

Indoor Environment & Productivity in Commercial Buildings



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CSIRO Sustainable Ecosystems



**Does IEQ really
affect occupant
productivity?**



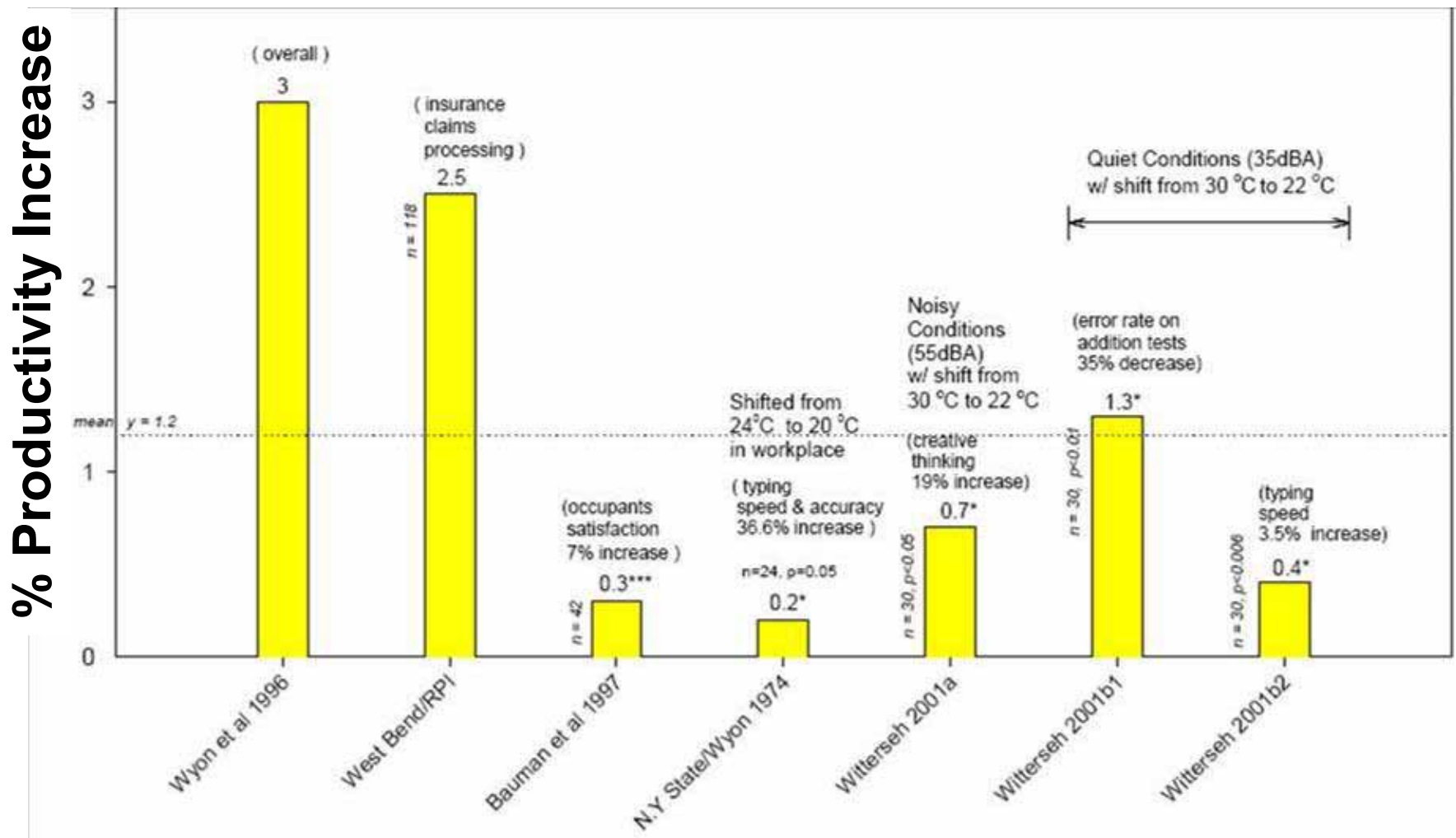
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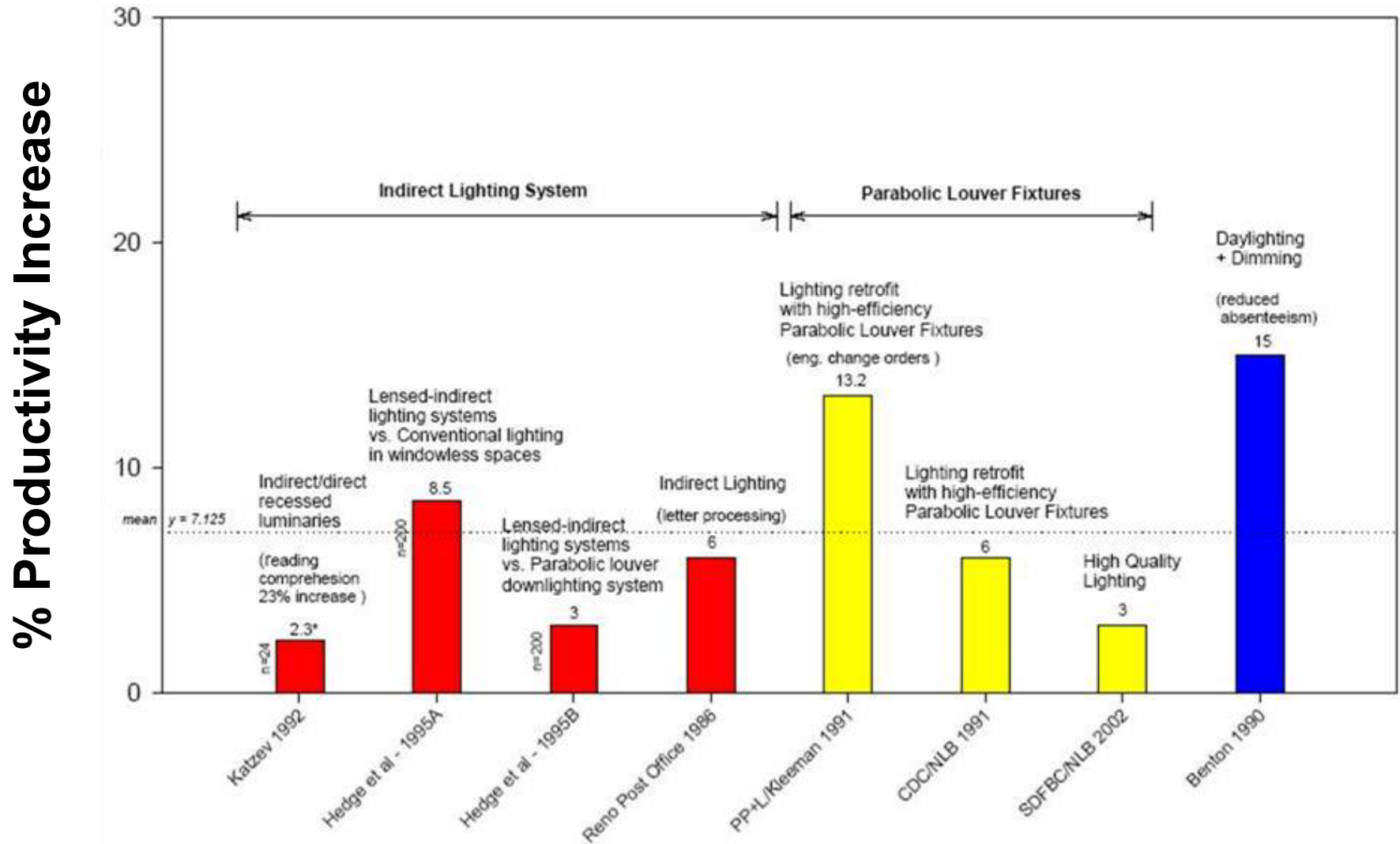
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Productivity Increase Vs Temperature Control

