

**1 Day Workshop: “Industrial Energy Audits”**  
**Tuesday Feb 9, 2016**  
**Room B1-S003, College of Engineering**

# **Energy efficiency in residential buildings in Qassim region**

**K. K. E. Shenashen M. S. Alshitawi and R. A. Almasri**

**Presented by:**  
**Prof. Dr. R. Almasri**

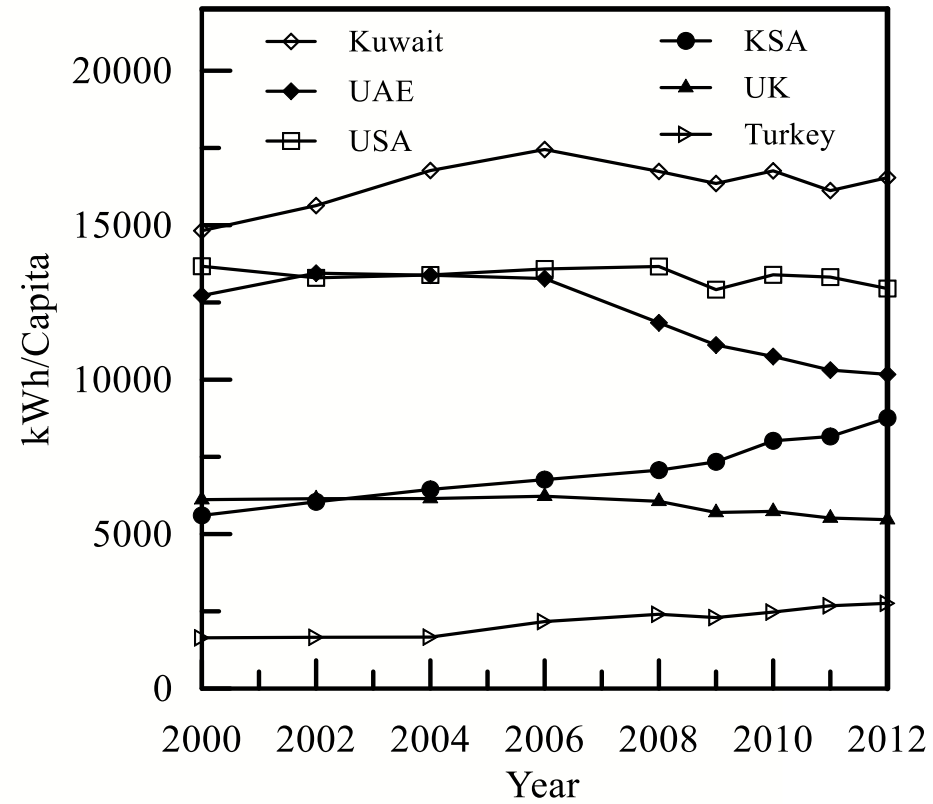
- INTRODUCTION
- OBJECTIVES
- SUMMARY DATA FROM THE SURVEYS
- CONSUMPTION PER DWELLING
- CONSUMPTION PER CAPITA
- CONSUMPTION PER AREA VILLAS, FLATS
- CONSUMPTION OF APPLIANCES
- CONSUMPTION OF LIGHT
- CONSUMPTION OF WATER HEATERS
- CONSUMPTION OF AIR CONDITIONING
- SUMMARY OF DETAILED ELECTRICITY CONSUMPTIONS
- CONCLUSION
- RECOMMENDATIONS

## INTRODUCTION

- Energy efficiency goals reduce the amount of consumed energy in an application without negatively affecting the main function or output of the application.
- Energy efficiency is one of the easiest and most cost-effective ways to reduce energy consumption and achieve savings in residential, commercial, industrial or services sectors.
- Kingdom of Saudi Arabia (KSA) ranked in the 17th place of the world countries with respect to the energy consumption per capita.
- On the other hand the share of residential electric consumption in KSA constitutes the biggest portion of the total electric consumption, about 50% and worldwide average value which is between 27-31 %.

