CHAPTER 2

LITERATURE SURVEY

Biomass power is generated from biomass resources such as forest products, agricultural residues. The power generation involves gasification in which the solid biomass is converted to gaseous fuels (producer gas). By using producer gas it is possible to operate diesel engine on dual fuel mode with marginal changes to the air inlet. This engine is coupled with an alternator for power generation.

Chanakya et al (1993) has developed CGPL technology for biomass gasification which includes the possibility to utilise biomass from traditional low-efficient systems for heating and electricity by steam cycles, high-efficient bio-energy production by gas engines and combined gas- and steam turbine cycles. This involves combustion with air and reduction of the product of combustion (water vapor and carbon dioxide) into combustible gases (Carbon Monoxide, Hydrogen, Methane, other Hydrocarbons), and inerts (Carbon Dioxide and Nitrogen). The process leads to a gas with some fine dust and condensable compounds termed tar, the gas is to be used in internal combustion engines. Each must be restricted to less than about 100 ppm. This technologies have the potential to offer a major contribution to meeting the targets of the European Union for CO₂ mitigation.

Venkat Raman and Srinivasan (1997) have proposed that Biomass power plants can generate grid quality power. A wide variety of fuels like firewood, rice husk, coconut shell and crop stalks etc; can be used. Biomass
gasification can be used for both thermal and electrical applications. Thermal gasifiers find applications in industries like tiles manufacturing, brick kilns, chemical industries. Biogas produced from organic materials such as animal dung, canteen waste, industrial wastes and selective plants could be also used in biogas plants. The gas essentially comprises of methane and carbon dioxide in the ratio of 55:45 methane has the fuel value.

Shaine Tyson et al (2002) was suggested that bio-refinery technology can improve the income of firms that produce energy products combined with bio based co products. By doing this producing a variety of high value products in addition to the typically low value fuels can be obtained. Most of a petroleum refinery’s profits come from 10% of the barrel of petroleum oil that is used to produce high value petrochemicals, while the low value bulk fuels pay for the feedstock cost. This approach allows investors in petroleum refineries to earn higher returns on their invested equity than they would without the petrochemical product lines.

By applying this model to biomass bio-refineries risk has to be taken to compensate losses due to low marginal profit and rate of return. Higher rates of return attract investors and lead to expanded capacity. Profits generated by the biobased fuels may encourage more investment, large facilities, and eventually a larger biofuel supply. Thus, biomass bio refineries need biobased co products to succeed in the fuels industry. Point to be noted is that bio refinery technology does not reduce the production cost of fuels.

Those fuels must still be sold at a price that covers the feedstock and whatever share of the capital and processing costs are attributable to the fuel. If that is not the case, the fuel production of this industry will be in bottom along with the investor’s returns in the next generation of productivity. If the biomass fuel’s production cost is higher than the price of the competing petroleum fuel, incentives will be necessary to market the fuel
at a price that the public accepts. If incentives are offered, they must be offered in a manner that promotes industry stability, ensuring at least a five year improvement.

William and Horsfield (1977) have developed a model to carry on the thermodynamic viability of a newly proposed power generating system based on atmospheric gasification of sugarcane bagasse combined with fluidized-bed heat-exchanger and gas turbine. Under imposed conditions, several configurations of the power unit have been tried until the most efficient was found. The performance of that system was compared with a more conventional concept based on bagasse pressurised gasification, gas cleaning and turbine, or BIG/GT process. To ensure equivalence for the comparisons, optimum to near optimum atmospheric and pressurised gasifier operations have been obtained with the aid of a comprehensive mathematical simulator. This work may help to reach decisions concerning developments in the area of power generation based on biomass

Kadoli (2001) in his work of cogeneration system explained the fact that is a proven technology for process industries where heat and electrical power are the major energy inputs. In today’s economic crisis where focus is on energy conservation and concern for environment, the cogeneration system is an important technology. The economic viability of a cogeneration plant is largely dictated by a careful balancing of heat and power output. For industries where the requirement for steam for process also exists, as fertilizer, paper, petrochemical and sugar industries, cogeneration of power and process steam is the obvious choice. By careful study of the thermodynamic layout of the system, the gains are realized. Inlet steam parameters normally used for small industrial power plants vary between 40 bars to 106 bars in pressure and 400°C to 520°C in temperature. There are various combinations possible within these limits of pressures and
temperatures. Selection of these parameters is normally dependent upon the fuel and the type of the boiler used in the plant. One more aspect that has to be analyzed in detail is the exhaust steam conditions which vary from industry to industry depending upon their process steam requirement.

In cogeneration applications, where large quantities of steam are extracted for the process, it is essential to check whether the extracted steam can be used directly in the process without a further loss of power. Pressure Reducing and De superheating station (PRDS), extraction conditions are dependent upon inlet parameters and turbine efficiency. Hence, it is important to determine these parameters in such a manner that the maximum output power is within acceptable limits of extraction pressure and temperature to suit the process applications.

The concepts of thermodynamic analysis of cogeneration plants are given by Horlock. The present study relates to the performance analysis of cogeneration plants concerning the extraction type steam turbine operations at different inlet steam pressures and with constant condenser pressure. The performance parameters, like energy utilization factor (EUF) and overall efficiency were analyzed with useful heat to work ratio.

