



Improving Energy & IEQ Performance in Practice – case Indian Schools

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santrupti

Two Different Kind of Schools



Government Schools

- 60 children per classroom
- Floor area 600 sq.ft.

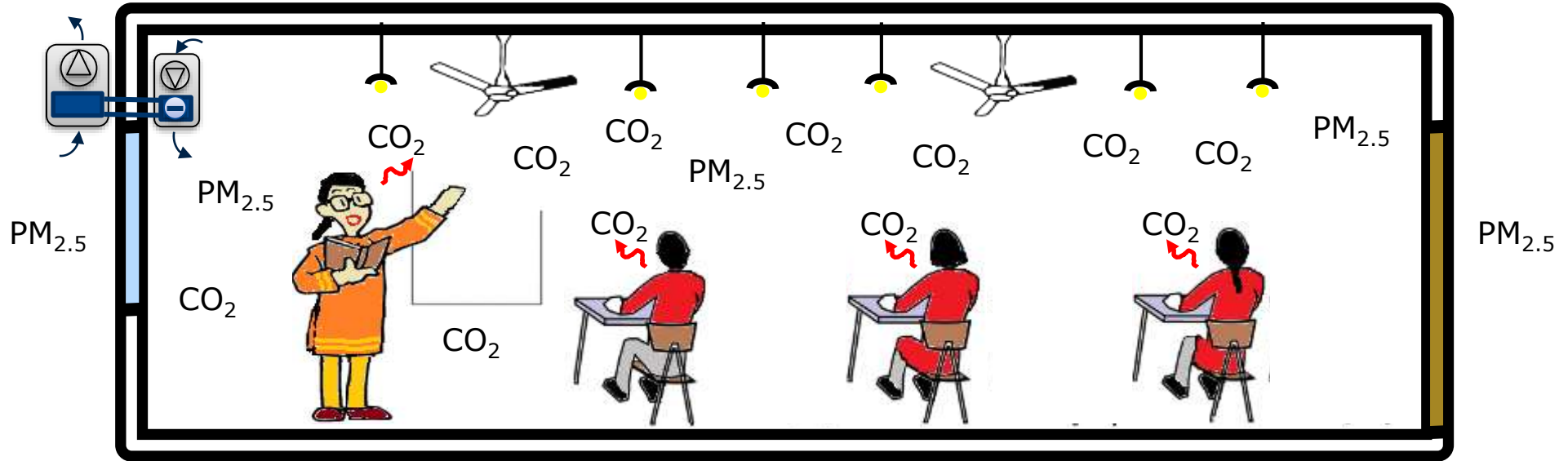


Private schools (international & Indian)

- 30 children per classroom
- Floor area 600 sq.ft.



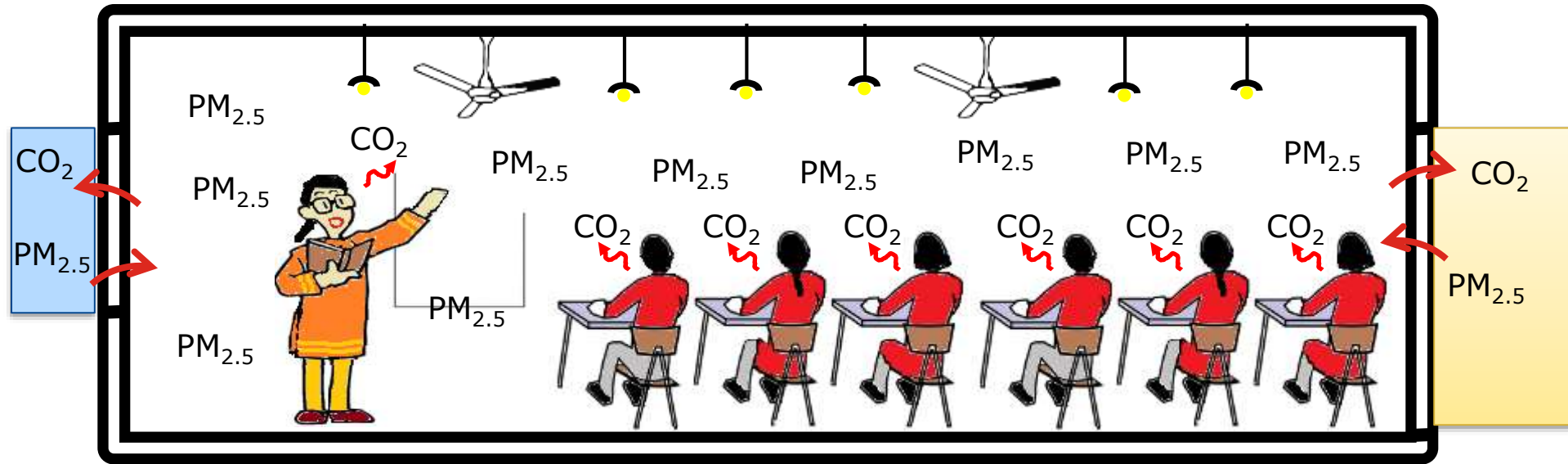
Current Energy and IEQ Performance: Private Schools



