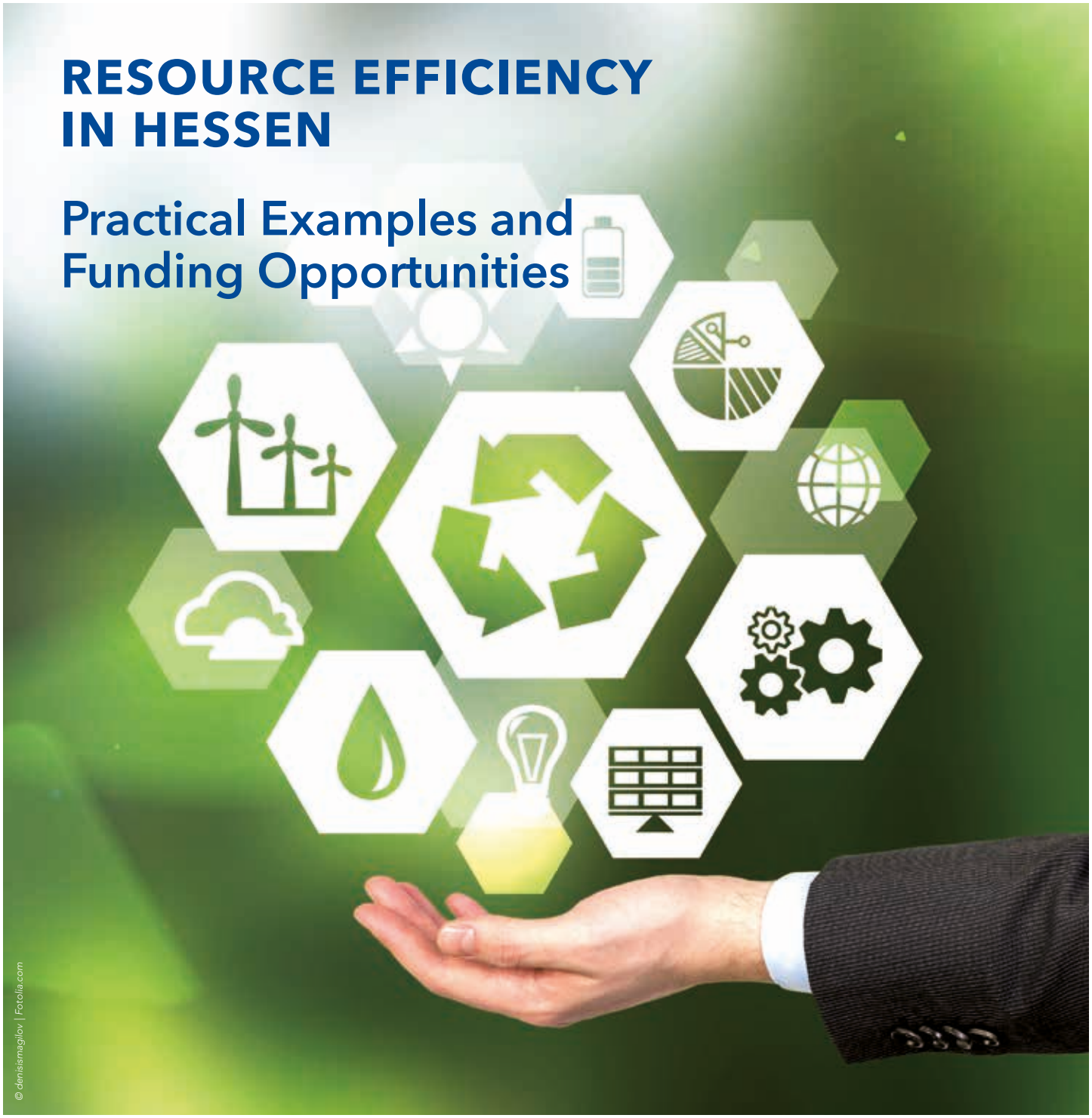
HESSEN

TECHNOLOGIELAND HESSEN

# RESOURCE EFFICIENCY IN HESSEN

## Practical Examples and Funding Opportunities





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CREATE.
FUTURE.
NETWORK.

## Contents

# Foreword

Efficient management of resources is an ecological and economic necessity. Future technologies such as renewable energies and electromobility are increasing the demand for rare materials which are often difficult to obtain and whose natural occurrence is limited. To compound matters, they are also unevenly distributed across the planet. The future of our economy, therefore, depends on our becoming more efficient in our use of resources – not only when it comes to energy supplies, but also of raw materials. Ultimately, the average share of material costs in industry lies at around 40 per cent; energy costs, on the other hand, only make up two per cent.

Possible solutions could include more efficient production processes, the substitution of scarce raw materials with less expensive or more readily accessible alternatives as well as the use of secondary raw materials. Ideally, we should be aiming for closed material cycles.

A lot can be done in this respect: the list of measures ranges from minor, organisational changes or process optimisation right down to novel production methods such as 3D printing. Digitalisation opens up particular opportunities.

Here in Hessen, we are making good progress on the way to resource efficiency. The examples presented in this brochure are confirmation of this. I wish you an enjoyable, inspiring read.

**Tarek Al-Wazir**
Minister for Economics, Energy, Transport and
Regional Development, State of Hessen

# 1. Resource Efficiency as a Competitive Factor

**Efficient management of limited resources is an ecological and economic necessity. The first Hessen Conference on Resource Efficiency, which took place in November 2016 in Frankfurt am Main, pointed the way to a sustainable economy.**

In 2016, "Earth Overshoot Day" fell on 8 August. According to the environmental protection organisation Global Footprint Network, humanity consumed as many natural resources in the time between 1 January and this date as the Earth can generate in one year. The fact that Earth Overshoot Day is continuously moving forward – ten years ago it fell in October, five years ago in September – brings with it considerable problems such as climate change and the extinction of species," according to Hessen's minister for economic affairs, Tarek Al-Wazir, at the first Hessen Conference on Resource Efficiency in November 2016 in Frankfurt am Main. "We need to consider ecology and economy together, while at the same time not forgetting the social aspects of economic activity."

The subject of resource efficiency is not only about the optimised use of raw materials and protection of the environment. Above all, it is a question of safeguarding the competitiveness of local industry. At the same time, it should be remembered that the economic potential of material efficiency is considerably larger than that of energy efficiency. Closed material cycles therefore not only help the environment, but also save costs.

