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FOREWORD

New Technologies for a Better Future

Dear Readers,

In 2018, it will be 10 years since I initiated the journey of Fraunhofer in India, and 5 years since we inaugurated our Indian office in Bangalore, housing an experience theatre, which showcases some of our technologies, as well as the Fraunhofer Innovation and Technology Academy which brings Fraunhofer experts from various Institutes to connect with our clients and partners. While we have been active in India for several years, this augmentation of our visibility has indeed resulted in highlighting our competencies and unique positioning across industry, academia and government.

2017 was a very exciting year for us. We conceptualised and closed on several strategic initiatives across various Industry domains. The most important being our work in Smart Cities, in support of the Government of India's Smart Cities Mission. Fraunhofer will be working with Coimbatore and Kochi to set up Smart City Innovation Labs, and a Water Competence Network, which are expected to kick off in the 1st quarter of 2018. While we would be setting up a Water Competence Network in Coimbatore and focussing on Mobility issues together with the Smart City Mission in Coimbatore, in Kochi we would work closely with the Kochi Smart City Mission to develop solutions for Mobility and ICT initiatives. The Lab will bring together multiple stakeholders and leverage the complementary strengths. Another key activity, which we hugely value, is our cooperation with the Department of Heavy Industries, Government of India. The MoU that was signed in the presence of Chancellor Dr Angela Merkel and Prime Minister Narendra Modi aims to help the Indian manufacturing industry to improve its innovation and R&D capability. With the active leadership of the DHI, Fraunhofer is working with some of the leading PSUs and well as engaging in industry-academia partnerships in Smart Manufacturing.

Electro Mobility is another area where Fraunhofer has some major innovative technology solutions. Here too, we are cooperating with some of the leading companies in India to develop and implement exciting solutions. An important development here is that Fraunhofer is now an associate member of CharIN, the leading association for charging infrastructure, and will support CharIN in its activities in India. In the field of Renewable Energy, we have been working very closely with many industries as well as organisations. The International Solar Alliance has expressed interest for Fraunhofer to be their Technology Partner and we are very excited about this relationship. Of course, there has also been a surge in contracts received from Industry for various projects, which makes it a very fulfilling year for us.

2018 promises to continue this trend, with the kick-start of many of these partnerships and the augmentation of our existing portfolio. This edition of our Newsletter, while looking back on the year that it was, also features Technologies for the Future in the key areas of focus. Fraunhofer is constantly pushing the boundaries of applied research, bringing breakthrough technologies to the market, faster, better and more efficient. This will give you a glimpse into the world of the future, a world where technology will enrich our lives, and find solutions to our everyday problems. We thoroughly enjoyed putting this together and I hope you too will love reading it.

As always, we look eagerly forward to your feedback and contact.

Happy Reading!

Anandi Iyer
Director, Fraunhofer Office India

India and Germany: A Strategic and Global Partnership

An interview with **German Ambassador to India H.E. Dr. Martin Ney**

1. What are they key areas of cooperation between India and Germany at present?

Indo-German relations are of great significance to the German Government. Let me tell you why: Today we are witnessing dramatic global developments that are unveiling at a breathtaking pace. These developments hold great promise and, at the same time, confront us with formidable challenges.

To seize new opportunities together, and to jointly address global challenges such as financial instabilities, climate change, energy security and health, Germany and India forged a Strategic and Global Partnership in the year 2000.

Building on this strong foundation, the five German Missions in India are working to deepen the dynamic Indo-German partnership. Our key areas of cooperation are business, trade, agriculture, energy, environment, sustainable development, higher education, vocational training, science and technology. To realise the full potential of our partnership we engage with the government at union and state level, the business community, research institutions, civil society and non-governmental organisations.

My experience, from a number of joint projects with Fraunhofer, is that the work of Fraunhofer is highly appreciated by our Indian partners. I see Fraunhofer as an important technology partner for India and an important pillar of our bilateral relations.

- H.E. Dr. Martin Ney

2. What is the outlook for the near future?

India is a country on the move - gaining weight with great strides in the international community. The German Government is enormously interested in supporting India on this journey. The same applies to the German business community. We truly believe that Germany is an ideal partner for India – having the expertise to support some of India's key initiatives such as "Make in India", "Skill India" and "Smart Cities". Germany wants to assist India in realizing its full potential and is offering a full-scale partnership. We already have very good and very close relations. However, the potential is far from being exhausted. We at the German Embassy are constantly working to deepen our cooperation in existing areas and to open up new areas of cooperation.

3. How does Germany see Innovation and R&D collaboration with India?

During his last visit to Germany in 2017, Prime Minister Modi said: "India and Germany are made for each other". This applies in particular to collaboration in research and innovation. The beginnings date back to the 1950s, when Germany supported the development of the IIT Madras. For us, India is a strategic partner in scientific and technological cooperation. This is why we have founded a joint institution that is unique for us: The Indo-German Science and Technology Centre (IGSTC), which finances German-Indian applied research projects. A call for proposals on the topic of "Advanced Manufacturing" is currently running.

In addition, there are numerous joint funding programmes for Indo-German research projects. Moreover, Germany offers many different scholarship and fellowship programmes for Indian students and scientists. One challenge is to inspire more German scientific organizations and researchers to work with India. We therefore view all initiatives aimed at internationalizing the Indian scientific landscape with great goodwill, as this will make India more attractive for German scientists.

4. Your view of Fraunhofer's contribution to the relationship.

Fraunhofer Society is one of Germany's leading research organizations. Moreover, Fraunhofer is also one the world's most innovative research organizations. I am therefore glad, that Fraunhofer has such a strong presence in India, encompassing production technologies, renewable energy, smart cities, smart materials, electronics, Industry 4.0 and skill building.

Future of Production: Industry 4.0

Source: Fraunhofer Institute for Manufacturing Engineering and Automation IPA

Products, such as machines and automobiles, form the core of Indian industry. In the future, their design and production will become increasingly complex in order to satisfy global demands concerning sustainability, personalization and regionalization, as well as stay abreast of international competition.

This development can only be leapfrogged through the use of so-called cyber-physical systems. These are "intelligent" machines, tools, components or even orders, which communicate with each another via the Internet in realtime. They use sensors to collect physical data, such as production, logistics, engineering, coordination and management processes, and influence physical operations with the aid of actuators as well as Internet services.

They are also linked to one another via digital networks and utilize internationally-available data and services. They have multimodal man-machine interfaces enabling the use of innovative functions, services and features. Decentralized, autonomic systems are key to maximizing productivity in this environment. The race to develop the next generation of manufacturing systems has started and it can only be won by integrating Industry 4.0 into existing systems.

Key drivers of Industry 4.0

- Efficiency of resources: While we have confronted the challenge of improving productivity based on optimising staff costs and machine utilisation over the past century, in the future we shall deal with optimising costs in relation to materials and energy. Industry 4.0 brings with it new approaches for creating affluence on a global scale. Germany will play a major role in this, because our expertise and technology will influence the factories of this world more than any other country. The effective and efficient use of materials and energy will decide the competitive position.

- Competitive ability: Variety is necessary is to adequately confront the level of complexity. Managing complexity will become a decisive competitive factor and forms one of the core proficiencies of elite companies. The approaches will differ according to product lifecycle, market and technology. A wide-ranging portfolio, which is developed through a selection process, may also represent a practical strategy. Individual products based on a modular system are also an option. Production is to be structured on the basis of complexity drivers and production techniques will be standardized by technology platforms.

1. Image Courtesy: Fraunhofer IPA

- Profitability: The market ultimately decides whether or not a company makes a profit.

Market criteria will substantially change, as will the ways in which we consume and therefore also the design of our supply chains. This means that the lifecycle costs of all influencing factors (environmental aspects, process costs, risks) must be the central focus of manufacturers. The market will demand that all solutions are sustainable in future. Sustainability has to be analysed and assessed to ascertain true cost. These are to be controlled in real time based on actual costs.

- Robustness and flexibility: The optimisation of transparency along the value chain supports companies in the holistic planning and realisation of flexibility and adaptability. In this regard, virtual reality can play a supportive role similar to that of improved use of business software. The analysis and rating of successful planning strategies and adaptive software facilitate soft factory structure, in which adaptability can be quickly achieved at low investment costs.

- Security: The introduction and operation of IT systems designed to optimise factory planning and operations have not yet made great progress. With the help of "Virtual Fort Knox", a federal, secure cloud-based platform for distributed service-oriented applications, information from factory planning and operations can be prepared and then ultimately networked in a task-oriented manner, before finally being assessed. At the same time, the Virtual Fort Knox approach reduces costs for companies.

Key advantages

In nearly all areas of production, especially in indirect areas, Fraunhofer IPA sees major potentials to cut costs and save on resources. A few examples are listed below:

- Inventory costs cut by 30 to 40 percent due to the availability of realtime information, enabling security stocks to be minimized
- Optimized manufacturing costs through process control loops based on realtime information. This improves overall machine effectiveness.
- Staffing costs cut by 10 to 20 percent through optimized, flexible implementation of human resources
- Lower logistics costs through higher levels of automation.
- Lower quality costs due to availability of realtime quality data and ability to set up realtime control loops.

Service offerings

The department combines sector-specific business expertise with special technical know-how to provide a range of services conceived specially for implementation in your company. As an independent research institute, within the context of Industry 4.0 Fraunhofer IPA has developed numerous solutions and offers a wide range of services. Some of these are listed below:

2. Image Courtesy: Fraunhofer IPA

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Fraunhofer lighthouse project: E³ Production

With its lead project E³-Production, the Fraunhofer-Gesellschaft is striving to improve resource efficiency. This demands a paradigm shift from "maximum profit with minimal capital outlay" to production with "maximum added value and minimal resource consumption".

The aim of the project is to align the production process, factory and man in an optimum way. An E³ factory is one that manufactures goods using energy and resources efficiently, integrates man into the production process and has zero emissions. In order to achieve the project aim, all future production processes have to be capable of producing the same or higher yield but with the use of less energy and resources. At the same time, processes have to be both assessable and plannable. An E³ factory is realized by optimally planning and controlling material, energy and information flows.

Major outcomes of the project:

Efficient – zero emissions – human integration

- Safeguard and reinforce Germany's pioneering role and strength in manufacturing engineering
- Maximum added value from scarce and ever-more expensive energy and raw materials
- Full use of materials recycled in a closed loop economy

Alliance/ Project partners/ sponsors

Project partners of the leading project E³:

- Fraunhofer Institute for Production Technology IPT
- Fraunhofer Institute for Machine Tools and Forming Technology IWU
- Fraunhofer Institute for Building Physics IBP
- Fraunhofer Institute for Applied Information Technology FIT
- Fraunhofer Institute for Chemical Technology ICT
- Fraunhofer Institute for Factory Operation and Automation IFF
- Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB
- Fraunhofer Institute for Laser Technology ILT
- Fraunhofer Institute for Material Flow and Logistics IML
- Fraunhofer Institute for Production Systems and Design Technology IPK
- Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT
- Fraunhofer-Gesellschaft

India Experience

In India Fraunhofer is working very closely with the Department of Heavy Industry, Government of India to support the SAMARTH Udyog Bharat 4.0 - an initiative, in developing centres of excellence for Industry 4.0 in India.

A Roadmap for cooperation between India and Germany has recently been brought out by Fraunhofer in collaboration with the Bertelsmann Stiftung, which looks at the key strengths of both countries, and suggests an action plan for fastracking the implementation of Industry 4.0 in India, and also sharing the best practices.

This document is available on www.fraunhofer.in

3. Image Courtesy: Fraunhofer IPA
4. Image Courtesy: Fraunhofer IML

Future of Mobility: Electric

Source : Fraunhofer Institute for Transportation and Infrastructure Systems IVI

The combustion engine has been our main source of mobility for more than a century. In the meantime climate change and the constantly growing world population are placing new demands on mobility. Today cars, trucks, motorcycles, etc. are already responsible for approximately one fourth of the greenhouse gases emitted in Europe. What's more, noise, respirable dust and exhaust gas are a burden on the population at large. However, not so with electric cars, which are quiet, emission-free and which reduce dependency on petroleum imports. Another advantage: If these cars are powered by electricity from renewable sources, they are much more environmentally sound than gasoline or diesel-powered vehicles.

A way forward…

Future Mobility concepts for public transport

Fraunhofer Institute for Transportation and Infrastructure Systems IVI introduces the world's longest bus: AutoTram – Extra Grand

The AutoTram® Extra Grand – currently the longest and one of the most innovative busses in the world – combines the advantages of conventional trams with those of buses. It has a passenger capacity of over 250, can be driven fully electrically over a longer distance, is flexibly operable on diverse routes, and, perhaps most importantly, the costs for acquisition and operating are only half as high as those of trams.

Battery Research at Fraunhofer

Fraunhofer is active in every field of research surrounding battery technology

The researchers of the Fraunhofer-Gesellschaft are experts in every field, from the development of innovative materials and the optimal construction of battery cells, through efficient production methods, to sustainable energy storage. The Fraunhofer Battery Alliance involves 19 institutes. Their goal is to ensure the ongoing development of existing materials and technologies and to provide industry with innovative, practical solutions.

However, it's not about spectacular new inventions or scientific break-throughs. This is not expected, given the current state of the science. World-wide, experts expect that in the next five years, it will be possible to make incremental improvements in the existing materials, construction and production of rechargeable batteries. No one is expecting to make a spectacular break-through and develop a "super battery".

