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Efficiency for Sustainability—*Smart Energy Management in Social Housing*

Rolf Katzenbach, Frithjof Clauss, Jie Zheng

TU Darmstadt Energy Center, Technical University Darmstadt, Darmstadt, Germany
Email: zheng@energycenter.tu-darmstadt.de

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Abstract

An average energy consumption distribution in household at the worldwide level illustrates that more than three quarters of total consumption is contributed to room heating and almost 12% to water heating for all the living necessities. Although a slow fall of domestic energy consumption has occurred in the recent 20 years (from 1990 to 2011) with a regular decrease between −1.2% and −1.4%/year per dwelling as a result of a decrease income corresponding to the economic crisis in 2008, whereas energy prices for households has increase since 2004, the energy cost of paying especially for space heating and domestic hot water (DHW) supplying is still going up. At the EU level, the building sector including residential, commercial and other service buildings is regarded as the key to greater energy efficiency, because according to statistics the final energy consumption for building sector has taken the largest proportion about 40% until 2020, which is apparently higher than the share in transportation sector by 32% and industry sector by 24%. In the scope of the ongoing research and investigation on energy efficiency in residential fields and its impact on environment and climate, how to investigate smart energy management methods for the promotion of sustainable consumption and green living patterns has been already paid much attention, however it has to be studied further and thoroughly, especially among energy consumer groups whose energy costs have no or just little relevance or dependence on major income source, which leads to a lack of energy saving awareness by users. Energy consumers living in social housing buildings represent this kind of energy consumer group which receive the governmental relief fund as their family income in a great measure, they have different culture, educational and age backgrounds. This paper presents firstly some research results based on authors' practical experiences on the projects about energy efficiency in social housing buildings in European countries, which is supposed to be introduced in the aspects of subjective and objective energy saving potentials. It is proposed to be able to provide valuable and referential advices exchange our experience on a sustainable development in affordable housing.

Keywords

Smart Metering, Efficient Management, Sustainability, Social Housing

1. Introduction

How to achieve a balance between reducing energy costs and without sacrificing living comfort at the household

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level has always been a study focus, and been tested all the time for a replicable approach which aims to not only substantially control demand for energy and water, but also finally meet overall emission reduction targets.

Energy management is a work cycle in general on the basis of the order from survey and understanding of energy using purposes, to design and organization, then following implementation and operation, and monitor as well optimization, each part is always along with this entire process, and finally to pursue an energy conversation methods worth promotion (**Figure 1** illustrates Energy management concept in common).

In addition to be qualified with the basic principles, smart energy management possesses the requirements of strategic and operational perspective of energy use during all the processes of living and production.

Energy saving activities can be carried out at any time in any household and people just need to know-how, nevertheless more critical is their consciousness to live in an energy-efficiency way initiatively. It is very significant for all the energy users and especially most challenging to accomplish in the user group who reside in the social housing, because some or most of their household income come from the governmental subsidies or other financial support. Therefore, it is firstly supposed to clarify where could be more efficient in energy using, and secondly how can we make it accomplish throughout the daily life.

2. Trend of Energy Using in Social Housing

2.1. Overview of Household Energy Consumption

In the recent few decades, the energy consumption patterns in household has experienced obvious changes as a result of on the one hand demographic changes in family sizes, and on the other hand the changes of habitation and living styles, climate conditions as well household expenditures or other economic factors. However, the average energy consumption is still showing a tendency of rising. According to research by the International Energy Agency (IEA), China, South and West Asia, East Asia, Latin America, Africa will account for 68 per cent of the increase in world energy demand between 1997 and 2020 [1]. But there is an average rate of decrease of energy consumption per dwelling above 1%/year since 2008 in 20 Europe countries, with a very strong reduction (>−4%/year) in Portugal, UK, Ireland and Cyprus [2].

Energy consumed in homes is to meet the requirements of the householders for a proper heating and cooling, a comfortable living habitation. For households, the achievement of energy saving and the evaluation of energy efficiency consist in the following aspects:

- Heating and cooling
- Water heating
- Cooking
- Lighting
- Other electrical appliances.

For a normal German household the average power consumption distribution is illustrated depending on its application in **Figure 2**.