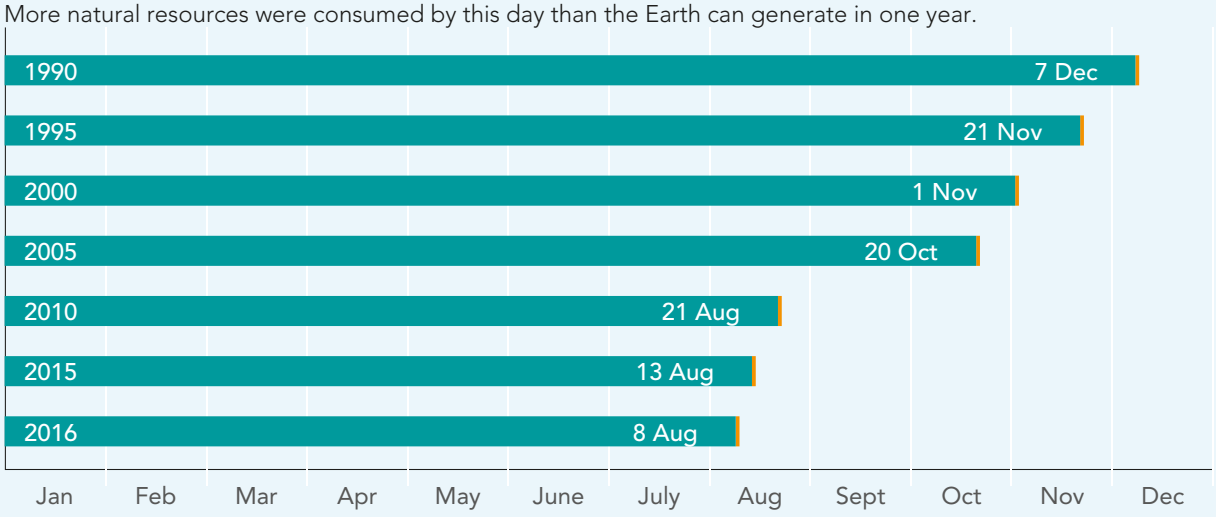
## Digitalised production

Addressing the Hessen Conference on Resource Efficiency, Dr Raoul Klingner, Director of Research at the Fraunhofer-Gesellschaft e.V., emphasised that "from now on, maximum added value must be gained from minimum resource deployment, instead of maximum profit from minimal capital investment as up to now." Klingner is convinced that digitalisation plays a key role on the path to a sustainable economy. Smart machines, for example, are learning how to limit scrap rates in production, and the increasing digital transformation of processes is facilitating the closure of material cycles.

Ken Webster, Head of Innovation at the British Ellen MacArthur Foundation, emphasised the way digitalisation is helping us to turn our back on the linear economy, based on a "take, make and dispose" mentality. Resource efficiency can be more easily achieved if companies offer a performance or service instead of having to sell a product. If they do not completely relinquish control of their products, they are more able to manage their materials within a cycle.

### Earth Overshoot Day

More natural resources were consumed by this day than the Earth can generate in one year.




Source: Global Footprint Network

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## New manufacturing methods

New production techniques such as 3D printing also contribute to increased resource efficiency. The natural world provides the blueprint for additive manufacturing, according to Klingner: "A tree, for example, only grows more wood where notch stress is greatest – an extremely resource-efficient process." Similarly, the soles of running shoes would not have to be made of solid material in future, but would consist instead of delicate but wearable, cushioning compositions, modelled on nature. This would also apply to many other components, from helmets through car bodies to bridge piers.

Whether it is digitalisation or circular economy, material-saving manufacturing or new energy-supply systems, companies and research institutions in Hessen are driving the changeover to a resource-efficient economy. They presented their ideas and business models at the Hessen Conference on Resource Efficiency in Frankfurt, as outlined on the following pages. May these successful examples from Hessen prove an inspiration to many others – so that Earth Overshoot Day is gradually put back year by year.


**The first Hessen Conference on Resource Efficiency**

took place on 16 November in Frankfurt am Main and was attended by 280 visitors and 20 speakers. A detailed report on the conference as well as videos of the keynote speeches and summaries of the various sessions can be found at www.ressourcen-effizienz-hessen.de (in German). The second Hessen Conference on Resource Efficiency is due to take place in the spring of 2018.



*Participants at the Hessen Conference on Resource Efficiency discussed new ideas and processes for a resource-efficient economy. The practical examples provide the basis for this brochure. (Photos: Jana Kay)*

# 2. Practical Examples from Hessen

## 2.1 Resource-efficient processes and products – Conscious use of materials and energy

**One of the fundamental aspects of a sustainable economy is the premise that raw materials, regardless of whether they are energy sources, precious metals or other substances, should not be wasted, and that products should be manufactured in a way which makes most efficient use of resources. They should also be durable and easily recyclable. Companies and research institutions in Hessen are generating ideas which contribute to increased resource efficiency.**

### Compressed air and heat from gas

The compressed-air-and-heat system from Bosch KWK Systeme GmbH boosts energy efficiency, lowers $CO_2$ emissions and cuts operating costs at the same time.

For production firms which require both compressed air and heat, the compressed-air-and-heat system developed by Bosch is an ideal solution. From the outside, it looks like a conventional cogeneration unit. At its heart, it also has a combustion engine. This does not drive a generator, however, but an air compressor instead. Since the combustion engine passes on the mechanical output of the drive shaft without any efficiency loss, this represents a highly efficient way of producing compressed air. Furthermore, the installation cuts operating costs, since it uses natural gas instead of electricity to produce the compressed air.

*Compressed-air-and-heat system at the energy centre of Bosch Thermotechnik GmbH in Lollar. (Photo: Bosch)*

Our compressed-air-and-heat system works highly efficiently and economically at the same time: savings of around 450,000 euros in ten years can be achieved, depending on the number of hours of use per year and the primary energy costs.

**Ulrich Inderthal**, Managing Director of Bosch KWK Systeme GmbH in Lollar

During the transformation of mechanical energy into compressed air, around 95 per cent of the energy used accumulates as heat. A large proportion of this and the heat recovered from engine cooling and from the exhaust is fed into the heating circuit. In this way, 60 kilowatts of shaft power generates 48 kilowatts of heat. The thermal output of the installation as a whole is 135 kilowatts, which corresponds to a thermal efficiency of 82 per cent; in addition it delivers up to 570 cubic metres of compressed air per hour. The combined provision of compressed air and heat reduces $CO_2$ emissions by almost half, as opposed to when these are generated separately.

The company, which is based in Lollar in central Hessen, has proven its expertise in cogeneration technology over many years and, alongside gas-driven cogeneration units, also offers ORC systems which transform waste heat into electricity. Their portfolio has therefore adapted to suit the energy market and can be combined with other Bosch solutions, building intelligent networks.

*Corroded pump components: the effect of chloride in swimming pool water on cast iron. (Photo: Herborner Pumpentechnik GmbH & Co KG)*

## Sustainable bathing fun

By applying a plastic coating, Herborner Pumpentechnik GmbH & Co KG boosts the efficiency and service life of swimming pool pumps.

Swimming pool water presents pumps with a real challenge, since its often high chloride content has a corrosive effect. The problem has intensified now that an increasing number of swimming pools are made of stainless steel, since the corrosive products accumulate on the stainless steel surface. Around 90 per cent of pumps in municipal swimming pools are made of cast iron which corrodes at levels of chloride as low as 150 milligrams per litre. By comparison, the limit for drinking water lies at 250 milligrams of chloride per litre.

The Hessian company Herborner Pumpentechnik has found a solution to this problem, in collaboration with the TH Mittelhessen University of Applied Sciences. A novel plastic coating, around half a millimetre in thickness, protects the cast iron against corrosion and wear. In addition, the coating improves flow behaviour and therefore makes the pump hydraulics more energy efficient. Hydraulic efficiency increases by up to eight per cent.

The Herborn manufacturer opened its own coating facility in 2016 and already coats 70 per cent of its swimming pool pumps on site. The company has brought to market a range of particularly thick coatings for pumps used in salt-water baths with extremely high salt concentrations.

This also saves metal resources, because pumps made of bronze or stainless steel are traditionally used in this segment.

