Comparative Study of Sustainability of "Community Boiler" and "Individual Boiler" in Small Scale Industries: A Case Study from Gujarat India

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Abstract— If the concept of Community Boiler is to be enforced through policy, it is required to establish its positive impacts objectively through study and research. Going through literature study and study material available on the internet, it is felt that in depth study / research considering Indian industrial conditions have not been conducted so far on the subject and there is need to carry out such study. The objective of this study is to compare the sustainability of "community boiler" and "individual boiler" in small scale industries in the state of Gujarat. Outcome of the study will be analysed and if found that the community boiler is a useful tool to control industrial air pollution control, it can be adopted through framing necessary policy on the subject. A representative case study of community boiler at Sachin, Surat has been considered for the same.

Keywords: Community boiler, Individual Boiler, Sachin Industry

I. Introduction

The concept of the community boiler is very common in the developed industrialized countries. In this concept, relatively large sized boiler located at strategic location caters steam through pipeline to the nearby industrial units eliminating their requirement to install small industrial boilers. This concept is not very common in the country like India. Gujarat being one of the most industrialized states in the country needs to adopt this concept which has many benefits.

Gujarat is the pioneer state to adopt and nurture the concept of common effluent treatment plant (CETP) for industrial wastewater treatment. CETPs treat the industrial effluent being generated from the individual industry (mostly the small scale industries) and eliminate the burden of the treatment of industrial effluent on individual industry. This has helped in the reduction in industrial water pollution and facilitated better monitoring and control.

Likewise, the community boiler if adopted in the Gujarat has great potential to reduce industrial air pollution.
Though benefits of community boiler over individual small industrial boilers are obvious and apparent, there was no attempt made so far to record it in systemic and scientific way through study.

Agarwal and Suhane, (2017)mentioned that**,** the paper is related to the study of boiler maintenance and deals with the possible causes responsible for the breakdown of the boiler and the potential impacts of such breakdown that could occur in the system of which boiler is a part. Various measures that could be taken to reduce such breakdown have been suggested. The various components of boilers including the material used for its construction, the probable causes of material failure, the suitability of materials based on different parameters like pressure, temperature and various operating conditions have been discussed. The importance of boiler aging factor together with other related factors like financial factor, service history has also been considered to take decisions related to repair and replacement of the boiler

This paper showcase. Excellent case of EPOD. In which changes made in existing environment audit scheme of board where rigorously studied and suitable changes are suggested in the existing system.

Barma et al. (2017) suggested that, the boiler is a widely used steam generating system in industries and power plants. A significant portion of the world energy consumption is being used in boilers. A small improvement on the boiler efficiency will help to save a large amount of fossil fuels and to reduce CO_2 emission. This study describes the amount of energy used in boilers, ways employed to evaluate their energy efficiency, losses occurred and their causes, ways of waste heat recovery and minimizing heat loss using technologies, role of maintenance activities, and technical education to make people aware of the energy usage. The efficiency of the boiler can be improved by doing scheduled maintenance work, which helps to run a boiler at its highest efficiency. In order to create awareness about energy use, education programs and seminars need to be arranged on regular basis for the staff involved.

Li et al. (2016) discribed that Steam boilers are one of the most important components for steam and electricity production. The objective of this paper is to establish a theoretical framework for the sustainability analysis of a utility boiler. These analyses can be used by decision-makers to diagnose and optimize the sustainability of a utility boiler. Seven utility boiler systems are analyzed using energy and embodied solar energy (emergy) prin- ciples in order to evaluate their environmental efficiencies. Their relative environmental impacts were compared. The results show that the natural gas boiler has significantly lower CO_2 emission than an equivalent coal or oil fired boiler. The refuse derived fuel boiler has about the same CO_2 emissions as the natural gas boiler. The energy sustainability index of a utility boiler sys- tem is determined as the measure of its sustainability from an environnemental perspective.

II. Study Area

The study project is carried out in Sachin - GIDC (Gujarat Industrial Development Corporation). Sachin is an industrial cluster on the outskirt of the Surat city as shown in the map. Surat City is about 20 Km and Navsari is at about 30 Km. It was established in the year 1984. It has total area of 745 hectare. It houses about 2300 industries most of them are textile weaving (90%). It houses dyes and dyes intermediate (55 units), textile dyeing and printing (70 units), Engineering (95 units) and other types of industries. It has Common Effluent Treatment Plant of 50 MLD capacity for the textile-dyeing and printing units and another CETP for chemical units of (0.5 MLD). Community Boiler is also important common environment infrastructure of the GIDC for which study is carried out.

