Benefits of sensor controlled ventilation

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Benefits of sensor controlled ventilation

- **Demand controlled ventilation in office cubicles – can it be profitable?**
  - Theoretical study

- **Occupancy density and benefits of demand-controlled ventilation in Norwegian primary schools**
  - Empirical and theoretical study

Demand controlled ventilation in office cubicles – can it be profitable?

- **Maximum profitable investment:**
  - **Due to reduced energy use only**
  - **Due to reduced energy use, installation cost and reduction of technical area**

Basis for calculations

No.	Category	Energy Demand (kWh/m²year)
1	Local heating	65
2	**Central heating** = $E_{ch\text{-}CAV}$	**12**
3	Hot water	12
4a	**Fans** = $E_{fa\text{-}CAV}$	**33**
4b	Pumps	15
5	Lightning	45
6	Equipment	27
7	Local cooling	20
8	**Central cooling** = $E_{cc\text{-}CAV}$	**6**
Sum		235

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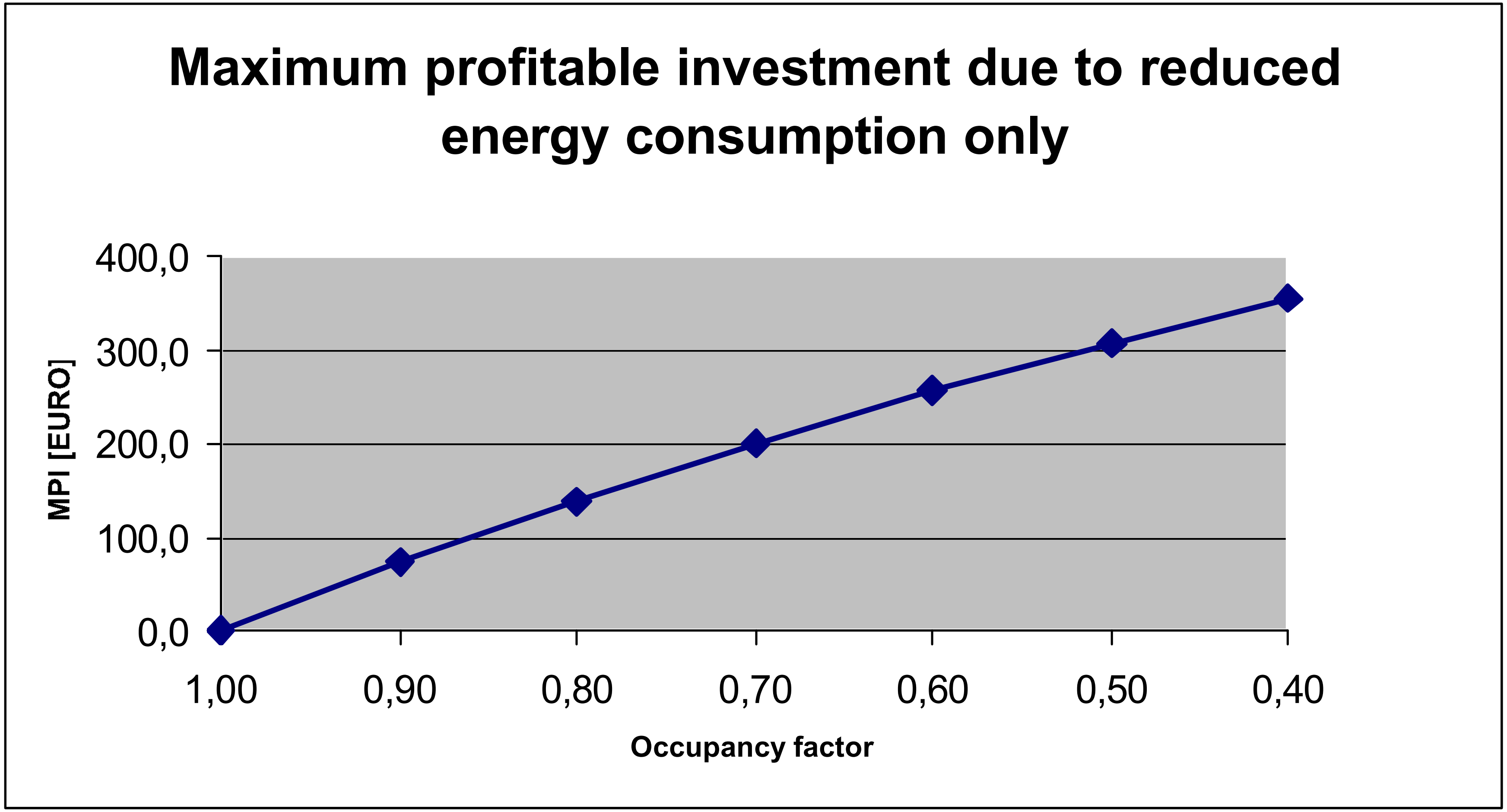
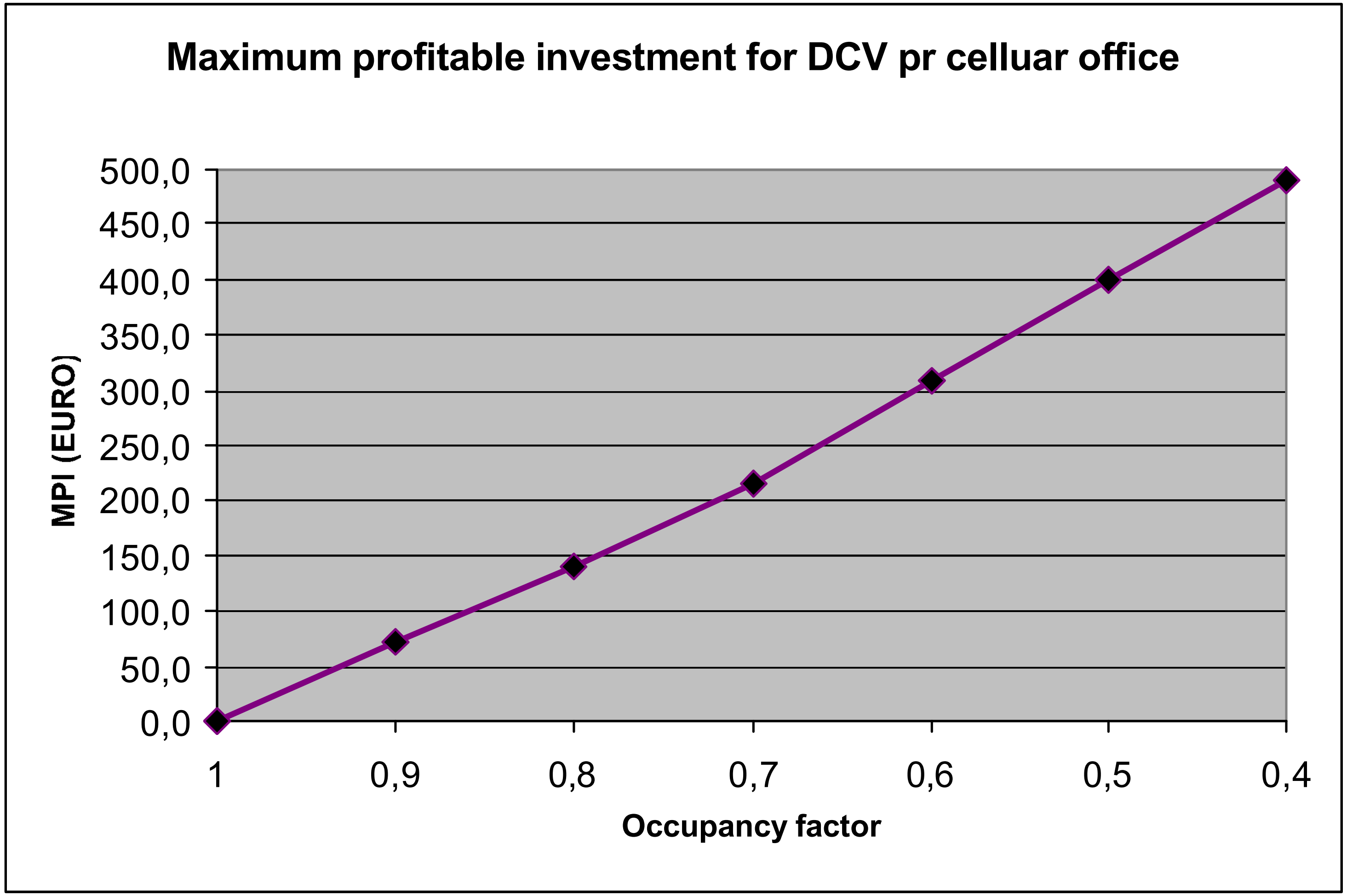
Basis for calculations

