Ministry of Water & Electricity (MOWE)
Kingdom of Saudi Arabia

No.

The Master Plan Study for Energy Conservation in the Power Sector in the Kingdom of Saudi Arabia

Final Report (Annex)

February 2009

JAPAN INTERNATIONAL COOPERATION AGENCY

Tokyo Electric Power Company, Inc. (TEPCO)
The Institute of Energy Economics, Japan (IEEJ)

Annex 1

Survey Results on Commercial and Residential Sector

CONTENT

1. Outline of the Survey

1.1 Survey Purpose

In order to collect data and information about residential and commercial sector's energy use and energy conservation activities, this survey was conducted as a part of Energy Conservation Master Plan Study for KSA.

1.2 Survey Period

Local consultant office "MABDA Engineering" visited survey sites and collected data in June through October of 2007. In November, survey results were assembled and reorganized.

1.3 Survey Location

The survey was conducted in four major cities from different regions in KSA; Riyadh, Jeddah, Abha and Dammam.

Figure AP1-1 Survey Location

• Riyadh as the capital has the largest population in KSA. Situated away from the coasts in desert climate, Riyadh experiences large temperature difference within a day and also between summer and winter. The air is dry especially in summer. Heating is required in some winter period.

• Port city Jeddah has long been the center of trade and commerce in the Red Sea area. It has the second largest population in KSA, and also welcomes large number of pilgrimage Islam to Makah. Temperature and humidity are high all through the year.

• Dammam is the core city in the eastern megalopolis region on the Gulf Coast, where major petrochemical industries are concentrated. Temperature is similar to Riyadh through the year, but humidity is higher compared to Riyadh.

• Abha is the capital of southwestern Asir Province, which rests on high plateau and receives more rainfall than the rest of the country. Because of its altitude, Abha has cooler climate compared to other cities.

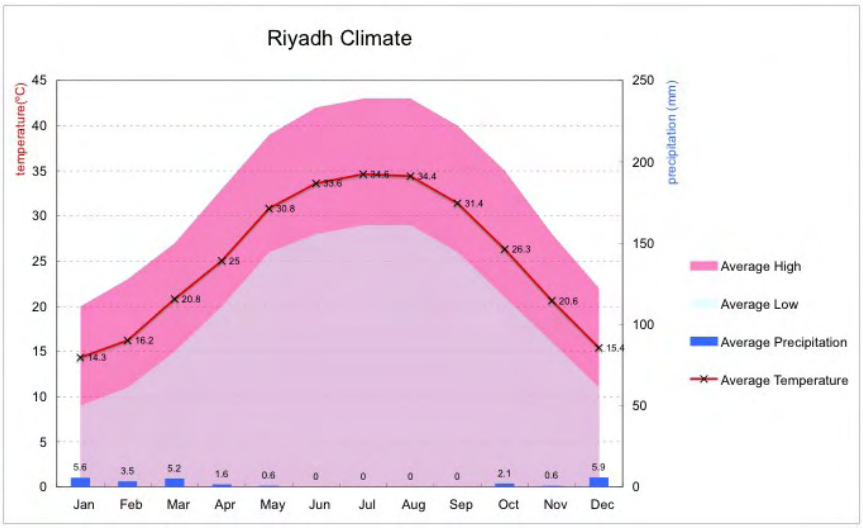

Figure AP1-2 Riyadh Temperature and Precipitation (Source: Climate Design Data 2005)

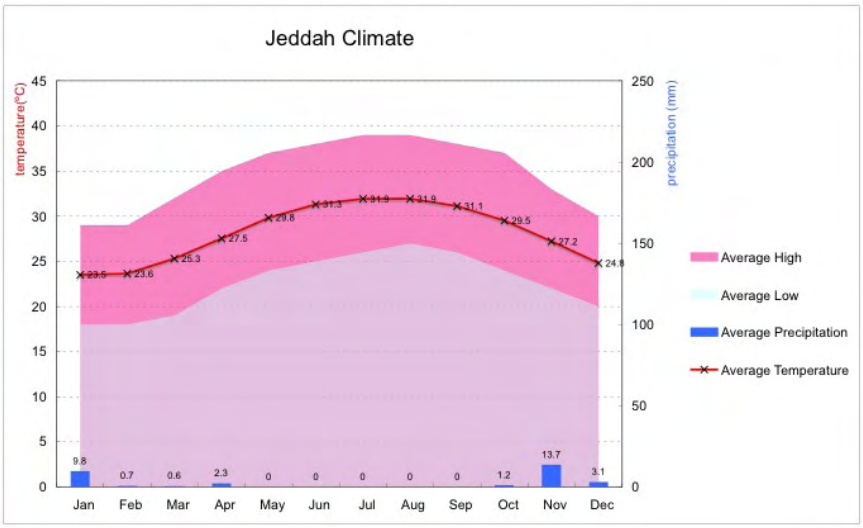

Figure AP1-3 Jeddah Temperature and Precipitation (Source: Climate Design Data 2005)

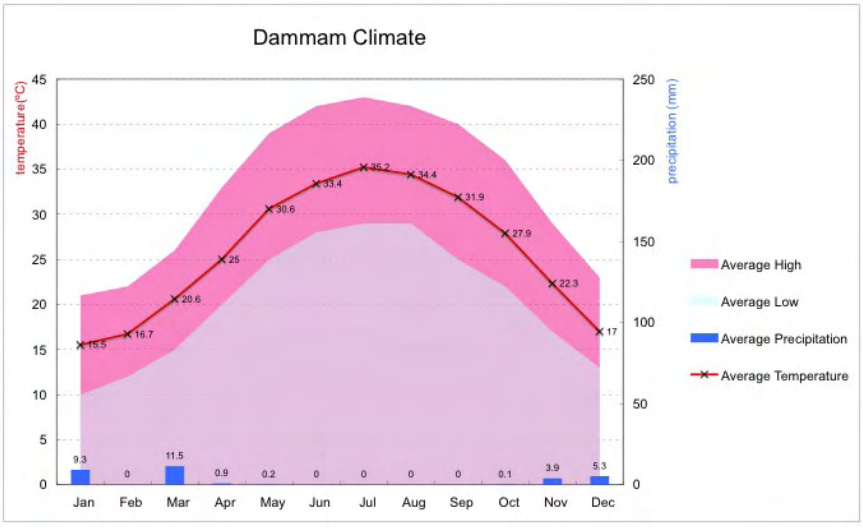

Figure AP1-4 Dammam Temperature and Precipitation (Source: Climate Design Data 2005)

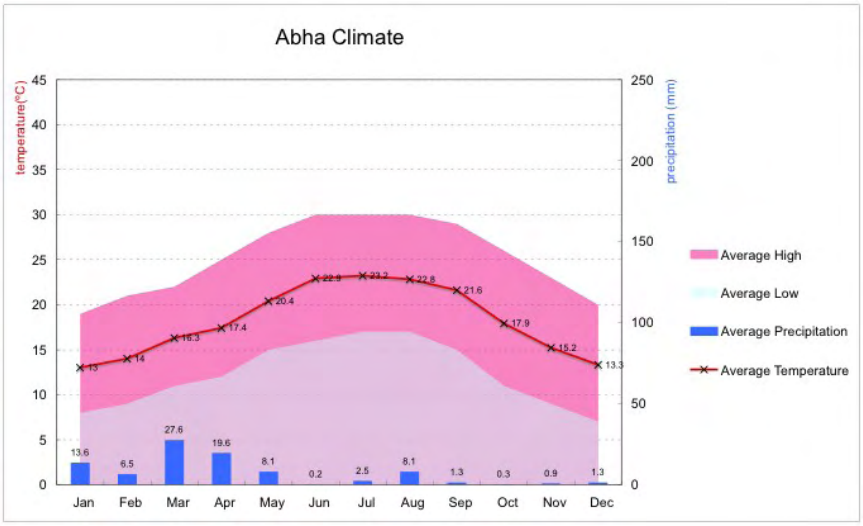

Figure AP1-5 Abha Temperature and Precipitation (Source: Climate Design Data 2005)

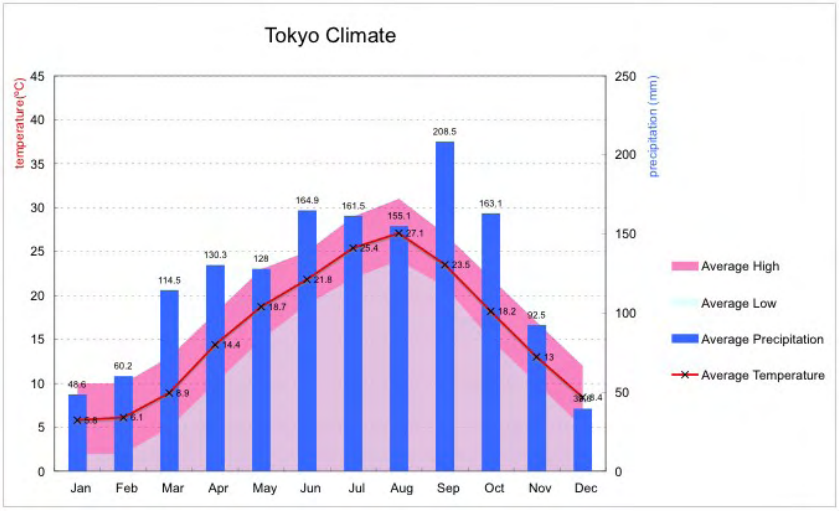

Figure AP1-6 Tokyo Temperature and Precipitation (Source: Climate Design Data 2005)

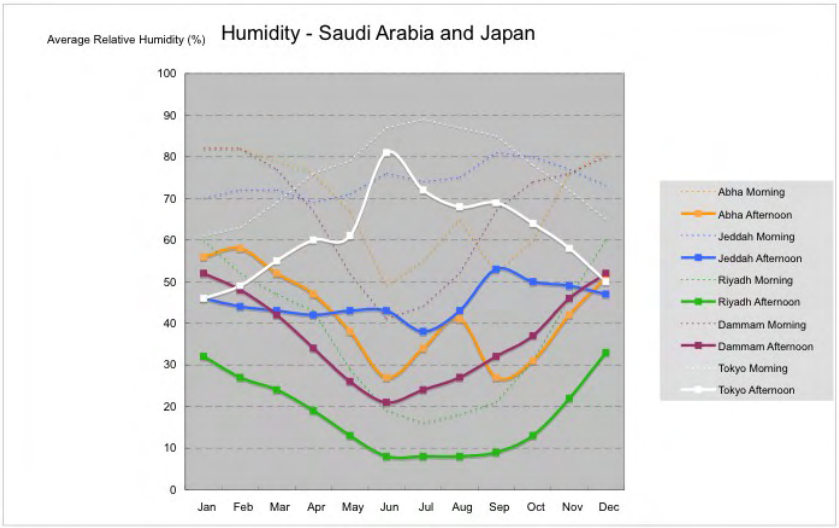

Figure AP1-7 Relative Humidity in Saudi Cities and Tokyo (Source: Climate Design Data 2005)

1.4 Surveyed Sites and Methods

1.4.1 Residential Sector

25 residences were selected randomly and surveyed in each city, in such a manner that there would be no regional bias. Two conditions were adopted in the selection so that samples include different types of houses; 1) small and large apartments, small, medium and large detached houses should be included in each city 2) 5 of 25 sites should be rural (suburban) houses.

If selected site was not possible to survey, the process of selection was repeated until cooperative site came up.

1.4.2 Commercial Sector

Hospital, hotel, shopping center and office buildings were surveyed in the commercial sector. From obtained list of these facilities, small, medium and large samples of each use were chosen randomly. In each city 12 sites were surveyed altogether. One school survey was conducted in Riyadh.

1.5 Surveyed Items and Procedure

1.5.1 Surveyed Items

In both residential and commercial sector, more than 100 questionnaires were prepared by study team concerning;

1) General information of family (facility) and its activity
2) Structure and insulation of building
3) Used energy
4) Equipped appliances and their use
5) Awareness and practice on energy conservation (management of equipments)
6) Dissemination of EC campaign

Through discussion with the local consultant, necessary amendments were made on questions to suit local conditions.

1.5.2 Survey Procedure

Workshops were hold for consultants with electrical engineering degree, in order to develop understanding of questionnaires and survey. Pilot surveys were conducted to find possible barriers and measures were prepared. In some sites where obtaining of all the answers was not possible within one day, several visits were made. Nevertheless, some items were left unanswered or with no information.

Study team members accompanied some of commercial site visits.

2. Residential Sector Survey

2.1 General Information

2.1.1 Type and Size of Houses

Apartments, detached houses and villas are three major types of houses in KSA. The term “villa” is usually used for suburban second houses in Europe. In KSA, houses larger than average detached houses are called as “villas” in both urban and rural area. One villa can be a single building or plural buildings. According to the Eighth Development Plan, numbers of three types are almost similar.

Graph below shows the relationship between total floor area (horizontal) and family member (vertical) in each sample house. Houses are larger in the order of villa, detached house, apartment. Apartment houses generally accommodate smaller members. Villas do not necessarily have larger family members compared to detached houses.

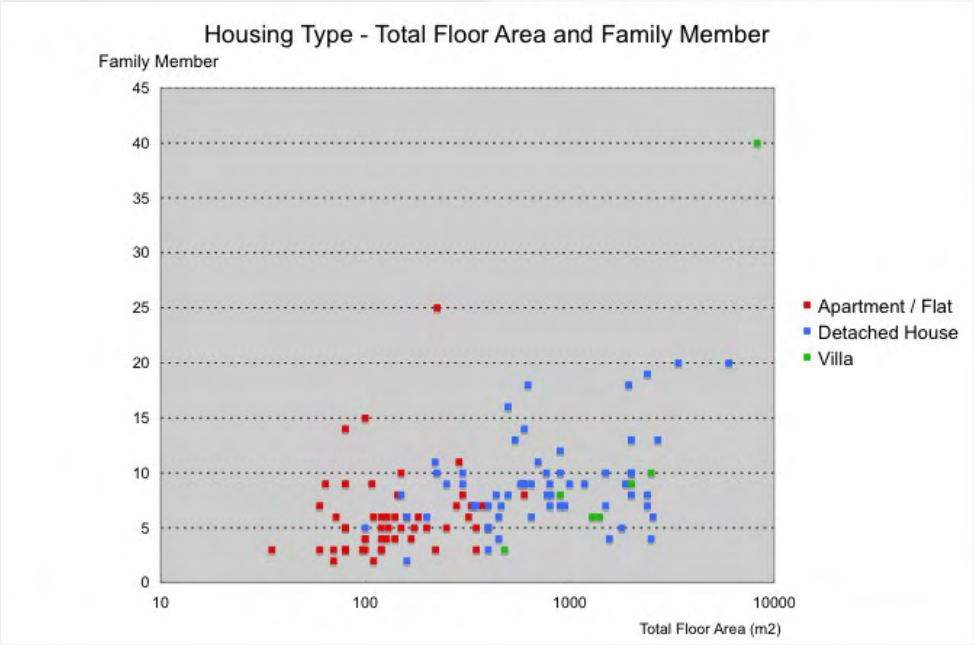

Figure AP1-8 Housing Type and Size

2.1.2 Built Year of Houses

Sorting by built year clearly shows that construction of houses is increasing rapidly, reflecting population and urban growth. Detached houses are increasing more rapidly in recent years compared to apartments, possibly because 1) apartments were built under settlement policy in earlier periods 2) detached houses, which are strongly preferred from cultural familistic value, became easier to obtain in these years with the economic development.

This result tells the importance of building energy performance in residential sector, since the demand and supply of houses will continue to grow in the foreseeable future.

