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Business Case: Waste Heat Recovery

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

It is Worth to Recover and Reuse Waste Heat

The textile sector is a highly energy-demanding industry. Particularly, in the dyeing and finishing processes large quantities of energy are continuously required to generate hot water and steam. However, a significant fraction (20-50%) of the required energy gets wasted by releasing the same to the environment via exhaust gases from boilers and dryers, generators, steam condensate, cooling water, wastewater effluent, and more. This waste heat which is either of low grade (<100°C), medium grade (100°C–400°C), or high grade (>400°C) is an expensive resource[1]. Waste Heat Recovery (WHR) can therefore help to achieve significant cost savings, improving both profitability and competitiveness.

Advantages of Waste Heat Recovery at a glance:

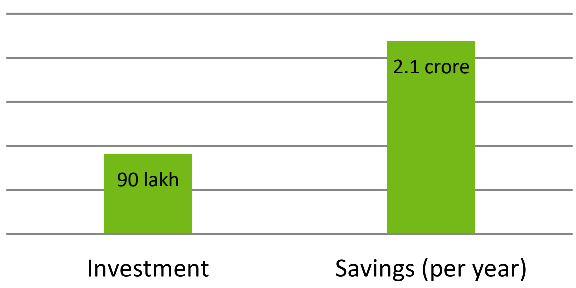
- Enhanced Resource Efficiency
- Reduced energy costs
- Reduced GHG emissions
- Reduced sewer disposal costs

WHR systems work on the basis of extracting and reusing waste energy from industrial processes, which otherwise is dissipated to the environment. The recovered heat can be used for on-site power generation, to preheat combustion air, or to generate steam. Potential sources for waste heat recovery in textile factories include:

- Exhaust gas from generators (high grade heat)
- Boiler blowdown flash steam (high grade heat)
- Hot condensate flash steam (high grade heat)
- Processed wastewater, dumped to sewage (low grade heat)
- Jacket cooling water (low grade heat)

Methods for waste heat recovery include transferring heat between gases and/or liquids (e.g., combustion air preheating and boiler feedwater preheating), transferring heat to the load entering furnaces (e.g., batch/cullet preheating in glass furnaces), generating mechanical and/or electrical power, or using waste heat with a heat pump for heating or cooling facilities. WHR technologies used in the garment and textile sector include Heat Exchangers, transferring heat from combustion exhaust gases to combustion air entering the furnace, or Waste Heat Recovery Boilers, using exhaust gases to generate steam[2].

Approximate Investment Cost and Annual Savings (BDT)



Depending on the technology, quality and quantity of waste heat and the development of the prices for fossil fuels, the estimated pay-back period for WHR systems may range from 6 months to 5 years[3,4].

Detailed information about the cost and benefits of WHR systems can be found on the next page, followed by a case study 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.

Case study result from AOne Polar Ltd.

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[1] PaCT (n.d.). Cleaner Production Case Study: Waste Heat Recovery

[2] U.S. Department of Energy (2008). Waste Heat Recovery: Technology and Opportunities in U.S. Industry

nd Utilization in Textile and Garment Factories. Final Report

[4] Pattanapunt, P. et al. (2013). Waste Heat Recovery from Boiler of Large-Scale Textile Industry

Saving Energy and Reducing Fuel Consumption

Recovering and reusing waste heat offers significant saving potentials in energy and fossil fuels. The estimated energy and fuel saving potential of different WHR systems relevant to the textile industry is shown in the table below:

Reduced energy costs and Fossil Fuel demand by Technology:

Heat recovery from exhaust air	Recovering and Reusing Waste heat from hot exhaust gases can significantly reduce a factory's energy demand. Especially during drying processes, large amounts of warm and moist air are exhausted into the environment. Case study results from the Bangladesh textile sector suggest possible energy savings of 14%from reducing the factories energy and gas demand.
Boiler blow down recovery	To ensure optimal heat transfer the level of suspended and total dissolved solids (TDS) in boilers has to be controlled (Blow Down). However, excessive blow down will waste energy, water, and chemicals. Minimizing the blow down rate can substantially reduce energy losses and makeup water demand. An example from the factory in Bangladesh shows that optimizing the blow down rate can save up to 4.7 kg fuel per hour (assuming ~2 TPH, 4.7 kg = 4% saving, considering the total fuel input at 80% boiler efficiency) leading to an annual saving potential of approximately BDT 2.16 lakh in the particular case.[5,6]
Wastewater heat recovery	Wastewater contains heat which can be utilized for heating process water. As per environmental norms, wastewater cannot be disposed at high temperature. It becomes even more important to recover heat from hot wastewater (>60°C) to preheat fresh cold water (25°C). Energy calculations of wastewater discharged from a wet processing textile unit producing 10 tons of textiles per day and using heavy fuel oil, shows that annual energy savings of up to BDT 99.7 lakh may be achieved through hot wastewater alone.[7]
Condensate heat recovery	Depending on the pressure ,steam vapour condensate can still contain up to 16% of the total steam energy. Returning hot condensate to the boiler will therefore reduce the fuel consumption as well as the requirement for makeup water. Experiences show that fuel requirements can be reduced by up to 8%. In the particular case of a polyester processing factory fuel savings of approximately 2.8 kg per hour and an annual saving potential of about BDT1.31 lakh were achieved.[8]

