BIOMASS

International Directory of Companies, Products, Processes & Equipment

J. COOMBS

RESEARCH

public sector, commercial

BIOMASS

raw materials, waste

EQUIPMENT

biological conversions, thermal conversions

PRODUCTS

fuels, chemicals

INFORMATION

journals, services

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Products, Processes & Equipment

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INTRODUCTION

The Biomass Energy Concept

This DIRECTORY covers commercial and research activities related to the production of biomass and its use as a source of fuels or bulk chemicals. For a microbiologist the term biomass has a rather specific meaning, referring to the living cells which are cultured within a fermenter. For an ecologist the term refers to all living organisms within a given ecosphere. However, as far as energy production is concerned, a rather different meaning has gradually evolved, with the term biomass being used to describe any organic material, generally of plant origin, which may be used as feedstock for any process which is aimed at the generation of energy or fuel in some form or another. Due to the predominantly plant-based origin of most biomass feedstocks it has been suggested by some purists that a more appropriate term would be 'phytomass' (from the Greek phyton a plant). However, as is often the case, general usage rather than etymology has the last word and the term 'biomass energy systems' is now widely accepted to cover the concept.

Oil Substitution

The origin of current biomass energy systems lies in the revival of interest in solar energy, as one of the many renewable energy options, which has evolved over the last decade. The concept of using wood, agricultural residues or other organic wastes as fuel is not of course new. Prior to the industrial revolution, fuelled first by coal and then by oil, biomass-derived fuels were used worldwide. For many developing countries they remain the only source of heat or light available to the large rural population, but have become more scarce under the combined effects of deforestation, increased population and pressure to use tribal lands for the production of cash crops. In the developed countries the availability of cheap fossil fuel led to a general decline in biomass use other than in some domestic situations or in the form of residues in factories as a process fuel.

However, as is well known, the situation changed in the early 1970s. Large variations in the price of oil, which had become the major commercial fossil fuel, led to industrial instability and a general recession in manufacturing worldwide. Concern was also felt about the long-term availability of oil, due to diminishing reserves, and short-term security of supply, with oil becoming a political bargaining point. The ability to buy oil decreased as income decreased from agricultural products in the developing countries and from manufactured goods in the industrialized nations. Against this background considerable sums of both public sector and private sector development and demonstration projects with the aim of oil substitution.

Changing Emphasis

The various approaches taken and the achievements in various sectors are considered in more detail in the **Overview.** However, irrespective of the technical success questions of biomass production and conversion it is now obvious that original short-term pressures which led to this massive investment in development of biomass research, development and demonstration (RD&D) do not apply today. However, the oil shortages of the 1970s have been replaced by the crop surpluses of the 1980s, coupled with increased concern about the use of lead in petrol, acid rain and the environment in general, worry about the nuclear reactor as an energy source and stricter legislation on pollution control in the industrialized countries.

As a result, in these countries interest in biomass energy has shifted from the primary objective of oil substitution to a broader one with conservation of raw materials, energy and the environment the main foci. Although many of the technologies which have been developed were originally aimed at purpose-grown energy crops or designed to use farm wastes, these sectors have shown few successful commercial installations - mainly due to economic factors. On the other hand many of the concepts developed with energy generation as the primary objective have now been adapted to combine some recovery of energy with material recycling, pollution abatement or waste disposal.

Extensive R,D&D

This change in emphasis continues to bring new people or organizations into contact with the biomass energy concept and hence into contact with the very broad multi-disciplined area in which, over the last 10 or 15 years, thousands of organizations have been involved worldwide in R,D&D. This interest and commercial activity has generated many publications, in the form of technical reports, proceedings of conferences, feasibility studies and economic assessments and these are of course accessible through a number of the large databases. However, prior to the publication of this **Directory** there has been no readily accessible listing of such activities, suppliers of equipment and research groups. Hence, this volume has been produced to fill the gap.

The Directory Format

The format of the book and the methods adopted to obtain the information follow those used for the very successful

Introduction

International Biotechnology Directory, which is now in its third year of publication.

