

# Optimization of fuel mix of waste to energy plant using Genetic Algorithm.

*A Thesis submitted in partial fulfillment of the  
Requirements for the award of degree of*

**Master of Engineering**

**in**

**Power System and Electric Drives**



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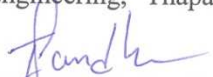
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## DECLARATION

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I hereby certify that the work which is being presented in thesis entitled “**Optimization of fuel mix of waste to energy using Genetic Algorithm** ” in partial fulfillment of ward of degree of **Master of Engineering in Power System and Electric Drives** submitted in Electrical and instrumentation Engineering department, Thapar University, Patiala is an authentic record of my own work carried under the supervision **Mrs. Suman Bhullar**, Assistant Professor and **Ms. Manvir Kaur** , Lecturer, Department of Electrical and Instrument Engineering, Thapar University Patiala, Punjab

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I certify that the above statement made by student is correct to the best of my knowledge and belief.

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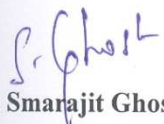
  
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Tejinder Singh Sandhu

## **Abstract**

Growing population and industrialization results in continuous demand of power. Fossils fuels are major sources of generating power but they have been exploited to maximum extent so we have to think about alternate sources of power. Producing energy from waste is the new frontier for this problem. The use of this technology helps us to tackle two most important problems of present industrialization age civilization i.e. pollution and power demand at the same time. In this thesis various waste to energy technologies are discussed but main focus is on optimization of the fuel mix using optimization technique i.e. genetic algorithm. Genetic algorithm is a optimization technique which results out best fit answer or solution from a set of available values. In this thesis various combination of fuels are optimized to maximize the calorific value and minimize the cost of the fuel. Using programming in matlab final results are achieved.

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## CHAPTER 1

### INTRODUCTION

## **1.1 NEED OF ENERGY**

Energy, particularly in its electrical form, has become virtually the backbone of human activities. Undoubtedly, it is one of the most vital inputs to every sector. In fact, there is no field of human activity where we can imagine without electricity. But, with a growing population and industrialization, the gap between the available electric power and its demand is growing day by day. Fossil fuels are the main source of energy nowadays, is expected to depleting and reached to the full exploitation. In an era where depletion of fossil fuels is a major problem and pollution an even bigger issue, it is the only alternate sources of energy which can meet the energy requirements for the future. Various alternative sources of energy are being thought of, including the nuclear, solar, geothermal, wind, tidal and the biomass based. Keeping in view the three fold objective stated above viz. economic-viability, sustainability and safety, waste to energy as a source of energy holds a good and bright promise.

Every year there is an estimated 30 million tonnes of solid waste and 4,400 million cubic meters of liquid waste generated in the urban areas of India. The municipal solid waste (MSW) generation ranges from 0.25 to 0.66 kg/person/day with an average of 0.45 kg/person/day. In addition, large quantities of solid and liquid wastes are generated by industries. Most wastes that are generated find their way into land and water bodies without proper treatment, causing severe water pollution. As major part of the Indian economy is based upon agriculture and also India has largest no. of livestock animals, so agriwaste and cattle waste is available in every part of country in sufficient amount which can be used as fuel for production of electrical energy.

## **1.2 WASTE-TO-ENERGY – AT A GLANCE**

Waste to energy refers to the process in which the power is generated from the waste that has to be disposed off in the landfill. In other words we can say that waste to energy refers to use of modern combustion technology to recover energy in the form of electricity from the solid waste. It is a renewable source of energy because its fuel that is garbage is not depleted .It is similar to the thermal coal fired plant but differs in the fuel.



**Fig.1 power plant based on waste**

The fuel is burned where high temperature combustion completely destroys viruses, bacteria, rotting food and other organic compounds found in household garbage that could harm human health. The heat produced due to combustion is used to boil the water to produce steam. Typically the high-pressure steam turns the blades of a turbine generator to produce electricity. After any incombustible residue (ash) cools, magnets and other mechanical devices pull metals from the ash for recycling. This is an important step, since a waste-to-energy plant can recycle thousands of tons of metals from its ash. The really advanced technology in burning trash is the air quality (emission) control system. America's waste-to-energy facilities today meet some of the strictest environmental standards in the world and employ the most advanced emissions control equipment available including scrubbers to control acid gas, fabric filters to control

particulate, selective non-catalytic reduction (SNCR) to control nitrogen oxides, and carbon injection to control mercury and organic emissions. Another challenge is the disposal of the ash after combustion. Ash can contain high concentrations of various metals and harmful chemicals that were in the original waste. The ash is tested for harmful substances and can then be reused for many applications. Most of the ash is used to build roads and make cement. Finally a utility company sends the electricity that was generated along power lines to homes, schools, and businesses. The burning of the garbage releases the chemicals and substances found in the waste. These chemicals can be hazardous to people and the environment if they are not properly controlled. Another concern is that waste-to-energy plants will impede recycling programs. If all the waste is burned then there will be little incentive to recycle used products. However because of the nature of most waste recycling and waste-to-energy can actually complement each other. Waste-to-energy plants generate enough electricity to supply millions of households. However, providing electricity is not the only major advantage of waste-to-energy plants. In fact, it costs more to generate electricity at a waste-to-energy plant than it does at a coal, nuclear, or hydropower plant. The major advantage of burning waste is that it reduces the amount of garbage we bury in landfills. Through the combustion of everyday trash in modern facilities, waste-to-energy plants provide feasible options to populations that would otherwise buy power from conventional power plants and dispose of their trash in landfills. Waste-to-energy power plants provide vital trash disposal services and generate clean, renewable energy

### **1.3 LITERATURE REVIEW**

**Porteous .A [13]** discussed that the 1991 NFFO allocations for renewable energy generation were reviewed with emphasis on electricity from municipal solid waste (MSW) and landfill gas (LFG) combustion tranches. The implications of materials recovery on the calorific value of MSW were considered, as were the environmental impacts of both MSW and LFG combustion with special reference to air pollutant emissions. The performance and economics of state of the art incineration and LFG power generating plants were examined. It was shown that energy recovery from these wastes could be both cost effective and environmentally desirable.

**Rae G. W. [17]** discussed in his paper that each year the South East of England, including London, generates some 27.5 million tonnes of municipal, industrial and construction wastes.

With a few exceptions this waste was disposed of at landfills, often some distance from the origin of the waste. However these landfills were nearing completion and, because of planning and environmental constraints, were not being replaced at a rate sufficient to guarantee demand was met. This paper, using a proposed plant at Belvedere as an example, looked at the waste-to-energy solution in the context of the evolving disposal crisis. It reviewed the role it could play and considered whether this well proven technology truly represented a new jointer for waste management in the UK.

**Maunder D.H., Brown K.A. [11]** discussed about the production of electricity from biofuels, Electricity may be generated from a range of bio fuels which were themselves derived from a wide variety of biologically based feed stocks. Source materials comprise both biomass of agricultural or forestry origin and waste matter. These sources of energy were becoming increasingly important in both the developed as well as the developing nations, providing viable and environmentally attractive fuels able to compete effectively with more conventional energy sources in niche markets.

**Emsperger .W et al. [8]** discussed that one very attractive solution to these conflicting requirements was the gasification of oil residues through an integrated gasification combined-cycle (IGCC) process to generate exclusively electricity or provide combined electrical power and, for example, hydrogen and/or process steam for use within the refinery. Worldwide there could be (based on projected refinery capacities and residues for the year 201 0) an estimated 135GW of power available from burning oil refinery residues irrespective of quality.