Efficient materials, short charging times

The most urgent priority is the incremental improvement and optimization of battery technology. To achieve this, researchers are experimenting with new materials and new combinations of existing materials, for example, sodium-sulfur or lithium-sulfur batteries. These raw materials are readily available and inexpensive. These issues are being looked into

1. Implementation of AutoTram® Extra Grand for trial runs in Germany, Fraunhofer IVI
Image Courtesy: Fraunhofer IVI

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primarily by the Fraunhofer Institute for Material and Beam Technology IWS in Dresden, the Fraunhofer Institute for Chemical Technology ICT in Pfinztal and the Fraunhofer Institute for Silicon Technology ISIT in Itzehoe.

Experts have high hopes for metal-air batteries. Typical batteries produce electricity based on the electrochemical reaction of two different materials, such as nickel oxide hydroxide and cadmium. In metal-air models, only metals such as lithium or zinc are needed. The reactant oxygen is derived from the surrounding air using an electrode. This leads to increases in storage density. In particular, lithium-air batteries are showing great potential. The Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM in Bremen is working in this area. In everyday life, the charging time for batteries remains a problem. Petrol-powered cars can be refueled within minutes, whereas the current state of technology means that a battery-powered car can take hours to recharge.

Cell production

Manufacturing processes are also a priority. Here, the focus is on efficient, ecological, inexpensive battery production. The Fraunhofer Institute for Silicon Technology ISIT, for Ceramic Technologies and Systems IKTS, for Material and Beam Technology IWS as well as for Manufacturing Engineering and Automation IPA are all committed to this field. The IPA is working on the issue of reducing production costs. In the "LoCoTroP" project, together with its partners, the Institute is working on a dry-coating process for battery electrodes. This makes energy efficient production possible at significantly reduced costs, compared to solvent-based processes.

The IKTS is making use of its expertise in ceramics to optimize the preparation of active materials and separator components and to pursue the continued processing of the materials into battery electrodes. The ISIT is conducting research into flexible production processes which, among other things, allow lithium cells to be tailor-made for a variety of uses. The institute possesses an "electrochemical system construction kit"; these components can be assembled as needed. As part of its "DryLIZ" research project sponsored by the BMBF (Bundesministerium für Bildung und Forschung: Federal Ministry of Education and Research), the IWS was able to significantly reduce both the processing time for electrode assembly and the processing costs.

Safety tests for new battery types

Safety is a central issue. Highly compressed, complex batteries can react in treacherous ways under certain circumstances. A small defect can go unnoticed for a long time, but can suddenly result in fire. This means that comprehensive safety tests are a mandatory part of the program. The Fraunhofer Institute for Chemical Technology ICT, the Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut EMI, and the Fraunhofer Institute for Solar Energy

One feature of special importance is the excellent maneuverability of the double-articulated, over 30 m-long vehicle. Due to its novel joint and gangway systems in combination with an electronic multi-axle steering system, it is almost swept path-free in curves, both in forward and in reverse drive. With its turning circle of 12.5 meters, which is extremely small considering its length, the AutoTram® Extra Grand meets the registration criteria for road vehicles in public transport. Due to its high passenger capacity, comparably low costs and high operational flexibility, the AutoTram® Extra Grand is especially well-suited for urban areas and mega cities with a fast-growing demand for transportation.

2. Image Courtesy: Fraunhofer IVI

Systems ISE are all working on battery safety. Most importantly of all, in order to eliminate every risk ahead of time, new battery types and concepts must be tested before they can be brought to market.

Crash tests show how batteries, such as the battery of an electric car, react in extreme situations. Batteries are hit, buckled, pulled, hit with pointed, sharp and blunt instruments and subjected to extreme temperatures. Thus researchers can analyze what effects the damage has on the battery and whether safety is negatively impacted as a result. This means that the construction quality of the batteries can be improved. The combination of materials used is also subject to safety tests, as in isolated cases it is possible for poisonous gases to be emitted. Battery management is an undervalued subject. The aim is to develop a system able to provide exact information about battery charge levels at any time, and able to predict how much longer the battery will last.

Batteries for stationary power supplies

Energy storage is not only important for electric cars. In the future, stationary facilities such as emergency power generators in hospitals or in private homes will run on batteries. For example, researchers at the Fraunhofer ICT are developing redox-flow batteries. With these batteries, energy is stored in liquid form in external tanks. The power converters and the electronics are separated from one another. This allows for the battery performance needed to be scaled at any time to nearly any level. While batteries for mobile devices or cars are highly dependent on weight and size, these factors are not nearly as important for stationary storage.

Inductive charging: Charging on the go

In the future, it will be possible to charge cars while they are moving: researchers at the Fraunhofer Institutes for Manufacturing Technology and Advanced Materials IFAM and for Transportation and Infrastructure Systems IVI have constructed a 25-meter-long test route along which coils have been set into the road. The project was supported by the German Federal Ministry of Transport and Digital Infrastructure and two further project partners. It was a success: the FreccO demonstrator, a sports car converted into an electric vehicle, managed to travel the strip at a moderate speed while simultaneously charging its battery. When it's pouring rain, a driver who has to connect a thick, unwieldy cable between their electric car and a charge spot is sure to get soaked to the skin. But sometimes there's no alternative – the battery is empty. Using wireless inductive systems to charge the car is much more convenient. This involves transmitting energy through the air, or, more precisely, through a time-varying magnetic field. Electric cars have only a limited range.

In the future, a wireless charging system will allow electric cars not only to charge their batteries, but also to feed energy back into the power grid, helping to stabilize it. The cost-

3. Coil system for the inductive charging of electric cars, which is built into the road.
Image Courtesy: Fraunhofer IWES

effective charging system achieves high levels of efficiency across the whole power range, from 400 watts to 3.6 kilowatts, while the car and the charging coil can be up to 20 centimeters apart.

Alliance/ Partnering Institutes for Electro Mobility

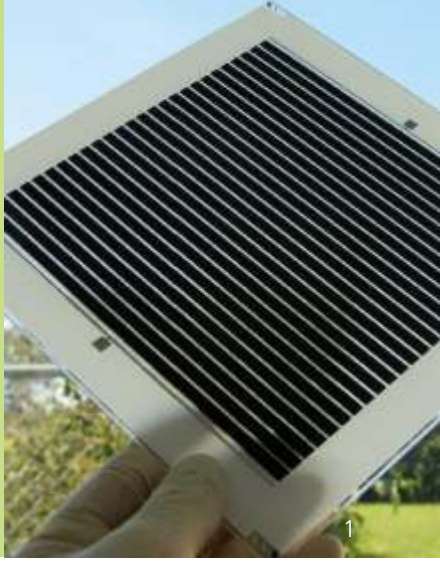
Fraunhofer Institute for Chemical Technology ICT
Fraunhofer Institute for Digital Media Technology IDMT
Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM
Fraunhofer Institute for Integrated Circuits IIS
Fraunhofer Institute for Integrated Systems and Device Technology IISB
Fraunhofer Institute for Laser Technology ILT
Fraunhofer Institute for Manufacturing Engineering and Automation IPA
Fraunhofer Institute for Production Technology IPT
Fraunhofer Institute for Solar Energy Systems ISE
Fraunhofer Institute for Silicon Technology ISIT
Fraunhofer Institute for Transportation and Infrastructure Systems IVI
Fraunhofer Institute for Wind Energy Systems IWES
Fraunhofer Institute for Mechanics of Materials IWM
Fraunhofer Institute for Machine Tools and Forming Technology IWU
Fraunhofer Institute for Structural Durability and System Reliability LBF
Fraunhofer Institute for Machine Tools and Forming Technology IWU

India Experience

Fraunhofer in India has been collaborating with several public, private and government owned industries, institutions and associations as technical partner for developing strategies, roadmaps and conducting feasibility studies for implementing Electro Mobility drive to achieve the steep targeted mission visualized by the Government of India to achieve all electric vehicle by 2030.

Few of the most eminent partners consist of industry giants such as Association of State Road Transport Undertaking (ASRTU)*, Ministry of New and Renewable Energy (MNRE), Ernst and Young, SONA Group, National Thermal Power Corporation (NTPC), Tractor and Farm Equipment Limited (TAFE), Automotive Components Manufactures Association of India (ACMA) and Society of Indian Automobile Manufacturers (SIAM).

* To be confirmed



Future of Energy: Emerging Photovoltaic Technology

Source: Fraunhofer Institute for Solar Energy Systems ISE

Photovoltaics (PV) is a key cornerstone technology for the transformation of our energy system. Fraunhofer's R&D services in PV Modules and Power Plants comprise module development with respect to optimum efficiencies, reduced costs and maximum reliability as well as special applications such as building integration. From the planning phase through to continuous system operation, Fraunhofer offers its services in quality assurance of PV power plants.

Fraunhofer's research on Emerging Photovoltaic Technology encompasses dye and perovskite solar cells, organic solar cells, photon management and tandem solar cells on crystalline silicon. The aim is to evaluate optimization potentials in photovoltaics with the help of these novel technologies and to reduce the levelized cost of electricity. This includes improving the efficiency of well-established solar cells, e.g. of crystalline silicon, by improving the absorptive and reflective properties via advanced photon management.

Another approach is provided by alternative processes and materials such as dye and organic solar cells, which – although their efficiency is somewhat lower – offer clear potential for cost reduction. Fraunhofer conducts basic research on organic solar cells, particularly addressing the fundamental properties of selective contacts and their implementation with inexpensive, durable raw materials and extremely thin films. In addition, we aim to transfer promising results from the cell level to the module level with the goal of realizing cost-efficient, flexible and durable organic solar modules. Our overall aim is to cooperate with industrial partners in developing stable coating and encapsulation processes on our roll-to-roll coater which can then be used in full-scale equipment.

Perovskite solar cells also consist of very inexpensive raw materials and can be produced in low-temperature processes, similar to organic solar cells. However, the properties of the crystalline perovskite absorber layers and the high efficiency values already achieved make them more similar to crystalline inorganic solar cells. In order to realize adequate long-term stability, we draw particularly on the experience we have gained in upscaling dye solar modules based on glass configurations.

1. Screen-printed electrode for further development of perovskite solar modules
Image Courtesy: Fraunhofer ISE

Fraunhofer is developing silicon-based tandem solar cells to make better use of the solar spectrum by reducing thermalization losses. In addition to adapting the processes for the Si bottom cell and developing tunnel contacts, we are also working on new silicon nano-

crystalline materials with adjustable band gaps and III-V-based absorber materials. The two single sub-cells are combined either by growing the top cell epitaxial directly on the bottom cell, or by wafer bonding. A further focus of our work is the development of perovskite and silicon layers for highly efficient perovskite-silicon tandem solar cells. In doing so, we specifically apply our photon management concepts to ensure good current matching between the sub-cells.

In the area of photon management, we develop concepts, materials and technology to increase the efficiency of conventional photovoltaic technology by applying optical approaches. These include light-trapping structures such as diffractive gratings and scatterers, up-conversion, angular selectivity and spectral splitting. The investigated concepts are usually not restricted to a specific solar cell technology.

The Fraunhofer Institute for Solar Energy Systems ISE premiered a multi-junction solar cell made of III-V and silicon semiconductor materials. The novel solar cell converts a record 31.3 percent of sunlight into electricity.

Organic Photovoltaics (OPV) employs organic semiconductors such as polymers and oligomers to convert light into electrical energy. Due to the extremely low material consumption, no heavy metal use and low temperature processing, the environmental impact of this technology is exceptionally low and energy payback times are only a few months. Further advantages are low weight and ultimate flexibility. All materials can be coated and printed with high throughput production methods at low costs allowing solar cells designed in nearly arbitrary shapes. Moreover the absorption spectrum can be tailored so that different colours can be realized; even neutrally tinted semi-transparent windows are possible.

Due to these outstanding properties, OPV is ideally suited for novel applications in important future markets like "Internet of Things", Building-Integrated Photovoltaics and Agricultural PV. The world-wide effort in research and development has led to a dynamic evolution of the power conversion efficiency of OPV exceeding 10 % for a variety of materials.

Innovative Coating for Coloured Photovoltaic Modules

At Fraunhofer ISE we have demonstrated the feasibility of producing such a colour-giving three dimensional surface structure on large area cover glass for PV modules. The solutions inspired by nature. A phenomenon observable in the Morpho butterfly provided the starting point for our work. The fascination of the Morpho butterfly lies in its brilliant blue wing colour.

The coating consists of a dielectric material enabling high colour saturation as well as good

Agro-photovoltaics: Harvesting the Sun for Power and Produce

Agro-photovoltaics Increases the Land Use Efficiency by over 60 Percent. The idea of Agro-photovoltaics was first initiated by Prof. Adolf Goetzberger, who founded Fraunhofer ISE in 1981. Until now, land was utilised for either photovoltaics or photosynthesis, that is, to generate electricity or grow crops. Dual use of land is resource efficient, reduces competition for land and additionally opens up a new source of income for farmers. The solar modules for electricity production are installed directly above crops covering an area of one third hectare. Now the first solar harvest of power and produce has been collected on both levels.

2. APV Plant
Image Courtesy: Fraunhofer ISE

India Experience

1. MoU with Ministry of New & Renewable Energy (MNRE), Govt. Of India (and its affiliated institutes like National Institute of Solar Energy NISE, etc.)* for the cooperation in the field of Solar Energy, Hydrogen & fuel cells .

