1.5 Conclusions and Further Possibilities

(1) Possibility of Model House from Dwelling Point

Through workshops, opinions on model house were collected. It was generally accepted as realizable, from dwelling point of view. Only remark was that 3 stories house would be difficult to live for Saudi people, who are used to horizontal wideness, especially among elders.

Large Saudi families have elder family members at high rate. Positioning of some bedrooms on lower levels can be an alternative.

(2) Construction Cost

Although model house utilizes domestically available material such as cement/concrete or chemical insulation products, supposed products are not widely used at local construction sites. This fact easily leap to conclusion that proposal is not realizable economically, but this is too simple misunderstanding because if benefits of EC design are proved worth industrial investments, products will be available in market.

More difficult issue is, how to evaluate field and other expenses regarding quality control of construction. The best way for this evaluation would be actual construction (even in small size) of prototype. Many related issues will arise if it were done.

(3) Industrialization of Housing

Above issue relates to harsh working condition at construction sites in Riyadh climate. Quality control of house performance accompanied by cost efficiency can be improved with industrialization of house construction. Specially because housing supply needs to expand in this country.

Proper industrialization such as introduction of prefabrication will also contribute to better total lifecycle energy performance of houses. Development of model house design in this view is necessary future step.

(4) Utilization of Renewable Energy

In energy efficiency simulation, use of natural airflow during interim period was intended at first. This could not be done because temperature change within a day was too large. In essence, model house is designed in such a way that it is protected from exterior heat load.

Next step should be the use of renewable energy. Monitoring device will also help energy conservation and interaction with natural energy resource.

Roof louver material is actually not specified up to now. Wooden louvers will easily bend because of dryness and sun radiation. They can be made with photovoltaic panels.

(5) Use of Local Tradition

Some comments at workshops hoped for development of project utilizing vernacular housing tradition. Adobe bricks and Mashrabiya are great examples of wisdom to sustainability dwell local climate and culture. In this respect, further cooperation is necessary between both contributors.

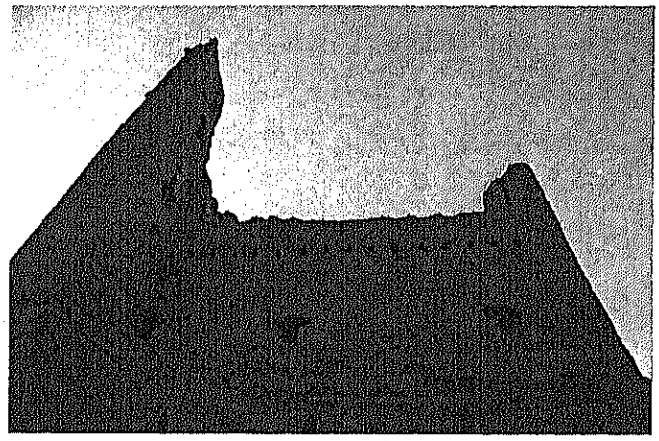

Figure AP4-1.54 Adobe Structure near Riyadh

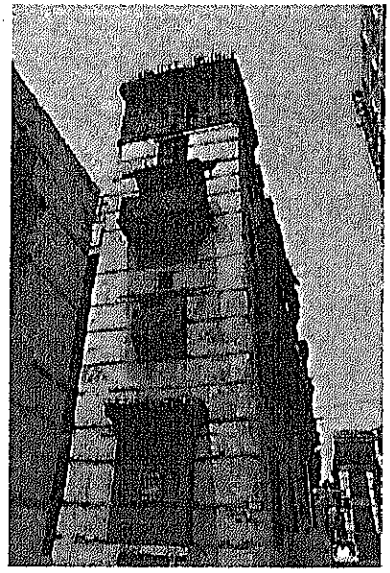

Figure AP4-1.55 Mashrabiya in Jeddah

(6) Fruitage of Project

Apart from acquired results, whole project was fruitful because it created discussions between local and Japanese teams, and helped raising many issues concerning residential energy conservation in KSA.

2. Energy Management and Energy Conservation Implementation in Cement Industry

2.1. Purpose and Outline of Activity

(1) Purpose

1) Dissemination of energy conservation
2) Provision of information on Cement industry in Japan
3) Introduction of benchmark implementation procedure, survey and analysis
4) Popularization of benchmarking method

(2) Reasons to apply benchmarking to cement industry

1) Product grades are limited.
2) Cement industry is a typical energy-intensive industry.
3) It is easy to collect Japanese basic data.

(3) Collected data

1) Electricity consumption
2) Amount of production
3) Number of employees

2.2. Outline of cement industry in the KSA

(1) Cement enterprises in the KSA

9 plants of 9 enterprises are in production, and annual production of cement and clinker in 2005 is 25,358 tons and 19,881 tons respectively. And it can be said that 27 new comers are preparing to join the business.

Cement enterprises and their plants are shown in Table AP4-2.1. Project team visited yellow highlighted enterprises.

Table AP4-2.1 List of Cement enterprises and plants in the KSA (in 2005)

		Cement Production	Clinker Production	Number of Employee	Location
1	Saudi Cement Co.	4,708	4377	2216	Dammam
2	Yanbu Cement Co. Ltd.	4,257	3452	782	Yanbu
3	Yamama Saudi Cement Co.	3,514	2557	1295	Riyadh
4	Southern Province Cement Co.	3,500	3070	400 614	Abha Bieshah Jizan
5	Arabian Cement Co. Ltd.	2,830	2523	800	Rabigh
6	Eastern Province Cement Co.	2,375	2243	1000	Dammam
7	Qassim Cement Co.	2,125	1837	717	Buraydah
8	Tabuk Cement Company	1,445	1307.6	366	Dibaah
9	Saudi White Cement Co.	186	182	-	Riyadh

(2) Trend of cement production in the KSA

Amount of production surges steadily upward shown in Figure AP4-2.1, and the average growth rate in these 10 years (1994-2005) is 4.9%. Most of products were consumed in domestic use. Saudi cement enterprises are growing steadily with economic development, and they can sell their products as much as they produce. Products are also exported to GCC. All cement enterprises in the KSA are affiliated with AUCBM (Arab Union for Cement and Building Materials)[4]. This organization arranges meetings and seminars to communicate and make information exchange among Arabian countries.

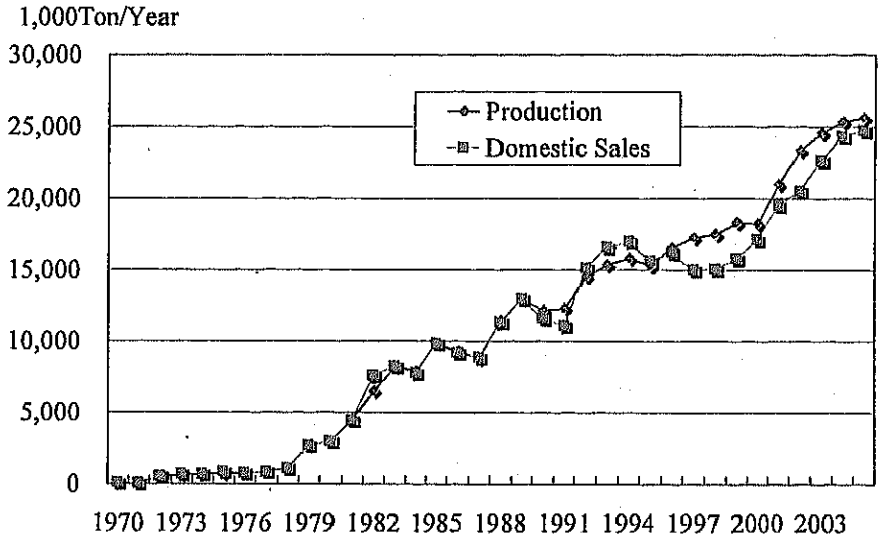

Figure AP4-2.1 Trend of cement production in the KSA[5]

2.3. Report of cement plant tour

Table AP4-2.2 shows data of cement enterprises, which JICA project visited.

