Replacing Fossil Fuel based thermal generation with Renewable Fuel in textile and garments sector in Bangladesh

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für Internationale
Zusammenarbeit (GIZ) GmbH

Introduction

Objectives

The goal of the study is to identify potentials to reduce the GHG emissions with the focus on renewable energy resources in Bangladesh textile and garments sector

Phase-1: Pre-feasibility study on renewable fuel market and identify alternative renewable sources for boilers or thermal application replacing fossil fuel

Phase-2: To conduct a detail study on the most relevant and suitable renewable fuel source to use in boiler operation in the industry (proposed in Way Forward)

Phase-3: To support H&M to initiate a pilot in 8 - 10 factories and demonstrate the viability of renewable fuel boiler

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AREAS OF THERMAL ENERGY DEMAND IN TEXTILE AND GARMENT FACTORIES

Woven & Knitted Fabric Processing (Non-denim)	Water	Steam
Fabric Bleaching	Yes	Yes
Fabric Washing	Yes	Yes
Fabric Dyeing and Printing (Reactive)	Yes	Yes
Fabric Finishing	Yes	Yes

Denim Fabric Processing	Water	Steam
Denim Rope Dyeing	Yes	Yes
Denim Fabric Processing	Yes	Yes
Denim Fabric Finishing (Sizing, Mercerizing etc.)	Yes	Yes

Denim Garment Process	Water	Steam
Denim Garment Dyeing	Yes	Yes
Garment Washing	Yes	Yes
Laundry Drying	No	Yes
Garment finishing	Yes	Yes

Knitted Garment Process	Water	Steam
Garment finishing (pressing)	No	Yes

Renewable Energy Options Evaluated

Bio Mass

Steam generation (Combustion and Gasification)

