ENERGY AND WATER CONSERVATION MEASURES FOR SUSTAINABLE BUILDINGS IN OMAN

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1. Introduction

The concept of sustainable buildings has emerged in recent years as one of potential solutions for the serious environmental problems. Energy and water conservation is a key strategy in sustainable buildings. It is important as it will expand the availability of finite energy resources and also reduces the detrimental environmental effects of energy production and use. Energy and water conservation measures need collective support from all stakeholders. Adopting an appropriate energy and water use policy delivers increased and sustainable performance. Conservation measures are meant for efficient use and effective utilization of energy and water resources. While efforts are being made, it is more important that there should not be any compromise on the quality of services offered, (for example, in electrical lighting, no compromise on illumination levels, and in air –conditioning, air quality, and indoor conditions) or interference with the primary function of the building.

In Oman power demand has been increasing rapidly due to population growth and fast economic developments. More than 75 percent of the total electricity consumed in Oman is attributed to buildings, with almost 50 percent used by households. The absence of mandatory energy efficiency regulations for buildings, coupled with population growth, has led to a significant increase in annual energy consumption. Public Authority of Electricity and Water (PAEW), during the year 2013, in association with Japan International Co-operation Agency (JICA) and Tokyo Electric Power Company (TEPCO) prepared a master plan for energy consumption in Oman [1] and strongly recommended to promote Energy Efficiency and Conservation Policy in order to reduce electricity consumption. This study mooted the importance of Energy Management System; Minimum Energy Standards and Labelling System; Energy Efficiency and Conservation Building Regulations; Smart Metering; and Energy Efficiency and Conservation Dissemination.

During the year 2017 as a part of initiative to construct energy efficient buildings or green buildings, Oman's government has carried out a detail energy audit of buildings through a specialized agency in order to create frameworks for design of energy efficient buildings in the future. Authority for Electricity Regulation (AER) in Oman gathered empirical data instead of theoretical data on reasons for high energy use in buildings and studied the behavioral aspects of users and noticed that by small behavioral improvement energy savings of 7 to 8% could be achieved. The King Abdullah Petroleum Studies and Research Center (KAPSARC) as part of the joint KAPSARC-UNESCWA project "Energy Productivity in the GCC," carried out a study [2] and found out that investment in energy efficiency measures to retrofit existing buildings could lead to significant economic and environmental benefits in addition to the potential to create new employment in Oman. Al-

Saadi et al [3] reported results of their study from a simulation work for a typical villa in Muscat, a hot humid city in Oman.

The results of this case study insist the need of detail analysis to conserve energy in typical buildings in Oman. Turner et al [4] reported sustainable water management strategy and warned that extraction of water from the groundwater sources should be reduced to stop the intrusion of saline water. Many developed countries in the globe realized the fact that the 'energy efficiency first' principle should be consistently applied across all the legislative proposals in the energy sector. Countries in Europe believe that energy efficiency gains should be measured in primary energy savings in order to account for efficiency improvements across the whole supply chain [5]. One of the major challenges in Oman's energy sector is that average summer load is more than double the average winter load as shown in figure 1 [6].

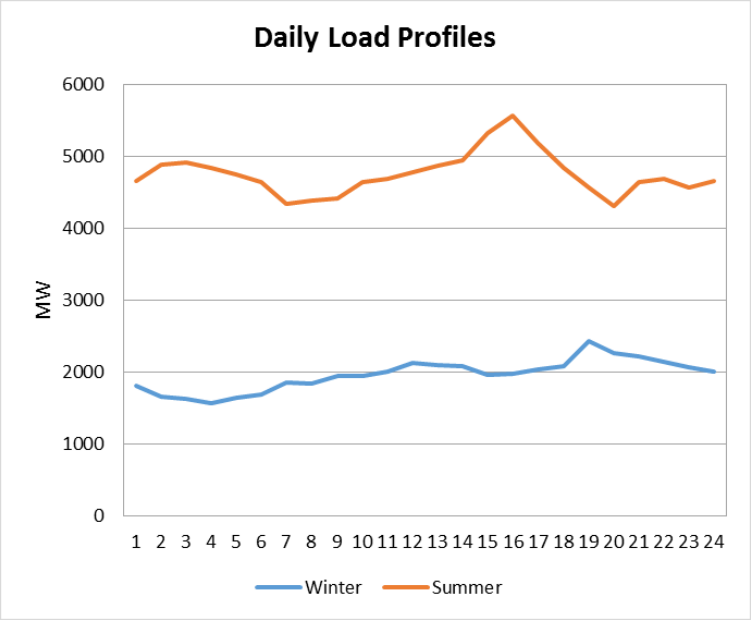

Figure 1: Daily electrical profile for a typical winter and summer day

Cooling Degree Days (CDD) is an important parameter indicating climate variations. This parameter determines the quantity of energy required to cool a building. It is a measure of how much (in degrees), and for how long (in days), the outside air temperature was above a certain level. They are commonly used in calculations relating to the energy consumption required to cool buildings. CDD values are used to design the size and capacity of the AC units. Figure 2 shows the total CDD values of Muscat per month during 2015 [7].

