JITH 2017
18èmes Journées Internationales de Thermique (JITH 2017)
Monastir (Tunisie), 25 - 27 Octobre 2017

Buildings energy consumption information in Algeria

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Abstract. The services demanded of buildings — lighting, cooling in the summer, warmth in the winter, water heating, electronic entertainment, computing, refrigeration, and cooking require significant energy use, about 13 Mtoe in 2012. Energy consumption in buildings has been growing in over time. Algeria's population about 39.21 million people and more than 8 million houses consume more energy than the transportation or industry sectors, accounting for nearly 43 percent of total Algeria energy use. Heating and cooling represent the largest component of energy uses, therefore represent a potentially significant part of the future energy and CO2 emission savings, intensity evolution and the impact of buildings energy consumption on the environment. Population growth, increasing demand for building services and comfort levels, with the rise in time spent inside buildings; assure the upward trend in energy demand will continue in the future. For this reason, energy efficiency in buildings is today a prime objective for energy policy at regional, national and international levels regardless of Algeria. This paper analysis available information concerning buildings energy consumption in Algeria, particularly related to heating and cooling systems, comparisons between different regions are presented specially for heating and cooling energy consumption and forecasting of energy consumption for Algeria residential buildings until 2040.

Keywords:
Energy consumption, buildings energy, heating and cooling of building, Environment. CO2 emission.

1. Introduction

1.1 Energy

Energy as one of the ingredients in the social and economic development process of any nation and especially for the developing countries, today, energy consumption contributes to pollution, environmental deterioration and global warming emissions. Increases in energy consumption are driven by population growth, it is estimated that Algeria population will be 47 million by 2050 [1]. In 2013, Algeria has produced a total amount of 154.6 ktoe of energy. Its main energy source is crude oil 52.1%, followed by gas 44.8%. In comparison, the numbers concerning the renewable energies are much smaller and close to zero [2]. Other energy sources, such as nuclear power, coal or heat are in fact zero, thus giving an impression that Algeria has quite a unilateral energy landscape. The gross domestic product in Algeria was worth 210.18 billion US dollars in 2013 [3]. Algeria's total final consumption has steadily been increased in recent years. While in 2012 the energy consumption added up to around 50.6 ktoe, energy consumption increased in 2013 by 5.4% and accounted for 53.3 ktoe. Taking a closer look at various sectors, the residential sector is the one which consumes the most energy 43%, followed by the transport sector 36% and the industry sector 21%. More detailed figures are outlined in the table below.

Table 1: Final energy consumption in Algeria 2012 and 2013 by sector (ktoe)

Sector	2012	2013	Change in %
Residential	15,068	16,425	+9
Transport	13,371	13,889	+3.9
Industry	7,939	8,229	+3.7
Total	36,377	38,543	+6

In electricity consumption the residential sector is the biggest consumer in Algeria, representing 38.1% of the nationally consumed energy. Other important sectors are the tertiary sector 20.93% and the manufacturing industry 17.83% [2].

Table 2: Electricity consumption by sector (2012) in ktoe.

Sector/ Product	in ktoe	in %
Residential	1,413,960	38.10
Tertiary	776,735	20.93
Manufacturing industry	661,555	17.83
Hydraulics	468,786	12.63
Gas and oil industry	273,239	7.36
Agriculture	89,865	2.42
Mines and quarries	27,365	0.74
Public works	17,742	0.48
Transport	11,670	0.31
Total	3,710,917	100

Energy conservation, which leads to more efficient use of energy without reducing levels of comfort, does not mean rationing or curtail mentor load shedding, but it is a means of identifying areas of wasteful use of energy and taking action to reduce energy waste. There are vast opportunities to reduce increase energy efficiency and electricity consumption within buildings. It is estimated that new buildings can reduce energy consumption on an average between 20% and 50% by incorporating appropriate design interventions in the building envelope, HVAC 20–60%, water heating 20–70%, lighting 20–50%, refrigeration 20–70% and electronics and other.

1.2 Sustainability

Today sustainability is a goal that just about every organization, business, institution, or individual claims to be striving for, and sometimes claims to have achieved. Given the profound impact of buildings on the environment, the work of HVAC design engineers is inextricably linked to sustainability. The sector of engineering has seminal influence on building performance, and HVAC designers' work is inherently related to overall sustainability in buildings.