Organizations, comprising companies, research institutes and universities are grouped alphabetically on a country basis in Part I and listed alphabetically in the Organisation Index in Part II, the Buyers Guide. A further Products and Services Index lists the various research topics, products or services covered in the Buyers Guide section, which is organized alphabetically by product or service, with each main heading followed by a list of all relevant organizations, further divided into subheadings as appropriate.

One result of the rapid changes in oil price as well as the change in emphasis within the biomass energy concept from oil substitution to material recycling, conservation and dealing with problems of land use and agricultural surpluses, has been an equally rapid change in the interests of some organizations. This has been particularly true during the first half of 1986, the period over which this volume was completed. As a result some companies have shifted their interests, and a few may indeed have ceased trading. Obviously it is not possible to continually update a printed volume or indeed always to obtain information on such changes. Hence, you are invited to bring such matters to the attention of the editor. If your company or organization is not included and you would like an entry in the next edition please let us know. We would be pleased to receive company reports, product catalogues or similar literature.

How to use the DIRECTORY

The **BIOMASS DIRECTORY** has been designed to make a large amount of information easily accessible to a wide variety of users. The Directory has been divided into two main parts, the listing of organizations and companies and the listing of products, services and research topics. The resulting sections are arranged alphabetically. Part I is organized by country, whereas Part II is organized on the basis of products or services offered. Three indices, covering (i) Countries, (ii) Organizations and (iii) Products and Services enable specific entries to be identified.

The **Product and Services Index** is cross-referenced to enable identification of a general heading in the **Buyers Guide.** Where appropriate the major sections such as, for example, **Anaerobic Digesters** are subdivided into second-level categories. Within each section relevant organizations are listed alphabetically by the name as it appears in the country listing (Part I). The relevant country is indicated by an abbreviated country code. The abbreviations used are listed in the **Country Index.**

OVERVIEW

The technical aspects of biomass energy use fall into three categories of (i) raw material production, (ii) conversion or upgrading to produce a higher-value fuel, chemical or energy vector and (iii) end use.

Raw materials may be derived from purpose grown traditional agricultural crops producing sugar or starch, forestry species grown in short rotation or using coppice, stands of natural vegetation (scrub, reeds and rushes, bracken, etc), aquatic plants (such as water hyacinth) or algae (with an emphasis on fresh water micro-algae and seawater macro-algae). Alternatively, raw materials may be by-products or wastes generated by agriculture (including manures), forestry, the paper and pulp industry or the processing of agricultural raw materials to refined food products. More recently, interest has shifted away from purpose-grown crops towards the use of the organic fraction of solid refuse, forest residues and waste streams from the processing industries which contain a high organic loading (chemical or biological oxygen demand - COD or BOD).

The reasons for the choice of raw material are a mixture of expediency and economics. At current prices of alternative competing fuels derived from gas, oil or coal, the biomass raw materials must be available at low cost in order to justify investment in the necessary handling, conversion and end-use equipment. Costs of purpose-grown biomass may be high both in straight economic terms and in terms of energy.

Although biomass raw materials are included in the so-called renewable energy sources since they can be regenerated and the total availability of new material produced worldwide greatly exceeds the world's energy needs, their use is often beset with problems of accessibility, collection, transport, drying and storage. Furthermore, high production rates are dependent on good agricultural or forestry practice with significant inputs in terms of fuels, chemicals to protect against pests and disease, and fertilizer. Apart from the actual costs of such inputs the net gain in terms of energy in the harvestable biomass as a function of fossil fuel inputs must be optimized in order to justify such use. The search has thus been for crops or species which will give high yields (in terms of weight of dry matter per unit land area per annum) at low energy and labour costs to generate a product which can be stored, so as to be available year-round, without too much loss through biodeterioration. Obviously, the yields which can be obtained are largely dependent on the climatic and environmental conditions of the region under consideration, with the sub-tropics, where a reasonable annual solar irradiance is linked with a good, even, rainfall pattern, offering the best growing conditions.

Many trials have been carried out on varying scales with the objective of identifying optimum species and growth conditions. In general these have indicated that where the objective is to optimize the trapping of solar energy into a non-specific biomass raw material, fast growing tree species such as eucalyptus, willows, poplars, ipil-ipil, or various pines and firs offer the best yields. To obtain such yields may require a move away from the traditional forestry practices, with either coppicing or short rotation forestry on a three to five year basis predominating.

