ENERGY EFFICIENT DESIGN IN SHOPPING CENTRES - ENERGY DEMAND SCENARIO MODELLING UNTIL 2030

Raphael Bointner and **Agnė Toleikytė**, Vienna University of Technology
Institute of Energy Systems and Electric Drives, Energy Economics Group – EEG
Gusshausstrasse 25-29/370-3, A-1040 Vienna, Austria
Phone +43(0)1-58801-370372, Fax +43(0)1-58801-370397, e-mail bointner@eeg.tuwien.ac.at
Phone +43(0)1-58801-370337, Fax +43(0)1-58801-370397, e-mail toleikyte@eeg.tuwien.ac.at

This work and the presented findings are based on the FP7-Project "Re-conceptualize shopping malls from consumerism to energy conservation", funded by the European Commission (Grant Agreement No. 608678). www.commonenergyproject.eu

Overview

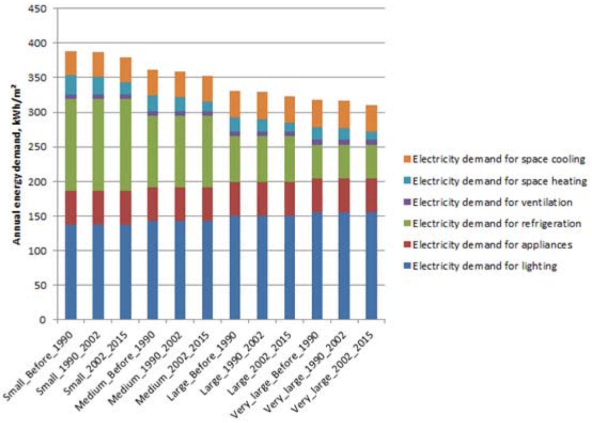
The non-residential building sector is more heterogeneous and complex compared to the residential sector due to variations in usage pattern, energy intensity and construction techniques. Shopping centre buildings equate this complexity. This paper aims to 1) analyse energy demand for energy services in different shop types and shopping centres built in different periods, 2) calculate the final energy demand of the shopping centre building stock in France and Poland and 3) model the final total energy demand from 2012 to 2030 taking into account new building construction and energy saving while retrofitting the existing building stock. The potential to reduce energy demand in the shopping centre building stock is strengthened compared with other buildings due to the following reasons, shopping centres offer plenty opportunities to implement cost effective energy saving measures [1], second, these kind of buildings are redesigned more often than other types of buildings [2] and third, the shopping centre market is immature in many European countries and many centres are expected to be built over the next years, which has an impact on the future energy demand. This paper builds on the current shopping centre stock in Europe [3], [4], [5]. Based on this data, i.e. the current energy consumption, the GLA, GDP and market growth, future scenarios on the energy saving potential are calculated and recommendations are given.

Methods

To calculate the total final energy demand in the shopping centre's building stock, a bottom-up approach is applied. The shopping centres are categorised based on the building period, building size and types of shops in the building. For each category, the specific energy demand for space heating and cooling, lighting, ventilation, refrigeration and appliances is calculated. The modelling of the future energy demand is based firstly on the development of the shopping centre building stock, taking into account the renovated floor area and new building construction and, secondly on the energy savings by using two different renovation options, namely thermal renovation of the building envelope and substitution of the lighting appliances with new LEDs. The specific power and daily usage duration for lighting, appliances, refrigeration and ventilation is calculated [6], [7], [8], [9], [10]. Invert/EE-Lab is a dynamic bottom-up techno-socio-economic simulation tool that evaluates the effects of different policies on the total energy demand, energy carrier mix and CO_2-emission reduction [11]. The two energy efficiency measures, lighting replacement and building envelope refurbishment are then implemented in Invert/EE-Lab in order to calculate the energy demand today and scenarios until 2030. The annual renovation of the shopping centre building stock for each building age band is being calculated following a Weibull-distribution. The calculation of the new built shopping centres is linked to the economic development of the respective country, in particular the gross domestic product (GDP) and the annual sales growth in the shopping centre branch as shown by Bointner and Toleikytė [2].

Results

Fig. 1 shows the electricity demand for different building types and services in France´s shopping centres, Fig 2. for Poland. In comparison to France building´s energy demand, the share of heating is higher due to the climate, while the cooling demand is lower. Larger shopping centres tend to have a lower specific energy demand per m². The type has a significant influence on the electricity demand for lighting and refrigeration and the building construction period, which also has an influence on the electricity demand for space heating and space cooling. Large shopping centres tend to have a higher share of retail stores with more lighting demand and a lower share of supermarkets, which mainly need refrigeration, compared with small centres. This is the major reason for the different composition of the total final electricity demand between small and large shopping centres. Figure 3 shows the scenario results of the final total energy demand for space heating, cooling, lighting, ventilation, refrigeration and appliances from 2012 to 2030 in the French shopping centre building stock. The total final energy demand is 4.5 TWh in 2012 and reduced by 13% by 2030 due to the renovated building stock. The new annual building construction varies from 1-3%. The share of the new buildings energy consumption is 14% of the total shopping centre building stock energy demand in 2030. Final total energy demand is 3.3 TWh in 2012 and 3.6 TWh in 2030 in the Polish shopping centre building stock as shown in Fig. 4. The modelled final energy demand is increasing due to the high number of new shopping centres in this emerging retail market. The new building annual construction rate varies from 3-7%. The energy demand reduction is achieved in the existing building stock due to the implementation of the abovementioned retrofit solutions. Thus, the total energy demand of the existing shopping centre building stock can be reduced by 27%.