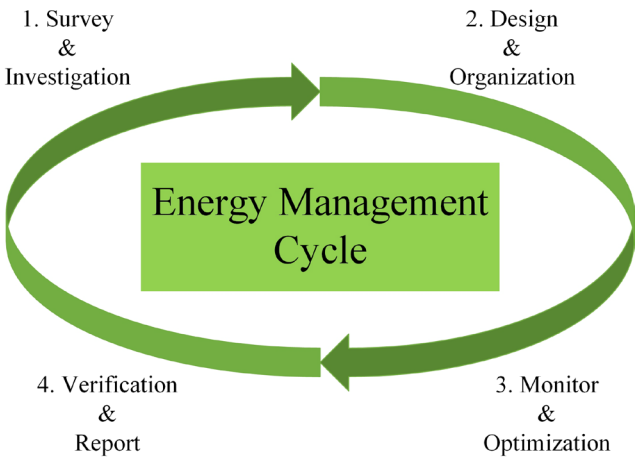

Figure 1. Energy management cycle.

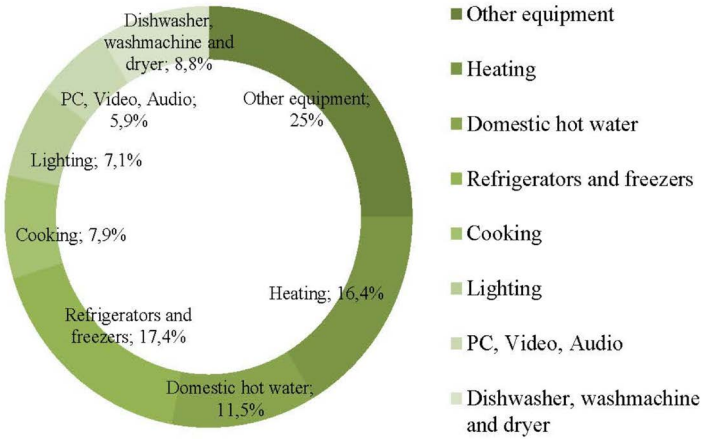

Figure 2. Average power consumption distribution in German household (Source: VDEW*).

2.2. Objective of Energy Efficiency

In European there are about 21 million dwellings representing the social housing. Because of the relevant complicated tenant structure and background it contains appreciable energy savings potential and also challenge in this household group, and it has been proved that there is much more energy consumption than actually needed. As another point of view, it make more sense than others to improve the energy efficiency in social housing on account of improving the quality of housing buildings and alleviating the financial burdens of dole by local governments to a certain extent, while helping the low-income families save energy costs in an efficient and effective way, reduce the greenhouse gas emission and fuel poverty, ultimately to achieve a green as well healthy habitation with high living quality for householders, which contributes to establishing a low carbon and sustainable economy.

3. Methodology

Meeting the energy efficiency requirements in affordable housing means that firstly tenants can live in warmer homes with the possibility and ability to manage their energy consumption more efficiently for a lower energy bills, besides, housing owners or landlords will have incentive to invest in energy efficiency which benefit their reputation in building markets by bringing equipment to its proper operational state, optimizing the relationship with tenants through increase of tenants' satisfaction, and improving facility and operation and maintenance [3]. In addition, a strong support from government respects of finance and technical as well educational development both local and global is indispensable for a successful implementation of energy conservation in affordable housing. Responsibilities for management and operation of housing have to be clear, and improvements have to be technically correct so they include a higher efficiency [4]. The aim is to make the energy efficiency approach acceptable by all the stakeholders and also replicable for the future projects and programs.

3.1. Energy Efficiency by Design

Starting from the design means that energy saving concept can be indoctrinated into building structure design taking the following views especially by means of passive components into consideration:

- New building materials with high levels of insulation properties to be used in wall, windows, roofs and basements, e.g. superinsulation and airtightness are focus of design for passive house like the first passive house residences (see **Figure 3**) were built in Darmstadt, Germany in 1990.
- Solar panels on rooftop to generate electricity.
- Energy efficiency in boiler for proper heating and domestic hot water supplying, also in air conditioner and lighting.
- Heat recovery from recycled air or other internal sources of heat like the existing household appliances.

*Verband der Elektrizitätswirtschaft e.V. (engl.: German Electricity Association), since 2007 VDEW has been included in Bundesverband der Energie- und Wasserwirtschaft (BDEW) [3].

Figure 3. The world's first passive house in Darmstadt Kranichstein, Germany, built in 1990.

- Effective rainwater collection and management for the purpose of conservation and recycle of resources.
- A building automation system aiding to avoid energy and resource waste.

