Steaming electricity from waste.

UNIFI Capital

Metamorphosis of a Ductile Iron Company

After the acquisition of its partner's stake in 2012, one of India's largest Ductile Iron pipe manufacturers was jostling to turnaround its operations. It was loss making, heavily inefficient in key operating cost parameters and was staring at financial distress. The manufacturing process of Ductile Pipe is highly complex and requires seamless integration of various sections, which are Coke Oven Battery, Sinter Plant, and Centrifugal Casting, to name a few. For a manufacturer to be competitive, it has to highly operating cost efficient.

Steaming electricity from waste | Out of the various initiatives undertaken by the DI Pipe manufacturer, one of the most critical one was to focus on recovering waste heat in the manufacturing process and use it to generate electricity. The manufacturer installed a 10 MW of Captive Waste Heat Recovery Plant which utilises the heat from exhaust flue gases from the coke ovens. This helped the company to meet a significant portion of power requirement for manufacturing operations for both pig iron (an intermediate product) as well as Ductile Iron pipes.

Power Cost Savings + Reduction in Pollution

While the direct benefits of the recovery process was that it added to the overall efficiency of the process and thus reduced the costs of fuel and energy consumption, it also substantially reduced the overall carbon foot print. Thermal and air pollution dramatically decreased since less flue gases of high temperature are emitted from the plant.

The table below shows financial benefit, the company derived by installation of Waste Heat Recovery Plant instead of purchasing from Grid.

Significant Power Cost Savings from Waste Heat Recovery Plant		
	EBITDA Level	**PBT Level**
Waste Heat Plant Capacity (MW)	**10**	**10**
PLF - %	80	80
Power Production (Mn Units)	70	70
Waste Heat Plant Cost(Rs/Unit)	1	2
Power Purchase Cost(Rs/unit)	7	7
Power Cost Savings (Rs/unit)	6	5
Total Savings (Rs. Mn)	**420**	**350**

If the same quantum of 10 MW of power was to be generated using a coal fired thermal power plant, likely emission of CO2 would be 20 Million kgs per annum.

Clean Energy through Industrial Turbines

Steam Turbines form an integral part of any captive power generation setup. While in the example quoted above, waste heat was used as input, the input material could be a by-product/waste of any manufacturing plant.

In simple terms, a steam turbine extracts thermal energy from pressurized steam and uses it to do a mechanical function on a rotating output shaft, working like a cross between a wind turbine & water turbine. Like a wind turbine, it has spinning blades that turn when steam blows past them; like a water turbine, the blades fit snugly inside a sealed outer container so the steam is constrained and forced past them at speed. A turbine is the middle component of B-T-G type of power generation i.e. Boiler-Turbine-Generator.

Industrial Turbines are smaller size steam turbines with power production capacity of less than 200 MW.

A Win-Win Synergy - Application across multiple industries

The market for these relatively smaller capacity steam turbines can be broadly categorized into 3 segments:

- Dedicated captive power generation,
- Co-generation &
- Renewable energy

Dedicated captive power generation units are set up by businesses who look at in-house production & consumption of power rather than purchasing power from grid for use in their manufacturing process. These power plants use boilers to generate high pressure steam and pass it through a steam turbine which in turn converts the thermal energy from the pressurized steam to mechanical energy with the rotation of an output shaft, thereby generating power for the manufacturing process.

Co-generation, also referred to as combined heat & power generation, works on the concept of producing two different forms of energy by using a single source of fuel i.e. electrical / mechanical energy from the rotating turbine & heat / thermal energy from the exhaust steam.

