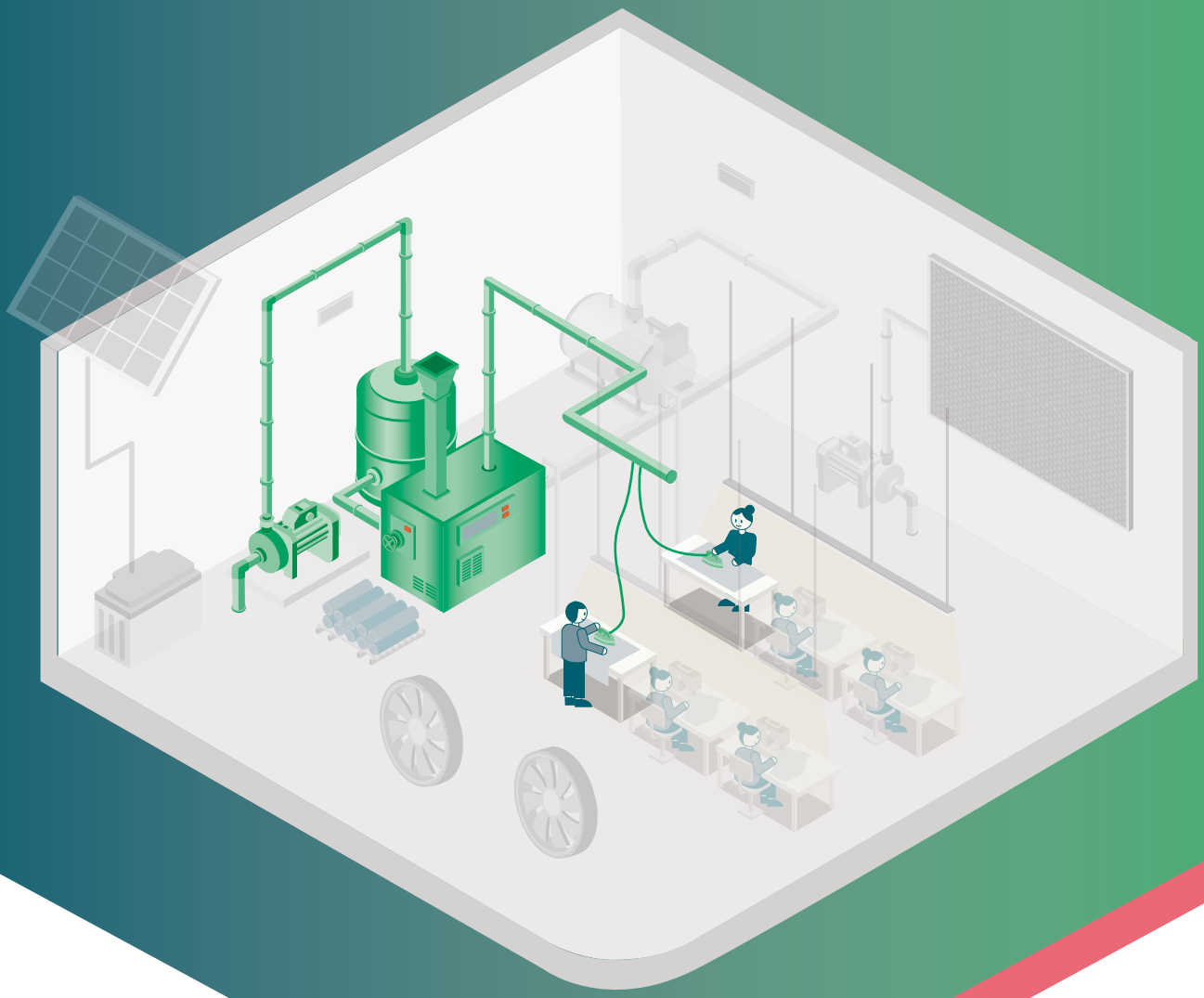
Technical Brief on Sustainable Energy

BOILERS AND STEAM SYSTEMS



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SWITCH GARMENT
PROMOTION OF SUSTAINABLE ENERGY PRACTICES IN THE GARMENT SECTOR IN CAMBODIA

AFD
AGENCE FRANÇAISE DE DÉVELOPPEMENT

VETHIC

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ACTING FOR CLIMATE SOLIDARITY

TAFTAC

BOILERS AND STEAM SYSTEMS USE IN INDUSTRY

Boilers and steam systems are used when heat or **steam is needed in industrial process.**

A boiler is a closed vessel **producing steam** at specific level of pressure and temperature by **burning fuel** or by **electrical heating** for industrial use.