Corrosion-resistant pumps are by no means the first innovation from Herborner Pumpentechnik. Over 45 years ago, the company was the first to develop a swimming pool water circulation pump with an integrated hair and fibre filter. An energy-saving pump, which feeds up to 95 per cent of its waste heat into the water, a special pump for natural pools and many other ideas for sustainable swimming pool technology have also originated from the Hessen pump manufacturer.

Our resource-efficient swimming pool pump has turned out to be a trendsetter. The new generation of pumps is safeguarding our production site.

**Sascha Korupp**, Technical Manager at Herborner Pumpentechnik GmbH & Co KG in Herborn

*Swimming pool pumps from Herborner Pumpentechnik: A novel plastic coating increases the pumps' service life and boosts energy efficiency at the same time. (Photo: Herborner Pumpentechnik GmbH & Co KG)*

## Saving materials with 3D printing

FKM Sintertechnik GmbH is a pioneer in the field of industrial laser sintering, a variation on 3D printing.

The company knows all about material efficiency. Founded over 20 years ago in Biedenkopf near Marburg, it manufactures car consoles, mobile-phone cases and a host of other products using laser sintering technologies. These are among the group of additive manufacturing methods generally referred to as 3D printing.

The selective laser sintering method is used to construct products by the application of layer upon layer of metal or plastic powder. It all starts with a data set which describes the design of the product to be manufactured in wafer-thin layers. The data indicates the pattern which the laser burns into each layer of powder. The powder melts at the points hit by the laser, the next layer of powder is applied, and the irradiation process is repeated until layer by layer the required object has been constructed. The loose, residual powder is removed, mixed into new material and in this way re-used.

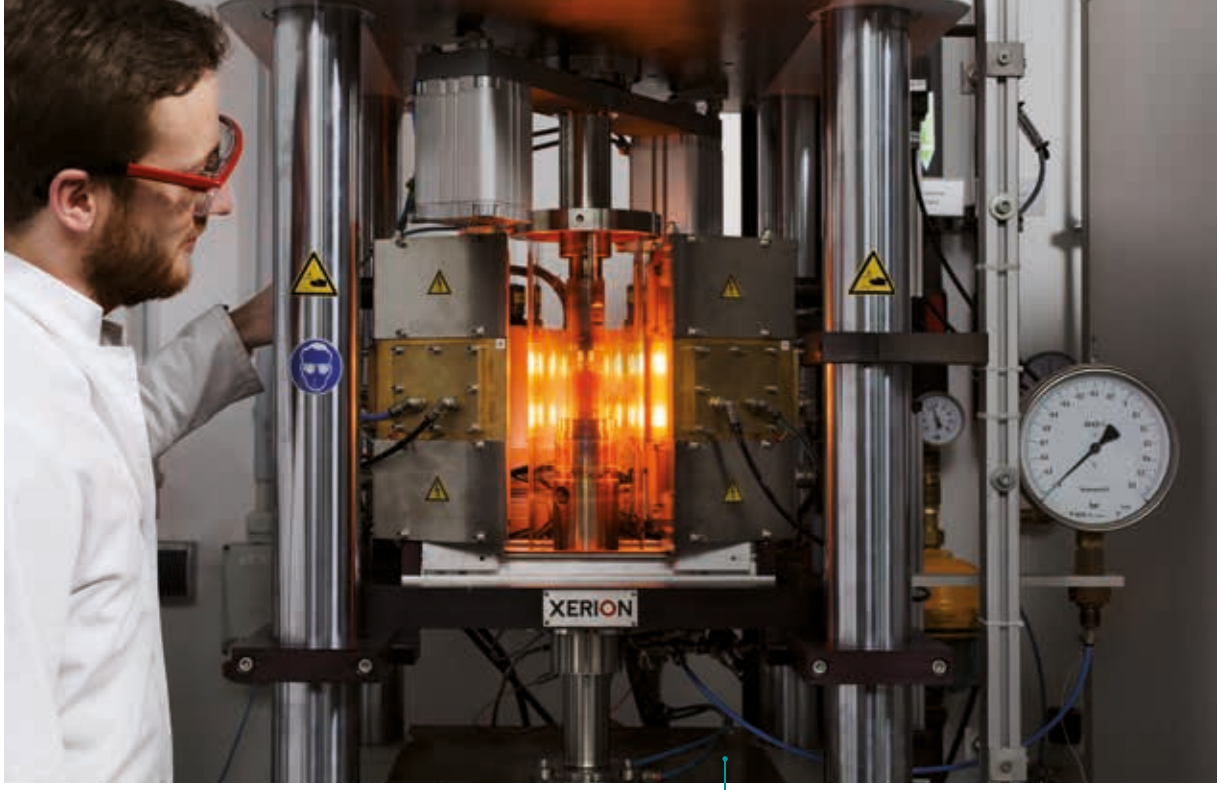
Selective laser sintering allows large proportion of the used material to be mixed into the raw material. We have developed our own processing method to do this.

**Jürgen Blöcher**, Managing Director of FKM Sintertechnik GmbH in Biedenkopf

This technology not only saves material, but also produces far finer structures than with classic milling or casting methods. In future, running-shoe soles, helmets, components for vehicle and machine construction and numerous other products can be composed of delicate yet cushioning, wearable structures inspired by nature rather than being constructed out of solid material as in the past. FKM Sintertechnik, for example, has used laser sintering to produce a component for an industrial robot which used to be constructed out of aluminium and weighed 3.6 kilograms. The resulting plastic part is considerably smaller, weighs only 230 grams and improves the robot's performance by ten per cent.

FKM Sintertechnik produces both small batches of prototypes as well as series of several hundred pieces for its clients. In addition to various plastics, the company also processes a wide range of metals, from light alloys, stainless and tool steels down to superalloys.

*Following selective laser sintering, the plastic powder is removed to reveal the product, in this case a lampshade. (Photo: FKM Sintertechnik GmbH)*




*Research at the TU Darmstadt: hot pressing of a neodymium-iron-boron magnet. (Photo: Katrin Binner/TU Darmstadt)*

## Environmentally friendly magnets

Professor Dr Oliver Gutfleisch from the Technische Universität Darmstadt and the Fraunhofer Project Group for Materials Recycling and Resource Strategies IWKS researches into high-performance magnets with reduced rare-earth content.

High-performance magnets, such as those used in wind turbines and electric motors, largely consist of iron, a small quantity of boron for stabilising purposes and almost 30 per cent by weight neodymium. The related elements dysprosium, terbium and others which enhance certain of the magnet's properties also occur in smaller quantities. The problem is, that these exotic-sounding metals belong to the group of rare earth elements. They may not all be rare, but generally occur mainly in China where the mining practices used to extract them are often environmentally questionable.

The team led by Professor Dr Oliver Gutfleisch from the TU Darmstadt and the Fraunhofer Project Group IWKS want to drastically reduce the proportion of rare earth metals used in high-performance magnets. Their aim is to introduce elements such as dysprosium and terbium into the magnetic material in a more targeted manner by means of a diffusion process. As a rule, the elements are molten in a primary alloy. They are then homogeneously dispersed throughout the magnet, although they are only needed in specific areas, at the so-called grain boundaries. Using the targeted diffusion technique being developed by Gutfleisch and his team, the dysprosium content can be reduced in some instances from eight to below two per cent by weight.

Magnetic materials which contain no rare earth elements at all also serve as an alternative. Iron nitrides, for example, consisting of iron and nitrogen, exhibit excellent magnetic properties. They decompose, however, at raised temperatures – a problem which Gutfleisch and his colleagues are already trying to solve. When developing new materials, thought is always given to subsequent recycling and closing material cycles. The recovery for re-use of neodymium and the like could reduce dependency on China and improve the ecological footprint. To do this, however, the next step is to significantly increase recycling rates for rare earth elements, which currently lie at below one per cent.

