

Simulation of proactive HVAC occupancy control for Linate Airport, Milan

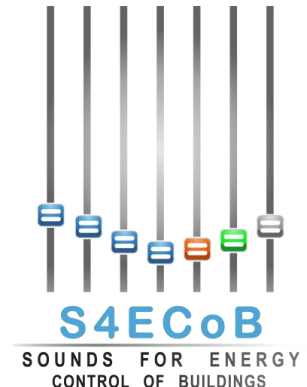
Methodology for reducing energy consumption using occupancy data.

Blaise Kelly

Sustainable Buildings and Cities

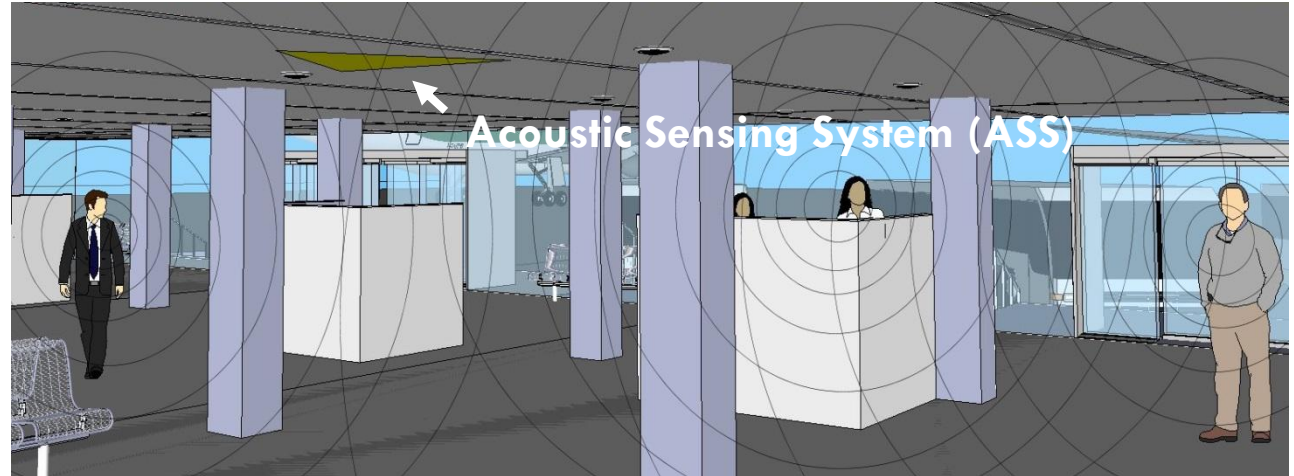
Austrian Institute of Technology

16.04.15



S4ECoB (Sounds for Energy Control of Buildings)

- One of three pilot sites: **Linate Airport**, Milan, Italy
- Acoustic occupancy detection system linked to HVAC operation
- **Goal:** Proactive HVAC control before temperatures have chance to fluctuate





Acoustic Sensing System (ASS)



2.6m



HVAC System

Generation

- Hot water supplied from onsite Natural Gas CHP unit

Distribution

- Twin duct Variable Air Volume (VAV) system
- Supplies air with average flow rate of $26,000 \text{ m}^3/\text{hr}$ at 22°C 24/7