3.2. Renovation and Retrofitting

For the existing social housing buildings the most economical and practical method is supposed to take measures with a set of high efficient standards for renovation and refurbishment.

- Firstly, it needs to collect information on energy consumption and the existing as well potential barriers to energy efficiency systematically.
- Energy efficiency indicators should be adjusted for higher energy saving standards.
- Typologies of technical optimization corresponding to the current building and occupation situation, such as energy system replacement for heating, DHW, ventilation and lighting, global retrofitting including windows, facades, external shell, gables, ceilings and roofs etc.

All the contributions by means of renovation and retrofitting aim to update the existing social housing buildings into low-energy affordable building construction.

3.3. Smart Metering and Other Services

Smart Metering Systems (or: Advanced Metering Infrastructure) are remotely readable measuring devices to record and communicate the supplied and used energy (electricity, gas), water and long-distance heating consumptions in one system (Multi-Utility-System) [5]. Smart meters enable the terminal devices with high electricity consumption such as wash machine or dryer to work in a more intelligent and targeted way. In addition, smart meters make it possible that some devices or equipment run at night or weekend consciously and profit from the special tariff for non-productive time or avoid the peak time of energy using, in order to spare energy costs and lead to more consistent energy consumption in social housing buildings.

About 500,000 smart meters have been installed in Germany, so far. In view of current situation it is suggested that smart metering system shall be installed just for particular customer groups based on a cost-benefit-analysis and also under the condition of technical requirement on the communication network [6].

For social housing the main task by housing providers is to improve the energy efficiency with a set of effective resource management services, which can monitor precisely the energy consumption and performances of the equipped flats and houses. These services include [7]:

- *Web Portal* to provide housing manager with timely information on energy consumption of tenants of social housing dwellings. The great strength of this function is that the heavy energy consumers can be identified easily, and corrective actions can be transmit to and put in place for those tenants.
- *Balance the energy needs* and supply, which means the supplied amount of energy can be adjusted according

to the needs of tenants.

- *Multi-energy sources* possibility, which integrates other energy like renewable energy in the energy mix of building, and adjust their performances separately according to the weather conditions.

3.4. Renewable Energy Initiative

Fuel switch from single fossil energy to multi sources of renewable energies contributes to not only reducing the energy crisis, but also enhancing the energy security and protecting the climate and environment.

Distinct from normal residential buildings even passive houses, a typical building model with renewable energy is Zero Carbon Building, which can get the necessary energy only from renewable energy sources including solar energy, wind energy, biomass energy and geothermal energy etc. As a new energy saving alternative Zero Carbon Building do not use any energy that entails CO_2 emissions and also have no requirement on the connection to the energy grid as well have the capacity to store energy for night-time or wintertime use [8], which is worth investigating by social housing providers in a wider extent.

3.5. Education and Training

The last not the least, lack of adequate information has become a general barrier to energy efficiency in social housing groups, which consist of energy customers with different educational levels and age structures. Without a proper understanding of the meaning and features of energy saving in the daily life, housing providers and local government may not achieve a significant and long-term saving plan for tenants, for themselves and the entire environment. The energy saving awareness of energy users is vital for the success of energy efficient use and management, so that it has to be motivated by all possible supervision.

In general the most efficient solution for this barrier is to make frequent communication with tenants in social housing, so that housing owners can provide an easy access to information on energy efficient tipps. This process of information transmission can be carried out in different ways, such as:

- *Online Service*: tenants have access to checking and keeping a record of their energy consumption regularly and comparing their consumptions (also bills) monthly or weekly, in order to assess the impact of their behavior on the energy costs;
- *Energy Coach*: housing companies provide their staff as energy coaches to teach tenants about how to reduce their consumption and indoctrinate the energy saving consciousness.

4. Conclusion

Energy efficiency and social housing are linked and synthetically considered owing to helping the low-income households reduce their energy costs and balance their expenditures between heating (and water) and others, which would multiply a series of positive chain effects on reducing the pressure of energy overexploitation and climate change, improving the habitation quality of residents. The further investigation and development of energy conservation and social housing are related to energy policy and economic situation as well current technical standards. The reproductive application should be based on the local social, financial and technical conditions. Energy efficiency in social housing ought to be taken in consideration of all the stakeholders which on the one hand take the responsibilities to drive the development of efficient technologies and affordable housing, and on the other hand benefit from the efficient energy use.

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