Shell (1995) has pointed out that until the end of the 90’s there was no interest from the owners of sugar mills in selling surplus electricity generation to the grid. Local utilities also did not consider seriously this option. Despite the commercial availability of more efficient cogeneration systems, cultural aspects and the lack of an institutional framework did not allow its implementation in the sector. Nowadays, the situation has changed in Brazil. The Brazilian development bank (BNDES) launched a program, allowing special credits for biomass power plants that will generate electricity and sell the electricity surplus to utilities or engage in its direct
commercialization, encouraging the introduction of more efficient technologies.

The PROINFA plan is divided into two phases. In the first phase within the first 24 months after the law dismissal, long-terms contracts (of 15 years) are supposed to be made over 3,300 MW by the eletrobras (holding of the Brazilian power system). Fixed amount is supposed to be achieved equally by the following energy sources: wind power, small hydropower projects and biomass. The acquisition of this energy will be defined by the economical value for each specific technology. This value is calculated by the execution force and is represented by the average 80% of the total energy expenditure.

Mock et al (2002) has proposed in November 2002 in his report on “Biomass Fed Fuel Cells” which was prepared for the Ohio biomass program, focused on biomass in general and outlined the system that might be used to convert these renewable into energy using fuel cells. By adopting this technology which is now in large scale, improves energy efficiency in the distributed power generation and thus flexibility of feed can be achieved.

The improvisation has to be done by using different fuels, basically starting with the liquid fuels. Normally the new approach is nothing but converting the bio waste into hydrogen and then use that along with air to produce electricity. The hydrogen conversion is made in this way produces minimal pollution and reduces green house gases. End products in this case are pure water and corbondioxide. Fuel cell process is more efficient than combustion in the production of the electricity, but analogous technique is normally very tedious and requires lot of technical details. This is usually taken as a tedious process. General trend is that alternative fuel is considered considering cost in to account.
Hall and Rosillo-Cale (1998) have developed a theory that alternative fuel used in gasifiers are solid mass which are considered as large potential source but are very slow in combustion. In this system gasifier is used for the conversion. It also states that present day technology using solid biomass for the conversion of electricity lot of constraints and logistics and the economics have to be taken into account. Environmental impacts are also to be considered.

For the effectiveness in using the solid mass as fuel as we have to consider moisture percentage. This reduces efficiency of power generation by requiring heat input to bring the reactor to operating temperature and evaporate the water. Bio waste could also be feed to a gasifier to produce gas (producer gas) which would be further processed into hydrogen. Pyrolysis is another option for the biomass/biowaste. Oil results from the high temperature treatment of biomass in the absence of oxygen. This oil can then be fed to a reformer where steam and air or oxygen is added to produce hydrogen and CO₂. Pyrolysis oil would be a way to collect and concentrate biomass for a central processing plant that produces hydrogen.

Marteli et al (2002) has suggested that biogas plant design could be optimized for the overall cost rather than merely for the cost of the mild steel in the construction of the biogas floating drums. By each changes it was possible to look at the underlying processes, conversion efficiencies, physiochemical changes, mass balance, heat balance, nutrient conservation, microbial changes etc. This really helped in minimal construction costs due to relative simple design and changes were accepted readily which brought down the biogas plant costs by 40% and made it an important contribution at that time.

Although the overall biogas yielding is maximum its reaction is mildly exothermic, the conventional digesters do not heat up. Many methods
are put forward for using biomass for biogas. The method of adopting this is
digester type where each digester has its own designing for the conversion. In
reality, such powdered biomass slurries inevitably very difficult to convert it
in to suitable matter and another problem relating is after conversion it will
not be useful to any person.

Ravindranath and Chanakya (1986) have proposed the fact that
anaerobic digestion of animal waste in biogas plants for energy, manure and
sanitation has made a significant impact in quality of rural life wherever it has
been deployed. Scarcity of animal dung resources limits the use of this
technology to only an eighth of the overall Indian rural population. Yet the
convenience of a biogas plant in rural households has led R&D efforts to
extend the use of biogas plants to other biomass feedstock and rural residues.
Fermenting typical biomass residues in conventional slurry-based biogas
plants has been far from successful.

Most attempts to convert rural biomass residues into ‘flowable’
slurries like animal dung have rarely been successful. Alternative concepts
were required. Achieving successful quasi-continuous fermentation of
biomass residues has come through a break away from the ‘slurry’ fixation
and animal dung digester designs of the past. A better understanding of the
underlying processes has greatly helped evolve new fermentation concepts.
Success has emerged only through use of multi-stage processes, where key
fermentation properties of biomass feedstock have been acknowledged and
digesters designed accordingly.

The processes of biogas and biomass fermentation, developing new
techniques and technologies to ferment biomass feedstock and efforts at
simplifying the technology to enable sustainability carried out at the Centre
for Sustainable Technologies, IISc, Bangalore is described. Finally,
integration of the two or three fermentation steps into a single reactor
configuration has enabled evolving simple-to-use digester designs for biomass feedstock, namely the plug flow and the solid-state stratified bed digesters.