Other Benefits

Reduced Greenhouse Gas Emissions	In general, WHR systems reduce the demand for energy and fossil fuels, therefore also reducing GHG Emissions. Case study experiences from the Bangladesh textile sector show that by installing a WHR System GHG Emissions can be reduced from 5 tonnes to 4.3 tonnes per kg fabric (14%).
Reduced wastewater management cost	Reusing condensate from boilers reduces the amount of discharged water into the sewer system, therefore leading to lower disposal cost for the factory.

Calculating the Cost of a WHR System

The cost of WHR systems depends heavily on the type of technology, the quality, quantity and chemical composition of the available waste heat within the factory as well as the minimum allowable temperature. Experiences show that the average cost for this improvement range from BDT 90.7 lakh to BDT 33.3 crore.

Apart from the WHR installation costs, annual maintenance costs of up to BDT 4.67 lakh might have to be taken into consideration.

The following table shows typical investments required for the installation of a heat exchanger system for the textile industry. The respective average cost is the result of cost calculations of three textile factories with a capacity between 15 – 24.5 tons/day (knitting) and 18 – 20 tons/day (dyeing):

Possible investments for WHR[9]:

Type of Investment	Average Cost (BDT)[10]
Heat exchanger	57.9 lakh
Wiring and piping work	33.6 lakh
Submersible water pumps	47.4 lakh
Ancillary equipment	18.5 lakh
Control board	33 lakh
Auto valve	2.3 lakh
Flow meter	8.7 lakh
Other(instruction, test operation)	10.4 lakh
Average Total Costs	**90 lakh - 1.8 crore**
Average amortization period	**0.5 - 3.6 Years**

[5]Sherin, K. M. & Prince M.G. (2013). Potential of Waste Heat Recovery in Textile Industries

[6]Sonawane, V.J & Keste, A.A. (2016).Waste Heat Recovery in Textile Industry: A Review

[7]Sonawane, V.J &Keste, A.A. (2016).Waste Heat Recovery in Textile Industry: A Review

[8]Ebd.

[9] PEAR Carbon Offset Initiative (2014). Waste Heat Recovery and Utilization in Textile and Garment Factories. Final Report

[10]Proportionate costs for one large factory

Case Study Spotlight: A One Polar Ltd, Dhaka, Bangladesh

Description of the Factory

A One Polar Ltd. is an export-oriented Knit Fabrics and Ready-Made Garments manufacturer, located in Narayangonj, Dhaka. The factory was established in 2008,spreads over 11,000m^2 and has 8,200 employees. A One Polar's value chain includes knitting, dyeing & finishing, printing, spinning, yarn dyeing, doubling & twisting, knit dyeing, washing, embroidering, as well as cutting and sewing. The factory's dyeing unit operates 24 hours a day and 340 days per annum with a production capacity of 40 tons per day.

Implemented Measures

Energy is one of the most important factors in any industrial activity. However, its availability is not infinite. The textile sector is one of Bangladesh's major energy consumers and is moreover known for not using their energy very efficiently. In other words, a significant fraction (20-50%) of the required energy gets lost to the environment via exhaust gases from boilers and driers, steam condensate, cooling water, etc. Waste heat however should be considered as a valuable resource that can be recovered and reused.

As waste heat recovery system offers factories an economic and green solution to save valuable energy, A Polar One's management team decided to explore different options to make the most use of the waste heat they generate as a by-product in their production processes.

