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European shopping center building stock – a pathway towards lower energy consumption

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Motivation

- European shopping center building sector makes up almost 30% of the total non-residential building stock
- Shopping center is a complex building due to its complexity as physical structures and multi-stakeholders decisional processes
- There are already many studies assessing buildings' energy efficiency, however, only few looking at the non-residential buildings and even less for commercial centers

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Main aim and objectives

- Modell current and future energy demand for lighting, refrigeration, ventilation, space cooling and heating in the European shopping centers in EU28 and Norway
- Provide different policy scenarios
- Derive policy recommendations on how to increase the use of energy efficiency measures in the European shopping centres

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Methodology

- Data collection
- Definition of the shopping centre types
- Calculation of the energy demand for space heating and cooling
  - Monthly energy balance approach (Invert-EE/Lab)
- Calculation of the energy demand for lighting, refrigeration, ventilation
  - Defining the specific power and specific duration taking into account the opening hours of the shopping centres and national holidays
- Assessing the renovation rate
  - Weibull-distribution (for all energy services and building constructed in different building periods)
- Assessing the new building construction
  - Trend function based on the GDP (period) and sales growth
- Defining energy efficiency solutions
- Modeling policy instruments: renovation rate and depth obligation

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What is a shopping center?

"a large retail complex containing several stores with a minimum gross leasable area (GLA) of 5,000 square meters"

Trondheim, Norway


Valladolid, Spain

Genova, Italy

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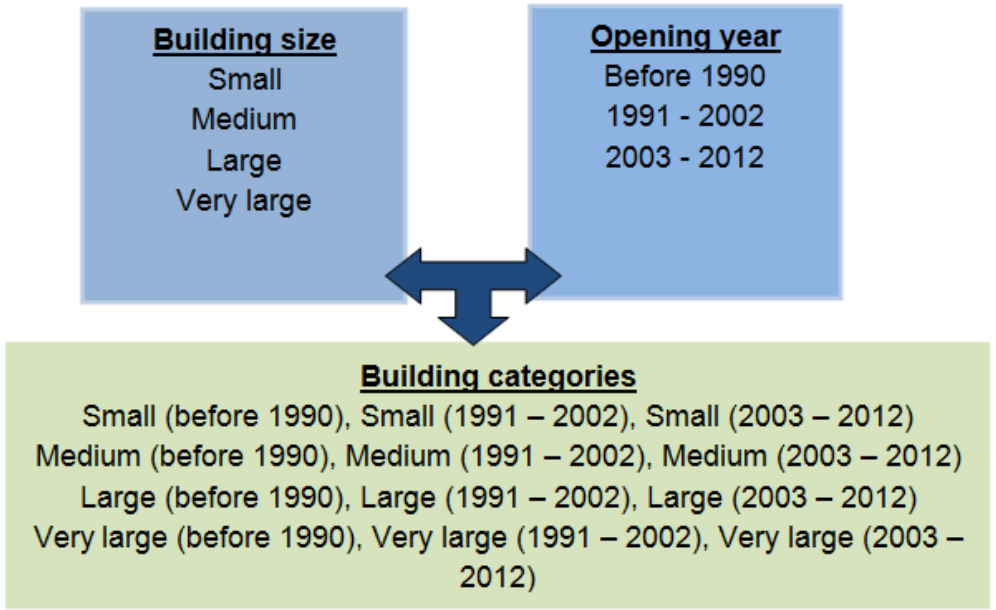
Shopping centre categorisation

- Statistics provided by the International Council of Shopping Centers (ICSC)
- Gross leasible area in EU-28 + Norway by building size and opening year



Building categories as combination of the building size and opening year used for each European country

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Energy demand calculation

- Energy demand for space heating and cooling is calculated using monthly energy balance approach defining the geometry, U-values, climate in each country
- Energy demand for lighting, ventilation, appliances and refrigeration is calculated

Specific power, W/m²	Shop types				
	Retail stores: clothing, hobby, home	Common area	Medium stores, big size stores, super-markets	Restau-rant, cafes, food courts	Other services: ware-house, service rooms etc.
Lighting	36.2	23.7	27	28	15
Appliances	10	10	10	10	10
Refrigeration	0	0	67	1.3	9.6
Ventilation	6.8	6.8	5.7	9.3	5.1

Source: ASHRE 2013, Schönberger et al 2013, Steen&Strom 2012 etc.

