

# **Future requirements for the energy efficient indoor environment (1)**

**Olli Seppänen**

**Professor**

**Helsinki University of Technology**

**olli.seppanen@hut.fi**

**President**

**Federation of European Heating and Air-  
conditioning Associations**

# **Life cycle calculations in design and operation stage of building**

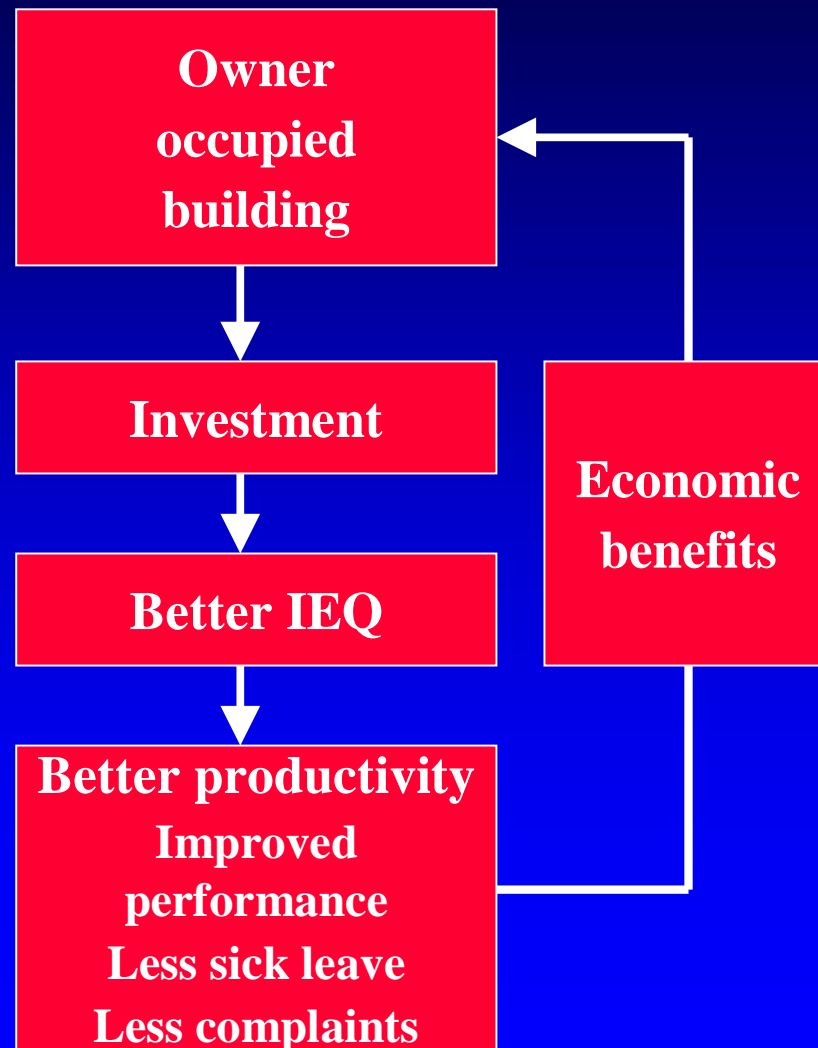
**traditionally include only**

- **investment cost**
  - including space
- **operation cost**
  - including energy

**but should also include**

- **productivity benefits**
  - sick leave days
  - performance at work

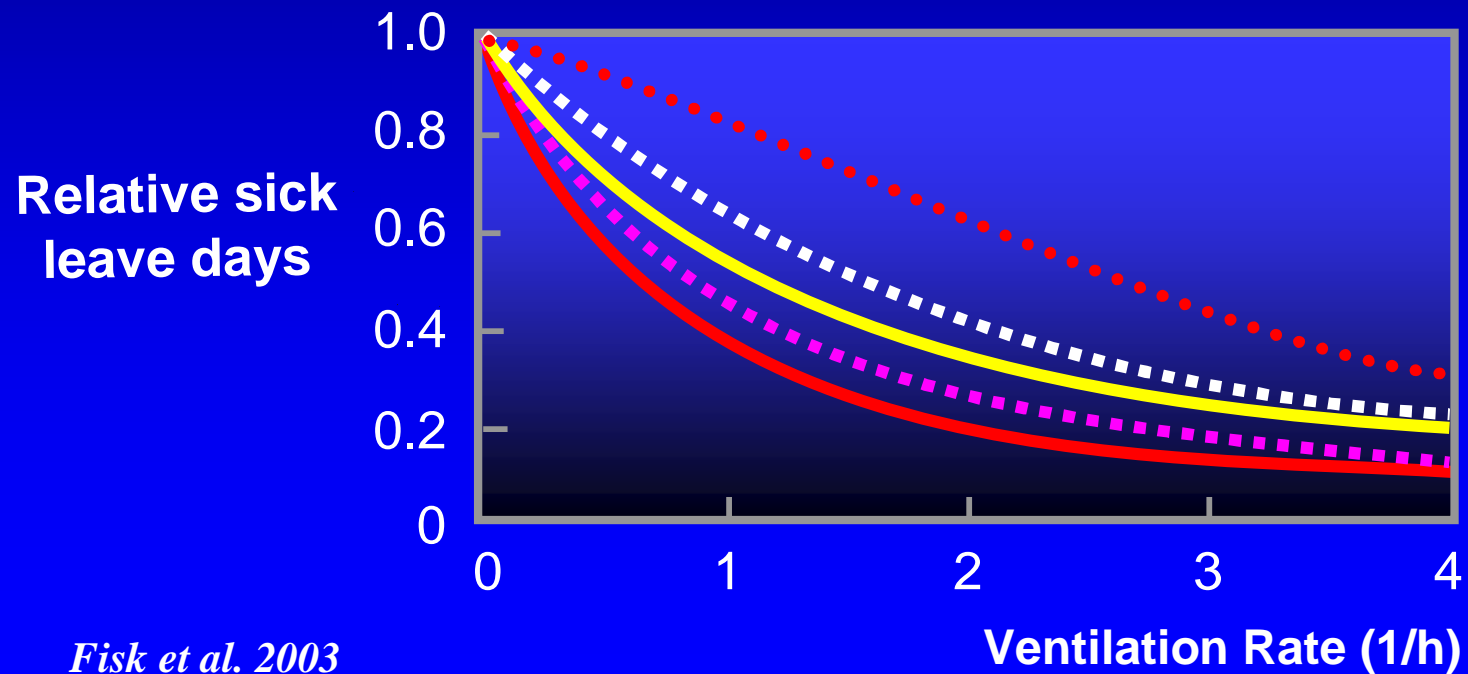
# Economic benefits as a driving force for better IEQ



