Biomass Refinery - A Way to Produce Value Added Products and Base for Agricultural Zero Emissions System

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Abstract

It has been shown that biomass refinery (biorefinery) with Zero Emissions perspective could convert agricultural wastes into value-added chemicals and materials. Agricultural and plantations wastes would become as main resources for biorefinery without soil degradation and needs of additional land. Biorefinery non-farm production cycle is crucial for job generation and poverty elimination in rural areas. Breakthrough biorefinery case technologies were analyzed.

Biorefinery CO_2 generation cycle is closed and it can stabilize atmospheric greenhouse gases (GHG) concentration.

Introduction

The comprehensive use of all waste components of agriculture as a value-added products (product which is of more value than the material in its raw state) is a critical proposal for developing countries which need not only to preserve their environment and biodiversity, but also to supply additional goods to their growing population. It can be achieved using biorefinery approach and concept of dispersed industrial clusters, i. e. clusters where different industries join forces on the basis of their material cycles leading to comprehensive utilization of all raw components of the base material without harmful emissions. According to ZERI (Zero Emissions Research Initiative, UNU, 1994), industries will be organized into clusters in a way that waste from one industry becomes an input for other industries, forming an integrated system. Instead of land, labor and capital, knowledge is the main driving force for Zero Emissions biorefinery. So, biomass based economy should be knowledge based.

Can the diversity of products coming from future biorefinery match the multitude of products obtained from oil refinery? Can biorefinery reach the same high conversion rates and product yields as oil refinery? Such kind of questions are opend for discussion.

Sustainable Agriculture

According to the U.S. “Food, Agriculture, Conservation, and Trade Act of 1990 (FACTA)” [1]:

Sustainable agriculture was defined in Public Law 101-624, Title XVI, Subtitle A, Section 1683, Government Printing Office, Washington, D.C., NAL KF 1692.831 1990. Under that law, "the term sustainable agriculture means an integrated system of plant and animal production practices having a site-specific application that will, over the long term:

A) satisfy human food and fiber needs;

B)enhance environmental quality and the natural resource base upon which the agricultural economy depends;

C) make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls;

D) sustain the economic viability of farm operations;

and

E) enhance the quality of life for farmers and society as a whole.

An introductory course book for environmental sciences, gives three criteria for sustainable agriculture:

1) it must feed the world’s hungry today;

2) it must feed the world's hungry tomorrow;
3) it must prevent deterioration of soil and water.

Despite the fact that today a U.S. farmer feeds 96 people, it is estimated that in the world 841 million people remain hungry and undernourished [2]. Seven hundred million (projected to rise to 1.5 billion by 2030) people live in 42 so-called Highly Indebted Poor Countries (HIPCs, Jeffrey Sachs). In general 3 billion people survive on less than 2 USD per day [3]. In developing countries rural economy characterizes with high unemployment and poverty. Agriculture wastes industrial conversion into biofuels or value-added products in rural area is a new non-farm activity form. These activities create occupational diversification by increasing interdependence between farm and non-farm. Such non-farm activities and occupational diversification should be bases for job generation and poverty elimination.

Agriculture is important not only for developing but also for developed countries. What Americans are calling a farm crisis is really an export crisis. The $90 billion farm sector with the nation's 1.9 million farms has become the most export-sensitive part of the $7 trillion U.S. economy [4]. One in three acres of U.S. farmland is used to grow crops for export. From 25% to 33% of total U.S. farm output is shipped to foreign markets. 380,000 U.S. farmers are organized under the U.S. United Soybean Board (USB). Investigation of new uses for soybeans, including industrial uses, is one of the missions of this board [5]. One of the USB's goals is to introduce 60 new products and applications by 2005. In 1997, 898,000 tons were used for industrial purposes in the USA. Estimates are that in 2005, 3.27 million tons will be used for industrial purposes in the U.S. [5]. 380, 000 farmers (USB) 0.5% of year sell products money supported for soybean new uses. Replacement of synthetic litographic inks and varnishes (LIV) with soybeans and other vegetable oils facilitates recycling of waste paper. When printed or varnished papers are deinked in order to recycle fibers, process waters containing the ink formulations can be easily reused after biochemical degradation [6].

What does Biorefinery Mean? Biorefinery separates the plant biomass, so-called lignocellulosic materials, into its building blocks - phenols and sugars. Biorefinery technologies produce value-added products that might range from basic food ingredients to complex pharmaceuticals and from simple building materials to complex industrial composites. Products such as biofuels (ethanol, biodiesel), glycerol, lipids, oils, citric acid, lactic acid, acetic acid, furfural, isopropopanol, vitamins, levoglucosan, sugars and protein polymers could be produced for use in food, cosmetic and pharmaceutical industries. Intermediate fuels as charcoal and briquettes should also be manufactured using clean and energetically self-efficient small scale production units [7]. A crucial for biorefinery is development of products such as fibers, new adhesives, biodegradable plastics, degradable surfactants, detergents, specific polymers and enzymes, etc., to fill particular niches. Recently almost 50 percent of all detergents in the USA contain enzymes and the market share in Europe and Japan for enzyme based detergents is over 90 percent. The cost of enzymes has dropped by more than 75 percent in the last 10 years [8]. Biorefinery CO_2 production cycle is closed and it can stabilize atmospheric greenhouse gases (GHG) concentration. In general, biomass as renewable is a sustainable resource and thanks to photosynthesis is CO_2 neutral. This is a principal advantage of biorefinery in comparison with oil refinery and other fossil fuel consumption systems. Viewing biorefinery in terms of its role in ecorestructuring of the society, biomass, particularly agricultural waste, will become the major raw material for production of industrial chemicals and related materials. It is analogous to petroleum as the basic feedstock for oil refinery. However, the petrochemical industry has a significant lead in technology for converting their primary raw material to various products. The scope of methodology for conversion of biomass is much smaller and the list of products available from renewable biomass is much shorter than for petrochemicals. So, in contrast to oil refinery, which operates with nonrenewable resources similar manipulation of renewable resources lies far behind. We can conclude biorefinery needs serious technological development. Biorefinery would include cost effective technologies of harvesting, transporting, drying and manufacturing of the biomass.

