Technical Brief on Sustainable Energy

VENTILATION AND COOLING SYSTEMS

switchasia

Funded by the European Union

SWITCH GARMENT

PROMOTION OF SUSTAINABLE ENERGY PRACTICES IN THE GARMENT SECTOR IN CAMBODIA

AFD AGENCE FRANÇAISE DE DÉVELOPPEMENT

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VENTILATION AND COOLING SYSTEMS USE IN INDUSTRY

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.

Electricity consumption in the Cambodian Garment Industry

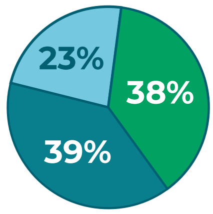


Chart source: *Energy efficiency NAMA in the garment industry in Cambodia.*

Apparent Temperature

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:

- Yellow: Extended exposure and activity may result in exhaustion
- Orange: Extended exposure and physical activity can result in heatstroke
- Red: Severe health risk – Heatstroke imminent
- Outlined box: Main weather in Cambodia

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

Relative Humidity	Air Temperature								
	21°C	24°C	27°C	**29°C**	**32°C**	**35°C**	38°C	41°C	43°C
30%	19*	23*	26*	**29***	**32***	**36***	40*	45*	51*
50%	21*	24*	27*	**31***	**36***	**42***	49*	57*	66*
60%	**21***	**24***	**28***	**32***	**38***	**46***	56*	65*	
70%	**21***	**25***	**29***	**34***	**41***	**51***	62*		
80%	**22***	**26***	**30***	**36***	**45***	**58***			
90%	22*	26*	31*	39*	50*				

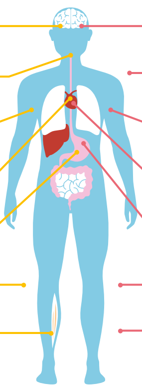
* Apparent temperature (°C)

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

Temperature and Health

Long exposure to excessive heat can lead to severe **dehydration** and **heat stroke.**

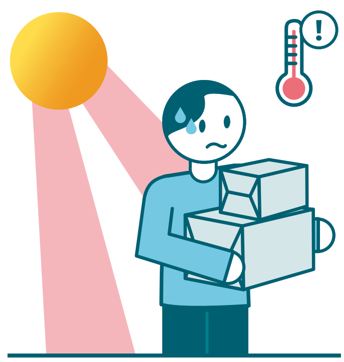
Heat Exhaustion	Heat Stroke
Dizziness, fainting	Headache, confusion
Intense thirst	High body temperature
Excessive sweating	No sweating
Rapid weak pulse	Rapid strong pulse
Nausea, vomit	Nausea, vomit
Pale, cold, clammy skin	Red hot skin
Muscle cramps, fatigue	May loose conciousness
Move to a cooler place, drink water, take a cold shower, use cold compresses.	**Call emergency services, take immediate action to cool down the person.**



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.**

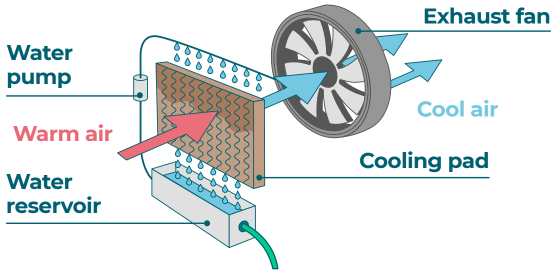


To ensure employees comfort and maintain high productivity, **controlling the ambient apparent temperature at all times is crucial.**

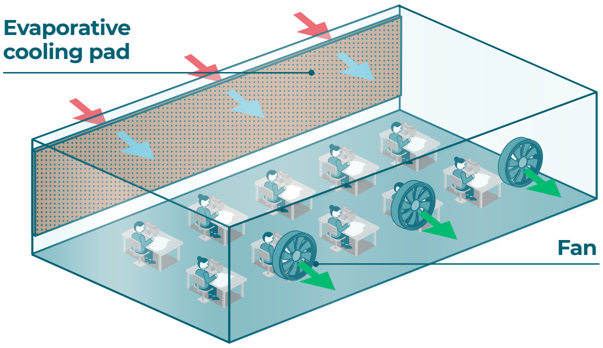
1. Production Area – Evaporative Cooling System

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.

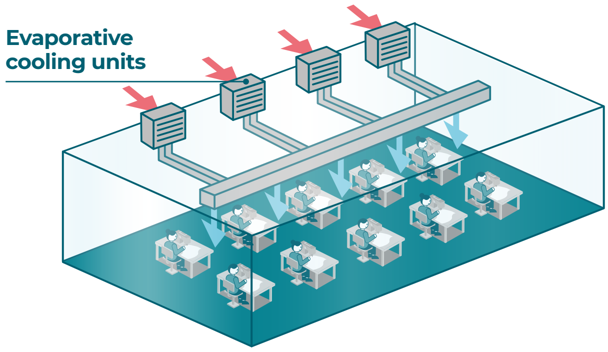
Suited for cooling large spaces, they are **economical**, relying mainly on fans to operate. However, **cooling capacity is limited**, especially in humid external environments (rainy season).



