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Opportunities in Biomass to Liquid Fuel: A review

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Abstract— **The humankind is currently confronted with the twin crises of petroleum products exhaustion and ecological ruin. Excessive use of fossil fuels has major local, regional and global environmental impacts are air pollution, acid rain and airborne pathogens, global warming, respectively. our natural resources will be exhaust up to end of the this century if we are using fuels as a current rate. Due to this reason rate of crude oil is increasing day by day , which are effecting major economy of the various country including India. Researcher and Scientists are finding alternative and renewable energy methods to complete our energy requirement.**

The FT(Fischer Tropsch) process plants can be use natural gas, coal, biomass or mixtures as feedstock. Technical data and technological and economic assumptions for developments for 2020 were derived from the literature. For emergent nations like India, meeting energy requirements (primarily in the form of electricity and transportation fuels) in various sectors such as agriculture, industrial and transport is very important to attain sustainable development and economic development. Various options for decentralized electricity production from beginning to end renewable sources include solar, wind, biomass gasification and small hydropower projects. However, from Indian point of view, biomass gasification is the most practicable alternative amongst these for various reasons(1) biomass is abundantly and evenly spread in the country, (2) it is available throughout the year at cheap rates, (3) capital investments for gasifier, duel fuel or 100% producer gas generator, gas cleaning system and other accessories are quite low, (4) technology is simple and unskilled/semi skilled labor can handle operation and maintenance of the plant.

Index Terms— **Biomass, Fischer Tropsch process, Biomass to Gas ,Biomass to Liquid, Fuel , Pyrolysis, Carbon , Methanol ,Syngas**

I. INTRODUCTION

1.1 Natural gas significance in world

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Enormous consideration in last decades to keep away from crude oil collapse in next century. By means of the improbability of existing petroleum reserves and increasing load for energy assets, renewable or alternative fuels have drawn If our energy requirement is increasing as current rate now a days [1] .Natural gas has played a very important function of the world's supply of energy for years. As a fossil fuel, natural gas is commonly used as an energy source for heating, cooking, and electricity generation. In broad way, natural gas is odourless and colorless in its pure type and it exists as a burnable mixture of numerous hydrocarbon gases, which frequently contains about 80–95% (v/v) methane mixed with other heavier alkanes such as ethane, propane, butane and pentane

One of the major obstacles for the production of renewable fuels will be the supply of feedstock [2]. Conversely, more than 1.1 × 1014 ft^3 (1 ft^3 gas is equal to 1000 Btu and 0.008 GGE) According to the Twelfth Plan document of the Planning Commission of India indicates that overall domestic energy production of 669.6 million tons of oil equivalent (MTOE) will be reached by 2016-17 and 844 MTOE by 2021-22. This will meet around 71% and 69% of estimated energy consumption, with the balance to be met from imports, projected to be about 267.8 MTOE by 2016-17 and 375.6 MTOE by 2021-22[3].

The technology of the renovation of natural gas into hydrocarbon liquid fuels has been comprehensively researched and developed for last century. On a worldwide range, investigation of this technology has long-drawn-out even more in recent last decade duration, since more natural gas has been found in remote sites where gas pipelines may not be cost-effectively justified yet. Recently, Fischer–Tropsch (FT) technology has gathered increased attention for the conversion of natural to liquid products [4][5]. However, the gas to liquid (GTL) technology require syngas generation, syngas conversion and hydro processing. Besides the technological hurdles, the FT process also requires a extremely huge amount for successful industrialization, mostly due to the wants for huge manufacture amenities and sustainable gas make available[6]additionally, conventional FT technology can only accomplish carbon conversion efficiency (CCE) from 25 to 50% [7]. During the syngas steps, huge amount of energy and heat are involved, limiting the energy efficiency of this process [8,9]. hence alternative GTL processes, accomplished of given that high liquid production yield with higher CCE and lower energy or heat input, bear evaluation.[10]

For developing nations like India, meeting energy requirements (primarily in the form of electricity and transportation fuels) in various sectors such as agriculture, transport and industrial is very important to attain social growth, economic development and sustainable development. Electricity generation in India is conquered by coal thermal route [11]. Although total installed capacity for electricity generation is 148 GW (as on February 2009), it is far insufficient to meet up the requirements of peoples[12]. furthermore, deliver of electricity to far-flung regions and hilly terrains (particularly in the north eastern states) is not easy as expansion of grid to these places is not practical. Transmission losses are as high as 30% and fluctuations in voltage are ahead of tolerable limit [11,12]. Consequently, there is an urgent need to make the most of and encourage renewable energy sources in order to make these regions autonomous from grid supply [13].