Solar Energy

Mainly Solar Thermal and comparison with Solar PV

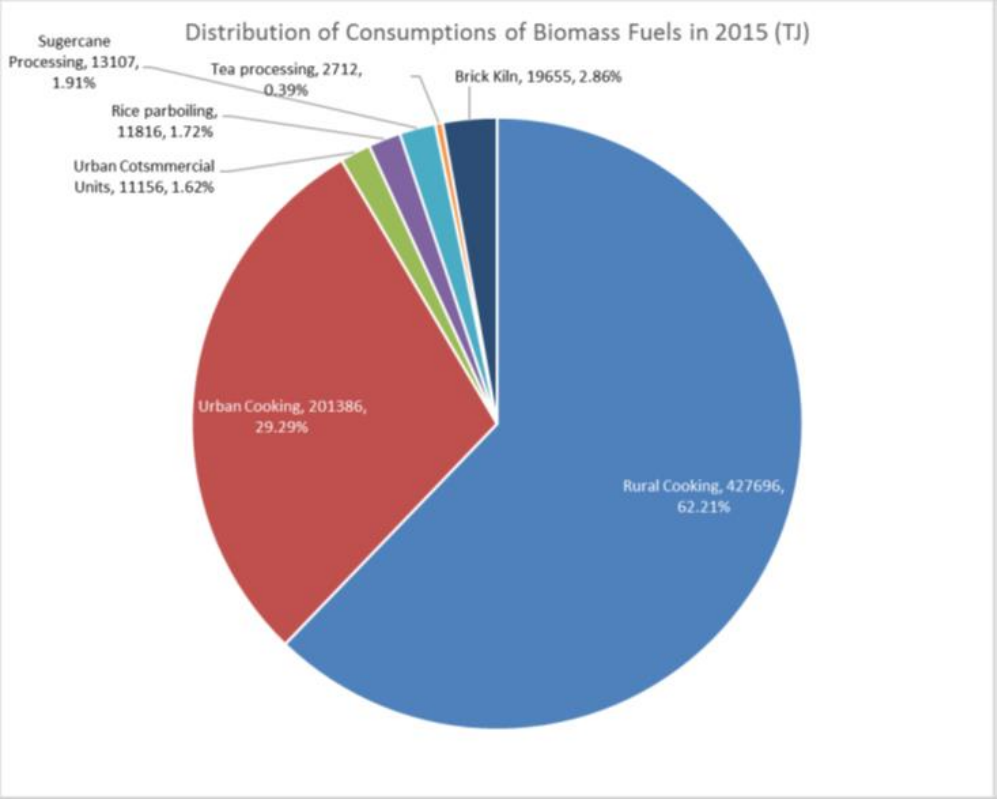
Bio-mass for Steam generation

Bio-mass availability from various sources in Bangladesh

Bio-mass	Annual Quantity (million tons)	Comments
Tree residues	16.18	Available as fuel as well. Village forest extraction decreasing generally; timber extraction increasing
Agricultural residues	111.00	Mostly used in higher economic value options; ~43 million available for fuel
Animal dung (dry)	10.90	Out of 23.64 million cattle, 97.3% are found in households; mostly used for domestic cooking
Total	**138**	**Total 53.9 million Tonne available for fuel; 51.3 million Tonne consumed in 2015**

Challenge: Above data is for year 2015. No reliable country-level data available after year 2015 on bio-mass supply and demand.

Bio-mass Usage as Fuel in Bangladesh



Source: A comprehensive assessment of the availability and use of biomass fuels for various end-uses with special attention to power generation, SREPGen Project, UNDP Bangladesh, June 2019

Bio-mass Usage as Fuel in Bangladesh

Three seasons for rice cultivation:

- January – May
- July – December
- June – September

Estimated paddy production = 52 million tonnes

- 30% kept by farmers for their own consumption mostly for cooking as fuel including the related agricultural waste and rice husk
- 70% (36.4 million tonne) are processed in rice mills

Rice husk availability

- Husk is 17.5% of total paddy weight (7kg rice husk is produced from 40 kg rice paddy)
- 50% of husk is used by traditional mills to run their boilers
- 50% are sold to poultry farms for feed, and to fuel stick (briquettes) manufacturers to be sold for domestic cooking
- Rice Husk supply from rice mills is not uniform in quantity throughout the year
- Sometimes the husk supply is surplus so that the husk is leftover after consumption and sometimes the husk supply is deficit than needed
- Rice husk is also sold to industrial units for use as fuel
  - instability of supply and fluctuation of price → higher cost of steam production compared to most commonly available fuel (Natural Gas)

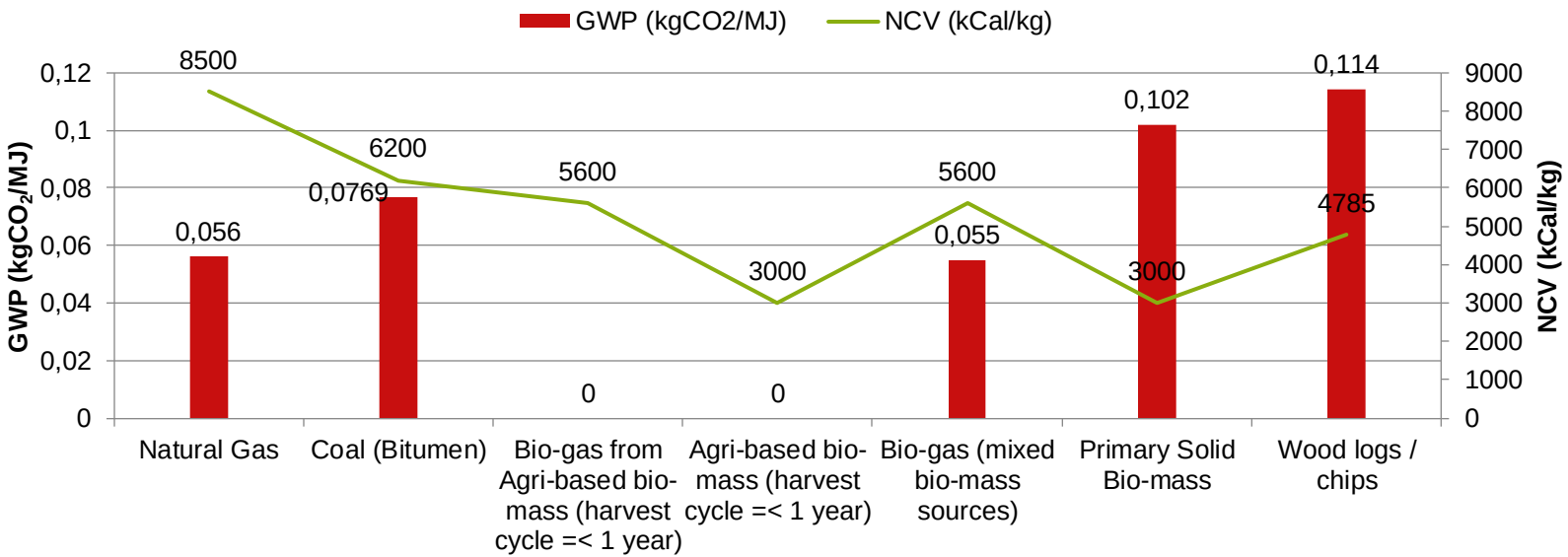
Bio-mass Fuel Prices in Bangladesh

Bio-mass prices are variable; farther a factory is located from bio-mass source, more is the price