Biomass distribution density as well as energy is low in comparison with existing fossil resources. Hence the economic value per unit weight of the materials is also low and consequently the value-added becomes low. As a consequence, development of biorefinery technologies should be based on the principle of local uses in small areas. Biorefinery technologies should be compact and mobile, oriented to be applied in rural areas and generate new jobs. Particularly it is to important for developing countries because about 90 percent of growth in the world's population will be among people living in these countries with traditional village-based ways of life. The biorefining conversion of biomass should be considered not only as a substitute for fossil resources but also as an integrated use of living organisms, microorganisms and enzymes in a cycle producing food-stuffs, fuels, feeds, value added chemicals and industrial materials. Biorefinery technologies should not adversely affect the environment, living things and life of people in community. The systems approach requires analyses of such three important agricultural and forestry cycles as carbon (respiration, photosynthesis, organic matter decomposition), water (precipitation, evaporation, infiltration, runoff) and nitrogen (N fixation, mineralization, denitrification) and their interdependencies. Soil degradation minimization and biodiversity conservation are dominating factors to consider in biomass biorefinery. Principles of ecological conservation and the balance between production and utilization of biomass resources should be used by applying biorefinery technologies. The global target for biorefinery technologies is the eco-efficiency that can guarantee "resource productivity increasing by a factor of four, the world could enjoy twice the wealth that is currently available, whilst simultaneously halving the stress placed on our natural environment" [9]. From the thermodynamic viewpoint, photosynthesis is the most important material- producing process on the Earth. At the same time ecological productivity is limited. Biomass can not grow infinitely. From the material cycle viewpoint mankind irreversibly dissipates energy and materials. Only biomass in natural cycles concentrates renewable materials and dissipates energy. Fortunately for this sun energy we shouldn't pay.

Zero Emissions Concept

Zero Emissions is the concept which represents a shift from the traditional system based on large exploitation of natural resources and large waste production to integrated cluster industries in which all resources are used. In principle Zero Emissions industrial cluster imitates natural material cycles and eliminates waste and pollution. Zero Emissions represents two leading wings: industrial performance with increasing efficiency and resource consumption with reducing emissions (Fig.1).

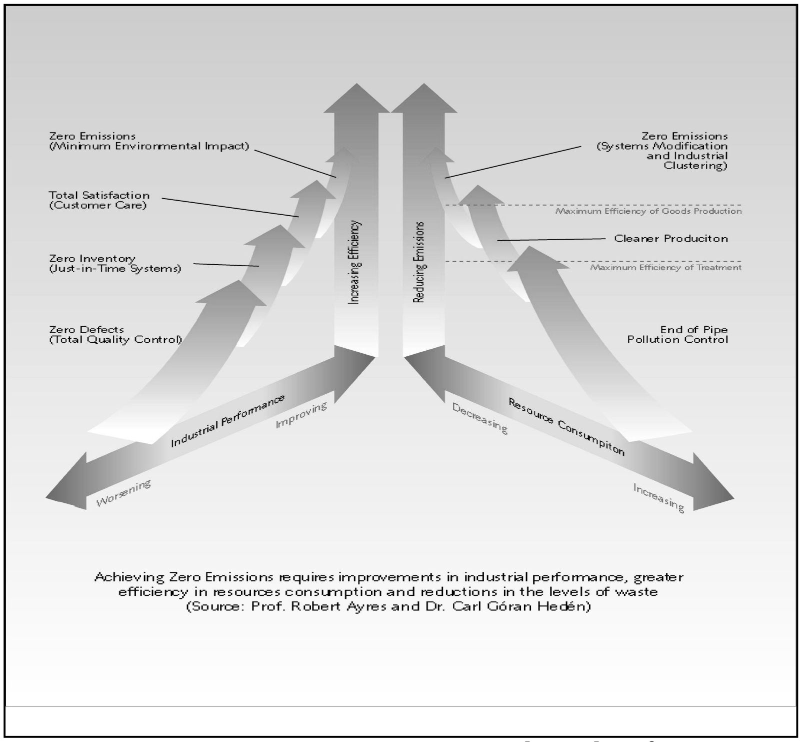

Fig.1 Achieving Zero Emissions requires improvements in industrial performance, greater efficiency in resources consumption and reduction in the levels of waste according to R. Ayres and C-G Heden [10]

Hence, in case of biomass, particularly agricultural and plantation waste utilization strategy would be oriented to create Zero Emissions Biomass refinery integrated cluster. Change from oil refinery to biorefinery means that the traditional 3R approach (reduce, reuse, recycle) is modified to 4R (replace, reduce, reuse, recycle). From business, it means to replace core business based on production only one main product (grain, sugar, oil, etc.) to diversification of production with many market products [11].