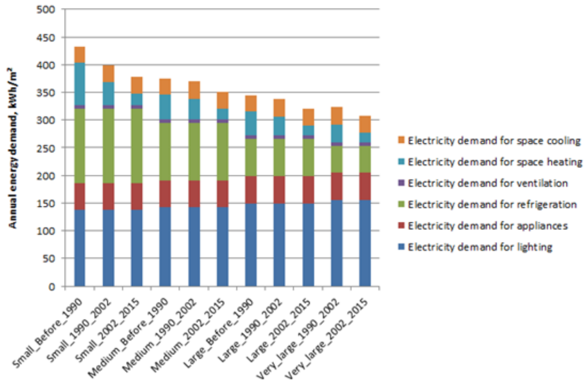
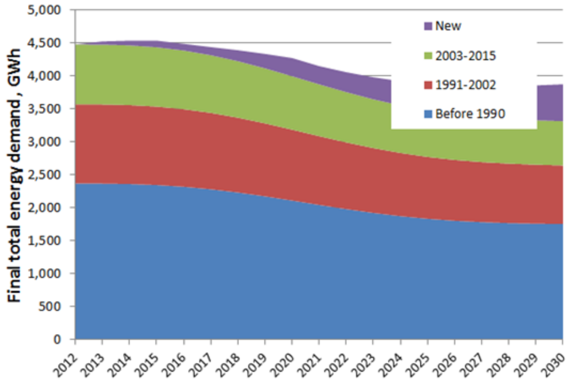


Fig. 1 & Fig. 2 Breakdown of electricity demand of different shoping centre types in France (Left) and in Poland (Right)



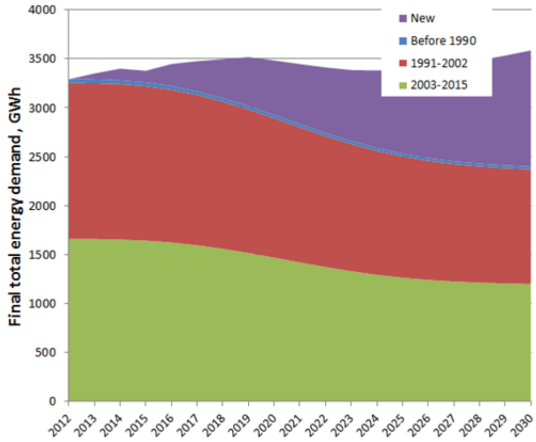


Fig. 3 & Fig. 4 Scenario results on the total final energy demand of shopping centres built in different periods and new buildings in France (Left) and in Poland (Right)

Conclusions

The breakdown of the energy demand has shown that the share of the electricity consumption for lighting and refrigeration is dominant in all shopping centres. The final energy demand scenarios show a high energy saving potential by implementing the two investigated retrofitting options, lighting retrofit with LEDs and thermal improvement of the building envelope. Due to the fact that shopping centres are refurbished and more often than other types of buildings [2] the achievement of this energy saving potential is realistic. The transition of lighting towards LEDs is already ongoing in shopping centres and better insulation results in a better thermal comfort for the customers, which is a vital aim of shopping centre managers. On the other hand, the future energy demand is depending on the market saturation, meaning that emerging markets will still have a growing energy demand, even if energy efficiency measures are being implemented.

References (selection)

[1] Haase M. et al (2015), "Drivers for deep retrofitting of shopping malls", Report 2.5 of CommONEnergy, Oslo, 2015
[2] Bointner, R.,Toleikyte, A., (2014) "Shopping malls features in EU-28 + Norway", Report 2.1 of CommONEnergy, Vienna, 2014
[3] BPIE 2011, Europe's buildings under the microscope, A country-by-country review of the energy performance of buildings
[4] ICSC (2014), ICSC's Database "QuickStats", http://edata.icsc.org, last accessed 11 December 2015
[5] ICSC 2008, The Importance of Shopping Centres to the European Economy, 2008.
[6] ASHRE Standard 90.1-2013 -- Energy Standard for Buildings Except Low-Rise Residential Buildings
[7] [Online] http://www.integral-led.com/education/what-are-lumens, last accessed 11 December 2015
[8] Schönberger H., Galvez Martos J. L.., Styles D. (2013), Best Environmental Management Practice in the Retail Trade Sector, European Commission, Joint Research Centre – ISSN 1831-9424, Luxembourg 2013, http://susproc.jrc.ec.europa.eu/activities/emas/documents/RetailTradeSector.pdf
[9] Westphalen D., Koszalinski S.: Thermal Distribution, Auxiliary Equipment, and Ventilation, U.S. DoE, Cambridge, MA, Oct. 1999: Fan Power Data"
[10] Goetzler et al, 2009, Energy Savings Potential and R&D Opportunities for Commercial Refrigeration, Navigant Consulting, Inc. for the U.S. DoE
[11] L. Kranzl, et. al., „Renewable heating: Perspectives and the impact of policy instruments", Energy Policy, Bd. 59, S. 44–58, Aug. 2013