Cross-through or Direct installation (negative pressure)



Ducted or Indirect installation (positive pressure)



While **cross-through** systems are the most common in **Garment factories in Cambodia, ducted systems popularity is increasing.**

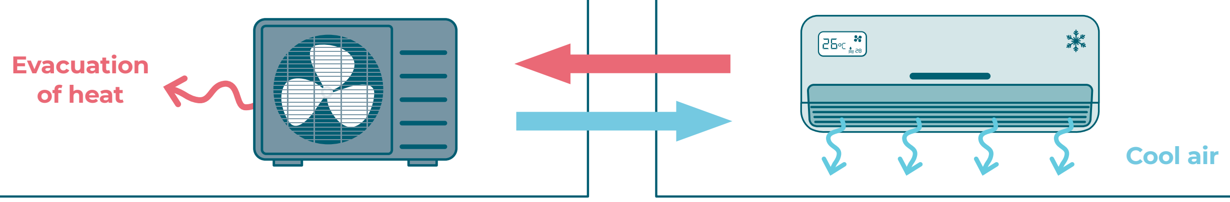
(Refer to p6 for temperature and flow distribution details for both systems.)

2. Office Area – Air Conditioning

Air conditioning systems uses 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.**

01. Outdoor Unit

02. Indoor Unit



Evaporative Cooling vs. Air Conditioning Comparision

Item	Temperature	Humidity	Energy Consumption	Initial Investment	Other
Evaporative cooling	Limited cooling capacity, especially in humid external conditions	Higher humidity	Low	Low	Simple technology easily maintained
Air conditioning	Precise temperature control, can reach lower temperature	Maintains dry and clean air	High	High	Refrigerant can be harmful to human and environment

Maintenance	Modification	Habits	Optimization
Investment	**Labour Time**	**Savings**	**Confort improvement**

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.

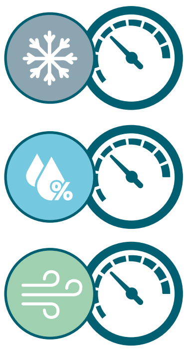
3. When possible, **isolate heat-generating areas (ironing, heat presses, drying, etc.)** from other process sections.

2. Habits to Reduce Consumption

1. **Turn off the fans** when leaving the area
2. **Switch off the AC** between 30min to 1h before leaving the office.
3. **Close doors and windows** in all cooled area.
4. Set the temperature **thermostat above 25°C.**
5. Choose stand-alone **fans over air conditioners** whenever possible. Fans consumes 30 times less energy than air conditioners.

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.



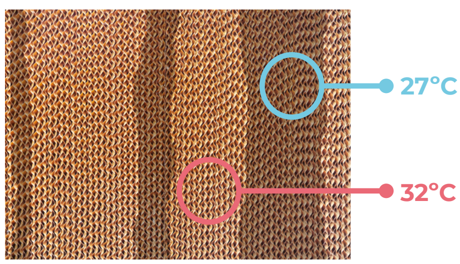
4. Change to More Efficient Technologies

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.

