Fraunhofer

FRAUNHOFER IN INDIA NEWSLETTER - ISSUE 2022

Circular Economy - Creating a Sustainable Environment

Content

FOREWORD

Ms. Anandi Iyer
Director, Fraunhofer Office India

Dear Readers

It's all happening right here in India!! The Indian Growth Juggernaut rolls on and breaks new records. India surpasses UK to become the **5th largest economy in the world. India was ranked 40th position out of 132** in the Global Innovation Index (GII) 2022 rankings released by World Intellectual Property Organisation (WIPO). India was ranked 46th position in 2021, and 81st rank in 2015, thus showing a remarkable Northward trajectory. Driving the global digital economy, India has already clocked about 70 billion digital payment transactions in 2022—the highest in the world. According to a recent report by ACI Worldwide **India leads worldwide in real-time transactions**, almost three times to that of China, and 6.5 times greater than transactions of the US, UK, Canada, and Germany. In the global start up scenario too, **India has emerged as the 3rd largest startup ecosystem in the world**, behind US and China. Adding 3 unicorns every month and taking the total count of unicorns to 105, ahead of UK (44) and Germany (29).

The Government has been pushing all the right buttons to create and foster an environment that is invigorating for innovation and technology interventions. Whether it is the innovation clusters in multiple cities, the GatiShakti Initiative to modernise Freight & Logistics, the UPI framework for cashless payments, the Performance Linked Incentive Scheme (PLI) for boosting Solar Energy manufacturing, the major thrust for Electronics through the Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors (SPECS); the clear focus and vision is Atmanirbhar or Self-Reliance.

Fraunhofer has been a proud partner to the Indian Government, Industry and Research since decades, and is delighted to strengthen the cooperation with Indian innovation ecosystem in developing applied research capability. The key areas of focus remain Manufacturing, Renewable Energy, Smart Cities, and Artificial Intelligence. Over 55 of the 76 Fraunhofer Institutes are already active in India and we see a growing trend of young Indian researchers joining Fraunhofer, thereby underscoring mutual respect and interest.

As we go into the last quarter of the year 2022, we are busy tying up the collaborations and projects initiated this year, but also preparing for 2023 with new energy and vigour. Our participation at ALUCAST 2022 in Chennai, at the International Rubber Conference 2022 in Bangalore and the projects discussions on Aqua Hub in Coimbatore and Sholapur as well as Manufacturing /Automotive with ARAI will assume focus for the next 2 months. Looking ahead into 2023, we are excited about our Demonstration project on "Sustainable Neighbourhood in Kochi" which will be inaugurated, the activities in Hydrogen Technologies with the Govt of India, the project collaboration with CSIR on Battery Technologies and Sustainable Buildings, as well as our Flagship event "6th Fraunhofer Innovation and Technology Platform" with its thematic focus on Circular Economy.

We have put together this edition of our newsletter to give you a glimpse into our competencies, reference projects and the collaboration with India on this extremely important topic of Circular Economy and Sustainability. There is a huge potential and a clear business case for more responsible business models, and we hope to engage with you on these topics so that we can create mutually rewarding projects and collaborations.

Happy Reading!

Anandi Iyer

How can a circular economy be established?

Source : Fraunhofer Institute for Systems and Innovation Research ISI

The circular economy aims to maintain the value of products, materials, and resources in the economy as long as possible and at the same time increase material efficiency, reduce the pollution to the environment and obtain climate neutrality. The transition to a circular economy means transforming entire added value chains and encompasses design, production and consumption phases and closing the circle after use.

Fraunhofer ISI investigates the realization conditions and perspectives of a circular economy under different aspects. These include Germany's technological performance with underlying technologies (among others by patent analyses), the changing roles and strategies of actors in the value-added chain, new practices (for example regarding property) and forms of governance.

Another important aspect of research at Fraunhofer ISI is the impact assessment of different circular economy scenarios – also (macro) economic and regarding their contribution to managing large societal challenges and the attainment of the SDGs.

Projects

Environmental Protection as an Economic Factor: Analysis of the Economic Significance of Environmental Protection by Up-dating Important Indicators

It is very important to have reliable and up-to-date information concerning the economic importance of environmental protection and innovation activities in order to design environmental policy measures in an innovation-friendly way and ease their implementation. Indicators on employment effects, production, foreign trade, environmental research, and patents are regularly compiled within the project family "Environmental protection as an economic factor ".

Innovative models of circular economy in the textile industry (Wear2Share)

Innovative models of circular economy in the clothing industry no longer offer clothes to buy but to rent for a certain length of time. Because particularly clothes for small children or fashionable ladies' clothes are often not worn for very long. Wear2Share investigates whether and how such business models lead to more sustainable consumption and whether they are suitable for mass consumption in the long term. Also, the project is to drive the development of more sustainable clothing for such rental models.

Scientific accompaniment of two pilot projects in order to increase the collection quota of electric and electronic cold devices in Baden-Württemberg (SEEK)

The project scientifically accompanies two model projects in recycling centers and classifies how effective the applied measures are in order to increase the collection quota of old electric and electronic appliances. Based on the data of these model projects as well as on scientific data from the research literature practical and generalizable recommendations for action for public waste disposers in Baden-Württemberg are given. In addition, alternative disposal methods for large old electrical appliances are investigated in order to better estimate collection quantities.

Conserving resources in the health sector

So far, there has only been a rudimentary examination of where the health sector intersects with the topic of conserving resources. This research project's objective is to exploit synergies and

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Image Courtesy: © emkanicepic, Fraunhofer ISI

potentials between the policy fields of resource conservation and health. The project is commissioned by the German Environment Agency and develops strategic fields of activity and options.

Quantification Methodology for, and Analysis of, the Decarbonisation Benefits of Sectoral Circular Economy Actions

The project developed a generic approach to allocate GHG emissions savings to various circular actions and lifecycle stages for a sector. This approach has been applied to quantify the decarbonisation benefits of circular economy actions within the construction industry and the buildings sector.

Political scenarios ProgRess

The aim of the research project is to identify promising measures and fields of action with a high potential to increase resource efficiency. Based on the identified fields of action systematic political instruments to implement the measures are worked out as well as their efficiency mode of action analysed. The focus here is on classic economic instruments.

Coordinating scientifically the funding priority "Sustainable management: Synthesis and transfer economy" (NaWiKo)

Within the project NaWiKo a team of the Ecologic Institute coordinates together with Fraunhofer ISI and the Research Center for Environmental Politics at the Free University of Berlin a total of 30 projects with a focus on sustainable management funded by the Federal Ministry for Education and Research. The multitude of topics of the 30 funded projects creates a large potential of thematic and methodological synergies, which have to be explored. That is the purpose of the project NaWiKo.

Developing the scientific foundations for a German eco innovation plan (ECO-AP)

The "Europe 2020" strategy postulated a transformation to a resource efficient and environmentally friendly economy. In this context the EU introduced the "Eco innovation action plan" (ECO-AP) in 2011 which was to address the obstacles of eco innovations but also the associated opportunities. The German federal government decided to reinforce the European eco action plan by a German eco innovation plan. Fraunhofer ISI elaborated the scientific foundations and thematized the necessity of a new ecological innovation policy.

Brief Profile of Fraunhofer ISI:

The Fraunhofer Institute for Systems and Innovation Research ISI conducts applied research in seven Competence Centers with a total of 28 Business Units and sees itself as an independent institute for society, politics, and industry. Its expertise in the area of innovation research is based on the synergy of the technical, economic and social science knowledge of its staff members. Fraunhofer ISI's work not only applies a broad spectrum of advanced scientific theories, models, methods and social-science measurement instruments, but continually develops them further, utilizing the empirical findings from the research projects conducted.

Fraunhofer ISI investigates on behalf of its customers the scientific, economic, ecological, social, organizational, legal and political framework conditions for generating innovations and their implications. It uses scientifically based analysis, evaluation and forecasting methods. Its assessments of the potentials and limitations of technical, organizational or institutional innovations help decision-makers from industry, academia and politics in making strategic decisions and thus assist them in creating a favourable environment for innovations. Thus, Fraunhofer ISI one of the leading innovation research institutes in Europe.

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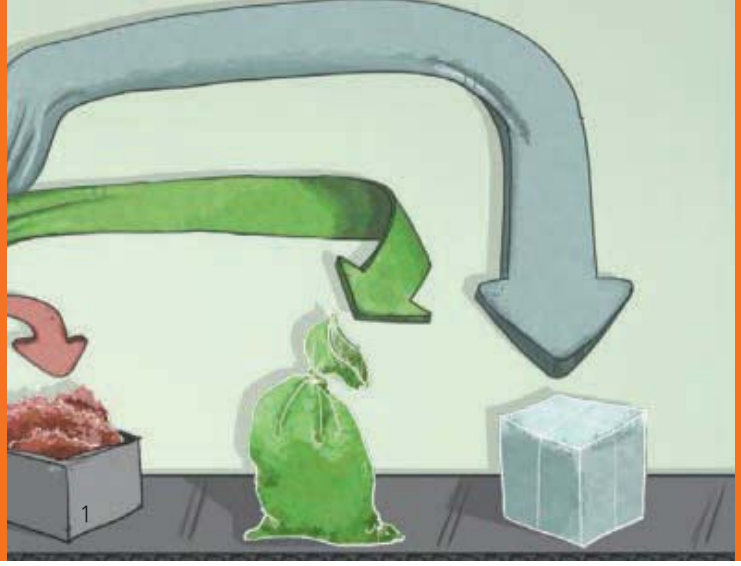
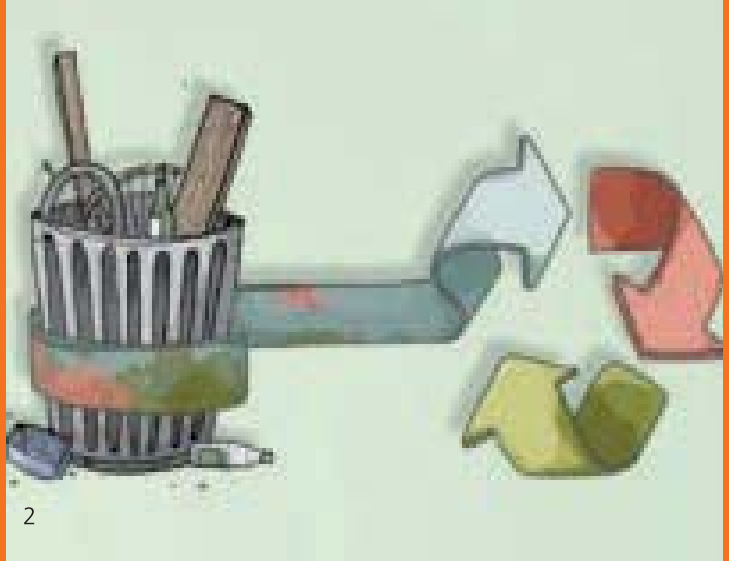
Image Courtesy: © Pexels, Fraunhofer ISI





Circular Systems: Understanding-Detecting-Optimizing-Managing

Source: Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT

Understanding

In times of increasingly scarce raw material deposits and high raw material prices, companies increasingly have to concern themselves with a secure and continuous supply of raw materials and assume their responsibility towards the environment and society in order to achieve long-term success.

Efficient and intelligent resource management is based on knowledge of material flows, materials and applications and forms the basis of economic development. The Sustainability and Resource Management department at Fraunhofer UMSICHT develops strategic decision bases and planning aid for sustainable action together with companies and institutions.

Fraunhofer supports companies in the development of recycling and innovation strategies. It identifies strengths and weaknesses, opportunities for improvement and helps reduce the need for primary raw materials by replacing them with secondary raw materials.

Fraunhofer acquires knowledge in order to be able to make quantitative and qualitative statements about the raw materials used, their current and future use and possible uses as high-quality secondary raw materials, applications, and products.

Process optimization, secondary raw materials and efficient recycling of residual materials are its topics. It carries out material flow analyses, plans the intelligent use of raw materials, and develops recycling strategies for sustainable resource management.

Detecting

Fraunhofer locates potential anthropogenic raw material stocks and valuable residual material flows and analyses the associated material flows in terms of space, time quantity and quality. Together with companies, Fraunhofer takes a look at internal and external material flows and evaluates them with regard to more efficient use.

Optimizing

Fraunhofer analyses the interface between material and application. Among other things, it answers the questions:

- What does a secondary raw material have to fulfil for successful use in industrial applications?
- Which processing and assembly steps are necessary so that a secondary raw material can be used?
- How can existing processes be optimized in a targeted manner?
- Which products are possible and how do they have to be structured?
- How can circular systems look like with these products?

Managing

Material flows must be actively managed to ensure resource and cost efficiency. Especially in our dynamic industrial and service society, resources and products in different value creation chains must be recycled and used efficiently.

In many cases, however, there is a lack of knowledge about alternative areas of application for materials, and possible potential is lost through static approaches. The right resources and services

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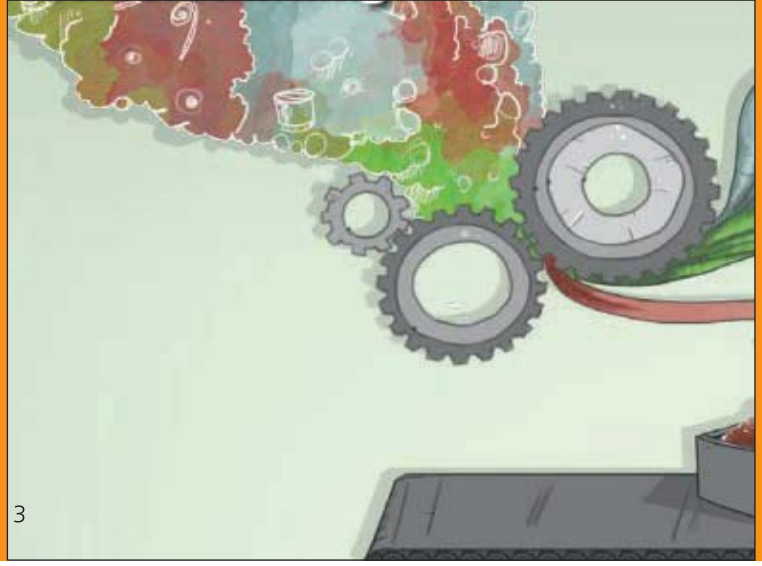
Image Courtesy: Fraunhofer UMSICHT



must be deployed in the right place at the right time- this means competitive advantages and increases resource efficiency.

Fraunhofer's Services Include:

System Analyses
The economic sectors, industries and companies are analysed and evaluated on regulatory, technological, organizational, and socio-economic trends with regard to the sustainable use of raw materials

Material flow analyses
Fraunhofer systematically examines and evaluates systems that use raw materials in technology, customer group and product-oriented material flow analyses for suitable fields of action and business.

Recycling technologies
Fraunhofer supports the evaluation of possible processing routes for materials into high-quality secondary raw materials and support companies in resource management.

Secondary raw materials management
Fraunhofer accompanies the use of secondary raw materials and optimizes the interface between secondary raw material and application.

Circular systems and products
Together with its customers, Fraunhofer evaluates and develops technical approaches for the recycling of products. It examines the market situation and provides support in developing business models for circular products.

Feasibility studies
In addition to its services, Fraunhofer carries out economic feasibility studies and checks the framework conditions for successful implementation.

Brief Profile of Fraunhofer UMSICHT:
Fraunhofer UMSICHT is a pioneer for a sustainable world. With its research in the areas of climate-neutral energy systems, resource-efficient processes and circular products, Fraunhofer UMSICHT makes concrete contributions to achieving the 17 Sustainable Development Goals (SDGs) of the United Nations.

Fraunhofer UMSICHT develops innovative, industrially feasible technologies, products and services for the circular economy and bring them to application. The focus is on the balance of economically successful, socially equitable and sustainable developments.

The institute has sites in Oberhausen, Willich and Sulzbach-Rosenberg. In 2021, Fraunhofer UMSICHT generated a turnover of more than 57.8 million euros with a workforce of 608 employees. As an institute of the Fraunhofer-Gesellschaft, the world's leading applied research organization, Fraunhofer UMSICHT is globally networked and promotes international cooperation.

3.
Image Courtesy: Fraunhofer UMSICHT

1. How can Research and Innovation bridge the circularity gap?
Research and Innovation are the key drivers of bioeconomy. Research can provide sustainable solutions in collaboration with industry. At Fraunhofer IGB, we develop processes and technology for a great variety of applications for a circular economy. For example, we use biogenic raw, residual and waste materials (including CO2) as source for chemical feedstocks or biobased products. We also use engineering technologies for processing these materials, scaling them up and implementing them in collaboration with our partners in industry. Research and innovation, therefore, provide the ground for a sustainable, circular production and way of life.

2.What are the challenges faced by the circular economy framework in driving Industry participation and how is Fraunhofer IGB working towards this?
One main challenge, of course, is the funding of the transformation. First, for research and development, and second, for the actual transfer into practice. Change always is more expensive than keeping processes, which have been in place and optimized for decades. Circular economy procedures often require new technological concepts and those are not only expensive but also come with increased risks during implementation. This can make production even more expensive and the acceptance of industry in this regard is sometimes limited.

At Fraunhofer IGB, we work closely with our partners in industry and academia. If funding is a challenge, we apply for funding programs on government and state level together with our partners and support our industrial partners during the entire process.
A second challenge is the lack of realization that change is necessary in order to provide all people around the world with goods, food and water and preserve our environment. At IGB, we inform industry and the public in our social media channels and other ways about new concepts and possibilities, bioeconomy is providing. We hope to increase the awareness for new and sustainable procedures and products and thus, direct consumer behaviour, which in itself drives industrial production.

3.Strongly rooted in environmental sustainability, the circular economy framework lacks an elaborated description of the social dimension of sustainability (e.g., the fulfilment of human needs, territorial implications). What is your view on this?
The Fraunhofer IGB conducts research for healthy people in a healthy environment. Our vision speaks for itself and with the same motivation; we promote the implementation of the bioeconomy. It is often overseen that bioeconomy not only aims for a circular economy, but also for a society in which all people can live in health and on the same standard of living. However, it is true: bioeconomy itself is neither sustainable per se nor focused on social issues. But what we make of it is what matters!