Definition of sustainability very similar to that developed in 1987 by the United Nations' Brundtland Commission UN 1987 “providing for the needs of the present without detracting from the ability to fulfill the needs of the future”. Others have defined sustainability as “the concept of maximizing the effectiveness of resource use while minimizing the impact of that use on the environment” [4]. Sustaining those elements on which human kind’s existence and that of the planet depend, such as the environment, health, and energy, are worthy goals.

The energy efficiency program is governed by Algeria’s commitment to promote a more responsible use of energy and to investigate all the ways to protect the resources and systematize efficient and optimal consumption.

Energy efficiency aims to produce the same goods and services by using least possible energy. The program provides for measures that favor forms of energy most suitable for different uses and require behavioral change and improved equipment. The energy efficiency program is as follows [5]:

Thermal of buildings: In Algeria, the residential sector is the most energy intensive sector. It uses more than 42% of overall energy consumption. Proposed measures to achieve energy efficiency in this sector include the introduction of thermal insulation of buildings, which will reduce energy consumption related to home cooling, heating and ventilating significantly.

Solar water heating development: The penetration of solar water heaters in Algeria remains undeveloped but the potential is significant. There are plans to develop the system of solar water heating to replace the conventional system.

Encouragement to use lamps low energy consumption: this strategy for prohibit the marketing of incandescent lamps on the domestic market to reach a total ban by 2020. In parallel, there are plans to put low-energy bulbs on the market. Furthermore, local production of low consumption lamps will be encouraged in particular through partnerships between foreign producers and local.

Introduction of key technologies for solar air conditioning: Solar energy for air conditioning is a technology that should be promoted in the south of Algeria, as far as the needs for cooling mostly coincide with the availability of solar radiation. Moreover, solar collectors may also be used for hot water production and room heating during the winter. The overall performance of a solar cooling system is therefore of a great interest.

Studies will be launched to harness solar cooling technologies and choose the system best suited to the Algerian context. Two pilot projects for air cooling using absorption and adsorption chillers will be launched for the cooling of residential buildings in the south of Algeria.

1.3 CO2 emission in Algeria

By 2050, the demand for energy will be almost twice as high as current demand, driven by rapid growth the population, by the continuing increase the number of electrical devices used in homes and commercial buildings, and by the growth in electrically driven industrial processes. M. Allali et al proves bi-directional causality between CO_2 emission and electric power consumption (modeling the impact of CO_2 emission in Algeria) [6].

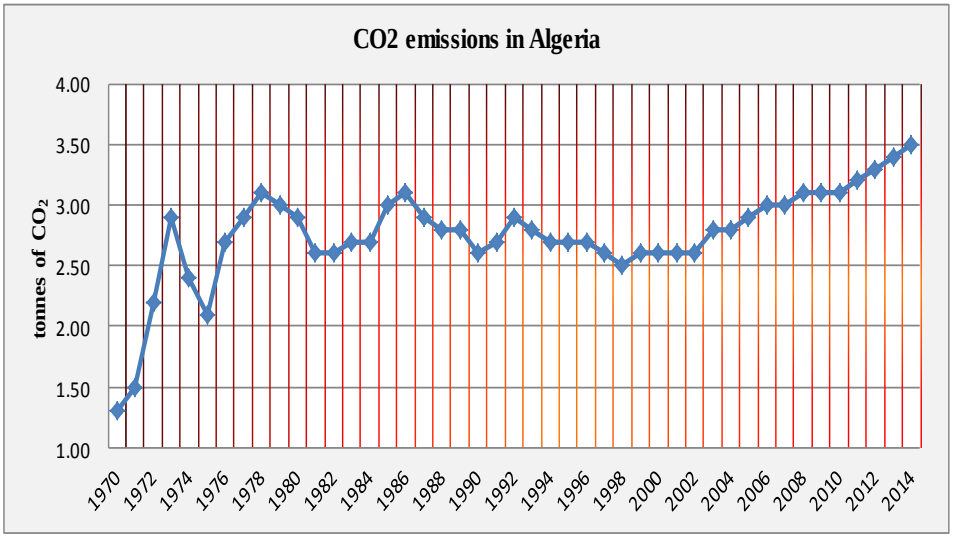

Figure 1. Global per capita CO2 emissions 1970-2014 in Algeria [7].