IAQ	★
Thermal comfort	★ ★ ★
Energy	★
Lighting	★ ★ ★
Acoustics	★ ★

CO_2

Current Energy and IEQ Performance: Government School

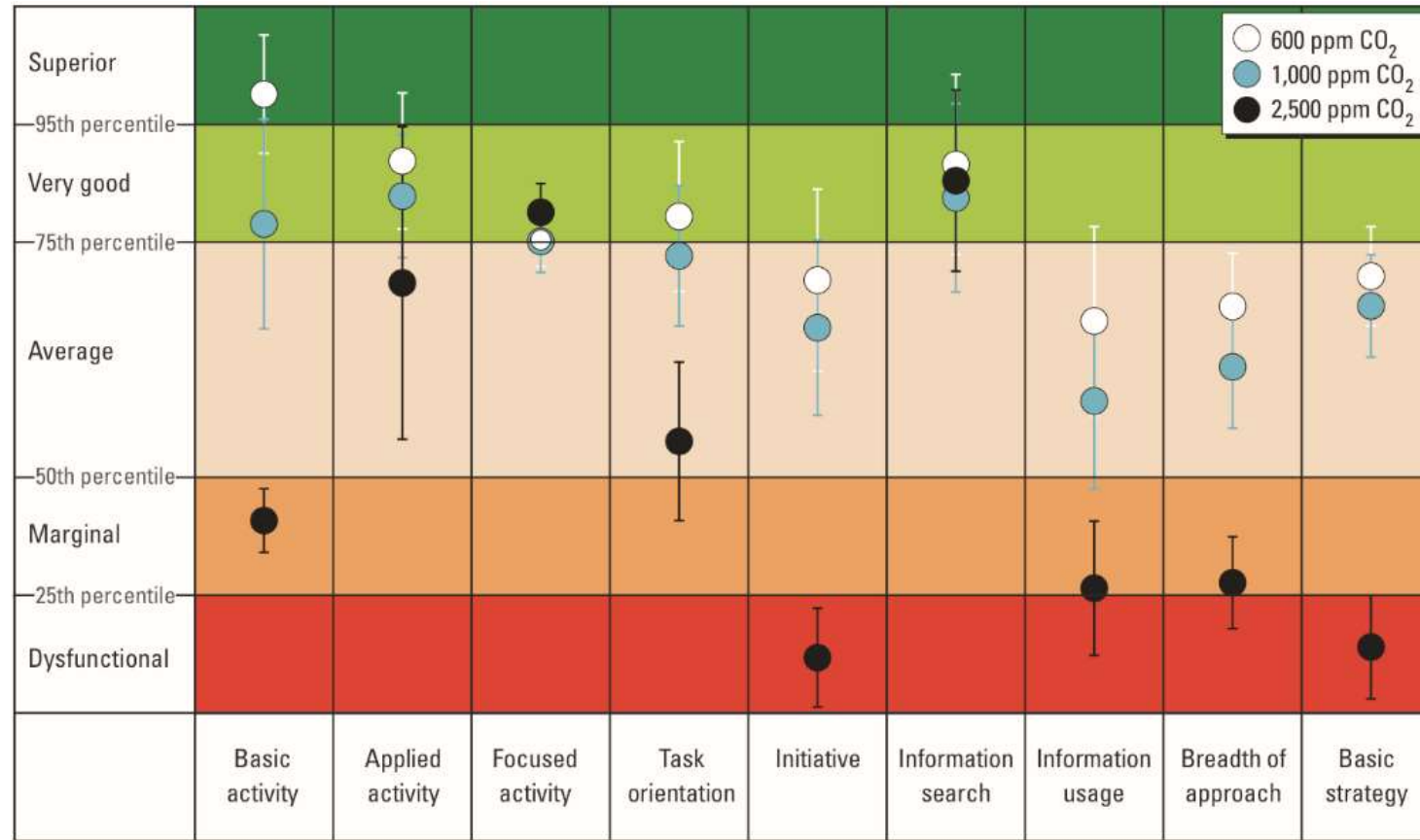


IAQ ★
Thermal comfort ★
Energy ★★ ★
Lighting ★★
Acoustics ★

$PM_{2.5}$
Temperature

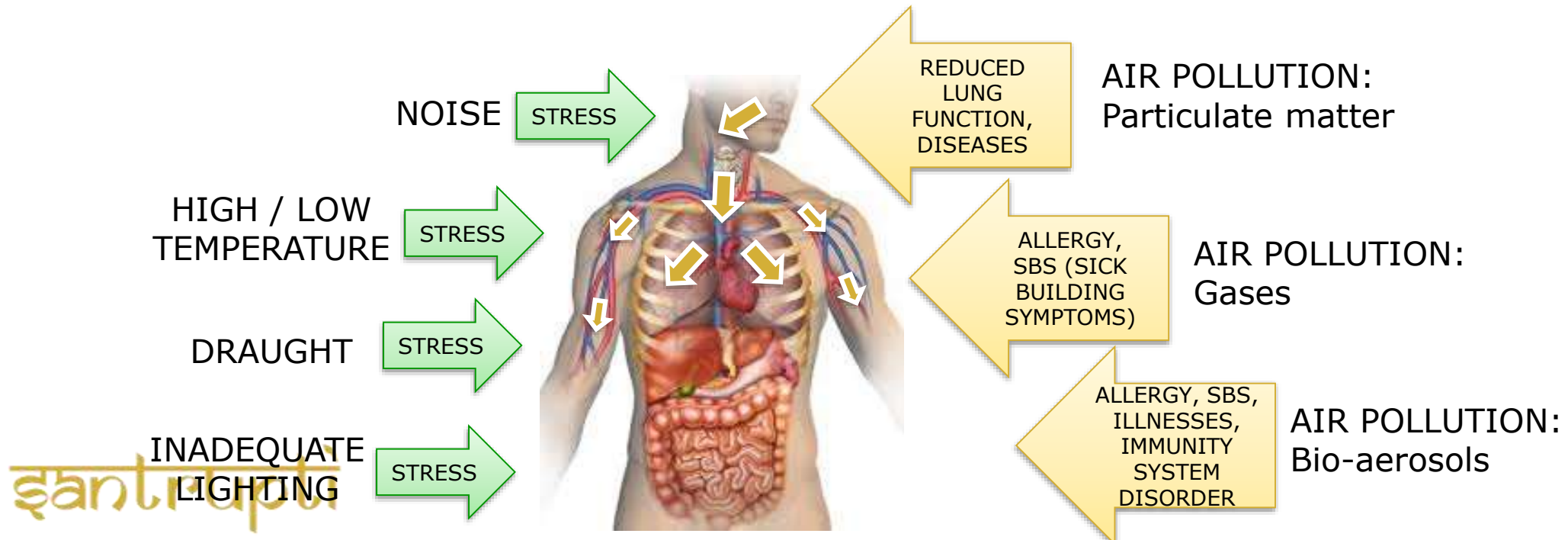
Is CO₂ an Indoor Pollutant?

Direct Effects of Low-to-Moderate CO₂ Concentrations on Human Decision-Making Performance by State University of New York, Syracuse, and Lawrence Berkeley National Laboratory, Berkeley



Health Impacts of Poor IEQ