Bio-mass	Price
Rice Husk	8-12 USD-cents/kg (7-10 BDT/kg)
Saw Dust	2.3-14 USD-cents/kg (2-12 BDT/kg; Average 5 BDT/kg)
Wood logs / chips	4.5-5.7 USD-cents/kg (4-5 BDT/kg)
Other bio-mass	No reliable price data available

Global Warming Potential and Calorific Values of Available Fuels for Boilers

- Agriculture based bio-mass is considered to have Net-Zero Emissions as per IPCC 2019 guidelines
- General NCV of agri-based bio-mass is quite low compared to Natural Gas and other alternatives
- Bio-gas contains higher NCV but becomes even more expensive, and requires larger scales



Technology options for steam boilers (considering 10TPH boiler for comparison)

Fuel	Boiler Technology	Investment (USD)	Investment for emission control equipment (USD)	Additional Space required
Natural Gas	Fire tube	220,000	-	-
Rice Husk	Water tube Travelling Grate, Circulating Fluidized Bed	320,000 – 400,000	18,000 – 40,000	7,700 m^3
Rice Husk briquettes	Water tube Travelling Grate	Boiler 320,000 – 400,000 Briquetting machine ~5,000	18,000 – 40,000	9,000 m^3
Wood Logs / chips / saw dust	Water tube Travelling Grate	320,000 – 400,000	18,000 – 40,000	7,700 m^3
Wood chip/saw dust briquettes	Water tube Travelling Grate	Boiler 320,000 – 400,000 Briquetting machine ~5,000	18,000 – 40,000	9,000 m^3 for storage
Bio-gas (Agri-based or sewage waste bio-mass)	Bio-gasification + fire tube boiler	860,000 – 1,100,000	-	7,700 m^3 for storage 1,676 m^3 for gasifier

Note: Investment for natural gas boiler is not mentioned considering these are already installed in the factories and are to be replaced with other presented options.

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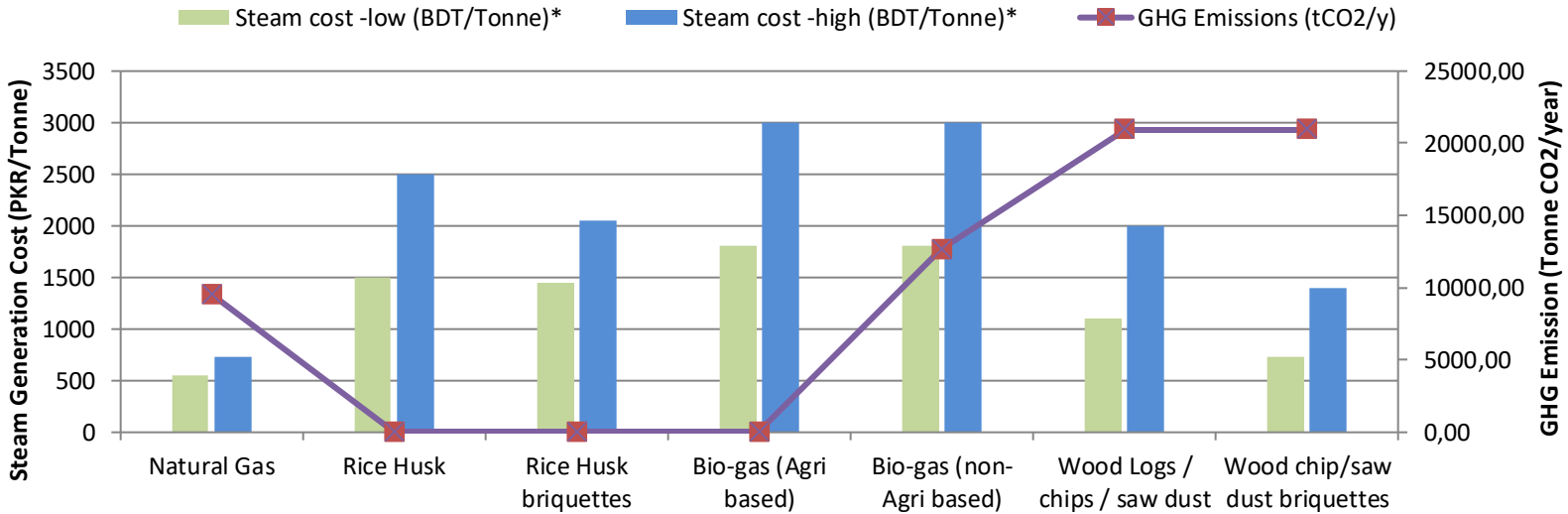
Comparison of Steam Cost and Annual GHG Emissions in Bangladesh
(considering 10TPH boiler for comparison)