The comparison with other countries, contribution of Algeria to global climate change is up to now very small, Algeria meets all the requirements of signed international conventions in the field of atmospheric pollution. Algeria is also involved in the carbon capture and storage technology, with one of the very few functioning projects in the world.

2. Heating and cooling energy needs in different region of Algeria

The quality of housing built by private and public developers is uninhabitable in Algeria, expressing a total lack of consideration of thermal comfort. The north of Algeria is cooler, enjoying a Mediterranean-style climate. Temperatures in Algiers average 26°C in July, though humidity can make the summer heat uncomfortable. In winter, average temperatures are around 12°C, but can drop right down, with snow common in certain highland regions. Summer temperatures are high throughout the country, particularly in the south where it is both very dry and very hot. North of the Sahara, temperatures are very mild from September to May and vary little between day and night like Bechar city. In the Tell, temperatures in summer average between 21° C and 24° C and in winter drop to 10° C to 12° C. Winters are not cold, but the humidity is high and houses are seldom adequately heated. In eastern Algeria, the average temperatures are somewhat lower, and on the steppes of the High Plateaus winter temperatures hover only a few degrees above freezing [8]. This part in this work is analysis a consumption of energy in building (cooling and heating) for this different climate in Algeria.

Table 3. Information about the various cities regions [9].

Cities	BECHAR	ALGIERS	TIARET	TAMANRASSET	HASSI MESAOUD
T max C°	40.1	32.2	35	35.4	44
T min C°	3.5	5.5	2	5.2	4
longitude	2.233°W	3.25°E	1.43°E	5.517°E	6.483°E
latitude	31.617°N	36.717°N	35.25°N	22.783°N	31.667°N
Altitude *m*	772	25	1127	1377	142

As we see, these five cities have different climates, so it is not possible to find the same energy consumption for cooling and heating, the figure 2 below shows the energy consumption for cooling and heating for each region of the five cities.

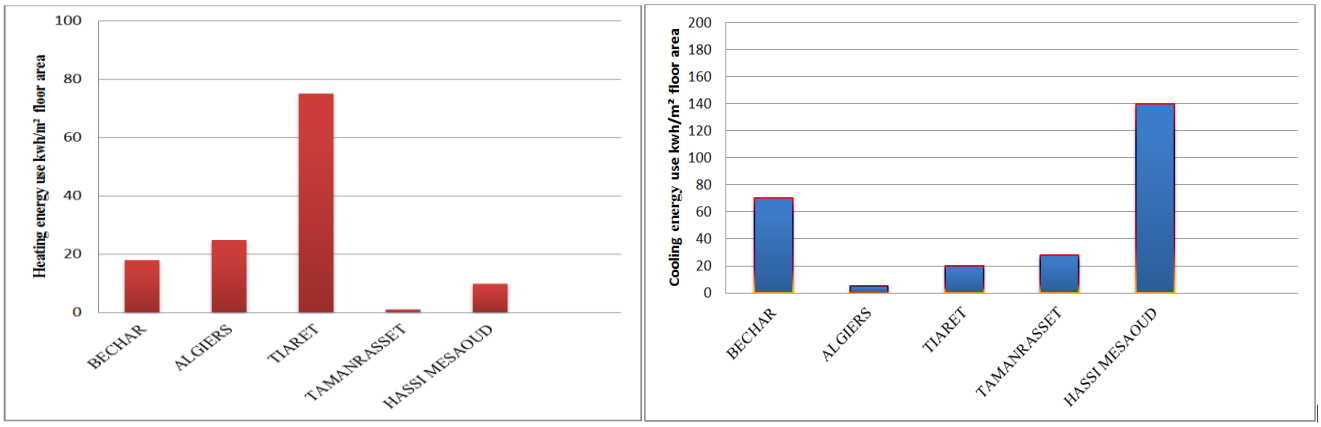

Figure 2. Cooling and heating energy consumption for different region in Algeria [10].

