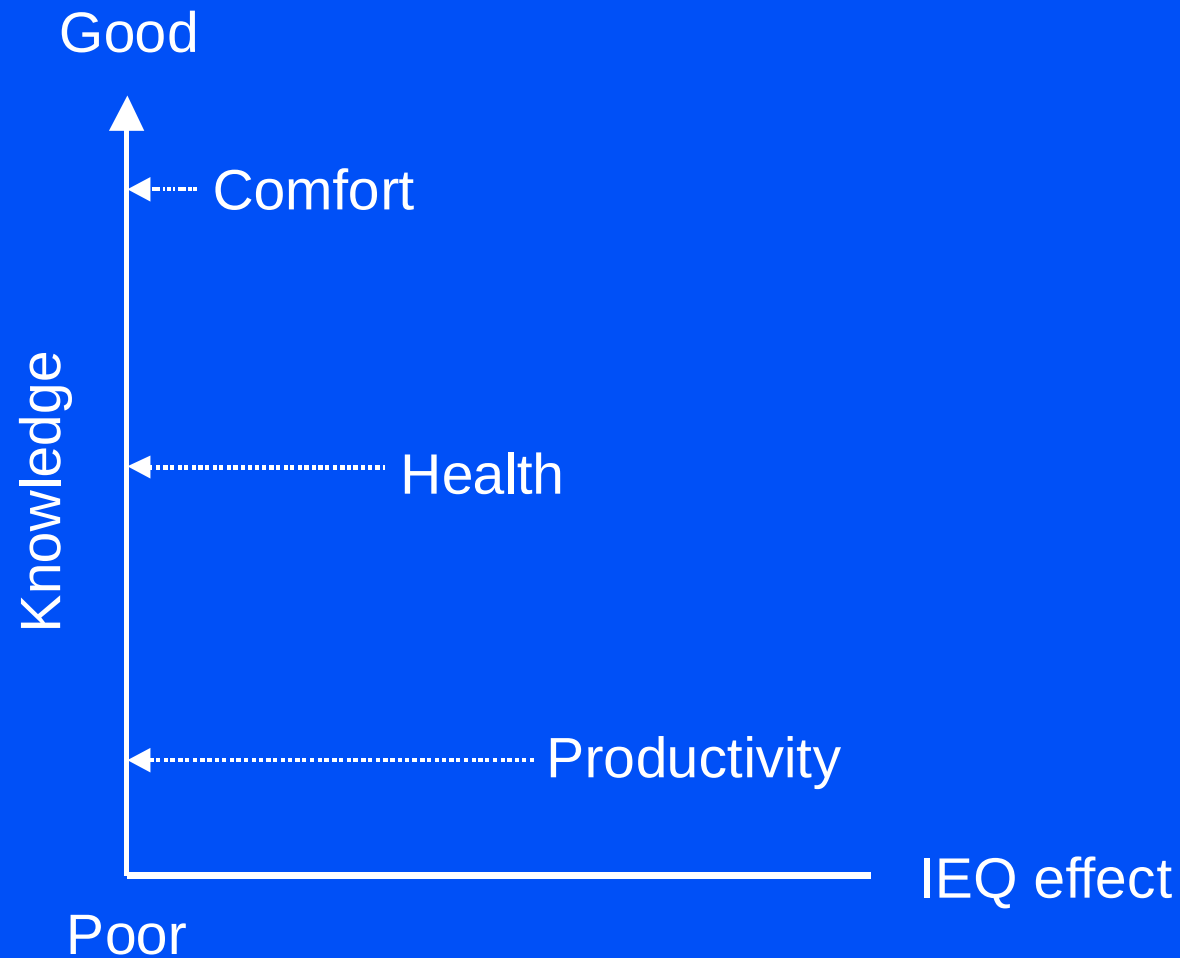


Benefits of demand controlled indoor environment: comfort, productivity and energy efficiency