[4] Head Quarter is in Syria. Regular meeting is held every year. (At Syria and Cairo in 2007)
[5] All enterprises

Table AP4-2.2 Data from cement enterprises, which JICA project visited

				A-Company	B-Company	C-Company	D-Company
Capital			Million SR		450		25
Capacity (ton/day)	Clinker	Existing	DL[6]	4×1,000 = 4,000		#1 ~ #5	#1 (300) 8,300
			NSP[7]	1×4,000 = 4,000	4,700	#6	#2 ~ #7
		Future	NSP	2008/End (7,000) 2010 (10,000)	2007 (4,500)	2008/1 #7 ? #8	
Establishment				1956	1980		1961
Number of Employees				800	660		
Area			km^2	43	33		
Electricity Intensity			KWh/ton	122	98	#1 - #5 84 → 80 #6 68 → 65	
Electricity	Purchase			None	Yes	8 ~ 10 MW	For #1 only
	Generation			Fuel: Heavy oil[8]	None	Peak: 64, average: 48MW	Natural gas: 9 Gas turbines, Total 25MW
				Diesel; 7 units		Generator: 27MW×3units	
				Gas turbine: 3 units		One: Stand by	Emergency: Diesel
Fuel[9]					Crude oil, 40,000 liter/hour	Fuel gas	Natural gas and crude oil
Others	Lime stone		Years	20	400		
	Power Factor			-	0.95	0.90 → 0.94	-
	Energy Management Org.			-	Yes (6 members)	None	None
	ISO Certificate			9001 (in 2004)			

[6] Dry Long (DL) kiln type
[7] New Suspension Pre-heater (NSP) type
[8] Free from Aramco except transportation
[9] From Aramco

2.4. Benchmarking analysis of Energy Conservation

(1) International comparison of energy intensity

Figure AP4-2.2 shows recent trend of heat intensity and electricity intensity in Japanese cement industry. Heat intensity is improved steadily, but electricity intensity is getting worse (increasing) contrary. Increase of heat intensity results from effective utilization of waste materials.

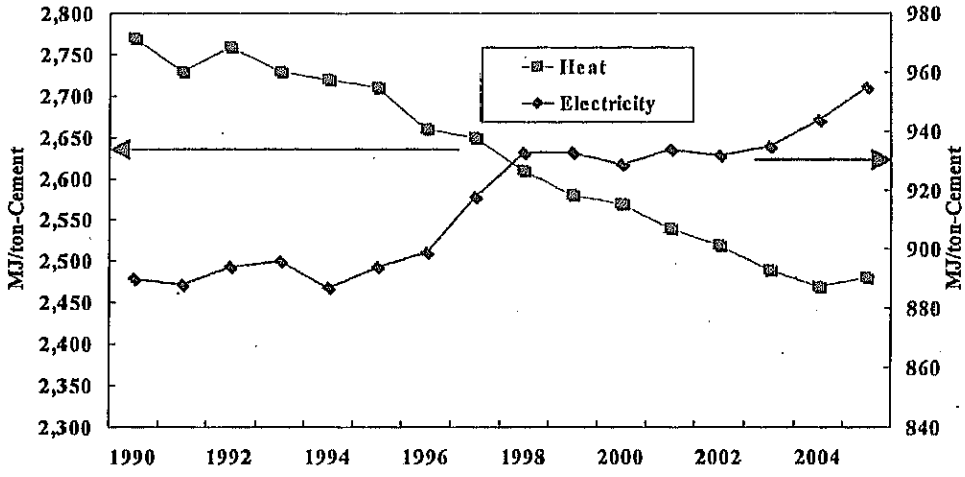

Figure AP4-2.2 Trend of heat intensity and electricity intensity in Japanese cement industry[10]

Electricity intensity was improved by more than 20 kWh/ t-Cement in Figure AP4-2.3 showing past 40 years trend. Trend of increasing is recent phenomenon by using waste materials.

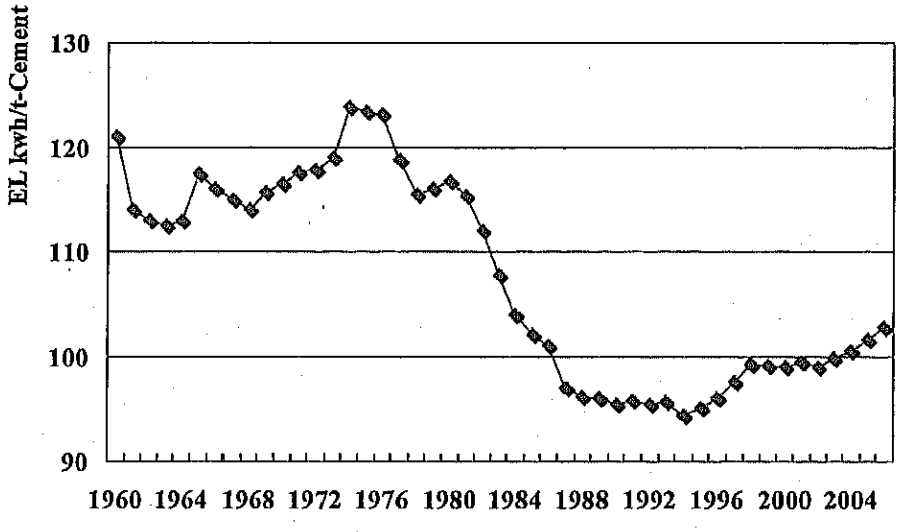

Figure AP4-2.3 Trend of average electricity intensity in Japanese cement industry

Japan is said to be the top drawer of energy intensity in the world cement industry. (Figure AP4-2.4)

[10] Source: Cement Handbook (published by Japan Cement Association)
Conversion ratio from electricity to heat is calculated using 39.98%(1kWh=2,150kcal) of efficiency at thermal power plants.

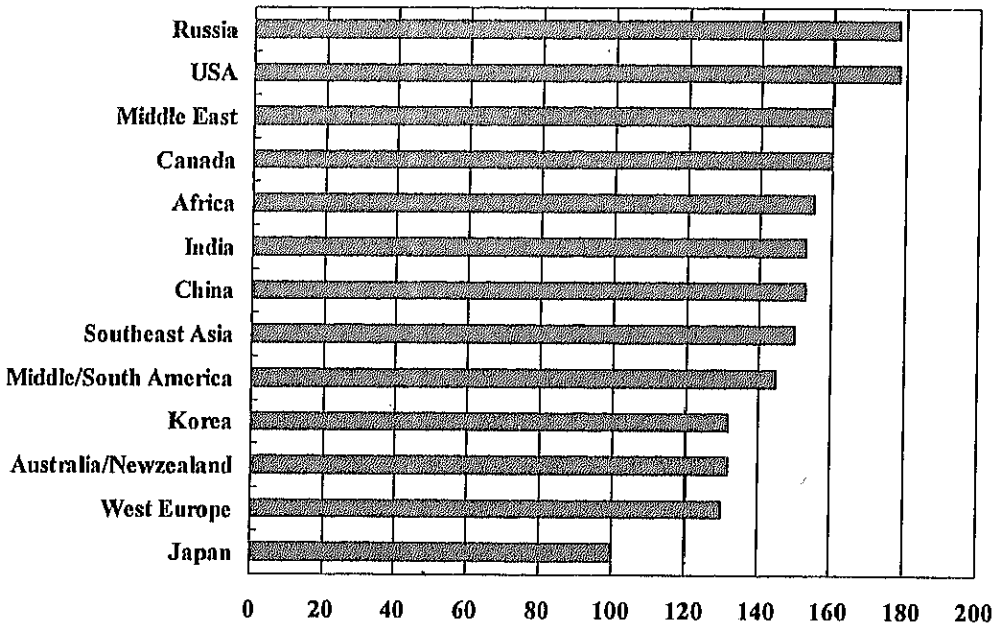

Figure AP4-2.4 International comparison of energy consumption in clinker production (in 2000)[11]

(2) Comparison of energy intensity and productivity between Japanese and Saudi cement enterprises

Energy intensity and other parameters are compared between Japanese and Saudi cement enterprises, and shown in Table AP4-2.3. Japanese average data are from Cement Handbook published by Japan Cement Association, and company data are from CSR (CSR: Corporate Social Responsibility) reports of Taiheiyo Cement[12] and Sumitomo Osaka Cement[13].