Raw Materials for Biorefinery

The main argument against biorefinery is limited land resources and soil degradation. Indeed 2 billion hectares were degraded in past 50 years and 5-10 million hectares lost annually to severe degradation [12]. However, biorefinery is principally orientated to organic waste materials utilization. In "Foreign Affairs" Lugar and Woolsey analysis showed "There is, in short, no basis for the argument that America does not have land to produce enough ethanol to make a very large dent in U.S. gasoline consumption" [13]. Today the world's industry is utilizing not more than 10% of biomass of raw materials from plantations [11]. At the same time only 1% of all materials disposed of in landfills could not be readily recycled by a process already available. Each year Americans produce over 100 million tons of organic greenwaste in the form of tree cuttings, yard waste, and construction site debris. Laws restrictions to use of landfills in many U.S. states has become crucial for communities and facilitate recycling of these organic materials which can represent nearly 30% of the waste stream at many landfill sites [14]. In 1989, 172 million tons of fossil fuels were used in the USA for making industrial products (excluding construction materials like asphalt). At the same time, aside from papermaking (80.9 million tons), only 6 million tons of plant matter were consumed in the USA are used for industrial purposes [8]. Hence the ratio of fossil fuels to plant materials are 30:1. At the same time there is a great potential for lignocellulosic materials based biorefinery. In the USA alone there are approximately 350 million tons of agricultural waste currently disposed each year [8]. China has about two times more agricultural waste materials. Unused residual biomass from tropical plantations is also enormously high. Many types of quite abundant wastes from tropical plantations are waiting for effective utilization (Table 1).

Table 1. Biomass waste materials from tropical plantations (dry weight except products) [15].

Plantation	Biomass	Unit	World	Asian	**Country**	
Rubber	Latex production	$\times 10^6$ tone	5.99	5.65	1.72	Thailand
	Residual wood	$\times 10^6$ M^3	100.0	94.2	28.5	
Oil palm	Oil production	$\times 10^6$ tone	15.6	12.7	7.8	Malaysia
	Residual wood	$\times 10^6$ M^3	80.8	65.8	40.8	
	Frond	$\times 10^6$ tone	18.0	14.6	9.2	
	Coir	$\times 10^6$ tone	28.0	22.8	14.0	
Coconut	Oil production	$\times 10^6$ tone	45.1	38.2	10.3	Philippines
	Residual wood	$\times 10^6$ M^3	157.6	133.5	36.0	
	Shell	$\times 10^6$ tone	8.32	7.05	1.95	
	Coir	$\times 10^6$ tone	13.3	11.3	3.05	
	Coir dust	$\times 10^6$ tone	4.82	4.08	1.10	
Sugar cane	Production	$\times 10^6$ tone	1149	511	259	India
	Bagasse	$\times 10^6$ tone	254	113	57	
Rice	Crop production	$\times 10^6$ tone	562	513	190	China
	Rice straw	$\times 10^6$ tone	275	250	93	
	Rice hull	$\times 10^6$ tone	100	91	33	
Log wood	Production	$\times 10^6$ M^3	3440	1150	306	China
Fire wood	Production	$\times 10^6$ M^3	1891	879	269	India
Pulp wood	Production	$\times 10^6$ M^3	498			

Tropical biomass such as oil palm (*Elaeis guneensis* Jacq.), coconut (*Cocos nucifera* L.)

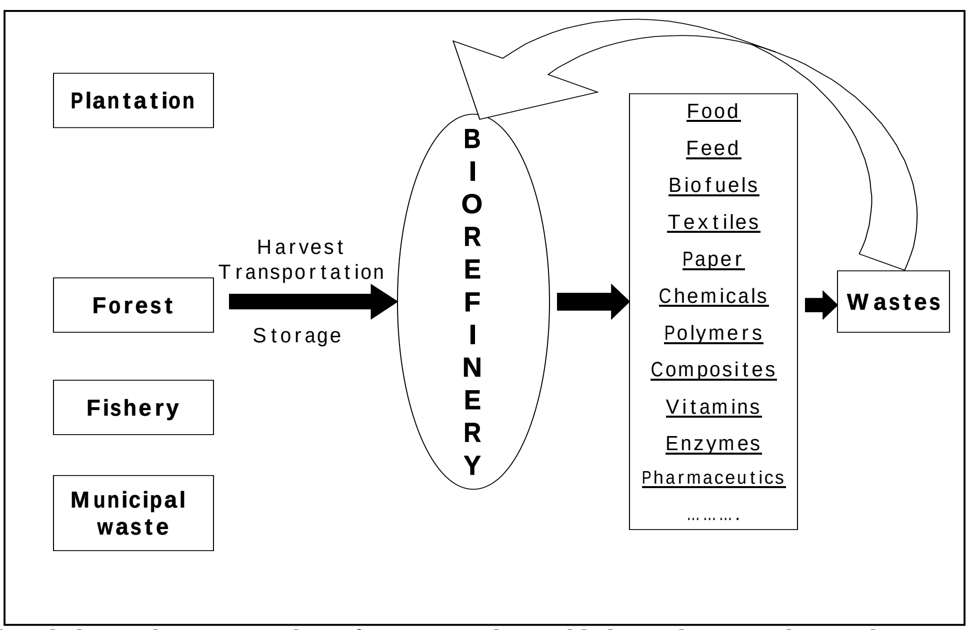

Fig. 2 Closed loop: biomass - biorefinery - value added products - disposed waste – biorefinery [16].