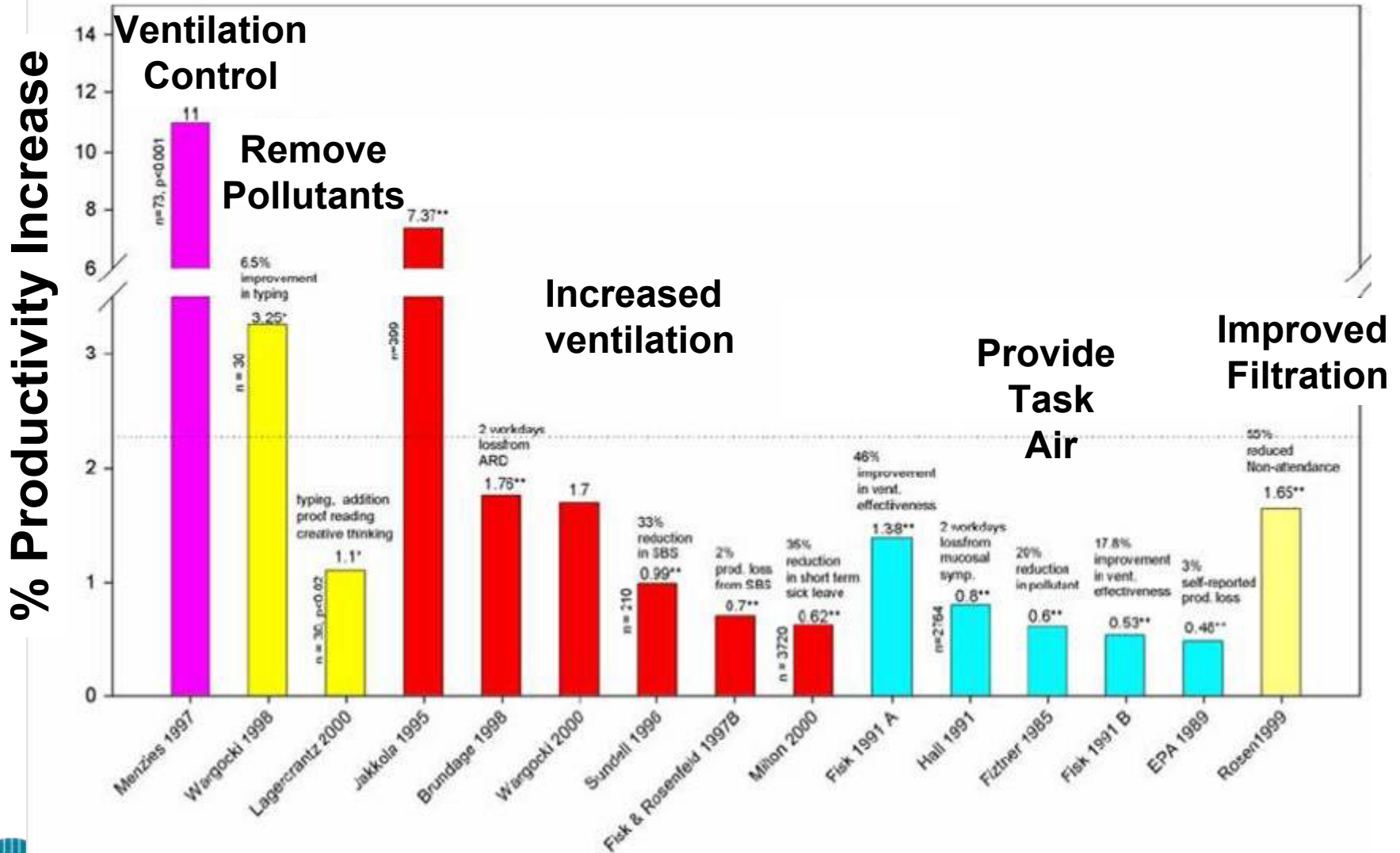


Productivity Increase Vs Improved Lighting



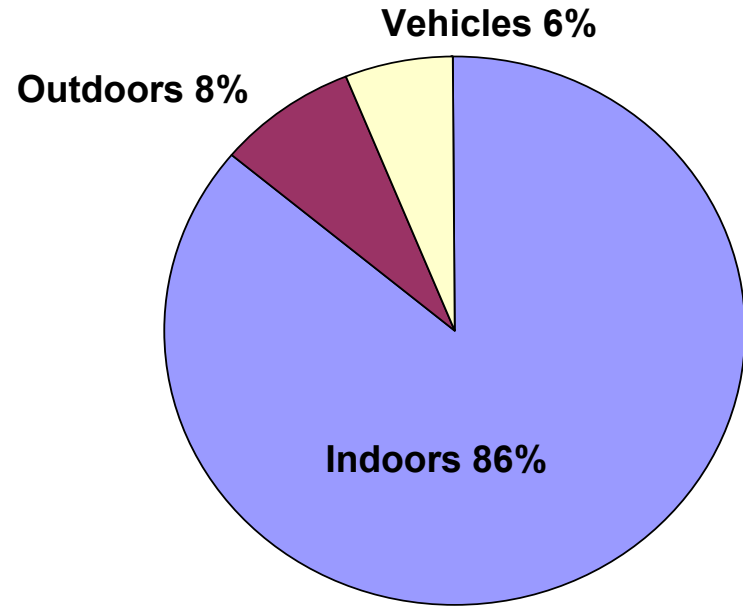
Source: Kats (2003)

Productivity Increase Vs Improved IAQ



Source: Kats (2003)

IEQ Impact - Human

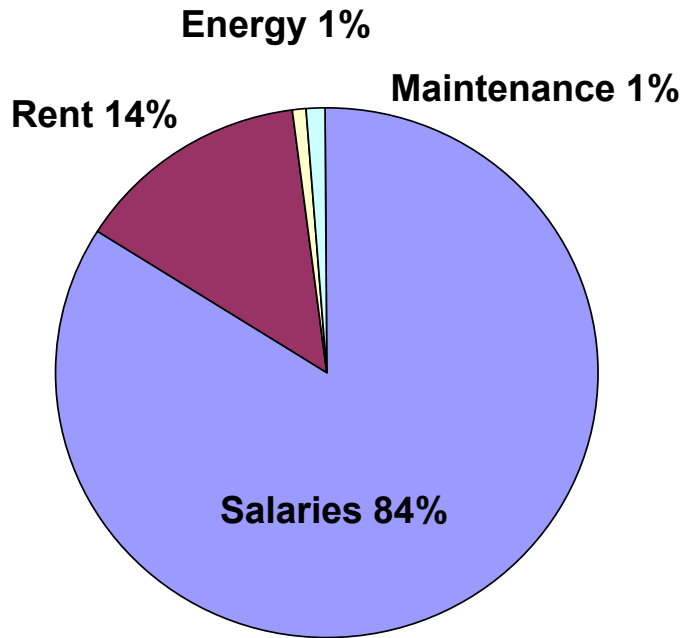


- People spend 90% of their time 'indoors'
- Most human activities are undertaken in enclosed spaces