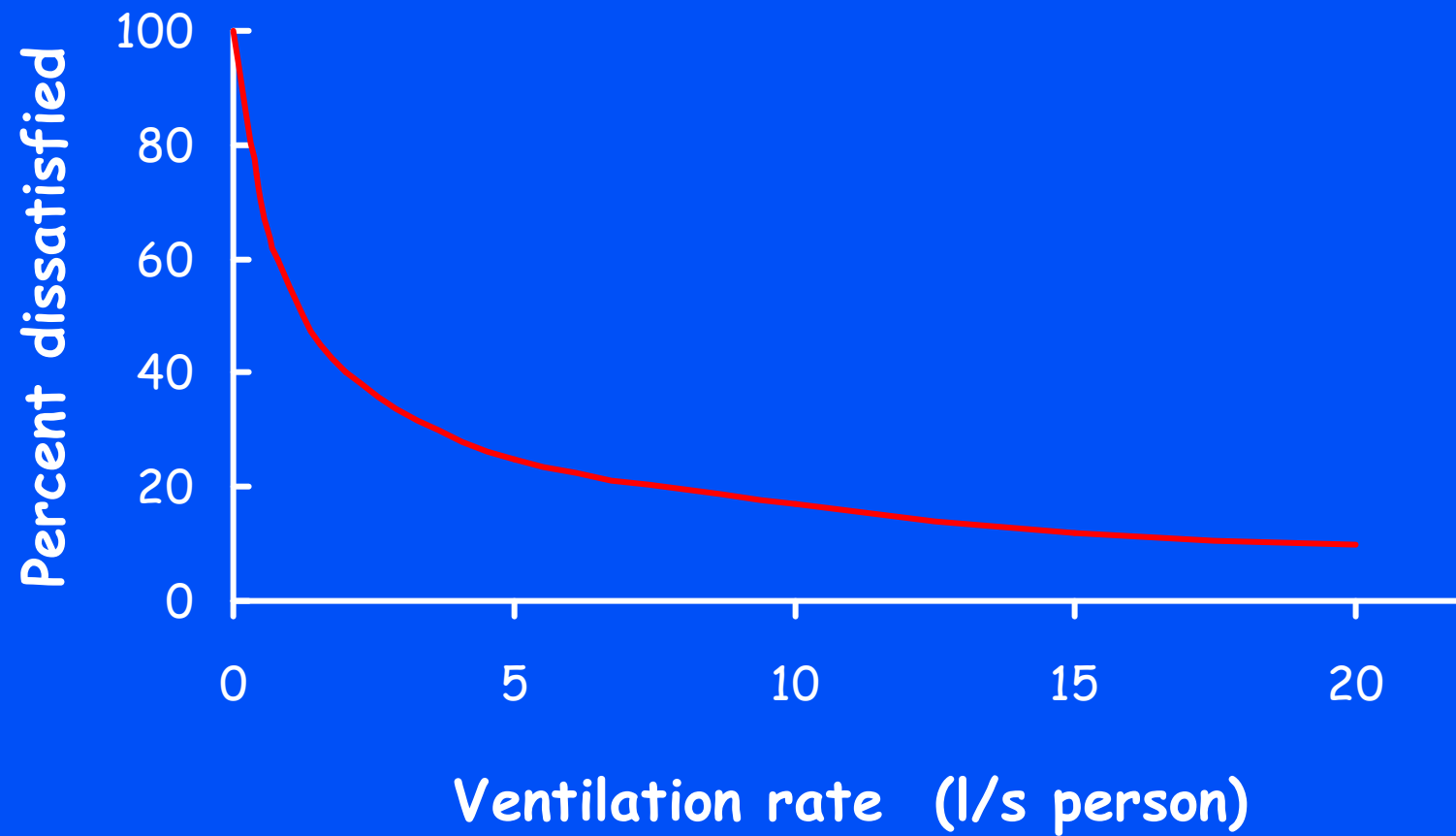
Jørn Toftum

International Centre for Indoor Environment and Energy
Department of Mechanical Engineering
Technical University of Denmark