Originally, the factory covered its energy demand by operating natural gas-fired electricity generators (IC engine) with a capacity of 3.6 MW. To supply the thermal energy, A Polar One Ltd. additionally operated two steam boilers fuelled by natural gas. The generators produced large volumes of flue gases which were directly emitted to the environment. In the case of A Polar One Ltd., the temperature of the flue gases was 550 °C. The management team realised that the factory was losing valuable process energy by emitting the flue gasses to the environment. Thus, it decided to increase the factory's energy efficiency by putting the waste heat produced from their generators to effective use.

To recover and utilize waste heat from their electricity generators A Polar One Ltd. invested in a simple but highly effective Waste Heat Recovery System. The management team decided to install a 3.1 tons per hour (TPH) waste heat boiler which operates at a pressure from 6-8 bars (see below diagram for schematics of system upgradation). The Waste Heat Recovery System extracts heat from the flue gases produced by natural gas driven electricity generator through heat exchange and utilizes it to produce steam. The steam is then reused in other production processes such as ironing or dyeing. Besides the waste heat boiler, A Polar One Ltd. operates two additional steam boilers with the capacity of 10.2 TPH running at a pressure of 10 bar, which help covering demand during peak times.

Challenges during Implementation

Although the installation of the Waste Heat Recovery System only required three months, A Polar One Ltd. faced some challenges when upgrading to the new system. To begin with, it was hard to secure the initial funding for the investment. Moreover, limited space to install the additional boiler system within the factory posed a challenge. A 3 TPH (3 tons per hour) boiler with sufficient spacing for system inspections, maintenance and emergency exits requires approximately 10m x 6m.

Investments and Savings

The integrated Waste Heat Recovery System required investments in a waste heat boiler, controls and additional piping. In total, the cost of the initial investment summed up to be BDT 90.72 lakh. However, it is vital not only to consider the initial costs in investing in the Waste Heat Recovery System but also the operating costs. On average fuel consumption (natural gas) for operating the electricity generators increased by 3.2% (14.226 m3) resulting in an additional cost of BDT 1.37 lakh per month. Moreover, water consumption increased due to the additional demand in cooling water for the electricity generators.

Although fuel and water consumption increased, due to the additional energy demand, overall fuel consumption could be reduced drastically in the thermal system producing the steam required for ironing and dyeing. By replacing the fuel combustion boiler with the waste heat boiler, A One Polar Ltd. is able to save 190,000m^3 in fuel resulting in savings of about BDT 18 lakh per month. Consequently, when taking all costs into consideration, the investment clearly off-sets the increased costs for electricity and water and resulted savings of16.9 lakh per month. As the annual maintenance costs are negligible, the investment has a payback period of 6 months.

EGB Gas Boiler (3.1) at One Polar Ltd

Key Performance Measures

Investing in the Combined Heat and Power (CHP) system (i.e. waste heat recovery boiler) helped A Polar One Ltd. to significantly bring down total fuel consumption from 0.33m3/kg to 0.063 m3/kg, a reduction by 0.267 m3/kg. Besides saving 16.9 lakh per month on fuel, the Waste Heat Recovery System also reduces Green House Gasses (GHG) by 4,226t CO_2 per year.

References for the Installation of WHR Systems in Bangladesh

Although no binding legal references regarding the efficient use of energy have come into effect in Bangladesh yet (May 2018), the Government has recognized the increasing importance of energy as a factor for economic growth and declared Energy Efficiency to be a cross cutting issue for the country. To improve the country's energy efficiency, the Sustainable and Renewable Energy Development Authority (SREDA) in 2013 published the "Energy Efficiency and Conservation Master Plan (EECMP) up to 2030". The EECMP aims at improving energy intensity (national primary energy consumption per gross domestic product/GDP) in 2030 by 20% compared to the 2013 level. Under the action-plan of the EECMP, three EE&C programs are being promoted, namely, (1) Energy Management Program, (2) EE Labelling Program and (3) EE Buildings Program. In particular, the Energy Management program targets large industrial energy consumers in Bangladesh. Policy measures which are planned to be implemented in the next years include (amongst others): (i) Mandatory energy audits, (ii) energy consumption reporting and (iii) benchmarking. Furthermore, the authority is planning to develop and recommend procedures and regulations for the implementation of minimum energy performance standards and energy efficiency labelling for equipment and appliances[11].

