Renovation of shopping centres in Norway

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Introduction

The CommONEnergy project wants to transform shopping malls into lighthouses of energy efficient architectures and systems.

The objective is to re-conceptualize shopping malls through deep retrofitting utilizing an holistic systemic approach involving innovative technologies and solution sets.

Performance targets:

- Up to 75% reduction of energy demand (factor 4)
- Power peak shaving
- 50% increased share of renewable energy source favoured by intelligent energy management and effective storage
- Improvement of comfort and health conditions for occupants and visitors

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Transform shopping malls into lighthouses of energy efficient architectures and systems

Partners

- Monitoring and control system manufacturer
- HVAC, Refrigeration and Lighting manufacturer
- Storage systems manufacturers
- Solar system manufacturer
- Materials manufacturer
- Building enterprises
- R&D experts (building physics, HVAC+R systems, monitoring, lighting, materials)
- Engineering/Architectural consultants
- Building owners

Inroduction

- The planning of a high-quality retrofitting requires taking into consideration different aspects simultaneously:
  - climate and location
  - architecture
  - selection of HVAC, lighting, refrigeration, renewable energy sources and storage systems.
- Due to the variety of systems present in e.g. shopping malls, their retrofitting needs a decision process based on a comprehensive evaluation approach which considers the actual energy performance of the building, climate, management and user behaviour.
- Building energy simulations allow to identify effective retrofitting solutions and to assess the associated energy savings, power need profile and impact on comfort.