ASTRA scientists tried not to implement biogas production with the powdered biomass residues. They tried to use low-energy alternative method for biomass conversion. The floating property of the biomass became the critical issue and thus required new fermentation processes

Mann and Spath (1997) have carried out the work with respect to stem diameter and production of biogas yield. This study is stated as very important in the catchments area where we have the condition of rainfall is observed. Hard wood is taken as bio feed in this area. In this method surface area and biomass is sampled together. Usually wood and bark are included for the estimation. Recently surface area alone is considered for the productivity calculation.

Any type of biomass is a renewable energy source, since the energy it contains is from the sun. From the time of Prometheus to the present, the most common way through, to heat, steam and electricity is by burning. But advances in recent years have shown that there are more efficient and cleaner ways to use biomass it can be converted to liquid fuels in a process called gasification to produce combustible gases. Certain plants are planted for this purpose which is generally termed as energy crops. The conventional way of converting biomass to energy, practiced for thousands of years, is by burning. This is how most of the biomass is put to use, in the United States and elsewhere. The heat can be used directly, for heating, cooking and industrial processes or indirectly to produce electricity. The problem with burning biomass is that some percentage of the energy is wasted and if it is not carefully controlled that it can cause some pollution.
Estimates of the ultimate potential for biomass energy vary, and depend on agricultural forecasts, waste reduction by industry and paper recycling. The department of energy believes that it is possible to produce four percent of our transportation fuels from biomass by 2010 and as much as 20 percent by 2030. Researchers envisage that energy crops and crop residues alone could supply as much as 14 percent of our power needs.

Stephen Karekezi (2000) has suggested that technology of traditional charcoal, production releases uncontrolled fires, which destroy biodiversity and contribute to regional air pollution. Traditional biomass is considered to be a major contributor to deforestation and land degradation. Traditional charcoal production is also inefficient process, resulting in significant loss of energy in the conversion of wood fuel to charcoal. Some of the key challenge faced by the developing countries depends heavily on traditional use of biomass, are

(i) Ensuring the biomass used is sourced from sustainable biomass resource.

(ii) Adaptation of improved biomass technologies that use a wide range of biomass resources to generate high quality fuels, gases and electricity.

There are several advantages of using improved biomass technologies such as more efficient cook stoves these advantages are not only limited the reduction of local pollution but also because more efficient biomass conversion technology can reduce the negative deforestation impacts of traditional charcoal production.

Other benefits from the use of Improved Biomass Technologies (IBTS) include the alleviation of the burden placed on women and children in
fuel collection, and reduced fuel collection time. This can also helps the rural women to educate their children in their leisure time.

The growth of the biomass resources can also poses several challenges 1). Inappropriate high-input mono cropping can result in the loss of biodiversity, soil fertility and land degradation, and can be accompanied by the use of fertilizers and pesticides, which could lead to pollution of underground and surface water sources. 2). It could lead to competition for land between food production and biomass resources. Although useful long term scenarios of potential conflict between food and biomass energy plantations have been undertaken, available data is not sufficient conclusive. Aditional research is required to provide a more nuanced (feeling) and disaggregated understanding of the challenge.

The development of modern biomass energy often requires significant capital investments and technical expertise, which may not be readily available in many developing countries. This can be a major barrier for the co-generation of electricity. One of the main challenges faced in modern biomass use is the extent to which it can compete on cost and reliability with conventional fossil fuel options both for transportation and for electricity supply.

There is, however, a growing body of assessments of national implementation programs demonstrating in an unequivocal fashion, that modern large-scale biomass energy systems are fully proven on both economic and technical grounds. Examples include bio fuels in Brazil; co-generation using a wide range of agro-residues (using wood residues, sugarcane bagasse, rice husks, etc.). In addition, there are cases where the legal and regulatory framework in place does not support the development of modern biomass energy technologies. This has been a major barrier, for
example, in the co-generation of electricity for sale to the national grid by sugar companies.

Anil and Rajvanshi (1986) have carried out an experiment on the production of generator gas (producer gas) by a gasification process which is partial combustion of solid fuel (biomass) and takes place at temperatures of about 1000°C. The reactor is the gasifier. The combustion products from complete combustion of biomass generally contain nitrogen, water vapor, carbon dioxide and surplus of oxygen. However in gasification where there is a surplus of solid fuel (incomplete combustion) the products of combustion are combustible gases like Carbon monoxide (CO), Hydrogen (H₂) and traces of Methane and non useful products like tar and dust. The production of these gases is by a reaction of water vapor and carbon dioxide through a glowing layer of charcoal. Thus the key factor in gasifier design is to create conditions such that (i) biomass is reduced to charcoal and, (ii) charcoal is converted at suitable temperature to produce CO and H₂.

The condition of gasification is similar to the pyrolisis of the wood. According to Chandrakant Turare (2003) gasification is basically a thermochemical process which converts biomass materials into gaseous components. The results of gasification are the producer gas, containing carbon monoxide, hydrogen, methane and other inert gases. Mixed with air, the producer gas can be used in gasoline or diesel engine with little modifications.

Based on the design of gasifiers and the type of fuels used, there are different kinds of gasifiers. Portable gasifiers are mostly used for running vehicles. Stationary gasifiers combined with engines are widely used in rural areas of developing countries for the purpose of generation of electricity and running irrigation pumps. Relating to gasification almost all kinds of biomass with moisture content of 5-30% can be gasified, however, not every biomass fuel can lead to the successful gasification. Most of the development work is
carried out with common fuels such as coal, charcoal and wood. It was recognized that fuel properties such as surface, size, shape as well as moisture content, volatile matter and carbon content influence gasification.

