energy innovation austria

1/2018

Current Developments and Examples of Sustainable Energy Technologies

Pioneering industrial energy technologies
Innovations on the way to low-carbon industry

Austrian industry is very productive and makes a substantial contribution to value creation and employment. Energy and raw-material-intensive sectors play an important part here. In collaboration with research organizations Austrian firms are constantly developing path-breaking technologies and production processes, so as to make industry metabolism more energy and resource-efficient, cut costs, and safeguard and consolidate their technological lead and competitive position.

Dry slag granulation pilot facility at voestalpine blast furnace, photo: Primetals Technologies

Targets and strategies for pioneering industrial production

Austrian industry is a significant and very productive economic factor, making a vital contribution to growth and securing jobs. In 2016 almost 415,000 people were employed in Austrian industry. The five sectors with the most employees are: machines, metal goods and foundries, electrical and electronic goods, chemicals, vehicles, and food and beverages.

The manufacturing sector consumes a great deal of energy. In 2014 end-use energy consumption in industry was 315.5 PJ (petajoules), i.e. 29.7 % of total energy consumption in Austria, which came to 1063.2 PJ.[1] The most energy-intensive sectors of industry are iron and steelmaking, chemicals and petrochemicals, stone, earth and glass industry, and paper and printing industry. These four sectors account for nearly 60 % of the energy consumed in manufacturing.

Saving resources and costs

For many years Austrian firms have been developing new technologies and processes in collaboration with researchers, so as to make manufacturing more energy and resource-efficient. For instance, in Austrian steelmaking energy consumption has been reduced by 15 % and carbon-dioxide emissions reduced by 22 % since 2000.[2] Between 2004 and 2015 trends in end-use energy consumption and emissions of greenhouse gases were successfully uncoupled from production: while production increased by 46 %, end-use energy consumption went up by 11 %.[3]

Slag flowing to granulator, photo: Primetals Technologies

Making efficient use of energy in industrial production processes helps to cut costs and achieve competitive advantages. However, in many processes the potential for improving energy efficiency has been more or less exhausted today – in some cases we run up against thermodynamic limits. Further improvements are feasible only via novel technologies and new production processes.

In some sectors of industry Austrian firms have succeeded in taking the lead by developing pioneering approaches. Innovation is crucial to preserve industry‘s technological lead and keep it competitive. In this issue we present some seminal examples of innovative production processes that Austrian firms have developed and demonstrated in collaboration with research organizations and with the support of the Climate and Energy Fund and the Austrian Federal Ministry for Transport, Innovation and Technology (BMVIT). ◘

[1] Source: Studie Energiestatus 2016, BMWFW (in German)
[2, 3] Source: IV, Österreichs Industrie für Energie und Klima der Zukunft, 2016 (in German)

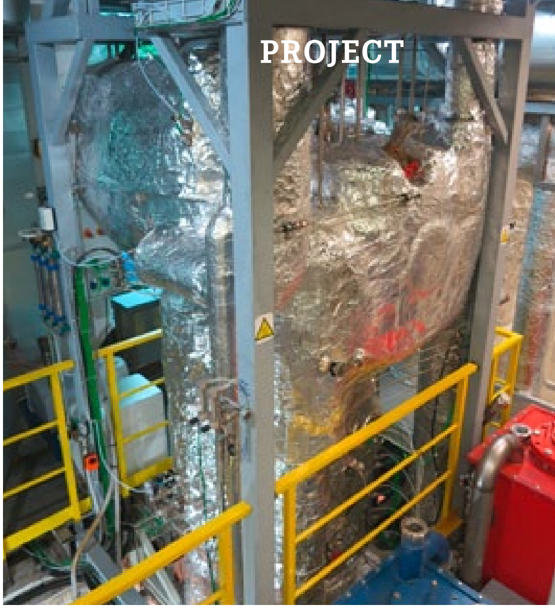
European strategies

Industrial production plays a decisive part in implementing the EU‘s energy policy aims. The European Strategic Energy Technology Plan (SET-Plan) provides the framework for developing and implementing new technologies intended to make European industry less energy-intensive, reduce carbon-dioxide emissions and improve competitiveness. In SET Plan Action 6 the current focus is on iron and steelmaking and on the chemical and pharmaceutical industry. The activities are aimed at making existing, but not yet competitive technologies more cost-effective, and at developing pioneering new approaches.
https://setis.ec.europa.eu/system/files/integrated_setplan/declaration_action6_ee_industry_0_0.pdf

