Designing Healthy nearly Zero Energy Schools

Energy Performance in Schools: past, present, future

REHVA
Federation of European Heating, Ventilation and Air Conditioning Associations

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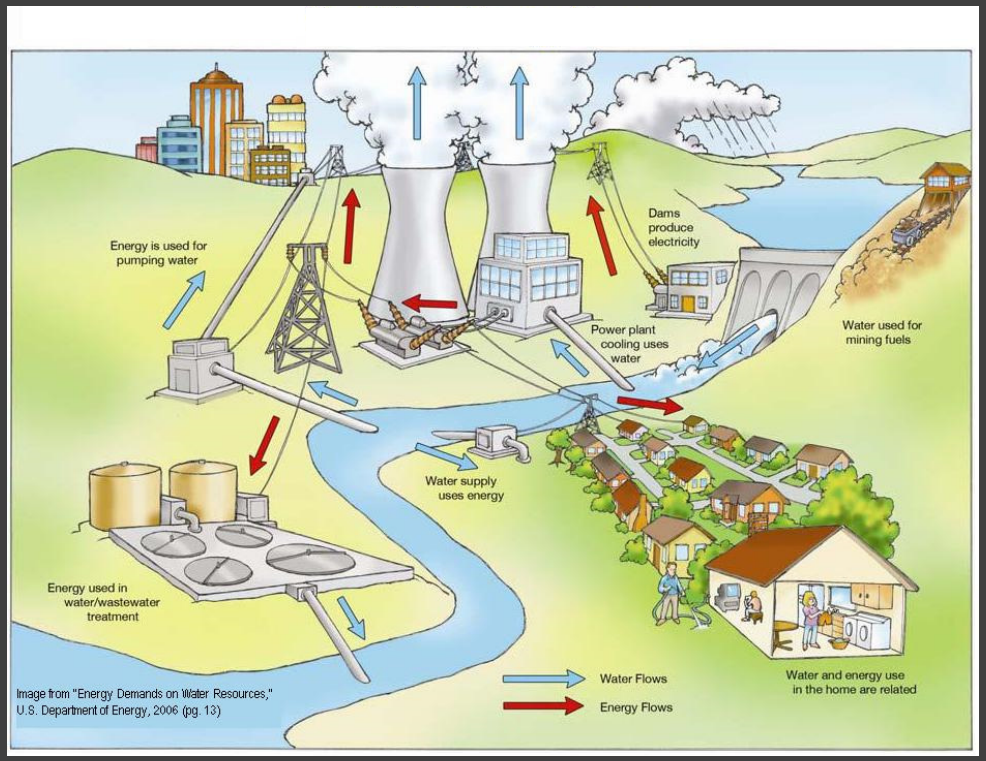
Why schools ?

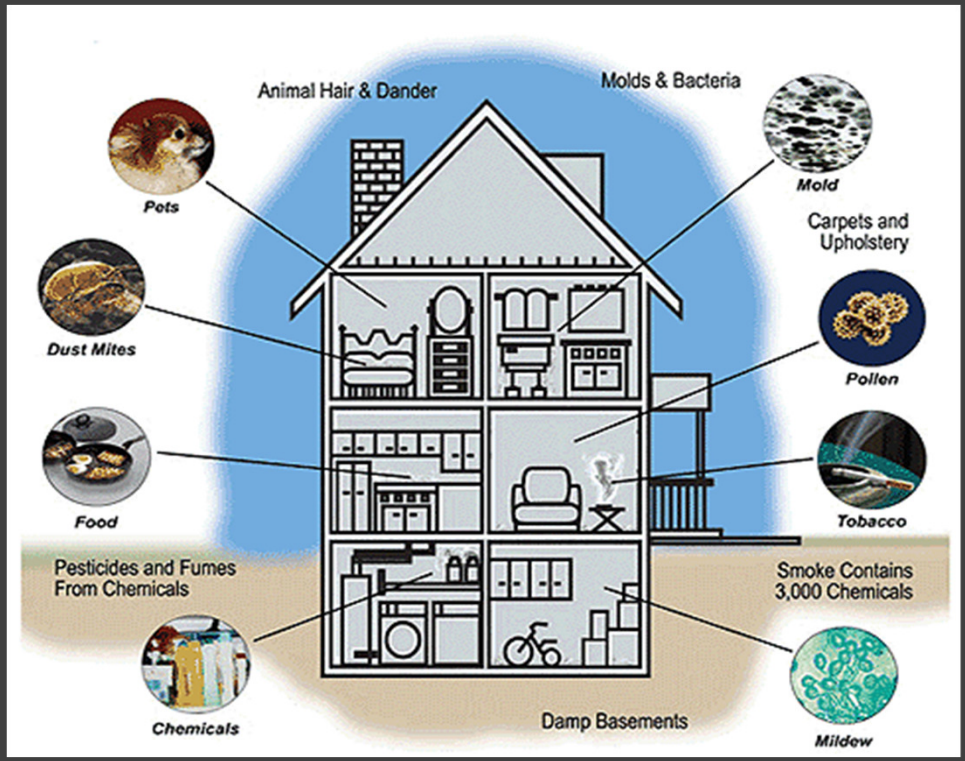
- Captive Users (cannot complain ?)
- Users cannot evaluate effects of non-compliance
- Compromised AQ leads to lower learning ability
- School management / owner interested in reducing costs (energy consumption)
  - Unviable RoI affects school operations / expansion
- Future citizens of the world need proper grooming

