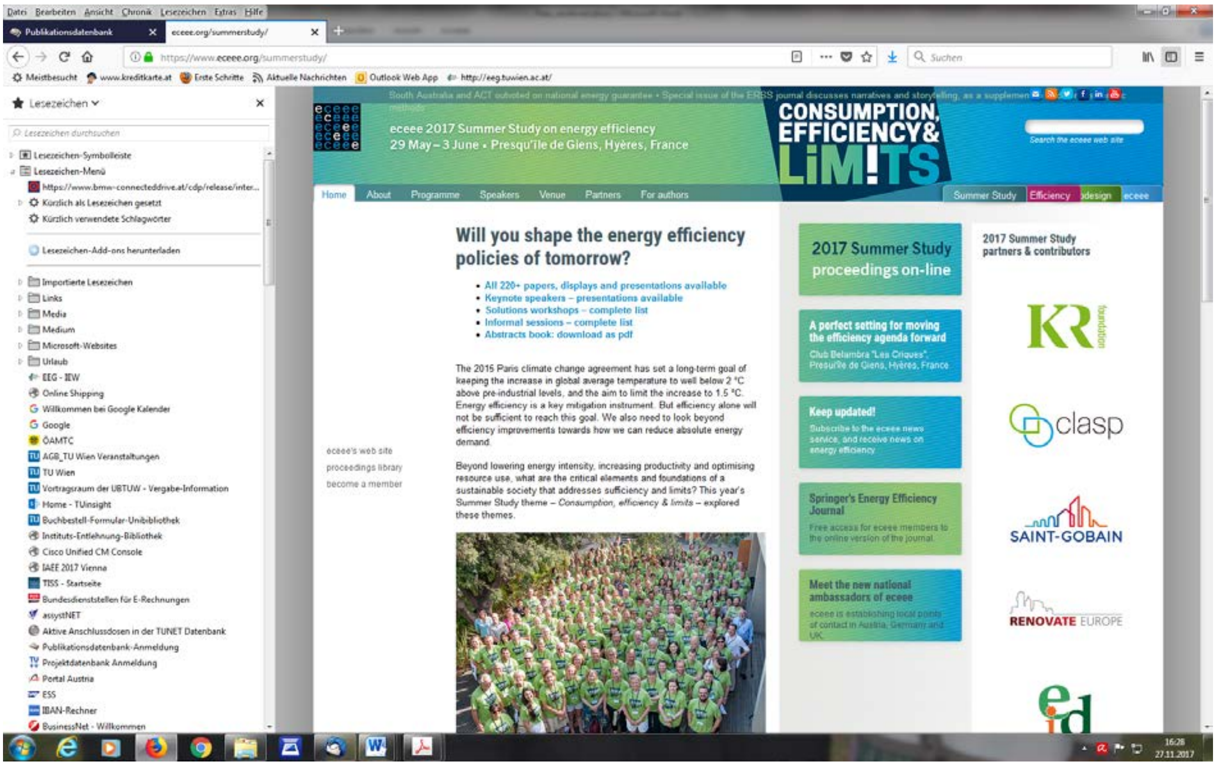

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No. 6-229-17 # Agnė Toleikytė

European shopping centre building stock – a pathway towards lower energy consumption via innovative energy policy

Agnė Toleikytė
Energy Economics Group, Technische Universität Wien
Gusshausstrasse 25-29/370-3
1040 WIEN
Email: toleikyte@eeg.tuwien.ac.at

Raphael Bointner
e-think energy research (Affiliation 1)
Argentinierstrasse 18/10
1040 WIEN
Energy Economics Group, Technische Universität Wien (Affiliation 2)
Gusshausstrasse 25-29/370-3
1040 WIEN
Email: bointner@e-think.ac.at

Maarten De Groote
Email: maarten.degroote@bpie.eu
Filippos Anagnostopoulos
Email: filippos.anagnostopoulos@bpie.eu
Buildings Performance Institute Europe (BPIE)