Hallgren et al (1993) has adopted Integrated Gasification Combined Cycle (IGCC) for gasification. In this new type of gasifiers suitable for gasification of biomass, so called alternative solid fuels being developed. The system includes an integrated hot gas clean up system that forms the basis for the activities of the gasification.

One of the main technical issues is the gas cleanup process for clean gas utilizations and IGCC (Integrated Gasification Combined Cycle) concepts. Potential advantages are expected if the gas cleaning process can be accomplished at enhanced temperatures. Available options for integrated hot gas cleanup are being tested ranging from particulate removal to emission control.

At present about 80% of the energy consumption during the European Union is from the use of fossil fuels. Within the power and heat production, 40% of the production is produced from coal utilisation. These production systems have often modest efficiency and contributed a large extent to the global emissions of nitrogen oxides, sulphur oxide, carbon oxide, and particulate matter. Until today natural gas and fossil fuels have been regarded as the most economic and appropriate fuel for heat and power production.

The project work is collaborative work between Coal Research Establishment (CRE) in the UK, Deutsche Montan Technologic (DMT) in Germany, and LIT in Sweden. The objective of the project is to collect end-user oriented information for process development in advanced thermochemical conversion of biomass. Integrated pressurized hot gas cleansing
units at DMT and LIT have been provided with different filters so as to find the most suitable filtering system for biomass gasification purposes.

Maniatis and Buekens (1982) have improved the gasification process. The procedure can substitute fossil fuels in high efficiency power generation. The main applications, is the production of liquid fuels and chemicals by synthesis gas. Gasification technology consists of several unit operations, the most critical of which is gas cleaning and conditioning for utilisation in power production engines.

Numerous types of gasifiers have been developed and tested and many industries can use the technology. Significant progress has been achieved over the last five years and some applications are on the threshold of chief commercialization. However, for most of the applications the efficient and economic removal of tar is the main technical barrier to be overcome.

Biomass fuels and residues can be converted to energy by thermo chemical and biological processes. Biomass gasification has attracted the highest interest among the thermo chemical conversion technology as it offers higher efficiencies in relation to combustion while flash pyrolysis is still in the development stage.

Pressurized fluidized bed systems either circulating (PCFBG) or bubbling (PBFBG) are considered of less market attractiveness due to the more complex operation of the installation and to the additional costs related to the construction of all pressurized vessels. On the other hand, pressurized fluidized bed systems have the advantage in integrated combined cycle applications as the need to compress the fuel gas prior its utilisation in the combustion chamber of the gas turbine is avoided.
Atmospheric Downdraft Gasifiers (ADG) are attractive for small scale applications (<1.5 MW) as there is large scope not only in developed but developing economies also. However, the problem of efficient tar removal is still major problem to be addressed and there is need for more automated operation especially for small scale industrial applications. Nevertheless, recent progress in catalytic conversion of tar gives credible options and ADG can therefore be considered of average technical strength.

Atmospheric Updraft Gasifiers (AUG) have practically no market attractiveness for power applications due to the high concentration of tar in the fuel gas and the subsequent problems in gas cleaning. Presently there is no company proposing AUG for power utilizing. For large scale applications the preferred and most reliable system is the circulating fluidized bed gasifier while it is for the small scale downdraft gasifiers. Bubbling fluidized bed gasifiers can be competitive in medium scale applications.

Jared Ciferno John and Marano (2002) have analyzed the computer models for gasification. Computer models were developed of the BCL (Battelle Columbus Laboratory) biomass gasifier. It became apparent during this analysis that the BCL gasifier may not be the best match of biomass gasification technology to downstream conversion technology for liquid fuels, chemicals or hydrogen production. The BCL gasifier has only been demonstrated at relatively low operating temperatures and near-ambient pressures, conditions.

Directly heated circulating fluidized bed (CFB) gasification of biomass has not been demonstrated to the same extent as bubble fluidized bed (BFB) gasification. Very few demonstrations have been carried out at elevated pressures, and all results reported are for temperatures less than 1000°C. Demonstrations have not been conducted using pure oxygen as the oxidant.
Fixed bed biomass gasifiers have also been demonstrated at a limited range of temperature. Because of their tendency to produce large quantities of either tar or unconverted char, they have not been prime candidates for further development.

Indirectly heated biomass gasification systems, both CFB and BFB are at an earlier stage of development, and their flexibility for a variety of applications has not been explored. They are inherently more complicated than directly-heated systems, due to the requirement for a separate combustion chamber, but they can produce a syngas with very high heating value, ideal for combined heat and power (CHP) applications. These systems, CFB (direct and indirect) and BFB (indirect), require further development in order to be considered suitable for fuels, chemicals and hydrogen.

