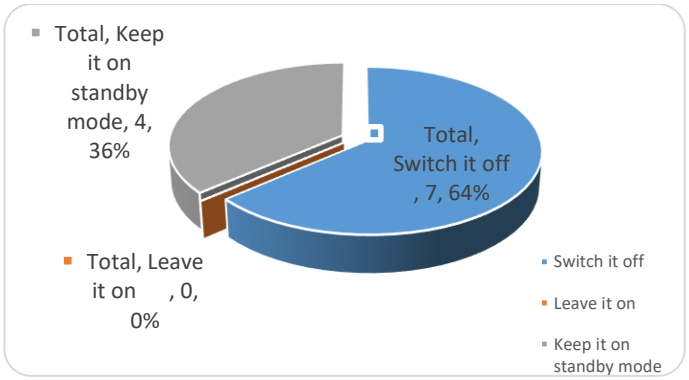

Figure 5.64: Pie Chart shows Computer & laptop mood (International city, Dubai)

5.6.7 Air Conditioning (AC)

Table 5.13 provide overall data for the AC required load according to different assumed time. The bigger households need more AC units than the apartments. By calculating the total number of bedrooms, living rooms, and kitchen the total approximated required load of A/C will as below table (5.35)

Table 5.35: Approximate required load for A/C during one month for (International city, Dubai)

Hour	24 hr	18 hr	12 hr	6 hr
Required Load	23256.000	17442.000	11628.000	5814.000

** The used Appx Average Load (W) 1700 for window/spilt A/C
** Consumption is based on 1 Unit = 1000 Watts per hour

AC energy use is considered one of the items related to the occupants' behavior. For that, the questionnaire included questions if they are turn AC off when they left the house or the room. The figure illustrates the questionnaire result

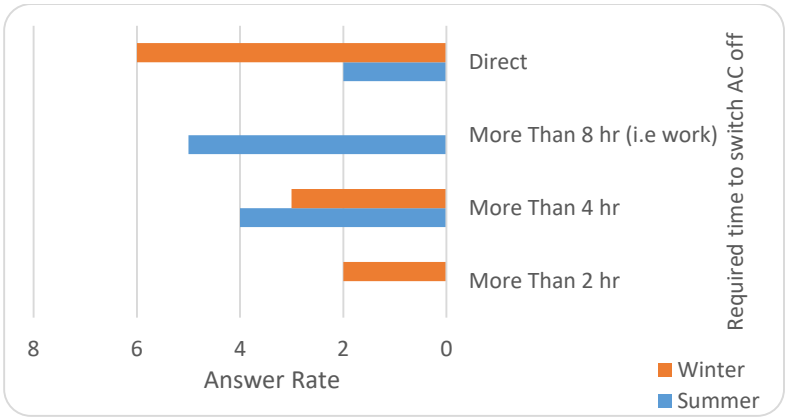

Figure 5.65: Chart shows questionnaire result, if they turn AC off when they left house or room (International city, Dubai).

5.7 Midriff Analysis results:

Results of questionnaire investigation for the International city will be analysis the most important aspects as detailed below:

5.7.1 Basic Buildings information

It is a villa development area in Dubai that consists of different nationalities. The survey building rang between attached and de-attached. As surveyed, the number of rooms was 68 % for bedrooms, 29% for living rooms, and 3% for others rooms (Figure 5.66). Furthermore, the survey result categorized bedrooms as 50% for 2 bedrooms, 30% for 3 bedrooms, and 20% for 1 bedroom.

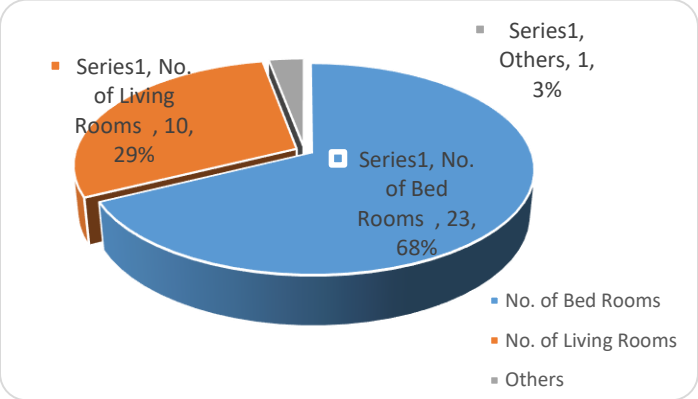

Figure 5.66: Percentage of Rooms for all investigated household (Mirdif, Dubai)

As surveyed, the total occupancy numbers per household were summarized in table 5.36. As investigated the number of residents per household for this area was an average of 3.2. The dominant percentage for the residents per household was ranged between families with four members.

Table 5.36: Composition of households (Mirdif, Dubai)

Number of persons in the household	2	3	4	5 or More
Percentage of households with the specified number of people	21%	22%	45%	22%

Figure 5.67 illustrates the occupancy patterns during the day. It clearly shows that most of the household residents would be away from home between 6:00 am to 2:00 pm and only about 8% of the household members would stay at home during that's time. About 37% of household members would return home from 6:00 pm. Nearly, after 10.00 pm all the household members would return home.

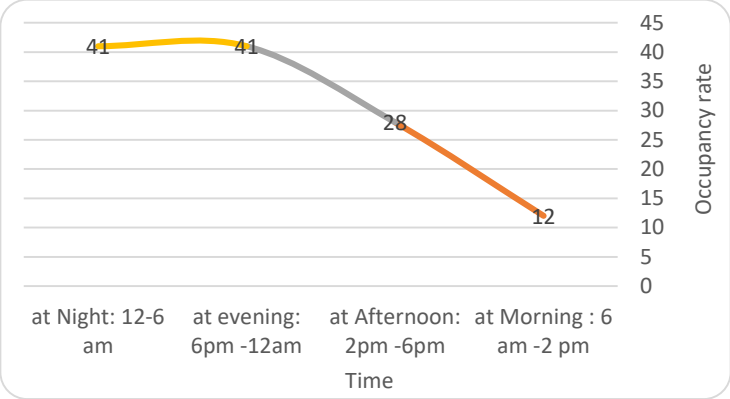

Figure 5.67: Number of occupants that present in the house during the day (Mirdif, Dubai)

5.7.2 Water Heaters usage

This part of the research illustrates the water heater usage per household. Figure 5.78a shows that more consumption of the water heater during the winter was up to 71%, while water heater usage was 29 % in the summer. It's found from figure 5.78b the different timing usage for water heater during winter and summer. The water heater demand reached a maximum during the winter season in the evening followed by the morning and afternoon. But during the summer season it's almost used during morning and evening, whiles it's not used during afternoon time.

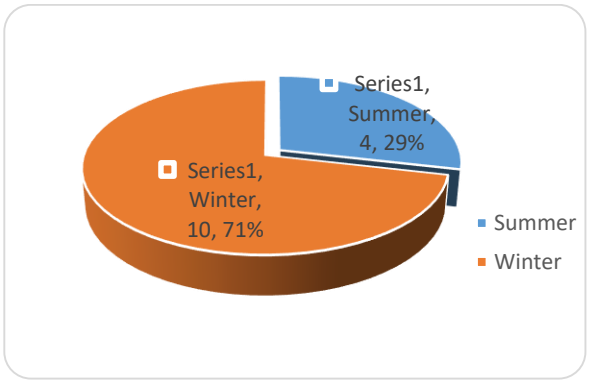

Figure 5.68a: Water heater profile for summer and winter seasons(Mirdif, Dubai)

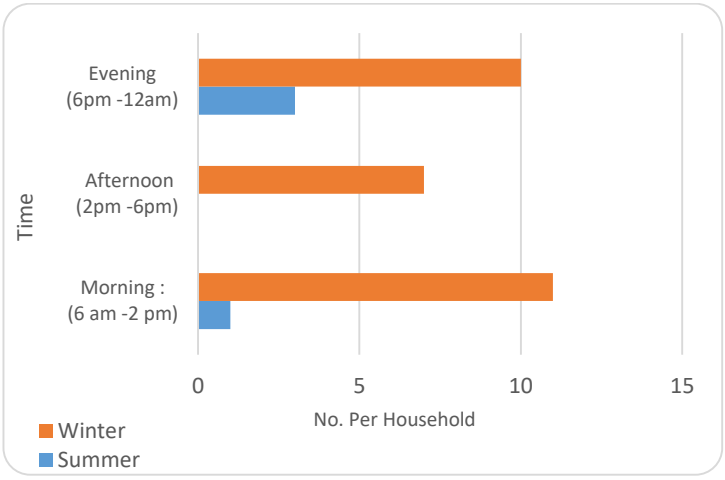

Figure 5.68b: Demand of water heater during the day for summer and winter seasons (Mirdif, Dubai)

For Mirdif, 83% stated they used a shower compared to 17% using the run bath. The majority claim that they showered once a day which was about 60% compared to 40% showered twice a day. The below figure 5.56a Shows the shower/ bath demand during the day and reached peak times during morning followed by evening. On other hand, 50% of households members claimed that they needed 10 minutes for show,30% need 15 minutes, 20% need 5 (figure 5.69b).

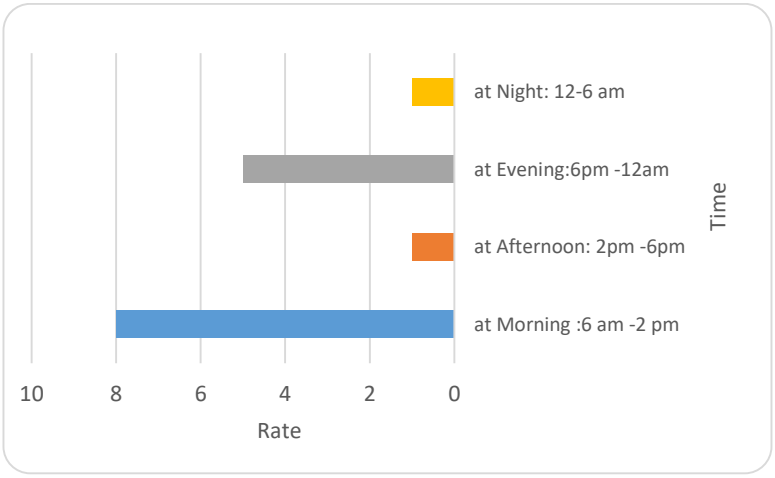

Figure 5.69a: Water demand during Day (Mirdif, Dubai)

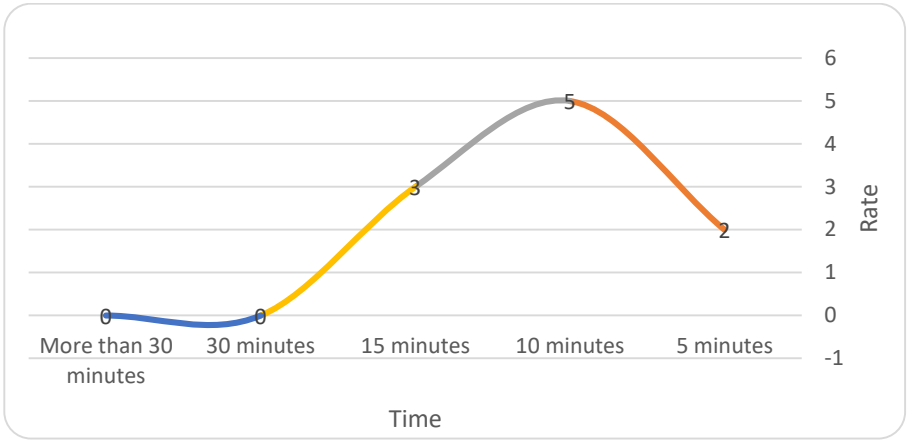

Figure 5.69b : Residents' bathing length (Mirdif, Dubai)

5.7.3 White Goods

The surveyed household in this area was provided with clothes washers /dryers, cloths iron, dishwashers, and refrigerators. Below figure 5.70a shows the using frequency for different white goods items with a range between daily uses, 2-3 times and 4-5 times. Figure 5.70b shows frequency using time for different white goods.