2. Technology/Research Partner with:

- The Energy and Resources Institute (TERI)
- Indian Wind Turbine Manufacturing Association (IWTMA)
- International Solar Alliance (ISA)*
- Indian Renewable Energy Development Agency (IREDA), Govt. Of India
- Strategic partnership cooperation with Ernst & Young (EY)

* To be confirmed

incident angle stability. The colour is individually adjustable. Right now the coated cover glass for coloured solar modules is still in the prototype phase. First test modules have already been manufactured. The next challenge is to optimize and scale up the production process to industrial level in cooperation with module and glass manufacturers. We are convinced that this technology not only allows wider design variations for solar modules, but also will contribute to a broader acceptance of building-integrated photovoltaics (BIPV).

Alliance/ Partnering institutes for Energy

Fraunhofer Institute of Building Physics IBP
Fraunhofer Institute for Ceramic Technologies and Systems IKTS
Fraunhofer Institute for Chemical Technology ICT
Fraunhofer Institute for Energy Economics and Energy System Technology IEE
Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT
Fraunhofer Institute for Factory Operation and Automation IFF
Fraunhofer Institute for Integrated Circuits IIS
Fraunhofer Institute for Integrated Systems and Device Technology IISB
Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB
Fraunhofer Institute for Manufacturing Engineering and Automation IPA
Microstructure of Materials and Systems IMWS
Fraunhofer Institute for Optronics, System Technologies and Image Exploitation IOSB
Fraunhofer Institute for Branch Advanced System Technology AST
Fraunhofer Institute of Silicate Research ISC
Fraunhofer Institute for Silicon Technology ISIT
Fraunhofer Institute for Solar Energy Systems ISE
Fraunhofer Institute of Systems and Innovation Research ISI
Fraunhofer Institute for Transportation and Infrastructure Systems IVI
Fraunhofer Institute for Wind Energy Systems IWES
Fraunhofer Center for Sustainable Energy Systems CSE

3. Morpho butterfly with brilliant blue wings
Image Courtesy: Fraunhofer ISE

4. Coloured Solar Test Modules
Image Courtesy: Fraunhofer ISE

Future Field of Energy System Technology

Source: Article by Prof. Dr. Clemens Hoffmann, Director, Fraunhofer Institute for Energy Economics and Energy System Technology IEE

Energy System Technology

We are convinced that a future energy supply system can be built completely on renewable energy sources. The scientific and technological tasks for research and development lie for the most part in cost reduction and the further development of different conversion technology as well as a new energy system technology with the aim of realizing reliable and stable supply systems using 100 percent renewable energy under complex technological, economic and environmental boundary conditions. Energy system technology as a discipline focusses not so much on the individual components of generation and consumption but targets the optimal mixture of components necessary for a well-functioning system as a whole. Looking at the system level, new requirements for the design and control of the individual subsystems and components may emerge.

Examples of our research activities include:

Simulations and scenarios for the energy transition

As part of studies and investigations, IEE generates renewable energy feed-in data sets. The computations are based on meteorological and hydrological conditions from different years, resulting in very detailed time series for wind, solar, geothermal, biomass, and hydro power. These can be used for assessing network expansion, the addition of storage systems, and the management of the energy economy. In addition, conventional power generation scheduling and the balancing of fluctuations due to electrical transport, storage, and energy management are modeled. Therefore, Fraunhofer IEE provides a unique simulation platform on a powerful computer cluster with high time and spatial resolution. This is coupled with software tools for load flow calculations as well as planning and analysis tools. These simulations are being used to develop scenarios to expand the scope of renewable energy, right up to a completely renewable energy supply, and for measures for the integration and harmonization of renewable and conventional electricity generation.

Increasing the wind energy use potential onshore

The use of wind energy on land will play an important role as a pillar of future energy supply systems. Germany's federal government has set clearly defined targets that shall lead to a total onshore wind energy capacity of around 60 GW by 2020.The technological development of wind turbines in recent years has led to the availability of especially high towers and large rotors. This has caused the potential of onshore wind energy use to increase significantly. Using large, modern wind energy turbines with hub heights of up to 150 meters

1. Image Courtesy: Fraunhofer IEE

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Main elements for a new holistic energy system technology include:

- the design of energy supply systems, i.e. the number, mixture and spatial distribution of different forms of generation
- the design of energy grids
- the design of control structures for generation, transmission and consumption for the system in operation
- Modelling of the environment, where the latter provides parametric input to the technical system
- Measurement technology for technical and environmental quantities
- Development of new actuators at the interfaces between the system components
- Energy storage
- Communication technology for transmission of measurement, control and economic quantities
- Micro- and macroeconomic assessment of the design for energy supply systems
- Design and analysis of market regulatory instruments used in transforming energy supply systems.

would be sufficient to meet approximately 60 percent of present German electricity needs. For such analyses exact knowledge of the wind characteristics of hilly or wooded inland regions by using high resolution measurements and models are necessary. Besides established measurement methods using wind measure masts IEE researchers are using LIDAR (laser-supported wind speed measuring) systems and developing methods for the deployment of the measurements in complex terrain. This ground-based remote measuring technology should be capable, in the long term, of replacing wind measuring masts.

Modern control systems for wind turbines

The growing height and rotor diameter of wind turbines exert an enormous increase in structural loads. Modern control systems limit and reduce both extreme loads and fatigue loads. Active load reduction through individual pitch control encompasses two different targets: the reduction of periodic excitations caused by dissymmetric airflow and the attenuation of natural oscillation through controlled generation of aerodynamic counterforces. The first target comprises the compensation of tilt and yaw moments acting on the rotor by means of individual pitch control. To do this, a small individual offset to the collective pitch angle is predetermined for each rotor blade that varies cyclically with the rotor revolutions. The second target comprises active tower vibration damping whereby pitch control is used to generate periodic aerodynamic force components in antiphase to the displacement speed at tower top.

Grid integration of wind and solar energy

The Wind Power Management System (WPMS) of Fraunhofer IEE is a system that is used both nationally and internationally to forecast the wind energy supply in the short and medium term and is being continuously further developed. In future renewable energies will frequently cover the overall energy demand. Conventional power stations will be used sparingly or shut down and renewable energy will provide system services to support stable grid operation. Fraunhofer IEE is developing tools such as online forecasting models and systems for managing power generation clusters to aid voltage and frequency control. Windfarm control systems coordinate the dynamic interplay of individual wind turbines taking into account the interactions caused by wake effects and observing numerous other criteria. This demands the use of highly developed optimization processes capable of handling multi criteria target functions.

Expansion of photovoltaics and decentralized grid integration

The requirements for safe and reliable grid operation must also be met when a high number of PV systems are integrated into the grid. Fraunhofer IEE is evaluating measures for reducing local overvoltage in distribution networks and impermissibly high loads on equipment. This

2 & 3 Image Courtesy: Fraunhofer IEE

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approach often allows capital-intensive grid expansion to be delayed or even avoided. Controllable PV systems can, for example, increase the capacity of distribution grids by making grid services available and so make an important contribution to reliable and safe grid operation. Fraunhofer IEE systematically investigate the control of photovoltaic systems and photovoltaic battery systems in grid operations. In consultation with manufacturers, grid operators, regulators, and testing institutes, new requirements for decentralized electricity generators are evaluated here.

Bioenergy on demand

Bioenergy, being a storable form of renewable energy, has a special role to play in future energy supply structures. For electricity grids in particular, it can be used as an as-needed form of energy to help balance supply and demand. Fraunhofer IEE uses a systemic approach and is making a key contribution to the integration of bioenergy into supply structures. This work covers all forms of bioenergy – from direct conversion into electricity via the combined production of heat to the production of natural gas substitutes and fuels. When designing technologies, sustainable concepts must be developed which allow bioenergy to be used with the highest possible efficiency, and utilizing its special properties. This is because biomass cannot fulfil all applications, nor cover all needs as the sole energy generation option. It is also essential that the technologies allow a seamless transition from the current fossil fuel dominated energy landscape via hybrid systems to totally renewable supply structures.

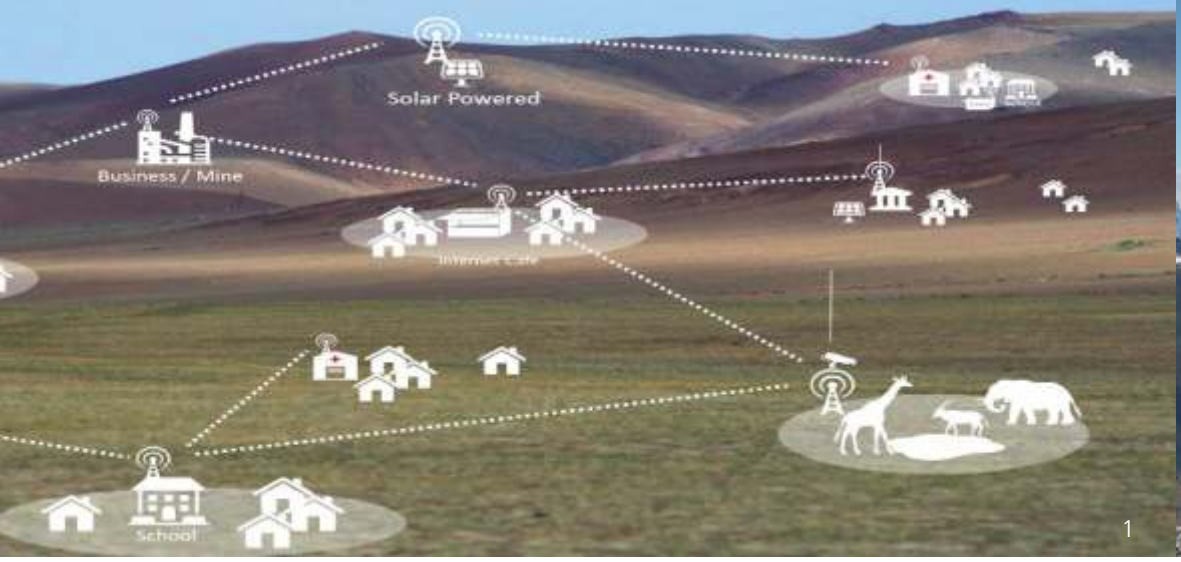
Long term storage: Connecting electricity and gas networks

For balancing over short periods, pumped-storage power stations are a good solution although their capacity in Germany is limited. They can only alleviate fluctuations over a short period. Fraunhofer IEE is researching with partners on the long term storage concept Power-to-Gas. At times when more renewable electricity is generated than can be used or transported across the network, this excess energy is used to split water into oxygen and hydrogen. Subsequently a methane-rich gas is produced in a Sabatier process from hydrogen and CO2, and this gas is equivalent to natural gas. The renewable gas also plays an important role in de-carbonizing the transport sector.

Renewable E-Mobility

E-Mobility using renewable energy sources is the future of individual transport. Fraunhofer IEE is working on advanced power supply concepts and their integration into future energy supply structures. It develops bi-directional power transfer systems for inductive charging, emulations of real batteries (virtual batteries) and strategies for efficient energy management.

4 & 5 Image Courtesy: Fraunhofer IEE



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Wireless Technologies of the Future: WiBACK - "Connecting the Unconnected"

Source: Fraunhofer WiBACK and Fraunhofer Institute for Applied Information Technology FIT

Key features that make Fraunhofer's WiBACK unique are the combination of:

- A wireless network that can span huge distances (several 100 km);
- Provisioning of carrier-grade (guaranteed) service qualities for voice and data traffic;
- Low capital expenditure (CAPEX) due to the use of commercial off-the-shelf hardware (typically IEEE 802.11 mass-market components);
- Low operational cost (OPEX) due to auto-configuration and self-management capabilities, as well as low energy consumption;
- The possibility to run most nodes in the network on solar energy due to their energy efficient hardware and software, and the integrated solar charger.

The wireless backhaul (WiBACK) technology introduces a cost-effective solution to provide broadband Internet access to rural communities – world-wide. Building upon proven protocols and mechanisms combined with self-management principles, the WiBACK technology simplifies the tasks of deploying and operating a carrier-grade wireless network, thus enabling a wide-spread deployment with minimal expert knowledge.

World-wide, rural areas often lack sufficient or affordable access to the Internet. This situation is often referred to as the 'Digital Divide' as it separates the 'unconnected' population in the rural regions from the 'connected' population in the urban areas, where people are targeting gigabit connections to the Internet for every household. This leads to unequal chances for access to education and health services as well as economic growth.

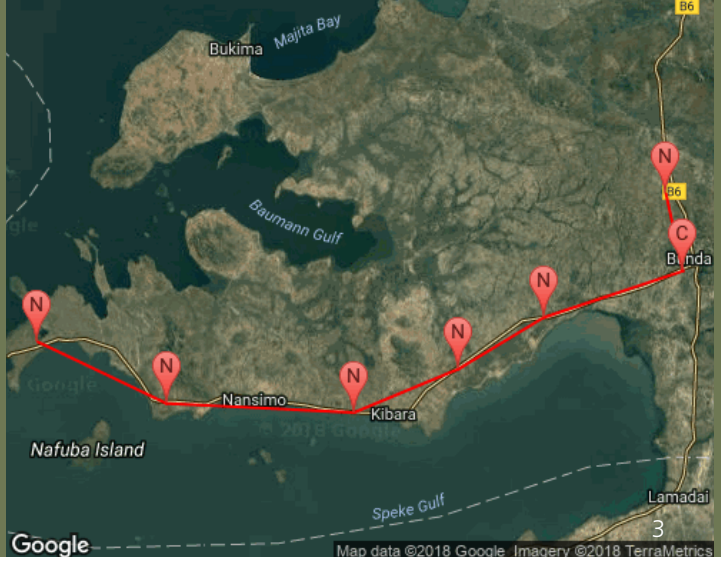
The main challenge is the high costs associated with most communication technologies (Fibre, Satellite, Long-term-evolution LTE) when operated is sparsely populated rural areas. This typically renders such scenarios as economically not feasible for commercial operators. Additional challenges for emerging regions are the lack of access to a stable power grid and the lack of skilled personnel.