Biomass gasification is the conversion of an organically derived, carbonaceous feedstock by partial oxidation into a gaseous product, synthesis gas or “syngas,” consisting primarily of hydrogen (H$_2$) and carbon monoxide (CO), with lesser amounts of carbon dioxide (CO$_2$), water (H$_2$O), methane (CH$_4$), higher hydrocarbons (C$_{2+}$), and nitrogen (N$_2$). The reactions are carried out at elevated temperatures, 500-1400°C, and atmospheric or elevated pressures up to 33 bar (480 psia). The oxidant used can be air, pure oxygen, steam or a mixture of these gases. Air-based gasifiers typically produce a product gas containing relatively high concentration of nitrogen with a low heating value between 4 and 6 MJ/m$^3$ (107-161 Btu/ft$^3$). Oxygen Steam based gasifiers produce a product gas containing a relatively high concentration of hydrogen and CO with a heating value between 10 and 20 MJ/m$^3$ (268-537 Btu/ft$^3$).

Srivasta and Pachauri (1990) have invented a new and staged gasification process, characterized by a close integration of the gas cleaning part. The unit and process use a new device named Total Char
Combustion and Tar Cracking Chamber (TCC) positioned between a pyrolysis unit (PYR) and a char reduction reactor (CRC), in a stage divided gasifier. The char conversion takes place in two steps. In the first step, the char produced in the pyrolysis unit (PYR) is introduced in the (CRC) whose main purpose is to convert as much as possible carbon of the char. The (CRC) belongs to the fluidized bed type. The second step takes place in the (TCC) whose purpose is to perform both a complete conversion of the remaining carbon still present after reaction in the chamber(CRC) and the thermal cracking of the tar contained in the pyrolysis gases, the residual ashes being vitrified simultaneously and eliminated as a slag.

Low grade feedstock like straw and bark with low melting point can be used. A new vibrofluidized pyrolysis unit is installed to achieve an appropriate and constant quality of char with a minimum preparation of the biomass, and offers the opportunity to orientate the process for gas or solid. The invention lead to the following advantages: higher tolerance toward different quality of feedstocks including low grade feedstocks, recovery of the residual carbon content in ashes; production of a clean gas (low residual tar, ashes and alkali) for a direct injection in an engine/turbine. These results will induce a higher efficiency to the process and consequently a better gasification technology.

Guehenneux et al (2003) has developed the concept of the gasification and pyrolysis of solid materials. Both these related technologies have been used extensively to produce fuels such as charcoal, coke and town or producer gas. Charcoal and coke are produced by pyrolysing wood and coal respectively and "producer gas" is generated, this being a combustible gas produced by the gasification of coke in the presence of air and steam.
It is only in recent years that such pyrolysis and gasification have been commercially applied to the treatment of municipal solid waste (MSW). Pyrolysis and gasification technologies are in its Infancy in the United Kingdom, but large scale plants have been built and are in operation in Europe, North America and Japan. The process of gasification is more efficient in producing controllable energy than combustion, and extract more useful energy from, carbonaceous materials than would be possible, by burning them. Coal gasification ensures reliable, cost-effective technology with good CO$_2$ management that will eventually gain a huge market. Using gasification to make renewable transportation fuels is winning favor and innovative technologies are rapidly emerging to gasify non-edible agricultural parts of plants to make CO$_2$-neutral bio fuels.

Scahill et al (2002) has analyzed the case of the gasifier using pure oxygen in combination with steam for the gasification. In this process there is no nitrogen and gas heating values may be up to 15-18 MJ/m$^3$. Also by the use of specially designed steam reformers and other advanced equipment, the gas can be tailored to give a desired composition. In most cases, the product gas from such advanced plants will be tailored to "synthesis gas" with specific ratio of CO to H$_2$ and no hydrocarbons.

Having such a gas one may proceed to a chemical synthesis like Fischer-Tropsch to produce propane, a diesel substitute, di-methyl-ether, and methanol or just about anything. Depending on if the gas composition is CO+H$_2$ or this gas is called "Syngas" Obviously, there is low heating value (LHV) and high heating value (HHV) and different cost levels associated with these types of gasification.

LHV gas is a low quality gas that is sufficient for furnace operation, it needs only a fairly simple gasifier and it takes minimal operating cost since it needs no steam, oxygen and advanced technologies. It can be
used directly in cars but the total efficiency in such an application is low, as the sensible heat in the gas is not used up. With a well insulated gasifier the losses are brought down to 5-25% depending on scale and consequently have 75-95% of the original fuel energy in the gas. In total maybe 30-50% as sensible heat and the rest is in the form of chemical energy. For electricity production, the use of solid bio fuels in combination with a conventional steam cycle is probably the most cost effective, and will remain.

The advanced gasification processes currently so favoured by research funding authorities will definitely have a role to play in the future. This is not applicable, for bulk products such as car fuels or electricity or direct heating however it will be in bio refinery applicable where the final product is more advanced.

Reto Hummelsho and Jens DallBentzen (2000) have proposed the concept in order to reduce CO$_2$ emissions to the atmosphere. It is the Danish and the European policy to increase the use of renewable energy for heat and power production. In Denmark, the government has decided that 20% of the electric power shall be produced by renewable energy by the end of 2002 (the present contribution is about 13%). In EU as a whole, there is a political decision of doubling the coverage of energy from renewable sources there is an increase from 6% in 1997 to 12% by 2010. Gasification of biomass is an important technology to achieve these political goals which are environment friendly and energy efficient by gasification of wood chips or straw, the solid fuel is converted to a combustible gas, which can either be used in an internal combustion engine, in a gas turbine or be burned in a combustion chamber e.g. in connection with an external steam super heater. Thus, biomass can be used for energy production with high electric and overall efficiency.
The economy of these plants is improved by the higher prices that can be obtained for electricity produced from CO₂ neutral sources, but the most important reason for a better economy is that biomass is substantially to be cheaper than natural gas. How much cheaper depends on the tax system of the actual country. In Denmark, for example, the overall cost of woodchips for use of combined heat and power plant is less than half of the overall cost of that of biomass gasification.