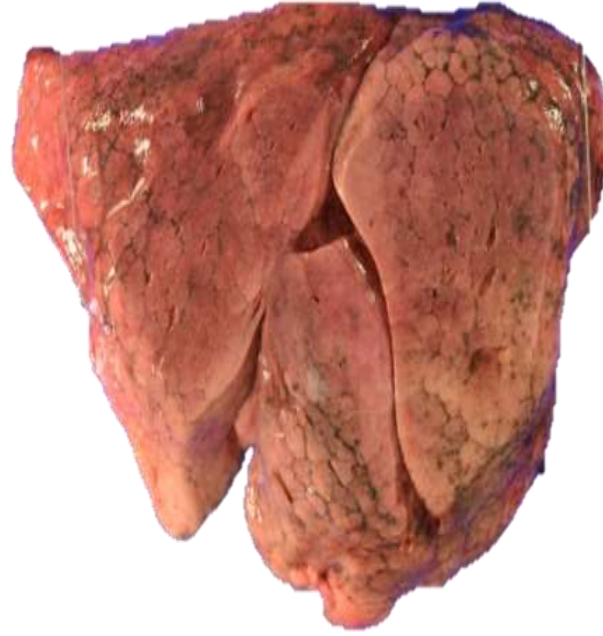
- Particulate matter and other pollutants present in indoor air, have a clear link with productivity, sense of wellbeing and occupant health. In long term, they lead to health hazards like asthma, allergies, headaches, respiratory diseases and cancer.
- Temperatures that are too high or too low, continuous high noise levels, or excessively bright or inadequate lighting level increase the stress levels in the human body, thus creating health issues like sleep disorder, digestive problems, memory and concentration impairment.