- Lowest steam generation cost on Natural Gas with least variations
- Other fuels are subject to higher and more variable steam cost due to more frequent price fluctuations.
- Briquetting reduces the steam generation cost significantly as it has better calorific value due to reduced and controlled moisture in the bio-mass.
- Agri-based bio-mass are more suitable in terms of climate improvement targets due to Net-Zero Emissions



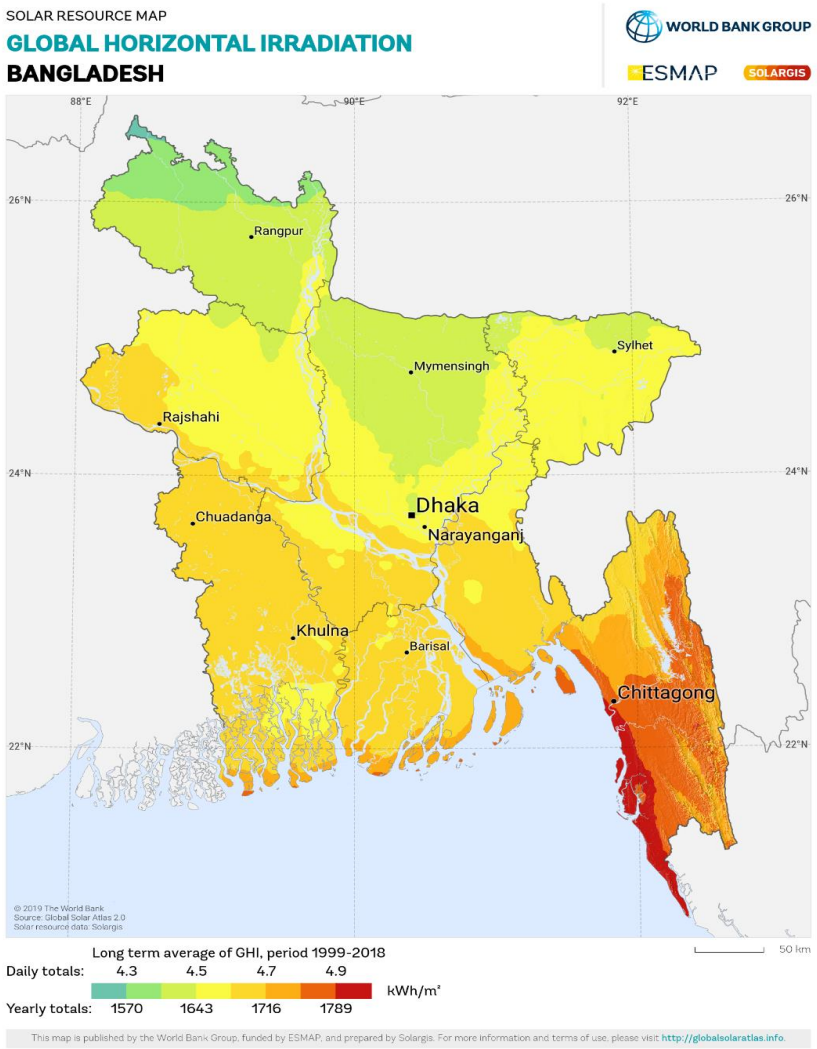
Limitations of Bio-mass based Steam Generation Systems