4.Currently, the circular economy framework does not provide specific criteria to

Brief Profile of Dr. Markus Wolperdinger
Dr. Markus Wolperdinger has been Director of the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB since 2018. Dr. Wolperdinger holds a PhD in chemistry and has many years of industrial experience in industrial biotechnology, plant engineering and the translation of scientific findings into industrial implementation. His international career has taken him from development, sales and management positions at innovative start-up companies and in medium-sized industry to leading positions in globally operating industrial groups. Dr. Wolperdinger is Spokesperson of the strategic research field of Bioeconomy of the Fraunhofer-Gesellschaft and a founding member of the Fraunhofer Group for Resources Technologies and Bioeconomy. He is active as an advisor and expert in numerous commissions and committees at state, national and European level.

support the selection of actions nor specific guidelines on how to implement the concept. How to address the lack of strategic guidelines and standardisation aspect while conducting R&D around this topic?

This depends on the country you are looking at. In many countries around the world, unfortunately, there is still no awareness that a sustainable bioeconomy and industrial transformation is a necessity for industry as well as society. In Germany, there are bioeconomy strategies at both the federal and state levels that provide guidelines for implementation of bioeconomic approaches. Funding programs for the bioeconomy have been set up based on these guidelines and are awarded to applicants who best meet these criteria. The Fraunhofer IGB is happy to act as a partner and to provide supportive advice on the biological transformation that bioeconomy entails, to all the readers who might be interested in such a cooperation.

5.What are the ways in which technological innovation can address the problems identified around natural resource depletion?

Technological innovations make it possible to use previously unexploited resources, thus avoiding the depletion of fossil raw materials and a further increase in the CO2 exhaust into the atmosphere.

For instance, we can already recover important nutrients such as nitrogen or phosphorus from wastewater, which are then reintroduced into the cycle e.g., as fertilizer. Residues from food production become the basis for important chemical substances. In this way, biogenic waste or simple wood or straw become valuable resources for the production of many valuable products including those for the chemical industry. CO2 and water (H2O) can also be utilized for the production of chemicals. Thus, resources are not only conserved, but innovations allow the extraction and recycling of many substances and return them into the value creation cycle.

6.Moving towards a circular economy would incur considerable transition costs for any industry. Will R&D around this topic focus on price competitiveness and resilience? What is Fraunhofer's point of view on this?

Yes, we are focusing on competitiveness, not only in terms of price, but also in terms of consumer acceptance. We want to actively change industrial processes in the direction of the bioeconomy, and this can only succeed if we bring the best products to market that incur no or very low additional costs in comparison.

In research - and so at Fraunhofer -, it is inevitable to keep in mind that the cost of goods should be as low as possible to make them available to all people. For this reason, many of our innovations have comparably low and in some cases even lower process costs than conventional processes. In addition, the support by industry and through government programs plays an important role in this context. Only a joint effort will lead to a resilient economy and society for generations to come.

2.
Image Courtesy: Fraunhofer IGB

Wastewater as a resource: Utilization and recovery of wastewater ingredients

Source : Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB

Wastewater – Precious resource for raw materials and energy

The technological challenges in connection with water are manifold. Innovative approaches and methods are needed to use existing resources more effectively and to exploit new strategies, such as semi-centralized and adaptable infrastructure systems for collecting, treating, and distributing water or – just as important – finding possibilities for reusing water.

Combining wastewater treatment with energetic and material utilization of its ingredients

In terms of a sustainable circular economy, the decisive factor is how the wastewater is treated. Wastewater can be purified with modern, cost-effective filter technologies; dissolved compounds that are harmful to the environment and health can be destroyed using advanced oxidation processes. Ideally, further wastewater ingredients are recycled almost completely for energy and solids, when the wastewater is treated with adapted biological processes, which are combined with suitable recovery technologies if required.

Material or energetic use of organic load

Most wastewater streams have high organic loads. If the water contains high concentrations of a single compound, it may be worthwhile to separate the substance for further material use. In a project with dairy wastewater containing high amounts of lactose for example, the objective was to develop an environmentally sound process for the manufacturing of lactic acid from acid whey, in order to combine waste treatment with the production of valuable materials. Sludge at wastewater treatment plants can be efficiently converted to biogas using a high-load digestion process. The fractions obtained with this process can be recovered in different ways.

Recycling of nutrients

Besides organic solids, wastewater also contains large amounts of nutrients such as nitrogen, phosphorus, magnesium, or potassium. Great efforts and in some cases huge amounts of energy are being put into eliminating nutrients from wastewater by means of nitrification, denitrification and/or biological phosphorus elimination, to prevent them from entering and eutrophying surface waters. New concepts and processes developed at the institute aim to recover inorganic nutrients as fertilizers.

The wastewater treatment plant as a biorefinery

The circular economy is considered a key strategy for conserving resources and achieving climate targets. The ingredients in wastewater can also be used – if it is treated in an

Valuable material fractions of the high-load digestion

1.Biogas, a mixture from methane and CO2

- Energetic use of methane in combined heat and power plant
- Material use of CO2, e.g. for cultivation of microalgae or chemical/electrochemical synthesis

2.Nutrient-rich sludge water

- Recovery of nutrients as fertilizers
- Fertilizing irrigation
- Growth medium for microalgae

3.Carbon-rich digestate

1. Wastewater contains organic ingredients and nutrients that can be used or recovered.
Image Courtesy: Fraunhofer IGB, Dr. Marius Mohr

2. Nutrients can be recovered from wastewater as fertilizer and replace conventional fertilizers.
Image Courtesy: Fraunhofer IGB

appropriate manner.

High-load digestion enables utilization of wastewater ingredients

The prerequisite for the utilization of the various substances involves making them available: through concentration, separation, and processing.

The technical basis for this is the high-load digestion process developed at the IGB and implemented in many cases at wastewater treatment plants. High-load digestion not only converts the sludge produced at a wastewater treatment plant into biogas as a regenerative source of carbon and energy, but also supplies sludge water and sludge digestion residues (digestate) as further usable material flows.

The sludge water is rich in valuable plant nutrients, especially phosphorus and ammonium. Fraunhofer IGB has developed various concepts for recovering the nutrients from this water, which is produced when the sludge is dewatered, and processing it as fertilizer. Alternatively, the nutrient-rich sludge water can be used directly, for example for fertilizing irrigation or hydroponic plant production. Or as a growth medium for cultivating photosynthetic microalgae that grow with CO2 and synthesize plant-stimulating polysaccharides, for example.

Brief Profile of Fraunhofer IGB

The Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB develops and optimizes processes, technologies, and products for health, sustainable chemistry and the environment. In doing so, it relies on the unique combination of expertise in biology and the engineering sciences in order to contribute to human welfare, a sustainable economy, and an intact environment with the systems approach of bioeconomy as well as bioinspired, biointegrated and biointelligent solutions.

Fraunhofer IGB provides its customers and partners with research and development services encompassing the entire material value chain, accompanied by a wide range of analysis and testing services. The ability to deliver end-to-end solutions, from laboratory to pilot-scale applications, and a demonstration of the developed processes, is one of the institute's strong points. This all-round service makes the IGB a reliable partner for industrial companies, small and medium-sized enterprises operating in many different sectors, local authorities and special-purpose associations. It also performs contract research for the EU as well as Germany's federal and regional governments.

With Fraunhofer IGB's applied and customer-focused research, it develops biotechnological processes for resource-friendly production within a sustainable economy and to technology that is designed to maintain human health within a healthy environment – in short: it develops sustainable technologies for human health and the health of our planet.

3. High-load anaerobic digestion offers the possibility of making the ingredients in wastewater available.
Image Courtesy: © Verbandsgemeindewerke Edenkoben

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Water technologies and resource recovery

Source : Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB

This innovation field develops concepts, processes, and technologies for purifying water and recovering valuable substances from water. Hygiene in drinking and process water and the associated water analysis play an important role in this. For water management, the innovation field develops comprehensive concepts, e.g., within the framework of the Morgenstadt City Lab. One focus is on international cooperation to develop and adapt solutions for emerging countries (e.g., South Africa, India, Brazil).

Fraunhofer IGB's activities within this innovation field are not limited to the topic of water. As part of system solutions, Fraunhofer IGB is developing technologies for the use of organic and recycling inorganic (waste) materials. In particular, it treats organic residues such as organic waste or sewage sludge anaerobically in order to economically produce biogas as a regenerative energy source.

Fraunhofer IGB also uses the electro-oxidative and reductive processes developed for water treatment in the electrochemical production of basic chemicals from aqueous solutions.

Water Technology Areas:

- Water management and water reuse
- Water processing and wastewater treatment
- Desalination
- Advanced oxidation processes (AOP)

Competence Fields

Water technologies

Water management and water treatment is confronted with new challenges. The pollution of the past as well as climate change have a direct impact on the natural sources of water, surface waters and groundwater. Insufficiently treated wastewater that is discharged into bodies of water results in long-term damage that then has to be tackled later on at great expense. The pollution of rivers, lakes and groundwater with pesticides, mineral oil residues or pharmaceuticals are examples of this.

In the water technologies competence area, the innovation field "Water Technologies and Resource Recovery" therefore develops concepts, processes, and technologies for purifying water and recovering valuable substances from water.

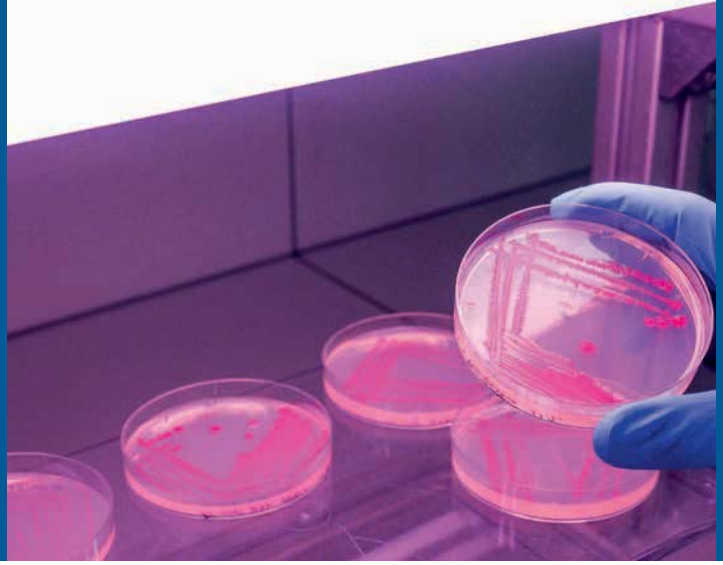
Resource recovery

Fraunhofer IGB develops processes to create an added value from waste or residual materials. Biotechnological processes can be established economically and ecologically advantageous for the substance recycling along with waste and wastewater treatment.

The best-known substance recycling process of organic materials such as biowaste or sewage sludge is the recovery of biogas as a renewable energy source. Organic residues that cannot

1.
Image Courtesy: Fraunhofer IGB

2. Electrochemical cell for CO2 reduction
Image Courtesy: Fraunhofer IGB



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be recycled further are particularly suitable for conversion by means of digestion. In this process, anaerobic microorganisms break down organic carbon compounds via various intermediate stages to produce biogas, a mixture of methane and carbon dioxide.

By integrating further appropriate process steps, additional value substances such as fertilizer salts (from nitrogen and phosphate ingredients of sludge, sludge water, digestion residues and other waste) can be recovered.

- High-load digestion on sewage plants
- Optimized digestion processes for biogas plants
- Recovery and recycling of nutrients
- Bioleaching/biomining

Biofilms and hygiene

Microorganisms such as fungi and bacteria are omnipresent in nature. They play an essential role in natural material cycles and are thus of elementary importance for the continued existence of ecosystems. Microorganisms are used industrially in food technology or for the production of antibiotically active substances for pharmaceuticals.

Enormous efforts are also being made in the health sector to prevent the growth of biofilms on natural surfaces such as dental material, but also on synthetic materials such as implants, catheters or medical devices – mainly because of high costs in the event of damage to humans.

Fraunhofer IGB has been working for several years on issues involving the interactions between microbial cells and surfaces. It also has the technical expertise to characterize biofilms and surfaces and to develop individual approaches to prevent bacterial deposits. The areas of work include:

- Detection of microorganisms
- Biological characterization of antimicrobial surfaces
- Biofilms – characterization and avoidance

Electrosynthesis of basic chemicals

The energy transition in Germany (Energiewende) is in full swing and the associated expansion of wind and solar power is further increasing the supply of electricity from fluctuating sources. In periods of low demand for electricity, the excess supply of electrical energy can be alternatively used for the production of value. Some of Fraunhofer IGB's competencies include:

- Gas diffusion electrodes
- Electrochemical cells
- Demonstration of power-to-X-to-Y processes

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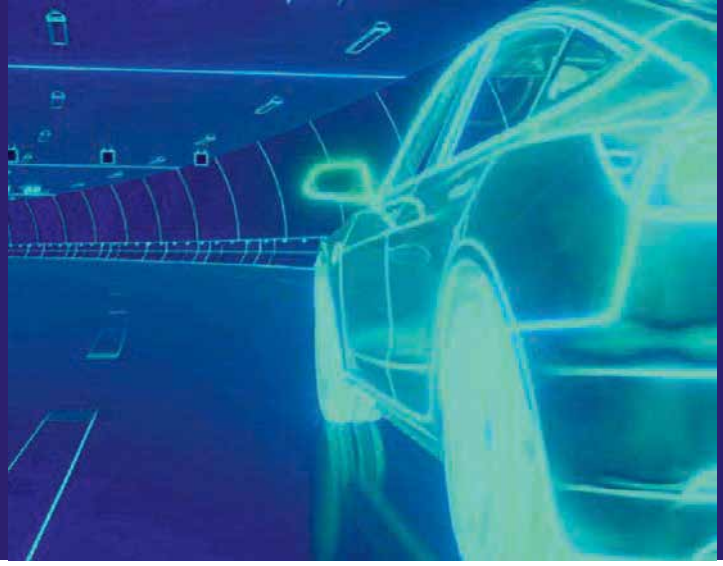
Image Courtesy: Fraunhofer IGB



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Closing the Value Chain in Electromobility-Recycling for the Energy of Tomorrow

Source : Fraunhofer Research Institution for Materials Recycling and Resource Strategies IWKS

Research focus

The Fraunhofer Research Institution for Materials Recycling and Resource Strategies IWKS stands for a responsible use of resources. The aim of the research of Fraunhofer IWKS is to establish a closed circular economy. Therefore, the scientists work at recovering recyclable materials and introducing them into a new product cycle or to substitute valuable materials through sustainable alternatives. Therefore, Fraunhofer IWKS develops innovative processes in the area of functional materials (magnet materials, energy materials, analytics) and functional materials (urban mining, biogenic systems, material flow management).

Recycling of batteries and PV modules

Combining photovoltaics and electromobility is mandatory for decentralised power supply. The German government is calling for one million electric vehicles on Germany's roads by 2022 and as many as 6 million by 2030. Electric mobility as we know today requires large quantities of traction batteries. First and foremost are the high-performance lithium-ion batteries, the production of which requires large quantities of valuable raw materials, which should be preserved in the material cycle as far as possible after the batteries have reached their end of life. This requires a closed recycling chain including expandable logistics solutions. With the trend towards more and more private households with photovoltaic systems and ever cheaper storage systems, the use of PV in combination with electromobility is becoming increasingly worthwhile, and the number of installed photovoltaic modules is increasing not only in Germany.

Fraunhofer IWKS is taking on the challenges of recycling PV modules and traction batteries in connection with the technological revolution. The topic is also becoming more important, as the first solar modules have now reached the end of their at least 25-year lifespan. Europe's dependence on imports is a situation that is aggravated by the increasing electrification of our vehicles. It is imperative to establish a functioning recycling chain for these traction batteries and to maintain essential material flows in Europe.

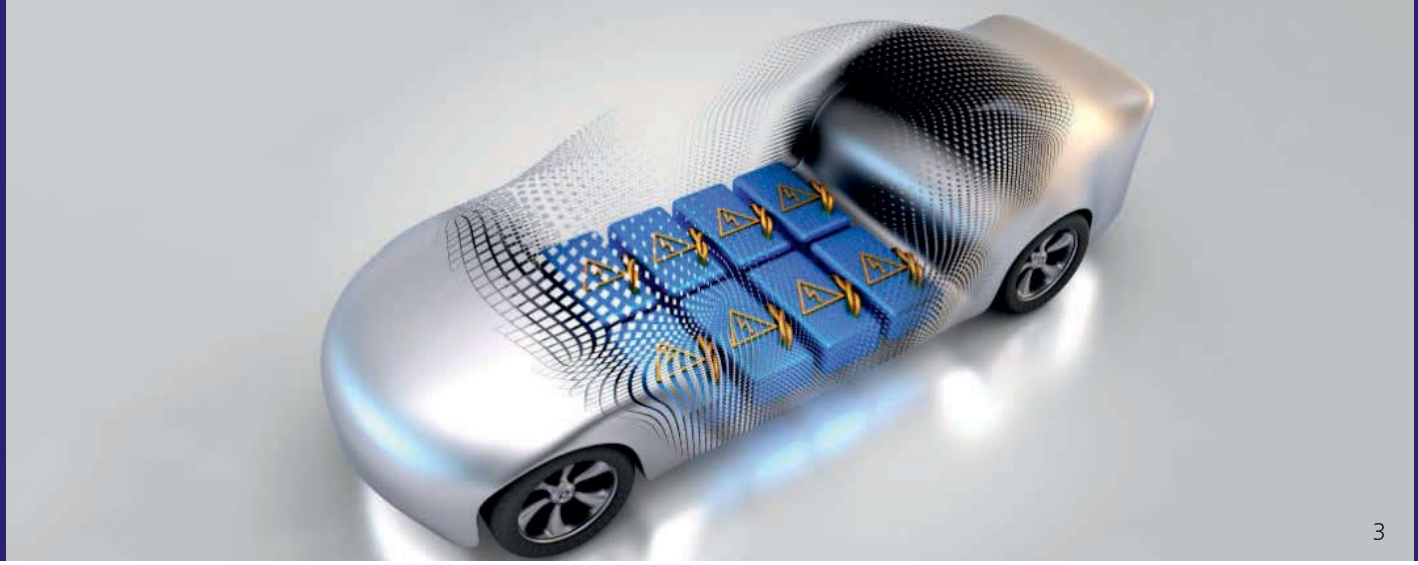
Battery Recycling in Electromobility

Rechargeable batteries are used in a wide variety of applications and are becoming increasingly important. In addition to usage in mobile devices, power tools and stationary energy storage devices, applications in electromobility are particularly noteworthy. Large-

Research projects

In the collaborative project AutoBatRec2020 (Automotive Battery Recycling 2020), scientists at Fraunhofer IWKS have been working on the intelligent recycling of traction batteries from electric vehicles since the beginning of 2018. Work is underway to intelligently recycle used batteries from electric vehicles and to identify ecologically and economically advantageous ways of efficiently recycling batteries, including upscaling for industrial application. The entire recycling chain is to be improved in such a way that the valuable raw materials are recovered and thus secured for the European industry. The aim is to evaluate the individual processes with regard to their efficiency and profitability as well as their sustainability and to establish an economically interesting value chain through their intelligent combination and further optimization. Consequently, the end-of-life management of traction batteries will be developed in the direction of circular economy and sustainability.