Thermal losses on high plateaus region (Tiaret) are more important in heating period compared to other sites (Algiers and Bechar) (see figure 3), because the temperature is much lower. For this fact, the demand for heating is more important and more consumption in this region. Energy consumption for cooling in southern region (Bechar, Hassi messaoud, Tamanrasset) is lower than in Northern region for the heating period.

In the south, the temperature is higher in summer, for this the cooling degree days is more important and reaches 328 degree days, as well as thermal losses which reach 1942.42 ≈ 2000 kWh in July [11]. For this reason the energy consumption for heating and cooling in Algeria is very high.

Table 4. Cooling and heating costs for the five regions.

cities	Intervals (€/m2)	
	cooling	heating
Hassi messaoud	2,561 - 3,191	
Bechar	1,931 - 2,561	0,008 -0,024
Tamanrasset	1,301 - 1,931	
Tiaret	0,672 - 1,301	0,040 - 0,056
Algiers	0,042 -0,672	0,0244 - 0,040

The cooling regions is so similar to the sum energy consumption cost, which mean the heating consumption cost has no influence in regions comparing with cooling consumption cost, and that can be explained with the big different between electricity and gas tariffs, since the gas tariff is almost the third of electricity tariff.

3. Buildings energy consumption by products

In Algeria the products utilized in the buildings are represented on electricity, natural gas, LPG and biomass. As it is shown in figure 3 natural gas consumption have been rising during the years, while it increase from 4.085Mtoe in 2010 to 5.63Mtoe 2012 by 4.2% per year, the electricity demand also increased 3.73 Mtoe within two years, but it is noticed a decline in the consumptions of LPG and biomass, while it were respectively 17.4 Mtoe and 0.17 Mtoe in 2010 to be 17.2 Mtoe and 0.03 in 2012, and that can be explained as reflection of the rising of electrification and gas penetration rate in Algerian houses, what leads Algerian households to abandon using LPG and biomass more and more.

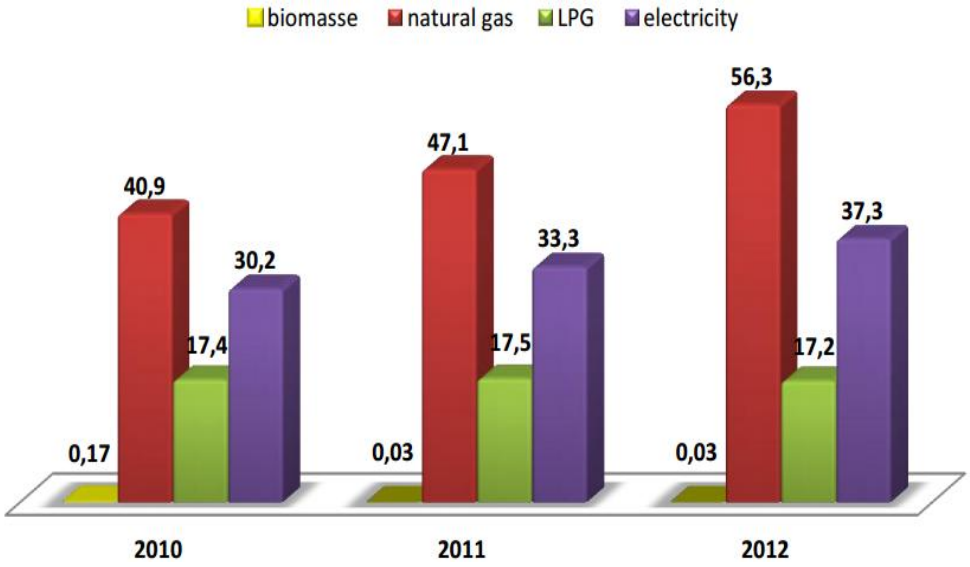

Figure 3. Residential energy consumption by products (Mtoe) [12].

4. Repartition of buildings energy consumption

According to the figure 4, shows the repartition of buildings energy consumption, natural gas is the major energetic product consumed by the households, which represent 51% of the total, followed by electricity with 34% then LPG with 15%, when the biomass only represent 0.02%.