# Ventilation rates and sick leave

# Short term sick leave or illness inflicted by infectious diseases vs. ventilation rate (ach) (Adapted to Wells-Riley-model)

- ..... Drinka (1996), illness in nursing home
- ..... Brundage (1988), illness in barracks, all years
- Particle concentration model
- ..... Brundage (1988), illness in barracks, 1983 data
- Milton (2000), sick leave in offices



*Fisk et al. 2003*

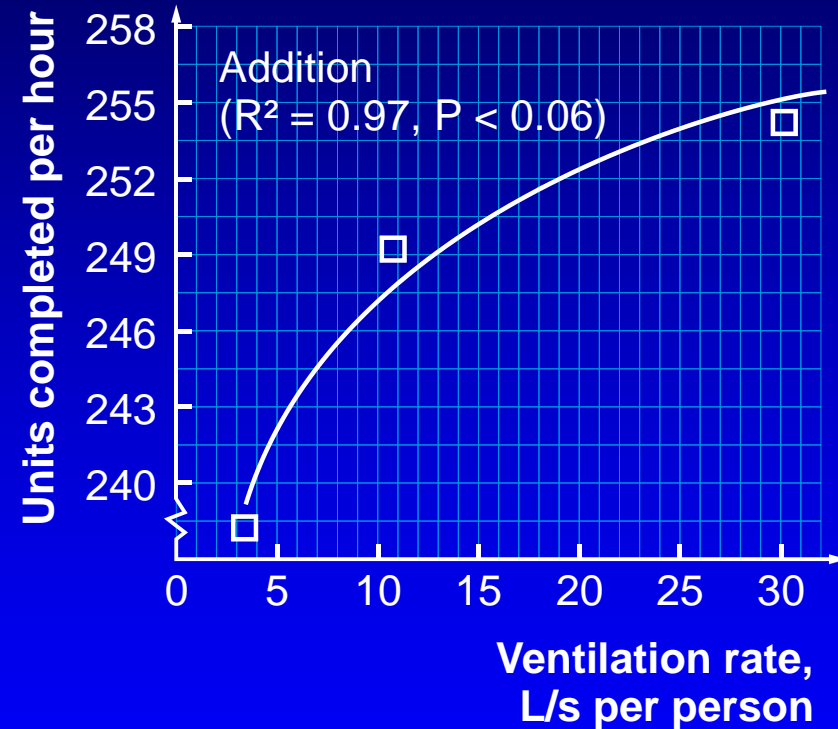
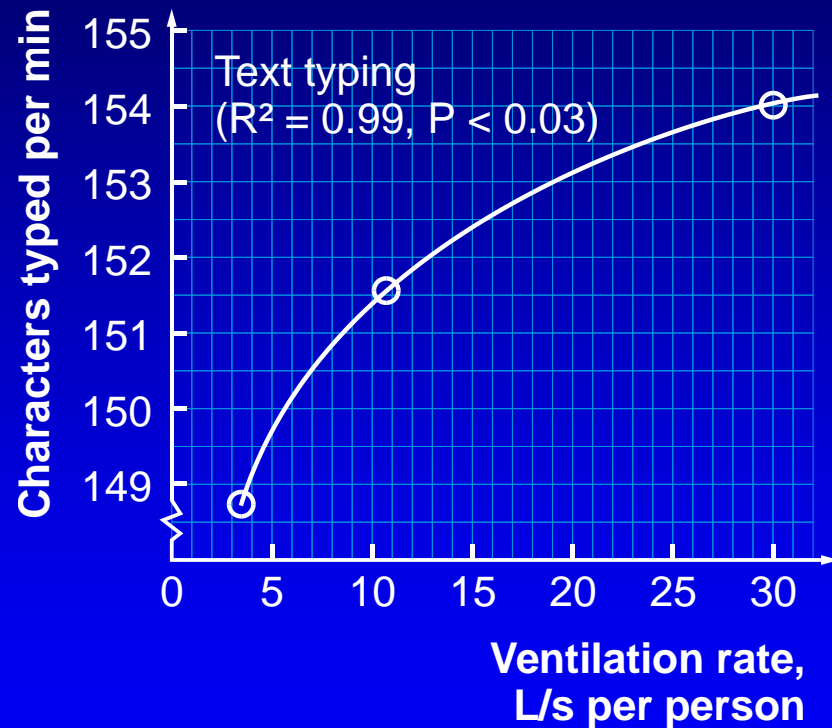
# **Ventilation rates and performance**