1. & 2.
Image Courtesy: Fraunhofer IWKS



3

Challenges and Solutions

- Digitization and automation of battery disassembly as far as possible
- Development of alternative dismantling solutions through innovative shredding technologies
- Material-selective fragmentation of battery cells in a liquid medium for passivation of pollutants and efficient separation of composite materials
- Enrichment of recyclable materials - especially active materials - through innovative separation and sorting processes in the first stage of recycling
- Recovery and processing of functional materials (already synthesized compounds) instead of metallurgical separation into individual elements
- "Design for Recycling" and "Design for Disassembly" of the batteries by unification of the design forms, easily separable connections as well as labels and markers

format traction batteries made of high-performance lithium-ion cells are the heart of modern electric vehicles and thus a key technology for the European automotive industry.

These batteries contain valuable and, in some cases, critical resources such as cobalt, lithium, nickel and copper, which mostly have to be imported from countries outside the EU. They also contain substances that would endanger our environment and health if disposed of improperly. Effective battery recycling is therefore of great relevance from both an economic and an ecologic point of view. But how can valuable resources be preserved in the value chain?

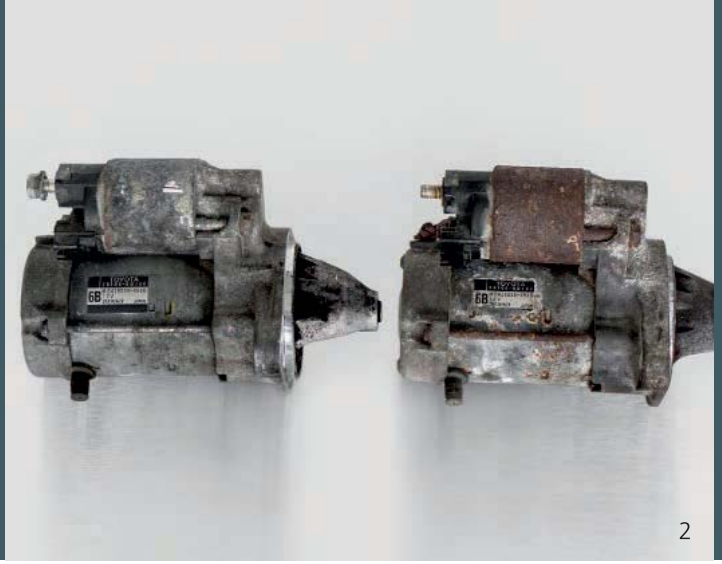
Raw Materials Source Spent Batteries

Battery recycling is currently attracting a great deal of attention from industry and research. According to the current forecast of the National Platform Future of Mobility (formerly National Platform for Electromobility), approximately one million electric cars are expected to be registered in Germany alone by 2022. Experts estimate that the number of electric vehicles in Germany will rise to 2 to 3 million by 2025. The service life of their batteries is limited for automotive applications and ranges from a few years to ten years or longer, depending on type and workload. This means that a steadily growing number of used traction batteries can be expected in the near future. "At the moment, however, the complete recycling of e-car batteries is very cost and energy intensive and therefore not yet economical. Therefore, the current focus is only on the recovery of the most valuable ingredients such as cobalt. The process must be mechanized and automated and then the recycling of batteries becomes more economical with increasing quantities", explains Dr. Jörg Zimmermann.

"There are two different basic approaches to recycling a lithium-ion battery. One is the pyrometallurgical route, where the module is opened by heat and the cell is completely melted. On the other hand, there is an increasing trend towards mechanical processes in which the batteries are shredded.
Finally, you have to work with chemicals in the end to extract the cobalt, for example. Fraunhofer IWKS is going one step further and is working on the selective separation of the material fractions directly at the beginning of the process chain in order to make the process more efficient."

In order to overcome these challenges and establish forward-looking recycling processes in good time, increased and joint research and development work is necessary.

3. Rechargeable batteries are used in a wide variety of applications and are becoming increasingly important
Image Courtesy: Fraunhofer IWKS, ©Patrick P. Palej



2

Turning old into new: A second life for vehicle components

Source : Fraunhofer Institute for Production Systems and Design Technology IPK

A huge number of used parts end up in the scrap yard for recycling every year. It is far more resource-efficient, however, to remanufacture alternators, starters, and the like as part of a recirculation approach. This reduces waste, lowers the CO2 footprint, and extends the service life of products. In the EIBA project, the Fraunhofer Institute for Production Systems and Design Technology IPK is developing an AI-based assistance system for semi-automated image-based identification of used parts without QR or bar codes. This will assist the worker with the sorting process so that more used components can be sent for remanufacturing.

Four-eyes principle reduces error rate

Clearly identifying and assessing vehicle components is one key challenge in the remanufacturing process. Many products are virtually indistinguishable from one another and are difficult to identify due to dirt and wear. Up to now, this task has been carried out manually by specialists under considerable time pressure. This is where Fraunhofer IPK's AI-based assistance system comes in: This system will help employees to identify and assess defective wear parts such as starters, air-conditioning compressors and alternators based on the four-eyes principle.

Humans and machines working hand in hand

"In the automotive industry, once the used part has been removed, it is assessed at the sorting center based on certain criteria to determine whether it can be reused," says Marian Schlüter, a scientist at Fraunhofer IPK. "This is far from trivial, however. Part numbers, which are the only visually reliable feature, are no longer legible, are scratched, painted over, or the type plates may have fallen off. This means that the worker ends up discarding it by mistake, and it is recycled purely as a material. This is precisely where AI comes into play. It identifies the used parts based on their appearance, irrespective of the part number, and sends them off for a new lease of life." Identification features such as weight, volume, shape, size and color characteristics are used, but customer and delivery data are also included in the evaluation. The employee, on the other hand, spots any loose components or burnt parts, which is where the AI system's image processing function comes up short.

The employee has the final say

But what exactly does the process entail? First of all, the used part undergoes image-based processing. This involves the system scanning the packaging to gather information about the product group. By breaking this process down into subtasks, the search range for identification is reduced from 1:120,000 to 1:5000. The used part is then weighed and

1.
Image Courtesy: © Fraunhofer IPK/Larissa Klassen, AI-supported assistance system for semi-automated sorting of used components.

2.
Image Courtesy: © Fraunhofer IPK/Larissa Klassen, Condition variance – two starters with identical part numbers differ in appearance due to wear marks.

The circular economy is a major lever for achieving the objectives of the Paris Climate Agreement. Remanufacturing – the process of rebuilding used equipment to reflect its original condition – may become a key element of the circular economy. Given the fact that equipment is reused, the service life of products is extended. Researchers at Fraunhofer IPK are pursuing this goal as part of the EIBA project, which is funded by the German Federal Ministry of Education and Research (BMBF). The project partners are Circular Economy Solutions GmbH, Technical University Berlin and the National Academy of Science and Engineering Acatech. The aim is to remanufacture used parts instead of recycling them. According to a study by the VDI Centre for Resource Efficiency, manufacturing costs can be cut by up to 80 percent by remanufacturing used parts and material consumption can be reduced by up to around 90 percent.

recorded by 3D stereo cameras. The results obtained from the image-based processing stage are combined with the analysis of the part-specific commercial data, such as the origin, date, and location, in order to identify the part reliably. The information is processed by two AI systems simultaneously. The results of the image-based processing stage are merged with the analysis of the part-specific commercial data, such as the origin, date, and location, so that the used part is identified in a reliable and comprehensive manner. "One AI system was trained for image processing, which was our task for the project, and the other one was trained for commercial data. Fraunhofer IPK uses convolutional neural networks for the image processing AI method. These are algorithms from the field of machine learning that specialize in extracting features from image data," explains the production engineer. The outcome of the identification process is shown to the employee, who receives a suggestion list with a preview image and part number, thus retaining full control. "The AI is incorporated into the ongoing operation and the work process is not disrupted. The worker has no extra tasks to perform, which is extremely important in this time-sensitive process. Our AI system runs on conventional desktop PCs. All of the company's sites can be networked via the cloud, meaning that the practical knowledge of one employee can benefit workers at other sites." The versatile technology can be used for all types of dimensionally stable components.

Every year, about five to seven percent of one million used parts processed by Circular Economy Solutions GmbH – that is, up to 70,000 parts – are discarded because they cannot be identified. A study conducted as part of the project revealed a recognition accuracy of 98.9 percent. Seen in terms of the 70,000 used parts that are discarded, it is expected that AI-based identification will allow 67,200 more used parts to be fed back into the cycle than before.

The project partners are continuously reviewing the sustainability of this scheme. The aim of the project is to keep more used parts in circulation. But is all this worth it given the high amount of energy required to train the AI and power the cameras and PCs? "The answer to this is a resounding yes. The potential for CO2-equivalent savings is high, whereas in contrast the energy requirements for the AI are negligible. According to our projections, the AI system will pay for itself in terms of CO2 equivalents in no more than a week," summarizes the researcher.

3. Product variance – two generators with different part numbers are visually identical.
Image Courtesy: © Fraunhofer IPK/Larissa Klassen

PERC Solar Cells from 100 Percent Recycled Silicon

Source : Fraunhofer Institute for Solar Energy Systems ISE

Around ten thousand tons of silicon in discarded photovoltaic modules end up on the recycling market annually in Germany. This figure will rise to several hundred thousand tons per year by 2029. Currently, the aluminium, glass and copper of the discarded modules are reprocessed, however, the silicon solar cells are not. In order to be able to reuse the silicon, researchers from the Fraunhofer Center for Silicon Photovoltaics CSP and the Fraunhofer Institute for Solar Energy Systems ISE together with the largest German recycling company for PV modules, Reiling GmbH & Co. KG, have developed a solution, in which the silicon in the discarded modules was recycled on an industrial scale and reused to produce new PERC solar cells. Already in 2021, the total installed quantity of PV modules in Germany was about five million tons, with a silicon content of 150,000 tons. As a semiconductor material, silicon is the main component of solar cells.

A working group at Fraunhofer CSP, together with Reiling GmbH & Co. KG, has therefore developed a process for recovering the silicon material with funding from the German Federal Ministry for Economic Affairs and Climate BMWK (formerly BMWi). With this process, it is possible to recycle all crystalline silicon PV modules, regardless of manufacturer and origin. Prof. Dr. Peter Dold, project manager at Fraunhofer CSP, explains: "If this were not the case, then this would be far too much work for the recycling companies. It was important for us to develop a scalable process that makes economic sense. A lot is possible in the lab, but our new process should prove itself in the practice for the recycling industry."

For the process, solar cell fragments are separated and collected from by-products of the mechanical recycling process, which is already established. At Fraunhofer CSP, the cell fragments with sizes from 0.1 to 1 millimetre are first freed from the glass and plastic by various sorting processes. This is followed by the step-by-step removal of the backside contact, the silver contacts, the anti-reflective layer and finally the emitter by wet chemical etching. The silicon cleaned in this way is processed into monocrystalline or quasi-monocrystalline ingots in standard processes and then into wafers.

The crystallization is carried out with 100 percent recycled silicon without the addition of commercial ultrapure silicon. The wafers made of recycled silicon were fabricated into PERC solar cells at Fraunhofer ISE's PV-TEC. In the first trial, the solar cell conversion efficiency was 19.7 percent. "This is below the efficiency of today's premium PERC solar cells, which have an efficiency of around 22.2 percent, but it is certainly above that of the solar cells in the old, discarded modules," says Prof. Dr. Dold, putting the initial results into context."

Most PV systems in Germany were installed between 2009 and 2011 during the first wave of photovoltaic expansion. "This expansion will foreseeably be followed by a first wave of disposal twenty years later, around 2029, when the feed-in tariff for the installed PV modules expires," explains Prof. Dr. Andreas Bett, Institute Director of Fraunhofer ISE. "Therefore, it is necessary to establish adequate processes and procedures for recovering the silicon material from the discarded modules at an early stage."

1. By-products of the treatment process at Reiling GmbH, from which the solar cell fragments are separated and collected (left). Purified silicon and wafers made from 100% recycled silicon (middle). PERC solar cells made of 100 % recycled silicon with an efficiency of 19.7 percent (right).
Image Courtesy: Fraunhofer ISE

Recycling and Green Battery

Source : Fraunhofer Institute for Ceramic Technologies and Systems IKTS

Services offered

- Characterization of (resynthesized) active materials for lithium-ion batteries
- Battery cell design suitable for recycling
- Inline test systems and digitization concepts for optimized use of resources
- Ecological and economical evaluation of recycling processes

An end-of-life battery goes through many different process steps during the recycling phase until materials that have already been used can be reused. With the help of computer-aided techniques, these are analysed on the basis of process data and optimized with regard to ecological and economic target variables. Fraunhofer IKTS designs sensor and digitization concepts in order to build up a comprehensive database across the entire value chain using special evaluation algorithms.

The acceptance and long-term future of e-mobility is also related to the options for battery recycling. This is where the "Recycling and Green Battery" working group steps in. The goal must be an economical recycling of battery components in order to avoid losses in the product and material cycle and to reduce negative environmental impacts of batteries as well as geopolitical dependencies. Fraunhofer IKTS is developing various concepts with which material cycles can be closed and raw materials can be fed back into battery cell production.

Resynthesis of active materials for lithium-ion batteries

One focus of research activities is on the resynthesis of active materials from recovered raw materials, the so-called secondary raw materials. Fraunhofer IKTS is investigating the question of how such materials can be reused and what influence this has on the performance of battery cells. In this context, existing recycling processes are specifically adapted to ensure the necessary material purity of consistently high quality.

Recycling-friendly design for lithium-ion cells

At the end of their first life cycle, battery systems are usually only mechanically dismantled, and the individual cells are then sent for thermal recycling. Up to now, battery systems have not been optimized for recycling in terms of design and materials. Against this background, Fraunhofer IKTS is developing design guidelines for liquid electrolyte and solid-state batteries in order to implement a cycle-oriented design and a recycling-friendly construction. This also includes the consideration of dismantlability and separability.

Inline test systems for optimized use of resources

The processes established in industry for battery production are mostly experience-based and optimized. In order to enable the scientific consideration of all process steps and thus to advance novel developments more efficiently, detailed data acquisition is inevitable. At the Battery Technology Application Center in Freiberg, suitable and inline-capable test methods based on quality assurance requirements are developed in conjunction with process experience. The high-tech pilot plants enable the causes of defects to be investigated with a view to reducing scrap and optimizing the use of resources.

The large variety of measurement technology used allows a novel combination of data and thus the determination of important correlations. Furthermore, the generated data form a basis for the future automatic control of the plants and thus the transition to Industry 4.0. This information is used to improve the influence of material and energy efficiencies as well as the output quality of the recyclates.

1. Efficient recycling and resynthesis processes for active battery materials.
Image Courtesy: Fraunhofer IKTS

2. In-line process inspection in electrode production for scrap minimization and quality assurance.
Image Courtesy: Fraunhofer IKTS

1. Circularity is not a new-age idea to the Indian ecosystem.. Given the present situation, how can India disrupt the 'take-make-waste' model and adopt circular economic models ,to pay equal attention to people, planet and profits?

While the concept of circular economy may have gained global importance in recent years, its underlying principles have long been rooted in the ethos of Indian society. India's thriving informal recycling value-chain recycles tonnes of materials across waste streams, such as paper, plastics, metals, electronics waste etc. It is critical to strategically embed circularity in our business landscape to achieve sustainable growth. One of the most effective ways to enable the transition from a linear to circular economic model is by emphasizing design for circularity. All manufactured goods should be designed for long life as well as easy end-of-life recovery and reuse of components and base materials. Industrial processes should be designed to maximize resource use efficiency and minimize waste generation. Moving to a circular economic model will require an ecosystem level approach, and it will be critical to build capabilities, deploy cutting-edge technologies and create a strong business case for all stakeholders. It is also important to closely engage with all sections of our society in order to strengthen and formalize the large informal recycling sector in India.

2. How do you see the movement in India towards circular economy initiatives with SDG goals? What is Tata Sustainability Group's point of view on this?

As the world moves forward in the Decade of Action, the urgency and criticality of achieving the Sustainable Development Goals (SDGs) adopted by the United Nations has never been starker. Especially in the context of India, the SDGs represents both a pressing need as well as a big opportunity to reimagine the way we want to create growth and prosperity for our people. The historical model of creating economic prosperity has been fundamentally tied to endless resource extraction from nature, inefficient and often inequitable consumption of industrial goods, and the ensuing negative environmental and social impacts created across entire value chains. A circular economic model offers a fundamental shift away from this unsustainable and inequitable form of growth, as highlighted in SDG 12 viz. 'Ensure sustainable consumption and production patterns. The positive impacts of a circular economy however go far beyond SDG 12. Reduced extraction of virgin resources and lower levels of pollution and waste will help improve the quality of our natural environment and mitigate the impacts of climate change. Strengthening our country's informal waste economy through scientific know-how and better working conditions can help achieve several social goals, including decent work, good health, and reduced inequalities. Adoption of circular economy initiatives can therefore help India achieve progress across all SDGs. This importance of circular economy is also reflected in the Tata Group's ambition of becoming a global model for best practice in circularity.

3. What role will bioplastics and other bio-based materials play in the shift away from non-renewable materials for packaging and products?

Bioplastics, which refers to plastics that are made at least partly from biological material or those that are biodegradable in nature, are an important tool in addressing the

Brief Profile

Mr. Siddharth Sharma was appointed as the Group Chief Sustainability Officer at Tata Sons in June 2019. Prior to that, he was a civil servant for more than two decades, starting his career with the Government of India (GOI) on 12th October 1992. He has handled important assignments in key ministries of the GOI such as the President's Secretariat, Finance, Urban Development & External Affairs. After serving as the Internal Financial Advisor to the 13th and 14th Presidents of India for almost six years, he took voluntary retirement from the Government of India in February 2018 and subsequently transitioned to the Tata group in 2019. Mr. Sharma possesses a deep insight and knowledge of the Indian Financial System, having worked in the Ministry of Finance in different stints. He was a key member of the top management team of the Pension Fund Regulatory and Development Authority of India (PFRDA), the pensions regulator, during 2007-09, and in that capacity oversaw the expansion of the National Pension System (NPS) to the unorganised sector, insurance & banking sectors, and the State Governments.