**Breakdown of Human Activities:
National Activity Pattern Survey (US)**



IEQ Impact - \$\$



Breakdown of Typical Business Costs:
Romm & Browning (1994)

- **Benefit/Cost to Business**
 - Worker salaries typically comprise more than 80% of business costs
 - Health & Productivity can have potential impact on business bottom line
- **Benefit/Cost to Building Owners**
 - Poor IEQ large source of :
 - Occupant complaints
 - Tenant turnover
 - Future Regulatory Compliance

IMPACT - \$\$

Potential Productivity Gains From Improvements in Indoor Environments (\$AUD)

Source of Productivity Gain	Potential Annual Savings or Gains
Reduced respiratory illness	\$1 - \$2 billion
Reduced allergies and asthma	\$0.1 - \$0.5 billion
Reduced SBS symptoms	\$1.1 - \$3.5 billion
Increased work performance: improved thermal, lighting, acoustics	\$2 - \$15 billion
TOTAL	\$4.2 - 21 billion

Adapted from : Fisk (2002)



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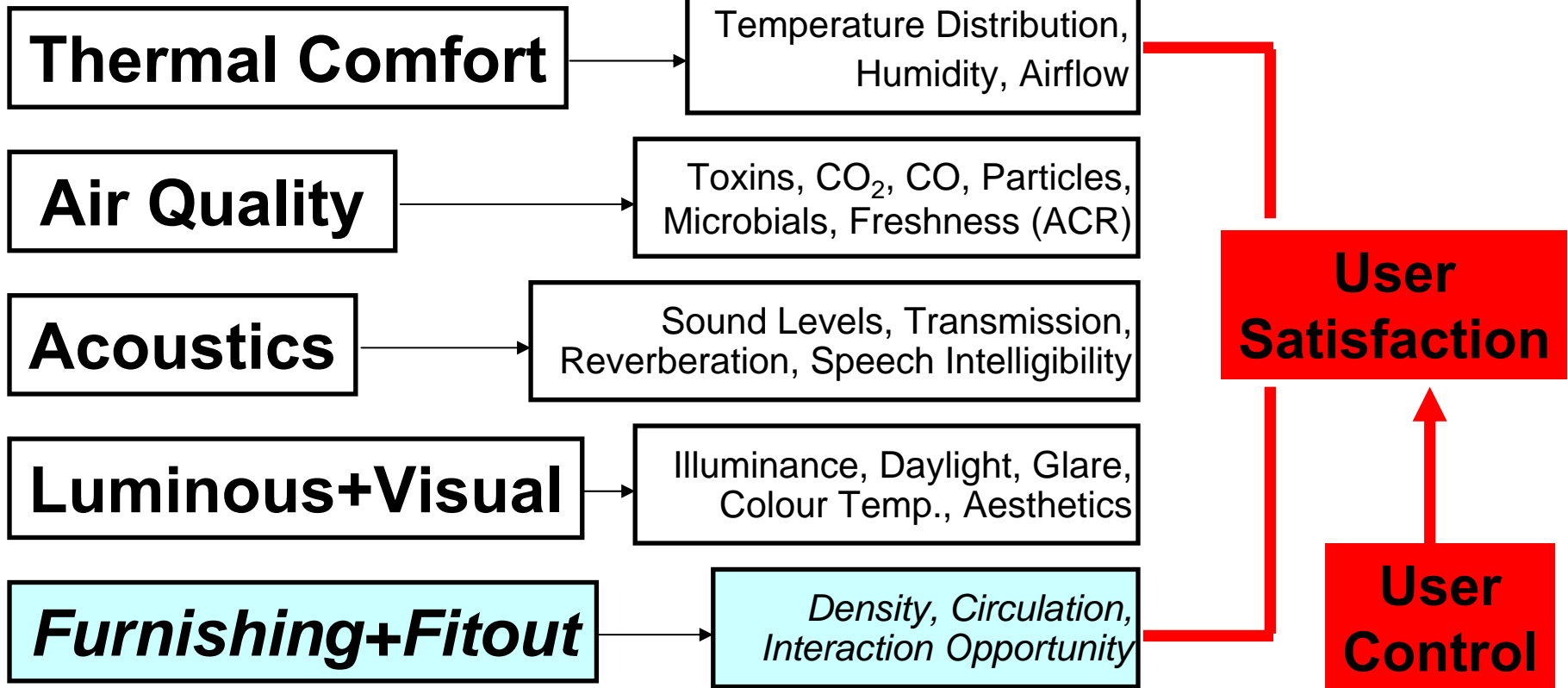


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Indoor Environment Quality (IEQ)

Attributes

Indicators



Thermal Comfort

.... a condition of mind that expresses satisfaction with the thermal environment