**Chakravarthi Janani [3]**discussed that Biomass is one of the longest used energy sources employed in human activity. The bioconversion of organic matter to biogas is a complex anaerobic fermentation process involving the action of microorganisms such as methane producing bacteria. In the paper, biogas and energy production from cattle waste was investigated. There are two significant reasons that motivate this study. First, treating animal waste with the technology of anaerobic digestion could reduce environmental pollution and generate a relatively cheap and readily available source of energy in dairy farms. The gas

produced could be used for space and water heating of farm houses, cooking, lighting, grain drying and as a fuel for heating greenhouses during cold weather.

**Palanichamy .C[14]** proposed one such technology of generating electricity from municipal solid waste (MSW), to be implemented in Tamilnadu State. To do so, a complete feasibility survey had been conducted with a probable developer and the benefits of this project were compared with the existing wind farm project to attract more investors in the future.

**Themelis .Nickolas J., [19]** discussed that the Waste-to-Energy Research and Technology (WTER) Council was formed in May 2002. Its mission is to link academic researchers and professionals concerned with integrated waste management and energy recovery from wastes and promote R&D that will advance resource recovery by combustion or gasification. This paper reported on the activities of WTER in its first year and the research directions that had been identified and initiated.

**Tomberlin Gregg & Moorman Brad [20]** discussed that recovering energy from our garbage, or (waste-to-energy) as it's called in the U.S., wasn't a new idea but it had evolved over the years from the simple incineration of waste in an uncontrolled, environmentally unfriendly way to the controlled combustion of waste with energy recovery, materials recovery and sophisticated air pollution control equipment insuring that emissions are within U.S. and EU limits. The waste-to-energy industry has proven itself to be an environmentally friendly solution to the disposal of municipal solid waste and the production of energy. Recovering energy from the waste we throw away is still a good idea Waste-to-Energy is now a clean, renewable, sustainable source of energy, and a common sense alternative to land filling

**Pappu Asokan *et al.* [15]** discussed that in India, about 960 million tonnes of solid waste was being generated annually as by-products during industrial, mining, municipal, agricultural and other processes at that time. Of this 350 million tonnes were organic wastes from agricultural sources; 290 million tonnes are inorganic waste of industrial and mining sectors and 4.5 million tonnes were hazardous in nature. In this paper, status of generation on that time and utilization

of both non-hazardous and hazardous solid wastes in India, their recycling potentials and environmental implication were reported and discussed in details.

**Psomopoulos S, Bourka A. *et al.* [16]** discussed in their paper that WTE facilities for MSW management served about 30 million people in the USA. According to the US experience, the environmental impact of MSW management was reduced (lower GHG emissions, energy production, land savings, materials recovery, etc.). Furthermore, the emissions of toxic and dangerous substances like mercury and dioxins had been significantly reduced, thus protecting public health.

**Baidoo Ransford R. [1]** research addresses three major problems currently confronting our globe. These problems were the pending energy crisis, the environmental degradation due to waste and the environmental degradation due to the continuous generation of greenhouse gas emissions. A preliminary survey of available technical data indicates that the three problems could be solved through the use of an efficient plasma gasification technology. The two other methods of converting biomass to heat energy, namely combustion and gasification were also presented with the chemical compositions of the three methods analyzed, using thermo chemical data to determine which of the three has the best option for heat energy generation and hence power generation.

**Cardenas R *et al.* [4]** evaluated the performance of a biomass gasification plant for power production has been evaluated using a developed methodology based on geographical information systems to evaluate and quantify the available biomass resources and a simulation software to analyze the power production based on the data obtained from the methodology. This analysis had been performed for twelve districts of the Valencian province in Spain and the main results and conclusions were presented.

**Kayes Imrul *et al.* [10]** discussed that the enormous increase in the quantum and diversity of waste materials generated in Dhaka city and their potentially harmful effects on the general environment and public health had led to an utmost necessity of adopting scientific methods for safe disposal of garbage.

**Sarker Moinuddin [18]** discussed about the generation of the electricity from the waste, Generation of electrical energy from imported fossil fuels was subjected to the price fluctuations of the global marketplace and, thus, constitutes a major expense in its distribution to the end users. Emissions from the evaporation and combustion of these traditional fossil fuels contribute to a range of environmental and health problems, causing poor air quality, and emitting greenhouse gases that contribute to global warming. Alternative fuel created from domestic sources had been proposed as a solution to these problems, and many alternative fuels were being developed based on solar, wind, biomass, hydropower, fuel cell, geothermal, etc.

**Bardi Silvia [2]** discussed in his paper that the Municipal and industrial waste had been treated in incineration plants since the beginning of the 20th century, mainly to reduce the landfill volume. The incineration process transformed environmentally hazardous components of waste, such as aromatic hydrocarbons and organic solvents, into harmless compounds. Additionally, incineration plants converted the released combustion heat into steam and electricity. This article described the incineration process and its mathematical modeling. The model which focused on the chemical and thermodynamic aspects of the process was the base for the development of an advanced controller that uses input/output linearization

**Curry Nathan [5]** discussed about the urban waste generation and disposal . As the world's population continues to grow toward the 7 billion mark and more people move to urban areas, the amount of waste generated would soon become unmanageable. In 2008, the number of people living in cities surpassed those living in rural areas and it has been estimated that by 2030, 5 billion people will be living in cities. As our urban areas continue to grow and consume large quantities of energy and produce massive amounts of waste, we are facing with the challenge of how to manage this situation in a sustainable way. Waste-to-Energy technology could provide a solution to this problem in the forms of anaerobic digestion and plasma gasification. These two technologies could be used in the urban environment separately or complementarily to reduce the amount of waste requiring processing and land filling.

**Hobson H. [9]** proposed to divide paper into two sections—the first dealing with the various forms of waste energy available and the general conditions governing their employment for the

purpose of electrical generation, and the second dealing with the considerations involved in the disposal of the power thus generated.

**Cardenas R, Perpina C [7]** discussed that methodology development and application were carried out using GIS to evaluate available biomass resource, and logistic and transport strategies. An important characteristic of the methodology is its application to different hypothetical scenarios (changing the area of study, types of crop as energetic cultivation, statistical data, and so forth) and the fact that it could be updated at any time.

**McCallum Don [12]** discussed that increasing interest producing power from waste was being driven by the need to conserve landfill, minimize environmental problems, reduce greenhouse gas emissions and obtain renewable source of energy. Approximately 25000 tonnes per year of municipal solid waste could be available to a waste to energy facility in Whitehorse.

**Crawford Shannon [6]** discussed waste-to-energy was a reliable and renewable form of energy that had become the basis for many of the most successful solid waste management systems in the country. More than 80 plants throughout the United States had allowed municipalities to reduce their greenhouse gas emissions and the amount of waste sent to landfills, while also benefitting the communities financially. These facilities required a significant capital investment and were typically financed through the sale of municipal revenue bonds.

#### **1.4 OBJECTIVE OF THE THESIS**

With the growing demand of power we have to think about new alternative source of energy and utilize them to their best. Waste to energy is the one of the new source of energy for meeting the growing demand of power. But at the same time we have to optimize the fuel value and cost from variety of fuels so that more power can be generated from waste raw .In this thesis, the main objective is to find out the best fuel from the various available combinations of the fuels. To obtain the required result, an optimization technique has been used in this thesis.

