R&D AT FRAUNHOFER: CLEAN ENERGY TECHNOLOGIES

Prof. Reimund Neugebauer, President of the Fraunhofer-Gesellschaft

1st Conference on “R&D 20 for clean energy technologies (RD20)”, October 11th, 2019, Tokyo, Japan

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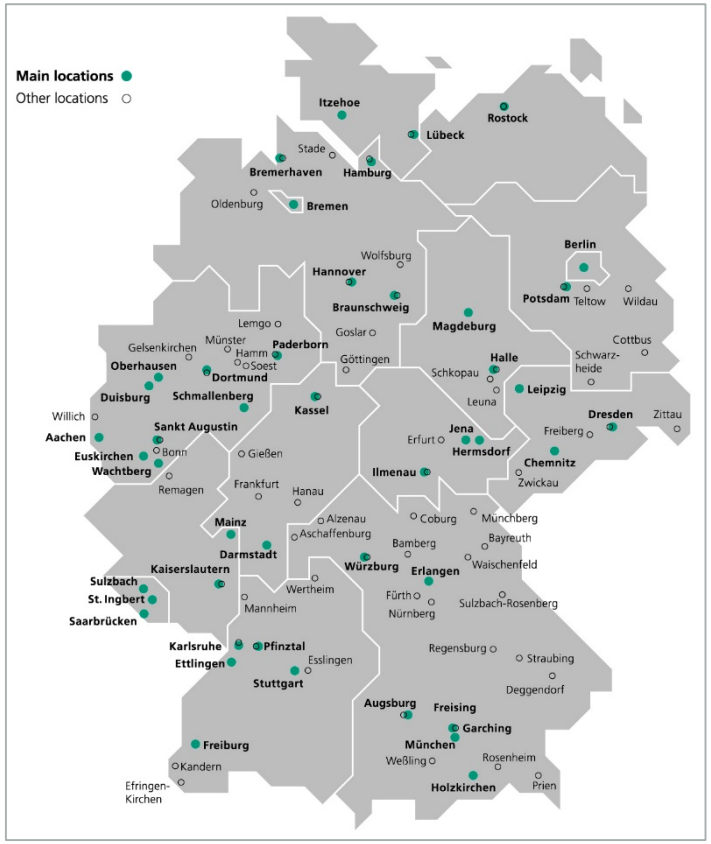
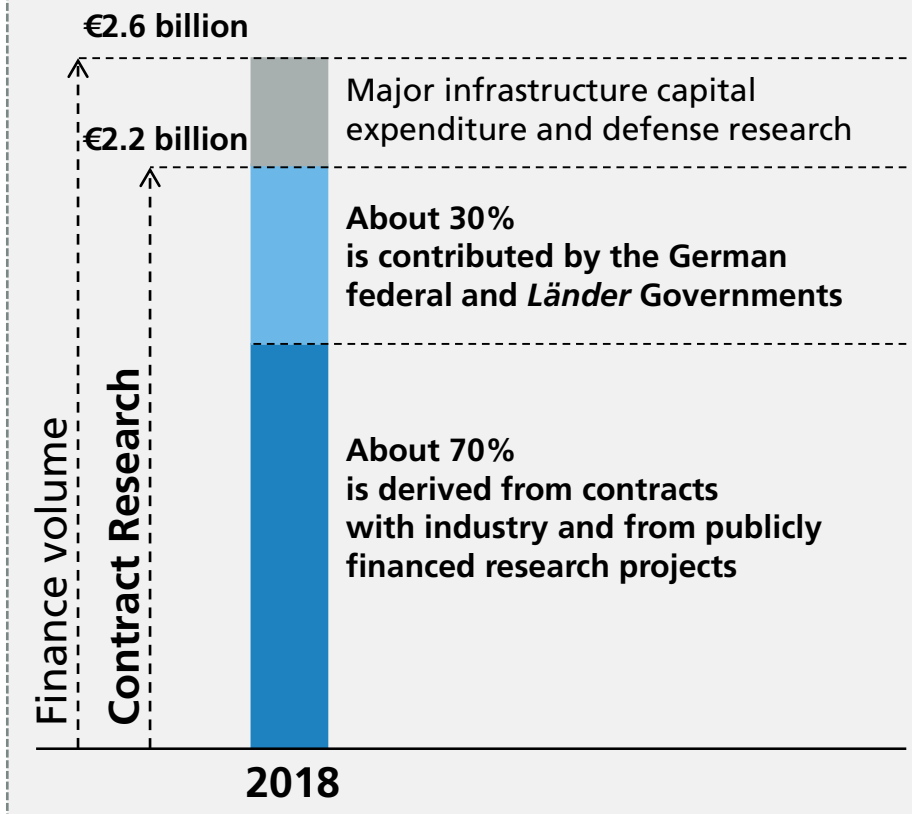
R&D OF CLEAN ENERGY TECHNOLOGIES AT FRAUNHOFER