## Reasons for increase residential electric energy consumptions in KSA:

- Low electricity price,
  - Rapid population growth, and
  - Economic growth.
- ❑ The presentation focused on the energy efficiency in residential building in Qassim region to find out areas for energy rationalization.
- ❑ An independent survey was constructed for collecting data of dwelling electric consumptions based 27 indicators.



**Electric Energy Consumption per Capita in Different Countries.**

## OBJECTIVES OF THE PRESENTATION

Aim to analyze and evaluate the electrical energy consumptions in rural residential buildings in the Qassim region, KSA by the followings consumptions measures:

- The monthly and yearly electrical energy consumption in Qassim region per dwelling, capita and area.
- The effect of building type Villa or Flat on the electrical energy consumption
- The share of different consuming items; domestics' appliances, lighting, water heating and air conditioning.

About 1000 surveys were distributed (collected data from 131 Villas and 60 Flats) in urban areas of big cities: Buraydah, Unayzah, Al-Bukayriyah, Ar-Rass, Al-Miznab, Riyadh ALKhbra and Uyun Al-Jawa within the Qassim region which lies in the middle area of KSA.

## Summary of responses and data from the surveys

Survey Indicators	Response Result	
	1) Type of unit	31.5 % Flats
2) Unit area	100 m <sup>2</sup> minimum	1640 m <sup>2</sup> maximum
3) Status of the occupant	71 % owners	29 % tenant
4) Number of occupant	1 minimum	14 maximum
5) Age of the occupant	78 % above 10 years	22 % below 10 years
6) Is the floor insulated?	11.5 % Yes	88.5 % No
7) Are the outer walls insulated?	41 % Yes	59 % No
8) Is the roof insulated?	31 % Yes	69 % No
9) Material of window frame	99% Aluminum	Steel 1%
10) Using water heater	100 % Yes	0 % No
11) Method for heating water	100% Electric	0% Gas or other
12) Using A/C	100% Yes	0% No
13) Using washing m/c	98% Yes	2% No
14) Using fridge	98.5 % Yes	1.5 % No

1) Using deep freezer	88 % Yes	20 % No
2) Using oven	69.5 % Yes	30.5 % No
3) Using dishes washer	25 % Yes	75 % No
4) Using micro-wave	79 % Yes	21 % No
5) Using water cooler	63.5 % Yes	36.5 % No
6) Using TV	100 % Yes	0 % No
7) Using PC	66 % Yes	33 % No
8) Using dust m/c	95 % Yes	5 % No
9) Using partially or totally saving lighting	30% Yes	70% No
10) Using water filter	47.5 % Yes	52.5 % No
11) Using blower	71% Yes	29% No
12) Using others electrical devices	50% Yes	50% No
13) Monthly electricity consumption (according to the monthly bill)	Collected and analyzed as will be demonstrated in the subsequent figures and discussions	