Abstract

The European shopping centre building stock offers a high energy saving potential and good ground to implement energy efficiency measures. Looking at macro-economic parameters such as sales growth and shopping centre floor area per capita, the stock of shopping centres is expected to growth especially in the European transition economies while remaining stagnant in the saturated markets of western and northern Europe. The energy demand for lighting, refrigeration, ventilation, space cooling and heating, is correspondingly growing in these transition markets. On the other hand, in the saturated markets, the major challenge is to renovate the existing building stock of shopping centers. Both, new and retrofitted buildings require technology solutions and a corresponding policy framework to enhance energy efficiency and the use of renewable energy sources, while improving indoor environmental quality that is of primary importance for the attractiveness of the sales place. In this paper, the current and future energy demand in the European shopping centre building stock is assessed to 2030 using (i) specific power consumption and operating duration for lighting, appliances, refrigeration and ventilation, (ii) shopping centre categories' gross leasable area, (iii) developments in building renovation and new construction and (iv) standard and advanced energy efficiency technologies. A number of policy scenarios on the future total energy demand are derived showing the impact of the most important drivers such as renovation rates and implemented energy efficiency solutions. The paper provides recommendations on how to increase the use of energy efficiency measures in European shopping centres, thus assisting the sector to contribute to the European 2030 climate and energy targets addressing the following stakeholders, owner/tenants, real estate investors and policy makers.

Introduction

European shopping centre provides a huge potential to reduce total energy demand and contribute to the European low carbon economy. However, the European shopping centre building sector is a complex sector compared to the residential sector due to their complexity as physical structures and the social multi-stakeholders decisional processes. Investments in energy efficiency solutions leading to long-term energy savings are often hampered by several barriers. First of all, the thermal renovation is not always cost-effective in the shopping centres (Haase et al 2015, Bointner et al, 2014). That is why the shopping centres are not willing to invest. These retrofitting solutions, however, provide a huge potential to reduce energy demand and greenhouse gas emissions. Secondly, decision making process when implementing energy renovation measures is a complex process involving two main stakeholders, tenants and owners/managers. While the energy efficiency of shopping centers is not of primary importance for tenants, the owners and managers are interested in energy efficiency (Woods et al, 2015). And last but not least the future retail market development and the growth of internet sales in web shops are essential, potentially leading to lower footfall, reduced shopping centres sales and in turn to lower renovation and construction rates or a change of use.

The main aim of this paper is to calculate final energy demand in the European shopping centre stock until 2030 by defining four different scenarios which address some of the abovementioned barriers. Moreover, the recommendations on how to increase the use of energy efficiency measures and overcome the barriers are derived.

This paper contains the following steps: (I) describing the methodology and the main input data of the shopping centre building stock (II) defining the scenario framework (III) showing the results on the development of the gross leasable area of the shopping centres and their energy demand (IV) providing recommendations on how to overcome barriers which hamper to invest in energy efficiency solutions and finally (V) deriving conclusions.

Methodology and input data

Total final current and future energy demand in the shopping centre's building stock is calculated using a bottom-up approach. 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.

Modelling of the future energy demand is based (I) on the development of the shopping centre building stock, taking into account the renovated floor area and new building construction and (II) on the specific energy demand of the installed new technologies for appliances, lighting and refrigeration as well as insulation of the building envelope influencing energy demand for space heating and cooling. Four different scenarios are calculated shoving the influence of abovementioned parameters.

Breaking down the shopping centre building stock

The shopping centre building stock in Europe is classified by small, medium, large and very large buildings. This classification is based on statistics of the International Council of Shopping Centers (ICSC), dividing European traditional shopping centres into four sizes: very large (80,000 m² and above), large (40,000–79,999 m²), medium (20,000–39,999 m²) and small (5,000–19,999 m²) shopping centres (ICSC, 2008). This disaggregation enables to define the composition of the shop types such as common areas, retail stores, restaurants and others, which are typical for different size of the shopping centres investigated in the FP7-project CommONEnergy (see Table 1). Table 1 shows that in small shopping centres, the share of the supermarkets is higher compared to large and very large shopping centres while in large and very large shopping centres, the share of restaurants, cafes and food courts is higher compared to small and medium shopping centres. Thus the large and very large shopping centres typically offer more entertainment, for example restaurants and cafes. All this information let us to define the typical specific energy demand for lighting, refrigeration and appliances typically used in different shop categories.