For the last six years, the Network Research group at Fraunhofer FOKUS has been developing its carrier-grade broadband backhauling technology WiBACK to push broadband coverage deeper into rural areas. Now, this development continues at Fraunhofer FIT, with a strong focus on usability and ease-of-use. The key design goals follow the Global Research Alliance (GRA) theme of 'Inclusive Innovation' to develop good-quality cost-efficient technologies for mass deployments preferring sustainability over the extra few percent of performance.

Hence, the key design goals are lower procurement and especially operational costs, which can be achieved by matching energy-efficient and cost-effective hardware with a light-weight software design and a network management system following Self Organizing Networks (SON) principles, which are implemented on top of a Software Defined Networks (SDN) architecture. The WiBACK technology aims at complementing, extending or even replacing traditional operator equipment.

The self-management "Plug & Play" capabilities of the WiBACK technology are the main innovation and pose significant progress over alternative technologies. WiBACK

1. Image Courtesy: Fraunhofer FOKUS
2. Image Courtesy: Fraunhofer WiBACK



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automatically forms multi-hop networks or ring topologies in unlicensed or licensed frequency bands while supporting adaptive Traffic Engineering and Quality-of-Service (QoS) management.

With its ease of deployment, operation and maintenance, WiBACK significantly lowers the operational expense while providing a flexible, reliable and easy to manage solution, which can grow and adapt to changing demands and requirements. Consequently, WiBACK also allows to "Connect the Unconnected", thus increasing the potential customer base and narrowing the "Digital Divide".

Commercial WiBACK deployments are operated by partners in Germany, Italy and Colombia, while pilots are installed in Tanzania, Uganda as well as Germany. Depending on the scenario, these networks connect schools, agricultural information centres, governmental offices, hospitals, companies and household – all of which might otherwise have no or only limited access to the broadband Internet.

A typical scenario for WiBACK

One or multiple edge nodes connecting to a fixed and reliable network infrastructure are available. These can be provided by a commercial service provider or they can be interfaces to the existing network of an operator.

Located far from these edge nodes, multiple locations require high-quality connections to a voice or data network / the Internet. What "far" means depends on the local situation. In particular, the challenge cannot be easily solved by a simple point-to-point radio-link or by digging cables into the ground.

WiBACK provides the technology to connect infrastructure edge nodes to (many) user access points.

Examples for this deployment include temporary wireless networks for large events, fast network deployment in disaster areas, broadband Internet services for rural areas, and wireless wide-area infrastructures in emerging regions.

Implementation of WiBACK in Bunda, Tanzania:

Bunda, a rural municipality in Tanzania wanted to connect the rural areas in order to provide health, education, government and agricultural information services. A small local team is operating the self-configuring WiBACK network, which has been installed jointly with Fraunhofer researchers and DIT (Dar es Salaam Institut of Technology). While the installation of the whole network (poles, WiBACK nodes, antennas, etc.) has be funded by the UN the ongoing costs to operate the network are covered by service fees (to business) and increased tax revenue (GIZ ITAX).

The WiBACK network in Bunda is a very good example where WiBACK provides affordable connectivity to rural areas in developing and emerging countries to allow for Internet connectivity as well as other services.

3. Overview of Network in Bunda, Tanzania
Image Courtesy: Fraunhofer WiBACK

4. Image Courtesy: Fraunhofer WiBACK

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Cities of Future

Source : Fraunhofer Institute for Industrial Engineering IAO

According to the United Nations (UN), in 2030 over 60 percent of the world's population will live in cities – and the number is constantly increasing. Urbanization is a mega trend that means big challenges and big opportunities both for people and the environment. Innovative concepts for the cities of the future represent a major future market. Fraunhofer IAO understands cities as complex and holistic systems. Urban processes are becoming increasingly connected and tightly interwoven – not least due to digitization. Together with forward-looking stakeholders, Fraunhofer IAO develops system innovations that range from

- City-wide transformation processes and
- New home and work concepts to
- Solutions that addresses mobility,
- Urban governance and demographic change

The aim is to realize a sustainable, resilient city of the future designed for the benefit of the people living in it by undertaking following measures, as per the Morgenstadt (Cities of Tomorrow) approach:

Urban Crisis Management

Crisis management has to start before a crisis does. When a city is hit by a natural disaster, major incident or terrorist attack, it's often the rescue plans and infrastructure, the information and communication processes that make the difference between life and death. Effective crisis management also protects property, keeps businesses running and maintains public order. Fraunhofer IAO helps public authorities, rescue services, companies and IT providers to prepare their response to crisis situations in their city or region before they occur. This means drawing up clearly defined processes and information management, and selecting and implementing the right crisis response technologies.

Creating business areas and cooperation models for the city of future

Urbanization means big opportunities for industry. The challenge companies face is to identify and design innovations for the city of the future. Cities are lucrative places for industry and commerce: More and more people live in urban environments and are demanding new products and solutions. Sustainable construction, consumer goods, energy and security are just some of the areas in which there is a demand for innovative products and services. Fraunhofer IAO helps companies to identify viable business areas early on and support municipalities in creating smart city strategies. These are fruitful synergies bring together companies, municipalities and Fraunhofer Institutes.

Sharing models

Sharing infrastructure, resources and facilities cuts costs and gives sustainability management

a boost. In cities in particular, the service industry, manufacturing companies, the public sector and research institutions could benefit from models that allow for collaboration and cooperation. Researchers at Fraunhofer IAO develop economic and ecological sharing models for B2B and B2C. Some of the solutions are for mobile infrastructure with short-cycle usage patterns, such as tools, information technology and vehicles. Sharing immobile infrastructure such as work environments or production facilities are also devised at Fraunhofer IAO.

District Concepts: Solutions for liveable, sustainable cities

Sustainable urban development dovetails home, work and play – in other words, it combines economic appeal with a high quality of life and social sustainability. Fraunhofer IAO has access to more than 1000 examples of good practice for project developers, city planners, investors and property developers and offers cities and communities the benefit of its wide-ranging experience at the interface between technology management, sustainability strategies and communal development to ensure a high quality of life and social sustainability.

Fraunhofer IAO contributes its multifaceted experience in developing a smart city to forward-looking innovation networks. Together with partners from municipalities, industry and research, Fraunhofer IAO works to convert the latest research findings into practical applications.

Virtual Reality for planning support: More effective planning for cities, buildings and transportation concepts

Planning processes are complex, with a lot of hidden potential for errors and misunderstandings. Modern 3D visualization systems are a way to improve both communication and safety, with city planners, project developers, architects, building contractors and transportation experts all benefiting from the possibilities, which are unlocked by this sort of virtual rendering. Fraunhofer IAO possesses state-of-the-art presentation environments that enable detailed and full-scale real-time visualizations. 3D virtual spaces make it possible to

- Optimize construction processes using building information modelling
- Visualize innovative city / district concepts
- Perform architectural visualizations
- Tour virtual buildings and plan interior installations
- Simulate transport projects
- Map noise or particulate matter / pollution in cities

Virtual reality can also be used to communicate with the public and show them the plans for city development and transportation projects.

India Experience

With Coimbatore

Fraunhofer IAO has entered into a Memorandum of Understanding (MoU) with Coimbatore City Municipal Corporation (CCMC) to setup a 'Smart City Innovation Lab', which will address mobility-related challenges in Coimbatore. This Innovation Lab is funded by Kreditanstalt Für Wiederaufbau (KfW).

Fraunhofer IGB has collaborated with the City of Coimbatore to set up a 'Water Competence Centre' namely "Smart Water Future India" to address challenges pertaining to wastewater management in Coimbatore. This project is funded by The Federal Ministry of the Environment, Nature Conservation, Building and Nuclear Safety (BMUB).

With Kochi (Cochin)

Fraunhofer IAO has entered into a cooperation with Cochin Smart Missions Ltd. (CSML) to set up a 'Smart City Innovation Lab', to transform Cochin into a Smart City by developing sustainable solutions for Cochin in Smart City's perspective. This Innovation Lab is funded by The Federal Ministry of the Environment, Nature Conservation, Building and Nuclear Safety (BMUB).

Possible Innovation Projects

1.Project: Innovation District

Prague needs to create an innovation ecosystem to foster local innovation and to attract international business and skilled workforce. Innovation district project intends to bring business and research together in a specially designed space to accelerate the development of new and innovative products and services from an idea stage to a market rollout.

2.Project: Smart City Think Tank

The research landscape of Prague is scattered and collaboration with businesses is not managed in a proactive way. A Think Tank that connects local universities, local (and non-local) companies, as well as the city administration has the potential to transform existing innovation potential into tangible projects that can improve the economic basis of Prague and support a smart city development.

3.Project: Multimodal Transportation App

The multimodal transportation app helps reducing congestion and traffic within the city and incentivizes the public to use alternative transportation modes instead of motorized private transportation. The app simplifies the use of public transport and promotes more sustainable mobility behaviour through a targeted pricing system, combined with nudging and gamification elements.

Overview of Morgenstadt Assessment for City of Prague

Prague: An Overview

Today, Prague is standing at a crossroad. The city has the potential for a bright and strong future, but it has not yet defined the strategic pathways towards a successful transition. Moreover, there is no clear vision in place for the future and Prague has not quantified goals for development and progress. However, the city has recently updated the strategic plan and it is in the middle of the process of developing the new Masterplan (Metropolitan Plan). This, combined with the city's economic strength and its rich history and attractiveness for people worldwide, creates a large potential for focused, smart, and sustainable urban development. This was the reason why Prague was selected as the first winner of the Morgenstadt City Challenge in June 2014.

Prague: City Lab Process

The in-depth analysis of Prague was carried out based on the Morgenstadt assessment framework for sustainable urban development. This framework is structured into three main levels of analysis, which in sum are designed to understand the current sustainability performance of cities and result in coherent strategies and an integrated roadmap for development. A mixture of quantitative benchmarks and qualitative data analyses certifies that an objective performance profile of Prague can be generated, while at the same time respecting the individual factors of the city that make a direct comparison with other cities difficult. This leads towards an individual strategy for Prague.

Alliance/Partnering Institutes for Smart Cities

Fraunhofer Institute for Industrial Engineering IAO
Fraunhofer Institute for Building Physics IBP
Fraunhofer Institute for Open Communication Systems FOKUS
Fraunhofer Institute for Wind Energy and Energy System Technology IWES
Fraunhofer Institute for Solar Energy Systems ISE
Fraunhofer Center for International Management and Knowledge IMW
Fraunhofer Institute for Factory Operation and Automation IFF
Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB
Fraunhofer Institute for Material Flow and Logistics IML
Fraunhofer Institute for Manufacturing Engineering and Automation IPA
Fraunhofer Institute for Systems and Innovation Research ISI

Prague wins Morgenstadt City Challenge

2 PRAGUE CITY LAB PROCESS

City Team


Alanus von Radecki


Nora Fanderl


Maike Buttler


Elena Krylova


Adam Fajgrt


Klara Novakova

Benchmarking of Prague
Comparison of Indicators with Morgenstadt benchmarks

Prague Impact Factors
Identification of challenges, opportunities, barriers, and ideas for action by means of semi-structured interviews

57 Interviews with local stakeholders and experts on the most important urban factors

Profiling of Prague with the Morgenstadt Action & Response Model for sustainable urban development

Prague Roadmap
- Definition of details (costs, timeframe, funding opportunities, stakeholders, etc.) for each project
- Integration of measures, projects, and actions into a coherent roadmap
- Maximization of synergies between projects

Creation of Prague systems models based on most important impact factors

Prague Indicators
- Assessment of 106 indicators for Prague
- Pressures on the city system
- State of the city system
- Impact on the city system

Measures & Ideas for Action
- Development of 10-15 measures and ideas for action that support and accelerate smart and sustainable development of Prague
- Workshops with local stakeholders for developing the measures and initiating first projects
- Involvement of Morgenstadt Partners as experts for technologies, infrastructures, and smart city solutions

Prague Action Fields
Assessment of 83 Action Fields for smart & sustainable development of Prague

Final conference: April 6, 2016
- Presentation & handover of Roadmap
- Kick off: first projects

March April May June July August September October November April

A

B

Future of Health: BIO-NANOTECHNOLOGY APPLICATION LABORATORY (BNAL)

Source: Fraunhofer Institute for Ceramic Technologies and Systems IKTS

The Bio-Nanotechnology Application Laboratory (BNAL) in Leipzig represents a research infrastructure jointly run by Fraunhofer IZI and Fraunhofer IKTS. With this laboratory, both institutes are opening up new fields of application in biomedicine related to various nanotechnologies. State-of-the-art equipment allows biological and medical issues to be handled in an interdisciplinary manner. BNAL provides research and development services from fundamental biomedical research by process development up to the development and validation of innovative technologies and system solutions.

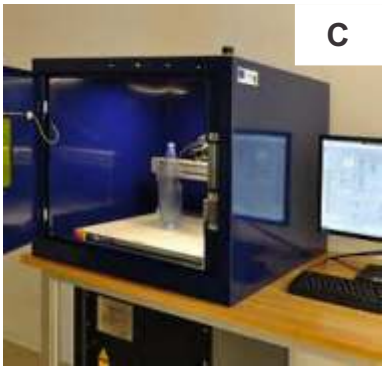
Biological and medical expertise at Fraunhofer IZI (e.g. oncology, chronic inflammatory diseases and neurodegenerative diseases) in combination with stablished analysis methods for material diagnostics at Fraunhofer IKTS enable the development of new diagnostic and therapeutic technologies and procedures.