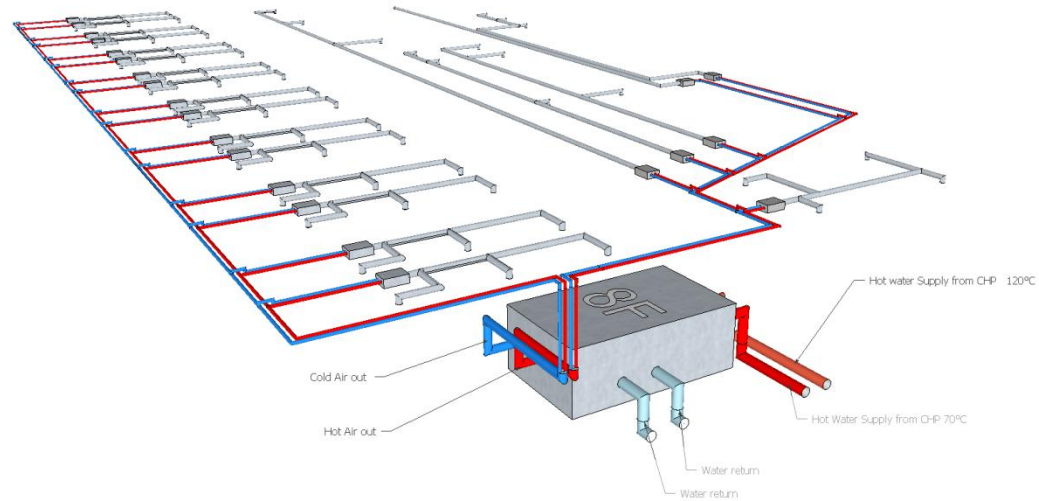
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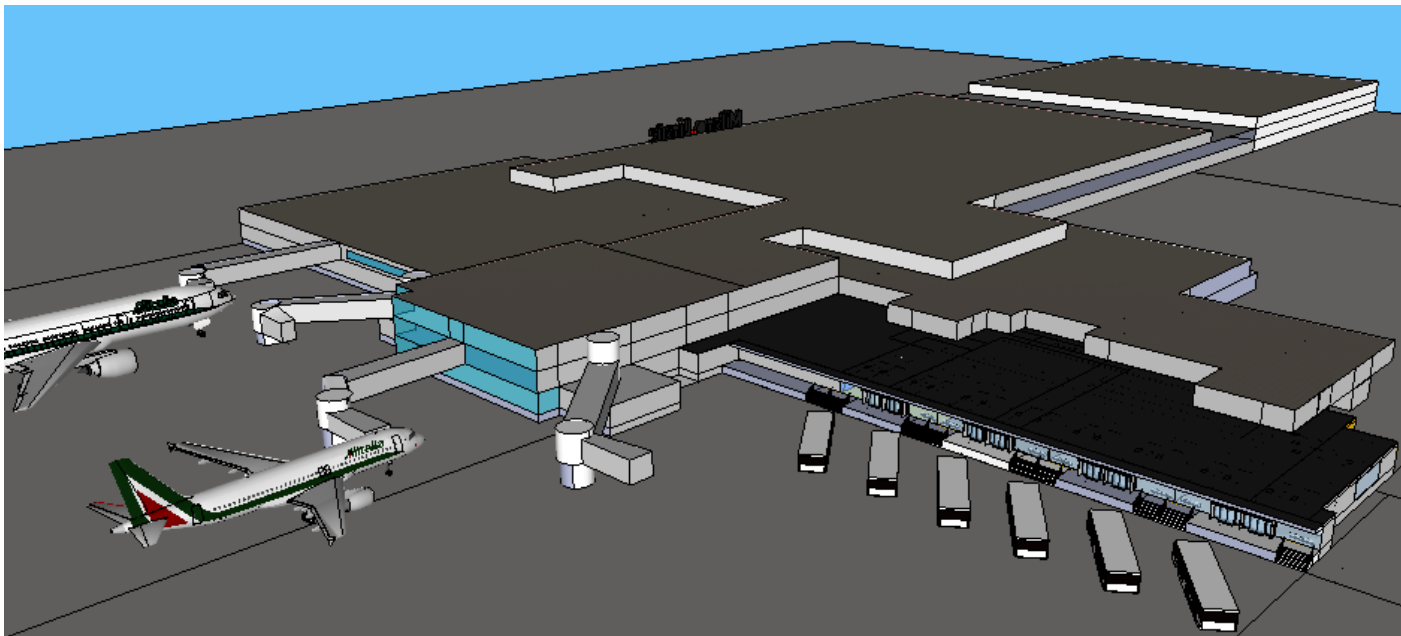
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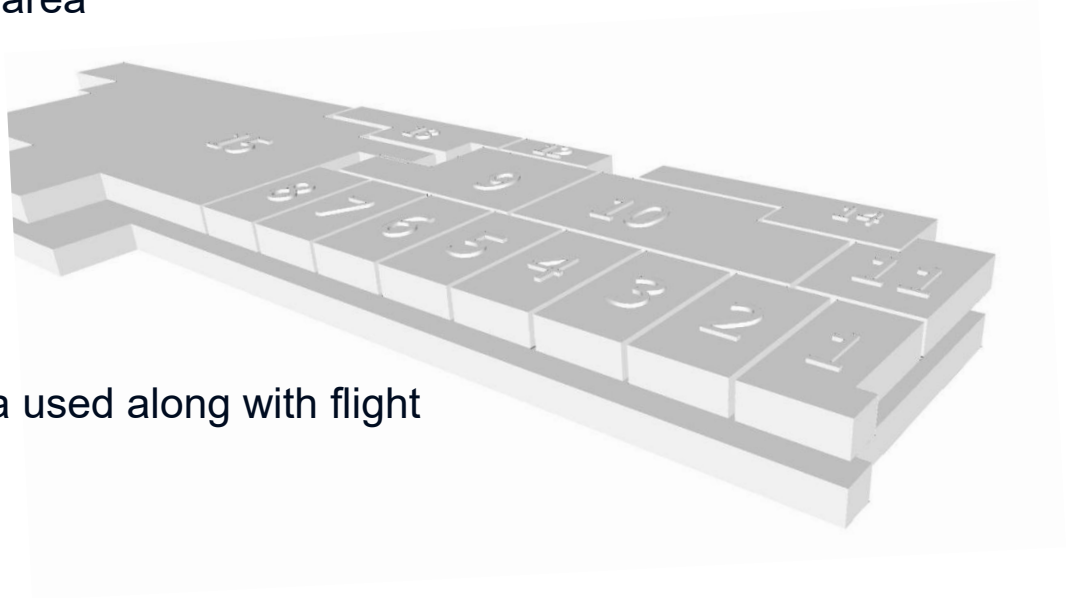