Table 1 Shopping center store composition, share of shops on the total shopping centre floor area (calculation based on raw data from Steen & Strøm (2012), Unibail-Rodamco (2013), ECE 2013, Intu Gr. (2013), Britishland (2014), IGD (2014))

Building categories	**Shop types**				
	SHP (Retail stores: clothing, hobby, home)	***CMA (Common area)***	***MDS (Medium stores, big size stores, super-markets)***	***RST (Restaurant, cafes, food courts)***	***WRH (Other services: ware-house, service rooms etc.)***
Small	36%	25%	20%	8%	11%
Medium	42%	25%	15%	9%	9%
Large	50%	25%	9%	10%	6%
Very large	54%	25%	6%	12%	3%

In the next step, the buildings are disaggregated into four building age periods: shopping centres built before 1990, built between 1991 and 2002, built between 2003 and 2015 and new shopping centres built between 2016 and 2030. This categorization let us to identify the U-values (thermal transmittance values of the building elements) of the buildings built in different time periods. Moreover, based on the number of buildings built in different time periods we calculate the renovation rate and new construction rate until 2030 in all European countries. Figure 1 shows the share of the shopping centre gross leasable area by opening year on the total gross leasable area in 2012 in EU-28 and Norway. The oldest shopping centre building stock is in Sweden followed by Denmark and Finland. Almost 50% of the shopping centres were built before 1990 in Sweden, Denmark, Finland, France, United Kingdom, the Netherlands and Norway. There are many shopping centre buildings in the EU-15 which have to be refurbished and reconstructed in order to have a modern design. The shopping centre building stock is young in the following countries: Slovenia, Estonia, Hungarian, Greece, Latvia, Poland, Czech Republic, Lithuania, Slovakia, Romania and Croatia. The shopping centre era began after the economic transition in the formerly socialist CEE countries.

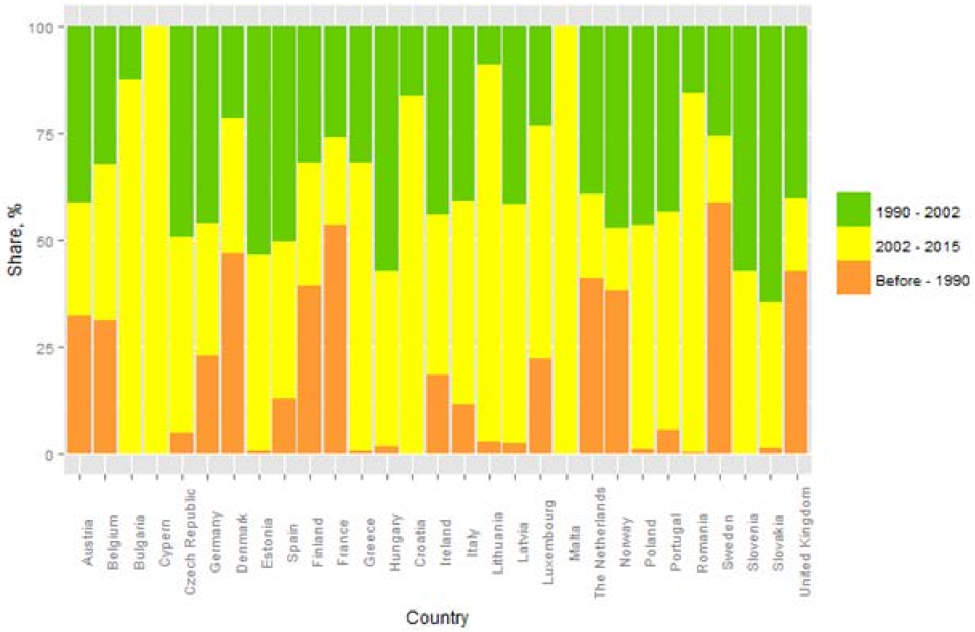

Figure 1 Share of the total gross leasable area by opening year in EU-28 and Norway in 2012(ICSC, 2014)

Future new building construction and renovation rates

To assess the future construction rate and renovation rate in the buildings in each European country, the country's GDP (Gross Domestic Product) and sales growth data are analysed. The GDP for each country, between 2000 and 2030, was derived from the OECD (2016). Historical sales growth data of shopping centres per country from 2000 to 2012 comes from the ICSC (2014) statistics. The historical sales growth data of shopping centre are then correlated with the GDP by 2030. In this analysis, we identified that the development of new shopping centres is limited in most European countries. However, there is still an under-supply in the so called non-mature markets in Central and Eastern Europe (CEE).

The renovation rate $\lambda(t)$ in year t for each building age class is calculated with a Weibull-distribution.

$$\lambda(t) = \frac{\beta}{T} * \left(\frac{t}{T}\right)^{\beta-1}$$

in which β denotes the shape factor and T the characteristic life time.