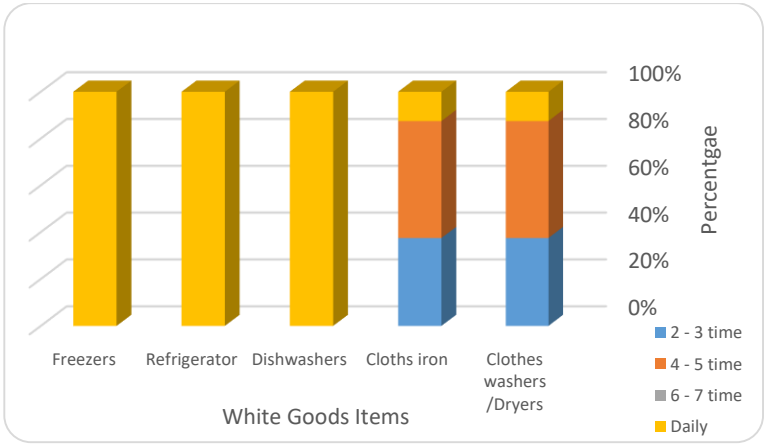

Figure 5.70a: Frequency for different white goods items (Mirdif, Dubai)

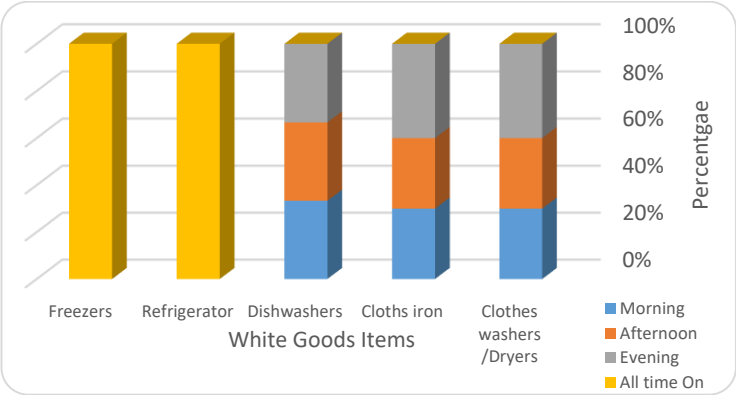

Figure 5.70b: Pattern of white goods using time (Mirdif, Dubai)

Below table 5.37 Provide illustrative data for the amount of consumed energy per day and month. The refrigerator was the largest white goods item that consume energy, consuming 3960.000 KW monthly.

Table 5.37: Total Units Consumed per white good items (Mirdiff, Dubai)

White Goods Name	Appx Average Load (W)	Quantity	Total Appx used time (hr)	Total Units Consumed / per Day	Total Units Consumed / per month
Clothes washers /Dryers	700	10	1	7.000	210.000
Electric iron	800	10	3	8.000	240.000
Dishwashers	1300	10	1	13.000	390.000
Refrigerator	550	10	24	132.000	3960.000

- Consumption is based on 1 Unit = 1000 Watts per hour

5.7.4 Kitchen & Cooking Appliances

Table 5.38 provides illustrative data for the amount of consumed energy per day and per month for kitchen & cooking appliances. The total energy consumed for items, such as bread makers/toasters/espresso machines/juicer/rice cooker consuming 1072.500 KW monthly.

Table 5.38: Total Units Consumed per Kitchen & Cooking Appliances (Mirdif, Dubai)

Kitchen & Cooking Appliances	Appx Average Load (W)	Quantity	Total Appx used time (hr)	Total Units Consumed / per Day	Total Units Consumed / per month
electric cooker	1000	05	12	60.000	1800.000
microwaves	1000	10	3.5	35.000	1050.000
Bread makers / Toasters /Espresso Machines / Juicer /rice cooker /others	650*	15	5	48.750	1462.500
Consumption is based on 1 Unit = 1000 Watts per hour					

*Bread makers / Toasters /Espresso Machines / Juicer /rice cooker have different load & 650 is calculated as an average load for mentioned appliances

The questionnaire also contained a question of whether the users were examined power and voltage ratings when they buy an electrical appliance. 54% claimed that they checked power rating compared to 46% they checked nothings (Figure 5.71)

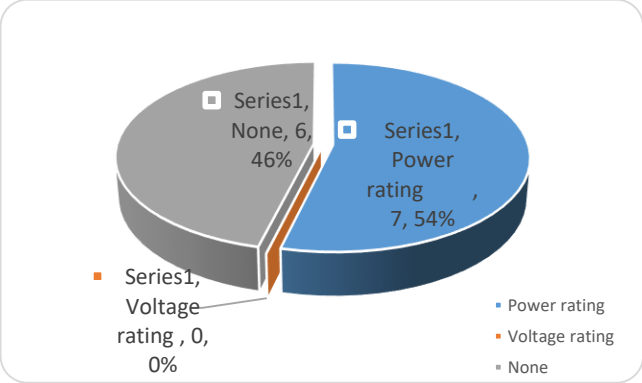

Figure 5.71: Pie Chart shows Computer & laptop mood (Mirdif, Dubai)

Home Entertainment

The surveyed, 42% stated that they have LCD/Plasma TV compared to 41% has tube TV and 17% for items such as Sat, DVD, Video, and Stereo. Table 5.39 Provide illustrative data for the amount of consumed energy per day and month. TV consumed more energy than others entertainment items because it was used by all household members and used between 4 to 8 hr daily (Figure 5.72a). The peak time for the use of entertainment items range between evening and afternoon time (Figure 5.72b)

Table 5.39: Total Units Consumed per home entertainment for each 1hr per day and month (Mirdif, Dubai)

home entertainment	App. Average Load (W)	Quantity	Total Units Consumed / per Day	Total Units Consumed / per month
TV (LCD/Plasma)	300	12	3.599	108.000
TV (Tube)	200	05	2.400	72.000
Sat/DVD/Video/Stereo	118*	12	1.416	42.480
Consumption is based on 1 Unit = 1000 Watts per hour				
* Sat/DVD/Video/Stereo have different load & 118 is calculated as an average load for mentioned appliances				

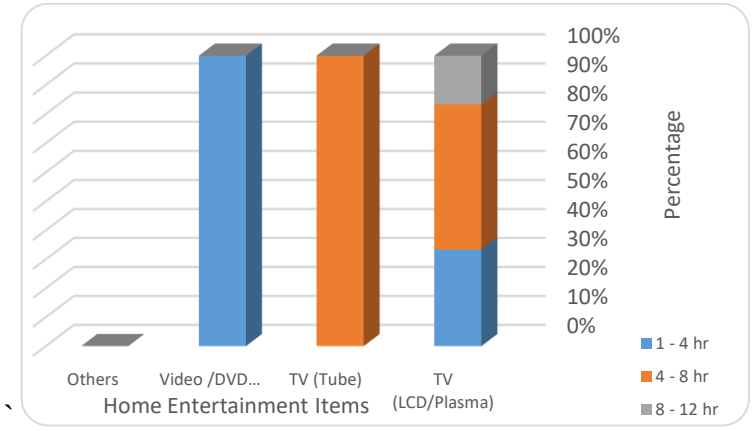

Figure 5.72a: Chart shows frequency of using home entertainment items per day (Mirdif, Dubai)

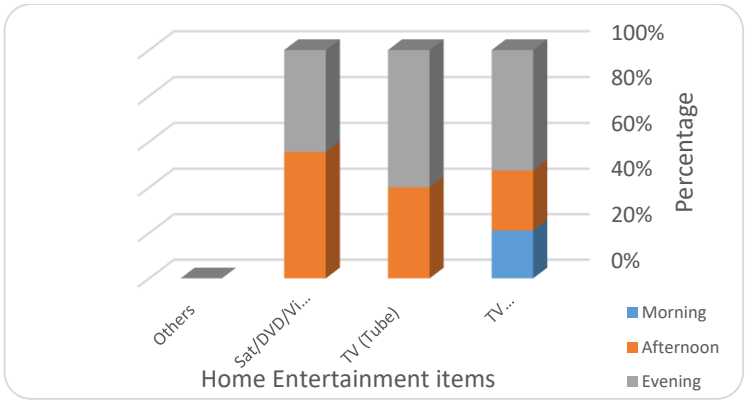

Figure 5.72b: Chart shows frequency of using home entertainment items per day (Mirdiff, Dubai)

5.7.5 Computers and Peripherals

Table 5.40 Provide illustrative data for the amount of consumed energy per day and month. Laptops and computers consumed more energy than other peripherals since the percent of laptops was 31%, desktop computers, and 58% and 11% for the other for printers, fax, etc. Figure 5.73 shows the dominated using time.

Table 5. 40: Total Units Consumed per Computers and Peripherals for each 1hr per day and month (Mirdif, Dubai)

Computers and Peripherals	App. Average Load (W)	Quanti ty	Total Units Consumed / per Day	Total Units Consumed / per month
Desk Top	200	09	1.800	54.000
Laptop	150	08	1.200	36.000
Printer / Scanner /Fax /Others	135*	09	1.215	36.450
Consumption is based on 1 Unit = 1000 Watts per hour				

* Printer / Scanner /Fax /have different load & 135 is calculated as an average load for mentioned appliances

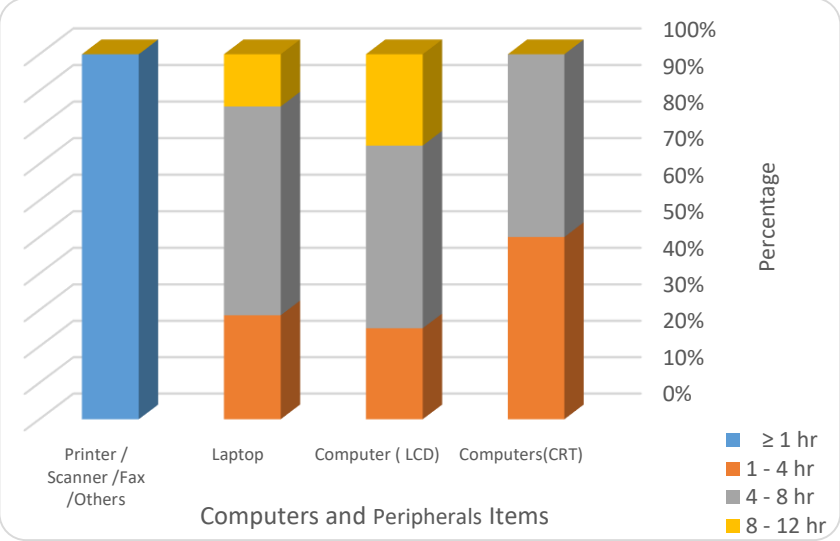

Figure 5.73: Chart shows frequency of using computer and peripherals items per day (Mirdif, Dubai)

By Asked household members if they were switched computer and laptop off, leave it on, or kept it on standby mode. The majority (55%) claimed that they were switched it off and 38% were kept it on standby mood (Figure 5.64).

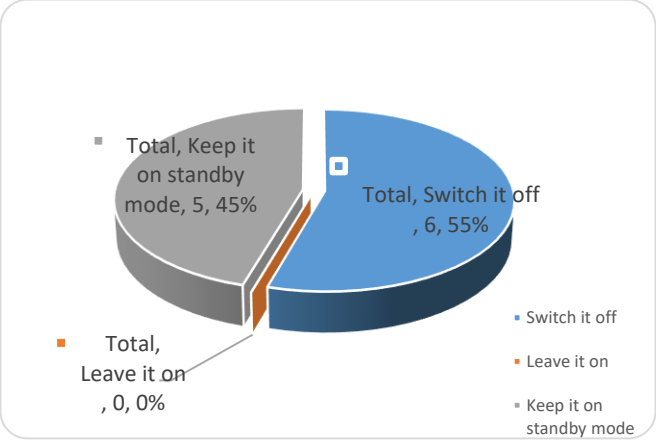

Figure 5.74: Pie Chart shows Computer & laptop mood (Mirdif, Dubai)

5.7.6 Air Conditioning (AC)

Table 5.41 provide overall data for the AC required load according to different assumed time. The bigger households need more AC units than the apartment. By calculating the total number of bedrooms, living rooms, and kitchens.

Table 5.41: Approximate required load for A/C during one month for (Mirdif, Dubai)

Hour	24 hr	18 hr	12 hr	6 hr
Required Load	24768.000	18576.000	12384.000	6192.000

** The used Appx Average Load (W) 1700 for window/spilt A/C
** Consumption is based on 1 Unit = 1000 Watts per hour

AC energy use is considered one of the items related to the occupants' behavior. For that, the questionnaire included questions if they are turn AC off when they left the house or the room. The figure illustrates the questionnaire result (Figure 5.75).

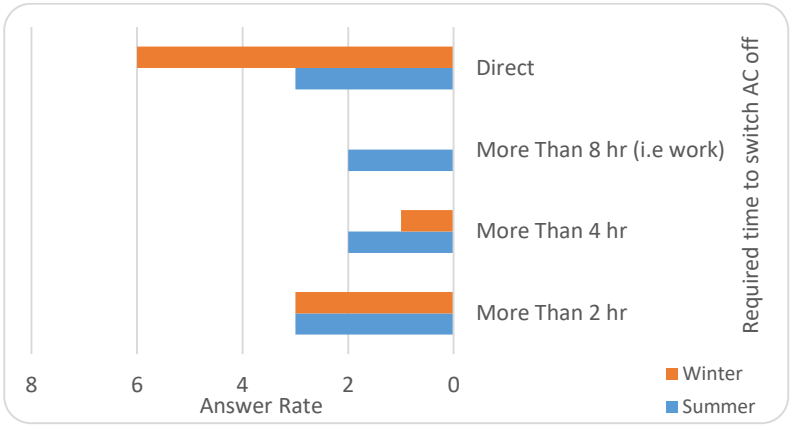

Figure 5.75: Chart shows questionnaire result, if they turn AC off when they left house or room (Mirdif, Dubai)

5.8 Al Satwa Analysis results:

Results of questionnaire investigation for Al Satwa will be analysis the most important aspects as detailed below:

5.8.1 Basic Buildings information

Age of construction for this area as 10% constructed before 1980, 30% “between” 1980 to 1990 and 60% constructed “between” 1990 to 2000. On other hand, 20% of investigated as individual villas and 80% as Arabic houses. Also, 90% were with one story and 10% with two stories. As surveyed, the number of rooms was 62 % for bedrooms, 25% for living rooms, and 13% for others rooms (Figure 5.76). Furthermore, the survey result categorized bedrooms as 30% for 3 bedrooms, 50 % for 4 bedrooms, and 20% for 5 bedrooms.