coir dust and coir fiber, and rubber (*Hevea brasiliensis*) wood were analyzed [15] for chemical and structural characteristics of wall polysaccharides and lignin to develop effective utilization. K.Iiyama [15] has proposed to construct a Biological Industrial Complex (BIC) with few emissions for total utilization of wastes from tropical plantations. Thus, resources for biorefinery can be used without damaging forests and agriculture land (not more than 10% of forest biomass can be used for chemicals without its destruction) at the same time cleaning the environment. Organic materials from forestry, fishery as well as municipal waste also can be used as sources for biorefinery (Fig. 2).

Breakthrough Technologies

A case study (Table 2) shows the advantages of new technologies in comparison with conventional pulping technologies of plant materials. Targets for these technologies are different.

Cellulose and fibers are targets for the conventional pulping industry, for the steam explosion [17] - fibers, cellulose, sugars, lignin and phenols, for the solid state extrusion [18] - sugars and composite materials.

Tab. 2 Comparison of the conventional wood pulping, steam explosion and solid-state extrusion technologies [19].

Wood Pulping (Pulp and Paper Industry)	**Steam Explosion**	**Solid State Extrusion**
• high water and energy consumption;	• high temperature steam;	• no water consumption;
• additional chemicals (sulfur and chlorine compounds);	• chemicals from biomass;	• no chemicals;
• high environmental pollution	• small emissions	• no pollution
processing –		
• hours	• minutes	• seconds

Another breakthrough technology is Simultaneous Saccharification and Fermentation (SSF) [20]. When enzymatic hydrolysis is employed after a pretreatment step, for instance after steam explosion (Fig.3) enzymatic hydrolysis and 6- carbon atoms containing sugars fermentation can be combined into one process. Next breakthrough in biomass to ethanol technology was simultaneously fermentation of both xylose (5-carbon sugars) and glucose (6- carbon sugars) by using genetically- engineered bacterium Zymomonas mobilis [21].

These techniques eliminate the need and the cost of separate tanks for saccharification and fermentation of glucose and xylose.

Furfural from low grade wood and agricultural wastes as equivalent to fossil oil. A case studies

Furfural has fantastic application possibilities (Fig. 4) and in future can become as an alternative source which partially replace fossil oil for production of chemicals and motor fuel.

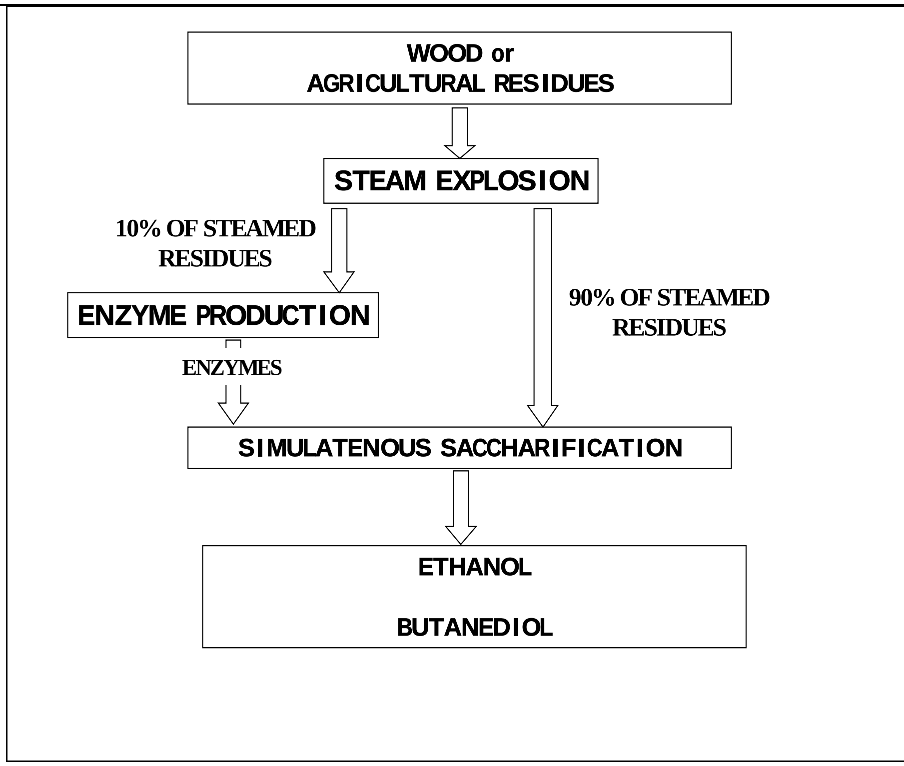

Fig. 3 A simplified process of biomass conversion to ethanol or butanediol using steam explosion and SSF according to E.K.C.Yu and J.N.Saddler

