Energy Efficiency Guidelines for Office Buildings in Tropical Climate

Energy Efficiency Strategies

Organization of American States
TTA Introduction

• Founded in Barcelona in 1986

• Independent Consultancy in Renewable energies and Sustainable Development

• Experts in energy management and micro generation with renewable energies

• Offices in Barcelona, San José (Costa Rica) and Quito (Ecuador)
Consultancy & Engineering

- Photovoltaic
- Solar Thermal
- Biomass
- Wind
- Integration of renewable energy in buildings
- Energy efficiency
- Sustainable buildings
• Introduction
  – Energy efficiency in buildings

• New construction and refurbishment design criteria for high efficient buildings
  – HVAC
    • Radiant panels
    • Mechanical Ventilation
    • Internal air dehumidifiers
    • Zoned cooling
    • Zone dampers
    • Extraction air Heat Recovery
  – Artificial lighting
  – Elevators
Energy efficiency in buildings

• Why do we need energy in buildings?
  – Energy Services
    • Comfort
      – Demand
      – Cooling (/heating)
    • Ventilation
    • Hot water
    • Lighting
Energy efficiency in buildings

• Why do we need energy in buildings?

• Energy Efficiency or Energy Conservation?
European DIRECTIVE 2010/31/EU

Aims to establish:

a) A common framework for a methodology to calculate the energy efficiency of a building
b) Application of minimum energy efficiency requirements to new or refurbished buildings and their mechanical installations
c) National Programmes foster the construction of net-zero energy buildings
d) Building energy certification
e) Periodical supervision of HVAC installations
f) Independent control of Energy Efficiency Certificate system and supervision reports
How to get there: Energy Efficiency and Renewable Energy in Built Environment

New buildings must be designed to demand little energy and to achieve local generation of energy.
In some countries of Europe, buildings with reduced energy demand are being built, as little as 15 kWh/m².
The European Directive on energy efficiency in the built environment aims at delivering new and existing buildings with very high efficiency and to the extent possible, local energy generation.
• Efficiency: input to meet desired output
• Certifying / goals of efficiency

<table>
<thead>
<tr>
<th>Certificación Energética de Edificios</th>
<th>Edificio Objeto</th>
<th>Edificio Referencia</th>
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<tbody>
<tr>
<td>Indicador kgCO2/m²</td>
<td></td>
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<tr>
<td>&gt;25.9</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>14.9-22.9</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>9.6-14.9</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>6.0-9.6</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>&lt;6.0</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td></td>
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<tr>
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<td>G</td>
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</table>

| Demanda calefacción kWh/m²           | C 25,2          | D 42,8              |
| Demanda refrigeración kWh/m²         | B 4,1           | C 5,4               |
| Emisiones CO2 calefacción kgCO2/m²  | C 5,8           | E 13,7              |
| Emisiones CO2 refrigeración kgCO2/m²| C 1,5           | D 2,0               |
| Emisiones CO2 ACS kgCO2/m²          | A 2,6           | D 4,9               |
• Again, why do we need energy in buildings?
  – Energy Services:
    • Comfort
      – Demand
      – Cooling (/heating)
    • Ventilation
    • Hot water
    • Lighting

• Demand reduction... and efficiency in delivery of required energy services
• Radiant panels
  – Radiant temperature: Comfort achieved by reducing the radiant temperature of the internal surfaces of the occupied spaces.
  – Low temperature: A relatively low radiant temperature improves the comfort even if the air temperature is slightly warm.
Advantages of radiant cooling vs. conventional cool air distribution:

- Decrease volume of air to be conditioned and transported
- Decrease the air velocity, drafts and noise
- More effective in decreasing the relative humidity of the renovation air and that of the ambient air
- Room air temperature can be higher: comfort temperature felt by the users has a strong component of the radiant temperature supplied by the radiant cooling system.
- Zoning to relatively small spaces
- Comfort operative temperature achieved given impact of radiant temperature (average between the room air temperature and the radiant temperature of the surfaces)
- Lower energy demand to cool water: it can be delivered at 15-17 ºC instead of 7-9ºC for all-air systems; this is thanks to the big radiant exchange surface used.
- The radiant panels take very little usable space and are practically invisible.
The response is fast so it can be turned on little before the activity in the building begins and can be turned off once finished, thus reducing the energy consumption.

Results of reduced electricity demand for:

- cooling device
- heat dissipation
- recirculation of fluids
- terminal unit

- 21% lower with radiant panel system
• Ventilation with cooled+dehumidified air:
  – Why mechanical ventilation?
    • Keep the healthy conditions of the ambient air in order to avoid the non-controlled entry of humidity and heat. Also in order to ensure a hygienic comfort, in terms of CO2 and other contaminants generated by the activity within the building.
  – HVAC units provide
    • fresh, external, filtered, conditioned and de-humidified air into the building.
  – Distribution: through ducts delivering it to all closed and conditioned rooms.
  – Extraction: network of ducts to extract rejection air with slightly lower volume rates, in order to compensate the air losses and create a slight overpressure in the rooms to avoid the non-controlled infiltration of outside air.
• Zoned cooling
  – Why? Office buildings:
    • clearly distributed and separated spaces (meeting rooms, offices, printer rooms etc.)
    • as well as open spaces, with uniformly distributed workstations.
  – Non-uniform cooling demand: demands vary depending on:
    • orientation of the closest façade
    • density of electronic equipments
    • requirements of the users, etc.
  – Thus, the cooling distribution system must allow for a zoning of all closed spaces.
  – In spaces without separating walls, the possibility to regulate the intensity of cooling should exist, focused on small working spaces.
– **Zone dampers**
  - Regulate the delivery of conditioned air to zones:
    - without any activity or with a varying activity
    - manually activated or automatically with a sensor:
      » motion or CO2 concentration
  - Thus, the total air flow can be regulated and the energy used for this purpose saved.