We need to re-think material design. In future, resource efficiency will come first.

**Professor Dr. Oliver Gutfleisch**, Professor of Functional Materials at the TU Darmstadt and head of the corresponding business unit within the Fraunhofer Project Group for Materials Recycling and Resource Strategies IWKS at its Hanau site.

## 2.2 Closing material cycles – From residue to raw material

**Closed cycles save natural resources. The recycling of worn-out products plays a role here, as does the recovery for reuse of waste and side streams. Whether in the chemical, biotechnology or construction sectors, companies in Hessen are already successfully implementing circular economy concepts.**

### Biogas from the Industriepark

Infraserv GmbH & Co. Höchst KG operates sustainable waste recycling facilities in the Industriepark Höchst.

Covering around 460 hectares and accommodating more than 90 companies, the Industriepark Höchst in Frankfurt is one of the largest chemical and pharmaceutical sites in Europe. The disposal concept developed by Industriepark operator Infraserv to deal with the waste produced on site reflects the principles of the circular economy. Alongside facilities for waste water treatment and the incineration of sewage sludge, alternative fuels and production residue, Infraserv Höchst operates Germany's largest biogas plant at the Industriepark.

The plant produces up to 30,000 cubic metres of biogas per day. Sewage sludge from the Industriepark's waste water treatment plant is fermented in two 30-metre-high fermenters, enriched with organic waste such as fermentation residue from pharmaceutical production and external food waste. The biogas is either converted into electricity and used directly in the Industriepark or upgraded to natural-gas quality in a plant specially constructed for this purpose. The plant feeds up to 80 million kilowatt hours of biomethane, corresponding to the annual consumption of around 4,000 households, into the public gas network, thereby reducing $CO_2$ emissions by around 16,000 tonnes per year.

The fermentation residue is subsequently pressed. The remaining liquid is fed into the waste water treatment plant; the solid remains are burned and used to generate heat.

In addition to their fermentation and thermal disposal, the recovery for reuse of biogenic sludge will play a role in the circular economy in the future, for example, in the recovery of phosphorous, a dwindling resource. The disposal experts at Infraserv are already working on this topic today.

In order to close material cycles, you need to be of a certain size. Sites like this Industriepark therefore offer ideal conditions for a high-quality, sustainable circular economy.

**Thorsten Appel**, Head of Waste Management at Infraserv GmbH & Co. Höchst KG from Frankfurt am Main

*The biogas plant at the Industriepark Höchst. (Photo: Infraserv GmbH & Co. Höchst KG, 2017)*

## Recycling batteries

Umicore AG & Co KG recovers precious metals from worn-out nickel metal hydride and lithium ion rechargeable batteries.

Even batteries which can be re-charged do not go on working for ever. For the Belgian metal concern Umicore they become raw materials, as the worn-out rechargeable batteries from electric vehicles, smartphones and other devices contain precious metals. Umicore recycles all types of nickel metal hydride and lithium ion rechargeable batteries. The plant can handle an annual capacity of 7,000 tonnes – that corresponds to 250 million smartphone batteries or 35,000 batteries from electric vehicles. The Hanau site has an important role to play, since it is here that battery systems from hybrid and electric vehicles are prepared for recycling.

After progressive concentration the metals to be recovered are separated in a high-temperature smelting process and chemically treated until they are sufficiently pure for re-use. Umicore is currently recovering cobalt, nickel, copper and rare earth elements from nickel metal hydride and lithium ion rechargeable batteries. In the case of some metals the recovery rate is over 95 per cent. Umicore has also developed a process which can be used for treating lithium in response to the growing volume of lithium ion batteries on the market.

As one of the world's leading manufacturers of cathode material for batteries, Umicore uses the recycled metals in the production of new rechargeable batteries, thus closing the material cycle. Sustainability also takes top priority during the recycling process itself: the residual electrochemical energy from the rechargeable batteries as well as the organic compounds present in the battery materials are used as energy sources for the smelting process and therefore reduce the consumption of primary energy.

Umicore's recycling activities are not limited to batteries. The concern leads the world when it comes to the recovery of precious metals from complex waste streams and is a key global recycler of precious metals from electronic devices and platinum from automotive catalysts.


*Schematic diagram of the battery recycling process (Diagram: Umicore)*


*Charging an electric car: the rechargeable battery contains precious metals which Umicore recovers at the end of its useful life. (Photo: Umicore)*

Recycling makes a key contribution to resource efficiency. Metals are ideal candidates, since there is no "downcycling" effect.

**Dr. Christian Hagelüken**, Director EU Government Affairs at Umicore AG & Co KG in Hanau

*A look inside the BRAIN BioArchiv.*
*(Photo: Kristian Barthen, BRAIN AG archive)*

## Bacteria as treasure-hunters

BRAIN AG has discovered microorganisms which can isolate high-tech metals in electronic waste, ash and other industrial residue.

Worn-out electrical equipment, ash from waste incineration and other industrial residue are increasingly turning out to be sources of raw materials. One tonne of computer circuit boards, for example, contains more than half a pound of precious metals and a host of other high-tech elements. Biotechnology specialists, BRAIN, based in Zwingenberg in southern Hessen, want to salvage this hidden treasure trove – with the aid of microorganisms no less.

As part of a screening campaign, BRAIN employees took samples from disused silver and mercury mines and other deposits. The samples were found to contain a total of 1,800 microorganisms which are set to help industry with the recovery of platinum and other precious metals. Researchers at BRAIN isolated bacteria, for example, which can enrich various precious metals. They also discovered organisms which can selectively bind metals from the group of rare earth elements, including bacteria of the bacillus and pseudomonas strains which have a marked preference for scandium, a light, rare earth element. Scandium makes aluminium alloys more durable and is used, among other things, in data storage media.

BRAIN is developing a flow-through process which separates scandium from waste water and other solutions. The technique can also be applied to other metals. BRAIN researchers are also working on biotechnical processes for extracting metals from solids such as slag and electronic waste. In a study carried out for the Federal Environment Agency they have already demonstrated that certain bacteria cells isolate precious metals from waste incineration ash.

BRAIN's activities in the field of microbial metal extraction are being conducted as part of the nationwide ZeroCarbon Footprint (ZeroCarbFP) research alliance. Against this backdrop, BRAIN is also looking into the use of $CO_2$ and other carbon-rich waste or side streams as raw materials for industrial production.

When we talk about the extraction of high-tech metals we are no longer referring to the exploitation of classic mining areas and rock as a resource. Instead we mean industrial waste streams which we treat with microorganisms.

**Dr. Guido Meurer**, member of the Management Board of BRAIN AG in Zwingenberg

## Building with rubble and ash

Baureka Baustoff-Recycling GmbH treats industrial residue, soil and building rubble for re-use in the construction industry.

The technology is in place for using mineral recycled construction material. That means a considerable reduction in building costs.

**Dirk Röth**, Geschäftsführer der Baureka Baustoff-Recycling GmbH aus Kassel

Around half of all waste in Germany consists of construction and demolition waste. The construction industry therefore plays an important role in the circular economy of the future, not least because the extraction of natural mineral resources such as gravel is increasingly being restricted for reasons of environmental protection. Recycled materials represent a sensible alternative in ecological and economic terms. Around 95 per cent of construction and demolition waste is in fact already being recovered, but then mainly used as a filling material during excavation work or for other inferior purposes. Only around 10 to 15 per cent is re-used as construction material.