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Outcomes (I)

- Total final energy demand was 43 TWh in 2012
- Energy demand for lighting makes up the highest share on the total final energy demand (33%) followed by space cooling (25%), appliances (16%), refrigeration (15%), ventilation (6%) and space heating (5%)
- The highest energy demand is in the United Kingdom followed by German and Spain

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Scenario framework

- **Scenario 1**: Moderate renovation rate (1.8% building envelope (space heating), 5.5% lighting, 5.3% other); moderate renovation package
- **Scenario 2:** More ambitious measures and mandatory use of control systems
- **Scenario 3:** In addition to scenario 2 there is an obligation for the thermal building renovation (3.5%/yearly building envelope)
- **Scenario 4:** Growing market of the online shopping and low new building construction rate

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Outcomes (II)

- Overall in all scenarios, there is a reduction in energy demand in the saturated markets and energy demand increase in CEE markets
  - In 2030, more than 50% of the buildings are built between 2012 and 2030 in CEE markets
- Lighting technologies have the highest replacement rate and energy saving potential

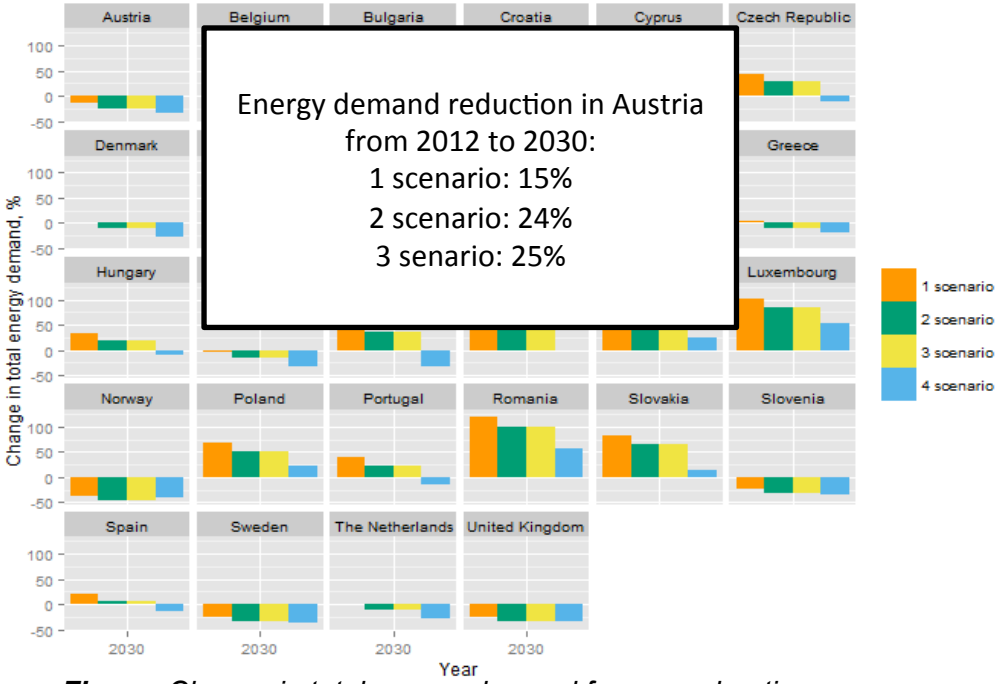

***Figure**: Change in total energy demand for space heating, cooling, appliances, ventilation, refrigeration and lighting from 2012 to 2030 in the European countries in different scenarios*

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Conclusions

- Customer satisfaction is the essential motivation to renovate, shopping centres are the only sector with high building renovation rates (4.4%)
- High potential to realize the energy-saving solutions along the planned aesthetic renovations
- To avoid lock-in effects and to achieve higher energy saving potential, more ambitious energy efficiency measures have to be implemented
- Shopping centers are buildings regularly visited by the public, so they can be used to promote energy efficiency technologies

