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• Members States shall ensure that:
  – after 31 December 2020, all new buildings are nearly zero-energy buildings, and
  – after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings.
  – intermediate targets for improving the energy performance of new buildings, by 2015.

- Members States shall:
  - calculate cost-optimal levels of minimum energy performance requirements using the comparative methodology framework
  - report to the Commission all input data and assumptions used for those calculations and the results of those calculations. The first report shall be submitted by 30 June 2012

- The Commission shall establish:
  - by 30 June 2011 a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements.
Level of minimum energy performance
Objectives

• To define from the private economy perspective the cost-optimal combination of energy efficiency level and application of renewable energy systems

• Indirectly to indicate the cost-optimal energy supply system for the Net ZEB located in the dense city area
Study case – Bolig+

- 10/6 multi-storey residential building of 60 apartments with total area of 7000m²
- Prefabricated building process – 114 modules with area of 61.4m²
- Energy supply system:
  - PV installation of 1782m²
  - PV/T installation of 203m²
  - Air/solar heat pump of 110kW
- Primary energy use (BE10) – 18.9kWh/m²a
- Total primary energy use – 56.5kWh/m²a
  (with assumption of max. annual household electricity use of 1725 kWh/per apartment)
- The annual balance between exported and imported energy is zero
Life Cycle Cost

**Investment Cost:**

1. the foundation
2. the materials used for constructing the modules
3. the process of producing, transporting and assembling the modules
4. the windows
5. the technical work connected to building construction
6. the installations
7. the connections to the utilities: electricity grid, water-supply and sewage grid and district heating

**Operation & Maintenance Cost:**

1. the operation and maintenance of energy supply systems components, floor heating installation, and ventilation installation
2. the water bills
3. the subscriptions to electricity and district heating grid
Replacement Cost:
1. PV,
2. PV/T,
3. heat pump,
4. windows
5. installations of floor heating & ventilation system

Demolition Cost:
1. construction
Assumptions:

• Building – grid interaction is based on the net-metering agreement

• PV-DH alternative:
  – heat consumption can be offset by electricity
  – cost of the purchased heat divided by the factor 3.125 equals the cost of additional electricity fed into the grid.
Minimum energy performance requirements:

- Level 0: BR20
  \[ 22.0 \text{ kWh/m}^2\text{year} \]

- Level 1: BR15
  \[ 30.5 \text{ kWh/m}^2\text{year} \]

- Level 2: BR10
  \[ 52.7 \text{ kWh/m}^2\text{year} \]
Energy supply systems

• **PV-PV/T-HPs:** Photovoltaic installation in combination of photovoltaic/solar thermal collector and an air/solar source heat pump.

• **PV-HPgr:** Photovoltaic installation in combination with ground source heat pump

• **PV-DH:** Photovoltaic installation in combination with district heating
## Study cases

<table>
<thead>
<tr>
<th>Energy frame</th>
<th>System</th>
<th>PV-PV/T-HPs</th>
<th>PV-HPgr</th>
<th>PV-DH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 0</td>
<td>PV-PV/T-HPs(0)*</td>
<td>PV-HPgr(0)</td>
<td>PV-DH(0)</td>
<td></td>
</tr>
<tr>
<td>Level 1</td>
<td>PV-PV/T-HPs(1)</td>
<td>PV-HPgr(1)</td>
<td>PV-DH(1)</td>
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<tr>
<td>Level 2</td>
<td>PV-PV/T-HPs(2)</td>
<td>PV-HPgr(2)</td>
<td>PV-DH(2)</td>
<td></td>
</tr>
</tbody>
</table>

* Base case in the LCC analysis – Bolig+
Net savings

Million DKK

Level 0

Level 1

Level 2

PV-PV/T-HPs(0)*
PV-HPgr(0)
PV-DH(0)

PV-PV/T-HPs(1)
PV-HPgr(1)
PV-DH(1)

PV-PV/T-HPs(2)
PV-HPgr(2)
PV-DH(2)

Investment
O&M
Replacement
Total

energieffektivt og bæredygtigt bygge
District heating analysis

Annual district heating cost

<table>
<thead>
<tr>
<th>Million DKK/year</th>
<th>DH (m²)</th>
<th>DH variable</th>
<th>DH new tariff</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV-DH(0)</td>
<td>0,00</td>
<td>0,04</td>
<td>0,08</td>
</tr>
<tr>
<td>PV-DH(1)</td>
<td>0,12</td>
<td>0,16</td>
<td>0,20</td>
</tr>
<tr>
<td>PV-DH(2)</td>
<td>0,12</td>
<td>0,16</td>
<td>0,20</td>
</tr>
</tbody>
</table>

Innovationsnetværket for energieffektivt og bæredygtigt byggeri
Conclusions

• With the current price level and PV installation for producing electricity, the investment in energy efficiency is more cost-effective than investment in renewable technologies.

• The most cost-effective combination is for the Net ZEB in the dense city is the PV-HP(0) scenario.
Conclusions

• The high O&M cost in the case of PV-DH solution makes this alternative the most expensive one and thus unattractive from the private economy perspective.

• The most energy efficient solution is the one in which the PV installation is combined with PV/T and a solar heat pump.

• Prefabricated modular building construction could have great potential for reducing the cost of construction with higher thermal properties.
Thank you for your attention