energy innovation austria

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Current developments and examples of sustainable energy technologies

BIOBASED INDUSTRY

Austrian strategies for producing from renewable raw materials

Sustainable strategies for industry, making increasing use of biogenic raw materials and sources of energy, are among the key elements of the ecologically sound economic system that we shall need in future. At the European level biobased industry and biobased products receive targeted promotion, since our dependence on fossil raw materials and sources of energy is reduced as this type of production is further developed and expanded, while the value created stays within Europe. Austrian research institutions and enterprises have for years actively pursued new approaches to employing renewable resources in industry and to developing innovative products and processes.

Photobioreactor, Photo: toa555, fotolia.com

Sustainability in industry
Strategies for biobased production

The expression “biobased industry” is used to refer to producing material goods from biomass; the focus is on utilizing non-fossil, biogenic carbon as material and on using biomass efficiently, i.e. as completely and sustainably as possible. Biomass is the only renewable raw material containing carbon, and offers many ways of making foodstuffs, animal feed, fertilizers, a variety of chemicals and materials, plus sources of energy. Biobased industry is extremely versatile, and can cope with biomass from agriculture and forestry, with organic residues and with new raw materials such as algae.

Biogenic raw materials are capable of replacing petrochemical raw materials in many sectors of industry, and will make it possible to develop pioneering new products. One particularly cutting-edge approach to converting biomass efficiently is that of the biorefinery; here biomass can be exploited to the full in integrated processes coupling material and energy flows, and can be turned into a wide range of marketable products.

In Austria there are a large number of technologically and economically successful enterprises both in classical sectors of biobased industry (such as timber processing, the paper industry or food processing) and in new segments (such as producing biofuels or microalgae). Roughly 6 % of the total value created in Austria is attributable to biobased industry. In all the fields involved there is a demand for research, technology and innovation (RTI) that will make it possible to utilize biogenic raw materials efficiently and sustainably and to make biobased industry and biobased products even more competitive. Potential for development is thought to reside in cross-linking the various stakeholders and forming interfaces between individual industries and technologies.

The Federal Ministry for Transport, Innovation and Technology (bmvit) provides significant impulses by way of the RTI initiative “Production of the Future”, a framework within which pioneering projects for biobased industry are supported. Once a year the stakeholder forum “ Biobased Industry” is held. There successful research projects from the RTI initiative are presented. In 2014, at the instigation of bmvit, an RTI roadmap was drawn up for biobased industry in Austria, which identifies future opportunities and development paths.

Below relevant strategies, and pioneering Austrian research and demonstration projects implemented as part of the RTI initiative “Production of the Future”, are presented. ◘


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Publication BIOBASED FUTURE

On behalf of bmvit, information on renewable raw materials, on using them in material and energy flows, and on Austrian participation in the International Energy Agency‘s Implementing Agreement IEA Bioenergy, is provided by Bioenergy 2020+ GmbH at regular intervals in the bulletin “Biobased Future”.
www.nachhaltigwirtschaften.at/publikationen/sonstige.html


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RTI-Roadmap
for biobased industry in Austria

The RTI strategy drawn up by ÖGUT (Austrian Society for Environment and Technology) presents possible developments in the fields of supplying raw materials, of process engineering and of actual products, formulates targets and recommends actions for expanding biobased industry in Austria. The analysis focusses on the non-food sector in particular. The roadmap builds on the findings of the survey "Am Weg zu einer biobasierten Industrie - Chancen für Österreich" (A. Windsperger et al., 2010), in which the main principles applying to raw materials from forestry were worked out. Supplementary data on raw materials and residues from agriculture have been included in a comprehensive RTI strategy matched to the industrial setting in Austria.

Photo: ÖGUT

„One of Europe`s central future questions is the subject of raw materials. In fact, we are heavily dependent on imports of fossil fuels, thus million Euros annualy flowing abroad. The bio-based industry has the chance to strengthen regional economic cycles and to add value in Austria. In the course of the project it became clear that biobased industry will continue to play an important part in Austria, particularly if we succeed in cross-linking the entire value-adding chain vertically and horizontally, utilizing existing know-how across sectors, developing it further and thus benefiting from synergies not previously exploited."