Fig. 1 : Map of Sachin Industry

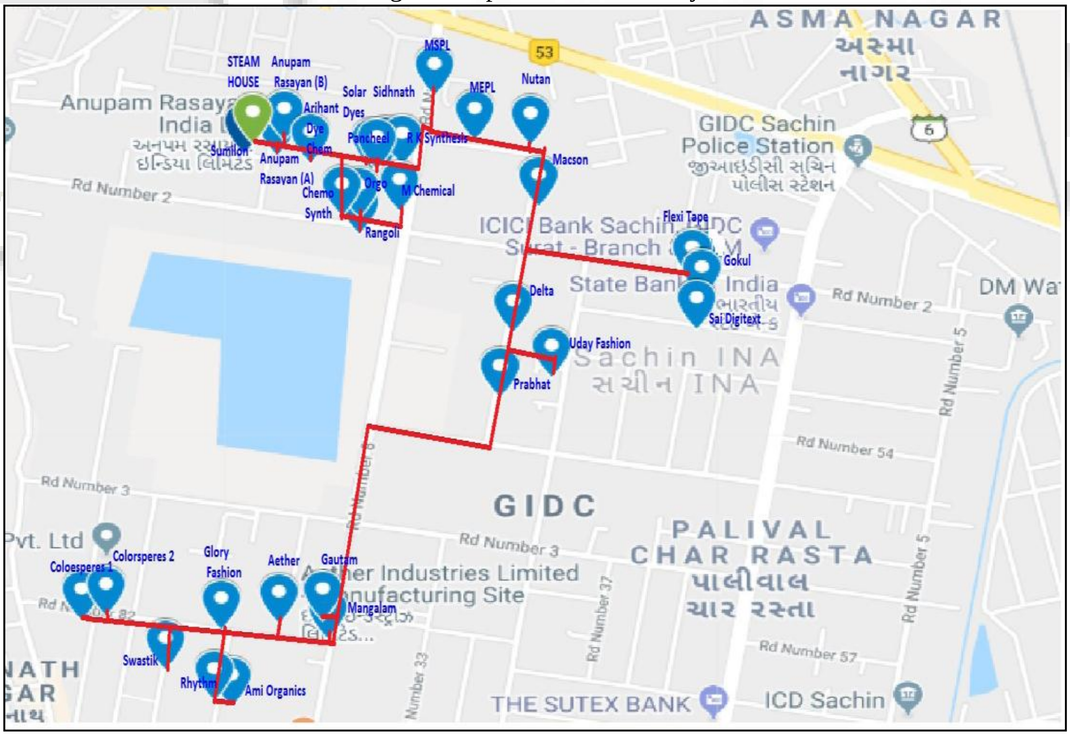

Fig. 2 : Map showing the location of the member units:

III. METHODOLOGY OF THE STUDY

- Analysis of the tangible benefits of community boiler over individual small boiler through comparative study of Sachin, Surat, community boiler example.
- Analysis of the intangible benefits of community boiler through comparative study of community boiler vis-a-vis individual small industrial boiler.
- Preparation of index like Pollution Index and Environment Index for comparative analysis and give objectivity to intangible benefits.