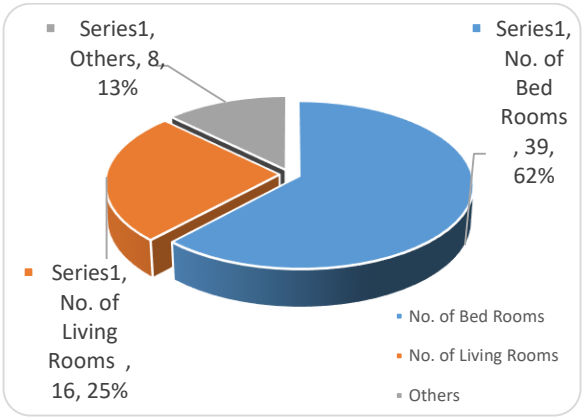

Figure 5.76: Percentage of Rooms for all investigated household (Al Satwa, Dubai)

As surveyed, the total occupancy numbers per household were summarized in table 5.42. As investigated the number of residents per household in this area was an average of 5.5. The dominant percentage for the residents per household was for families with five and six members.

Table 5.42 : Composition of households (Al-Satwa, Dubai)

Number of persons in the household	4	5	6	7 or More
Percentage of households with the specified number of people	20%	30%	37%	20%

Figure 5.77 illustrates the occupancy patterns during the day. It clearly shows that most of the household residents would be away from home between 6:00 am to 2:00 pm and only about 6% of the household members would stay at home during that's time. About 39% of household members would return home after 6.00 pm.

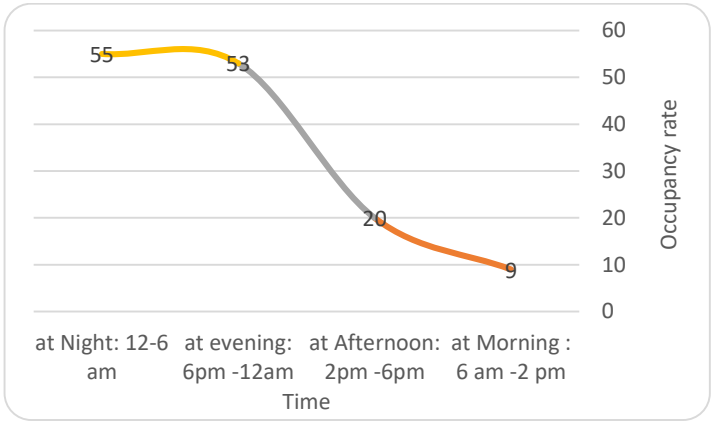

Figure 5.77 : Number of occupants that present in the house during the day (Al Satwa, Dubai)

5.8.2 Water Heaters usage

This part of the research illustrates the water heater usage per household. Figure 5.78a shows that more consumption of the water heater during the winter was up to 82%, while water heater usage was 18 % in the summer. It's found from figure 5.78b the different timing usage for water heater during winter and summer. The water heater demand reached a maximum during the winter season in the evening followed by the morning and afternoon. But during the summer season, it's almost used during morning and evening, while it's not used during the afternoon time.

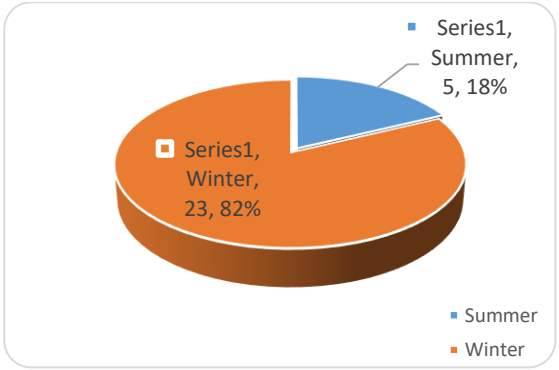

Figure 5.78a: Water heater profile for summer and winter seasons(Al Satwa, Dubai)

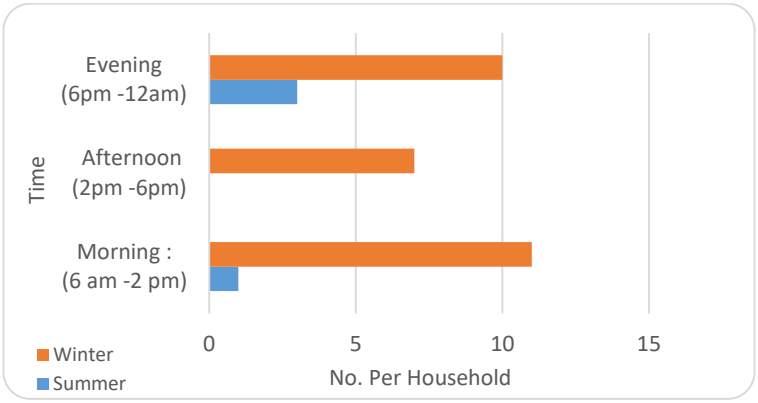

Figure 5.78b: Demand of water heater during the day for summer and winter seasons (Al Satwa, Dubai)

For Al-Satwa, 100% stated they used the shower bathing method. The majority claim that they showered once a day which was about 82% compared to 18% showered twice a day. The below figure 5.79a Shows the shower/ bath demand during the day and reached peak times during morning followed by evening. On the other hand, 58% of households' members claimed that they needed 10 minutes for the show, 42% they need only need 5 minutes (figure 5.79b).

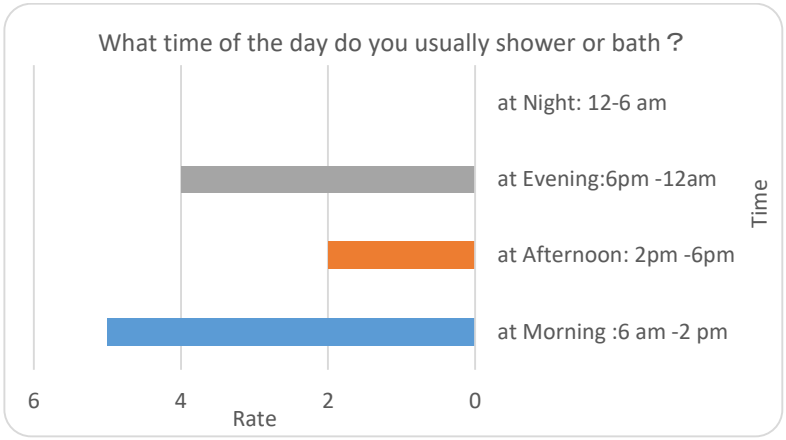

Figure 5.79a: Water demand during Day (Al Satwa, Dubai)

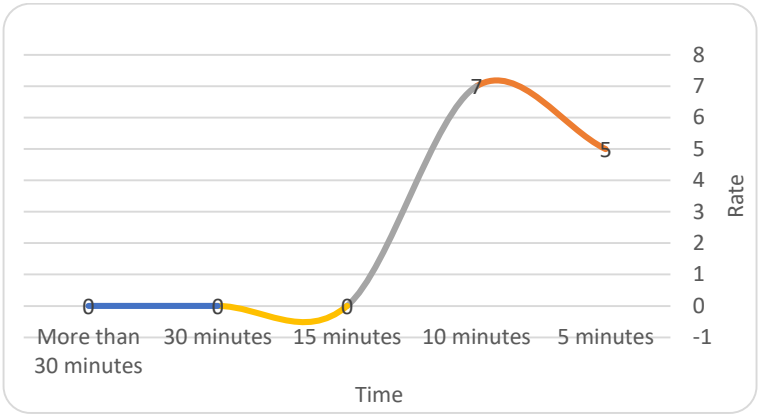

Figure 5.79b : Residents' bathing length (Al Satwa, Dubai)

5.8.3 White Goods

The surveyed household in this area was provided with clothes washers /dryers, cloths iron, dishwashers, and refrigerators. Below the figure, 5.80a shows the using frequency for different white goods items with a range between daily uses, 2-3 times and 4-5 times. Figure 5.80b shows frequency using time for different white goods.

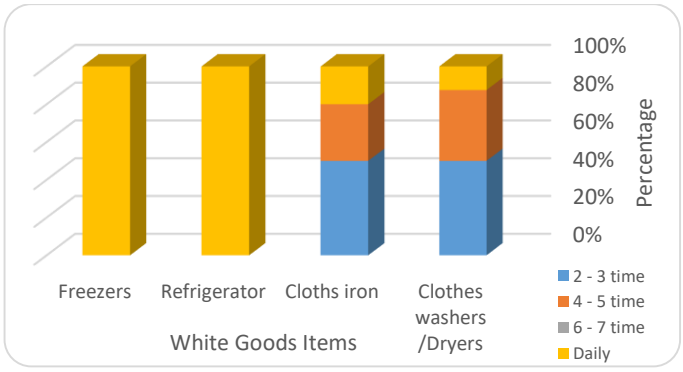

Figure 5.80a: Frequency for different white goods items(Al Satwa, Dubai)

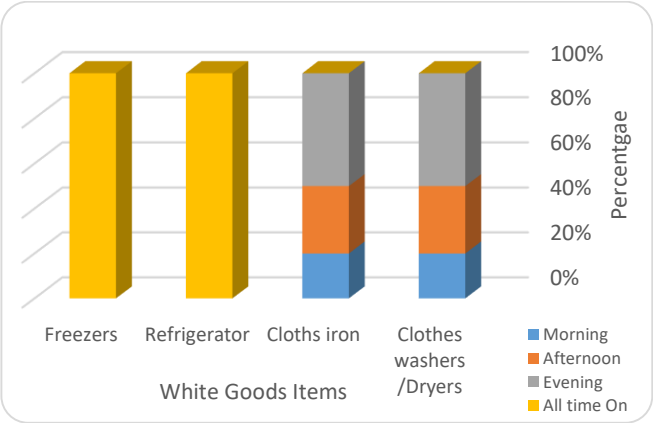

Figure 5.80b: Pattern of white goods using time (Al Satwa, Dubai)

Below table 5.43 Provide illustrative data for the amount of consumed energy per day and month. The refrigerators were the largest white goods items that consume energy, consuming 3960.000 KW monthly.

Table 5.43: Total Units Consumed per white good items (Al Satwa, Dubai)

White Goods Name	Appx Average Load (W)	Quantity	Total Appx used time (hr)	Total Units Consumed / per Day	Total Units Consumed / per month
Clothes washers /Dryers	700	10	1	7.000	210.000
Electric iron	800	10	3	8.000	240.000
Refrigerator	550	10	24	132.000	3960.000
Freezer	550	1	24	13.200	396.000

- Consumption is based on 1 Unit = 1000 Watts per hour

5.8.4 Kitchen & Cooking Appliances

Table 5.44 provides illustrative data for the amount of consumed energy per day and per month for kitchen & cooking appliances. The total energy consumed for items, such as bread makers/toasters/espresso machines/juicer/rice cooker consuming 1267.500 KW monthly.

