Technical Brief on Sustainable Energy

VENTILATION AND COOLING SYSTEMS

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Cooling systems, whether they are air conditioners or evaporative systems, maintain thermal comfort for factory employees by reducing excessive heat.

Ventilation systems ensure constant renewal of fresh air and removal of indoor pollution (fabric dust or chemicals), guaranteeing healthy air conditions for the employees.

A person’s perceived heat depends on temperature and humidity: at 80% relative humidity, 29°C feels like 36°C. This is called apparent temperature or heat index:

<table>
<thead>
<tr>
<th>Relative Humidity</th>
<th>Air Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>21°C</td>
</tr>
<tr>
<td>30%</td>
<td>19*</td>
</tr>
<tr>
<td>50%</td>
<td>21*</td>
</tr>
<tr>
<td>60%</td>
<td>21*</td>
</tr>
<tr>
<td>70%</td>
<td>21*</td>
</tr>
<tr>
<td>80%</td>
<td>22*</td>
</tr>
<tr>
<td>90%</td>
<td>22*</td>
</tr>
</tbody>
</table>

* Apparent temperature (°C)

Source: Steadman, R.C. The assessment of sultriness. Part I.

Extended exposure and activity may result in exhaustion

Severe health risk – Heatstroke imminent

Main weather in Cambodia

Extended exposure and physical activity can result in heatstroke

Table: Temperature and Health

<table>
<thead>
<tr>
<th>Heat Stroke</th>
<th>Heat Exhaustion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dizziness, fainting</td>
<td>Headache, confusion</td>
</tr>
<tr>
<td>Intense thirst</td>
<td>High body temperature</td>
</tr>
<tr>
<td>Excessive sweating</td>
<td>No sweating</td>
</tr>
<tr>
<td>Rapid weak pulse</td>
<td>Rapid strong pulse</td>
</tr>
<tr>
<td>Nausea, vomit</td>
<td>Nausea, vomit</td>
</tr>
<tr>
<td>Pale, cold, clammy skin</td>
<td>Red hot skin</td>
</tr>
<tr>
<td>Muscle cramps, fatigue</td>
<td>May loose consciousness</td>
</tr>
</tbody>
</table>

Move to a cooler place, drink water, take a cold shower, use cold compresses.

Call emergency services, take immediate action to cool down the person.

To ensure employees comfort and maintain high productivity, controlling the ambient apparent temperature at all times is crucial.

Temperature and Productivity

Prolonged periods of excessive heat inside the factory tend to exhaust workers and negatively impact productivity.

With apparent temperature above 27°C, productivity can decrease by 4% per °C.

Note: Fans help reducing body temperature by creating a draught.

Ventilation and Cooling Systems Use in Industry

Electricity consumption in the Cambodian Garment Industry

Chart source: Energy efficiency NAMA in the garment industry in Cambodia

02 VENTILATION & COOLING SYSTEMS
**1. Production Area – Evaporative Cooling System**

Evaporative cooling systems use the principle of **water evaporation** in dry, warm air flow, reducing its temperature up to 10°C while increasing its humidity.

*Suited for cooling large spaces,* they are **economical**, relying mainly on fans to operate. However, **cooling capacity is limited**, especially in humid external environments (rainy season).

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**2. Office Area – Air Conditioning**

Air conditioning systems use the principle of **compression/expansion** of a gas called **refrigerant** for cooling. Despite its **higher cooling capacity**, this system consumes **substantial energy** and is not suitable for large spaces, but is **effective in smaller rooms**.

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**Evaporative Cooling vs. Air Conditioning Comparison**

<table>
<thead>
<tr>
<th>Item</th>
<th>Temperature</th>
<th>Humidity</th>
<th>Energy Consumption</th>
<th>Initial Investment</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaporative cooling</td>
<td>Limited cooling capacity, especially in humid</td>
<td>Higher humidity</td>
<td>Low</td>
<td>Low</td>
<td>Simple technology easily maintained</td>
</tr>
<tr>
<td></td>
<td>external conditions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air conditioning</td>
<td>Precise temperature control, can reach lower</td>
<td>Maintains dry and clean</td>
<td>High</td>
<td>High</td>
<td>Refrigerant can be harmful to human and</td>
</tr>
<tr>
<td></td>
<td>temperature</td>
<td>air</td>
<td></td>
<td></td>
<td>environment</td>
</tr>
</tbody>
</table>
**1. Improve Building Thermal Protection**

1. Optimize building envelope to mitigate thermal effects and prevent indoor temperature rise (see details on p.6).
2. Install automatic non-return louvers on all exhaust fans to block hot air entry when fans are off.
3. When possible, isolate heat-generating areas (ironing, heat presses, drying, etc.) from other process sections.

**3. Optimize Monitoring and Control**

1. Maintain optimal airflow through evaporative pads; avoid excessive speed or slowness. Regulate airflow with variable frequency drives on fans or by shutting down some fans if air flow is excessive.
2. Integrate temperature and humidity automatic controls to reduce ventilation when predefined levels are reached.

**4. Change to More Efficient Technologies**

1. Use efficient technologies for exhaust, ceiling and stand-alone Fans:
   - Use efficient fan blade profiles that are efficient, generating more airflow with the same energy input compared to conventional designs.
   - Replace heavy metal fan blades with lighter fiber-reinforced plastic blades, requiring less energy for movement.
   - Choose brushless direct current (BLDC) fans over asynchronous belt motors to conserve energy.
2. For Air Conditioners, use inverter technology, adjusting compressor speed based on cooling demand.