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Policy recommendations

- Engaging stakeholders
- Communicating the benefits of renovation
- Promoting energy efficient technology packages
- Supporting the energy transition

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- Back-up

Valladolid, Spain

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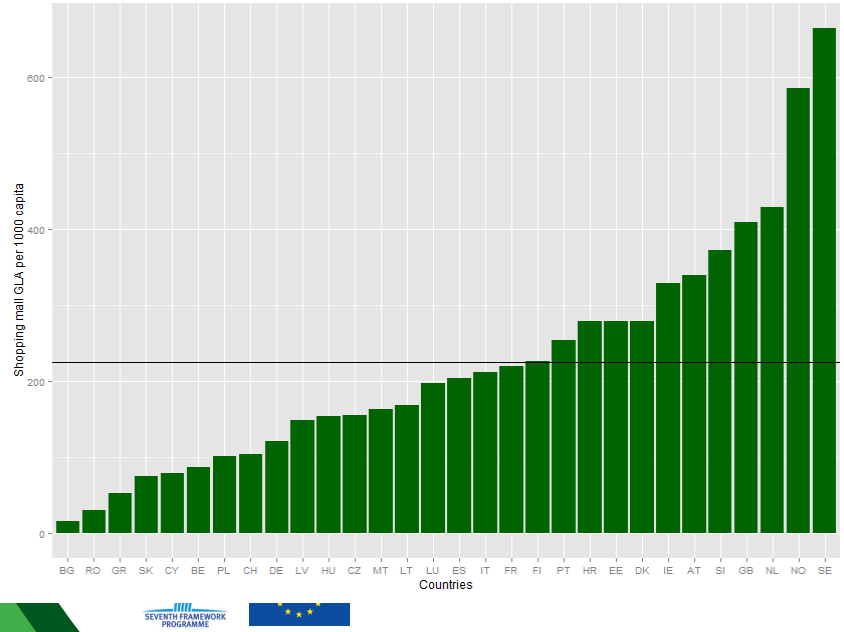
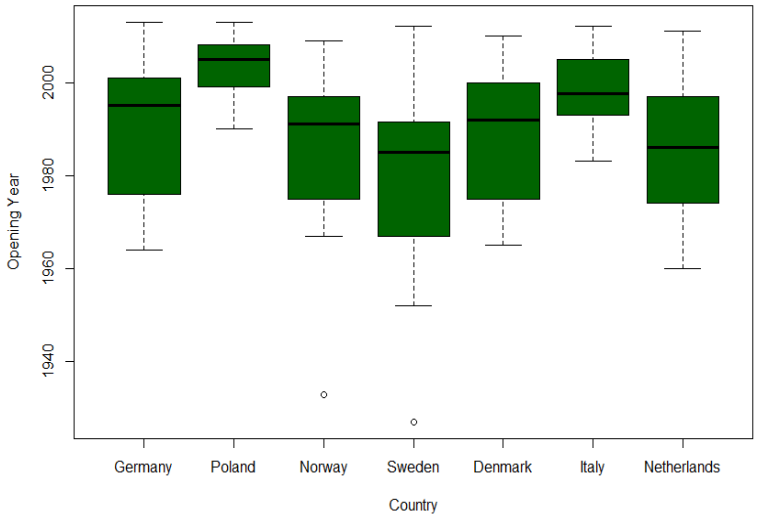
Breakdown of the shopping center building sector

Shopping mall GLA per 1000 capita in EU-28 + Norway and Switzerland (figure left hand) and Distribution of shopping malls opening years (right hand)