Different shape factors and characteristic life times assessed in CommONEnergy are being used for the replacement of lighting, appliances, refrigeration, ventilation, heating and cooling systems and thermal renovation of the building envelope. The characteristic life time has been calculated with data on opening and renovation years of shopping centres listed in the Global Shopping Center Directory (ICSC, 2016).

Energy demand calculation

Energy demand for space heating, space cooling, appliances, ventilation, refrigeration and lighting was calculated for each shopping centre category (see section “Breaking down the shopping centre building stock”) for each country. Specific energy demand calculation for space heating and cooling was carried out using the monthly energy balance approach based on EN13790 methodology (ISO 13790:2008). The calculation was made with the building simulation tool Invert-EE/Lab (Müller, 2015).

Energy demand for lighting, appliances, refrigeration and ventilation is calculated using specific power (see Table 2). For each shop type, the specific power and daily usage duration for lighting, appliances, refrigeration and ventilation is set. Data on specific power and usage duration are based on the ASHRAE Energy standards 90.1-2013 for buildings and shopping centre case studies as analysed in the project Commonenergy (Schönberger 2013, Westphalen and Koszalinski 1999, Goetzler et al, 2009). By multiplying the power of services in a particular shop with duration (hours per year) we calculate the specific energy demand for lighting, appliances, refrigeration and ventilation. Duration of use of lighting, appliances and refrigeration was specified taking into account the typical opening hours of the shops and vacations in a particular country.

Table 2 Specific power for different shop types and services (ASHRE Standard 90.1-2013, Schönberger 2013, Westphalen and Koszalinski 1999, Goetzler et al, 2009)

Specific power, W/m²	**Shop types**				
	SHP (Retail stores: clothing, hobby, home)	***CMA (Common area)***	***MDS (Medium stores, big size stores, super-markets)***	***RST (Restaurant, cafes, food courts)***	***WRH (Other services: ware-house, service rooms etc.)***
Lighting	36.2	23.7	27	28.2	15
Appliances	10	5	10	10	5
Refrigeration	0	0	25.9	16.4	0
Ventilation	6.8	8.3	3.7	20.8	10.6

Figure ***2*** shows calculated specific annual demand for appliances, lighting, refrigeration, space heating, space cooling and ventilation used in different shop types in four countries representing four different climate zones, Germany, Italy, Lithuania and Norway. Energy demand for lighting makes up the highest share on the total annual energy demand followed by space cooling. Small shopping centres have the highest energy demand due to the high share of the supermarket floor area on the total shopping centre floor area which leads to higher energy demand for refrigeration and appliances compared to other shop types.