However, in general, all buildings need this approach

Why Energy?

- Schools operate during peak electrical load demand: ToD
- Energy Conserved is money saved
- Energy Conservation should not compromise IEQ parameters*
  *Lighting, Thermal Comfort, IAQ, Noise Vibration, User Satisfaction
- Energy is a scarce resource and EC should begin from classrooms





The IAQ-Energy nexus

PAST
What happened till now?

Standards are in place for:

IEQ

and its components like:

IAQ, Lighting, Thermal Comfort, Noise, User Satisfaction

Also, standards are available for:

Green Building Certification, Energy Modelling, BIM, High Performance Buildings

PAST: The IAQ-Energy nexus

It is intrinsic that Energy is required to maintain IAQ, which leads to these assumptions:

- Maintaining IAQ requires higher Energy
- Lowering Energy Consumption leads to compromise in IAQ

  applies to both residential and commercial / institutional indoor spaces

PRESENT: Major Components of IAQ and ~~Energy~~ **Resources**

- IAQ :
  - Particulate Matter (PM_{10}, $PM_{2.5}$, PM_{1}..)
  - Gases (CO_2, VOC's, CO ..)
  - Odour *
- Energy :
  - Electricity, oil, biomass,…
- Water consumption
- Air pollution

} **Resources**

Energy Prediction Models

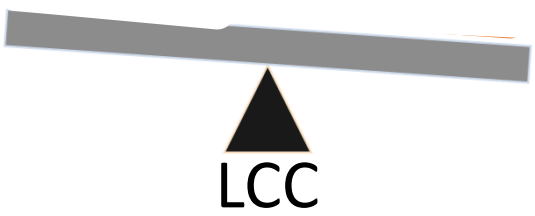
- Available for:
- Air-conditioned Spaces : Heat Load Calculations
- Mechanical Ventilation (MV)
- Exhaust Ventilation (ExV)

- Additional Research needed to make these available
- Adaptive Comfort (AC)
- Naturally Ventilated Spaces (NVS)
- Evaporatively Cooled Spaces (IDEC, EC)
- Predicting IAQ in occupied spaces