Apart from this, the further development of energy prices (in particular of gas) in Bangladesh has to be taken into account in the context of considering energy efficiency measures. In February 2017, the price of domestic gas was already hiked by 22.70%resulting in a price of BDT 7.35 per cubic meter of gas.[12] For 2018, the Government of Bangladesh plans to include LNG in the national Gas Grid by further increasing imports of LNG and developing the LNG import infrastructure. Since LNG is more expensive than domestic gas, the Energy and Mineral Resources Division took the initiative to off-set the cost by raising consumer prices. To cope with this price hike the Bakhrabad Gas Distribution Company (BGDC) recently proposed the Bangladesh Energy Regulatory Commission (BERC) to again hike commercial prices for gas by up to 70%[13].Given the increasing demand for natural gas, prices are expected to further rise in the future.

Key Steps Required for Implementation

Experiences from Bangladesh show, that the installation of a WHR system can be accomplished in about three months (including planning and design).

For the implementation of this retrofit/upgrade measure, keep the following steps in mind:[14]:

- Identification of sources and sinks of waste heat within the factory from both plant and process perspective. Heat sources and sinks can be measured using either invasive techniques(i.e. thermometers, Resistor Temperature Detectors (RTDs) and thermistors) or non-invasive devices(i.e. infrared thermography). Flow rates can be measured using a range of flowmeters and flow sensors
- Quantitative and qualitative assessment of the waste heat. Important parameters that must be determined include:
  - Heat quantity
  - Heat temperature/quality
  - Waste heat composition
  - Carrying medium of waste heat sources and sinks (i.e. liquids or gases)
  - Minimum allowed temperature
  - Operating schedules
  - Availability of waste heat
  - Special availability
- Selection of appropriate technology. Using the gathered data non compatible WHR systems can be excluded and compatible systems can be compared regarding factors such as cost, volume and special requirements
- Planning and installation of the selected WHR system
- Monitoring and maintenance

Availability of Materials in Bangladesh

The majority of required materials can be sourced via local traders; certain components need to be imported. Please contact A One Polar Ltd for their recommendation.

Nature of Services Required to Support the Implementation

- Pre-assessment for identifying the waste heat amount based on flue gas temperature and fuel consumed in base boilers, design the boiler capacity based on waste heat availability and steam/ hot water property required.
- Installation and commission conducted by a certified operator required for the steam system and the chemical water pre-treatment
- Maintenance services conducted by either in-house engineers or external service providers

Sources of technical support/expertise used

For further technical details and guidance regarding the implementation of WHR Systems the following resources can be used:

- Simeone, A. et al. (2014). A decision support system for waste heat recovery in manufacturing

[11] SREDA (2015). Energy Efficiency and Conservation Master Plan up to 2030

[12] Mahfuj Risad (2018). Titas, Bakhrabad, Karnaphuli sought Price hike of Gas. Available online at: https://energybangla.com/titas-bakhrabad-karnaphuli-sought-price-hike-of-gas/. Last checked on 08.05.2018

[13] Sanchita Shetu (2018). Commercial gas price might rise by 70%, household gas could cost double. Available Online at: https://www.dhakatribune.com/bangladesh/power-energy/2018/03/22/commercial-gas-price-rise/. Last checked on 08.05.2018

[14] Simeone, A. et al. (2014). A decision support system for waste heat recovery in manufacturing

- Sonawane, V.J &Keste, A.A. (2016). Waste Heat Recovery in Textile Industry: A Review

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

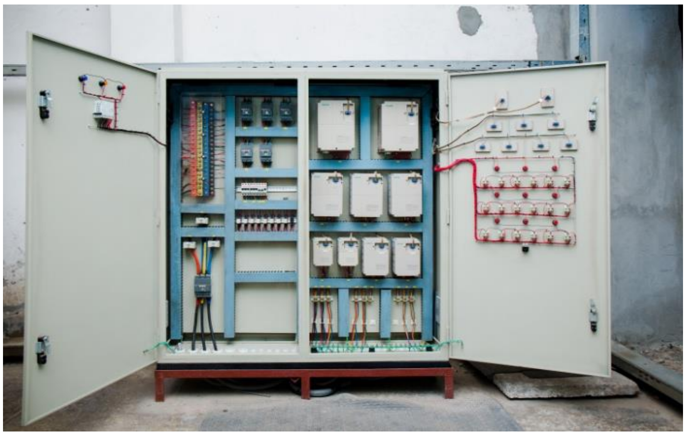
Economiser of Gas Boiler

as Boiler 2 at One Polar Ltd.

PPPP Pump Flash Steam

Condense Set (Heat Exchanger)

Make Up Water Pump



Inverter Panel

Chimney of Exhaust Gas Boiler

Steam Flow Meter Control Box

Flash Steam Feed Heat Water Heat Exchanger