Pathological Changes in the Lungs



Healthy lungs



Outdoor air pollution
exposure

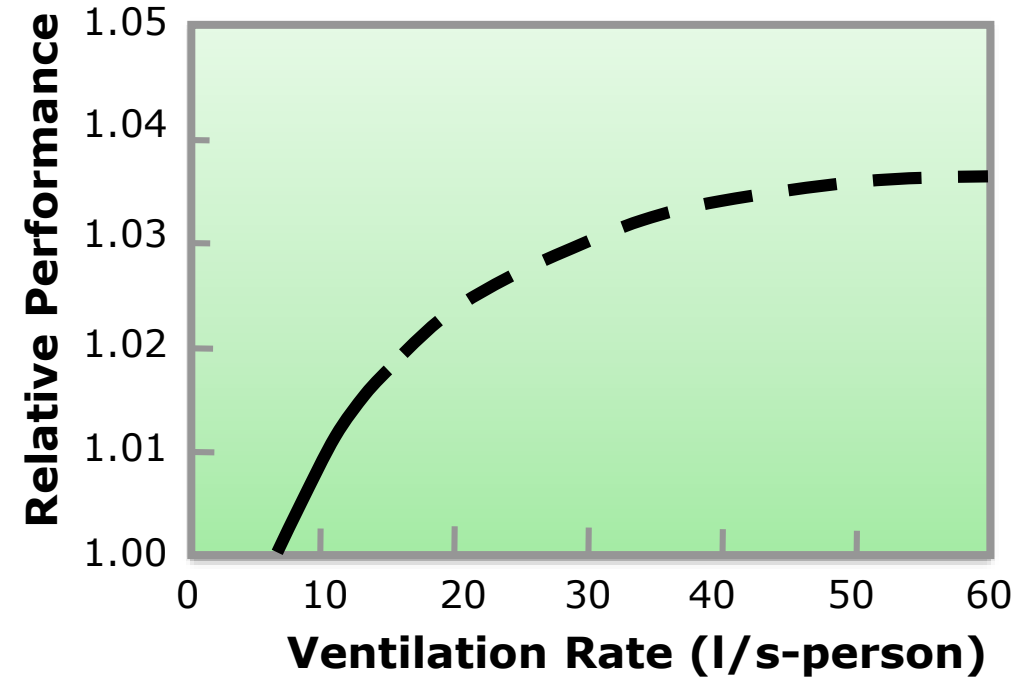
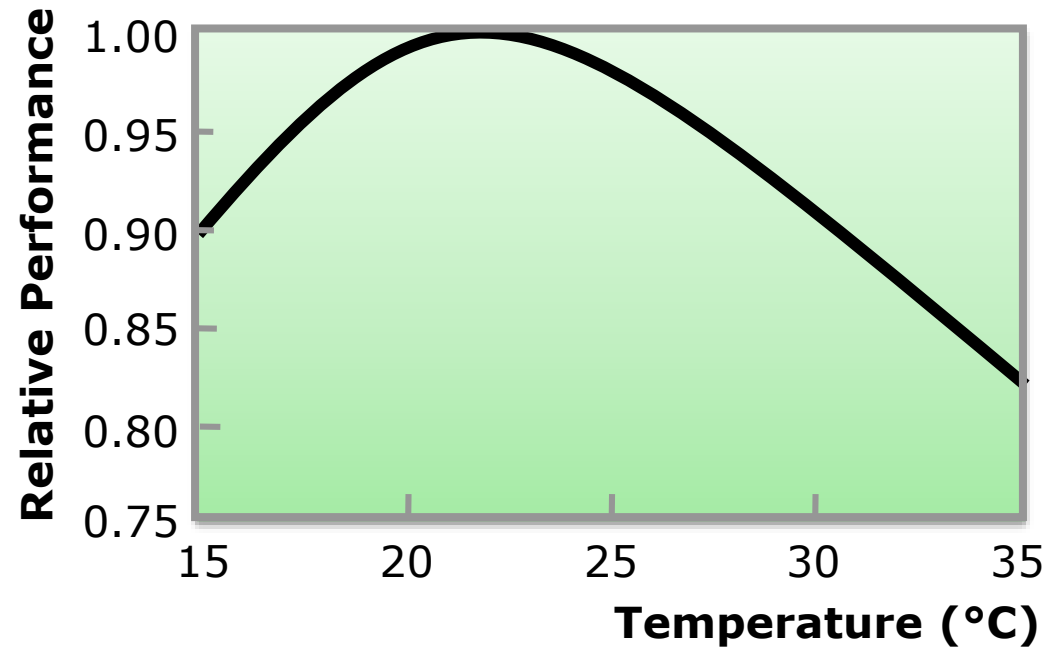