International collaboration within the IEA

In the context of the International Energy Agency’s technology programme “Industrial Energy-related Technologies and Systems” Austrian researchers and firms are involved in global research collaboration on further developing pioneering energy technologies for industry. For instance, Annex 15, concerned with industrial excess heat recovery, is now in progress.
http://www.iea-industry.org/ongoing-annexes/annex-15.html

Lower part of the research plant without thermal insulation, photo: TU Wien



Upper part of the research plant with thermal insulation, photo: TU Wien

ERBA II
Carbon-dioxide-neutral hydrogen from biomass for steelmaking

At the Institute of Chemical, Environmental & Biological Engineering of TU Wien (Vienna University of Technology), in collaboration with voestalpine, work is currently in progress on further developing a new process in which a hydrogen-rich gas stream is produced from biomass. The gas should be used in iron and steelmaking. The long-term aim is to integrate renewable sources of energy in the production of integrated steelworks and to improve the carbon-dioxide balance sheet.

The so-called Sorption Enhanced Reforming (SER) Process was developed in the earlier ERBA[1] project at TU Wien. The process involves steam reforming of solid biomass in a special fluidized-bed system with lime as bed material. Here biomass is converted at high temperatures to yield two separate gas streams, one rich in hydrogen, the other rich in carbon dioxide.

Renewable sources of energy in iron and steelmaking

In blast furnaces hot metal is obtained from treated iron ores in a continuous reduction and melting process. The iron oxide contained in the ore must be separated into oxygen atoms and iron atoms. For this process carbon monoxide, derived from using coke, is needed. But hydrogen can also serve as a reducing agent to a certain extent. So far investigations have revealed that the share contributed by renewable sources of energy can be increased in blast furnaces with the new process, without impairing the quality of the final products.

An integrated steelworks involves a large number of production steps, from pig-iron to finished steel products. In future the hydrogen-rich gas produced could be employed in various process steps.

In ERBA II the entire process chain, from producing the hydrogen-rich gas stream to using it in a steelworks, is now further investigated in collaboration with voestalpine. A research plant (100 kW power) has been set up at TU Wien for this purpose; here the efficiency, rate of hydrogen production and selective carbon-dioxide transport of the process are being examined and further improved, so as to achieve the technical prerequisites for implementation in scaled-up industrial demonstration facilities.

Below-Zero Emission

The biomass reforming process delivers a hydrogen-rich gas stream plus an off-gas rich in carbon dioxide. If this carbon dioxide is returned to the environment, the carbon cycle is closed, since only the carbon dioxide previously stored in the biomass is emitted. The process is thus carbon-dioxide-neutral. The carbon-dioxide balance sheet can be improved even further if the carbon dioxide in the off-gas is captured and utilized. In this case we speak of “negative” emissions and of a “below-zero emission” process.

Results so far show that the approach is technically feasible. However, implementing it under current conditions with high-grade biomass such as wood chips is not yet economic. The next stage of research is meant to make other low-cost biogenic raw materials (e.g. forest residue wood, bark, sugar cane bagasse and other biogenic residues) usable as well. ◘

[1] **ERBA** = **E**rzeugung eines **R**eduktionsgases aus **B**iomasse mittels **A**nwendung des SER-Prozesses (Generation of a reduction gas from biomass using the SER process)

On right: Pilot facility,
photo: Primetals Technologies
Below: Refractory lining of the exhaust pipe,
photo: voestalpine Stahl GmbH

FORWÄRTS 2.0
Dry granulation of blast-furnace slag with heat recovery

For each tonne of pig-iron produced in a blast furnace, the process results in roughly 300 kg of hot, molten slag as a by-product, mainly consisting of CaO and SiO_2 (calcium oxide and silicon dioxide) plus Al_2O_3 and MgO (aluminium and magnesium oxide). Around the world about 400 million tonnes of blast-furnace slag are produced each year, at temperatures up to 1,500°C. The slag's mineral properties depend on how fast it cools down: slow cooling in air yields crystalline blast-furnace slag, rapid cooling in water glassy slag sand. Ground slag sand is mainly used in the cement industry as a constituent of so-called Portland blast-furnace cements and high-slag blast-furnace cements.

The standard process for obtaining slag sand is wet granulation; in this process the energy potential of the blast-furnace slag, around 1.8 GJ per tonne of slag, is wasted.

New technology

As part of the FORWÄRTS project and its successor, FORWÄRTS 2.0, an innovative approach to dry granulation of blast-furnace slag is being implemented by Primetals Technologies Austria GmbH in a pilot facility. This new process makes it possible to recover the heat given off to the air and use it in further processes, thus saving energy and water. Apart from voestalpine Stahl GmbH, Montanuniversität Leoben/Chair of Thermal Processing Technology and FEhS – Building Materials Institute are partners in implementation at a voestalpine blast furnace on the Linz site. The facility is currently in process of being commissioned.