Envelope Simulation



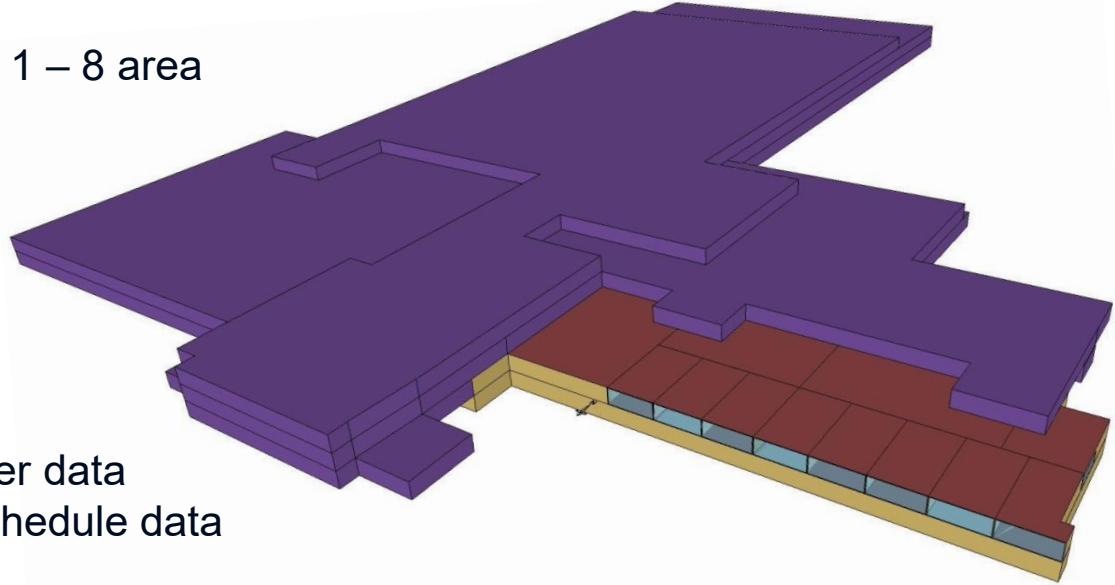
Envelope Simulation

- Simplified model of gate 1 – 8 area created in TRNSYS
- Simulated for June and December 2014
- Actual (adjusted) weather data used along with flight schedule data for occupancy