# **Meta analysis of studies on ventilation rate and performance**

- **six studies in office environment**
- **two studies in laboratory**
- **one in school**
- **some with multiple ventilation rates**

# Example of results from a laboratory study

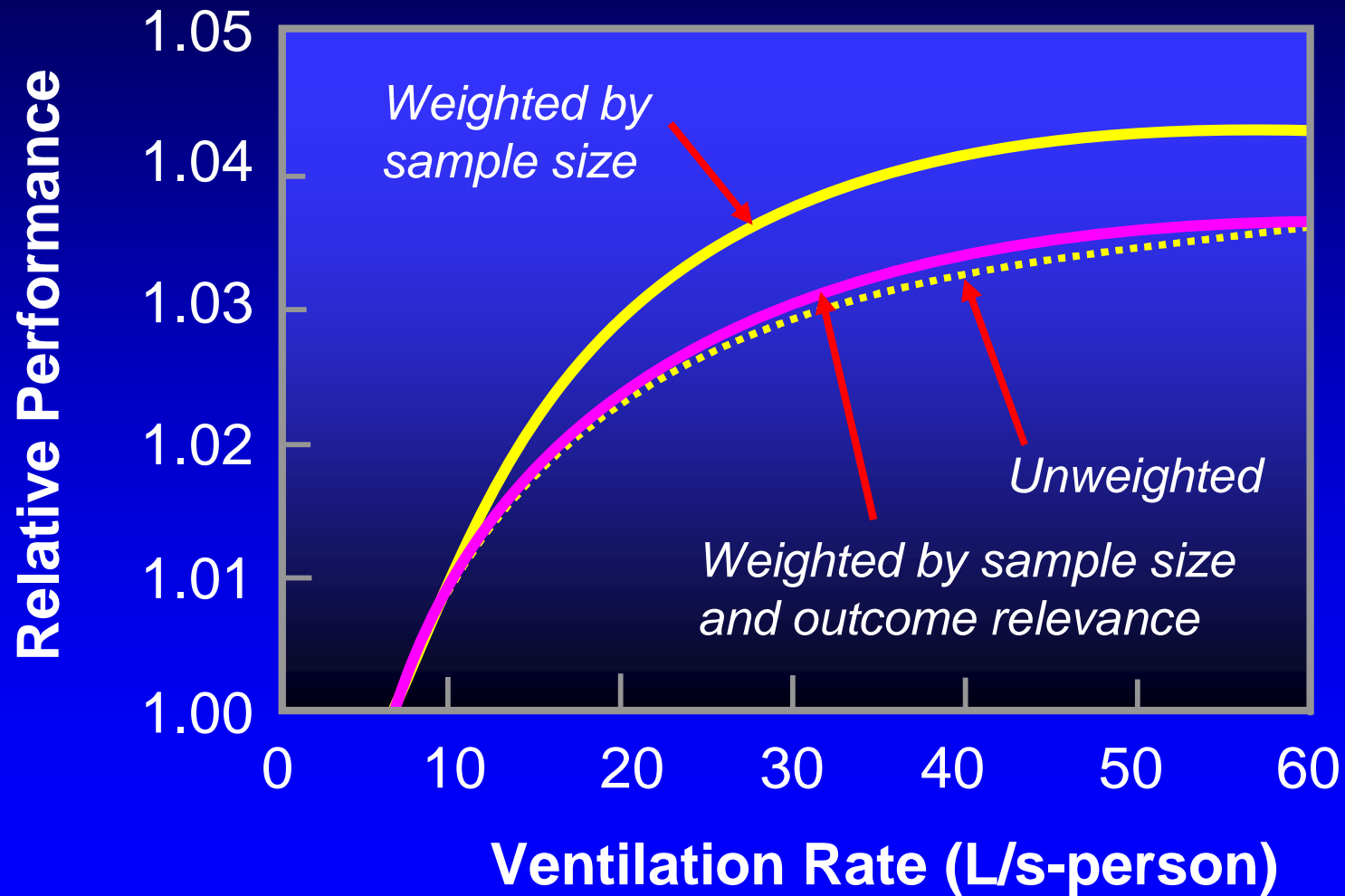
(Wargocki et al. 2000)