Table 5.44: Total Units Consumed per Kitchen & Cooking Appliances (Al Satwa, Dubai)

Kitchen & Cooking Appliances	Appx Average Load (W)	Quantity	Total Appx used time (hr)	Total Units Consumed / per Day	Total Units Consumed / per month
microwaves	1000	08	3.5	28.000	840.000
Bread makers / Toasters /Espresso Machines / Juicer /rice cooker /others	650*	13	5	42.250	1267.500

Consumption is based on 1 Unit = 1000 Watts per hour

*Bread makers / Toasters /Espresso Machines / Juicer /rice cooker have different load & 650 is calculated as an average load for mentioned appliances

The questionnaire also contained a question of whether the users were examined power and voltage ratings when they buy an electrical appliance. 55% claimed that they checked power rating compared to 45% they checked nothings (Figure 5.81)

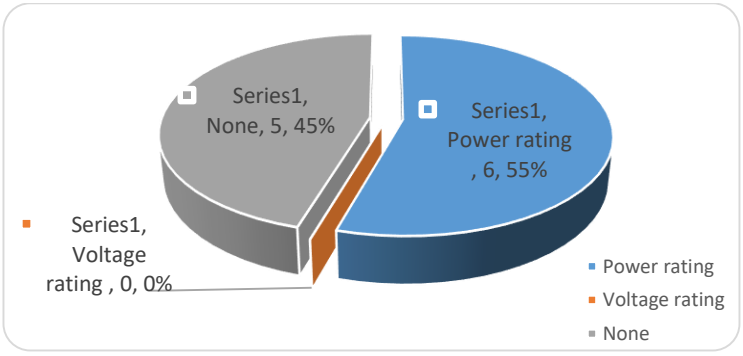

Figure 5.81: Pie Chart shows Computer & laptop mood (Al Satwa, Dubai)

5.8.5 Home Entertainment

Of the surveyed, 15% stated that they have LCD/Plasma TV compared to 41% has tube TV and 15% for items such as Sat, DVD, Video, and Stereo. Table 5.45 Provide illustrative data for the amount of consumed energy per day and month. TV consumed more energy than others entertainment items because it was used by all household members and used between 4 to 8 hr daily (Figure 5.82a). The peak time for the use of entertainment items range between evening and afternoon time (Figure 5.82b)

Table 5.45: Total Units Consumed per home entertainment for each 1hr per day and month (Al Satwa, Dubai)

home entertainment	App. Average Load (W)	Quantity	Total Units Consumed / per Day	Total Units Consumed / per month
TV (LCD/Plasma)	300	12	3.599	108.000
TV (Tube)	200	05	2.400	72.000
Sat/DVD/Video/Stereo	118*	12	1.416	42.480
Consumption is based on 1 Unit = 1000 Watts per hour				
* Sat/DVD/Video/Stereo have different load & 118 is calculated as an average load for mentioned appliances				

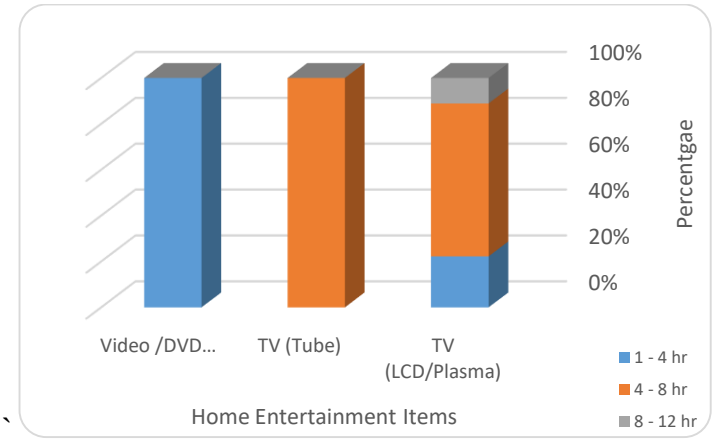

Figure 5.82a: Chart shows frequency of using home entertainment items per day (Al Satwa, Dubai)

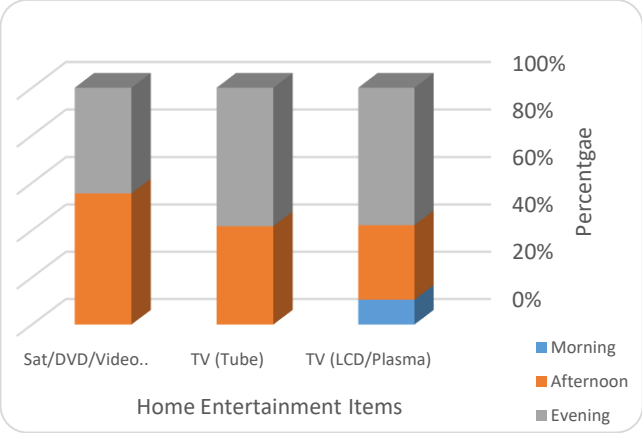

Figure 5.82b: Chart shows frequency of using home entertainment items per day (Al Satwa, Dubai)

5.8.6 Computers and Peripherals

Table 5.46 Provide illustrative data for the amount of consumed energy per day and month. Laptops and computers consumed more energy than others peripherals since the percent of laptops was 38%, desktop computers, and 54% and 8% for the other for printers, fax, etc. Figure 5.83 shows the dominated using time.

Table 5. 46: Total Units Consumed per Computers and Peripherals for each 1hr per day and month (Al Satwa, Dubai)

Computers and Peripherals	App. Average Load (W)	Quanti ty	Total Units Consumed / per Day	Total Units Consumed / per month
Desk Top	200	09	1.800	54.000
Laptop	150	08	1.200	36.000
Printer / Scanner /Fax /Others	135*	09	1.215	36.450
Consumption is based on 1 Unit = 1000 Watts per hour				
* Printer / Scanner /Fax /have different load & 135 is calculated as an average load for mentioned appliances				

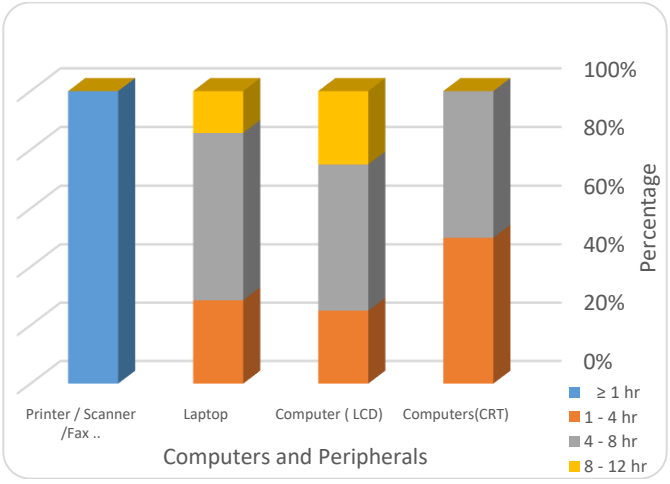

Figure 5.83: Chart shows frequency of using computer and peripherals items per day (Al Satwa, Dubai)

By Asked household members if they were switched computer and laptop off, leave it on, or kept it on standby mode. The majority (62%) claimed that they were switched it off and 38% were kept it on standby mood (Figure 5.84).

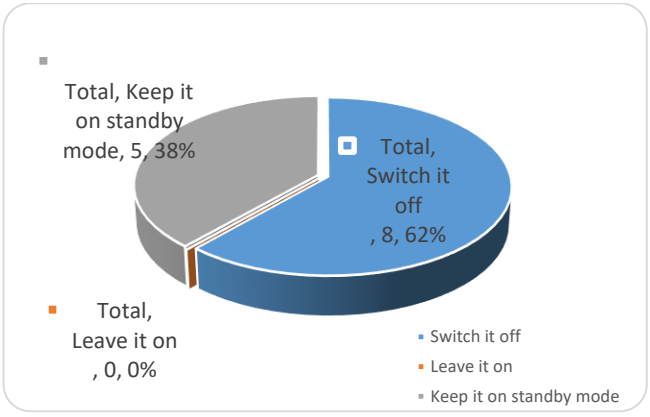

Figure 5.84: Pie Chart shows Computer & laptop mood (Al Satwa, Dubai)

5.8.7 Air Conditioning (AC)

Table 5.47 provide overall data for the AC required load according to different assumed time. The bigger household needs more AC units than the apartments. By calculating the total number of bedrooms, living rooms, and kitchens.

Table 5.47: Approximate required load for A/C during one month for (Al-Satwa, Dubai)

Hour	24 hr	18 hr	12 hr	6 hr
Required Load	79560.000	59669.999	39780.000	19890.000

** The used Appx Average Load (W) 1700 for window/spilt A/C
** Consumption is based on 1 Unit = 1000 Watts per hour

AC energy use is considered one of the items related to the occupants' behavior. For that, the questionnaire included questions if they are turn AC off when they left the house or the room. The figure illustrates the questionnaire result (Figure 5.85).

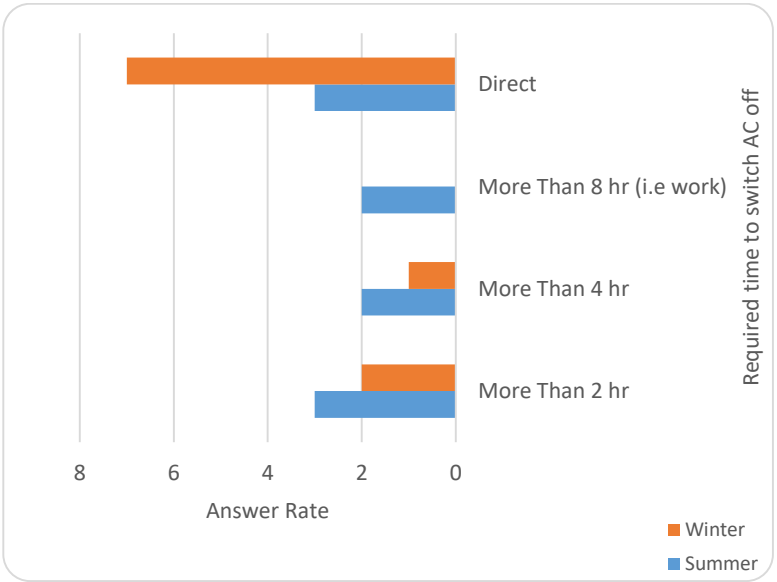

Figure 5.85: Chart shows questionnaire result, if they turn AC off when they left house or room(Al Satwa, Dubai)

5.9 Comparison results between all regions:

A domestic energy consumption survey was being used to collect information for eight different regions all around Dubai. Comparison results between all regions were presented to provide an illustrated details across the selected regions and provide differences of energy consumption of the selected areas. In addition to that, investigate factors that might affect energy consumption such as building area, nationally or occupants' number.

Currently, there is no statistical standard for the occupancy density within households. But based on the collected data from the distributed surveys, the occupancy numbers are summarized in the below figure 5.86. It was clear that culture influence the number of occupants per household for that, the Nad-Alhammer area had the higher average of occupant per household, while Dubai Marina had the lowest rate

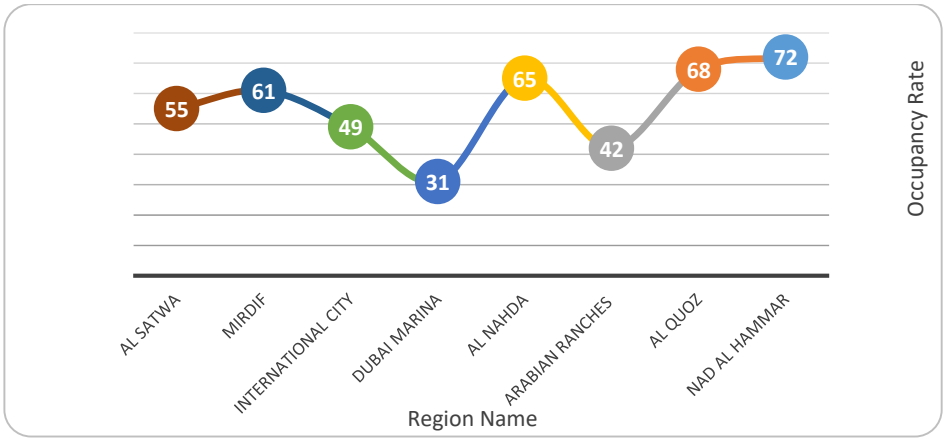

Figure 5.86: Average of Occupancy per regions (Dubai)

Occupants' numbers influence electricity use and have a linear relationship with energy consumption. On other hand, the rate of energy demand varies during the day and depends on the

number of residents during the day. Below figure (5.87) shows the Occupancy pattern for all regions. It's clear that occupancy pattern presented as four periods as below:

Morning (6 am – 2 pm): most of the household residents would be away from home, members would stay at home during that's time and could be adults like mother and maid or could be children's, while other members would be at work or schools.

Afternoon (2 pm – 6 pm): household members would return home

Evening (6 pm-12 am): Almost all household members would return home

Nigh (12 am-6 am): Nearly, after 9.00 pm all the household members be at home.

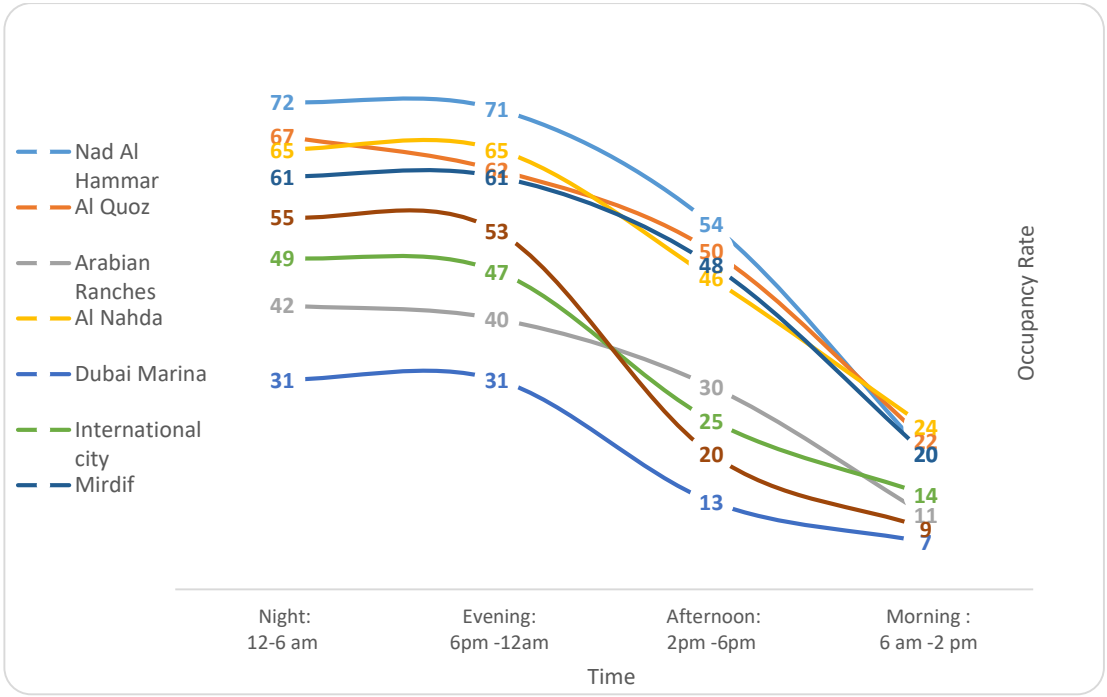

Figure 5.87: Occupancy pattern for selected regions (Dubai)

For water heaters investigation usage, it was found that 17% of the households might use water heaters during summer in the morning or evening time, and almost they were used WH at the beginning period of the summer season. Compared to 83% of them were claimed that they use water heaters during the winter season. The below figure illustrates the different rates of water heater usage between the summers and winter seasons (Figure 5.88). All households' consumption was range "between" 20-30 in winter and "between" 3-9 in summer.

