Technical Brief on Sustainable Energy

ENERGY SOURCES FOR STEAM PRODUCTION

switchasia
Funded by the European Union
SWITCH GARMENT
PROMOTION OF SUSTAINABLE ENERGY PRACTICES IN THE GARMENT SECTOR IN CAMBODIA
AFD AGENCE FRANÇAISE DE DÉVELOPPEMENT
VETHIC
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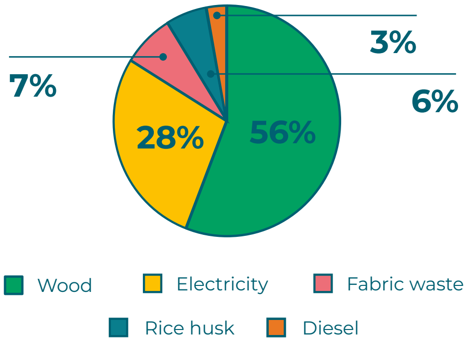
ENERGY SOURCES FOR STEAM PRODUCTION IN GARMENT INDUSTRY

The Cambodian garment industry relies heavily on wood for steam generation:

- **Wood is used by half of the garment factories** along with almost all the factories with large steam requirements (sweaters, denim, laundries, etc.).
- **Wood represents 80% of the total energy consumption** for a factory using wood for boilers, but only 20% of the costs.
- **Electric boilers are used for smaller steam requirements** and especially by factories supplying brands with strict requirements.

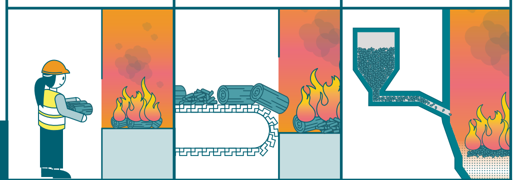


Source: Audit data from 75 garment factories in Cambodia – number of factories using each fuel for steam generation (excluding footwear and travel goods).

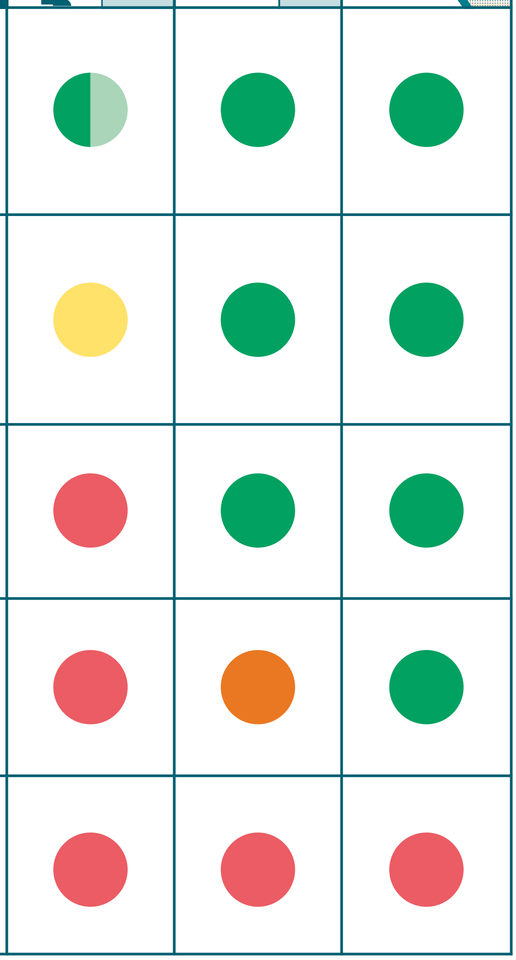
FUEL SUITABILITY WITH THE MAIN BOILER TECHNOLOGIES

The compatibility between boiler technology and the fuel type will dictate which kind of fuel can be used in the factory.