A. Methodology Followed:

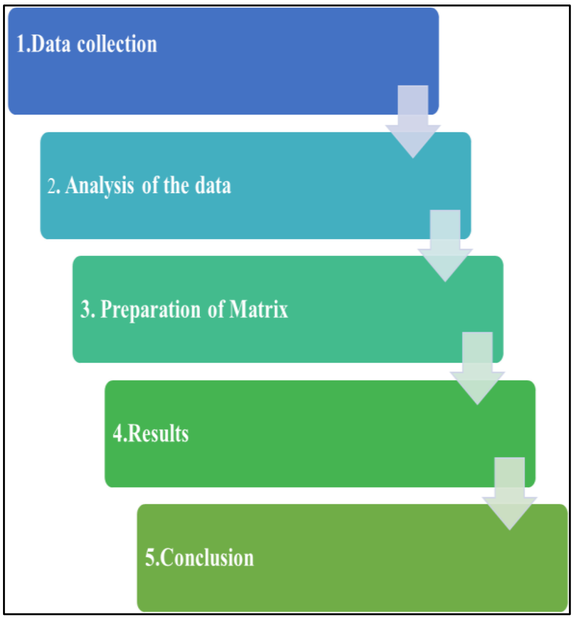

Fig. 3: Stepwise procedure for current research work

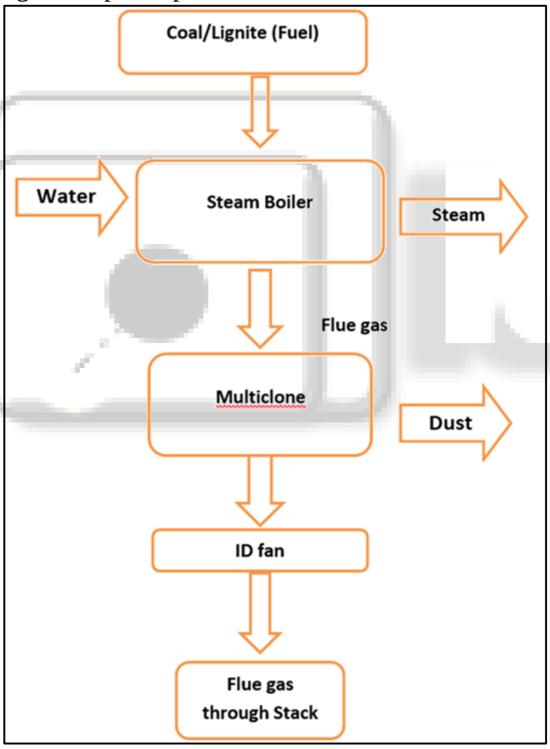

Fig. 4: Schematic flow chart of small industrial steam boiler operation in small scale industry

IV. Results and Discussion

Sample calculation for the individual boiler based on the steam generation capacity:

Coal Consumption Calculation for the Steam Boiler		
Input	Quantity	Unit
Give Steam Generating Capacity in kg/hr	600	kg/hr
Specific Enthalpy of Steam	664.5	kcal/kg
Specific Enthalpy of Water	70	kcal/kg
Efficiency of Boiler	0.65	
NCV of Coal (Fuel)	3500	kcal/kg
Fuel Consumption	124.89	kg/hr
	3.0	MT/day

Coal consumption is calculated based on the formula:

$$\text{Coal consumption} = \frac{\text{Steam generation capacity} * (\text{Specific Enthalpy of steam} - \text{Specific Enthalpy of water})}{\text{Efficiency of boiler} * \text{NCV of fuel}}$$

$$\text{Coal consumption} = \frac{600 * (664.5 - 70)}{0.65 * 3500}$$

Coal consumption= 124.89 Kg/hr

Coal consumption= 3 t/hr.

Similarly, the coal consumption of the each of the boiler was calculated and it was compared with the industry's actual consumption. The coal consumption calculated through above was found to be conservative by 10-15% of the actual value. Considering above the coal consumption of the individual unit is summarized as below.

SR. NO.	NAME OF UNIT	STEAM GENERATION CAPACITY OF BOILER	FUEL OF THE BOILER	QUANTITY OF FUEL USED (Mt/day)
1	SIDHDHANA INDUSTRIES	600 kg/hr	COAL / Lignite	3
2	R. .SYNTH LIMITED	500 Kg/hr	COAL / Lignite	2.5
3	PANCH INTERMEDIATES	500 Kg/hr	COAL / Lignite	2.5
4	ARIHANT CHEM	300 Kg/hr	COAL / Lignite	1.5
5	M/S ANUPAM LTD. U-1, PART-A	2TPH	COAL / Lignite	6
6	M/S RASAYAN LTD.	8 TPH	GAS - PNG	-
7	MANGAL Chemicals	600 kg/hr	COAL / Lignite	3

SR. NO.	NAME OF UNIT	STEAM GENERATION CAPACITY OF BOILER	FUEL OF THE BOILER	QUANTITY OF FUEL USED (Mt/day)
8	NUAN CHEM	1000 kg/hr	COAL / Lignite	5
9	SUMIT LIMITED	600 kg/hr	COAL / Lignite	3
10	SYNTH CHEMICAL INDUSTRIES	500 kg/hr	COAL / Lignite	2.5
11	SOLA DYES INDUSTRIES	400 kg/hr	COAL / Lignite	2
12	SHANKER CHEMICALS	500 kg/hr	COAL / Lignite	2.5
13	RANG TEXTURISERS PVT. LTD.	400 kg/hr	COAL / Lignite	2

Table 1: Details of Coal Consumption of the Individual Units in the Study Area.

Total coal consumption of all units: 36Mt/day
Plus Gas consumption by one unit.
Coal consumption of the Community boiler- 30 Mt/day
Saving in coal consumption- 06 Mt/day

A. Impact on Ambient Air quality of Community boiler project:

Ambient air quality modeling (Lakes Environ Model) was carried out for two sets of data:

1) Individual boiler stack- flue gas emission impact on ambient air quality
2) Community Boiler Stack- flue gas emission impact on ambient air quality.