A choice of options for decentralized electricity production from beginning to end renewable sources include wind, solar, small hydropower and biomass gasification projects. However, from Indian point of view, biomass gasification is the most practicable alternative amongst these for various reasons [14-19]: (1) biomass is abundantly and evenly spread in the country, (2) it is available throughout the year at cheap rates, (3) capital investments for gasifier, duel fuel or 100% producer gas generator, gas cleaning system and other accessories are quite low, (4) technology is simple and unskilled/semi skilled labor can handle operation and maintenance of the plant.

II. Biomass Gasification

Fluctuating prices of oil in the worldwide marketplace make condition even worse. Thus, there is also an urgent need of hunt for alternative and renewable fuels. Biomass gasification integrated Fischer Tropsch (BGIFT) synthesis is now being explored as an option for synthesis of liquid transport fuels [20-24]. Although Fischer- Tropsch (FT) reaction is more than a century aged, attention of scientific/industrial community in it is improved in past one and half decades [25-28], as it is a potential way to synthesize excellent quality transportation fuels. Producer gas from biomass gasification that contains carbon monoxide and hydrogen as main components could be a possible feedstock for FT synthesis. Conventionally, alkali promoted cobalt catalyst was used for FT synthesis, with producer gas feed in the molar ratio of H_2/CO. [29-32]However, extensive research has taken place in the past two decades to build up iron based catalysts that can handle "sub-stoichiometric" producer gas, which does not contain H_2 and CO in the required molar ratio. Other reasons which put thrust on use of renewable energy sources are fast running down of fossil fuels, and environmental pollution and greenhouse gas emission that contributes to global warming. As far as electricity production through thermal way is concerned, replacement of coal by biomass be capable of help reduce emission of CO_2 at a rate 0.85 kg/kWh. Replacement of 1 kg of petroleum derived diesel by FT diesel reduces the CO_2 emission by 3.2 kg [33].

Taking interested in consideration these two potential outlets for producer gas obtained from biomass gasification, it is essential to find optimum operating conditions for gasifier operation in terms of temperature, air ratio and composition of gasifying medium. The desired characteristics of producer gas for two applications, viz. power generation and FT synthesis, are different. In the former case, we have to find operating conditions beneath which the producer gas has maximum LHV, while in the latter situation, the H_2/CO ratio is important. In this paper, we have addressed the issue of optimization of biomass gasifier for the above two applications. Setup for biomass gasification There are two approaches for the modelling and optimization of biomass gasifiers, viz. kinetic and equilibrium.

Kinetic models take into account rate expressions for a variety of simultaneous and parallel reactions taking place in the gasifier even though kinetic models are physically more reasonable, In the first place, the reaction schemes may possibly not take into consideration all possible reactions taking place in gasification process. There is some divergence in the kinetic constants (for same reaction) reported by different authors. In addition, these models contain parameters related to the design of the gasifier. Any error in evaluation/ measurement of these parameters may perhaps direct to significant error in predictions of producer gas composition made by the model. furthermore, this aspect frequently renders the kinetic model system specific. Equilibrium models, on the contrary, are independent of design of the gasifier. Secondly, equilibrium models predict thermodynamic limits of gasifier performance under different conditions, which be capable of form helpful for design and optimization of the process. Input data required for equilibrium models. Major drawback of these models is that actual performance of gasifier (in terms of composition and quality of producer gas) may deviate from that predicted by the model, as total equilibrium conditions may not be achieved in the gasifier. But overall trends in molar composition and LHV of the producer gas predicted by the model for different combination of operating parameters stay essentially unchanged. Therefore, equilibrium models form qualitative guidelines for the design, optimization and improvement of the gasification process.

2.1 Non-stoichiometric & Stoichiometric model

The equilibrium models are sub categorized as non-stoichiometric and stoichiometric models. Stoichiometric models take into concern various reactions during gasification process and their equilibrium constants. Non-stoichiometric models are based on method of Gibbs free energy minimization to calculate the equilibrium composition of the species resulting from the reaction between gasifying medium and biomass. Comparing between these two approaches, we find that stoichiometric models suffer from drawback that equilibrium constant for all reactions in the gasification process may not be accessible. Secondly, the suitable range of temperature and pressure for the equilibrium constants possibly will be inadequate, which restricts scanning of extensive parameter space for function of the gasifier. Non-stoichiometric models have distinct advantages such as simplicity in handling of feed streams with unknown molecular formula and unknown chemical species.