Boiler technologies: Fixed grate | Chain grate | Fluidized bed



Types of fuel	
	**Wood logs and wood briquettes** are compatible with most existing boiler technologies. However, if lower-grade wood like cashew is used, adjustments in operation may be necessary for fixed grate boilers.
	**Rice husk briquettes** generate a significant amount of ash, which can disrupt operations when used with traditional fixed grate boilers. In such cases, retrofitting the boiler or switching to a chain grate boiler is required.
	**Small wood chips and wood pellets** are not appropriate for fixed grate boilers. The factory would need to be equipped with a chain grate or fluidized bed boiler to use this fuel.
	**Loose agricultural residues and waste** require advanced boiler technologies like fluidized bed boilers and are therefore limited to factories with larger steam needs (> 10 t/hour).
	**Fabric waste** requires specialized technologies with advanced emission controls to handle its unique characteristics. Fabric waste is banned by law in other boiler technologies.



Energy Sources Comparison

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	Fuel	Cost USD per t of steam	Direct Emissions CO_2 per t of steam
Wood logs with fixed grate boiler	Forest wood (19% moisture and 47.5% efficiency)	13,5 US$/t	653 $kgCO_2/t$ (assumed fully not renewable)
	Cashew wood (26% moisture and 47.5% efficiency)	14,9 US$/t	0 $kgCO_2/t$ (assumed fully renewable)
	Rubber wood (26% moisture and 47.5% efficiency)	16,7 US$/t	0 $kgCO_2/t$ (assumed fully renewable)
	Acacia wood (26% moisture and 47.5% efficiency)	17,1 US$/t	0 $kgCO_2/t$ (assumed fully renewable)
Processed biomass with chain grate boiler	Cashew wood (19% moisture and 75% efficiency)	9,3 US$/t	0 $kgCO_2/t$ (assumed fully renewable)
	Rubber wood (19% moisture and 75% efficiency)	10,4 US$/t	0 $kgCO_2/t$ (assumed fully renewable)
	Acacia wood (19% moisture and 75% efficiency)	10,7 US$/t	0 $kgCO_2/t$ (assumed fully renewable)
	Rice husk briquettes (7% moisture and 75% efficiency)	19,2 US$/t	30 $kgCO_2/t$ (accounts for processing)
	Wood chips (from acacia or rubber) (50% moisture and 85% efficiency)	26,0 US$/t	5 $kgCO_2/t$ (accounts for processing)
	Wood pellets (from acacia or rubber) (15% moisture and 85% efficiency)	28,1 US$/t	58 $kgCO_2/t$ (accounts for processing)
Fossil fuel boilers	Heavy Fuel Oil (82% efficiency)	62,3 US$/t	261 $kgCO_2/t$
	LPG (94% efficiency)	68,6 US$/t	187 $kgCO_2/t$
	Diesel Oil (88% efficiency)	80,5 US$/t	233 $kgCO_2/t$
Other	Electricity (96% efficiency)	123,8 US$/t	187 $kgCO_2/t$ (national grid 2012 emission factor, exclude on-site PV)
	Fabric waste (with specific advanced incinerators)	0,0 US$/t (60% efficiency with on-site wastes; excludes high investment costs)	111 $kgCO_2/t$ (estimate, value will vary with waste)

Source: *Average Forests.AI estimation based on fuel price, average moisture and boiler efficiency assumptions. Costs and CO2 emissions are indicative only and real value will depend on specific factory parameters.*

Parameters to consider when selecting a fuel:

Calorific Value: the amount of heat energy released per unit mass of fuel, typically measured in kilojoules per kilogram (kJ/kg). Higher calorific value provides more heat energy per unit mass.

Moisture Content: the amount of water present in the fuel can significantly reduce its calorific value as energy is required to evaporate the water during combustion.

Ash Content: the incombustible residue left behind after combustion can affect operations, leading to increased maintenance requirements, and can affect the performance of the boiler.

Fuel Availability and Cost: global market prices and national or regional demand. Some prices can fluctuate strongly, especially for seasonal biomass resources in cases of strong demand.