Taking an example from road construction, the aggregate recycler Baureka in northern Hessen makes the case for the economic viability of using recycled building materials. A road construction project generates, say, 10,000 tonnes of broken concrete. It costs 80,000 euros to recycle this material and a further 45,000 euros to make it suitable for re-use as a frost protection layer – the water-impermeable base course under paths and roads.

Without recycling, waste disposal costs for landfilling this broken concrete come to 250,000 euros, and the use of natural stone as a frost protection layer swallows up 80,000 euros. In general, recovery and re-use saves around 60 per cent of costs.

Alongside an annual total of 400,000 tonnes of soil and building rubble, Baureka treats some 50,000 tonnes of industrial residue, including incinerator bottom ash from the facility in Kassel. First of all, the metals are recovered, and the remaining minerals are used in road construction and earthworks. Bareka recently supplied over 50,000 tonnes of recycled material, reclaimed from incinerator bottom ash, for the construction of a car park in Lichtenau in Hessen, cutting down on landfill space and saving natural resources in the process.

*Building rubble: after treatment, the material can be re-used, for example in road construction. (Photo: Baureka)*

## 2.3 Tomorrow's production: Networked and efficient – Sustainability in practice

**Digitalised and automated processes, material-saving manufacturing methods, the use of waste heat and waste water as valuable resources: there are many ways of making operating processes more economical and more environmentally friendly at the same time. Hessian entrepreneurs and scientists are leading the way, demonstrating how to achieve more while using fewer resources and staying globally competitive.**

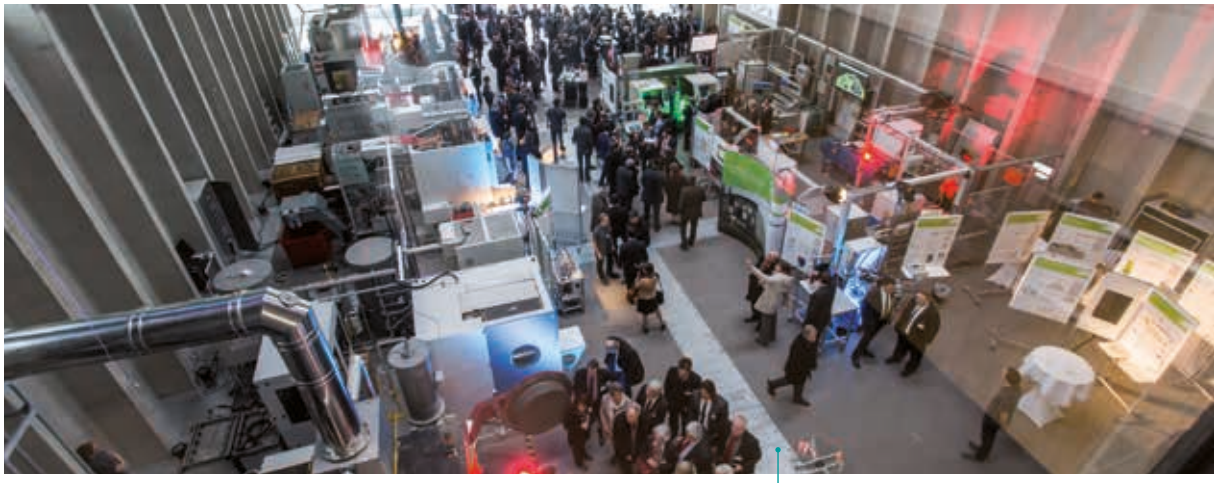
### Digital transformation as an opportunity

Researchers at the Technische Universität Darmstadt are using model factories to explore new concepts for manufacturing industries.

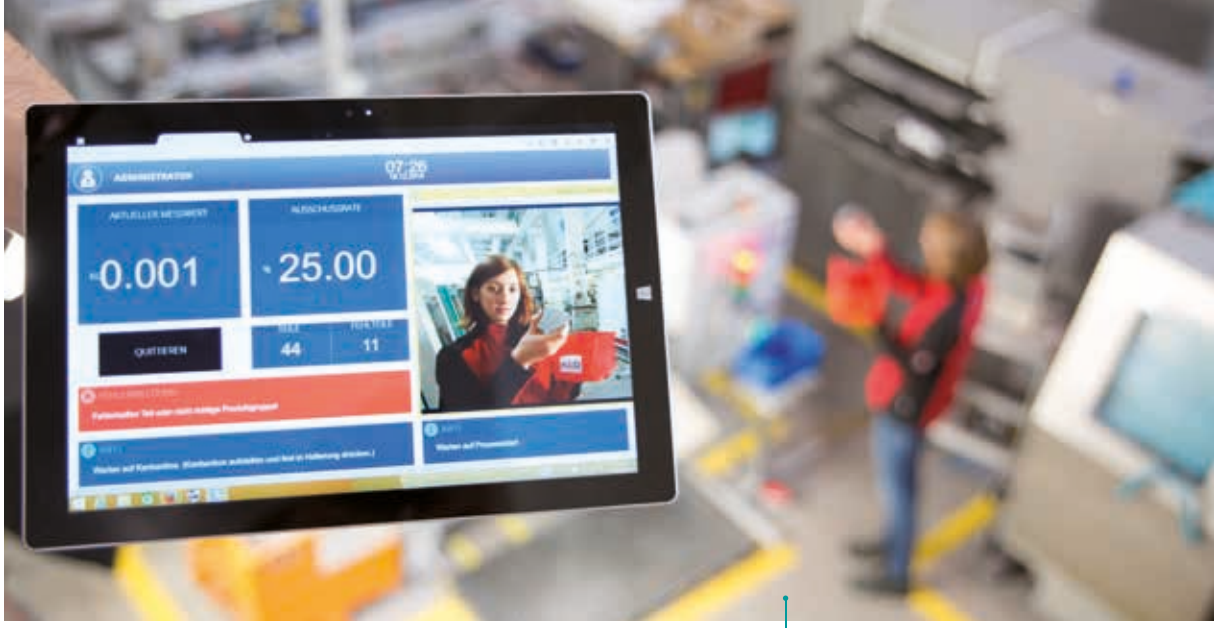
Many production firms want to boost the efficiency of their processes in order to save materials and energy. However, according to a study coordinated by the TU Darmstadt, "Resource Efficiency through the Digital Transformation of Industry in SMEs", they often underestimate the contribution digitalisation can make to improving resource and energy efficiency. A quality inspection process, for example, which records product data in real time and transmits it automatically to the production facilities, minimises production errors. Similarly, machines which measure material fluctuations and react to them, reduce scrap rates. Increased levels of digitalisation also contribute to improved warehouse organisation, facilitate the flexible use of plants and systems and optimise maintenance tasks.

The digital transformation process offers manufacturing industries numerous opportunities. At the same time, however, it lays down certain prerequisites such as the need for standardised interfaces, machines with integrated sensors, new hard- and software and correspondingly trained personnel. Furthermore, the various departments within an enterprise, or even in many instances separate companies, must be prepared to work together. This cannot be taken for granted, not least because digitalisation requires initial investment and entails certain risks besides. A strategy for safeguarding IT security and data security, for example, therefore becomes necessary.