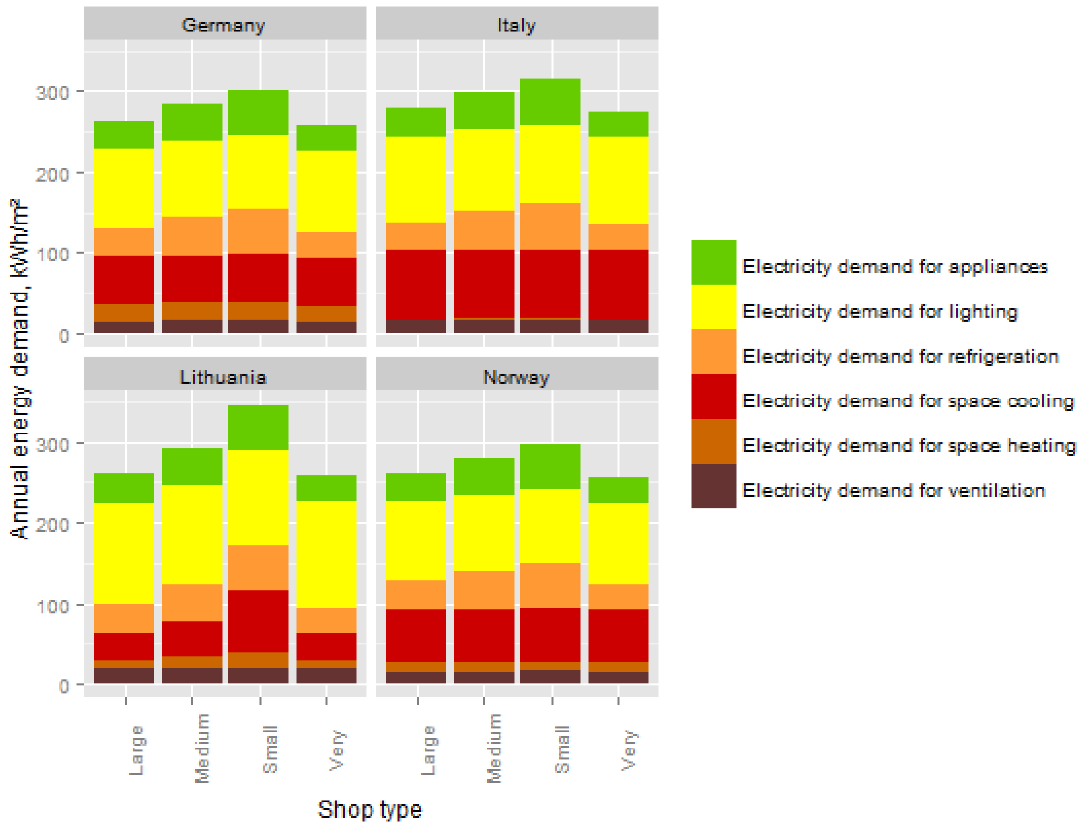

*Figure 2 Calculated specific annual electricity demand for appliances, lighting, refrigeration, space heating, space cooling and ventilation used in small, medium, large and very large shop types in Germany, Italy, Lithuania and Norway (*Very – very large buildings)*

Scenario framework

Shopping centre sector is a very dynamic sector. The growth and market saturation is influenced by different parameters such as demographic development and consumer incomes, cultural preferences, difficulties in obtaining government permits, planning policies and dominant presence of other retail formats (DTZ 2012), (EMEA 2013). We built four different scenarios which reflect these abovementioned parameters and try to identify their impact on the final energy demand development: (1) status quo scenario, (2) energy efficiency scenario, (3) internet sales scenario and, (4) energy efficiency obligations scenario. Each subsequent scenario builds upon the previous ones and leads to energy demand reductions compared with its antecessor (see Figure 3). These scenarios consider technologic, economic and legal changes between 2015 and 2030.

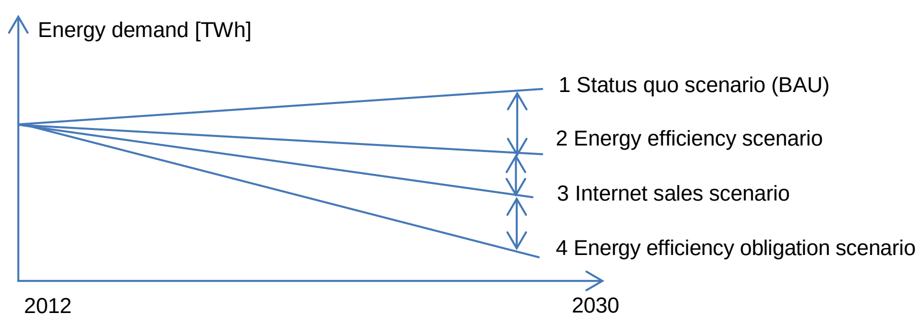

Figure 3: Indicative illustration of the scenarios

(I) *Status quo scenario*. New construction is based on shopping centre market sales in the respective country. In general, the lower the market saturation, the more shopping centres will be built and extended.

(II) *Energy efficiency scenario*. The market uptake and diffusion of energy efficient technologies plays a central role in this scenario. These technologies become cheaper and cheaper and it is economic reasonable for shopping centres to invest in energy efficient lighting, appliances, refrigeration, ventilation, heating and cooling systems. The same replacement rates as in status quo scenario are applied but lower power.

(III) *Internet sales scenario*. More and more people search and buy goods and services in web shops. This is comfortable, independent from opening hours and location. The online market is growth by 1.5% every year. As a consequence conventional shopping centres have to re-think their sales strategies. On the other hand internet sales are not a full substitute to traditional markets but partial complimentary. For instance, customers order/reserve a good in the internet and check the quality, fit, etc. in the shop before making their purchase decision. It can be assumed that not saturated shopping centre markets are less affected by internet sales than saturated markets, in which shopping centres lose their attractiveness due to the online shopping. This leads to lower footfall, reduced shopping centres sales and in turn to lower construction rates and/or an increased change of use, e.g. a shopping centre is rededicated to an office building. This assumption is modelled with an annual reduction of the initial sales growth by 1.5%.