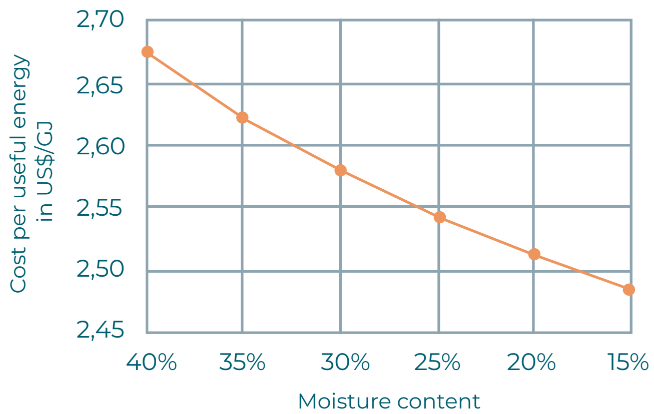
Sustainability: the emissions will depend on the fuel and its management. Proper biomass traceability and certification will be increasingly required to ensure its sustainability.

1. Biomass drying and processing

Fuel costs could be reduced by 10% by drying and resizing the wood before loading it into the boiler.

- Wood moisture content can exceed 40% and the drier the wood, the lower the cost of steam as shown in the graph below.
    - First-in, first-out (FIFO) stock management should be implemented to ensure proper wood rotation, along with protection from the rain.
- Smaller logs lead to more complete combustion, minimizing the creation of pollutants, and maximizing energy efficiency.

Cost of steam at different level of wood drying



Source: Forests.AI calculation of plantation wood costs for various moisture levels at a price of 15 $/m³.

Maintenance | Modification | Optimization

Investment | Labour Time | Savings

2. Maintenance

Proper boiler and steam system maintenance is one of the most cost-effective options for reducing fuel consumption.

Main interventions include:

- Steam trap maintenance
- Pipes and boiler insulation
- Steam leakage prevention
- Regular boiler cleaning
- Stack temperature control
- Feed water treatment

The Technical Brief on Boilers and Steam Systems provides detailed information on these topics.

3. Lower grade biomass residues with chain grate boilers

Chain grate boilers offer an efficient solution for using a diverse range of biomass sources that can allow for a multi-fuel strategy.

It is appropriate for factories with medium steam requirements ranging from 1 to 10 tonnes of steam per hour (TPH).

- The chain allows for the use of biomass with high ash content such as rice husk briquettes or smaller sized pellets and wood chips.
- It can address operational factors associated with the use of lower-grade wood logs, such as cashew wood compared to forest wood.
- It can reduce wood consumption by nearly 50%, which can mitigate the impact of increased biomass fuel costs.

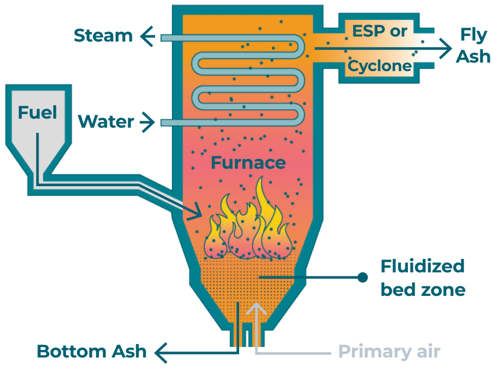
4. Loose biomass with fluidized bed boilers

Fluidized bed boilers enable the use of lower grade biomass with high efficiency.

It offers an interesting solution for factories with substantial steam requirements (above 10 TPH).

A wide range of biomass can be used, including fuels such as chopped firewood, cashew shells, wood chips, loose sawdust, and loose rice husk, but also some type of municipal wastes.

This versatility not only reduces fuel costs but also helps to manage fluctuations in biomass fuel prices through diversification.

