Germany and China: The Race to the Next Technological Frontier

24\textsuperscript{nd} June 2021

- Introduction to Fraunhofer
- Sustainable Manufacturing
- Industry 4.0

Fraunhofer-Institute for Production Systems and Design Technology (IPK) Berlin

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The Fraunhofer-Gesellschaft at a Glance

Applied research of direct utility to private and public enterprise and of wide benefit to society

28,000 staff

74 institutes and research units

More than 70% is derived from contracts with industry and from publicly financed research projects

Almost 30% is contributed by the German federal and states governments

Major infrastructure capital expenditure and defense research

Finance volume

Contract research

2019
Intellectual Property Rights of Fraunhofer

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active patent families at year end*</td>
<td>6407</td>
<td>6625</td>
<td>6573</td>
<td>6762</td>
<td>6695</td>
<td>6874</td>
</tr>
<tr>
<td>Invention disclosures reports per year</td>
<td>733</td>
<td>736</td>
<td>670</td>
<td>798</td>
<td>756</td>
<td>734</td>
</tr>
<tr>
<td>Patent applications per year</td>
<td>603</td>
<td>563</td>
<td>506</td>
<td>608</td>
<td>602</td>
<td>612</td>
</tr>
<tr>
<td>Brands (New registrations)</td>
<td>55</td>
<td>55</td>
<td>56</td>
<td>48</td>
<td>42</td>
<td>47</td>
</tr>
</tbody>
</table>

* Portfolio of active rights (patents and utility models) and patent applications at year end.

2017: Fraunhofer

➔ **17th place** of the most active patent applicants and
➔ **8th place** among the most active trademark applicants at the DPMA

2018: Fraunhofer is one of the 100 largest applicants at the European Patent Office (rank 44)

2018: According to a study by the international group Clarivate Analytics, Fraunhofer is one of the »Top 100 Global Innovators«.
(3 other German companies: BASF, Bayer, Merck)
International Network

- 8 independent Fraunhofer affiliates
- Active with partners in approximately 80 countries
- Representative Offices and Senior Advisors worldwide leverage networks abroad
The Top 50 Technologies Driving Global Innovation and Commercial Growth

Environment and Sustainability
- Agriculture 4.0
- Battery Recycling Technologies
- Carbon Upcycling
- Clean Coal Technologies
- Next Gen Desalination Technologies

Information and Communication Technologies
- Augmented Analytics
- Cognitive Security
- ConvNets
- Extended Reality
- Fog Intelligence
- Hybrid Blockchain
- Platform-ization

Health and Wellness
- Biomanufacturing
- CRISPR Therapies
- Immuno-oncology
- Microbiome Enablers
- Multiomics
- Protein Engineering
- RNA Drugs

Energy and Utilities
- BIPV
- Digital Oil Fields
- Distributed Energy
- Grid Edge Energy Storage
- Thermal Energy Storage

Medical Devices and Imaging
- Electroceuticals
- Magnetic Resonance Elastography
- Molecular Radiotherapy
- Radiomics
- Telerobotic Surgery

Chemicals and Advanced Materials
- Advanced Ceramics
- “Clean” Ingredients
- High Performance Polymers
- Nanohybrids
- Self-healing Technologies
- Sustainable Packaging
- Ultra-metals

Microelectronics
- 5G Chipsets
- AI Accelerators
- GaNtronics
- Multi-core SoCs
- NVMe-oF

Advanced Manufacturing and Automation
- Automated Optical Metrology
- Cognitive Manufacturing
- Collaborative Industrial Robots
- Extreme Ultraviolet Lithography
- Metal 3D printing

Sensors and Instrumentation
- Millimeter Wave Sensors
- Printed Sensors
- Sensor Fusion
- Solid State LiDAR

Source: Frost & Sullivan

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INSTITUT PRODUKTIONSANLAGEN UND KONSTRUKTIONSTECHNIK
INSTITUT WERKZEUGMASCHINEN UND FABRIKBETRIEB
TECHNISCHE UNIVERSITÄT BERLIN
Sustainability – Selected Definitions

- “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”
  
  (Frequently referred to as the Brundtland report after Gro Harlem Brundtland, Chairman of the Commission)

- “Sustainable development involves the simultaneous pursuit of economic prosperity, environmental quality and social equity. Companies aiming for sustainability need to perform not against a single, financial bottom line but against the triple bottom line.”
  