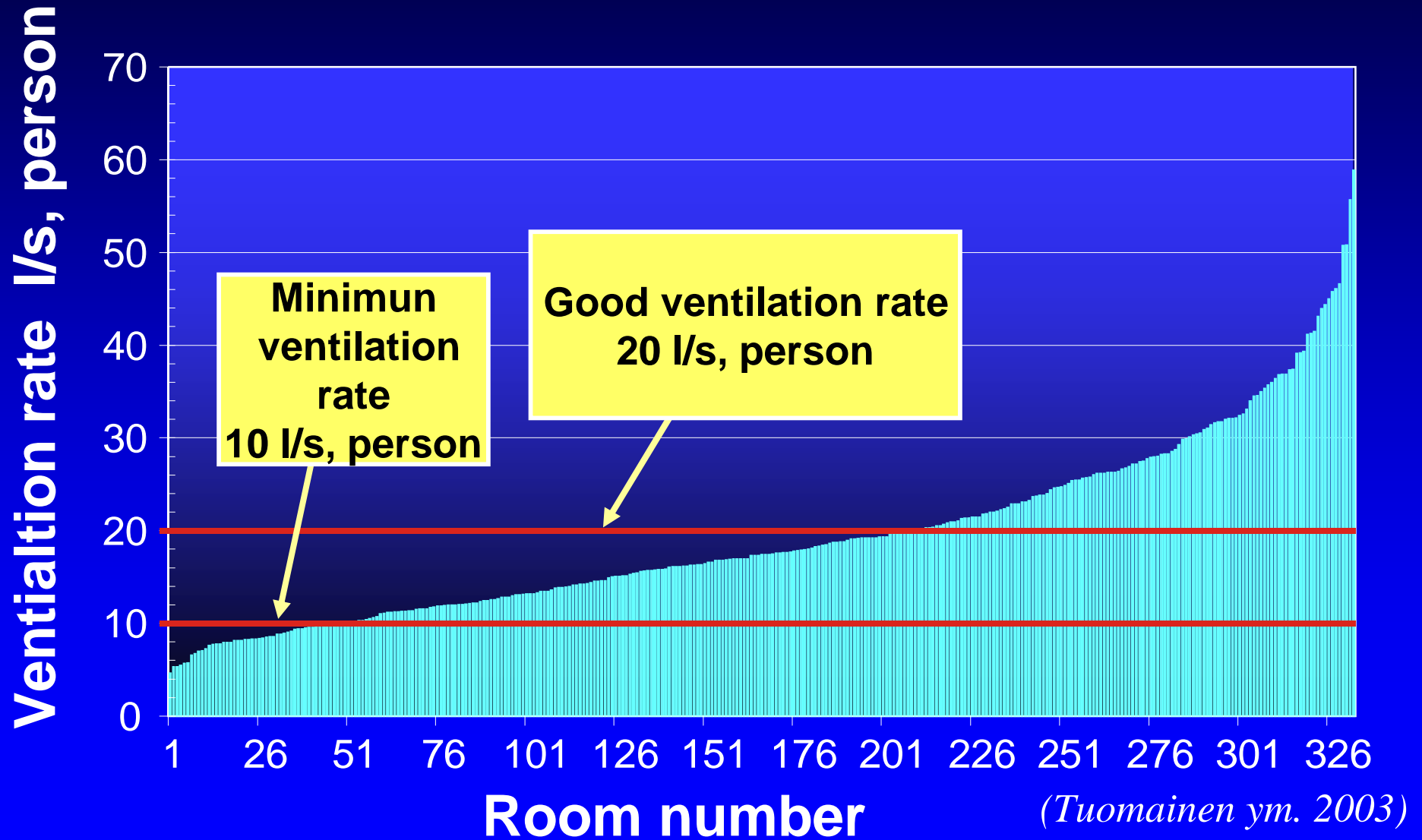
Increase of ventilation rates 3, 10, 30 L/s per person improved performance of office tasks in simulated office environment