## CONSUMPTION PER DWELLING

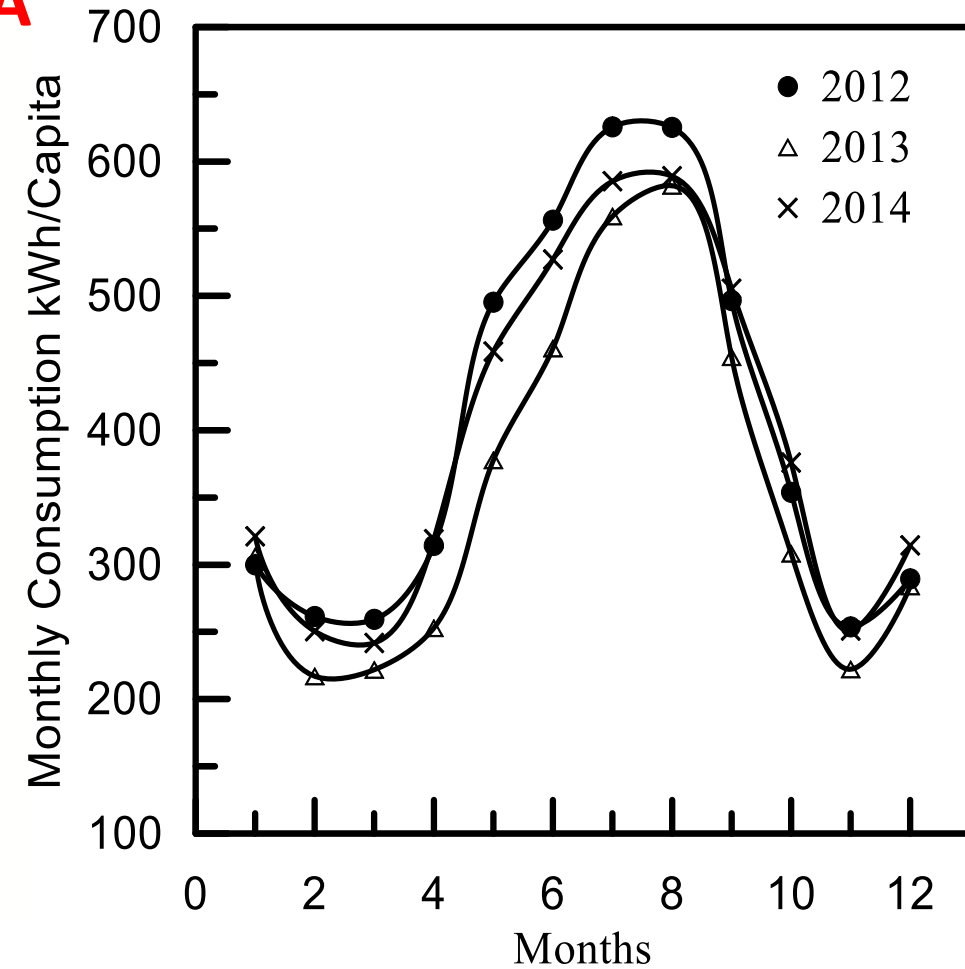
- The electrical energy consumption values of the surveyed dwellings through the three years 2012-2014
- the average consumption through 2013 is lower than the consumption through the two years 2012 and 2014 by 6.7 % and 5.2 % respectively.
- Moreover, summery of total yearly consumptions per dwelling are in this table.

Yearly energy consumption (kWh)	<u>2012</u>	<u>2013</u>	<u>2014</u>
Maximum	83167	80275	86616
Minimum	2214	1613	2018
Average	<u>31071</u>	<u>29002</u>	<u>30577</u>



