Overview and Recent Scenario of Biomass Gasifier Plants in Tamilnadu—A Field Survey

M. Mohamed Iqbal, Kashif Ahmed, and Nazia Fathima

Abstract Biomass has been the traditional source of energy for many decades in rural electrification. This paper presents a detailed report of a field survey on biomass plants in Tamilnadu, India along with Global and Indian Renewable Energy statistics. In this field survey, a total of 84 biomass plants have been visited and analyzed their status based on installation capacity, installation cost, type of fuel source used, fuel availability, day schedule and annual schedule, ownership details and working status. Wood waste was identified as the major source of fuel in most of the plants, followed by sago wastewater, cow dung, night soil and poultry litter. The availability of fuel in almost 50% of the plants has been found to be inadequate. Majority of the plants which are owned by the local panchayaths have been found to be non-functional. The main reasons for the failure of these plants have also been reported in this paper. Further, remedial measures to overcome the failure of these plants are also furnished to satisfy future energy needs.

Keywords Biomass gasifier plants · Field survey · Installation status · Operational status · Remedies for operational failure · Renewable energy scenario

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1 Introduction

For socio-economic development of any nation, energy is considered to be one of the indispensable block. The resources produced from fossil fuels such as coal, oil, gas etc., are expected to get exhausted by another 100–130 years [1]. This has led to the birth of alternative and sustainable energy sources such as solar, wind, biomass, tidal, etc. Utilization of these sources will prevent the rising emission of greenhouse gases which are the biggest cause of global warming [2, 3]. About 18.2% of total final energy consumption was from renewables, out of which 10.4% came from traditional biomass by the year 2016. It was used mainly for heating applications. Furthermore, the hydroelectricity contributes 3.7% and rest 4.1% from the renewable sources [4]. By the end of 2017, India had completed over 500 biomass power and cogeneration projects [5]. India, being the country with more bioenergy potential of 25 GW, a cumulative installed capacity was about 8.9 GW as on 30 September 2018 [5]. It includes the power generation from biomass power/cogeneration as 8730.8 MW and wastes to energy as 138.3 MW [6].

As energy production from biomass costs less compared with other sources, it is more suitable for villagers who are mostly dependent on agriculture, forestry and fishing to meet their needs [7]. The cost of power generation through biomass is said to be in the range from Rs. 3.25 to Rs. 3.75 for every kWh, which is cheaper than solar PV costing Rs. 7–8 per kWh [8–10]. About 32% of the total primary energy consumption in India is derived from biomass which accounts for nearly 75% of rural energy needs as the rural population constitutes 70% of the total population of India [11, 12]. With a production of about 450–500 million tons of biomass power per year, India can generate more quality power from biomass using the presently available energy conversion techniques [13].

Since, biomass was seen as a major contributor in renewable power generation, many research works were carried out on modelling, control and analysis of biomass-based gas turbine power plants [14–18]. As Tamilnadu has been a pioneer in Renewable Energy (RE) based power generation in India, a sample survey was conducted based on various aspects by visiting 84 biomass plants in different regions of the state. The complete details of the plants visited and their installation and operational status are reported in this paper.

Chapter 2 of the paper describes the global and Indian renewable scenario. The installation and operational status of the biomass plants in Tamilnadu are furnished in Chap. 3. Chapter 4 highlights various reasons for the operational failures of the biomass plants along with remedies followed by the conclusion in Chap. 5.

2 Renewable Energy Scenario Worldwide and India

2.1 Global RE Scenario

In this section, worldwide RE scenario in terms of the status of fossil fuel, RE potential, availability of biomass energy and RE consumption are presented. International Renewable Energy Agency (IRENA), reported that the usage of fossil fuel for energy would fall to one-third of today's levels by the year 2050. It is also highlighted that the oil and coal consumption for energy will reduce to 70 and 85% respectively. Natural gas usage is expected to be the largest source of fossil fuel by 2050 [19].