## **1.5 METHODOLOGY**

In this thesis genetic algorithm is used to optimize calorific value and the cost of the combinations of several fuels. Genetic algorithm is one of the optimization techniques available in matlab. First Programming is done in matlab to make objective and nonlinear constraints and then use the optimization toolbox for running the optimization. Then optimized values is being done to get the final results

## **1.6 ORGANIZATION OF THESIS**

The thesis is organized into five chapters. The organization of thesis is as follow:

- 1) The first chapter summarizes the brief introduction of the waste to energy and literature review, methodology, objective of thesis and organization of thesis.
- 2) The second chapter deals with waste to energy plants in India and the techniques of producing power from the waste.
- 3) The third chapter describes the optimization technique that is used to optimize the fuel mix i.e. genetic algorithm (G.A)
- 4) The fourth chapter includes the programming used for the optimization and the calculations
- 5) The fifth chapter presents the results, conclusion and the future scope of the related work.

## **CHAPTER 2**

# **WASTE TO ENERGY AND TECHNIQUES CONVERTING WASTE TO ENERGY**

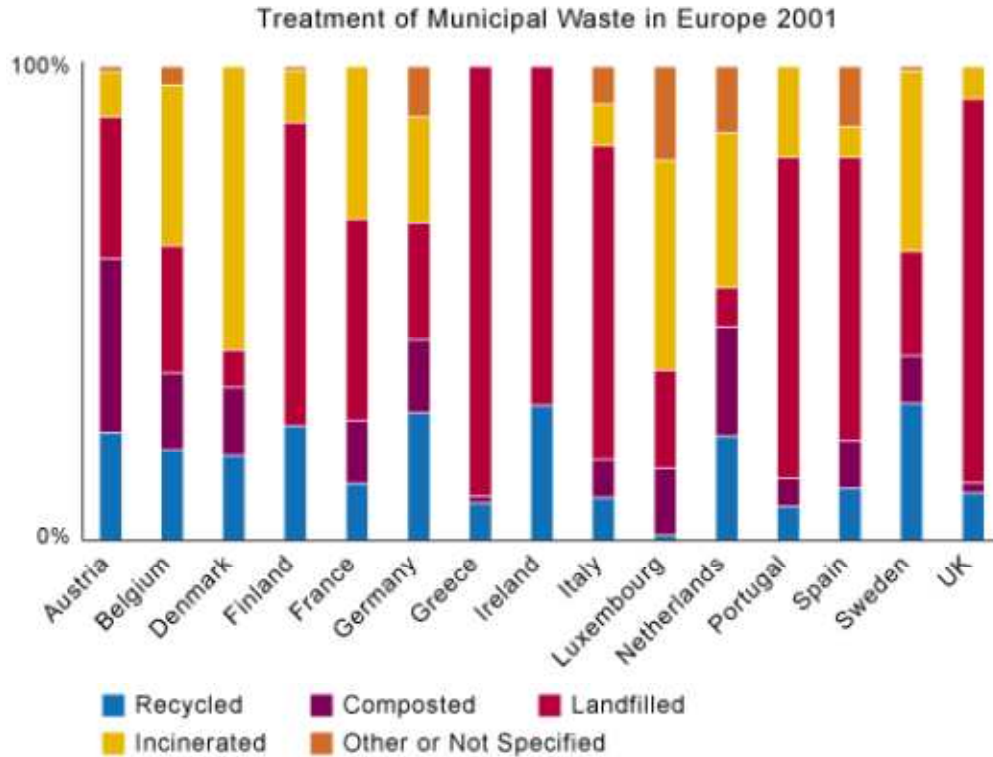
## **2.1 WASTE-TO-ENERGY AS RENEWABLE ENERGY SOURCE**

Modern WTE is considered to be a source of partly renewable energy by the U.S. federal government and 15 U.S. states that have established renewable energy programs. Also some European countries that have established renewable energy programs consider energy production through WTE as renewable. To determine the percentage of WTE output that qualifies as renewable, there must be a measurement of the percentage of the feedstock coming from biological sources (e.g., food, paper, fabric, wood, leather) and from fossil fuel sources – namely plastics.

According to an article published in *The Economist* in December 2006, “Different countries dispose of their rubbish in different ways. Americans and Australians, with lots of land at their disposal, like to dump it. More crowded places, such as Singapore and Taiwan, and ones with great reverence for their landscape, such as Switzerland, tend to burn it. Germans, says Denis Gasquet of Veolia Environmental Services, have a soft spot for industrial schemes that recycle waste or generate energy from it.

A trend in favour of new energy technology integrated within an overall waste management strategy focusing on materials and energy recovery is illustrated by the recently announced French government's plan to phase out landfills and to develop up to 150 new municipal solid waste conversion facilities.

In 2007 there are more than 600 WTE plants in 35 different countries. The United States processes 14 percent of its trash in WTE plants. Denmark, on the other hand, processes more than any other country – 54 percent of its waste materials.



**Fig. 2.1**

## 2.2 WASTE TO ENERGY PLANTS

More than 70% of India’s population depends on biomass and about 32% of the total primary energy use in the country mainly in rural areas is still derived from biomass. biomass gasification based power production, is relevant today especially in the Indian context mainly because of its potential to provide distributed power at rural level, especially for small remote villages that have good access to biomass but no access to grid power, and which require only small scale power production. Biomass based power is also relevant in the context of climate change and global warming as biomass based power production is net carbon neutral

**Table 2.1**

**State wise biomass generation in India.**

State	Upto 31.3.2003	2003- 2004	2004- 2005	2005- 2006	2006- 2007	2007- 2008	2008- 2009	2009- 2010	2010- 2011	Total (MW)
Andhra	160.05	37.7	69.5	12	22	33	9	20	--	363.25

Pradesh										
Bihar	--	--	--	--	--	--	--	--	9.5	9.5
Chhattisgarh	11	--	--	16.5	85.8	33.5	9.8	43.8	--	199.9
Gujarat	0.5	--	--	--	--	--	--	--	--	0.5
Haryana	4	--	2	--	--	--	--	1.8	28	35.8
Karnataka	109.38	26	16.6	72.5	29.8	8	31.9	42	--	336.18
Madhya Pradesh	--	1	--	--	--	--		--	--	1
Maharashtra	24.5	--	11.5	--	40	38.5	71.5	33	10	288.5
Punjab	22	--	--	6	--	--	--	34.5	--	62.5
Rajasthan	--	7.8	--	7.5	8	--	8	--	28	59.3
Tamil Nadu	106	44.5	22.5	--	42.5	75	43.2	62	23.5	419.2
Uttar Pradesh	46.5	12.5	14	48.5	--	79	172	194.5	14	581
West Bengal	--	--	--	--	--	--	--	16	--	16
Total	483.93	129.5	136.1	163	228.1	266	345.4	447.6	113	2312.63

**Table 2.2**

**The table provides a list of biomass plants installed in India.**

Power capacity	State	Location of the plant	Built/Supported
1Kw			
	New Delhi	UNIDO	CGPL
	Gujarat	Speri, Vallabha Vidyanagar	CGPL
	Maharashtra	IIT Bombay	CGPL
	WB	Tezpur University	CGPL
	WB	Banahut	CGPL