Where the need is to produce a specific raw material amenable to a specific conversion process, such as the production of fuel alcohol by yeast fermentation, the traditional starch and sugar crops (maize and sugar cane in particular) remain the only proven source of such raw materials, although significant research and demonstration work is being directed at crops such as Jerusalem artichoke and sweet sorghum.

Collection, transport and storage costs remain a significant factor in any biomass energy system. There are obvious advantages where these costs can be off-set in part against the production of a higher value co-product; for instance the use of bagasse for power and electricity generation in the cane sugar industry. However, where separation of the required higher value product and the residue takes place in the field (as is the case with most large-scale grain production) the economics of collection and use of the residual straw remain problematic and various concepts which may be generally covered by the term **whole crop harvesting** have yet to be proven.

In some localities natural vegetation represents an important source of biomass used for fuel; this is true in many developing countries. The problems here are associated with the implementation of schemes for replacement. The harvesting of natural vegetation may be associated with a change in land use towards the large-scale production of cash crops, or may precede dereliction and degeneration towards desert.

Algae, aquatic and emergent aquatic plants have many traditional uses as sources of polysaccharides, fuels or structural materials. However, often the scale of use has been such as not to disrupt the natural ecology of the region, leaving a sustainable resource. The extent to which such species can be farmed has yet to be proven. Many studies have been carried out concerning the farming of both macro-algae (seaweeds) and micro-algae. In general, structural, engineering and harvesting costs would appear to argue against the large-scale production of micro-algae in sophisticated bioreactors, although production in large scale open ponds in regions of high annual irradiation may

well be feasible. An attraction of such systems is that high levels of biomass production become feasible in desert regions. An alternative approach, relevant to such arid regions, has been trials on higher plants adapted to low moisture conditions. In such regions yields are constrained by water availability. However, a number of such plants are of particular interest since the mechanism of adaptation includes the production of significant quantities of hydrocarbons, aromatic compounds, latex or rubber.

As far as wastes are concerned there are few biomass materials which cannot be used from the technical aspect. The decision to use such materials as fuels remains an economic one in which the benefits of use as a fuel must be balanced against the additional capital costs required and compared with the costs of alternative methods of disposal. Most wastes of a biological origin will of course rot away through biological degradation if simply discarded and left. Where such residues are accumulated as a result of factory processing, and particularly where decomposition can lead to pollution of water courses, legislation may force alternative treatments. Hence, the establishment of strong, enforced, anti-pollution legislation may be a major factor in the development of waste-based energy systems.

Irrespective of the source of biomass in general it can be divided into two categories on the basis of water content and the solubility of the organic fraction. The first group of materials, generally with a high lignocellulose content, has a low moisture content and is amenable to combustion or thermochemical conversion. The second group, with high moisture (where much of the organic material comprises low molecular weight compounds, and sugars in particular) contains those sources of raw material more suited to biological conversion. Obviously the two groups are interconvertible. Where the aqueous streams of a production plant contain biological inhibitors or only low concentrations of compounds which are readily metabolized, it may be necessary to concentrate the residue for combustion or thermal treatment. In contrast, a very large research effort has been directed at developing methods for converting ligocellulosic raw materials into lower molecular weight fraction.

Although at present the greatest use of biomass as a fuel concerns combustion of dry residues to produce heat or steam, this represents the lower end of the added-value scale where biomass competes against coal and fuel oil and a very wide range of stoves, stokers, modified grates, boilers and steam generators is available, ranging from small domestic systems to district heating or electricity generating systems in the megawatt range. This is a large and well established proven market for both the sale of raw materials and the sale of equipment.

Associated with combustion of biomass is a wide range of equipment designed to reduce large pieces in size or to compact or compress small residues (such as sawdust and straw) into pellets or briquettes with the objective of producing an even-sized material suited to automatic boiler firing. In general, shredders which disrupt the material at random are robust and reliable, although chippers which aim to produce an even-sized output may require more maintenance and be more erratic. Compacting equipment varies in the mechanism used (piston, screw or rotating die), the temperature of operation, the degree of densification, the extent of charring and hence the size, density and calorific value of the output. Systems vary from the small unit suited to farm use to very large RDF (refuse-derived fuel) plant handling several tonnes per hour. In general, the validity of compaction depends on local economics, the availability of competing fuel (biomass-based or otherwise) and the technical need to have a pelleted fuel for the combuster. Alternative approaches to combustion (or gasification) of particulate biomass include the use of cyclonic burners, fluidized beds or entrained systems.

