NAVITAS – The Energy Concept

Improving Energy Efficiency in University Buildings
Navitas is a 35,000 m$^2$ university/office building in Aarhus, Denmark, which is currently under construction. It is a building where the desired function, aesthetics and indoor climate quality come together in a low-energy building design. This presentation describes the design process where the goal of the design team was to design a building with a 50% lower energy demand compared to the national building energy code - without subtracting any on-site renewable energy production.

**Speaker:**

Steffen Petersen is M.Sc.(eng) and finished his PhD studies "Simulation-based support for integrated design of new low-energy office buildings" in the summer 2011. Parallel to his PhD studies he worked as a consultant engineer in ALECTIA where he was a part of the team who designed the Navitas building. He is now an assistant professor at Aarhus School of Engineering and part time consultant in ALECTIA.

www.alectia.com/eng
The project

The building
A 35,000 m² building which is shared by ASE, ASMTE and INCUBA Science Park. The City of Aarhus will construct a public parking lot with approx. 450 parking spaces.

Project basis
• Turn key contract
• Maximum price of 720 mio. Dkr. (€ 96 mio.)
• Low energy class 1 ≈ 50 kWh/m² year for heating, ventilation, lighting, mech. cooling, pumps ≈ 50% lower than 2008 standard ≈ expected minimum requirement in 2015
• An explicit demand for Integrated Energy Design
The design team

*Turn key contractor*
Pihl & Son A/S

*Engineers*
ALECTIA A/S

*Architects*
Kjær & Richter A/S
CCO A/S

*Landscape architect*
Marianne Levinsen
Prerequisites for Integrated Energy Design

Interdisciplinary Collaboration and Communication

System thinking

[Diagram showing Venn diagram with overlapping circles labeled Social, Environment, and Economy]
Interdisciplinary Collaboration and Communication

Day 1
A multi-disciplinary steering group managed by the contractor was created.

Project kick-off
Workshop with the aim of 1) get to know each other, 2) reaching a common understanding of the content of the construction programme, 3) align expectations within the group, and 3) make an action plan.

Series of workshops with different themes
- Organisation, users and flow
- Car parking and functions on ground level
- Energy and sustainability
- Principles for the bearing structure

Weekly status meetings

Common work days when needed
System thinking

Example: A low energy building

**Environmental factor**
Reducing CO$_2$ emissions

**Economic factor**
Reduced running costs
Higher productivity

**Social factor**
Good indoor environment
(better quality of life)
Starting up the design process: Where is the key?

Standard parking

Automated parking
Energy performance and sustainability
We are building designers!

Ambition for Navitas
Low energy class 1 without subtracting sustainable energy production
Don’t forget the indoor climate!

We are indoor 90% of our life time…
How glass quality affects energy performance, daylight, thermal and indoor air quality

Result from iDbuild (www.idbuild.dk)

<table>
<thead>
<tr>
<th>Variations</th>
<th>Energy Use [kWh/m²]</th>
<th>Daylight Factor [%]</th>
<th>Operative Temperature</th>
<th>Indoor Air Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Var. 1</td>
<td>46</td>
<td>1.4</td>
<td>46%</td>
<td>8.01%</td>
</tr>
<tr>
<td>Reference</td>
<td>48</td>
<td>2.1</td>
<td>44%</td>
<td>7.72%</td>
</tr>
<tr>
<td>Var. 2</td>
<td>43</td>
<td>2.2</td>
<td>46%</td>
<td>8.87%</td>
</tr>
</tbody>
</table>

Daylight Autonomy: Var. 1: 0.74, Reference: 0.77, Var. 2: 0.76
Solar Shading: Var. 2: 0.4
Facade design

-0.85 m parapet
-Window from parapet to ceiling
-Solar coated glazing
INTEGRATED VENTILATION AND NIGHT COOLING WITH DIFFUSE CEILING VENTILATION


Air flow is controlled by CO₂ level and/or temperature in the occupancy zone.

Inlet air: outdoor temperature + 1 °C, min. 16 °C.
INTEGRATED VENTILATION AND NIGHT COOLING WITH DIFFUSE CEILING VENTILATION

Average heat transfer coefficient: 10.5 W/m²K (or 0.095 m²K/W.)
"Normal" inlet

- All year: 39% Class I, 42% Class II, 13% Class III, 6% Class IV
- Summer: 57% Class I, 27% Class II, 7% Class III, 10% Class IV
- Winter: 25% Class I, 54% Class II, 18% Class III, 4% Class IV

Diffuse ceiling inlet

- All year: 22% Class I, 73% Class II, 3% Class III
- Summer: 29% Class I, 59% Class II, 6% Class III
- Winter: 16% Class I, 84% Class II

Operative temperature, mixing

Operative temperature, diffuse

Supply temperature, mixing

Supply temperature, diffuse

Outdoor temperature
Overall building design

- Stretch across the entire building plot
- Hold on to the corners of the plot

- A more dynamic and sculptural figure
- Urban spaces along the facades
- Maintaining the amount of facade
- More intimate internal space
Architectural programming

Figure 4. Variation of the orientation for an office for three people.

Figure 5. Variation of the orientation for a student group room for six people.
Architectural programming
Space for ventilation units

Zones with plumbing (toilets, kitchenettes)
Energy frame

Solid constructions
- Wall: 0.14 W/(m²K)
- Floors: 0.15 W/(m²K)
- Roof: 0.09 W/(m²K)

Windows
- 3-layer solar coated glazing (0.6/0.3/0.54)
- Frame (1.1/0.05)
- Total U-value 0.72 W/(m²K) in average

Ventilation
- Minimum air change: Class II according to DS/EN 15251
- Maximum air change: Depends on the thermal indoor environment in the different functions
- SFP 1.2 kJ/m³ in average, VGV 0.85
- Infiltration approx. 50% lower than standard

Lighting
- Good daylight conditions (at least 3% on working plane)
- Energy efficient lighting (in general 4.5-6 W/m², 200 lux)
- Motion sensors and daylight control (mandatory from 2011)

1.750 m² solar cells
Questions after presentation

• **Q: The extra cost of a plenum for ventilation?**
  A: In this project it was “free” due to the principle of the bearing constructions. HVAC routing has to pass beams perpendicularly which triggers a free height for the plenums.

• **Q: Temperature in plenum?**
  A: Outdoor air temperatures around 0 ºC results in a inlet and ceiling temperature around 16 ºC. Please see the Ph.D disseration (in English):
  [http://orbit.dtu.dk/All.external?recid=271241](http://orbit.dtu.dk/All.external?recid=271241)
Questions after presentation

- **Q:** *The design process – any conflicts?*
  
  **A:** The attitude of the team members towards building design and energy efficiency was very much the same. Consequently, reaching a common understanding of the project was very easy. I have never experienced anything like this. There is always fundamental discussions/disagreements within a design team, but here there was a foregone alignment. On top of this there was a great sense of empathy across the disciplines. It very much depends on the persons in the core design team. It has to be a certain type of personality.
Questions after presentation

- **Q:** *Did you use a life cycle approach?*
  **A:** In relation to energy-saving measures - no. The embedded energy is still a fraction of the energy for operation. There might be other environmental issues in production weighing more than CO₂ but it has not been taken into consideration. My opinion is pretty much aligned with the content of this blog: [http://www.buildingscience.com/documents/insights/bsi-012-why-energy-matters](http://www.buildingscience.com/documents/insights/bsi-012-why-energy-matters)
Thanks!

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