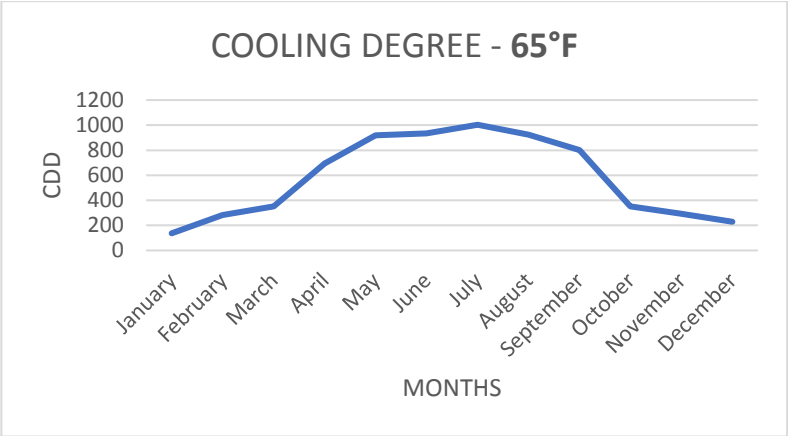

Figure 2: Monthly cooling degree days (CDD) in Muscat for the base temperature of 65°F

Above figure indicates that CDD values follow a cyclic trend. During January, the value was lowest and it increased every month and reached its peak during the month of July and hence summer load is high. Detailed regression analysis of CDD values and its documentation is required. Therefore to monitor energy consumption during all seasons an effective energy policy, procedures and guidelines are required. Any new policy or guidelines should review current practices and provide a good starting point and be reviewed regularly and updated. An energy conservation policy, in general, will Establish clear management commitment to energy efficiency; Improve the overall approach to energy management; Maximize the use of resources, both in time and money; Provide goals against which to monitor; Provide a clear direction for the energy team etc. This paper makes an earnest attempt to insist the need of well defined energy policy and guidelines along with some tips to save energy and water in building sector. Also nessaity of bench marl for various types of buidlings is highligted.

2. Some guidelines for Energy Saving Opportunities in Electrical System

2.1. Use of most efficient lighting System

Lighting energy consumption is approximately 20-45% of total energy consumption of any typical building. Significant energy savings can be realized with a minimal capital investment under this category. Few guidelines are given below for guidance.

- Use Energy Efficient Electronic chokes / Ballast- For example conventional tube light fixture with 36W lamp consumes Min 55W power, by using electronic ballast the power consumption of same fixture reduces to 36W i.e. saving of 19W per Fixture (Approx. 35% power saving, also increases the life of lamp).
- Use Energy efficient, high lumen, high color index, without affecting the quality of the lux level of the buildings.
- Automatic control- Photocell / Timers / Occupancy sensors / Timed – Turnoff switches can be used to control the lighting system.
- If better Color Rendering Index (CRI**)** is not required (area lighting only) prefer High-Pressure Sodium Vapor lamp (HPSV) instead of High Pressure Mercury Vapor (HPMV) lamps. Lamp efficacy (Lumen/Watt) for HPSV lamp is 90 Lumen/Watt,

Average life burning hours 12000 & for HPMV efficacy is 50 Lumen/Watt & Average life burning hours 5000 only.

- Use energy efficient lamps instead of conventional lamps. If need use of incandescent lamps shall be banned by proper legislation.

2.2. Use of energy efficient motors and Soft Starters

Use of energy efficient motors along with suitable starters will give opportunity to save good amount of energy. DOL starters are very cheap but not efficient and hence prefer Star-Delta starter wherever possible. Besides soft starters provide a reliable and economical solution and also extend the life cycle of motors and hence soft starters should be preferred than other starters.