The Tatas as a responsible corporate citizen have always played their part in partnering government on national priorities and ensuring that our growth impulses are firmly aligned to the requirements of sustainability and the judicious use of scarce resources. The Tata Group has pioneered several business models that support reuse of resources and end-of-life products, upcycling of waste and industrial by-products as well as extension of the useful life of products. At the Tata Group, we are also focused on developing new advanced materials; on human centric innovative design; clean and affordable energy; electric vehicles and digital technologies which are expected to usher in the next frontier of responsible growth.

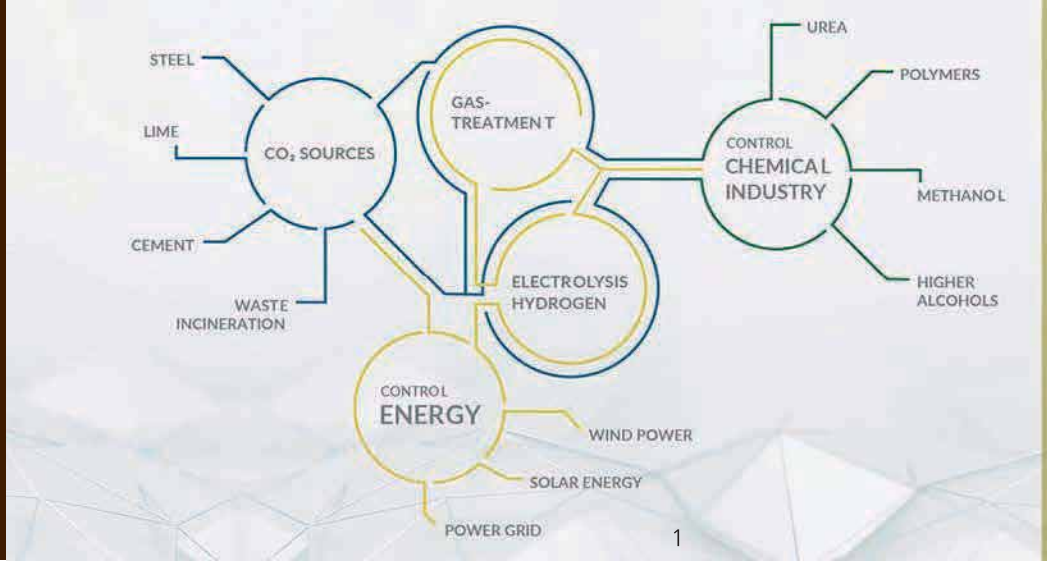
environmental challenges associated with the growing use of plastics. Depending on their specific type, bioplastics produce lower greenhouse gas emissions than traditional plastics over their lifetime and can have better end-of-life outcomes by naturally degrading in the environment through biological processes. For an agricultural economy like ours, there is also a big potential for Agri-waste to be utilized as a feedstock for producing bioplastics. Research and development are needed to enable their application for common uses and ensuring their sustainability benefits. Manufacturing at scale and reducing production costs are other important aspects for that will help the widespread use of bioplastics. Finally, since bioplastics have a wide range of chemical composition and biodegradability, there is a need for adopting uniform classification system, certification standards as well as labelling norms to promote and regulate their use.

4. What are the recommendations for policy framework that will enable a faster and smoother implementation of circular economy initiatives?

As the industry continues to apply circularity principles in the business context and implement various initiatives on the ground, regulations will need to evolve for enabling a large-scale transformation at the national level. We have already seen some movement in this direction in the form of the revised Extended Producer Responsibility (EPR) regime that seeks to strengthen the circular economy in plastic packaging and electronic waste through stringent targets around recovery and recycling of these materials. At the most fundamental level, waste needs to be seen as a valuable resource, and this will need to reflect in the country's existing waste management rules. Incentives should be provided for designing out waste and using resources at the highest levels of efficiency. On the other hand, appropriate market mechanisms and policy interventions will be needed to increase the competitiveness of products and packaging items that are made from recycled materials. Appropriate changes in the public procurement policies can also play an important role in scaling up of products designed for circularity. Design for obsolescence should be disincentivized which will ensure that products are made to last longer and generate less amount of waste at the end of their useful life.

5. Changing consumer behaviour is an important prerequisite towards a circular economy. What are the drivers towards this?

While proactive business actions and a conducive regulatory landscape are important for the production and supply of sustainable goods, an informed consumer base is critical in driving the demand for such products, thereby leading to mass adoption and economies of scale. Government and the private sector have an equally important role in driving awareness and enhancing transparency. Product and packaging labelling norms that clearly and objectively specify the social and/or environmental attributes can go a long way in creating an informed society and helping customers make the right choices. Consumer behaviour can also be influenced by incentivizing circular choices through discounts or loyalty points, for example by bringing their own container for purchasing staples, recycling of old electronics through authorized recyclers etc.



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Carbon2Chem® – A Key Building Block for the Climate Protection

Source : Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT

We need to recycle carbon – a short sentence that nevertheless clearly describes the Carbon2Chem® project. An improvement in climate protection requires not only a reduction in CO2 emissions but also a reduction in the use of fossil fuels. Extensive efforts by industry are constantly reducing its energy requirements and the emission of climate-damaging gases. However, in some cases, thermodynamic and economic limits have been reached within the processes. As a rule, new innovative processes are not yet available for large-scale use.

At this point, cross-industry networks offer the energy and emission-intensive industrial sectors the opportunity to make a sustainable contribution. The joint Carbon2Chem® project aims to use gases from the steelmaking process as a valuable raw material source for the chemical industry. The project is coordinated jointly by Fraunhofer UMSICHT, Thyssenkrupp AG, and the Max Planck Institute for Chemical Energy Conversion (MPI-CEC). The project is funded by the German Federal Ministry of Education and Research (BMBF).

Aim

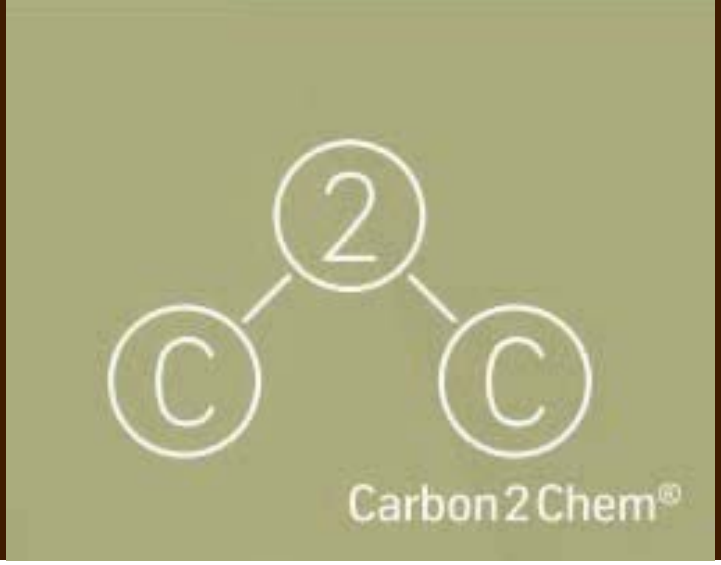
Using renewable energies, unavoidable carbon dioxide emissions from the steel industry are to replace fossil raw materials in the chemical industry. To this end, a cross-industrial production network will be set up comprising the steel industry, the chemical industry, and the energy industry. Process gases from smelting used to date for energy production serve as raw materials for the production of synthetic fuels, plastics, and other basic chemicals. The modular approach to CO2 use within cross-industry networks enables the combination of climate protection and competitiveness for large industrial sites in Germany and other parts of the world.

During the first project term for Carbon2Chem® (June 2016 to May 2020), the focus lay on developing and researching suitable processes. This centered on technical feasibility and evidence of cost-effectiveness and sustainability. The second phase of Carbon2Chem® will validate the developed processes for large-scale implementation and thus lay the foundations for low-emission steel production. The German Federal Ministry of Education and Research (BMBF) has made a further 75 million euros available for this by 2024. The partners involved are planning investments of more than 100 million euros by 2025. The joint project also takes on the challenge of considering the economic dimension of a transformation of this kind, such as how jobs can be secured while also contributing towards climate neutrality, even in other CO2-intensive industries such as cement and lime works and waste incineration plants.

Portfolio of services

- Modelling and simulation (process engineering, energy)
- IT infrastructure, software development
- Gas purification (sorption, NT plasma)
- Catalysis (methanol, higher alcohols)
- Power-to-X, energy systems
- Scenario/process concept development, system evaluation
- Life cycle assessment
- Project management for interdisciplinary R&D projects

1. Developing steel mill gases from steel production as a source of raw materials for the chemical industries. This is the objective of the Carbon2Chem® joint project.
Image Courtesy: Fraunhofer UMSICHT Carbon2Chem®



Milestones

With the milestones achieved in the individual lighthouse projects during the first phase of Carbon2Chem® (June 2016 to May 2020), the foundations and prerequisites for the second phase, which runs from June 2020 to May 2024, were created. This included the provision of a dedicated laboratory building for the project with 500 m2 of laboratory space and 30 office workstations on the Fraunhofer UMSICHT campus. This is where processes are developed for gas purification using defined gases as well as to produce methanol and higher alcohols, which then undergo further tests in the specially built pilot plant station with real gases. The pilot plant station offers 3700 m2 of space and is directly next to the Thyssenkrupp Steel Europe AG premises in Duisburg. During the second project phase, the focus lies on long-term tests both in the laboratory and in the pilot plant station. The technical processes should be further validated and upscaled for industrialization from 2025.

The subproject L-III "Synthesis Gas" will also intensively look into the composition, purification, and treatment of steel mill gases at the Thyssenkrupp site in Duisburg during the second phase. This is the starting point for subprojects L-II, L-III, L-IV, and L-V, which are concerned with the different product paths, methanol, urea, higher alcohols, and polymers. Subproject L-I "CO2 Sources and Infrastructure" is a new addition. It looks into the transfer of Carbon2Chem® technology to various industrial CO2 point sources, such as power stations, waste incineration plants, and cement works. There is also a focus on how a suitable infrastructure for hydrogen and carbon dioxide might look for major carbon capture and utilization (CCU) solutions.

The individual elements are ultimately brought together in an optimized, coherent plant network by the overarching subproject L-0 "System-Integration". For this system integration, simulation calculations are performed, and investigations conducted into cost-effectiveness and sustainability. The subproject L-KK "Coordination and Communication", which supports the coordination of the overall project and communication both within the consortium and externally, is a further new addition. Thyssenkrupp AG, the Max Planck Institute for Chemical Energy Conversion, and Fraunhofer UMSICHT are responsible for the overall coordination of the joint project. Subproject L-KK is additionally intended to develop suggestions for the regulatory framework for a climate-neutral industry by 2050.

2. Logo of the joint project Carbon2Chem ®
Image Courtesy: Fraunhofer UMSICHT

3. In the Carbon2Chem technical center, the technical implementation of the concept is tested under real conditions. It has an area of 3, 700 square meters and is located right next to the premises of Thyssenkrupp Steel Europe AG in Duisburg
Image Courtesy: Fraunhofer UMSICHT,
© Thyssenkrupp

Recycling plastics - The CreaSolv® Process

Source : Fraunhofer Institute for Process Engineering and Packaging IVV

The CreaSolv® Process allows efficient separation of plastic composites and contaminated post-consumer waste. Odorous substances and contaminants (PBDE, HBCD, etc.) can therefore be efficiently removed. In order to recover high-purity materials from complex mixtures of waste materials, Fraunhofer specifically combines the CreaSolv® Process with mechanical, chemical, and thermal processes. For economic and technical process evaluation, it carries out trial runs producing high-quality polymer recyclates for you.

Fraunhofer's range of services in the field of plastics recycling

- New recycling process technology
- Recycling of packaging materials
- Recycling of contaminated plastic
- Recycling of plastic composites
- Higher quality plastic recyclates
- Recycling plants

Ultra-high-quality recycled plastic using the CreaSolv® Process

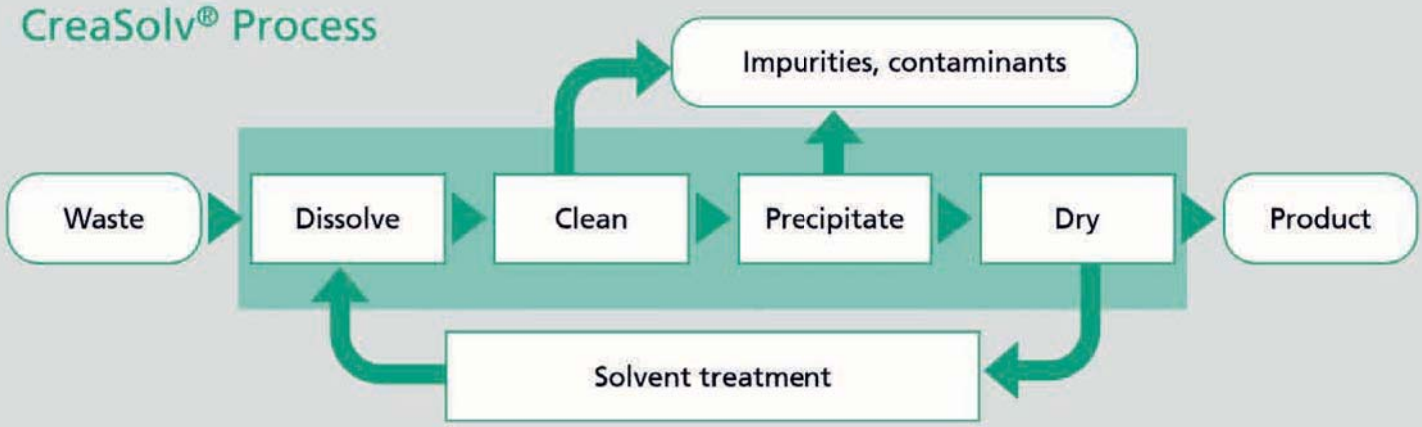
The CreaSolv® Process produces recycled plastic having virgin material properties. The solvent based CreaSolv® Process effectively removes contaminants and additives that reduce the quality of the recycled plastic produced by conventional recycling processes. This means that a wide variety of very pure plastics can be recovered even if they are initially present in mixed plastic waste. The high quality of the recycled plastics enables their reutilization to manufacture plastic products.

Dissolve	The target polymer is selectively dissolved in a special solvent formulation. Only solvents that are non-hazardous for users and the environment and that are certified in accordance with GHS criteria (Globally Harmonized System) are used. The specific solubility of the polymers allows their recovery with high purity. The non-hazardous solvents have high flash points and guarantee safe plant operation.
Clean	Undissolved components are mechanically removed. Dissolved substances (e.g., non-target polymers, printing inks, aluminium oxide, odorants, hazardous substances) are removed at the molecular level using special purification steps. After the purification, one has a solution of macromolecules of the target polymer. The size and molecular weight distribution of these macromolecules are the same as in virgin materials.
Precipitate	The target polymer is recovered from the solvent by precipitation.
Dry	The recycled polymer is dried.
Solvent treatment	Distillation of the solvent recovered from the purification, drying, precipitation, and drying steps and its return to the recycling process.
Product	The plastic recyclate is of high quality and can be used as a secondary raw material for the production cycle.

Closed-loop recycling even for plastic composites

The CreaSolv® Process is based on selective separation, so allowing the recovery of pure polymers from complex mixtures of plastics. The target plastic is effectively separated from other materials such as metal, wood, and undissolved polymers. Mixed plastic waste and composite plastic materials such as laminated films, and shredder materials from the scrapping of end-of-life vehicles and waste electronic and electrical equipment which up until now have had to be disposed of via thermal energy recovery, landfill, or export can now be

1.
Image Courtesy: Fraunhofer IVV



2

Service offerings of Fraunhofer IVV include:

- Development of recyclable packaging
- Advice about recyclability
- Recycling processes for packaging

sustainably recycled. The recyclates from composite plastics and mixed plastic waste are of near virgin quality and for a circular economy can be returned to production processes. Special purification modules also allow the separation of undesired low molecular weight materials. The CreaSolv® Process therefore for the first time allows the closed-loop recycling of contaminated plastic waste such as building waste containing polystyrene mixed with flame retardants.

What are the benefits of the CreaSolv® Process compared to conventional recycling processes?

- Hazardous materials, contaminants, and additives such as flame retardants and plasticizers are effectively removed
- Mixed waste and laminated materials can be recycled
- Plastic mixtures can be recycled
- The plastic recyclates have the quality of virgin materials
- Closed-loop recycling is possible

Compared to mechanical separation methods, solvent-based plastic recycling has the advantage that the target polymer is selectively dissolved and as such is recovered with high purity. Other polymers and other solids remain undissolved and can be effectively removed. Dissolved contaminants such as flame retardants and plasticizers are separated using specific solvents, allowing the recovery of high-purity plastic recyclates. Waste fractions that cannot be recycled using conventional recycling processes can be fed into the CreaSolv® Recycling process.

Recycling of multilayer packaging materials using the CreaSolv® Process

The recycling of multilayer packaging materials that are used to effectively protect products is a huge challenge for recycling companies. The different materials must first be separated and then individually processed. Fraunhofer IVV's patented CreaSolv® Process enables both post-consumer packaging and post-industrial waste to be recycled in a closed-loop process. The process can be customized for the particular composition of the waste materials. It dissolves the target polymers as mono-materials from the mixed plastics or composites and processes these into high-quality regranulates. These can then be used, for example, for the manufacture of new packaging materials. Recycling quotas for composite packaging and multilayer films can thus be significantly increased.

CreaSolv® Recycling plants

A number of plants designed to use the CreaSolv® Process are under construction. The first operational plant was commissioned in 2018 by Unilever in Indonesia. It recycles three metric tons of material a day. Fraunhofer provides on-site expertise at all sites that commission this novel and advanced recycling technology. CreaSolv® Technology offers an environmentally-friendly and sustainable end-of-life process for the recycling of packaging materials.