The facility is based on the so-called rotating-cup principle: molten slag is poured into a rapidly rotating cup – the forces acting on the slag atomize it, and eject it radially against a water-cooled wall.

Test facility in Leoben, photo: Primetals Technologies

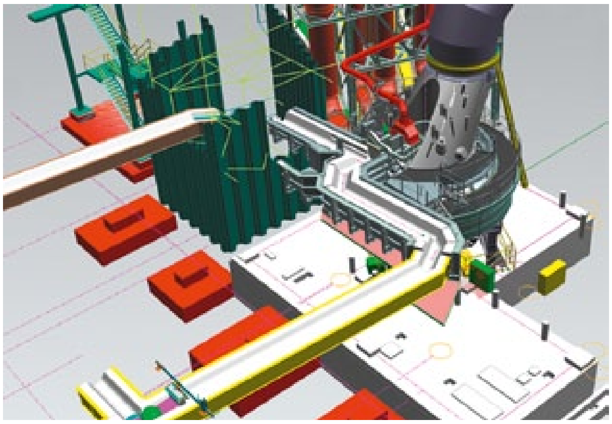


Diagram of equipment, image: Primetals Technologies

Above: Granulation in progress
On left: Dry granulate
photos: Primetals Technologies

photo: Primetals Technologies

„Transforming the blast furnace iron-making slag into a valuable product for the cement industry while recovering the huge amount of heat contained is an unsolved issue of the industry. Primetals Technologies and its development partners have committed to develop a dry slag granulation process in industrial scale and condition in which the slag's heat content is exploited to the maximum. This is one of Primetals Technologies' most significant research projects. The DSG[1] process has immense potential for boosting energy efficiency in iron and steelmaking. Assuming that half the blast furnaces around the world adopt this process, the resulting electricity savings correspond to the consumption of about 3.5 million households or 6.5 million electric cars, each travelling 10,000 km per year."

Alexander Fleischanderl
Technology Officer Up-Stream, Vice President Iron & Steelmaking and Head of ECO Solutions, Primetals Technologies Austria

On the way there (it takes milliseconds) these particles are cooled in air, and the hot exhaust air is removed. At this stage of the project the target is to produce high-grade slag sand. The most important criterion of slag sand quality is its glass content, which ought to be more than 95 % – this has a considerable effect on the sand's latent hydraulic reaction, which in turn influences the strength of the cements and concretes produced with it.

If the current project phase is completed successfully, with the engineering approach adopted and the slag sand's quality both confirmed, an overall strategy on an industrial scale, including heat recovery, can be worked out. To develop the right approach to downstream heat recovery a further research project could follow on, starting in 2019. The thermal energy recovered from the slag can be put to work to produce process stream or generate electricity or for various other heating or preheating purposes.

Saving resources

With the newly developed dry slag granulation process water consumption can be cut by up to 95 %. In addition, no energy is needed to dry the slag sand. With wet granulation subsequent drying consumes about 130 kWh of energy per tonne. Thus, starting from current practice, roughly 280 PJ of thermal energy could be saved per year. With the option of electricity recovery this is equivalent to a possible worldwide carbon-dioxide emissions reduction of 17 million tonnes per year.

Demonstration and evaluation

In the pilot facility at voestalpine's Linz site the process is being tested, fine-tuned and developed further under real-life steelworks conditions. Since June 2017 every test run has been followed by detailed evaluation. The findings are incorporated in process modifications. The focus is on the process in the rotating cup, the exhaust air from the process, the fluidized bed and the product quality. Initial analyses of the slag sand's glass content show positive results and are above the target.

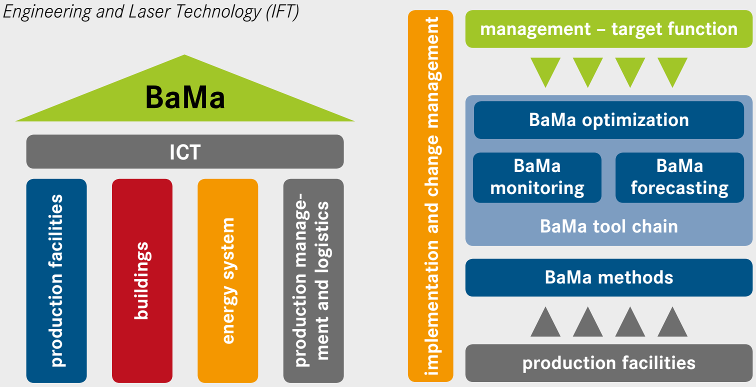
To achieve the research objective – automated operation plus compliance with the product specification laid down – suitable instrumentation and control systems are needed for atomizing the molten blast-furnace slag with a rotating cup. On the basis of the findings accumulated so far the research partners are investigating fundamentals; their results are then cross-checked in the pilot facility. ◘