The world energy council (London, UK) highlighted that 30–80% of worldwide energy demand would be met by RE sources by 2100 [20]. Currently, the worldwide net power generation capacity from RE sources is around 2179 GW. The RE power contribution by various parts of the world including Asia, Africa, Europe and America at the end of the year 2017 are furnished in Table 1 [21].

Further, the net bioenergy power generation capacity worldwide (in MW) from various biomass sources such as solid biofuels and renewable waste, bagasse, renewable municipal waste, other solid biofuels, liquid biofuels and biogas are presented by International Renewable Energy Agency (IRENA) [21]. It shows that the solid biofuels and renewable waste contributed more to biomass-based electricity generation. It is also reported that the share of renewable energy in Total Final Energy Consumption (TFEC) for different sectors would increase from 18% in 2015 to 65% in 2050 [19]. The report also witnesses that there is a vital contribution by renewable energy for electricity production followed by industry and building and transport. Being the country gifted with almost all renewable energy sources, the status of the renewable energy potential of India has been analyzed and furnished in Sect. 2.2.

Table 1 Net RE power generation capacity worldwide [21]

Location	Renewable energy (MW)	% Contribution
Asia (India)	918,655 (106,282)	35.00 (4.04)
Europe	512,348	19.52
European Union (EU)	445,496	16.97
North America	347,635	13.24
South America	202,120	7.70
Eurasia	96,326	3.67
Africa	42,139	1.60
Oceania	27,155	1.03
Middle East	18,920	0.72
Central America and Caribbean	13,801	0.52

2.2 Indian RE Scenario

Renewable energy potential of India is estimated to be around 900 GW. It includes the power generation in GW from wind, solar, bioenergy and small hydro as 102, 750, 25 and 20, respectively [22]. Based on the potential, the Government of India has increased the RE capacity target to be achieved in 2022 as 175 GW. It comprises of 100 GW from solar, 60 GW from wind, 10 GW from bioenergy and 5 GW from small hydro [22]. Total capacity of around 62.84 GW has been added by December 2017, which accounts for 18% of the cumulative capacity addition as shown in Fig. 1 [5]. The availability of biomass in India is estimated to be 500 million metric tonnes per year. Karnataka renewable energy development limited reported that the surplus biomass of about 120–150 million metric tonnes per annum is available. It covers agricultural and forestry residues potential equivalent to a capacity of about 18 GW [23].

Due to the technological development, modernization of the sugar mills and the power generation from bagasse cogeneration, an addition of 7 GW is estimated to be achieved from sugar mills [5, 23], Table 2 gives the state-wise installed capacity of grid-connected biomass/ bagasse power plants as on 31 December 2017 [5].

India has implemented a scheme named National Biogas and Manure Management Programme (NBMMP) during the year 2017–18 that aims to provide biogas plants as an asset for households for meeting their clean cooking fuel needs. It is planned in particular to rural/semi-urban households for raising farm yield and maintenance of soil health. Under this scheme, already 20,000 family type biogas plants have been installed up to December 2017. The estimated potential and cumulative achievements of the states having more than 1 lakh family type biogas plants till 31

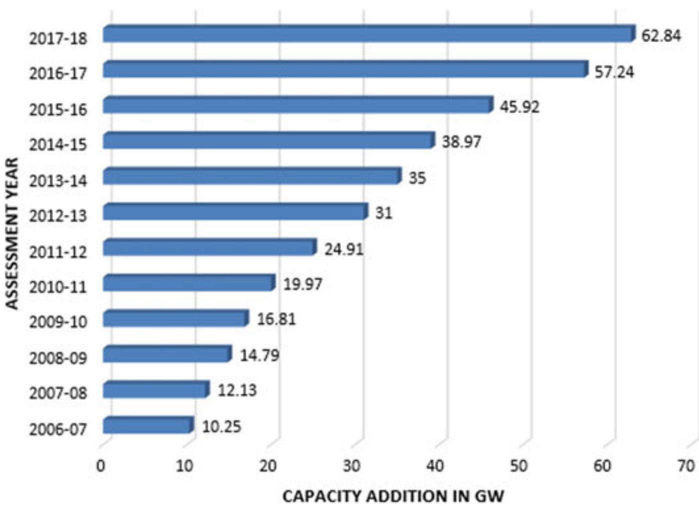

Fig. 1 Total installed renewable capacity in MW [5]