# Relative performance vs. ventilation rate in L/s-person in relation to 6.5 L/s-person



# Ventilation rates in an office building in Helsinki

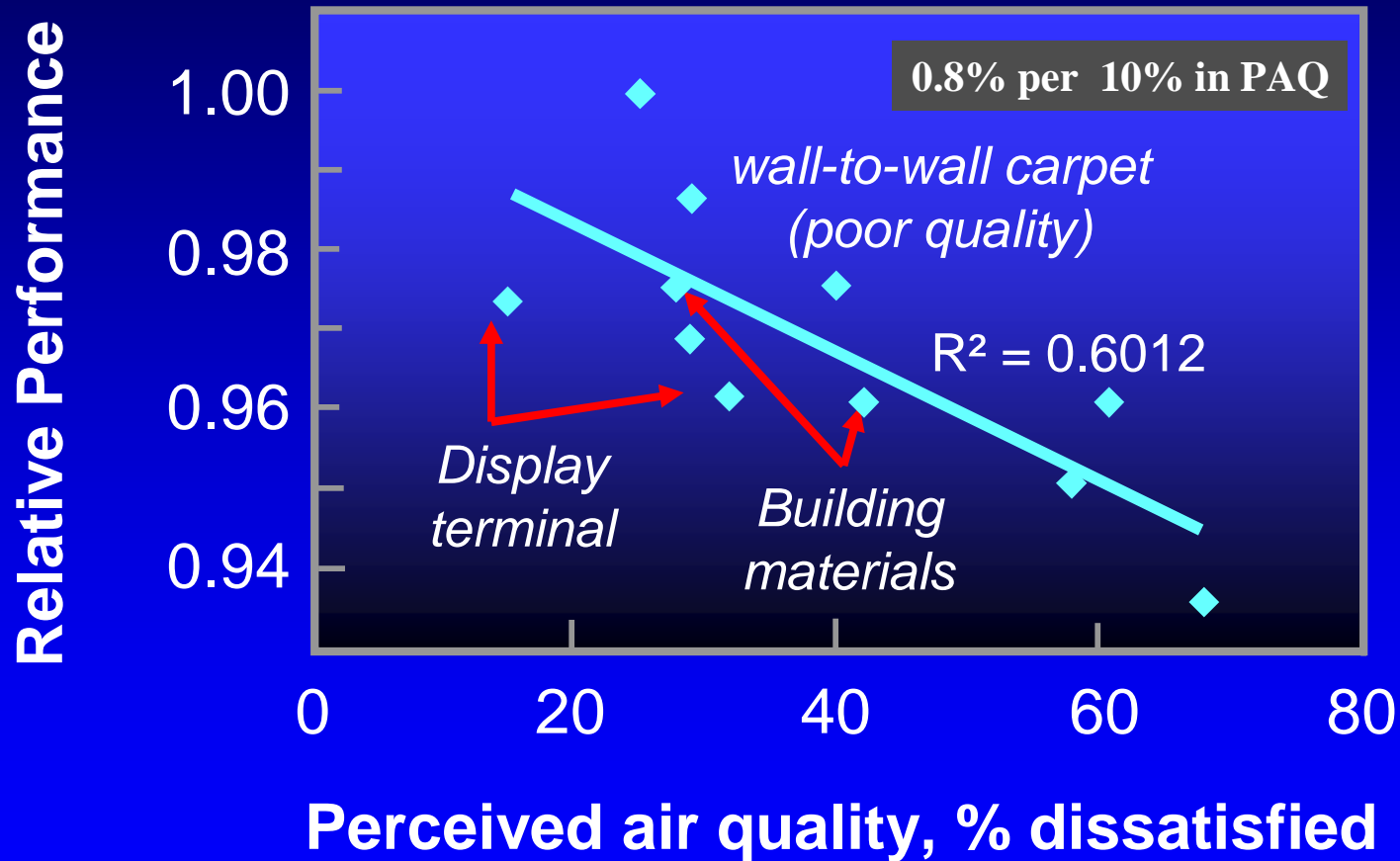


# **Performance and perceived air quality (PAQ)**

- **Perceived air quality = subjective evaluation of air quality immediately after entering into a room**
- **It has been used close to hundred years as a criteria of air quality and ventilation rates – also in many national standards**
- **PAQ is used also as an indicator of air quality for performance**

# Performance in text-typing vs. perceived air quality in percentage of dissatisfied (PD%)

(Bako-Biro 2004)