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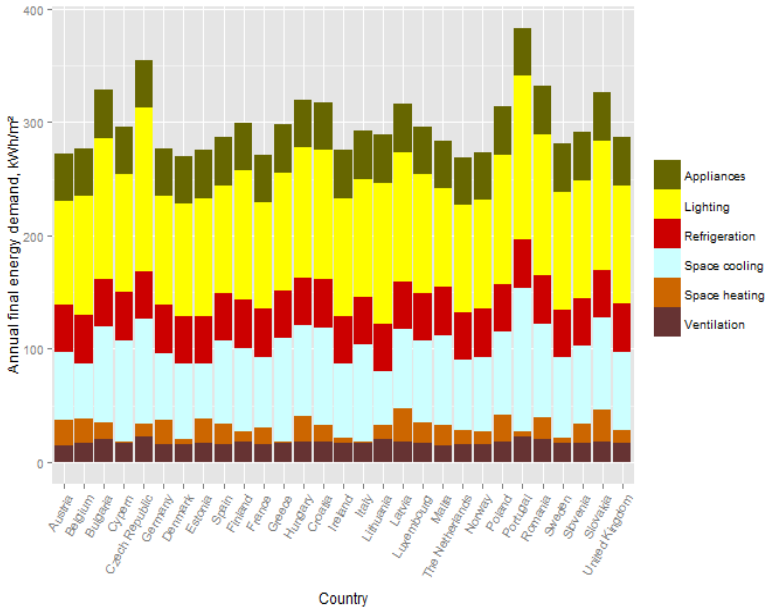
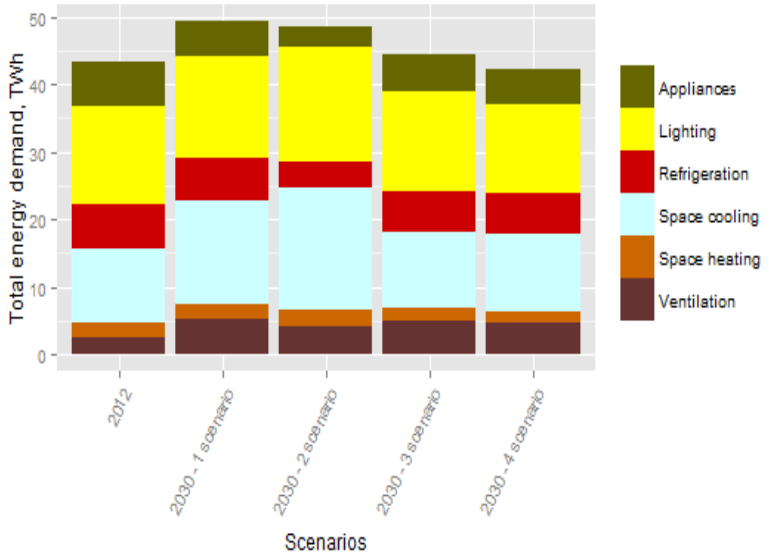
Results

Specific final energy demand (figure left hand) and total energy demand in EU28 and Norway in 2012 and 2030 in different scenarios (right hand)





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Conclusions

- The total future final energy demand in the **existing** shopping centre building stock is expected to decrease
- High energy saving potentials:
  - LEDs
  - envelope insulation
- Emerging markets will have a growing energy demand
- Style and customer preferences are the major renovation driver; the renovation rate is much higher than in other building sectors