	Bihar	Chief Executive Officer, Shri Domen Mehto, C.G.C.Vaishali, Vaishal (Dist)	OVN
	UP	Arun Shah CAPART,Janak Puri,New Delhi-58	OVN
	WB	Dimapur	SYNERGY
	WB	Kolkata	SYNERGY
5 Kw			
		NTPC	ARUNA
7.5 kW			
	Tamil Nadu	Dharmapuri	
	Tamil Nadu	Kanchipuram	ARUNA
	Arunachal Pradesh	Arunachal Pradesh	CGPL
10kW			
	Tamil Nadu	Periyambattam, Dharmapuri	ARUNA
15kW			
	MP	Kasai	ARUNA
	MP	Debrabandi	ARUNA
20kW			
	Assam	Assam	
	Karnataka	Astra – CGPL	BETEL
	Karnataka	Hosahalli	CGPL
	Arunachal Pradesh	Central Institute of Himalayan Culture Studies, Dahung, Bomdila Distt: West Kameng	OVN
	Arunachal Pradesh	Central Institute of Himalayan Cultural Studies, Dahung, Bomdia, PO: Dahung, Distt: West Kameng	OVN
	Bihar	Drishtee Foundation, Sarut, Madhubani	OVN
	Nagaland	NBM-IT, Pageland Bamboo Development Agency,	OVN

		Red Cross Building, Kohima	
	WB	WBREDA	SYNERGY
25 Kw			
	Karnataka	Siemens, Bangalore	BETEL
	Assam	Bashistha, Guwahati, Assam Forest Department.	OVN
	Manipur	Tamenglong Bamboo and Cane Development Centre, DC Office Complex, Tamenglong HQ	OVN
35 kW			
	Manipur	Tamenglong Bamboo and Cane Development Centre	
	Karnataka	Diwan Estate, Bethmangala	NETPRO
	Rajasthan	Sankalp	NETPRO
	Tripura	Common Facility Centre, Katlamara	OVN
	Tripura	Don Bosco Training School, Bishram Ganj	OVN
	Tripura	Rubber Producer Society, Rangmala	OVN
	Tripura	Rubber Producer Society, Laxmandepa	OVN
45 kW			
	Tamil Nadu	Javalgiri, Hosur	ARUNA
	Karnataka	JNNCE, Shimoga	BETEL
50 kW			
	Bihar	DESI Power Baharbari	NETPRO
	Karnataka	WSD, Varlakonda	NETPRO
60 kW			
	Karnataka	Gem & Sons, Chitradurga	BETEL
75 kW			
	Tamil Nadu	Aruna	ARUNA
	Kerala	Ideal Crumb, Palakkad	BETEL

	Mizoram	Malson Bamboo Pvt. Ltd, Bairabi	CGPL
	Karnataka	NIE, Mysore	ENERGREEN
	Tamil Nadu	Bhagavathi Bio-Power, Mettupalyam	ENERGREEN
	Tamil Nadu	Kongu	ENERGREEN
	Tamil Nadu	G.B.Engineering Enterprises	NETPRO
100 kW			
	Karnataka	Elite Crumb Rubber, Mangalore	BETEL
		Synergy	BETEL
	Karnataka	MVIT– II	NETPRO
	MP	DESI Power Orchha (P) Ltd.	NETPRO
	Tamil Nadu	Dev Power Corporation	NETPRO
	Tamil Nadu	Vellore Institute of Technology	NETPRO
	Tamil Nadu	VIT, Vellore	NETPRO
	Tamil Nadu	G.B Food oils	NETPRO
125 kW			
		Edathala Polymers	BETEL
150 kW			
	Karnataka	BERI, Kabbegiri Village, Tumkur	ENERGREEN
	Sagar Island	Sagar Island	SYNERGY
	WB	WBREDA	SYNERGY
225 kW			
	Karnataka	BERI, Kabbegiri Village, Tumkur	NETPRO
250 kW			
	Tamil Nadu	Pointech	ARRYA
	Jammu	Hindustan Pencils	BETEL
300 kW			

	Tamil Nadu	Tahafet	
415 kW			
		Sanghvi Woods	BETEL
	Jammu	Hindustan Pencils	BETEL
500 kW			
	Karnataka	Bethmangala	ENERGREEN
1 MW			
	Tamil Nadu	Arashi, Tamil Nadu	ENERGREEN
	Tamil Nadu	Gomathy	ENERGREEN

**Table 2.3**

**List of upcoming waste to energy plants in Punjab.**

Sr. No.	Name of the company	Location	Capacity
1	M/s Turboatom-TPS project pvt. Ltd.	Vill. Booh,patti (Amritsar)	10 MW
2	M/s Turboatom-TPS project pvt. Ltd	Vill. Kot majlis batala Gurdaspur	10 MW
3	M/s Turboatom-TPS project pvt. Ltd	Vill. Burj baghel singh ,malerkotla Sangrur	20 MW
4	M/s Turboatom-TPS project pvt. Ltd	Vill. Jhok tehal singh, Ferozpur	10 MW
5	M/s Green field energy Pvt. Ltd.	Talwandi sabo	6 MW

6	M/s Sea sky cargo and travels pvt. Ltd.	Ajnala,Amritsar	10 MW
7	Menakshi infrastructure pvt. LTD.	Sunam,sangrur	31 MW
8	M/s universal biomass energy pvt. Ltd.	Malout	14.5 MW
9	M/s food fats and fertilizers Pvt. Ltd.	Mansa	20 MW
10	M/s P&R Engg. Services Ltd.	Anadpur sahib	5 MW
11	M/s P&R Engg. Services Ltd.	Ropar	10 MW
12	M/s P&R Engg. Services Ltd.	Nawanshehar	10 MW
13	M/s orient green power Pvt. Ltd.	Amritsar	10 MW
14	M/s orient green power Pvt. Ltd.	Patiala	10 MW

## 2.3 BENEFITS

- Waste to energy facilities address more than one environmental problem
- With these power generation facilities there is no need for foreign oil or fossil fuels
- Waste to energy plants offer many benefits to people and the environment

### 1. Dependence On Fossil Fuel Is Reduced

The waste to energy plants uses the waste raw material as fuel for the generation, therefore it does not rely on fossil fuels. Fossil fuels have exploited to the extreme for the generation of power. Hence this is the alternate source of power and reduces the dependence on fossil fuel for the power.

## **2. Energy Is Produced Domestically**

With this technology energy is produced domestically. There is plenty of agriculture waste and other household available in India, enough so that materials for the process would never have to be transported very far or run out. This garbage is created every day, and landfills are overflowing with this alternative energy source.

## **3. Stability In Availability And Pricing**

Using this waste to generate electricity can help in bringing stability to both the price of the electricity and the availability. With this process enough energy can be produced so that there will be no wide fluctuations or availability shortages. These facilities can operate twenty four hours a day every single day of the year, providing enough electricity to meet the local community needs

## **4. The Local Community and Economy Benefit from These Facilities**

As waste to energy facilities are locally situated, and this offers many advantages to the local economy .Employment will be created for local community, taxes will be paid to govt. And energy is provided for a reasonable cost that does not pollute or harm the environment. These facilities will be located to provide for the local area instead of being situated far away.

## **5 More Space In Landfills Is Available**

By generating power from waste more landfills will be available. Waste that is incinerated would otherwise take up space in the landfill, and contribute to the environmental pollution. A number of landfills around the world have closed because they have reached full capacity, and the world is running out of places to dump the trash being created.