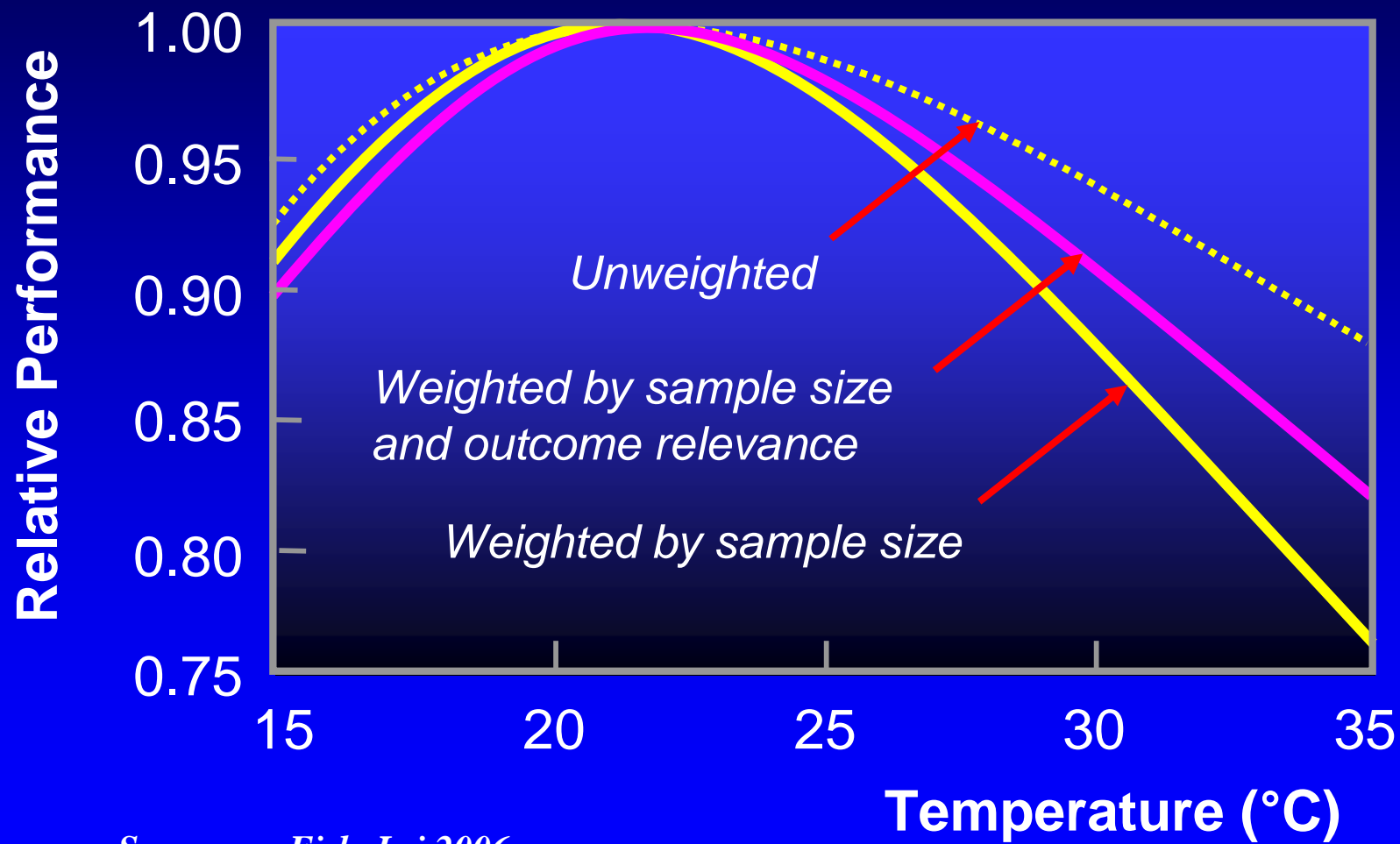
# Temperature and performance

# Meta analysis of studies on temperature and performance in office work

*(Seppänen, Fisk, Lei, Proceeding of Cold Climate HVAC 2006 )*

- 24 studies with objectively measured performance and temperature – 148 data points
- All included studies were controlled for
  - work environment (ventilation, humidity, work load etc.)
  - clothing
  - personal factors

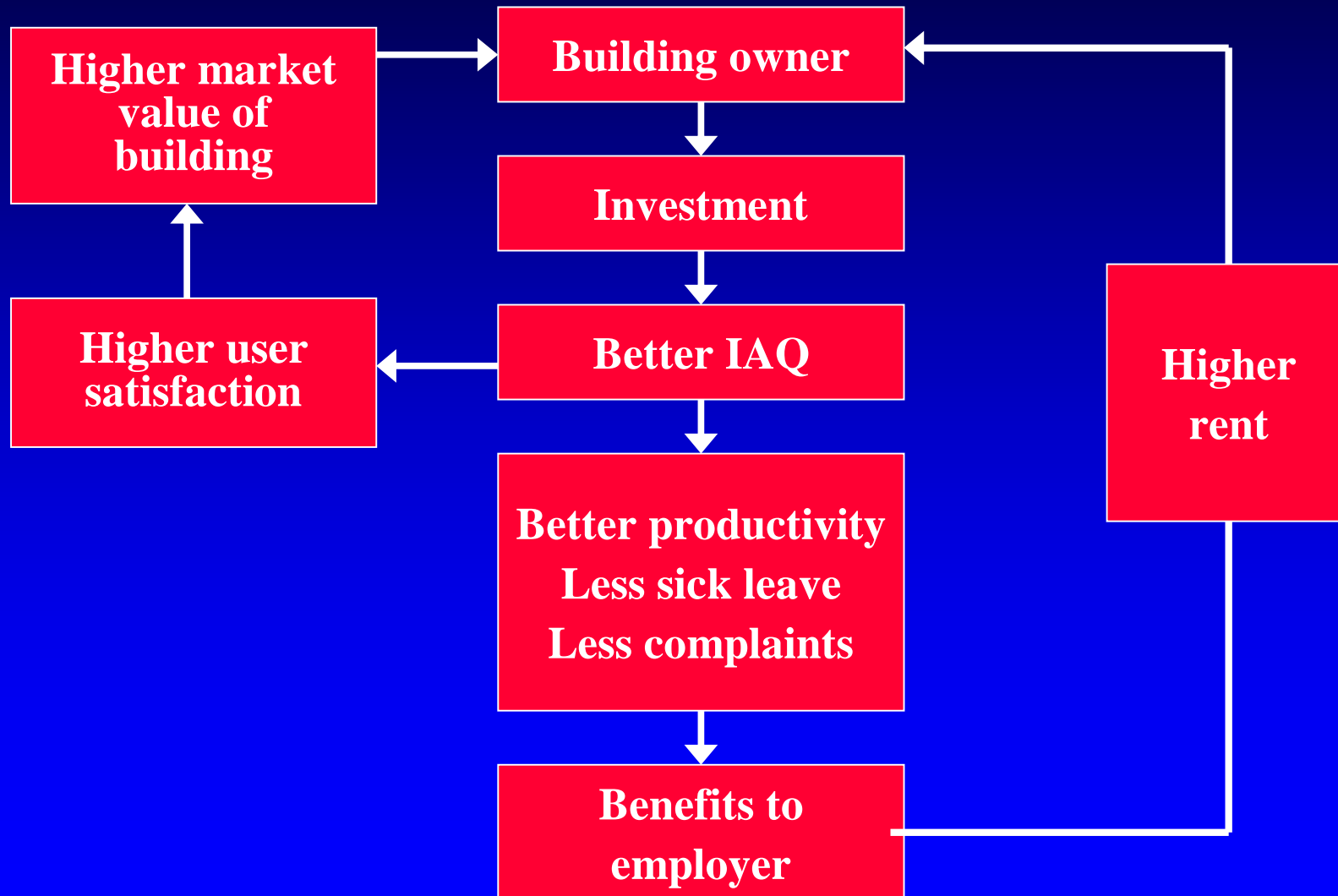
# Relative performance vs. temperature compared to the maximum



