Energy efficiency potential of demand-based ventilation and air-conditioning systems in commercial and public buildings

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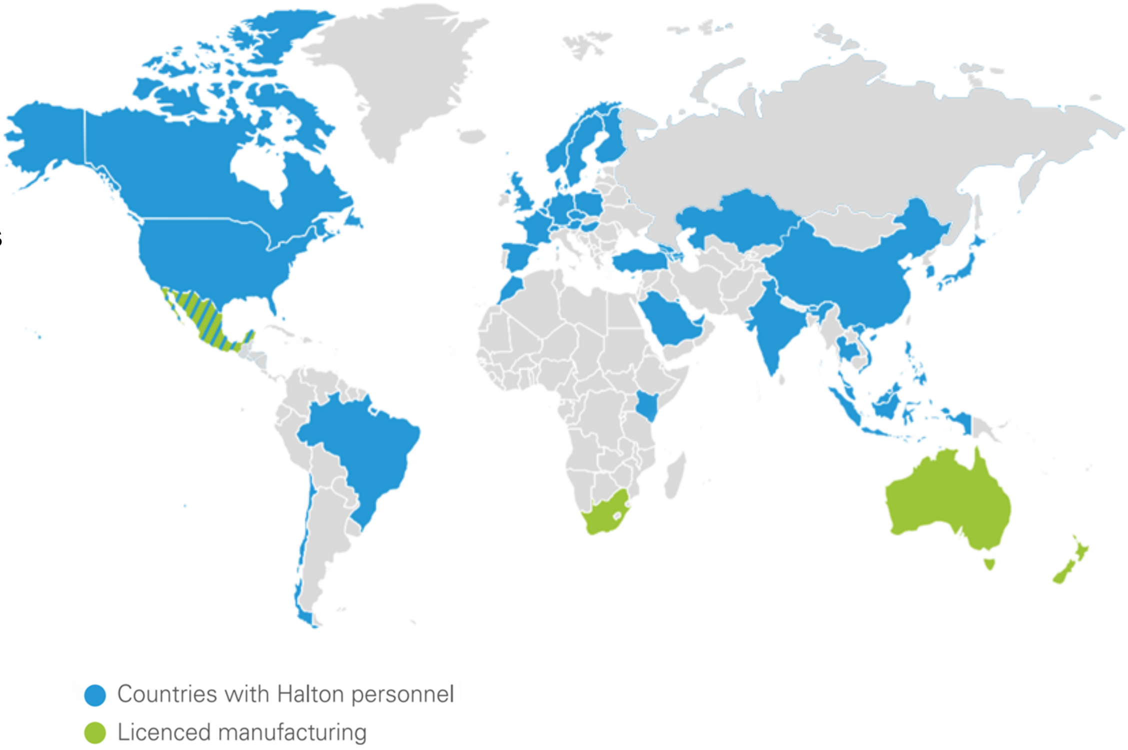
Contents

- Background of Halton
- Demand-based ventilation and air-conditioning systems
- Case study of office building for revealing the energy efficiency potential
- Demand-based ventilation systems for special applications

Background of Halton

Our operations are built close to customers

- Halton's mission to enable sustainable wellbeing in demanding indoor environments
- Family owned company founded in 1969
- Revenue 270 MEur in 2022
- 1900 people in over 35 countries
- Own production in 9 countries, 14 factories
- Group HQ in Finland, regional HQ's in USA and Malaysia
- 10 R&D Centers, *Halton Innovation Hubs*, in 8 countries around the world



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Customer areas we serve

- Professional kitchens
- Restaurants
- Food courts
- Food processing

- Workplaces
- Large spaces
- Public buildings
- Datacentres
- Healthcare
- Cleanrooms

- Ships
- Energy production environments
- Infrastructure

THE CHALLENGE

How to maintain healthy & safe, comfortable indoor environment quality with less resources being consumed?

Public and Commercial Buildings

Contribution to sustainability through solutions

HIGHLIGHTS

- Up to **50 % reduction** in energy consumption with demand-based HVAC systems
- **Reduced HVAC renovation** needs with flexible and adjustable systems
- **High-quality and reliable** systems for VAV (variable-air-volume) applications, including airflow management dampers, air diffusers, chilled beams and radiant panels
- Enabling use of **renewable energy** sources in:
  - High-temperature cooling and low-temperature heating air-water systems
  - Heating and cooling with photovoltaic electricity
- Supporting customers' **sustainability targets** through carbon-neutral production by the end of 2023

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Background of Halton

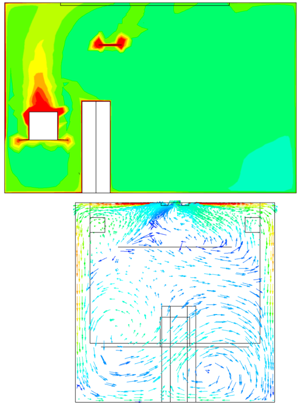
Halton Innovation Hub, Kausala

- R&D of indoor climate solutions with experimental and computational methods

- Standardized product measurements

- Tests of indoor climate conditons in customer projects, verification and selection of most optimal design