Added value may be achieved by converting biomass which, in its original form, is only suited to direct combustion to gas, liquid fuel, transport fuels or electricity. A wide range of thermochemical systems, varying in size from small vehicle mounted gasifiers to design studies for a thousand tonne per day methanol plant have been investigated. These can be classified on the basis of the organization of the biomass bed in respect of the gasification medium with fixed bed updraft or downdraft small-scale systems quite widely available and larger fluidized bed systems under investigation. The end product may be fuel gas, for direct process use, or in small-scale systems may be used to power an internal combustion gas-engine for electricity generation. Alternatively, oxygen-blown systems may be aimed at production of synthesis gas for methanol, hydrogen or ammonia (fertilizer). Although a number of prototype and demonstration systems have been constructed, large-scale commercial plant have to compete against alternative (fossil-fuelled) systems with economies of scale and fewer problems of collection, storage and transport, which make it difficult for biomass systems to compete in most countries at present fuel and chemical prices.

Problems remain in many gasifier systems, associated with removal of particulate materials and tars from the gas stream. The need for gas treatment or conditioning can add substantially to the cost of a small gasifier/generator system resulting in borderline economics at present. An alternative approach is pyrolysis, where the system is optimized towards the production of either charcoal, where there is a large market in most countries, or tar-oil production. In theory such oils can be used as fuels. However, unmodified pyrolysis oils are often unpleasant mixtures of potentially harmful compounds ranging from phenols and other aromatics to aliphatic or nitrogen containing molecules. These may require further treatment, cracking or refining if they are to be used as a transport fuel. An alternative approach has been to try and produce a higher quality liquid hydrocarbon

fuel using a direct catalytic/hydrogenation system - often based on the use of tetralin as a hydrogen donor in a pressurized reactor. Such systems remain at the research level. It is also possible to generate hydrocarbons from biomass by a combination of gasification to produce synthesis gas, conversion to methanol using standard chemical technology and then polymerization of the methanol using zeolite catalysts.

Other potential sources of liquid hydrocarbon fuels are the various arid crops which produce latex. At present, more studies are being carried out in relation to increased productivity in the field than to end use. In contrast, studies have taken an alternative approach in the use of vegetable oils in diesel engines, being largely been concerned with modification of the oil, by esterification, investigation of diesel/vegetable oil blends or modification of pre-combustion engines to reduce problems of engine coking. Although at present such use may not be economic, it is thought to have particular strategic importance since use of such oils would permit continuation of farming and hence food production during periods of local dislocation of supply.

The production of fuel ethanol by fermentation remains the largest area of biomass processing for liquid fuel production. The major programmes, based on sugar cane in Brazil and maize in the United States, are now producing over ten million tonnes per annum although the objectives differ. In Brazil the programme was launched as a means of reducing oil imports, and has led to the widespread introduction of modified cars to run on 95% ethanol. By contrast, in the US the objective has been to combine the production of an octane enhancer for lead free petrol with the generation of a market for surplus agricultural produce.

In Europe the possibilities of using ethanol as a petroleum additive have attracted considerable attention for these reasons as the European Community is faced with similar crop surpluses and has introduced legislation to remove lead from petrol by the end of this decade. The main feedstocks are perceived as sugar beet and wheat and a number of pilot or demonstration projects, including a wheat based plant in Sweden, have been built. The main constraint remains the cost of raw materials, which at European prices sustained by the Common Agricultural Policy (CAP), remain at about twice world prices. Sugestions have been made that fuel alcohol should be subsidized with the objective of maintaining farmers' incomes and overcoming problems of taking land out of production. However, the size of subsidies which would be required brings the concept into question - even in Brazil and the US, where feedstock costs are lower significant subsidies are required.