Wood energy share is much more important than all other energies combined in garment sector in Cambodia. Wood being used mainly for Steam generation, it is the **highest area of energy consumption.**

Total Energy Consumption (toe/year)

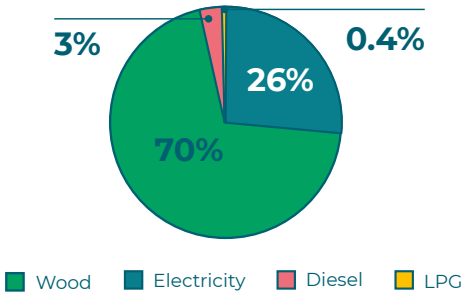
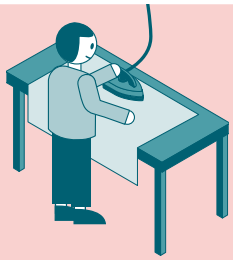
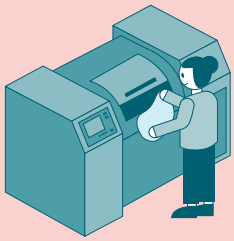


Chart Source: *Switch Garment 49 walkthrough energy audits of Cambodian garment factories 2022.*

Machines Using Steam in Garment Factories

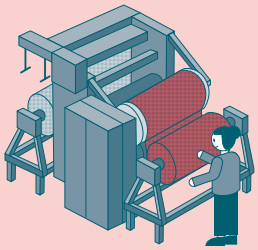


Ironing



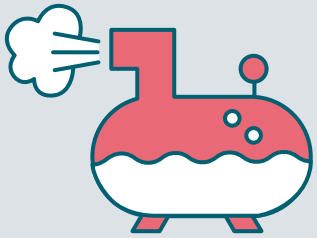
Washing

Drying



Dyeing

Why use steam and not hot water?



Steam can store much more energy than hot water.

Boiling water to transform it into steam, changing its phase from liquid to gas, requires much more energy than heating up water in its liquid form.

The resulting steam will contain all that energy used to produce it and will be able to deliver it when condensing at the point of usage in a much more efficient way than hot water could ever do.

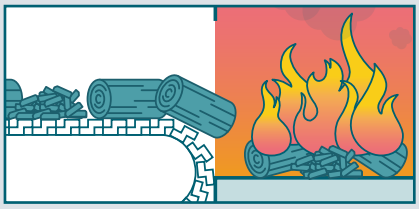
Different feeding system for different fuels

Fixed grate:

(most seen in Cambodian garment sector)

The feeding is manual, leding to more operational cost and irregular heat generation.

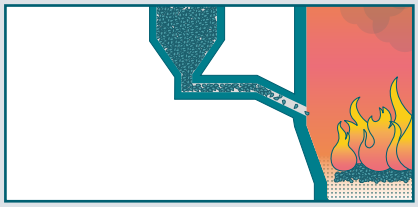
Type of fuel: large pieces (wood logs, coal blocks).



Chain automated grate:

The feeding of fuel is automatic and adjusted to the needs, saving a lot of energy compared to fixed grate.

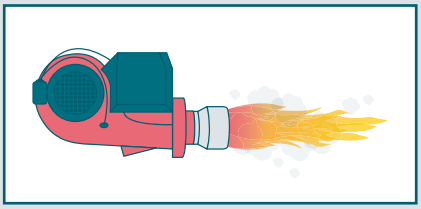
Type of fuel: smaller granulometry fuels (small wood logs, chips, pellets).



Fluidized bed:

Highly efficient technology, typically used for high power boiler with a highly efficient combustion.

Type of fuel: also allow powdery fuels (rice husk, wood dust, pulverized coal).



Burner:

Ensure the mixing of air and fuel with high efficiency combustion.

Type of fuel: Specific to liquid or gaseous fuels (diesel, LPG fossil fuels).

(Refer to the technical brief ***Energy Sources for Steam Production*** for more information.)