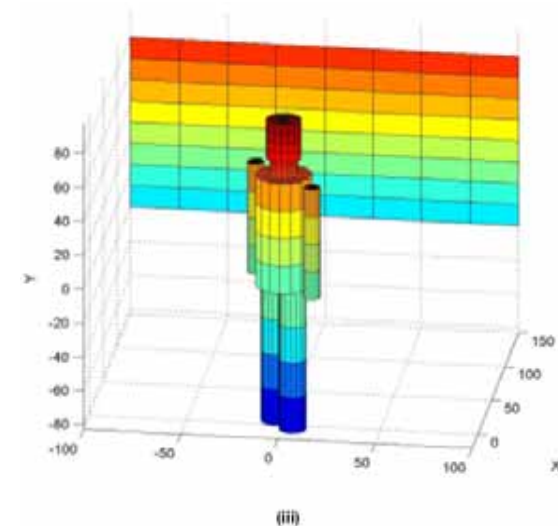


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Thermal Comfort is Characterised by ...

- Temperature
 - T_{air} , $T_{\text{operative}}$
 - Gradient
 - Temporal Consistency
- Humidity
- Air velocity
- Activity levels and clothing type
- Level of personal control
- Level of occupant satisfaction
 - e.g. 80% satisfied



Improving Thermal Comfort

Good Practice:

- Establish, monitor and maintain thermal comfort criteria
- Use latest standards / guidelines
 - AIRAH, ASHRAE, ISO
- Provide personal control where possible
 - openable windows
 - personal fan / heater
- Occupant feedback
 - ***Seek it – Listen to it - Act on it quickly***



Acoustic Environment Quality

... the totality of the acoustic characteristics of a building Interior that impact on the occupants' aural perceptions.



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Acoustic Environment Quality

Dependant on:

- Noise Levels (dB)
- Sound Transmission / Absorption / Isolation
- Acoustic 'Feel' (Dead or Lively)
 - Reverberation Time
- Speech Intelligibility / Privacy
 - Important for productivity



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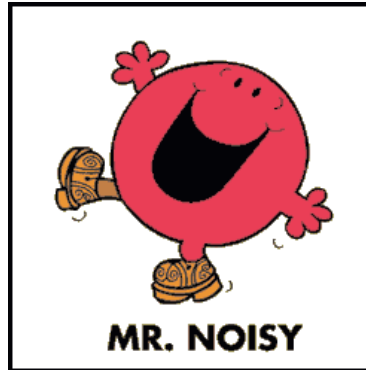


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Improving Acoustic Environment

Three basic principles:

- Eliminate noise sources
- Isolate noise sources
- Mask unwanted sounds



Good practice:

- **Establish criteria**
 - background noise / noise transmission / speech privacy levels
- **Identify** noise sources and **separate** noisy and quiet spaces
- **Limit transmission** of noise from building services and outside
- Select surface finishes to **reduce reverberation times**
- Use 'sound masking' to **maintain speech privacy** if necessary
- Use active noise control for problem situations



Indoor Air Quality

*... the totality of attributes of indoor air
that affect a person's health, wellbeing & productivity*



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IAQ is Characterised By ...

Physical Factors

- Temperature
- Humidity
- Ventilation rates

Air Pollutant Factors

- Pollutant levels
 - VOC's, CO, CO₂
- Exposure times

Human Factors

- Occupant health status
- Individual sensitivity

DO YOU WORK IN A TOXIN FACTORY?

The modern office is home to as many as 350 different volatile organic chemicals released by building materials, furnishings, and office equipment. That's not to mention the molds and bad indoor air that often flourish in these sealed-up environments. Some of the biggest offenders:

Printers and fax machines

They all ooze ozone. Scientists have yet to figure out definitively what happens when that ozone mixes with the workplace's other volatile organic chemicals.

Smoking

When people in your office sneak a smoke—even if it's behind closed doors—the second-hand stuff funnels through the ventilation system to the rest of the office.

Exterminators

It doesn't help that exterminators spray pesticides that may contain carcinogens over your workspace.

What fresh air?

Believe it or not, many fresh air vents are located over loading docks and parking garages, sucking in carbon monoxide and other contaminants.

Hidden Dangers: A Glossary

HVACs Heating, ventilation, and air-conditioning systems. Often they circulate contaminated air.

VOCs Volatile organic chemicals. They're emitted by furnishings, cleaning products, and equipment.

MCS Multiple chemical sensitivity. Sufferers are hypersensitive to chemicals.

CCP Carbonless copy paper. Found in credit-card and bank receipts. It contains known and probable carcinogens.

Sealed windows

Most people now work in enclosed offices. Not being able to crack open a window means that you're relying on building managers to pump through enough fresh air—something they don't always do.

Carcinogenic cleaning products

There are 70,000 chemical cleaning products on the market, many of which are used to clean up your office. Some of these products may contain carcinogens.

Copy machines

They also emit ozone. What's worse, they are not always next to vents, so their emissions stay trapped in the office air.

The office bathroom—the modern mold machine

Who hasn't seen a clogged toilet? Flooded bathrooms can create molds.

The stack effect

Co-workers who smoke may think they are doing you a favor by taking it outside. But experts say this can be even worse. When you open the revolving door, the building sucks in the second-hand smoke like a chimney.