(IV) *Energy efficiency obligation scenario*. In general, system component replacement and renovations are more frequent in the wholesale and retail sector than any other sector (Bointner et al, 2014) because a modern design is essential for the excitement of shopping. Nevertheless, on top of technologic and economic solutions as introduced in the previous scenarios, legal obligations to foster energy efficiency could lead to further energy demand reductions. For instance, literature showed that thermal renovation is not always cost-effective in the shopping centres (Haase et al 2015, Bointner et al, 2014). That is why the shopping centres are not willing to invest. These retrofitting solutions, however, provide a huge potential to reduce energy demand and greenhouse gas emissions. In this scenario, the energy efficiency obligations are implemented with (1) a renovation rate obligation (total floor area) according to the Energy Performance of Buildings Directive (EPBD, Art 5) and (2) the mandatory use of active control systems for lighting, appliances, refrigeration, ventilation, heating and cooling systems. These obligations are implemented by a an increased renovation rate (T=18 yrs) with an annual average of 3.5% and reduced power for lighting, appliances, refrigeration, ventilation, heating and cooling systems due to active control. Building automation according to EN 15232 offer large energy saving potential in wholesale and retail (Siemens, 2016). According to Siemens (2016) 5% additional savings are assumed for lighting, appliances and refrigeration, 13.5% for heating and 27% for ventilation and cooling. These savings are equal to a shift from C (standard case) to B (advanced energy efficiency) class building automation control systems in the wholesale and retail sector. Further possible obligations, which are not included in this scenario, are listed in the recommendations section.

Table 3 Parameters used in four different scenarios

	New building development	**Renovation rate**	**Market uptake of innovative technologies**	**Policy instruments: energy efficiency obligation**
Status quo scenario	Linked to GDP scenario from 2012-2030 (OECD (2016)) and historical sales growth resulting in high growth in the mature markets and limited growth in saturated markets	Moderate renovation rate (thermal renovation reducing space heating – app. 1.8% yearly and for other energy services: such as lighting app. 5.5 % yearly rate)	Standard technologies are implemented (see Table 2)	None
Market uptake scenario	As in status quo scenario	As in status quo scenario	There are more innovative technologies on the market	None
Internet sale scenario	Modelled with an annual reduction of the initial sales growth by 1.5% which reduce new building construction rate	As in status quo scenario	As in market uptake scenario	None
Energy efficiency obligation scenario	As in internet sale scenario	Increased yearly renovation rate of thermal renovation reducing space heating – 3.5 % yearly	As in market uptake scenario	Increased yearly renovation rate of thermal renovation reducing space heating – 3.5 % yearly

Results

Figure 4 shows the change in the final energy demand in the existing shopping centre building stock from 2012 to 2030 in all four scenarios. There is an obvious trend in the results showing an energy demand reduction in all scenarios in the saturated markets and energy demand increase in non-mature markets from 2012 to 2030. One of the reasons is the development of the shopping centre building stock. Figure 5 shows the share of the total final energy demand by buildings built in different periods on the total energy demand in 2012 and 2030 in status quo scenario. In saturated markets such as Austria, Norway, Sweden, France, the share of the new building gross leasable area built between 2012 and 2030 is 24%, 8%, 25% and 30% respectively. In non-mature markets such as Bulgaria, Lithuania, Poland and Romania, the share of new buildings built between 2012 and 2030 gross floor area is 60%, 70%, 50% and 63% respectively. This has an influence on the total energy demand in 2030. The share of the final total energy demand of these new buildings is 26%, 7%, 20%, 50% in Austria, Norway, Sweden, France and 73%, 75%, 60%, 75% in Bulgaria, Lithuania, Poland and Romania in status quo scenario. Due to the strong increase of new buildings in the non-mature markets until 2030, the total energy demand will increase, too. In the status quo scenario, the final energy demand from 2012 to 2030 will increase by 114%, 125%, 67% and 120% in Bulgaria, Lithuania, Poland and Romania respectively. The Internet sale scenario shows a significant difference of the change in energy demand compared to the status quo scenario in abovementioned markets. In the internet sale scenario, the final energy demand from 2012 to 2030 will increase by 58%, 24%, 23% and 56% in Bulgaria, Lithuania, Poland and Romania respectively. Energy efficiency obligation scenario which includes additional measures to the internet sales scenario leads to the additional reduction of the final energy demand in all countries. Final energy demand will increase by 33% in Bulgaria in energy efficiency obligation scenario and will decrease by 2%, 45% and 19% in Lithuania, Poland and Romania respectively.