The widespread adoption of bioethanol programmes depends on the identification of lower cost feedstocks. Obviously, there is a potential for use of wastes such as straw, forest residues and paper. However, the problem with such lignocellulosic feedstocks remains the identification of economically viable cellulose hydrolysis processes. Considerable work has been carried out in respect of both acid and enzyme based systems. A number of acid based cellulose plant exist, although the efficiency could be improved. Problems are associated with acid recovery or waste disposal, corrosion and loss of product through degradation. In contrast, the milder enzyme based systems are still limited by enzyme costs and activities. Considerable work is being carried out with the objective of genetic manipulation of organisms producing cellulase to overcome such problems.

As far as fermentation is concerned, work continues in the areas of novel fermentation systems (solid substrate fermentations, thermophilic systems, immobilized cell reactors, etc) and the use of novel organisms such as Zymomonas, various Clostridia or fungi. However, unless these are capable of using novel substrates they will not overcome the basic problem of raw material cost.

The degradation of lignocellulosic materials remains one of the problems associated with the use of anaerobic digestion to produce methane (biogas). A large number of different designs of small and intermediate size (10 - 1000 cubic metre) digesters have been built worldwide based on stirred tank or semi-plug flow operation as a means of treating manures and slurries with concurrent generation of energy for farm use. The viability of such systems has been affected by problems of reliability and the question of what to do with the gas on the farm, where energy needs are limited, resulting in a rather static market except where government grants have promoted such systems. At the lower end of the scale large numbers of simple digesters have been built in developing countries, providing some light and cooking fuel. The success or otherwise of such systems appears to depend on the robustness of the construction material and the dedication of the operator in ensuring the system works. In the developed countries the emphasis now lies on disposal of industrial effluents, where a wide range of different systems (anaerobic filters, sludge blankets, contact digesters, fluidized bed systems, etc) have been built with the objective of reducing hydraulic residence time whilst achieving a high degree of microbial biomass retention.

The most active current market as far as biogas production is concerned is that associated with the recovery of biogas from landfill sites. On very large sites gas purification systems based on scrubbers, molecular sieves or membrane separation can result in large volumes of pipeline quality gas. However, in general there is now a move towards on-site electricity generation.

The generation of heat or steam, the production of elctricity, or the manufacture of a liquid transport fuel, remain the main end-use objectives of most biomass energy systems. The aim is to convert the raw biomass into a form where it is compatible with existing technology. Hence, as far as engines, vehicles, generators, turbines, etc, are concerned the need has been for slight modification rather than radical re-design.

Problems associated with biomass derived fuels include higher water content, lower calorific value associated with their usual oxygen content, and generation of corrosive gases, ash and/or abrasive particulates. At present there is a wide variation in the extent to which such problems have been overcome, with some systems working well whereas other, basically similar, designs show continued problems. The important thing to do, prior to investment, is to look at performance of existing competing products or systems and choose those with a proven track record.

Biomass energy continues to attract considerable research funding with an emphasis on forest production and utilization of lignocellulosic materials. For many countries biomass energy is seen as making a significant contribution to the national energy budget in the next century. In the shorter term it is seen as a means of solving problems of pollution, environmental protection and as a sink for surplus agricultural production. For those countries with foreign exchange problems biomass energy offers the opportunity for self-sufficiency, whereas for the rural dweller in many countries it is the only source of fuel, diminishing in quantity with a need for more efficient use.

Whatever your interest it is hoped that this volume will enable easy identification of sources of equipment, services or expert advice necessary for the continuing growth of this viable alternative energy resource.

CONTENTS

Part I
COMPANIES AND ORGANIZATIONS

ARGENTINA

CEFOBI
Centro de Estudios Fotosinteticos y Bioquimicos, Suipacha 531, 2000 Rosario
Tel: 041 38 1480 Tlx: 41817 ciros ar
Have carried out an evaluation of the potential for biogas production from agricultural wastes including design, construction and operation of an anaerobic digester for a model dairy farm. Also have a pilot scale digester using water hyacinth in conventional mesophilic semi- continuous operation or thermophilic operation for evaluation of biogas and effluent treatment potential.

Estacion Experimental Agro-Industrial
Casilla de Correo No 71, Tucuman
Tel: 16561
Agricultural experimental station carrying out research on the energy potential of agricultural wastes.