Renovations

Working in a building—especially those with sealed windows—can cause workers to inhale paint fumes, construction dust, and odors from new furnishings that can irritate skin, eyes, and airways.



Improving IAQ ...

Reduce Toxin & Odour Sources:

- New Building Materials
- New Office Furniture / Furnishings
- Office Equipment



HVAC System Performance:

- Ensure Adequate Ventilation & Balance
- General Maintenance
 - filters / fans/ duct cleaning (limited)



Moisture Control: NO
persistent moisture,
condensation or dampness

Consider Other Issues:

- Poor Outside Air Quality
- Enclosed Garages
- Bathroom/Kitchen Odours
- Indoor Plants
- Maintenance & Cleaning Practices



Luminous & Visual Environment

... the totality of the luminous and visual characteristics of a building interior that impact on occupants' visual perceptions



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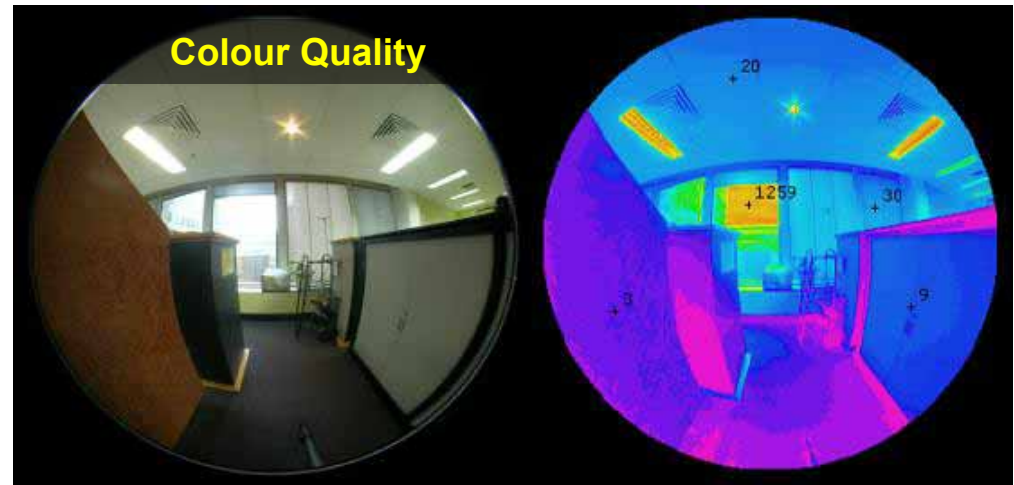


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Luminous & Visual Environment Quality

Dependant on:

- Background / Task Light Levels
 - Measured by Illumination level 'lux'
- Lighting Characteristics
 - Colour Temp, Ballast Flicker
- Glare
 - Unified Glare Rating
- Daylight & Views
- Aesthetic Considerations
 - Colour scheme
- Personal Control



Improving Luminous & Visual Environment

Basic principles:

- Occupants should be able to see easily, comfortably and accurately
- Required illumination levels depend on space and activity type



Good practices:

- **Establish criteria** for background and task light levels for different spaces in the building
- Provide **personal control** where possible
 - task lighting, ceiling lights, operable blinds ...
- Maximise **daylighting**
- **Integrate** natural and electric lighting strategies
- Clean windows and luminaries regularly



