Business Case: Reducing Workers Heat Stress Exposure

Support to Safety Retrofits and Environmental Upgrades in the Bangladeshi Ready-Made Garment (RMG) Sector

It's Worth to reduce Workers Heat Stress

When considering a healthy working environment an adequate working temperature is an important aspect which has to be taken into account. Given the high average temperature of 26.9°C to 31.1 °C, an average air humidity of up to 78% during summer and the high physical workloads involved, textile workers in Bangladesh are especially vulnerable to high temperatures and heat stress during work[1]. "Heat Stress" can hereby be defined as the sum of the heat generated in the body (metabolic heat), plus the heat gained from the environment (environmental heat), minus the heat lost from the body to the environment".[2]

Advantages of reducing heat stress at the workplace:

- Reduced work-related illnesses
- Reduced loss of working hours
- Increased machine operating time and increased overall worker productivity
- Reduced error rate
- Better Worker Management relationship
- Enhanced workplace conditions attract skilled workers and international clients and reduce turnover rate

When a person's body temperature reaches or exceeds 38°C under the exposure of heat stress, it can cause physiological effects on the body such as heat stroke, heat exhaustion, heat syncope, heat cramps, and heat rashes, or even death. Furthermore, heat stress decreases productivity and increases the risk of workplace injuries, caused for instance by sweaty palms, fogged-up safety glasses or dizziness[3].

Therefore, adequate measures to regulate the temperature levels within a factory are not only desirable from the perspective of the staff, but also contribute considerably to labour productivity and promote the economic growth of a company by reducing the level of work-related illnesses as well as the corresponding loss in working hours and productivity.

To reduce heat stress at the workplace, it is necessary to either reduce the metabolic heat production of the staff or to regulate heat exchange by convection, radiation, or evaporation. In textile factories, the latter three can be influenced through engineering controls such as increasing ventilation, bringing in cooler air from outside, reducing the hot temperature of a radiant heat source, shielding the worker, or using air conditioning equipment (HVAC Systems).

Although installation cost for these engineering controls can strongly differ depending on the factory size and the measures taken, experiences from the textile industry in Bangladesh indicate that an average investment of about BDT 58 lakh per factory is required. Based on the benefits from the increased working hours and the improved output rates of up to 10%, the payback period of the investment is usually below 2 years[4].

Detailed information about the cost and benefits of reduced worker heat stress can be found on the next page, followed by data from a case study example on page 3. Technical details on the installation and implementation process as well as legal requirements and possible means of financing can be found on pages 4 to 5.

[1] Rajib, M.A. (2011). Increase of Heat Index over Bangladesh: Impact of Climate Change

[2] Ebd.

[3] NIOSH (2016). Criteria for a recommended standard: Occupational exposure to heat and hot environments.

[4] Parsons K. (2003) Human thermal environment. The effects of hot, moderate and cold temperatures on human health, comfort and performance. Second Edition

Reduce Heat Stress, Increase Productivity

The reduction of occupational heat stress is connected to a range of direct and indirect benefits which are further explained in the following tables:

Direct Benefits

Increased overall worker productivity	Studies show that occupational heat stress can negatively influence the overall worker productivity, reducing it by up to 10% depending on the heat stress exposure level. Avoiding heat stress will therefore have a positive impact on the productivity. Furthermore, studies show that an improved room temperature can significantly reduce the error rate within a factory. [5]
Enhanced workplace conditions attract skilled workers and international clients	Reducing occupational heat stress of workers significantly improves their working conditions and will increase a factory's reputation as well as its attractiveness as an employer. This will make it easier to find skilled workers and new international clients.
Increased worker satisfaction and reduced worker turnover rates	Improved indoor temperature conditions, help to retain skilled personnel within the company thereby reducing the turnover rate of the workforce. A comparison of measures from 114 case studies shows that improved working conditions in non-office jobs reduced the turnover rate by 40% on average. [6]

Indirect Benefits

Reduced Work-related illness and sick-leave days	Occupational heat stress has well-documented physiological effects on the human body, including heat stroke, heat exhaustion, heat syncope, heat cramps, and heat rashes, or even death. The installation of engineering controls that reduce heat stress within a factory can significantly reduce the risk of heat related illness and sick-leave days.
Reduced risks of work-related injuries to staff and reduced risk of compensations claims	Improving the working environment positively affects worker health and prevents work related injuries or accidents which might be caused by sweaty palms, fogged-up safety glasses or dizziness. The results from case studies of 5 major US companies show that the implementation of ergonomic programs within the companies lead to a significant reduction of worker's compensation claims by between 35% to 91%. Furthermore, the average cost per injury claim was reduced by up to BDT 13.5 lakh.[7]

Calculating the Cost of Engineering Heat Control

The cost of reducing occupational heat stress heavily depends on factors such as the number of workers, the kind of work that is done or the machinery used. Experiences from Bangladesh show that the cost for the systematic design and implementation of HVAC Systems are approximately BDT 58.5 lakh for a garment factory with 5,000 workers. A selection of possible investments for HVAC systems in a factory of that size is shown in the table below.