AUSTRALIA

Bio-Energy (Australia) Pty Ltd
Research Centre, Waterview Industrial Park, 4/1 Atkinson Road, Taren Point, NSW 2229
Tel: 02 524 4324
Developing methods for use of vegetable oils as substitute fuel for diesel engines. Offers equipment and advice for the production of fatty acid esters as superior fuels of lower viscosity and wax content, as well as seeds and catalysts to enable a farmer to grow his own diesel fuel.

CSIRO
Division of Chemical and Wood Technology, Clunies Ross Street, Black Mountain, via Canberra City, PO Box 1666, ACT 2601
Tel: 062 46 5685 Tlx: 62337-aa
Studying properties and chemistry of wood in relation to use as fuel.

CSIRO
Division of Food Research, PO Box 52, North Ryde, NSW 2113
Tel: (02) 887 8333 Tlx: 23407
Carrying out tests on a pilot-scale digester at a cannery plant using fruit and vegetable wastes as feedstock to investigate biogas production and pollution control.

CSIRO
Division of Chemical and Wood Technology, Bayview Avenue, Private Bag No 10, Clayton, Victoria 3168
Tel: 03 542 2244 Tlx: 35675 aa
Have carried out projects on anaerobic fermentation of crop residues and carbohydrate streams to investigate the production of liquid ketone fuels and volatile fatty acids as well as evaluation of the use of vegetable oils as vehicle fuels.

CSR Ltd
Colonial Sugar Refiners, Sugar Division, 55 Clarence Street, Sydney 2000
Tel: 02 235 7285 Tlx: 127016
Have carried out technical and economic studies on the feasibility of producing fuel ethanol from sugar cane.

California Pellet Mill
PO Box 294, 57 Railway Parade, Marrickville, NSW 2204
Tel: 516 5944
Outlet for sales and service for equipment produced by CPM/International Inc (US).

AUSTRALIA

D J McCann & Associates
44 Greentrees Ave, Brookfield, Brisbane 4069
Tel:07 374 1691
Energy and agro-industrial consultants with interests in alcohol fuels production including aspects of cellulose hydrolysis technology.

Humphreys & Glasgow Ltd
77 Pacific Highway, North Sydney, NSW 2060
Tel: 929 8033 Tlx: 21105
Construction and consultant engineers with experience in catalytic production of methanol. Part of the Humphreys & Glasgow Organisation (UK).

Industrial Sheet Metal Fabricators (Pty) Ltd
50 Lothian Street, North Melbourne 3051
Tel: 329 6400 Tlx: AA 33627
Appointed sales agent for Van Tongeren UK Ltd.

LEC Geomembranes
PO Box 124, Beecroft, Sydney NSW 2119
Tel: 02 627 4200 Tlx: 27983
Offer a wide range of plastic sheeting including high density polyethylene, linear co-polymer and polyolefin co-polymer manufactured in a variety of thicknesses from 0.5mm to 2.00mm depending on the material. The project engineering department can provide technical support backed by a fully equipped materials laboratory and welding development workshop. Materials are delivered in wide seamless rolls and welded in the field. Applications include landfill sites, reservoirs and waste containment.

Macquarie University
School of Chemistry, North Ryde, NSW 2311
Has evaluated the potential of natural stands of Calotropis as source of plant hydrocarbons.

Monsanto Australia Ltd
Separations Business Group, East Tower
Princes Gate, 151 Flinders Street, Melbourne
Tel: 613 654 4333 Tlx: AA 30288
Offer a hollow fibre membrane system suitable for use in purification of biogas.
Subsidiary of Monsanto Company (US).

NSW Agricultural Engineering Centre
Glenfield, New South Wales 2167
Tel: 02 605 1511 Tlx: aa20199
Have carried out an evaluation of farm-based fuel-grade ethanol production.

Sugar Research Institute
PO Box 689, Mackay, Queensland 4740
Tel: 521 511
Evaluation and technical assessment of the feasibility of producing fuel ethanol from sugar cane.

University of New South Wales
School of Biotechnology, PO Box 1,
Kensington, NSW 2033
Tel: 697 2222 Tlx: 26054 aa
Developing methods for the production of fuel ethanol from sugar and starch crops using immobilized cells of the bacteria Zymomonas mobilis.