Imaging procedures

Optical coherence tomography (A): Uses near-infrared light to depict the internal and surface structures of various materials in high resolution. Multi-acousto-scope: The combination of three microscopy techniques paves the way to innovative new examination strategies.

Cell characterization and classification

Diagnosis and mapping for cell biology studies: Non-intrusive way of delivering high-resolution, geometric information from the inside of test objects. Spectrometer for time-resolved fluorescence spectroscopy: Procedure to characterize cells based on electromagnetic radiation. Ultrasound broadband spectroscopy system: This procedure has long been used in the medical diagnosis of cell tissues, biological materials and in the analysis of fluid media. It mainly identifies acoustic and mechanical properties of substances. High-throughput flow cytometry (B): Rapid, multiplex, high-throughput screening of cells and beads in suspension.



C

Surface sterilization and modification

Electron beam dosimeter © Dose measurement of highenergy radiation (e. g. gamma or electron radiation) on even on the different positions of bent

A. Image Courtesy: Fraunhofer IZI
B. Image Courtesy: Fraunhofer IZI
C. Image Courtesy: Fraunhofer IZI

3D free-form surfaces. System for electron irradiation of surfaces (D): Sterilization of package / surfaces, inactivation of microorganisms for vaccine production or targeted adjustment of material properties by means of electron irradiation.

Nanotechnology

Droplet digital PCR system: PCR-based, absolute quantification of microbial / viral or eukaryotic DNA / RNA as well as precise detection of low genome copy numbersZetasizer: Determination of particle and molecule sizes, e. g. for characterizing recombinant proteins, micelles and nanoparticles.

Micro-spotter unit (E): Automated dosing of tiny quantities of liquid (e. g. biological or organic solutions, or solutions containing nanoparticles) on a broad range of different surfaces for the production of microarrays.

Hot-embossing system (F): Production-relevant manufacturing of nanostructured surfaces on glass and polymer surfaces.

Alliance / Partner

Fraunhofer Institute for Biomedical Engineering IBMT
Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB
Fraunhofer Institute for Marine Biotechnology and Cell Technology EMB
Fraunhofer Institute for Molecular Biology and Applied Ecology IME
Fraunhofer Institute for Toxicology and Experimental Medicine ITEM
Fraunhofer Institute for Process Engineering and Packaging IVV

D. Image Courtesy: Fraunhofer IKTS
E. Image Courtesy: Fraunhofer IZI

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Future of Food:

Source : Fraunhofer Food Chain Management Alliance FCM

Guaranteeing a reliable, healthy and affordable food supply is one of the most important issues for the future of society. Due to global climate change and ongoing industrialization, new food production solutions that are supported through the utilization of sensors and high frequency technology systems are urgently needed. Food production today extends from small, part-time farming to large-scale, modern concerns. Enhanced efficiency is still a central focus in the area of food production. The aim is to produce a growing volume of food on agricultural lands that are steadily decreasing in size. The efficient use of resources such as water, fertilizers and pesticides is important to guarantee a secure food supply. Other issues, apart from increased food production, also play an important role, namely environmental protection and consumer health. Equal consideration must be given to the needs of large-scale agricultural enterprises and the requirements of small farmers in developing countries. Fraunhofer is committed to improving the quality, reliability, packaging and nutritional health of food and products. Following are some of the recent researches conducted in the field and food technology.

1. Future of Food chain management: Food scanner

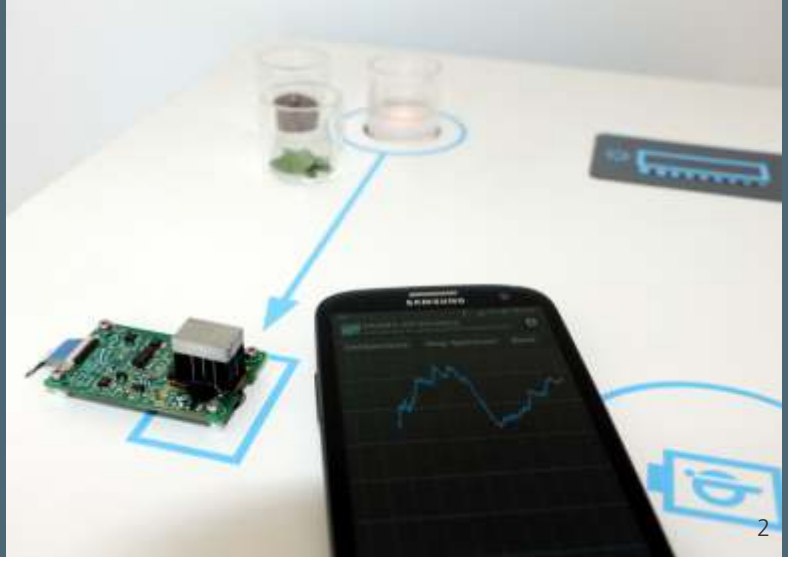
"Food scanner" is becoming a topic of common interest. The European Commission has recognized its relevance and provides funding for the development of the technologies required. For 10 years, the Fraunhofer alliance Food Chain Management has been active in the field of spectroscopy technologies for food analysis. One of its partners, Fraunhofer IPMS filed a patent for a novel device that enables not only food analysis but as well access to quantity and nutrition facts.

This new idea brings new momentum to food scanning. Here, the mobile phone will not only consider the quality of selected food items but also provide individual advice about nutrition and fitness. Besides the estimation of quality and caloric value a volume estimation using camera based 3D triangulation will provide real nutrition information. This can be correlated to user specific data (build, weight …) as well as activity data. Thereby, nutrition and consumption can be evaluated and a recommendation for the user can be given.

1.1 Extended hardware components

Comprehensive information about the composition of food such as statements regarding ripeness of fruit, freshness of vegetables or the real fat and protein concentration of meat can be estimated by spectral analysis in a non-contact and non-destructive way. The key to success is the correct wavelength band. Relevant data can be obtained with in depth information through near infrared (NIR) measurements. Organic matter provides a variety of NIR bands. Unfortunately, these bands are not accessible to silicon based camera chips, as

1. Image Courtesy: Fraunhofer FCM



these devices are limited in spectral range. Instead, appropriate NIR light sources are required in combination with NIR-sensitive spectral analyzers. Here, Fraunhofer IPMS is conducting research and IP generation for future systems.

1.2 The lab in everyone´s mobile phone

Ongoing developments aim at the integration of miniaturized spectrum analyzers into the mobile phone. This approach directly benefits from the system components of the mobile phone including power, processor, display, human interface and data access. A particular challenge is posed by the outline of the optical bench because the overall device height is limited to 4.5 mm in order to meet the specifications of mobile phone producers. New fabrication techniques and miniaturized components developed at Fraunhofer IPMS address these requirements.

1.3 More than a hardware question

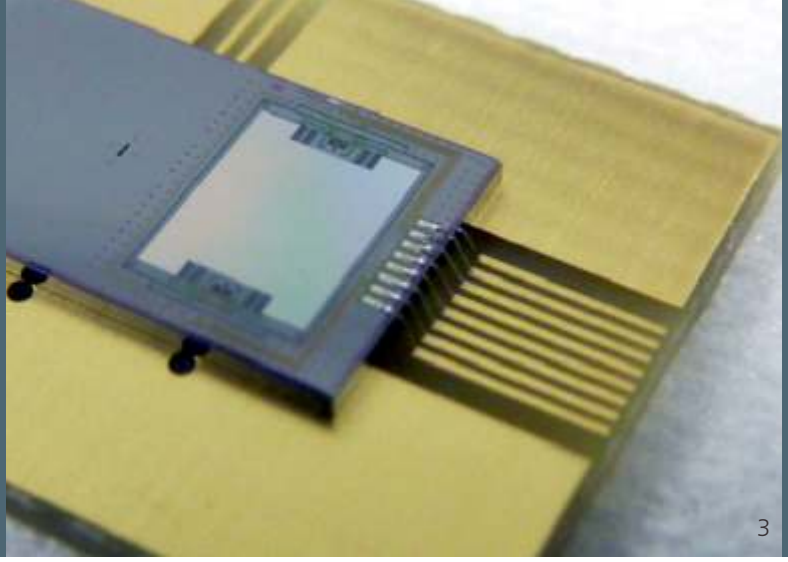
Generating suitable information from a spectral measurement requires precise algorithms for data analysis. Measurements must be performed at the right spot. System parameters need to be considered. Finally, data evaluation requires access to the appropriate reference data. The spectral fingerprint of different products may vary even if they consist of similar components. The bands correlated to fat vary for instance between beef, fish or cheese. Similar considerations apply to protein and carbs. Thus, additional information is important for the correct interpretation of spectral data. The analysis becomes a complex task requiring software based evaluation and reference data from a broad data base. This data base requires continuous updates based on validation techniques. Both tasks are in the scope of Fraunhofer Institute of Optronics, System Technologies and Image Exploitation (IOSB) in Karlsruhe.

1.4 Interdisciplinary cooperation

Besides expertise in micro systems technology, appropriate lab analysis for generating highly accurate reference data is a key for accurate data evaluation. No on-site measurement is reliable without precise knowledge of the complex matrix of food compositions. The Fraunhofer Institute for Molecular Biology and Applied Ecology (IME) in Schmallenberg is providing state of the art food analysis though its expertise in sample extraction, preparation for composition analysis and trace detection by chromatographic methods. This is a unique synergy.

In addition to statements regarding food quality aspects and nutritional facts, also food contamination might be an issue. This can be related to fungi, micro biological degradation products or to chemical substances from the environment, fertilizer or pesticides. The detection limits required here are very tough. Quick testing can only be achieved by applying sophisticated methods like fluorescence analysis or Raman spectroscopy. The Fraunhofer Institute for Reliability and Microintegration (IZM) in Berlin has a long standing experience in this field. Recent developments aim at the miniaturization and integration of such systems to

2. Image Courtesy: Fraunhofer FCM



The application is based on a near infrared spectrometer which measures the amount of water, sugar, starch, fat and protein present in the products. The system "looks" several centimeters below the outer surface of the foodstuffs – which means it can detect, for instance, whether the core of an apple is already rotting. Thin packaging film is no problem for the device as it takes measurements straight through it.But how does the device actually work? By shining a broad-bandwidth light on the item to be tested – for instance a piece of meat. Depending on the meat's composition, it will reflect different wavelengths of light in the near infrared range with different intensities. The resulting spectrum tells scientists what amounts of which substances are present in the foodstuff.

3. Image Courtesy: Fraunhofer FCM

enable a broad use of these technologies in the field.

All of these methods and expertise can be combined in a not too distant future, which makes information directly available. These synergies will make it possible to provide correlated and interlinked information to end consumers – in a quality which nowadays is only available in specialized labs. **Contact: heinrich.grueger@ipms.fraunhofer.de**

2. Future of Food: Rapid testing of food quality with near infrared

Whether fruit, meat or cheese – the quality of food is not always as consumers would like it to be. But, in future, a spectrometer will allow them to gage the quality of food before they buy it. No bigger than a sugar cube, the device is inexpensive to manufacture and could one day even be installed in smartphones. In future, all you will need to do is hold your smartphone near the product in question, activate the corresponding app, choose the food type from the menu – e.g. "pear" – and straight away the device will make a recommendation: the fructose content of the pear is high, so buy it!

2.1 Smaller than a sugar cube

The novel thing about this spectrometer is its size. With a volume of only 2.1 cc, it is 30 percent smaller than a sugar cube, and thus substantially more compact than its commercially available counterparts, which are around 350 times larger. Another advantage is that the devices are inexpensive to make and suitable for mass production. "We expect spectrometers to develop in the same way that digital cameras did," says Dr. Heinrich Grüger, who manages the relevant business unit at the Fraunhofer Institute for Photonic Microsystems IPMS in Dresden, where the system is being developed. "A camera that cost 500 euros ten years ago is far less capable than the ones you get virtually for free today in your cell phone."

3. Future of Food: SUSMILK – Green Dairy

SUSMILK wants to save 50 percent energy and 30 percent water in the European dairy industry. Before milk gets from the cow into the bottle or carton, its processing is characterized by a multitude of heating and cooling processes. Even though the infrastructures necessary for this are most often not aligned with current sustainability standards, they often are utilized in the foodstuffs industry for up to 30 years. In the EU Project SUSMILK, Fraunhofer UMSICHT and the project partners are developing components for use in existing dairy infrastructures, with the objective of savings in energy, water and CO2 emissions.

3.1 Technical "greenification" in foodstuffs production

Based on five dairies of different sizes, an overall concept of a green dairy is being developed. This encompasses the development of technical components, their installation and testing at partner dairies, as well as process simulation and eco balance sheets. The goal is not a one-

size-fits-all solution for dairies but rather an optimization of individual systems, customized to the situation of a dairy. There are different optimization options: "To save energy on-site, we utilize solar-thermal energy conversion through which we want to provide the thermal base load energy for the dairy. In addition, we use - for example - solar energy in high temperature solar panels for steam generation, which we couple with biomass boilers. In turn, we use the waste heat streams of the dairy to generate cold (absorption refrigeration). For this, we optimally adapt the systems to the respective dairy. Furthermore, heat pumps that feature both a high and a low temperature side help to optimally distribute the heat in the dairy", project manager Dr. Christoph Glasner explains the concept.