The Fraunhofer-Gesellschaft at a Glance

72 Fraunhofer institutes and research institutions in Germany
(1/2019)

> 26,600 staff
(12/2018)





Applied research is the foundation of our organization.
We partner with companies to transform original ideas into innovations.

Fraunhofer international – Business models

ICON – International Cooperation and Networking

- Project based
- **Scientific excellence**; novel approach
- **Joint** strategic research agenda
- Researcher exchange
- **Matched funding** by both partners **~€ 1 million** each
- **3 years**

Fraunhofer Project Center / Fraunhofer Innovation Platform

- Project based
- **Joint applied research and acquisition**
- Working groups at Fraunhofer and partner location
- **Matched funding** by both partners **~€ 1 million** each
- **5 years**, extension possible

Fraunhofer Center

- **Institutionalized**
- Similar to a Fraunhofer institute
- Legal entity: **Fraunhofer foreign affiliate**
- Base funding from host country required
- **>5 years**

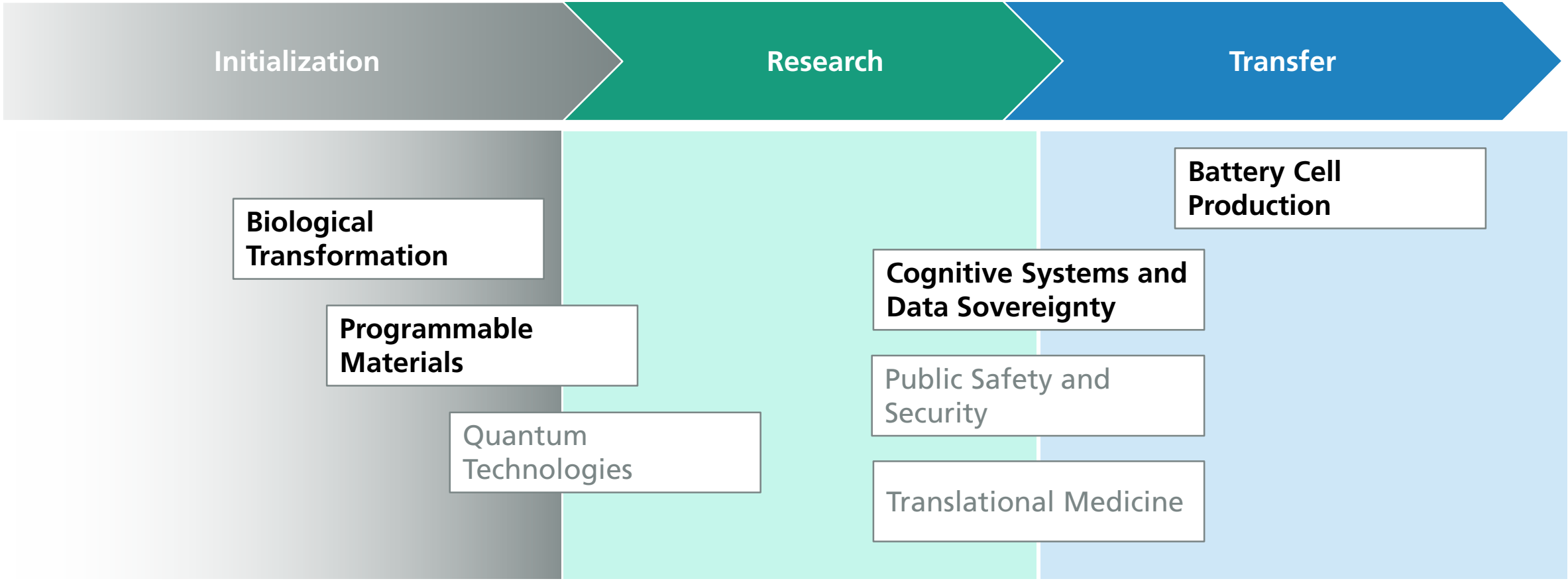
R&D projects with industrial and/or scientific partners abroad