Table AP4-2.3 Energy intensity and productivity of Cement enterprises

	Unit	Japan			The KSA		
		Average	Taiheiyo	Sumitomo Osama	Saudi Cement	Arabian Cement	Qassim Cement
Heat	MJ/ton-Cement	2,450	2,333	3,099			
Elect-ricity	KWh/ton-Cement	102.7	108.2	92.4	135.7	121.6	98.2
Energy	MJ/ton-Cement	3,420	3,349	3,966			
Produc-tivity	Cement-ton / person×year	19,600	10,209	10,762	3,716	3,825	3,095

And some issues were confirmed as follows.

1) Electricity intensity of Qassim and Sumitomo Osaka Cement is less than 100kWh/t-Cement, and they are less than Japanese cement industry average. All facilities of Qassim are NSP process, and it must be the main reason of low electric intensity. Sumitomo Osaka Cement shows good electric intensity, but total energy intensity is not good. The reason is not clear.

[11] "Toward a sustainable cement industry sub study 8: Climate change (March 2002)" (Battel)
[12] http://www.taiheiyo-cement.co.jp/index.html
[13] http://www.soc.co.jp

2) Only electric energy data were inquired to Saudi cement enterprises, then total energy cannot be compared and discussed. As heat and electricity energy have any affect to each other, both heat and electricity data collection is must at such surveillance.
3) Productivity per person in Saudi cement industry is one third of that in Japan. Level of automatization, difference of worker quality and personnel expense must be major reasons of difference between these two countries.

Though obtained benchmark data in this project is not so much, it became clear that energy efficiency differs vastly with country, enterprise and production process. It is recommended that Saudi cement enterprises collect data and information of production efficiency, analyze them and make and implement improved production scheme in the PDCA cycle. Co-operational activities with AUCBM on benchmarking might be helpful.

2.5. Production facility, labor productivity and electricity intensity in the KSA

Table AP4-2.4 Production, Productivity and electricity intensity of Saudi cement enterprises

	Item		A-Company	B-Company	C-Company	Japan (Total)	Japanese S-Company**
Facility	Number of Kiln	Dry Long	4		5		
		Suspension Preheat				*	*
		New SP	1	2	1	*	*
	Clinker Production Capacity (t/day)		8,000	4,700	7,070		
Production	Clinker Production (t/year)		2,600,000	1,776,000	2,550,000		
	Cement Production (t/year)		3,060,000	2,042,400	2,750,000	73,170,000	12,780,000
	Number of employee		800	660	740		
	Productivity (t/year/person)		3,825	3,095	3,716	19,600	-
Electricity	Purchased from SEC (kWh/year)		0	210,880,000	345,000,000		
	Private generation (kWh/year)		417,035,000	0	28,124,000		
	Total electriity (kWh/year)		417,035,000	210,880,000	373,124,000		
	Elec. Consumption for Cement (kWh/year)		372,218,400	200,614,000	373,124,000	7,512,000,000	1,140,000,000
	Elec. Intensity (kWh/t-cement)		122	98	136	103	89

*: Kilns are included in these criteria.

: **Estimate value from disclosed data

(1) Production Facility

Saudi cement enterprises with histories still have old type production facilities such as Dry Long. Recently demand of cement is increasing rapidly with construction boom, and these companies are introducing cutting-edge facilities and technologies. Newly born plants introduce most advanced facilities.

(2) Labor productivity

Labor productivity of cement enterprises in the KSA is almost same in spite of difference of production facilities, and it is about one fifth of Japanese cement industry average.

(3) Electricity consumption and electricity intensity

There are various styles of power supply; from 100% of SEC supply to 100% of private power

generation. Fuels are gas, diesel oil, heavy oil, etc.

Electricity intensity is in dependence upon old or new of facilities. Low electricity intensity is attained with NSP (new suspension pre-heat) type kilns, and a certain enterprise has lower electricity intensity than Japanese average. Generally speaking cement enterprises has deeply interested in improvement of electricity intensity.

2.6. Summary: Energy Management and Energy Conservation in Saudi Cement Industry

(1) Foreign technology introduction

Saudi Arabian cement industry introduces cement production technologies from west Europe such as Germany, Denmark and others. Energy efficiency of Europe is at the high level in the world same as Japan, then their energy conservation technologies are advanced.

(2) Energy management

1) Energy conservation by managers

One of cement enterprise, which project team visited, was not aggressive because of low energy price. And most of enterprises seem to have no energy managing organization and no specialized energy manager. It is strongly suggested that energy manager should be appointed and he grasps daily energy consumption even if he serves concurrently.

2) Energy data management

One of cement enterprise, which project team visited, had a plan to establish power data management system. Most of Saudi enterprises, not only in cement industry, don't control electricity. To appoint energy manager and to collect and analyze energy data is important.

3) Benchmarking

Benchmarking is useful for energy conservation target decision and energy conservation implementation. It is recommended to collect energy data through official or in-formal routes.

(3) Private power generation and Peak shift

Many cement enterprises cooperate to shift peak power demand time zone by operating raw material and finishing processes mainly at night in Japan. Kilns, however, are operated all through day. In the case of having loose fitting production capacity and/or stock capacity, this type of peak shift operation is possible.

Cement industry is energy intensive one. Following conditions should be confirmed.

1) Private power generation

Many Saudi cement enterprises have private power generation facilities. These enterprises buy cheap fuel from Aramco, and constantly generate cheaper electricity than buying from SEC. Enterprises generating most all electricity by themselves cannot help peak shift operation for SEC.

2) Electricity buying enterprise

One of cement enterprises, which project team visited, cooperated SEC urgently by peak cut operation at

peak demand time zone (12:00-16:00) last summer. It must be possible that cement enterprises can cooperate to peak shift operation of electricity in summer when TOU tariff operation is introduced.

3. Questionnaire Survey to Housewives on Energy Conservation

3.1. Background and Objectives

According to SEC report, the electric power consumption in the residential sector accounted for 50% of the whole KSA in 2005; therefore it is important to promote energy conservation in individual households. In addition, taking into account that most housewives are fulltime homemakers in the KSA, awareness raising of women and housewives in particular on energy conservation is quite influential.

As described in Appendix 1, a survey was conducted by contracting out to a local consultant on the status of energy use and conservation in the residential sector in four areas and by housing types. The survey, however, was not necessarily addressed to female respondents.

For the purpose of complementing the survey mentioned above, a mini project was carried out based on questionnaires addressed to the Steering Committee members intending women and housewives to be respondents.

3.2. Respondent

Although the survey targeted the housewife layer, the number of female respondents was only five out of the total 15 as shown in the table below. It can be considered that this was due to 1) the questionnaire was prepared in English so that all the targeted women could not necessarily answer to the questions, and 2) the questionnaire sheet did not explicitly say that the respondents should be women.

Table AP4-3.1 Breakdown of Respondent

	Gender	Occupation		Age Bracket
Total Respondents 15	Female	Housewives	2	20s – 40s
		Employees	1	40s
		Students	2	10s – 20s
	Male	Employees	10	30s – 50s

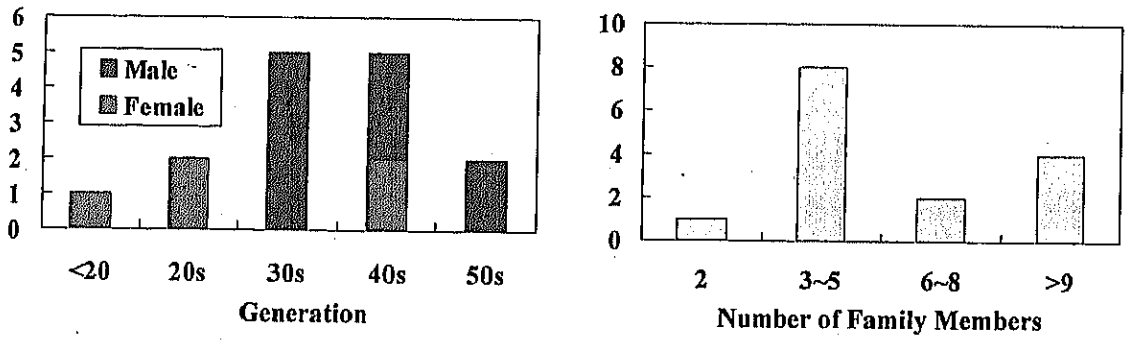

Figure AP4-3.1 Respondent Generation and Number of Families

3.3. Energy Conservation Activities

As shown in the following table, two-thirds of the respondents are conscious of energy conservation and carrying out day-to-day EC practice.