Table 2 State wise installed capacity of grid-connected biomass/bagasse power plants as on December 31, 2017 [5]

State	Total capacity (MW)	State	Total capacity as MW
Andhra Pradesh	378.2	Telangana	158.1
Bihar	113	Punjab	194
Chhattisgarh	228	Rajasthan	119.3
Gujarat	65.3	**Tamilnadu**	**893**
Haryana	121.4	Uttarakhand	73
Karnataka	1604.6	Uttar Pradesh	1957.5
Madhya Pradesh	93	West Bengal	300
Maharashtra	2065	Odisha	50.4
Total		12,081	

March 2017 has been presented in [5]. On analyzing these statistics, it is clear that only 40% of the estimated plants are achieved until March 2017. It is also witnessed that the targeted plants have not been achieved during 2017–18. Therefore, it has been proposed to analyze the status of biomass gasifier power plants in Tamilnadu through a detailed survey and the details are presented in Sect. 3.

3 Status of Biomass Plants in Tamilnadu

Biomass is considered to be a primary source of energy since the olden days. It was a traditional source used for heating applications [24–26]. In order to improve the renewable energy power generations, especially from biomass sources, an attempt has been made to analyze the installation and operational status of the biomass gasifier plants in Tamilnadu and the survey details are presented in this section.

3.1 Installation Status of the Plants

The survey is made on biomass plants, totally 84 plants from different regions in Tamilnadu which includes 29 plants from Coimbatore, 18 plants from Namakkal, 10 plants from Salem, 5 plants from Trichy, 7 plants from Chennai, 5 plants from Rasipuram and about 10 plants from other regions namely Hosur, Palani, Vellore, Madurai and Thenkasai. Various aspects of the plants such as installation capacity, installation cost, ownership details and working status of the plants have been analyzed in this section. The details of the plants visited and the capacity of all the plants in different regions are shown in Tables 3, 4 and 5. The field survey conveys

Table 3 Installation capacity of the plants from Coimbatore, Namakkal regions

Place name	Capacity (kVA)	Place name	Capacity (kVA)	Place name	Capacity (kVA)
Coimbatore Region				Namakkal Region	
Odanddhurai	9	Cheyur 1	10	Bommu Sago	100
Semmipalayam	9	Periyakotai	9	LSF Sago	150
Nellaithurai	10	Chiniampalayam	9	PN Sago	75
Vavipalayam	9	Kattoor	9	Mahalakshmi Sago	100
Marudur	10	Kadathur	10	Sri Lakshmi Enterprises Sago	250
Malimichamatti	9	Kanakampalayam	9	Ravi Poultry	62.5
Kalangal	9	Pungamuthur	9	Sri Lakshmi Sago	100
Karaipudur	10	Jaminkottai	9	Ilyaraja Sago	75
Kunnathur	9	Chikkarampalayam	9	Elango Sago	75
Kattampatti	9	Singanallur	10	KSF Sago	150
Chikkarampalayam	9	Kovilpalayam	9	SRG Sago	150
Boomalur	9	Kalipalayam	70	Radhakrishna Sago	150
Arumuthampalayam	9	Pettupudurpatti	133	MSL Sago	250
Arasur	9	Cheyur 2	10	LAC Sago	250
Saravanampatty	10			Prabu Sago	250
				Sri Venkateshwara Sago	250
				SVA Poultry	35
				Gemini Sago	75

that the following list of plants as shown in Table 6 are highly rated plants from various regions.