- Natural gas combustion efficiency is easier to control compared to solid fuels like bio-mass
- Bio-mass fuels require extensive monitoring and manual control by operators; automation works only if bio-mass type is fixed and quality is consistent
- Not all boilers are capable of firing all types of bio-mass materials.
- Moisture in bio-mass varies across the year which significantly effects boiler combustion efficiency
- Large storage space is required to stock enough bio-mass to allow natural moisture reduction as well as to reduce transportation cost
- Bio-mass price fluctuations result in significant variation in steam generation cost which puts the bio-mass behind natural gas in the race.
- Managing the supply chain for bio-mass is a formidable challenge because of the distributed nature of the resources, availability over a short period of harvesting time and its physical characteristics.
- Bio-mass combustion generates significant amount of ash and particulate matter for which special arrangements are required for
  - filtering out the ash from air and water
  - drying, handling and storing the ash
  - safe disposal. All these arrangements result in additional operational cost

Solar Energy

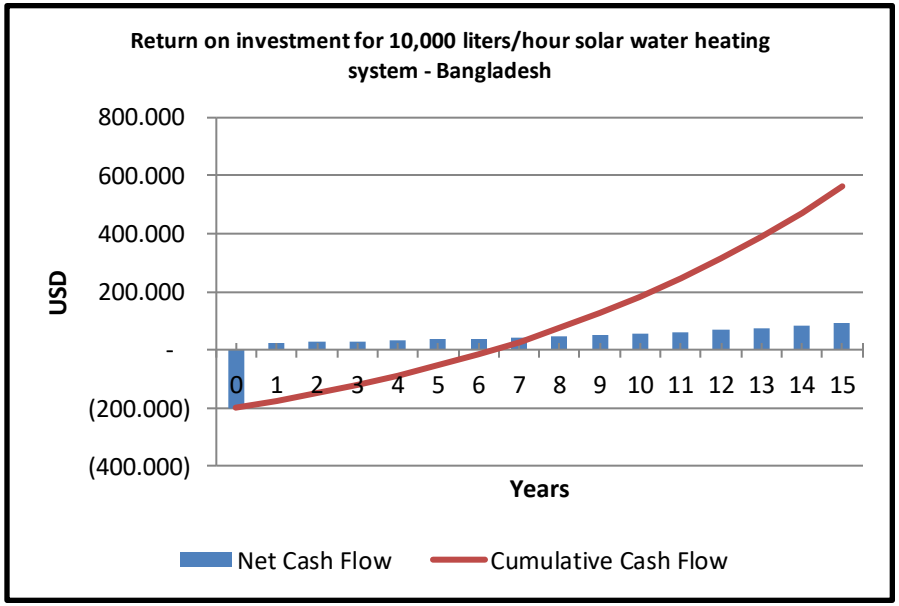
Global Horizontal irradiation in Bangladesh

- Average potential Global Horizontal Irradiation (GHI) in Bangladesh is 4.596 kWh/m2
- Great potential for Solar Water Heaters



Economic feasibility of Solar Water Heating - Bangladesh

- Analysis is conducted considering hot water demand of 10,000 litres per hour, heating water from 25°C to 65°C on average (may go up to 90°C in summer) for 8 hours a day.