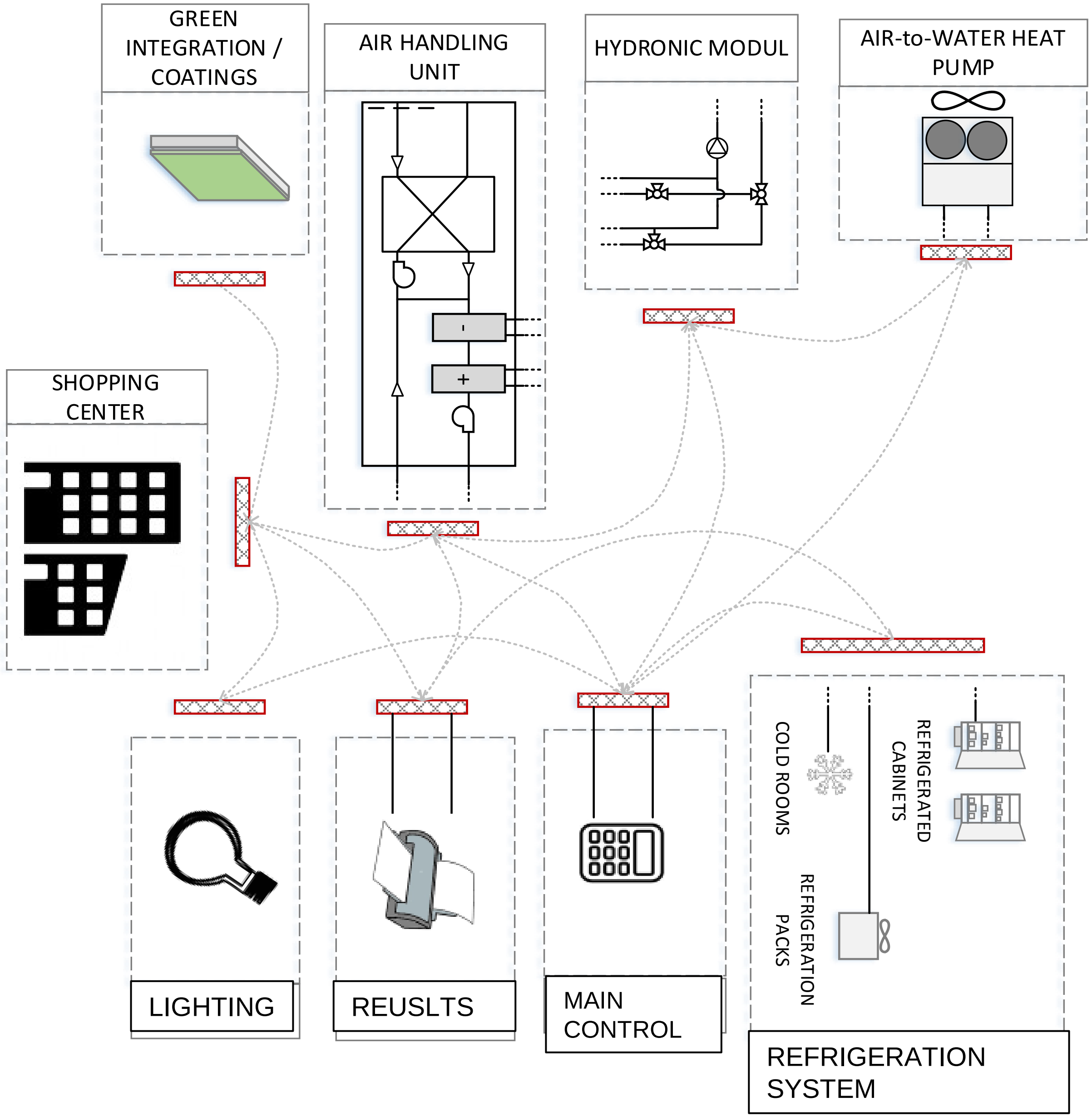
Objectives

- An advanced modelling process was used with help of Integrative Modelling Environment (IME). The IME is based on the Trnsys simulation software and it has been developed to:
- i) support the shopping malls retrofitting phases managing complex systems;
- ii) run parametric analysis of different configurations;
- iii) develop control strategies for the different systems and for the whole system;
- iv) gather in the same numerical model contributions from different partners (in EU project).

Methodology

- The IME gathers and couples in the same simulation model
  i. building
  ii. HVAC and refrigeration systems and components
  iii. daylighting/shading/lighting (iv) storage technologies
  iv. RES technologies
  v. natural ventilation and infiltration
  vi. non-conventional envelope solutions (vegetation, multi-functional coating and materials, etc.).

IME


GREEN INTEGRATION / COATINGS
AIR HANDLING UNIT
HYDRONIC MODUL
AIR-to-WATER HEAT PUMP
SHOPPING CENTER
COLD ROOMS
REFRIGERATED CABINETS
REFRIGERATION PACKS
LIGHTING
REUSLTS
MAIN CONTROL
REFRIGERATION SYSTEM

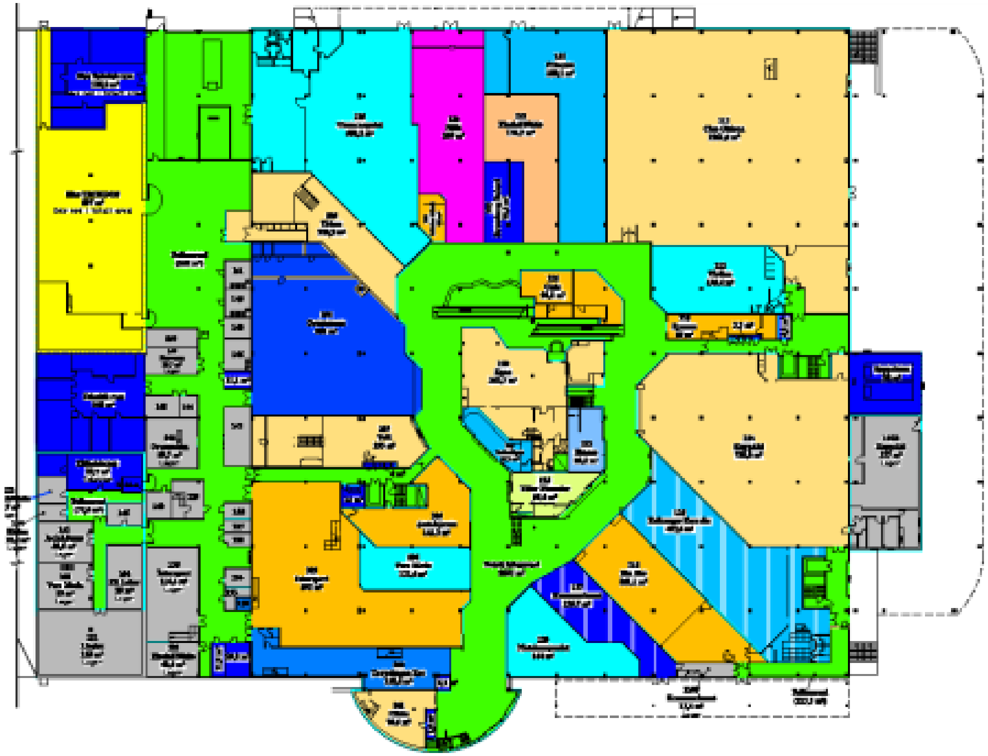
Methodology

- The modularity of the IME allows, with reduced modelling efforts:
  1. To characterize energy savings of shopping mall retrofitting scenarios
  2. To define and optimize control algorithms at whole building and/or sub-system level;
  3. To address optimal scenarios by overall energy system parameterization.
  4. To optimize installed power.