Tobacco smoke

Source: Pathology slides - Courtesy Prof. Saldiva, São Paulo, Brazil



Productivity Research



First Indoor Air Quality Problem of Human Being

170,000 years ago



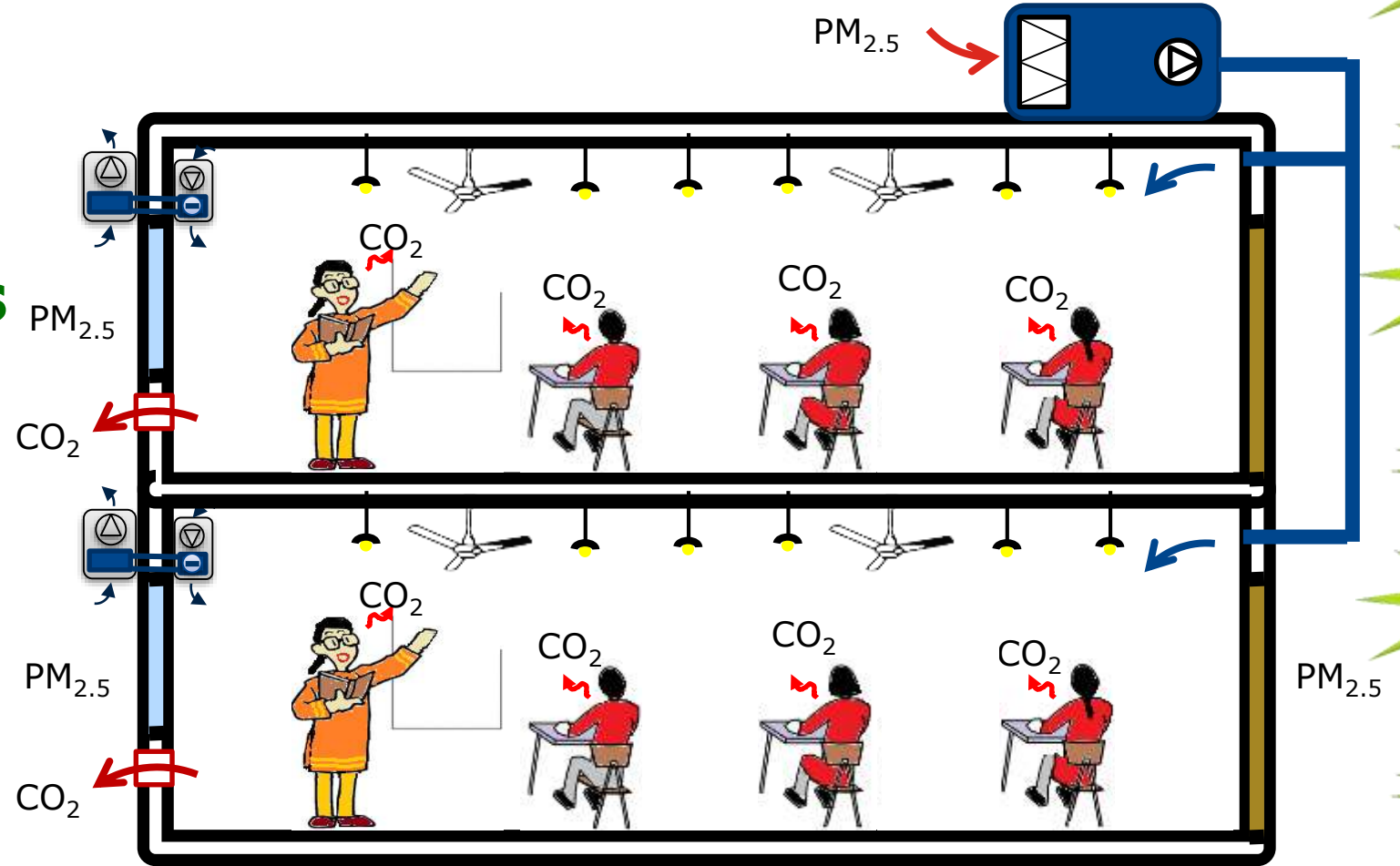
Solution: Ventilation



Improved Energy and IEQ Performance: Private Schools

Ventilation Filtration 5★ Rated Products

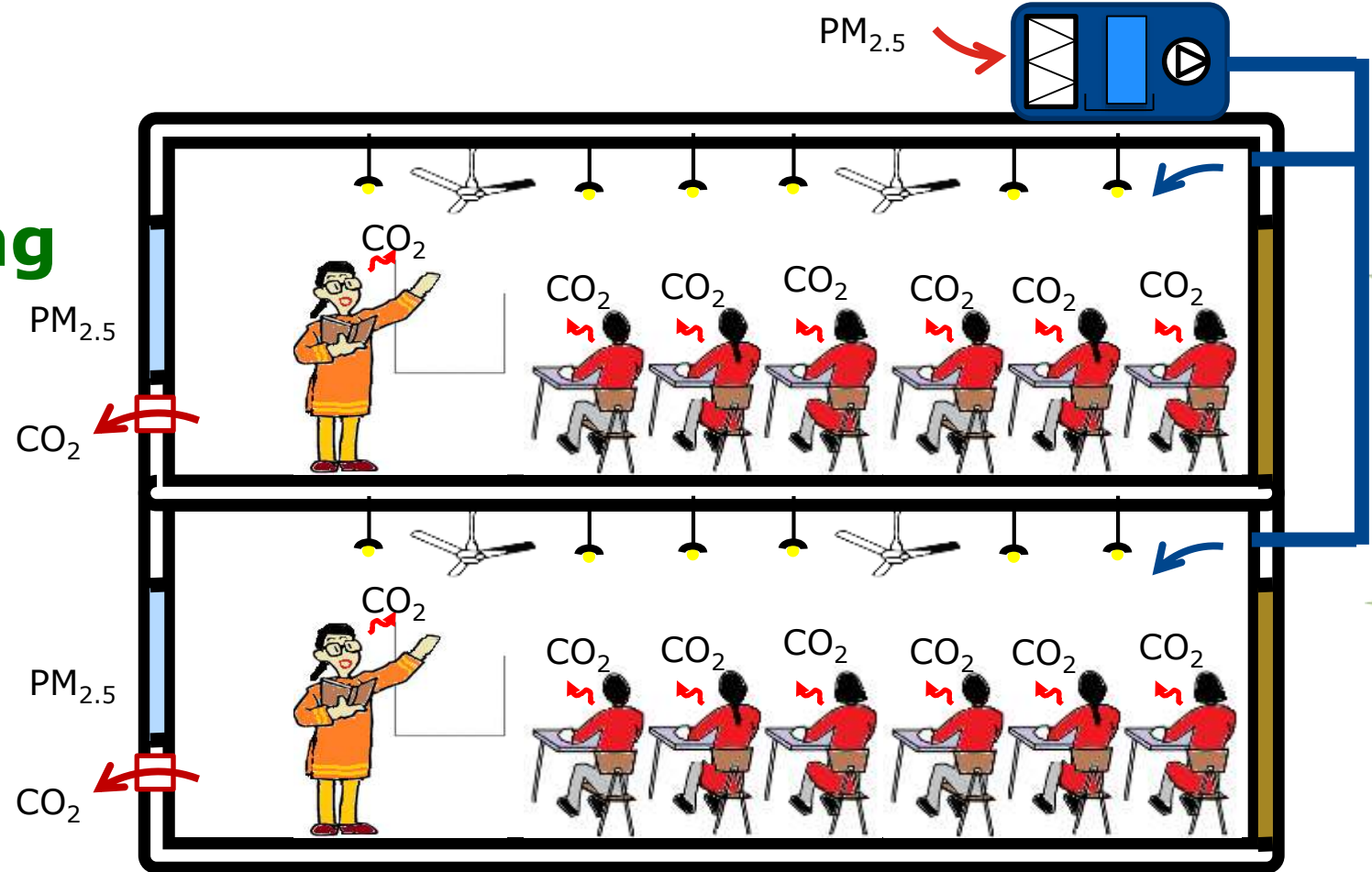
IAQ	★ ★ ★
Thermal comfort	★ ★ ★
Energy	★ ★ ★
Lighting	★ ★ ★
Acoustics	★ ★