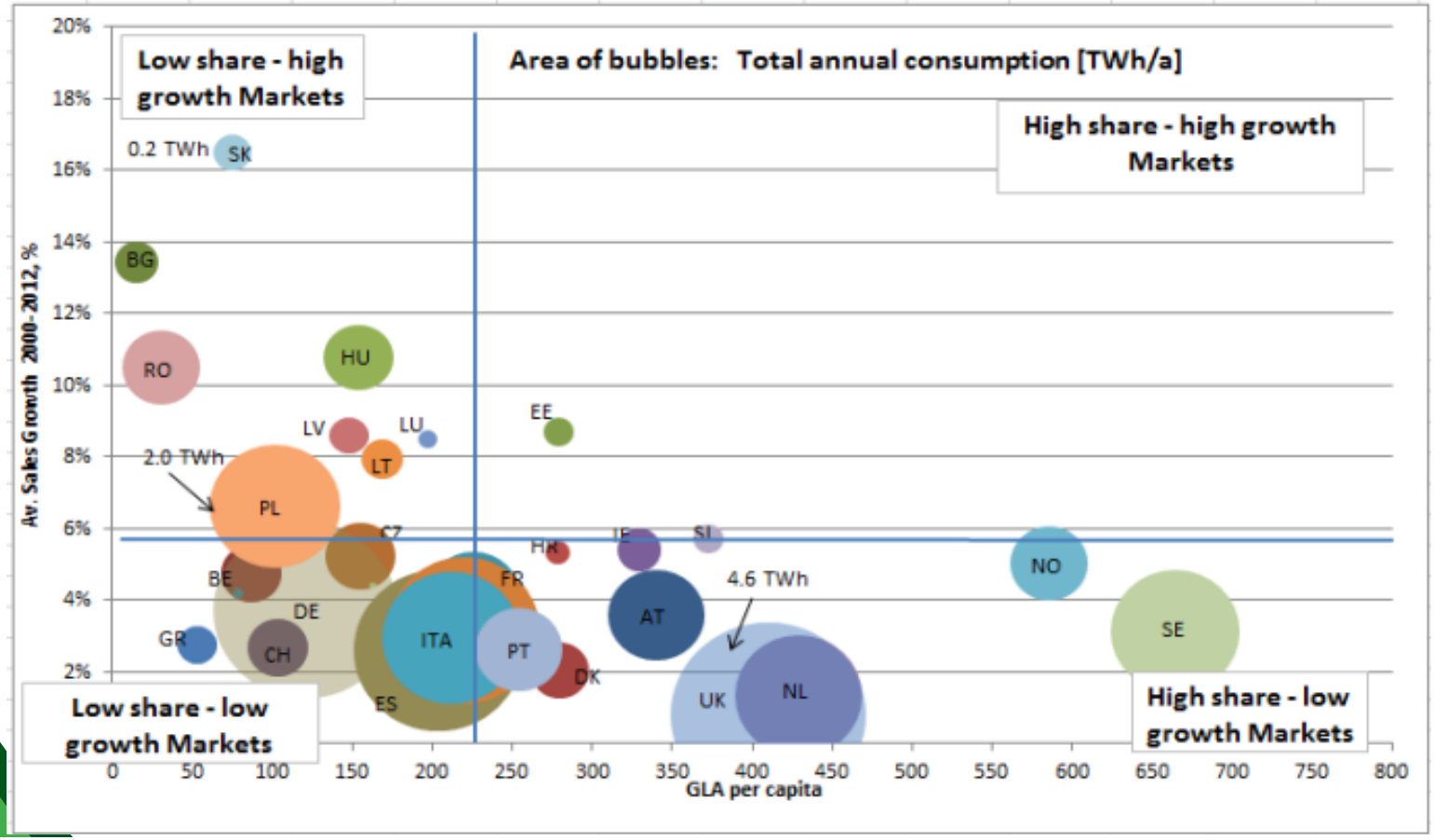
Future growth and renovation rate of the buildings
Methodological steps. Bottom-up approach

- Development of building renovation and new construction until 2030
- The annual renovation of the shopping centre building stock for each building age band is being calculated following a Weibull-distribution with the renovation rate λ(t) in year t
- $\lambda_{(t)} = \frac{\beta}{T} * \left(\frac{t}{T}\right)^{\beta - 1}$
- in which β denotes the shape factor and T the characteristic life time

Methodological steps. Bottom-up approach

The calculation of the new built shopping centres is linked to the gross domestic product (GDP) and the annual sales growth

Final energy consumption, Sales grow & Gross Leasable Area



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Summary

- Shopping Centre GLA: 112.1 Mio. m² (EU+NO)
- Shopping Centre energy consumption: 32.2 TWh (EU+CH&NO)
- Energy efficient retrofit offers a huge savings potential (0.85 - 2.81 TWh in EU 28 by 2030)
- Style and customer preferences are the major renovation driver; the renovation rate is much higher than in other building sectors

- Share of the specific power of different energy services