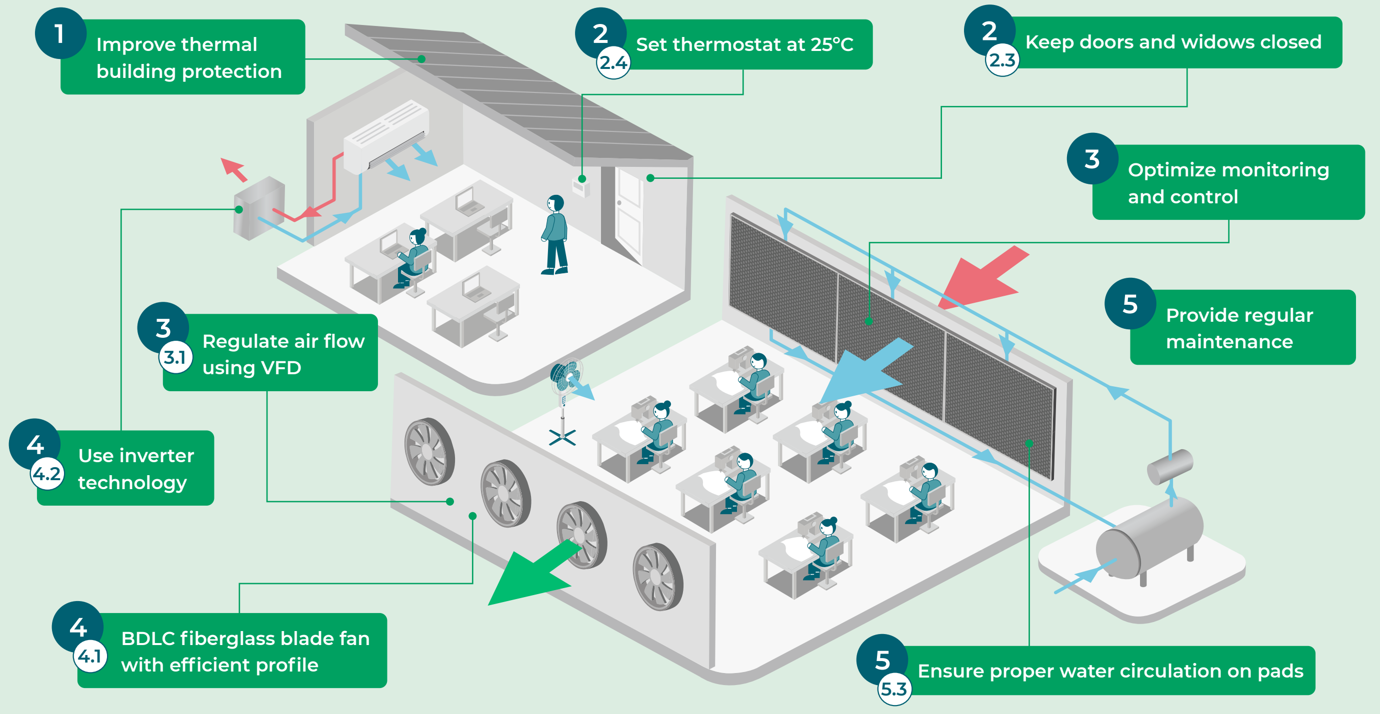
2. For **Air Conditioners**, use **inverter technology**, adjusting compressor speed based on cooling demand.

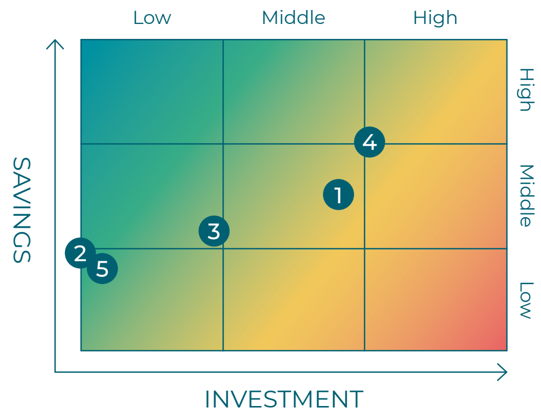
5. Provide Regular Maintenance

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



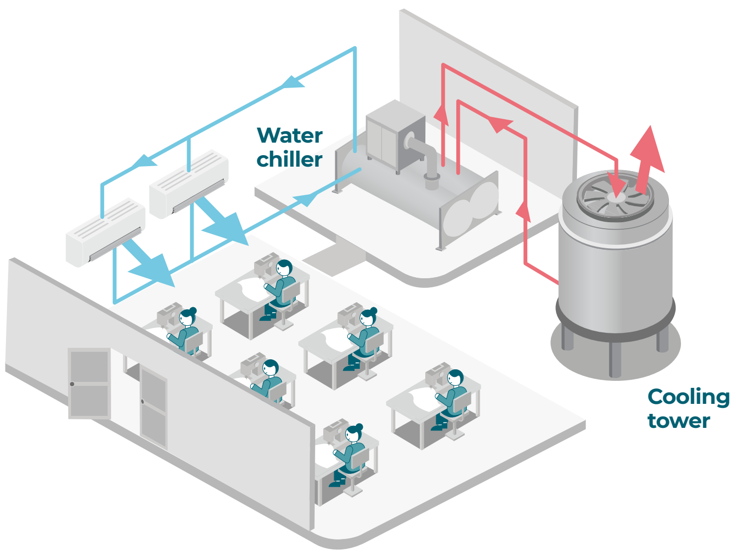


1. Improve Building Thermal protection
2. Habits to Reduce Consumption
3. Optimize Monitoring and Control
4. Change to more efficient technologies
5. Provide regular maintenance