Improved Energy and IEQ Performance: Government Schools

Ventilation
Filtration
Evaporative Cooling

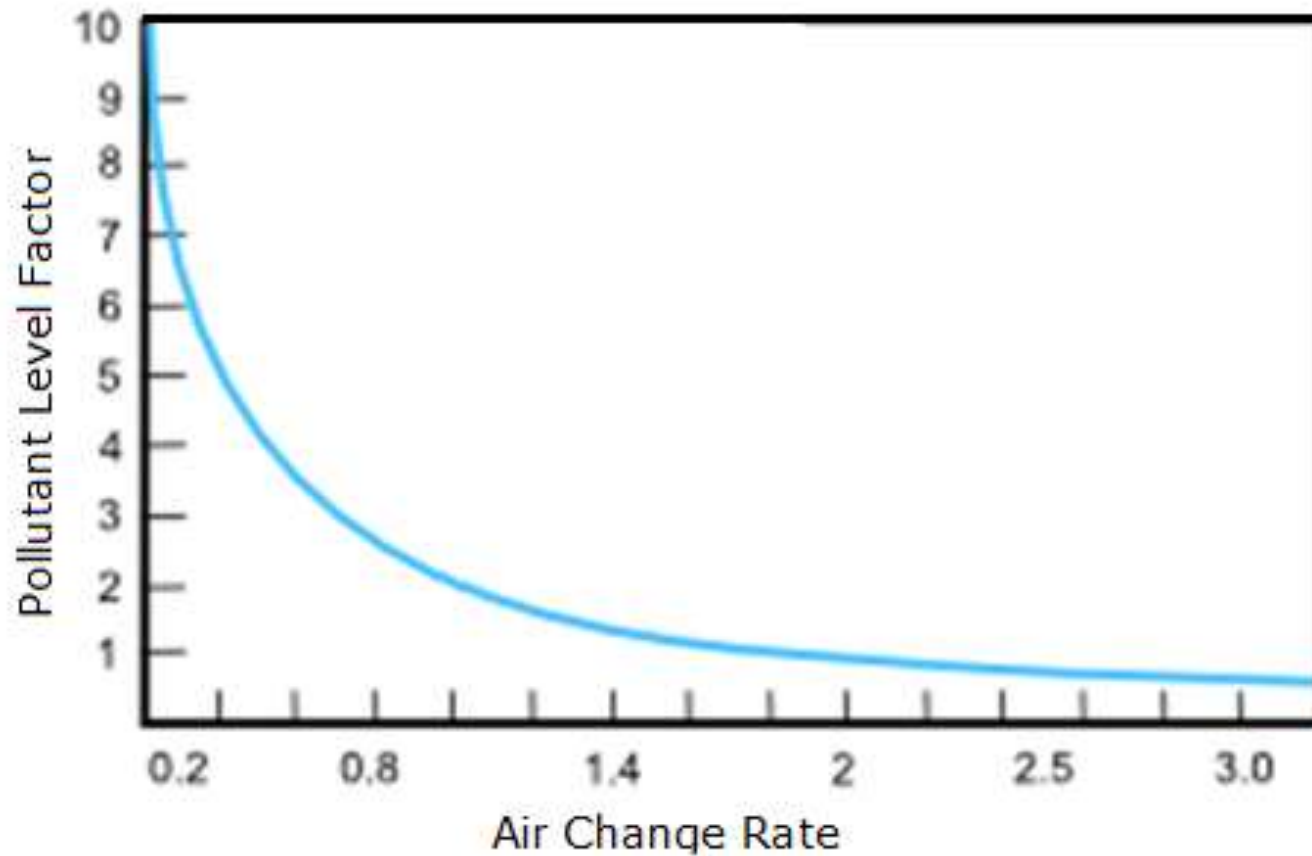
IAQ	★ ★ ★
Thermal comfort	★ ★
Energy	★ ★
Lighting	★ ★
Acoustics	★ ★