3.2 Milk concentrate saves water and energy

To save water and energy, Fraunhofer UMSICHT in one part of the project is specializing in the energy-efficient manufacturing of milk concentrate with improved quality. This measure has the potential to reduce both the transport energy and the tank sizes at the dairy. Standardized and dried concentrate is not only of interest for the manufacturing of products such as cheese, yoghurt and baked goods, but also for bridging the gap in case of supply shortages. In some regions of Europe, the supply with milk in part varies seasonally. With concentrated, dried milk, a storable product is at hand that is available the whole year in consistent quality and quantity.

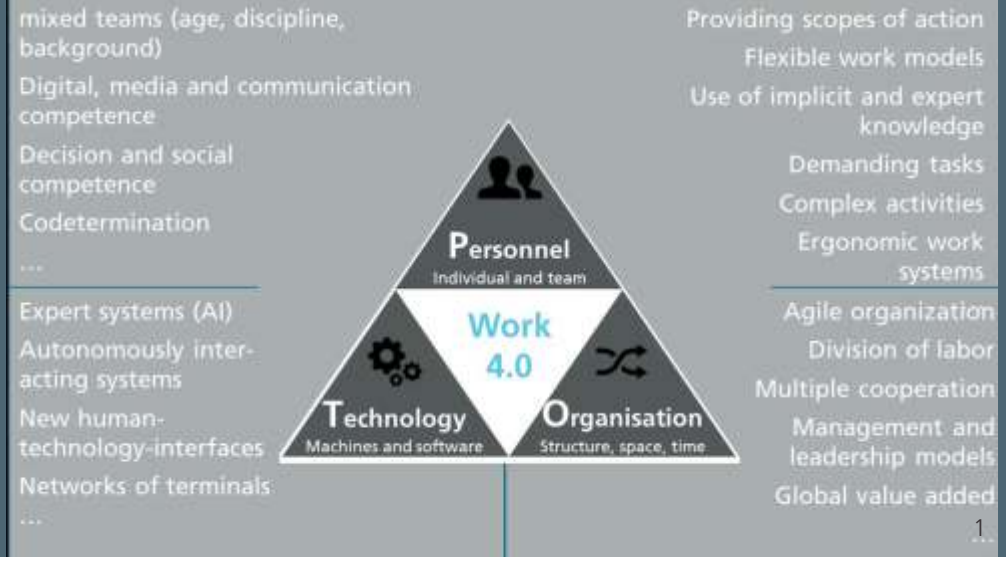
3.3 Recycling of waste water and waste

The waste water inescapably generated in production and system cleaning has high organic loads. It is cleaned up via membrane technology and thus put to reuse in closed water circulation systems. Additionally, it is conceivable to generate energy in the form of biogas or bioethanol from waste treatment and to use it within the dairy for heat and electricity. Also, there is the option to recycle the universal material lactic acid from water streams.

Alliance/ Project partners

Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB
Fraunhofer Institute for Integrated Circuits IIS
Fraunhofer Institute for Material Flow and Logistics IML
Fraunhofer Institute for Microelectronic Circuits and Systems IMS
Fraunhofer Institute for Molecular Biology and Applied Ecology IME
Fraunhofer Institute for Optronics, System Technologies and Image Exploitation IOSB
Fraunhofer Institute for Photonic Microsystems IPMS
Fraunhofer Institute for Physical Measurement Techniques IPM
Fraunhofer Institute for Silicon Technology ISIT
Fraunhofer Institute for Process Engineering and Packaging IVV
Fraunhofer Institute for Reliability and Microintegration IZM
Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT

4. Image Courtesy: Fraunhofer UMSICHT



Future of Work: Successful Industrial work of tomorrow – look, feel, experience and create

Source :

Designing the Industrial work of the future

The industrial work of the future is characterized by a new understanding. The growing spread of smart living and working environments is based on socio-technical networking. The classic success factors in technology, organization and personnel are experiencing a potential- and requirement-oriented expansion in times of digital transformation: human activities will in the future be almost completely supported by technology machines as well as software applications, thereby further optimizing individual and team work. The future industrial working world takes place in real and virtual spaces, which are characterized by system integration and user adaptivity. In the future, human beings will continue to be at the center of the studies in the field of labor science, and within this new, hyperflexible and mobile working world, there is still unprecedented support.

The main design fields of the industrial work of the future are the shaping of the framework conditions with regard to flexibility and work-life balance, the human-centric technology design and the interpretation of the interaction between workers and technology as the upcoming assistance systems (digital and physical) show clearly. In addition, the qualification and competence requirements for a successful design of future working situations are critical to success.

Future work lab: Innovation laboratory for Work, People and Technology

In order to make these aspects of future work design visible, tangible and experienceable, the goal of the Future Work Lab is to set up and operate a new innovation laboratory for work, people and technology »FUTURE WORK LAB« in Stuttgart. This lab is designed as a living and widely visible center of competence with three pillars.

To this end, demonstrators of the technical possibilities of digitization and further automation in the core areas of industrial work will be realized in a Demonstration Center for current and future time horizons (1). The course 1 »Today+« shows operational requirements for the demonstration of industrial work in todays technology and organizational expression. This creates an important point of focus in the industrialized and modern small and medium sizes companies (lean production, lean systems, integrated production systems) at the FUTURE WORK LAB. Two further courses show operational applications for the digitization and

1. The traditional triangle of work T-O-P becomes redefined.

intelligent automation of industrial work in the time horizon until 2025. They sum up different demonstrators between the poles of technology-centric automation and human-centered specialization, which in 2025 can be "standard" in the manufacturing industry. This refers to the two scenarios for the development of an industry 4.0, the automation and the specialization scenario [12], currently discussed in the context of the digital transformation of science and companies.

The two scenarios stress a field of tension in which the work of the future can be shaped by the operational requirements. In this context, a "digitally strengthened shop floor" could emerge as a course with demonstrators from this tension field. In the FUTURE WORK LAB, not only elements of the two extreme scenarios (automation and specialization scenarios) are to be mapped, but the resulting design space and possible realizations should be shown transparently. On the one hand, the interaction of human workers with machines is at the forefront of all aspects of operational value creation (e.g. planning, production operation, maintenance). On the other hand, new forms of automation in the form of physical assistance systems (e.g. human-robot cooperation) can be made tangible. Current challenges with regard to the future world of work are the application of new technologies in the field of "artificial intelligence" with regard to the teaching of machines by humans, "big data" for statistical machine learning and autonomous optimization of machines. Abstract and complex technologies such as these are made tangible in the FUTURE WORK LAB in the sense of utility potentials and also by showing the limits of the new applications.

The design of the courses is based on today's typical work profiles in the FUTURE WORK LAB as they are anchored in the company's value adding process. These are geared to different groups of employees with different qualification levels, taking into account the low levels of skills (skilled workers). In addition to this demo center, the sensitization, qualification, value proposition and the social dialogue of future-oriented working systems are carried out in a Center for Competence Development and Counselling (2) focusing on the social interest groups. The third pillar provides a platform for technology-oriented research and academic discussion of the changes in industrial work within an Ideas Center (3).

This is how the FUTURE WORK LAB combines solutions for the sustainable design of innovative industrial work with a work-centered research perspective and thus contributes to the successful further development of Germany as a successful industrial location.

The **FUTURE WORK LAB** is the first project-based lab to develop an innovative laboratory, which makes the design of future-oriented working concepts transparent for companies, employees, trade unions and all other stakeholders. The laboratory integrates the path from the demonstration of concrete industry 4.0 applications through the development of competencies to the integration of the current state of work research, thereby enabling holistic development steps in the area of work, people and technology.

To this end, the Future Work Lab offers an attractive qualification and seminar program, which can be used by companies, associations, trade unions and employees. In addition to the interested target group, the lab is also made open for n house exhibitions, lectures at congresses and events. The academically oriented center of ideas develops new research contents. These allow the creation of future research perspectives on new projects and programs.

2. Structure of the new FUTURE WORK LAB
Image Courtesy: Fraunhofer IAO

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SpatialSound Wave System

Source : Fraunhofer Institute for Digital Media Technology IDMT

Technical information:

- Dynamic room simulation (regenerative, convolution-based) comprising as many as 16 audio objects.
- Use with any Digital Audio Workstation or live input.
- Quick installation due to intuitive setup
- Timecode synchronization
- Supports different interfaces, such as OSC or MIDI (can easily be extended)
- Allows integration of tracking systems
- Easy-to-use, browser-based GUI for personal computers and mobile devices.

SpatialSound Wave is an object based system for producing and replaying true-to-life three-dimensional sound. While the system allows the listener to virtually immerse in the sound and enjoy an acoustically realistic sound experience, it offers sound engineers new options to easily and efficiently produce spatial sound.

A three-dimensional sound experience

Using SpatialSound Wave, audio objects can be positioned at will, providing a totally realistic compliance of what is seen and what is heard. The system features an innovative module for interactive room simulation – by a simple push of a button, any room you can think of is simulated in a perfectly realistic fashion, giving the listener the impression that they are actually right in the middle of a given acoustic scene.

Easy and intuitive use

SpatialSound Wave's web based, easy-to-use user interface is platform independent. Due to its modular structure, the system can easily be adapted to individual requirements, allowing users to integrate SpatialSound Wave into their daily workflow routine. As the system can be accessed simultaneously over multiple end devices, a number of users can work on the same project at the same time.

Flexible system adaptation

SpatialSound Wave supports any type of loudspeaker. Sound mixes produced with the help of SpatialSound Wave can be replayed via different speaker arrangements without losing the sound impression intended by the artist. Conventional speaker arrangements (e.g., L/R, L/C/R, or delay lines) can easily be integrated.

Areas of application

- Full dome
- Live sound
- Entertainment
- Exhibitions, trade shows, and other events
- Research and education

1. Fraunhofer IDMT

Recent Research News @ Fraunhofer

Digitization in Automobile production
Research Compact / 2.1.2018

The optimization pressure in the halls of the automobile manufacturers is large: The variance is constantly increasing; the costs must remain within limits. Fraunhofer researchers are now using RFID technology to increase transparency in the logistics and production processes of car manufacturers. That means: The effort is reduced, the profitability increases.

Fraunhofer promotes Intelligent Agriculture
Press Release / 8.12.2017

Fraunhofer yesterday signed a Memorandum of Understanding in Lisbon with the Portuguese research funding organization FCT (Fundação para a Ciência ea Tecnologia). It envisages promoting the digitization of agriculture and forestry. Among other things, digital and agricultural land will be used to cultivate farmland and forestry land in a more targeted and sustainable way. A joint task force should develop possible fields of application and application scenarios.

Rotor blade inspection with Thermography and Sound
Research Compact / 1.12.2017

Wind turbines are designed for a service life of 20 years. Rotor blades must be inspected for structural integrity by periodic inspections at least every four years. This task is carried out by industrial climbers. However, inspections of offshore installations are only possible if wind and weather conditions permit. This makes deployment planning extremely difficult. In the research project Thermoflight, Fraunhofer scientists work together with partners from industry and research on alternative inspection methods. Offshore drones equipped with Thermographic Technology, combined with sound-based testing methods, could help to make maintenance more efficient and reduce downtime in the future.

Beyond 5G - the next step
Research Compact / 2.11.2017

Even today, it is becoming apparent that the data rates of the upcoming 5G mobile communications standard will not be able to satisfy the growing data hunger of private users and industry for long. Therefore, Fraunhofer experts with partners from industry and research are already conducting research on 6G in the framework of the EU project Terranova. By the end of 2019, the TERRANOVA team will be working to embed terahertz wireless solutions into high-speed optical fiber networks, tap into new frequency bands, and pave the way for a resilient communications infrastructure ready for the needs of the future.

Fight against human trafficking: Fraunhofer IBMT and partners introduce mobile, smartphone-capable ultrasonic hand-held scanners for identifying underage victims
Press Release / 26.10.2017

Human trafficking is a serious, worldwide crime that severely affects the mental and physical integrity of victims. As part of a multidisciplinary research project, the Fraunhofer Institute for Biomedical Engineering IBMT has developed a mobile, non-invasive ultrasound hand-held

1. RFID technology makes the logistics and production processes at automobile manufacturers more transparent.
Image Courtesy: Photo Fraunhofer IFF, Andreas Süß

2. The acoustic emission system under test: monitoring of the root canal bond during a fatigue test
Image Courtesy: Fraunhofer IWES

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scanner for identifying underage victims of illegal border crossings, whose mission is to detect, combat and prevent trafficking in human beings. The »PRIMSA« ultrasound system will also be presented at the world's leading trade fair for the medical sector MEDICA 2017 from 13 to 16 November 2017 in Düsseldorf in hall 10, booth G05.

Old wood - new life as a secondary raw material
Research Compact / 2.10.2017

So far, waste wood has either been used thermally or shredded into chipboard. The aim of the EU project CaReWood, on the other hand, is to reuse the raw material several times - for example for building houses or for making furniture out of it. Fraunhofer researchers have found that large used wood pieces can be recycled without loss of quality. The appropriate techniques for detecting and removing contaminants were developed in the project.

Generate Electricity with Elastomeric films
Research Compact / 2.10.2017

At around 33 percent, water is still Bavaria's most important renewable energy source, as Energie-Atlas Bayern shows. But especially conventional micro-hydropower plants with a manageable yield are controversial - they intervene in the ecosystem. Fraunhofer researchers are working on an environmentally friendly alternative: In the future, novel elastomer materials will convert the mechanical energy of water flows in small rivers directly into electrical energy.