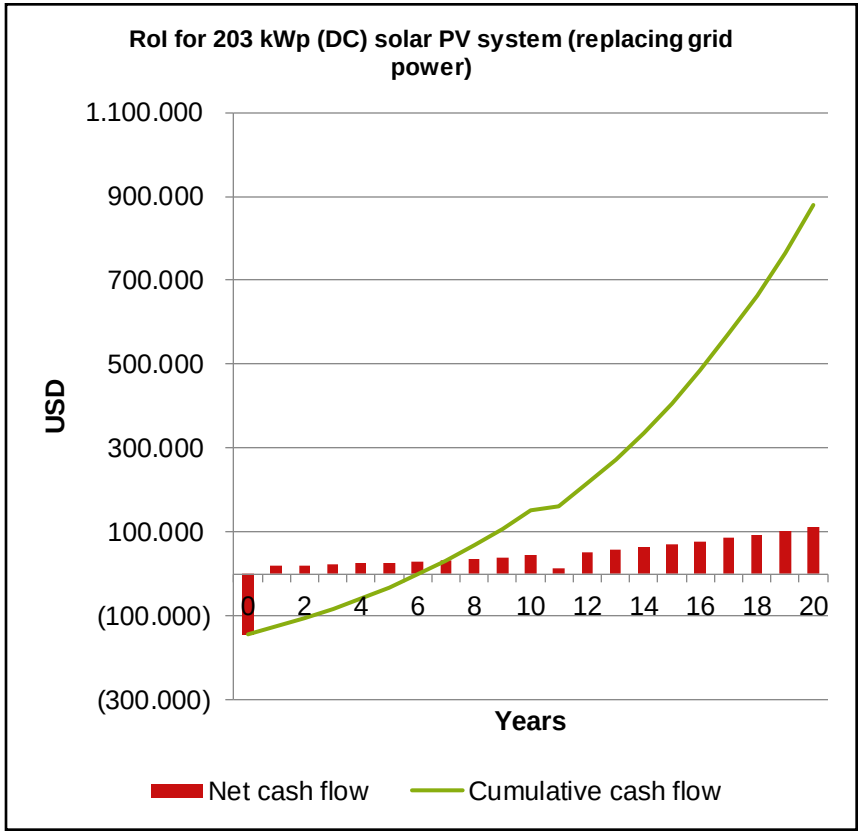
Water flow	80	m^3/d
Collectors (50 tubes each)	180	
Average Temperature gain (ΔT)	40	C
Energy gain	13,408	MJ/d
Hours of operation (average)	8	hrs
Footprint area	1,487	m2
Specific weight of the system	38.75	kg/m^2
Gross weight of the system on rooftop	57,606	kg
Storage tank	20	m^3
Pumping energy cost	4,041	USD/year
Natural Gas saving	711	m^3/d
GHG emission reduction	**434**	tCO_2/year
Natural Gas cost saving (1st year)	**28,085**	USD/year
Investment	200,237	USD
Dynamic payback period	**6**	years
Lifecycle	15	years
IRR	**18**	%
NPV	**116,028**	USD

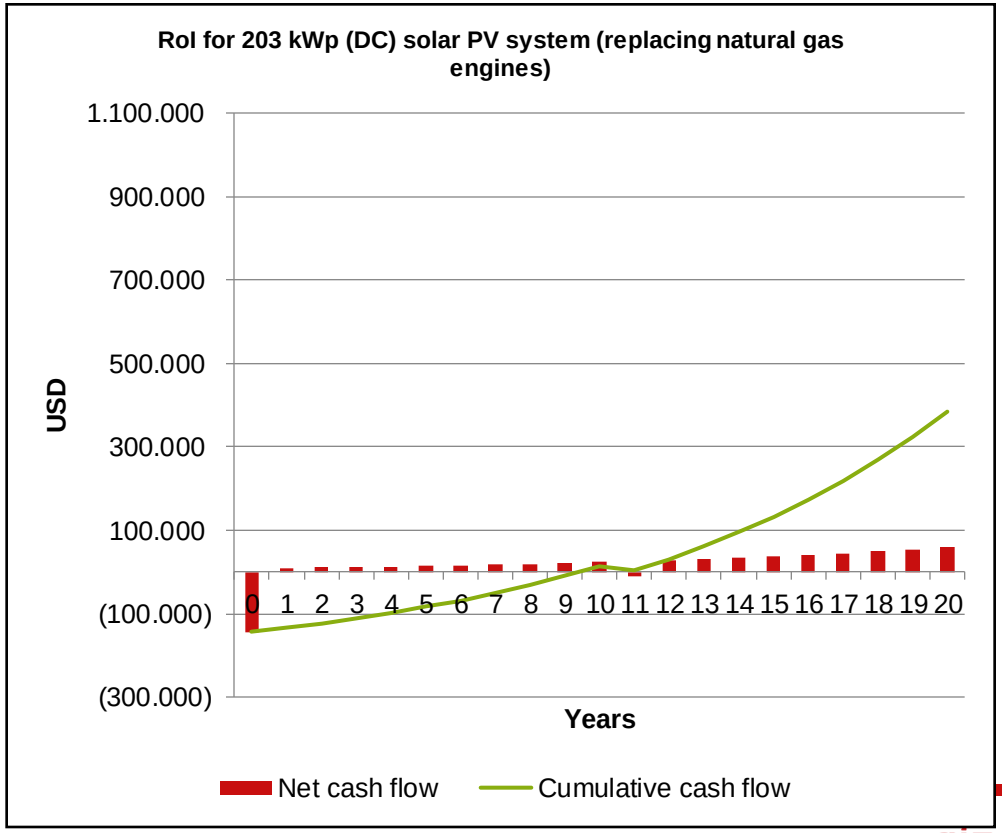
Economic feasibility of Solar PV - Bangladesh