Table AP4-3.2 Actual EC Practice in Daily Life

	Yes	No
Female	3	2
Male	7	3
Total	10	5

EC activities are categorized and summarized in the following table. Female respondent activities were limited to the operation of energy consuming equipment and facilities while men were carrying out maintenance and replacement of equipment and facilities as well.

Table AP4-3.3 EC Activities in Households

Gender	Target	Operation	Maintenance	Replacement
Female	Air Conditioner	3		
	Lighting	3		
	Heater	1		
	TV	1		
Male	Air Conditioner	4	3	
	Lighting	3	1	4
	Others	1		

Details of EC activities are listed in the table below. It should be noted that temperature settings on air conditioners are rather low.

Table AP4-3.4 EC Activities to Home Appliances

Appliances	EC Activities	Female (5)		Male (10)	
		Yes	No	Yes	No
Lighting	Frequently switch off the light	5	0	10	0
	Select high efficiency lamp	2	1	4	0
Refrigerator	Leave a clearance of 5cm to the wall	5	0	10	0
	Frequently close the room doors	5	0	10	0
	Select cool placement	4	1	8	2
	Avoid excessive storage	4	1	7	3
Air Conditioner	Keep temperature settings 20 – 23℃	4	1	7	3
	Keep temperature settings ＞24℃ while running fans	2	3	2	7
	Avoid placing material goods near the outdoor unit	4	0	9	0
	Switch off the units when nobody is in the room	5	0	10	0
TV/Audio	Disconnect the plug when nobody use	4	1	8	2

3.4. Electricity Price

The electricity pricing system for the residential sector in the KSA is shown in the following figure.

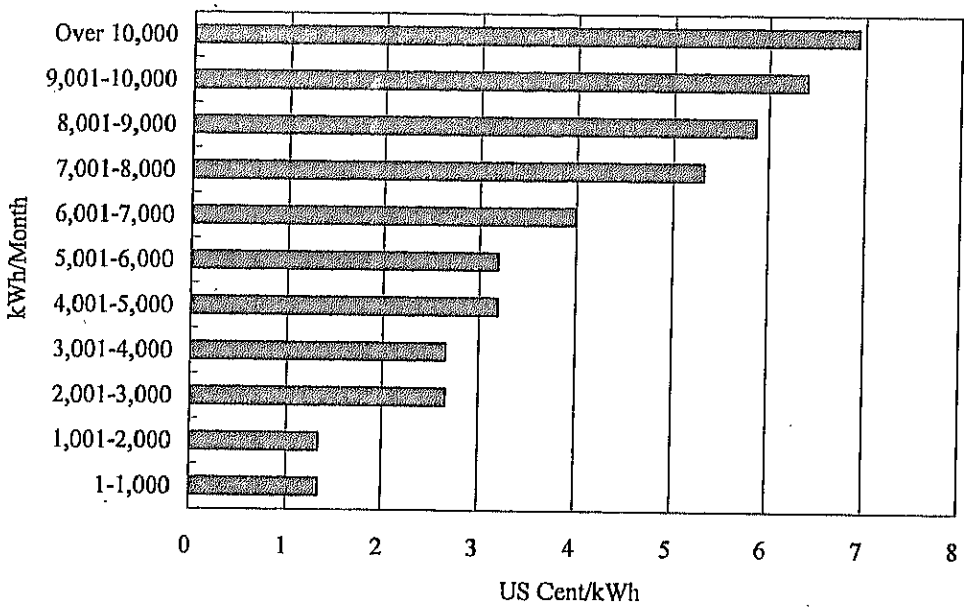

Figure AP4-3.2 Electric Power Tariff for the Residential Sector in the KSA

The next table shows responses to the electricity tariff for the residential sector.

It is interesting that all the female respondents considered the electricity tariff cheap while half of the male respondents said it was still expensive. Reasons for this may be as follows:

- Housewives who handle family finances recognize that electricity cost makes up a small proportion of the total expenses; and/or
- Men keep in mind that the KSA is an oil producing country and consider that even the current electricity tariff is on a high level.

The further study will, however, need a greater sampling set.

Table AP4-3.5 Response to Electricity Tariff in the KSA Home

Gender	Expensive	Cheap
Female	-	5
Male	5	5

3.5. Criteria for Selecting Home Appliances

The next figure shows priorities for selecting home appliances. Although the number of samples is small, it is understood that respondents give higher priorities to price and energy consumption rate. Actually, however, there is some uncertainty about how to evaluate energy consumption rate in the KSA where the energy labeling system has not yet been implemented and energy consumption rates are not currently displayed in appliance shops.

3.6. Energy Consuming Home Appliances

As for the question about much energy consuming appliances, a reasonable result was obtained that air conditioner made a most showing.

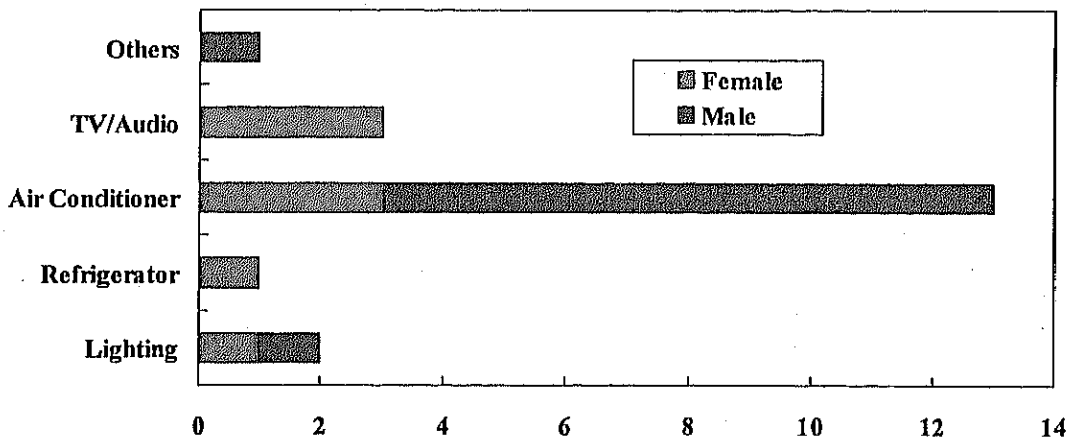

Figure AP4-3.3 Energy Consuming Appliances (selected all that apply)

3.7. Conclusion and Recommendations

Although the samples were small in number, important information was obtained through this mini project, which can be highly valued as a survey methodology. It is worthwhile continuing this type of questionnaire survey, which can be easily implemented with cooperation between the counterpart and the Steering Committee members.

It is recommended to pay attention to the following in future implementation:

- Prepare questionnaires in Arabic as well as in English; and
- Put some thought into questionnaire sheets so as to enable respondents to make answers easily (e.g. illustration insertion).

It is recommended as well to increase samples in number by enlarging target area through the cooperation from energy related governmental agencies and/or schools.

4. Electricity Consumption Measurement (Residence)

4.1 Purpose

The measurement was conducted in order to grasp the daily trend of electricity consumption and the potential for energy conservation at residential houses.

Measurement survey was conducted at 3 residential houses. Since the result of one house is written on 7.3.2, other 2 results are described below.