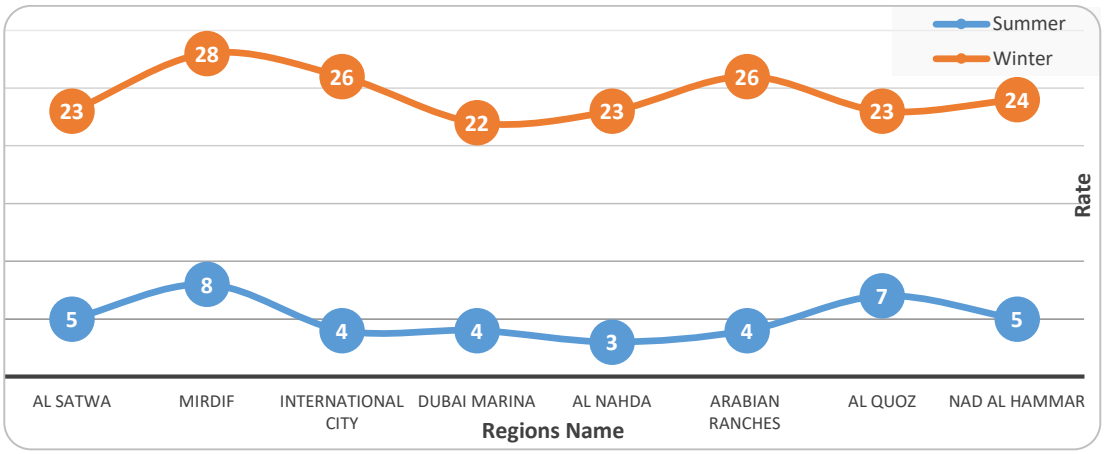

Figure 5.88: Rate of water heater usage during Summer & Winter for the selected regions (Dubai)

The demand for water heaters for all regions during the summer and winter seasons was shown in figure 5.89. It was found during the winter season water heater usage reached a maximum during morning time and evening. While in summer, reached maximum during the evening and followed by morning.

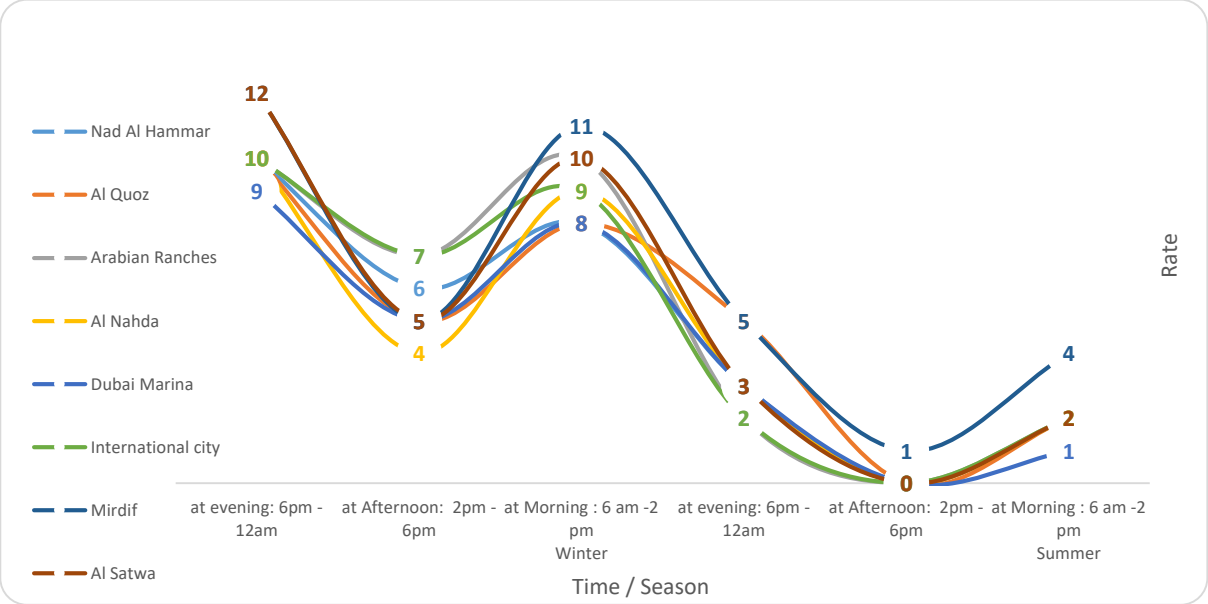

Figure 5.89: Illustrative pattern of water heater usage during Winter & Summer seasons for the selected regions (Dubai)

The approximate energy load required for a water heater is around 1000-2000 watts. The water heater demand for the winter season was a range between 18 to 24 hr, while during the summer season demand was almost during the evening and follows by morning with maximum approximate usage of 6 hr. Table 5.48 provide illustrative data for the water heater usage with different usage time.

Table 5.48 : Approximate required load by Watts during one month for 1 WH

Hour	24 hr	18 hr	12 hr	6 hr
Load (watts)	83160.000	62370.000	41580.000	20790.000

The above load is for one toilet only and the total consumed energy by water heater depends on the number of toilets per household. From, the investigated area, the Nad-Al hammer area was the

largest consumer of water heaters followed by Al-Quoz and Arabian Ranches areas due to the size of houses and number of toilets per household.

Occupants' behavior was investigated by asking them about the bathing method and how long they need for bathing. The majority with 87% were used the shower method compared to 13% for the run bath method. Also, they were claimed that they almost use run baths during the weekend. Moreover, water demand increased during weekends because family members almost stay at home during weekends or present at home more than weekdays.

On other hand, 47% of the occupants stated that they need 10 minutes for showing, while 25% need 15 minutes, 22% need five minutes, 4% need 30 minutes and 2% need more than 30%. Many claimed that shower length depends on different times and would be longer when washing their hair (Figure 5.90). Moreover, the peak time for water usages (shower/ bath) during weekdays was varied between morning and evening time, but it was reached a peak during the afternoon time of Friday and Saturday (Figure 5.91).

Accuracy was difficult to be predicted since it is not a quantitative measurement and is affected by residents' behavior which is a variable factor.

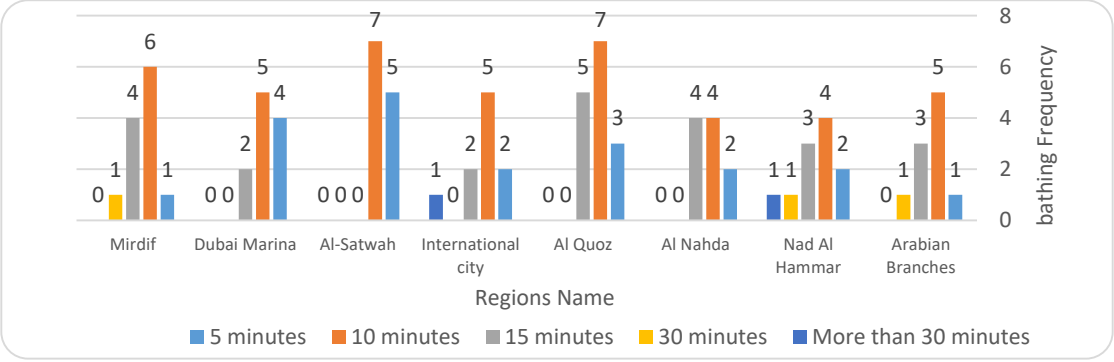

Figure 5.90: Comparison Charts between the selected regions for bathing frequency (Dubai)

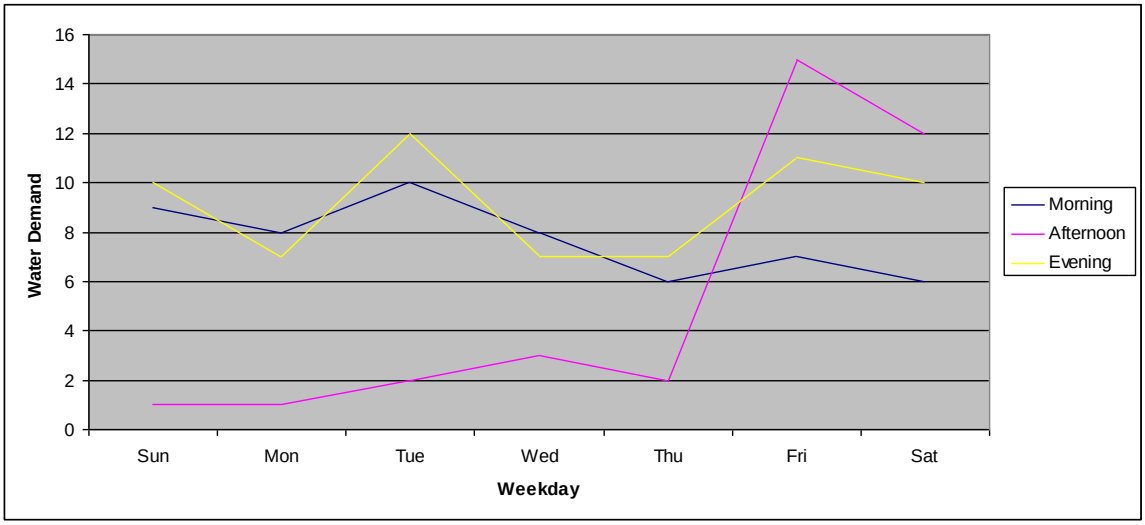

Figure 5.91: Average of Water Demand during weekday & weekend days for the survey area (Dubai)

The surveyed white goods include clothes washers /dryers, cloths iron, dishwashers, refrigerators, and freezers. All households were provided with the mentioned white goods except dishwashers and freezers. Below figure 5.92 shows the using frequency for different white goods, refrigerators and freezers were used daily as 24hr, the dishwashers were used daily between two to three times, while clothes iron and clothes washers were different from house to house, some were claimed that they used those items daily and others usage range between 4 to 5 times weekly or 6 to 7 times weekly. Overall areas, the items were more consumed by Nad Al-Hammar area

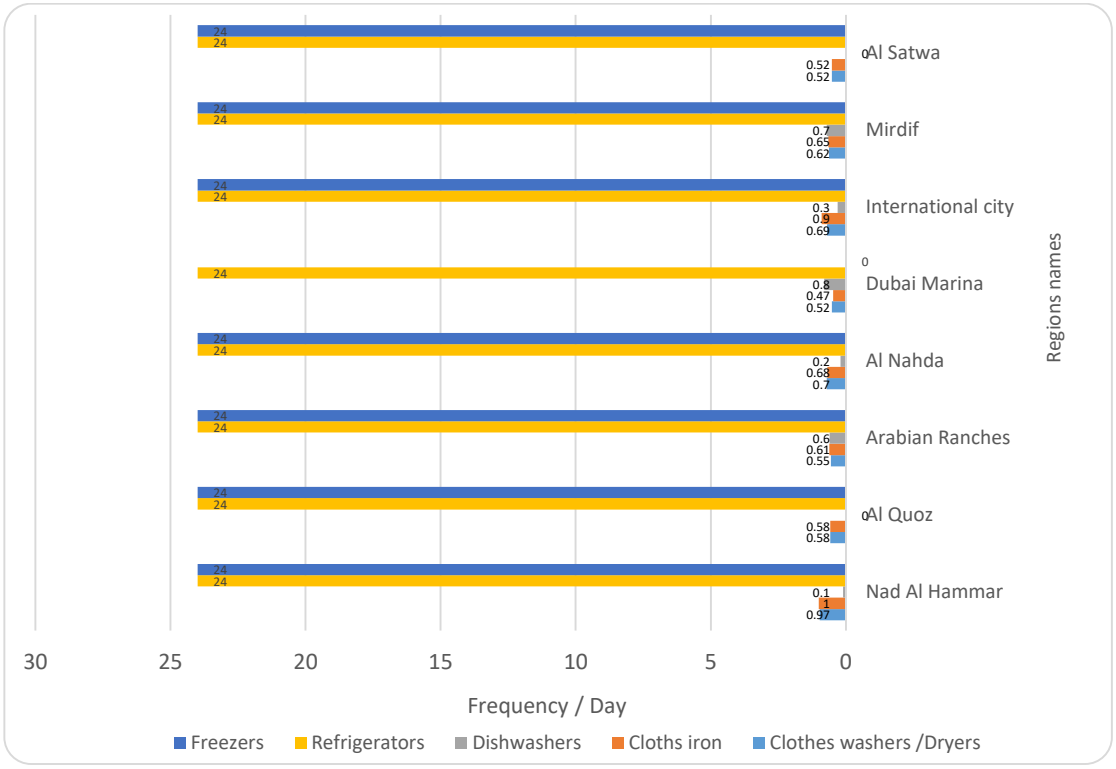

Figure 5.92: Comparison of White goods using frequency between the different regions (Dubai)

The electricity demand increased for the refrigerators and the freezer since it working for 24hr. the required load for each white goods item per day is shown in figure 5.93. The load for refrigerators range “between” 120 – 230 W. Nad Al-Hammer is the largest energy consumer for white goods items, including, refrigerators, freezer, clothes washer/dryer, and clothes iron. That’s due to the number of equipment per household and the frequency of use. Dubai Marina, consider the largest energy consumer for dishwashers because almost all surveyed households were equipped with a dishwasher.