The study was carried out for PM_{10}, SO_2, NO_x Parameters. The Back ground weather conditions were kept same during both run of the model so as to nullify the external impact and to calculate actual impact of community boiler in lieu of individual boiler. The results indicate that the significant reduction in the pollutants PM_{10}, SO_2, NO_x are observed in the model study.

Station Code	Sampling Location	Approx. Aerial distance from project site, km with Direction	GPS Locations	Type of Area	Upwind or downwind w.r.t predominant wind direction
AQ-1.	Project Site	0.00	285493.00 m E, 2252441.00 m N	I	--
AQ-2.	Location1	1.93 SW	284023.00 m E, 2251120.00 m N	R	Downwind
AQ-3.	Location 2	2.29 NE	286276.00 m E, 2254554.00 m N	R	Upwind
AQ-4.	Location 3	1.06 SE	286338.00 m E, 2251778.00 m N	R	Crosswind
AQ-5.	Location 4i	2.68 NW	283492.00 m E, 2254197.00 m N	R	Crosswind

Table 2: Details of locations considered for air modeling

Note: I- Industrial, R- Residential

Parameter	Particular	Highest Incr. GLC	AQ 1	AQ 2	AQ 3	AQ 4	AQ 5
PM10 μg/m3	Highest Incr. GLC 24 hr for individual boilers	14.08	14.08	3.69	1.30	2.89	2.83
	Highest Incr. GLC 24 hr for single boiler	3.61	3.40	0.92	0.52	1.01	0.44
SO_2 μg/m3	Highest Incr. GLC 24 hr for individual boilers	37.48	37.48	9.80	3.45	7.67	7.52
	Highest Incr. GLC 24 hr for single boiler	9.62	9.08	2.44	1.39	2.69	1.18
Nox μg/m3	Highest Incr. GLC 24 hr for individual boilers	13.90	13.90	3.93	1.42	3.19	2.97
	Highest Incr. GLC 24 hr for single boiler	2.77	2.62	0.70	0.40	0.78	0.34

Table 3: Result Summary

Note:-Pm, SOX, NO single boiler highest value coordinate- X:285553.3, y: 2252517, for other AQ1 is the highest value

B. Interpretation

In this project we have considered 13 nos of small capacity boilers against one community boiler (10 T) to study the difference between the emission levels. As per air modeling result, the PM and Sox level is reduced 74 % and NOx level reduced up to 80% in community boiler as compared to individual boilers.

Sr. No.	Parameter	Reduction in Percentage in ambient air quality (GLC_{max})
1	PM_{10}	74%
2	SO_2	74%
3	NO_X	80%

Table 4: Reduction in pollution in ambient air

C. Reduction in Wastewater Generation (Boiler Blow down):

Apart from this, the use of community boiler will also reduce the water requirement and wastewater generation from blow-down, the anticipated blow-down wastewater from individual boilers is 16 KLD as 24hr operation, and in community boiler the expected blow-down wastewater will be 9 KLD that's 40 % of reduction. Hence use of community boiler more feasible than use of many numbers of small capacity boilers.

D. Space Saving at Individual Industry Level:

Cumulative Space required by individual unit for boiler installation- 570 sqm
Cumulative Space required by individual unit for coal storage-170 sq m
Total area required- 740 Sqm
Area required by community boiler- 600 Sqm
Space saving =18%

E. Fly Ash Management and Savings:

Cumulative Total Coal / Lignite consumption by individual boiler: 36 Mt/day
Conservative figure of 20% of ash content (Most of them are using Lignite in which ash content is found as high as 30%) - 7.2 Mt/day
Coal Consumption of the Community boiler-30 Mt/day
As the high grade bituminous coal is used, the ash content is as low as 5% of the coal:
Fly ash generation in the community boiler-1.5 Mt/day
Reduction in fly ash generation in %-80% reduction.
About 2000 Mt / Annum less generation of fly ash due to community boiler project

F. Intangible benefits of the project

– It would be very effective for regulator like Gujarat Pollution Control Board to effectively monitor and control pollution at a single location rather than at multiple locations
– effective control of emissions on account of professional management of project
– growth of industries and thereby economy of the country
– reducing health impacts resulting from air pollution
– protecting the environment by the prevention and control of the air pollution
– Space saving of the boiler installation at individual industry level.
– Space saving of the coal / solid fuel storage at individual industry level
– No need of man power (boiler attendant, boiler supervisor, labour for boiler operation at individual industry level
– Less risk of closure from GPCB at individual industry level
– Better housekeeping and work zone air quality due to no boiler related activity.