Main Components of a Boiler and Steam System 1

01. Water Intake Management

Water contains particles and gases that make it unsuitable for the boiler, generating corrosion and scale deposits, lowering the heat transfer efficiency.

Then, a treatment is needed to remove those impurities and optimize the pH level.

1. **Filters, water softener and pH regulator:** used to remove chemical and minerals naturally contained in the water and adjust the water's acidity.
2. **Deaerator:** removes gases like oxygen and carbon dioxide contained in the water.

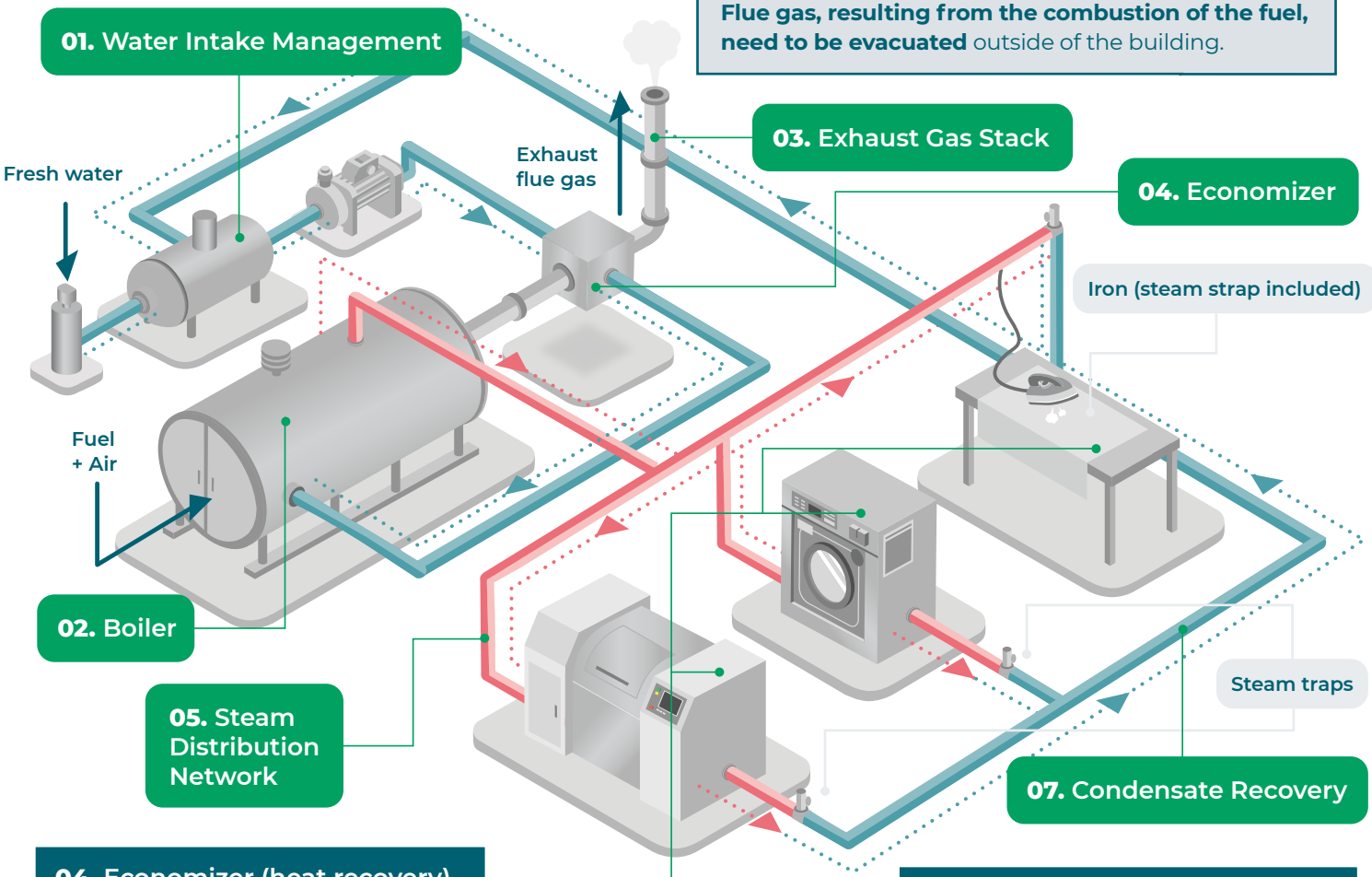
02. Boiler

This is the equipment transforming water into steam. It is made of the following parts:

1. **Fuel feeding system:** Fixed or chain grate, fluidized bed (refer to page 2).
2. **Combustion chamber** where the combustion takes place, liberating the heat contained in the fuel.
3. **Water jacket** is the part containing the water that is being boiled into steam.