Data theft - quickly discovered!
Research Compact / 1.8.2017

So far, computer experts have little chance of permanently protecting companies or public authorities from network failures. Too numerous and unimportant are the events that point to possible hacker attacks. With PA-SIEM, IT managers get an effective tool at hand. In this way, they can expose data theft and others more quickly and better protect data.

Machine park is waiting for itself
Research Compact / 1.9.2017

In the EU project SelSus, Fraunhofer scientists are working in consortium with partners from industry and research on a technology that predicts machine breakdowns in production before they occur. This allows the operations manager to correct errors before the machine stops working. Some defects even eliminate the system automatically.

Smartpump: Small but powerful
Research Compact / 1.8.2017

Particulate matter damages the heart and lungs. A smartphone with a built-in gas sensor could warn of a high load in the future. In order for the sensor to respond quickly and provide accurate readings, Fraunhofer researchers have developed a high-performance micro-diaphragm pump that supplies the ambient air.

Earthquake-proof buildings
Research Compact / 4.7.2017

Again and again, heavy earthquakes shake entire areas of the world. More than two billion

3. In the TERRANOVA project, the Fraunhofer IAF is focusing on the integration of radio modules at the chip level. The picture shows a function prototype of a 300 GHz multi-channel radio system for further integration as a system-on-chip.
Image Courtesy: Fraunhofer IAF

4. A first demonstrator:
The ultrasonic hand-held scanner »PRIMSA« in action.
Image Courtesy: Fraunhofer IBMT

people live in endangered areas. Many of them live in homes that are not earthquake-proof. Together with industry partners, researchers at the Fraunhofer Institute for Wood Research WKI are developing building materials that protect buildings from collapse in the event of natural disasters.

Clean wastewater effectively

Special Edition Research Compact / 30.5.2017

Water is vital - so effluents have to be cleaned as efficiently as possible. The ceramic membranes make this possible. Researchers from the Fraunhofer Institute for Ceramic Technologies and Systems IKTS in Hermsdorf were able to significantly reduce the separation limit of these membranes and reliably filter out dissolved organic molecules with a molar mass of only 200 daltons for the first time. This allows even industrial wastewater to be cleaned efficiently.

1000 km range thanks to new battery concept

Research Compact / 2.5.2017

Electric cars do not get very far today. One reason: The batteries require a lot of space. Fraunhofer scientists stack large cells on top of each other. That brings more power into the vehicles. First tests in the lab were positive. In the medium term, the project partners are aiming for coverage distances of 1000 kilometers for electric cars with the installation concept.

Secure cloud platform links production and IT

Research Compact / 3.4.2017

With Virtual Fort Knox, researchers from the Fraunhofer IPA have collaborated with industry partners and the Fraunhofer Production Verbund to create an online marketplace that brings together manufacturing companies and providers of IT solutions. The hybrid cloud platform enables SMEs to digitize production processes and develop new business models - in the spirit of Industry 4.0. The researchers will be demonstrating the added value of the marketplace for industrial applications from 24 to 28 April at the Hannover Messe (Hall 17, Stand C18).

Fast-Charging Electric Bus

Research Compact /

"The Fraunhofer IVI has been working towards the implementation of fully electric bus operation following the »DockingPrinciple« for over ten years now. The term »DockingPrinciple« stands for a new electric propulsion concept for public transport vehicles, in which an on-board energy storage unit serves as the sole source of energy for the vehicle. The storage unit takes in energy from fast-charging stations (DockingStations) installed along the road and releases it on demand to the vehicle propulsion or the electric auxiliaries."

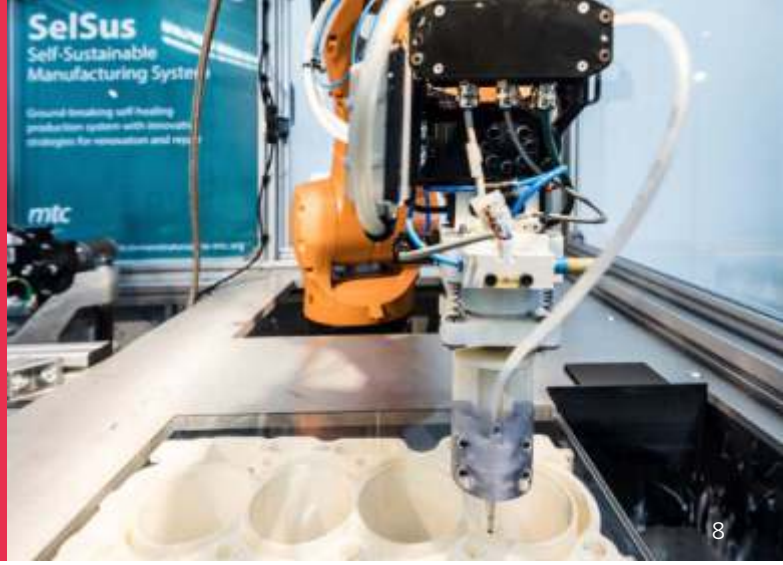
OpSim: Test and Simulation environment for Grid control and Aggregation strategies

Research Compact

OpSim is a test- and simulation-environment with applications ranging from developing prototype controllers to testing operative control software in the smart grid domain. OpSim is created by Fraunhofer IWES and University of Kassel and enables users to connect their software to simulated power systems, or test it in conjunction with other software. The power grid simulator of OpSim is capable of emulating large power systems with multiple voltage

5. Physicist in the determination of inorganic wood preservatives on window scantlings using X-ray fluorescence analysis.
Image Courtesy: Photo Fraunhofer WKI, Simone Piest

6. The world's longest teak bridge will replace parts of the more than 150-year-old trunks. It is planned to continue to use the old wood as hand rails or benches at the bridge.
Image Courtesy: Fraunhofer WKI
Peter Meinlschmidt



levels and substantial amounts of generators, storages and loads.
The core of OpSim is a flexible message bus architecture; it allows arbitrary co-simulations in which power system simulators, controllers and operative control software can be coupled together.

Reactive Power Coordination Strategies with Distributed Generators in Distribution Networks
Research Compact

The need for the supply of reactive power from distributed generators (DGs) in order to provide ancillary services in distribution grids becomes higher the more conventional power plants will be shut down. There are several strategies how reactive power from DER can be coordinated and utilized to compensate the missing part from the central power plants. In this paper, three different approaches are presented and compared them with each other in different application contexts.

These approaches are:
1. Central global coordination using optimization algorithms and full knowledge of network information (topology, assets, measurements, …)
2. Central control strategies using the local control of DGs and only little to no knowledge of network information.
3. Local voltage control using (optimized and variable) droop curves.

7. The sensor-controlled steel connections of the Fraunhofer WKI can hold a building together in an earthquake.
Image Courtesy: Fraunhofer WKI

8. Self-repairing dispenser developed by the project partner Manufacturing Technology Center for engine production in the EU research project SelSus.
Image Courtesy: Fraunhofer IPA

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Recent Activities

Workshop On Accelerating India's Rooftop Solar Programme
30th May, 2017

To promote the Government's efforts to increase Rooftop Solar capacity, the Confederation of Indian Industry CII, in partnership with Hero Future Energies organized the 'Powering Your Rooftops - A Workshop Series on Accelerating India's Rooftop Solar Programme' across the leading solar-rich states in India. Ms. Iyer was one of the panellists and discussed the implementation of Rooftop Solar policy from stakeholder's perspective regarding how to achieve state-specific targets given the present scenario, policy, regulatory framework, available and potential opportunities, and standardization of solar rooftops.

Visit of Prof. Dr. Boris Otto, Managing Director, Fraunhofer ISST, Dortmund & Chair, Industrial Data Space Programme to India and Roundtable on Industry 4.0
20th - 21st June, 2017

Two Roundtables were organized by Fraunhofer Office India each in Kirloskar HQ, Pune and Fraunhofer Office India, Bangalore to set a forum to discourse the various aspects of Industry 4.0 and accentuate a creation of future roadmap for the Indo German cooperation to implement new measures in a distinctive manner. It also laid down the ground level realities faced by Indian and German companies in India. Participants were the stakeholders from Industry, Industrial Associations, Technical Universities and the Government. Both the Roundtables were chaired by Prof. Dr. Boris Otto, Managing Director - Fraunhofer Institute for Software and Systems Engineering ISST, & Chair, Industrial Data Space Programme. These roundtables also served the bases for the study, conducted by the Fraunhofer ISST in collaboration with Fraunhofer Office India, Bangalore in the context of a project for Bertelsmann Stiftung.

Seminar on Exploring Business and Technology Prospects in Water Sector
23rd June, 2017

Mahratta Chamber Of Commerce, Industries And Agriculture MCCIA had organized a Seminar on Exploring Business and Technology Prospects in Water Sector in Pune which highlighted policies, regulations, technical aspects, capabilities of international organizations in devising innovative water technologies and business potential in Water sector. Ms. Anandi Iyer presented on **'Systems oriented and multidisciplinary applied research in the field of Water Management'** in this seminar.

Visit of Dr. Andreas Sterzing, Head of Department - Solid Forming, Fraunhofer IWU and Mr. Peter Blau, Senior Head of the Department - Machining, Fraunhofer IWU to India

1. Ms. Anandi Iyer as a panellist at the workshop on Accelerating India's Rooftop Solar Programme

2. Prof. Dr. Boris Otto presenting on 'Global Models of Industry 4.0' during Roundtable

3. Ms. Anandi Iyer presenting on 'Indo - German Roadmap Study on Industry 4.0' during Roundtable

4th - 6th July, 2017

Dr. Andreas Sterzing and Mr. Peter Blau visited India from July 4th to 6th to discuss and finalize several project proposals with Bharat Forge Ltd., IIT - Madras, TVS Group, Rane Engine Valve Ltd. They also met Mahindra & Mahindra Ltd. to discuss project opportunities in Light weighting Technologies.

Visit of Prof. Frank Treppe, Associate Member of the Board & Director of International Affairs and Research Programs, Fraunhofer Gesellschaft and Ms. Silke Ladewig, Advisor - International Affairs and Research Programs, Fraunhofer Gesellschaft to India

28th August - 01st September, 2017

Prof. Frank Treppe accompanied by Ms. Silke Ladewig visited India between Aug 28th - Sept 01st, 2017 and had strategic meetings with the German Ambassador, GiZ India, Confederation of Indian Industry CII, NITI Aayog, Bangalore Airport and Dept. of IT, BT and S&T, Govt. of Karnataka. Prof. Treppe also delivered a lecture at the BML Munjal University (BMU) on the subject of **Advanced Manufacturing Technologies**, which was attended by more than 300 Students and Faculty.

Visit of Fraunhofer's Electro-mobility Delegation

5th - 8th September, 2017

Fraunhofer's e-Mobility delegation chaired by Prof. Dr. Matthias Busse, Director, Fraunhofer IFAM and Director, Fraunhofer Systems Research Electro-mobility, and consisting of experts namely Dr. Julian Schwenzel, Head of Department - Electrical Energy Storage, Fraunhofer IFAM, Dr. Thoralf Knote, Head of Department - Vehicle and Transport System Engineering, Fraunhofer IVI, Dr. Andreas Middendorf, Business Developer, Fraunhofer IZM and Ms. Mandy Koritz, Controller and Deputy Head of Administration – International Business Development, Fraunhofer IVI visited India and had strategic meetings with several industries, Govt. bodies and Public sector companies following discussions related to future of e-Mobility in India. The delegation had also participated in Society of Indian Automobile Manufacturers (SIAM) Annual Convention and Automotive Component Manufacturers Association (ACMA) Annual General Meeting held on Sept 7th and 8th, 2017 respectively. Prof. Busse presented on **'Future of Mobility is Electric'** in the knowledge session of ACMA Annual Convention, which was very well appreciated the audience.

Signing of MoU between Fraunhofer IAO and Coimbatore City Municipal Corporation (CCMC)

11th September, 2017

Fraunhofer Institute for Industrial Engineering (IAO) has entered into a memorandum of

4. Prof. Treppe delivering a lecture at BML Munjal University

5. Prof. Busse delivering presentation at ACMA 2017

6. Mr. Aditya Fuke presenting at TIA Summit 2017

understanding with Coimbatore City Municipal Corporation on Sept 11th, 2017 to set up the India's first Smart City Innovation Lab in the city of Coimbatore, Tamil Nadu with a view to scale intelligent growth through sustainable innovation in Coimbatore based on the Morgenstadt Initiative (Cities of Tomorrow) of the Fraunhofer Society. The MoU was signed in presence of Thiru. S.P. Velumani, Minister for Municipal Administration, Rural Development and Implementation of Special Programme, Govt. of Tamil Nadu and Mr. Achim Fabig, Consul General of Germany (in Chennai) at the Chennai Secretariat.

The Advantage India (TIA) Summit 2017
22nd September, 2017

Integro Infotech & Consulting Pvt. Ltd. had organized The Advantage India Summit 2017 to showcase Smart City Solutions for India, and invited Fraunhofer to be one of the speakers and present the 'Morgenstadt Initiative' - and its feasibility in India. Mr. Aditya Fuke, Asst. Manager - Market Intelligence represented Fraunhofer during the summit and presented the **'Morgenstadt Model'** and its phases of development in Europe, and underlined the various functions of a Smart City Innovation Lab.

15th Global Conference on Sustainable Manufacturing (GCSM) organized byTechnion – Israel Institute of Technology, Haifa, Israel
25th - 27th September, 2017

Ms. Anandi Iyer was the Chairperson for the session on 'Business Models' at 15th GCSM and presented a paper on Sustainable Manufacturing in India titled 'Moving from Industry 2.0 to Industry 4.0: A Case Study from India'.