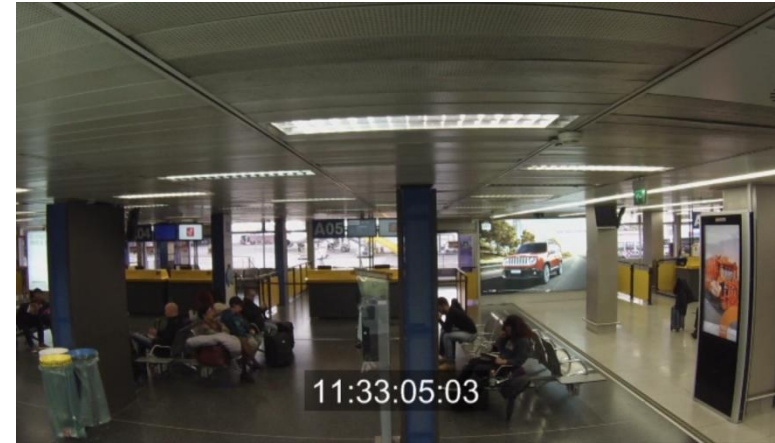
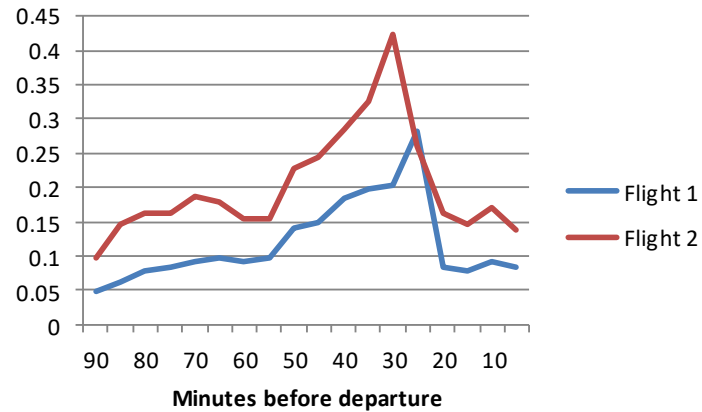


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Occupancy Estimation

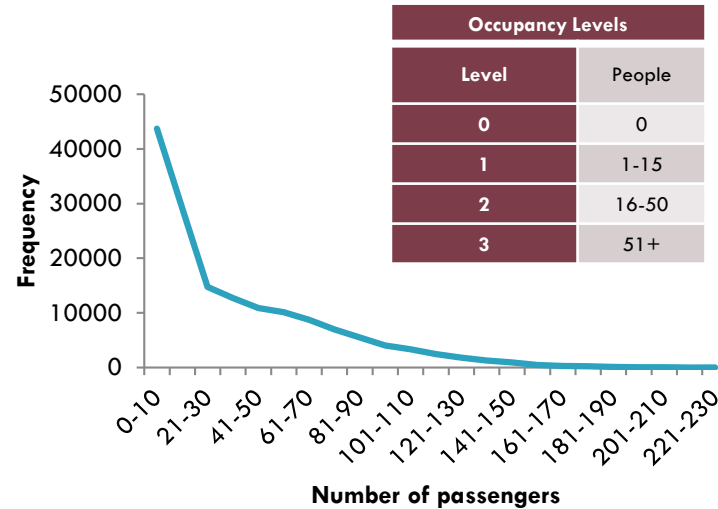


Mins	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5
% total	7.34%	10.49%	12.00%	12.36%	13.93%	13.87%	12.30%	12.65%	18.42%	19.59%	23.38%	26.12%	31.35%	27.09%	12.36%	11.19%	13.11%	11.14%
People	11	16	18	19	21	21	18	19	28	29	35	39	47	41	19	17	20	17

Time series estimation for a flight with 150 passengers boarding.

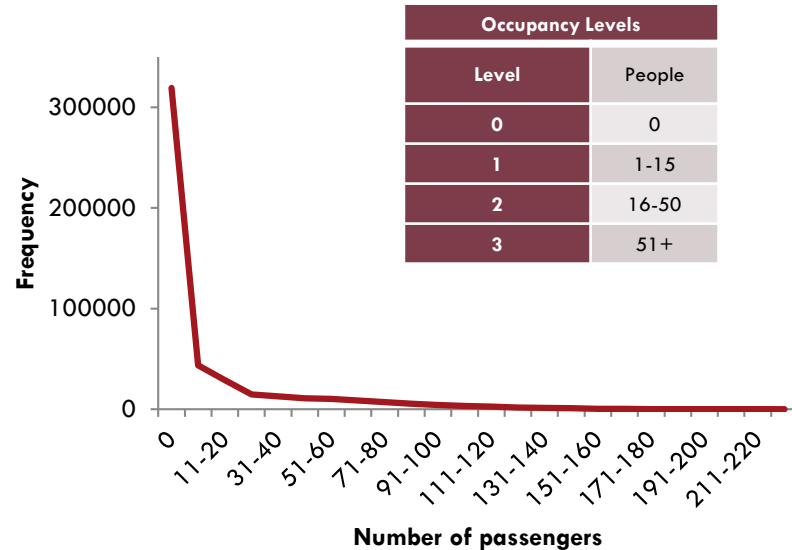
Occupancy Estimation

- 5 minute occupancy profile used to create a frequency distribution
- 74% of time gates not occupied
- Occupied periods focused on 3 levels created to maximise applicability with acoustic detection system