## **6. There Is An Unlimited Supply Of Waste**

The best thing of the Waste to energy technology is its fuel which is available in abundant and provide an unlimited supply. With all the garbage generated around the world every single day, plus all the refuse in the many landfills, there is enough trash to create all the electricity needed.

## **7. Greenhouse Gas Emissions Are Significantly Reduced**

Another advantage of this method is its non contribution to Greenhouse gas emissions which play a big role in global warming, and this alternative energy generation method does not release a fraction of these emissions that fossil fuel power plants do. .

## **8. This Energy Generation Is Environmentally Friendly**

Using waste to generate energy is a process that does not pollute the environment. It does not produce any dangerous chemicals or toxins which can poisoned wildlife and contaminate the land and water in the area, and pollution and greenhouse gas emissions are far less than thermal plants.

## **9. Waste to Energy Promotes Recycling**

This form of alternative energy generation promotes recycling, and that means less waste because of items being sorted and recycled. It has been proven that for each item recycled there is around twenty percent more energy conserved than what is needed to manufacture the item. Recycling minimizes the need for natural resources and the environmental damage done.

## **10. Waste to Energy Plants are strictly Monitored**

These power plants must go through very strict emissions testing, and every aspect of the process is monitored closely. In fact, these facilities must meet stricter operating standards than any other type of power plant, and if these are not met the plant is immediately shut down.

## **2.4 TECHNIQUES**

There are numerous techniques by which conversion of waste to useful energy in the form of electricity takes place.

1. Combustion
2. Biological conversion
3. Advanced thermal conversion.

### **2.4.1 COMBUSTION**

In this process waste is directly burnt to recover heat energy. Then Conventional steam cycles can be used to produce electricity from it. There are numerous different types of developed and demonstrated boiler designs available, many of which have been developed specifically for biomass fuels. The combustion of biomass in the form of comminuted wood, straw or 'dry' energy crops can be carried out effectively in widely available automated combustion plant. Essentially, this plant has the same basic design as that for coal combustion with the addition of more refractory lining to allow the relatively wet fuels to dry on the grate, and secondary air to ensure complete combustion of volatiles. Such plant can handle fuels with a moisture content as high as 60% by weight, and are available in a wide range of sizes from a few hundreds of kilowatts to many megawatts. The emissions from these plants are low with only a vapour plume from the stack after start-up. At the larger sizes, fluidised bed combustion is possible. In all combustion plant types, cereal straw presents problems as the ash has a low melting point which may lead to boiler fouling. Given that most biomass fuelled plant will be small in size due to the constraints on transporting the fuel over long distances, the efficiency of conversion will be low – at around 20.25% in the range 1 to 30 MWe. At the 100s kWe scale this efficiency falls even lower making small-scale electricity generation uneconomic in all situations other than where fossil fuels prices are high, or where the biomass fuel is obtained free. Solid wastes can be burnt 'whole' (mass burn incineration), or can be processed into dense or coarse refuse derived fuels (RDF). In which the waste is sorted to remove recyclable and lower calorific value components before combustion. Waste combustion is essentially a pre-treatment option for reducing the volume of waste (and hence transport and final disposal costs) prior to land filling. Typically, incineration reduces waste volume to 10% of its original bulk and its mass to 30% of the original. Because of the nature of this residue, however, it will still require careful control to prevent environmental harm. Waste combustion with energy recovery is well established overseas, but in the UK the availability of low-cost landfill has limited its uptake. Increasing awareness of the environmental impacts of land filling, together with NFFO support, has stimulated a revival in energy from waste combustion in the UK. However, difficulties securing long-term waste disposal contracts and problems with planning have introduced significant non-technical hurdles to project developers. To date, only one new energy from MSW plant has been commissioned in the UK in the past two decades. Continued development of the industry is further challenged by the need to meet increasingly strict standards governing gaseous emissions

from combustion plant. In many cases, these limits are, in fact, substantially lower than those applied to fossil-fuelled power plants. Overseas experience suggests that waste combustion enjoys greatest success as part of an integrated approach to waste management, where waste minimisation, reuse and recycling, and optimised final disposal are considered together. Such facilities allow pre-sorting of refuse to remove recyclable components as required (e.g. paper, glass, ferrous and non-ferrous metal), with energy recovery from the residue. The wetter, 'putrescible', components of the waste stream, such as food wastes, are also removed before waste combustion, thus increasing the calorific value of the waste fuel, whilst enabling energy to be recovered from the wet fraction through biological conversion. Such techniques are, however, more expensive in the UK than the currently dominant landfill waste management option. The uptake of such waste disposal options depends primarily on economic pressures on the waste management industry, themselves influenced by political, social and environmental issues.

#### **2.4.2 BIOLOGICAL CONVERSION**

Anaerobic digestion is the bacterial fermentation of organic material in the absence of oxygen, in fabricated tanks. The activity of these 'anaerobic' bacteria leads to the formation of a methane-rich biogas comprising about 60% methane. The calorific value of this biogas is about 25 MJ/m<sup>3</sup>. The gas, when filtered and dried can be used as a fuel for heat recovery, or it can be used in conventional spark ignition engines or gas turbines, replacing conventional fuels like gasoline or natural gas. It can also replace the majority of the diesel in compression ignition engines, but because of the low cetane number of methane, a small injection of diesel is still needed to initiate combustion. All these types of engine can be used as prime movers driving alternators. The efficiency of these engines is anything between 25% for gas turbines to 43% for compression ignition engines and when in combined cycle, gas turbines can achieve efficiencies close to 50%. Most new applications tend to use spark ignition engines. Anaerobic digestion can be used for any wet organic feedstock, including 'green' agricultural crops and residues, animal slurries, food industry wastes, sewage sludge and the easily digestible fraction of MSW. In other parts of Europe, notably in Denmark, anaerobic digestion is used as a major treatment option for agricultural and some industrial wastes. It could also form one part of an integrated MSW management option, taking the wet fraction while the dry fraction is treated through combustion. As with any technique acting as a waste management option, its uptake will depend on the same

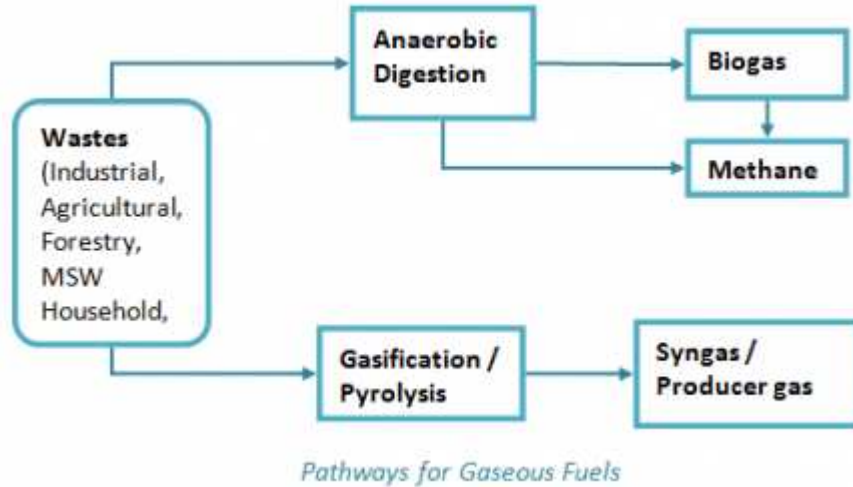
pressures as described above for combustion. The solid residue from digestion can, given a relatively clean original feedstock, be used as a soil conditioner, just like more conventional compost. However, if the feedstock is contaminated with metals, for example, as can happen with a mixed MSW stream, the residue cannot easily be used and is likely to be disposed of in landfill, or used as daily landfill cover. When organic waste is deposited in landfill sites, uncontrolled anaerobic digestion occurs. Because it is uncontrolled, the yield of gas from the waste is less than the yield achieved through the type of digestion described above, and the methane content of the gas is less. If this 'landfill gas', LFG, is allowed to escape uncontrolled from a landfill site, it can pose an environmental hazard because it is potentially explosive. Because of its methane content, it also has a significant effect on the greenhouse gas loading on the atmosphere; methane has an effect many times that of carbon dioxide, molecule for molecule. Its safe control is therefore important, and energy recovery from collected gas can complement its control. Electricity generation from LFG uses very similar technologies to those described above for anaerobic digestion like all the other energy from waste options, using LFG is not a waste management option. It is simply a consequence of a waste management option: land filling. As pressure on the environmental control of landfills strengthen, using LFG will become increasingly important in order to provide a revenue stream to offset the costs of site control measures. It is also possible that landfill sites will be designed and operated in the future to accelerate waste stabilisation, which implies faster generation of LFG and better prospects for its use.