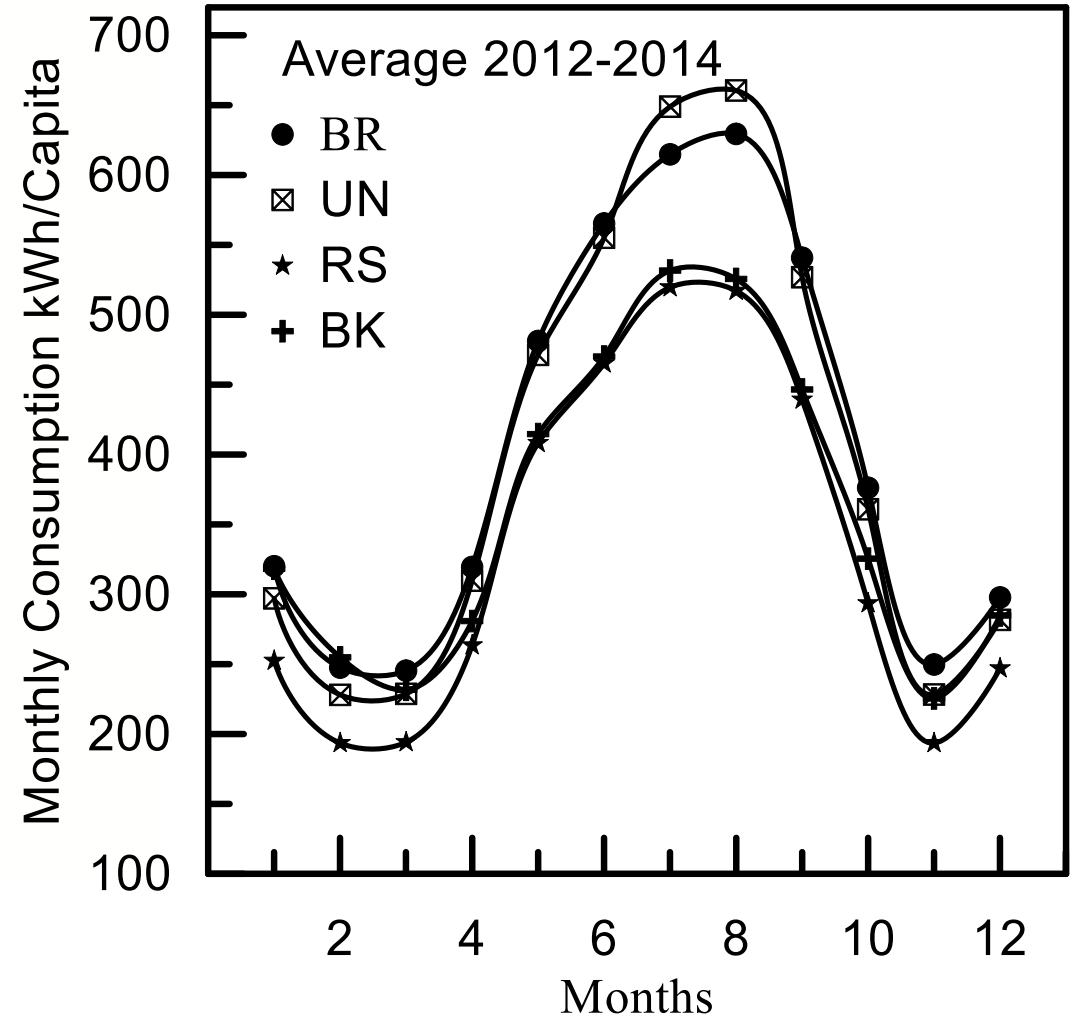
## CONSUMPTION PER CAPITA

- The figure shows the monthly average of the electricity consumption per capita for three year.
- consumption curves have typical trends with maximum consumption during July and August while minimum consumptions during February, March and November. Meanwhile.
- The figure indicates the consumption during all months of 2013 are lower than their corresponding values during 2012 and 2014.