[1] **DSG** = **D**ry **S**lag **G**ranulation

Production facility at MPREIS, photo: Thomas Jantscher

Chiller, photo: Infineon Technologies Austria

Graphic: TU Wien, Institute for Production Engineering and Laser Technology (IFT)



The software tool chain comprises the following core modules:

> monitoring function: data on resource consumption are gathered, edited and visualized

> forecasting function: starting from the product footprint and the production plan, the factory's energy consumption is forecasted

> optimizing function: on the basis of data from and numerical simulation models of the fabrication subsystems, the operating settings for the production facility are adapted to approximate the targets (reducing energy consumption, processing time and cost and improving product quality).

BaMa
Balanced Manufacturing

With energy costs going up and consumers making more responsible choices, energy efficiency in production is now a decisive competitive advantage for many manufacturers. Methods and tools for improving energy efficiency normally address individual aspects of a production facility; so far there has been no systemic, holistic approach to analysing and improving energy and resource flows in production in combination with estimating the economic effects of the relevant steps. In its BaMa project, the Institute for Production Engineering and Laser Technology (IFT) at TU Wien (Vienna University of Technology) has developed a simulation-based methodology for planning and controlling energy consumption in industrial production. Application-oriented software tools make it possible to minimize energy consumption in production processes, taking the economic factors time, cost and quality (which are vital for success) into account. 18 partners from research and industry collaborated in the lead project of energy research.

The BaMa System

The Balanced Manufacturing System enables manufacturers to analyse and forecast energy consumption in production processes and to reduce it by means of adaptive operating strategies. All the relevant modules of a production unit (production, buildings, energy, logistics) are modelled, taking management aspects into account. The method involves a modular approach: the production facility is divided into individual segments with defined system boundaries (so-called "cubes"), identified by clearly specified interfaces. This makes it possible to identify subsystems with especially large influence on the energy consumption of the system as a whole. Broad assessments of energy consumption at product level are derived from energy and resource flow analyses, and a product footprint (time, costs, energy, carbon-dioxide emissions, etc.) is drawn up.

Demonstration

The methods and software tools developed are currently being tested in production facilities owned by **MPREIS** and **Infineon Technologies Austria**, two of the project partners. Energy savings in the range of 10 to 20 % are expected for both applications.

The supermarket chain MPREIS puts the tools to work in its large bakery "Bäckerei Therese Mölk", where the energy factor is being taken into account for the first time in production planning. As a first step, energy consumption for all products and manufacturing processes was recorded and a simulation model drawn up to map real production. Next, the project team developed an optimization tool in which all production variables (locations, times of day, energy demand, etc.) are harmonized. In total, all four production lines where included in the system.

At Infineon Technologies Austria, a semiconductor manufacturer, the BaMa system is being used to improve the operating strategy for chillers. Semiconductors are manufactured in clean rooms, in which a specific temperature and humidity are required. These rooms are air-conditioned by chillers which consume a great deal of energy. In the course of the project potential for improvements in regulating and loading the chillers is identified, and recommendations for action are worked out. ◘

Both photos: Zinner, Wienerberger

DryPump
Efficient drying with vapour-compression heat pumps in industry

Desiccating and drying products are among the most energy-intensive industrial processes, accounting for up to 25 % of total energy consumption in industry around the world. Roughly 85 % of all drying processes involve fossil-fuelled convective driers. In 99 % of these systems the water vapour produced in drying is simply expelled with the exhaust air and no use is made of its energy content.

Employing compression heat pumps in industrial drying processes is the subject of research in the DryPump project managed by the AIT Austrian Institute of Technology GmbH. The new technology is intended to recover the energy content of the water vapour from the exhaust air and feed it back into the drying process. Technically feasible approaches have been developed and assessed for cost-effectiveness in selected processes.

In air-conditioning and eliminating moisture from construction materials the compression heat pump is an established technology for desiccating air flows. The DryPump project investigated whether this technology is suitable for industrial drying in an evaporation temperature range from 60 to 95°C and at condensation temperatures up to 170°C. At Wienerberger and AGRANA, two of the project partners, preliminary investigations identified seven different processes requiring incoming air at temperatures in the range 80 to 170°C. Functional prototypes of compressors from the project partner Bitzer Kühlmaschinen GmbH were used to investigate under real-life operating conditions how heatproof critical materials are. Safe starting up and shutting down and direct injection to cool gas were also examined. Approaches to process integration were developed.

