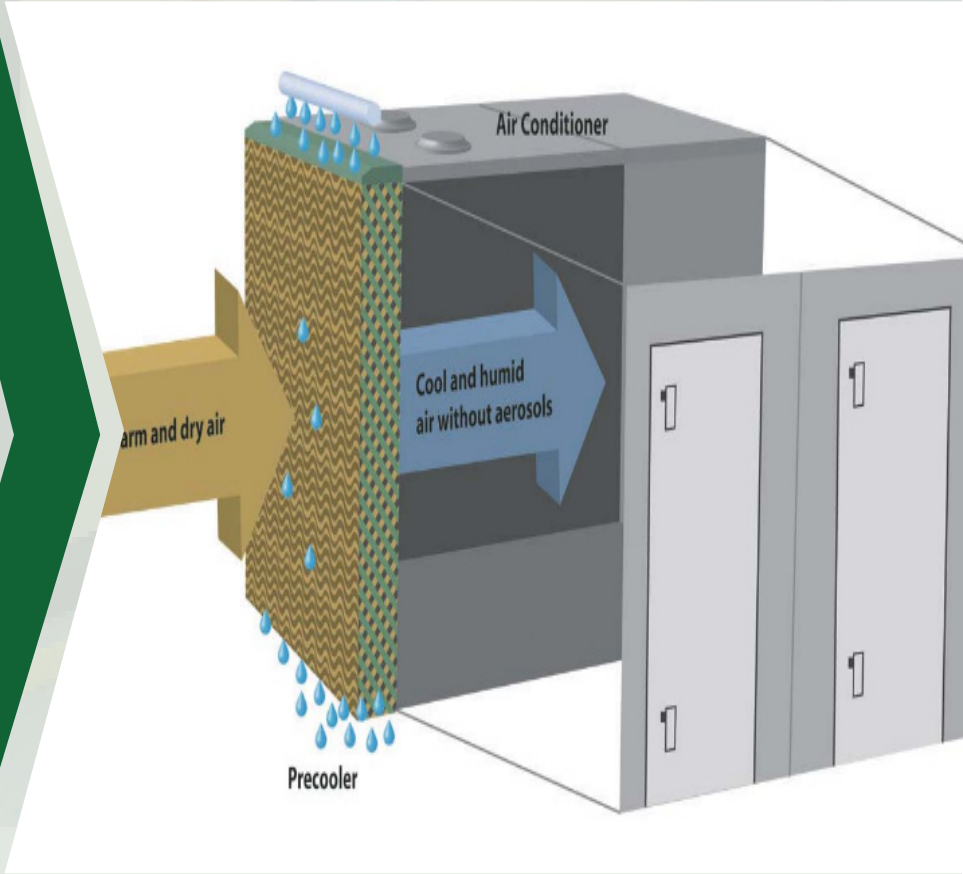
THE GENERAL SECRETARIAT OF THE NATIONAL COUNCIL FOR SUSTAINABLE DEVELOPMENT
MINISTRY OF ENVIRONMENT

CASE STUDY ON IMPLEMENTATION OF BEST PRACTICES OF OPTIMIZATION OF COOLING EQUIPMENT SUCH AS AIR CONDITIONERS AND VENTILATION FANS IN GARMENT INDUSTRY IN CAMBODIA



FOR IMPLEMENTATION OF OUTPUT 1.1.4:

AWARENESS RAISING AND LESSON LEARNED DISSEMINATION WITH FOCUS ON RESOURCE EFFICIENCY IN CAMBODIA

UNDER THE FRAMEWORK OF THE UNIDO PROJECT
LOW CARBON DEVELOPMENT FOR PRODUCTIVITY AND CLIMATE CHANGE MITIGATION THOUGH THE TRANSFER OF ENVIRONMENTALLY SOUND TECHNOLOGY (TEST) METHODOLOGY

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CASE STUDY ON IMPLEMENTATION OF BEST PRACTICES OF OPTIMIZATION OF COOLING EQUIPMENT SUCH AS AIR CONDITIONERS AND VENTILATION FANS IN GARMENT INDUSTRY IN CAMBODIA

