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Energy consumption and conservation practices in Qatar—A case study of a hotel building

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ABSTRACT

This paper considers energy conservation practices in Qatar with special emphasis on commercial buildings. Energy conservation approaches are classified into five main areas and an Energy Conservation Matrix (ECM) database for buildings is developed. The ECM maps the energy conservation techniques/technologies to models versus their application domain. Three scenarios (building envelope design, change in customer behavior, and consideration of renewable energy supply) are analyzed to study different alternatives for efficiency improvement. The analysis is done in a case hotel. The analysis shows that, the energy conservation potential of using envelope redesign for the case study is about 7.5% while conservation through behavior change ranges between 2.74% and 15.80%. The conserved energy potential ranges between 10% and 24.12% of the site energy in the combinatorial scenario that integrated envelope design alternatives with customer behavior change. The renewable energy (RE) scenario conserves energy, indirectly, by using green energies generated from renewable sources. The output shows that due to changes as per the three scenarios, total CO_2 emissions of the building are also reduced. The analysis shows that adoption of 30% RE alternative can reduce emissions by about 27% with respect to the reference scenario. It is believed that the scenarios developed in this paper and the results obtained will motivate the designers to consider alternative designs or redesigns in the large scale commercial buildings.

1. Introduction

Qatar's climate is arid, i.e. it is dry, very hot and humid. In addition, Qatar is the second highest electricity consumer among Gulf Cooperation Council (GCC) countries. About 65% of Qatar's electricity is consumed by cooling systems in all types of buildings [1]. The growth in economy and population in Qatar has been accompanied by an increased number of industrial entities as well as construction of industrial and commercial buildings. As a result electricity production in Qatar, between 1999 and 2010, increased by about 3.7 times [2]. Fig. 1 shows the pattern of electricity growth, for four consumption sectors, namely; residential, industrial, commercial and governmental organizations, in the past 12 years.

The amount of energy consumption by sector in GWh and the share of each sector in percentages for first and last year data (1999, 2011) of the analyzed period are compared as shown in Fig. 2.

It is easy to recognize that there is a real change between residential sector and industrial sector. According to the statistics of Ministry of Energy and Industry, the number of recorded industrial units increased from 482 in December 2007 to 611 in December 2011. Main growth is in the textile group (textile, apparel and leather) and basic metallurgical group. The electricity consumption in industrial sector increased by about 15% of the total demand in this period (i.e. from 1999 to 2011) while there is a relative percentage decline in the residential sector demands by about 12%. The growth in electricity consumption of commercial sector reached 295% and governmental sector by 441%.

Although electricity consumption in industrial sector increased from 1134 GWh in 1999 to 8233 GWh in 2011, with a growth rate of 726%, the sectors related to number of population (residential and governmental) have kept control over the energy consumption until year 2009 after which a turning point in the favor of industrial sector is observed. In year 2011, the electricity consumption

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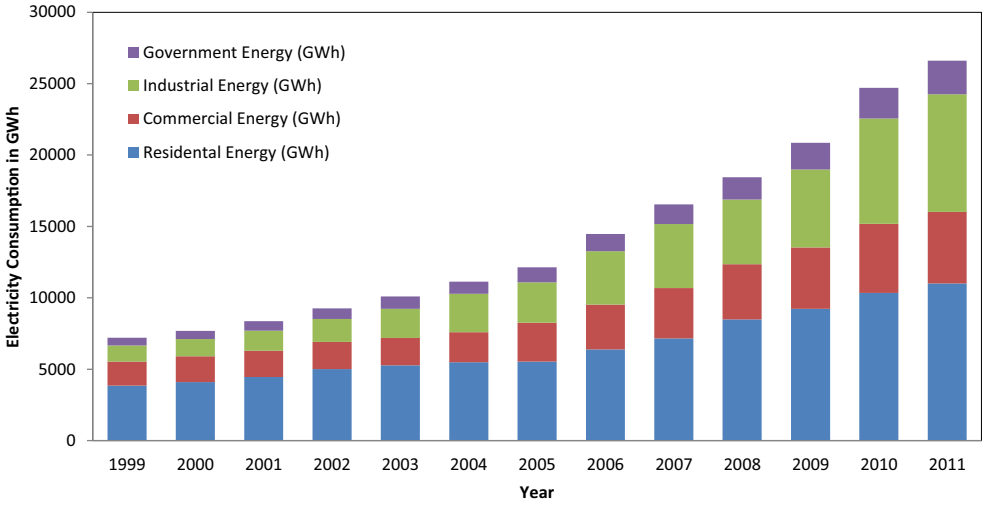

Fig. 1. Electricity consumption by sector in Qatar from year 1999 to year 2011 [3].

by commercial and industrial buildings in Qatar reached 50% of the electricity demand [3]. This makes it worthy to investigate the possibilities of energy conservation systems in those sectors.