- German Federal Ministry of Education and Research BMBF (e.g. **2+2 R&D Projects**)
- European Commission (e.g. **Horizon 2020**)
- contract research for customers from industry

R&D OF CLEAN ENERGY TECHNOLOGIES AT FRAUNHOFER

2 Fraunhofer strategic areas and energy R&D

Key Strategic Initiatives – Focus Topics



Fraunhofer pioneering sustainable energy system based on renewable energy

Energy generation

- **Solar thermal energy / Photovoltaics**
- Wind energy
- Bioenergy
- Hydropower
- Geothermal energy

Energy storage

- **Battery cells**
- Hydrogen / Fuel cells
- Mechanical
- Thermal
- Energy Harvesting

Energy efficiency

- **Efficient production technology**
- Mobility
- Interconnecting grids
- Energy conversion
- Energy distribution
- Energy usage

R&D OF CLEAN ENERGY TECHNOLOGIES AT FRAUNHOFER

1 Fraunhofer and international activities

2 Fraunhofer strategic areas and energy R&D

3 Research examples

4 Outlook

3. Research examples – energy generation

Multi-Junction Solar Cell: Record Efficiency of 34,1%

Challenges:

Highly efficient and **low-cost solar panels** for energy generation

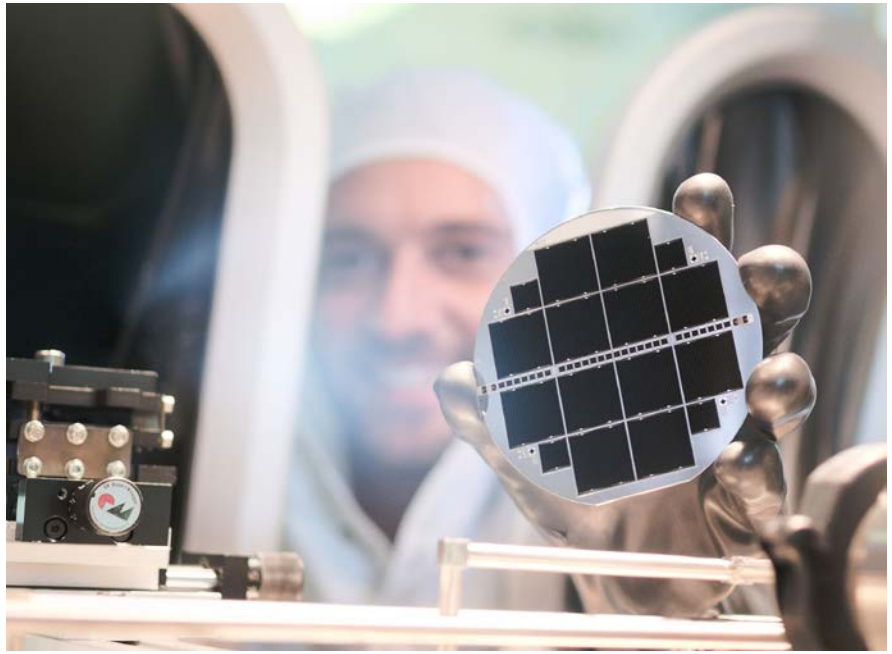
(former efficiency record of similar cells: 33.3%)

- Reduction of material consumption
- Reduction of required area
- Higher energy yield of sunlight

Solution:

Transfer of **0.002 mm thin semiconductor layers** onto silicon
by **wafer bonding** enables **highly efficient triple-junction solar cell**:

- Gallium indium phosphide (**visible light**)
- Gallium arsenide (**infrared light**)
- Silicon (light of **lower frequency**)



Triple-junction solar cells made of III-V semiconductors and silicon have the potential to raise photovoltaics to a new level of efficiency. Fraunhofer ISE

Further challenges:

- **Process optimization** to reduce manufacturing costs

3. Research examples – Energy storage

Solid state batteries for tomorrow's electric cars

Challenges:

Interface engineering for **sustainable high-performance batteries**

- **Quick** and **stable** charging/discharging cycle at **room temperature**
- **No** requirement for **flammable** liquid electrolytes
- **Size** and **weight reduction**

Research Goals:

International Collaboration to merge knowledge and expertise

- Development of **solid state electrolytes**
- Development of **nanostructured anode materials**
- Production of **thin film model electrodes** and **stable interface layers**
- Development, manufacturing and testing **prototypes of battery cells** for applications in:
  - Consumer electronics
  - Land and airborne mobility

At the Fraunhofer ISC, Würzburg, the complete process chain for the production of battery cells is available. Picture: © K. Selsam, Fraunhofer ISC

Project partner: Fraunhofer Institute for Silicate Research ISC and Empa (Switzerland)

3. Research examples – Energy efficiency

Alternative machine-tool structures for improving energy efficiency

Example: Bionic design – **Structural bionics, topology optimization**

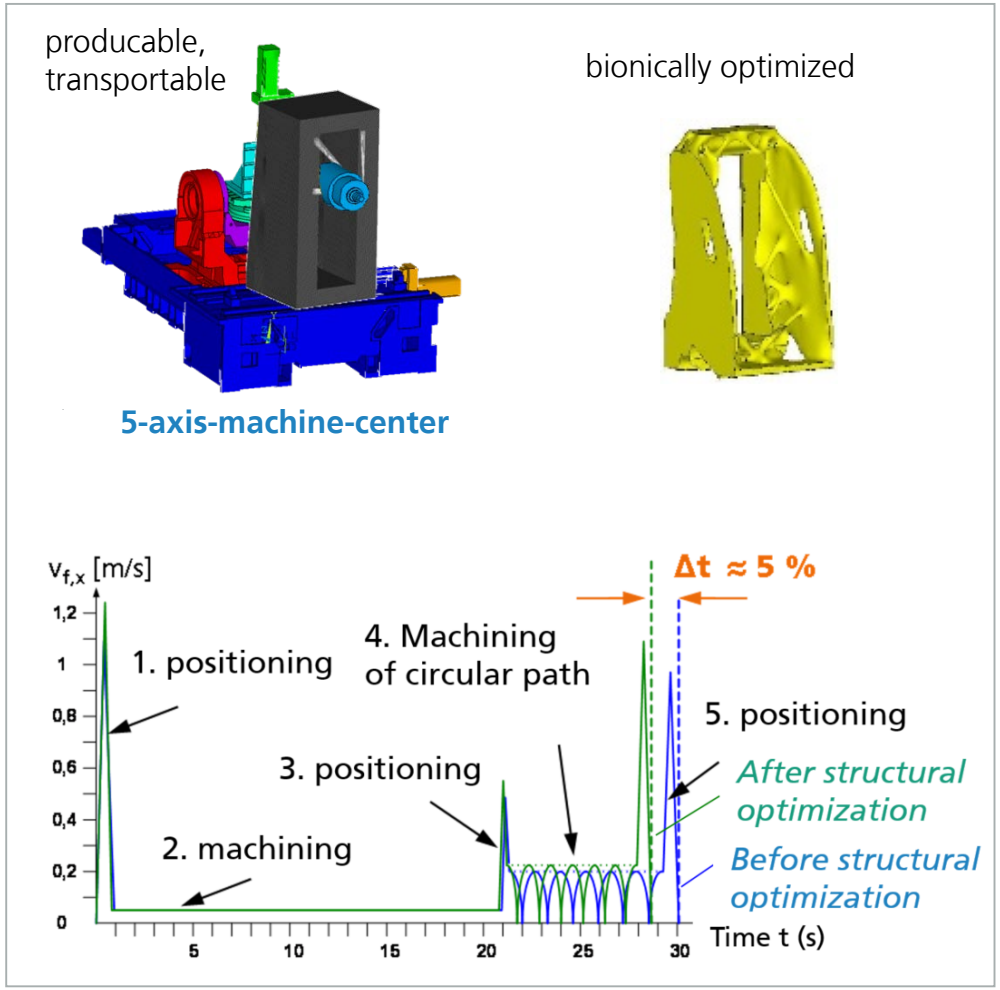
Advantages for sustainability Reduction of:

- **Mass** by **30 %**
- **Electrical loss** in power train by **42 %**
- **Cycle time** by **5 %**

  → Lowering of base load by reduction of machining time t_B

Further challenges:

- **Living topology** → load path dependent
- **Self-healing coatings** → tribology
- **Control algorithm** → swarm optimized



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3. Research examples – Energy efficiency

Most Efficient Data Center in the World "BodenTypeDC"

Challenges:

- **High energy consumption** of data centers
- **Increasing demand** by
  - Industrie 4.0,
  - IoT,
  - Machine Learning,
  - Big Data,
  - simulations etc.
- Reduction of **ecological impact** of computing

Solution:

Boden Type Data Center One

- Prototype plant with 500 kilowatts power consumption as experimental laboratory and demonstration center
- Realistic tests for huge volumes of data
- Utilization with 100% renewable power possible

Data centers should be energy-efficient and cost-effective
Image: © www.pexels.com

Image: www.pexels.com

Project funded by European Comission's Horizon 2020

Project partner: Boden Business Agency Sweden), EcoCooling (UK), Fraunhofer IOSB (Germany), H1 Systems (Hungary), RISE SICS North (Sweden)

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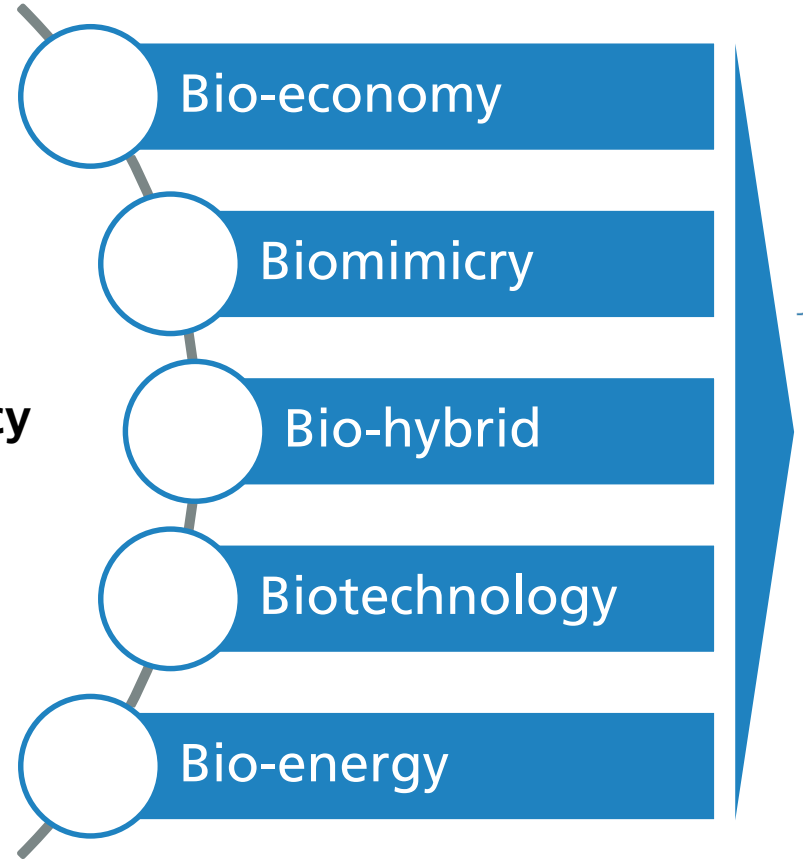
4. Outlook

Biological Transformation: A next level for resource and energy efficiency

Biological Transformation of Manufacturing Systems for improving resource and energy systems

Inspiration from biology for resource efficiency in technological applications



- Circular Economy
- Additive Manufacturing
- Swarms and self organization
- Integrated (bio)sensors
- Renewable microbial resources
- Cell-inspired factory-design
- Neuro-inspired computing
- Evolutionary design principles

4. Outlook

Central goals and challenges for a successful energy transition

Renewable energy sources	Ensure supply	synthetic energy sources	Sustainable transport	Energy-efficient buildings:	Less industrial emissions:	Energy transition:
New technology and faster development	More flexible consumption, controllable power plants	Develop technologies and markets	Increase of electric mobility and new technology mix	Comprehensive, and faster renovation	Use of efficiency, renewable energies and new processes	Holistic control and facilitating investments

Goals for Germany:

Energy generation:	Reduction of emissions:
2022: phase-out nuclear 2038: phase-out coal 2040: 65% electricity from renewables	2040: 70% less CO_2-emissions than 1990 Towards emission-free mobility, production and living

- **Global energy and environmental challenges** have to be **solved together**
- **Fraunhofer** is **pioneering** a **sustainable energy system** based on **renewable energies**
- Research on **clean energy** and **sustainable growth** requires **international cooperation**