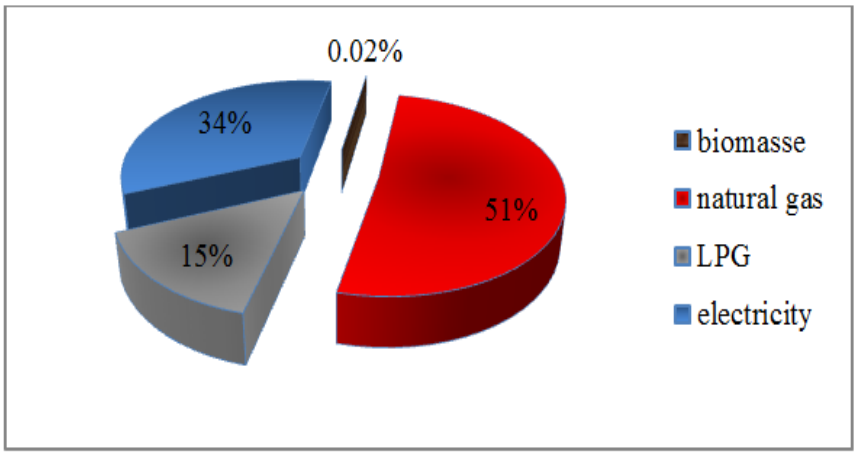

Figure 4. Repartition of the residential energy consumption by product [12].

5. Economic Factors

Price is clearly an important factor in discussing energy usage and Table 5 presents the prices of electricity and natural gas in residential sector about some countries for comparison

Table 5. Electricity and gas prices, second half of year, 2015 [13].

Countries	Electricity prices for households by €/kWh	GAS prices for households by €/kWh
Algeria	0.02 – 0.0505	0.000055
Germany	0.295	0.068
Spain	0.237	0.093
France	0.168	0.073
Italy	0.243	0.091

6. Appliance efficiency

The growth in housing unit size and demand for energy services has been countered by improvements in appliance efficiency. Some energy end uses have become much more efficient in the past years, such as refrigeration and clothes washing. Efficiency gains also have been made in heating, ventilation, and air conditioning equipment, as well as in windows and insulation. As a result, from 2005 to 2010, the energy consumption of the buildings decreased by 6.95 percent as measured by energy use per household 3917.8 kWh in to 3645.4 kWh, nevertheless, the growth in the number of households and size of houses increased total energy use, more details in the table 6.

Table 6. Specific annual energy consumption by household appliances (kwh) [14].

years	2005	2006	2008	2009	2010
lighting	533	529	524	520	518
refrigeration	409	400	372	361	353
freezer	511	510	493	487	478
TV	287	280	278	278	278
Clothes washer	673	668	660	657	653
Microwaves	10,8	10,6	10	9	8,4
air-conditioning	1370	1350	1290	1270	1240
ironer	108	106	103	103	103
fan	16	16	14	14	14

7. Forecasting energy consumption for residential buildings in Algeria

Buildings are the principal energy consumer in Algeria. Therefore, energy consumption forecasting is a critical and it helps to make good planning, long term strategies, efficient initiatives to decreasing emissions and controlling energy usage in the building sector. Ghedamsi et al has been used bottom-up approach for modeling

and forecasting of energy consumption for Algeria residential buildings until 2040. The results showed, the energy consumption increased from 73.23 TWh in 2008 to 179.78 TWh in 2040. Furthermore, climatic zone in Algeria is delineated in seven zones. Zone seven consumes 73% of the energy in Algeria. Heating, cooking, and hot water are the major energy consumers in Algerian [15].