Ventilation Rate

- Outdoor air as per ASHRAE 62.1: $10 \text{ cfm/person} + 0.12 \text{ cfm/ft}^2$
- Private school:
 - Outdoor air flow rate: $(30 \times 10) \text{ cfm} + (600 \times 0.12) \text{ cfm} = 372 \text{ cfm} (3 \text{ l/s, m}^2)$
 - Air change rate: $(372 \times 1.7) \text{ m}^3/\text{h} / (600 \times 0.093 \times 3) \text{ m}^3 = 3.8 \text{ ac/h}$
- Government school:
 - Outdoor air flow rate: $(60 \times 10) \text{ cfm} + (600 \times 0.12) \text{ cfm} = 672 \text{ cfm} (5 \text{ l/s, m}^2)$
 - Air change rate: $(672 \times 1.7) \text{ m}^3/\text{h} / (600 \times 0.093 \times 3) \text{ m}^3 = 6.8 \text{ ac/h}$

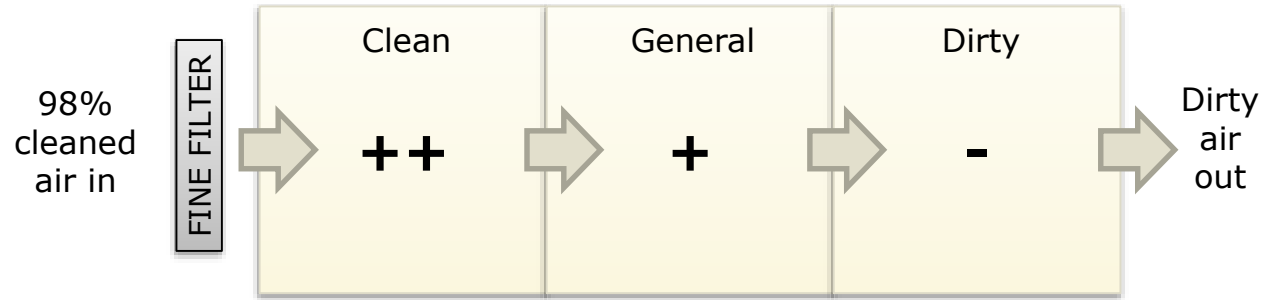
Good IAQ by Diluting Indoor Pollutants



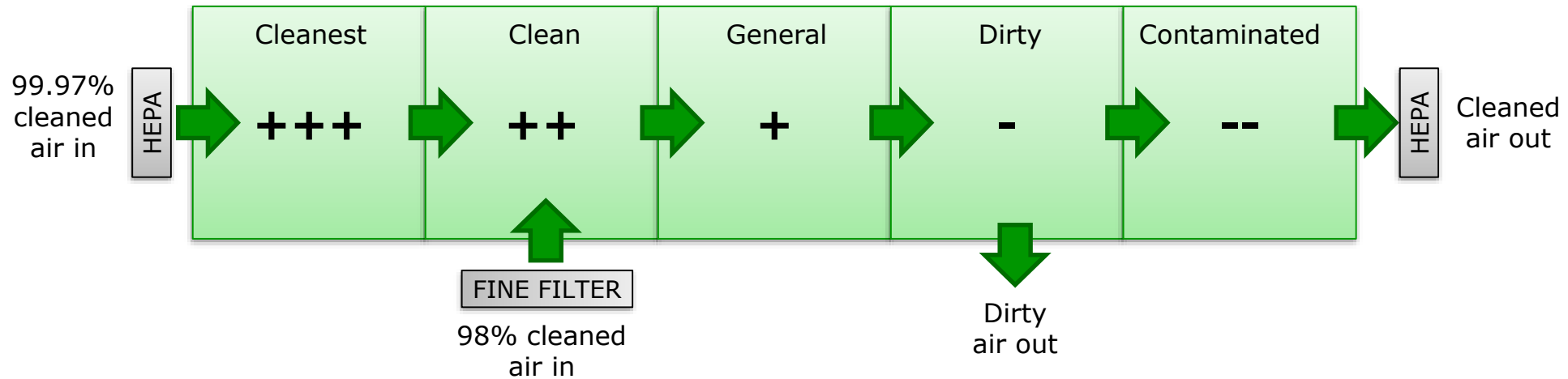
**Air change rate of 0.5 ac/h reduces indoor pollutants by 60%.
To achieve 90% reduction, the air flow rate of 2 ac/h is required.**

Pressurization with Clean Air

COMMERCIAL BUILDINGS



HOSPITALS



Filtration and Purification Technologies

Filtration technology	Substances to be removed						Possible by products
	RSPM	CO ₂	VOC	Inorganic Gases (NO ₂ , O ₃)	Bio-aerosols	Odour	
Mechanical filters	x						Odour
Electrically charged mechanical filter & ionizer	x				x		Ozone, odour
HEPA filter	x				x		Odour
Electrostatic precipitator	x				x		Ozone
Active carbon filter			x	x		x	Particulates
Potassium permanganate (KMnO ₄) filter			x	x		x	Particulates
Ultraviolet Germicidal Irradiation (UVGI)					x	x	Ozone
Photocatalytic Oxidation (PCO)			x		x	x	CO ₂ , VOC, ozone
Plasma—technology	(x)				x	x	Ozone
Photo-hydro-ionization (PHI)	(x)		x		x	x	Ozone
Ionizer	(x)					x	Ozone, ionized particulates
Ozoniser						x	Ozone
Outdoor air (dilution)	x	x	x	x	x	x	Outdoor pollutants if not filtered