2.
Image Courtesy: Fraunhofer IVV

Recycling of waste electrical and electronic equipment

Source : Fraunhofer Institute for Process Engineering and Packaging IVV

Recycling of waste electrical and electronic equipment into high-value polymers

Electrical and electronic products are firmly established in everyday life. At the end of their useful service life these products, so-called waste electrical and electronic equipment (WEEE), must be recycled. The products often consist of a number of different plastics, many of which contain brominated flame retardants. Some of the latter are persistent organic pollutants (POPs) or listed in the RoHS directive of the European Commission. These facts present particular challenges for recycling waste electrical and electronic equipment. Currently less than 25% of the plastics in waste electrical and electronic equipment are recycled.

Separation of plastics in waste electrical and electronic equipment prior to recycling

Prior to being recycled, waste electrical and electronic equipment in Germany is separated into different groups that are then specifically pre-treated. The current state-of-the art is to separate polyolefins and flame retardant free (or low) ABS and PS from other plastics into a light fraction via density separation. A further separation based on density separates ABS and PS from the polyolefins. Then electrostatic sorting methods finally separate the ABS and PS. Other plastics such as high-value PC/ABS end up in the bromine-containing plastic fraction. These are incinerated for energy recovery at high cost and are hence not available for other recycling processes.

Trials of dry separation of plastics in waste electrical and electronic equipment

The objective of the WEEEsense project is to use an innovative dry process chain to separate high-value ABS, PS, and PC/ABS polymers from WEEE that are compliant with RoHS and REACH. To do this, the recycling company ZME Elektronik Recycling GmbH is collecting and sorting selected styrene-rich waste electrical and electronic equipment and subjecting the equipment to a special initial procedure. Then, specialized company ReToVal GmbH shreds the material, removes metal, and spectroscopically sorts the material to produce low metal/halogen mixed plastic fractions. These are then taken to Unisensor Sensorsysteme GmbH for sorting by colour-independent laser-induced fluorescence spectroscopy into ABS, PS, and PC/ABS plastic types. Subsequently, Hoffmann + Voss GmbH takes the ground material and manufactures high-quality recompounds suitable for making new electrical and electronic equipment. In parallel, the project partners will conduct an economic feasibility study of the relevant processes. The Fraunhofer IVV is coordinating the project and performing analytical testing. The intermediate fractions and products are being analysed for hazardous substances, contaminants, quality, and yield. Opportunities for optimization will be identified.

Dry separation enables the manufacture of quality polymers from WEEE

The particular benefit of this process chain is that valuable technical plastics can be reprocessed into high-quality polymer recyclates - rather than merely disposing of the plastic which is the current practice. The recycled polymers can then be reutilized to make new electrical and electronic equipment. The WEEEsense project is recovering PS, ABS, and PC/ABS as example polymers. However, other high-quality thermoplastics from waste electrical and electronic equipment, such as PA and PPE/PS, can also be recovered using this process chain. The transfer of the research results to other plastic-rich sorting fractions is possible such as shredder residues from end-of-life cars and would provide a key contribution to the reutilization of plastic-rich material streams.

1. Waste electrical and electronic equipment WEEE can be recycled to a high standard. Image Courtesy: Fraunhofer IVV, © iStock.com/LesPalenik

1

iCycle®
intelligent composite recycling

2

iCycle® Recycling of Composite Materials

Source : Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT

The iCycle®-process

The iCycle® process is a thermo-chemical technology able to separate many different materials. In the process, plastics and further organic materials are thermally decomposed in an oxygen-free atmosphere. Thus, not only contained metals and fibers are gently disintegrated, but also high-calorific fuels can be gained as oil and gas. The iCycle® process is able to fully separate and eliminate pollutants such as halogens or dioxins in order to win products of a unique quality.

One of the iCycle® technologies major fields of application is the treatment of shredder residues, which are generated during the mechanical processing of end-of-life vehicles or electrical and electronic equipment. Although they still contain many valuable metals and energy, commonly, such residues are treated inferior in combustion plants or are even landfilled.

For operators, the iCycle® process enables a production of a metal concentrate, which can be sold directly to metal recycling plants such as smelters. Gaseous and liquid fuels, produced with the iCycle® process, can be used energetically not only to deliver energy for the process, but also for further applications in the form of heat and electric power.

Metal recovery from electronic scrap

The iCycle® Technology was developed to recover precious metals from electronic scrap and shredder residues thereof. The process is based on a thermo-chemical conversion under the absence of oxygen. Thus, a sufficient disintegration of metals from plastics is enabled without oxidation. The revealed mixture of char and metals can directly be fed into integrated copper smelters enabling the recovery of up to 20 single metals from the mixture. At the same time, the plastics, that are converted into oil and gas (pyrolysis gas) under the given process conditions act as energy carrier for the self-sufficient operation of the plant and, if desired as a source of valuable chemical building blocks that can be isolated in downstream process.

Industrial sectors

- WEEE-Treatment
- Plant Operators
- Metal Recycling
- Remelting and Refinery
- Plastics Compounding

Features and development of iCycle® technology

- Patented continuously operated auger reactor ensuring optimum process conditions by permanent wall contact of the feedstock and precisely adjustable retention time and heat supply to the feedstock
- Patented combined heat exchanger system enabling heat-supply via the surface of the auger reactor and via the inner section of the auger reactor by a cycled spheres heat exchanger
- Prevention of clogging of feedstock to the heat exchanger by indirect heat-transfer
- Prevention of tar-formation and clogging of condensation units by innovative cleaning unit
- Rapid ramp-up of temperature in order to skip temperature ranges critical to the formation of Dioxins and Furans
- High process stability and plant availability
- Temperature up to 700°C, adaptable retention time of feedstock
- Flexible scalability from 70 kg/h up to > 5t/h
- Low pre-treatment requirements

1. & 2.
Image Courtesy: Fraunhofer UMSICHT

3

Implementation and commercial application

- iCycle® can be implemented highly flexible in existing plant configurations for WEEE-dismantling and recycling
- If new WEEE-dismantling and recycling facilities are planned, iCycle® allows significantly reduced mechanical pre-treatment efforts apart from manual dismantling and pre-shredding

As soon as commercial application of iCycle® is desired by the customers it can offer:

- Know-how transfer and support during implementation and commissioning
- Mediation of contacts to Fraunhofer Spin-Offs as licensees and cooperation partners
- Direct exclusive or non-exclusive License agreements for construction and operation of iCycle® units for different feedstocks and countries
- Mediation of experienced EPCC partners for scale-up and construction of iCycle® units

Brief Profile of Fraunhofer UMSICHT:

Fraunhofer UMSICHT is a pioneer for a sustainable world. With its research in the areas of climate-neutral energy systems, resource-efficient processes and circular products, it makes concrete contributions to achieving the 17 Sustainable Development Goals (SDGs) of the United Nations.

Fraunhofer UMSICHT develops innovative, industrially feasible technologies, products and services for the circular economy and bring them to application. The focus is on the balance of economically successful, socially equitable and sustainable developments.
The institute has sites in Oberhausen, Willich and Sulzbach-Rosenberg. In 2021, Fraunhofer UMSICHT generated a turnover of more than 57.8 million euros with a workforce of 608 employees. As an institute of the Fraunhofer-Gesellschaft, the world's leading applied research organization, Fraunhofer UMSICHT is a globally networked and promote international cooperation.

3. Various WEEE-feedstocks tested in iCycle®
Image Courtesy: Fraunhofer UMSICHT

BAUCYCLE: From Fine-Grained Demolition Rubble to Functional Building Materials and Components

Source : Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT

The construction industry is one of the most resource-intensive economic sectors in Germany due to the production and processing of mineral products. No other industry causes a higher waste volume. At the same time, only about 5% of the material is suitable for the high-quality recycling on the product-level. Most of the construction demolition is partly re-used as subgrade in the field of road and dump construction or goes directly to landfills as a result of the downcycling. Due to the ongoing discussions on the framework of ordinance of the German Government, which regulates the use of mineral replacement construction materials in technical buildings, the situation is becoming increasingly topical. The ordinance already has noticeable consequences: mineral waste, which has been used to date as a replacement construction material, is increasingly being deposited in landfills. In particular for the fine fraction (i.e.,<2mm), there are no high-quality processing paths.

Goals of Fraunhofer:

The Fraunhofer in-house research project "BauCycle" aims at converting heterogeneous building rubble back into homogenous construction products. Within the project, potential economic applications are being developed for the non-usable fine fractions of mineral construction waste in combination with an innovative logistics approach. The Fraunhofer institutes involved therefore set themselves the following goals in the business area of "Product Development", "Marketing" and "Sorting Technology".

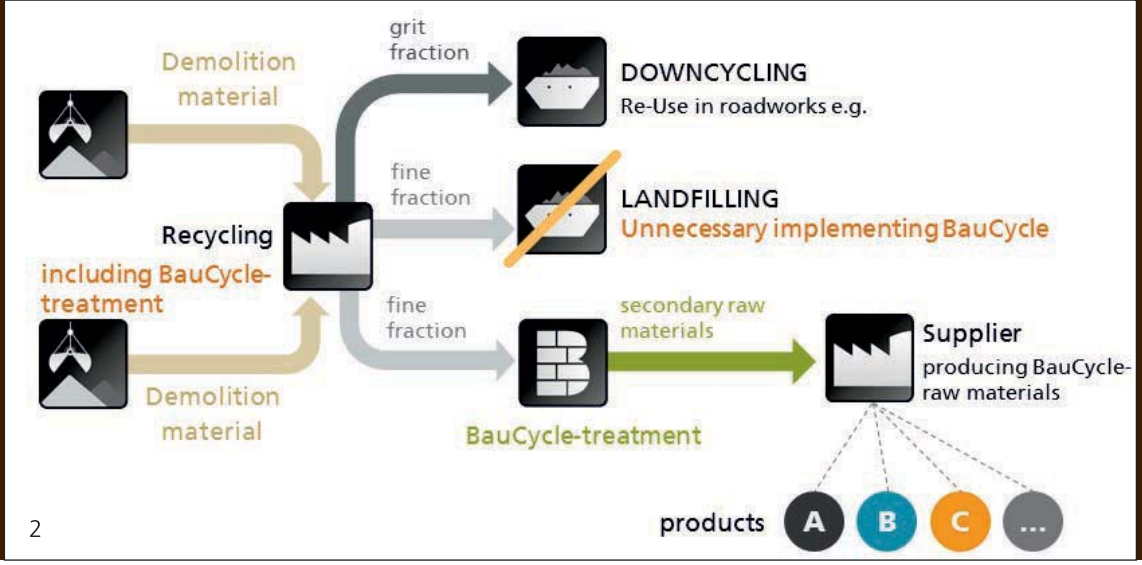
- Development of recycles and secondary raw materials for building construction from the fine fraction of demolition rubble.
- Development of a new sorting technology based on optical computing for material separation according to chemism and colour for an optimal material separation.
- Creation of genuine raw material cycles through the innovative logistical platform.

The Challenges Include:

The challenges lie both in the field of processing and analysis, as well as in the marketing and production of recycled products. Due to the heterogeneity of the materials and the technical safety-related challenges associated with the fine-grained material flow, the industry requires novel sorting procedures, logistics concepts and product innovations which go far beyond the current technological level.

- Which components of the fine fraction can be reused as raw materials in which processes and products?

1.
Image Courtesy: Fraunhofer UMSICHT



2

- How accurate is the sorting technology required for the material separation?
- Can the fine fraction be recycled as secondary raw material under economic and environmental requirements?
- Can quantity and quality be secured?

Fraunhofer's Approach

The BauCycle approach takes into account all elements of value creation in order to establish genuine raw material cycles. The Fraunhofer project consortium wants to produce high-quality, quality assured and certified products from material, which now has virtually no negative market value and, in the future, possibly even a negative market value. Three following tasks have to be solved concurrently, since this is the only way for the system to function economically:

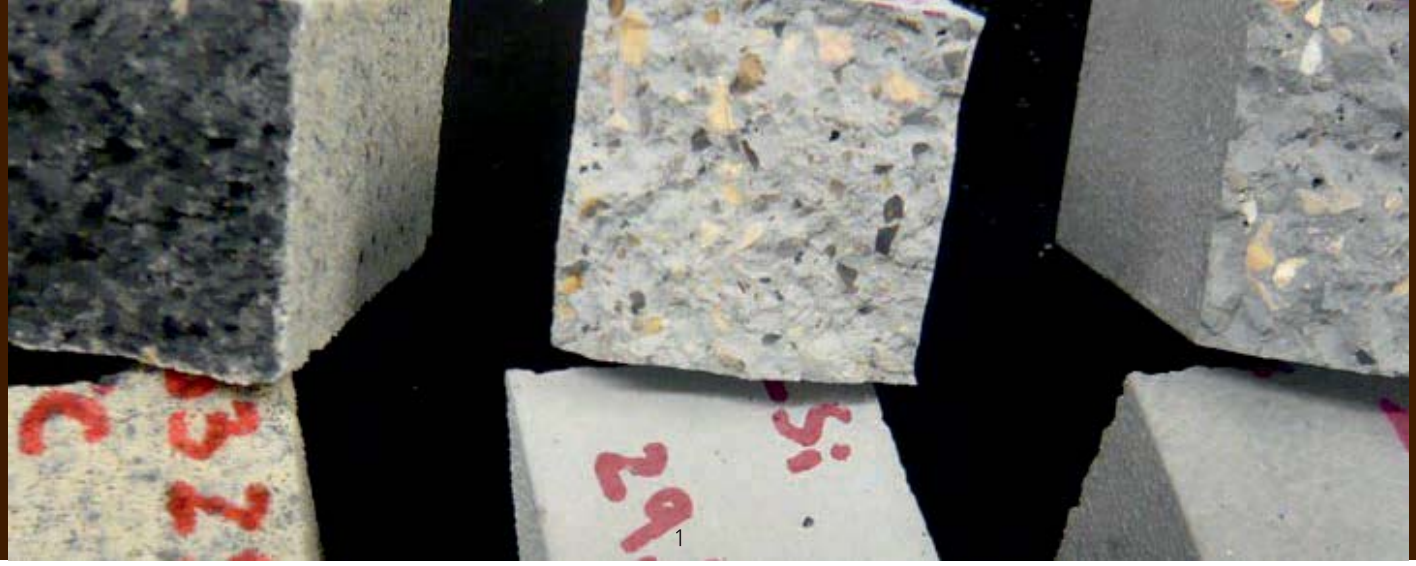
- Development of a sorting process which is able to sort the demolition rubble according to chemical criteria, e.g., "sulphatic", "siliceous" or "calcitic" rubble
- Manufacturing of aggregates, granulates, bonding agents, and functional components made of fine-grained demolition materials.
- IT-supported systems solutions for controlling the material traffic in a prospective dynamic network

Benefits

This project aims at developing a holistic technological and logistical solution for the circular economy in the building industry. In cooperation with the industry, Fraunhofer is striving to establish new routes for the recycling of building materials in the construction sector. No matter for which stakeholder of the construction industry- BauCycle provides added value for every business area:

- Increased value-adding capacity from the Germany's largest waste stream
- Reduction of the amounts of waste
- Increasing the resource efficiency of building products
- Optimization of the building logistics
- Conservation of primary raw materials
- New sales markets for construction products and services

2.
Image Courtesy: Fraunhofer UMSICHT



Inorganic raw materials and material cycles

Source : Fraunhofer Institute for Building Physics IBP

In Germany, approximately 350 million tons of waste is generated every year, with over 50% coming from the construction industry. At the same time, people in Germany consume three times as much raw material as can be obtained from natural deposits. Fraunhofer IBP develops sustainable recycling concepts for building rubble, slags from steel mills, or ashes from waste incineration plants and other inorganic residues and, together with its customers, transforms them into marketable products. It implements innovative processing methods in order to use slags, refractory concretes and waste from landfills or mines as raw materials specifically for the building materials sector.

Building rubble: a circular economy instead of landfilling

For some, it's just a demolished building. For Fraunhofer IBP, it is a supply of a versatile secondary raw material which is used to develop new, high-quality building materials

Ashes and slags: yesterday's waste - tomorrow's raw materials

From yesterday's waste, Fraunhofer IBP develops sustainable building materials for urban spaces for today, such as paving stones for pedestrianized zones, without losing sight of environmental issues.

Processing refractory materials to develop sustainable sources of raw materials for the future

Fraunhofer breathes new life into refractory concretes and ceramic residues from industry and recycle them for use in demanding industrial applications.

Recycling gypsum: processing building materials instead of disposing of them in landfills

After a building has been demolished, up till now the gypsum waste has largely been landfilled, because it causes huge problems when recovering it to make recycled building materials (so-called RC building materials). Fraunhofer makes sure that gypsum - an increasingly scarce building material - does not end up as landfill waste but instead returned to the production cycle as a high-quality raw material.

Masonry rubble

When buildings are demolished, masonry rubble containing brick is generated. The inhomogeneous nature of this rubble is often considered a hurdle to recycling. Fraunhofer, on the other hand, see this rather as a challenge and develop sustainable, resource-efficient building materials made from recycled brick.

High-carbon residues

Residual materials from pyrolysis processes such as coal or recovered carbon black (rCB) contain significant amounts of carbon as well as minerals and metallic constituents. Processed appropriately, these materials can be utilized as raw materials, adding value through their use in new applications.

1.
Image Courtesy: Fraunhofer IBP

Obtaining tomorrow’s raw materials from today's waste with optimal processing methods

Source : Fraunhofer Institute for Building Physics IBP

Processing technologies are used both in mining to extract raw materials and in recycling to recover secondary raw materials. In addition to conventional crushing or grinding, composites need to be processed using methods that not only reduce the size of the material but also separate it into its various constituents. One such process is electrodynamic fragmentation, which cleanly sorts complex inorganic composites such as ashes, slags, refractory concretes or concrete. Fine-grained materials can be processed with selective hydrothermal techniques or special sorting methods: In this way, heavy metals are selectively precipitated and separated, and fine-grained materials sorted according to chemical criteria. If impurities are chemically bound, such as sulfate in aerated concrete, wet-chemical methods like the patented “ENSUBA” process developed by Fraunhofer IBP can be implemented. Fraunhofer IBP’s scientists have made it their business to find the best solution for each problem fraction by combining established as well as new processing methods. For instance, they have demonstrated that aerated concrete can be produced from mixed building rubble. Fraunhofer is convinced: today's waste materials are tomorrow's raw materials.