University of Queensland
Biotechnology Unit, St Lucia, Queensland 4067
Tel: 3371111 Tlx: uivqld aa40315
Studies on yeast fermentation to produce ethanol as well as the production of single cell protein combined with waste treatment using Candida ingens.

University of Sydney
Department of Chemical Engineering, NSW 2006
Tel: 692 2455
Carrying out investigations on upflow tower anaerobic digestion processes as well as the use of flocculants in anaerobic digestion to enhance COD reduction at increased loadings.

AUSTRIA

Andritz AG
Machinenfabrik, Riechstrasse 66, A-8045 Graz-Andritz
Tel: 0316 615 80 Tlx: 031313
Manufactures dewatering machinery for use with municipal and industrial sludges derived from clarification and filtration plant treating wastewaters, sewage or effluents.

Arge Biotechnologie
A-2112 Hetzmannsdoff
Tel: 02263 64094 Tlx: 3222 154 Biotech
Engineering consultants in biotechnology and fermentation.

Association of Constructors of Agricultural Machinery
Fachverband der Maschinen und Stahlbauindustrie Oesterreichs, Postfach 430, Wiedner Hauptstrasse 63, A-1045 Wien
Tel: 222 65 053440 Tlx: 613222440
Trade association promoting the interests of the agricultural machinery industries.

Austrian Association for Agricultural Research
Hollandstrasse 2, A-1020 Wien
Tel: 0222 262242 Tlx: 116761

Austrian Research Centre Seibersdorf
Institute of Biology, Lenaugasse 10, A-1082 Wien
Tel: 02254 80 Tlx: 014353 Fzs
Studying production of hydrogen by the green alga Chlorella. The research centre is jointly funded by government and industry, and deals mainly with aspects of nuclear physics.

Biologische Verfahrens-Technik
BVT, Bergstrasse 8, A-6900 Bregenz
Tel: 05574 25 925 Tlx: 57683
Manufacture the BIMA-biogas fermenters for the anaerobic treatment of highly contaminated waste water or solid wastes from distilleries, potato and fruit processing and systems for sewage sludge treatment in the range of 1600-4000 cubic metres, and for manures from intensive animal farming over the range 50 to 1800 cubic metres.

Bundesanstalt fur Landtechnik
Postfach 33, A-3250 Wieselburg/Erlauf
Tel: 07416 2175
Federal research institute for land technology, carrying out comparative tests on biomass fired boilers as well as investigating biogas technology.

Bundesanstalt fur Pflanzenbau und Samenprufung
Alliirtenstrasse 1, A-Wein
Federal research institute for glasshouse crops and plant breeding carrying out energy cropping experiments. Also investigating the utilization of agricultural byproducts for energy.

Chemie Linz AG
Postfach 296, St Peterstrasse 25, A-4021 Linz
Tel: 073 25 91 Tlx: 021324
Manufacturers, process plant engineers and constructors serving most aspects of the chemical industry.

EBS GmbH & Co KG
Entsorgungsbetriebe Simmering, Kapleigasse Vis a Vis 26, A-1110 Vienna
Tel: 222 76 1610 Tlx: 131477
Offer waste management services including energy recovery.

Ekono GmbH
Hietzinger Haupstrasse 122b, A-1130 Vienna
Tel: 43 222 827 494 Tlx: 135966 ekono a
Consultant engineers specializing in energy projects, building engineering, process design and technical services for both the pulp and paper, and the mining and metallurgical industries. Provide complete consulting services from prefeasibility studies to supervision of plant start-up and services for plants utilizing peat combustion. Researching new peat production and processing methods, especially those that are applicable irrespective of climatological conditions, in order to make peat a more competitive fuel and expand its production and utilization.

Forstliche Bundesversuchsanstalt Tirolgarten
A-1131 Wien
Federal forestry organization carrying out research on energy cropping.

Dr L Holinger
Matznergasse 17, A-1140 Wien
Produces and markets cultures of soil bacteria for converting organic wastes into a fertilizing humus.

Institute for Environmental Research
Institut fur Umweltforschung,
Elisabethstrasse 11, A-8010 Graz
Tel: 0316 36030
Activities include studies on the production of biogas by anaerobic digestion.