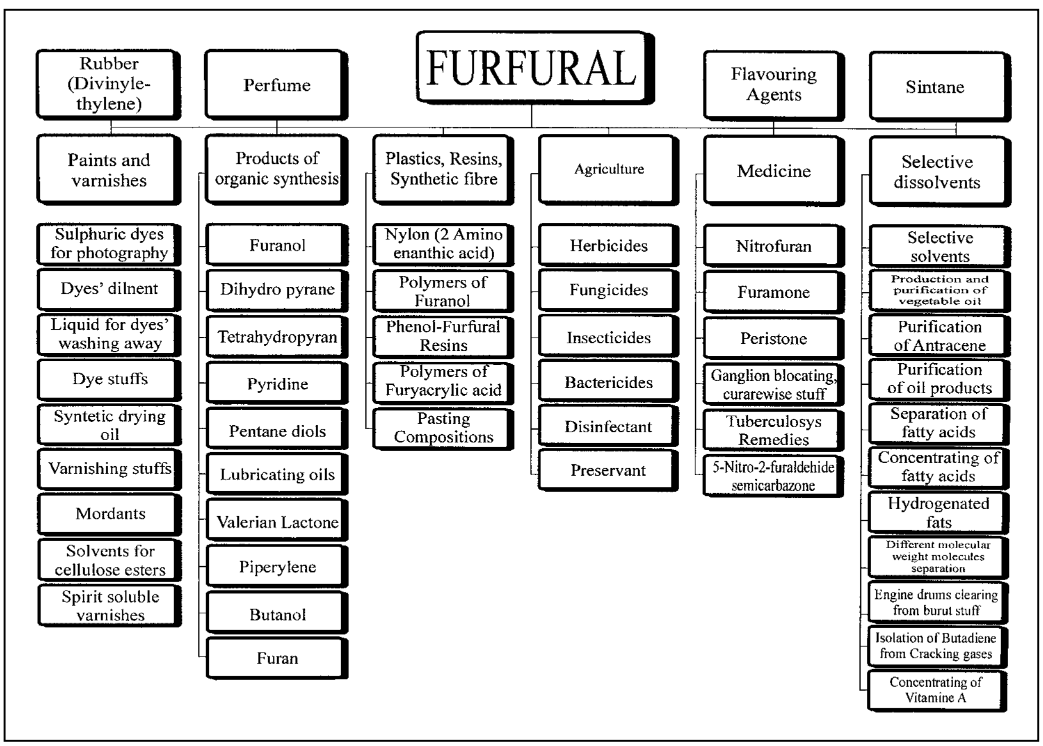

Fig. 4

A new theory to solve this problem was developed at the Latvian State Institute of Wood Chemistry (LSIWC) by N. Vedernikov [22]. The theory is based on idea of differential catalysis of hydrolysis and dehydration reactions using small amounts of concentrated sulfuric acid and acetic acid generated from hemicelluloses during the treatment. The aimed change of the mechanism of process has permitted to solve two problems simultaneously: to make increase the furfural yield from 55% up to 75% from theoretical and to diminish 5 times degree of the cellulose destruction. On the basis of theoretical studies a new technology including two-step hydrolysis of foliage wood and other pentosan containing raw material has been elaborated. Since 1997 for the first time in the world's industrial practice this technology yielding furfural and fermentable sugars further processed into bioethanol has been realized in Russia with capacity 4.300 t/a of furfural and 8.800 t/a of bioethanol [22]. The degree of raw material utilization has grown 3 times, the total yield of furfural and fermentable sugars - 4 times when compared to the only furfural production. Recently world's furfural market is around 300,000 tons per year. About 80,000 tons are produced from sugar cane bagasse.

Economic assessment of steam exploded biomass fractionation as case studies

As a method to obtain various value-added products from biomass, particularly from agricultural waste, the steam explosion (SE) autohydrolysis treatment has been proposed as core technology around which complementary industries cluster can be build. Studies at the LSIWC had shown that SE treatment allowed to obtain fibers and a variety of value-added biochemicals from wood and non-wood (bamboo, oil palm, parts of pineapple plant, corn cobs and kernels) biomass [23,24]. The SE and also mentioned above solid state extrusion (or shear deformation under high pressure (SDHP) as model process) action on wood and non-wood biomass will be interpreted as a "self-sufficient" treatment method [19,23]: system components or conversion products start to act as physical and/or chemical factors necessary for further transformations during the process. A crucial for new lignocellulosic economy (or sometimes in literature was used "carbohydrate economy") to compete with traditional hydrocarbon economy is market forces of oil and biomass refineries. The main economic analyses for SE were done by Avellar and Glasser [25]. As a starting point authors used biomass materials refinery flow diagram (Fig.5).

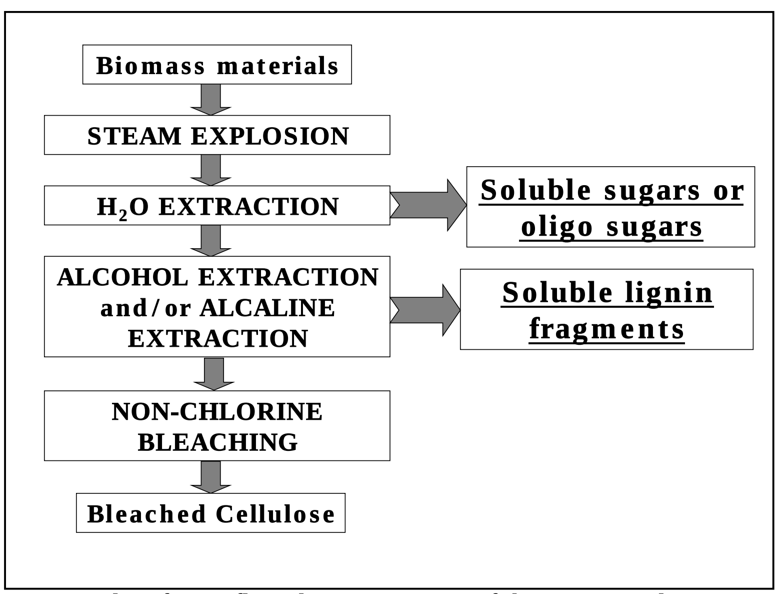

Fig. 5 Biomass materials refinery flow diagram in case of the steam explosion pretreatment

The manufacturing cost items are summarized in Table 3.