Scientists at the TU Darmstadt led by Professor Reiner Anderl, Head of Computer Integrated Design, and Professors Eberhard Abele and Joachim Metternich from the Institute of Production Management, Technology and Machine Tools are testing Industry 4.0 concepts at model factories. The now completed "Efficient Factory 4.0" research project demonstrates using actual case studies how processes can be designed to be more resource efficient. Examples include paperless quality control, digital value-stream mapping, components used as information carriers and monitoring of machine status and energy consumption.



*Opening of the ETA Learning Factory: insights into a typical production process chain (Photo: Felipe Fernandes/TU Darmstadt)*




*Digital data capture boosts resource efficiency. (Photo: Sibylle Scheibner/TU Darmstadt)*

At the ETA-Fabrik (ETA Learning Factory), which was inaugurated in March 2016, civil engineers, mechanical engineers and architects from the TU Darmstadt are examining how manufacturing industries can reduce their energy consumption. ETA stands for "Energy efficiency, Technology and Application centre" but also makes reference to the Greek letter "eta" which in the world of technology denotes efficiency.

The scientists chose a process chain from the field of metalworking as a concrete example for the ETA Learning Factory. Their point of reference was the manufacture of a component at their industry partner Bosch Rexroth. Overall, energy consumption is to be reduced by 40 per cent. At the ETA Learning Factory, attention is paid not only to the energy efficiency of the machines, but also of the technical infrastructure and the building itself. For this reason, the north and south façades of the ETA Learning Factory are fully glazed, whereby special slats on the south side protect against direct sunlight while still letting light into the interior. The façades also feature capillary matting which, depending on the season, either heats or cools the building. The ETA Learning Factory concept also includes the utilisation of waste heat. Machine tools and cleaning systems, for example, which are normally operated separately, are connected via a heat pump.

The ETA Learning Factory is a 15-million-euro project on which around 40 companies and research bodies are collaborating. The Federal Government is financing the endeavour, together with industry partners, the TU Darmstadt and the State of Hessen.

*In the Learning Factory: digital value-stream mapping illustrates production process status data. (Photo: Sibylle Scheibner/TU Darmstadt)*

Industry 4.0 is paving the way to more energy and resource efficiency in the factories of the future. Policy-makers have recognised the importance of Industry 4.0 and are taking action.

**Professor Dr. Reiner Anderl**, Head of Computer Integrated Design at the Technische Universität Darmstadt

Our LED lamps save a lot of electricity and are 60 per cent lighter than comparable bulbs. Consequently, raw material consumption is reduced and the annual output of greenhouse gases falls by around 500,000 tonnes.

**Dr. Andreas Ritzenhoff**, Managing Director of Carus GmbH & Co. KG in Marburg

## Pioneering lamps

Carus GmbH & Co. KG produces LED lamps in a fully automated process requiring significantly reduced material usage.

The LED lamps from the Marburg high-tech company Carus fit in conventional light-bulb sockets and look like them, too. They last 25 times longer, though, and use around 85 per cent less energy. Unlike current energy-saving lamps they reach their full intensity immediately they are switched on. They also offer other advantages. Thanks to the new design concept, based on particularly thin-walled aluminium and plastic components, they consist of 60 per cent less material. The novel, fully automatic manufacturing process saves Carus almost 260 tonnes of aluminium, 40 tonnes of copper, 20 tonnes of tin and 10 tonnes of plastics and adhesive materials per year.

Since the innovative lamps are made without the use of adhesives or composites, they can be dismantled into their constituent parts in next to no time for easy recycling. The Federal Environment Ministry has been funding material-efficient manufacturing since 2014 with money from the Environmental Innovation Programme. Since 2016 one of Carus' LED lamps has also been certified with the "Blue Angel" ecolabel. So far, it is the only representative from this sector to fulfil the label's strict criteria.

Carus, which emerged from the established company Seidel, didn't decide to go into the production of LED lamps until 2012. Until then, the Hessian company had marketed candle holders, vases and other home accessories. Production began in September 2014. In the meantime, they have developed a wide range of environmentally friendly lamps "Made in Hessen", also including dimmable versions, whose brightness and colour temperature can be adjusted as required, and even one which lets you control the light and other useful functions via Bluetooth from your smartphone. The ecologically compatible light bulbs, which are produced entirely in Fronhausen near Marburg, earned the company Germany's oldest innovation award, the Diesel Medal, in 2016.

**Information films on the Internet:**

Carus LED Made in Hessen:
https://www.youtube.com/watch?v=YBI_9qVmra8

Innovative light control via app, Carus Connect Smart White:
https://www.youtube.com/watch?v=HqHDsnVKZdU&t=21s


*The shape of the Carus LED lamps is reminiscent of conventional light bulbs. (Photo: Carus GmbH & Co. KG)*

## Valuable waste water

EnviroChemie GmbH develops, builds and sells systems for the treatment of water and waste water.

Many industrial processes produce waste water which is pre-treated and discharged into bodies of water or a waste water treatment plant. Facilities built by EnviroChemie in Rossdorf, on the other hand, can turn waste water into a valuable resource. This means production processes can be designed to be ecologically and economically more viable.

On behalf of a potato-processing company, EnviroChemie runs a process which generates more than 310,000 cubic metres of biogas per year from its starchy production waste water. Aerobic processes were used previously to treat the waste water, around one million litres of it per day. EnviroChemie has inserted an anaerobic step into the process upstream. At this point, organic content in the waste water ferments to create biogas, which the factory uses instead of fossil fuel as a source of energy to generate steam. By converting the process, electricity consumption for waste water treatment has fallen by around 70 per cent. Since the amount of sewage sludge to be disposed of at the aerobic stage is reduced by more than half, the company also saves disposal costs.

EnviroChemie carried out the necessary reconstruction work at its own expense for a sum of around two million euros. A management fee is used for re-financing. Models like this offer manufacturing companies a number of advantages: they can optimise the efficiency and sustainability of their processes, without making substantial investments, and profit from EnviroChemie's know-how. At the same time, they gain financial planning security.

Resource-efficient and energy-efficient water management lets companies optimise their operating costs and satisfy sustainability strategy criteria.

**Claudia Müller**, Project Manager Business Development, EnviroChemie GmbH

*Optimised waste water treatment in a food-processing factory. (Photo: EnviroChemie)*

It is not only the food industry which provides a valuable resource in the form of its waste water. EnviroChemie has designed a process for an industrial laundry which combines waste water treatment, energy recovery and water recycling. Up to 70 per cent of the waste water can be recycled in this way. In addition, the company saves over one million kilowatt hours of energy per year. Again, as plant operator EnviroChemie, recovers up to 6,000 tonnes of glaze components and ceramic raw materials annually from the waste water produced by a ceramics manufacturer. This, too, lowers disposal and production costs and increases resource efficiency.

*Waste water recycling plant in an industrial laundry: up to 70 per cent of the water used is treated and channelled back to the laundry for re-use. (Photo: EnviroChemie)*

# 3. Business development activities in Hessen

## 3.1 Hessen Trade & Invest GmbH services

**The economic development company Hessen Trade & Invest GmbH (HTAI) is the main point of contact for companies in Hessen as well as for scientific, political and social institutions. Its task is to safeguard and promote the competitiveness of Hessen as a business and technology location in the long term.**

Resource efficiency and environmental technologies are among the priorities of the technology promotion policy established here. As in the past under its brand name "Hessen-Umwelttech", HTAI will continue to provide information (from now on as "**Technologieland Hessen**") about technical developments and market opportunities, help establish contacts and promote networking among companies and also with research institutions on the subjects of environmental technologies, resource efficiency and production-integrated environmental protection (known in German by the acronym PIUS). Target audiences include both the supply and the demand side of the technologies in question.