- Specific ventilation rate: 10 m³/(hm²)
- Minimum ventilation rate factor: 0.2
- Specific fan power: 4 kW/(m3/s)
- Hours of use: 3000 h
- Real interest: 5%
- Predicted lifetime: 20 years
- Electrical energy cost: 0.083 EURO/kWh
- Thermal energy cost: 0.064 EURO/kWh
- Specific ventilation cost: 7.75 EURO/(m³/h)
- Share of the ventilation system which can be reduced with DCV: 60%
- Relationship between necessary area for the air-handling unit and the corresponding conditioned airflow in m3/h: 0.8%
- Total building cost for technical area: 1200 EURO/m²

Due to reduced energy use only



Energy use, installation cost and reduction of technical area



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Increased electrical energy cost

- Electrical energy cost of 0.25 EURO/kWh
- MPI is 700 EURO per celluar office

Occupancy density and benefits of demand-controlled ventilation in Norwegian primary schools

Find the

- *Actual* occupancy density
- *Actual* hours of use of the ventilated areas
- Analyse the influence of different ventilation strategies on ventilation air volume and energy use

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Ventilation control strategies

- CAV: 30 occupants - 7 l/s·person and an additional 1 l/s·m²
- DCV-CO_2: Actual number of occupants. Minimum airflow of 1 l/s·m² when the CO_2-level is less than 700 ppm. The minimum airflow is maintained until the CO_2-level rises to 900 ppm after the start of the lesson. The ventilation rate is then increased and regulated to keep the CO_2 concentration at a steady state level of 900 ppmv. At the end of the lesson this ventilation rate is maintained until the CO_2-level drops below 700 ppmv when the ventilation rate is reduced to minimum (1 l/s·m²).
- DCV-IR: 30 occupants (7 l/s·person) plus an additional 1 l/s·m². Minimum airflow - when the classroom is unoccupied. Design airflow when the classroom is in use).

Inspection of 157 classes

	Mean	Min.	Max.	Standard deviation
Pupils assigned to the class	22.3	13.0	28.0	3.5
Pupils present during inspection	20.9	13.0	28.0	3.6
Teachers present during inspection	1.3	1.0	3.0	0.5
Floor area of classroom [m²]	61.5	43.0	93.0	8.2
Volume of classroom [m³]	190.0	150.0	285.0	31.0
t_{use} - Use of classroom during inspection day [h]	4.0	3.0	5.0	0.4

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Occupancy density

	Mean	Min.	Max.	Standard deviation
Occupancy density [pupils/m²]	0.37	0.21	0.62	0.07
OF1 - Number of pupils present divided by the number of pupils assigned to the classroom	0.94	0.70	1.00	0.06
OF2 - Number of occupants (pupils + teachers) present divided by 30 (which is assumed to be design maximum)	0.74	0.47	1.00	0.12