Meeting with Shri. Dharmendra Pradhan, Hon'ble Minister for Petroleum & Natural Gas and Minister for Skill Development & Entrepreneurship
27th September, 2017

Prof. Dr. Alexander Michaelis, Director, Fraunhofer IKTS had a strategic meeting with Shri. Dharmendra Pradhan, who is the incumbent Minister of two Ministries - Ministry of Petroleum & Natural Gas, and Ministry of Skill Development & Entrepreneurship, Govt. of India to discuss cooperation between India and Germany

Visit of Mr. Ruediger Heim, Deputy Head of the Institute, Fraunhofer LBF
25th - 29th September, 2017

Mr. Ruediger Heim visited India during Sept 25th to 29th and had several project related meetings with Mahindra Electric Mobility Ltd., Mahindra & Mahindra Ltd. and SATVEN Pvt. Ltd. He also delivered a lecture on **'Skill Development in Automotive sector for India'** at Automotive Skills Development Council, Skill India Initiative - Govt. of India organized by Brij Mohanlal (BML) University in New Delhi.

7. L to R: Ms. Anandi Iyer - Director, Fraunhofer Office India, Mr. Achim Fabig - Consul General of Germany in Chennai, Thiru. S.P. Velumani - Minister for Municipal Administration, Rural Development and Implementation of Special Programme, Govt. of Tamil Nadu, Thiru. Harmander Singh IAS - Principal Secretary to Government, Municipal Administration and Water Supply Dept. Govt. of Tamil Nadu, Dr. K. Vijayakarthikeyan - Commissioner, Coimbatore City Municipal Corporation

8. R to L: Shri. Dharmendra Pradhan, Prof. Alexander Michaelis

9. Mr. Sanmati Naik presenting at German - Indian Solar Forum

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German - Indian Solar Forum
3rd October, 2017
The German - Indian Solar Forum was organised by Solar Cluster, Baden-Württemberg in cooperation with Indo-German Chamber of Commerce on Oct 3rd, 2017 in New Delhi. Mr. Sanmati Naik, Manager - Renewable Energy represented Fraunhofer during the event and delivered presentation on "Competencies of Fraunhofer in Solar Energy for India". The session was chaired by Mr. Klaus Peter-Murawski, State Minister and Head of the State Chancellery of the State of Baden-Württemberg, Germany.

Visit of Dr. Marius Mohr, Head of Group Bioprocess Engineering in Water Management and Circular Economy, Fraunhofer IGB for WaterScapes Symposium 2017
5th - 6th October, 2017
DWIH (German House for Research and Innovation) and DAAD (German Academic Exchange Service) had organized WaterScapes Symposium 2017 from October 05th to 06th, 2017 in New Delhi. Fraunhofer Office India coordinated the session on 'Urbanisation and Sustainable Water Resources Management - Industry Perspective' at Waterscapes Symposium 2017, which was chaired by Ms. Anandi Iyer, Director, Fraunhofer Office India. Dr. Marius Mohr delivered a presentation on **'Fraunhofer Water Systems Alliance – Solutions for Industrial Water Management'** in this session.

Visit of Mr. Damian Wagner, Sr. Project Manager - Smart Cities and Coordinator - Triangulum, Fraunhofer IAO for a planning workshop with Coimbatore City Municipal Corporation.
6th - 11th November, 2017
To embark on next steps under the MoU between Fraunhofer IAO and Coimbatore City Municipal Corporation (CCMC), a planning workshop with the stakeholders of Coimbatore was organized at CCMC to draw out project ideas in this cooperation.

Release of the study on "Industry 4.0 – The Future of Indo-German Industrial Collaboration"during the visit of Dr. Bernhard Holtkamp, Senior Scientist and Deputy of Head of Logistics Department, Fraunhofer ISST to India.
21st - 24th November, 2017
The study on **"Industry 4.0 – The Future of Indo-German Industrial Collaboration"**, authored by Dr. Holtkamp and co-authored by Ms. Anandi Iyer, Director, Fraunhofer Office India, and funded by Bertelsmann Stiftung was released in presence of H.E. Dr. Martin Ney, German Ambassador to India and Shri. Atul Chaturvedi, Additional Secretary, Dept. of Industrial Policy and Promotion, Govt. of India in New Delhi. Dr. Holtkamp also presented the important findings of this study during

10. Dr. Marius Mohr presenting at WaterScapes Symposium 2017

11. Mr. Damian Wagner speaking at the planning workshop

12. Release of the study on Industry 4.0
L to R: Mr. Murali Nair from Bertelsmann Stiftung, Shri. Atul Chaturvedi, H.E. Dr. Martin Ney, Dr. Bernhard Holtkamp, Ms. Anandi Iyer

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the release. This study can be downloaded from www.fraunhofer.in

Mahratta Chamber of Commerce, Industries and Agriculture (MCCIA) had organized a one-day event on "Leadership in Industry 4.0", in association with IIM-Ahmedabad Alumni Association Pune Chapter in Pune. The conference comprised of MCCIA members, reputable industrialist and IIMA alumni. Dr. Bernhard Holtkamp was invited as a keynote speaker for sharing his thoughts on **"Industry 4.0 and Challenges in India"**. His presentation was extremely well received with great appreciation.

Indo-German Industry Roundtable on Smart City Innovation Lab in Coimbatore
27th November, 2017

Fraunhofer Office India in coordination with Coimbatore City Municipal Corporation (CCMC) had organized an Indo-German Industry Roundtable in presence of the German Ambassador to India, H.E Dr. Martin Ney and the Commissioner of CCMC, Dr. K. Vijayakarthikeyan on Nov 27th 2017 in Coimbatore. This roundtable aimed at discussing the collaboration between Fraunhofer and the City of Coimbatore to setup **'India's first Smart City Innovation Lab on Mobility'** funded by Kreditanstalt Für Wiederaufbau (KfW) and a Water Competence Centre namely **"Smart Water Future India"** funded by The Federal Ministry of the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) in cooperation with Coimbatore City Municipal Corporation. This roundtable was attended by senior representatives from the key industries, research institutes, NGOs and urban local bodies of Coimbatore, who discussed their experiences and interests, and suggested ideas to strengthen the Indo-German cooperation between CCMC and Fraunhofer prior to launching the two initiatives.

Summit on "Women Entrepreneurship" at Indian School of Business, Hyderabad
30th November, 2017

On the occasion of visit of Ms. Ivanka Trump, Advisor to the President of United States of America, Mr. Donald Trump, Federation of Indian Chambers of Commerce & Industry (FICCI) had organized a summit on "Women Entrepreneurship" at Indian School of Business, Hyderabad and invited Ms. Anandi Iyer as a panellist to share her insights on building and strengthening a congenial environment for women entrepreneurs in India. This meeting was attended by both illustrious and budding women entrepreneurs of India, who are contributing significantly in all walks of life.

Seminar on Future Factories organized by Messe Frankfurt in Mumbai
14th December, 2017

Ms. Anandi Iyer delivered the keynote address on **'Roadmap for implementation of Industry 4.0 in line with ''Make in India"** mission' in this seminar.

13. L to R: Dr. K. Vijayakarthikeyan, H.E. Dr. Martin Ney, Ms. Anandi Iyer during Indo-German Industry Roundtable

14. Ms. Anandi Iyer along with other panellists at summit on 'Women Entrepreneurship'

EVENTS CALENDER 2018

Visit of Prof. Dr. Karlheinz Brandenburg, Director, Fraunhofer IDMT to India
Jan 5th to 11th, 2018, Chennai, Bangalore and New Delhi
Prof. Brandenburg delivered a lecture at SHAASTRA 2018; a technical fest organized by IIT Madras and had meetings with prospective clients.

Launch of German Innovation and R&D Forum
Jan 23rd, 2018, Bangalore

Indian Metal Forming Exhibition (IMTEX) 2018
Jan 25th to 30th, 2018, Bangalore, Chennai and New Delhi
Fraunhofer participated as an exhibitor in IMTEX 2018. Prof. Dirk Landgrebe, Institute Director of the Research Division of Forming Technology and Joining, Fraunhofer IWU delivered a keynote address at IMTEX 2018.

Visit of Dr. Thomas Tradler, Head of Business Development/Patent Management, Fraunhofer IZI to India
Feb 18th to 24th 2018, Bangalore and Hyderabad
Dr. Thomas Tradler visited India to attend BioAsia 2018 and explore business opportunities.

Visit of Dr. Marius Mohr, Head of Group Bioprocess Engineering in Water Management and Circular Economy, Fraunhofer IGB to India.
March 18th to 26th, 2018, Coimbatore and Bangalore
Dr. Marius Mohr, will be visiting India for meetings related to Smart city project, Smart Water Future India in Coimbatore and project related meetings in Bangalore.

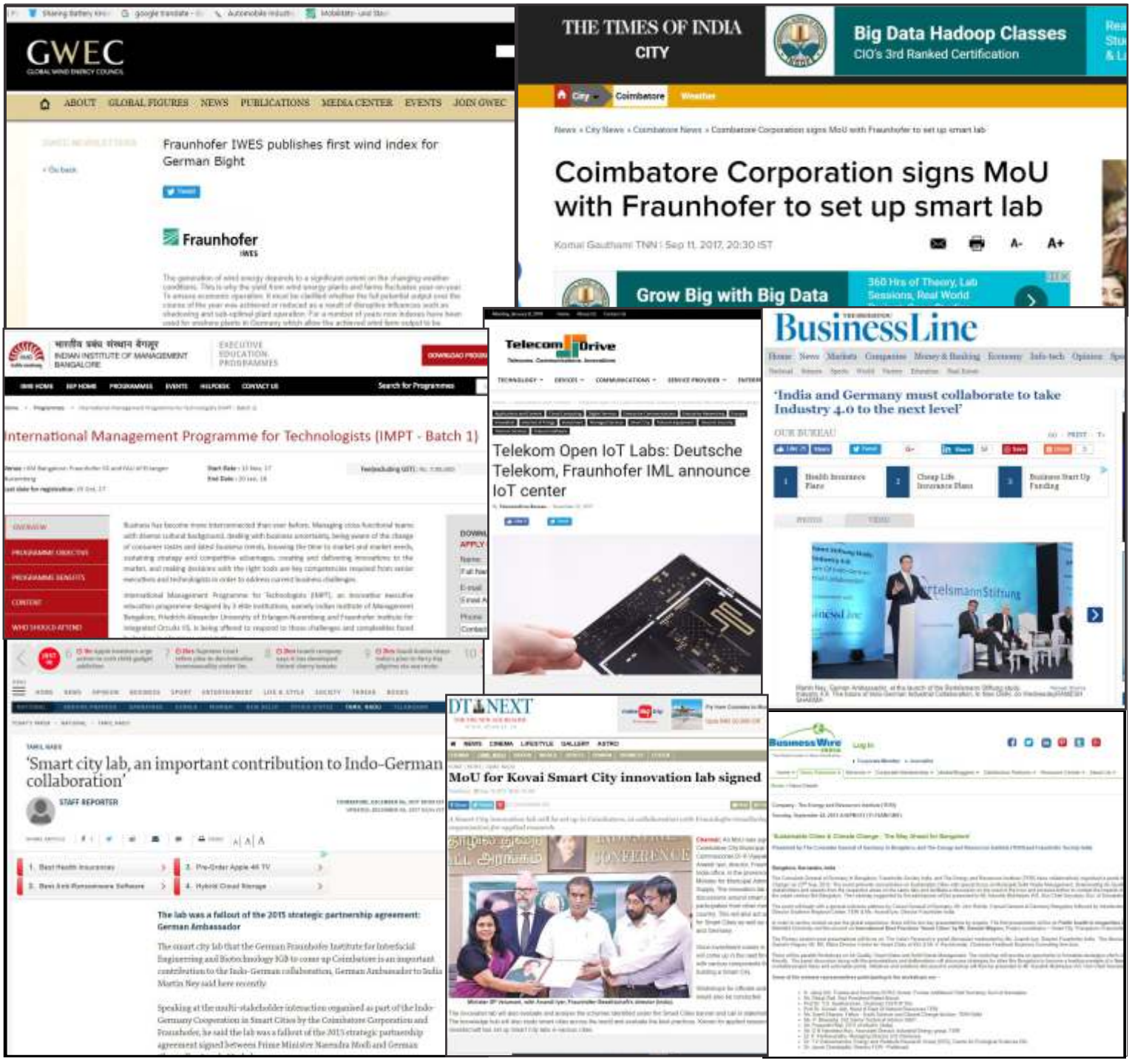
Global RE-Invest 2018: (India - International Solar Alliance ISA Partnership)
April 19th to 21st, 2018, New Delhi

Hannover Messe 2018
April 23rd to 27th, 2018, Hannover, Germany
Ms. Anandi Iyer and Mr. Aditya Fuke will represent Fraunhofer Office India in Hannover Messe 2018.

Visit of Mr. Damian Wagner, Sr. Project Manager - Smart Cities and Coordinator - Triangulum, Fraunhofer IAO to India.
May 2018, Coimbatore and Kochi
Mr. Damian Wagner will be visiting India for meetings related to Smart City projects in Kochi and Coimbatore.

Fraunhofer Innovation and Technology Platform (FIT) 2018
4th Quarter 2018 (date tbc)
A biennial innovation and technology event organized by Fraunhofer Office India.

Fraunhofer India: Recent Media Coverage



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