- Analysis is conducted considering same footprint area as for Solar Water Heater
- IRR is lower when replacing Natural gas based power due to low price of natural gas
- GHG emission reduction potential for both options is equivalent

	Solar PV replacing Grid Power	Solar PV replacing Natural Gas Power	Units
Footprint area	1,487		m^2
Typical potential (monocrystalline)	7.3		m^2/kW
Total potential capacity	203		kW DC
Annual energy generation capacity	209,538		kWh/Year
Energy gain	2,066		MJ/d
GHG emission reduction	126.5	118.9	tCO2/year
Hours of operation (average)	3.2-3.9		hrs
Specific weight of the system	25		kg/m^2
Gross weight of the system on rooftop	37,175		kg
Investment	144,142		USD
Electricity cost saving (1st year)	22,268	13,639	USD/year
Dynamic payback period	6	9	years
Lifecycle	20		years
IRR	20	12	%
NPV	163,137	20,501	USD

Economic feasibility of Solar PV - Bangladesh

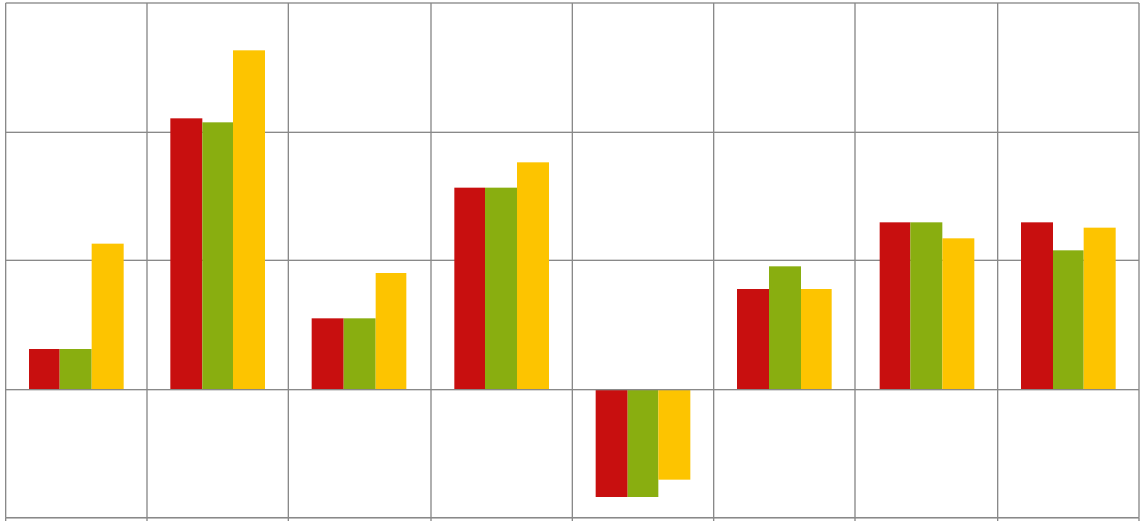




Comparison between Solar Water Heater and Solar PV

- Higher energy gain by Solar Water Heater
- Potential to reduce GHG emissions is much higher for Solar Water Heater compared to Solar PV.
- Almost equivalent IRR for Solar PV replacing grid power and Solar Water Heater. Very low IRR for Solar PV replacing Natural Gas based power
- Solar PV system are easier to install and operate as they do not require allied utilities like pumps, heat exchangers and storage tanks.
- Specific weight of Solar PV is lesser than that of solar water heaters reducing requirements for structural reinforcement.
- Solar water heaters have shorter lifecycle compared to Solar PV and also have higher operations and maintenance costs.