4.2 Measurement of Site 1

(1) General Information

1) Type of House

Independent House in Riyadh

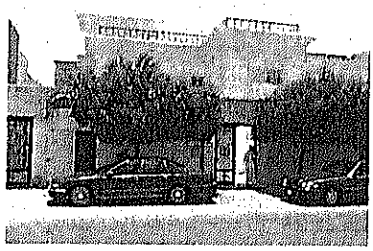

Figure AP4-4.1 Site 1

2) General Profile

- No of SEC Meter: 2
- Other Information: No Information

(2) Measurement Period

From June 17th, 2007 to August 29th, 2007

(3) Measurement Results

1) Inside and Outside Temperature

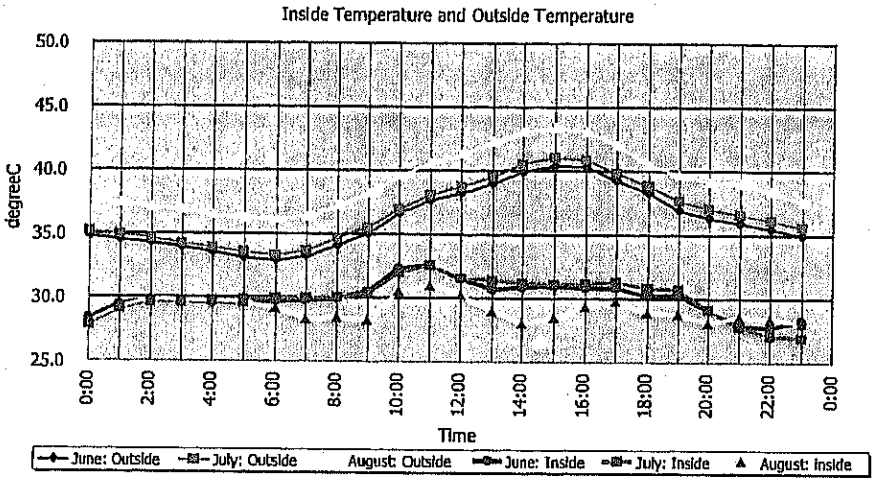

Figure AP4-4.2 Inside and Outside Temperature

2) Daily Load Curve on Weekdays

Small peak load existed around 15:00 and peak time was in the night. It might be lunchtime and dinner. Since the load demand after midnight was remaining and relatively high, it is considered that the family left on A/Cs when they were sleeping.

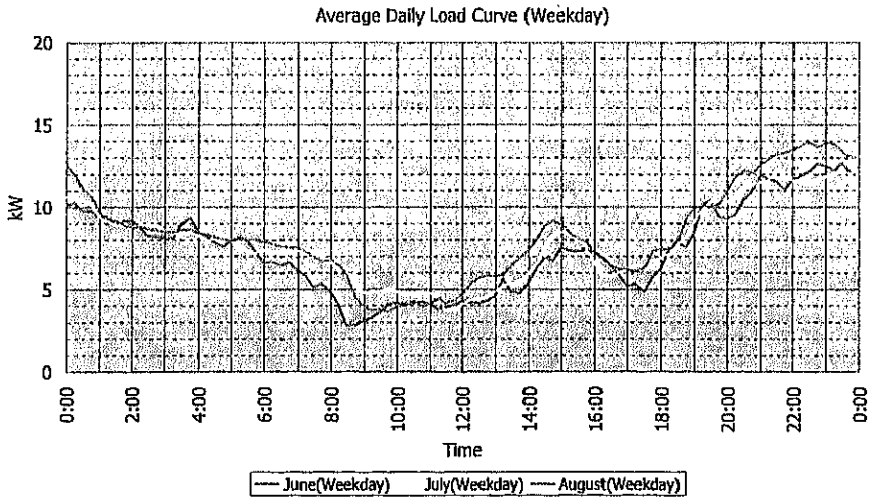

Figure AP4-4.3 Daily Load Curve on Weekdays

3) Daily Load Curve on Weekends

The peak demand of weekends was higher than that of weekdays.

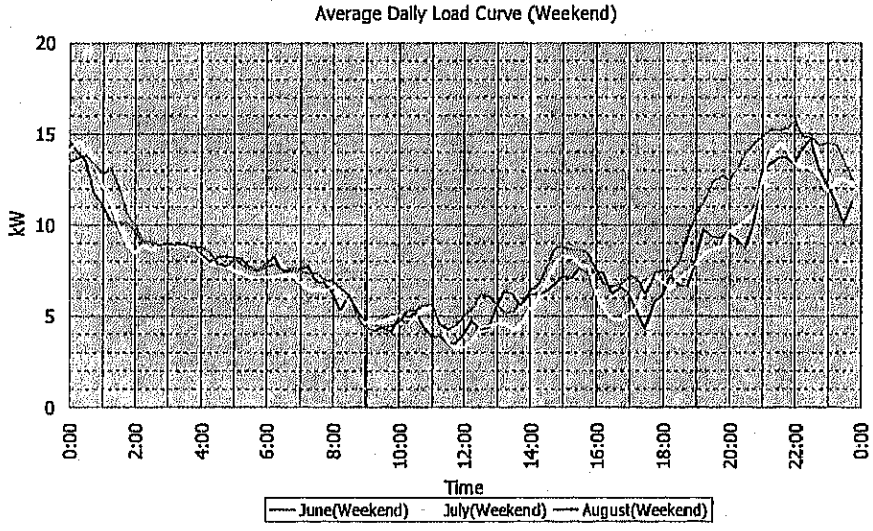

Figure AP4-4.4 Daily Load Curve on Weekends

4) Recommendations

Though the information concerning this site is very limited, it is presumed that the load mainly consisted of A/Cs. If the existing A/Cs are replaced by high-efficient A/Cs, it is expected that the load demand and the electricity consumption would be significantly reduced.

4.3 Measurement of Site 2

Figure AP4-4.5 Site 2

(1) General Information

1) Type of House: Flat with approx 60 square meters

2) Floor: 1 Living room, 2 bed room and kitchen

3) No of SEC Meter: 1

(2) Measurement Period

From June 23, 2007 to November 22, 2007

(The husband lived alone during for a period of some weeks because his family went back to home country to spend summer vacation.)

(3) Measurement Results

1) Daily Load Curve (Family)

The figure below shows daily load curve when the family lived together. The highest peak was recorded family after midnight. It will mainly consist of ACs load.

In November, they might not use ACs at all.

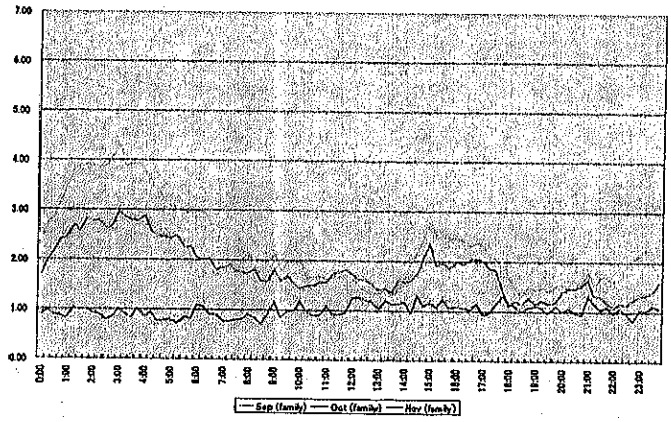

Figure AP4-4.6 Daily Load Curve (Family)

2) Daily Load Curve (Single)

The figure below shows daily load curve when the husband lived alone.

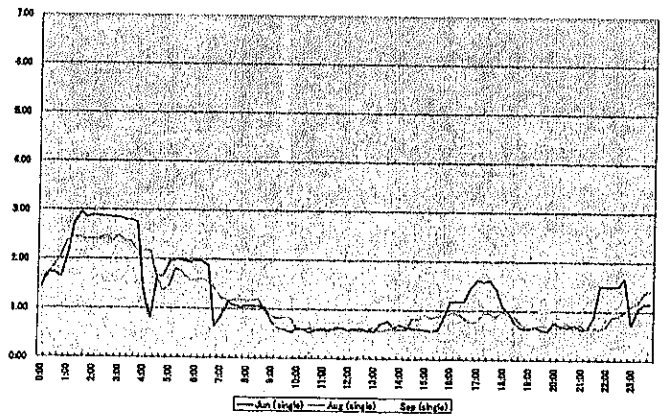

Figure AP4-4.7 Daily Load Curve (Single)

3) Recommendations

According to hearing investigation with the family, they seldom use ACs in November. Since the load demand in November was almost flat, the peak load mainly consist of ACs load.