**The following services are on offer to companies:**

- **Up-to-date sector information** on the Internet, e-mail newsletter and other publications
- **Conferences and workshops** for exchanging information and networking
- Participation in **trade fair stands** in Hessen
- Information relating to **production integrated environmental protection** (see Chapter 3.2)
- Support with export activities for environmental technology companies in collaboration with Federal **export initiatives**
- Advice on and/or establishment of contacts with **Hessen "ModellProjekte" programmes** and with the partner in the **Enterprise Europe Network** in Hessen
- Establishment of contacts with other actors concerned with resource efficiency (see Chapter 3.3)
- Main point of contact for all questions relating to environmental technologies and resource efficiency

Since 2017 HTAI has been responsible for the **nationwide office of the PIUS Internet portal** www.pius-info.de. The portal is one of the most popular German-language platforms dedicated to the subjects of material and resource efficiency in production. The heart of the web offer is an information pool containing around 1,000 documents. Clearly structured and easy to use, the pool is a source of specialist information on actual in-company practice for interested companies.

Furthermore, HTAI supports the Ministry of Economics, Energy, Transport and Regional Development with regard to the **EU SUPER project**. Together with partners from ten other European regions with expertise in environmental innovations, the ministry optimises support services for innovative companies. The objective is to create for the companies in the regions involved an easily accessible and tailor-made support system which helps providers bring innovative environmental technologies and resource-efficient production solutions quickly to market and make the implementation of such innovations easier for consumers.

HESSEN TRADE & INVEST

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**A selection of publications from HTAI:**


**Praxisleitfaden Ressourceneffizienz in der Produktion – Zerspanungsprozesse** (German only)
A Practical Guide to Energy Efficiency in Production Processes – Metal processing: This practical guide looks into the question of how production in the metal sector can make both good economic and environmental sense. It is based on the TU Darmstadt project "Learning Factory: Resource Efficiency in Production – Pilot Project: Metal Processing", funded by the State of Hessen and the EU. The publication describes reference projects for drilling and milling processes with specific key figures, for example, relating to consumption of lubricants and energy or the amount of waste generated. It also presents a variety of measures for process improvement. This practical guide aims to help companies define key figures for their own processes and savings potential.


**Stoffkreisläufe in Hessen – Praxisbeispiele und Potenziale** (German only)
Material Cycles in Hessen – Practical Examples and Potentials: Closing material cycles can make a significant contribution to the conservation of resources and to saving costs. The publication, issued by the Wuppertal Insititut, describes 25 good practice examples. These were selected according to their economic relevance, their relation to waste streams in Hessen, their practicality as well as topicality and the availability of data. They are divided into six material streams: construction and building rubble as well as sand; chemicals, paper and timber; metals; plastics; organic matter, waste water, and others; substitution with organic-based materials.


**Ecodesign for a Resource-Efficient Economy**
Lightweight construction in cars, recyclable office furniture, contaminant-free insulation materials – using these and many other examples, the brochure illustrates how ecodesign works in practice. The highlighted solutions relate to the entire life cycle of products and include the optimisation of material and energy use as well as contaminant-free and risk-free design and the extension of life spans and use phases. In addition, the brochure explains strategies and business models which go beyond mere production design, emphasising the significance of product service systems and social innovations. It contains cross-references to methods and tools as well as a section with information on framework conditions, funding instruments and actors in the field of ecodesign. The publication is available in German and English.

These and other publications can be ordered free of charge or downloaded as PDFs from: www.technologieland-hessen.de

## 3.2 Hessen-PIUS and PIUS-Invest funding programmes

**PIUS-Invest and Hessen-PIUS are initiatives by the Ministry of Economics, Energy, Transport and Regional Development in Hessen for reducing $CO_2$ emissions and funding production-integrated environmental protection (PIUS). Companies are supported in their efforts to cut their consumption of energy, water, air, raw materials, auxiliary and operating materials. This enables them to bring down costs and produce in a more environmentally friendly way at the same time. Both programmes are co-funded with resources from the European Regional Development Fund.**

At the heart of **Hessen-PIUS** is a financially backed advisory programme for small and medium-sized enterprises (SMEs) in production, commerce and the service sector in Hessen. Furthermore, Hessen-PIUS also provides information under www.technologieland-hessen.de/hessen-pius and promotes networking on topics relating to PIUS and resource efficiency. Project management and implementation of the advisory programme is the responsibility of RKW Hessen GmbH which supports companies and establishes contacts with appropriate consultants.

A PIUS consultation can be subsidised up to a maximum of 600 euros (650 euros in ERDF priority areas) per day, for a maximum of 10 days per project. Funding can total up to 12,000 euros per company (13,000 euros in ERDF priority areas) over a period of 3 years.


RKW Hessen

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*The projects are co-financed with European Union funds.*

EUROPEAN UNION:
Investment for the future
– European fond for regional development

HESSEN
Ministry of Economics, Energy, Transport and Regional Development, State of Hessen

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Potential for optimisation can in some cases be realised by simple organisational changes, though often larger investments are required. **The PIUS-Invest** programme therefore subsidises innovative investment projects in which resource-efficient measures are implemented and $CO_2$ emissions reduced. Eligible projects are those in SMEs which lead to a considerable improvement in their carbon footprint brought about by process and/or organisational innovations. In so doing, they must exceed statutory minimum standards (where applicable) and pursue at least one of the following objectives:

- Improvement of energy and resource efficiency
- Energy storage; production, distribution and use of renewable energy; adaptation to climate change
- Saving of reusable materials and establishment of materials recycling; use of advanced manufacturing technologies

PIUS-Invest funding takes the form of a grant which can amount to up to 30 per cent of the eligible investment project costs, to a maximum, however, of 500,000 euros. Generally speaking, the projects should aim to achieve a $CO_2$ saving of at least one kilogram per euro of the project volume. Eligible costs must amount to at least 30,000 euros. Before a grant can be allocated, an expert must assess the degree of innovation and the $CO_2$ saving to be achieved. Participation in the PIUS advisory programme can be of an advantage but is not essential. Applications to PIUS-Invest are to be submitted before the start of the project to the WIBank for economic and public infrastructure development in Hessen.

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WI Bank
Wirtschafts- und Infrastrukturbank Hessen

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## 3.3 Partners

**Hessen Trade & Invest GmbH cooperates in Hessen and at national level with partners who also place strong emphasis on the subject of resource efficiency. Most notably, these include the VDI Centre for Resource Efficiency, the RKW Hessen and the Fraunhofer Project Group IWKS. Cooperation entails the joint organisation of events, provision of information and the exchange of contacts, networks and know-how.**

### VDI Centre for Resource Efficiency Nationwide point of contact for SMEs

At around 40 per cent, material costs account for the largest share of costs in the manufacturing sector. Consequently, savings in this area have a huge impact on the company accounts. Small and medium-sized enterprises (SMEs) often lack the capacity to closely examine the opportunities presented by improved resource efficiency. The VDI Centre for Resource Efficiency (VDI ZRE) was founded in 2009 to support these SMEs and motivate them to develop and implement their own measures.