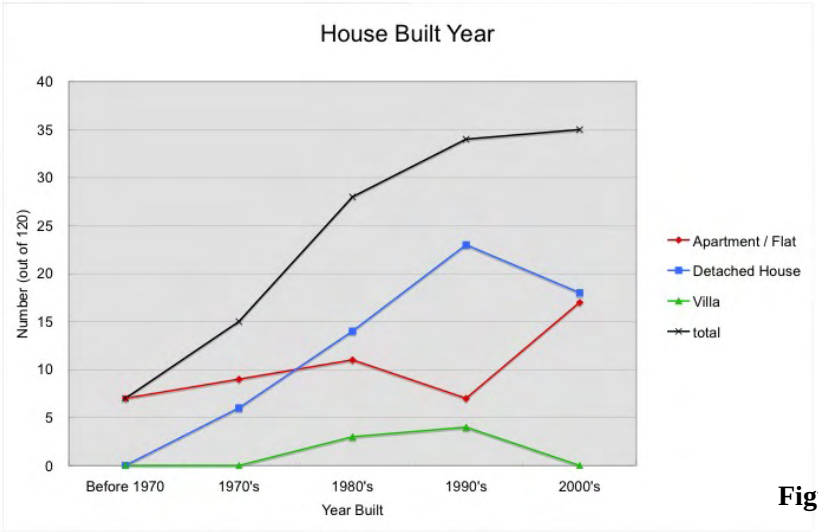

Figure AP1-9 House Built Year

2.1.3 Structure of Houses

Structure of houses is almost singular in any type of houses. That is, steel-reinforced concrete framework of columns, beams and slabs, with filled walls of either concrete blocks or bricks.

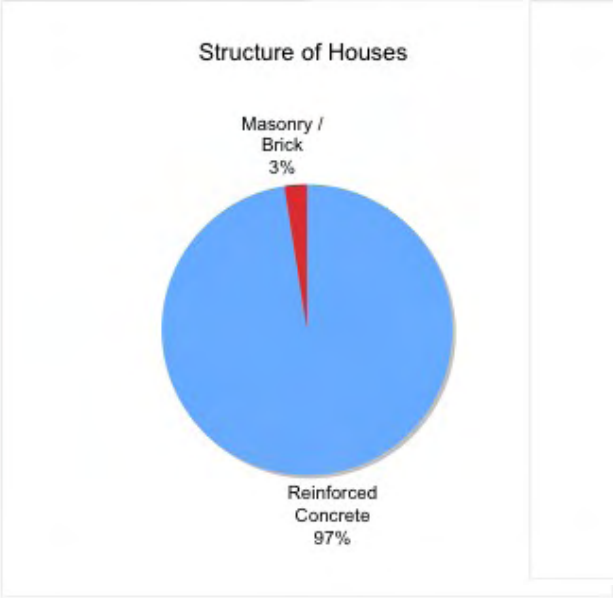

Figure AP1-10 Housing Structure

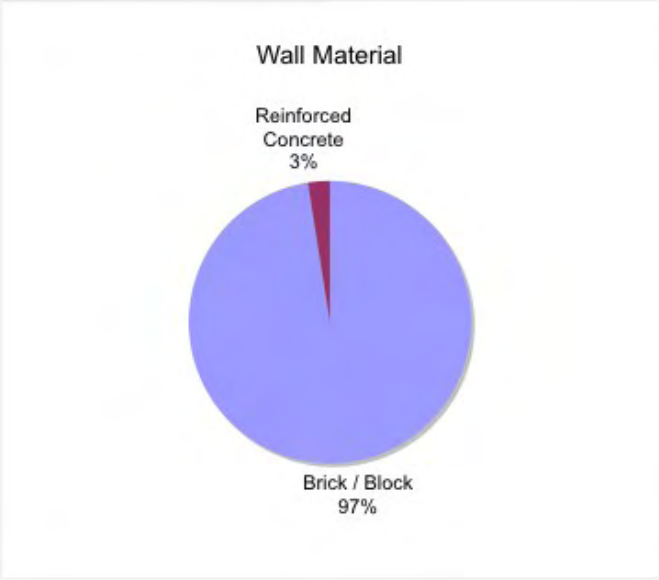

Figure AP1-11 Housing Walls

2.1.4 Family Members

(1) Number and Male/Female Ratio

Graph below shows number of male members (horizontal) and female members (vertical) in each family. Families are clearly larger compared to countries such as Japan. There are several samples with male only members. These are company dormitories and show the presence of considerable migrant workers in this country.

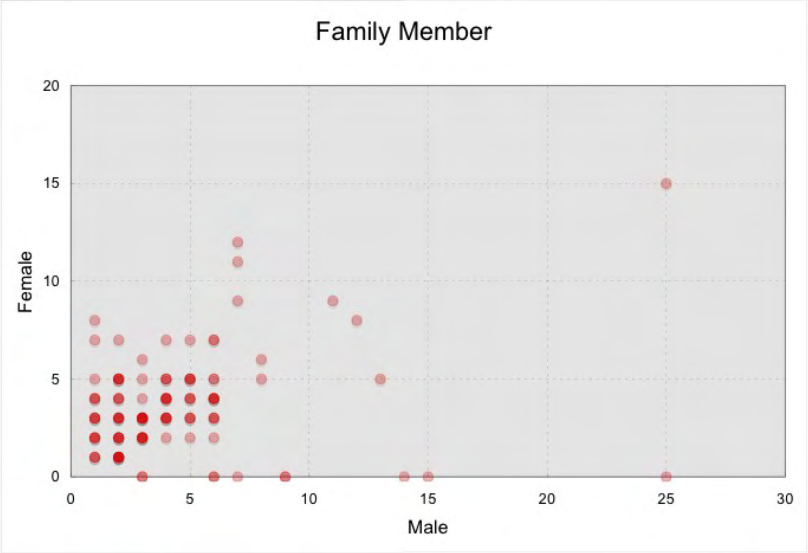

Figure AP1-12 Family Member

(2) Age Distribution

Age distribution in surveyed families (graph below) reflects high population growth in the past years in KSA. Higher number between teens to 40s, compared to demographic composition, is possibly due to 1) driver and maid residents in houses 2) slight decline in recent population growth rate.

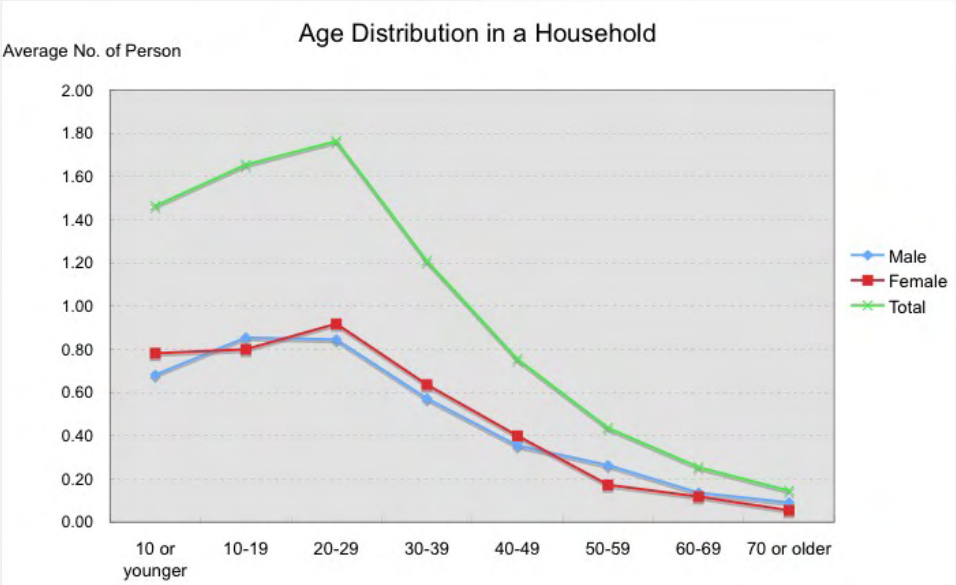

Figure AP1-13 Age Distribution in Houses

(3) Standard Family and Housing

Table below shows average and median size, annual income and family member of each housing type. Median value can be considered as typical, rather than average value, since every type includes excessively large samples (e.g. 6000m^2 detached house).

Apartment size and residents are similar to other countries. Large size of detached houses and villas is one of major reasons for prominent residential electricity use in KSA.

	Average (Median) Total Floor Area	Average (Median) Annual Income	Average (Median) Family Member
Apartment	160 m^2 120 m^2	74,000 SR 48,000 SR	5.98 5
Detached House	1,072 m^2 650 m^2	206,000 SR 144,000 SR	8.75 8
Villa	2,402 m^2 1,400 m^2	1,815,000 SR 162,000 SR	11.71 8
Japan (per Family Unit)	92.5 m^2 (Statistics Bureau Japan, 2003)	201,200 SR (5,761,000 Yen) (Statistics Bureau Japan, 2007)	2.83 (Statistics Bureau Japan, 2007)

Table AP1-1 Standard Family and Housing

2.1.5 Used Energy

Graphs below show source of energy, used for household purposes.

(1) Cooking

Broiling is popular way of local cooking. LPG gas is major energy source for household cooking. “Others” answers imply use of both gas and electricity

(2) Water Heating

Almost all houses use electric (not heat pump) water heaters for hot water supply.

(3) Cooling

All sample houses use air conditioners with electricity.

(4) Heating

Many houses use electricity (either air conditioner or stoves). “Others” are supposed to be kerosene stoves.

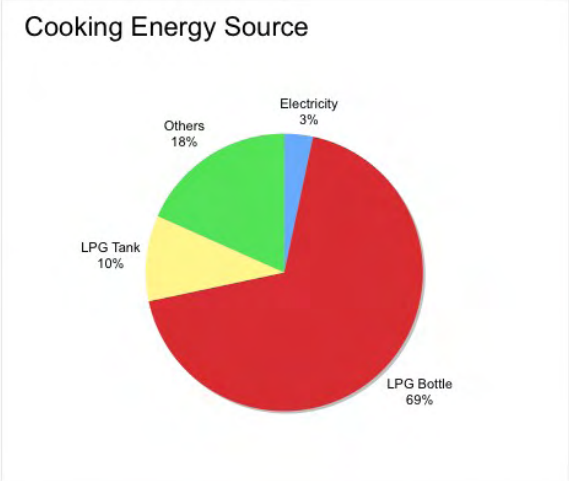

Figure AP1-14 Cooking Energy Source

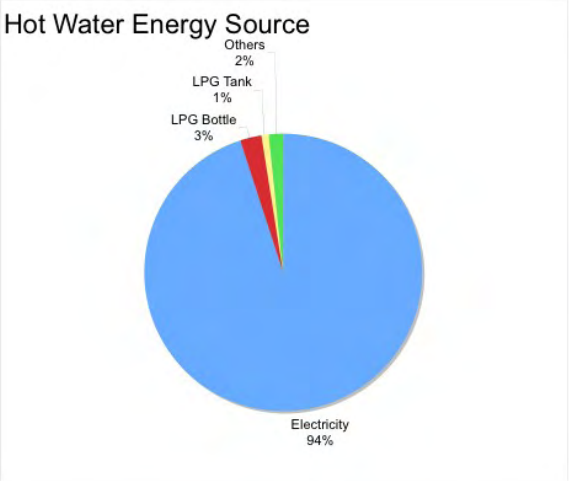

Figure AP1-15 Hot Water Energy Source

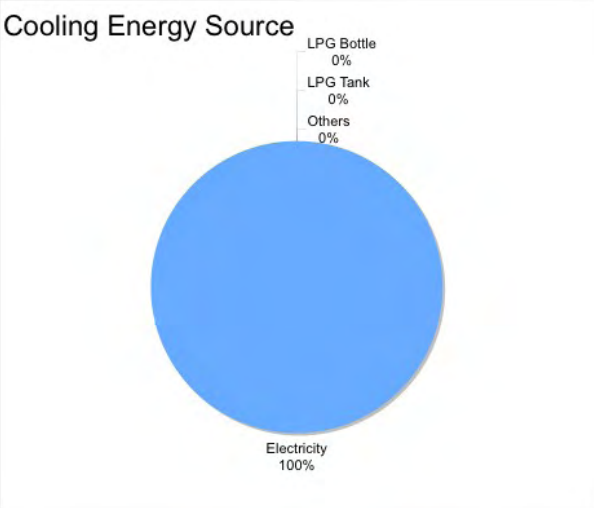

Figure AP1-16 Cooling Energy Source

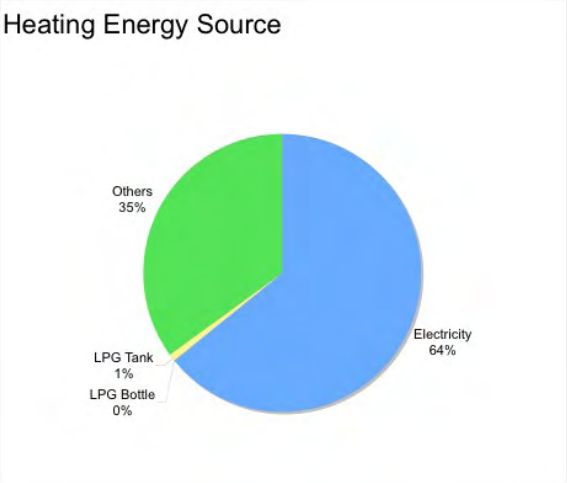

Figure AP1-17 Heating Energy Source

2.1.6 Life Pattern in Households

In each sample, wake-up/sleeping time and meal time on weekdays (Figure AP1-18) / weekend (Figure AP1-19) were surveyed. Two distinctive features relating to energy use in residential sector arise from this survey.

(1) Peak Lunchtime

Breakfast and dinnertime distribute over wide range and differ on weekdays and weekends. Whereas lunchtime concentrates around 2:30 pm on both weekdays and weekends. This should come from Islamic habit of 1) strict daily prayer time after high noon and before sunset 2) lunchtime as the most important occasion for daily family gathering. Peak electricity use in residential sector around this lunch hour is therefore inevitable.

(2) Late-Night Life Pattern

Dinnertime and sleeping time are late, compared to foreign standards. On weekends, they become even later (some families have dinner after midnight). Large nighttime use of electricity resulted in household electricity measurement (see another chapter) should have strong connection with this late-night lifestyle in KSA.