Therefore, replacement to high-efficient ACs will be effective in order to promote energy conservation.

5. Electricity Consumption Measurement (Governmental Building)

5.1 Purpose

The measurement was conducted in order to grasp the daily trend of electricity consumption and the potential for energy conservation at an office building.

5.2 Site Information

(1) Site

Head Office of a Ministry in Riyadh

(2) General Information

- No. of stories: 12 stories (B2, B1, G, 1~9)
- Office hours: 7:30am ~ 2:30pm
- No. of employees
  - On weekday
    - Office hours: Around 1000 persons
    - Other than: 10~15 persons or more
  - On weekend: 10~15 persons
- Architectural Information
  - Area: 15000~16000 m2 (Approx. 1440m2 *11 stories)
  - Structure: Masonry construction
  - Wall
    - Material: Reinforced concrete
    - Insulation: Polystyrene
  - Roof: Flat concrete slab
- Used energy
  - For cooling: Electricity
  - For heating: Electricity
  - For hot water supply: Electricity
- Electrical wiring: Due to no existence of Single Line Diagram, the detail wiring is unknown. The rough diagram is shown below.

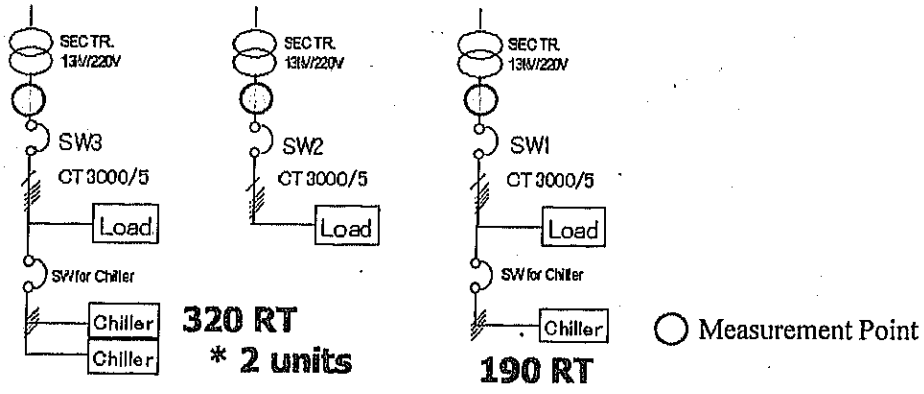

Figure AP4-5.1 Single Line Diagram

(3) Electric Facilities

- Chillers: 2 units of 320RT Chiller
  1 unit of 190RT Chiller
- Air Handling Units (AHU): 22 units
- Split-type A/Cs: 25 to 30 units
- Widow-type A/Cs: 15 to 20 units
- Lightings
- Elevators
- Outlet (PC, copy machine) etc.
- Operation of Chiller and AHUs
  - Daily operation: 24hours a day
  - Thermostat: 20 deg. (8:00~14:00), 24 deg. (Other time)
  - Seasonal operation
    From Nov. to Middle of March: 2 chillers (320RT and 190RT)
    Other: 3 chillers (2*320RT, 190RT)

5.3 Measurement Period

From November 26th, 2007 to May 18th, 2008

* Data of Line 3 where 2 units of 320RT Chillers connected was not measured from March 18th to May 18th for unknown reason. The curves of March, April and May include assumption by JICA team.

5.4 Measurement Results

(1) Outside Temperature

The figure below shows average outside temperature from December 2007 to May 2008. The trends vary with seasons. May was the warmest month during the period.

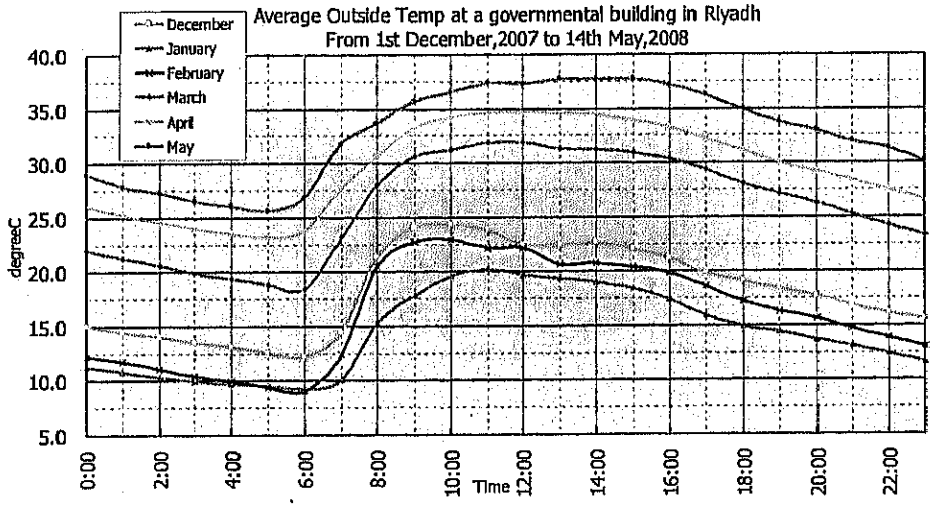

Figure AP4-5.2 Average Outside Temperature each Month

(2) Indoor Temperature

Since the setting temperature of thermostats were changed from 24 deg C to 20 deg C and Window-type A/Cs and Split-type A/Cs were tuned on around 8:00am, hence the indoor temperature was getting lower. On the other hand, after 2:00pm when office hours finish, it was increasing gradually.

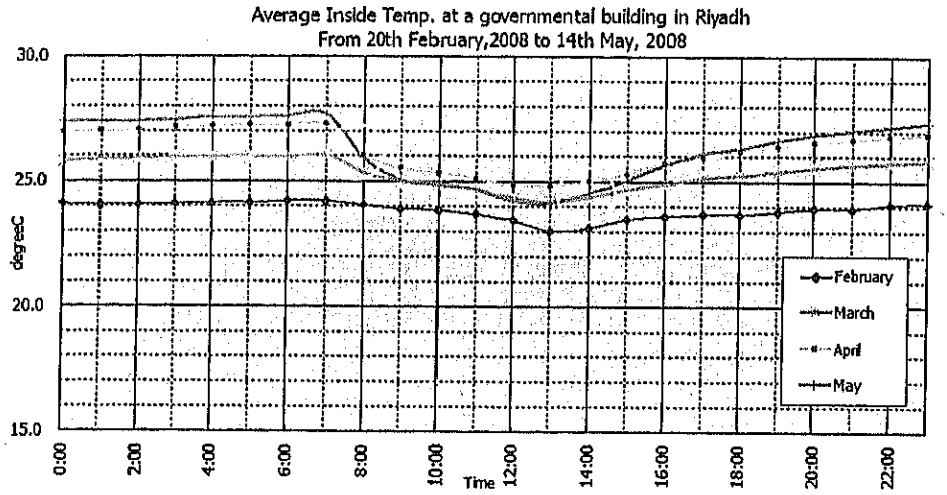

Figure AP4-5.3 Average Indoor Temperature each Month

(3) Daily Load Curve on Weekdays

The load demand was increasing from around 7:00 as the office hours started. And the peak load was seen around 12:00 to 13:00.

During off-office hours, the load was measured consistently and its value was around 500 to700 kW. The ministry operates 2 chillers in winter and 3 chillers in other 3 seasons. And some maintenance staffs told us that they left on lightings all the time same as the operation of chillers. 500 to 700kW at the night might be huge and there would be the potential to reduce the load.