Seppanen, Fisk, Lei 2006

# Economic benefits as driving force

## Leased office building



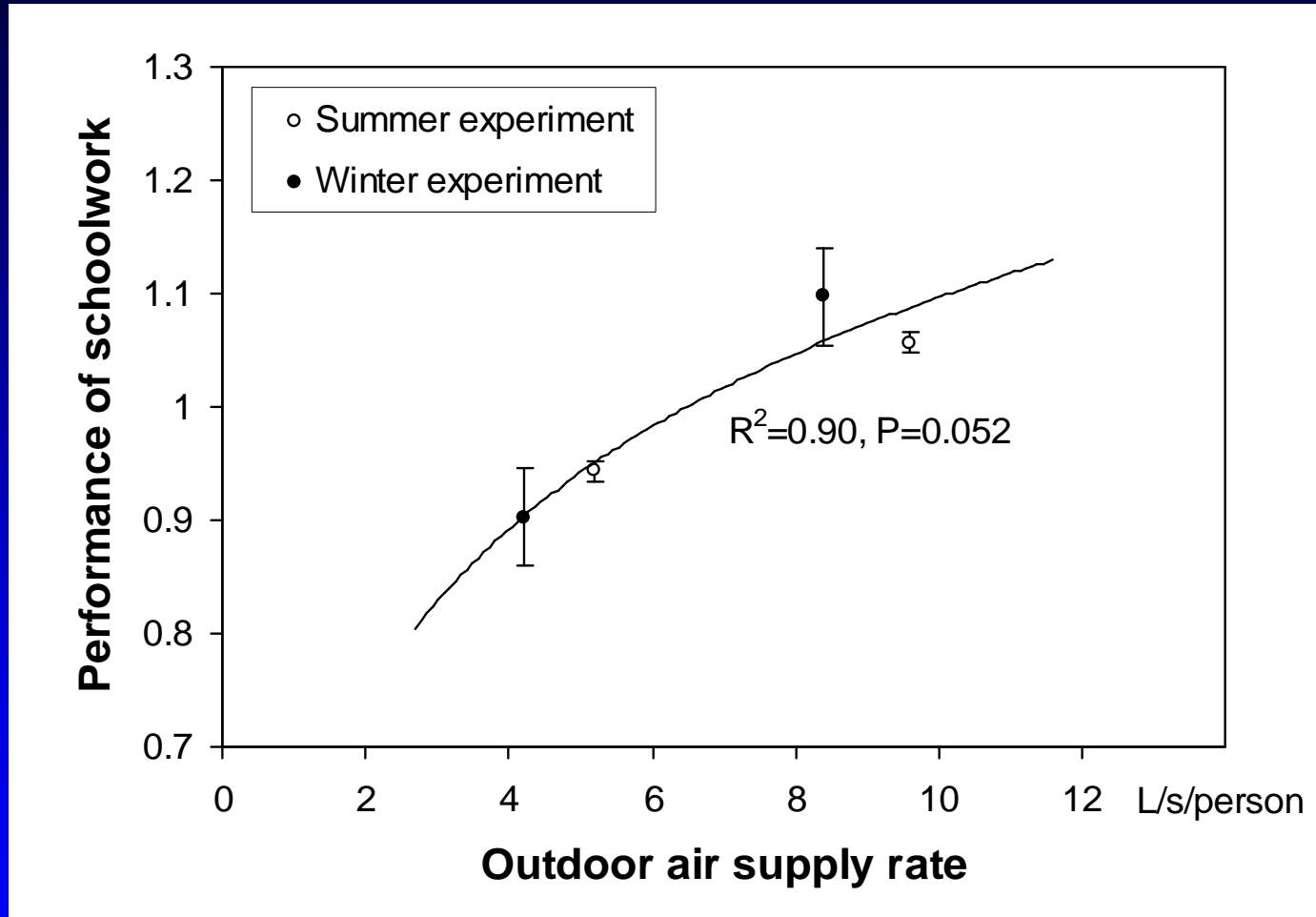


# **Indoor environment and learning in schools**

- **Increasing evidence on the effects, studies at:**
  - **University of Reading, UK**
  - **University of Oklahoma, USA**
  - **Danish Technical University, Denmark - ASHRAE**
  - **Institute of Public Health and Helsinki University of Technology, Finland**
  - **TNO, the Netherlands**