Cleanly separating solids - electrodynamic fragmentation

The disruptive technology of electrodynamic fragmentation is used to selectively separate composites such as concretes, slags, or ceramic composites into their various constituents by means of ultra-short, high-voltage, electrical pulses. EDF can play a major role in reducing CO2 emissions in the building materials industry because secondary lime is obtained from processing waste old concrete - which in turn is an ideal substitute raw material for cement. In this way, EDF technology makes it possible to fully close material cycles for composites, i.e., to recycle instead of downcycle.

Mechanical processing: Using the right amount of force

To break up materials with varying degrees of hardness, adapted mechanical processes are called for. Therefore, in addition to jaw crushers and ball mills for coarse grinding tasks, Fraunhofer IBP’s laboratory also has vibrating disk mills for “gently” grinding sensitive materials. For numerous applications and analytical methods, the materials used must have the appropriate grain size or fineness. Mechanical processing plays a key role. This is because the processing method must be matched not only to the base material but also to the desired target parameters. Fraunhofer IBP’s laboratory is equipped with a jaw crusher and ball mill for roughly breaking up and grinding materials, as well as a vibratory disk mill and vertical wet grinding processes for sensitive materials. Agglomerations can be crushed by high-intensity

1. Electrodynamic fragmentation: selectively separating materials with “flashes” instead of just crushing
Image Courtesy: Fraunhofer IBP

2

Brief Profile of Fraunhofer IBP:
Applying the principles of building physics forms the foundation of the research and development work conducted by the Fraunhofer Institute for Building Physics IBP. In addition to conventional building physics topics such as acoustics, energy efficiency, indoor climate, hygiene & sensor technology, hygrothermics and recycling building materials, the institute also carries out research on a wide range of projects with a high social relevance.

Fraunhofer IBP runs centers that have been approved by the German building inspection authorities for testing, monitoring and certifying building products and construction types in Germany and Europe. Four of the institute's test laboratories have been granted flexible accreditation by the German accreditation body Deutsche Akkreditierungsstelle GmbH (DAkkS) according to DIN EN ISO/IEC 17025. This entitles Fraunhofer IBP to develop new test methods or modify existing ones. The accredited certification center is an independent unit within Fraunhofer IBP and carries out monitoring and certification tasks on various construction products within the scope of German state building regulations and the Building Products Act or Building Products Directive. This applies to products used for windows, thermal insulation, fireplaces and exhaust systems.

ultrasound. Then, depending on requirements, various classification and screening techniques are used for specific grain sizes during mechanical processing.

Chemical-physical processing methods: Knowing every trick in the book

In cases where impurities or undesirable contaminants are chemically bound in a material, physical processing methods reach their limits. To solve such problems, Fraunhofer's experts develop hydrometallurgical or specific extraction processes - for example, to remove gypsum from building materials. If necessary, they also develop new concepts to treat mineral solids and mixtures that are tailored to the exact requirements and specifications of our customers and partners. Over and above the classic wet chemical methods, Fraunhofer IBP also carries out processes under controlled temperature and pressure conditions in its laboratories. In addition to microwave pressure digestion, it uses a reaction autoclave which can be coupled with diverse post-treatment steps, such as vacuum filtration. This setup enables Fraunhofer IBP to optimize processing methods for the various materials in a highly flexible manner. At the same time, when developing new methods and processes it never loses sight of sustainability or cost-effectiveness and is committed to developing innovative and attractive concepts for its customers.

Sorting: Putting the right ones in the pot

Today, electro-optical sorting techniques are indispensable when it comes to selectively separating composites. In addition to spectroscopic techniques, Fraunhofer IBP collaborates with its partners to develop methods based primarily on the chemical characterization of the particles concerned.

- **Innovative sorting techniques for the smallest particle sizes**

Fraunhofer's scientists have the necessary technical equipment to separate particles down to a minimum grain size of one millimetre from mixtures. They use colour and multispectral cameras to sort particles by chemical composition and colour. Special sensors can be deployed to identify material-specific spectra - like fingerprints - and use them as a sorting criterion. The sorting system can be "taught" new tasks, thus continuously extending, and optimizing the sorting spectrum in line with requirements.

- **From laboratory scale to pilot plant**

At its branch in Holzkirchen, Fraunhofer IBP is currently optically sorting mixtures on a laboratory scale. However, it is planning to expand its services there with a pilot plant so that it can process "practicable" quantities of material to the standards required by industry. A key area of Fraunhofer IBP's expertise lies in sorting inorganic residues such as building rubble, ashes, and slags.

2.
Image Courtesy: Fraunhofer IBP

Fraunhofer Digital Transformation Assessment (DTA) Tool

Source : Fraunhofer Institute for Production Systems and Design Technology IPK

Fraunhofer Institute for Production Systems and Design Technology (IPK) has developed the "Digital Transformation Assessment" (DTA). It is an online survey on digital transformation that Fraunhofer IPK conducts in Europe, America and Asia (available in five languages). This tool is not just a simple scientific survey, but a self-assessment for companies. This means that companies know their position/maturity level from a general perspective after 15 minutes. Benefits of this tool are:

1. It is a benefit for companies as they know their position/maturity level after 15 minutes.
2. Based on the total responses received, Fraunhofer IPK can develop a "mini market study", e.g., status of digital transformation in India, and also benchmark / international comparison (e.g. India vs. Europe vs. global).
3. In addition to an assessment of Digital Transformation, Fraunhofer IPK also offers solutions for this, in terms of technology and consulting.

Digital Transformation Assessment

Digitalisation offers enormous opportunities to actively shape one's own future and at the same time confronts companies with great challenges. Digital transformation describes the process of change that companies must shape in order to master digitalization. With the help of our self-assessments, you can determine the status of digital transformation in your company. Answering the questions takes about 10-15 minutes. At the end, you have the opportunity to register for a free benchmarking. This provides insights into how you compare to your national and international competitors in your industry.

Who can participate?

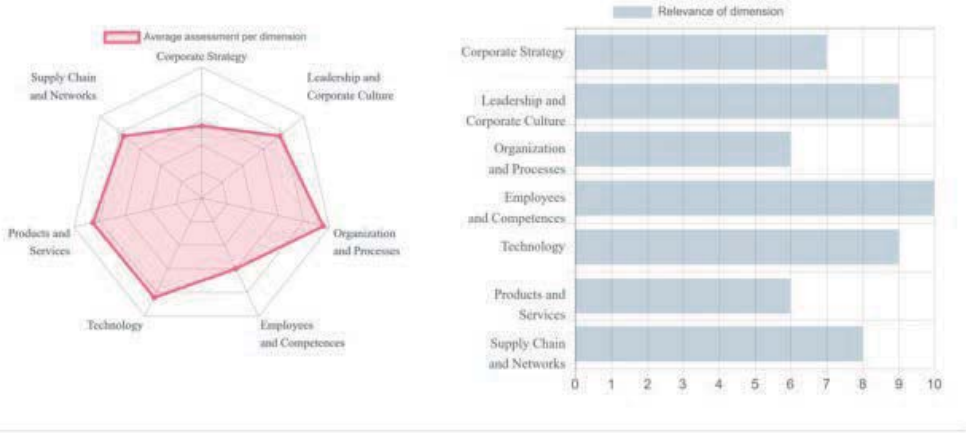
- Everyone involved in the digital transformation at their organization
- CEOs interested in digitally transforming their company
- Managers who want to get insights in their company's status quo on digitalization and potential for improvement
- Organizations and companies of all industry sectors

Why should I participate?

Find out in which areas of digital transformation your company is already well positioned and which areas still have optimization potential. To do this, you will use a variety of questions to determine your company's position in the following seven key areas:

- Corporate Strategy
- Leadership and Corporate Culture
- Organization and Processes

1. The seven assessment areas of your digital transformation process
Image Courtesy: Fraunhofer IPK



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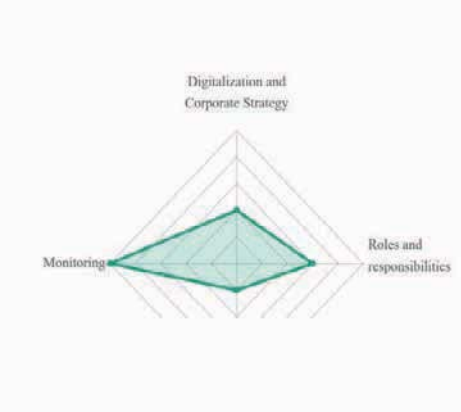


3

- Employees and Competences
- Technology
- Products and Services
- Supply Chain and Networks

What do I get as a result?

After you have completed the questionnaire, you will receive your company-specific evaluation online. The results will help you understand where you are on your digital journey. This will enable you to identify the main topics that are of particular importance for the digital viability of your company.

Summary- Digital Transformation Assessment

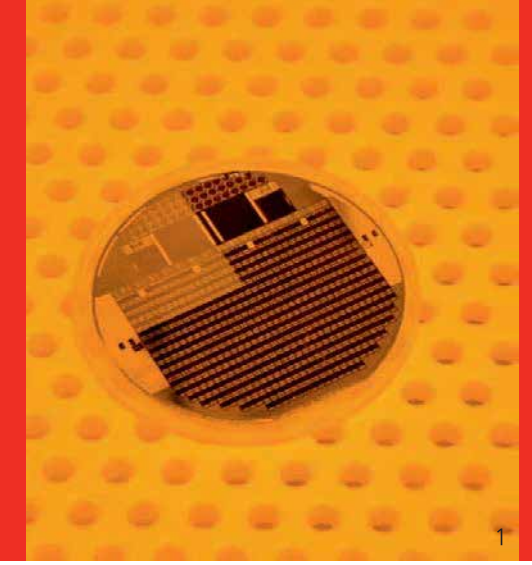
Digital transformation describes the process of change that companies must shape in order to master digitalization. The process of digital transformation confronts companies with a bundle of challenges that require new thinking at various levels.

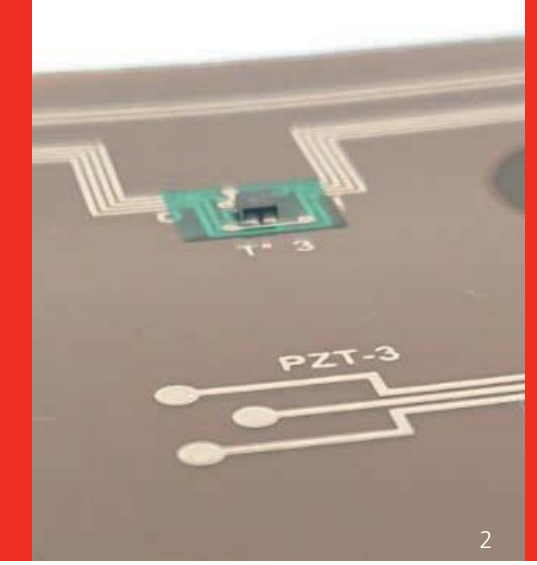
Below you will find your personal evaluation based on the previously evaluated dimensions of digital transformation, These seven dimensions do not represent self-contained areas, they are strongly interlinked. In order to master the digital transformation successfully, a careful chorography is necessary, which considers all dimensions balanced.

Corporate Strategy

Digitization is massively changing value creation structures. Market opportunities are opening up for companies, but new competitors are also appearing on the scene. Digital transformation requires strategic work. Clear corporate goals and a sustainable business model are of central importance.

2. & 3.
Image Courtesy: Fraunhofer IPK





Recent Research News @ Fraunhofer

PERC Solar Cells from 100 Percent Recycled Silicon
Press Release / February 07, 2022
Around ten thousand tons of silicon in discarded photovoltaic modules end up on the recycling market annually in Germany. This figure will rise to several hundred thousand tons per year by 2029. Currently, the aluminum, glass and copper of the discarded modules are reprocessed, however, the silicon solar cells are not. In order to be able to reuse the silicon, researchers from the Fraunhofer Center for Silicon Photovoltaics CSP and the Fraunhofer Institute for Solar Energy Systems ISE together with the largest German recycling company for PV modules, Reiling GmbH & Co. KG, have developed a solution, in which the silicon in the discarded modules was recycled on an industrial scale and reused to produce new PERC solar cells.

Silicon carbide pressure sensors working at 600°C could make air travel easier on the environment
Tech News / March 08, 2022
Built to take the heat: While conventional sensors reach breaking point at around 300°C, researchers at Fraunhofer IZM are creating a sensor that works reliably at twice that temperature. The secret of the heat-loving sensors: Silicon carbide, etched with exceptional precision. Their ability to monitor pressure even in extremely adverse environments could help fine-tune the combustion process in jet turbines and reduce the fuel consumption of aircraft.

How to increase the performance of zero-gap electrolyzers
Press release / March 29, 2022
Reducing CO2 in our atmosphere electrochemically and using it as a basis for chemical products – this is the goal of numerous projects in industry and research. The focus is no longer on developing new catalysts and electrodes, but on scalability and optimization of existing electrolytic systems. Scientists from Fraunhofer UMSICHT, Ruhr-Universität Bochum and RWTH Aachen took a closer look at one of these systems – the so-called zero-gap electrolyzer. Result: They were able to improve both the stability of the electrolyzer and the faraday efficiency for the CO produced over a longer period of time.

High Speed Processing on Large Wafers with Newly Developed On-the-Fly Laser Equipment
Press Release/ April 25, 2022
In order to be able to manufacture more efficient solar modules, the photovoltaic industry is increasingly switching its production to larger wafer formats. Being able to guarantee the production of these solar cells with an edge length of up to 210 millimeters with consistent quality and cycle rate poses new challenges for equipment manufacturers. A research team at the Fraunhofer Institute for Solar Energy System ISE has now succeeded in implementing a novel system concept, whereby large-format solar cells are continually processed as they move at high speed under the laser Screw connections on critical infrastructures are exposed to major stresses and must therefore be checked on a regular basis. Researchers at the Fraunhofer Cluster of Excellence Cognitive Internet Technologies CCIT have now developed a technology that allows the stability of the screw connections to be checked at any time by remote monitoring. This increases safety and reduces the time and effort spent on inspections.

Always ready to receive — RFicient chips for a sustainable Internet of Things
Press Release / May 19, 2022
Keeping things constantly connected to the internet costs energy — a lot of energy. Even small Internet-of-Things nodes run out of battery entirely in just a few weeks. All of this is

1. Thanks to improved antireflection layers, the efficiency of the best four-junction solar cell to date improved from 46.1 to 47.6 percent. © Fraunhofer ISE

2. Details of the printed circuit board for the battery sensor system with mounted temperature sensor and printed ultrasonic sensors. © A. Latour, CEA for SPARTACUS

3. Reactor for catalytic methanation of Co2, 50 kW nominal output. © Fraunhofer IMM

changing with the RFicient® chip, developed by the Fraunhofer Institute for Integrated Circuits IIS, which saves power consumption by up to 99 percent. This development is a big step forward for the Internet of Things and has secured the Joseph von Fraunhofer Prize for the developer team.

Fraunhofer ISE Develops the World's Most Efficient Solar Cell with 47.6 Percent Efficiency

Press Release / May 30, 2022

Researchers at the Fraunhofer Institute for Solar Energy Systems ISE, using a new antireflection coating, have successfully increased the efficiency of the best four-junction solar cell to date from 46.1 to 47.6 percent at a concentration of 665 suns. This is a global milestone, as there is currently no solar cell with a higher efficiency worldwide.

Fraunhofer process increases methane yield from biogas plants

Press Release / June 01, 2022

Biogas plants produce methane along with more than 40 percent CO2 which has been released into the atmosphere in conventional biogas plants. Researchers from the Fraunhofer Institute for Microengineering and Microsystems IMM have now found a way to convert this waste product into additional methane, thus drastically increasing the methane yield from biogas plants. The process is up and running and the research team is currently scaling up the demonstration plant to five cubic meters of methane per hour.

Software combines Life Cycle Assessment and Economics for buildings

Press Release / June 01, 2022

The European Union wants the Life Cycle Assessment of buildings to be given more significance in the future, and the EU Taxonomy creates a systematic basis for this: It defines criteria for evaluating investments, including for the climate change mitigation objective of the taxonomy. Researchers from the Fraunhofer Institute for Building Physics IBP worked together with a business partner to develop a software suite that combines ecological indicators and economic calculations for investments. This has an influence on banks' lending decisions since interest surcharges are possible for non-green investments in the future.

SPARTACUS makes batteries stronger

Press Release / June 01, 2022

Batteries for electric cars and mobile devices are easy to use, but repeated charging and discharging accelerates aging, reduces the performance of battery cells and shortens their service life. In the SPARTACUS research project, researchers at Fraunhofer ISC are using a range of different sensors to monitor the internal status of battery cells. The data can be used to optimize the battery management system, the charging and discharging processes and the stress on individual cells in the battery module. This makes batteries significantly faster to charge — and even extends their service life.

4. The new system concept enables solar cell manufacturers to perform laser processing at the highest speed without having to compromise on structure size or processing area. © Fraunhofer ISE

5. Always ready to receive signals from neighboring nodes with a current of just three microamperes.
© Fraunhofer/Piotr Banczerowski

6. The Smart Screw Connection is a fully integrated, self-powered IoT device for determining the preload force. The data are transmitted wirelessly.

Recent Activities

Workshop on Indo-German Collaboration for Advanced Wastewater Treatment
28th October 2021
Fraunhofer IGB has entered into a cooperation with Jodhpur City Knowledge and Innovation Cluster (JCKIC), a S&T Cluster set by Principal Scientific Adviser (PSA) to Govt. of India at IIT Jodhpur to develop a smart and sustainable water management strategy for Jodhpur industrial cluster and establish a Water Innovation Hub for long-term cooperation between local industry and German institutes and companies.

4th webinar in the Science Curio Series, Fire-Side Chat: "Innovation and Applied Research made in Germany for the world"
9th November 2021
The 4th webinar in the Science Curio Series, Fire-Side Chat: "Innovation and Applied Research made in Germany for the world" focused on the collaborations between Germany and India in the field of "Innovation and Applied Research". The session was organized in partnership with Nuffic Nesco India, Euraxsess India, German Consulate Bangalore and Fraunhofer Office India.

Meeting with NASSCOM's Engineering R&D Council
17th November 2021
Ms. Anandi Iyer, Director, Fraunhofer Office India was invited by the senior management of the National Association of Software and Service Companies (NASSCOM) to introduce the profile of Fraunhofer and discuss the proposal to setup an Innovation Supercluster in cooperation with NASSCOM in the areas of Mobility, Energy & Climate, Digital Healthcare and Smart Manufacturing.

