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Consideration of energy consumption, energy costs, and space occupancy in Finnish daycare centres and school buildings

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ABSTRACT

The building sector contributes up to 30% of global annual greenhouse gas emissions and consumes up to 40% of all energy. Failure to encourage energy-efficiency and low-carbon in new builds or retrofitting will lock countries into the disadvantages of poor performing buildings for decades. The journey towards low-carbon and energy efficient buildings starts with good design, commissioning and measuring.

The share of energy costs can be up to 50% of all maintenance costs [7] in Finland. In the studied buildings the average costs were 39% for daycare centres and 45% for schools. Since the share of energy costs is remarkable in maintenance, it is important to find out the most concrete indicators to measure energy efficiency in practice. This study explores ways in which building usage and occupancy influences the energy cost in Finnish daycare centres and school buildings.

This study shows that energy costs vary a lot between different energy efficiency indicators, i.e. there is great variation in energy costs regardless of the building age and when child or student density varies. Results indicated that actual use of space is profiled in the operational phase where the energy costs variation is remarkable.

1. Introduction

Debate on tangling climate change challenges has been ongoing for decades. It is widely acknowledged that climate change due to emissions of greenhouse gases is one of the major environmental challenges facing our globe today. Nevertheless, the construction and use of buildings are important factors in the overall game. The global contribution from buildings towards energy consumption, both residential and commercial, has steadily increased reaching figures between 20% and 40% in developed countries, and has exceeded the other major sectors: industrial and transportation [1]. Buildings use materials and energy. Materials also impact on energy efficiency though structures. For this reason, energy efficiency in buildings is today a prime objective for energy policy at regional, national and international levels [1]. The needed energy amount for heating buildings reduces as insulation level develops and heating recovery efficiency advances [2]. In addition, the use purpose effects on building's energy consumption. Furthermore, energy consumption is linked to greenhouse emissions as buildings primarily consume fossil-fuel based energy [3,4]. Given the massive growth in new construction in economies in transition, and the inefficiencies of existing building stock worldwide, if nothing is done, greenhouse gas emissions from buildings will more than double in the next 20 years.

In Finland the built environment accounted for 59% of the final energy use and 56% of the greenhouse gas emissions in 2007 [5,6]. Besides the impact on the emissions, the energy use in buildings represents a significant cost factor in the building operation phase. According to a survey of KTI Property Information Ltd [7], the share of energy costs can be up to 50% of all maintenance costs.

The two core forms of energy in Finland are district heating and grid electricity from mixed sources that make use of renewable and non-renewable technologies. In recent years, these two forms of energy have become more expensive in relation to inflation, so their prices have escalated [8–10]. The developments of the real price of district heating during the last 30 years are shown in Fig. 1. The district heating real prices are adjusted for cost-of-living index and are based on price indices of 1.1.1981 = 100 [8]. Developments of the electricity prices during the last 20 years are shown in Fig. 2 [9,10].

Kantola and Saari [11] have studied the current price situation in the Finnish energy market. Study concluded that the most polluting and commonly used solution, combination of district heating and grid electricity, was also the most expensive solution. The main

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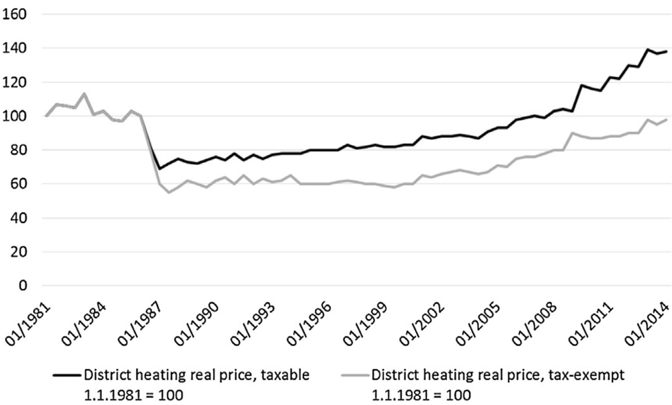

Fig. 1. Development of the real price of district heating. The real prices are adjusted for cost-of-living index and are shown in index of 1.1.1981 = 100. Figure shows taxable real price and tax-exempt real price [8].

reason for this is the increase in energy prices in Finland in the twenty-first century.

From an environmental and economic point of view, the reduction of energy consumption and costs is therefore becoming central to the planning, construction and use of buildings. A continuously growing interest in an efficient use of energy and in energy cost planning has been observed [12–14]. Property owners already include energy consumption and cost planning in the design phase of the building, while there are increasing references to consumption and cost benchmarking in the usage phase.