6. Additionnal recommendation for cooling capacity improvement

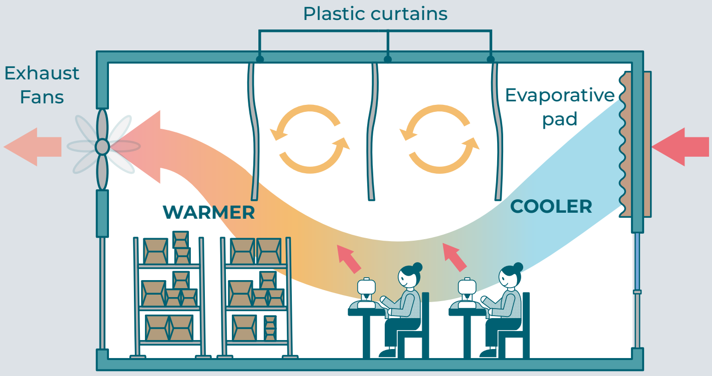
1. Install **individual stand-alone fans** for work stations. Especially those exposed to heat (ironing, heat presses, washing machines, dryers).
2. Switch from evaporative cooling to **centralized air conditioning**, using **chiller** and **cooling tower**. This system generates flow of cold distributed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

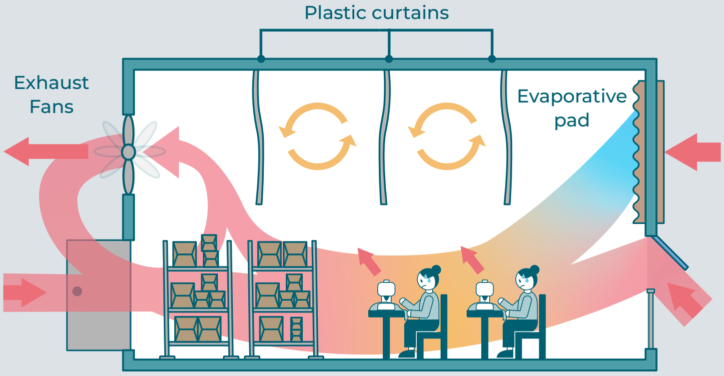
Note: The operational costs are higher but **the comfort is improved** in addition to allowing **better control** of temperature and humidity.



Temperature Distribution in the Factory with Evaporative Cooling 3

Cross through cooling





Common practices

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.

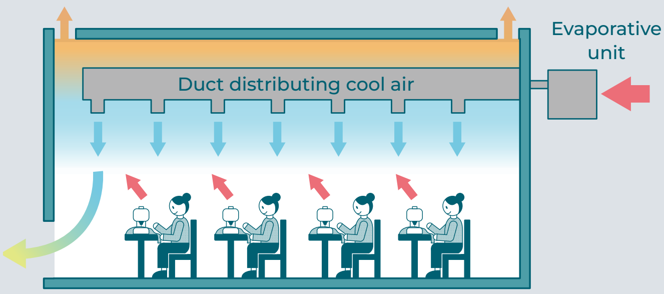
Non-Efficient practices

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.**

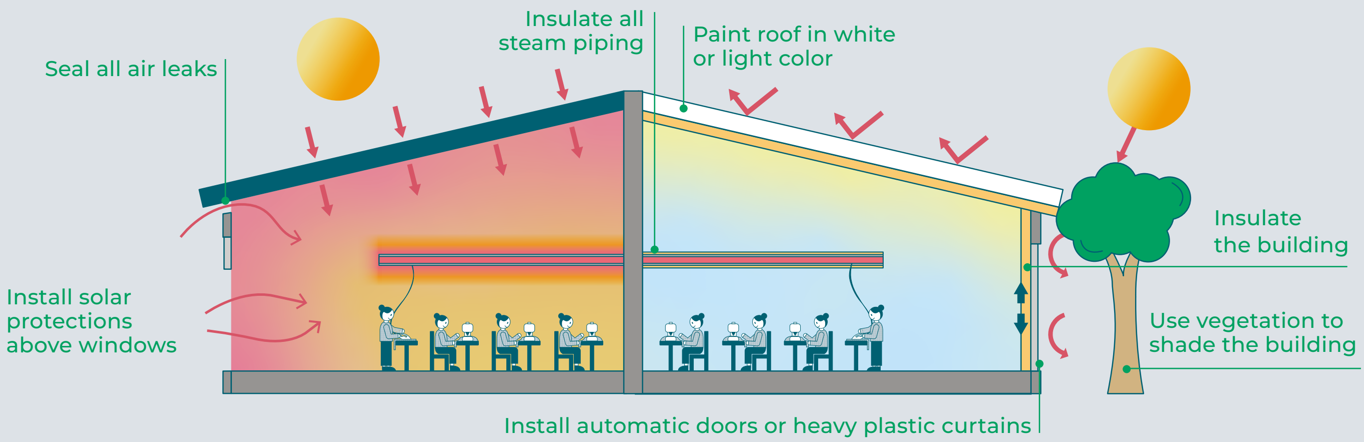
Ducted cooling



- 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 4

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



Energy Management Steps

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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

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PIERRE-MARC BLANCHET

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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).

This document was developed with the inputs and extensive review provided by the partners GGGI and TAFTAC.

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