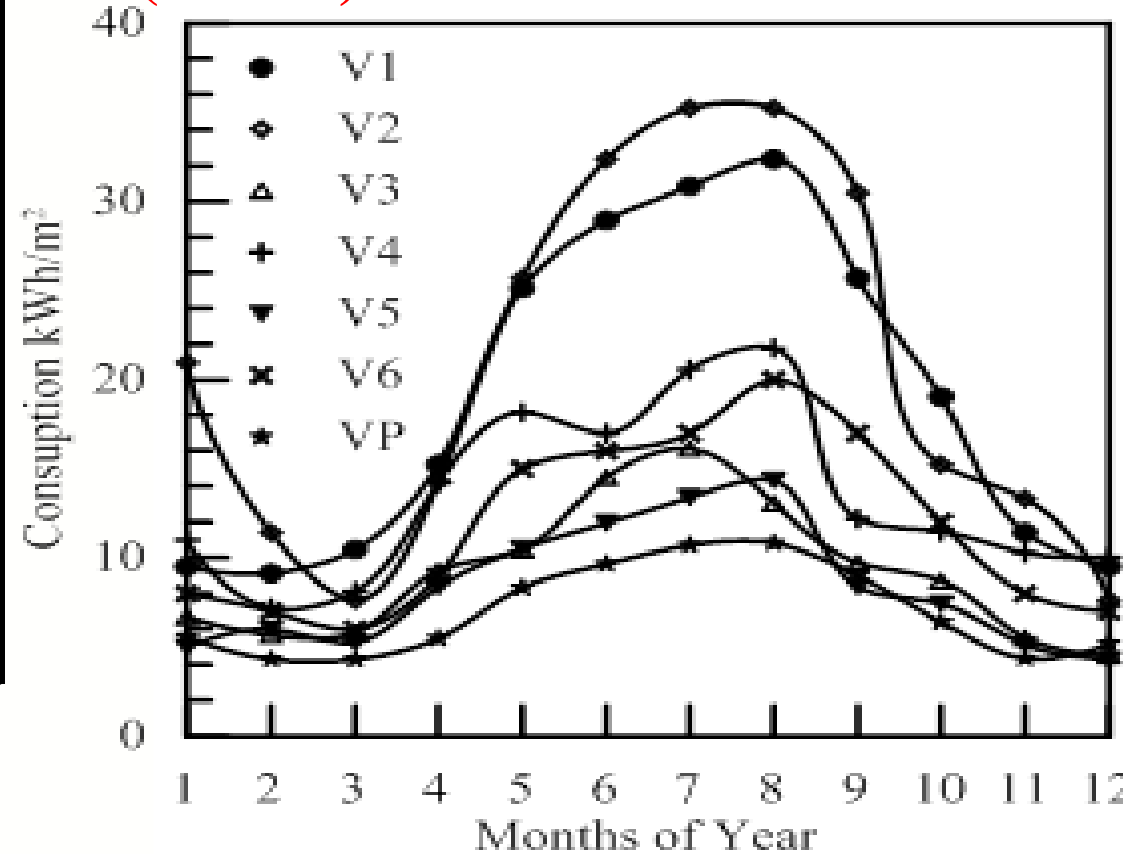
## Average of the electricity consumption per capita in different cities.

The figure shows the consumption per capita in Unayzah is higher than the other three cities, while Al Bukayriah is mostly has the lowest consumption per capita.



## CONSUMPTION PER AREA (Villas)

		V1 Error! Referen ce source not found.	V2	V3 Error! Referen ce source not found.	V4	V5 Error! Referen ce source not found.	V6	VP
Area (m <sup>2</sup> )		525	525	688	418	418	428	532.8
Location		Riyadh	Dhahran	Riyadh	Riyadh	Riyadh	Dhahran	Qassim (present study)
Monthly (kWh/m <sup>2</sup> )	Maximum	32.4	35.2	16.1	21.8	14.4	20	10.8
	Minimum	9.1	7.6	4.5	7.2	4.3	6	4.3
	Average	18.9	20.8	9.2	13.5	8.3	11.8	7.0
Yearly Consumption (kWh/m <sup>2</sup> year)		227.4	249.5	110.2	162.1	100.1	142.0	84.2



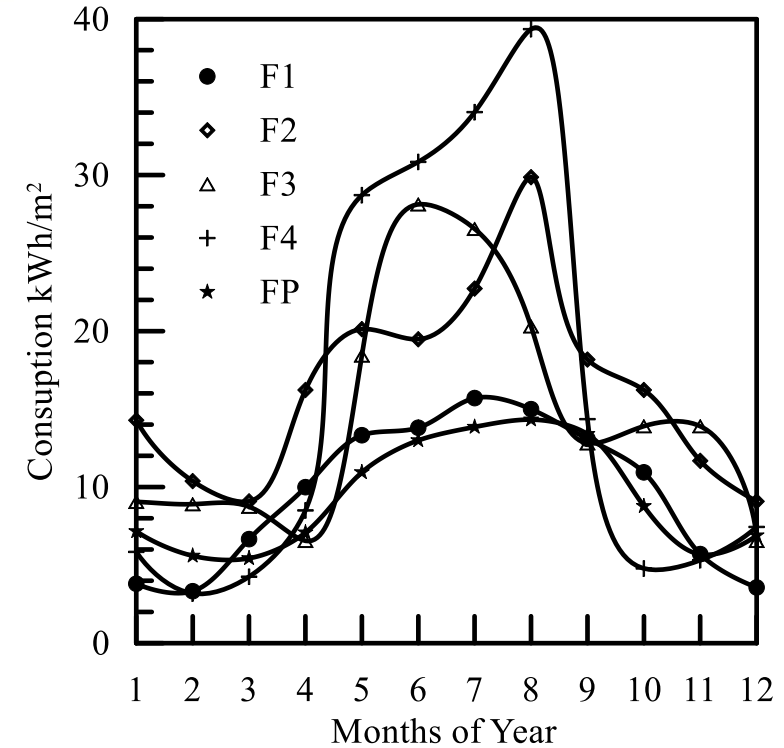
Comparison of monthly consumption per area for Villas