Parameters	Present Boilers	Community Boiler
APCM as per GPCB	– MDC + Bag Filter + Water Scrubber* (in case of lignite)	– ESP (5 field)
Running Cost	– Regular replacement of bags and high cost of lime and water pumping in case of scrubbers – Also fast spoiling of chimney and other metal parts	– Moderate maintenance and low power consumption
Side Effects	– Water scrubbers have already started adding to issues of water pollution as small industries are not able to handle the water properly	– No side effects
Accuracy	– Bag filters if not periodically checked loose bags, and start pollution – Scrubbers are tough to manage instruments and Small industries are facing trouble maintaining	– Not much recurring parts, no water usage, maintained by professionals
Fuel	– Wood – Imported Coal – Lignite (high sulphur) etc. (cases of illegal fuel are also frequent) – Further industries have no mechanism to check in coming fuel	– Imported Coal, (very low sulphur content) – Monitoring & Testing Mechanism

Table 5: Comparison of various parameters of present individual industrial unit boiler with community boiler

G. Impact of Community Boiler over Individual boiler:

1) Efficiency

Presently individual small capacity boilers are operating at low efficiency to meet steam demand of their operating industry Community steam boiler shall be operating above 82% efficiency and reduce fuel consumption compared to cumulative fuel consumption by various industries. Also, on flow of steam from back pressure steam turbine, power will get generated without burning of additional fuel. Operation of combined cycle co-generation plant will improve fuel efficiency.

2) Health

Burning of fuel generate ash, carbon dioxide, carbon monoxide etc. which normally is disposed in the atmosphere. Small scale industries boiler's operate at poor efficiency and don't have adequate pollution control equipment. In these boilers high CO2 along with coal and ash particles get discharged in the atmosphere. On installation of most modern technology based high efficiency boilers equipped with latest pollution control equipment, generation and disposal of coal/ ash, CO_2 to atmosphere will be substantially less compared to the cumulative disposal by multiple small boilers. With this air quality will improve for the mankind Also, avoidance of fuel storage at multiple location, will improve cleanliness in that industry.

3) Fire & Safety

Presently in the industries where small capacity boilers are under operation, inadequate fire and safety protection system are there. On completion of this project and supply of steam to the industries, their boiler will stop and the fuel needs to be stored in their premises. This will enhance the safety in their premises to the property as well as the operating manpower.

4) Forex Exchange Loss:

The project would result into substantial saving in consumption of coal by the GIDC-Sachin cluster of industries as a whole. That would result into reduction in import bill of coal to the tune of Rs.1890 Lakh in a year at current prices.

5) Impact of Project -Environment

Concept of installation of a community boiler and distribution of steam to various small consumers conceived to minimise air pollution in Sachin GIDC, On completion of the project and commission of all systems, ambient air quality will improve substantially Present ambient air quality data is placed at annexure Also heat dissipation from boilers in the form of flue gas will get minimised on stoppage of small boilers and operation of community boiler. Moreover, efficient operation of boiler will reduce carbon emission to the atmosphere.

V. Conclusion

By the data collection and analysis, it is clearly coming out that community boiler has significant positive impact on pollution prevention and environmental protection through (1) Reduction in resource consumption like fuel-coal by 16%, (2) Reduction in pollutant like PM,SO_2, NOx by 70-80%, (3) Reduction in fly ash generation to 60-80%, (4) Reduction in waste water generation by 40%.

In addition to above, Intangible benefits are (1) Space saving by 18 %, (2)

Enhancement in productivity by 5%, (3) Reduction in fugitive emission, (4) Reduction in cost of production of steam by 33%, (5) Enhance safety due to the absence of boiler, (6) Improved housekeeping, (7) Savings in foreign exchange (our most of the fuel being imported)

By the Evidence for Policy Design (EPoD) concept, we can conclude that,

1) In any industrial cluster which has potential of more than 10 boilers (small industrial boilers) GPCB should meditate through policy to have one community boiler in place to which all this industry has to be either its member or to install their own boiler having only cleaner fuel like gas/clean liquid fuels.
2) The above case study is an example of community boiler only catering steam (without power generation). In case steam distribution is done along with co-generation of power, the economic viability will be still better and such projects will have further green impacts.

VI. Declaration

A. Authors Contribution

All the authors make a substantial contribution to this manuscript. DT, and DS participated in drafting the manuscript. DT wrote the main manuscript; all the authors discussed the results and implication on the manuscript at all stages.

B. Acknowledgements

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C. Availability of data and material

All relevant data and material are presented in the main paper.

D. Competing interests

The authors declare that they have no competing interests.

E. Funding

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F. Consent for publication

Not applicable.

G. Ethics approval and consent to participate

Not applicable.

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