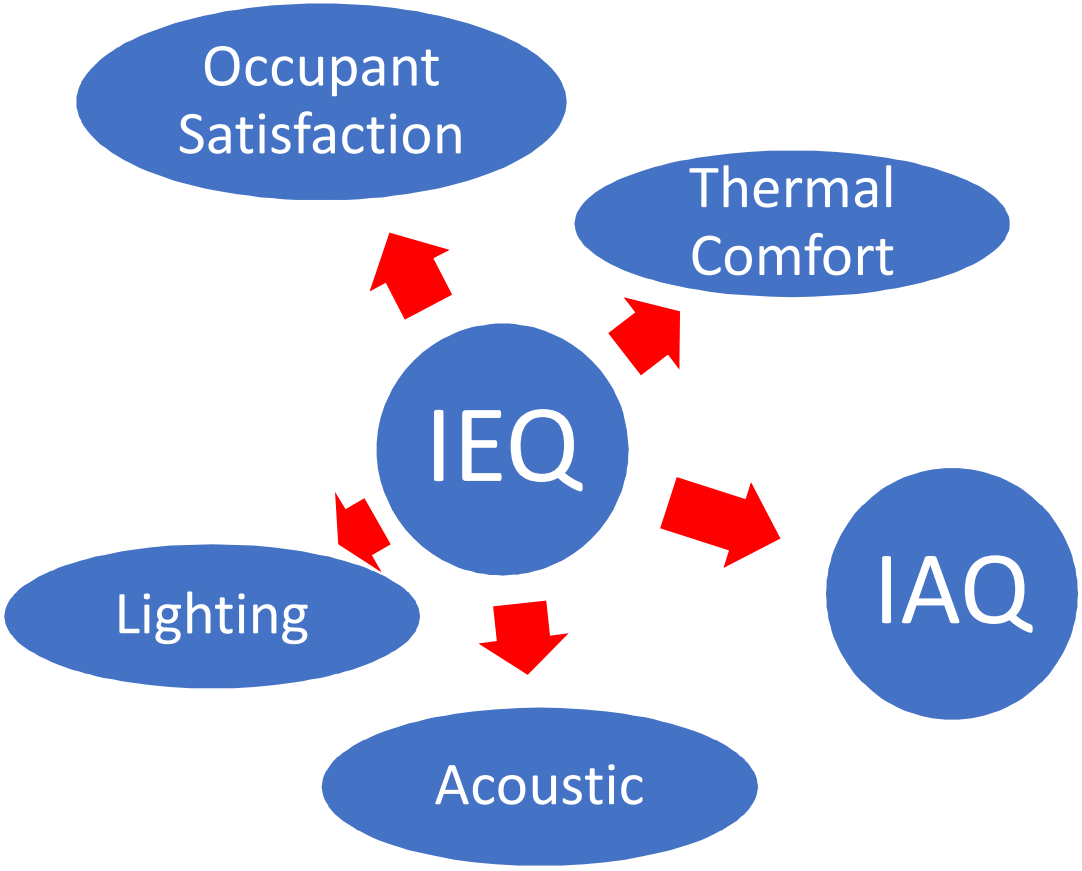
Life Cycle Cost analysis (LCC)

Cost

Benefits



IAQ is a part of IEQ



Global Codes, Standards, Guidelines for IAQ

- NBC of India 2016
- USGBC LEED, WELL standard
- IGBC
- GRIHA
- AHSRAE
- REHVA
- NABER
- ISHRAE

Indoor Environment Quality Standard

ISHRAE Standard – 10001 : 2016

First Version : 2016-2017

IAQ-Energy Nexus

Design approach of :

- Architects : Functionally efficient building with limited focus on Energy Consumption and IAQ
- Energy Experts: Capex and Opex optimised for RoI, may lead to compromising IAQ

A BALANCE needs to be achieved by the Building Designer, HVAC Designer, HVAC Contractor and HVAC Operator

PRESENT: Improving IAQ while reducing Energy

I. Reducing Installed Tonnage (reducing heat load)

a) Managing Fresh Air

b) Managing heat recovery

II. Reducing Operating Cost (reducing energy consumption)

III. Solar passive

Improving IAQ while reducing Energy

I.a) Managing **Fresh Air** to reduce Installed Tonnage

1. Designing for Fresh Air as per ASHRAE 62.1, 62.2 method
2. LEED suggests 30% additional FA over 62.1
3. WELL standard suggests < 800 ppm of [CO_2] in densely populated spaces
4. Ventilation rates from EN15215 or infiltration rates from EN15242
5. EN 15242 for mechanical, hybrid and passive ventilation
6. EN15251/EN13799 for basing the calculation for mechanical systems on the required air flows

Improving IAQ while reducing Energy

I.b) Managing by Heat Recovery *

1. Heat Pipes
2. Heat Wheels: sensible only and enthalpy wheels
3. Exhausting thru' toilets to divert dehumidified air
4. Exhausting over air cooled condenser coils

* Consideration of normal exhaust

Improving IAQ while reducing Energy

II. Reducing Operating cost

1. DCV (Demand Controlled Ventilation)
2. ECMS (Energy Consumption Monitoring System)
3. ECPM (Energy Consumption Prediction Model) : AI