It is also observed from the survey that only two plants namely Amman Sago factory and Sri Velmurugan factory located in the Rasipuram region have a plant capacity of 380 kVA which is highly rated among all 84 plants. Out of 84 visited plants, 47 plants are owned by the private industries and the remaining 37 plants are owned by the panchayaths of that region. Apart from the Coimbatore region, all the other regions visited constitute the private-owned plants. Most of the plants which are located in the Coimbatore region are panchayath owned plants. The installation cost details of all the public-owned plants and some of the private-owned plants are collected and reported as shown in Fig. 2. Among the details obtained from 60 plants, it is observed that the majority of the plants owned by the panchayaths of that region are installed with the cost ranging from 1 to 5 lakhs. The remaining plants are with

Table 4 Installation capacity of the plants from Trichy, Rasipuram, Chennai regions

Place name	Capacity (kVA)	Place name	Capacity (kVA)	Place name	Capacity (kVA)
Trichy region		Rasipuram region		Chennai region	
Saraswathi KVK Foundation	5	Sri Velmurugan Dairy Farm	35	Sacred Heart College	5
Holy Cross Convent	5	Selvi Poultry Farm	17.5	Housing Board	5
Holy Cross Convent Branch	5	Amman Sago Factory	380	People For Animals	5
St James High Sec School	5	Sri Velmurugan Sago Factory	380	Gojan Engg College	5
Balaji Farms	5	SFS Health Centre	35	Chella Krishna Farm	5
				Anat Dairy Farm	5
				The Madras Pinjirapole	5

Table 5 Installation capacity of the plants from Salem and other regions

Place name	Capacity (kVA)	Place name	Capacity (kVA)
Salem region		Other regions	
Salem Corporation	5	Selvam Broilers Hosur	100
Tap Sago	100	Viswas Innovators Madurai	25
Panamarathupaty	5	Viswas Dairy Farm Madurai	35
Sankari	5	Mani Broilers Palani	15
Kalathur	5	Keelakarai Dairy Farm Ramnad	35
Ayodiatanam	5	Angel Garden Alangulam	17.5
Vembadithalam	5	Melagram Tenkasi Panchayat	5
Verampandy	5	Keelapayoor Tenkasi Panchayat	5
Salem Co-Op Sugar Mills	5	Parapatti Town Panchayat Vellore	5
Magudasavadi	5	Joy Ice Cream Vellore	5

Table 6 Installation capacity (kVA) of the plants from various regions

Name of the region	Name of the plant	Capacity (kVA)
Coimbatore	Pettupudurpatti	133
Namakkal	Sri Lakshmi Enterprises Sago, MSL Sago, LAC Sago. Prabu Sago and Sri Venkateshwara Sago	250
Salem	Tap Sago	100
Chennai	All the plants	5
Trichy	All the plants	5
Rasipuram	Amman Sago Factory Sri Velmurugan Sago Factory	380
Other regions	Selvam Broilers Hosur	100

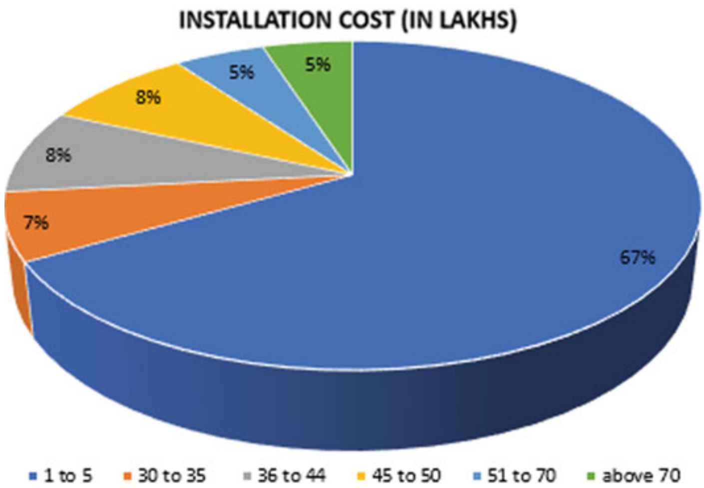

Fig. 2 Installation cost of the plants

the installation cost in the range of 30–70 lakhs with only three plants installed with more than 70 lakhs.