The housing area per capita for the surveyed dwellings as follows:

- Overall Average = 70 m<sup>2</sup>/Capita
- Average of Villas = 77 m<sup>2</sup>/Capita
- Average of Flats = 54 m<sup>2</sup>/Capita
- Maximum value = 400 m<sup>2</sup>/Capita
- Minimum value = 10 m<sup>2</sup>/Capita

## CONSUMPTION PER AREA (Flats)

		F1	F2	F3	F4	FP
Area (m <sup>2</sup> )		210	77	64	94	201.8
Location		Jeddah	Riyadh	Riyadh	Riyadh	Qassim (present study)
Monthly (kWh/m <sup>2</sup> )	Maximum	15.7	29.9	28.1	39.4	14.3
	Minimum	3.3	9.1	6.6	3.2	5.4
	Average	9.9	16.5	14.5	15.6	9.4
Yearly Consumption (kWh//m <sup>2</sup> year)		115.0	197.4	173.9	186.7	112.2



Comparison of monthly consumption per area for **Flats**

Average yearly consumption of the appliance per dwelling is 4457 kWh, which represents average ratios of 14.3 %, 15.4 % and 14.6 % in 2012, 2013 and 2014 respectively. The higher ratio in 2013 is due to the better climate which resulted in lower yearly consumption.

## CONSUMPTION OF APPLIANCES

Appliance	Rating Power (W)	Yearly Hours of Operation	Yearly Consumption (kWh/year)
Washing M/C	450	360	108
Fridge	330	2920	964
Deep Freezer	330	1825	602
Oven	2000	200	400
dishes washer	1200	180	216
Micro-wave	800	100	81
Water Cooler	330	750	248
TV	150	1460	219
PC	75	1460	110
Dust m/c	1000	90	90
Iron	1000	90	90
Water Pump	780	200	152
Water filter	50	360	18
Air blower	150	700	105

## CONSUMPTION OF LIGHT

$$\left[ \begin{array}{l} \text{Upper bound of active} \\ \text{number of bulbs} \end{array} \right] = \text{Min} \left\{ \begin{array}{l} 3 \times \text{No. of occupant} \\ (3/2) \times \text{Number of bulbs} \end{array} \right\}$$

The average ratios of light consumption from total are 8.25 %, 8.84 % and 8.38 % in years 2012, 2013 and 2014 respectively.

## CONSUMPTION OF WATER HEATERS

$$\left[ \begin{array}{l} \text{Upper bound of} \\ \text{active number of} \\ \text{water heaters} \end{array} \right] = \text{Min} \left\{ \begin{array}{l} \text{No. of occupant} / 2 \\ \text{Number of water heaters} \end{array} \right\}$$

The average ratios from total consumptions of 10.0 %, 10.7 % and 10.2 % in years 2012, 2013 and 2014 respectively.

## CONSUMPTION OF AIR CONDITIONING

- The consumptions of air conditionings were determined by subtracting the yearly consumptions of domestic appliances, light and water heaters from the total dwelling consumptions .
- The resulted average ratios of air conditioning consumptions are 67.4 % , 65. 1% and 66.9 % in the years 2012, 2013 and 2014, respectively.
- It is noticeable that the ratio of average consumption in year 2013 is lower than the ratios in 2012 and 2014 by 3.58 % and 2.76 % .
- These results are compatible with the previously demonstrated climate conditions through the three years.