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Occupancy profile using flight schedule

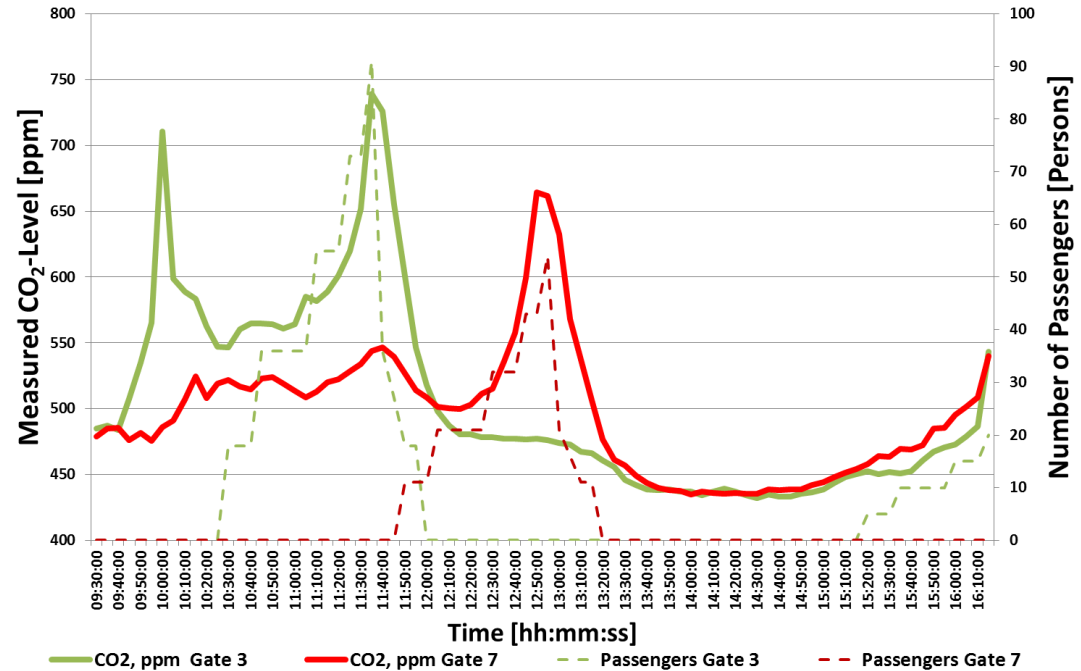
Airport	Year	Flight date	Gate	Pax Tot	Block off time	Scheduled time	Clearance Time
LIN	2014	01/07/2014	A01	46	0637	0640	0640
LIN	2014	01/07/2014	A01	58	0729	0725	0725
LIN	2014	01/07/2014	A02	130	0710	0655	0655
LIN	2014	01/07/2014	A02	68	0820	0820	0820
LIN	2014	01/07/2014	A02	80	1125	1125	1125
LIN	2014	01/07/2014	A02	148	1522	1515	1515
LIN	2014	01/07/2014	A02	58	1728	1725	1725
LIN	2014	01/07/2014	A02	119	1838	1820	1820
LIN	2014	01/07/2014	A02	86	2101	2105	2105
LIN	2014	01/07/2014	A03	139	0656	0655	0655
LIN	2014	01/07/2014	A03	92	0851	0855	0855
LIN	2014	01/07/2014	A03	137	1034	1035	1035
LIN	2014	01/07/2014	A03	67	1205	1205	1205
LIN	2014	01/07/2014	A03	143	1341	1340	1340
LIN	2014	01/07/2014	A03	131	1830	1830	1830
LIN	2014	01/07/2014	A03	78	2155	2155	2155
LIN	2014	01/07/2014	A04	93	0627	0630	0630
LIN	2014	01/07/2014	A04	131	0716	0715	0715
LIN	2014	01/07/2014	A04	150	1205	1155	1155
LIN	2014	01/07/2014	A04	83	1246	1255	1255
LIN	2014	01/07/2014	A04	71	1529	1530	1530
LIN	2014	01/07/2014	A04	115	1730	1730	1730
LIN	2014	01/07/2014	A04	157	1840	1835	1835
LIN	2014	01/07/2014	A04	129	2141	2130	2130