III. Literature review

Earlier authors have used both non-stoichometric and stoichiometric approaches for equilibrium modelling of biomass gasifier system. We give here with a concise review of the literature in this area. Denn et al. [34]. have examined the parametric sensitivity of a movable bed coal gasifier using kinetic-free or equilibrium model for the effluent gas composition and temperature. Cousins [35] . had investigated thermodynamic study of wood gasification process in both co-current and counter current method with air steam and oxygen steam a gasification medium in order examine relative merits and demerits of both systems. Buekens and Schouters

[36]. have suggested use of equilibrium models for design of coal and biomass gasifiers, as these models give significant results with least parameters. Shand and Bridgwater [37]. have reviewed thermodynamic models for downdraft gasifiers that integrate feedstock composition, moisture, HHV, heat losses, excess oxidant and extent of shift reaction as parameter. They pointed out difference between actual and theoretical equivalence ratio for matching the theoretical and experimental product gas composition. Kosky and Floess [38]. have found close correlation between product gas composition in oxygen or air blown fixed bed coal gasifier with that predicted using simple equilibrium model. Kovacik et al. [39]. have estimated product gas composition in entrained flow and fluidized bed gasifiers using equilibrium model for varying feed and operating conditions. Watkinson et al. [40]. have used equilibrium thermodynamic model for prediction of gas composition and yield from coal gasifiers. A evaluation of the experimental data from 9 semi -commercial and commercial gasifiers with speculative results from models has given reasonable agreement. Shesh and Sunawala [41]. have studied the air steam gasification of Bombay city municipal refuse at pressures 50 bar and temperature 1000 C using equilibrium models. They have also attempted to optimize functioning atmosphere based on calorific values and potential heat output of producer gas. Kinoshita et al. [42]. have attempted to optimize operational conditions for biomass gasification for methanol production using equilibrium model. Gururajan et al. [43]. have published a wide-ranging review of the models for fluidized bed gasifiers. They have also stressed that design and operation of gasifier requires understanding of the influence of fuel and operating parameters on plant performance. For this purpose, equilibrium models are perhaps best suited. Garcia and Laborde [44]. have calculated steam reforming of ethanol using an equilibrium model to assess effect of temperature, pressure and ethanol steam feed ratio. Schuster et al. [45]. have performed simulations of a biomass gasification system comprising of dual fluidized bed steam gasifier for decentralized heat and power generation. Carapellucci [46]. has reported thermodynamics and economics of biomass drying operation using waste heat from biomass turbine exhaust. Ruggerio and Manfrida [47] have predicted performance of a gasifier (like as overall efficiency and product gas composition) using an equilibrium model. They have also compared their results with trial data Zainal et al. [48] have studied performance of a downdraft gasifier for different biomass materials using equilibrium modeling. Especially, effect of moisture and gasification temperature content of biomass on product gas composition was studied. Melgar et al. [49]. have proposed an equilibrium model for thermo-chemical processes in downdraft gasifier. This model combines thermodynamic and chemical equilibrium of the worldwide reactions for forecast of producer gas composition. manipulate of parameters such as air/fuel ratio in gasifying medium and moisture content of biomass is also studied. Alderucci et al. [50] have done equilibrium analysis of biomass gasification with mixture of CO_2 and steam as gasification media. of Narvaez et al [51] Bharadwaj [52] has used the STANJAN program based on element potential method (Reynolds [53]) for prediction of gas composition resulting from pyrolysis of rice shell. Altafini et al. [54] have used a chemical equilibrium model to predict the performance of a downdraft wood gasifier, and have also assessed effect of moisture content in fuel on producer gas composition. Li et al. [55]have proposed an equilibrium model for circulating fluidized bed biomass gasifier. This model employs RAND algorithm of Gibbs energy minimization (Smith and Missen [56]). They found that product gas composition and heating value varies mainly with temperature and relative abundance of the key elements in biomass, viz. C, H, N and O. Li et al. [55] have also combined their equilibrium model with kinetic models, where the carbon conversion in equilibrium conversion would be preset according to the predictions of kinetic model. With this, the equilibrium model gives improved prediction of the gas composition that matches closely with experimental data. Brownet al. [57] have combined a stoichiometric equilibrium model for biomass gasification with artificial neural network (ANN) regressions. In this, the neural network relates temperature differences to fuel composition and gasifier operating conditions. The results investigations for atmospheric air gasification of fluidized bed reactor indicate that temperature difference for reaction relating to equilibrium of major gas species might be constant. On the other hand, temperature differences for char, light hydrocarbon and tar structure reaction are more strongly correlated to changes in operating conditions. Mahishi et al. [58] have also used the STANJAN non stoichiometric model (Reynolds [53]) for optimization of biomass gasifier for hydrogen production. Effect of parameters such as temperature, pressure, steam biomass ratio and equivalence or air ratio was studied. The optimum parameters for maximum hydrogen production have been found to be 1 bar, 1000 K, steam biomass ratio of 3 and equivalence ratio of 0.1.