Enabling Wellbeing



Demand-based ventilation and air-conditioning systems

Demand based ventilation and Variable airflow systems; Energy saving potential

- Buildings in Europe account for

40%
of energy consumed

36%
of energy-related greenhouse gas emissions

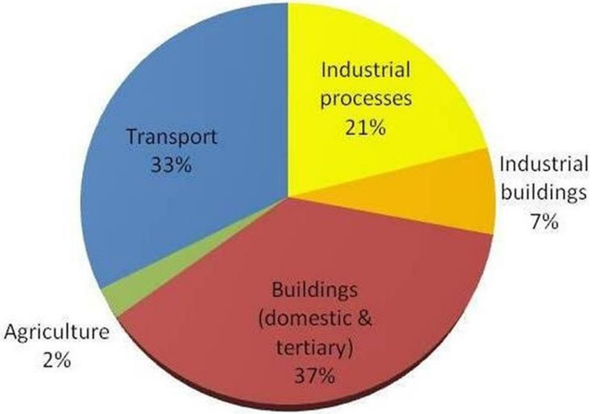


Figure 1: Share of total EU energy consumption (Energy World Magazine 02.2017, [

- The ventilation of buildings generates a significant part of that
- Energy saving potential by demand-based ventilation 20-50% from the energy used for ventilation
- Demand-based ventilation has the potential to improve both indoor climate conditions and energy efficiency in buildings

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Demand based ventilation and Variable Airflow Systems

Why to use variable airflow systems ?

Air quality

- maintenance of good air quality in spaces by increasing the ventilation rate when the need is high
  - Contamination rate / occupancy level is high

Thermal comfort

- maintenance comfortable indoor conditions by increasing the supply air rate when thermal loads / heat losses are high

Energy consumption

- conservation of energy by lowering supply air rate when
  - neither air quality nor thermal control does not require high flow rate
    - indicated by measurements
    - during non-occupied periods during office hours
  - maintain acceptable conditions in the spaces outside office hours

Special applications

- For instance, Contamination control in laboratories
  - Local exhaust airflow control to minimize contamination dispersion into the space ;
    - fume cupboards & exhaust benches etc.
  - Room airflow balance by supply air control

Applications & Building Types

Most beneficial in buildings and spaces where occupancy varies strongly
- daily
- hourly

Assembly buildings
- theatres, cinemas, concert halls
- exhibition halls

Conference facilities
- convention centers

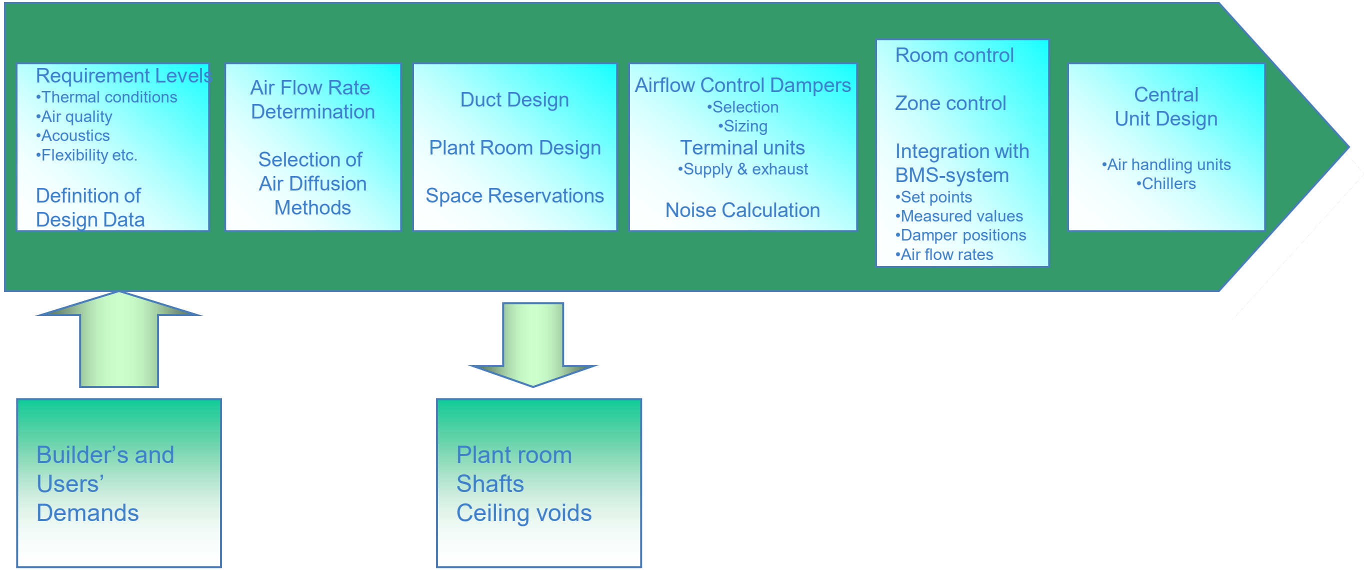
Hospitals
- patient care rooms
- laboratories (dedicated applications)