Date	Time	Gate							
		# of people							
		1	2	3	4	5	6	7	8
01/07/2014	04:50	0	0	0	0	0	0	0	0
01/07/2014	04:55	0	0	0	0	0	0	0	0
01/07/2014	05:00	0	0	0	6	0	0	0	0
01/07/2014	05:05	0	0	0	8	0	0	8	0
01/07/2014	05:10	3	0	0	10	0	0	13	0
01/07/2014	05:15	5	0	0	10	0	0	14	0
01/07/2014	05:20	5	0	0	12	0	0	14	0
01/07/2014	05:25	5	8	9	12	3	0	17	0
01/07/2014	05:30	5	12	13	10	4	9	17	10
01/07/2014	05:35	5	14	15	11	5	14	14	14
01/07/2014	05:40	5	14	15	15	5	16	16	17
01/07/2014	05:45	5	16	17	24	5	16	30	17
01/07/2014	05:50	7	16	17	31	5	18	34	20
01/07/2014	05:55	12	14	15	36	5	18	41	20
01/07/2014	06:00	14	15	16	41	5	16	45	17
01/07/2014	06:05	17	21	23	39	7	17	53	18
01/07/2014	06:10	19	23	23	27	7	23	48	25
01/07/2014	06:15	19	27	29	23	9	25	28	26
01/07/2014	06:20	13	31	32	26	10	31	28	32
01/07/2014	06:25	11	36	39	31	12	34	35	36

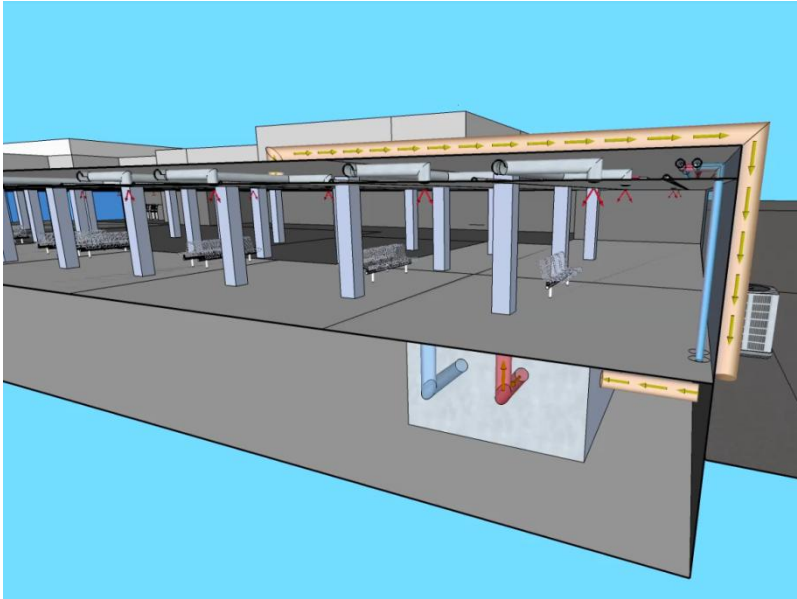
- Flight schedule feed into program
- Output 5 minute profile for every gate
- Other areas around can also be estimated

CO₂ measurements

- 500 - 1400 litres per second ventilation rate
- Peaks correspond with departures
- Potential for flow rate/fresh air reductions



Fresh Air



- By supplying outside air only when absolutely necessary energy consumption can be reduced significantly
- Rule of thumb $30 \text{ m}^3/\text{hr}/\text{person}$

Occupancy Levels		
Level	People	Mass Flow fresh air (m^3/hr)
0	0	0
1	1-15	450
2	16-50	1500
3	51+	2400