Hence, this paper focuses on studying the potential of energy conservation in commercial buildings in Qatar by identifying the current energy conservation practices and the possible development of such practices. To achieve this aim, the key energy conservation practices, techniques/technologies were explored by reviewing the related work worldwide and classifying them into a simple database matrix called Energy Conservation Matrix (ECM). As the weather in Qatar is similar to other GCC countries we reviewed the energy conservation methods and strategies used by researchers in the GCC countries. Then the significance of some of these methods on a case hotel in Qatar through scenario analysis in demand and supply sides is studied. Finally, the potential for GHG emission reductions associated with the applied energy conservation strategies is shown.

The rest of this paper is structured as follows; Section 2 includes the energy conservation methods classification and ECM explanation, energy conservation strategies in GCC countries and Qatar energy conservation initiatives based on the identified classes. Section 3 introduces the energy conservation scenarios used in the case study hotel building. The description of the case study hotel building model used in testing the scenarios is given in Section 4. The results and discussions of the results are presented in Section 5. In Section 6 conclusions, recommendations and future challenges are given.

2. Energy consumption and conservation practices

2.1. Energy conservation categories and matrix

There is large number of research work, worldwide on the energy conservation approaches [4–9]. These methodologies can be classified into five main categories, namely; (1) policies, regulations and programs [8,10], (2) efficient technologies and models [9,11], (3) efficient building design and materials [12,13], (4) using renewable resources for energy supply [14–17], and (5) behavioral changes [18,19]. To help in the design and adoption of energy conservation practices, a database of models, methods and techniques/technologies followed worldwide, called Energy Conservation Matrix (ECM), is built. The ECM database is composed of three levels; the ECM level, model/technique information level and literature sources level. As seen in Fig. 3, the two dimensions classes of the ECM are (1) the five categories presented here, and (2) models and techniques/technologies applied to reach specific energy conservation targets.

The five classes are further subdivided into application areas of the model/technology class. For example, the building design application areas include envelope, glazing, and interior design. In the information sheet, a short description is given about the model/technique; its advantages and disadvantages, its application and an example for application scheme. The literature sources of each energy conservation approach included in the database is referred to inside the information sheet, as shown in Fig. 3. The key

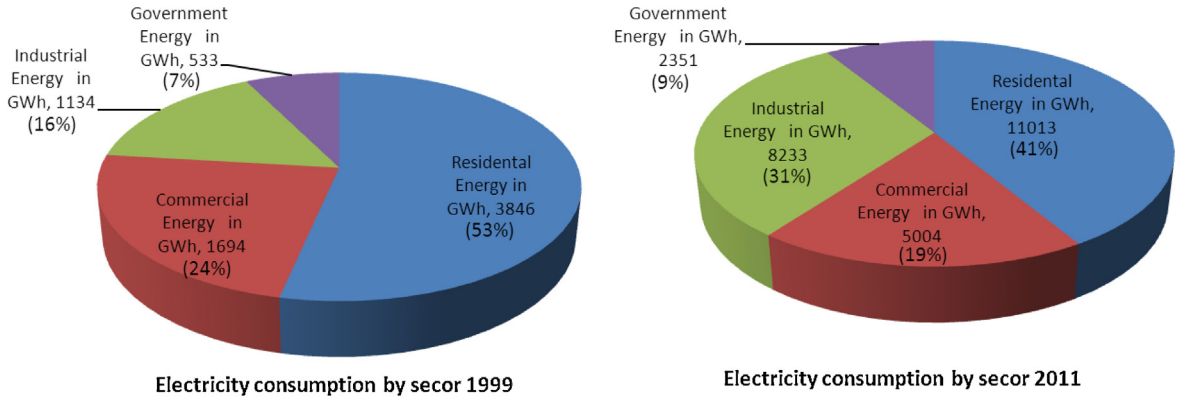

Fig. 2. Electricity consumption comparison between years 1999 and 2011.