03. Exhaust Gas Stack

Flue gas, resulting from the combustion of the fuel, need to be evacuated outside of the building.



04. Economizer (heat recovery)

It is a heat exchanger that recovers heat lost in exhaust flue gases for preheating water or air that will be used in the boiler.

05. Steam Distribution Network

Insulated piping to transport steam from the production to the point of use with minimal thermal losses.

06. Points of Use

Where the heat is transferred from the steam to the usage point: iron, washing machine, dryer, etc.

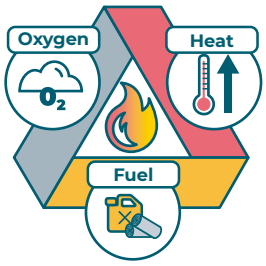
07. Condensate Recovery

When steam transfers its heat to the equipment, it cools down and condensates. **These condensates still contain energy that shall be reused in the boiler.**

Energy Savings in Boiler and Steam Systems 2

1. Optimize Combustion

Maintaining proper combustion is key to reduce emission and optimize fuel consumption:



1. **Manage air intake:** level of oxygen is key to manage proper combustion. Indeed, too much air leads to heat loss, while too little leads to incomplete combustion. The amount of oxygen can be controlled through **variable frequency drives (VFD)** and monitoring the quality of the combustion.
2. **Use smaller wood logs**. It allows a better control of the combustion, a higher combustion efficiency and more reactivity to the steam demand in the factory.
3. **Check the humidity level** of solid fuels (wood logs, coal, agricultural residue) and maintain it **below 15%**. Above that level, a large part of the combustion energy is wasted to evaporate the water contained in the fuel instead of producing steam.

Maintenance Modification Optimization

Investment Labour Time Savings

2. Install Condensate Recovery System

As the steam transfers its heat content to the point of use, it **condensates** into liquid water. This water still contains heat and has already been treated. It shall not be wasted but rather collected and returned to the boiler. **Reusing** condensates will **save energy, water and water treatment chemicals.**

3. Change to more efficient technologies

About 40% of the boilers used in Cambodia have an energy efficiency under 40%*. Some technologies have an efficiency of 80% resulting in important savings.

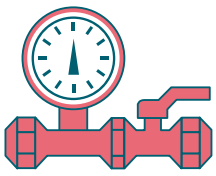
- Choose a feeding system technology that allow the use of a wide range of biomass (chain grate, fluidized bed). This allows more flexibility to **use more efficient and sustainable fuels.**

(Refer to *Technical Brief on Energy Source for Steam Production* for more details)

*Data: AFD Feasibility study of a credit-line program for energy efficiency projects in Cambodia – GERES, Green Move Consulting, 2018

4. Boiler Monitoring

Monitoring allows having measurements on the boiler to run it more efficiently.



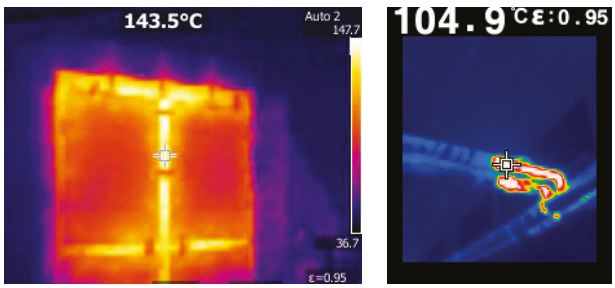
- **Install steam meter** to monitor the consumption of fuel per m^3 of steam produced and calculate the efficiency, making corrections accordingly.
- **Conduct regular flue gas tests** in order to optimize the combustion depending on the flue gas composition.