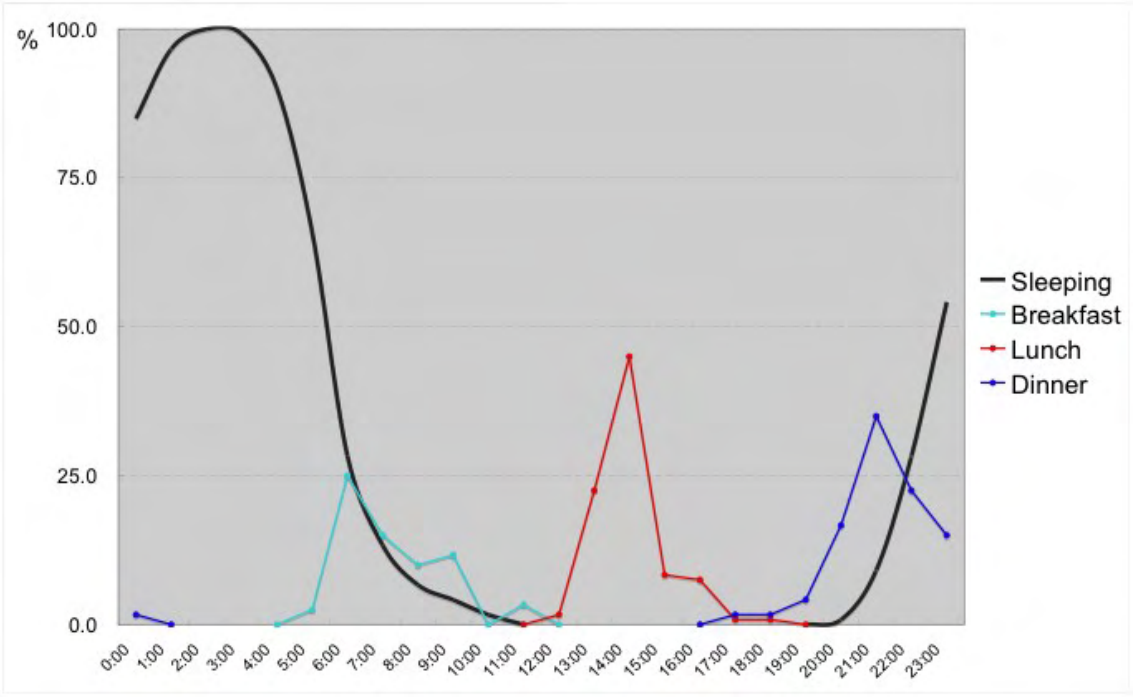

Figure AP1-18 Weekday Life Pattern

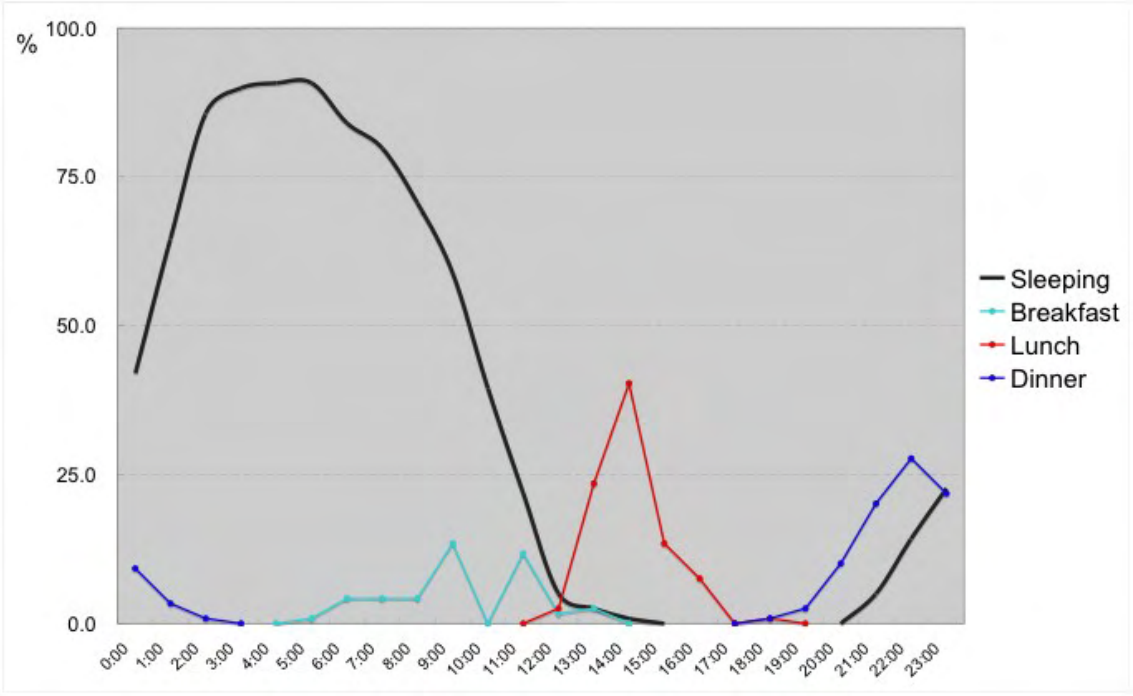

Figure AP1-19 Weekend Life Pattern

2.2 Insulation and Windows

2.2.1 Use of Insulation

Graphs below show use of insulation on walls and roofs in surveyed houses. The result with low percentage issues a grave problem on residential energy use in harsh climate.

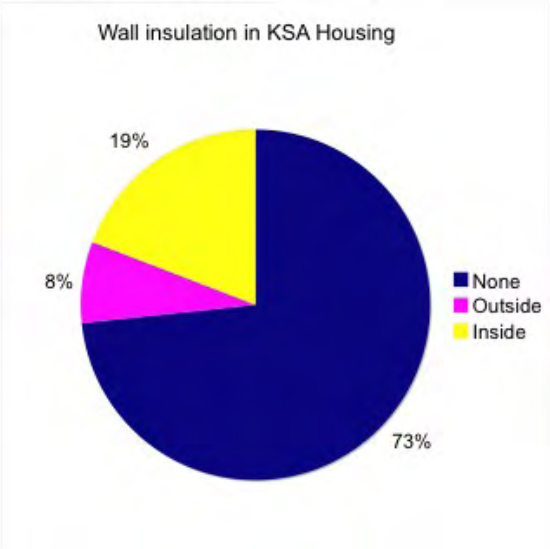

Figure AP1-20 Use of Wall Insulation

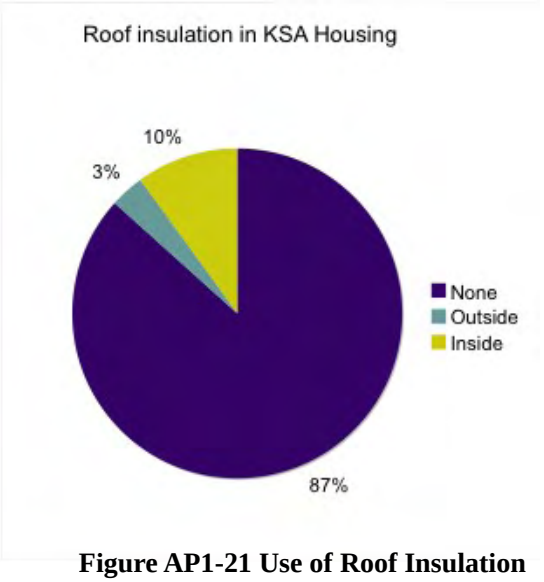

Figure AP1-21 Use of Roof Insulation

If we look at trend of insulation use for houses, it is clear that dissemination has been proceeding. At the same time 1) half of houses built after 2000 do not have wall insulation 2) roof insulation use, which is the main recipient of sun-radiation, is low. These need to be tackled and improved through measures as thorough implementation of Saudi Building Code, and/or incentives for dissemination.

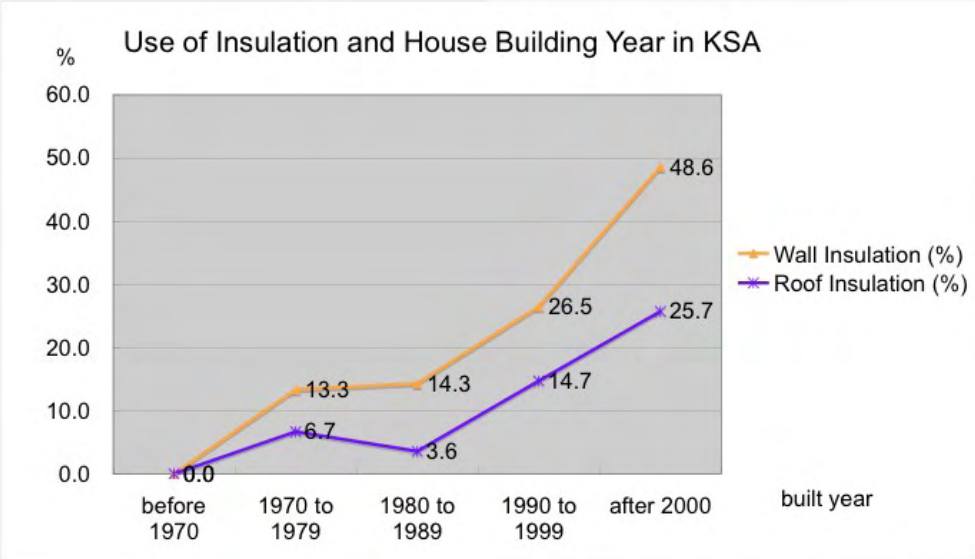

Figure AP1-22 Trend of Insulation Use

2.2.2 Window Area of Houses

Figure AP1-23 shows that window area in KSA houses has been steadily enlarging in recent years. Traditional masonry houses that could accommodate limited area of openings have almost been demolished. In present reinforced concrete houses, modern structure does not restrict area or shape of windows. It is natural that owners demand larger windows for light and view with the aid of air-conditioners.

Although windows can utilize renewable energy such as natural light and air-flow, in Saudi climate air-conditioning electricity use for heat load coming through glasses should exceed this benefit. Designing and construction with optimal total energy performance need to be developed.

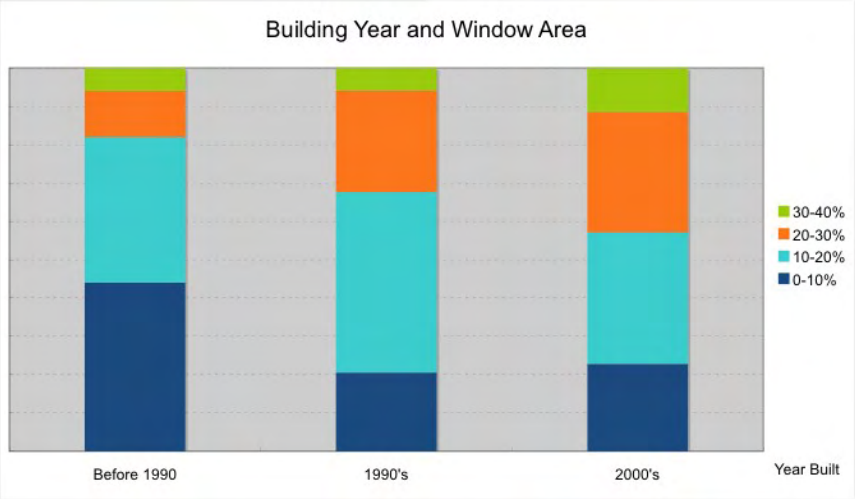

Figure AP1-23 Change of Window Area

2.3 Lighting

In each house, approximate number and wattage of different lamps were surveyed. Figure AP1-24 shows wattage ratio in all the samples. Chandeliers with incandescent lamps are said to be the favorite lighting equipments in KSA. The graph shows fluorescent lamps and CFLs (compact fluorescent lamps) are also popular in houses. In fact, more than third of houses do not use incandescent lamps at all.

Another question brought result shown on table AP1-2. Lifetimes of fluorescent lamps and CLFs are unnaturally short in their use. The reason can be 1) low quality of lamps 2) low quality of lighting equipments 3) instability of supplied electricity.

Low reliability of appliances can easily hinder social consensus on energy saving. Quality standard and measures to control market products are most necessary.

Also opinions declare that consumers buy cheaper products, half knowing their possible deficiency. Campaign to address lifecycle advantage is also necessary

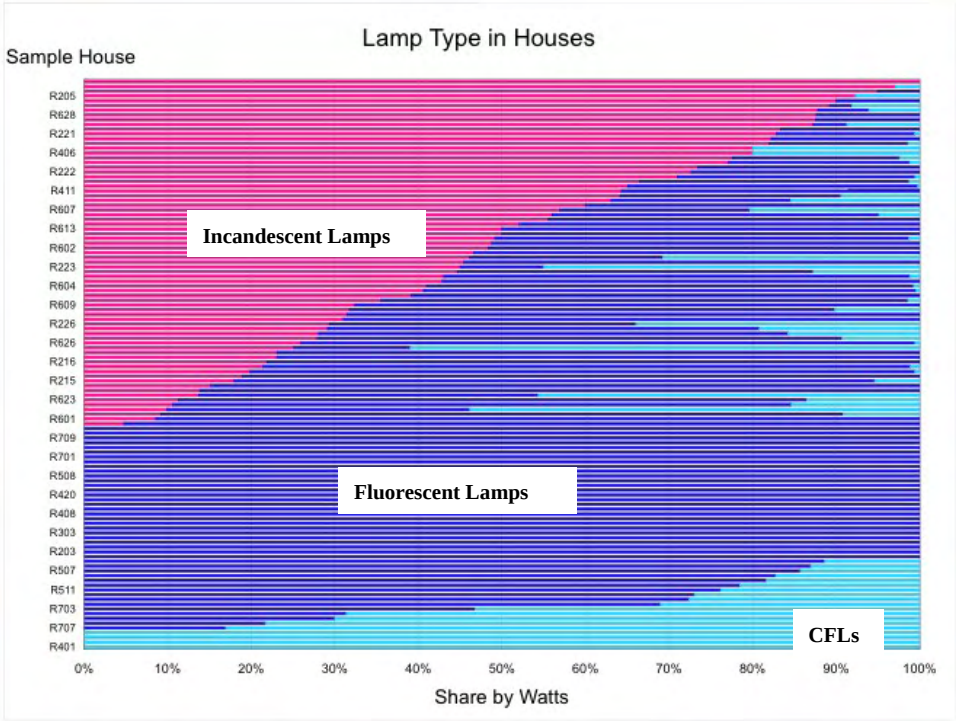

Figure AP1-24 Lamp Types in Houses

	Expected Lifetime (year)
Incandescent Lamps	1.02
Fluorescent Lamps	1.39
CFLs (Compact Fluorescent Lamps)	1.66

Table AP1-2 Lamps Type and Expected Lifetime

2.4 Air-Conditioning

2.4.1 Types of Air-Conditioners

Figure AP1-25 (apartments) and 26 (detached houses and villas) show equipped average cooling capacity per floor area in each surveyed city, with different colors for AC types. Use of cooling AC is not popular in Abha

Apartments only have small ACs, most of which are window types (wall-through type). Split types are more expensive and require outdoor space for outdoor units. These should be major factors preventing wider use of split ACs that are more energy efficient (larger COP: coefficient of energy performance) than window type ACs.

Even in detached houses, window type share is nearly half of the total. Concrete block walls with no steel rods, as well as cheap price, enable easier installation of window type ACs after construction.

There is large difference in average AC capacity between apartments and detached houses. This is possibly because detached houses have considerable area for additional space with no ACs, such as corridors, entrance halls or storage rooms. Therefore excessive operation of ACs due to air-leakage to these space, and lighting off in the area are other large issues concerning energy conservation.

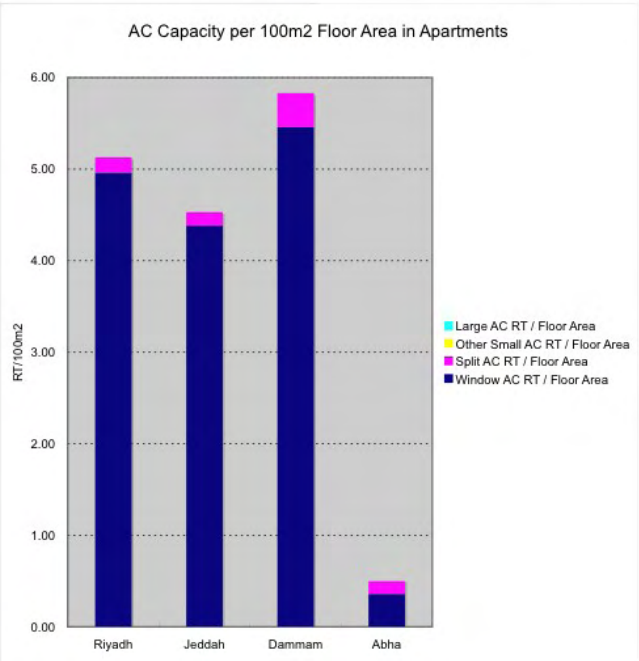

Figure AP1-25 Cooling Capacity in Apartments

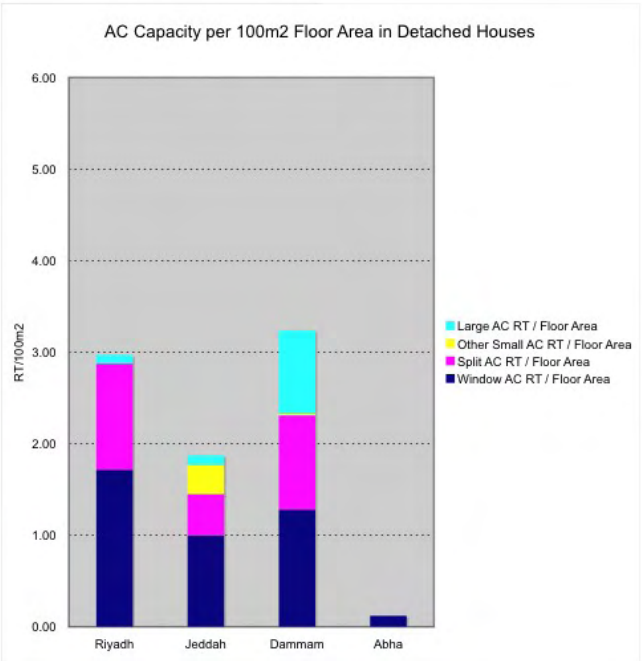

Figure AP1-26 Cooling Capacity in Detached Houses

2.4.2 Air Conditioner Manufacturer

Small ACs that dominate the market are mostly made by foreign manufacturers. This leads to 1) importance of import product testing regarding EC performance 2) importance of optimal design for dry hot climate and long operation.