### **2.4.3 ADVANCED THERMAL CONVERSIONS**

There are three principal advanced conversion technologies: pyrolysis; gasification; and liquefaction. All three can be used on any dry organic feedstock, including biomass and wastes

#### **a) pyrolysis**

Pyrolysis is the thermal degradation of an organic feedstock without an oxidising agent to produce a gas, liquid and char. By increasing the temperature, the proportion of gas and liquid is increased. The resultant pyrolysis oil can be used as a fuel in internal combustion engines acting as prime movers. The technologies for this 'flash' pyrolysis of biomass are fairly early in their development phase.



**Fig. 2.2**

**b) Gasification**

Gasification is the thermal oxidation of an organic feedstock, with limited supply of oxygen enough for combustion. It results in the production of a mixture of gases that can contain carbon monoxide, hydrogen and methane, all of which have calorific value. This gaseous mixture can be used to fuel internal combustion engines. In doing so, at scales appropriate to biomass and waste, the overall thermal conversion efficiency can be increased over that for conventional combustion techniques, from the low 20% range to approaching 40%, leading to similarly large savings in the emission of carbon dioxide. Gasification has been widely used in the UK in the past to manufacture fuel gas from coal (town gas), but was displaced with the 3WER discovery of North Sea gas in the 1960s. Biomass gasification also has a long history, going back several decades. The gasification of wastes is, however, at an early stage in its development cycle but may soon enter the pilot demonstration stage. An added benefit of gasification of waste over its combustion is that emissions control from gasification is likely to be more effective at achieving very low levels of pollutants.

## **CHAPTER 3**

### **OPTIMIZATION TECHNIQUE-GENETIC ALGORITHM (G.A)**

#### **3.1 INTRODUCTION**

Optimization is the best solution from some set of available alternatives. An optimization problem consists of maximizing and minimizing a real function by choosing the input values from available set and computing the value of function. More generally, optimization includes finding "best available" values of some objective function given a defined domain, including a variety of different types of objective functions and different types of domain. Various techniques are available for optimization which can be named as;

1. Genetic algorithm(G.A)
2. Particle Swarm optimization(P.S.O)
3. Ant colony optimization(A.C.O)
4. Simulated annealing(S.A)

Now for optimization of the waste to energy plant we have to optimize the calorific value and cost of the fuel used. In this thesis work genetic algorithm technique of optimization is used for the maximization of calorific value and minimization of the cost of the fuel used.

#### **3.2 GENETIC ALGORITHM(G.A).**

The genetic algorithm is a method for solving both constrained and unconstrained optimization problems that is based on natural selection, the process that drives biological evolution. The genetic algorithm repeatedly modifies a population of individual solutions. At each step ,the genetic algorithm selects individuals at random from the current population to be parents and uses them produce the children for the next generation .over successive generations ,the population “evolves” towards an optimal solution.

Genetic algorithms (GAs) are stochastic global search and optimization methods that mimic the metaphor of natural biological evolution. GAs operates on a population of potential solutions applying the principle of survival of the fittest to produce successively better approximations to a

solution. At each generation of a GA, a new set of approximations is created by the process of selecting individuals according to their level of fitness in the problem domain and reproducing them using operators borrowed from natural genetics. This process leads to the evolution of Populations of individuals that is better suited to their environment than the individuals from which they were created, just as in natural adaptation.

### 3.2.1 BASIC FEATURES OF GA:

- GA is a branch of artificial intelligence
- Artificial intelligence is an area of computer science that is concerned with the designing of intelligent computer system which exhibits the characteristics of intelligence in human behavior.
- It belongs to the category of random search algorithms which simulate the evolution process based on the theory of survival of the fittest.
- This branch is also related with the automation of intelligent behavior.
- . GAs is best suited for complex problems.
- Moreover it produces high quality solution.
- In the artificial intelligence we generally go for the probabilistic reasoning and it is predominately known as **soft computing**. The term soft computing was introduced by Lotif A. Zadeh of the University of California. According to him soft computing differs from the convention computing (Also known as hard computing) in its tolerance to imprecision, uncertainty and partial truth. Conventional computing is more oriented towards the mathematical approaches and therefore demands a high degree of precision. Whereas the soft computing basically inherent the characteristics of biological system and basically consist of Neural Networks (NN), Fuzzy Logic (FL) and Genetic algorithm (GA) .
- Genetic algorithms are basically a family of computational models which are inspired by the biological evolution. These algorithms encode a potential solution to a specific problem on a simple chromosome like data structure and apply genetic operators to these structures so as to preserve critical information.
- Genetic algorithms are often seen as a function optimizer.
- Genetic algorithms can be applied to a wide range of problems.

- In order to solve the problem by genetic algorithm the first step is to create the population (random) of chromosomes. Then these chromosomes are evaluated in such a way that the chromosome which represents a better solution for the problem will be given more chances than the poorer solution.
- The genetic algorithms are part of the evolutionary algorithms family, which are computational models, inspired in the Nature.
- GAs are more flexible than most search methods because they require only information concerning the quality of the solution produced by each parameter set (objective function values) and not like other optimization methods which require derivative information, or worse yet, complete knowledge of the problem structure and parameters.

There are some differences between GA's and other optimization/traditional searching algorithms. They are summarized as follows:

- 1) GAs work with a coding of the parameter set, not the parameters themselves. Therefore GAs can easily handle the integer or discrete variables.
- 2) GAs search within a population of points, not a single point. Therefore GAs can provide a globally optimal solution.
- 3) GAs use only objective function information, not derivatives or other auxiliary knowledge. Therefore GAs can deal with the non-smooth, non-continuous and non-differentiable functions which actually exist in a practical optimization problem.
- 4) GAs use probabilistic transition rules, not deterministic rules, Although GAs seem to be a good method to solve optimization problem, sometimes the solution obtained from GAs is only a near global optimum solution.