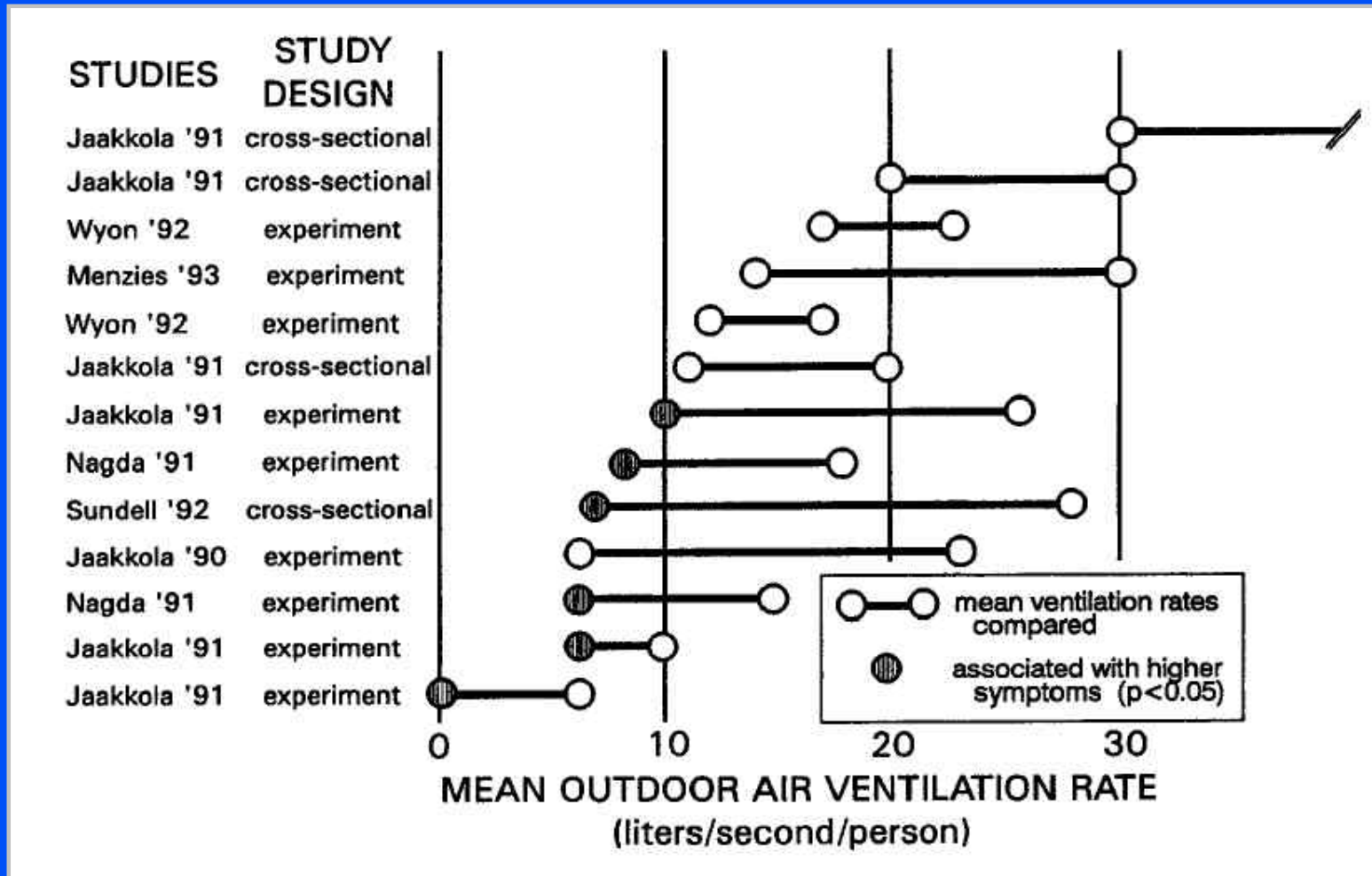
Knowledge of IEQ effects on humans



Ventilation requirements