“Evaporative Coolers” are used only in desert climate Riyadh.

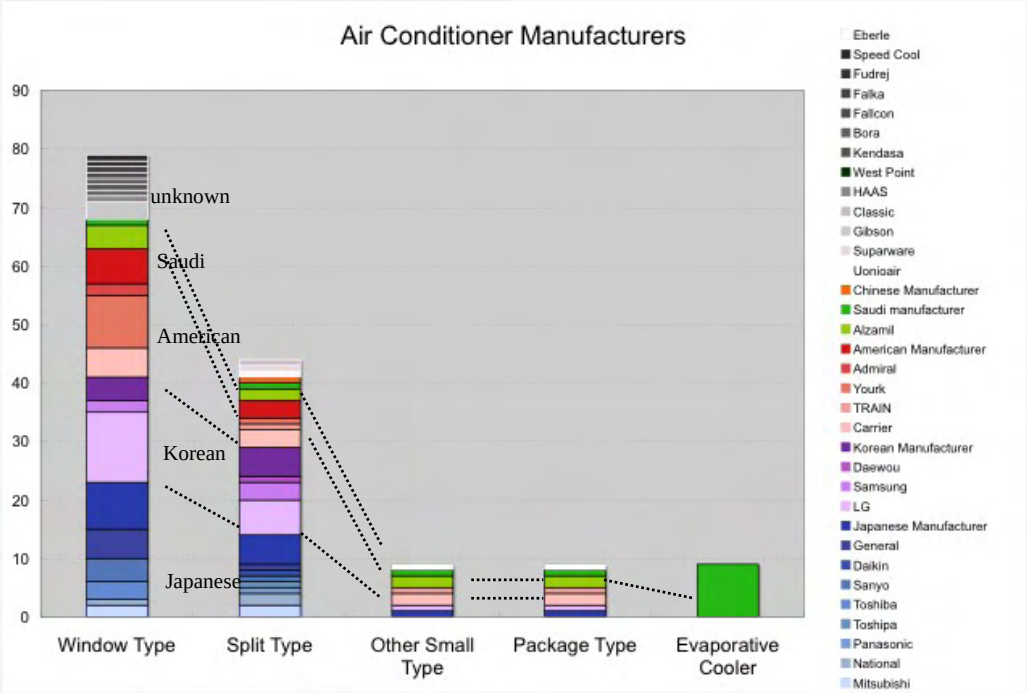

Figure AP1-27 AC Manufacturers

2.4.3 AC Operation Period

(1) AC Operation Period in a Year

In Jeddah where temperature is high throughout a year, ACs operate from January to December. Peculiar result is; although Dammam has similar temperature change as Riyadh with more humidity, operation period is shorter in Dammam. Daily operation time shows resembling tendency, but number of surveyed samples is not large enough to conclude this point.

Local consultant suggested westernized Dammam region practice more organized lifestyle e.g. in driving manner. If that is one background, Riyadh has large potential for EC through campaigning importance and promoting awareness.

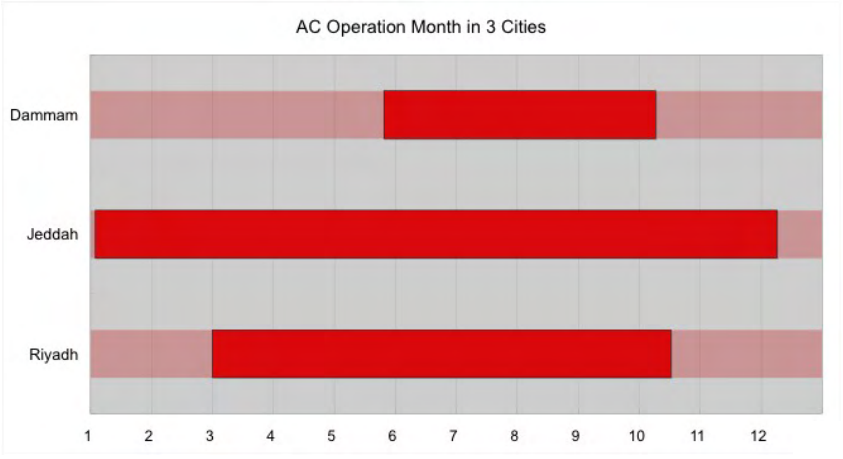

Figure AP1-28 Yearly AC (Cooling) Operation in Each City

(2) AC Operation Time in a Day

In Jeddah and Riyadh, many houses keep ACs running 24 hours. In Jeddah, outside temperature lowers around 25ºC degree in summer night. In Riyadh, it is higher but with low humidity. The reason for continuous operation can be higher temperature in houses (bedrooms) than outside. House building with no or poor insulation store heat received during day and emits during nighttime. Thus room temperature stays high even in nighttime.

Also it is most likely that Riyadh is experiencing “heat island effect” with high nighttime temperature as other modern large cities in the world.

Graphs below show operation hours of cooling AC in summer.

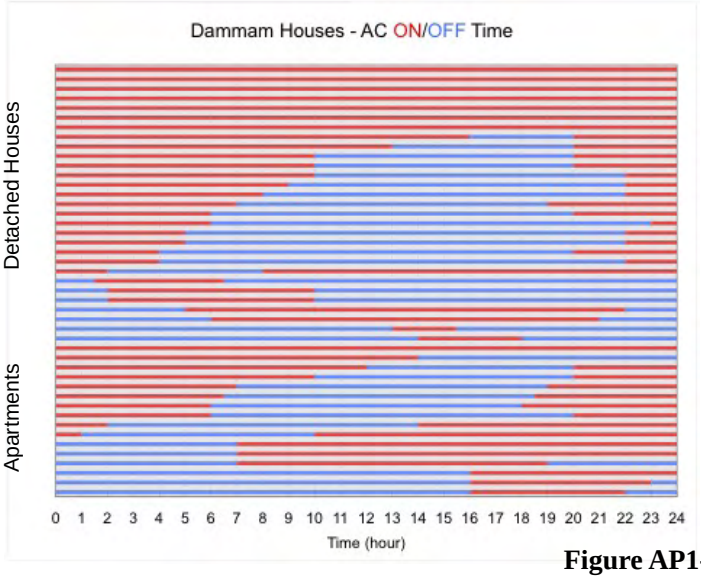

Figure AP1-29 AC (cooling) Operation in Dammam

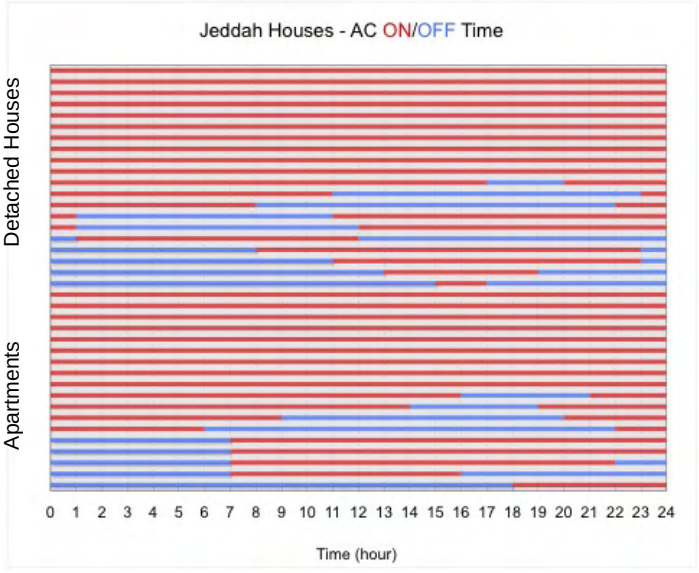

Figure AP1-30 AC (cooling) Operation in Jeddah

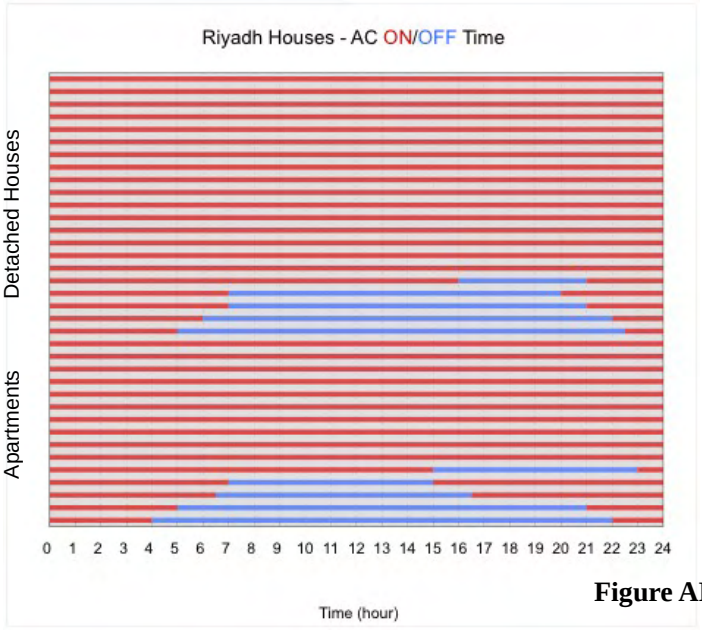

Figure AP1-31 AC (cooling) Operation in Riyadh

2.4.4 Temperature Setting of AC

Graphs below show that setting of AC is often kept excessively lower (higher) than comfortable sensible temperature. This result, in fact, shows large potential of energy conservation, because it means ACs are not operated at their optimum conditions. Lack of maintenance, use of malfunctioning machines, energy loss through air leakage, or unbalance between AC capacity and room volume can be the reasons and need to be tackled.

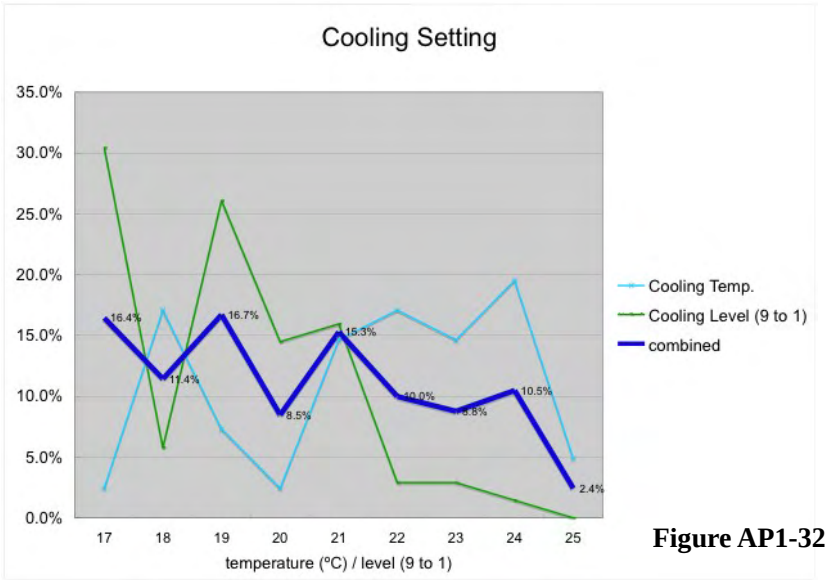

Figure AP1-32 Cooling Setting Temperature

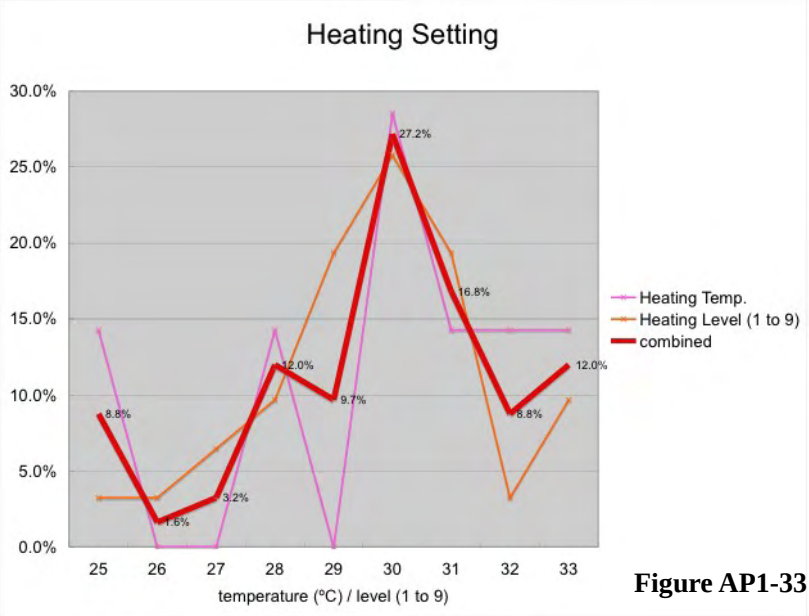

Figure AP1-33 Heating Setting Temperature

2.5 Awareness and Practice of Energy Conservation

2.5.1 Survey Results on Awareness and Practice

Graph below shows response from house owners on their level of EC awareness. They were asked in which group they think they belong to. More than half owners replied as “very conscious about energy saving”. We should admit there is a certain bias regarding this question, since owners who willingly cooperated in the survey generally should have bigger interest than average residential owners.