5. Insulation of the Entire Boiler and Steam System

A large amount of energy wasted because of heat loss can be saved by insulating the installation. The main points of attention are:

- **Boiler itself** (outer casing, door),
- **Steam distribution network** (piping, valves, distribution hubs, steam traps)
- **Condensate return piping.**

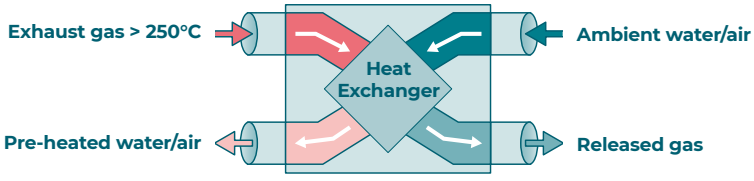
Note: it is essential to keep insulant dry as it will lose its insulating properties when wet.



Thermal scans showing insulation problems.

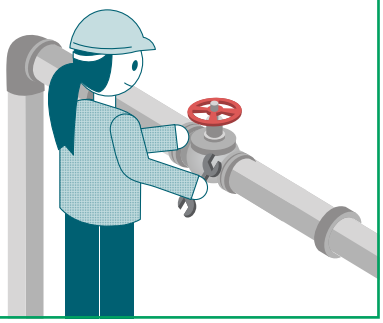
6. Implement Heat Recovery

If flue gases reach a temperature of **250°C** or more, it represents a **net loss** for the steam system and it is recommended to **recover** that lost energy for preheating boiler water or air. It can be done through an "economizer" which is a heat exchanger.



7. In-house Maintenance

- Optimize **water treatment** (soften and deaerate the infeed water, increase pH to 8.5).
- Prevent and fix **steam leaks**.
- **Blowdown** the water jacket on a regular basis in order to get rid of accumulated minerals at the bottom of the boiler.
- **Train operators** for running properly the boilers.
- Check **steam traps** weekly and change or repair the faulty ones.
- **Reduce steam pressure/temperature** to the needs of the process machines when possible.