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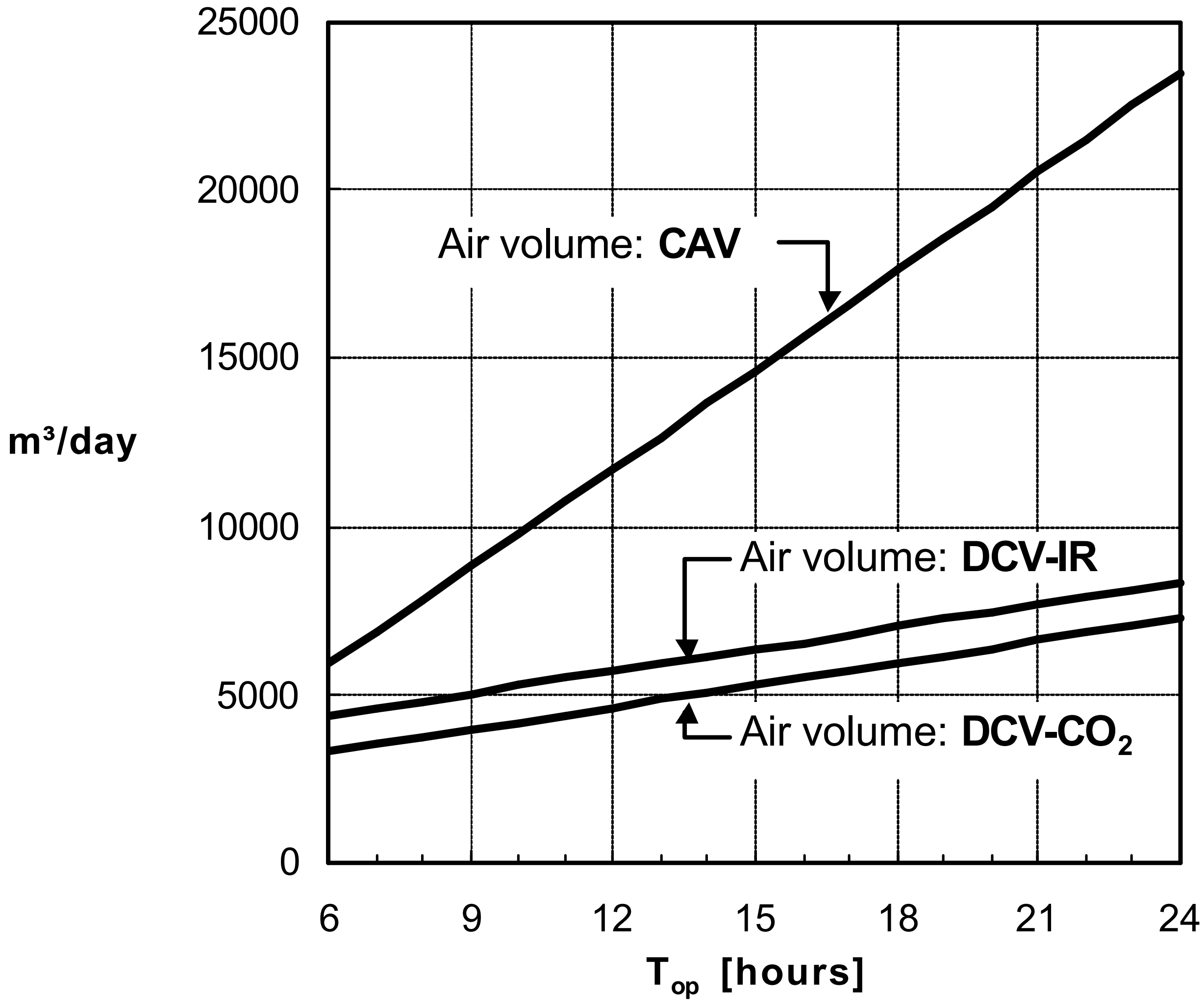