Table 3 Steam explosion manufacturing cost items

Cost item	Cost determination
Raw materials	Input as biomass, in dry tons per year, cost ($/dry ton)
Chemicals, alkali and acid	Input from mass balances, as tons per year, cost ($ t^{-1})
Labor	Summarized in spreadsheet from individual module input x salary per operator x benefits factor
Supervision	10% of total labor costs
Maintenance and repair (M&R)	5% of total installed capital cost excluding working capital
Operating supplies	10% of M&R per annum
Laboratory and quality control	Variable input percentage on total labor (10% base case)
Insurance	Variable input percentage on fixed capital (0.5% base case)
General and administrative	Variable input percentage on overhead (25% base case)
Marketing expense	Variable input percentage on total expense (5% base case)

The basic economic assumptions were:

• All product costs are production cost estimates only. No income tax, investment tax credits, return on investment or profit is assumed for any case. The reader should adopt a reasonable tax structure and profit margins for a complete economic evaluation.

• Equipment sizing and costing at scale + 109,000 green tons per year with scaling factor as exponent 0.6 total capital investment (including working capital).

• Evaluation at ca mid 1988 U.S. dollars, CE Index at 400.

• Plant life and straight line depreciation schedule, 15 year, no salvage value.

• Zero construction time.

•Instantaneous economic evaluation (i.e., no inflation, capital cost escalation, labor rate escalation or increase in maintenance or repair costs).

Authors [25] analyzed eight individual models:

MODULE 1: raw steam exploded fiber (including all woodhandling auxiliaries, steam generator and the StakeTech gun)

MODULE 2: water extraction

MODULE 3: water extract evaporators

MODULE 4: alkali extraction

MODULE 5: lignin extract evaporation

MODULE 6: alkali extract precipitation

MODULE 7: spray drying (this module would be used in the place of module 5)

MODULE 8: lignin filter cake dryer

Individual modules are connected into complete process simulations called <u>scenarios</u>. Each scenario models the unit operations required for that process complete with an economic evaluation to allow the estimation of production costs

The corresponding block and flow diagrams for scenarios 1, 2, and 3 are showed in Fig.6, 7, and 8.