# Ventilation and performance of schoolwork

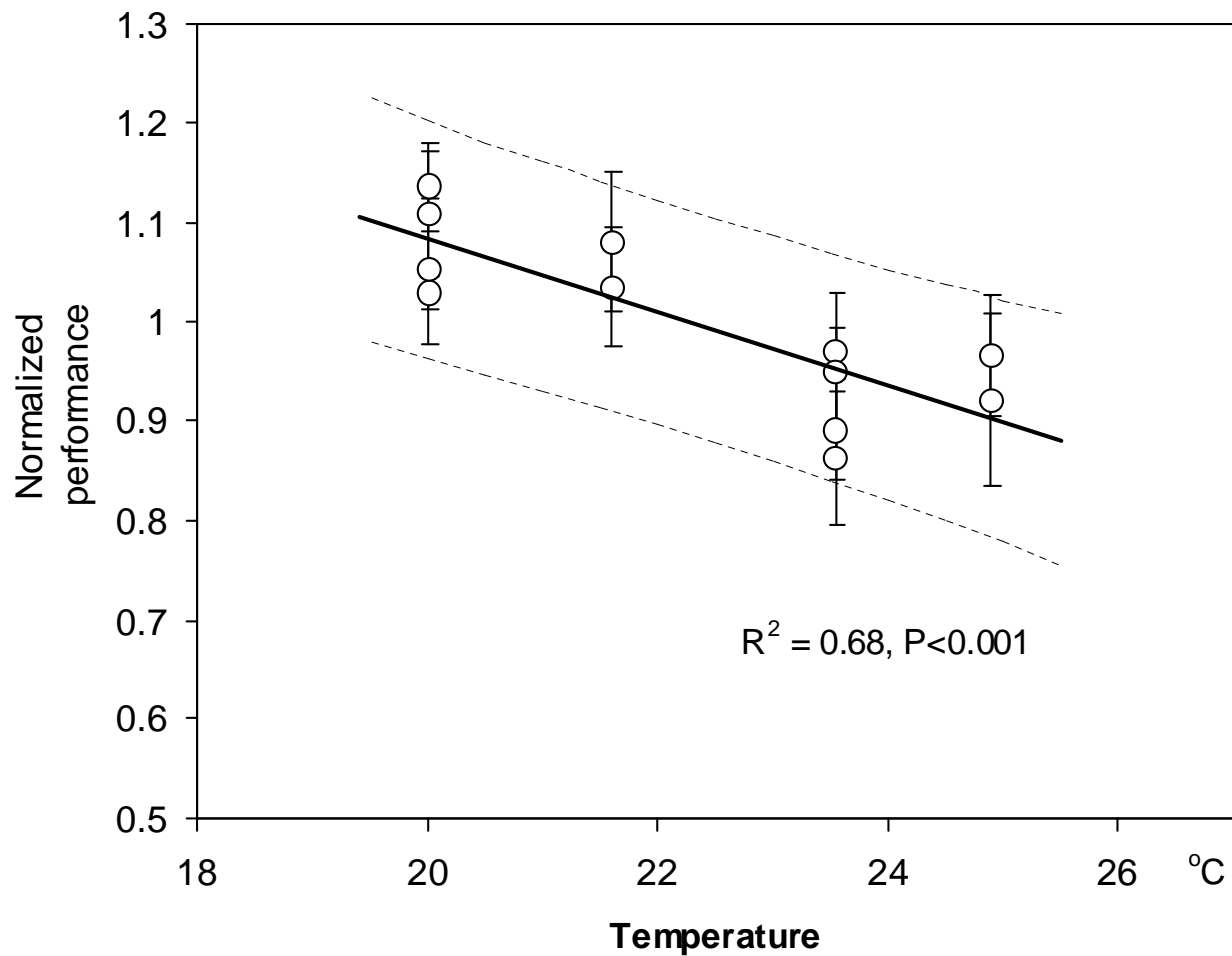
Wargocki P, Wyon D, Jark L et al. Proceedings of REHVA Clima Congress 2005



Addition of numbers; multiplication of numbers; subtraction of numbers; checking columns of numbers against each other; sentence comprehension; proof-reading ; acoustic proof-reading,; and reading a text

# Effects of temperature on schoolwork

Wargocki, Wyon, Matysiak and Irgens (2005) Proceedings of Indoor Air 2005 Congress



# Conclusions

- **Value of productivity and health improvements should be included in the life cycle calculations**
- **These costs are significant, and in order of magnitude or higher than the energy cost of buildings**
- **Better control needed for**
  - ventilation
  - temperature
  - air quality
- **Sensors and measurement needed for**
  - control
  - commissioning
  - operation
  - verification