Figure 4 Change in total energy demand for space heating, cooling, appliances, ventilation, refrigeration and lighting from 2012 to 2030 in the European countries in different scenarios

Figure 5 Share of building age periods on the total final energy demand in 2012 and 2030. In 2030, new buildings are these built between 2012 and 2030; status quo scenario.

Recommendations

We develop recommendations which are based on the scenario results, literature and Commonenergy project findings. Recommendations address the following stakeholders, owner/tenants, real estate investors and policy makers.

In the European policy on the energy efficiency (EPBD, Energy Performance building directive), the sector of shopping centers is considered within the wide group of non-residential or commercial buildings, without further specifications. The sector is a complex sector compared to the residential sector due to their complexity as physical structures and the social multi-stakeholders decisional processes.

Based on our analysis we suggest to following recommendations to achieve a long-term strategy for energy savings in the European shopping centre building stock:

(I) Addressing physical structure of the shopping centre. Implementation of the suggestions might be supported by the following policy measures, such as obligation to improve quality and compliances, to implement the nZEB definition addressing the retail sector as well as information and training:

a. Create key performance indicators for the evaluation of shopping malls energy needs;

b. Introduce minimum performance requirements for individual technical systems e.g. refrigeration cabinets, active control systems…

c. Mandatory energy manager or external reviewer, when the shopping center’s floor area is above a certain threshold;

d. Define max. illumination rates for a) shops and/or b) opening hours and night-time to reduce the energy consumption of tenants

e. Increase knowledge and awareness of tenants that they understand their role in energy consumption

f. Increase knowledge and awareness of facility managers

g. Design teams should guide shopping centres in their first year after construction or refurbishment, monitor energy consumption and help the centre to adjust their systems

(HVAC, control, lighting, …)

(II) Social multi-stakeholders decisional processes (Communication and voluntary measures)

a. design budget processes to overcome split incentives between tenants and landlords

b. Promote green leases in order to address the issue of unfair distribution of cost/benefits between owners and tenants, thus aligning the financial and energy incentives of building owners and tenants and enabling them to work together for the efficient operation of buildings

c. Use areas of high footfall to raise the customers' awareness for energy efficiency, e.g. display energy consumption, and highlight applied measures energy to reduce energy consumption.

(III) Implement a long-term vision for the building stock

a. Renovation roadmap obligations for shopping centers followed by guidelines

Conclusions

The total final energy demand is expected to decrease in the saturated markets and increase in non-mature markets from 2012 to 2030 in the status quo scenario. The final energy demand will increase by 114%, 125%, 67% and 120% in Bulgaria, Lithuania, Poland and Romania respectively from 2012 to 2030. However, in the internet sales scenario together with energy efficiency obligations, final energy demand will increase by 33% in Bulgaria and will decrease by 2%, 45% and 19% in Lithuania, Poland and Romania respectively.

The future energy demand is depending on the quality of renovation and the replacement rate of building technologies, the new shopping centre construction and the market saturation in the respective country. Literally this means all emerging markets have a growing energy demand in the status quo scenario. For instance, in the formerly socialist CEE countries the shopping centre era began after 1990 and the shopping centre stock is young compared to many western European countries. However, if energy efficiency measures are being implemented and the retail market will change by expanding web shops, the energy demand in these markets will go down.

The electricity consumption for lighting and refrigeration is dominant in all shopping centres, but there is a huge energy saving potential by replacing lighting technologies with LEDs and the installation of more efficient refrigerators with better energy efficiency classes and closed doors. Both replacements are cost effective and already ongoing in shopping centres.

The scenarios show high improvement potential for thermal renovation of the building envelope. Shopping centres are refurbished more often than any other type of building as shown by Bointner et al (2014), which makes an achievement of high renovation rates very likely. Beside design issues, a refurbished shopping centre has a higher thermal comfort and in turn the customers' comfort and well-being is the supreme maxim of every shopping centre.

The shopping centre is a complex and inhomogeneous building sector and the long-term energy savings potential can be achieved by addressing the specifications of the shopping centres. That is why, the recommendations were derived.

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Acknowledgment

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