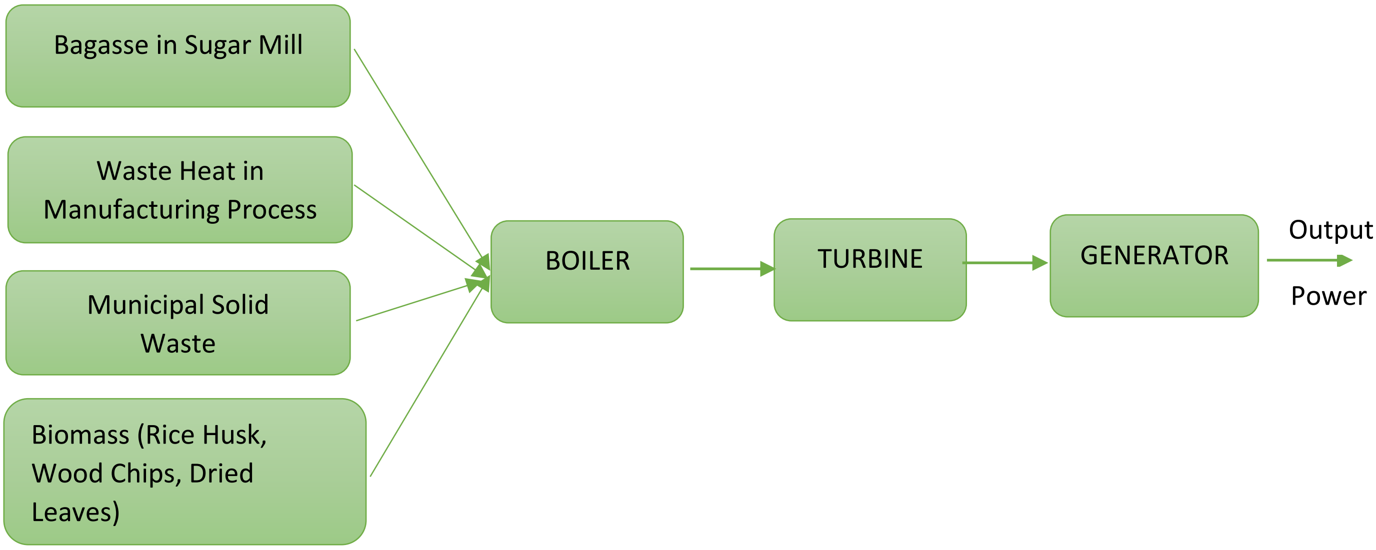
Renewable energy steam turbines also find application in the domain of renewable energy which utilizes agro-based co-generation, biomass power & waste to energy to generate the pressurized steam needed for power generation.

An important point to consider is that steam turbines are not standardized products but are customised to suit specific functional requirements of the buyer. This is where deep customer insight & technical expertise of market leaders come in.

While the ticket size of the orders varies significantly depending on the turbine type, application, specifications etc, these steam turbines broadly cost Rs. 6.0 - 7.0 Mn per MW to the buyer.

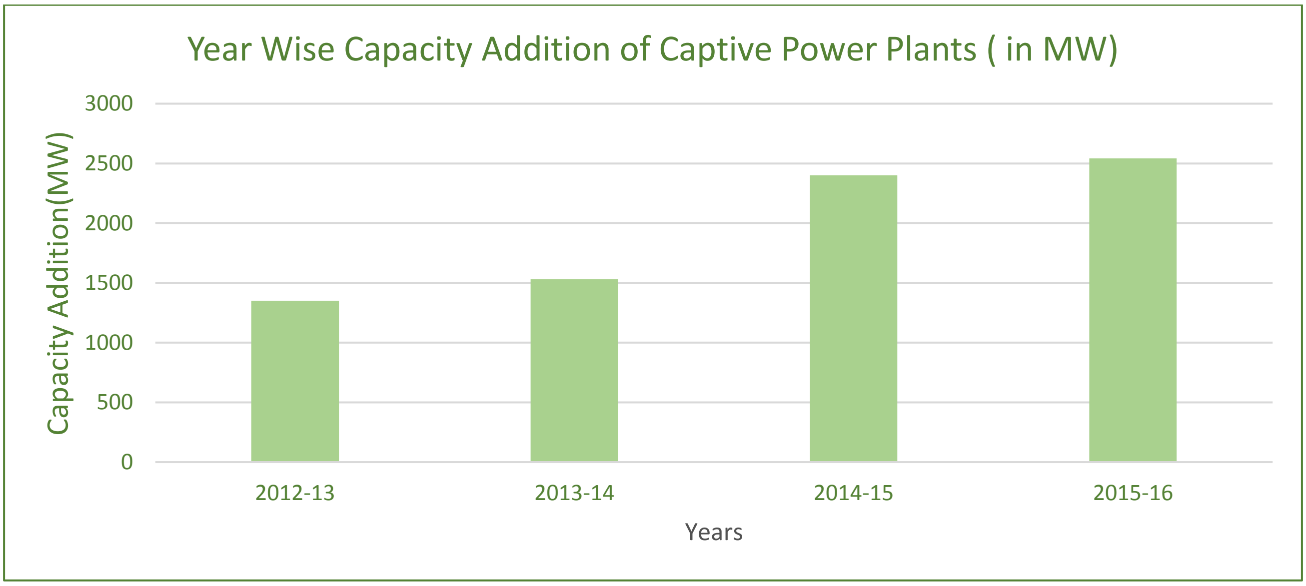
Multiple Raw Materials to generate same Power

Any raw material that can generate steam can be used as input for a Boiler and then as feed to a steam turbine. The chart below shows some of the input raw materials that are typically used for steam turbine -



Turbocharged - Capacity additions to improve

As per the Draft National Electricity Plan, 2016, the total captive power installed capacity in India is about 47 GW or 15% of total power installation in India and has grown by 5.69% from FY 2015 to FY2016. However, power generation from captive power plants increased by 8.7% from 148.9 BU in FY2014 to 162 BU in FY2015.