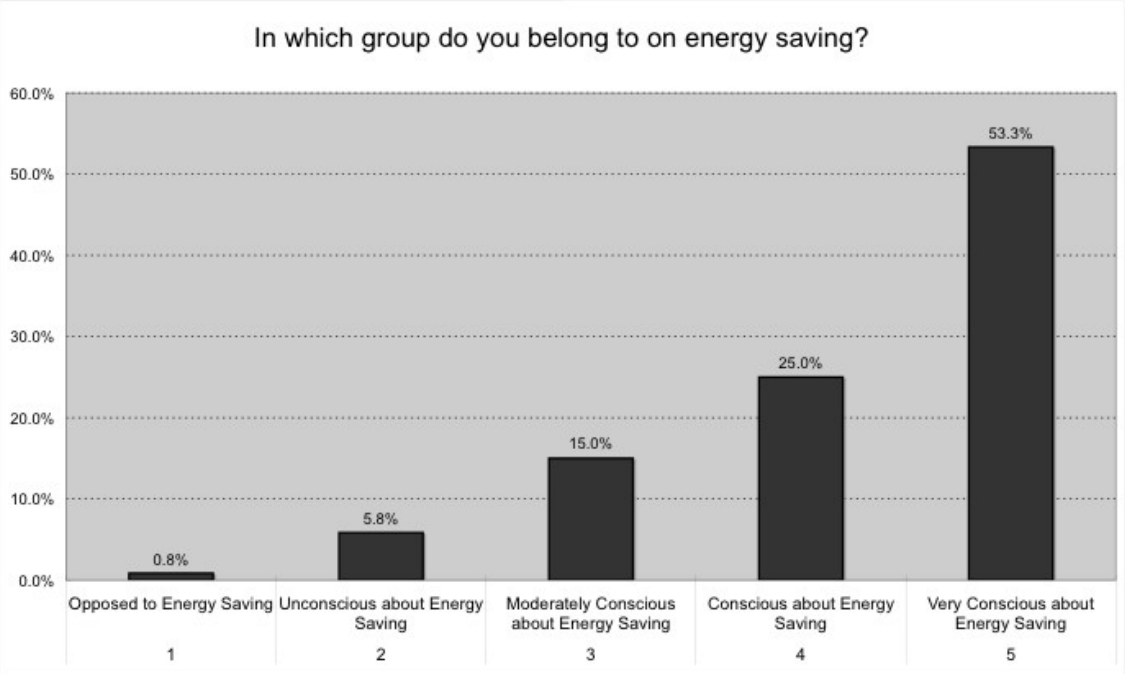

Figure AP1-34 EC Awareness Group

Also questions were answered concerning energy efficient use of house appliances.

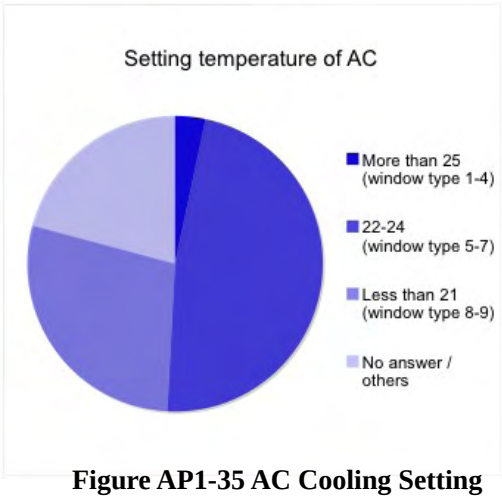

Figure AP1-35 AC Cooling Setting

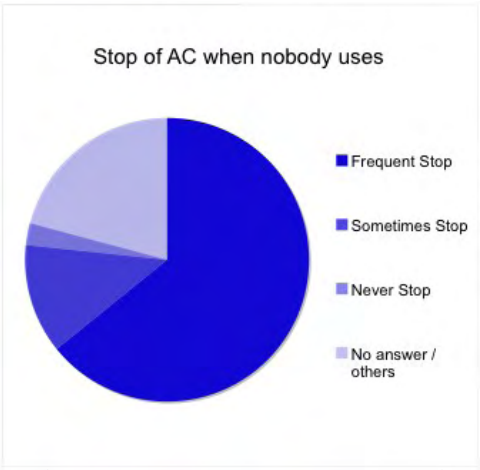

Figure AP1-36 AC Frequent Stopping

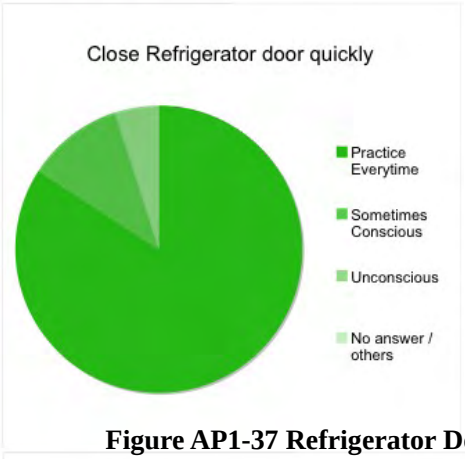

Figure AP1-37 Refrigerator Door

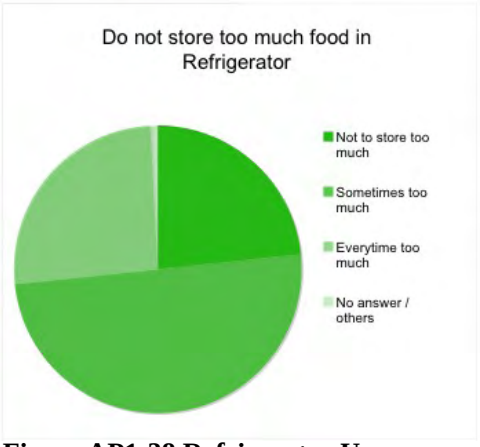

Figure AP1-38 Refrigerator Use

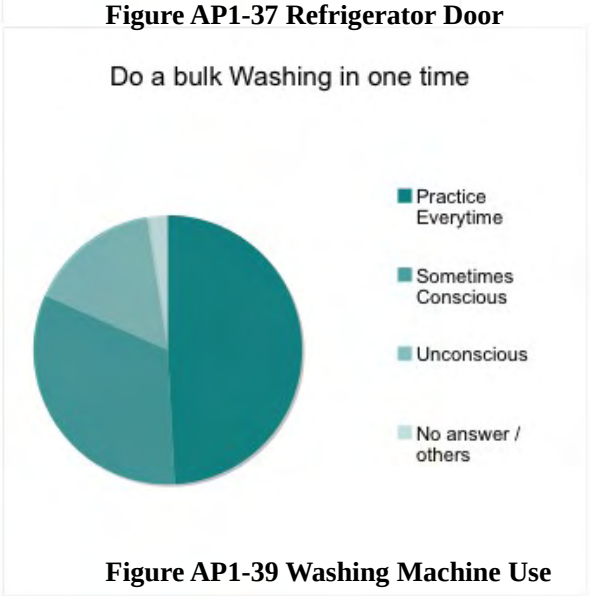

Figure AP1-39 Washing Machine Use

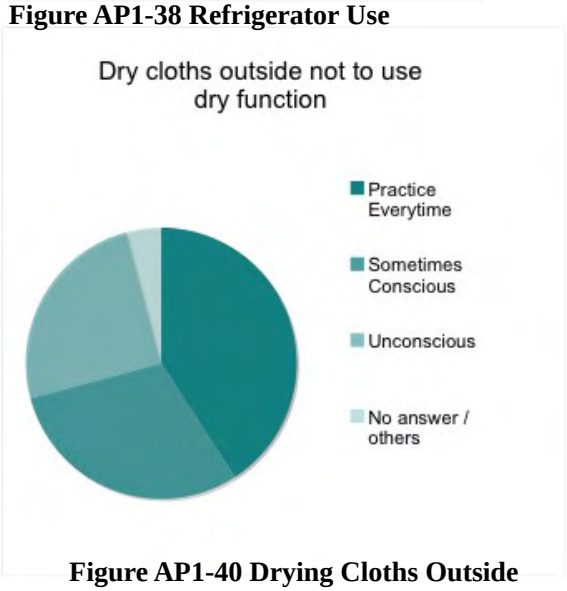

Figure AP1-40 Drying Cloths Outside

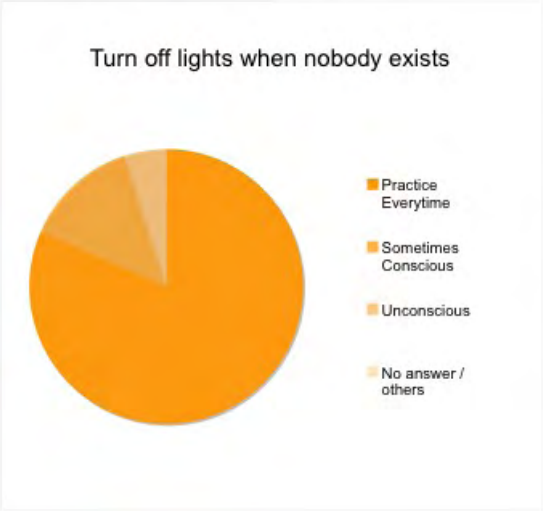

Figure AP1-41Turning Lights Off

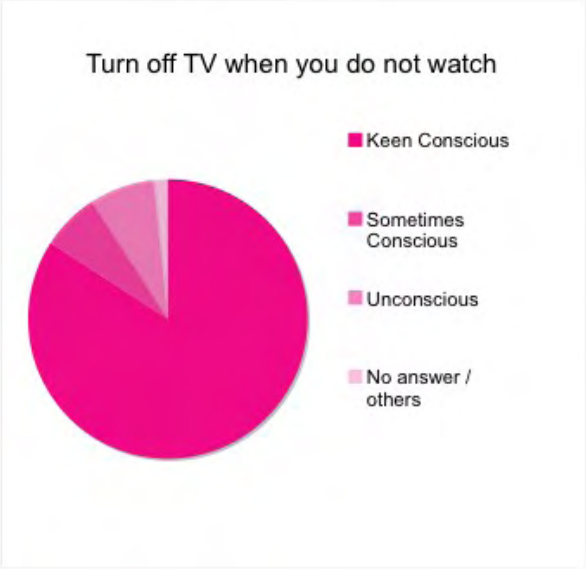

Figure AP1-42 Tuning TVs Off

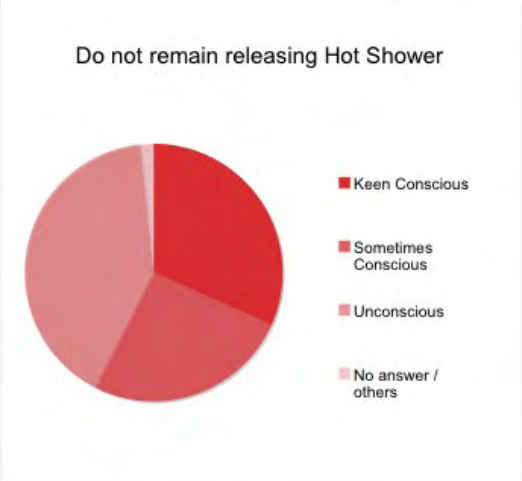

Figure AP1-43 Water Use for Shower

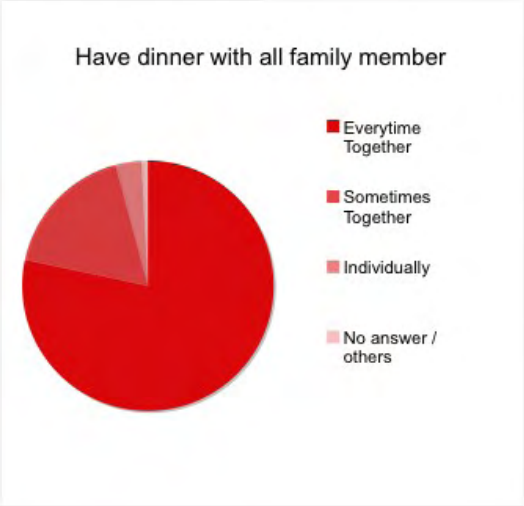

Figure AP1-44 Meal Time Practice

2.5.2 Correlation between Awareness and Practice

By weighting coefficients on EC practice activities, we investigated correlation between awareness and practice. Three groups of activities emerge as a result of this analysis.

(1) Activities Practiced/Unpracticed Regardless of Awareness Group

Family members gather for the meals in KSA, and cooling temperature is set low in every awareness group. External causes such as culture, climate and building hardware dominates awareness in practicing these activities. This result suggests that penetration of energy saving activity, as cultural virtue, will bring about great effect. Also improvement of energy performance of houses and AC equipments is the crucial issue in this country.

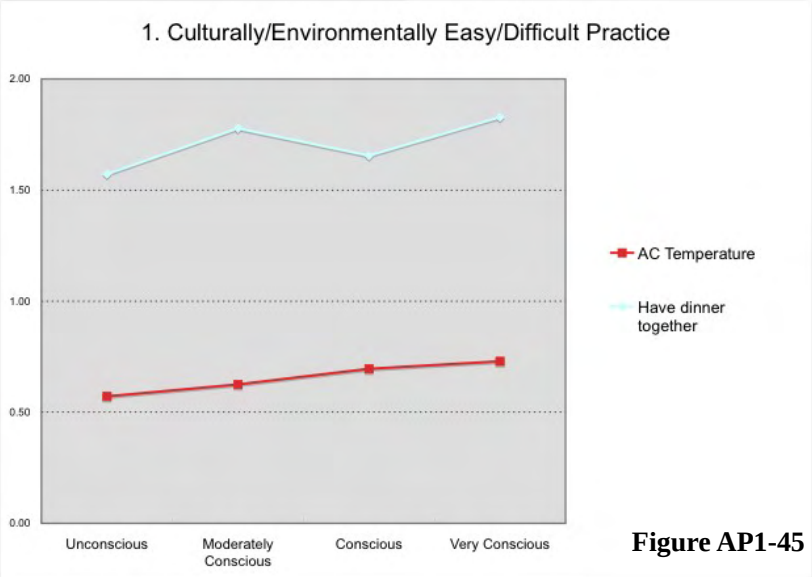

Figure AP1-45 Invariable Activities

(2) Activities Practiced in Aware Groups

Correlation between awareness and practices is clear in such activities as careful switching off and closing refrigerator doors. Fostering of EC awareness in wider range of society through various campaigns is indispensable for achieving EC targets.

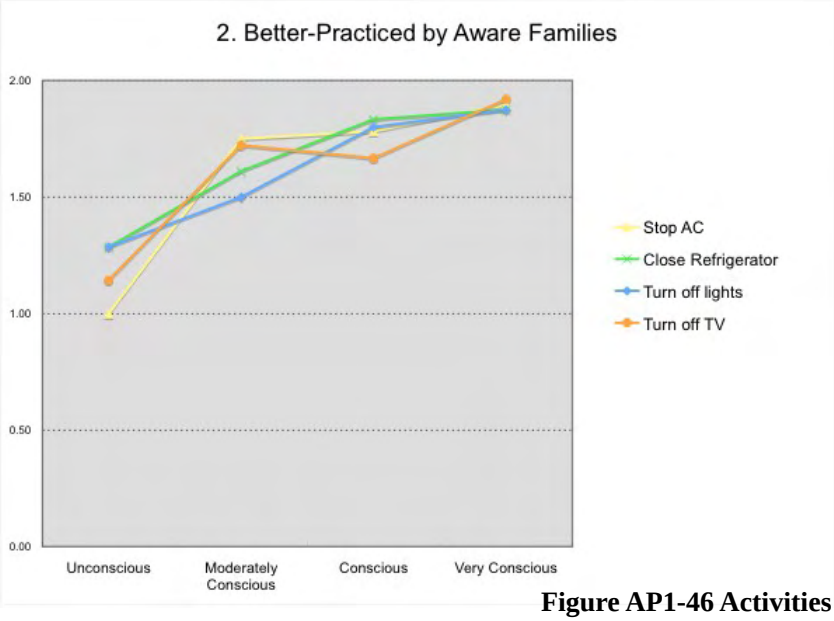

Figure AP1-46 Activities with Direct Correlation

(3) Activities with no correlation

1) Not to store refrigerators full 2) Not to leave water running in shower 3) To do bulk washing 4) To dry cloths outside, are activities with little correlation to awareness in their practice. The advantage should be addressed since this result shows EC effect of these activities are not well known. Other factors in lifestyle of a family, of course, are related to some activities. For example, in a family absent during daytime, it is difficult do leave cloths outside for drying.