I. Introduction of Transfer of Environmentally Sound Technology (TEST)

In the last three decades, a number of conceptual ideas and tools have been created to assist industry with being more manageable and sustainable in its production and more efficient in its utilization of resources. These incorporate pollution prevention, waste minimization, cleaner production, eco-efficiency, and eco-innovation; with a particular depend on waste, energy, and materials. These conceptual ideas and tools have the shared objective of bringing two apparently clashing purposes together, financial profit and environmental improvement. The term Resource Efficient and Cleaner Production (RECP) is to the appropriated adaption of cleaner creation methods to speed up the use of preventive environmental techniques to processes, products and services, with the purpose of improving material and energy efficiency and diminishing dangers and risks to people and the environment. Resource efficiency approaches are looked for as building blocks of the Circular Economy (UNIDO, 2018). The approach anticipated in these guidelines, which it is called the TEST approach, builds on all the concepts and tools mentioned above. TEST stands for Transfer of Environmentally Sound Technologies in which is an integrated approach that provides industries and small and medium enterprises (SMEs) with a combined set of tools to initiate a cycle of continuous improvements within their business operations to manage the transition towards a sustainable production. By combining combines internationally proven preventive environmental practices in Resource Efficient and Cleaner Production (RECP), the core elements of an Environmental Management System (EMS) and an Energy Management System (EnMS), which include exploring new eco-efficient technologies and an effective and supportive information system for material and energy flows based on Material Flow Cost Accounting (MFCA). TEST integrates all levels of the business management through creative thinking and effective collaboration. The project participant's companies applying TEST methodology follow the learning cycle "Plan-Do-Check-Act" to evaluate their processes and facilities to determinate improvement measures and feasible technologies as shown in the table 1

Table 1: TEST methods and their tools

TEST Methodology	TEST Integrated tools
Build on "one-stop improvement" approaches to resource efficiency in the system	Resource Efficient and Cleaner Production
Facilities creative thinking and effective collaboration through teamwork	Material Flow Cost Accounting/ Environmental Management Accounting
Match the needs of an enterprise within its operating framework conditions and enhance organizational learning	Environmental/Energy Management System
Address all levels of a business (operational, managerial, and strategic). Follow the learning cycle in line with ISO standard PLAN-DO-CHECK-ACT.	Corporate Social Responsibility

On the other hands, the effectiveness of TEST integrated approach contributes to the Sustainable Development Goals (SDGs) 6: Clean Water and Sanitation, 9: Industry, Innovation and Infrastructure, 12: Responsible Consumption and Production, and 13: Climate Action as shown in the figure 1 below.

Figure 1: TEST towards to achieve SDGs

II. Support mechanisms through policies and alignment with relevant ministries

Cambodian industry is highly energy inefficient, with energy consumption per unit of outputbeing higher than in many countries in the region and more than double that of the developed countries. Moreover, through the industrial production process and activities, there has been generate a lot of solid waste, hazard waste, wastewater pollution significantly into the environment and atmosphere. For instant, the food and beverage (F&B) sector will generate around 2,410,034 tons of waste in 2020, mostly in the form of industrial wastewater (IWW).[1] Garment waste represents 70% of industrial waste going to landfill and includes textile, footwear and leather offcuts and rejects. To cope with those issues, the current UNIDO's project called TEST project is designed with the purposes to analyze energy consumption data and trends, and identifies Significant Energy Users (SEU) to recommend potential energy saving practices, opportunities, and technological improvements.

Beside this, the Royal Government of Cambodia has formulated, developed, and implemented a series of national policies, strategies, action plans, and programs in order to ensure holistic social development and sustainable development, to promote green environment and renewable energy, to encourage efficient use of energy and to minimize detrimental environmental effects resulting from energy supply and use, and to encourage private investment on the green business, etc. The table 2 the briefly description of the Cambodia's policies, law, strategies, action plans, guidelines, other programs on/related to the promotion of renewable energy, power sector, green environment, waste management, and green industry, etc.

Table 2: List of policies, law, strategies, and action plans

No	Name	Period	Remark
1	Power Sector Strategy	1999-2016	
2	Cambodia's Law on Electricity	2000	
3	Renewable Electricity Action Plan (REAP)	2002-2012	
4	National Policy, Strategy and Action Plan for Energy Efficiency	2013	
5	National Policy on Green Growth	2013-2030	
6	Strategic Plan for Green Growth	2013-2030	
7	National Strategic Development Plan (NSDP)	2019-2023	