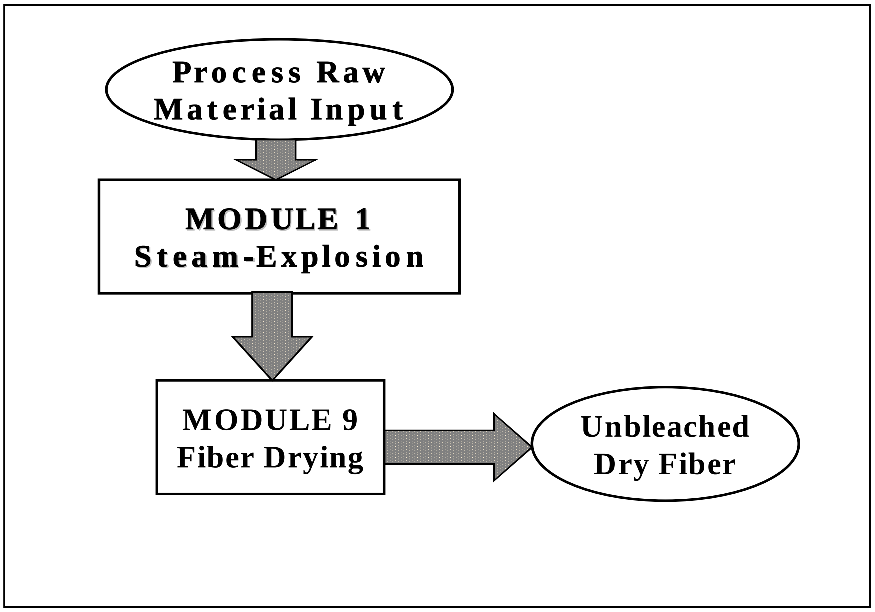

Fig. 6 Block flow diagram for scenario 1 - raw steam-exploded fibers

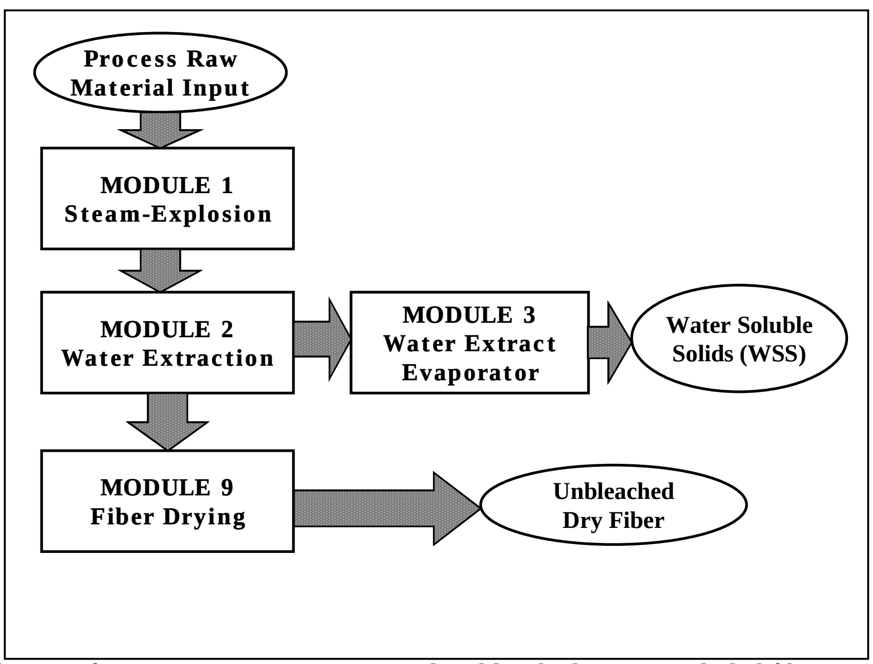

Fig. 7 Block flow diagram for scenario 2 - water extracted, unbleached steam-exploded fibers and WSS concentrate

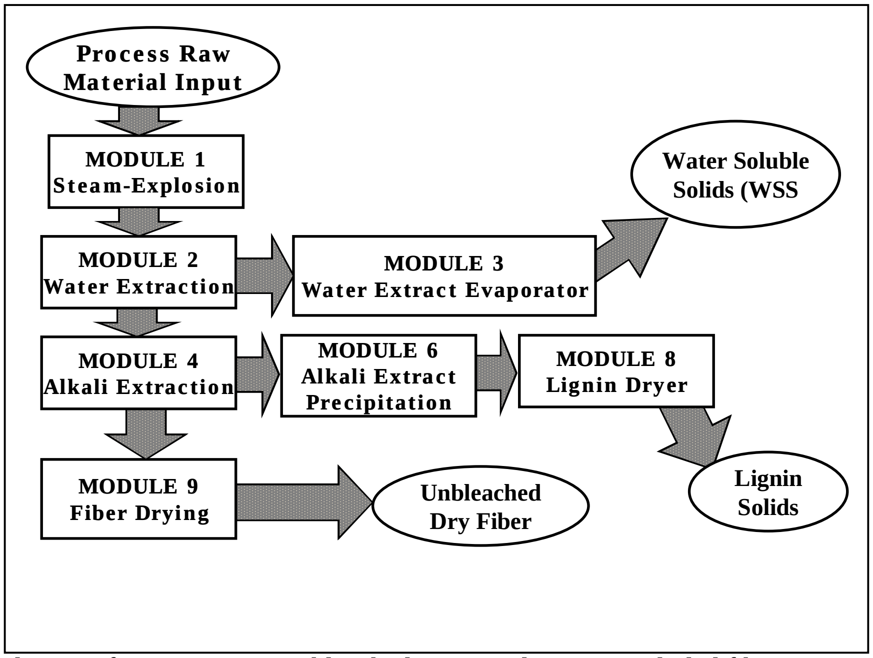

Fig. 8 Block flow diagram for scenario 3 - unbleached, extracted, steam-exploded fibers, wss concentrate and lignin precipitate (dry product)

Avellar and Glasser obtained interesting results. An unprocessed, undried (50% moisture), steam-exploded wood fiber can be produced for a total process cost of \$ 0.077 kg^{-1}, plus the cost of raw material. Using raw material cost of \$ 44 t^{-1} dry basis, the total process cost is \$ 0.117 kg^{-1} raw material processed. On the basis of pure cellulose (anhydroglucose AHG, the potential glucose yield), the total process cost is \$ 0.271 kg^{-1} AHG (including raw material). Variation in scale has the greatest effect on the total process cost. The point of diminishing effect of scale on the total cost is above 220,000 t of green feedstock raw material per year (base case is 109,000 green metric tons raw material per year). This allows the conclusion that steam-explosion processing can operate on a small scale and be economical. Water washed steam-exploded biomass fiber along with water-soluble solids (WSS) can be produced for \$ 0.165 kg^{-1}, plus raw material, if the WSS are recovered by evaporation concentration. More delignified, steam-exploded fiber with recovery of WSS and aqueous alkali soluble lignin can be produced for between \$ 0.222 and \$ 0.246 kg^{-1} of raw material processed, dry basis, depending on the lignin recovery option employed (i.e. evaporative concentration, precipitation from alkaline solution; or spray drying). An evaluation of current market conditions will indicate that steam-explosion alone for a raw fiber is marginally economical. Some high value co-products and markets must be developed for the lignin and water soluble solids WSS (pentosans/xylan) before the steam-explosion fractionation technology will be attractive as a new, stand alone industry.