### **3.2.2 HISTORY OF GENETIC ALGORITHM**

Many human inventions were inspired by the natural selection. Genetic algorithm is one of them. The main idea of this is the survival of the fittest or in other words it is known as natural selection. In nature the individual that has better survival chances will survive for a longer period of time. This in turn provides a better chance to produce offspring with its genetic material. By virtue of this, the entire population consists of a lot of genes from the good population than that of bad population. In other words we can say that the fittest candidate will survive and unfit

will not. This force of nature is called natural selection. The father of the original Genetic Algorithm was John Holland who invented it in the early 1970's and thereafter he and his students contribute much to the development of this field. Holland research was not focused on optimization and domain specific practical problem but was on the concept of adaptation as seen in nature. Many people included biologists, are astonished that life at the level of complexity that we observe could have evolved in the relatively short time suggested by the fossil record. The GA uses this power of evolution to solve optimization problems.

As we are saying that the genetic algorithm is related with the nature, so there is some analogy between them and this can be described as:

### **Analogy between GA and Nature**

**Table 3.1**

<b>GENETIC ALGORITHM</b>	<b>NATURE</b>
Optimization Problem	Environment
Feasible problem	Individuals living in that environment
A set of feasible solution	Population of organism
Fitness function	Individual degree of adaptation
Operators used for results	Selection, recombination, mutation in nature

### **3.3 GENETIC ALGORITHM TOOLBOX**

The Genetic Algorithm Toolbox is a module for use with MATLAB that contains software routines for implementing genetic algorithms (GAs) and other evolutionary computing techniques.

### 3.3.1 KEY FEATURES

The Genetic Algorithm Toolbox was developed by Andrew chipperfield, Carlos fonseca, Peter Fleming and Hartmut Pohlheim, who are internationally known for their research and applications in this area. The toolbox is a collection of specialized MATLAB functions supporting the development and implementation of genetic and evolutionary algorithms. Its main features include:

- a) Support for binary, integer and real-valued representations.
- b) A wide range of genetic operators.
- c) High-level entry points to most low-level functions allowing the user greater ease and flexibility in creating GA applications.
- d) Many variations on the standard GA.
- e) Support for virtual multiple subpopulations.

### 3.3.2 TOOLBOX ORGANIZATION

Representation and initialisation: *crtbase*, *crtbp*, *crtrp*

The GA Toolbox supports binary, integer and real-valued chromosome representations. Binary and integer populations may be initialized using the toolbox function to create binary populations, *crtbp*. An additional function, *crtbase*, is provided that builds a vector describing the integer representation used. Real-valued populations may be initialized using *crtrp*. Conversion between binary and real-values is provided by the routine *bs2rv* that also supports the use of Gray codes and logarithmic scaling.

Fitness assignment: *ranking*, *scaling*

The fitness function transforms raw objective function values into non-negative figures of merit for each individual. The toolbox supports the offsetting and scaling method, *scaling*, and the linear-ranking algorithm, *ranking*. In addition, non-linear ranking is also supported in the routine *ranking*.

Selection functions: *reins*, *rws*, *select*, *sus*

These functions select a given number of individuals from the current population, according to their fitness, and return a column vector to their indices. Available routines are roulette wheel selection, *rws*, and stochastic universal sampling, *sus*. A high-level entry function, *select*, is also provided as a convenient interface to the selection routines, particularly where multiple populations are used. In cases where a generation gap is required, i.e. where the entire population is not reproduced in each generation, *reins* can be used to effect uniform random or fitness-based reinsertion.

Crossover operators: *recdis*, *recint*, *reclin*, *recmut*, *recombin*, *xovdp*, *xovdprs*, *xovmp*, *xovsh*, *xovshrs*, *xovsp*, *xovsprs*

The crossover routines recombine pairs of individuals with given probability to produce offspring. Single-point, double-point and shuffle crossover are implemented in the routines *xovsp*, *xovdp* and *xovsh* respectively. Reduced surrogate crossover is supported with both single-, *xovsprs*, and double-point, *xovdprs*, crossover and with shuffle, *xovshrs*. A general multi-point crossover routine, *xovmp*, that supports uniform crossover is also provided. To support real-valued chromosome representations, discrete, intermediate and line recombination are supplied in the routines, *recdis*, *recint* and *reclin* respectively. The routine *recmut* performs line recombination with mutation features. A high-level entry function to all the crossover operators supporting multiple subpopulations is provided by the function *recombin*.

Mutation operators: *mut*, *mutate*, *mutbga*

Binary and integer mutation are performed by the routine *mut*. Real-value mutation is available using the breeder GA mutation function, *mutbga*. Again, a high-level entry function, *mutate*, to the mutation operators is provided.

Multiple subpopulation support: *migrate*

The GA Toolbox provides support for multiple subpopulations through the use of high-level genetic operator functions and a function for exchanging individuals amongst subpopulations, *migrate*. A single population is divided into a number of subpopulations by modifying the data structures used by the Toolbox routines such that subpopulations are stored in contiguous blocks

within each data element. The high-level routines, such as select and reins, operate independently on each subpopulation contained in a data structure allowing each subpopulation to evolve in isolation from the others. Based on the Island or Migration model, migrate allows individuals to be transferred between subpopulations. Uni- and bi-directional ring topologies as well as a fully interconnected network are selectable via option settings as well as fitness-based and uniform selection and reinsertion strategies.