As far as the working status of the plants is concerned, 55 plants mostly owned by the private industries are in working condition and 29 plants which are owned by the public belong to the Coimbatore region are not in operation. For analyzing the reasons for the failure of the plants, an operational status of the plants are analyzed and presented in Sect. 3.2.

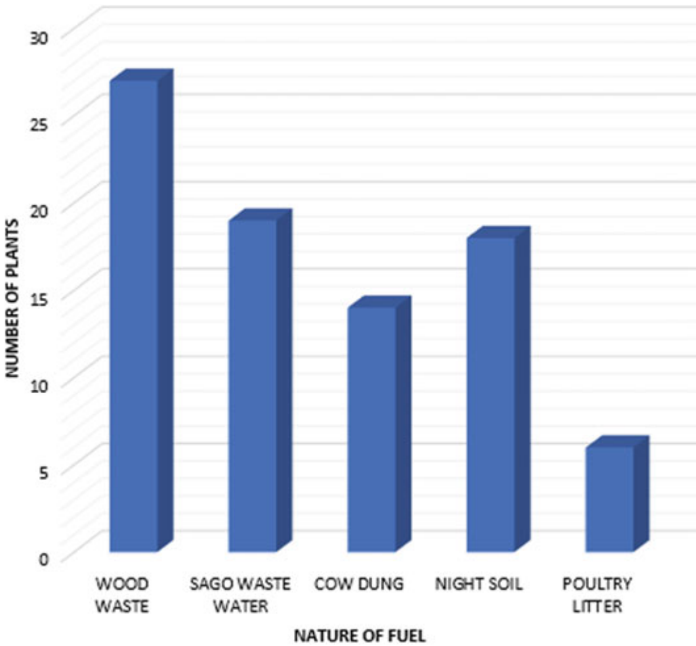

Fig. 3 Nature of fuel used in plants

3.2 Operational Status of the Plants

In this section, the operational status of the plants is analyzed based on the nature of the fuel used with the percentage of fuel consumption, availability of fuel, annual and day schedule of the plants and the application of the plants. The main source of fuel for the biomass gasifier power plants visited are identified and shown in Fig. 3 and the percentage of consumption of all these fuels by the plants are shown in Fig. 4.

It indicates that 32% of plants visited are fed with wood waste with others fuelled by sago wastewater, night soil, cow dung and poultry litter. The category of availability of fuel has been split into four namely excellent, good, average and shortage. Table 7 shows the number of plants and the category of fuel availability. It is observed from the survey that among the 84 plants visited, 11 plants from Coimbatore and Salem region are suffering from the shortage of fuel. Survey report conveys that 41 plants majorly from Namakkal and Coimbatore regions have sufficient biomass sources. In order to analyze the plant utilization, the operating schedule of all these plants have also been reviewed and presented.

The operating schedule of the plants is divided into day schedule and annual schedule and presented in Figs. 5 and 6 respectively. It is found from Fig. 5 that 56 plants out of 84 plants are operated 7–12 h a day irrespective of the fuel usage. About 18 plants are operated for less than 6 h a day which is mostly fuelled by cow dung and poultry litter. Only 10 plants are operated for more than 12 h a day which is mostly

