Re-Commissioning the HVAC of an Office Building: Systematic Performance Evaluation according

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Schematic overview building HVAC performance related parameters

INPUT: Building Use
- Occupant behaviour
- Comfort preferences

INPUT: Ambient Conditions
- Ambient Temperature
- Solar Irradiance
- Ambient Air Quality

Building & Installations

OUTPUT: Energy Consumption
- Electricity demand
- Gas demand

OUTPUT: Indoor Conditions
- Thermal Comfort
- Indoor Air Quality

Controllable Parameters
- HVAC control strategies
- HVAC maintenance

Non-controllable Parameters
- Building Physics
- HVAC hardware
Lean Energy Analysis RCx methodology

Step 1: RCx according L.E.A
- Design Analysis
  - Energy Performance
  - Indoor Performance
- Result Discussion

Step 2: Define Modeling Framework
- Benchmark
- Design
- Result Discussion

Step 3: Concussion Results
- Energy Performance
- Indoor Performance
- RCx Recommendations

Validated? (yes/no)
HVAC performance modelling
Ventilation system
Graphical representation of ventilation controls
Top-down performance analysis

- Energy Analysis
  - Electricity
  - Gas
  - Anomalies?
  - Stop

- HVAC Analysis
  - Indoor Cond.
  - Thermal Load
  - Anomalies?
  - Stop

- ATES Analysis
  - GW Cond.
  - State of Charge
  - Anomalies?
  - Stop

- Further Research
Comparison annual primary energy consumption

Annual Specific Primary building-related energy demand

- Heating
- Fans
- Hot tap water
- Pumps
- Cooling
- Humidification
- Lighting

Annual SPBED [MJ/m²/year]

Average Office

Ziggo EPC

Emperical 2013

Emperical 2014
Hourly aggregated electricity consumption office room
Daily mean indoor conditions of the office rooms

**Ti | Mean Building - Weekdays**

**CO2 | Mean Building - Weekdays**

**Ti | Mean Building - Weekends**

**CO2 | Mean Building - Weekends**
Regression for supply and extraction fan as a function of CO₂

If 6-23h, and 560 > CO₂ < 760

\[ Q_{AHU\,supply} = 0.01036 \times x + 8.353 \quad (R^2: 0.9614) \quad (1) \]

If 6-23h, and 560 > CO₂ < 760

\[ Q_{AHU\,extract} = 0.00516 \times x + 4.931 \quad (R^2: 0.8562) \quad (2) \]
Simulated and measured CO$_2$ concentration

Building Mean - Simulated vs. Measured

Room 2.2 Simulated vs. Measured
Simulated CO$_2$ and ventilation
# Saving potential AHU fan electricity use

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Tuesday [kWh]</th>
<th>Saving [%]</th>
<th>Saturday [kWh]</th>
<th>Saving [%]</th>
<th>Full Week [kWh]</th>
<th>Saving [%]</th>
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<tr>
<td>Benchmark</td>
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<td>1150</td>
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</table>
Conclusions

• The L.E.A. methodology gives guidance in finding the inefficiencies that matter most. It emphasis a data-driven approach, starting with graphical analysis on a top level.

• Due to its data-driven approach, L.E.A. can act as a first step in implementing a CCx process. The data variable(s) that discovered anomalies can act as the input for starting a CCx process.
Thank you for your attention!

Questions?

"If you weren’t an optimist, it would be impossible to be an architect."

~ Norman Foster