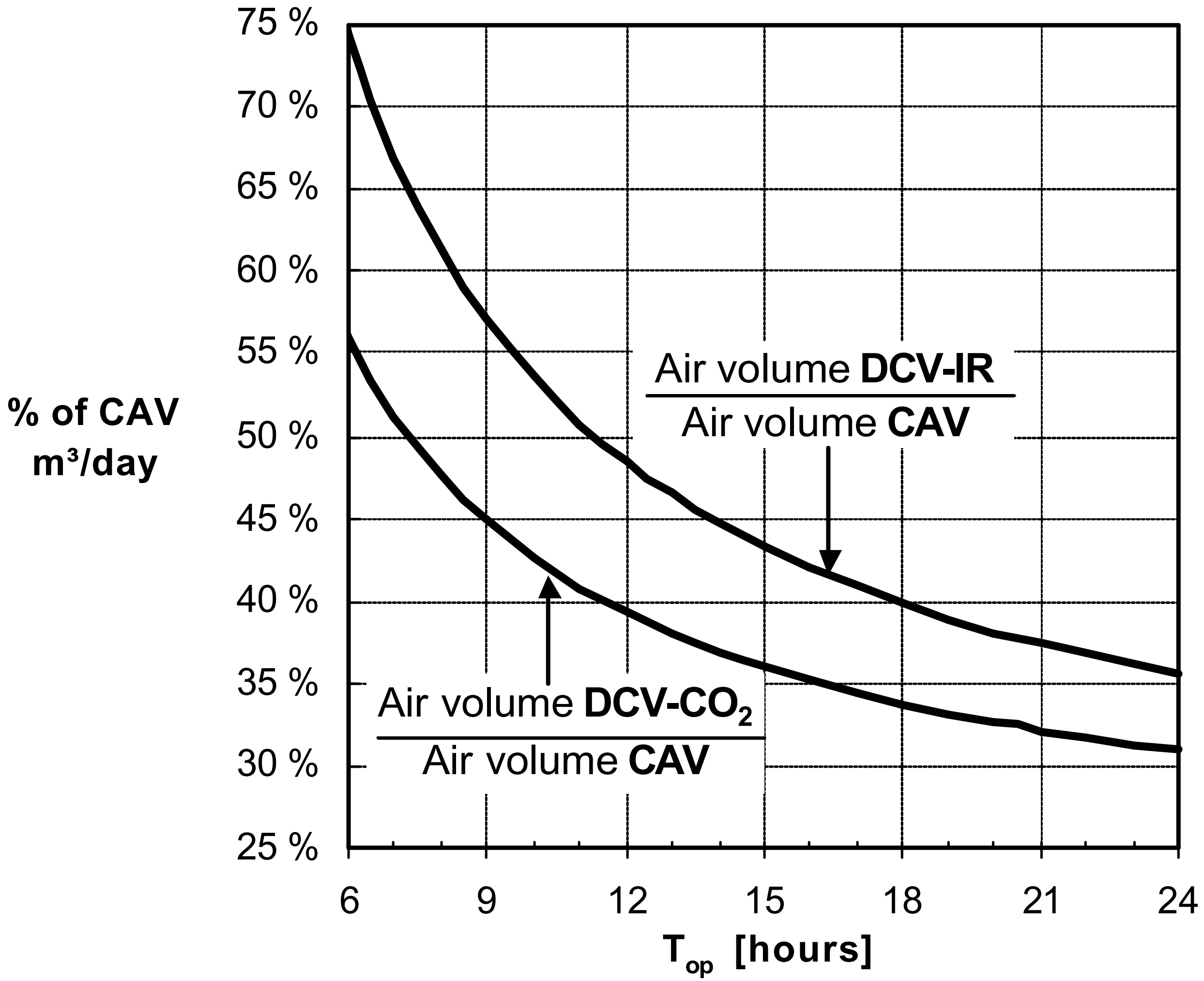
AHUs operation period on ventilating air volume