8	Cambodia Climate Change Strategic Plan (CCCSP)	2014-2023	
9	Climate Change Action Plans (CCAPs)	2014-2018	
10	Intended Nationally Determined Contribution (INDC)	2015	
11	Environment and Natural Resource Code	-	Draft
12	National Energy Efficiency Policy	2018-2035	
13	Sub-decree on energy efficiency standards and labeling for electrical appliances and equipment	-	Draft
14	National Waste Management Strategy and Action Plan	2018-2030	
15	National Policy on Solid Waste Management in Cities	2018	Official in Khmer version
16	Sub-decree on Solid Waste Management in the Cities	2015	Official in Khmer version
17	Sub-decree on Plastic Bags Management	2017	Official in Khmer version
18	Guideline on E-Waste Management	2017	
19	Sub-decree on E-Waste Management	2016	
20	Water Resources Management Law	2007	
21	Sub-Decree on Water Pollution Control	1999	

Government has a critical role in accelerating the energy transition. Government has the responsibility to enact an enabling policy framework that provides long-term certainty for the private sector and ensures a positive environment for the energy transition. The roles of the main actors in the power sector and wastewater management are set out in the below table 3.

Table 3: The roles of the main actors in the power sector and wastewater management

No	Ministry/Institute's Name	Duties
1	Ministry of Economy and Finance (MEF)	Involves in allocating the budgets.
2	Ministry of Mines and Energy (MME)	Is responsible for developing policies and strategies, power development plans, overseeing the electricity trade with neighboring countries, major investment projects and management of the rural electrification sector.
3	Ministry of Industry, Science, Technology and Innovation (MISTI)	Is responsible for developing policies and strategies related to green industry and involves in providing drinking water in 11 provincial capitals and for approximately 60 medium sized and small towns.
4	Ministry of Public Works and Transport (MPWT)	Involves in wastewater management.
5	Electricité du Cambodge (EDC)	Involves in generating, transmitting and distributing electricity throughout Cambodia. Its main functions are supplying electricity, developing the transmission grid and facilitating import and export of electricity to and from neighboring countries.
6	Electricity Authority of Cambodia (EAC)	Is the power sector regulator, and is responsible for granting licenses, approving and enforcing performance standards, and determining tariffs, rates and charges for electricity. The EAC may grant various types of electricity license, including licenses for generation, transmission, distribution, retail, or a combined license.
7	Ministry of Environment (MoE)	Reviews and approves Environmental Impact Assessments (EIAs) and Environmental Management Plans (EMP) for all energy and water related projects, etc.

8	National Council for Sustainable Development (NCSD)	Is a cross-sectoral and multi-disciplinary body with the mandate to prepare, coordinate and monitor the implementation of policies, strategies, legal instruments, plans and programs related to climate change in Cambodia. The NCSD aims to improve the coordination of climate change activities in Cambodia and to support a stronger, comprehensive and effective climate change response.
9	Ministry of Water Resources and Meteorology (MOWRAM)	Issues water licenses for hydropower projects.
10	Forestry Administration of the Ministry of Agriculture, Forestry and Fisheries (MAFF)	Is responsible for the management of wood-fuel and the production of crops as a source of renewable energy.
11	Ministry of Rural Development (MRD)	Involves in master plans and water supply and sanitation management in rural areas and towns.
12	Ministry of Interior and municipalities	Involve in master plans, operation and maintenance wastewater treatment system.

According to the above mentioned national regulations, laws, policies, etc. as well as following to all the relevant ministries and institutions' mandates and responsibilities related energy and power generation, waste management, and water supply and management, there are the fundamental ways and mechanisms in which allow for all stakeholders and private sector to access to water and energy consumption dramatically. In addition; so far, there were many supported activities and programs were provided and supported to those private sector and stakeholders for their businesses' program and activities as well. For example: Financial supports, capacity buildings, taxation reduction and exception for some imported equipment, issuing the licenses and certifications, and other services, etc. were provided.

III. Integrating the best practice pproach into the factory environmental roadmap

In 2013; as collaboration with 11 enterprises, the UNIDO project on low carbon development for productivity and climate change mitigation though TEST methodology in Cambodia has been applied various technology cases or approaches in which mainly focus on energy consumption to help those enterprises to reduce their energy consumption, to improve their business activities and productions, and to make a better surrounding environment.

50 factories in the first phase from the garment including laundry, textile, footwear, and the food and beverage sectors were selected as demonstration companies and will benefit from the comprehensive project technical support and other services, such as the provision of trainings both collectively and in-house on the TEST tools, followed by RECP assessment and energy audits of the production facilities, which will be carried out jointly by the factory's TEST team and project experts to identify or find out the causes of inefficiencies as well as recommended improvement measures. Moreover, there are a lot of technologies were selected and applied to deal with those causes as well as integrated into each factory environmental policy during the project implementation, and these technologies can be considered as the best practice approach to help each factory not only to achieve the environmental policy target but also can help each project participant's factory to reduce resources consumption, financing expenditure, and greenhouses emissions, etc.