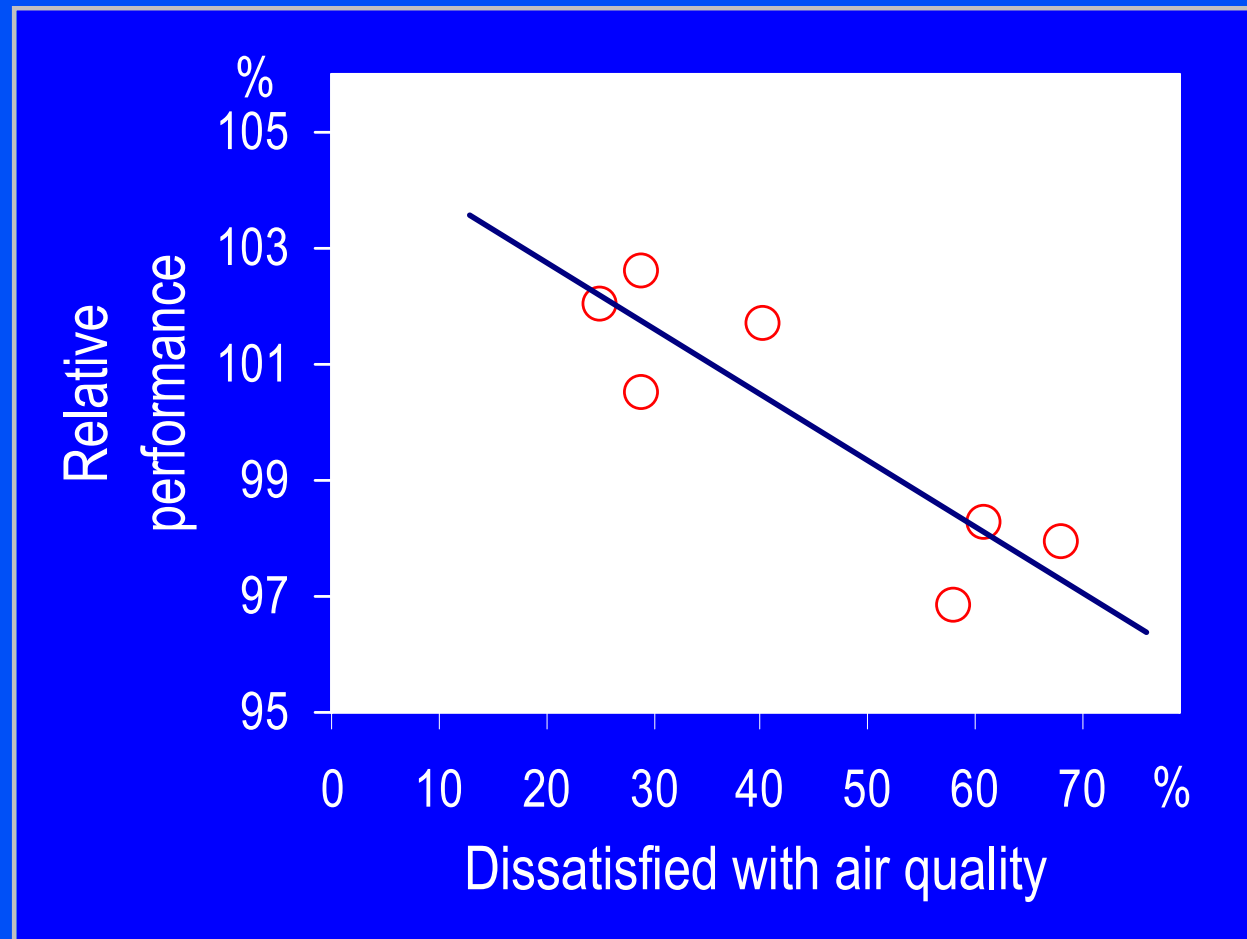


Outdoor air ventilation rates and work-related symptoms



(Mendell 1993)