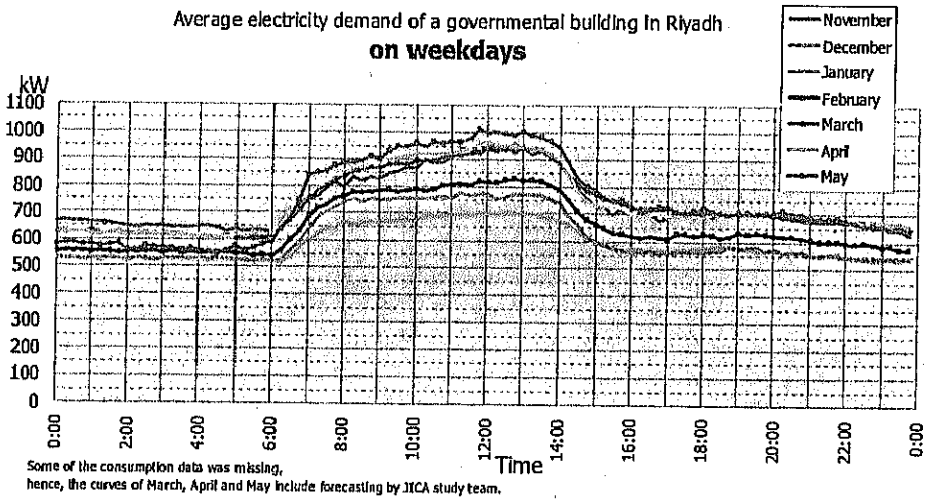

Figure AP4-5.4 Daily Load Curve on Weekdays

(4) Daily Load Curve on Weekends

Even though only 10 to 15 workers were usually in the building on weekends, the load of 500 to 600 kW was seen constantly. It is considered that this constant load comes from chillers, lightings etc.

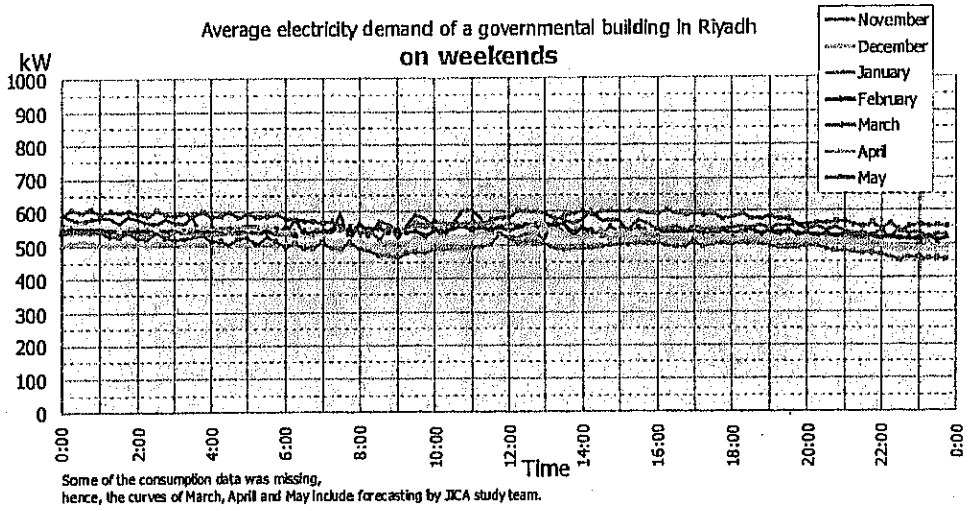

Figure AP4-5.5 Daily Load Curve on Weekends

(5) Recommendations

There might be much potential to reduce electricity consumption. Some ideas are as follows:

- Turning off lighting where it isn't necessary
- Tuning presetting temperature and operation schedule of chillers & AHUs
  Stopping standby power of PCs, elevator etc.
- Tuning operation of exhaust blower at parking on Basement floor etc.

Some employees said that they usually turned off lightings except for security ones, the other said that most of lightings left on all the time. In other words, energy conservation activities might not be conducted as organizational tasks at the office building. The organizational efforts are required in order to promote energy conservation furthermore.

6. Electricity Consumption Measurement (Mosque)

6.1 Purpose

The measurement was conducted in order to grasp the daily trend of electricity consumption at the mosque and the potential for energy conservation at the mosque.

6.2 Site Information

(1) Name of the mosque

The Al-Haigail mosque in Riyadh was surveyed. It is a private, Jama (Friday mosque) mosque.

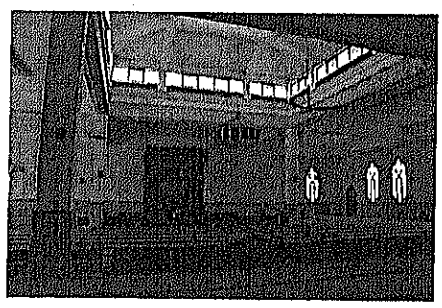

Figure AP4-6.1 Al-Haigail Mosque

(2) General Profile

General profile is shown below.

- Site Area: 4,700m2 (*assumption)
- Total Floor Area: 2,300m2 (*assumption)
- Hall Area: 1,300m2 (*assumption)
- Hall Volume: 9,000m3 (*assumption)
- Floor Number: 1 (partial mezzanine for women Salat (prayer))

(3) Number of prayers

According to the mosque staff, there are generally 30 people that pray at Isha'a, 150 at Maghrib, and more than 1,000 (filling the hall, courtyard, and outer areas) at Jumu'ah.

The mezzanine floor is for women. However, on Fridays, men are sometimes allowed on the mezzanine because the number of people is so great.

(4) Facility and Operation

(i) Air Conditioner

6 package units (each with 2.5 RT of cooling capacity) are placed on the roof for the prayer hall. Cooled air is supplied from ducts around the skylight. Air returns through ducts located on the corners of the ceiling.

There are 8 pendant fans in the hall and a few window-type air conditioners for back rooms. The temperature of 4 thermostats for A/C package units is set at 22 degrees. Two of the six units run 24 hours a day, even when prayer is not being conducted. The remaining 4 units are run from 11:00 to 21:00 (before Dhuhr to Isha'a).

(ii) Lighting

There are 9 large chandeliers in the hall, but they are not used because of the radiating heat. Instead, fluorescent lamps (not highly efficient) on the ceiling are turned on during prayers.

6.3 Measurement Period

From September 3rd, 2007 to September 17th, 2007

6.4 Measurement Results

(1) Daily load curve

The figure below is typical daily load curve on weekdays in summer.

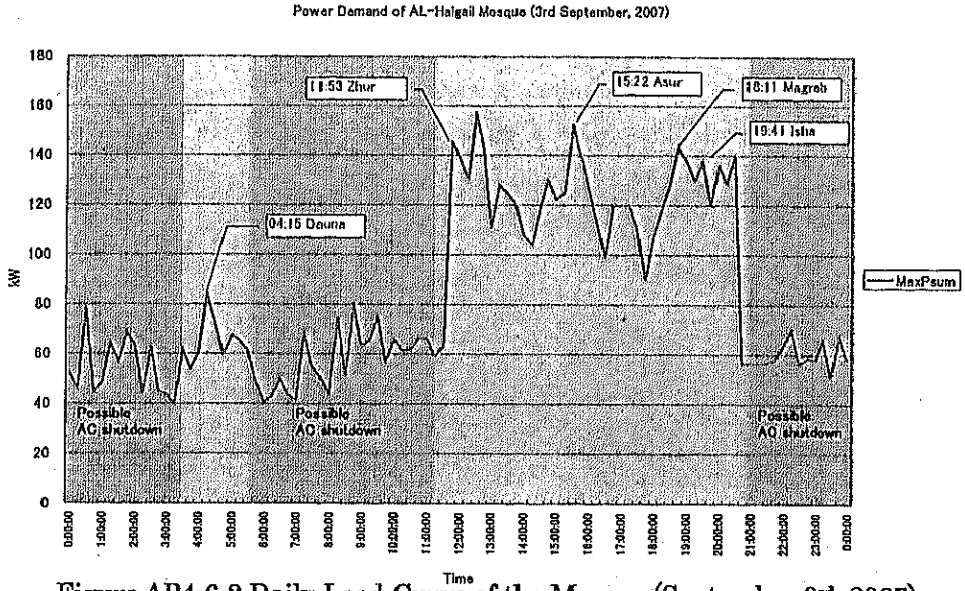

Figure AP4-6.2 Daily Load Curve of the Mosque (September 3rd, 2007)

Since all 6 A/C units run from 11:00 to 21:00, electrisity consumption is remarkable compaere to the other period. During the period when the prayer is not coducted, the moque consumes around 40 to 80 kW of electricity.