The below five measures can be the best practices that every factory owner could consider and apply:

- ✓ Optimize Compressed Air Usage by Repairing the Compressed Air Leakage and Optimizing Compressor Operating
- ✓ Increase the boiler efficiency by cleaning both water and fire side and optimize air fuel ratio
- ✓ Opportunities of installing Solar PV with Li-Battery System

- ✓ Advantages of replacing AC in the embroidery room with evaporative cooling
- ✓ Optimize resistive ovens for cooking, drying and baking with steam from LPG

Note: There are more appropriate technologies can be used and applied to improve each company's business. Please consult with UNIDO's project team for more information.

IV. The share of electricity consumption for cooling equipment in the garment industry

Cambodia's garment industry contributes approximately 19 percent to the national GDP and 72 percent of the country's exports. The garment industry is, therefore, Cambodia's most important manufacturing sector. However, inefficiencies in the production process and disproportionate consumption of high cost energy may lead the Cambodian garment industry to lose its competitive edge in a global market characterized by fierce competition. Even though actors in the garment industry are aware of their comparatively high energy costs and the significant market potential for industrial energy-efficient product and services; they have, so far, failed to achieve energy efficiency of any scale because of insufficient technical capacity, lack of human and financial resources, lack of qualified local suppliers, and financing constraints (UNDP, 2015).

Electricity is the main source used by all factories for their production processes and facilities. Mostly, electricity in each garment factory is used towards lighting and maintaining optimal temperature on the shop floor including the running of sewing, finishing, embroidery, air compressors, boiler/steam generators, air conditioners, ventilation fan, and other equipment, greatly contribute to the cost of products manufactured in that factory. As shown in the figure below, out of an annual (2018) consumption of 2,635,407 kWh, ventilation fans consumed the biggest amount of energy which is 503,942 kWh/year or 19% of total power consumption and AC is 52,708 or 2% of the total power consumption (OECC, 2019).

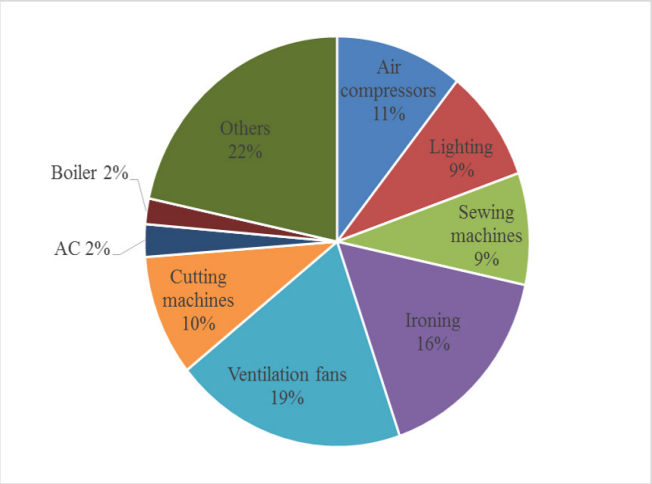

Figure 2: energy which is 503,942 kWh/year or 19% of total power consumption and AC is 52,708 or 2% of the total power consumption (OECC, 2019).

However, the amount of electricity consumption used by ventilation fan and AC varied depends upon to the needs and equipment capacities of each garment factory. For example, some factories, ACs consumed around 3% up to 30% while ventilation fans consumed 6% up to 27%.

V. The main drivers caused the demands for cooling in the garment factory's buildings

Cambodia dominated by the tropical climate; therefore, it is hot all year round. The weather conditions vary across the country. April is the hottest month of the year with temperatures peaking up to 40°C. Phnom Penh city is known as the heart of the country in which is being progressed in increase of high buildings and concreted construction on the ground. These will lead to heat up more temperature in the city if compare to the countryside, this process is called urban heat island effect.

The increase of heat-stress related climate and urban heat island effect will also increase the needs for cooling for all. The rapid of country income, urbanization, and population growth will result in increase of the demand for space cooling and refrigerants in the upcoming years. Hence, the comfort linked to cooling in buildings is needed.

Poor garment factory building design will also contribute to causing the need for cooling as well.