Inferences and validation for present study as evident from the literature review presented above, application of thermodynamic equilibrium models for biomass gasification has been extensively studied in past two decades. However, most of these studies employ stoichiometric models. stoichiometric models suffer from several limitations, which strongly confine their use for design and optimization of gasifiers utilizing variety of biomasses. On the other hand, literature on non-stoichiometric models is quite limited. It is evident from the literature that overall performance of the gasifier is a strong function of several parameters such as biomass feedstock, air/fuel ratio, gasification media and temperature of gasification. The present study gives a widespread and in detail analysis of the influence of these crucial parameters on gasifier performance using a rigorous non-stoichiometric thermodynamic model. furthermore, most of the studies in literature attempt to optimize the gasifier for thermal applications (i.e. generation of electricity or heat or both). modest effort is devoted to optimize the gasifier performance in view of downstream processing of the producer gas for liquid fuel production. This study also attempts to address this issue and presents an analysis based on the results of non stoichiometric model[59].

IV. TECHNOLOGY AND PRODUCTION PROCESSES

From the study of following plant, we can portray conclusions on the dimensions of the full scale plant, which presumably has started put into operation around 2010 at the location of Lubmin, Germany. The manufacture capacity of this full scale plant will be about 250,000 tons of (biomass to liquid)sun diesel. Taking the proportions of the Freiberg industrial scale plant, the full scale plant requirements a feedstock of around 1 million tons of anhydrous biomass. The crop yield per hectare depends on a lot of factors: what kind of energy plant is employed, the quality of the climate, soil, the use of fertilizers, the use of pesticides and herbicides etc. The development of the quality of the soil over time depends on the type of plant that is grown, but also on the volume and kind of fertilizers employed; the crop growing method influences the biodiversity which feeds back to the amount of infestation. In a (biomass to liquid) Sun Diesel model the yield per hectare will be an interesting parameter for which sensitivity analysis may produce interesting insights into the substitution potential of BTL, the requirement and the prospective amount of subsidies, etc. For the moment, let us suppose an average value of biomass produced on cultivated land of 15 tons anhydrous mass per hectare. In this case an area of cultivable land in the order of 700 km^2. Because in Germany even rural areas are quite densely populated, 700 km^2 of cultivable land can very well mean that the feedstock for one full scale plant has to be grown on an area of about 1000 km^2[60].

4.1. Pre-treatment

Biomass is different from coal in many respects; the most relevant relates to feeding. Biomass requires significant pretreatment to allow steady feeding into the gasifier without excessive inert gas utilization [61] numerous pre-treatment options can be select and the two most show potential are (1) torrefaction and (2) flash-pyrolysis to generate a bio-slurry. In this estimation pretreatment by torrefaction is assumed. Torrefaction is a mild thermal management in which CO_2 and H_2O are evaded and the material is made brittle and very easy to grind. The procedure is appropriate for a broad collection of biomass resources and has a high energy efficiency of up to 97%. The torrefied material can be handled and fed to the gasifier within presented coal infrastructure [62] In addition to the requirement to pre-treat the biomass for feeding, it may also be desired for purpose of densification of the material. Due to the smaller volume transport costs are reduced and the stability of the gasifier operation is increased, due to the higher energy density of the feed.

4.2 Pyrolysis

In this method, biomass is heated in the lack of oxygen to create liquid pyrolysis oil sometimes called bio-oil, which can be burned like fuel oil or refined into fuels and chemicals. A number of commercial services produce energy and chemicals from pyrolysis oil. Upgrading pyrolysis oil to high-quality hydrocarbon fuels has been confirmed at a non-commercial scale.

4.3. Gasification

The heart of the procedure is a pressurised oxygen-blown entrained flow gasifier. This technology was acknowledged as optimum technology for bio-syngas production as it has the advantages of: (i) high effectiveness to bio syngas[63], (ii) fuel flexibility for all types of biomass e.g. wood, straw, and grassy resources, (iii) suitability for scales of several hundreds to a few thousand megawatt, and (iv) possibility to operate on coal as back-up fuel[64]Entrained flow gasification for coal is a well-established and commercial technology.

4.4. Bio-syngas conditioning

The unprocessed syngas from the gasifier needs significant cleaning and conditioning and treating to be suitable for catalytic synthesis. A typical gas condition line-up comprises gas cooling, water–gas shift, CO_2 removal, and impurities removal (e.g. H_2S, COS, HCN, volatile metals). Cooling can be achieved with a cooler or water quench. The benefit of a cooler is that the latent heat in gas

can be utilized, however, in the case of biomass firing, there is an increased risk of fouling due to the relative high alkaline and chloride concentrations compared with coal. In a water quench fouling problems are avoided. Except for the gas cooling, the bio-syngas conditioning and treating is similar to fossil-based syngas e.g. a coal-to-liquid (CTL) plant. Biosyngas can be cleaned to meet FT specifications with proven and commercial available technologies. There are no biomass-specific impurities that require a totally different gas cleaning approach[65].