Erika Ganglberger, Project management RTI-Roadmap
ÖGUT - Austrian Society for Environment and Technology

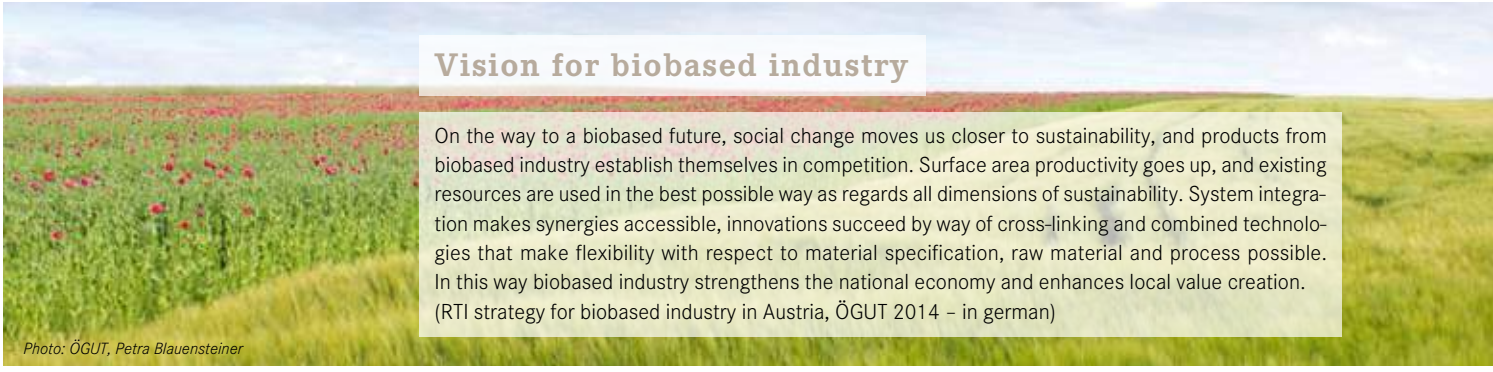


Photo: ÖGUT, Petra Blauensteiner

Vision for biobased industry

On the way to a biobased future, social change moves us closer to sustainability, and products from biobased industry establish themselves in competition. Surface area productivity goes up, and existing resources are used in the best possible way as regards all dimensions of sustainability. System integration makes synergies accessible, innovations succeed by way of cross-linking and combined technologies that make flexibility with respect to material specification, raw material and process possible. In this way biobased industry strengthens the national economy and enhances local value creation. (RTI strategy for biobased industry in Austria, ÖGUT 2014 – in german)

In the course of the project individual interviews took place with representatives of the food industry, the chemical, pharmaceutical and the timber-processing industry, to facilitate discussing and assessing future developments in the fields of raw materials, technology and actual products. Short-term, medium and long-term development paths were sketched out in the following areas:

> Supplying raw materials: agricultural raw materials, raw materials from forestry, algae as raw material
> Product development: building and insulation materials, biogenic composites, biopolymers, bulk chemicals, biofuels, fertilizers, special biobased products
> Processing: fermentation, gasification, pyrolysis, timber processing, new biorefinery approaches

Using biogenic raw materials to the full makes sense in terms of both ecology and economics. Biorefinery approaches to couple material and energy flows are resource-efficient and can be expected to maximize added value. Here integrated production processes must be developed and applications and selling markets found for each product and byproduct. Dovetailing with the food, animal feed and fertilizer sectors may also improve cost/benefit ratios.