**5. Provide Regular Maintenance**

1. Regularly monitor air conditioning refrigerant levels and promptly address leaks, as refrigerant emissions have significant greenhouse gas impact. Incorrect refrigerant levels reduce system efficiency.
2. Regularly clean AC air filters and fan grates from dust to maintain optimal airflow, thus preserving energy efficiency.
3. Ensure even water distribution across evaporative pads, preventing dry spots or clogged pipes, as efficiency drops when pads are dry.
4. Replace evaporative pads that are too old, dirty or damaged.
**Summary & Recommendation**

1. Improve Building Thermal protection
2. Set thermostat at 25°C
3. Optimize Monitoring and control
4. Use inverter technology
5. Provide regular maintenance
6. Additional recommendation for cooling capacity improvement

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**6. Additional recommendation for cooling capacity improvement**

1. Install individual stand-alone fans for work stations. Especially those exposed to heat (ironing, heat presses, washing machines, dryers).
2. Switch from evaporative cooling to centralized air conditioning, using chiller and cooling tower. This system generates flow of cold distributed throughout the factory with piping network.

Note: The operational costs are higher but the comfort is improved in addition to allowing better control of temperature and humidity.
Temperature Distribution in the Factory with Evaporative Cooling

Cross through cooling

Air flows through the factory:
- from cooling pads where air is colder
- to the fans where air has been warmed up by machines and air infiltration.

It is recommended to:
1. Install pads on the wider wall of the building if feasible.
2. Use plastic curtains for high ceilings to circulate cool air at human level.
3. Position employees where air is cooler.

Non-Efficient practices
Operating under negative pressure, openings will reduce the system efficiency:
- Hot outside air enters without being cooled through the pads.
- Prevent air infiltration by closing all openings to achieve optimal cooling capacity.

Ducted cooling

- Better temperature uniformity with the use of ducts.
- Air is pushed into the building, needing small openings for circulation. Nonetheless, maintaining closed doors and windows is important to prevent cold air from escaping.

Building Envelope Optimization

Optimizing the building envelope limits internal air heating, resulting in improved working conditions and energy savings.

- Insulate the building
- Use vegetation to shade the building
- Paint roof in white or light color
- Insulate all steam piping
- Install solar protections above windows
- Install automatic doors or heavy plastic curtains
- Seal all air leaks
Energy Management Steps

A step-by-step approach for investing in ventilation and cooling systems.

**01. Current state of the installation**

Inventory of the material and the use of the system. Knowing the components and requirements of the installation will help pre identify potential improvement and prepare further analysis:

- Capacity and number of ventilation and cooling systems (fan, pad, AC, cooling units, chiller etc.)
- Location of installation and distribution network
- Daily operating hour (h/day)
- Ventilation and cooling needs (temperature, humidity, air flow)

**02. Measurements**

Taking detailed measurements of the installation is the starting point for improvement and assessing its performance.

Measure and document the following:

- Electricity and water consumption
- Ventilation and cooling production (temperature, humidity and air flow)
- Air leaks into building (air flow, temperature, humidity)
- Refrigerant leakage
- Thermal losses
- Loading and unloading time
- Thickness and quality of building thermal insulation

**03. Data Analysis**

Once measurement is done, the analysis of the consumption gives information on possible improvements:

- Calculate efficiency of ventilation and cooling systems by comparing electricity consumption with ventilation and cooling output.
- Calculate percentage of thermal losses on buildings and water networks.

**04. Equipment & System Analysis**

Analyzing the individual components to identify potential improvements on the installation, understand the actual lifetime of the products, and monitor their quality.

**05. Implementation & Improvement**

Based on careful assessment and evaluation, identify improvement options.

Considering the information gathered in this technical brief, propose improvement (technical improvement, possible investment, energy management, etc.), indicate the potential savings or impacts and set priority for the implementation of each improvement.

**06. Verification & Monitoring**

After implementation, start monitoring the efficiency and consumption of the system, and organize a maintenance plan for the system:

- Monitor energy consumption
- Monitor air and water flow: temperature, humidity, etc.
- Estimate energy saving compare to previous system
- Monitor air leaks in the building, water leaks, refrigerant leaks
- Organize a maintenance plan
This technical brief has been made possible thanks to the Switch Garment and VETHIC projects. They aim at providing hand-holding support to garment manufacturing units in the country to identify and adopt sustainable energy practices.

Switch Garment, a project funded by the European Union SWITCH–Asia Grants Programme and jointly implemented by Global Green Growth Institute (GGGI) Cambodia, Textile, Apparel, Footwear & Travel Goods Association in Cambodia (TAFTAC) and Geres aims at ‘Promotion of sustainable energy practices in the garment sector in Cambodia’ ("Switch Garment"). The objective of this project is to increase the competitiveness and decrease the environmental impact of the Cambodian garment industry through sustainable production.

The VETHIC project (2022-2024), funded by Agence française de développement (AFD), aims to improve the environmental performance of the Cambodian textile sector by activating the levers of energy transition. The project is jointly implemented by Geres, TAFTAC, Cambodia Women for Peace and Development (CWPD), and Live and Learn Cambodia (LLC).

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