The first initiated development projects in Denmark were the following Updraft gasification of straw at the Kyndby power plant in order to utilize the gas in a gas engine for combined heat and power operation. Pyrolysis of straw at the town of Haslev with a view of using the pyrolysis gas in a separate steam super heater in order to increase the electricity output from straw and waste fired CHP plants with steam turbines. The system generates low heating value fuel gas at about 6–7 MJ/Nm³ (161–187.9 Btu/scf). The tars are cracked in a tar cracker with dolomite at 900°C. The fuel gas is cleaned by a filter and wet scrubbing. In addition, the ammonia is dissolved in water to reduce NOx formation from fuel nitrogen. According to TPS, the advantages of atmospheric pressure technology over pressurized technology are:

1. Less required development and reliable operation
2. Simpler fuel and ash handling systems
3. More reliable gas purification – use of gas scrubber ensures that the product gas is of sufficient quality for gas turbine operation
4. Higher heating value of the product gas
5. Supplementary firing of the heat recovery steam generator allows plant output to be boosted
6. Weak process coupling between gasifier and gas turbine
Rajvanshi (1986) has conducted several experiments and in his result his observation is that the modern agriculture is an extremely energy intensive process. However high agricultural Productivities and subsequently the growth of green revolution have been made possible only by large amount of energy inputs, especially those from fossil fuels. With recent price rise and scarcity of these fuels there has been a trend towards use of alternative energy sources like solar, wind, geothermal etc. However these energy resources have not been able to provide an economically viable solution for agricultural applications.

One biomass energy based system, which has been proven reliable and had been extensively used for transportation and on farm systems during World War II is wood or biomass gasification. Biomass gasification means incomplete combustion of biomass resulting in production of combustible gases consisting of Carbon monoxide (CO), Hydrogen (H\textsubscript{2}) and traces of Methane (CH\textsubscript{4}). This mixture is called producer gas. Producer gas can be used to run internal combustion engines (both compression and spark ignition), can be used as substitute for furnace oil in direct heat applications and can be used to produce, in an economically viable way, methanol an extremely attractive chemical which is useful both as fuel for heat engines as well as chemical feedstock for industries.

Since any biomass material can undergo gasification, this process is much more attractive than ethanol production or biogas where only selected biomass materials can produce the fuel. Besides, there is a problem that solid wastes (available on the farm) are seldom in a form that can be readily utilized economically e.g. Wood wastes can be used in hog fuel boiler but the equipment is expensive and energy recovery is low. As a result it is often advantageous to convert this waste into more readily usable fuel forms like producer gas, hence the attractiveness of gasification. However under present
conditions, economic factors seem to provide the strongest argument of considering gasification in many situations where the price of petroleum fuels is high or where supplies are unreliable. The biomass gasification can provide an economically viable system provided the suitable biomass feedstock is easily available.

Goss et al (1980) in his experiment clearly marked that biomass gasification provides a renewable basis for supplying not only direct energy products such as gaseous and liquid fuels, and electric power, but also a broad suite of chemicals such as Fisher-Tropsch liquids as well as hydrogen. A medium calorific value (MCV) gas is necessary to achieve the full potential of biomass gasification for fuels, chemicals, and hydrogen production. The Taylor gasification process, being developed by Taylor Biomass Energy is a biomass gasification process that produces a MCV gas. The Taylor gasification process provides improvements over currently available gasification processes by integrating improvements to reduce issues with ash agglomeration and provide in-situ destruction of condensable hydrocarbons (tars), an essential element in gas cleanup. The gas conditioning step integrated into the Taylor gasification process provides a unique method to convert the tars into additional synthesis gas and to adjust the composition of the synthesis gas to significantly increase its hydrogen to carbon monoxide ratio. Testing has shown that approximately 90% of the tars can be removed by the gas conditioning step providing a synthesis gas suitable.

Taylor Biomass Energy has developed an advanced, indirectly heated gasification process that effectively converts the tars in the gas to non-condensable, lower molecular weight species. This removal allows a higher level of the sensible energy contained in the synthesis gas to be recovered while simplifying any secondary conditioning of the gas that might be necessary.
Paul et al (1997) has related a distributed power generation system that has evolved at the Indian institute of Science, Bangalore. The technological and field-related experience pertaining to open top re-burn down draft biomass gasification system coupled with the internal combustion engine or thermal device are brought out. The gasifier reactor design uses dual air entry air nozzles and open top to help in establishing a thick temperature zone to remove the contaminants in the product gas; a gas clean-up system to further refine the gas to ultra-pure quality. These elements are integrated with other sub-systems, namely feedstock preparation, and other accessories to form an independent power producer. Based on this technology there are over 30 units operating in India and abroad, with an accumulated capacity of over 20 MW. Over 80,000 h of operation of these systems have resulted in a saving of about 350 tons of fossil fuel, implying a saving of about 1120 tons of CO$_2$ a promising candidate for Clean Development Mechanisms (CDMs), other than reduction in toxic gases like NO$_x$ and SO$_x$ (Appendix 7).