The experts recommended the following actions to boost biobased industry in Austria:

> Integrated approaches to using biomass for energy purposes and as raw material
> Comprehensive assessment of the ecological and economic impact of biobased products
> Wide-ranging promotion of biobased industry in Austria
> Cross-linking of and collaboration between stakeholders in administration, research and business
> Systematic (research) funding for issues arising in biobased industry
> Market interventions
> Development in collaboration with classical industries

Photo: gitanito, fotolia.com

LIGNO I & II
Using lignified biomass as raw material

The projects LIGNO I and II are intended to develop strategies for the complete use of lignified biomass as raw material, they are being carried out by the University of Natural Resources and Life Sciences (known as BOKU), Vienna, denkstatt GmbH and Technologie- und Dienstleistungszentrum Ennstal. Cascading woody biomass is being investigated in the fields of chemistry, wood research and biotechnology, and strategies for developing new materials based on biomass are being worked out.

The BOKU Departments of Biotechnology and Chemistry and the BOKU Institute of Wood Technology and Renewable Materials are developing chemical, physical and microbial methods with the aim of obtaining various material streams (depending on the raw material) which terminate entirely in products of economic value. Possible examples include lactic acid for making bioplastics, humus-like fertilizer to improve soil quality, or high-grade nanocellulose fibres. The material streams are mapped in process descriptions and in a business model, with the aim of exploiting the identified processes economically. In the course of the project denkstatt GmbH assesses profitability and ecological impact.

New methods for biomass-based materials

In LIGNO I the researchers were concerned with selecting and decomposing suitable raw materials, and developed new methods of hydrolysing the biomass with enzymes, removing lignin, fermenting with yeasts and obtaining fibres. A number of interesting products were made with the lignins extracted, yielding cues for promising application-oriented follow-up projects. Valuable new insights were gained in the field of fermentation. With the yeast employed, Candida lignohabitans, various sugars and lignocellulose hydrolysate were harnessed to make lactic acid and itaconic acid. This provides an interesting option for making more value of raw materials based on lignocellulose by biotechnological means.

Pioneering product developments

Building on these findings, LIGNO II is developing the chemical and biotechnological path further, to create the conditions needed for launching the new materials commercially. The Austrian Federal Forests and FERMTECH GmbH are also partners in this project.

The focus is on utilizing the lignocellulose biomass in a modular way and on making various products that could only be manufactured from petroleum in the past. For instance, it is possible to make dimensionally stable aerogels (not previously available) based entirely on lignin. Aerogels are ultra-light, highly porous materials with a growing number of technical applications, such as:

> high-performance thermal and acoustic insulation
> substrate for catalysts and filter systems
> electrode material for electrochemical applications

Another interesting chemical is itaconic acid, like lactic acid a precursor for polymers; until now it could be produced only under very specialized conditions. Itaconic acid resembles maleic acid, which serves as a precursor for making acrylates and resins. Both itaconic acid itself and its derivatives can be employed as building blocks in chemical synthesis. For instance, itaconic acid can be decarboxylated and then esterified to make methyl methacrylate, which is then turned into plexiglass.

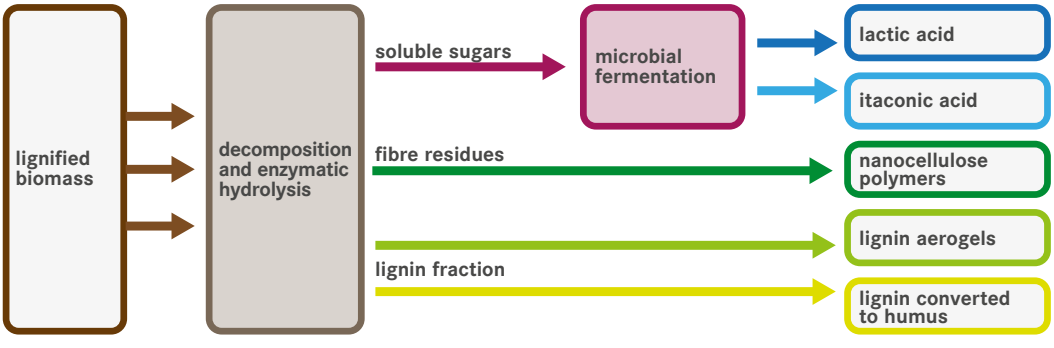


Diagram: University of Natural Resources and Life Sciences BOKU, Vienna

Top left: wood sample after steam explosion to break up its structure.
Top centre: enzymatic hydrolysis of wood to release the sugars.
Bottom left: the yeast Candida lignohabitans, which converts these sugars into exploitable substances.
On right: a laboratory fermentation unit in which the yeast performs this conversion.
Photos: University of Natural Resources and Life Sciences, Vienna, Department of Biotechnology