V. Fischer–Tropsch synthesis

Fischer–Tropsch synthesis is an established technology and the two companies Shell and Sasol have already commercialized their FT technology.[66]

5.1. Fischer–Tropsch conversion

Manufacturing of Fischer–Tropsch fuels require that the feedstock is gasified and the resultant synthesis gas catalytically transformed to hydrocarbons. The procedure is less efficient but additional flexible than biological handing out [67] and produces a much superior quality fuel than hydrothermal advancement[68] or direct coal liquefaction [69] at the same time as only natural gas, coal and biomass are considered now, gasification can be ready to work with numerous different feed stocks, including municipal waste [70] Fig. 3 depicts a schematic diagram of the configuration of the CTL or BTL FT plant used in this study. For example, the gasifier division includes gas cleaning and gasification. In their study, costs are calculated mostly for plants with a capacity of 400 and 2000MW_{th} input. For bigger plants, scale advantages are less pronounced, because much of the equipment would be installed in parallel sets. 2000MW_{th} input is equal to an output of around 16,000 barrels per day (bpd)[71].

5.2. Syngas production

For solid feedstock (coal and biomass intermediates) three types of gasifiers are used in this study:

- Fluidized Bed gasifier, which can be scaled to several hundred of MW_{th}. Temperature varies among 700ºC and 1100ºC. This type of gasifier produces considerable amounts of tar and aromatics [72] which make extensive gas cleaning necessary. Furthermore, it accepts a wide variety of feedstock in large particles (up to 10cm).
- Two-stage gasifier, such as the Carbo-V gasifier being developed by CHOREN Industries, combine feedstock flexibility with complete conversion but are also more complex to build [73].
- (Entrained Flow (EF) gasifier, which are in general large units (GW_{th}). The temperature usually exceeds 1300ºC, leading to almost complete conversion of the feedstock to syngas. This type of gasifier

requires very small (1 mm dia max) particles and produces inert slag.

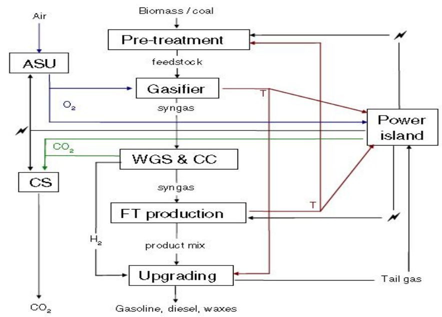

Fig.1:- General layout of an Fischer–Tropsch (FT) plant (ASU = air separation unit, WGS = water gas shift, CC = CO2 capture, CS = CO2 storage). [74]

Another option for syngas production is methane reforming. Dry[75] indicates that methane-fed plants are about 30% cheaper to build. There are potential to get better the conversion effectiveness of these plants by using catalytic reformers. Even in this configuration, syngas production accounts for around half of the capital costs of a FT fuels plant [76] Current plants fed with natural gas often use autothermal reformers (ATR)[76-79].

All gasification systems are oxygen-blown, as earlier research has indicated these to have superior performance [80,81] and the occurrence of nitrogen in the synthesis gas is not desirable. The entire gasifiers are pressurized (at 20bar or more) because it allows for a smaller gasifier and the FT synthesis requires a pressurized gas feed at least [82,83].The range of gasifier type ultimately depends on design choices such as scale, feedstock and product mix [84-86]modest development is estimated in the efficiency of EF gasifiers[87], which is currently just below 80% for bituminous coal in a Shell EF gasifier [83] or biomass in a CHOREN multistage gasifier [88] Existing auto thermal reformers for natural gas may be replaced by catalytic reformers [76] and model calculations show possibilities for a natural gas conversion efficiency of at least 80% [89] Gas cleaning facilities are used where required to reach a tar- and sulphur-free synthesis gas. The extent of the facilities depends on the gasifier type: only the fluidized bed gasifier requires tar removal, all except the ATR units need cyclones and dust filters and all plants have guard beds to protect the FT catalyst. A sour water–gas shift unit is included to provide the required H_2/CO ratio and assist in removing sulphur from the syngas. Cost data for the WGS unit are taken from [83], and for all other gas cleaning units from[82]. Advances are expected in gasifier peripherals. New feeding mechanisms [90,91] and dry gas cleaning systems for fluidized bed gasifiers [92]are under development, but these have not yet been deployed on a commercial scale [93]. The model plant based on a bubbling fluidized bed (BFB) gasifier[94] uses a dry gas cleaning system.

5.3. FT synthesis

In 2007, two Fischer–Tropsch processes had a significant market share: the Shell Middle Distillate Synthesis (SMDS) process and the Sasol Slurry Phase Distillate (SPD) process. Both were developed since the 1980s and have been in commercial use since the 1990s [76,95,96]. SMDS uses a tubular fixed-bed reactor[76]. SPD uses a slurry reactor but a fixed-fluidized bed reactor has also been used [96]. Other processes have been designed by companies such as Syntroleum, but these are not yet applied commercially[97].