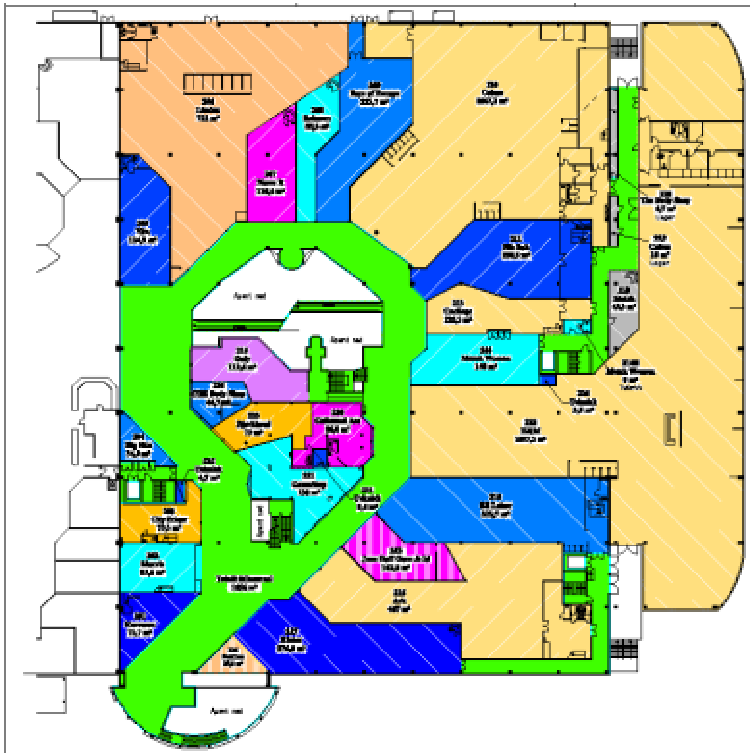
Figure 1 – aerial photo of the shopping centre.

Building

- Ground floor

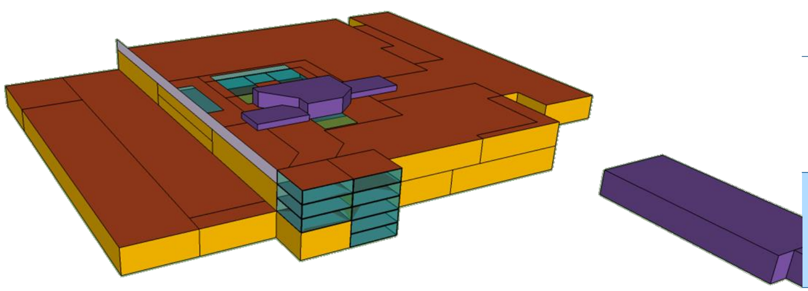


First floor



Building

Thermal zone model



Number of thermal zones	24
Floor height [m]	6.00
Restaurant / office floor height [m]	3.00
Zone typology	**Zone group area [m²]**
Shops	13969
Parking	308
Common areas	2776
Warehouse	1217
Office	161
Restaurants	655

Results

Solutions		measures
1	Lighting	Various measures for CMA, shops, restaurants, service areas
2	Ventilation	Natural ventilation in summer, better infiltration by new entrances
3	Appliances	Energy efficient appliances, escalators etc.
4	Heat recovery	High efficient heat recovery in 4 AHU
5.1	RES – Heat pump	Second heat pump
5.2	RES – PV	6750m2 PV plant (750kWp)
5.3	RES – wind power	4 Wind power plants (600kW), (CHP?)