EXPERT INTERVIEW

Franz Latzko, Austrian Chamber of Commerce, Association of the Austrian Chemical Industry (FCIO), on opportunities and perspectives for biobased industry

Photo: private

Biobased products derived (partly or entirely) from renewable raw materials may well gain considerably in importance in future. How do you see the opportunities for biobased industry located in Austria?

Biogenic raw materials are already in use on a substantial scale even today. Individual sectors (biofuel and semi-synthetic fibre manufacturers and rubber processors), individual pharmaceutical firms and some food additive suppliers make use of biogenic raw materials and account for more than a tenth of the total product value generated by the Austrian chemical industry. We should take advantage of this lead in experience.

What are the major challenges involved in expanding/developing biobased industry further?

A number of questions arise in connection with developing a biobased industry. One of them is whether there is enough biomass on hand for the various possible uses (sources of energy versus raw material) and the political aims attached to these. Surveys claim that this is a bottleneck; they also point out that cascading biomass is the way to maximize value creation. For the firms concerned it is specially important that the framework for investment remains stable. And at the end of the day customers must actually buy the new products.

Where could fossil raw materials be replaced by biogenic in the chemical industry?

In the long term no limit is in sight for chemists in the field of carbon-based molecules. The economic setting will be decisive; as already mentioned, the issues are competition for raw materials and market acceptance. In the case of anorganic products the biogenic raw materials are suitable as sources of energy at most. The parallel development of processes to utilize carbon dioxide in synthesis directly (carbon capture and reuse) is also of great interest and very promising; that might defuse the issue of how much biomass is available.

Which technologies and processing methods have the most potential for manufacturing biobased chemicals?

Just recently fine chemicals derived from algae have taken a major step closer to the market. The plastic processing industry is starting to use biobased material, too. Judging by the activities of the large German chemical firms, there are also definitely market openings for platform chemicals derived from biomass.

Where do you see opportunities for Austrian firms in international markets?

In my view development will follow two paths. Firms which are already using biogenic raw materials on a large scale in conventional processes will put their experience to work and invest in developing new products for the market. Smaller companies will establish themselves as niche players. In Austria we should not overlook the mechanical engineering sector, which will also cash in on its lead in know-how in this field.

Photo: Cowatech AG

ReNOx
Utilizing biogas and fermentation residues in industry

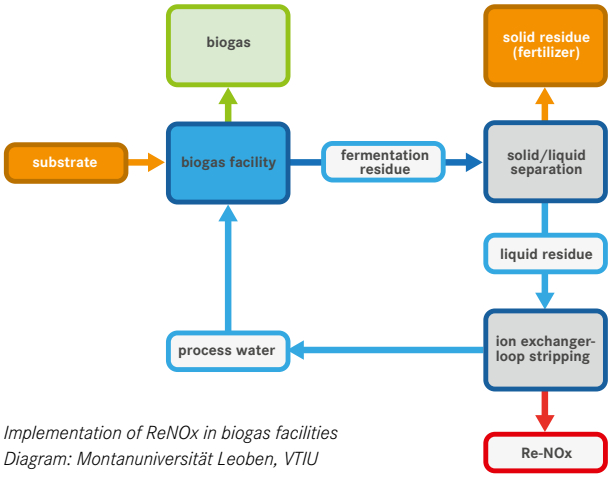
Using biogas from organic waste as a carbon-dioxide-neutral fuel in cement production is being investigated in a project at Montanuniversität Leoben (Chair of Process Technology and Industrial Environmental Protection). The project is being carried out in collaboration with a number of partners in industry and research (Lafarge Zementwerke GmbH, Christof International Management GmbH, Abwasserverband Knittelfeld und Umgebung, University of Natural Resources and Life Sciences, Vienna – Institute of Environmental Biotechnology, Energy Institute at the Johannes Kepler University (JKU) Linz).