Energy-intensive drying processes are particularly common in the paper industry, but also occur in the timber, sugar, paint, textile and brick industries. The researchers at AIT expect that in the mid term the new technology will make energy savings of up to 80 % and carbon-dioxide emission savings of up to 68 % possible. The results will provide a basis for follow-up demonstration projects.

Demonstration in EU project DryFiciency

With the support of the EU research and innovation programme Horizon 2020 (EC Grant Agreement Nr. 723576) the DryFicieny project with focus on industrial heat pumps is currently under way. In this setting a pioneering heat-pump technology for drying in industry will be demonstrated at two Austrian project partners, AGRANA and Wienerberger. www.dry-f.eu

In **AGRANA**'s sugar and starch production the new heat-pump system will be incorporated in producing and drying starch from potatoes, wheat and maize; it is intended to harvest around 25 % of the heat recovery potential on site.

At **Wienerberger** this heat-pump technology will be used to dry bricks, which are currently dried with hot air in "open" convection driers. In future the process is to run in a closed circuit, with the heat pump recovering heat from the moist exhaust air and returning it to the heating system. ◘

„The bulk of the thermal energy supplied to a brickworks ends up in the moist air expelled from the brick driers. So using heat pumps to recover heat from moist exhaust air is a key research area for Wienerberger. DryPump and the follow-up project DryFiciency are important elements in our R&D roadmap to reduce unit energy consumption in brickmaking.

photo: Wienerberger

For Wienerberger, as a representative of a very tradition-oriented sector, participating in collaborative research projects with public funding is most enriching."

Dirk Saldsieder
Head of Production Technology & New Materials
Wienerberger AG

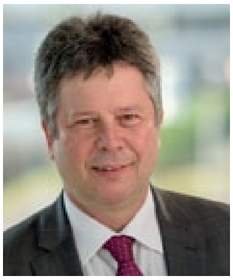


photo: voestalpine AG

Franz Androsch
Head of Group Research
voestalpine Group

voestalpine is not only a technological leader as regards upmarket steel products, but is also among the front runners in its field as regards energy efficiency and environmental impact. What part do energy-intensive industries play in shaping a sustainable future?

voestalpine contribute significantly to sustainability via their products and materials. High-strength steels for lightweight vehicles or laminated electrical strip cores for ultra-efficient electric motors are just two examples. The processes involved in the steel industry make it one of the largest energy consumers and emitters of carbon dioxide. That's why we are working hard on new, sustainable strategies in collaboration with the energy industry, and thus contributing to long-term solutions. The most promising development paths are switching from fossil sources of energy such as coal to electricity or hydrogen from renewables, and improving energy efficiency further – though, given the state of the art, there are only limited possibilities here. However, both routes involve completely restructuring our existing fossil energy system.

The Group invests a great deal in research and development, including resource-efficient production processes. Which research topics and technologies are currently the centre of attention?

The current research budget is at a record level of 159 million Euro, proving that research, development and innovation enjoy top priority within the voestalpine Group. Innovation is largely concerned with developing production processes further in the direction of digitalization. We focus on new technologies along the value creation chain, and developing products, components and entire system solutions for the markets with the highest standards of technology and quality, the transport and energy sector.

What is the significance of research and innovation for Austria as an economy?

R&D and innovation ensure the companies' survival, and thus a large number of jobs. For a highly developed country with high wages such as Austria, innovation is essential to secure our high standard of living and the ongoing development of our society.

energy innovation austria presents current Austrian developments and results from research work in the field of forward-looking energy technologies. The content is based on research projects funded by the Austrian Federal Ministry for Transport, Innovation and Technology and the Climate and Energy Fund. **www.energy-innovation-austria.at, www.open4innovation.at, www.nachhaltigwirtschaften.at, www.klimafonds.gv.at**

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IMPRINT
Published by Austrian Federal Ministry for Transport, Innovation and Technology, (Radetzkystraße 2, 1030 Vienna, Austria) in cooperation with the Climate and Energy Fund (Gumpendorfer Strasse 5/22, 1060 Vienna, Austria)
Edited and designed by Projektfabrik Waldhör KG, 1010 Vienna, Am Hof 13/7, www.projektfabrik.at
For change of your shipping address contact: versand@projektfabrik.at

Production minimizing impact on climate, FSC certified, Green Seal and Austrian Seal of Ecological Approval