Commercial buildings
- shopping centers
- restaurants, hotels

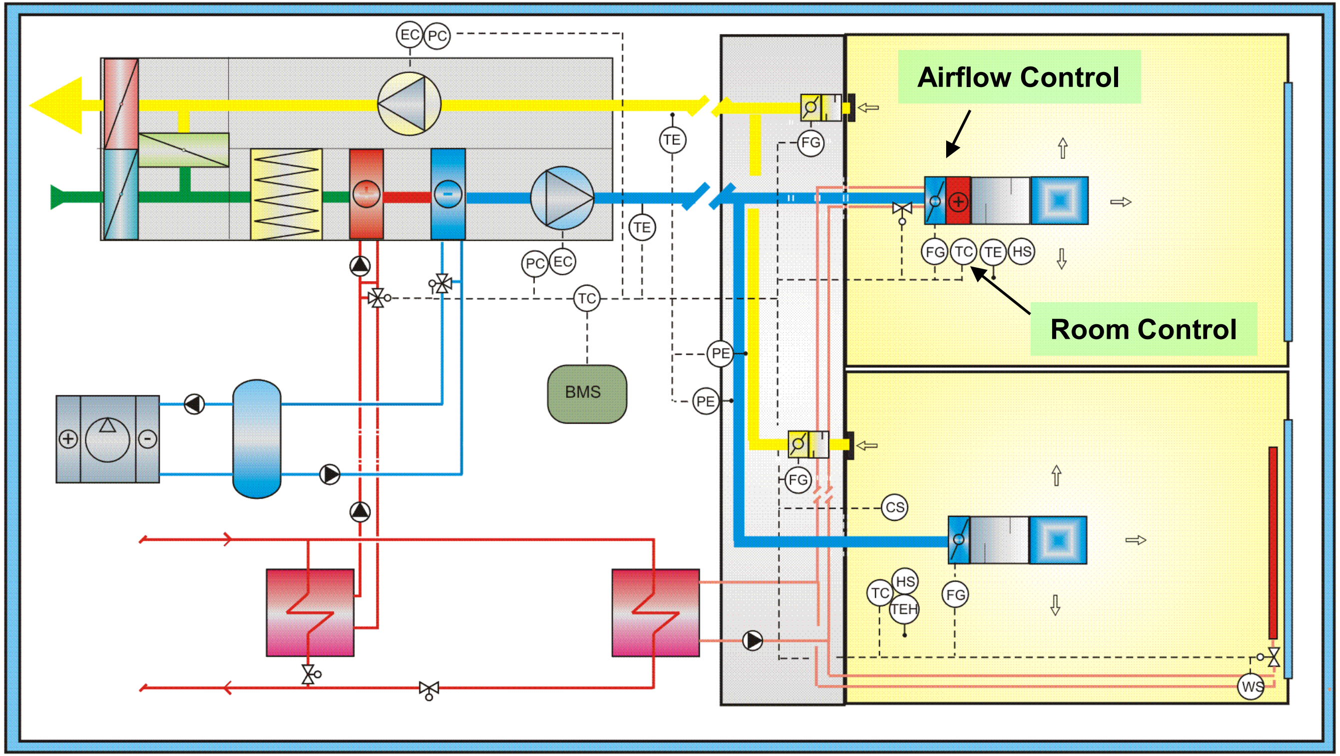
Educational Buildings
- universities, schools

Office buildings
- Meeting, team and conference rooms

Design Procedure
- begins with requirements for indoor environment



Example of
Demand-based system with pressure-independent airflow control



Variable Airflow Systems

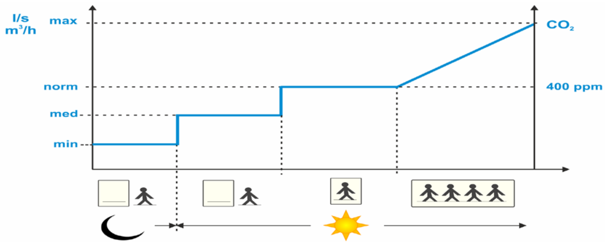
Room control ; Airflow range

Airflow range for variable airflow systems is typically defined is by minimum and maximum airflow rates

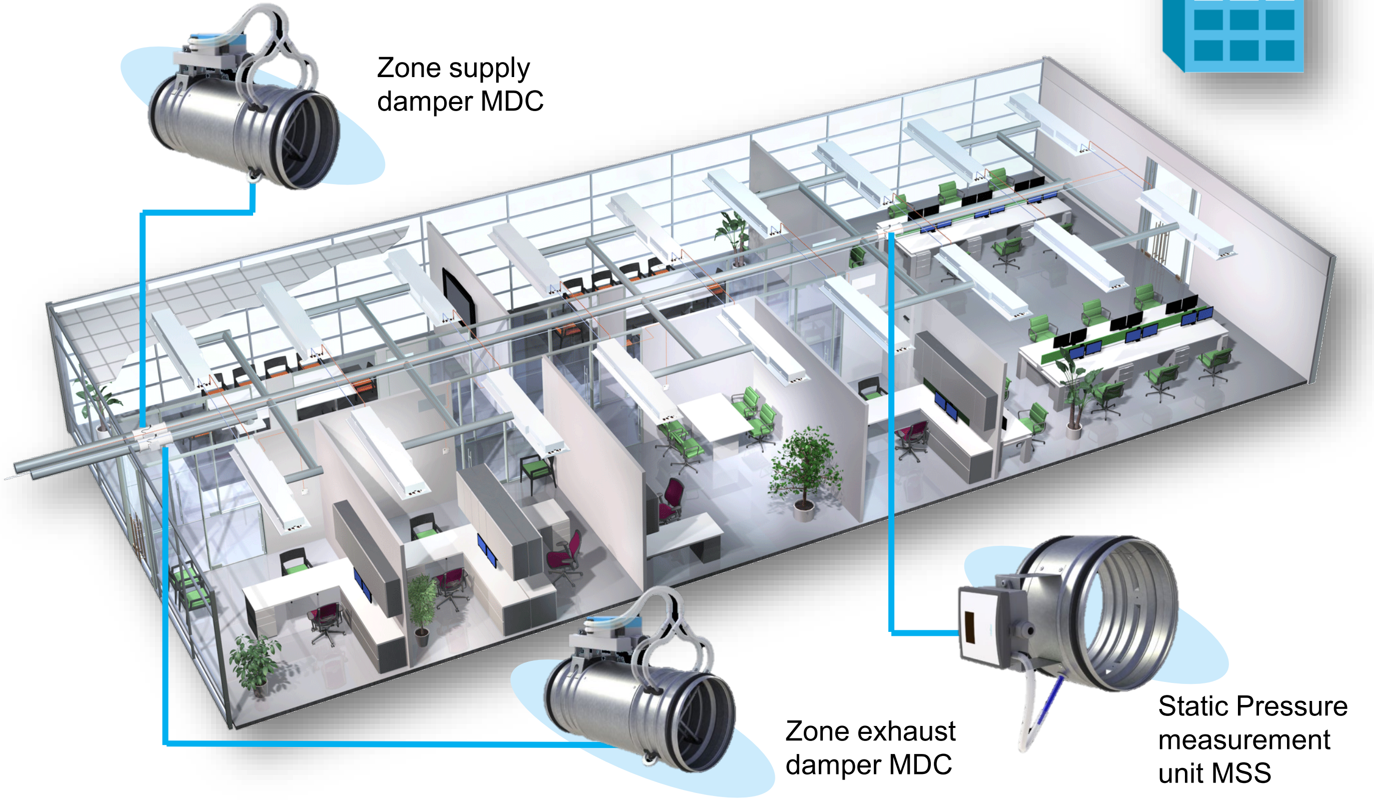
- Minimum airflow rate
  - Minimum airflow rate is typically defined by regulations / standards to be followed
    - Typical basis in offices are
      - Occupancy level during office hours
      - Contaminant release from building materials
  - Minimum airflow rate outside office hours
    - Typically meant to compensate building material contaminant release
- Maximum airflow rate
  - Maximum airflow rate is defined based on peak thermal loads / contaminant release rates