Task performance and air quality



(Wargocki et al. 1999, 2001)

Annualized cost of a typical 45 m² office with 11 m² per occupant

Salaries	100
Rent	10
Capital equipment	14
O&M	4
Energy	1 (2)

(Woods 1989)

IEQ and Demand Controlled Ventilation (DCV)

- Sorption effects
- Other transient effects
 - CO₂ build-up
 - adaptation

Estimated energy-cost savings from DCV

Application	Energy-cost savings range
Schools	20 % to 40 %
Day nurseries	20 % to 30 %
Restaurants, canteens	20 % to 50 %
Lecture halls	20 % to 50 %
Open-plan offices (40 % average occupancy)	20 % to 30 %
Open-plan offices (90 % average occupancy)	3 % to 5 %
Entrance halls, booking halls, airport check-in areas	20 % to 60 %
Exhibition halls, sports halls	40 % to 70 %
Assembly halls, theatres, cinemas	20 % to 60 %

(Emmerich and Persily 2001)

What do we need

- Multi-compound sensors?
- Artificial noses?
- Sensor networks?
- Sufficient air of good quality!

Future HVAC system trends

- EU directive on the energy performance of buildings
 - Continuous calculation of energy consumption
 - Built-in sensors for diagnostics and inspection
- Continuous commissioning
- Feedback to user regarding energy consumption and indoor environment

What do we need - DCV

- Building and system type
- Control approach
- Sensor location
- Sensor calibration and maintenance
- Baseline ventilation required to control contaminant sources not related to humans

Demand controlled ventilation

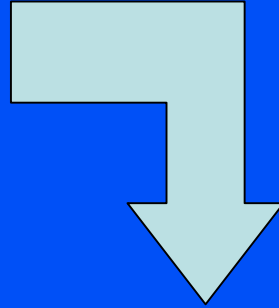
Most effective with

- Unpredictable variations in occupancy
- Building or climate where heating or cooling required most of the year
- Low pollutant emission from non-occupant sources

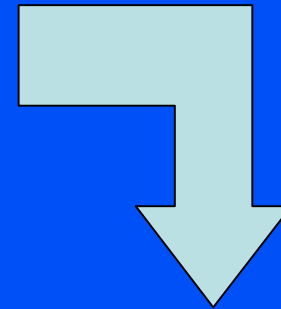
Non-conclusive results from case studies:

- Sometimes IEQ better, sometimes worse in terms of odour perception.
- Reports of increased feeling of warmth despite measured temperatures not higher.

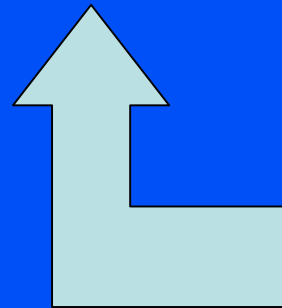
IEQ effects on
task performance



IEQ effects on productivity
(work output)



Investment in better IEQ



Macroeconomic estimation of productivity gains of improved IEQ

Source of productivity gain	Potential annual health benefits	Potential US annual savings or productivity gain (1996 USD)
Reduced respiratory illness	16 – 37 mill avoided cases of common cold or influenza	6 – 14 billion USD
Reduced allergies and asthma	18% to 25% decrease in symptoms for 53 million allergy sufferers and 16 million asthmatics	1 – 4 billion USD
Reduced SBS symptoms	20% to 50% reduction in SBS symptoms experienced by 15 mill workers	10 – 30 billion USD
Improved worker performance from changes in thermal environment and lighting		20 – 160 billion USD
Total cost of energy in US commercial buildings		70 billion USD

(Fisk 2000)