International Inst for Applied Systems Analysis
A-2361 Laxenburg
Tel: 02236 71521 Tlx: 079137
Sponsors interdisciplinary studies of global issues related to food and energy including aspects of biomass production and bioconversion as well as other renewable energies such as solar, ocean and wind. Offers an information service developing global models and surveying the state of the art in systems analysis.

Jenbacher Werke AG
A-6200 Jenbach, Tirol
Manufacture the Jenbach Gas Otto Engine range with multifuel operation including landfill gas suitable for cogeneration plant.

AUSTRIA

Jungbunlauer AG
Postfach 546, Schwarzenbergplatz 16, A-1011 Wien
Tel: 0222 65 7636 Tlx: 131800
Produce citric acid and ethanol by fermentation.

Ministry for Land and Forestry
Bundesministerium fur Land- und Forstwirtschaft, Stubenring 1, A-1010 Wien
Co-ordinating a biomass energy programme as part of the European rural energy network.

Rumpel GmbH
Seillerstrasse 16, A-1015 Wien
Tel: 0222 52 1574 Tlx: 011429
Supply water treatment, filtration and sewage treatment plant.

Ruthner Industrieanglagen AG
Aicholzgasse 51-53, A-1120 Wien
Tel: 0222 83 9501 Tlx: 131273
Manufactures, designs and constructs process plant for fermentation and water treatment, as well as composting plant for treatment of garbage and sewage.

Technical University of Graz
Institut fur Biotechnologie, Mikrobiologie und Abfalltechnologie, Schlogelgasse 9, A-8010 Graz

Thermostrom Kesselwerk
Ennser Strasse 91, A-4407 Steyr
Tel: 7252 8271 Tlx: 28228
Manufacture precombustion furnaces, hot water boilers and heat exchangers as well as supplying various types of internal combustion engines.

UNIDO
United Nations Industrial Development Organisation, PO Box 3000, A-1400 Vienna
Tel: 26310 Tlx: 135612
Co-ordinates international activities and disseminates information in all aspects of industrial technology and provides information through data bases and abstracting services.

University of Technology Vienna
Institute fur Verfahrenstechnik, Department of Chemical Engineering, Getriedemarkt 9, A-1060 Wien
Have developed a wood chip combustor for domestic heating purposes.

University of Vienna
Institute of Plant Physiology, Althanstrasse 14, A-1090 Wien
Tel: 0222 31 4510
Carrying out studies on basic physiology and photosynthesis in C-3 and C-4 plants in relation to biomass productivity.

Voest-Alpine Bausysteme GmbH
Vereinigte Osterreichische Eisen und Stahlwerke-Alpine Mont AG, Wienerstrasse 17, A-4020 Linz
Tel: 0722 5851 Tlx: 2209252 va-a
Manufacture composting plants and clarifying plants for industrial wastewaters. Parent company of Vogelbusch, Voest-Alpine and Bohler Brothers (US) who offer alcohol technology.

Vogelbusch GmbH
Postfach 52, Blechturmgasse 11, A-1053 Wien
Tel: 0222 54 1661 Tlx: 132144
Provide engineering and technical services for fermentation and distillation applicable to power alcohol (ethanol). Also offer plant for yeast (bakers' fodder), vinegar, potable alcohol, water treatment, anaerobic digestion, citric acid, acetic acid, single-cell protein, etc. Manufacture a deep jet process for microbial treatment of sewage. Produce an analytical detection system for on-line measurement and control of ethanol concentration during fermentation.

Zweigwerk Osterreich
A-4673 Gaspoltshofen
Tel: 07735 284 Tlx: 27781
Suppliers of Spanex Sander GmbH & Co KG (FRG) briquetters.

BANGLADESH

Al-Kamal & Co
PO Box 593, Dhaka 2
Provide consultancy services for the installation of biogas plants for energy self-sufficient villages. Also conduct training courses and technical supervision programmes for construction of family size plants and publish a newsletter called Biogas Sangbad.

Bangladesh Agricultural University
Department of Crop Botany, Mymensingh
Tel: 219162
Researching crops as a source of fuels.