The task of the nationwide competence centre, which is based in Berlin, is to gather all available information on resource-efficient technologies and processes and make it available to companies in a practical form. From a technical point of view, the focus lies on metal and plastics processing, mechanical and systems engineering, chemistry and process engineering, vehicle construction, the electrical industry as well as the building sector – all of which are characterised by small and medium-sized enterprises.

As an introduction to the subject of resource efficiency, companies can take a closer look at their material and energy flows and examine their cost structure by using the online cost calculator. Resource checks in the form of a short questionnaire identify possible energy savings in operations. Sector-specific know-how has been grouped together in process chains to make it more accessible to companies. They give an insight into research projects, present new resource-efficient technologies and indicate the best available techniques. Many good practice examples are also presented in short videos via the "Resource Germany TV" video magazine.

"Learning from others" is a motto of the VDI ZRE. The competence centre promotes networking among companies and with regional information facilities and funding agencies through their series of popular "Resource efficiency on site" events. In 2016 the VDI ZRE created the first nationwide, cross-sector Industrial Resource Efficiency Club aimed at companies which are already playing a pioneering role in terms of resource efficiency. It offers a platform for the exchange of ideas with other companies and decision-makers as well as economic, political and consultancy experts. In addition, both company employees and consultants can acquire the appropriate skills for planning and implementing resource efficiency measures by taking part in VDI ZRE training activities.

A wide range of information is made available by the VDI ZRE free of charge on the www.ressource-deutschland.de website. This information has been put together on behalf of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety and is funded by the National Climate Initiative.

VDI Zentrum Ressourceneffizienz

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## RKW Hessen GmbH – Guidepost to ecological practice

Since small and medium-sized enterprises (SMEs) in particular suffer because of rising energy and raw-material costs potential savings are desperately needed. Help is at hand from RKW Hessen as part of the Hessen-PIUS advisory programme (production-integrated environmental protection) with its pool of qualified consultants. The potential for efficiency improvements detected as result of the consultation enables processes as well as material and energy cycles to be optimised, costs bought down and the environmental impact sustainably reduced.

RKW Hessen is also a project sponsor of the Hessen Initiative for Energy Consultation (HIEM), a central point of contact for SMEs in Hessen. HIEM offers information on programmes and funding opportunities relating to energy efficiency as well as consulting services. Partners in Hessen include local business organisations, trade unions (DGB, IG Metall and IG BCE), chambers of industry and commerce, the Hessische Handwerkstag as well as the Ministry of Economics, Energy, Transport and Regional Development, State of Hessen, which is financing the initiative until the end of 2017.

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Practical examples

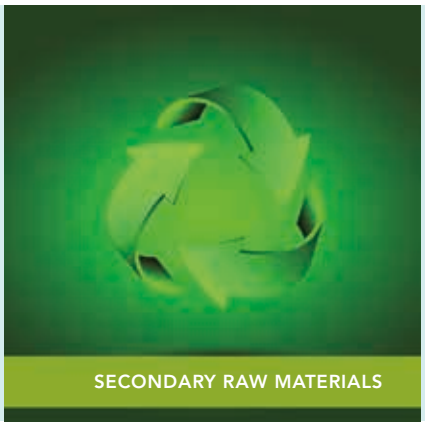
### Hessen-PIUS: Sälzer GmbH

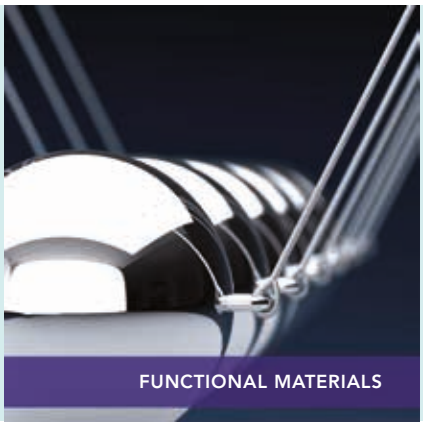
Sälzer GmbH in Marburg develops security concepts and technology for a variety of scenarios. The company manufactures doors, windows, façades, partition walls and grilles and supplies the appropriate additional fittings and electronics. The optimisation measures detected as part of a PIUS consultation included the systematic recording of returned materials as well as new provisions to govern the removal and ordering of operating materials. As a result, requirements of metals, plastics and components have been reduced to around five per cent per year, which corresponds to a financial saving of 100,000 euros. Moreover, fewer hazardous materials are produced. Overall, the Hessen-PIUS project has sensitised employees to the management of resources in a manner which preserves materials and the environment – which itself also offers potential for cost reductions.

### HIEM: Zement- und Kalkwerke Otterbein GmbH &. Co. KG

Zement- und Kalkwerke Otterbein GmbH quarries around 400,000 tonnes of limestone from its own opencast mine every year. Further processing takes place on site. The production processes are very energy intensive. Some 250 million kWh of energy from various sources were used in 2010 – responsible for 44 per cent of annual costs.There is potential for savings, as discovered by Dipl. Ing. Gert Fischer as part of the PIUS consultation arranged by RKW Hessen. Cost savings of up to 40 per cent are indicated in the areas of electric drives, compressed air, the conversion of heat into electricity, the reduction of peak loads as well as the use of alternative energy sources. The company is seeking to effectively link energy streams throughout the entire production process. Managing Director Winfried Müller justifies this striving for resource efficiency as follows: "Far-sighted environmental protection safeguards the long-term future of the company."

## Fraunhofer Project Group for Materials Recycling and Resource Strategies IWKS at the Fraunhofer ISC




The Fraunhofer Project Group for Materials Recycling and Resource Strategies IWKS was created against a background of increasing shortages of raw materials. Scarcity of resources is a key issue for the economic and social development of industrialised nations. Securing a sustainable supply of raw materials to industry is of vital importance. The IWKS is devoting its attention to this crucial task for the future through research and development of new technologies and recycling processes. Together with partners in industry, it is investigating innovative separating, sorting, treatment and substitution options and developing strategies for sustainable management of precious resources.

In the main business units, Strategy & Networks, Secondary Raw Materials and Functional Materials, the Fraunhofer Project Group IWKS is concerned with the subjects of resource strategies, recycling and material recovery as well as substitution of raw materials and materials. In terms of content, they are closely integrated into the individual departments, bundling competences in the fields of analytics, biogenic systems, energy materials and lightweight technology, magnetic materials, separation and sorting technologies as well as urban mining. An interdisciplinary approach can therefore be taken to tackling highly complicated issues.

The active creation of scientific networks is an essential strategic element of our work on a scientific level. We take an active role in international, national and regional networks which have dedicated themselves to the sustainable management of valuable resources.

At the beginning of 2015, in collaboration with leading German research institutions in the raw materials sector, the Fraunhofer Project Group IWKS co-founded the German Resource Research Institute (GERRI) as a virtual, interconnected institute. The institute, which is funded by the Federal Ministry of Education and Research (BMBF), is to coordinate future raw-materials research projects in Germany and give GERRI partners a competitive edge in an international environment. The Resource Cluster Rhein-Main is currently being set up at the initiative of the Fraunhofer Project Group IWKS. It is to be the main point of contact in the Rhein-Main area on matters relating to resources. The objective is to build a network of a broad range of regional actors focusing on resource questions and to initiate joint projects.

Fraunhofer
PROJEKT GRUPPE IWKS ISC

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