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ENERGY CONSUMPTION AND EFFICIENCY IN THE EU STOCK OF SHOPPING MALLS

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(1) Overview

Today's shopping mall gross leasable area (GLA) is 112.1 mil. m^2, which makes up approx. 6.7% of the total wholesale and retail building floor area in the EU-28 plus Norway in 2013 (BPIE, 2013 & ICSC, 2014). The largest shopping malls gross leasable area is located in UK (26.2 mil. m^2) followed by France (14.4 mil. m^2) and Italy (12.7 mil. m^2). These countries account for approximately 46% of the total shopping mall GLA. This paper comprises comprehensive information on the current shopping mall stock in Europe. Based on this data, the current energy consumption and energy savings potential is calculated and recommendations are given.

(2) Methods

Based on the measured energy consumption per square meter of 132 shopping malls throughout seven European countries (Steen & Strøm (2012), Unibail-Rodamco (2013), Intu Group (2013), Britishland (2014) and IGD (2014)) and their GLA, a linear regression of the specific energy consumption per m² of shopping malls is conducted to calculate the total energy use in a next step. Before, five significant outliers have been removed by using a Grubbs test with a significance level of 5% (two-sided) and a p-value <5%. The *GLA* of shopping malls *j* in these countries *i* (ICSC, 2014) multiplied by the abovementioned specific energy consumption per m² *ec* equals the total energy consumption *EC* [TWh] of shopping malls over time *t*.

$$EC_{(t)} = \sum_{i=1}^{n} ec_{i(t)} * GLA_{i,j(t)} \quad (1)$$

Further, data on the time span between the opening of 3400 shopping malls and their renovation year (ICSC, 2014) lead to a robust estimate of the renovation rate *(rr)* of 4.4% p.a. This is the basis for calculating the cumulative energy savings potential *ES* [GWh] of all shopping malls over time, where $es_{i(t)}$ denotes the specific energy saving potential of shopping malls [%] in country *i*.

$$ES_{(t)} = ES_{(t-1)} + \sum_{i=1}^{n}(rr_{(t)} * EC_{(t)} * es_{i(t)}) \quad (2)$$

(3) Results

Table 1 shows descriptive statistics of shopping malls in the investigated countries and the energy consumption calculated with formula (1). Compared to the literature, the energy intensity of the sample is quite low. Stensson et al. (2009) report a total energy consumption in Norwegian and Swedish shopping malls of 291 and 279 kWh/m^2a respectively. According to Schönberger et al. (2013) the total energy consumption of food stores ranges between 500 and 1000 kWh/m^2a. Further, they report for non-food stores smaller than 300 m² an energy consumption of 270 kWh/m²a and for stores larger than 300 m² 200 kWh/m²a. These numbers are also supported by Tassou et al. (2011) in a UK-case study and the database of the EU-project Entranze (2013). Therefore, it can be assumed that the energy consumption in Table 1 do not include tenants data and the results on the given energy intensity can be seen as bottom line of the energy consumption in European shopping malls. There real energy consumption and therefore the energy savings potential are likely to be somewhat higher, which will be subject to further investigation.

Given this restriction, low and high energy savings potentials, corresponding to different renovation measures, cf. Berkeley (2012), BPIE (2013), Schönberger et al. (2013), are calculated according to formula (2). By 2020, the cumulated energy savings potential of these shopping malls can be estimated to 169 GWh in the lower case, a 2.6% reduction compared to the total energy consumption in 2014. The high case lead to cumulated energy savings of 557 GWh by 2020, which means a 8.7% reduction according to 2014 levels. The full results are available in an online data mapper (www.commonenergyproject.eu/data_mapper.html) as well as in Bointner and Toleikyte (2014); final version in August 2014.

Table 1: *Descriptive statistics of shopping malls in 7 European Countries [Own calculation, based on Steen & Strøm (2012), Unibail-Rodamco (2013), Intu Group (2013), Britishland (2014), IGD (2014), ICSC (2014)]*

	DK	ES	FR	IT	NO	SE	UK	Total
No. of shopping malls with energy data	19	15	25	20	17	16	19	**131**
No. of shopping malls with GLA data	91	485	478	359	151	498	500	**2562**
GLA [mio m²]	1,45	12,89	10,45	8,73	2,63	7,25	17,65	**61,06**
Energy Consumption [TWh]	0,21	0,74	0,74	1,11	0,50	1,57	1,52	**6,38**
Energy Intensity [MWh/m² a]	0,14	0,06	0,07	0,13	0,19	0,22	0,09	**0,10**

Table 2: *Cumulated Energy Savings potential of the shopping mall stock of the 7 countries [Own calculation]*

	2015	2016	2017	2018	2019	2020	[%]
Renovated GLA [mil. m²]	2,69	5,38	5,38	5,38	5,38	**5,38**	8,8% of total GLA_{2014}
High energy savings [GWh]	92,77	185,53	278,30	371,07	463,83	**556,60**	8,7% of total EC_{2014}
Low energy savings [GWh]	28,11	56,22	84,33	112,44	140,56	**168,67**	2,6% of total EC_{2014}
Energy consumption with high energy savings [TWh]	6,29	6,20	6,10	6,01	5,92	**5,82**	
Energy consumption with low energy savings [TWh]	6,35	6,32	6,30	6,27	6,24	**6,21**	

(4) Conclusions

Although the abovementioned results present a bottom line of the energy consumption of European shopping malls, there is a high potential for energy savings. Compared to Tassou et al. (2011) the real energy saving potential is likely to be much higher. This high potential derives inter alia from high renovation rates and current inefficiencies as reported by Woods et al. (2014). In mature European shopping centre markets this potential can be exploited by a systemic retrofitting approach, comprising an efficient building envelope, integration of renewable energy sources, waste heat recovery, energy management concepts, efficient (natural) lighting, and energy efficient appliances; cf. Schönberger et al. (2013). In emerging shopping centre markets in Eastern Europe, where the number of new buildings is estimated to be high, energy efficiency measures have to be taken already beforehand in the construction phase. Thus, we recommend introducing energy efficiency standards for new construction, retrofit and operation of shopping malls to reduce both, the energy demand and the greenhouse gas emissions. In the eye of the EU targets for 2020, our results may serve as a comprehensive basis for decision making among European shopping mall stakeholders.

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