Improving IAQ while reducing Energy

III. Solar passive

1. Allows saving in other energy forms by building design

IV. Some other considerations

1. Water consumption
2. Air and noise pollution
3. Solar PV, Solar Thermal

PAST, PRESENT: The IEQ-Energy Nexus : FUTURE

PAST

- We have thus far aspired for “as low an energy consuming building” as possible with “IAQ” as a desirable element

PRESENT

- **Shift in Paradigm: “Cost of Health” can be compared with “Cost of Energy”**

Energy and IAQ converge in Environment

Buildings could have a

POSITIVE IMPACT on the ENVIRONMENT

&

NEED NOT

necessarily be a negative impact on Environment

Co-benefits of IAQ and Energy

Energy conscious,
Healthy and Comfortable Buildings are
THE FUTURE
of our Industry

The IAQ-Energy nexus

It is intrinsic that Energy is required to maintain IAQ, which leads to these assumptions:

- Maintaining IAQ requires higher Energy
- Lowering Energy Consumption leads to compromise in IAQ

However, this need not be true

Technology is available to optimise EC while maintaining IEQ

- ✓ IAQ: $A < IEQ_n < B$, where n=1,2,..y: is the constraint parameter
- ✓ Energy: f(*E*): parameter to be minimised

The IAQ-Energy nexus

Two approaches for:

Optimising Energy Consumption considering IEQ as a constraint parameter

I. Optimisation by Calculating Probability Distribution:

II. Optimisation by Convex Linear Programming

The IAQ-Energy nexus

I. Optimisation by Calculating Probability Distribution:

$$P(f(E) \mid A < IEQ_n < B, \text{ where } n = 1,2,\ldots.y) < f(E^*),$$

where E^* is the upper limit of the expected energy consumption

- Useful when a benchmark of E^* specified in the Standard
- Prescriptive approach
- Relatively simpler than the other approach

The IAQ-Energy nexus

II. Optimisation by Convex Linear Programming

Minimise *E* subject to $A < IEQ_n < B$, where n= 1,2,….y,

where $E = f(E_m)$ *where m=1,2,….m are components of Energy*

- Theoretically, infinite design opportunities exist
- Not nearly Zero, but Building could be energy surplus
- Descriptive approach
- Simulation based

What is the future ?

- Upgrading Existing Technology
  - Improving Existing System Efficiency
    - IAQ: detection, sensing, filtration, removal, treatment
    - Energy: continuous upgradation, research
- Coupling existing technologies with new technologies
  - Solar PV, Passive Solar, Solar Thermal
  - Heat Exchange: sensible, enthalpy wheels
  - Demand Control Ventilation
  - ECPM
- Disruptive Technologies
  - Displaces an established technology and shakes up the industry or a ground-breaking product that creates a completely new industry.

What happens now ?

A common standard for achieving both is required:

- nearly Zero Energy Consumption
(very low energy consuming school buildings)

- maintaining IEQ

Need for REHVA-ISHRAE Task Force for a Guide Book on:

Indoor Environmental Quality & Energy Efficiency in Schools

What happens NOW ? Tentative schedule

Readiness of final draft of Guidebook	Q3 2018
External review process	Q4 2018
Finalise Guidebook	Q1 2019
Presentation at ACREX 2019 & REHVA meeting	Q1 2019 (February) + TBD

To summarise

- Stakeholders* should include IEQ Standard during the design process in practise and not base building design on Heating-Cooling Loads alone

*Architects, Electrical Consultants, Lighting Designers, HVAC Consultants, Contractors, Facility Managers, Operators, User, Owners and others affecting IEQ

- Buildings should not only be IEQ compliant for Users but should be energy conscious for Owners (Capex) and Operators (Opex)

- **A comprehensive Guidebook and later a Standard to address both is being generated**

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Thank you

Any comments ?

Fresh Air vs Outdoor or Ventilation Air

1. Fresh Air: Outdoor air devoid of pollutants i.e. in compliance with AAQS of CPCB used to maintain IAQ

2. Outdoor Air or Ventilation Air: Actual Ambient air that is used for conditioning or ventilating indoor spaces to maintain IAQ

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