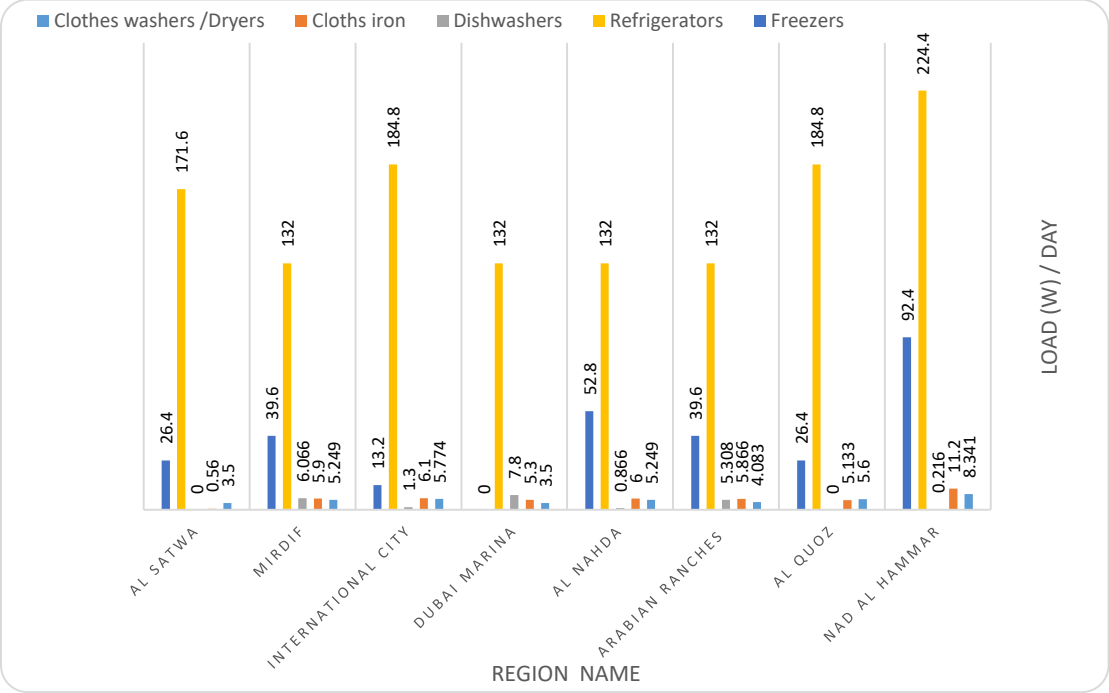

Figure 5.93: Comparison of White goods and required load between the different regions

The surveyed kitchen & cooking appliances include electric cooker, microwaves, bread makers/toasters/espresso machines/juicer/rice cooker /others. The consumed energy for each item depends on quantity and the approximate used time. The number of items per household is almost related to lifestyle and income. Even if the survey does not include information such as level income but it could be assumed according to the household location. Figure 5.94. shows that the Dubai Marina was the biggest consumer for the kitchen and cooking appliance flowed by Mirdif, Nad-Al Hammar, and Arabian Ranches. Figure 5.95 shows the consumption rate for the kitchen & cooking appliances.

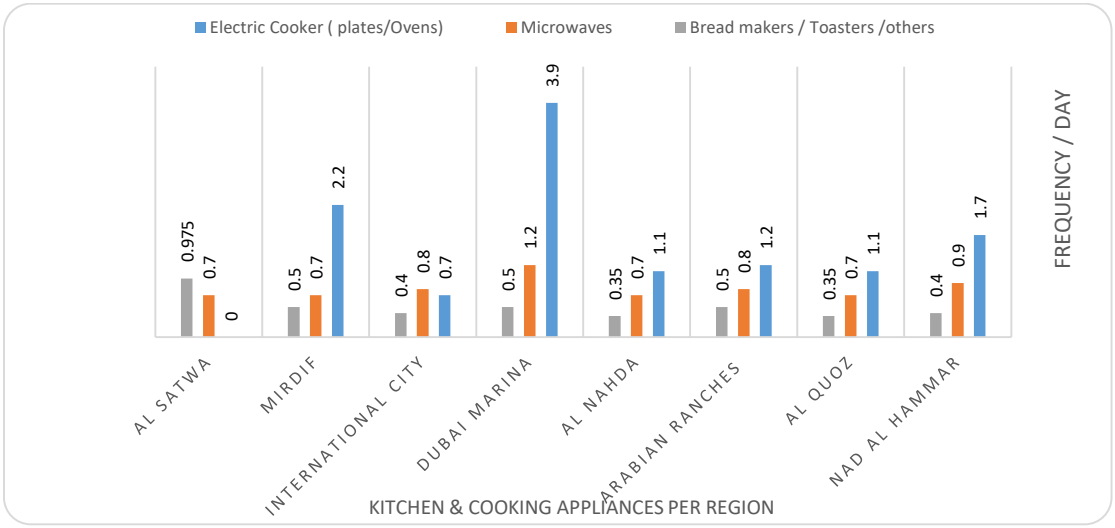

Figure 5.94: Compassion between using the frequency of kitchen & cooking appliance per region

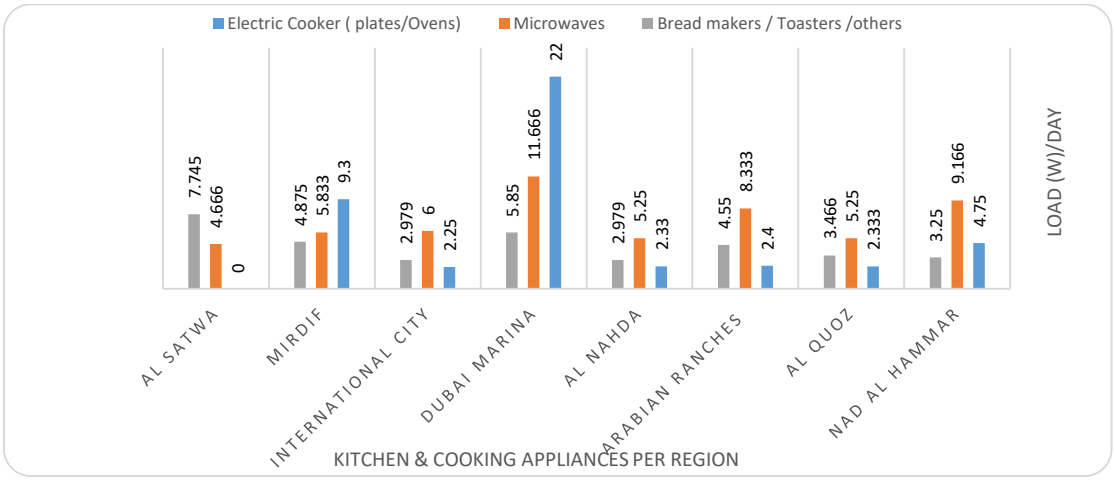

Figure 5.95: Compassion between energy use of kitchen & cooking appliance per regions

For the Home Entertainment items and as stated previously the surveyed home entertainment items includes TV, Sat, DVD, Video, and Stereo. The consumed energy by those items is almost related to factors of approximate load, quantity, and time. Of that item. In addition to that, consumers' behavior affects energy uses by leaving items on standby mood and by keeping plugged on.

TV consumed more energy than other entertainment items because it is used by all families' member. And many of them claimed they keep the TV on even if they are working or eating. The families how have members during all days consumed more energy than others because TV could be played morning, afternoon and evening time. While the single-family was used TV when they returned home only. The total average of using time range between 3 to 7hr (Figure 5.96). In addition to that figure 5.97 shows the consumed energy per item TVs were the largest energy consumer.

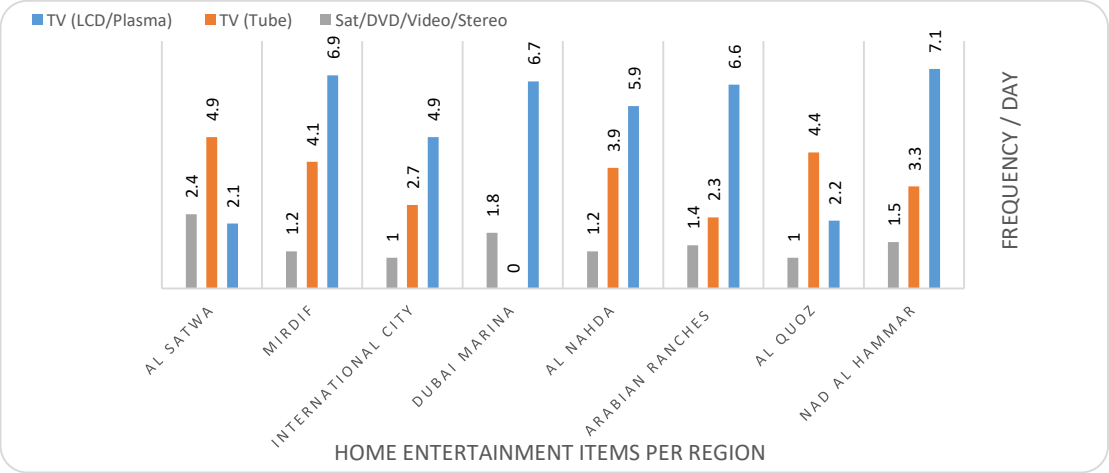

Figure 5.96: Compassion between using the frequency of Home entertainment appliance per region

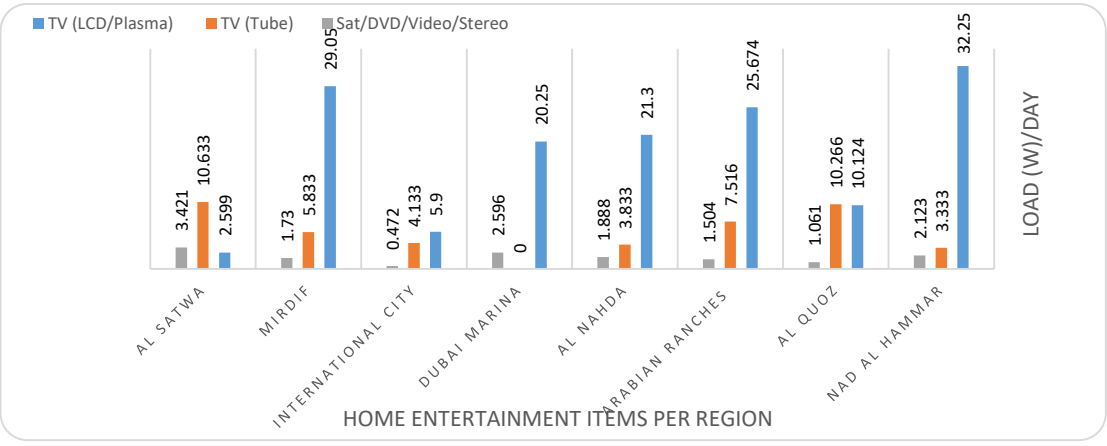

Figure 5.97: Compassion between energy uses of Home entertainment appliance perregions

The surveyed computers and peripherals include Computers, laptops, Printers, Scanner, and Fax. The consumed energy for each item depends on quantity and the approximate used time. Laptops consumed more energy than others entertainment items because almost all houses have one laptop or more. But on the other hand, fax consumed more energy in case if it is used as 24 hr (2.880 KW). Frequency using time for computers and laptops range between 2 to 5 hr daily (Figure 5.98).