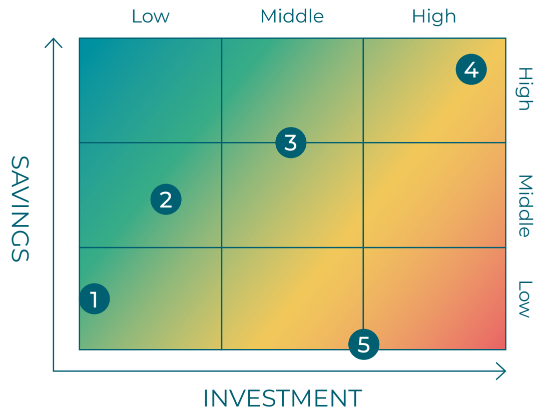


5. Decentralized electric boilers

Decentralized electric boilers can be a renewable source of steam only if the electric supply is sourced from carbon-free energy.

- It minimizes steam losses by being close to ironing tables and can be easily switched on and off as needed, resulting in energy savings.
- However, investment and operational costs remain high, making them a comparatively expensive option for steam production.
- Significant additional investments in renewable electricity generation will be needed to be considered as renewable. Indeed, Cambodia's grid electricity mix was still at 42% fossil fuels in 2021 (source: EAC) and is likely to increase in the coming years. For factories having small steam needs, using electric boiler avoid the operational costs of a boiler system.

Summary & Recommendation



1. Biomass drying and processing
2. Boilers and steam system maintenance
3. Lower grade biomass residues with chain grate boilers
4. Loose biomass and wastes with fluidized bed boilers
5. Decentralized electric boilers

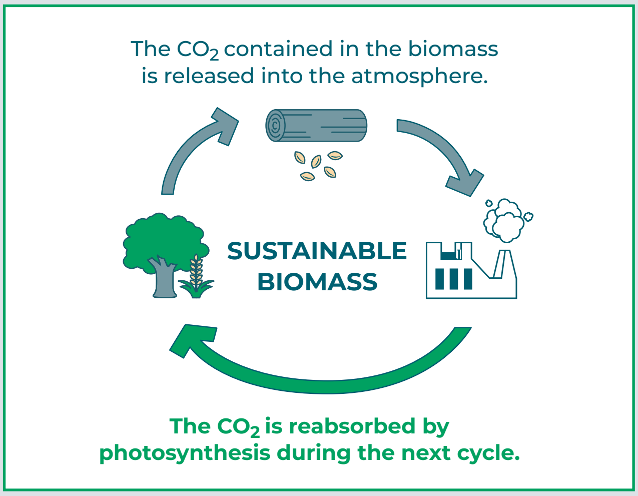
Which opportunity for which steam need?

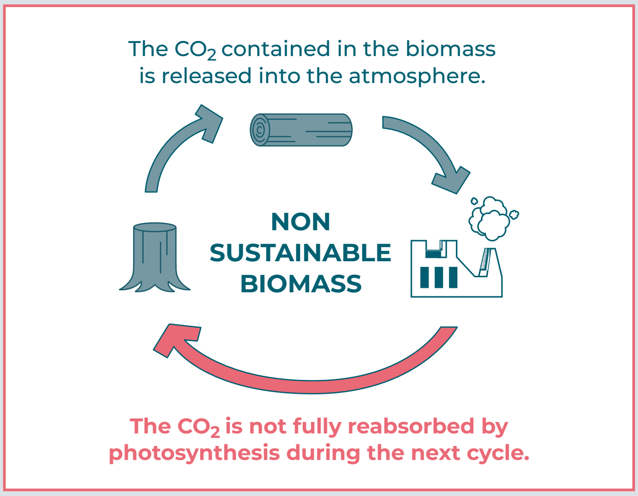
Average steam needs	Large steam needs	Small steam needs
1 2 3	1 2 4	5

Environmental and health concerns 3

Sustainability

Biomass can be sustainable and even considered carbon-neutral in some cases if the biomass stock and all the CO2 can be recovered within a reasonable amount of time and ecosystem services are maintained in the long term.