Comparison between Solar Water Heater and Solar PV - Bangladesh



	Energy gain (GJ/d)	GHG emission reduction (tCO2/y)	Hours of operation (hrs/d)	Gross weight (Tonne)	Investment (M-USD)	Dynamic payback (y)	Lifecycle (y)	IRR %
Solar PV (Replacing Grid)	2,07	127	3,55	37,18	0,14	6	20	20
Solar PV (replacing NGPower)	2,07	119	3,55	37,18	0,14	9	20	12
Solar Water Heater	13,41	434	8,00	57,61	0,20	6	15	18

Conclusion for Bio-Mass

- Natural gas is by far the cheapest fuel in Bangladesh in terms of steam generation cost, and also has the lowest variation in steam cost due to less frequent price fluctuations. However, there are no GHG emissions associated with Agri-based bio-mass fuels, hence establishing these as more suitable in terms of climate improvement targets.
- Bio-mass may become economically viable in Bangladesh if natural gas prices increase in future due to introduction of RLNG in the national supply line.
- Another important element to consider for switching to bio-mass fuels is additional space and human resource requirement which may become a challenge for smaller companies having low steam demand; however, medium and large-scale companies usually have sufficient resource available.
- Investment required for switching to bio-mass fuels may become a relevant indicator as well for companies who do not have a bio-mass boiler available at site. It is observed that larger companies keep bio-mass fired boilers as back-up option; in which case the critical indicators would be supply, steam cost and GHG emissions.
- It is evident that there might not be enough bio-mass available to drive a major shift from fossil fuels to bio-mass for energy generation in Bangladesh.

Conclusion for Solar Energy

- Solar Water heaters carry significant potential for thermal energy generation and GHG emission reduction.
- Requirement of hot water in garment washing process is usually intermittent. However, careful planning and proper designing and insulation of water circuit may resolve this issue to some extent.
- Industrial scale Solar Water Heaters may not be feasible for factories using steam only for garment pressing
- Solar water heaters are highly suitable for factories having more stable hot water demand, such as fabric processing mills and large garment washing units.
- Detailed feasibility study may be conducted on Solar Water Heaters for a specific case so that detailed analysis of hot water demand and generation potential could be conducted.
- Solar Photo Voltaic may also be considered for reducing dependence on national grid or fossil fuel (natural gas) fired engines.
- Solar PV systems require much more investment for same amount of energy compared to solar water heaters. However, it presents considerably less challenges.
- GHG emission reduction for solar PV is considerable when replacing grid power, however, potential significantly reduces when replacing natural gas power.

Mapping biomass /biofuel /alternate resource (Solar) potential assessment

Renewable energy options	Energy cost	GHG emission	Nature and direction of regulation	Geography	Seasonality	Key vendors	Pricing considerations	Current Uses
Bio-mass	Increased steam cost compared to natural gas	No GHG emission accounted for agri-based bio-mass with harvest cycle equal or less than 1 year	No restriction	Geographical variation in supply; Supply chain data only up-till 2015	Fluctuating based on crop harvesting cycle	No formal data of bio-mass suppliers; technology suppliers available but not formally organized	Basic price data available; concrete fluctuation data not available	Data only up-till 2015 for BGD..
Solar Thermal	Financially feasible even when compared with Natural gas fired steam boilers	Significant reduction	Sustainable Finance Policy for Banks and Financial Institutions, 2020	Geographically variable irradiation potential	Seasonally variable irradiation potential	Limited suppliers for industrial solutions, not formally organized	Generally established prices but variable based on currency exchange rate	No mapping available for industrial sector
Solar PV	Financially feasible compared to grid; longer payback against natural gas based power	Significant reduction	Sustainable Finance Policy for Banks and Financial Institutions, 2020	Geographically variable irradiation potential	Seasonally variable irradiation potential	Bangladesh Solar and Renewable Energy Association; Bangladesh Solar	Generally established prices but variable based on currency exchange rate	No mapping available for industrial sector

Way Forward

Option-1: Develop pilot for adopting bio-mass for one selected supplier

ideally selecting a supplier where bio-mass boilers are already installed or are located near the Agri-based bio-mass source

- Improving efficiency of the bio-mass steam generation system (Training, Briquetting, Combustion efficiency, heat recovery etc.)
- Adopting new bio-mass boiler using bio-mass from reliable source of Agri-based bio-mass
- Selecting right steam source mix to achieve GHG reduction while maintaining steam cost in acceptable range

Option-2: Develop pilot for adopting solar energy (thermal or PV) for one selected supplier

- Assessing solar energy potential at site
- Selecting suitable solar energy option (thermal, PV or both)
- Conducting pre-feasibility for selected option along with financial analysis and suitable financing options

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