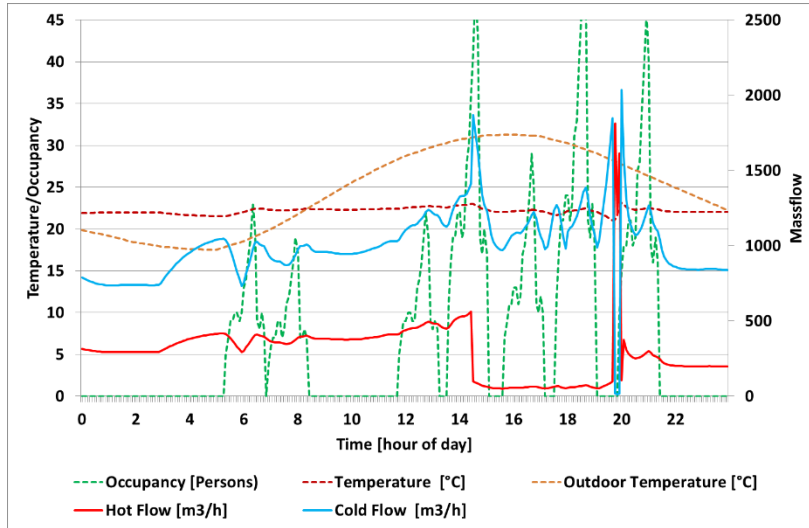
Final Set Points

	June			December			Fresh Air
	Hot Flow	Cold Flow	Flow Temp	Hot Flow	Cold Flow	Flow Temp	
Occupancy Level	m ³ /hr	m ³ /hr	°C	m ³ /hr	m ³ /hr	°C	m ³ /hr
0	150	200	21	1500	0	32	0
1	150	300	19	1000	200	29	450
2	300	1200	16	1200	300	28	1500
3	400	2000	15	1900	500	28	2400

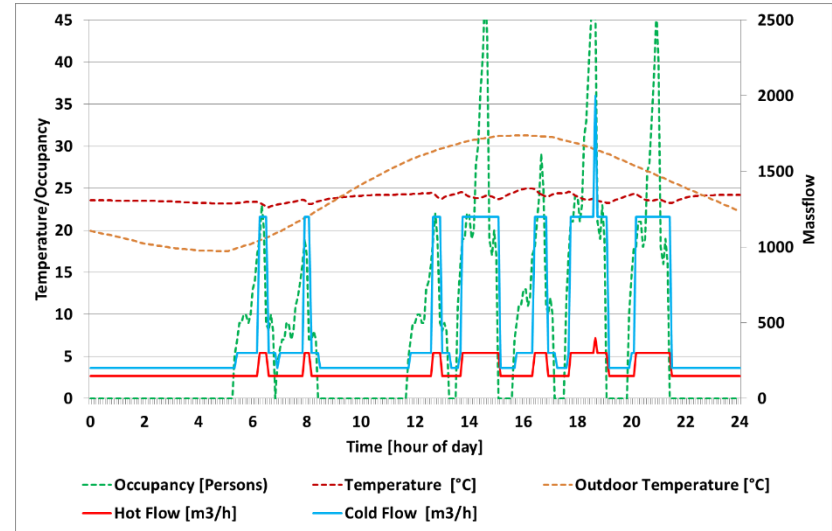
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3	51+

Simulation Results

Baseline



Occupancy Controlled

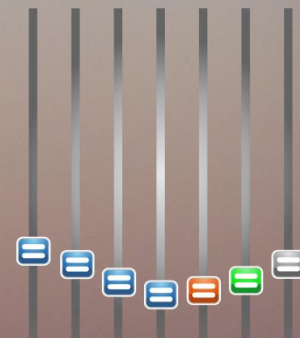


Simulated Mass flow, Occupancy and Temperature at Gate 5 on June 12

Simulation Results

- Key Principal:
 - Reduction of **Cooling** in the **Heating Season** and
 - Reduction of **Heating** in the **Cooling Season**
 - Reduction of overall Ventilation
- On average around 70% saving estimated

		Baseline June	Occupancy control June	Baseline December	Occupancy control December
		MWh	MWh	MWh	MWh
Cooling Energy		55.5	14.4	4.3	1
Heating Energy	Main coil	8.5	2.5	42.4	11.5
	Pre-Heat	0.5	0.01	25.7	2.1
Fan Energy		1.1	0.3	12.7	12.7
Total		424.3	123.1	418.6	234.4



S4ECob

SOUNDS FOR ENERGY
CONTROL OF BUILDINGS

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