2.3. Use of variable speed drives (VSD) wherever applicable

A variable speed drive controls motor speed and torque by varying the motor input voltage and frequency. Modern electrical VSDs can be used to accurately maintain the speed of a driven machine to within ±0.1%, independent of load, compared to the speed regulation possible with a conventional fixed speed squirrel cage induction motor, where the speed can vary by as much as 3% from no load to full load.

3. Some guidelines for Energy Saving Opportunities Energy saving in air conditioning system

Conventional air conditioning systems using vapor compression is an energy intensive process. Optimization of operation of centralized air conditioning units during pre-office and post office hours linked with timer based microprocessor controllers such as BMS will help to conserve energy. The rational use of the air conditioning units based on load and occupancy resulted in energy savings to the tune of 15% without any investment. Also maintaining the comfort temperatures even without human occupancy consumes energy due to unavoidable losses in the system. Switching on and off of air conditioning systems are to closely co-relate with occupancy levels. This will avoid unnecessary consumption of energy. Use of solar energy based cooling systems should be encouraged.

4. Some guidelines to save water in building

One of the best ways to identify suitable water conservation measures is to establish a water saving plan and subsequently to benchmark with other facilities to compare, analyze, rate, rank, and prioritize effective measures. Few guidelines to conserve water are given below:

- Use of water-conserving devices and maintain it regularly.
- Check the possibility of use of grey water.

- Use of pressure reduction devices as per the site condition-
- Regular inspection for leak of water and its repair.
- Reduction of water use in toilets by installing latest water saving devices.
- Manage on-site laundry facilities efficiently
- Utilize efficient technology in kitchen areas.

5. Energy Audit and need of Energy Management policy guide

Energy audits, which primarily deal with the supply of energy to a facility, are usually undertaken by the facilities manager. First step of energy audit is recording and compiliation of data of use of enery and other utilites of buildings. Basic objectives of collection of data are :

- To identify the energy consumption pattern in relation to the ambient conditions, building occupancy and other factors.
- To use latest analytical tools to analyze the collected data and convert these data into useful information to arrive bench marks and to frame a comprehensive energy policy.
- To suggest investing capital costs to procure energy saving devices/equipment to conserve energy/water/utilities to lead to sustainable buildings.

Building energy benchmarks provide representative values for the selected building types, against which we can compare building's actual performance. Comparison with simple benchmarks of annual energy use per square meter of floor area will permit the standard of energy efficiency to be assessed and enable remedial action to be taken. Energy benchmark is seen as a valuable tool to raise awareness among facility managers and improve the energy efficiency. Energy Use Intensity (EUI) is one of the major parameter used in energy benchmarking processes. EUI is the total annual energy consumption divided by the total gross area. EUI can vary significantly depending on the building type and the climatic features. EUI standards for Oman are not available. A typical EUI values used in Singapore is shown in Table 1.

Table 1: Standard EUI Values by Singaporean [8]

Building Type	**Average size (m^2)**	**Average EUI range(kWh/m^2)**
Hospitals	25,000	400-600
Health care centers and clinics	15000	250-350
Food Facility Services	8000	650-900
Educational Institutes	10000	150-250
Office buildings	10000	300-400
Schools	10000	125-200
Recreation Centers	10000	350-400

Without any benchmarked values or standards set, it is quite difficult to compare the energy performance of different buildings. Energy auditing procedures and guidelines are to be documented in order to arrive at bench mark values of building's energy consumption. At present, no established procedures for energy auditing are available. Charter Institute of Building Services Engineers (CIBSE), UK recommends need of Energy Management policy guide with details such as building Energy Use, energy sources and costs, controlling energy Use, Framework for Energy Policy, strategies for managing energy use, promoting and investment in energy strategy, understanding energy regime of a building, improving energy performance in use, establishing energy facts, energy audits, energy monitoring and targeting, etc. In Oman such guide is not available. Compilation of such guide is the immediate requirement to conserve energy in Oman.

6. Conclusion:

The key to sustainable energy policy for an efficient energy and water management of a building is to gain a sound understanding of purpose and use of the building and set out a clear energy and management policy and implement it rigorously. Oman needs well researched and documented guidelines and policy to conserve energy and other utilities of building. Need of policy for energy conservation in Oman is reported in this paper. Also some guidelines for energy saving opportunities in electrical and AC systems and guidelines to save water in building and the need of regular energy audit is explained in this paper. It is recommended to develop a National statistical system to record energy data for all the major building in Oman. Also use of alternative technologies such as vapor absorption system using solar energy to reduce the use of energy consumption in conventional Vapor compression system for AC application is recommended.

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