Also 3-step of 4-step airflow control sequences can be used. As an example ;

- Minimum air flow rate outside office hours
- 1st step standby airflow rate during office hours ; space is unoccupied
- 2nd step for occupied space during office hours
- proportional airflow control based on occupancy level or thermal loads



Flexible ventilation with constant pressure zones



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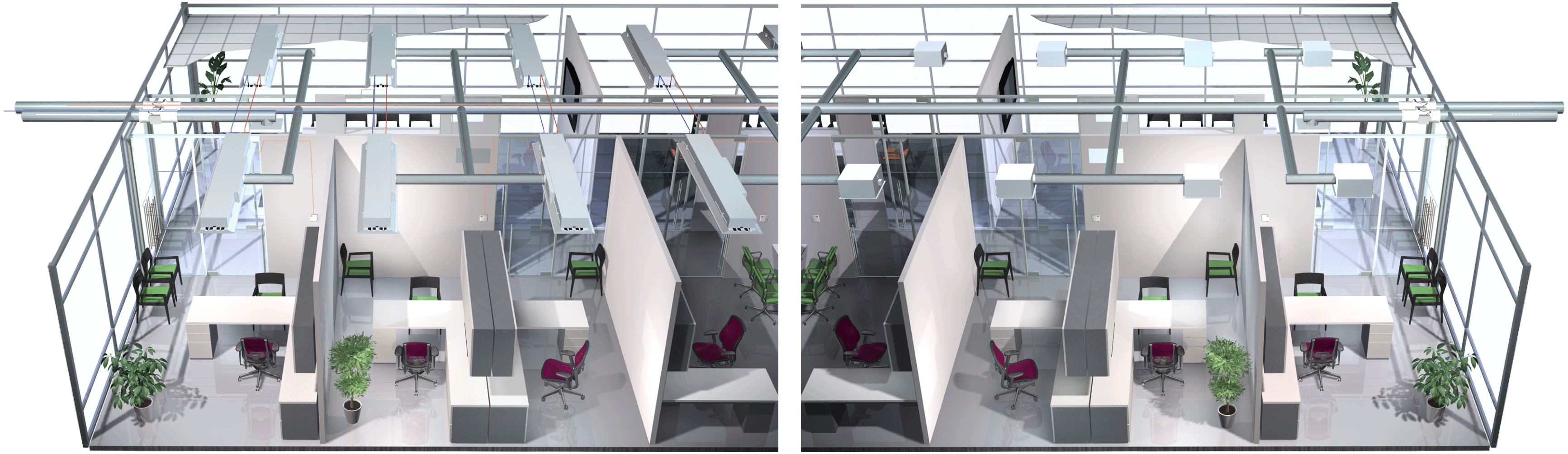
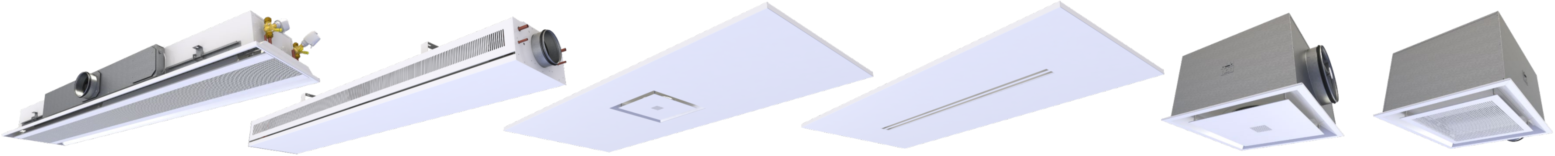
Halton Workplace system room unit alternatives