Possible investments for reducing occupational heat stress:

Type of Investment	Average Cost
Window cooling pads	12,000 BDT/m^2
Ventilation Fans	16,000 BDT/unit
Vapour compression chillers	Depending on size
Ventilation systems	Depending on size and level
Heat shields	Depending on size
Total Costs and net present value	**BDT 58 lakh for HVAC**
Estimated amortization/payback period	**2 Years**

[5] Parsons K. (2003) Human thermal environment. The effects of hot, moderate and cold temperatures on human health, comfort and performance. Second Edition

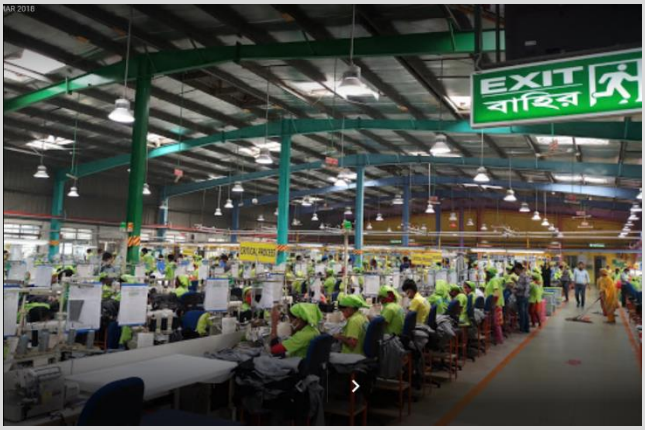
[6] Goggins et al. (2008).Estimating the effectiveness of ergonomics interventions through case studies: Implications for predictive cost-benefit analysis

[7] ebd.

Case Study Spotlight: Fakhruddin Textile Mills, Sreepur, Bangladesh

Description of the Factory

Fakhruddin Textile Mills is an export-oriented knitting factory in Sreepur. The factory has 4,950 employees, with knitting, dyeing, cutting, printing, sewing, washing and packing being the main processes of the facility.



Implemented Measures

In order to improve the overall thermal comfort and reduce their workers heat exposure in the production floor, Fakhruddin Textile Mills installed Window Cooling Pads (Evaporative Cooling System) in one of their production floors in 2010. This investment was further complemented by the installation of a Ducting Cooling System in 2011 which was preferred over a vapour compression chiller system otherwise commonly used in the industry.

The installed cooling and ventilation fan capacities of the Window Cooling Pads are given in the table below. Total installed capacity is 435 tonnes of refrigerant (TR) which is an equivalent to 174,000 CFM. The cooling load per person such a system provides is 35.8 CFM. The total load of fans and pumps of the system is 199 kW with the system efficiency being 0.46kW/TR

Section	Installed Cooling Capacity (TR)	Ventilation Fan Capacity (kW)
Knitting & Embroidery	23	20.64
Dyeing	127	23.1
Cutting	3	11.4
Sewing 1,2 & Sample Floor	40	89.25
Packing & Wirehouse & Inspection	7.5	4.05
Printing	8	30.8
Washing	0	12.1
Knitting & Sewing	102	7.7
Administration	124.5	0

Investments and Savings

The overall investment for Fakhruddin Textile for installing the 435 TR evaporating cooling system amounted to approximately 58.5 lakh (350 USD per 1 KW). Besides the installation costs, running costs of approximately 570,000 kWh per year, resulting from the energy requirements of the cooling system, have to be considered.

To achieve similar cooling effects with a vapour compression chiller a system with a capacity of approximately 361 kW would have been necessary, requiring an initial investment of about BDT 40 lakh and consuming about 1,300,000 kWh of energy per year. Although the initial investment is slightly higher Fakhruddin Textile Mills was able to save more than 50% of energy cost per year by installing the evaporating cooling system instead of the vapour compression chiller system. In total, the energy savings per year amount to approximately BDT 29 lakh. Thus, the higher investment cost payed off within two years.

Apart from direct energy savings, the combined installation of Window Cooling Pads and Ducting Cooling System lead to reduced maximum demand loads and power factor compensations.

Key Performance Measures

The installation of Window Cooling Pads in combination with the Ducting Cooling systems resulted in a significantly improved air quality on the production floors, achieving average CO_2 values of 489 ppm, which is well below the recommended maximum of 700 ppm. The specific CO_2 values measured in the knitting, dyeing and seamless knitting section are shown table below.

Section	After Retrofit
Knitting Unit	464
Dyeing Unit	506
Knitting Unit	496

Besides improving the air quality, the installation of the window cooling pad lowered the atmospheric temperature in Fakhruddin Textile Mills' production units by about 4° C, significantly reducing the thermal stress workers are exposed to on the production floors.

Last but not least, the annual greenhouse gas reduction when operating with Window Cooling Pads instead of a Vapour Compression Chiller system is 489 tCO_2eq.

Features of Engineering Controls for Reducing Occupational Heat Stress

Engineering procedures can control heat stress by influencing convective, radiative, and evaporative heat exchange.