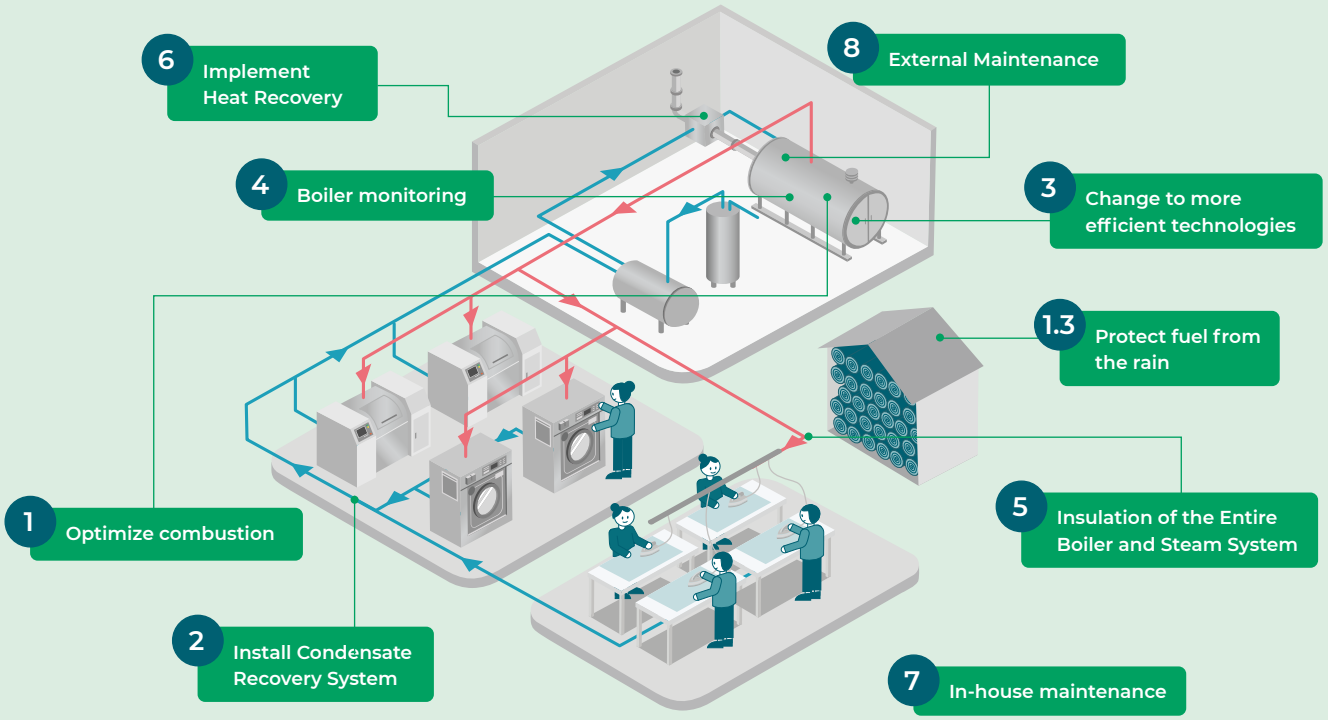


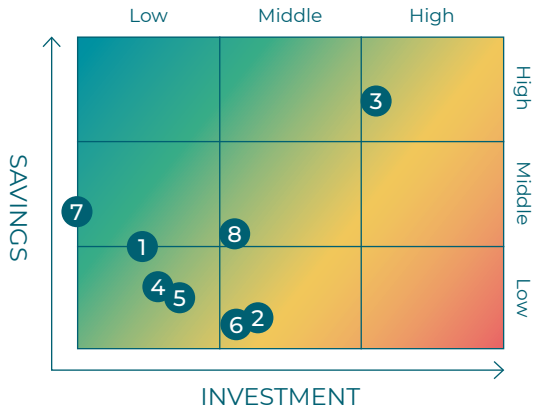
8. External Maintenance

Specific type of maintenance needs to be done by an external company because it needs specific expertize:

- Cleaning scale in the water jacket.
- Cleaning soot in the fire side of the boiler, exhaust stack and fumes heat recovery systems.

Summary & Recommendation





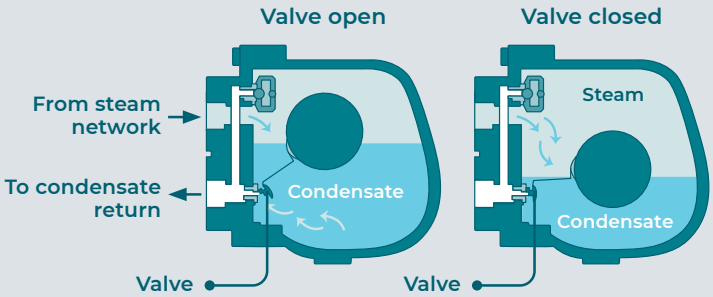
1. Optimize combustion
2. Install condensate recovery system
3. Change to more efficient technologies
4. Boiler Monitoring
5. Insulation of the Entire Boiler and Steam System
6. Implement Heat Recovery
7. In-house Maintenance
8. External Maintenance

Points of Attention in Maintenance of Boilers 3

Steam Traps

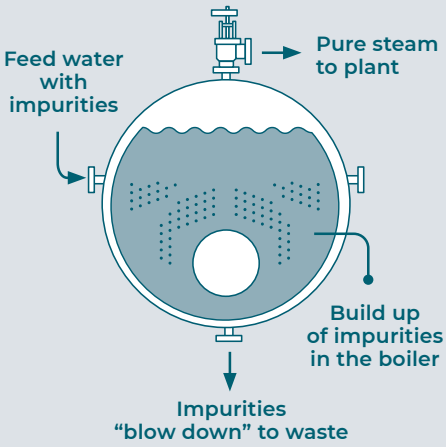
A steam trap is a device evacuating condensates from the steam piping network without letting the steam out. **It is a critical component** for, if it leaks, very large quantities of steam will be wasted, resulting in excessive fuel consumption.

Hence, it must be closely monitored, on a weekly basis, in order to make sure they operate optimally at all times.