AHUs operation period and ventilating air volume in % of CAV



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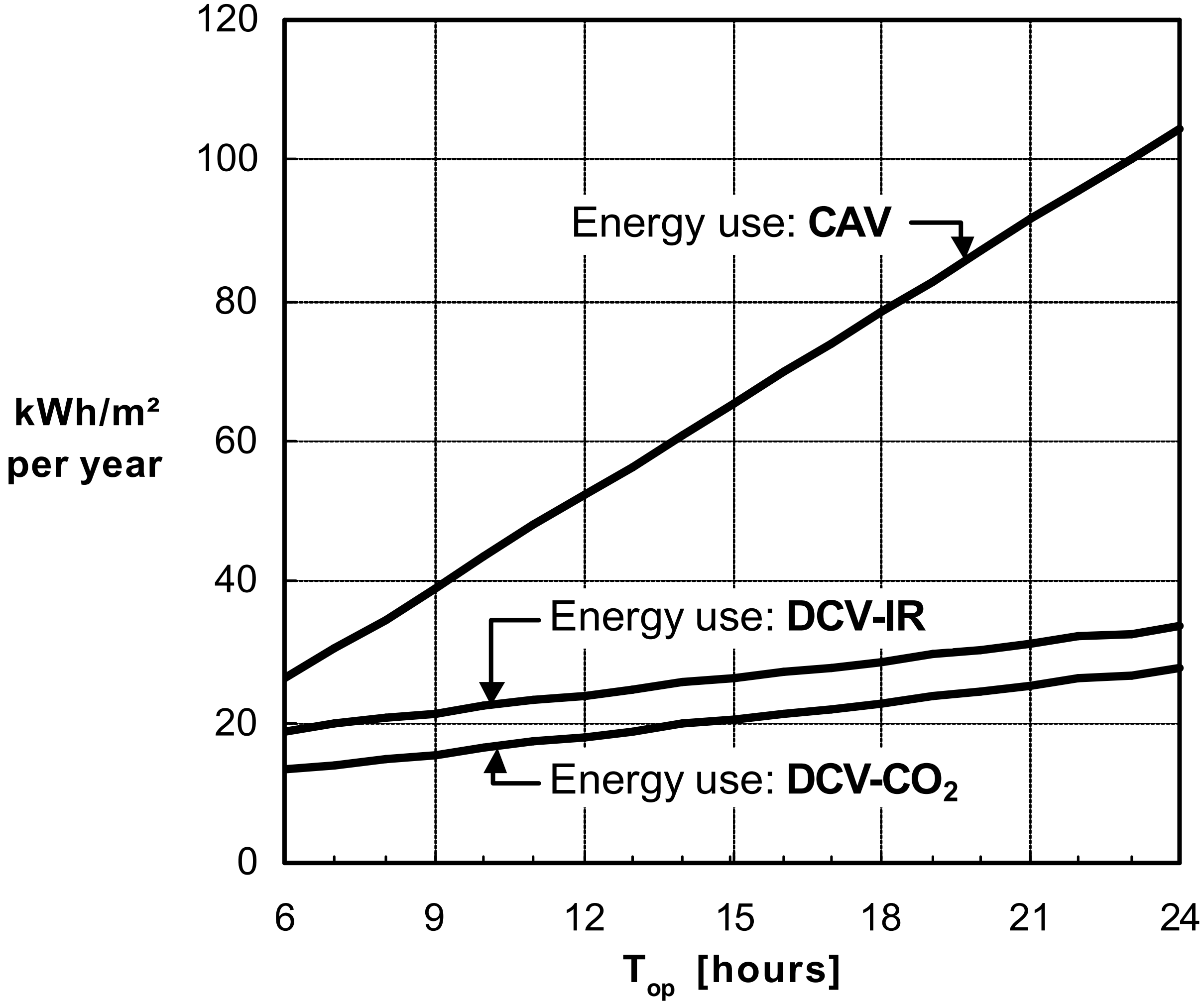
AHUs operation period and energy use