The Fischer–Tropsch process has become significantly cheaper and more efficient since it was invented. The most extreme improvement is in reactor design. New plants use low temperature FT processes with values for α[82] of at least 0.92 [75]. Moving from a multi-tubular to a slurry phase reactor has reduced construction costs, pressure drop and catalyst consumption by 3=4, increased conversion and reduced maintenance requirements. On the downside, catalyst poisoning is more damaging in a slurry phase reactor[75], so syngas cleaning must be very reliable. Upgrading of the FT product is required. In both process designs, a hydrotreating and hydrocracking unit is present to convert waxes to additional fuels[76,96]. For the Shell heavy paraffin conversion (HPC) unit, the output share of diesel fuel was maximised. The diesel fraction has excellent fuel characteristics. The naphtha fraction is further reformed and isomerised to improve the octane number for use as petrol[98]. Closer cooperation among producers, or the expiration of patents, may allow competing state of the art techniques to be combined in the future for a 'best of breed' facility. Based on literature descriptions [75,76,95]. The combination of a Sasol slurry phase reactor, a state of the art FT catalyst, and a Shell heavy paraffin converter unit may provide an optimal combination with regard to production cost, product flexibility and yield. In this study we assume a process of this kind is commercially available by 2020.

VI. Production of BTL fuels

The biomass to liquid (BTL) technology is one of the most potential technologies in the fuel segment. A technology is essential to bridge the gap between today's biodiesel and ethanol fuel and the fuel of the future hydrogen. This technology must use biomass and not be subject to any limitations of use in also today's engine or predictable future next-generation engines. These demands can be fulfilled using biomass gasification and a subsequent synthesization to fuel. As BTL technology makes it potential to harness the energy from all sorts of biomass, the spectrum of usable biomass will be comprehensive significantly.

The yield per hectare could be increased significantly compared to first-generation biofuels (up to 4000 l of fuel per cultivated hectare). BTL mostly used in Germany a great opportunity to become more independent from fossil energy sources and could thus be a vital ingredient in the medium to long term safeguarding of supply in the fuel sector. As it also has the potential to reduce carbon dioxide emissions by over 90% compared to fossil fuels, BTL can also make an important contribution to the improvement of climate change. In addition to its technical, climatic and supply advantages, the BTL technology could also safeguard existing employment and indeed generate new jobs in plant production and agriculture. Germany plays a leading role today in the field of BTL technology, and the extension of this would also serve to open up new sell to other countries opportunities. Due to its high quality and the fact that its properties can be optimized systematically during synthesis, BTL is an ideal fuel for the next generation of internal combustion engines. It can also be used without problem in turboprop and jet engines. BTL be capable of thus be considered one of the few fuel options accessible for aviation as well fossil kerosene.

In its fuel policy, the German government has hence stated that BTL fuels have huge prospective to safeguard supply, mitigate climate change and make available added value in rural regions, and in addition to providing economical and dynamic support for this implementation report, it previously promotes a variety of BTL fuel projects, one of the aims being to provide answers to unanswered questions concerning the technology and to provide an environmental and cost-effective estimate of these second-generation biofuels. The Federal Ministry of Food, Agriculture and Consumer Protection (BMELV), has been taken lots of proposal using the encouragement to hunt a widespread approach in the manufacture of synfuels using biomass. The promotional measures not only include the narrower technical development of BTL processes, but also cover the complete production chain, from nurturing and harvesting to the conditioning of adapted biofuels.
The BMELV's promotional actions, thus cover the entire BTL manufacture chain, from research and development (R&D)projects on provision and cultivation processes in the joint energy crop project EVA,. The German government is also working to provide good conditions for the further development of these fuels through introduction of the Biofuel Act[99] and has helped Choren Industries to fund the construction of a first commercial BTL plant in the Saxon town of Freiberg. Interest in the BTL technology is now also very strong at a European level. The EU Biofuels Directive issued in 2003 requires biofuels to be given a market share of 2% by 2005, increasing to 5.75% by 2010. BTL is expected to play an important role in the follow-on regulations, which are currently being drawn up. In the well-regarded, Well to-Wheels analysis, which was carried out by the Joint Research Centre of the European Commission with the European Council for Automotive R&D (EUCAR) and the European petroleum industry (CONCAWE)[100], the outstanding potential of BTL as a climate friendly fuel option was clearly shown. The recently established European Biofuels Technology Platform is also dedicating a large part of its activities to second generation biofuels. If BTL fuels are to become competitive, industrial BTL production in Germany must be made possible.BTL Implementation report is an important step in the right direction. The schematic line-up of the integrated biomass gasification and Fischer–Tropsch synthesis (BTL) plant is shown in Fig. 2. The heart of the process is a pressurised oxygen-blown entrained flow gasifier. This technology is the optimum technology for bio-syngas production as it has the advantages of: (i) high efficiency to bio-syngas, (ii) fuel flexibility, (iii) scalability from hundred to a few thousand megawatt, and (iv) possibility to operate on coal as backup fuel.

