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A literature survey on measuring energy usage for miscellaneous electric loads in offices and commercial buildings

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ABSTRACT

This paper presents the current state of the art regarding work performed related to the electric energy consumption for Information and Communication Technologies (ICTs) and Miscellaneous Electric Loads (MELs), in office and commercial buildings. Techniques used for measuring the energy consumption of office plug loads, and efforts for saving energy by using this equipment more rationally and efficiently are identified and categorized. Popular methods and techniques for energy metering are discussed, together with efforts to classify and benchmark office equipment. Our study reveals that many issues are still open in this domain, including more accurate, diverse and meaningful energy audits for longer time periods, taking into account device profiles, occupant behavior and environmental context. Finally, there is a need for a global consensus on benchmarking and performance metrics, as well as a need for a coordinated worldwide activity for gathering, sharing, analyzing, visualizing and exposing all the silos of information relating to plug loads in offices and commercial buildings.

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1. Introduction

It has been stated that "*if putting a man on moon was one of the greatest challenges the 20th century faced, tackling climate change is a much bigger challenge that we in the 21st century are confronted with*" [1]. Electricity represents 40% of the total energy used in the U.S. [2], primarily being used for heating, cooling, lighting and powering appliances across all sectors – residential, commercial and industrial. The importance of energy efficiency for computing equipment in offices is becoming more relevant. If one considers the total cost of ownership (TCO), while manufacturers have continuously driven down the capital cost of such equipment, the operational costs (i.e. electric consumption) have been rising [3–6].

In 2008, commercial buildings consumed about 20% of total U. S. primary energy (18.3 Quadrillion BTUs per year) [7], a figure projected to grow by 36% at 2030 (from 2008) [8]. Unlike the residential sector with 115 million households (in 2009), the commercial sectors' energy consumption is concentrated in 5 million buildings. As a result, energy use intensity (energy per unit floor area per year) is the greatest in commercial buildings when compared to residential or industrial.

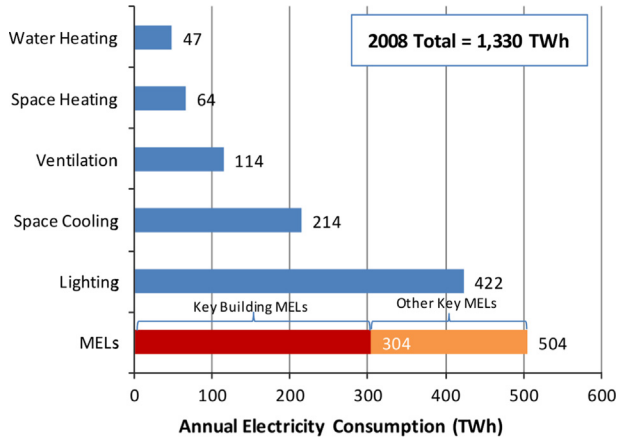

Fig. 1. Annual energy consumption of MELs in relation to other loads (Source: [7]).

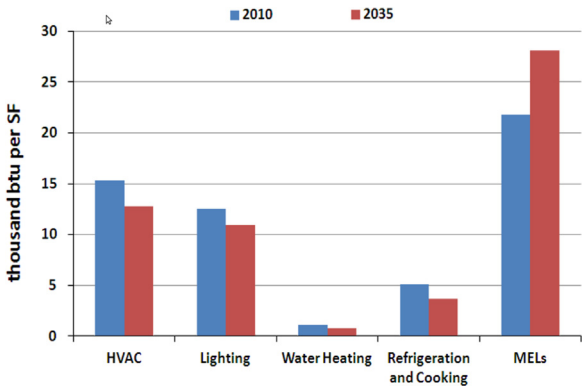

Fig. 2. Projection of energy demand in 2010 vs 2035 (Source: [14]).

1.1. Miscellaneous electric loads

Miscellaneous electric loads (MELs) are defined as non-main commercial building electric loads, that is, all electric loads except those related to main systems for heating, cooling and ventilation [7]. MELs are also described as electricity-consuming loads that do not fall under conventional end uses, such as lighting, HVAC and refrigeration [9]. Key types include consumer electronics and recent evidence suggests that MELs contribute significantly to the building's energy load.

MELs account for more than 20% of primary energy used in commercial buildings, and this percentage is projected to increase by 40% in the next 20 years [8,10]. This has made MELs one of the fastest growing load categories [11]. This growth relates to the fact that PCs and other office devices are penetrating office buildings, creating a large installed base of computing equipment. In 2001, yearly power consumption of office equipment accounted to 2% of the total electricity use in U.S. [12], while, as Fig. 1 shows, MELs consume more electricity than any of the traditional building main loads.

MELs constitute the large majority of office equipment, while an important part of them is about plug loads related to Information and Communication Technologies (ICTs), such as desktops, monitors, and printers. A study measuring consumption in a controlled environment at the University of California, San Diego [13], revealed that ICTs accounts for more than 70% of the MELs-based electricity load, being 50% of the total load during peak hours, reaching almost 80% during off-peak hours.

Traditional end uses are projected to decrease or remain the same from 2010 to 2035, while energy intensity of MELs is projected to increase[1] [14], as displayed in Fig. 2.

This is partly because research on energy efficiency and deployments has focused on the traditional end uses in the past two decades. At the same time, the rapid market penetration of consumer electronics has expanded the MELs category significantly, however, the energy use and reduction strategies for MELs have so far received little attention.

Reducing plug load consumption in offices could be a potential measure to improve net-zero energy buildings [15]. While tight regulation and efficiency have pulled down lighting and HVAC loads down to 50%, consumption from unregulated plug loads has been increasing. MELs are evolving into dominant loads, and this creates a threat in achieving net-zero energy [14].

[1] This study has been performed specifically for Germany. For different climatic conditions, this projection could be different.