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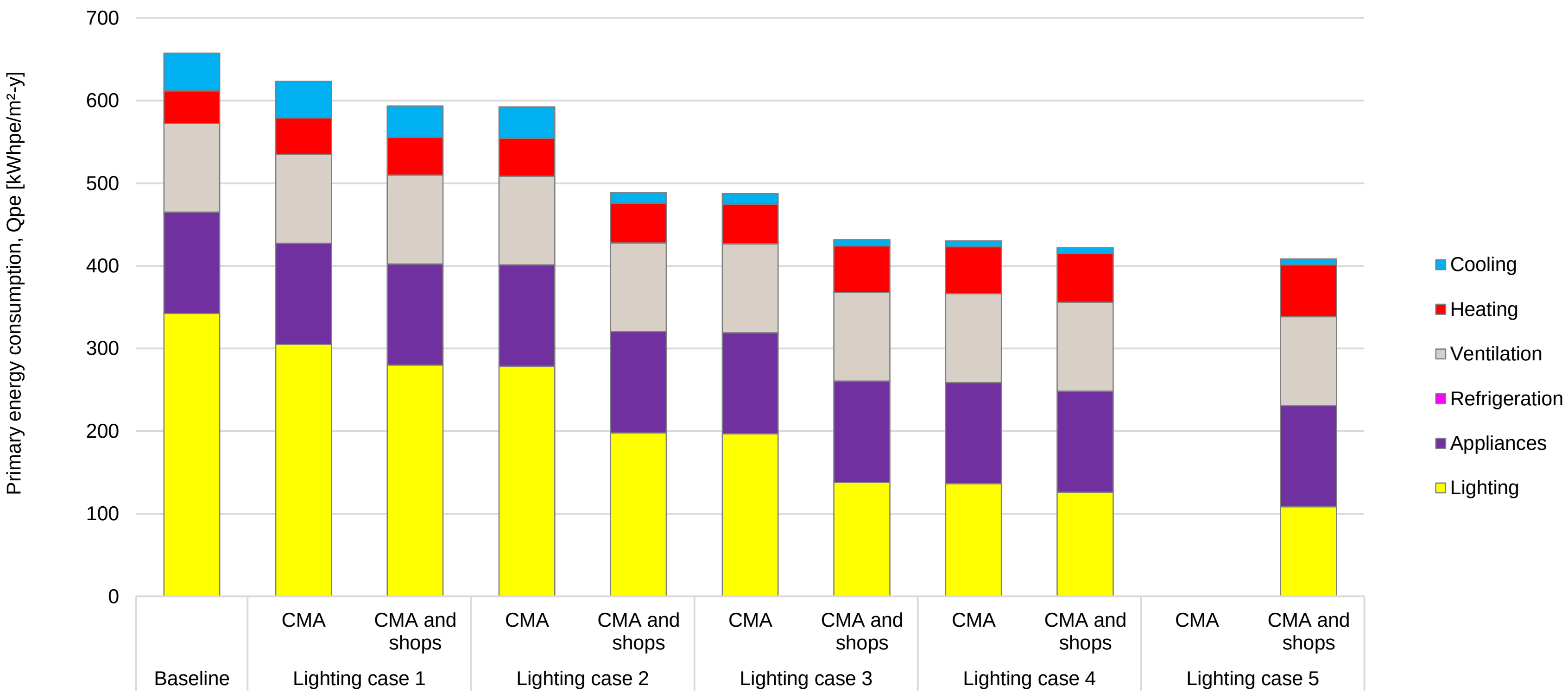
Results – Solution 1: Efficient lighting system and control

- Lighting power density is reduced down to 4.5 W/m² in the common areas and galleries and to 18.1 W/m² in the vending area (shops, midsize stores, food store) because of the installation of LED lamps.
- Advanced controls allow to reduce lighting intensity by half during preparation hours, before and after the opening time, and also during night milieu, after sunrise during opening time. The concept of the zonal spatial distribution consisting of a comprehensive set of solutions that was applied that let us expect savings in energy demand of around 60% against the initial situation. These measures include:
- Daylight harvesting by 3 light tubes illuminating the center of the sale room with natural light.
- Application of newly developed LED high lumen retail wallwasher which precisely illuminates merchandise with high efficacy and homogeneity. Glare will be reduced due to very good longitudinal glare control. Beam angle was extended to 120° in order to illuminate not only the merchandise wall but also the area in front to enable optimal examination of goods by customers.
- Introduction of a evening scenario with warm-white light color of 2700 K und reduced intensity. This lighting scene considers human biorhythm as the indoor room