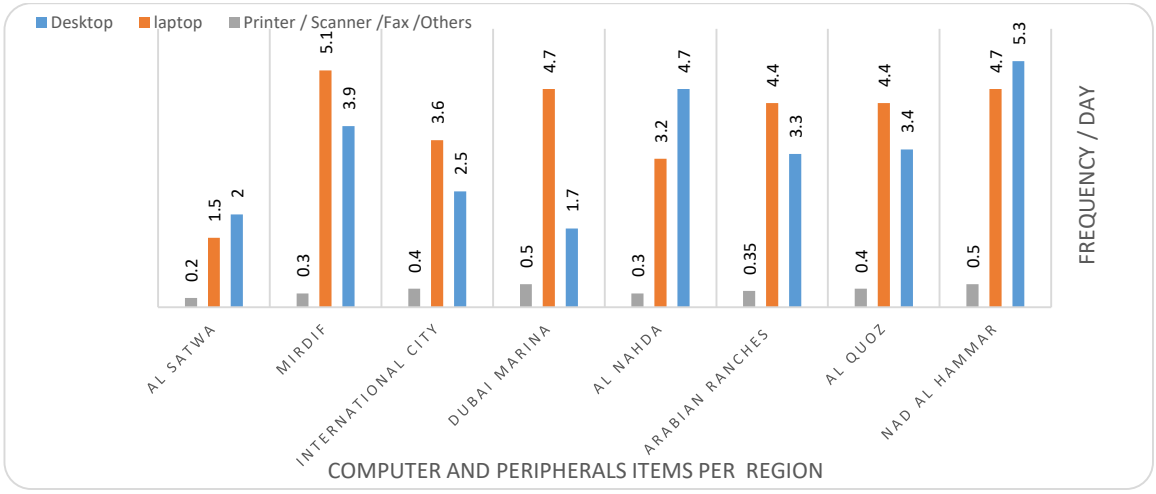

Figure 5.98: Compassion between using the frequency of computers and peripherals per region

		Nad Al Hammar			Al Quoz			Arabian Ranches			Al Nahda			Dubai Marina			International city			Mirdif			Al Satwa		
		NO.	Feq	Load	NO.	Feq	Load	NO.	Feq	Load	NO.	Feq	Load	NO.	Feq	Load	NO.	Feq	Load	NO.	Feq	Load	NO.	Feq	Load
White Goods	Clothes washers /Dryers	13	0.97	8.341	12	0.58	5.6	10	0.55	4.083	10	0.7	5.249	10	0.52	3.5	11	0.69	5.774	10	0.62	5.249	10	0.52	3.5
	Cloths iron	14	1	11.2	11	0.58	5.133	10	0.61	5.866	10	0.68	6	10	0.47	5.3	10	6.9	6.1	10	0.65	5.9	10	0.52	0.56
	Dishwashers	1	0.1	0.216	0	0	0	7	0.6	5.308	2	0.2	0.866	9	0.8	7.8	3	0.3	1.3	7	0.7	6.066	0	0	0
	Refrigerators	17	24	224.4	14	24	184.8	10	24	132	10	24	132	10	24	132	14	24	184.8	10	24	132	13	24	171.6
	Freezers	7	24	92.4	2	24	26.4	3	24	39.6	4	24	52.8	0	0	0	1	24	13.2	3	24	39.6	2	24	26.4
Kitchen & Cooking Appliances	Electric Cooker (plates/Ovens)	3	1.7	4.75	2	1.1	2.333	2	1.2	2.4	2	1.1	2.33	6	3.9	22	3	0.7	2.25	5	2.2	9.3	0	0	0
	Microwaves	10	0.9	9.166	9	0.7	5.25	10	0.8	8.333	9	0.7	5.25	10	1.2	11.67	9	0.8	6	10	0.7	5.833	8	0.7	4.666
	Bread makers / Toasters /Espresso Machines Juicer /rice cooker /others	15	0.4	3.25	16	0.35	3.466	14	0.5	4.55	11	0.35	2.979	18	0.5	5.85	11	0.4	2.979	15	0.5	4.875	13	0.975	7.745
Home Entertainment	TV (LCD/Plasma)	15	7.1	32.25	13	2.2	10.12	13	6.6	25.67	12	5.9	21.3	10	6.7	20.25	4	4.9	5.9	14	6.9	29.05	4	2.1	2.599
	TV (Tube)	5	3.3	3.333	11	4.4	10.27	3	2.3	7.516	5	3.9	3.833	0	0	0	8	2.7	4.133	7	4.1	5.833	11	4.9	10.63
	Sat/DVD/Video/Stereo	12	1.5	2.123	9	1	1.061	9	1.4	1.504	12	1.2	1.888	12	1.8	2.696	4	1	0.472	11	1.2	1.73	12	2.4	3.421
Computers and Peripherals	Desktop	6	5.3	6.6	6	3.4	4.1	6	3.3	4	9	4.7	8.25	3	1.7	0.95	3	2.5	1.5	7	3.9	5.483	5	2	2
	laptop	17	4.7	11.69	11	4.4	7.287	10	4.4	6.625	8	3.2	5	11	4.7	7.7	9	3.6	4.837	15	5.1	11.63	5	1.5	3.875
	Printer / Scanner /Fax /Others	13	0.5	0.877	8	0.4	0.45	6	0.35	0.472	9	0.3	0.303	10	0.5	0.562	8	0.4	0.27	10	0.3	0.337	3	0.2	0.101

Table 5.49: provides an illustrative date for all appliances per household; where No. number of appliances Freq: Frequency and Load (W)

O_2 emissions have a direct relation the energy consumption. Table 5.50 Provides an illustrative summary for the energy consumption per households' appliances in addition to the CO2 per day.

Table 5.50: Summary for the energy consumption and CO_2 emission per households' appliances

	Appliances	Load KWH	kgCO2
White Goods	Clothes washers /Dryers	41.3	53
	Cloths iron	46.1	59
	Dishwashers	21.6	28
	Refrigerators	1294	1648
	Freezers	290	369
Kitchen & Cooking Appliances	Electric Cooker (plates/Ovens)	45.4	58
	Microwaves	56.2	72
	Bread makers / Toasters/rice cooker /others	35.7	45
Home Entertainment	TV (LCD/Plasma)	147	187
	TV (Tube)	45.5	58
	Sat/DVD/Video/Stereo	14.8	19
Computers and Peripherals	Desktop	32.9	42
	laptop	58.6	75
	Printer / Scanner /Fax /Others	3.37	4

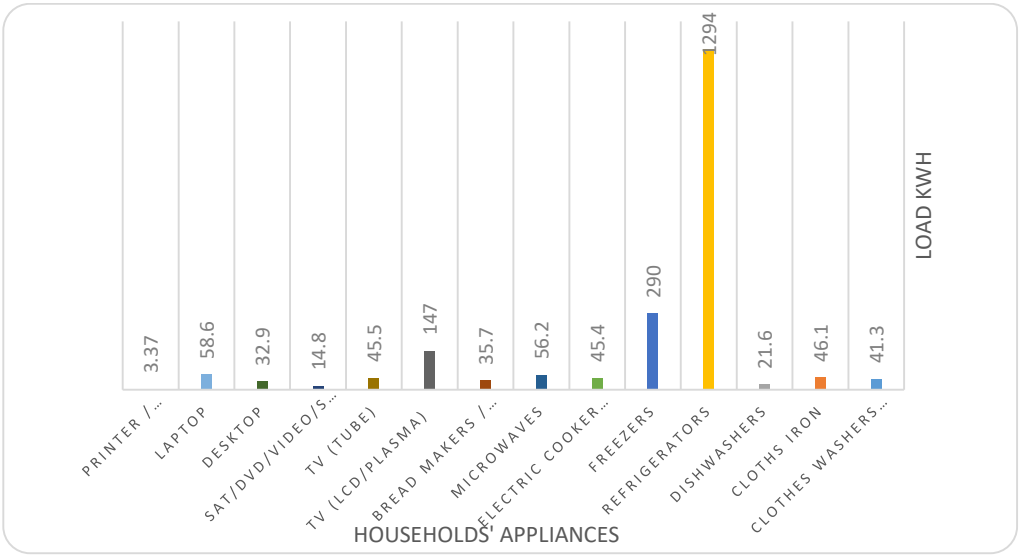

Figure 5.99: compassion between using the frequency of computers and peripherals per region

For the Air Conditioning and according to the surveyed results, no not all household occupants are aware of the A/C power, and some of them answered about the type of used A/C, but without a mentioned number of units per area. Almost all surveyed apartments with duct, while villas differ between spilled, duct, and window type. The first two are more dominated and window units used in the old constructed area or the house annex block. The below table 5.7 provides A/C consumption per area, as well as, CO_2 emissions. The bigger households need more A/C units than smaller houses, which means the required load and energy use are almost related to the house area and number of rooms per house. In addition to the physical factors, such as building orientation and building envelope. From that, it concludes that Nad Al-Hammar considers as the largest energy consumer for space cooling since villas range between 4 bedrooms to 8 bedrooms and followed by Al-Quoz Area. Also, the villas consumed more energy than apartments, as well as, have more CO_2 emissions.

Table 5.51: Summary for the energy consumption and CO_2 emission for A/C

Location	Consumption (KW/H)	CO_2 emissions ($kgCO_2$)
Nad Al-Hammar	4436.999	5651
Al-Quoz	3825	4872
Arabian Ranches	2958	3768
Al-Nahda	1734	2209
Dubai Marina	2091	2663
International city	696	886

Mirdif	1032	1314
Al-Satwa	3315	4222

For the household lighting and as collected questionnaire result. accuracy was difficult to be predicted since it is not a quantitative measurement and not all occupants are aware of the bulb type and power rating although the questionnaire was supported with pictures. On other hand, accuracy from the collected data couldn't be used. For that, a completed questionnaire was selected as a sample for each region.

Day(s) 1

Appliances	Approx. Load (W)	Actual Load (W)	Quantity	Hours / Day	Minutes / Day	Units/ Month
Lighting						
Tube Lights	40	37.5	22	12	0	9.899
Lamps	100	70	42	12	0	35.280

Consumers' behaviors always have an impact on energy use. And by Asked household members if they are switched computer and laptop off, leave it on or keep it on standby mode. 64% of them claimed that they were switched it off compared to 36% they were kept it on standby mood.

6 Conclusion and future work:

6.1.1 Conclusion

There has been a rise in energy consumption for the residential sector in Dubai. The electricity use patterns for this sector were illustrative for different eight areas in Dubai. The main finding for the selected areas will be highlighted as follows:

Nad Al-Hammar Area:

It's a new residential area. Villas consist of (G) only floor or (G+1), the number of residents per household for this area was an average of 7.2. And the average of rooms for this area was 5.4. They dominated time for the water heater was during the evening followed by morning time. The dominant bathing method was for 10 minutes showering. For the white goods, refrigerator considered as the largest consumer since all houses were provided with one refrigerator or more and it's working for 24 hr. and consumed around 224.400 KW per day. For kitchen & cooking appliances, microwaves consumed more energy than other appliances. Also, TVs are considered as most consumer items for home entertainment items with 5.500 W per day. A/C is considered as the largest consumer item per household and by calculating the average load for 6hrs as an example, only the required load is equal to 26621.999 KW.

Al-Qous Area:

It’s an old residential area with Arabic houses or villas. The number of residents per household for this area was an average of 6.8. And the average of rooms for this area was 4.6. They dominated time for the water heater was during the morning followed by evening time. The

dominant bathing method was for 10 minutes showering. For the white goods, refrigerator considered as the largest consumer since all houses were provided with one refrigerator or more and it's working for 24 hr. and consumed around 184.800 KW per day. Microwaves were consumed more energy than others for kitchen & cooking appliances. Also, TVs are considered as most consumer items for home entertainment items with 3.399 KW per day. A/C is considered as the largest consumer item per household and by calculating the average load for 6hrs as an example, only the required load is equal to 22950.000 W.

Arabian Ranches Area:

It’s a new resident villas area. Villas range between attached and de-attached villas. The number of residents per household for this area was an average of 4.2. And the average of rooms for this area was 4.6. The dominant time for the water heater was during the morning followed by evening time. The dominant bathing method was for 10 minutes showering. For the white goods, refrigerator considered as the largest consumer since all houses were provided with refrigerator plus it's working for 24 hr. and consumed around 184.800 KW per day. Microwaves were consumed more energy than others for kitchen & cooking appliances. Also, TVs are considered as most consumer items for home entertainment items with 4.500 KW per day. A/C is considered as the largest consumer item per household and by calculating the average load for 6hrs as an example, only the required load is equal to 17748.000 W

Al-Nahda Area:

It’s a new residential apartment area. Villas range between attached and de-attached villas. The number of residents per household for this area was an average of 4.3 and the average of rooms

for this area was 2.3. Water heater almost used during morning time and followed by evening. The bathing method was for 10 and 15 minutes showering. For the white goods, refrigerator considered as the largest consumer with around 132.000KW per day. Microwaves were consumed more energy than others for kitchen & cooking appliances. Also, TVs are considered as most consumer items for home entertainment items with 3.599 KW per day. A/C is considered as the largest consumer item per household and by calculating the average load for 6hrs as an example, only the required load is equal to 10404.000 W.