In Finland, various tools exist to support energy use as well as energy cost planning and benchmarking [15,16]. Calculations typically provide information about development of energy use in the large building stock over long periods of time. The study by Tuominen et al. [17] presents a novel calculation tool named REMA that assesses the effects of various energy efficiency measures in buildings. Also in this study the calculations covered the whole building stock of Finland.

In addition to calculations tools, KTI Property Information Ltd. has performed annually the building maintenance cost benchmark since year 1997. In the benchmark, the focus is on realised yearly costs in different maintenance cost categories and in energy consumption. Basic property information (i.e. net floor area) is used to classify properties in different cost categories.

Energy consumption in schools and daycare centres is usually high, and it has an impact on the communities' energy consumption and thereby the energy bill [18–23]. It was reported that UK schools could reduce energy costs by around £44 million per year, which would prevent 625,000 tons of CO2 from entering the atmosphere [24]. As comparison in Finland in the City of Espoo, the annual energy costs of the public service building stock are approximately EUR 16 million. The majority of the City of Espoo's owned public buildings (60%) are educational buildings such as schools and daycare centres. Their share of energy costs are approximately EUR 11 million. The efficient use of facilities has been raised in the City of Espoo facility strategy. Improving energy efficiency is carried out primarily for economic reasons and impact of the energy saving measures should result cost savings.

1.1. *Energy performance indicators*

The indicators are not merely data; rather, they extend beyond basic statistics to provide a deeper understanding of the main issues and to highlight important relations that are not evident using basic statistics [25]. For example in recent literature Xia et al. [26] compared energy efficiency in Chinese and American case office buildings and Zhao et al. [27] studied the effect of supervision on energy efficiency on large-scale public buildings in China. In European, Boyano et al. [28] estimated energy demands and energy savings potentials in case offices, Pikas et al. [29] calculated cost optimal zero energy building solutions for office buildings in Estonia and Nunes et al. [30] compared energy efficiency in two Portuguese case offices.

Two of these studies [27,30] included occupancy and space use in their scope. Nunes et al. [30] attempted to take into account space efficiency in indicators by introducing what they call energy efficiency index per standard occupants ($EEI_{REAL,OCC}$) where the building energy use is divided with the normalized amount of occu-

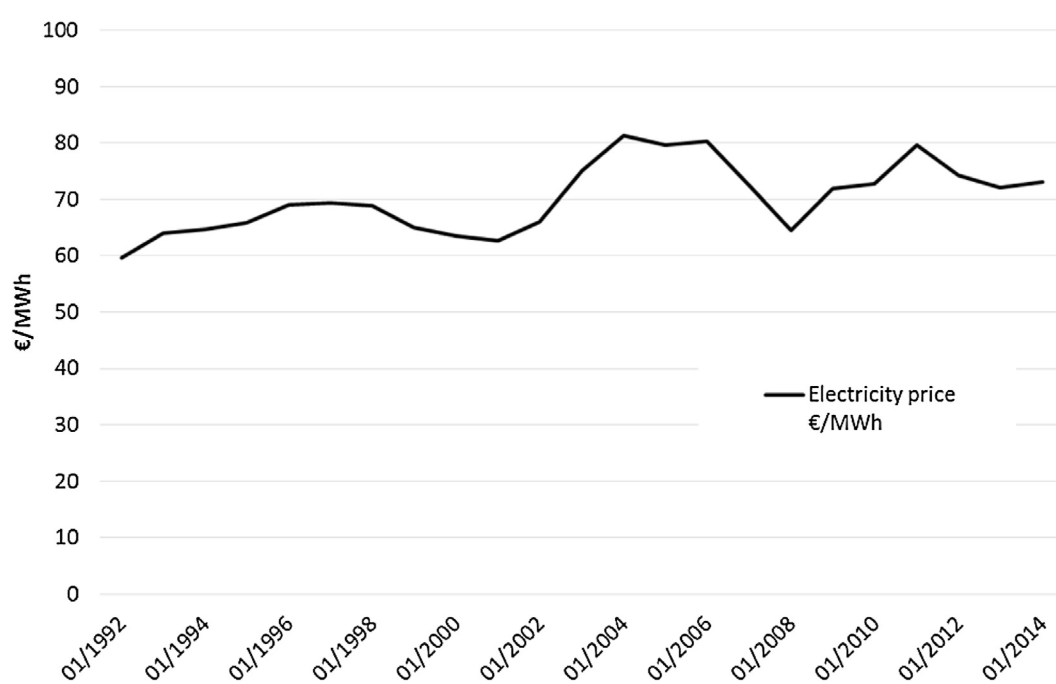

Fig. 2. Development of the price of electricity, €/MWh. Prices includes of electricity, the transfer fee and taxes [9,10].