Without paying much attention on the factory building space and air flow design, each factory owner will spend an extra cost on electricity consumption relate cooling equipment. Therefore, the owner should consider this issue before starting their construction plan.

Without green and blue spaces around the garment factory buildings, there will lead to need more cooling equipment in order to keep the factory building inside comfortable and cooling. Green and blue space play very important role in keeping the surrounding environment clean and friendly, coping with climate change impacts, especially, dealing with the increase of hot weather.

VI. The common causes of cooling equipment problems in garment factories' buildings

No one can work under hot temperature. To improve and to ensure working efficiency and safety, the factory rooms and/or buildings must be clean and comfortable. Therefore, the usages of ACs and ventilation fans are really needed. However, problems always happen on your ACs and ventilation fans when they are used in every day. For example, ACs and ventilation fan consumed a lot of electricity than usual. The reason why electricity consumption of ACs are high, is because of hot temperature outside, poor insulation, and under size of AC and setting of temperature. Setting the lowest temperature of the AC will lead to continuous excessive power consumption. In addition, most of the AC condenser units were installed directly under the sun, which is very hot normally. In addition, the reason why ventilation fans consumed a lot of electricity because most of the factory run 100% of them since the morning till evening. Thus, these are the main causes of cooling equipment problems in the garment factory's buildings in which the energy audit team had found.depend upon on the context and situation of the factory location. Proper maintenance and operation of cooling systems is important with regard to efficiency and reliability. As the project implementation policy, all of the project participant's companies were given a free service for energy audit as well as the measurements or best approaches to minimize the costs, resources, and other fatalities with focusing on the energy efficiency. Therefore, below measures in table 4 were applied for each participant's factory to cope with the finding issues around the cooling systems and their equipment such ventilation fans and ACs.t such ventilation fans and ACs.

VI. The common causes of cooling equipment problems in garment factories' buildings

Cooling systems are the main financial costs for most garment factory's production cycle processes, yet the measures for protecting these costs may vary depend upon on the context and situation of the factory location. Proper maintenance and operation of cooling systems is important with regard to efficiency and reliability. As the project implementation policy, all of the project participant's companies were given a free service for energy audit as well as the measurements or best approaches to minimize the costs, resources, and other fatalities with focusing on the energy efficiency. Therefore, below measures in table 4 were applied for each participant's factory to cope with the finding issues around the cooling systems and their equipment such ventilation fans and ACs.

[1] SPB: Simple payback period of investments

Table 4: Best measures to improve the cooling systems in the garment industry through UNIDO project's implementation

Description of the best solutions for cooling equipment's optimization	Investment	Financial Saving	SPB	GHG Saving	Electricity Saving
	USD	(USD/Yr.)	(Yrs.)	(tCO_2e/Yr.)	(kWh/Yr.)
Replace ACs in the embroidery room with evaporative cooling	15,000.00	34,866.04	0.43	128.83	193,704.04
Install evaporative cooling or mister at condensers of ACs	800.00	11,762.83	0.07	43.46	65,349.06
Reset the default temperature of ACs from 16 to 25 °C with a poster	0.00	37,040	0	145.41	218,625
Run 50% ventilation fans in the morning and evening time	0.00	13,914.33	0	52.95	79,622.81
Redesign the ventilation system	100,000	41,072	2.43	161.23	242,422

VIII. Conclusion and recommendations

The garment industry is the most important manufacturing sector in Cambodia. It contribute approximately 19 percent to the national GDP and 72 percent of the country's exports. However, inefficiencies in the production process and high rate of energy cost and energy consumption on manufacturing facility may reflect heavily on the costing of the products manufactured in that facility, and that may also lead the Cambodian garment industry to lose its competitive edge in a region and global market.

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As the project implementation policy, all of the project participant's companies were given a free service for energy audit as well as the measurements or best approaches to minimize the costs, resources, and other fatalities with focusing on the energy efficiency. For this case study, UNIDO's project team had identified and provided several best practices to optimize the cooling equipment such as ACs and ventilation fans in whole garment factory's buildings, please see the detail in the table 4 above for these practices. In addition, by implementing these practices, the factory owner(s) is/are able to earn money from 12,000 USD/year up to 41,000 USD/year and to save 43 tCO_2e/year up to 161 tCO_2e/year. That is the huge contribute to the environment as well as the commitment of the Royal Government of Cambodia to reduce GHGs emission in the country as stated in the Nationally Determined Contribution (NDC-Update).

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