• **Internal air dehumidifiers**
  – **Why?**
    - Human activity increases air humidity
    - Keep relative humidity of the ambient air below 60%
    - Below the dew point for the setpoint temperature, if radiant elements are used.
  – **Electrical de-humidifiers will be used as needed in order to limit the increase of the relative humidity even when the number of occupants increases.**
• Extraction air Heat Recovery
  – Air renovation is necessary.
  – The extraction of conditioned air is one of the big energy losses in an air-conditioned building.
  – Use of Heat Recovery units is suggested in order to cool the input, fresh air.
The strategies to develop such Heat Recovery are the following two:

a) Heat recovery unit
- equipment composed of two fans, air filters and a plate heat exchanger for air, with counterflow, through which the internal, extracted air and the external, fresh air move.
- in the plate heat exchanger, the external warmer air, transfers heat with the extraction cooler air, thus cooling the fresh air taken into the building for air renovations.
### From the “Parametric Study” for the Guidebook

<table>
<thead>
<tr>
<th>Option</th>
<th>Lighting</th>
<th>Cooling</th>
<th>Total</th>
<th>Improvement</th>
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</thead>
<tbody>
<tr>
<td>No HR device</td>
<td>23,2</td>
<td>384,0</td>
<td>407,2</td>
<td>Ref.</td>
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<tr>
<td>Sensible HR</td>
<td>23,2</td>
<td>367,5</td>
<td>390,7</td>
<td>4,1%</td>
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<tr>
<td>Latent HR</td>
<td>23,2</td>
<td>305,7</td>
<td>328,9</td>
<td>19,2%</td>
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</table>

#### Heat recovery unit

![Heat recovery unit chart](image-url)
b) Heat pump

- the cooling air-air or air-water equipment can use the extracted air flow as a heat sink.
- Since the extracted air is cooler than the fresh, external air, the efficiency of the heat pump will increase, delivering an energy saving equivalent to that of the heat recovery unit.
Replacing fluorescent and incandescent lights with LED lights:

- High efficiency 90 lm/W
- Almost no maintenance cost
- Estimated life 50,000 h
- Decreases considerably thermal load – decreases cooling demand
- LED models similar to other existing lamp models
• **Daylighting in Energy Efficient Design:**
  - reducing the depth of the zones
  - Reduced window-to-wall ratio 20%
  - A different solar protection solution for every orientation.
  - No skylights; all daylight enters through facades.
    • Mostly diffuse light into the building

- Between 170 and 340 lux in the perimeter and less than 170 lux in the center of the floorplan.
- Circulation areas and staircases are daylit.
• LED lighting

<table>
<thead>
<tr>
<th>Power</th>
<th>40</th>
<th>45</th>
<th>W</th>
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<tbody>
<tr>
<td>Size</td>
<td>60 x 60 x 1</td>
<td>120 x 20 x 1</td>
<td>cm</td>
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<tr>
<td>Luminous flux</td>
<td>3,590</td>
<td>4,010</td>
<td>lm</td>
</tr>
<tr>
<td>Luminous efficiency</td>
<td>89.8</td>
<td>89.1</td>
<td>lm/W</td>
</tr>
<tr>
<td>Lifetime</td>
<td>50,000</td>
<td>50,000</td>
<td>h</td>
</tr>
</tbody>
</table>

35 x DIALux DALLE LED 40W BN 600x600
79 x DIALux DALLE LED 1200x200 45W BN D

• 2.3 m high (hung from ceiling)
• Total installed power: 5025 W
<table>
<thead>
<tr>
<th>Color</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>300.00 lx</td>
</tr>
<tr>
<td></td>
<td>500.00 lx</td>
</tr>
<tr>
<td></td>
<td>750.00 lx</td>
</tr>
</tbody>
</table>
• What if fluorescent lighting instead of LED?

- 2,3 m high
- Total installed power: 12,728 W
• Installed power: 12728 W vs. 5025 W

• Lighting control: dim artificial light: 19% less
• Elevators
  – Control of lighting at elevators (inside/outside)
    • Often, lighting in elevators works 24h/day:
      – Inside and outside the elevator
    • Building in La Réunion (Case Studies), reduces 120 kWh/month to 55 kWh/month by controlling elevator light (from 24 hours to standby control)
• **Summary and other recommendations**
  – Selection of efficient chillers that can to work in the most usual conditions of local climate; possibility of modulating power depending upon demand (inverter).
  – Possibility to combine with “free cooling” equipment if local conditions allow.
  – Distribution of cooling at low temperatures; prefer radiant solutions to very low temperature air distribution.
  – High degree of zoning.
  – Control: possibility to turn off emitters if open windows are detected or in moments of no occupancy.
It is cheaper to save fuel than to burn it

Amory Lovins (Energy Expert, Rocky Mountain Institute)
Thank you

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