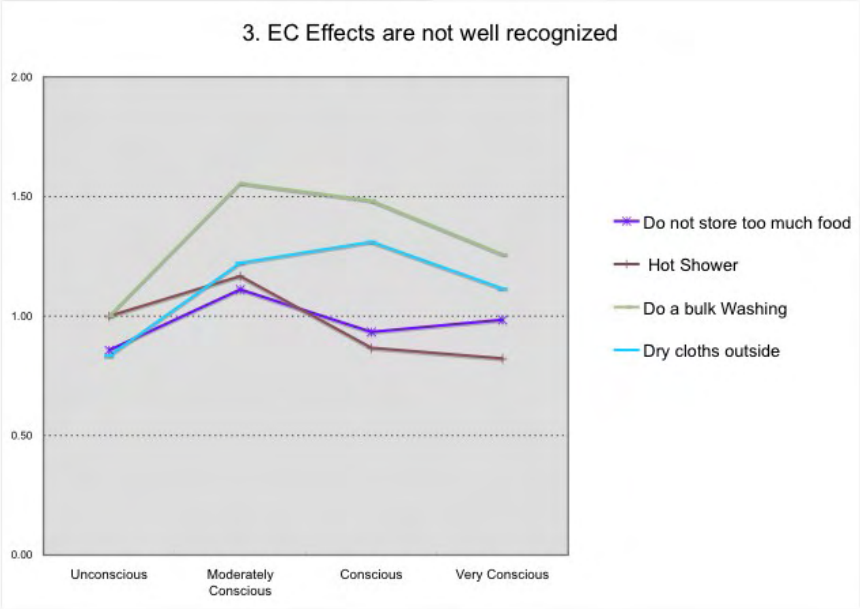

Figure AP1-47 Less Recognized EC Activities

2.6 Dissemination of EC Campaigns

Below graphs show how governmental and SEC EC campaigns are recognized. Both campaigns are only known to less than half of surveyed house owners. Strengthening and effective improvements are necessary.

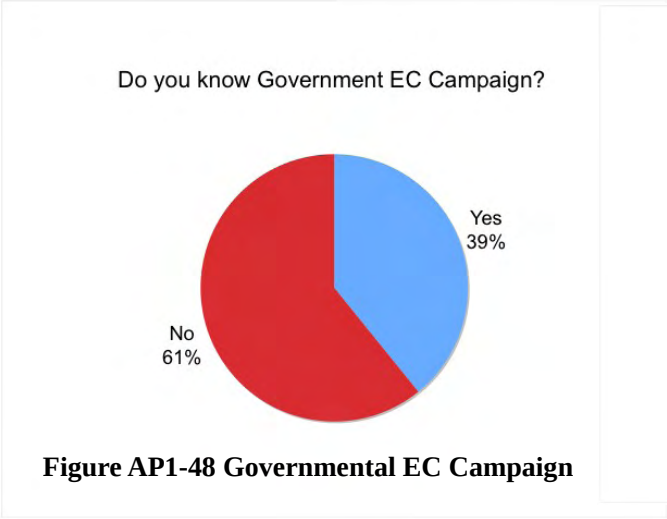

Figure AP1-48 Governmental EC Campaign

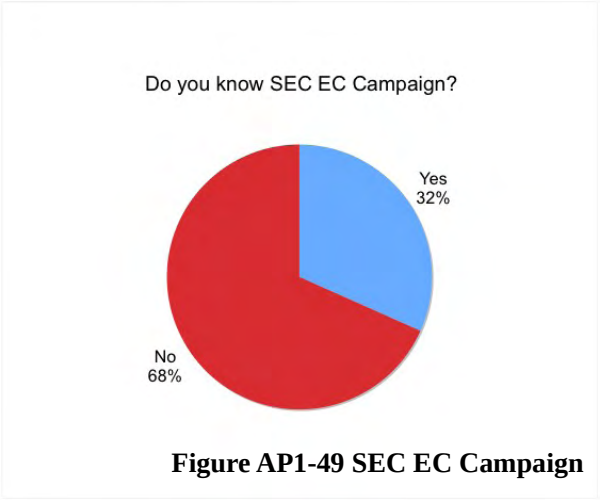

Figure AP1-49 SEC EC Campaign

2.7 Free Comments on Energy Conservation

Surveyors asked for free comments and opinions concerning energy conservation in KSA. Below are the 5 most frequent answers from house owners.

1. Energy efficient lamps and appliances are necessary	25 comments
2. Turning off of appliances is important and should be practiced more	18
3. Campaigns to improve awareness should be enlarged	14
4. Use of insulation is important	9
5. Unreliable electricity supply is the problem	8

These comments show positive and favorable attitude on energy conservation. At the same time many owners did not comment on the issue. As no.3 opinion tells, importance of EC should be addressed more extensively. Some of no.1 and no.4 comments said EC products should become more reachable. Suspicion on electricity stability expressed in no.5 needs to be overcome so that demand side will cooperate in EC enhancement.

2.8 Summary and Issues on Residential Sector Energy Conservation

(1) Housing Structure

Large size of detached houses means residential sector fundamentally has energy consuming nature. Other than air-conditioning, number of lightings or electric appliances increase with house size. Since the size of supplying houses is related to many factors and cannot be simply controlled, promotion of proper insulation use and energy efficient houses is important.

In KSA, structure and construction is almost uniform. This should be a favorable condition for standardization and dissemination of housing energy performance.

(2) Electricity Demand Peak

Peak time during lunch hour is inevitable because of cultural tradition. If we can implement EC measures that align with cultural habit as this, the effect will be fruitful in KSA.

It is ironical to note that late-night life pattern may be contributing to the leveling of electricity demand. Night consumption needs much attention in future, because it is core of residential electricity consumption and population growth continues to be high.

(3) Promotion of High Efficient Appliances

It is clear that air-conditioning (cooling) composes large portion of electricity demand. Lighting is also critical due to life pattern and housing size. Controlling schemes for appliances, such as labeling, and promotion incentives should be improved.

(4) Promotion of EC Awareness and Measures

Many replies claimed to have high consciousness towards energy conservation. It is doubtful although, if EC activities are practiced well in families. Because interviews were made only to male house owners, and excessive setting of AC temperature disagrees with the awareness. Fostering of EC awareness throughout every age and class of society, with teaching of actual EC measures, is most essential.

3. Commercial Sector Survey

3.1 General Information

In commercial sector, major facilities with different (small, medium and large) size were chosen from four cities. In all, 48 sites were surveyed. Table AP1-3 is the list of visited sites. Outline of these facilities is shown in Table AP1-4 and AP1-5.

Because we focused on collecting information about different uses and sizes of facilities, it is difficult to summarize them into standard types. Below three are sites that can illustrate Saudi commercial facilities from our survey..

(1) Al-Faisaliah Shopping Mall (Riyadh)

Figure AP1-50 Al-Faisaliah Shopping Mall
(source: flickr.com)

Built in 2003, Al-Faisaliah Shopping Mall is one of the largest shopping mall in KSA. Is a part of A-Faisaliah complex, which includes office tower, hotels, apartments, mosque and other facilities. This 70,668m^2 shopping mall has four floors above ground and one underground floor. It operates from 9am till 11:30pm with praying brake time (Friday has different opening hour). In the evening and on weekends, the mall is crowded with many visitors. Electricity is the main energy source, with some LPG use. The building is equipped with emergency diesel generators.

(2) Al-Jeraisy Group Office Building (Riyadh)

Figure AP1-51 Al-Jeraisy Group Office Building
(source: jeraisy.com)

This 17,100m^2 building in central Riyadh was built in 1997 and owned by Al-Jeraisy Group. It is used for offices and showrooms of group companies, and also rented to tenants. There are 200 rooms in 3 above ground floors and 1 basement floor. Electricity is the only energy source. There is no in-house generation

system.

(3) Abuzinadah Hospital (Jeddah)

Figure AP1-52 Abuzinadah Hospital
(source: abuzinadah-hospital.com)

It is a private general hospital in Riyadh. The building built in 1979 is owned by the hospital itself and used only for hospital and pharmacy purpose. Four floors building accommodates 74 rooms in its 4,766m^2 total floor area. Electricity and LPG are both used. Emergency generator operates with diesel oil.

Table AP1-3 Surveyed Commercial Sector Facilities

	Riyadh	Jeddah	Abha	Dammam
Hospital	1. Al-Mubarak Hospital 2. Saudi German Hospital 3. Adma Hospital	1. Abo Zanadah Hospital 2. Al-Hamra Hospital 3. Al-Jada'any Great Hospital	1. Abha Private Hospital 2. Specialized Hospital for Woman and Children 3. Al-Rahma Hospital	1. Al-Muasa Hospital 2. Al-Mane' Hospital 3. World Health Hospital
Hotel	1. Al-Khuzamy Hotel 2. Al-Faisalia Hotel	1. Al-Khaiyam Hotel 2. Alhamra Softile Hotel 3. Al-Attass Hotel	1. Kasr Al-Salam Hotel 2. Shafa Abha Hotel (with Offices) 3. Kaser Abha Hotel (with Offices)	1. Zahrat Alkhaleej Hotel 2. Sheraton Damman Hotel and Towers 3. Alhamra Golden Tulip Hotel
Shopping	1. Al-Othim 2. Mead Commercial Markets 3. Al-Faisalia Shopping Center (with Offices)	1. Al-Badriya towers (with Offices) 2. Panda 3. Mead	1. Benda 2. Ghnim Trade Center 3. Bin Shtoy for Marketing	1. Dana Compound 2. Benda 3. Mead
Office	1. 3rd. Aqaryyah, Manafeth Co. 2. Altathniyah Co. 3. Al-Jurasy Group of Co.	1. Nadar Office for Law & Translation 2. Muhammad Mandour Advisary Office 3. Omer Shkeb Al-Omaoi Corp.	1.Alnadwa Newspaper Office 2. National Development Group 3. Almadina Corp. for Press and Publication	1. Saed AbdElkarim Al-Muamer Towers- Al-Qatary Office 2. The Executive Office of Development 3. Al-Gazawi company for Law and Legal Advice
School	1. Al-Maordy Secondary School			

Table AP1-4 Outline of Surveyed Buildings (1)

City	Name of Building	Location	Use	Total floor area (m^2)	Year of completion	Nature of building (Shared or dedicated)
Riyadh	3rd. Aqaryyah, Manafeth Company for Ambulance and Disabled Vehicles	Olayya, Olayya Street, 3rd. Aqaryyah, 509	Office	172	1996	Shared building
Riyadh	Altathniya company for Electrical & Mechanical services	Sulaymania, Almuthnib str., Near Civil Defense	Office	300	2000	Shared building
Riyadh	Al-Khuzamy Hotel	Olayya, Olayya Street, PO Box 11491 - 4148	Hotel	8268	1980	Dedicated building
Riyadh	Al-Mubarak Hospital	Al-Muraba'a, King Faisal str.	General private hospital	900	1978	Dedicated building
Riyadh	Al-Othim	Almorouj	Shopping center	5000	2001	Dedicated building
Riyadh	Al-Faisalia hotel	Olayya str.	Hotel	-	2000	Part of Alfysayah complex
Riyadh	Al-Maordy Secondary School	King Faisal str., Near Amir Bander BinAbdElaziz str.	School	7000	1999	Dedicated building
Riyadh	Saudi-Germany Hospital		Hospital	14400	2001	Dedicated building
Riyadh	Mead Commercial Markets	Almadina Almunawara str, branch 61110	Local shop	80	2004	Shared building
Riyadh	Al-Jurasy Group of Companies	King Fahid Road	Office	17100	1997	Shared building
Riyadh	Adma Hospital (skin care)	Makka Road	Hospital	3000	2004	Dedicated building
Riyadh	Al-Faisalia Shopping Center	Olayya, King Fahid Road, Al-Faisaliya Tower	Shopping center with Office	70668	2003	Part of Alfaislia complex
Jeddah	Nader Office for Law & Translation	Mashrafa, Abu Znada str.	Office	520	1970	Shared building
Jeddah	Al-Khaiyam Hotel	AL-Balad, AL-Dahab str	Hotel	300	1970	Dedicated building
Jeddah	Alhamra Softile	Filastine str	Hotel	3631	1980	Dedicated building
Jeddah	Al-Attass Hotel	King Fahid str.	Hotel	2500	1958	Dedicated building
Jeddah	Muhammad Mandour Advisory Office	AL-Safa, Gabal Sateha str. Western	Office	300	2001	Shared building
Jeddah	Omer Shkeb AI-Omaoi Corp.	AL-Baghdadiya, Maqadicho str.	Office	110	1990	Shared building
Jeddah	Abu-Zanada Hospital	AL-Baghdadiya, Aqaba str.	General private hospital	4766	1979	Dedicated building
Jeddah	Al-Hamra Hospital	Al-Hamra, Arafat str.	General private hospital	529	1987	Dedicated building
Jeddah	Al-Jada'any Great Hospital	Ghalil, Hasan Hasanen str.	General private hospital	2025	1988	Dedicated building
Jeddah	Al-Badriya Towers	AI-Khalidiya, AL-Rouda str.	Shopping center with Office	6500	1996	Shared building Towers
Jeddah	Banda	AL-Safa, AI-Tahliya str.	Shopping mall	3241	2001	Shared building
Jeddah	Mead	AL-Raboa, Jawad br., Hara' str.	Local shop	150	2006	Shared building (Fuel station and services)

Table AP1-5 Outline of Surveyed Buildings (2)

City	Name of Building	Location	Use	Total floor area (m^2)	Year of completion	Nature of building (Shared or dedicated)
Abha	Kasr Al-Salam Hotel		Hotel	1200	2000	Sharsd building with Abha Private Hospital
Abha	Shafa Abha Hotel	Aqabat Dala', Jazan Road	Hotel	800	1991	Dedicated building
Abha	Kaser Abha Hotel	AlMuntaj, Najran Road	Hotel	10620	1997	Dedicated building
Abha	Abha private Hospital	King Faisal str	Hospital	2600	2000	Sharsd building with Assalam Palace Hotel
Abha	Specialist Hospital for Women & Chidren	Al-Yamaniya, Near Abha Alam hospital	Hospital	1800	2002	Dedicated building
Abha	Al-Rahma Hospital	AI-Nasiem, Alhezam Circle	General private hospital	1500	2000	Dedicated building
Abha	Alnadwa Newspaper Office	City Center, King So'od str.	Office	96	2000	Shared building
Abha	National Development Group	AL-Khamees Road	Office	400	2001	Shared building
Abha	Benda	AL-Khamees Road	Shoping center	4200	2007	Shared building
Abha	Almadina Corp for Press & Publication	AL-Khamees Road	Office	270	2006	Shared building
Abha	Ghnim Trade Center	Jazan Road	Shopping center	7663	1999	Shared building
Abha	Bin Shtoy For Marketing	Abu Khayal, Alhezam Circle	Local shop	59	2004	Shared building
Dammam	Dana Compound	AL-Souq	Shopping mall	2000	1986	Shared building
Dammam	Zahrat AlKaleej Hotel	Al-Adama	Hotel	1300	1987	Dedicated building
Dammam	Saed AbdElkarim AI-Muamer Towers - AI-Qatary Office	AlKorneich	Office	281	2005	Shared building
Dammam	Al-Muasa Hospital	Ohd	General private hospital	1500	1988	Dedicated building
Dammam	Al-Mane' Hospital	Abdullah Fu'ad Neighborhood	General private hospital	2110	1982	Dedicated building
Dammam	The Excutive Office of Development	Al-Gloia	Office	64		Shared building
Dammam	Sheraton Dammam Hotel and Towers	1st Street · P.O. Box 5397 · Dammam 3142	Hotel	25160	1981	Dedicated building
Dammam	Al-Gazawi Company for Low & Legal Advice	Al-Mazroue'ia	Office	550	1984	Shared Building
Dammam	Alhamra Hotel (Golden Tolep)	AL-Souq	Hotel	1072	1979	Dedicated building
Dammam	Benda	AI-Galoia	Local shop	1244	1975	
Dammam	Mead		Local shop	100	2005	Shared building
Dammam	World Health Hospital	Al-Mazroue'ia	General private hospital	550	1994	Dedicated building

3.2 Building Structure and Insulation

3.2.1 Building Structure

(1) Main Building Frame

Below graph shows main building frame of surveyed buildings. Almost all are made with steel reinforced concrete. Only one example is Al-Khozama hotel deigned by Japanese Architect Kenzo Tange that has steel frame structure. Tall towers, which would use steel structure for streamlining construction process and period in Western countries, are also made with concrete in this country.