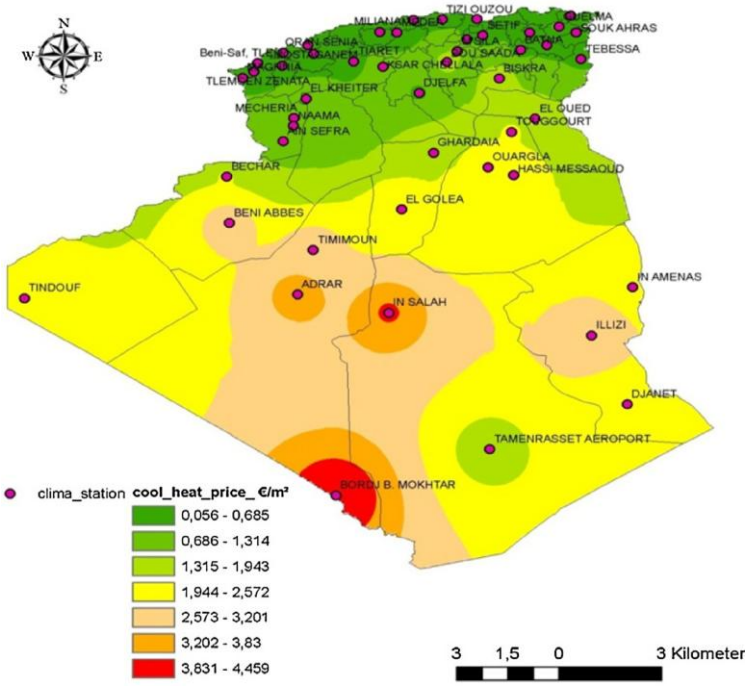

Figure 5. Climatic zones according to energy consumption costs.

Show the climatic zone maps, which are created using GIS based software. Climatic zones representing the range of cost thermal energy requirements for buildings (cooling and heating). The cooling zoning is so similar to the sum energy consumption cost, which means that the heating consumption cost has no influence in zoning comparing with cooling consumption cost. This result is due to the small influence of heating.

7.1 Heating and cooling consumption

The Table 7 shows the heating and cooling demand for seven zones. The energy consumption for cooling by consumer located in Zone one is significantly higher than the consumption of a consumer living in the Zone seven. This difference is due to the massive use of air conditioning, due to the climate of south Algeria is characterized by hot temperatures during several months of the year. The energy consumption for heating by the consumer located in Zone seven is significantly higher than the consumption of a consumer living in the Zone one. The weather conditions in winter are rather harsh in Zone seven explain the private use of this population to heat gas.

Table 7. Annual heating and cooling energy consumption per household.

Climatic zones	Annual consumption per household (kWh/year)	
	cooling	heating
Zone 1	969.81	2841.75
Zone 2	969.81	2409.03
Zone 3	969.81	1976.31
Zone 4	1185.50	1543.59
Zone 5	1455.48	1110.87
Zone 6	2339.31	678.15
Zone 7	2215.12	245.43

7.2 Energy consumption in one house

Figure 6 shows the consumption of one house for each zone. As it appears in figure the energy consumption can be categorized into two types of determinants:

Fix consumption: hot water, refrigeration, freezer, TV, lighting, microwave, ironer and others.

Variable consumption: cooling and heating which change from one zone to another as it is, has high co-relation to climate. The average annual consumption of one house in Algeria is 14,374 kWh [15]. Zone one is the highest consumer of energy by consumer. Zone seven consumes 73% of the final energy in Algeria due to the population density.

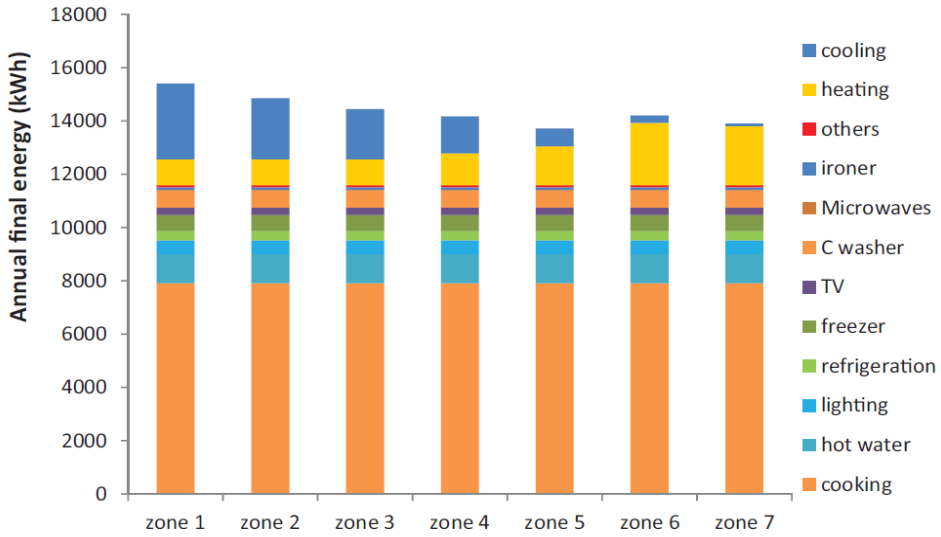

Figure 6. Energy consumption in one house for each zone.