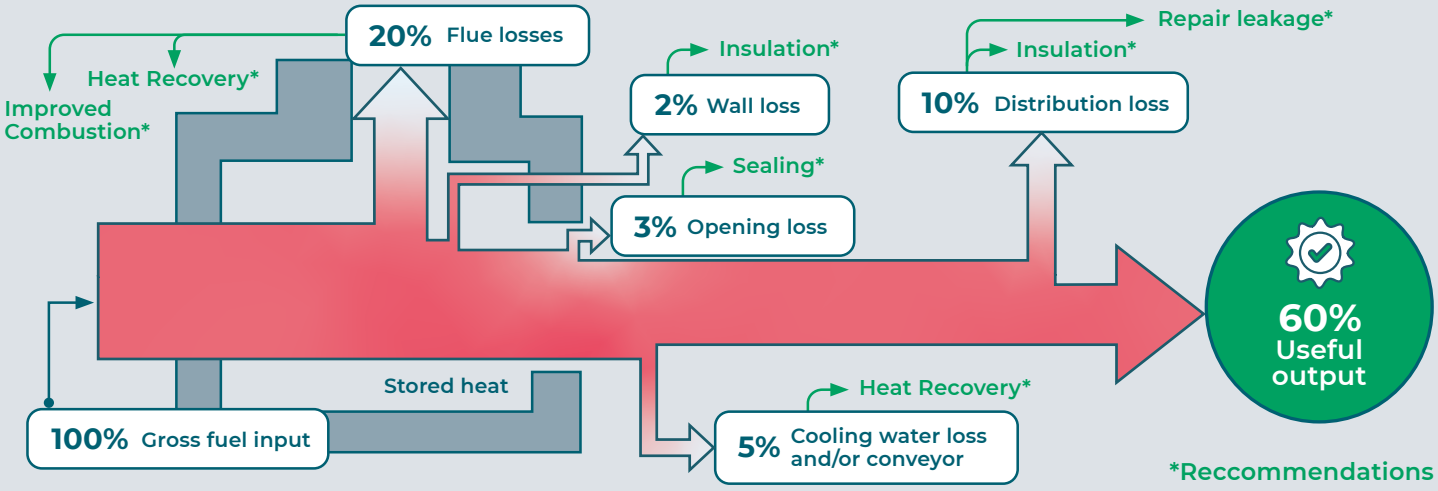
Blowdown of the Water Jacket

Blowdown is a purge of the boiler to remove all accumulated impurities as the water evaporates to produce steam. This operation reduces scaling and steam contamination and should be done regularly and can be automated.



Energy flow for Steam Production 4

A large part of the energy initially contained in the fuel is lost along the combustion and distribution process. While those losses cannot be completely avoided, the objective is to minimize them as much as possible.



Research paper on Analysis of Boiler losses to improve Unit heat rate of coal fired thermal power plant – Acharya Chiral et al. - Dept. of Mechanical Engineering, LDRP-ITR, Gandhinagar, India - 2014

Opportunities

Cheap way to produce and transfer large amounts of heat: water and fuel (if properly selected) can come at a relatively low cost.

High energy content in steam: steam can contain very large amount of heat per unit of volume in the form of latent heat.

Production of large quantity of steam/hour: an industrial boiler and steam system is able to deliver heat continuously to multiple equipment at the same time.

Safe handling of energy as the steam is always contained in airproof vessels (boiler, piping, heat exchangers, etc.)

Barriers

High capital investment: an industrial boiler and its steam system are expensive to implement and take several years to pay back.

Need of proper technical knowledge on boilers' principles and management to achieve efficiency in steam production and distribution, given the complexity of the system.

Risks of burns and explosions: as it contains steam under high pressure and high temperature, insulating the system prevent from those risks.

Pollutants/GHG emissions: incomplete combustion releases pollutants and green house gases.

Energy Management Steps 5

A step-by-step approach for investing in boiler and steam systems.

01. Current state of 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 steam and heat systems.
- Location of boilers and system installation.
- Daily operating hour (h/day).
- Process machine needs (temperature, pressure, flow).

02. Measurements

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

- Fuel/water consumption.
- Steam production (temperature, flow and pressure).
- Flue gas analysis (temperature, O_2, CO_2, CO, Nox, Sox, Rxs, etc.).
- Water quality (pH, mineral content, dissolved gases).
- Steam leakage.
- Thermal losses (boilers, steam network, condensate return network, process equipment).
- Loading and unloading time.

03. Biomass drying and processing

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

- Compare calculation in MJ of fuel per m^3 of steam produced with the theoretical consumption of the boiler to assess its efficiency.
- Calculate air excess/lack in the combustion process.
- Calculate percentage of thermal losses.

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 flow, pressure etc.
- Estimate energy saving compare to previous system.
- Monitor steam leaks of the system.
- Organize a maintenance plan.

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Developed by:
Geres

With the contributions of:

Implemented by

PIERRE-MARC BLANCHET

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 leveraging 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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