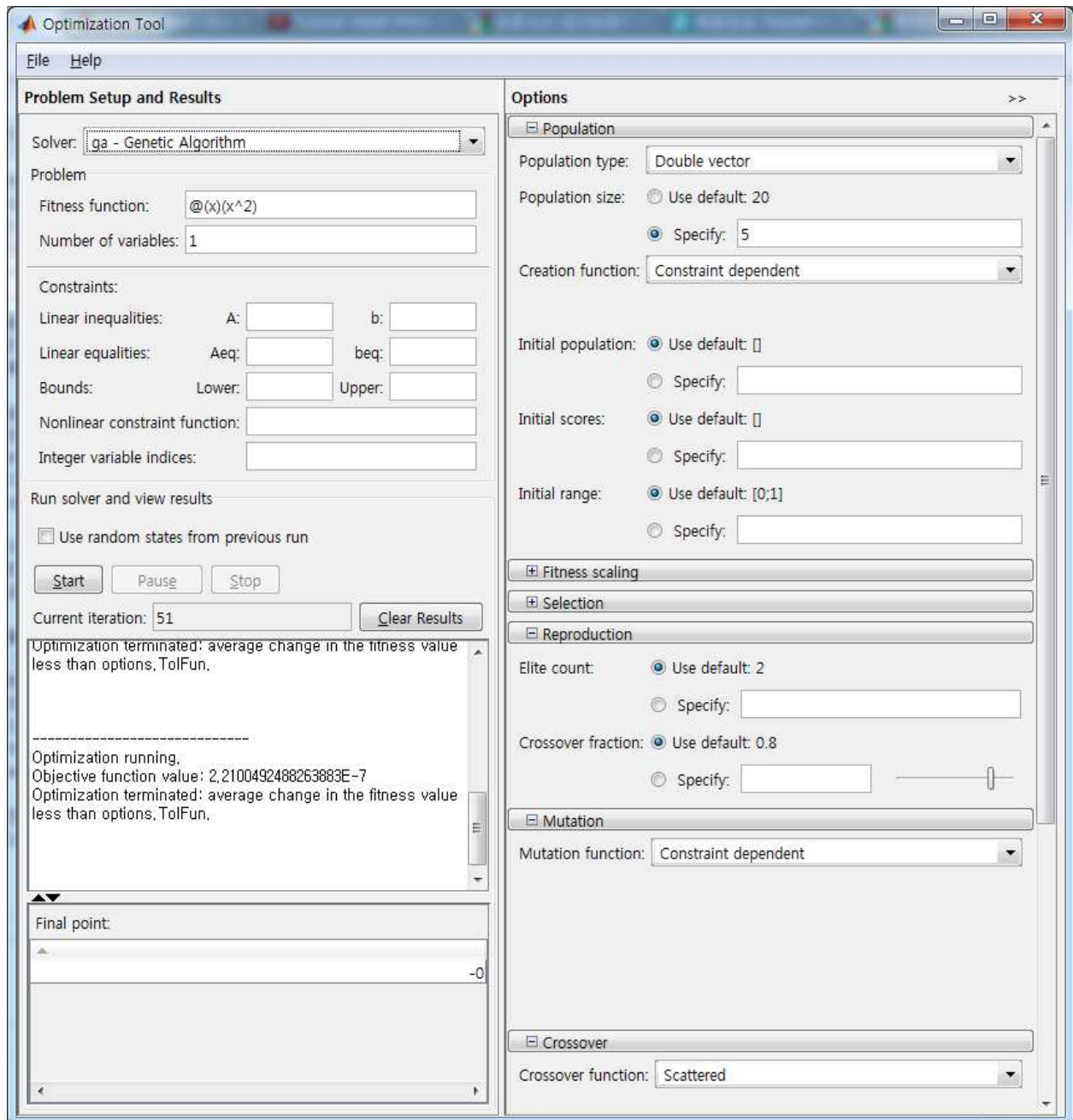


Fig.3.1 G.A Toolbox

# CHAPTER 4

## PROGRAMMING, CALCULATIONS AND RESULTS

### 4.1 FUEL MODELING (LINEAR PROGRAMMING)

Linear programming is applied to optimization models in which the objective and constraint functions are strictly linear. This technique is used in a wide range of applications. It has efficient computational algorithms for problems with thousands of constraints and variables. Due to its large computational efficiency LP is the backbone of solutions algorithms. In practice if linear programming models involve large number of variables and constraints the only feasible way to solve such models is by using computers. "MATLAB G.A TOOLBOX is one such computer package which was available for the present work to solve moderate size problems. Data input in G.A toolbox is straight forward and simpler.

The following equations were developed by using G.A Toolbox for maximization of calorific value (HHV) and minimization of cost.

Maximization of Calorific Value

$$W1 CV1 + W2 CV2 + \dots * W \times HHV \text{ (weight x calorific value)}$$

$$X1 CV1 + X2 CV2 + \dots \text{ _ HHV (Calorific value)}$$

$$W1 + W2 + \dots = W \text{ (weight)}$$

$$X1 + X2 + \dots = 1$$

$$W1 C1 + W2 C2 + \dots \text{ _ W X C (weight x cost)}$$

$$\text{Or } X1 C1 + X2 C2 + \dots \text{ _ C (cost)}$$

$$C = \text{Cost}$$

Minimization of cost

$$Z = X1 C2 + X2 C2 + \dots + Xn Cn \text{ (minimize cost)}$$

$$(1) X1 CV1 + X2 CV2 + \dots \text{ CVn Xn _ CV}$$

$$(2) X1 + X2 + X3 \dots \text{ Xn} = 1$$

$$(3) X1 C1 + X2 C2 + \dots \text{ Xn Cn _ C}$$

$$Xi \_ 0$$

$X_i$  = fraction of the fuel

$CV_i$  = Calorific value of the fuel

$C_i$  = Cost of the fuel

$W_i$  = Weight

$C$  = Cost, that is to be minimized

$CV$  = calorific value that is to be maximized

$C$  &  $CV$  are calculated for the maximum possible combinations

A computer programme in matlab was developed. The values of  $CV$  were calculated for different combinations. These were further validated by matlab

We have taken five wastes as fuel for optimizing their calorific value and cost to increase the efficiency and to reduce the cost of plant. Following are the fuels;

**Table 4.1**

Sr. No.	Name of the fuel	Calorific value of the fuel (kcal)	Cost of the fuel (Rs./tonne)
1	Wheat straw	4100	600
2	Rice straw	3469	600
3	Rice husk	3881	450
4	Sunflower	4300	200
5	Groundnut shell	4626	500

## 4.2 RESULTS

Now using the matlab g.a toolbox we have calculated calorific value and cost of the fuel for various combinations.

**Table 4.2**

Sr. No.	Fuel	Mf1	Mf2	Mf3	Mf4	Mf5
1	F1(wheat straw)	0.171	0.03	0.172	0.02	0.083
2	F2(rice straw)	0.207	0.3	0.377	0.82	0.104

3	F3(rice husk )	0.052	0.652	0.207	0	0.52
4	F4(sunflower)	0.464	0.012	0.17	0.16	0.144
5	F5(groundnut shell)	0.105	0.004	0.073	0	0.148
6	Total calorific value	4102	3764	3885	3615	4023
7	Total cost	395	496	493	536	449

## **CHAPTER 5**

### **CONCLUSION AND FUTURE WORK**

#### **5.2 CONCLUSION**

From table 4.2 it can be seen that we have five fuel combinations with their total calorific value and total cost. Out of these five combinations it can be seen that mf1 have the highest calorific value and lowest cost, then mf5, then mf3, then mf2, and at last mf4.

So from above it is concluded that mf1 is the best fuel for generating the electricity from waste

#### **5.3 FUTURE WORK**

In this we have used only five fuels for combinations, in future we can use other fuels for making combinations and optimize their calorific value and cost.

In future, other optimization techniques can be used for optimizing the calorific value and cost of the fuel. As in this thesis G.A technique is used for optimization, in future we can use other techniques like P.S.O, A.C.O, and S.A and a comparison can be made.

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## ANNEXURE

### MATLAB PROGRAMMING

#### Objective function;

```
function f = objfun(x)

CV1 = 4100;
CV2 = 3469;
CV3 = 3881;
CV4 = 4300;
CV5 = 4626;
f = x(1)+ x(2)+ x(3) + x(4) + x(5);
```

#### Non linear constraints

```
function [c,ceq] = nonlconstr(x)

c1 = 600;
c2 = 600;
c3 = 450;
c4 = 200;
c5 = 500;
C = 600;
CV1 = 4100;
CV2 = 3469;
CV3 = 3881;
CV4 = 4300;
CV5 = 4626;
HHV = 4626;
c = [ x(1)*c1 + x(2)*c2 + x(3)*c3+ x(4)*c4 + x(5)*c5 - C;
      CV1 * x(1) + CV2 * x(2) + CV3 * x(3) + CV4 * x(4) + CV5 * x(5)-HHV;
    ];
ceq = [];
```

## Output;

```
clc;
c1 = 600;
c2 = 600;
c3 = 450;c4 = 200;
c5 = 500;
C = 600;
CV1 = 4100;
CV2 = 3469;
CV3 = 3881;
CV4 = 4300;
CV5 = 4626;
HHV = 4300
x = input('Enter the values of X ');
NET_CV = CV1 * x(1) + CV2 * x(2) + CV3 * x(3) + CV4 * x(4) + CV5 * x(5);
NET_COST = x(1)*c1 + x(2)*c2 + x(3)*c3+ x(4)*c4 + x(5)*c5 ;
disp('Net Calorific Value ');
disp(NET_CV);
disp('Net Cost of the fuel ');
disp(NET_COST);
```