DELHI: Evaporative Cooling in Summer

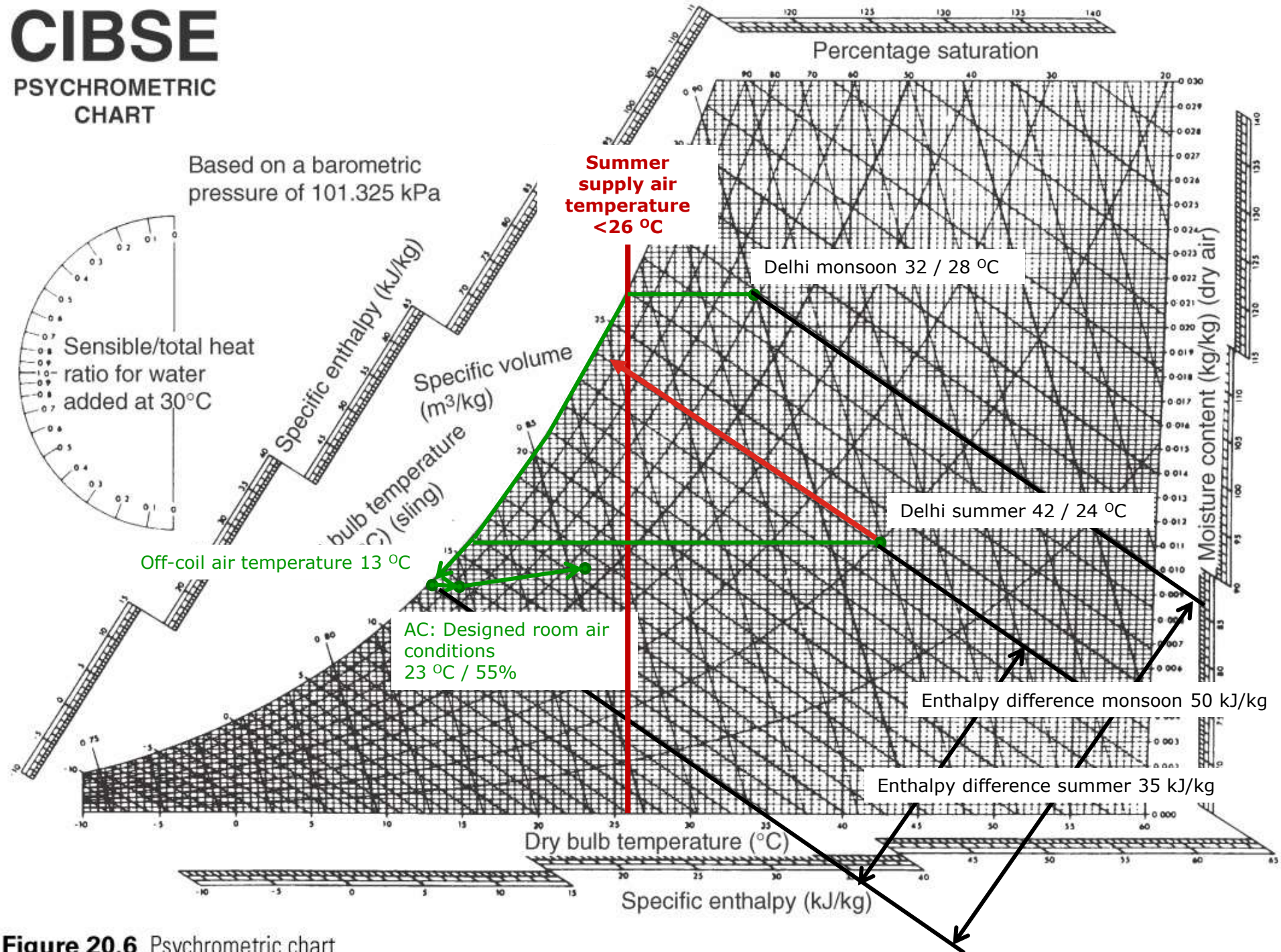


Figure 20.6 Psychrometric chart

Do What is Needed to Keep Indoor Air Clean & Healthy

- Ensure the high quality indoor air (low CO₂ and impurities levels) by bringing properly filtered outdoor air into the spaces.
- Prevent the dirty outdoor air entering into the building by positively pressurizing the spaces.
- Prevent dampness & fungi and limit the use of chemicals and VOCs.
- Clean classrooms properly but avoid cleaning products that disinfects the environment (kills necessary bacteria for humans and leaves most harmful fungi and bacteria to grow faster and to emit more toxic gases).
- Use energy efficient equipment and do not oversize them.
- Provide data to the school administration that there is a continuously healthy environment for children to study and personnel to work by installing continuous monitoring devices.

Result: Healthier and Smarter Students

- Even modest changes in room temperature affect student's abilities to perform in tasks requiring mental concentration.
- Children in classrooms with high outdoor air ventilation rates tend to achieve higher scores on standardized tests in math and reading than children in poorly ventilated classrooms.
- High particulate matter concentration prevents the proper development of children's lungs. At present, nearly 50% of Delhi's children suffer lung problems due to air pollution (PM_{2.5}).
- The presence of fungi and chemicals further increase the risk of asthma and related adverse respiratory health effects as well as allergy and immunity system disorder.