Site visit to Kochi under the project "Morgenstadt: Global Initiative - Kochi Smart City Innovation Lab"
18th-19th November 2021
Ms. Anandi Iyer, Director and Mr. Aditya Fuke, Manager - Smart Cities & IoT from Fraunhofer Office India conducted an onsite visit to Kochi under the project "Morgenstadt: Global Initiative - Kochi Smart City Innovation Lab". The project team also visited the Elamakkara Ward, which is the area that has been selected to implement the pilot demonstrator that will include sustainable technologies in wastewater management, renewable energy infrastructure installation and development of climate smart buildings. The onsite visit and the meetings were facilitated by Centre for Heritage, Environment and Development (C-HED), which is the local partner of the project "Kochi Smart City Innovation Lab".

IET India Digital Conversations - HMI in Digital Manufacturing
19th November 2021
The Institution of Engineering and Technology (IET) - India had invited Ms. Anandi Iyer, Director, Fraunhofer Office India to moderate the leadership panel discussion on "HMI in Digital Manufacturing".

TiE Women Accelerator Workshop
27th November 2021
Ms. Anandi Iyer, Director, Fraunhofer Office India was invited as a speaker on the corporate innovation panel, organized by TiE Women on Nov 27th, 2021, in Bangalore. TiE Women is a global initiative, which aims to embrace, engage, and empower women entrepreneurs, inclusive of all stages of an enterprise, origin, standing or background, across the globe.

1. L: Mr. Friedrich Birgelen, R: Ms. Anandi Iyer in the Science Curio Series, Fire-Side Chat.

2. Mayor's Office - R to L: Mr. M. Anilkumar, Ms. Anandi Iyer, Dr. Debjani Ghosh along with key stakeholders of Kochi

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2nd International Conference on Industry 4.0 and Advanced Manufacturing (I-4AM) was held
10th January 2022

The 2nd International Conference on Industry 4.0 and Advanced Manufacturing (I-4AM) was held on 10 Jan 2022. The conference was hosted online by the Centre for Product Design and Manufacturing (CPDM), partnering with twelve other departments at the Indian Institute of Science (IISc) Bangalore. Ms. Anandi Iyer, Director, Fraunhofer Office India participated as a panellist in this conference.

Transformative Innovation Policy (TIP) Conference 2022
19th January 2022

The TIP Conference 2022 is organised and funded by TIPC and the Eu-SPRI (European Forum for Studies of Policies for Research and Innovation) with the participation of Globelics and Africalics members and with the involvement of Sustainability Transitions Research Network (STRN) members. TIPC mobilises the Power of Innovation to address the Societal and Environmental Challenges of modern times. Fraunhofer Office India's application for presentation of an innovation concept in the water sector was accepted by the jury. Ms. Anandi Iyer, Director and Mr. Aditya Fuke, Manager – Smart Cities & IoT, from Fraunhofer Office India represented Fraunhofer and delivered a presentation on Fraunhofer's ambitious project in India namely "Water Innovation Hub" in the session on "Conceptualisation of innovation for transformative change"

CEO Roundtable and Discovery Workshop with NASSCOM
24th, 28th and 1st March 2022

NASSCOM (National Association of Software and Service Companies) has collaborated with Fraunhofer IPK to develop Innovation Superclusters on Research & Innovation in India, with a focus on futuristic technologies in the areas of Mobility, Energy & Climate, Healthcare, and Smart Manufacturing to create a new market and growth opportunities. Prof. Holger Kohl, Deputy Director, Fraunhofer IPK led the initiative along with Ms. Anandi Iyer, Director, Fraunhofer Office India. A roundtable was organized with CEOs of 25+ Indian and Multinational companies on Feb 24th, 2022, in which Prof. Kohl presented the global best practices of Innovation superclusters, discussed the future developments of domestic and international market demand related to Research & Innovation and Digitalization, along with macroeconomic indicators, trends and impacts that influence a Supercluster. The CEO Roundtable was followed by a Discovery Workshop with CTOs of 45+ companies that was organized for 2 days from Feb 28th – Mar 1st, 2022.

Special Address by Ms. Anandi Iyer, Director, Fraunhofer Office India IEEMA @ 75
25th February 2022

Fraunhofer recently submitted its partnership proposal to IEEMA. IEEMA which completed 75 years on Feb 25th, 2022, introduced Fraunhofer as its collaboration partner. Ms. Anandi Iyer was invited to deliver a special address highlighting areas of collaboration like masterclass series in the topics of electric drive technologies, power electronics and vehicle electronics.

International Collaboration with Ministry of Housing and Urban Affairs (MoHUA), Govt. of India on the Global Housing Technology Challenge India
February 2022

The Fraunhofer Institute for Building Physics IBP has been awarded a project by GIZ wherein it will support MoHUA in the framework of the Global Housing Technology Challenge India (GHTC-India) in advancing globally available "proven technologies", "demonstrable technologies" and domestic "potential future technologies". Fraunhofer IBP will develop Knowledge Products, Capacity Building and Mentorship in Construction Technologies for the

3. L: Ms. Anandi Iyer speaking at "TiE Women Accelerator Workshop"

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Ministry of Housing and Urban Affairs (MoHUA), Govt. of India. The technologies will be sustainable, environmentally friendly, disaster-proof, cost-effective, and quick to implement.

She Is: 75 Women in STEAM
3rd March 2022

To commemorate India's 75th year of Independence, Red Dot Foundation and Beyond Black, in collaboration with the Office of the Principal Scientific Advisor, Government of India, and British High Commission, New Delhi sought to honour the top 75 Indian Women in STEAM (fields of Science, Technology, Engineering, Applied Arts and Mathematics) through the 'She Is' book series. Ms. Anandi Iyer, Director, Fraunhofer Office India was among the 75 women that were selected as role models for youth by the PSA office and the British High Commission that was announced on March 3, 2022. The aim of the book series is to showcase more women role models for youth, make visible the leadership of women and generate interest in the SDG's.

Women in Tech: Charging New Frontiers, Breaking Gender Stereotypes
7th March 2022

To mark Women's Day, Women in Tech: Charging New Frontiers, Breaking Gender Stereotypes event was held on March 7, 2022, at the FICCI Federation House, New Delhi. The highlight of the event was the launch of the Women in Science and Entrepreneurship (WISE) council. The WISE Council together with FICCI Flo aims to empower women in Science & Technology as well as businesses to fearlessly aim high and achieve their best potential. The WISE Council was launched by Smt. Smriti Irani, Minister of Women and Child Development, Govt. of India. Ms. Anandi Iyer, Director, Fraunhofer Office India and Chairperson, WISE Council gave a brief introduction and shared the vision of the council.

12th Bengaluru INDIA NANO event held
7th-8th March 2022

Ms. Anandi Iyer, Director, Fraunhofer Office India, and Mr. Vinay Shenoy, Managing Director, Infineon, participated in the panel discussion for the 12th Bengaluru India Nano event that was held on 7th – 8th March 2022. The panel discussion was moderated by Friedrich Birgelen, Deputy Consul General of Germany in Bangalore.

Visit of Dr. Markus Wolperdinger, Director, Fraunhofer IGB to India
1st-5th April 2022

Fraunhofer Office India coordinated the visit of Dr. Markus Wolperdinger, Director, Fraunhofer IGB to India on his interest to intensify the cooperation between Fraunhofer IGB and Indian companies. The focus of his visit was to strengthen the cooperation between Fraunhofer IGB and India on the impact of technologies pertaining to circular economy and sustainability, which would drive future business growth for Fraunhofer IGB in India.

Visit of Mr. Marc Beckett, Project Coordinator "AQUA-Hub", Fraunhofer IGB to India
4th-6th April 2022

The project "AQUA-Hub" aims to set up water innovation hubs to address challenges related to water and wastewater in the cities of Solapur (Maharashtra) and Coimbatore (Tamil Nadu), thereby making "Technologies made in Germany" accessible to India. Mr. Marc Beckett visited these cities and met with important stakeholders from municipal administration to conduct city analysis for setting up a smart water monitoring system. In Coimbatore, Dr. Stefan Liehr from ISOE and Mr. Ashok Srinivasan from NIVUS Gmbh also accompanied Mr. Beckett during the visit. ISOE and NIVUS are the project partners in AQUA-Hub. Site visit in Coimbatore was organized by Coimbatore Smart City Limited. The project team visited and identified two lakes namely "Selvachintamani" and "Valankulam", where smart water

5. Ms. Anandi Iyer, sharing the WISE vision

6. AQUA-Hub project team

monitoring systems could be installed.

Industry meeting at Noyyal Life Centre:
6th April 2022
Fraunhofer Office India and Siruthuli had jointly organized a meeting with the stakeholders, majorly from industry and CSR sponsors, to present the project and create an appropriate framework with industry participation for successful implementation of AQUA-Hub in Coimbatore.

Visit of Morgenstadt: Global Initiative (M:GI) project team to Kochi
6th-7th April 2022
A delegation of experts from Fraunhofer IGB, IBP and IAO, University of Stuttgart and National Institute of Urban Affairs (NIUA) visited Kochi to conduct on-site assessment of the Government School in Elamakkara Ward, the area that has been selected to implement the pilot demonstrator that will include sustainable technologies in wastewater management, renewable energy infrastructure installation and development of climate smart buildings. Dr. Marius Mohr, Head of Innovation Field "Water Technologies and Resource Recovery" from Fraunhofer IGB led the delegation.

Fireside Chat - SME Innovation and Technology Cooperation between India and Germany
26th April 2022
Fraunhofer Office India organized a Fireside Chat on "SME Innovation and Technology Cooperation between India and Germany", jointly with DWIH New Delhi on 26th April 2022. Dr. Rainer Frietsch, Head of the Competence Centre "Innovation and Knowledge Economy" from Fraunhofer ISI and Prof. Rishikesha T Krishnan, Director, IIM - Bangalore were the speakers who represented the German and the Indian side of the SME status and perspective respectively. The objective of the Fireside chat was to set the focus and attention on the structure of the SMEs in both countries, the imperative as well as challenges they face in forging a collaboration. Ms. Anandi Iyer, Director, Fraunhofer Office India moderated the discussion.

India Energy Storage Week (IESW) – Conference & Expo
2nd May 2022
The India Energy Storage Week (IESW) conference and Expo, organized by the India Energy Storage Alliance (IESA) was held in Delhi on 2nd May 2022. Dr. Matthias Vetter, Head of Department – Electrical Energy Storage, Fraunhofer ISE delivered presentation on the topic "Stationary battery storage for successful energy transition - applications, developments, and challenge". Mr. Sanmati Naik from Fraunhofer Office India coordinated Fraunhofer's session at IESW. The session was well received with a good participation in both online and offline mode.

Signing of Joint Declaration of Intent (JDI) between Fraunhofer IGB and IIT Jodhpur
2nd May 2022
The signing of Joint Declaration of Intent (JDI) between Fraunhofer IGB and IIT Jodhpur was held during the 6th Indo-German Intergovernmental Consultations held in Berlin on 2nd May 2022. Hon'ble Prime Minister of India Shri. Narendra Modi led the highest Indian Parliamentary Delegation to Berlin on 2nd and 3rd May 2022 to meet H.E. Olaf Scholz, Chancellor of the Federal Republic of Germany and his cabinet for 6th IGC. Fraunhofer was a prominent part of the events and activities around the visit. Mrs. Anandi Iyer was present in Berlin on the invitation of the Indian Embassy and participated in the official events around the visit. JDI between Fraunhofer IGB and IIT Jodhpur was signed during the 6th IGC. The

7. Kochi Project Team

8. From L to R: Mr. Friedrich Birgelen, Mr. Vinay Shenoy, Ms. Anandi Iyer

objective of this cooperation is to generate and discuss ideas for future research and development projects in the field of Advanced Wastewater Treatment, to initiate and promote a scientific collaboration between JCKIC and Fraunhofer IGB.

Visit of Ms. Anandi Iyer, Director, Fraunhofer Office India to Germany 2nd-11th May 2022

Ms. Anandi Iyer, Director, Fraunhofer Office India visited Germany between 2nd-11th May 2022. She participated in the Indo-German Intergovernmental Consultations in Berlin on 2nd May 2022. While in Germany she also attended different meetings with key officials from German Agribusiness Alliance, Federation of German Industries (BDI), Fraunhofer IPK, Fraunhofer HHI, Berlin, Fraunhofer IPT, Berlin, Deutsche welle in Aachen and the International Office of the BMBF (IB) at the German Aerospace Center (DLR). Ms. Iyer was also part of the Fraunhofer IBD network meeting - Fraunhofer Forum Berlin and parallel MS Teams Conference that was held between 5th-6th May 2022 that was held at the Fraunhofer Forum, Berlin.

Visit of Dr. Fritz Bickel, Director, Dr. Fritz India to Fraunhofer Office India 18th May 2022

Dr. Fritz Bickel, Director, Dr. Fritz India visited the Fraunhofer India Office along with his successor Mr. Arthur Becker. Ms. Anandi Iyer presented a short profile of Fraunhofer to the guests. Dr. Fritz Bickel further discussed about production technology for solid state batteries and its future. It is currently being developed jointly by researchers at Fraunhofer IPA with the medium-sized companies. Dr. Fritsch special machines GmbH and Dr Fritsch GmbH & Co KG. The research project has received funding of over one million euros by the state of Baden-Württemberg.

Visit of Mr. Gerhard Stryi-Hipp, Energy Expert, Morgenstadt: Global Initiative (M:GI) project team to Kochi 22nd - 23rd May 2022

Mr. Gerhard Stryi-Hipp from Fraunhofer ISE visited Kochi between 22nd-23rd May 2022 to conduct on-site assessment of the Government School in Elamakkara Ward, the area that has been selected to implement the pilot demonstrator that will include sustainable technologies in wastewater management, renewable energy infrastructure installation and development of climate smart buildings.

Visit of delegation from NASSCOM and IEEMA to Fraunhofer booth at Hannover Messe 2022 30th May 2022

A very high-level Indian Delegation comprising of representatives from Electrical Equipment Manufacturing Industry and the Software Industry represented by IEEMA (Indian Electrical and Electronics Manufacturers' Association) and NASSCOM (National Association of Software and Service Companies) respectively, visited Fraunhofer booth to experience Fraunhofer's competencies in Industry 4.0 during the Hannover Messe 2022 that was held on 30th May-2nd June 2022. The delegation was given an exposure to select Fraunhofer exhibits in Wireless Industry Networks, Smart Factories, Industrial IoT, 5G and Digital Twins. Fraunhofer Office India coordinated these delegation visits.

India Global Innovations Connect (IGIC)- Fraunhofer as the supporting partner 2nd-3rd June 2022

Fraunhofer was the supporting partner at the India Global Innovations Connect (IGIC) event that was held in Bangalore. It was inaugurated by the Hon'ble Chief Minister of Karnataka Shri Basavaraj Bommai. This first of a kind conference saw around 22 sessions and more than

9. Mr. Gerhard Stryi-Hipp with C-HED

10. Visit of NASSCOM delegation to Fraunhofer booth

40 international speakers and well-known faces from the industry who focused on technological partnerships, ideas on Greentech, Fintech, Deeptech, Edtech, Web 3.0, Super Apps, and Unicorn Growth stories and partnerships. Ms. Anandi Iyer, Director, Fraunhofer Office India, was part of the panel discussion, "Last Mile Connectivity: Converting research faster into business success stories."

Fraunhofer Office India and CSIR, DSIR, Govt. of India jointly organize a tech dialogue
15th June 2022

Fraunhofer Office India and Council of Scientific and Industrial Research (CSIR), Department of Scientific and Industrial Research (DSIR), Govt. of India jointly organized a tech dialogue on "Sustainable Building Materials – Way to Net Zero Emissions". The session was jointly conducted by Dr. Simon Schmidt, Fraunhofer IBP, and Dr. Ashok Kumar, CSIR – CBRI. The tech dialogue is the first of the exclusive online Tech Dialogue Series under the MoU, which focuses on topics of Innovation and R&D in the areas of Sustainable Building Technologies, Battery Technologies, Advanced Production Technologies, and Water Management Technologies.

SME Technology and Cooperation Stakeholder dialogue in New Delhi
23rd June 2022

The SME Technology and Cooperation Stakeholder dialogue was jointly organized by DWIH New Delhi and Fraunhofer Office India simultaneously in Germany and India. The workshop served to present the interim status of the Blueprint to important stakeholders and give them the opportunity to contribute their expertise.

Visit of Dr. Neeraj Mittal, Principal Secretary of Dept. of Information Technology, Govt. of Tamil Nadu to Fraunhofer IGB and Fraunhofer IFAM
23rd-24th June 2022

Fraunhofer Office India had coordinated the visit of Dr. Neeraj Mittal, Principal Secretary of Dept. of Information Technology, Govt. of Tamil Nadu to Fraunhofer IGB and Fraunhofer IFAM to discuss and explore models of cooperation in Circular Economy in Water & Waste Management and Li-ion Battery Recycling.

Mr. Aditya Fuke visits Fraunhofer Institutes in Germany
24th June- 1st July 2022

Mr. Aditya Fuke, Manager, Smart Cities & IoT, Fraunhofer Office India visited Germany and had meetings at various Fraunhofer Institutes to learn more about new technologies developed by them in the fields of Circular Economy, Embedded Systems, Power Electronics, Robotics, Smart Cities and water management, and understand their relevance for Indian market. He had meetings at Fraunhofer IFAM, IPK, HHI, IZM, IOSB, IAO, IPA and IGB. The objective of his visit was to present the activities of Fraunhofer in India and to discuss the various avenues to strengthen these institutes' initiatives in India.

3rd Indo-German Standardisation Forum
8th July 2022

The 3rd Indo-German Standardisation Forum was held on 8th July 2022. The event was organized by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) on behalf of the Federal Ministry for Economic Affairs and Climate Action and GPQI.

Visit of Consul General of Germany in Bangalore to Fraunhofer Office India
14th July 2022

Mr. Achim Burkart, Consul General of Germany in Bangalore visited Fraunhofer Office India on 14th July 2022. Ms. Anandi Iyer, Director, Fraunhofer Office India gave a brief presentation

11. Group Photograph SME Dialogue

12. L to R: Prof. Matthias Busse, Dr. Daniela Fenske, Dr. Neeraj Mittal, Dr. Frederieke Langer, Mr. Aditya Fuke.

on the Fraunhofer profile and presented all the work that Fraunhofer has been doing in India for the past few years.