Production processes in the building material industry consume a great deal of thermal energy. In Austrian cement production, residues and secondary sources of energy (such as scrap tyres, plastic waste or waste oil) provide roughly two-thirds of the total. In future biogas from organic residues may be used as an additional carbon-dioxide-neutral fuel for making cement. As part of the ReNOx project a strategy is being developed to link up biogas and cement facilities in the same region, so as to integrate production with closed material and energy cycles.

Flexible process to digest fermentation residues

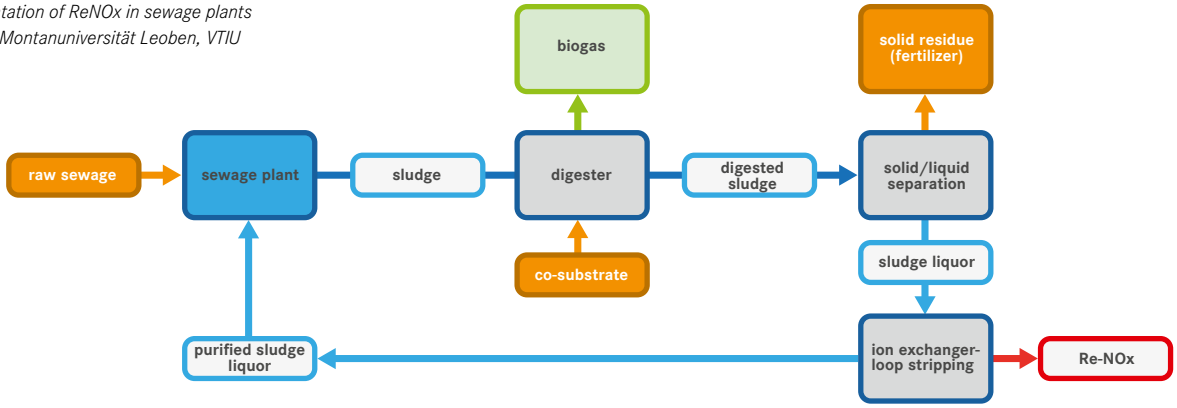
Alongside assessing a linked-up cement and biogas facility as regards technology and profitability, the project includes developing a pioneering digestion process for fermentation residues. The “ion exchanger-loop stripping” is designed to extract surplus ammonium ions from liquid fermentation residues and then use them to minimize the amount of nitrogen oxides in flue gases (“ReNOx”). To do this, an ion exchange process based on natural zeolites is combined with simultaneously stripping ammonium ions from the regeneration solution. At the same time, liquid digestates are purified to give process water for reuse in the biogas facility. Processing and recycling of the liquid phase (which can make up two-thirds of the residue mass from fermentation) creates an alternative path for utilizing fermentation residues apart from spraying them on fields; there is then no need to store large quantities of fermentation residues for months during the winter. An efficient technology capable of utilizing fermentation residues all year round is a prerequisite for implementing biogas generation on the scale necessary to contribute significantly to meeting cement production energy requirements.

Due to the flexibility of the process, ion exchanger-loop stripping can be used both in biogas facilities and to treat effluent from communal sewage plants. This is why developing compact units to retrofit existing plants is part of the project. This pioneering



Implementation of ReNOx in biogas facilities
Diagram: Montanuniversität Leoben, VTIU

Implementation of ReNOx in sewage plants
Diagram: Montanuniversität Leoben, VTIU



process is now being tested in real life for the first time in a demonstration plant (Knittelfeld Sewage Plant). If the implementation is successful, the operators of biogas and sewage plants will in future be able to obtain a product with market potential for purifying flue gas from fermentation residues, while at the same time reducing nitrogen oxide pollution from their facilities. The combination of diverse technologies and production processes (cement works, biogas facilities, sewage plants, farming) aimed at in this project to utilize biogas and fermentation residues on an industrial scale makes flexible, interconnected production possible with closed material and energy cycles across system boundaries. All the sectors participating could benefit from exploiting synergy effects. ◘

AMINOMAX
Maximizing the yield of amino acids in green biorefineries

In a green biorefinery lactic acid, amino acids, sugars and sulphates are obtained as products from grass silage. To achieve this, silage is pressed and the substances indicated are separated from the juice. The amino acids are the most valuable products; they are the basic building blocks of proteins, and play an essential part in metabolic processes. Amino acids are needed in many different areas of production; they are employed in the food industry, for pharmaceuticals, in animal feed or as biological fertilizers, for instance.