## SUMMARY OF DETAILED ELECTRICITY CONSUMPTIONS

The present study are very reasonable and in good agreement with published data.

	End uses consumption ratio (%)										
	Spain	EU	USA	UK	KSA	KSA	KSA	Present study			
								2012	2013	2014	Av.
Space conditioning	42	68	53	62	69-78	70*	72.6**	67.4	65.1	66.9	66.5
Domestic hot water	26	14	17	22	22-33	-	-	10.0	10.7	10.2	10.3
Lighting	32	18	30	16		30	27.4	8.3	8.8	8.4	8.5
Appliances					14.3	15.4	14.6	14.8			

\* The 70 percent includes 4% for heating

\*\* The 72.6 percent includes 12.1% for heating



## CONCLUSION -1

The consumptions data of 191 dwellings through three years 2012, 2013 and 2014 were comprehensively analyzed.

Areas for energy rationalization and energy efficiency measures in the following aspects: energy consumption for each dwelling, energy consumption for each capita, energy consumption per area. Many figures have been resulted from the present study analysis which can be briefed as follows:

- For the consumptions through the three years 2012, 2013 and 2014, respectively:
  - The average yearly consumption per dwelling: [31071, 29002 and 30577](#) kWh.
  - The average yearly consumption per capita: 4761, 4405 and 4591 kWh
  - The average yearly consumption per area (m<sup>2</sup>): 84.82, 78.5 and 83.9 kWh.
- The overall average area per capita for the surveyed dwellings is 70 m<sup>2</sup>/Capita.

## CONCLUSION -2

- ❑ The average yearly consumption of the domestic appliance is 4254 kWh per dwelling which represents average ratios of 14.3 %, 15.4 % and 14.6 % from total consumption in 2012, 2013 and 2014 respectively.
- ❑ The average yearly consumption of light is 2564 kWh per dwelling which represents average ratios 8.3 %, 8.8 % and 8.4 % from total consumption in years 2012, 2013 and 2014 respectively.
- ❑ The average yearly consumption of water heaters is 3113 kWh per dwelling which represents average ratios of 10 %, 10.7 % and 10.2 % from total consumption in years 2012, 2013 and 2014 respectively.
- ❑ The ratios of average yearly consumptions of air conditionings through years 2012, 2013 and 2014 are 67.4 %, 65.1 % and 66.9 % from total consumption respectively.

## CONCLUSION - 3

Reasons for the high energy consumption in Saudi Arabia in residential buildings, especially for air conditionings:

1. The use of air conditioners operation even in cases of vacant spaces (no occupant).
2. Operating the air conditioners on temperatures either below or higher than the comfortable temperature range (22-27 °C).
3. Low price of residential electricity tariff.
4. Improper insulation of the dwellings envelopes.
5. Use of large areas of glasses in windows and facades of buildings.
6. Low occupant awareness regarding the proper attitudes of energy use.
7. Generally, wrong behaviors regarding the energy use are noticeable.

## RECOMMENDATIONS

The followings are recommended measures and/or actions for energy efficiency in residential building:

1. Apply the Saudi Standards; Metrology and Quality Organization SASO-2856-2014-A standard for envelop insulation including walls, ceiling, windows and doors.
2. Local authorities should apply the energy measure on both new and existing buildings.
3. Increases the residential electricity tariff.
4. Spreading the culture and attitude of energy efficiency and rationalization.
5. Use renewable energy sources, specifically solar energy to substitute the electricity on different relevant applications.
6. Use natural gas instead of electricity for heating water, which represents average ratios from total consumptions about 10%.
7. Adhere to the applicable international/national codes for energy consumption in devices.

**Thank You  
Vielen Dank**

**شكراً جزيلاً**

<http://www.qec.qu.edu.sa/en/Pages/default.aspx>

masri.radwan@qec.edu.sa