Air-Water System

All-air system



Support for both pressure independent / dependent room units

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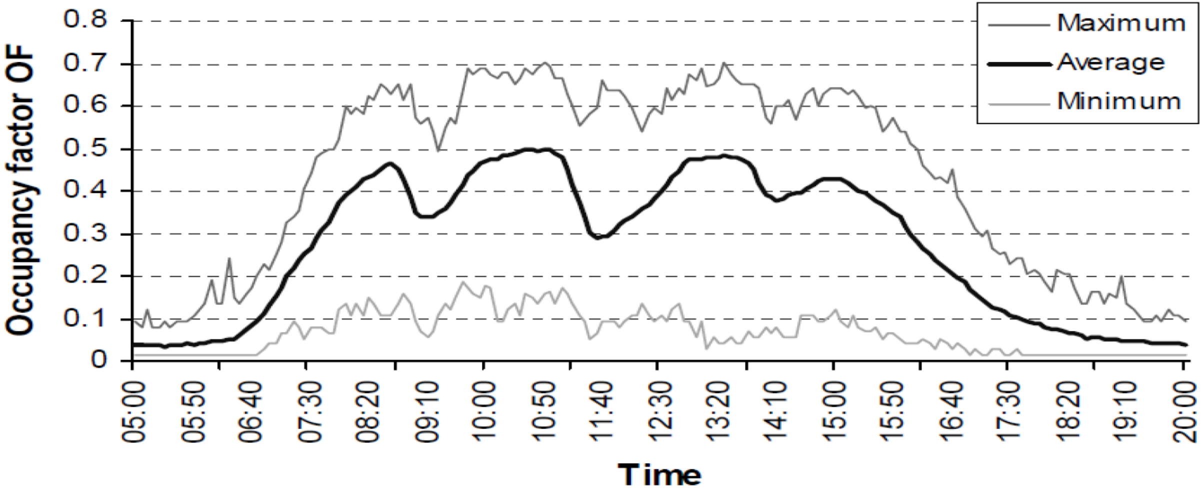
Demand-based ventilation system for office buildings

Halton Workplace Climate Plus solution

Energy efficiency study with dynamic energy simulation software

Target to study demand-based HVAC system performance with realistic office building usage



There is huge difference in the average occupancy ratio, but still in many cases occupancy ratio is low: 30-40% seat occupancy

(Halvarsson Johan. Occupancy Pattern in Office Buildings, Consequences for HVAC system design and operation. Doctoral thesis. Norwegian University of Science and Technology. 2012.)

Simulation tools used for energy modelling and HVAC ductwork simulation

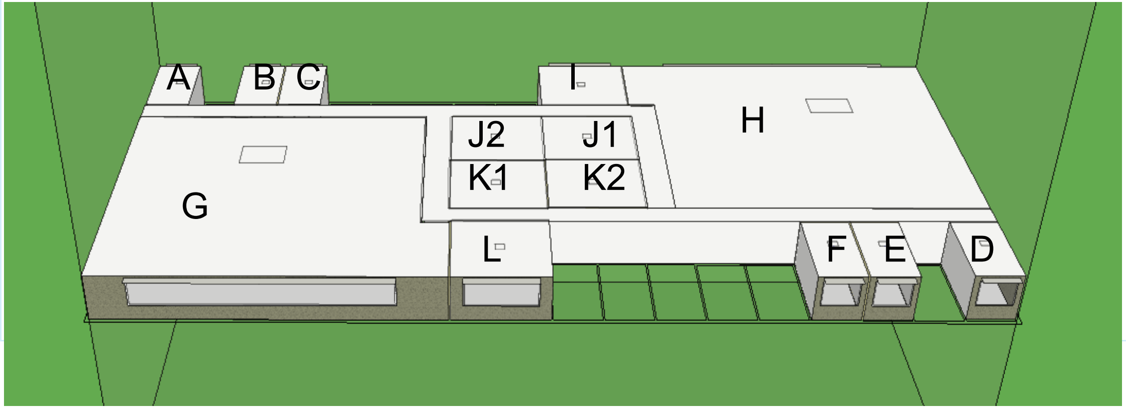
- **Simulation tool IDA-ICE 4.6**
  - Simulation software to model the building, its systems and controllers
  - Dynamic multizone simulation using finite difference method
  - Simulation of thermal indoor climate of individual zones
  - Energy consumption of the entire building

- **Halton specific calculation models in IDA ICE**
  - Air flow control in individual chilled beams

- **Halton HIT Balance**
  - Analysis of pressure conditions and air flow rates especially of constant pressure ductwork zones

Project building data

- 10 similar floors, 1100 m² each
  - Landscape office 57 %
  - Office rooms 20 %
  - Meeting rooms 15 %
  - Other 8 %
- Simulation for one middle floor



	Quantity	Area [m2]
A. Office N	1	13
B. Office N	3	13
C. Office N	5	13
Corridor	1	113
D. Office S	1	13
E. Office S	3	13
F. Office S	5	13
G. Open office S	1	290
H. Open office N	1	292
I. Meeting room N	1	27
J1. Meeting room	1	27
J2. Meeting room	1	27
K1. Meeting room	1	27
K2. Meeting room	1	27
L. Meeting room S	1	27

Internal loads

Office	Open office	Meeting room
Occupancy: 1 person variable 8-18	Occupancy: 40 persons variable 8-18	Occupancy: 14 persons variable
Lighting: 10 W/m² constant 8-18	Lighting: 10 W/m² constant 8-18	Lighting: 10 W/m² variable
Equipment: 15 W/m² variable 8-18	Equipment: 10 W/m² variable 8-18	Equipment: 25 W/m² variable