Source: Draft National Electricity Plan, 2016

While the above data reflects the captive power generation from multiple sources (including coal), industrial turbine business for co-generation is highly exposed to the country's capex cycle. Barring waste-to energy/renewable projects, the demand is driven by industrial expansion (Greenfield or Brownfield). Biomass based power producers also require to keep inventory of raw material which expands their working capital needs.

However, there is a huge potential in the demand for industrial turbines. According to the Ministry of New and Renewable energy (MNRE), the current availability of biomass in India is estimated at about 500 Mn MT per annum. Studies have estimated surplus biomass availability at 120-150 Mn MT per annum corresponding to a potential of about 18GW.

As per MNRE, additional ~7GW of power could be generated if ~550 Indian sugar mills were to adopt technically and economically optimal levels of bagasse-based cogeneration. With increasing focus on renewables, we are also likely to witness waste-to-energy projects (similar to developed markets) being envisaged in India.

Notwithstanding the current scenario, there is no dearth of opportunities in the long run. Companies with technological edge and market leadership are well placed to leverage on this opportunity.

Source Wise and State Wise Estimated Potential of Bio-Energy in India

States/UTs	Biomass Power (MW)	Cogeneration-bagasse (MW)	Waste to Energy (MW)	States/UTs	Biomass Power (MW)	Cogeneration-bagasse (MW)	Waste to Energy (MW)
Andhra Pradesh	578	300	123	Nagaland	10	0	0
Arunachal Pradesh	8	0	0	Odisha	246	0	22
Assam	212	0	8	Punjab	3172	300	45
Bihar	619	300	73	Rajasthan	1039	0	62
Chhattisgarh	236	0	24	Sikkim	2	0	0
Goa	26	0	0	Tamil Nadu	1070	450	151
Gujarat	1221	350	112	Tripura	3	0	2
Haryana	1333	350	24	Uttar Pradesh	1617	1250	176
Himachal Pradesh	142	0	2	UttaraKhand	24	0	5
Jammu & Kashmir	43	0	0	West Bengal	396	0	148
Jharkhand	90	0	10	Andaman & Nicobar	0	0	0
Karnataka	1131	450	151	Chandigarh	0	0	6
Kerala	1044	0	36	Dadar & Nagar Haveli	0	0	0
Madhya Pradesh	1364	0	78	Daman & Diu	0	0	0
Maharashtra	1887	1250	287	Delhi	0	0	131
Manipur	13	0	2	Lakshadweep	0	0	0
Meghalaya	11	0	2	Puducherry	0	0	3
Mizoram	1	0	2				
				All India Total	**17538**	**5000**	**1685**

Source: Biomass Knowledge Portal, Ministry of New and Renewable Energy

Huge Export Opportunity for Indian Players

There is a huge opportunity for Indian Turbine manufacturers targeting waste-to-energy and cogeneration opportunities in Europe, Africa and South Asia. As per the World Energy Council, waste-to-energy (WTE)/biomass had a market size of USD 29 Bn in 2015. The global market for WTE is expected to maintain its steady growth up to 2023, when it is estimated it would be worth c. USD 40 billion, growing at a CAGR of over 5.5% from 2016 to 2023. Europe is the largest and most sophisticated market for WTE technologies, accounting for 47.6% of total market revenue in 2013.

Asia-Pacific region is expected to register the fastest growth over this period (CAGR of 7.5%), driven by increasing waste generation and government initiatives in China and India; and higher technology penetration in Japan.

Improving policy environment

In recent times, Government has placed increased importance on Captive Power Plant. The opportunity for captive power plant emerged after the enforcement of the Electricity Act 2003 in the form of delicensing of power generation, implementation of open access and setting up of a common trading platform, having made captive power plants an attractive option for industries to meet their in-house power requirement and to maximise their profits from the sale of surplus power.

Case Studies of various applications of Steam Turbines:

Sugar Industry | The bagasse available after crushing of sugarcane is of little value to Sugar Mills. This bagasse is fired in boilers to raise steam. The steam raised, can then be fed to the turbines for generation of power and extract taken from the turbine can be used for the various processes in sugar manufacturing. The co-generation plants offers advantage of generating power required for operating the plant during the peak season. In off-season the power generated can be sold to the grid. This improves profitability, guards against cyclical nature of sugar business and reduces carbon foot print.