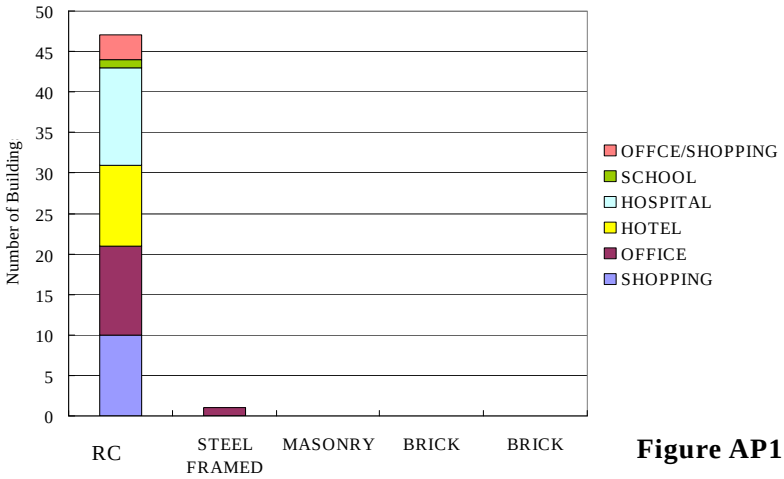

Figure AP1-53 Main Building Frame

(2) Wall Material

As shown in Figure AP1-54, major material for walls are blocks (concrete blocks or bricks) and reinforced concrete. Use of these materials seems to have started in early 80s. Although we observe increase of glass-curtain wall buildings such as Kingdom Tower in Riyadh, there is only one sample in our survey.

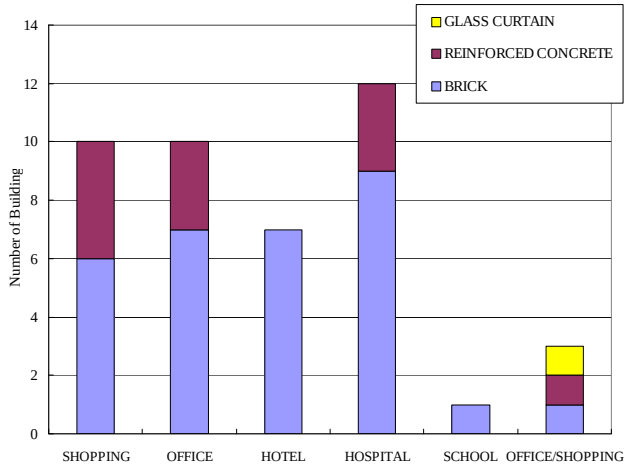

Figure AP1-54 Wall Material

3.2.2 Building Insulation

(1) Wall Insulation

Figure AP1-55 shows 59% of surveyed buildings do not have wall insulation. Most of insulated

buildings use interior insulation. Riyadh buildings comparatively have higher rate of wall insulation. Commercial buildings use large amount of energy for air-conditioning. Although Figure AP1-56 shows recent dissemination, this should improve further more. Quality of insulation is also an essential issue.

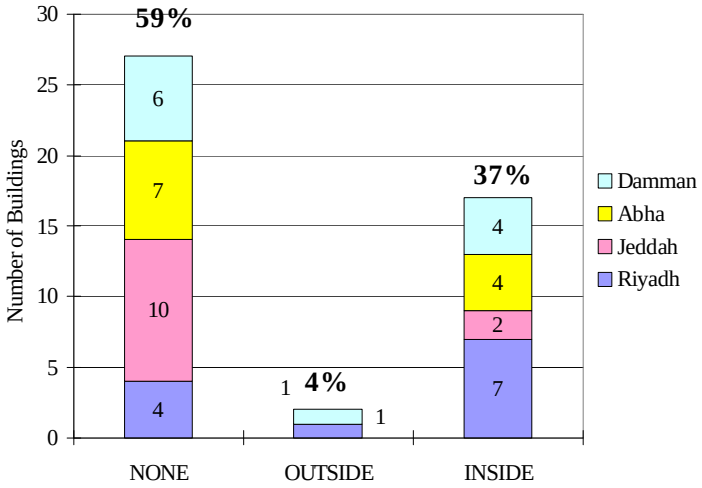

Figure AP1-55 Wall Insulation of Commercial Buildings

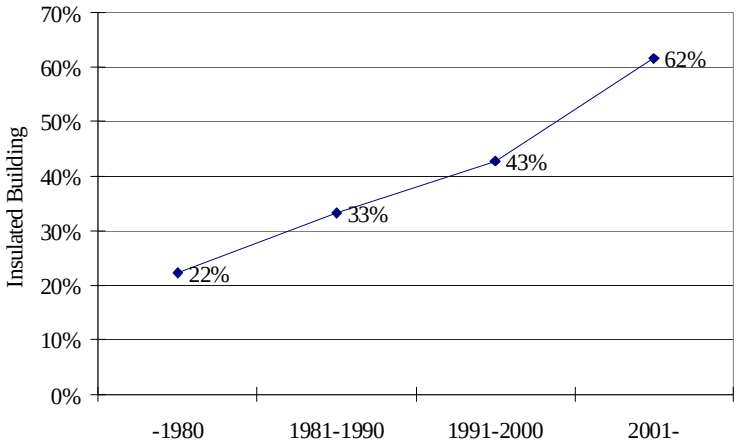

Figure AP1-56 Trend of Wall Insulation Use

(3) Roof Insulation

Figure AP1-57 shows 52% of surveyed commercial buildings have roof insulation. This rate is slightly higher than the use of wall insulation. Although samples are too small to account on this result, it can be due to large roof area resulting from large footprint of KSA buildings. Also relative low growth in roof insulation can be because of recent high-rise buildings, which dominate and concentrate in city centers and receive greater AC load from walls than roofs.

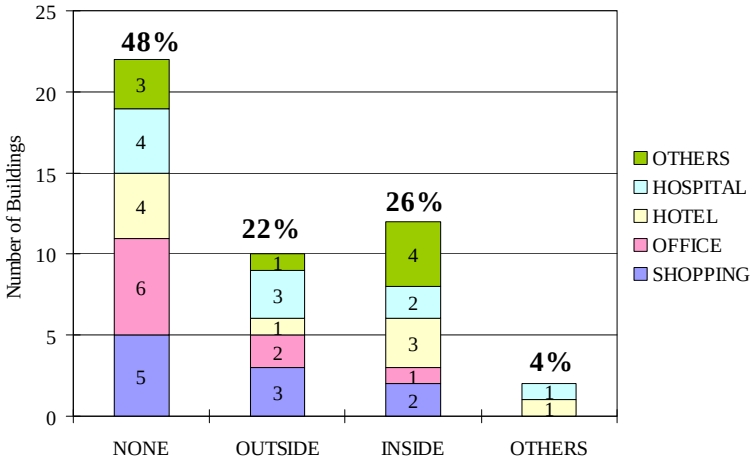

Figure AP1-57 Roof Insulation of Commercial Insulation

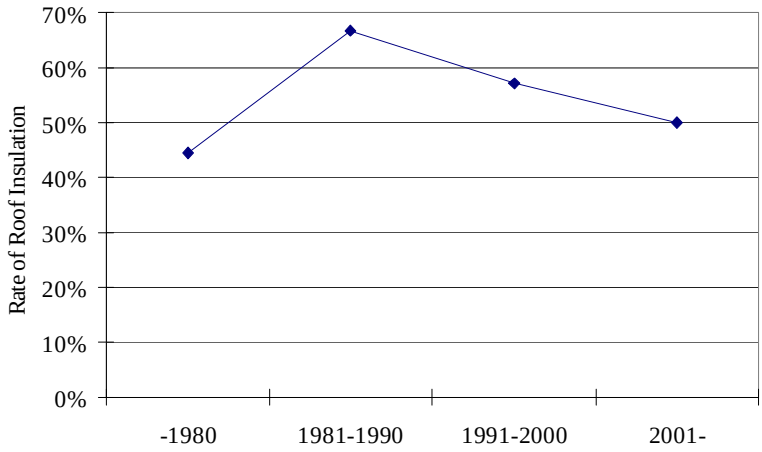

Figure AP1-58 Trend of Roof Insulation Use

3.3 Used Energy

Major energy sources in Saudi commercial buildings are; electricity, LPG (tanked or bottled), kerosene and diesel oil.

Electricity, LPG and other sources are used respectively, 37%, 41%, and 22%. Use of gas is more popular than Japanese buildings where fire protection issue and regulations are in favor of electricity use.

For heating in winter, electricity is the major energy source as shown in Figure AP1-60. Except in Abuzinadah hospital, buildings in Jeddah do not have heating equipments. High temperature throughout the year should be the reason.

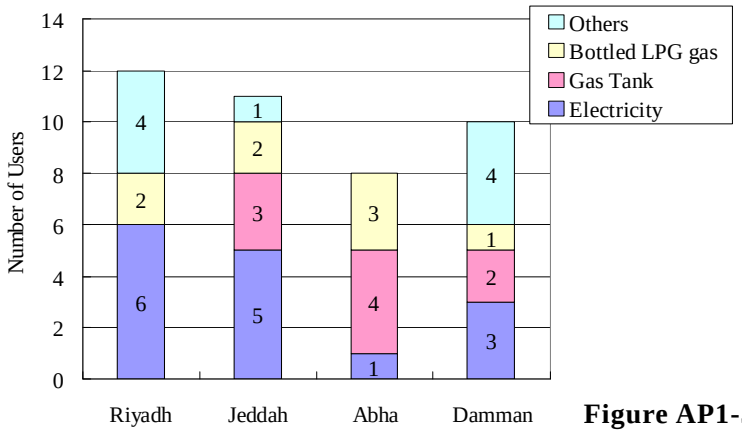

Figure AP1-59 Cooking Energy Source

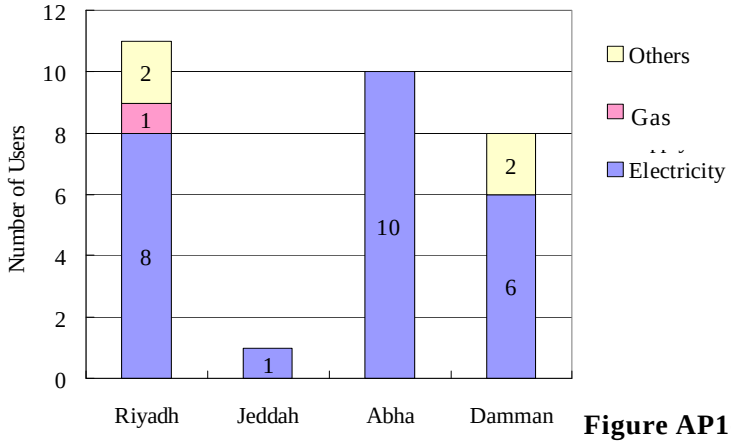

Figure AP1-60 Heating Energy Source

3.4 Lighting

Fluorescent lamps, CFLs, incandescent lamps, sodium lamps, metal halide lamps and mercury lamps are used in commercial buildings.

Figure AP1-61 shows average lifetime of used lamps. Incandescent lamps have short lifetime as 1 to 2 years. Other types of lamps should last for 3 to 5 years. Nevertheless, this result shows strangely short lifetime of these lamps.

1) Poor quality of lamps 2) Poor quality of lighting equipments 3) Effect of unstable electricity supply (e.g. fluctuation, harmonic disturbance) can be the causes for this short lifetime. This needs careful investigation and improvement.

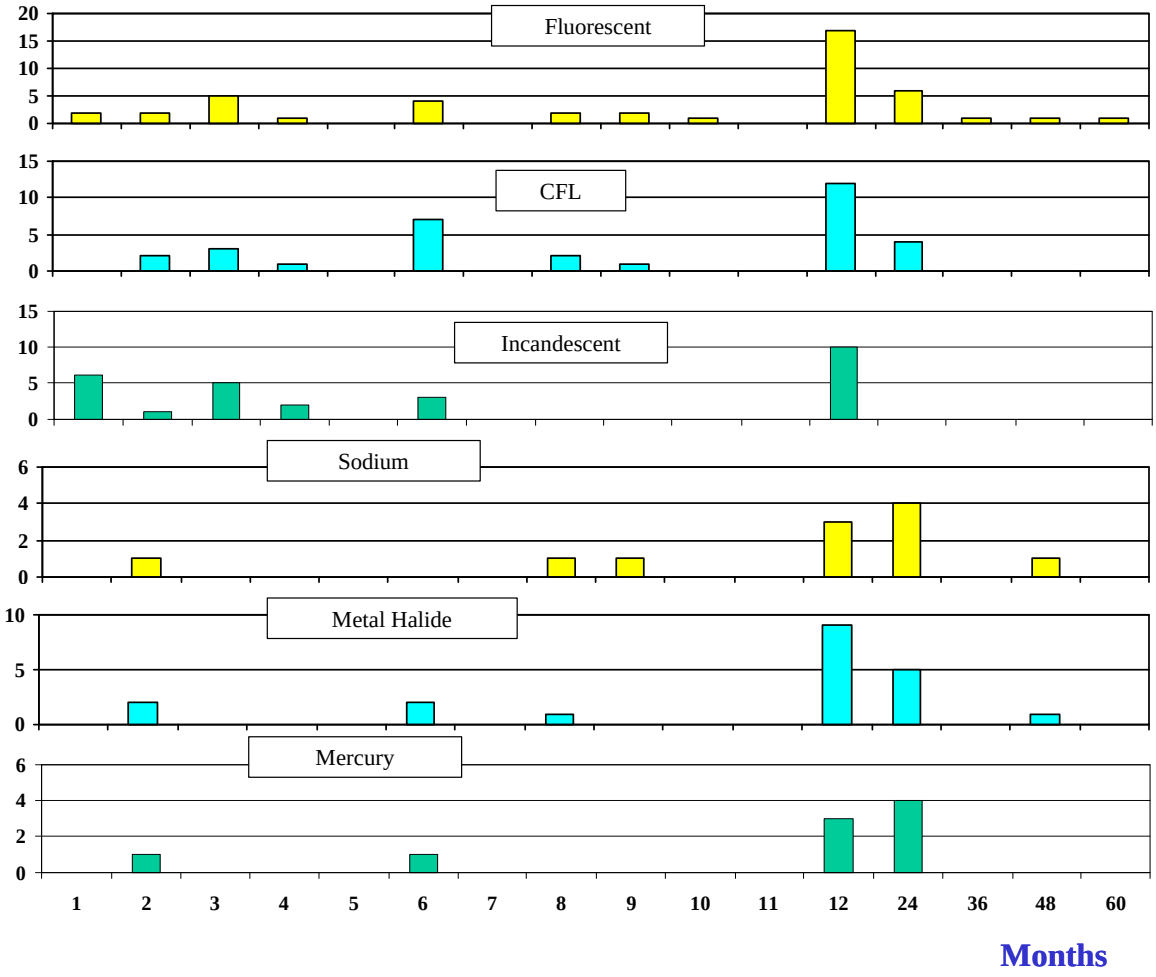

Figure AP1-61 Lifetime of Lamps

3.5 Air-Conditioning

3.5.1 Types of Air-Conditioners

Small ACs (window type and split type) are widely used in the commercial buildings ('others' in Figure AP1-62 are mainly window types). Refrigerant types such as VRV ('Building-Multi' in Japan) system are rarely used. Instead, package ACs transferring air are used as middle-size machines. Lower initial cost and easier setting/maintenance should be the reason of their dominance. Use of these machines means high electricity consumption.

