Capacities in Shopping centres to supply grid services

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SINTEF Building and Infrastructure
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Capacities in Shopping centres to supply grid services

Content

- Background
- Purpose
- Theoretical framework
- Results and conclusions
- Implications for ‘Resilience the New Research Frontier’
Background

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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**CommONEnergy**

**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
Purpose
Identification of potential in shopping malls to supply grid services, reducing the impact on power demand through
- peak shaving of its demand curve or its adaptation to the conditions of generation of the utilities, based on the classification of the demand.
- use of generation coming from renewable energy sources in moments of mismatch between energy supply and demand, either directly or from storage.

BPIE, 2011
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Energy use

- Shopping centers in Norway (avg. 270 kWh/m²)
- Shops in Norway (avg. 510 kWh/m²)

Haase and Woods, 2013
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Energy use

Hypermarts (Food-driven)
- Ventilation
- Food refrigeration
- Heating and air-conditioning
- Store lightning

Nonfood retail formats
- Ventilation
- Others (elevators, demonstration units, etc.)
- Store lightning

Retail forum for sustainability, 2009
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Baseline plans
Ground floor

First floor

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Baseline zoning with grid

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## Baseline Constructions

<table>
<thead>
<tr>
<th>Building codes</th>
<th>TEK-1985</th>
<th>TEK-1987</th>
<th>TEK-1997</th>
<th>TEK-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Building codes' as built to std. 1985</td>
<td>Building codes year of completion</td>
<td>Redevelopment in 2000 (extension)</td>
<td>Current min. std. (for reference)</td>
</tr>
<tr>
<td>U-value ext. wall (W/ (m² K))</td>
<td>0,45*</td>
<td>0,30</td>
<td>0,22</td>
<td>0,18</td>
</tr>
<tr>
<td>U-value roof (W/ (m² K))</td>
<td>0,23</td>
<td>0,23</td>
<td>0,15</td>
<td>0,13</td>
</tr>
<tr>
<td>U-value floor (W/ (m² K))</td>
<td>0,30</td>
<td>0,30</td>
<td>0,15</td>
<td>0,15</td>
</tr>
<tr>
<td>U-value windows / doors (W/ (m² K))</td>
<td>*to be included in the facade.</td>
<td>2,40</td>
<td>1,6 - 2,0</td>
<td>1,2</td>
</tr>
<tr>
<td>U-value doors / ports (W/ (m² K))</td>
<td>2,0</td>
<td>2,0</td>
<td>2,0</td>
<td>1,2</td>
</tr>
<tr>
<td>Air tightness c (ach)</td>
<td></td>
<td></td>
<td>1,50</td>
<td></td>
</tr>
<tr>
<td>Heat recovery d (%)</td>
<td></td>
<td></td>
<td>80 %</td>
<td></td>
</tr>
<tr>
<td>Specific fan power (kW/ (m³ /s))</td>
<td></td>
<td></td>
<td>2,0/1,0</td>
<td></td>
</tr>
</tbody>
</table>
Measured data 2012
Avg. electricity profile

Increased electricity use
Measured data 2012
Avg. district heating profile

Mainly space heating
Domestic hot water
Validated model

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![Bar chart showing energy demand in kWh for different categories: Shared El., Cooling, Distr. Heating, and Tenants estimate. Comparison between MÅLT_2013 and SIM_2013.](chart.png)
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Results

Winter Week, 14. - 20. Jan | Shared electricity demand

- COP_AUH-HEATING
- COP-AHU-COOLING
- CMA_EQUIPMENT
- SVC_EQUIPMENT
- CMA_LIGHTING
- SVC_LIGHTING
- SHP_COP-SPACECOOLING
- SPP_TOT
- 268015123_Mains.Old(kWh)
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Results

Spring Week, 8. - 14. April | Shared electricity demand
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Results

Spring Week, 8. - 14. April | Reduced shared electricity demand
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PV system

- Trondheim: 63° 25’ N, 10° 23’ E (south of Arctic circle)
- Average solar resource: 2.38 kWh m-2 d-1 onto a flat plate, 3.03 kWh m-2 d-1 onto a PV panel tilted 45° to the south.
- Here: 500kW (3200m2), 1MW, almost horizontal installation
# Concepts/scenarios for decrease mismatch

## Data requirements

<table>
<thead>
<tr>
<th>Indicator category</th>
<th>Load matching</th>
<th>Grid interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>On-site load and generation</strong></td>
<td>I: Load match index(^1) Solar fraction(^2) Cover factor(^4) Self-consumption factor(^7) Loss of load probability(^4)</td>
<td>II: Grid interaction index(^1) Capacity factor(^4) Peak power indicators(^4) Grid citizenship tool(^8)</td>
</tr>
<tr>
<td><strong>Additional data</strong></td>
<td>III: Mismatch compensation factor(^5) Market matching(^3)</td>
<td>IV: Profile addition indicators(^5) Coincidence factor(^6)</td>
</tr>
</tbody>
</table>

Concepts/scenarios for decrease mismatch

- Load Cover Factor
  \[ \gamma_{load} = \frac{\int_{t_1}^{T_a} \min[g(t) - S(t) - \zeta(t), l(t)] dt}{\int_{t_1}^{T_a} l(t) dt} \]

- Supply Cover Factor
  \[ \gamma_{supply} = \frac{\int_{t_1}^{T_b} \min[g(t) - S(t) - \zeta(t), l(t)] dt}{\int_{t_1}^{T_b} g(t) dt} \]

- Grid interaction
  \[ GI = \frac{g(t)}{l(t)} \]
Results

- 500kW PV system
Results

- 1 MW PV system
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Results

Spring Week, 8. - 14. April | grid interaction reduced lighting loads

<table>
<thead>
<tr>
<th>Day</th>
<th>Grid Interaction Factor (f)</th>
<th>Demand and Generation [kWh]</th>
</tr>
</thead>
<tbody>
<tr>
<td>07/04/2013</td>
<td></td>
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<tr>
<td>08/04/2013</td>
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<tr>
<td>09/04/2013</td>
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<td>10/04/2013</td>
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<td>11/04/2013</td>
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<tr>
<td>12/04/2013</td>
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<tr>
<td>13/04/2013</td>
<td></td>
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</tr>
</tbody>
</table>

Grid interaction factor [f] for demand and generation [kWh].
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Results
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Results

Monthly Statistics for GI

- max
- daily high
- mean
- daily low
- min
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Results

Monthly Statistics for GI_red
Results – including tenants

- 1 MW PV system
Conclusions

- The results show that there is considerable potential for the use of generation coming from renewable energy sources.
- Peak shaving of power demand is possible but limited. It seems that PV production will exceed the energy needs only if they are strongly reduced.
- Grid interaction increases which gives options for energy storage (batteries).

- When tenants energy use is included, more work is needed in order to optimize the design of the building and the technical systems.
- Other RE sources should be considered (Wind power?).
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THANK YOU!

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