The President Clinton's new Executive Order on bio-based products and bioenergy, August 12, 1999

Without doubt the biomass conversion program based on biorefinery needs state support and cooperation between government, business, industry and science. Recently the USA demonstrated such type of cooperation. On August 12, 1999 The Executive Order (cited further from [26]) issued by President Clinton will coordinate Federal efforts to accelerate the development of 21" century bio-based industries that use trees, crops, and agricultural and forestry wastes to make fuels, chemicals, and electricity. Owing to recent scientific advances, bioenergy and bioproducts have enormous potential to create new economic opportunities for rural America, enhance U.S. energy security, and help meet environmental challenges like global warming. In a separate Executive Memorandum, the President set a goal of tripling U.S. use of bio-based products and bioenergy by 2010. Meeting this goal could create $15 billion to $20 billion in new income for farmers and rural America, and reduce annual greenhouse gas emissions by an amount equal to as much as 100 million metric tons of carbon (MMTCE) - the equivalent of taking over 70 million cars off the road…

Recent scientific advances in farm, forestry, and other biological sciences are making bioenergy and bioproducts more technically feasible and more economically viable. Recent reports and studies - including the just-released National Research Council report, "Biobased Industrial Products" - have concluded that Federal support for research is essential to realizing the economic and environmental potential of bio-based industries. Today's Executive Order acts on this advice to create a powerful new research management team to focus Federal efforts with a goal of tripling U.S. use of bioenergy and bioproducts by 2010. Energy from biomass sources currently accounts for about 3 percent of the total U.S. energy supply - mostly from wood and wood waste….

Today's Executive Order also builds on the Administration's record of strong and consistent support for bio-based industries. This includes the Administration's electricity restructuring bill introduced earlier this year requiring that 7.5 percent of all U.S. electricity come from renewable resources by 2010; Executive Order 13101, signed in September 1998, instructing Federal agencies to make use of Biobased products; new proposed tax credits for bio-based electricity production; and increased research finding for the Department of Energy (DOE), the Department of Agriculture (USDA), and the National Science Foundation…

For rural America, a fast-growing bioenergy market will greatly increase the demand for energy crops and for agricultural and forest residues, or wastes, of all types. Since the cost of transporting the raw materials is high, most of the value-added work would occur in rural communities, providing new revenue streams for farmers and cash-flow for rural economic development. This means that good, high-technology jobs associated with producing biofuels and chemicals can be added in rural communities helping ensure that they will be an integral part of a prosperous 21st century American economy. By creating high-tech jobs and new economic opportunities, meeting the President's goal of tripling U.S. use of bioenergy and bioproducts could add $15 billion to $20 billion in new income for farmers and many rural communities. Finally, as the President's Committee of Advisors on Science and Technology highlight in their new report - "Powerful Partnerships: The Federal Role in International Cooperation on Energy Innovation" - investments in bioenergy technologies, infrastructures, and markets could increase profitability for U.S. firms competing in global markets, while simultaneously providing for the world's future energy needs in an environmentally sustainable way…

Substituting biomass for fossil fuels can dramatically reduce greenhouse gas emissions that contribute to global warming. Since biomass crops absorb carbon during growth, their use for energy and other applications results in near zero net carbon release. Meeting the President's goal of tripling our use of bioenergy and bioproducts by 2010 will reduce greenhouse gas emissions by up to 100 MMCTE - the equivalent of taking more than 70 million cars off the road. Substituting for fossil fuels, bioenergy will also reduce emissions of nitrogen oxides (NOx). sulfur oxides (SOx), and other pollutants. Additionally, the deep-rooted plants commonly used for biomass - such as poplar, willow, and switchgrass - are helpful in controlling erosion, filtering chemicals from water runoff, and slowing floodwaters…

President Clinton's FY 2000 budget on biomass [26]

The President's FY 2000 budget request contains $242 million for investments in biomass research, development and deployment, including:

* Advanced Biomass Power and Fuels. Funding for DOE and USDA to continue developing, testing, and demonstrating high-yield, low-cost biomass feedstocks; cofiring biomass with coal to produce electricity; advanced technologies for biomass gasification using paper industry by-products; and continued work on producing alternative fuels, such as ethanol, from biomass.

* National Biomass Partnership. Funding for DOE, USDA and other Federal agencies and private partners to launch a national partnership to develop advanced integrated biomass technologies.

The President has also proposed a package of biomass tax credits. The President proposes to extend for 5 years the current 1.5 cent per kilowatt hour tax credit for electricity produced from biomass. The proposal also expands the types of biomass eligible for the credit to include certain forest-related, agricultural and other resources. Finally, the package includes a 1.0 cent per kilowatt hour tax credit for electricity produced by cofiring biomass in coal plants.

To date, Congress has not only failed to enact these proposed new tax credits, but has terminated the current 1.5 cent per kilowatt credit and cut the President's budget request by 14 percent.

Conclusions

The authors propose that "sustainable agriculture" is not only to include sustainable agricultural management and engineering, but also the chemical and physical processing of biomass, particularly agricultural wastes, which can be obtained from sustainable agriculture, offering value-added products and generating additional jobs.

The agriculture, forestry and plantation sectors biomass refinery with Zero Emissions target could become the economic powerhouse of the 21st century just like the oil refinery was in the 20th century. The success of oil refinery is due to fact that the petrochemical industry utilize all molecules with high efficiency, nothing is wasted. So, biorefinery needs develop new technologies and methodologies to succeed in a similar full utilization of biomass molecules into value-added chemicals and materials. As a result many products would be available in abundance.

Powerful partnership between governmental institutions, business, industry and science is necessary for succesfull development of the Zero Emissions agricultural system using Biorefinery approach. Environmental issues and global climate change as well as additional income opportunities and rural sustainable economic development could be the main driving forces for Zero Emissions Biorefinery development.

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