Productivity and IEQ



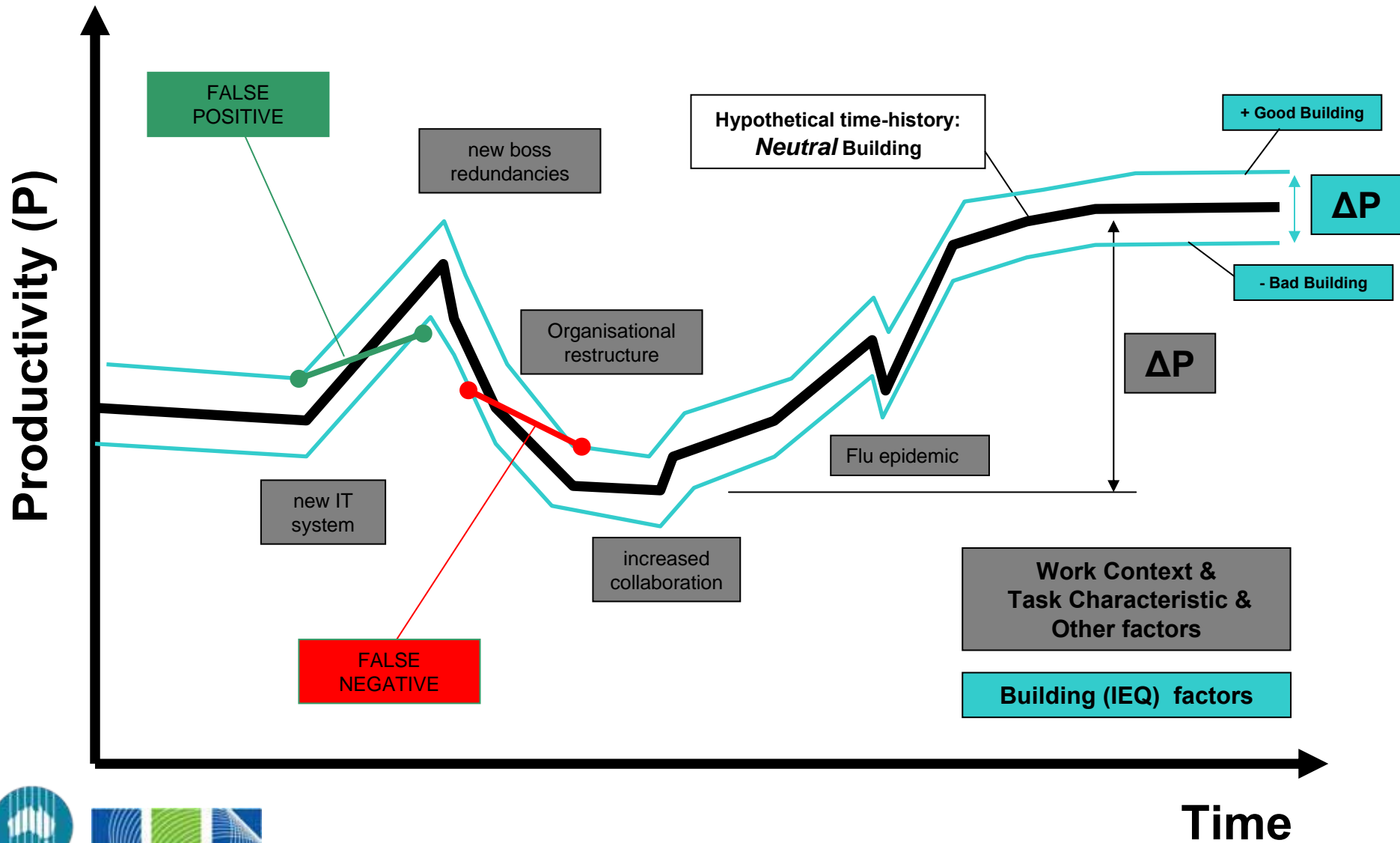
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Assessing IEQ impact on productivity



Productivity Variables by Category

Building-Related

NOT Building-Related

BASE BUILDING (IEQ related)