Visit of Mr. Kaspar Meyer, Science Counsellor, German Embassy in New Delhi to Fraunhofer Office India
16th August 2022
Mr. Kaspar Meyer, the recently appointed Science Counsellor, German Embassy in New Delhi visited the Fraunhofer Office in India along with Mr. Friedrich Birgelen, Deputy Consul General, German Consulate in Bangalore.

Visit of Dr. Katja Lasch, Director, DWIH to Fraunhofer Office India
22nd August 2022
Dr. Katja Lasch, Director, DWIH and Ms. Aadishree Jamkhedkar, Head of Programmes, DWIH visited the Fraunhofer Office India. Fraunhofer Office India is working with DWIH to develop a study on SME Innovation and Technology Cooperation between India and Germany, with a focus on developing ideas and concepts to strengthen the SME collaboration in Technology between the two countries to create an appropriate framework for technology collaboration between the stakeholders with existing initiatives and those that could be leveraged for future collaborations.

National Roundtable Conference on Agri-Renewables in India
23rd August 2022
The National Roundtable Conference on Agri-Renewables in India was jointly organised by National Solar Energy Federation of India (NSEFI) and The Indo-German Energy Forum (IGEF) in Delhi. Mr. Sanmati Naik represented Fraunhofer at the conference and delivered presentation on the topic.

Tech Dialogue on "Circular economy: Turning old into new - A second life for vehicle components"
8th September 2022
Fraunhofer Office India organized a Tech Dialogue on "Circular economy: Turning old into new - A second life for vehicle components". Dr. Marian Schlüter, Deputy Head of Department "Machine Vision", Automation Technology Division from Fraunhofer IPK was the speaker in this session. The tech dialogue's main focus was on introducing Fraunhofer IPK's key competencies in AI-based machine vision technologies, Automated virtual reconstruction and Pattern recognition in digital worlds.

AsiaBerlin Summit 2022
12th-16th September 2022
Ms. Anandi Iyer, who is also the Chairperson of the Women in Science and Entrepreneurship (WISE Council) participated in the AsiaBerlin Summit 2022, Berlin. The five-day summit was held between 12-16 September 2022 where all the ecosystem players from the investors, start-up founders, to government and policy makers and corporates were invited. With the focus on SDG's, the event aimed at diving into topics that contribute to global sustainable development through impact-driven innovation.

Indo-German Strategic Industry Networking Meet
21st September 2022
A high-level delegation of the State Baden-Württemberg of Germany visited Chennai on 21-22 Sept 2022, and on behalf of the State Baden-Württemberg and the State Agency for Environmental Technology and Resource Efficiency Baden-Wuerttemberg (Umwelttechnik BW GmbH), Fraunhofer Office India had coordinated an "Indo-German Strategic Industry

13. Mr. Achim Burkart with Fraunhofer India Team

14. Fraunhofer India Day, From L: Dr. Marius Mohr, Ms. Anandi Iyer, Dr. Simon Schmidt

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Networking Meet" at IIT Madras.

Meeting with Confederation of Indian Industry (CII)
22nd September 2022

Fraunhofer Office India had facilitated a roundtable with CII's key industry members working in water tech, with focus on climate change adaptation and food-water-energy nexus.

Visit of Delegation of Automotive Research Association of India (ARAI), Ministry of Heavy Industries (MHI) to Fraunhofer IFAM, IESE, ITWM and LBF
23rd September 2022

ARAI along with MHI are looking at possible research, trainings and collaborative project opportunities in the upcoming and futuristic technology domain areas prominent for automotive and mobility to enable "Self-Reliant India" Initiative of Govt. of India. The objective of this visit was to interact with experts at Fraunhofer Institutes IFAM, IESE, ITWM and LBF to understand the relevant domain knowledge as well as to get an essence of facilities and projects these institutes are engaged in.

Visit of Mr. Marc Beckett, Senior Scientist, Fraunhofer IGB to Coimbatore
23rd September 2022

Mr. Marc Beckett visited Coimbatore regarding the AQUA-Hub project. His visit was coordinated by Mr. Aditya Fuke, Manager - Smart Cities & IoT, Fraunhofer Office India and Ms. Sreya Prakash, Hub Manager, AQUA-Hub - Coimbatore. They had meetings with key stakeholders of the project, namely, Coimbatore City Municipal Corporation (CCMC), Siruthuli, Tamil Nadu Agricultural University (TNAU) and PSG College of Technology to discuss the roles and responsibilities of each stakeholder towards successful implementation of smart water monitoring stations in two lakes in Coimbatore.

Fraunhofer India Day 2022
7th October 2022

Fraunhofer India Day was organised by Fraunhofer Office India and was held in a virtual format. The main objective of Fraunhofer India Day 2022 was to provide an in-depth view of the Indian Market, the challenges, and the opportunities, as well as its strategy and support that Fraunhofer in India provides the institutes working in the Indian market, and deliberate on the partnerships with Industry, Government and Academia that would further help strengthen Fraunhofer's presence in India.

Meeting with Shri. Arun Goel, Secretary, Ministry of Heavy Industries (MHI), Govt. of India
14th October 2022

A meeting was organized to discuss strategic cooperation between Fraunhofer and MHI, with Fraunhofer being a Technology Partner to ARAI to support them in upgrading their existing facilities and developing an innovation cluster on futuristic technologies in Automotive and Mobility.

The World Hydrogen Energy Summit 2022
16th-17th October 2022

The World Hydrogen Energy Summit 2022 was held between 16th-17th October 2022 at the Federation of Indian Chambers of Commerce & Industry (FICCI), New Delhi. Fraunhofer and FICCI jointly organized a working session on Innovation Cluster for Green Energy, which was chaired by Prof. Dr. Christopher Hebling, Division Director of Hydrogen Technologies, Fraunhofer ISE. Prof. Dr. Hebling was also awarded the prestigious Global Hydrogen Award, an international award for outstanding scientific research and technological development in

15. Prof. Doc. Christopher Hebling (L), Ms. Anandi Iyer ®

16. Group Photograph, Indo-German Strategic Industry Networking Meet

2nd International Conference on Industry 4.0 and Advanced Manufacturing (I-4AM)
10th January 2022
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Transformative Innovation Policy (TIP) Conference 2022
19th January 2022
TIP Conference 2022 was held to mobilise the Power of Innovation to address the Societal and Environmental Challenges of modern times.

CEO Roundtable and Discovery Workshop with NASSCOM
Feb 24th , Feb 28th and Mar 1st, 2022
CEO Roundtable with NASSCOM on setting up Innovation Supercluster on Research & Innovation. It was followed by a Discovery Workshop with CTOs of NASSCOM's industry member organizations.

IEEMA introduces Fraunhofer as Collaboration Partner
25th February 2022
IEEMA had completed 75 years on Feb 25th, 2022 and introduced Fraunhofer as its collaboration partner.

Women in Tech: Charging New Frontiers, Breaking Gender Stereotypes
7th March 2022
To mark Women's Day, Women in Tech: Charging New Frontiers, Breaking Gender Stereotypes event was held on March 7, 2022, at the FICCI Federation House, New Delhi.

Visit of Dr. Markus Wolperdinger, Director, Fraunhofer IGB to India
1st-5th April 2022
Fraunhofer Office India coordinated the visit of Dr. Markus Wolperdinger, Director, Fraunhofer IGB to India on his interest to intensify the cooperation between Fraunhofer IGB and Indian companies.

Visit of Mr. Marc Beckett, Project Coordinator "AQUA-Hub", Fraunhofer IGB to India
4th - 6th April 2022
Mr. Marc Beckett, Project Coordinator, AQUA-Hub, visited the cities of Solapur (Maharashtra) and Coimbatore (Tamil Nadu) from April 4th - 6th 2022 and met with important stakeholders from municipal administration to conduct city analysis for setting up a smart water monitoring system

Industry meeting at Noyyal Life Centre
6th April 2022
Fraunhofer Office India and Siruthuli jointly organized a meeting with the stakeholders, majorly from industry and CSR sponsors, to present the project and create an appropriate framework with industry participation for successful implementation of AQUA-Hub in Coimbatore.

Visit of Morgenstadt: Global Initiative (M:GI) project team to Kochi
6th-7th April 2022
A delegation of experts from Fraunhofer IGB, IBP and IAO, University of Stuttgart and National Institute of Urban Affairs (NIUA) visited Kochi on April 6th and 7th 2022

Fireside Chat - SME Innovation and Technology Cooperation between India and Germany
26th April 2022
Fraunhofer Office India organized a Fireside Chat on "SME Innovation and Technology Cooperation between India and Germany", jointly with DWIH New Delhi on 26th April 2022.

India Energy Storage Week (IESW) – Conference & Expo
2nd May 2022
The India Energy Storage Week (IESW) conference and Expo, organized by the India Energy Storage Alliance (IESA) was held in Delhi on 2nd May 2022.

Signing of Joint Declaration of Intent (JDI) between Fraunhofer IGB and IIT Jodhpur
2nd May 2022
The signing of Joint Declaration of Intent (JDI) between Fraunhofer IGB and IIT Jodhpur was held during the 6th Indo-German Intergovernmental Consultations held in Berlin on 2nd May 2022.

FOCUS AREAS

PACKAGING & RECYCLING
AGRICULTURE
ENERGY & SUSTAINABLE DEVELOPMENT
SMART CITIES & INFRASTRUCTURE
WATER & WASTE MANAGEMENT

The Flagship event of the Fraunhofer – Fraunhofer Innovation and Technology Platform (FIT), held once in every two years focuses on different thematic fields and showcases Fraunhofer's cutting edge technologies, innovations and futuristic solutions, and is typically attended by more than 200 delegates from India and abroad. It is conceptualised to draw attention to the topics of relevance in the field of research and innovation, engage and in constructive dialogue with Indian Industry, Government and Research Institutes to find solutions for challenges in these areas. The 6th FIT Platform will focus on Circular Economy across Packaging & Recycling, Agriculture, Energy & Sustainable Development, Smart Cities & Infrastructure, Water & Waste Management, and catalyse collaboration in this very important field between India and Germany.

Visit of Mr. Gerhard Stryi-Hipp, Energy Expert, Morgenstadt: Global Initiative (M:GI) project team to Kochi
22nd – 23rd May 2022

Mr. Gerhard Stryi-Hipp from Fraunhofer ISE visited Kochi to conduct on-site assessment to implement the pilot demonstrator that will include sustainable technologies in wastewater management, renewable energy infrastructure installation and development of climate smart buildings.

India Global Innovations Connect (IGIC)- Fraunhofer as the supporting partner
2nd-3rd June 2022

Fraunhofer was the supporting partner at the India Global Innovations Connect (IGIC) event that was held between 2nd-3rd June 2022 in Bangalore.

Fraunhofer Office India and CSIR, DSIR, Govt. of India jointly organize a tech dialogue
15th June 2022

Fraunhofer Office India and Council of Scientific and Industrial Research (CSIR), Department of Scientific and Industrial Research (DSIR), Govt. of India jointly organized a tech dialogue on "Sustainable Building Materials – Way to Net Zero Emissions" on June 15, 2022

SME Technology and Cooperation Stakeholder dialogue in New Delhi
23rd June 2022

The Indo-German Stakeholder Workshop was jointly organized by DWIH New Delhi and Fraunhofer Office India simultaneously in Germany and India.

Visit of Dr. Neeraj Mittal, Principal Secretary of Dept. of Information Technology, Govt. of Tamil Nadu to Fraunhofer IGB and Fraunhofer IFAM
23rd-24th June 2022

Dr. Neeraj Mittal visited Fraunhofer IGB and IFAM to discuss and explore collaboration in Circular economy, with focus on Water and waste management, Li-ion Battery Recycling.

Fraunhofer India Day 2022
7th October 2022

The main objective of Fraunhofer India Day 2022 was to share the experiences of working in the Indian market, and deliberate on the partnerships with Industry, Government and Academia that would further help strengthen Fraunhofer's presence in India.

World Hydrogen Summit 2022
16th-17th October 2022

The World Hydrogen Energy Summit 2022 was held at the Federation of Indian Chambers of Commerce & Industry (FICCI), New Delhi. The conference was attended national and international delegates. Prof. Dr. Christopher Hebling, Fraunhofer ISE was a key speaker under the session, 'Hydrogen Towards Net Zero Pathway." Prof. Dr. Hebling was also awarded the prestigious Global Hydrogen Award, an international award for outstanding scientific research and technological development in hydrogen.

Intersolar India
7th-9th December 2022

Intersolar is the world's leading exhibition & conference series for the solar industry. As part of this event series, Intersolar India in Gujarat is India's most pioneering exhibition and conference for India's solar industry. It takes place annually and has a focus on the areas of photovoltaics, PV production and solar thermal technologies. Since 2019, Intersolar India is held under the umbrella of the smarter E India – India's innovation hub for the new energy world.

ALUCAST 2022
1st -3rd December 2022

ALUCAST 2022 will be held from 1-3 Dec 2022 in Chennai. Fraunhofer will the Knowledge Partner to ALUCAST 2022. As a Knowledge Partner, Fraunhofer will;

- Coordinate participation of one of the senior experts as a speaker in the conference on "Green & Smart Die Casting Solutions for Sustainability" Expert Name: Mr. Franz-Josef Wöstmann, Head of the Foundry Technology and Lightweight Construction department at the Fraunhofer IFAM.
- Support in inviting Die Casting and the Allied Industry representatives from Germany to the conference.
- Conduct and moderate a roundtable with Aluminium Caster's Association members in India to showcase new technologies and domain knowledge to create a viable research and innovation ecosystem for sustainable growth and development of the Indian casting Industry.

BusinessLine

Science and Technology

How sugar plants can fly airplanes

M Ramesh | Updated On: Feb 13, 2022

Sweet exchange: Sugar plants that burn bagasse for energy can produce sustainable aviation fuel through co-electrolysis | Photo Credit: MOORTHY RV

Co-electrolysis, an age-old technology, promises to eat up carbon dioxide and give aviation fuel in return

When electrolysis is here, can co-electrolysis be far behind? Pretty soon, sugar factories in India could be employing co-electrolysis to produce sustainable aviation fuel (SAF). The government of India has been apprised of this possibility and is reported to be warm to it.

A Pune-based company, H2e Power System, has been trying to promote SAF production through co-electrolysis. If its plans work out, a few sugar plants in Maharashtra, or an organisation like the Vasantdada Sugar Institute, Pune, could put up plants to produce SAF, for which there is a growing demand.

H2e Power has been producing solid oxide fuel cells (SOFC) for nearly a decade, a technology it developed in collaboration with the Fraunhofer Institute of Germany and holds the patents. An SOEC, which produces hydrogen from electricity, is the inverse of an SOFC, which produces electricity from hydrogen.

India has about 3.3 GW of co-generation plants and the Ministry of New and Renewable Energy estimates the co-gen potential in India's 550-odd sugar mills at about 14 GW.

UNITRACC.com

AQUA-Hub - Fraunhofer IGB Supports Market Development in India for Water Technologies "Made in Germany"

Apr 01, 2022

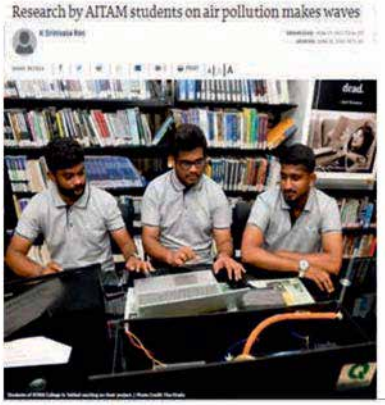
India's cities are growing rapidly and need an efficient infrastructure for supplying water and disposing of wastewater. Many German companies offer innovative solutions in this area, but often struggle to find access to the Indian market. Thanks to its extensive experience with projects in India, the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB can help to bridge the gap between demand and supply. To this end, the institute is now setting up the innovation network "AQUA-Hub" to mediate between German water technology suppliers and the Indian market.

In terms of population, India is the second largest country in the world after China. Continuous population growth and rapidly increasing urbanization pose major challenges across the country. One of these is the development of an effective and resilient infrastructure to supply the population with drinking water and to manage wastewater as sustainably as possible. Corresponding know-how is therefore in great demand.

At the same time, German companies and research institutions have precisely this ...logies and solutions. However, market ... local presence expected by business partners

THE HINDU

Research by AITAM students on air pollution makes waves



Under Digital Innovation Hub for Photonics Programme, the three students have been invited to conduct research for six months at Fraunhofer-IOF Research Institute located at Jena City in Germany. AITAM college director V.V. Nageswara Rao and placement officer M.N.V.S.S. Kumar felicitated the students for inspiring many youngsters with their project. Speaking to *The Hindu*, Dr. Nageswara Rao said that the college management was encouraging students to concentrate on research and innovation from the first year itself by providing all the facilities at the incubation centre.

The students said that their project won many awards in the competitions conducted by various institutions including US Consulate-Kolkata, BITS-Pilani, and LIGENTEC-SA of Switzerland.

"Air pollution is a huge problem for India as well as other developing countries worldwide. Reduction of emissions in a systematic manner will improve the quality of life for people living close to industries," Mr. Sandeep said.

pv magazine

The Hydrogen Stream: New tech to convert hydrogen into methanol for transportation

China presented on Mar. 23 its first long-term plan for hydrogen, targeting production of green hydrogen between 100,000 and 200,000 tonnes per year by 2025, while India and Japan have agreed to expand the scope of their energy collaboration to cover solar power, clean hydrogen, electric vehicles, and battery storage. Furthermore, French gas giant Air Liquide said it want to increase research investments in hydrogen mobility and heavy-duty mobility and German electrolyzer manufacturer Sunfire raised a total of €86 million to expand its manufacturing capacity.

MARCH 25, 2022 SERGIO MATALUCCI

Researchers at the German research institute Fraunhofer IMM are developing methanol reformers that can overcome challenges like catalyst attrition and space demand. The reformers reportedly need around 17% of the space that a comparable performance class conventional reformer would require. "We are opting for catalyst coatings containing precious metals similar to those used in automotive catalytic converters, because there is no attrition with these coatings," commented Gunther Kolb, Deputy Institute Director and Division Director at Fraunhofer IMM. "Less catalyst material is required as a result. Because our catalyst materials also have a higher activity, the amount of catalyst required is reduced even further, and consequently the costs." In the press release published earlier this month, Fraunhofer IMM said that its catalyst does not produce by-products such as carbon monoxide when operated at partial load. The idea behind, as explained by Fraunhofer IMM, is that hydrogen should be converted into methanol for transportation. The methanol should then be converted back into hydrogen and carbon dioxide for final consumption.