Biomass Independent Power Producers | Biomass most often refers to plants or plant-derived materials like wood chips, rice husk, agricultural residue etc. Biomass derived energy holds the promise of reducing carbon dioxide emissions, a significant contributor to global warming. The Biomass is burned in a Boiler and the steam is fed to turbines for power generation.

Chemical and Pharmaceutical industries | In certain processes (such as in chemical product drying), it is possible to integrate a steam turbine into the process with the associated electricity being used to power the plant.

Distilleries | Distilleries can be highly polluting as 88% of their raw materials result in waste, which is discharged into fields and water bodies. Spent wash is one of the polluting by products of the distilling process in molasses based plants. This brownish liquid waste is spewed out in large quantities and can be used to generate steam for producing power.

Pulp and Paper |Black Liquor is a by-product in the manufacturing process of Pulp. This black liquor derived through a chemical recovery process is fed into boiler to generate steam for running a steam turbine.

Municipal Solid Waste | Municipal solid waste (MSW), often called garbage, is used to produce energy at waste-to-energy plants. This MSW is burned to make steam for generating electricity.

Unifi's Strategy in Green Fund

A holistic approach to address the problem of environmental pollution and global warming will have significant implications for quite a few listed stocks. Non-conventional sources of generating power by either using a by-product or heat generated in a process or waste is expected gain significant traction in both domestic as well as international markets. Though the domestic industry is passing through a period of slow private capex cycle, we expect revival driven by increased capex spending by cyclical sectors like sugar, paper, metal industry and increased demand in export market. A combination of these factors will give fillip to increased demand for industrial steam turbines and we expect turbine manufacturers to benefit from this.

Unifi Green Fund has an investment in India's largest industrial steam turbine manufacturer, Triveni Turbine. An investment in a single share of Triveni Turbine, results in total CO_2 emission savings of 216 Kg per annum. For instance, a Rs.10 Lakh investment in Triveni Turbine will equal to CO_2 emission savings of 1658 tons per annum. This is equivalent to saving CO_2 emissions from 303 diesel buses or 22,711 cars per annum. Detailed calculations are shown in the following annexure.

Annexure:

The below table computes amount of CO_2 emission saved per annum by each share held in Triveni Turbine-

Company : Triveni Turbine	Calculation	Comments
Emission from Steam Turbine		
Cumulative Installed Capacity(in MW)	12,000	*Cumulative installed capacity by Triveni Turbine is 12000 MW*
Amount of Steel required for manufacturing 1 MW of Industrial Turbine (A) - (in Tons/MW)	139	
Approximate amount of Steel required for other parts like Boiler, Piping, Valves and other Auxiliaries & Systems. (in Tons/MW) (B)	74	*Based on Data for a Captive Power Plants*
Carbon Dioxide Emitted from manufacturing 1 MW Steam turbine Setup (in kgs) (C)	4,26,516	*1 Ton of Steel Manufacturing Emits 2 Tonne of CO2*
Total CO2 emission from Triveni Turbine Installed Capacity (in mn kgs) D = (A+B)*C	5,118	
CO2 Emission per Year from installed capacity - D = D/20 (in Mn Kgs)	**256**	***Assuming Life of a Steam turbine is 20 years; the total emission(C) is divided by 20 to calculate emission per year.***
Emission from Coal based thermal Power Plant		
No. of units generated from Triveni Turbine Installed Capacity (in Million KWh) (E)	73,584	
CO2 emitted (in Kgs) per KWh from coal based thermal power plant (F)	0.97	*CO2 emission per KWh = 0.97 kgs*
Total CO2 emission from coal based thermal power plant (in mn kgs) G = (E * F)	**71,376**	
Net CO2 emission saved (mn kgs) (G minus D)	71,121	
No. of shares of Triveni Turbine (in Million)	330	
CO2 emission saved (kg/share)	**216**	

Note: *The calculation for CO2 emission savings from using an Industrial Steam Turbine has been verified by an expert - Mr. Veerachamy Subramaniam. (Brief profile shared below).*

Assumption: The above calculation assumes source of Raw Material for Steam Turbine is Biomass. As the amount of CO_2 emitted while burning Biomass is equivalent to consumption of CO_2 during its growth, it is assumed to be carbon neutral.

<u>Brief Profile of Mr. Veerachamy Subramaniam:</u>

Mr. Veerachamy Subramaniam is currently a consultant to Tata Power - Trombay for steam turbines and for overall power plant activities. He has more than 4 decades of experience in design, engineering and commissioning of steam turbines, boilers and Power Plants. His past experience include about two decades in BHEL, a decade in Siemens and later in Cethar Energy.