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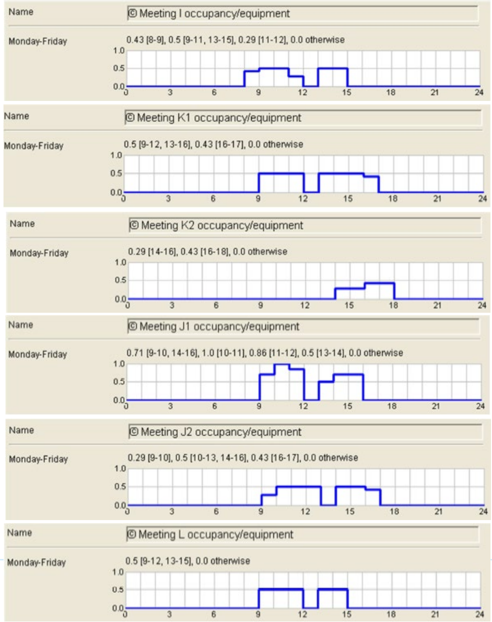
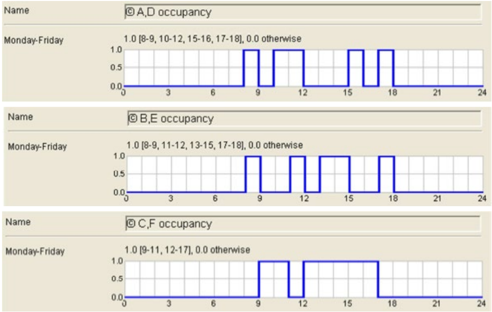
Occupancy profiles in energy simulation

Building occupied every week Mo-Fri from 8-18

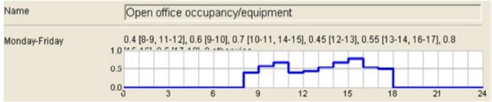
Meeting rooms:
Average occupancy 30%

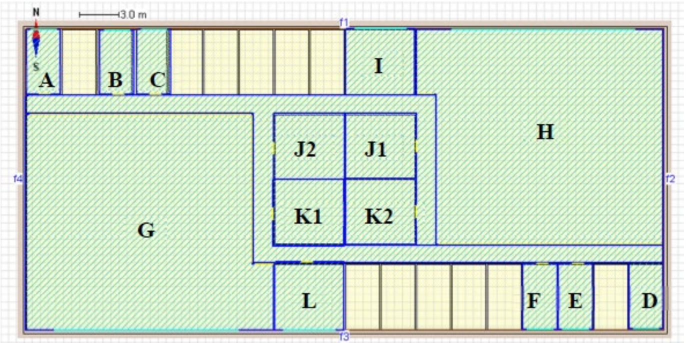


Office rooms:
Average occupancy 57%



Open offices:
Average occupancy 57%





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Air flows

- According to the standard EN 15251
- Category II
  - Ventilation for building emissions (low polluting building) 0,7 l/s/m²
  - Ventilation for occupancy 7 l/s/person
- Needed ventilation rates

	Area m²	Persons	Air flow for building emissions l/s	Air flow for occupancy l/s	Total air flow l/s	Total air flow l/s/m²
Office room	13	1	9.1	7	16.1	1.2
Open office	290	40	203	280	483	1.7
Meeting room	27	14	18.9	98	116.9	4.3

- Demand based ventilation in meeting rooms
  - Air flow min. 1.2 l/s/m² and max. 4.3 l/s/m²
- Ventilation in unoccupied rooms 0.35 l/s/m during office hours

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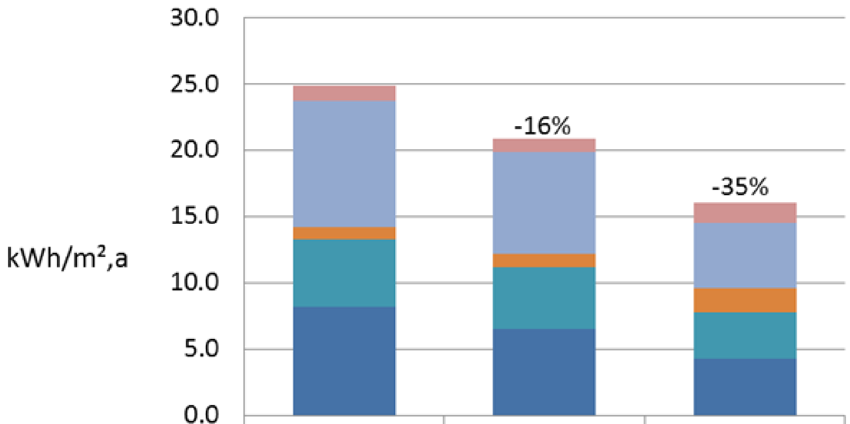
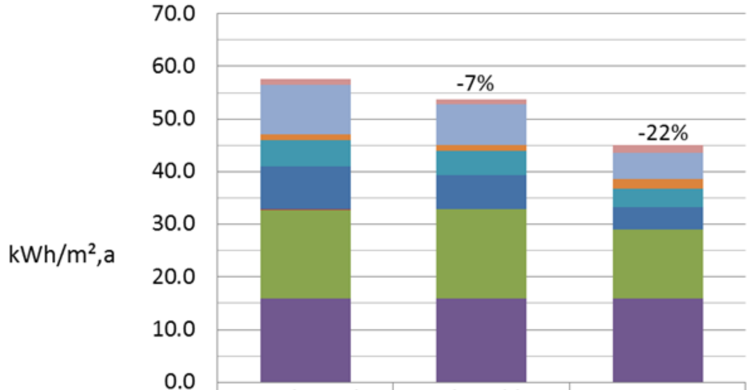
RESULTS – Paris with 57% occupation in offices