Reto Hummelshoj and Jens DallBentzen (2000) was projected that the biomass energy is now accepted as having the potential to provide the major part of the renewable energy provisions of the future in order to contribute to the stainable development of our world. The biomass gasification is one of the most efficiently form to use the energy from biomass. The gasification process for the electricity generation Cuban biomass potentials is used. Tar free downdraft gasifier is used for the production of medium power gas.

The Sugar Industry and the rail road depleted most of Cuba’s tropical forests at the beginning of the 20th Century. The remaining forests are subject to severe protection by the government. Still large amounts of waste biomass resulting from the agriculture, or the industries, that do not have yet a proper disposal and a productive use. Among those is the rice
husks produced in industrial rice mills, most of the sugar cane straw produced at the sugar factories preprocessing plants, and the sawdust produced in the carpentry workshops.

Marabou tree is very good source of energy that is, it’s calorific power are for a dry wood: 4,250 kcal / kg, for a wet wood: 3,250 kcal / kg and an average of 3,750 kcal /kg. If we compare this value with the calorific power of the biomass that has the most extensive use in Cuba as source of energy, the sugar cane bagasse (1,800 kcal/ kg), we obtain that value of the Marabou is more than two times energetic than the bagasse.

Maniatis and Buekens (1982) has developed gasification technology which consists of several unit operations, the most critical of which is gas cleaning and conditioning for utilisation in power production engines. Biomass fuels and residues can be converted to energy via thermo chemical and biological processes. Biomass gasification has attracted the highest interest among the thermo chemical conversion technologies as it offers higher efficiencies in relation to combustion while flash pyrolysis is still in the development stage. For heat applications there is no need to eliminate the tar from the fuel gas and thus any reliable gasifier system can be used successfully. However, although heat applications are relative easy, there are very few examples in the market. Woody biomass has the highest reliability in feeding into a gasifier and most problems related to fluidized bed gasifier is slag formation on heat exchange surfaces.

John Marano Martha and Rollins (2002) have experimentally verified the fact that most biomass fuel power generators use direct-combustion boilers coupled with steam turbines. These generators typically possess a biomass combustion chamber with equipment to evenly distribute biomass fuel over a grate which separates the ash from the burning biomass. The generated heat creates steam in an adjoining high-pressure water tube
boiler which feeds process steam through a multistage steam turbine. Generator uses a primary chamber devoid of air to gasify the biomass, which then passes into a secondary combustion chamber where the gas is used to produce heat. These plants tend to be inefficient, small, and expensive compared to traditional power generation from coal and natural gas. However, a more efficient and less expensive form of biomass power is known as a combined-cycle biomass gasification system. Biomass is converted to a gas, in an atmosphere of steam or air, and produces a medium to low-energy content gas. This biogas powers the combined-cycle power generation plant similar to the simple cycle. The direct losses in this case are reduced.

Lopamudra Devi et al (2004) has proposed that tar formation is one of the major problems to deal with during biomass gasification. Tar condenses at reduced temperature, thus blocking and fouling process equipments such as engines and turbines. Considerable efforts have been directed on tar removal from fuel gas. Tar removal technologies can broadly be divided into two approaches; hot gas cleaning after the gasifier (secondary methods), and treatments inside the gasifier (primary methods). Although secondary methods are proven to be effective, treatments inside the gasifier are gaining much attention as these may eliminate the need for downstream cleanup. In primary treatment, the gasifier is optimized to produce a fuel gas with minimum tar concentration.

The different approaches of primary treatment are

(a) proper selection of operating parameters,

(b) use of bed additive/catalyst, and

(c) gasifier modifications. The operating parameters such as temperature, gasifying agent, equivalence ratio, residence time, etc. play an important role in formation and decomposition of tar.
There is a potential of using some active bed additives such as dolomite, olivine, char, etc. inside the gasifier. Ni-based catalysts are reported to be very effective not only for tar reduction, but also for decreasing the amount of nitrogenous compounds such as ammonia. Also, reactor modification can improve the quality of the product gas.

David Sutton et al (2001) in his research work proposed that biomass gasification is a possible alternative to the direct use of fossil fuel energy. Biomass, a CO$_2$ neutral source of renewable fuel, can contribute to the demand for heat, electricity and synthesis gas. However, there are inefficiencies in the technology, which at present render biomass gasification economically unviable. The presence of condensable organic compounds and methane in the product gas renders the gas unsuitable for specific applications. Elimination of the condensable organic compounds and methane by a suitably cheap technology will enhance the economic viability of biomass gasification.

