A Systematic Approach to Real-Time Integrated Energy Performance and Monitoring
A little info about myself:

- MS in Sustainable Energy and Resource Recovery
- 3 years experience in HVAC design
- B.E. in Mechanical Engineering
1. Introduction

- Humlegården Project – Swedbank HQ, Sundbyberg
  - Gross area 45,000 m² (offices, restaurants, etc…)
  - Miljöbyggnad Guld (50 kWh/m²)
  - Detailed measurements on a system & zone level
  - Real-time visualization Green Fingerprint
2. Objectives

1. Novel criterion for assessing buildings’ energy performance; one that takes into account occupant satisfaction!
2. Key parameter selection for fault detection and diagnosis
3. Online auto-tuning simulation model
4. Real-time visualization
5. Off-line predictive control and optimization
2.1 Novel Criterion

How are buildings being assessed nowadays?

Energy Use Intensity (EUI) [kWh/(m² x yr)]

Occupancy

Thermal Comfort
2.1 Novel Criterion

Need to consider:
- Quality of service provided
  - Thermal Comfort
  - Productivity
- Environmental Impact
- Performance
- Service Efficiency
2.2 Key Parameter Selection

A detailed simulation model of a building entails thousands of parameters.

To obtain an accurate representative model these parameters need to be tuned.

Brute-Force tuning of 156 such parameters (screened from 3k+, min-max) requires $5 \times 10^{52}$ simulations (roughly $2 \times 10^{28}$ lifetimes of the known universe!)

Solution: Experience helps!
# 2.2 Key Parameter Selection

## Whole Building
- Windows U-Value
- Glazing Solar Heat Gain Coefficient
- Blind additional resistance

## Zone
- Air Leakage
- Thermal Bridges
- Temperature setpoints
- CO₂ setpoints

## AHU
- Heating Capacity
- Cooling Capacity
- Heat Recovery Efficiency
2.3 Auto-Tuning

Layered approach:
1. Real-time state adjustment control

2. On-line key parameter optimization
3. Off-line model adjustments
2.4 Real-Time Visualization

Effects on energy consumption?
2.5 Predictive Control & Optimization

- Manual FDD
- Automatic alarm signaling
- Short-term and long-term forecasting
- What-if scenarios and retrofitting options
- Testing control strategies
- ...and more
Questions?