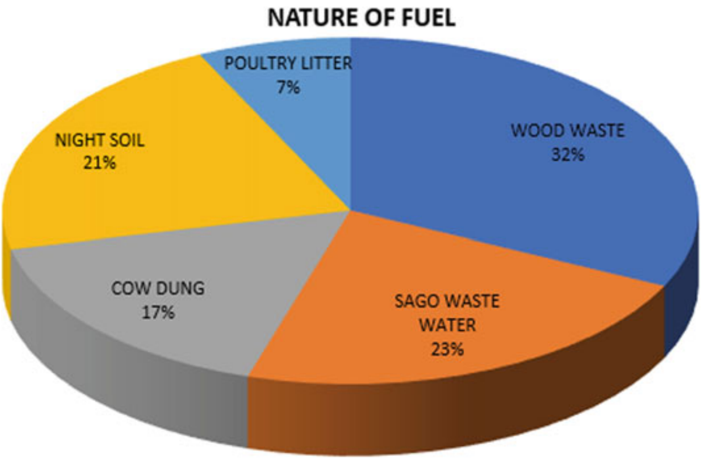

Fig. 4 Percentage consumption of fuel in plants

Table 7 Status of the availability of fuel

Category of availability of fuel	No. of plants (region vise)							Total plants
	Coimbatore	Namakkal	Salem	Chennai	Rasipuram	Trichy	Others	
Excellent	9	11	1	6	3	3	8	41
Good	11	7	1	1	2	0	2	24
Average	5	0	1	0	0	2	0	8
Shortage	4	0	7	0	0	0	0	11

the plants with wood waste as its fuel. It is found from the annual schedule of the plants that 11 plants from Coimbatore region, four plants from Chennai region with night soil as the fuel and seven plants from other regions are scheduled to operate for 10–12 months a year and the remaining plants are operated for 1–9 months a year only as shown in Fig. 6. It also witnesses that the plants fuelled by wood waste could be operated for a long duration.

Field survey states that the power generated by all the biomass plants is utilized for various applications depending upon the location of the plant. Power generated by most of the plants, i.e. about 38 of 84 plants is used for lighting purposes. Of the remaining plants, 27 plants are used for irrigation purposes especially in driving the well motors and booster motors. The remaining 19 plants which are located in the industry itself are utilized for industrial purposes. In the next section, the reason for the failure of the plants has been analyzed and the remedies are also suggested.