	Traditional beam	Adaptable beam	Vario beam
Heating of spaces	1.2	1.0	1.5
Heating of ventilation	9.4	7.7	4.9
Cooling of spaces	1.0	1.0	1.9
Cooling of ventilation	5.1	4.6	3.5
Fan energy	8.1	6.5	4.2
Pumping	0.1	0.1	0.1



	Traditional beam	Adaptable beam	Vario beam
Heating of spaces	1.2	1.0	1.5
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Cooling of spaces	1.0	1.0	1.9
Cooling of ventilation	5.1	4.6	3.5
Fan energy	8.1	6.5	4.2
Pumping	0.1	0.1	0.1
Lighting	16.9	16.9	13.1
Equipment	15.9	15.9	15.9

- Traditional beam case with 57% average occupation in offices – constant airflow rates
- Adaptable beam with 57% occ. – with variable airflow rates in meeting rooms
- Vario beam1 with 57% occ. - 0.35 l/s,m^2 in unoccupied rooms and thermostat settings 19/28C

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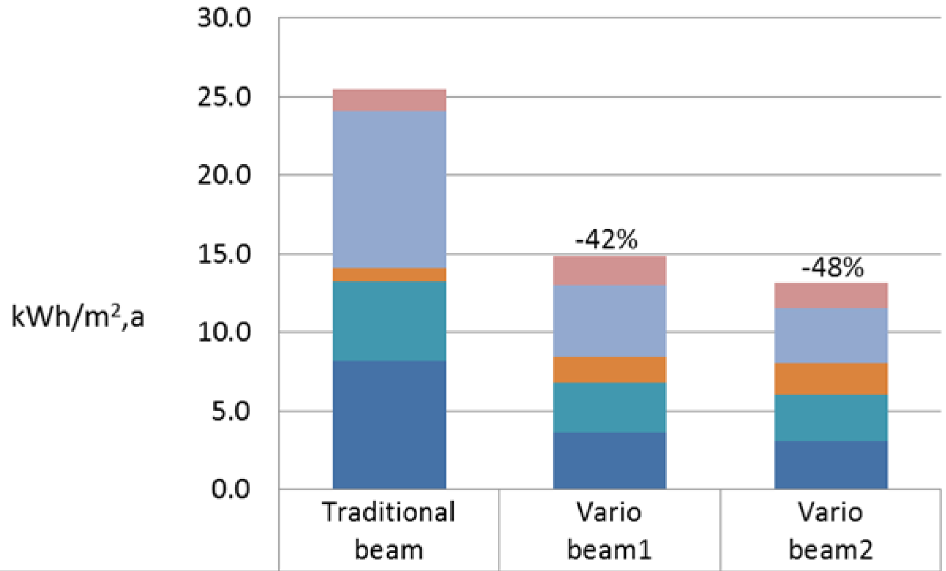
RESULTS – Paris with 37% occupation in offices



	Traditional beam	Vario beam1	Vario beam2
Heating of spaces	1.4	1.8	1.6
Heating of ventilation	10.0	4.6	3.5
Cooling of spaces	0.8	1.6	2.0
Cooling of ventilation	5.1	3.2	2.9
Fan energy	8.1	3.6	3.1
Pumping	0.1	0.1	0.1

- Traditional beam case with 37% average occupation in offices
- Vario beam1 with 37% occ.
  - With 0.35 l/s,m² in unoccupied rooms and thermostat settings 19/28C
- Vario beam2 with 37% occ.
  - With 0 l/s,m² in unoccupied rooms and thermostat settings 19/28C

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Demand-based ventilation systems for special applications

Halton M.A.R.V.E.L.

commercial kitchen ventilation solution

Towards Carbon Neutral Restaurants

- **Restaurants are among the buildings with the highest energy intensity in commercial sector**
- Cooking equipment and HVAC systems contribute for up to 80% of total restaurant energy consumption
- Energy efficiency is a path for net-zero energy restaurants and from engineering perspective this goal is achievable today

https://www.wsp.com/en-US/insights/2021-mcdonalds-opens-first-net-zero-restaurant

McDonald's Opens First Net-Zero Restaurant at Disney World

Key Solutions for Energy Efficiency

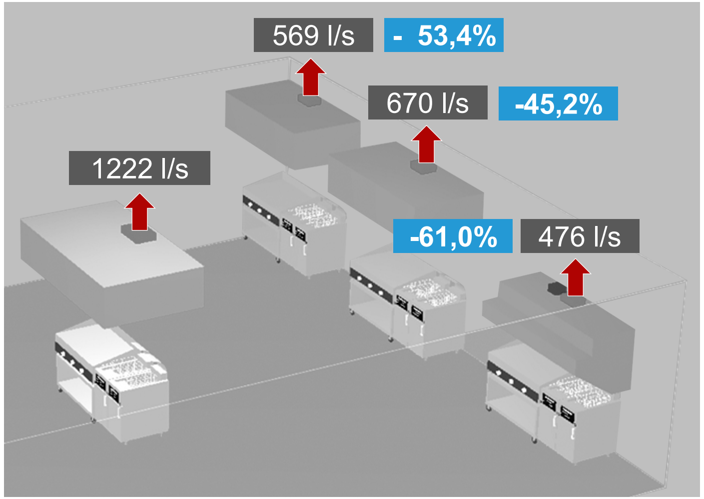
1. **Use high efficiency cooking appliances.**
   Cooking process and equipment effectively defines restaurant energy consumption.