  World Business Council on Sustainable Development
Overexploitation of Global Resources

- Today's human lifestyle far exceeds the earth's biocapacity
- The ecological footprint of industrialized countries is well above the global average of 1.75
- By far the largest area is accounted to carbon emissions

Source: Global Footprint Network, National Footprint Accounts 2019; URL: https://www.footprintnetwork.org/resources/data/Global_Footprint_by_fields
Global CO2 and Greenhouse Gas Emissions by Sectors

CO₂ Emissions by selected countries and groups

Sources of greenhouse gases broken down by economic sector

- Agriculture
- Construction and Industry
- Land use and Deforestation
- Transportation
- Households
- Others
- Electricity and Heat
- Chemical Processes

   Data: CAIT (2014) and CDIAC (2015)

Source: Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung. Aufbruch zu einer neuen Klimapolitik. Sondergutachten. 2019
Reasons for the Change of Co2-Emissions

- Increase in energy efficiency more than compensated by economic growth
- The oil crisis has reduced the carbon intensity, the coal renaissance has increased it again

Kaya Factors
- Human population
- GDP per capita
- energy intensity (per unit of GDP)
- carbon intensity (emissions per unit of energy consumed)

Source: Hilaire, Steckel based on IEA (2017) Data
Utilization of Processed Products

Value of manufactured goods, % of GDP (EU, 2012)

Low product utilization during productive life-time;
e.g. 2% for cars

Products only used 9 years on average
(28 years with buildings included)

After the first use cycle only 5% of the average
raw material value is recaptured

=> Effective Technologies for fostering Circular Economy are necessary

The Demand regarding Complexity
Order Specific Processes for Mass Production

Combination of Variants

One of a Kind Production in Serial

"Conveyor Belt Less" Production at Quattro GmbH for Audi

I would like to have this pump from the catalogue

but all rails should come from one sub-supplier and...

specific Parameters of assembly need to be documented for each pump.

110.338.690.475.432.439.829.762.481.848.320.000.000

Theoretical Variants to produce Audi A3
No Car has a twin in a time frame of a year

60.000 Pumps annually
Repetition Rate: 1,4

Source, Audi

Source, KSB AG

Source, Audi
**Individualization Index** – In particular in China the number of variants is increasing intensively, combined with expectations regarding realization time.

Example:
Truck Producer estimated for Chinese new Plant
Max: 60 Variants of Trucks

Today there are over 800 Variants and each Year there is an increase of 65 new variants.
Industrie 4.0
Challenges and Opportunities

The 4th industrial revolution leads to...

- Smart services
- Cloud computing
- Order-driven production
- Networked production
- New business models
- Cyber-physical systems
- Broadband infrastructure
- Leadership
- Qualification
- Changing work environments
- Human-machine interaction
- Vertical and horizontal integration
- Work organisation
- Big data
- Data sovereignty
- Smart factories
- Data protection

Source: Plattform Industrie 4.0: Shaping the digital transformation together
Sino-German Intelligent Manufacturing Research Institute - SGIMRI
German Engineering Excellence meets Chinese Speed

- Demonstration of possibilities in the field of industry 4.0
- Possibilities for strategical partners, to exhibit self created technologies and integrate those

- Change Management Training for the top und middle-management
- Interactive training in a industry 4.0 learning factory for operational staff

- Prototype development of industry 4.0 – solutions for production
- Fast integration of German technologies in Chinese applications
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