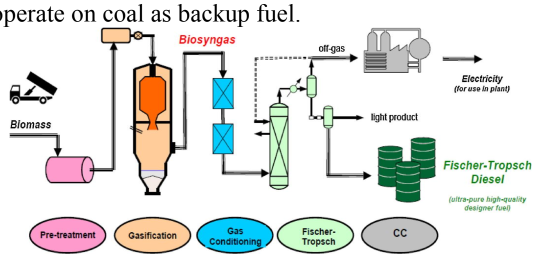

Fig. 2. A neat sketch of schematic line-up of the integrated BTL plant.[66]

Biomass requires significant pre-treatment to allow stable feeding into the gasifier without excessive inert gas consumption. Torrefaction is one of the most promising routes, as it has an efficiency of up to 97% and torrefied biomass can be handled and fed to the gasifier with existing coal infrastructure. The raw syngas from the gasifier needs significant conditioning and treating to be suitable for catalytic synthesis. Biosyngas can be cleaned to meet FT specifications with proven and commercial available technologies. There are no biomass-specific impurities that require a totally different gas cleaning approach. Fischer–Tropsch synthesis is an established technology and the two companies Shell and Sasol have already commercialized their FT technology. It is assumed that commercial FT processes are applied in BTL plants. To determine the (economic) optimum scale for BTL fuel production a simple logistics system based on local biomass (i.e. no overseas import) was used. The fuel production costs are composed of the costs for the biomass feedstock material, transport, transshipment, storage, pre-treatment, and the conversion (gasification, cleaning, synthesis, and product upgrading). [66]

VII. BY PRODUCTS OF BTL PROCESS

7.1 Dimethyl Ether

DME is a synthetic fuel, gaseous at ambient circumstances, which can be liquefied at reasonable pressure. DME has a cetane number of 55–60 , has a higher oxygen content, and produces low emissions of soot and nitrous oxides in comparison with fossil diesel. This makes it a appropriate clean burning fuel for diesel engines although it is also a potential LPG substitute. DME has a carbon to hydrogen ratio of 3:1, which makes it a potential aspirant as a hydrogen carrier for onboard fuel cells. The use of DME as a fuel, however, has a number of drawbacks. DME has only half the energy of fossil diesel; requires modification of engines, particularly plastic and rubber components; has poor lubricity and viscosity, requiring the possible use of additives; and is difficult to pump at high pressures. Conventional vehicles require dedicated onboard storage [101].

7.2. Methanol

Methanol is a commodity chemical with a wide range of end applications, including use as a fuel and as a chemical. Methanol has a high octane and a low cetane number; it is therefore better suited to spark ignition engines rather than compression ignition (CI) engines. It may be blended up to 3% by volume. Methanol has a higher oxygen content relative to petrol; this improves combustion and reduces pollution from emissions.It is also viewed as a potential hydrogen carrier for fuel cell vehicles, because it has a hydrogen to carbon ratio of 4:1 and has a lower reforming temperature than other fuels, simplifying the layout of the reformer and reducing its costs. However, methanol has a number of disadvantages as a fuel. It has only around half the energy content of petrol and there are a number concerns regarding health and safety, handling, and the potential for environmental damage from spillage[101].

7.3 BioSNG

Methane produced by the methanation of syngas and prepared to a standard suitable for use via the existing natural gas grid is termed bioSNG. BioSNG mainly consists of methane and can be used as a vehicle fuel .Methane is gaseous and can be used as compressed natural gas (CNG) or liquefied natural gas (LNG) in vehicles fitted with modified spark ignition engines or in dual fuel diesel/LNG CI engines. In dual fuel CI engines, 50–80% of the diesel can be replaced by gas; the diesel is needed to ignite the fuel mixture[101].

7.4. Gasoline

The BtL process is less suited for the direct production of gasoline products, principally due to the low octane value obtained from the resulting paraffinic molecules. However, gasoline can be produced from syngas via methanol and DME, both through direct conversion techniques where gasoline is produced directly from syngas in a single step and through indirect conversion technologies where gasoline is produced via an intermediate The MTG process is a two-step process. It first produces methanol, which is dehydrated using a γ-alumina catalyst to give DME. This is, in turn, further dehydrated with a zeolite catalyst (ZSM-5) that has high selectivity for molecules in the gasoline range (C4–C10). This produces a high-quality, high-octane, low-sulfur gasoline range product containing aliphatic and aromatic components. However, the high aromatic content means it does not conform to current petrol specifications. By changing the catalyst and process conditions, the MTG process can be modified to produce either light olefins or a mixture of gasoline and diesel[101].