Results – Solution 1: Efficient lighting system and control

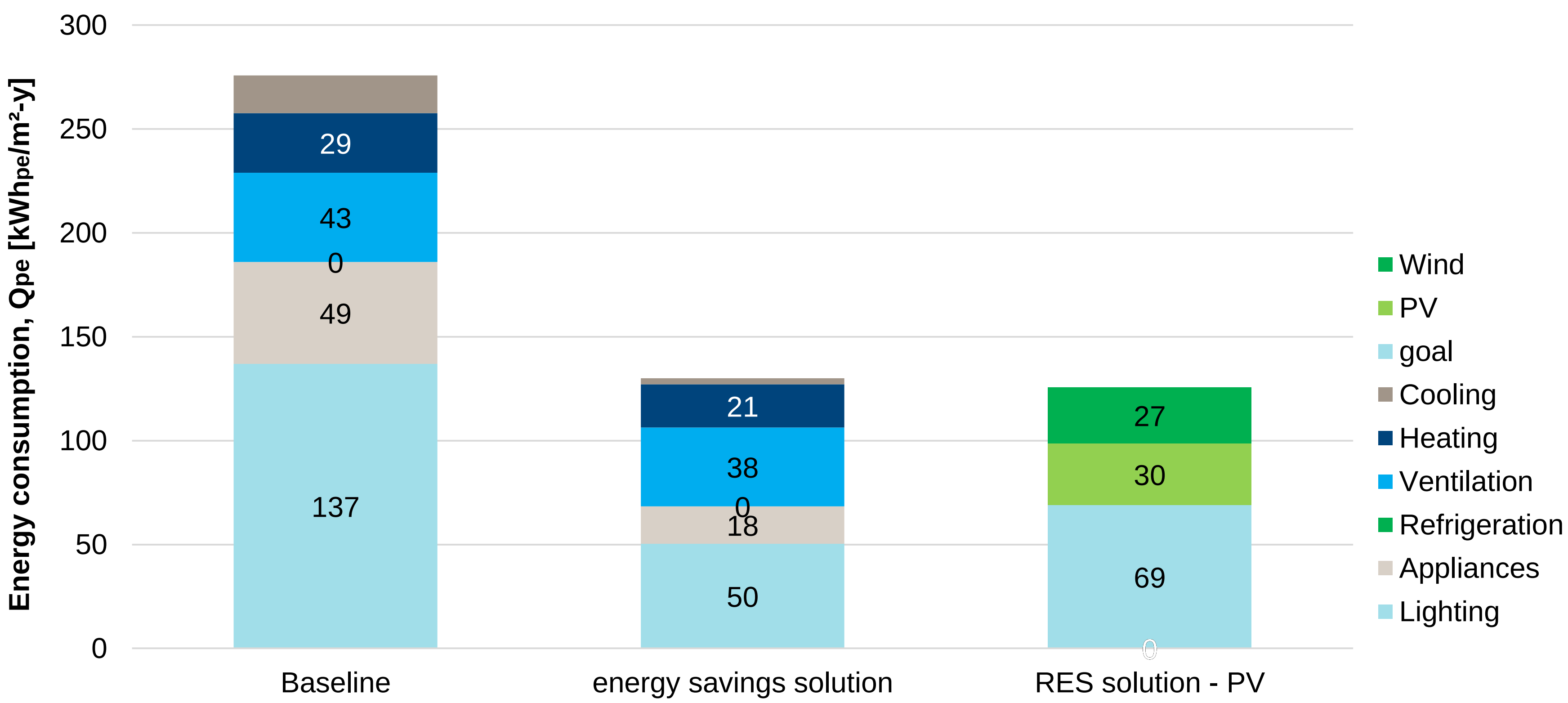
- Opening hours
  - Starting from the strategies that BLL proposed for the City Sud democase, the schedules and the values were used as a retrofit solution for the reference building.
  - According to BLL artificial lighiting design the schedule is basically characterized by four period within a day:
  - Out of Operation: is the period in which the shopping centre is closed (at night, Sunday and during holidays)
  - Preparation Hours-Morning : is the period before the public opening of the shopping centre. During this time some internal activities are performend (e.g. cleaning,restock of supormarket, shops,ecc…)
  - Business hour corresponds to the public opening hour of the shopping centre
  - Preparation Hours-Evening : same of the morning, is the period just after the closing to the public of the shopping centre

Results



Primary energy consumption, Qpe [kWhpe/m²-y]
700
600
500
400
300
200
100
0
Baseline
CMA
CMA and shops
Lighting case 1
CMA
CMA and shops
Lighting case 2
CMA
CMA and shops
Lighting case 3
CMA
CMA and shops
Lighting case 4
CMA
CMA and shops
Lighting case 5
Cooling
Heating
Ventilation
Refrigeration
Appliances
Lighting

Results


Energy consumption, Qpe [kWhpe/m²-y]
300
250
200
150
100
50
0
29
43
0
49
137
21
38
0
18
50
27
30
69
0
Baseline
energy savings solution
RES solution - PV
Wind
PV
goal
Cooling
Heating
Ventilation
Refrigeration
Appliances
Lighting

Conclusions

- The efforts for the development of a shopping mall model can be eased through the use of a modelling environment that integrates the different parts of a shopping mall (building, energy plant and control) and facilitates the implementation of control strategies.
- Moreover, a modular structure and a well-defined parameters and inputs implementation, helps the analysis of the optimal solution and the post processing of simulation results.
- It is expected that investment costs will provide a payback period of max 7 years. Economic evaluation needs to be further analysed.

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Acknowledgements

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