The figure below shows the load demand and the inside temperature on Septemnber 19th, 2007.

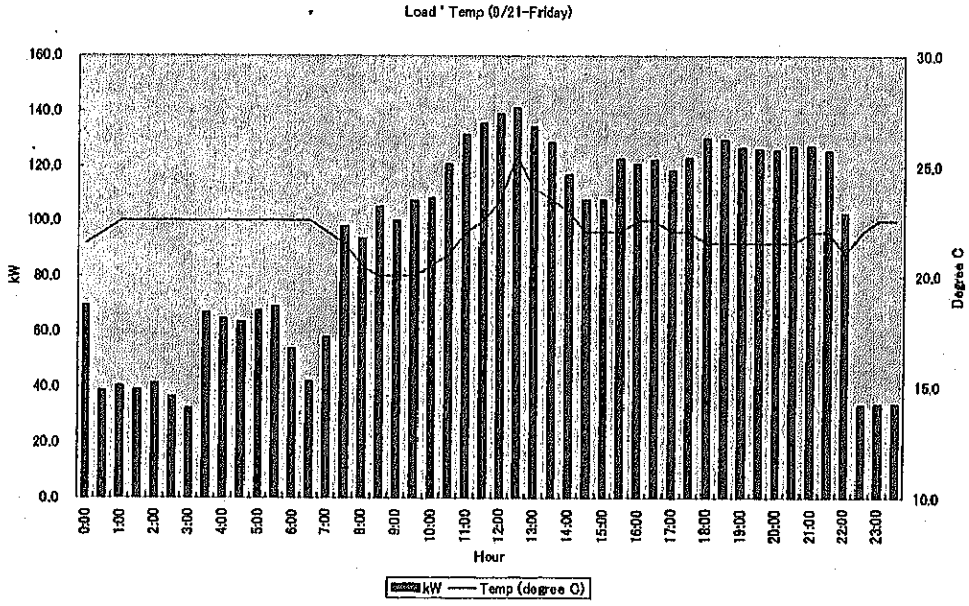

Figure AP4-6.3 Load Demand and Inside Temperature (September 19th, 2007)

(2) Recommendations

It is recommended that air conditioning operation be used only for prayer time. And the temperature

should be set at more than 22 degrees at all times. It might be too much cooling.

Besides, currently cooled air is supplied and returned to ducts located at the same place on the ceiling. However, prayers stay at only floor area in the mosque. In odder to reduce the air conditioning load, a low layer air conditioning zone can be designed.

7. Energy Conservation Potential

7.1. Turning off of Lights during Pray Time

Supposing that turning off lights for 30minutes at twelve o'clock at governmental buildings, and that turning off lights for 30 minutes each at twelve o'clock and 3o'clock at commercial buildings, electricity conservation effect was calculated. Total electricity conservation at both buildings is shown in Figure AP4-7.1. If this activity is implemented by all buildings, 0.8% and 0.95% of lighting electricity is saved in governmental and commercial buildings respectively.

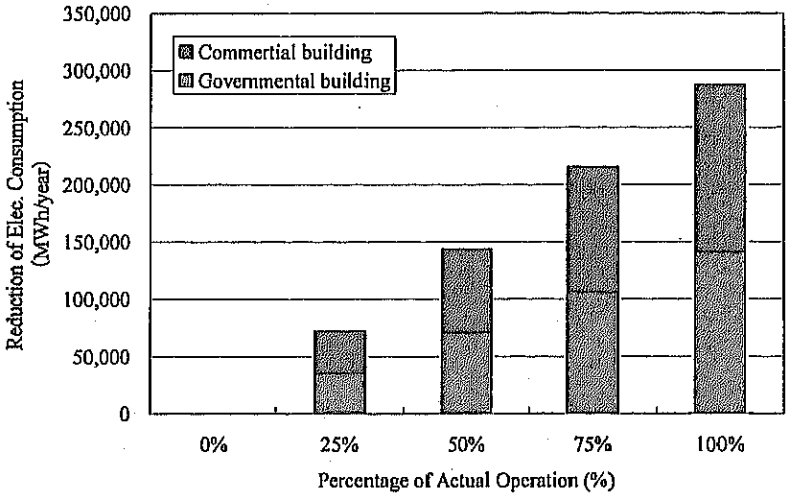

Figure AP4-7.1 Energy conservation potential of turning off lights during pray time

7.2 Rise of Preset Temperature of Air Conditioner by 1 degree Celsius

Supposing that air conditioning electricity conservation effect is 7% by rise of one degree Celsius of preset temperature, electricity energy conservation potential was calculated. Sum of electricity reduction in governmental and commercial buildings are shown in Figure AP4-7.2. If this activity is implemented at all buildings, 2,288,623MWh of electricity can be saved annually.

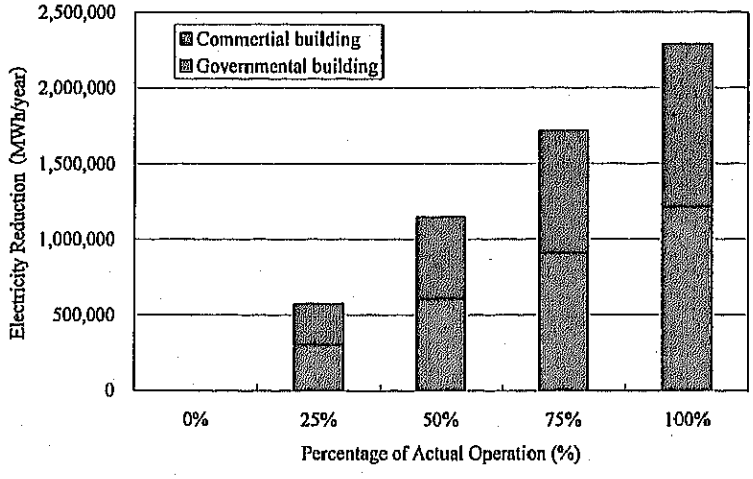

Figure AP4-7.2 Energy conservation potential of rising preset temperature of Air Conditioner

7.3 Power Factor Improvement in Industrial Sector

Supposing Power Factor is improved by 20% (PF: 0.7→0.95) in industrial sector, transmission loss is improved by approx. 30.5%. Reduction of electricity loss is shown in Figure AP4-7.3, assuming total transmission loss is 11% of electric power.

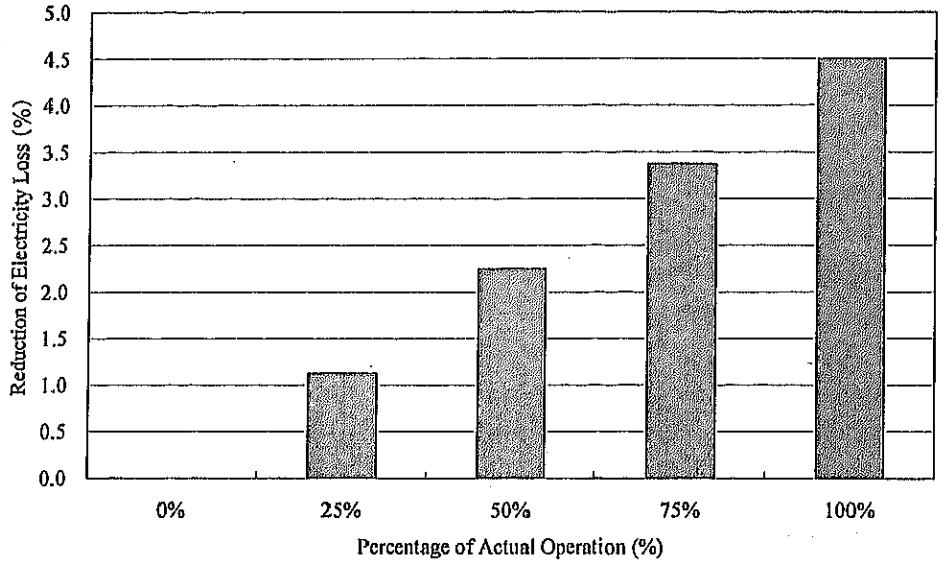

Figure AP4-7.3 Energy conservation potential of power factor improvement


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