Engineering approaches that enhance convective heat exchange modify the air temperature and air movement. When the skin temperature is lower than the air temperature an increase of either general or local ventilation will increase the rate of body heat loss. When the air temperature exceeds the skin temperature the air temperature needs to be reduced by bringing in cooler air from outside or by cooling of the air itself[8]. In such cases, air movement adds to the workers` heat stress level.

Engineering control of evaporative cooling can be accomplished by either increasing air movement or decreasing ambient water vapour pressure. Increasing air movement by the use of fans or blowers is often the simplest and cheapest approach to increasing the rate of evaporative heat loss. However, these may contribute to an unwanted distribution of air contaminants across the workspace. Ambient water vapour pressure reduction usually requires air-conditioning equipment (cooling compressors). Overall vapour pressure in the air can also be reduced by eliminating additional sources of water such as leaks in steam pipes or valves, thereby increasing evaporative heat loss by facilitating the rate of evaporation of sweat from the skin[9].

To reduce radiant heat exchange between workers and hot equipment or processes it is possible to either reduce the temperature of the heat source or shield the worker from the heat source[10].

Legal and other References

Although there are no binding references for controlling occupational heat stress in Bangladesh yet, several International organizations and national organizations outside of Bangladesh have developed and published standards, recommendations, and guidelines for limiting the exposure of workers to potentially harmful levels of occupational heat stress. The majority of these guidance documents use the Wet Bulb Globe Temperature (WBGT) to estimate the effect of temperature, humidity, wind speed (wind chill), and visible and infrared radiation (usually sunlight) on humans. The following table gives an overview of selected guidance documents[11]:

Guidance Document	Description
NIOSH - Occupational Exposure to Heat and Hot Environments. Criteria for a recommended standard	Suggests criteria for a standard for occupational exposure to heat, including exposure limits and guidance regarding the control of heat stress.
ISO 7243 - Hot Environments. Estimation of Heat Stress on Working Man	Can be used to assess a hot environment with a simple method based on the WBGT. It can easily be used in a workplace environment for evaluating the stresses on an individual.
ISO 7933 - Ergonomics of the Thermal Environment: Analytical Determination and Interpretation of Heat Stress	Method for predicting the sweat rate and the internal core temperature that the human body will develop in response to the working conditions.
AIHA - The Occupational Environment: Its Evaluation, Control, and Management	Contains an overview of many of the heat exposure limits available, including WBGT recommendations, time-weighted averages, NIOSH recommendations, ACGIH Threshold Limit Values (TLVs), and ISO recommendations

Key Steps Required for Implementing

As per experience, the implementation of engineering heat stress controls may range from a few days for simple insulation measures to several weeks for complex system (including planning and design).

Following steps should be taken into consideration when designing and implementing measures for the reduction of occupational heat stress[12]:

- Carry out a risk assessment for areas where there is the possibility of heat stress occurring. When carrying out your risk assessment, the major factors that need consideration are:
  - Work rate – the harder someone works the more body heat they generate
  - Working climate, including air temperature, humidity, air movement and effects of working near a heat source
  - Worker's clothing and respiratory protective equipment, which make sweating and other means of body temperature regulation less effective
  - Worker's age build and medical factors that may affect an individual's tolerance.
- Control the temperature using engineering controls that are appropriate for your factory. This might include the use of fans, air conditioning or physical barriers that reduce exposure to radiant heat.
- Regulate the length of your workers exposure to hot environments for instance by providing periodic rest breaks and rest facilities in cooler conditions.

[8] NIOSH (2016). Criteria for a recommended standard: Occupational exposure to heat and hot environments

[9] Ebd.

[10] Ebd.

[11] From NIOSH (2016). Criteria for a recommended standard: Occupational exposure to heat and hot environments

[12] HSE (2013). Heat stress in the workplace. A brief guide.

- Prevent dehydration by providing cool water in the work-place and encourage workers to drink frequently in small amounts before or during their work.
- Provide training for your workers, especially new and young employees, informing them about the risks of heat stress associated with their work, what symptoms to look out for, safe working practices and emergency procedures.
- Ensure regular monitoring and recording of heat stress levels.

Availability of materials in Bangladesh

The required materials can be sourced via local or international traders. For specific recommendations you may get in contact with Fakhruddin Textile Mills.

Nature of Services Required to Support the Implementation

- Heat stress monitoring and identification of "hot" spots, with support from external occupational safety & health expert
- Engineering assessment/ system design
- Installation services
- Worker training on heat stress awareness and personal remedial measures

Possible Sources for Financing

SREUP credit line could be a good source of financing for such an investment.

Main Feature of SREUP Credit Line	
Loan Type	Normally Term Loan
Discount	Provision and possibility of 20% discount from loaned amount
Loan Tenure	3-5 years in general and in special case up to 7 years
Loan Limit	Normally up to 1 Million Euro and can be increased up to 3 Million Euro in special cases
Interest Rate	7% p.a. (maximum)
Grace period. Debt : Equity Ratio. Repayment	All issues are subject to agreement between borrower and lender

Conclusion

Improved working environment can contribute to sustainability of business. Better workplace is associated with better productivity, better business and better growth.