Air quality - toxins *

Air quality - freshness

Lighting quality & comfort *

Thermal comfort

Acoustic properties and comfort *

Building-related sickness

Spread of disease *

Personal control *

WORK SPACE

Conversational and visual privacy

Space layout & interior design philosophy

Group sizes, layout and territory

Interaction and collaboration opportunity

Meeting rooms & team space

Storage & retrieval facilities

ICT infrastructure

Office facilities

Workstation type & location

Workstation functionality & comfort

Occupant density – space

Occupant density – time

Aesthetics *

WORK CONTEXT & TASK CHARACTERISTICS

Task characteristics

Task discretion

Collaboration requirements

Level of Autonomy

Organisational and workgroup communication

ICT systems & software

Management style & systems

Organizational culture, philosophies & objectives

OTHER

Occupant characteristics

Facilities management response

Change management

Personal happiness

Workgroup morale

Sickness epidemics

Overall satisfaction/comfort

Absenteeism

Presenteeism

Staff churn

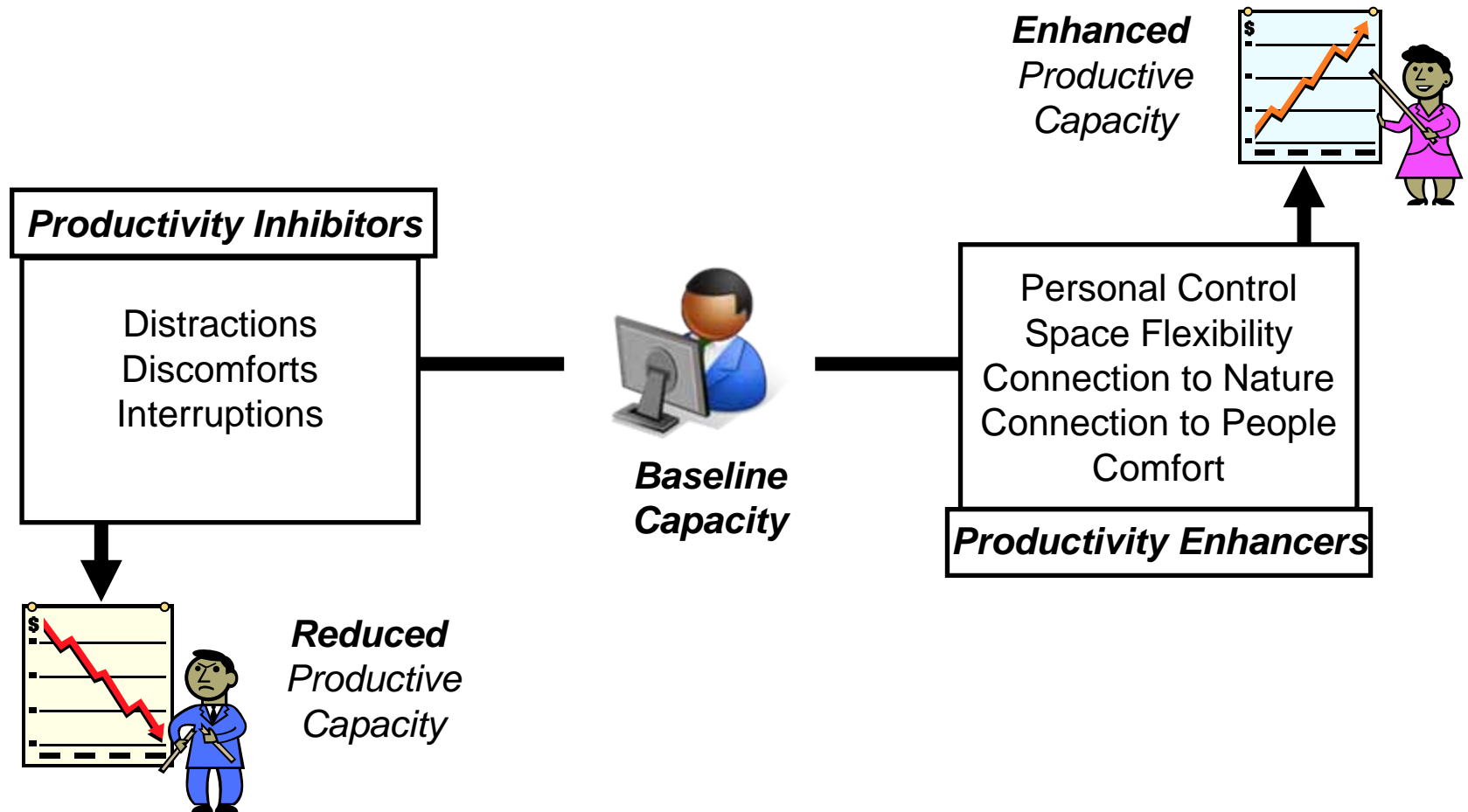
Perceived productivity

Safety and Security

* Indicates significant cross-category dependencies



Building-Related Impacts on Productivity



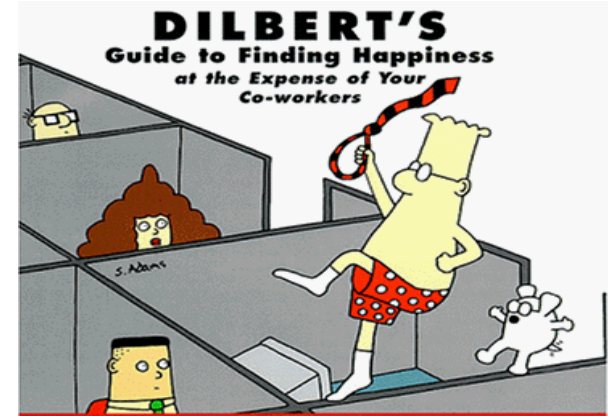
Productivity Inhibitors

- Unwanted noise and interruptions
- High occupant densities
- Poor workgroup layout / separation
- Slow response to complaints about building malfunction
- Poor thermal comfort conditions
- Deep-plan floorplates
 - worst locations usually in the middle.



Productivity Enhancers

- ***USER CONTROL***
- Flexible workspace layout
 - to meet the spatial, acoustic and communication requirements of a range of work tasks and contexts
- Appropriate and comfortable IEQ
- Lower workstation density
 - minimise distractions and interruptions
- Workstations, furniture and equipment that are ***ergonomic, comfortable, and adjustable.***
- Access to social spaces, daylight and views

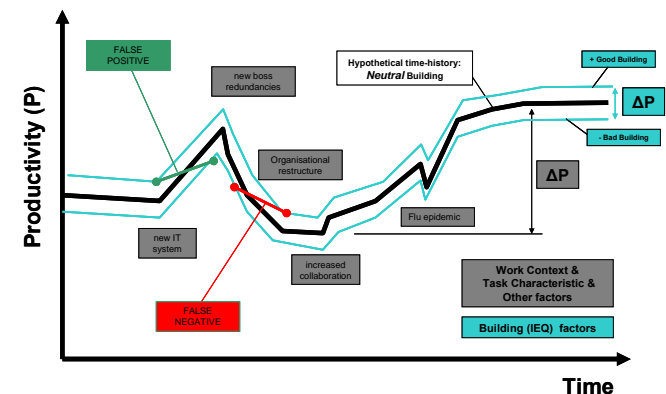


Final Words.....

- Being 'green' does not guarantee good IEQ...
→ *IEQ should be a target performance*



- Good IEQ is necessary but *not sufficient* for enhanced productivity



Acknowledgements

Contributing Authors to Your Building Indoor Environment & Productivity

- Adrian Leaman, Judith Heerwagen, Mark Luther

References

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