Peter Mckenery (2002) has stated that the use of renewable energy sources is becoming increasingly necessary, to achieve the changes required to address the impacts of global warming. Biomass is the most common form of renewable energy, widely used in the third world but until recently, less so in the Western world. Latterly much attention has been focused on identifying suitable biomass species, which can provide high-energy outputs, to replace conventional fossil fuel energy sources. The type of biomass required is largely determined by the energy conversion process and the form in which the energy is required. In the first of three papers, the background to biomass production (in a European climate) and plant properties is examined. In the second paper, energy conversion technologies are reviewed, with emphasis on the production of a gaseous fuel to supplement the gas derived from the landfilling of organic wastes (landfill gas) and used in gas engines to generate
electricity. The potential of a restored landfill site to act as a biomass source, providing fuel to supplement landfill gas-fuelled power stations, is examined, together with a comparison of the economics of power production from purpose-grown biomass versus waste-biomass

Dinesh Mohan et al (2006) in his study proposed that fast pyrolysis utilizes biomass to produce a product that is used both as an energy source and a feedstock for chemical production. Considerable efforts have been made to convert wood biomass to liquid fuels and chemicals since the oil crisis in mid-1970s. This review focuses on the recent developments in the wood pyrolysis and reports the characteristics of the resulting bio-oils, which are the main products of fast wood pyrolysis. Virtually any form of biomass can be considered for fast pyrolysis. Most work has been performed on wood, because of its consistency and comparability between tests. However, nearly 100 types of biomass have been tested, ranging from agricultural wastes such as straw, olive pits, and nut shells to energy crops such as miscanthus and sorghum. Forestry wastes such as bark and thinings and other solid wastes, including sewage sludge and leather wastes, have also been studied. In this review, the main (although not exclusive) emphasis has been given to wood. The literature on wood/biomass pyrolysis, both fast and slow, is surveyed and both the physical and chemical aspects of the resulting bio-oils are reviewed. The effect of the wood composition and structure, heating rate, and residence time during pyrolysis on the overall reaction rate and the yield of the volatiles are also discussed. Although very fast and very slow pyrolyses of biomass produce markedly different products, the variety of heating rates, temperatures, residence times, and feedstock varieties found in the literature make generalizations difficult to define.

Avdhesh Kr. and Sharma (2011), in their study proposed, an EQB computer program for a downdraft gasifier has been developed to predict
steady state performance. The objective is to develop a theoretical model of a downdraft gasifier system and to develop an efficient algorithm that allows rapid convergence and adequate accuracy of precisions. The model was developed in three stages. In the first stage, fluid flow module is carried out, second stage corresponds to heat transfer module and in third stage, the physical and chemical phenomena take place due to biomass drying, pyrolysis, oxidation and reduction reaction sub-process. None of the approaches like application of thermodynamic equilibrium, chemical kinetics, etc have clear advantage over the other. The modules that constitute the gasifier model have been validated against the experimental data. The predictions of fluid flow module for pressure drop in cold flow have also been validated. The predictions for the same range of particle sizes are in reasonable agreement with measured values of pressure drop for the case of extinguished gasifier. The drawback of this work is that for a freshly charged gasifier, the predictions deviate slightly at higher flow rates.

Kumararaja et al (2010) has developed a versatile, throat type biomass gasifier. This had facilities for bed temperature measurements, pressure measurements, physical observation, sampling of bed particles, etc. When the biomass bed height was increased in the gasifier by means of excessive feeding, the reaction front propagated upwards in the bed. This happened despite maintaining air flow rate constant. The reaction front can be made dynamic by either regulating the air flow rate or the biomass bed height or both.

Al Seyab et al (2006) has proposed a Model Predictive Control (MPC) can explicitly handle MIMO systems with input and output constraints. ALSTOM gasifier is a complicated non-linear process and issues related to benchmark control problem are high order, high non-linearity, strong interactions among process variable. The case study shows that the
model is also adequate to pass all tests under other load conditions specified in the benchmark problem and the performance deteriorates at 50% and 100% load conditions due to using a model liberalized at 0% load point.

Avdhesh Kr. and Sharma (2009) have conducted an experimental study on a 75 kWth, downdraft gasifier system has been carried out to obtain temperature profile, gas composition, calorific value and trends for pressure drop across the porous gasifier bed, cooling–cleaning train and across the system as a whole in both firing as well as non-firing mode. In firing mode, the pressure drop across the porous bed, cooling–cleaning train, bed temperature profile, gas composition and gas calorific value are found to be sensitive to the gas flow rate. The rise in the bed temperature strongly influences the pressure drop through the porous gasifier bed. In firing mode, the higher temperature in bed tends to better conversion of non-combustibles component (like CO₂, H₂O) into combustible component (like CO, H₂) in the resulting gas. This improves in the calorific value of product gas.

Zhao et al (1992) has proposed a fuzzy controller for solving difficulties involved in controlling a complex process under dynamic conditions. A fuzzy knowledge acquisition system is used for self generation of fuzzy if-then control rules. This is linked to the rule base. Also, a self-learning predictive system is made for updating the fuzzy sets for defining the control rules. This is linked to the data base. The fuzzy knowledge acquisition and self-learning predictive systems are implemented by an expert system shell and a predictive module. With the help of these systems, the control of biomass conversion is carried out. Here, the self generation of the rule base is achieved through structure identification with an expert system shell.

Shi Jingzhuo et al (2011) has developed model based on the experimental data, the two-input and one output dynamic model for speed control of ultrasonic motor is worked out using dynamic fuzzy modeling
method. The model structure and parameters are identified using equalized universe method and the least-square method, respectively. Using the proposed modelling methods, a few fuzzy rules are also proposed. The structure of the model is simpler and the amount of online calculation is smaller. Comparison between model output and tested data shows that the model can well simulate the nonlinear relationship among the amplitude of driving voltage, frequency, and rotating speed.