7.3 Total consumption projection Energy

According to the forecasting energy consumption in Algeria that is rapidly increasing due to the population growth, move to large cities, urbanization and improvement in standard of living. Figure 7 shows the final energy increased from 73.23 TWh in 2008 to 179.78 TWh in 2040. Cooking, hot water and heating are the major energy consumers in Algerian residential buildings.

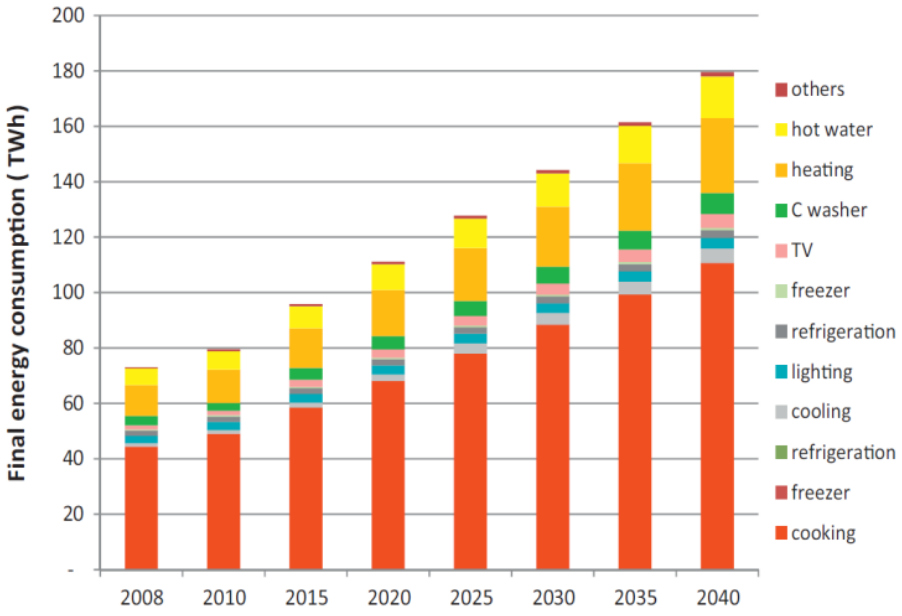

Figure 7. Total forecasting energy consumption in residential buildings until 2040 TWh.

Conclusion

In Algeria, demand on HVAC, lighting and refrigeration is rising which leads to more electricity consumption. Accordingly we presented in this article analysis of energy consumption in buildings. The paper firstly defined the problem statement, where energy, Sustainability and gas emission in Algeria. Then we presented influence of the residential buildings typology on energy needs in different regions. As well it highlighted the consumption by product. Finally we presented forecasting energy consumption for different regions in Algeria.

After this analysis we noticed that energy end uses have become much more efficient in the past years, such as refrigeration and clothes washing. Efficiency gains also have been made in, heating, ventilation, and air conditioning equipment, which improve the energy efficiency, but it is not enough cause it has been countered by the growth in population, houses realization, and housing unit size and as well as in windows and insulation. So, more procedures are required to improve energy efficiency.

The residential sector have a lot factors that influence it is consumption like the kind of appliances and the efficiency of the appliances of using an absorption chiller in one of many solution, so if reduce some of all the factors we will be massage gain.

During studying this subject, also we noticed an insufficient data about this kind of subjects in Algeria, so the residential sector needs more attention from the researchers. As long as data and statistics are rarely available about the consumption in the residential sector in Algeria, this study hopefully will give a closer look about this sector.

Acknowledgments

This work was supported by ENERGARID laboratory, University of Tahri Mohamed Bechar, Algeria. We like to thanks A. Khamouli and N. Fezzoui for their helps in the preparing of this paper.

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