At many sites, old low-efficient machines continue to be used. Cheap electricity price makes it difficult to renovate into new high-efficient system. Some incentive measure is necessary to promote this renovation.

It depends on each facility's use and operation, whether central chiller system or other individual system is suitable for a commercial building. Building Code needs to be practiced properly to optimize AC energy use in every commercial facility.

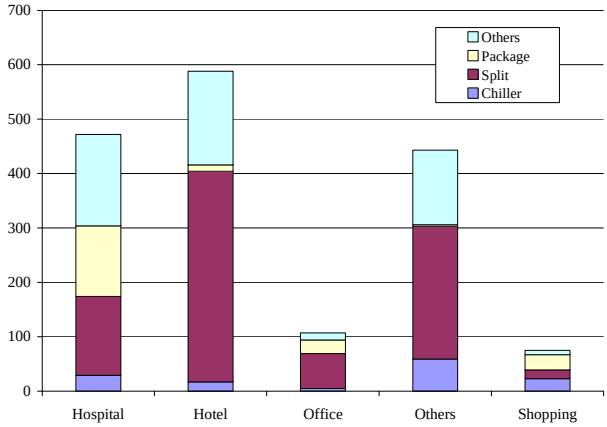

Figure AP1-62 Type and Numbers of ACs

3.5.2 AC Operation Period

At many commercial sites, ACs continue to be used throughout a year as shown in Figure AP1-63. Considerable number of samples in Riyadh stop ACs during wintertime. This means interior emitting heat from appliances is enough to warm up in Riyadh climate, which is a common phenomenon in contemporary offices.

Figure AP1-64 shows daily operation hour of ACs. Long time operation is unavoidable in hospital or hotels. Shopping centers should be able to limit their operation time by scheduling with their opening hours.

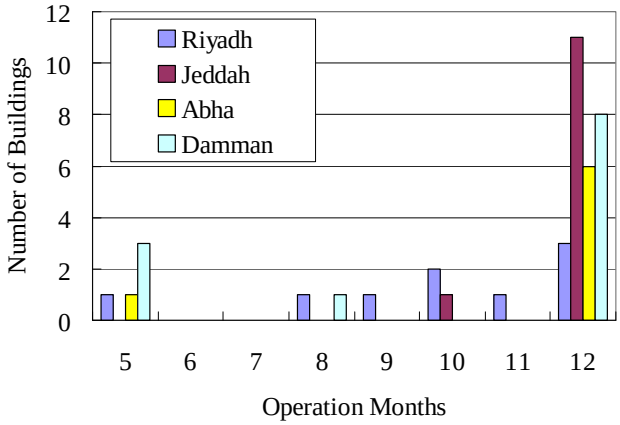

Figure AP1-63 Yearly AC Operation

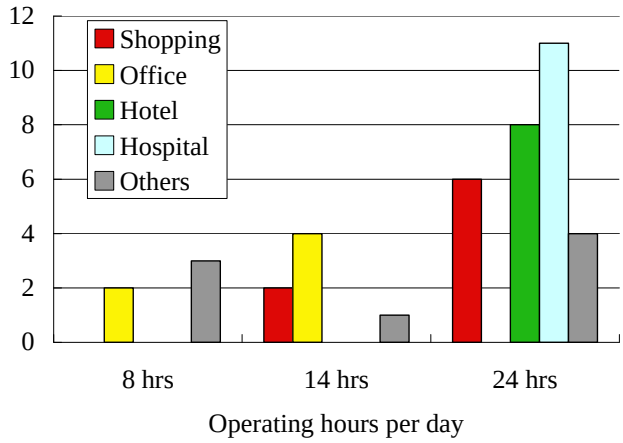

Figure AP1-64 Daily AC Operation

3.5.3 Maintenance of ACs

Many sites answered ACs are frequently inspected as shown in Figure AP1-65 (left). Dominant 'others' as purpose of this maintenance on the right graph are supposed to be mainly responding operation to claims from users. It is difficult to believe maintenance operation for optimal energy efficiency is being conducted.

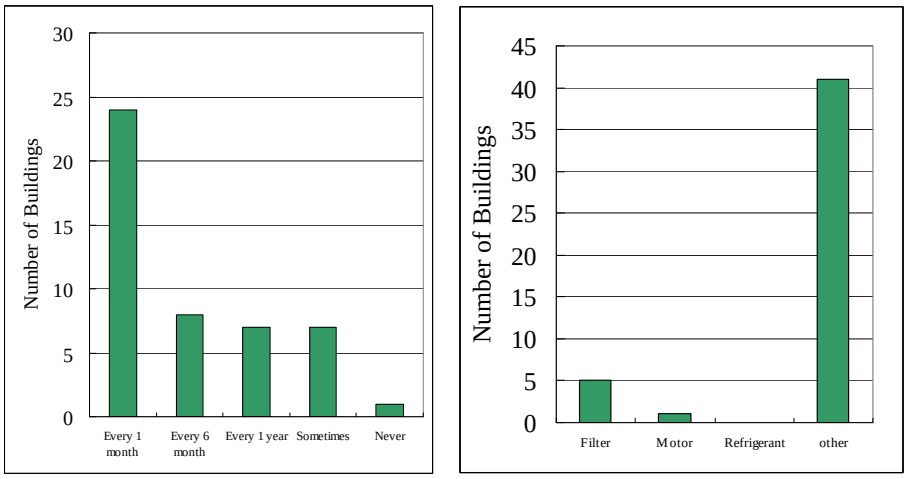

Figure AP1-65 Frequency and Purpose of AC Maintenance

3.5.4 Temperature Setting of ACs

Figure AP1-66 shows cooling temperature setting at each site. Some of them are set excessively low. This must be a result from malfunctioning of ACs or imbalance between room volume and AC capacity.

In many hotels, hospitals and shopping centers, standard setting temperature is 22ºC degrees. It is now common practice in KSA, but gradual rising of this temperature, with campaigning of awareness, should be possible. In offices setting temperature is set higher between 22 and 25ºC degrees.

Figure AP1-66 AC Cooling Temperature

3.6 EC Awareness and Practice

Figure AP1-67 shows opinions on light-off activities from building facility managers. Many agree on practice after hour and for unnecessary lights. Praying time light-off is opposed by many facility managers. Shortness and vicinity of praying hour probably is the reason. Also compared to Japanese offices, Saudi offices have fewer windows and would become difficult to work if lights are out even during daytime.

Figure AP1-68 is answers if facility managers agree on practicing mentioned energy conservation activities. Improvement measures for promotion of EC importance definitively are necessary for building owners and managers.

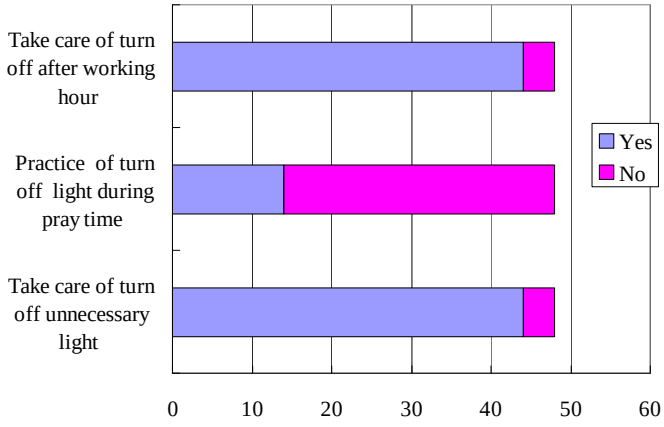

Figure AP1-67 Approval on Light-Off

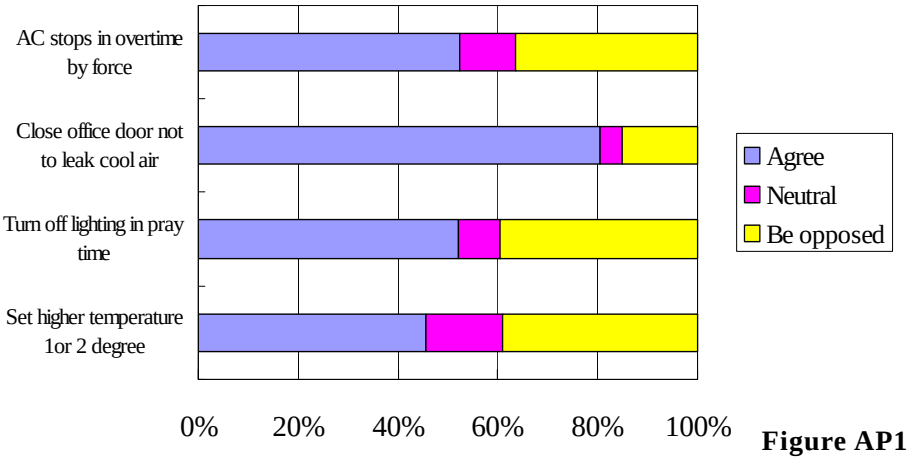

Figure AP1-68 Approval on EC Activities

3.7 EC Campaign and Electricity Tariff System

3.7.1 EC Campaign

Saudi government and Saudi Electric Company (SEC) conduct EC campaigns. The survey result shows these campaigns are not well recognized among facility managers of commercial buildings. Figure AP1-69 and Figure AP1-70 show this result. On one hand, dissemination in Jeddah needs special attention. Cultural background as historical commercial center, with strong connection with foreign countries, might have connection to the interest on energy conservation. It is necessary to investigate on the reasons in Jeddah, and improve future campaign measures.

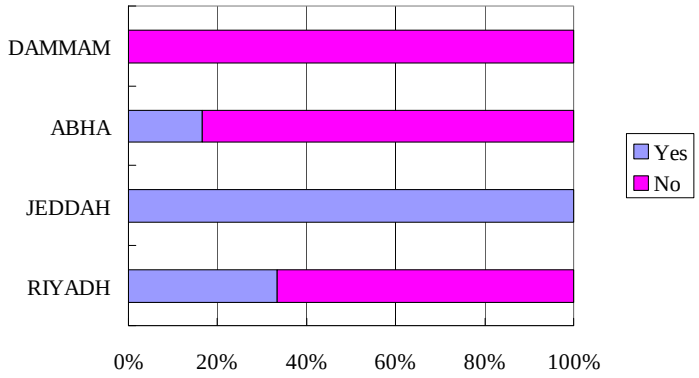

Figure AP1-69 How well Government EC Campaign is known

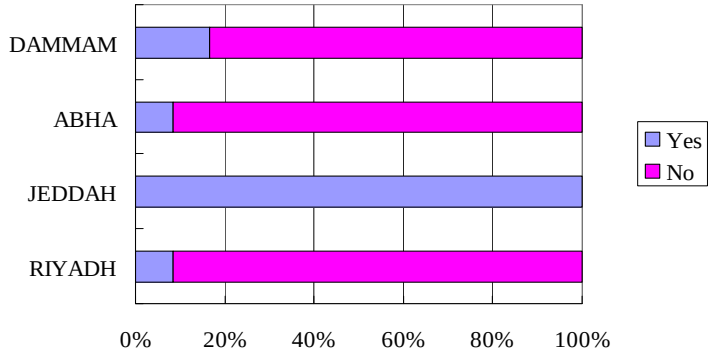

Figure AP1-70 How well SEC EC Campaign is known

3.7.2 Electricity Tariff System

Time of use tariff system (TOU) is an effective measure for peak-shifting in commercial sector electricity demand. Japanese TOU system aims at cutting daytime electricity use and converting to nighttime. Figure AP1-71 and Figure AP1-72 show TOU is not well known in KSA (for present TOU system in KSA, see chapter 6). Since electricity demand structure is different from Japan, careful discussion for suitable tariff system that leads to energy conservation, as well as publicity of TOU, is necessary.

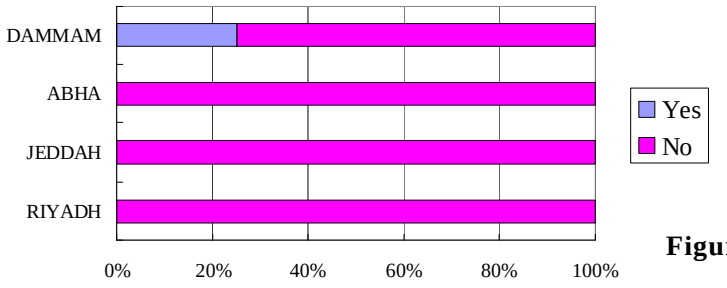

Figure AP1-71 How Well TOU is known

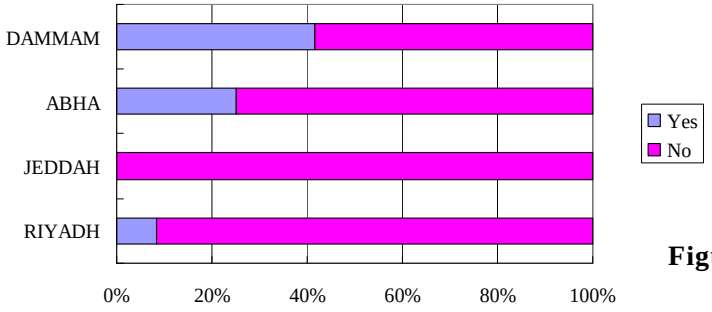

Figure AP1-72 Interest in TOU System

3.8 Summary and Issues on Commercial Sector Energy Conservation

(1) Building Structure, Insulation and Equipments

Similar to residential sector, there is large potential for improvement of building and equipments' EC performance. As economic entities, commercial sector will enhance its EC activity if they lead to their benefits. Policymaking and publicity campaign should utilize measures in this nature.

(2) Cooperation within Sector and Information Exchange

In KSA, organization and information sharing in industrial and commercial entities need to develop further. At present it is difficult to obtain reliable information in these sectors. We faced this difficulty while selecting sites that agree to provide information. In countries like Japan, where sector-wise EC activity in advanced, information exchange and competition between companies play important role. Establishment of SEEC (Saudi Energy Efficiency Center) and involvement of private sector in its administration should promote cooperation. The scope of this center also should support strategic policies for private sector development.

(3) Energy Management System

Difficulties we faced in statistical analysis of commercial survey were partly due to limited number of samples. These difficulties were also caused by instability of obtained data and information. It implies lack of basic management and monitoring skill in building facility management.

Improvement of this basic skill, parallel to the establishment of energy management system is essential.

4. Survey Outcome and Issues for the Future

There was scarce precedent information concerning energy use or conservation in KSA. In this respect, this survey should have such a value that it quantified information only supposed as common understanding before. Commercial sector survey faced difficulty in selecting sites by the lack of reliable facility lists. Continuing of the survey and obtaining of larger data is important.

In both sectors, we did not succeed in obtaining electricity consumption trends of surveyed sites. If these data were provided, outcome would have become more fruitful by comparing relation between equipments, activities and resulted electricity use.

In residential sector, sample number allowed us statistical analysis. The number is not yet large enough and wider survey will lead to more accurate evaluation. Also more detailed survey is necessary regarding use of appliances in houses. The answers were obtained from husband owners who are absent in daytime. If we can monitor housekeeping activities, the information will bring more effective and realizable measures for residential energy conservation.

In commercial sector, survey was focused in obtaining example data from different use and size. Therefore number of samples for each commercial use was not large enough for statistical treatment or highlighting average nature in each use. Next step survey needs larger number of samples from each type. Also more detailed investigation on facility management will be necessary.

Continuation and improvement of survey will clarify issues concerning energy conservation step by step. Establishment of continuous enrolling body such as SEEC is important for gathering of information.