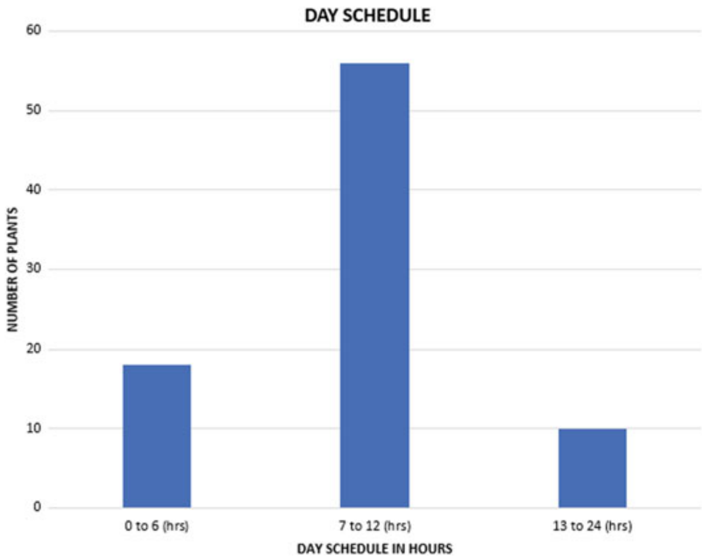

Fig. 5 Day schedule of the plants

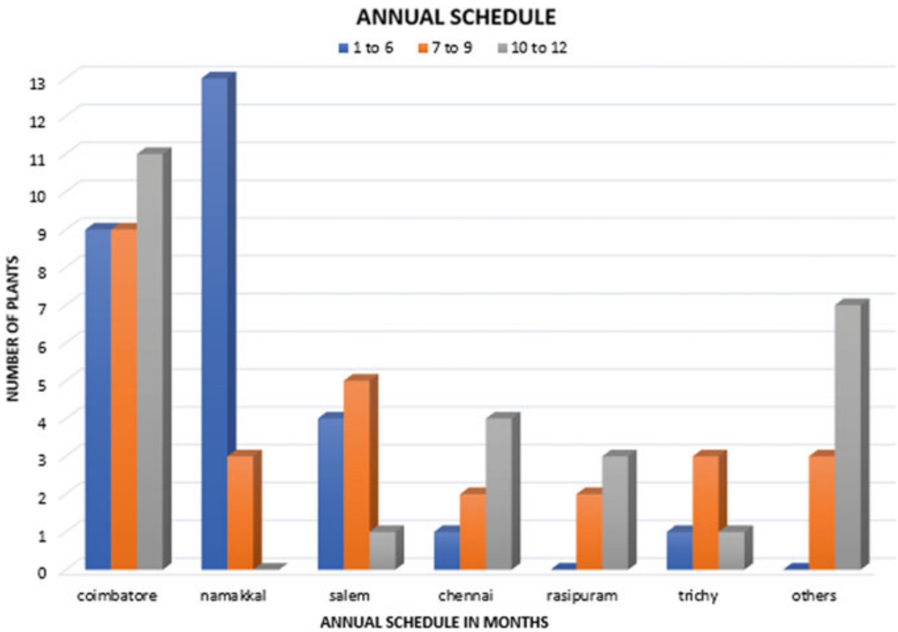

Fig. 6 Annual schedule of the plants

4 Causes and Remedies for Operational Failure

As mentioned in Chap. 3.1, around 35% of the visited plants which are owned by the public are not in operation. The reason for the failure of the plants is also critically analyzed by meeting the local authorities personally. The main reasons for the non-operating condition are found to be Poor wages, Lack of awareness, Lack of monitoring and control, Fuel shortage, Cost of Raw material, Lack of Technical Staff and Use of Low-Efficiency plants. Based on the survey and the discussion with the local authorities in the region, some of the suggestions for overcoming the failure of the plants are listed in Table 8.

The global and Indian statistics as presented in this paper on the availability of renewable energy sources witnessed huge potential for power generation. In large-scale grid-connected biomass generation, there would be a severe instability problem caused due to load disturbance and setpoint variations. Field survey report presented in this paper highlights that biomass sources will be a viable option to ensure reliable energy to utilities. By implementing proper control strategies and the remedial measures suggested, in this paper, the inevitable shutdown of the biomass plants can be avoided.

Table 8 Reasons for the failures and its remedies

Reasons for the failure	Remedies
Fuel shortage	• Along with wood waste, rice husk, cow dung, coconut shell, human waste can also be used as a fuel • Feedstock processing units can be set up near the plants based on the type of fuel
Lack of technical staff	• Workers have to be trained for the technical faults through technical interaction with experts • Service centre with skilled workers should be set up at different regions to improve the working status of the plants
Use of low-efficiency plants	• By optimal tuning of the controllers like Speedtronic Governor in the plants, efficiency of the plants can be improved
Cost of raw material	• The government may provide some concession in the fuel cost for biomass gasifier plants
Poor wages	• The wages for the workers of biomass plants should be increased
Lack of awareness	• The awareness about the biomass sources and their benefits should be created among the people
Lack of monitoring and control	• The government may take steps to implement a new cell to monitor the status of the plants all over the region • Proper control arrangements can be selected based on the status of the plants

5 Conclusion

A detailed report of the sample field survey has been presented by analyzing the installation and operational status of the biomass plants from different parts of Tamilnadu. The installation cost of the majority of the plants is found to be in the range of 1–5 lakhs. The main source of fuel for biomass power plants is found to be wood waste. The availability of fuel in almost 50% of the plants are found to be inadequate. The plants from Coimbatore and Salem fall short of fuel availability. The day schedule and annual schedule of all the plants are also surveyed and reported that only 10 plants, mostly the plants with wood waste as its fuel, are operated for more than 12 h a day, remaining fall less than 12 h a day. As far as the annual schedule is concerned, only 11 plants specifically from Coimbatore are found operating for 10–12 months a year. It is also observed that 38 of 84 visited plants are utilized for lighting purposes, 27 plants for irrigation purposes and the remaining 19 plants for industrial purposes. Then, the functionality of the plants is also surveyed and found that the plants which are mostly owned by the private industry are functioning well than the plants maintained by public panchayaths. The main reasons for the failure of the plants are identified and the remedies are also furnished. Adoption of suitable control techniques and proper monitoring of plants by trained technical staff are the major steps to improve the operational status of the biomass plants.

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