7.5. Alcohols (via Fermentation)

The conversion of synthesis gas to alcohols can also be accomplished by fermentation with anaerobic bacteria such as Clostridium ljungdahlii and Clostridium carboxidivorans P7. Alcohol production is based on three steps: gasification to produce syngas, conversion of the syngas to crude alcohol via fermentation, and the subsequent distillation of the alcohol to produce the desired purity. The fermentative route has a number of distinct advantages over the catalytic route. Fermentative processes operate at low pressures and temperatures, which reduces costs. High yields of a single product are achieved, enhancing economic attractiveness. In contrast to catalytic approaches, microorganisms can tolerate a range of hydrogen to carbon monoxide ratios in the syngas. In general, microorganisms prefer carbon monoxide to hydrogen, but both can be used simultaneously. The tail gas, which can be burned in an engine to provide power, could, therefore, be more hydrogen rich and could potentially be used for fuel cells in the future. The conversion efficiency depends on the microorganism and growth conditions, but in general ethanol concentrations need to be kept below 3% in the reactor since ethanol is toxic to microorganisms[101].

7.6. Mixed Alcohols (via Catalysts)

Mixed alcohol synthesis processes produce a mixture of methanol, ethanol, propanol, butanol, and smaller amounts of heavier alcohols from syngas. The ratio of alcohols produced varies according to the technology used; ethanol can be the most significant component, Mixed alcohol synthesis techniques were developed to provide a blend stock for octane enhancement of petrol fuels, As a fuel, higher alcohols have a lower vapor pressure, better solubility, increased water tolerance, and higher heating value compared to methanol. Interest in both mixed alcohol and ethanol production from synthesis gas has been rekindled recently due to the increased profile of biofuels. The conversion of syngas to mixed alcohols is achieved using catalysts similar to those used in FT and methanol production, but including alkali metals to promote mixed alcohol production. The required ratio of hydrogen to carbon monoxide is 1–1.2 , so there is less need for a water shift reaction compared to other conversion processes[101].

7.7 Hydrogen

Hydrogen is a clean burning gas that could be used in fuel cell vehicles, or in modified diesel and gasoline engines, although with low efficiency. The energy density of hydrogen is very low and is dependent on the pressure at which it is stored. Thus, conventional vehicles would require dedicated storage, Hydrogen is used in a large number of oil refinery and chemical manufacturing processes. The principal use for hydrogen, accounting for 60% of hydrogen use, is for ammonia production via the Haber–Bosch process, oil refining (23%), and then methanol production (9%). Production of hydrogen from biomass feedstocks by application of the water–gas shift reaction to cleaned syngas is more difficult and costly compared to its production from natural gas.[101]

CONCLUSION

Considering the recent volatility of crude oil prices and the potential for future shortages, the utilization of biomass as a substrate for liquid fuel production has tremendous potential. Hydrocarbon liquid fuel production from biomass could replace a significant amount of petroleum-based liquid fuel while at the same time capturing value from a wasted resource and mitigating climate change issues exacerbated by vented and flared biomass. Nevertheless, the challenges in moving from proof of concept to scale up and commercialization still remain to be solved. Only one BTL-fuel shows about the same acidification potentials as the fossil fuel car, while all others have higher emissions. The pressure on land and water resource is increased considerable due to the increased production of all BTL-fuels. This would be especially relevant if set-aside land is transformed to intensively use agricultural area. Until now many BTL-fuels produced from energy[10].

With such a concept the achievable fuel yields would be lower, but the overall energetic efficiency could be higher. It would also be possible to use other energy carriers than biomass in the conversion plant. One such concept is the use of hydrogen produced e.g. from renewable electricity. This would allow higher fuel yields but therefore considerable supplies of clean electricity would be necessary. The environmental impacts of BTL-fuels must be re-evaluated if BTL-fuels are introduced to the market. To quantify the real environmental impacts it is necessary to know the type of biomass used and key figures of the conversion plant, in particular the conversion efficiency, amount and revenues of by-products, emissions and wastes. Due to the variety of conversion concepts and possible biomass resources it is not possible to make generally valid statements concerning the overall environmental impacts of BTL-fuels compared to other types of renewable or fossil fuels.

Although there are evidences that BTL offers environmental advantages to fossil diesel, uncertainties regarding the profitability of producing BTL is the reason why there are at present no BTL plants at a commercial scale in operation. The costs and profitability of BTL depend on both endogenous and exogenous factors. The total costs are largely dependent on plant investment costs, feedstock costs and taxes. All studies reviewed have shown that the costs of producing BTL are larger than producing fossil diesel, and BTL is at present not competitive with fossil diesel. The competitiveness will however increase with increasing oil prices, with possible subsidies and CO2 and environmental taxes. Cost estimates of woody BTL production show that feedstock price, plant size and possibilities for utilizing the excess heat from the bio-fuel plant are the most vital factors for cost efficiency. [102].

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