The use of non-sustainable forest wood is still prevalent in factories and can bring high risks for brands in terms of exposure to deforestation and illegal logging.

The use of non-forest wood and agricultural residues can significantly reduce these risks.

Biomass energy in the HIGG FEM v4.0

Under the HIGG FEM 4.0, only certified biomass (FSC, PEFC, ISCC, SBP etc.) will be considered as renewable energy.

Air Pollution

Any combustion process can emit harmful pollutants that can present risks for factory employees, and the neighboring population.

Fuel	Harmful component	Main cause	Risks	Prevention
All fuels (wood, rice husk, diesel, LPG, HFO, etc.)	**Carbon monoxide** (CO) which is odorless and colorless gas.	Incomplete combustion (insufficient supply of oxygen during the combustion)	Dizziness, confusion, unconciousness and even death from direct exposure.	• Avoiding excess fuel dumping • Using smaller diameter wood • Regularly cleaning boiler to guarantee good air distribution • Ensuring good ventilation within the boiler room.
Rice Husk	**Crystalline silica** which is a fine airborne dust.	High temperature combustion >780 °C	Lung cancer and silicosis.	• Efficient temperature control to avoid reaching high temperature threshold • Use of cyclone air pollution control device • Use of respiratory protections for workers
Fabric waste (other fuels can emit dioxin but fabric waste is the most at risk)	**Dioxin** which is a particle persistent in the environment that can be airborne.	Incomplete combustion at low temperature of plastics materials and synthetic fabrics	Cancer, reproductive issues, and damage to the immune system from direct exposure and accumulation in the food chain.	• Use modern incinerators designed for fabric wastes and follow the manufacturer's recommendations. • Avoid the burning of plastic waste. • Maintain proper pressure and minimum temperature. • Maintain Air Pollution Control devices and safely dispose of ashes.

Overall, most sources of air pollution can be addressed by employing best practices and maintenance schedules, and the use of modern and efficient technologies. This can also reduce operational costs and improve safety.

A step-by-step approach for sustainable use of biomass for steam generation.

01. Biomass supplier due diligence

Implementing proper due diligence when selecting biomass suppliers is crucial.

- Biomass shall not come from illegal harvesting or deforestation and sustainable management practices should be implemented for plantations.
- Factories should clearly communicate its requirements in terms of wood species, moisture content, and size to suppliers.
- Opting for certified suppliers can allow the factory to be recognized as using renewable energy sources. These factories will be adhering to brand requirements and updated HIGG FEM guidelines.

02. Transportation and processing

Biomass transportation and processing can lead to significant greenhouse gas emissions and should be accounted for in the analysis when selecting an appropriate fuel.

Local biomass sources and processing using renewable energy should be prioritized to reduce GHG emissions.

03. Biomass drying and processing

Proper drying of the biomass is essential to optimize energy efficiency.

- Drying can be negotiated with suppliers to avoid excessive storage space in factory.
- After delivery, biomass should be stored in a sheltered area to protect it from the rain and maintain its quality.
- Wood logs should be resized to ensure complete combustion leading to better efficiency and lower air pollution.

04. Fuel consumption monitoring

Continuous monitoring of the steam system is crucial to promptly identify and address any losses or inefficiencies. The procedures described in the Boilers and Steam Systems Technical Brief should be followed to ensure that the systems operate at their peak performance, minimizing energy losses and optimizing the use of biomass fuel.

Multi-stakeholder collaboration for sustainable biomass supply chains

Achieving sustainable biomass supply chains requires collaboration among brands, factories, and suppliers.

Clear biomass sourcing guidelines are crucial for developing long-term sustainable biomass solutions (investment in new boiler and biomass supply and purchase agreement).

Maintaining close relationships with biomass suppliers is essential to ensure sustainable sourcing practices and optimize drying and fuel preparation for efficient use in boilers.

Finally, awareness raising of staff is vital for effectively disseminating and implementing good practices for sustainable biomass sourcing and use across the factory.

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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