2. **Place cooking equipment near walls** rather than in the middle of a kitchen.

3. **Taylor ventilation design for specific cooking equipment.**
   Main objective is to minimize hoods exhaust airflow because it defines HVAC system energy consumption.

4. **Use high efficiency hoods** and **Demand Controlled Ventilation** to minimize kitchen exhaust airflow.

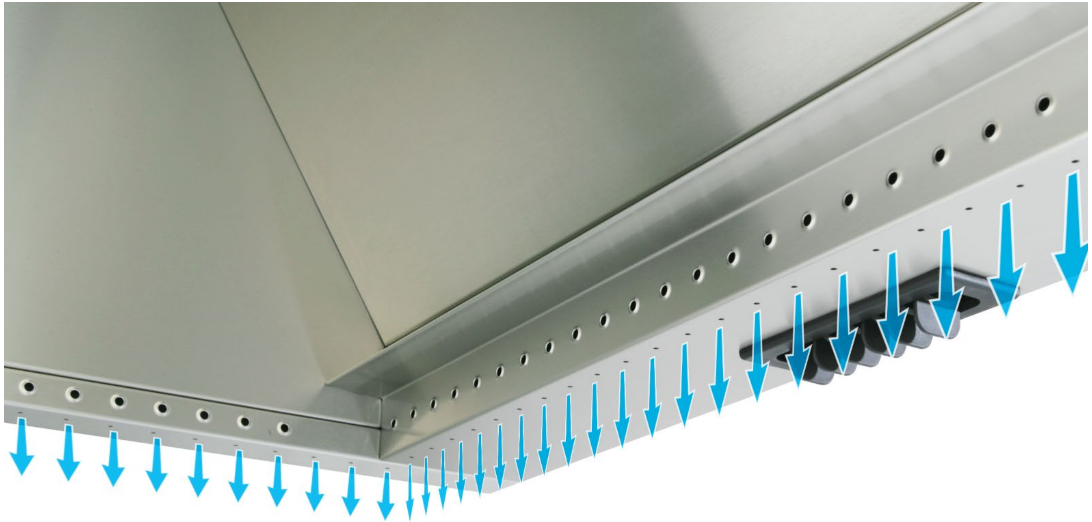
5. **Design air distribution system to avoid cross-drafts, effective space cooling and ventilation**



Appliance position and hood selection have **major impact on exhaust airflow**

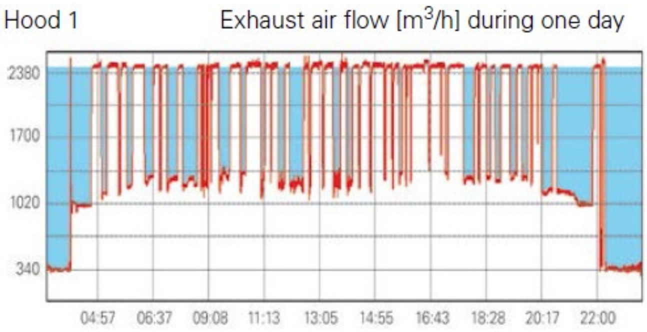
Capture Efficiency = Energy Efficiency

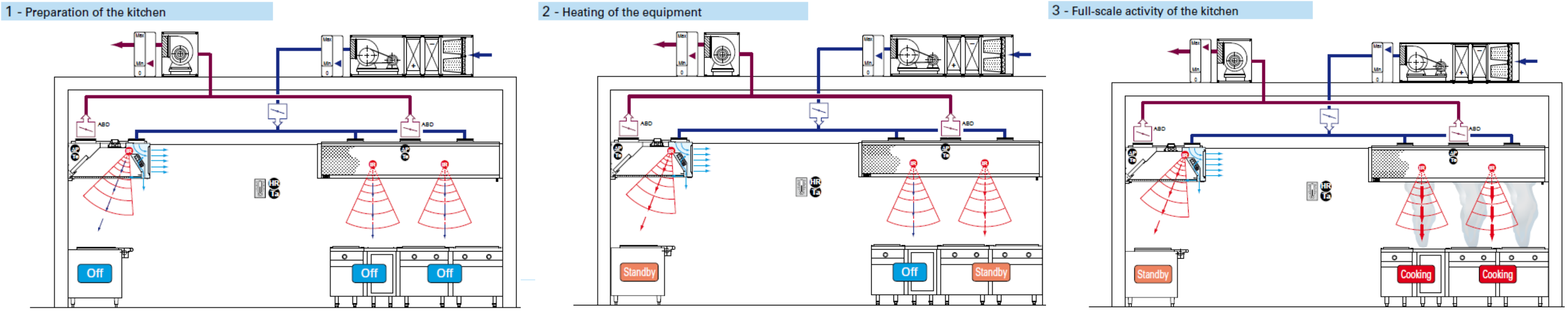
Halton's Capture Jet™ hoods require less exhaust airflow to capture effluents from cooking equipment



Halton M.A.R.V.E.L. demand-based ventilation solution

- Variable exhaust airflow rates controlled by infrared radiation sensors in kitchen hoods with three operating modes: switched off, heating up and cooking in progress
- Balance between supply and exhaust ventilation maintained with motorized dampers
- 44% energy savings reported from case study restaurant
- Connected to IoT platform Halton Connect & Care





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Thank You!