Photo: ÖGUT, Petra Blauensteiner

During silaging only about 30 % of the protein contained in the crop is converted into amino acids. In an exploratory project researchers at the Energy Institute at Johannes Kepler University (JKU) Linz have now investigated the issue of increasing the amino acid yield in green biorefineries. This project builds on the findings from several years' operation of a demonstration facility in Utzenaich, and is intended to make green biorefineries even more profitable. www.fabrikderzukunft.at/highlights/bioraffinerie

Breaking proteins down is the job of the special enzymes known as proteases. In the project the possibility of increasing yields by means of acid proteases was investigated.

In addition, new methods of solid/liquid separation were tested. All in all considerable know-how was accumulated in the field of proteolysis (hydrolysing proteins by means of enzymes). Commercially available proteases were added to the fractions grass silage, silage juice and press-cake, and the yield of free amino acids was determined. The proteases are obtained from microorganisms as extracellular enzymes by fermentation. With the enzymes actually used yields were somewhat higher (0-30 % by mass), with considerable fluctuation. To increase the yield of free amino acids from proteolysis significantly, it is necessary to develop a specific mixture of enzymes. For purposes of comparison a hydrolysis was carried out with chemicals; here the yield of free amino acids amounted to 80 % of the protein potential on hand.

A nitrogen audit of the entire process generated significant results. Grass silage, silage juice and press-cake were analysed chemically, so as to reveal where the largest dormant protein potential is. It turned out that only about 50 % of the protein in silage juice is available in the form of free amino acids. Noticeably more protein is left in the press-cake, so that is where the greatest potential for increased yields is to be found. ◘

International R&D activities to do with biobased industry

At the European level further development of biobased industry and biobased products is being promoted systematically. Austrian researchers and enterprises are participating in various international research activities.

In 2013, as part of the EU program Horizon 2020, the Joint Technology Initiative (JTI) on biobased industries was launched as a public-private partnership between the EU and the Biobased Industries Consortium (BIC), to encourage collaboration between research organizations and firms in this field of the future and thus make Europe more competitive. Austrian enterprises and research institutions are among the members of BIC.

Under the aegis of the International Energy Agency (IEA) Austrian scientists are deeply involved in research into this issue within the framework of the Implementing Agreement "IEA Bioenergy". As far as biobased industry is concerned, the main concern here is with Task 42: Biorefining. The program is focussed on analysing and disseminating strategically relevant information about biorefinery value creation chains. ◘

Photo: JOANNEUM RESEARCH GmbH

„In biorefineries the biomass available as a renewable resource is converted into a wide range of products – foodstuffs, animal feed, bioenergy (e.g. electricity, biofuels) and high-grade bioproducts such as biochemicals – with maximum efficiency. Internationally the consensus is that the combined material and energetic exploitation of biomass in the value creation chains of biorefineries provides the greatest potential for sustainability. In IEA Bioenergy Task 42 Biorefining, with its eleven participating states, the sustainability of biorefineries is being successfully appraised by means of scientific indicators for economics, the environment and society, in a Life Cycle Sustainability Assessment (e.g. biorefinery in Pöls/Styria, BioCRACK biorefinery in Schwechat). The results are presented in compact, uniform Biorefinery Fact Sheets, which provide the stakeholders with the essential basis for developing biobased industry further."

Gerfried Jungmeier, JOANNEUM RESEARCH GmbH
Austrian representative in IEA Bioenergy Task 42: Biorefining

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Information about the activities of the International Energy Agency (IEA):
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