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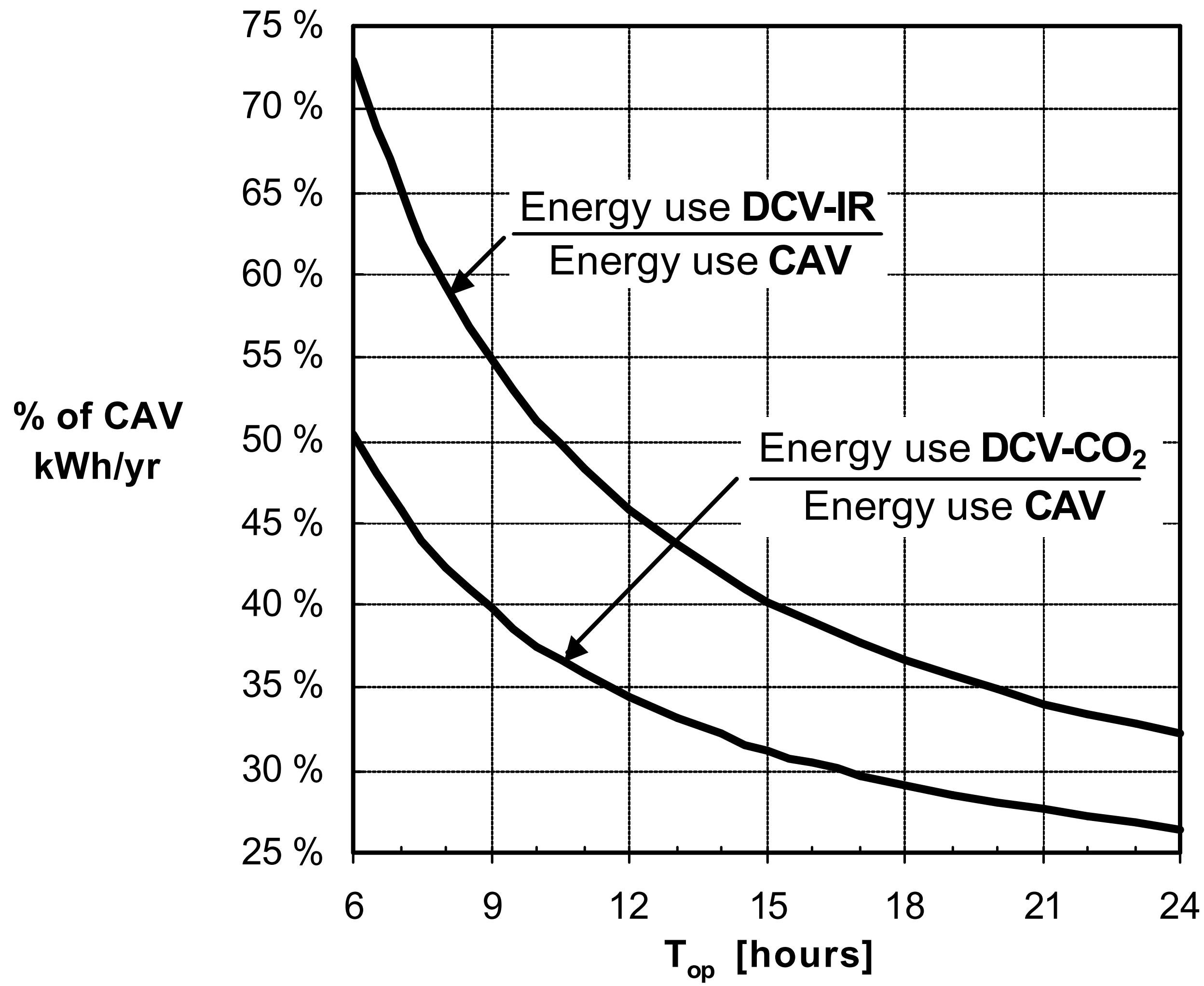
AHUs operation period and energy use in % of CAV



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Ventilation control and energy use

- 74% of classrooms max capasity used
- 4 hours use for school activities

- CAV 100% energy use or 50 kWh/m2
- DCV-IR 51% or 26 kWh/m2
- DCV-CO2 38% or 19 kWh/n2

CO_2 –level a poor measure of PAQ

Fang: Increasing the airflow from 3.5 l/s per person to 10 l/s per person did not seem to influence perceived air freshness and difficulty in thinking clearly at constant temperature of 20°C and relative humidity of 40%