Dubai Marina Area:

Its new resident apartments are located in heart of new Dubai. The number of residents per household for this area was an average of 3.1 and the average of rooms for this area was 2.1. Water heater almost used during morning time and followed by evening. The bathing method was for 10 minutes of showering. For the white goods, refrigerator considered as the largest consumer since it's working for 24 hr. and consumed around 132.000KW per day. Electric cookers were consumed more energy than others for kitchen & cooking appliances. Also, TVs are considered as most consumer items for home entertainment items with 4.500 KW per day. A/C is considered as the largest consumer item per household and by calculating the average load for 6hrs as an example, only the required load is equal to 12546.000 KW.

International City Area:

Is the new residential apartment area for different nationalities? The number of residents per household for this area was an average of 3.2. And the average of rooms for this area was 1.9. Water heater almost used during morning time and followed by evening. The bathing method was

for 10 and 15 minutes showering. The refrigerator was the largest kitchen & cooking appliance (132.000KW). Also, TVs are considered as most consumer items for home entertainment items with 4.399 KW per day. A/C is considered as the largest consumer item per household and by calculating the average load for 6hrs as an example, only the required load is equal to 5814.000 KW

Mirdif Area:

It's a villas development area with different nationalities. The number of residents per household for this area was an average of 5.5. And the average of rooms for this area was 3.4. Water heater almost used during morning time and followed by evening. The bathing method was for 10 minutes of showering. The refrigerator was the largest kitchen & cooking appliance (132.000KW). The electric cooker was consumed more energy than others for kitchen & cooking appliances. A/C is considered as the largest consumer item per household and by calculating the average load for 6hrs as an example, only the required load is equal to 6192.000 KW.

Al-Satwa Area:

It's an old development area with different nationalities. The houses range between Arabic houses and villas. The number of residents per household for this area was an average of 5.6. And the average of rooms for this area was 3.9. Water heater almost used during morning time and followed by evening. A/C is considered as the largest consumer item per household and by calculating the average load for 6hrs as an example, only the required load is equal to 19890.000 KW.

In general, energy consumption varies between the selected area for two reasons; according to the house area with the number of rooms and number of family members per the household with the time they spend at home a. For that, the detached villas consumed more energy than attached villas. At the same time, detached villas consume more energy than apartments. For that Nad, Al-hammer is considered as the largest energy consumer since the rate of rooms and occupancy members were higher. Moreover, consumers' behavior is considered the most important issue with the respect to energy consumption. And CO2 emitted by appliances is related to the use of that appliance and the amount of energy used per appliance. The largest energy consumer items were air condition, refrigerators, and lightings. But the lighting was not measured accurately since the surveyed data was not completed.

6.1.2 Recommendations for Future Work:

This research has been carried out in the Emirates of Dubai. The distributed questionnaire survey was for different eight locations in Dubai with different building types and nationalities. Some future work that could be carried out would be by repeating the questionnaire survey for one of the selected locations or re-distribute the questionnaire survey according to the building type or nationalities. To have further understood for the energy consumption be the households', as well as, consumers' behavior.

Some other suggestions for future work include:

- Select plans model as a standard for the selected area
- Extend the duration of the survey to be for two seasons (winter and summer) to investigate the occupant behaviors for each season separately.
- Provide residents with a weekly questionnaire, to study energy consumption in more detail
- Include filed measurement for the major appliance to have more accurate results for the energy consumption per appliance.
- Distribute surveys thru governmental entities to have more accurate responses. Because some were claimed that the questionnaire shall be by a governmental entity.
- Establish a research section with the laboratories in the Dubai Statistical Center or DEWA, to investigate energy consumption by residential section.
- Regulating the marketing appliance to be more energy efficient.

- Further study shall be carried out for the lighting consumption per house.
- Coordinate with Housing Authority for proposing a sustainable design plans for the beneficiaries.
- Recommended courses of action from BUID to the residential leaders, students. The holistic and integrated approach to the research objective, guided by Systems thinking and ecological design, capacities actors at three different levels to pro-Actively implement end-use energy efficiency.

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Appendix:

Questionnaire template

Kindly full the below survey to save our environment				
Building Location/Zone:		**Nationality:**		**Building Area:**
Building Type:				
Individual villa [ ]	Townhouse Villa [ ]	Arabic house [ ]	Apartment building [ ]	Comments:
Age Of Construction				
Before 1980 [ ]	Between 1980-1990 [ ]	Between 1990-2000 [ ]	Between 2000 to 2010 [ ]	No idea [ ]
No. Of Floors				
1 floor [ ]	2 floors [ ]	Low rise building (3-6 floor) [ ]	High rise building (more than 6) [ ]	Comments:
No. Of Rooms				
Total No. [ ]	No. of Bedrooms [ ]	Others [ ]	Comments:	
No. Of **Occupancy:**				
Total No. [ ]	During Morning : 6 am -12 pm[ ]	During Afternoon: 12pm -5pm [ ]	During Evening: 5pm -12am [ ]	During Midnight [ ]
Water Heaters Usage				
Hours per day	Morning : 6 am -12 pm	Afternoon: 12pm -5pm	Evening: 5pm -12am	Comments:
-Usage during Summer				
-Usage during Winter				
When bathing, do you usually:				
Shower? [ ]		Run a bath? [ ]	Comments:	
How many times a day do you shower or bath?				
Once [ ]	Twice [ ]	More than twice [ ]	Comments:	
How long do you usually shower for?				
5 minutes [ ]	10 minutes [ ]	15 minutes [ ]	30 minutes [ ]	More than 30 minutes [ ]
What time of the day do you usually shower or bath ?				
Morning : 6 am -2 pm [ ]	Afternoon: 2pm -12pm [ ]	Evening: 12pm -5 pm	Midnight [ ]	
White Goods				
Appliances Name	No.	Size (Big/Small)	used per week	Used primarily during Morning/Afternoon/Evening
Clothes washers				
Clothes dryers				
Clothes washers with dryers				
Cloths iron				
Dishwashers				

Refrigerators				
Freezers				
Others				

Kitchen & Cooking Appliances

Appliances Name	No.	Size (Big/Small)	hours used per day	Used primarily during Morning/Afternoon/Evening
Cooking Appliances (electric plate)				
Ovens				
Microwaves				
Bread makers / Toasters /Espresso Machines /Juicer /rice cooker /others				

When you buy an electrical appliance, do you examine?

Power rating [ ]	Voltage rating [ ]	None [ ]	Comments:

Home Entertainment

Appliances Name	No.	Size (Big/Small)	hours used per day	Used primarily during Morning/Afternoon/Evening
TV (LCD/Plasma) *				
TV (Tube) *				
Sat/DVD/Video/ Stereo				
Others				

Computers and Peripherals

	No.	hours per day		
Computer (CRT) *				
Computer (LCD) *				
Laptop				
printer / scanner /Fax /others				

When you are finished working on your computer/ laptop do you:

Switch it off [ ]	Leave it on [ ]	Keep it on standby mode [ ]	Comments:

Air Conditioners (AC)

AC Type	Window Wall Air Conditioners	Split System Air Conditioners	Ducted Air Conditioners	Chiller	District cooling/ DC
No. of Units					
Power rating					
You turn A/C off when you go out for	More than 2hr	More than 4hr	More than 8hr (i.e. work)	Comments:	
- Usage during Summer					
- Usage during Winter					

Lighting (Power rating KW) *

No. of Types per Location	Living/dining room	TV/Family room	Bedrooms	kitchen	office/ study	Hallway & corridors	Toilets
Incandescent light bulb:							

• Low (10 to 40 watts)							
• Medium (41 to 149 watts)							
• High (150 watts or more)							
Fluorescent:							
• Short tube (less than 24 inches)							
• Long tube (24 inches or more)							
• Compact /CFLs							
Halogen /Spot light							

When you buy a lamp, do you examine?				
type of bulb [ ]	energy saving [ ]	power rating of the bulb[ ]	lamp brightness [ ]	None [ ]

Do you switch the lights off when you leave your room?			
Yes [ ]	No [ ]	Sometimes [ ]	Comments:

Swimming pool		Comments
Location		
Heated or cooled		
way of cooling/heating		

Appendix

Computers Types		**TV Types**	
			
Computer (CRT)	Computer (LCD)	TV (Tube)	TV (LCD/Plasma)

Lighting Types

			
Incandescent	Fluorescent	Compact Fluorescents	Halogen /Spot light

Abbreviations : CFLs: Compact fluorescent lamp

Solved Questionnaire template

الجامعة البريطانية في دبي
The British University in Dubai

Residential Energy Consumption Survey

Building Location/Zone: INTERNATIONAL City		**Nationality:** ALGERIA		**Building Area:** AL WARSAN FIRST
Building Type:				
Individual villa [ ]	Townhouse Villa [ ]	Arabic house [ ]	Apartment building [✓]	Comments:
Age Of Construction				
Before 1980 [ ]	Between 1980-1990 [ ]	Between 1990-2000 [ ]	Between 2000 to 2010 [✓]	Comments:
No. Of Floors				
1 [ ]	2 [ ]	Low rise building (3-6 floor) [✓]	High rise building (more than 6) [ ]	Comments:
No. Of Rooms:				
Total No. [1]	No. of Bedrooms [1]	Others [ ]	Comments:	
No. Of Occupancy:				
Total No. [ ]	Morning : 6 am -12 pm [2]	Afternoon: 12pm -5pm [2]	Evening: 5pm -12am [3]	Midnight [3]
Water Heaters Usage				
Hrs per day	Morning : 6 am -12 pm	Afternoon: 12pm -5pm	Evening: 5pm -12am	Comments:
2 • Summer	/	/	2	
3 • Winter	/	/	3	
When bathing, do you usually:				
Shower? [✓]		Run a bath? [ ]	Comments:	
How many times a day do you shower or bath?				
Once [✓]	Twice [ ]	More than twice [ ]	Comments:	
How long do you usually shower for?				
5 minutes [ ]	10 minutes [ ]	15 minutes [✓]	30 minutes [ ]	More than 30 minutes [ ]
What time of the day do you usually shower or bath ?				
Morning : 6 am -2 pm [✓]	Afternoon: 2pm -12pm [ ]	Evening: 12pm -5 pm	Midnight [ ]	

White Goods				
Appliances Name	No.	Size (Big/Small)	freq per week	Used primarily during Morning/Afternoon/Evening
Clothes washers	1	small	3	Evening
Clothes dryers	1	Small	3	Evening
Clothes washers with dryers				
Cloths iron	1	Big	4	Afternoon
Dishwashers				
Refrigerators	1	Big	24/24	24/24
Freezers	1	〃	〃	〃
Others				

Kitchen & Cooking Appliances				
Appliances Name	No.	Size (Big/Small)	hrs per day	Used primarily during Morning/Afternoon/Evening
Cooking Appliances (electric plate)	1	Big	3	evening
Ovens	1	small	1	evening

Microwaves	1	Big	1	morning
Bread makers / Toasters /Espresso Machines /Juicer /rice cooker /others				

When you buy an electrical appliance, do you examine?						
Power rating	[✓]	Voltage rating	[✓]	None	[ ]	Comments:

Home Entertainment				
Appliances Name	No.	Size (Big/Small)	hrs per day	Used primarily during Morning/Afternoon/Evening
TV (LCD/Plasma) *	1	Big	8	Afternoon/Evening
TV (Tube) *				
Sat/DVD/Video/Stereo				
Others				

Computers and Peripherals				
	No.	hrs per day		
Computer (CRT) *				
Computer (LCD) *				
Laptop	2	5		
printer / scanner /Fax /others				

When you are finished working on your computer/ laptop do you:						
Switch it off	[✓]	Leave it on	[ ]	Keep it on standby mode	[ ]	Comments:

Air Conditioners (AC)					
AC Type	Window Wall Air Conditioners	Split System Air Conditioners	Ducted Air Conditioners	Chiller	District cooling/ DC
No. of Units				✓	
Power rating					
You turn A/C off when you go out for	More than 2hr	More than 4hr	More than 8hr (i.e. work) ✓	Comments:	
• Summer					
• Winter	✓		✓		

Lighting (Power rating KW) *							
No. of Types per Location	Living/dining room	TV/Family room	Bedrooms	kitchen	office/ study	Hallway & corridors	Toilets
Incandescent light bulb	✓	✓	✓	✓		✓	✓
Low (10 to 40 watts)							
Medium (41 to 149 watts)							
High (150 watts or more)							
Fluorescent				✓			
Short tube (less than 24 inches)							
Long tube (24 inches or more)							
Compact /CFLs						✓	✓
Halogen /Spot light							

When you buy a lamp, do you examine?								
type of bulb	[✓]	energy saving	[ ]	power rating of the bulb	[ ]	lamp brightness	[✓]	None [

Do you switch the lights off when you leave your room?						
Yes	[✓]	No	[ ]	Sometimes	[ ]	Comments:

Swimming pool		Comments
Location		
Heated or cooled		
way of cooling/heating		

*** Ref to Appendix**