CO_2 and temperature – a better measure of PAQ

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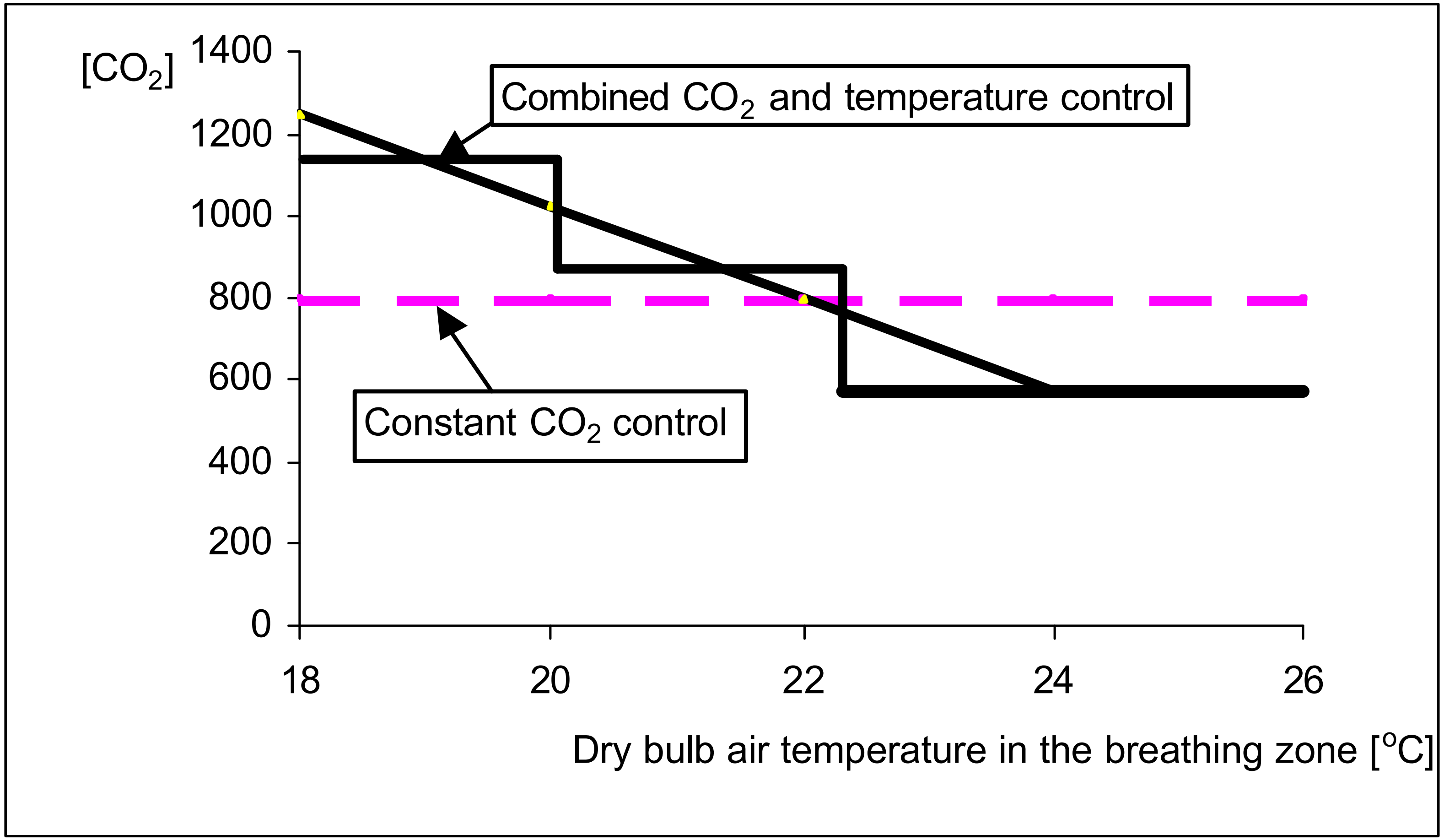
Is temperature compensated CO_2 set-point an option?



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Is temperature compensated CO_2 set-point an option?

- Existing standards CR1752/ASHRAE -
  - air volume per people
  - do not include temperature influence on PAQ
- A barrier towards pragmatic ventilation strategies

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Final perspectives on ventilation control

- Goal: Sustainable built environment
- 40% global resource consumption
- Factor 4/Factor 10
- CAV – enormous energy waste
- DCV – one step further

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