

Energy Research at Fraunhofer

Prof. Dr. Hans-Martin Henning

Fraunhofer-Gesellschaft

1. Introduction

The energy supply structure in Germany is undergoing a comprehensive transformation process towards ambitious renewable energy and climate policy goals:

- 2022: Shutdown of the last nuclear power plant
- 2025: 40-45% share of renewable energy on electricity consumption; 2040: 65%
- 2030: 55% reduction of greenhouse-gas emissions compared to 1990; 2040: -70%
- 2038: Shutdown of the last coal-power plant

Regarding the definition of clean energy, Fraunhofer is orienting itself on the rationale of the German government. “Clean energy” are energy forms that do not harm the environment, especially in regard to greenhouse-gasses and other harmful emissions (e.g. radioactive material). The vision of Fraunhofer is to shape the transformation towards an economically, environmentally friendly, secure and socially accepted energy supply for electricity, heat and mobility.

As the largest research organization for applied research in Europe and a leading international organization for applied energy research, the Fraunhofer-Gesellschaft develops innovative technologies and solutions for the successful transformation of the energy system towards clean energy applications.

2. R&D activities related to clean energy technology

Our work covers the entire value-added process — from new ideas and concepts to the development of new technologies, processes and systems, quality assurance and market implementation support. Thus, customers from economy as well as public clients are supported in the successful transformation of the energy system.

Fraunhofer clean energy related research topics span a wide field, which includes energy generation (especially solar and wind), hydrogen technologies, material science, R&D for improving the energy grid, intelligent energy management and load balancing, energy storage (including batteries and power-to-X), energy efficiency and energy harvesting.

The Fraunhofer-Gesellschaft has an “Energy Alliance” consisting of 19 Fraunhofer institutes with more than 2,000 scientists, which deal with different topics in the field of energy R&D. The areas of business and competences include:

- Renewable energy
- Energy systems
- Energy efficiency

- Energy storage
- Urban energy applications
- Digital energy management

The decentralized structure of the Fraunhofer-Gesellschaft enables to quickly take up new topics and developments and to develop solutions in close cooperation with customers.

3. Specific research activities in next generation energy management systems with batteries, renewable energy, hydrogen, CCUS, and related technologies

Selected project examples:

- Carbon2Chem (2016-2024, 74 million €): Brings together the energy, steel and chemical industries to form a cross-industry production network. The hydrogen synthesis process plays a key role, as hydrogen is required for almost all subsequent synthesis routes. In this project Fraunhofer co-operates with institutes of the Max-Planck-society and other partners.
- HYPOS - Hydrogen Power Storage & Solutions East Germany (2018-2020, 45 million €): One of the ten innovation projects of the "2020 - Partnership for Innovation" funding initiative launched by the German Federal Ministry of Education and Research (BMBF). The objective of the project is the production, storage, distribution and broad application of green hydrogen in the chemical and refining industry, mobility and energy sectors.
- SALCOS (2017-2020): SALCOS® focuses on the primary avoidance of CO₂ formation in the steel production process through research innovative process technologies. Specialists from a large German steel producer are working together with Fraunhofer Institutes and other partners on integrated the new technologies into smelting plants.
- Research Fab Battery Cells (2019-2023, 140 million €): The Research Fab Battery Cells supports industrial partners and customers in the implementation of new battery cell concepts and the development of advanced production processes. The institutes of the Fraunhofer-Gesellschaft, the MEET of the University of Münster and the PEM Chair of the RWTH Aachen University are working together for this aim.
- Fraunhofer Research Cluster Integrated Energy Systems CINES (2019-2021, 10 million €): This cluster addresses central technological and economic challenges of the energy revolution. This includes comprehensive, cross-sectoral energy system analyses, digital solution models for the system integration of new technologies and decisive advances in electrolysis.
- Kopernikus project Ariadne (2020-2023, 30 million €): The aim of the project is to better understand the impact of various policy instruments in order to develop socially sustainable energy system transformation strategies. From the very beginning, political decision-makers, business representatives and citizens will be involved through a large-scale dialogue process. Here, Fraunhofer collaborates with many other R&D institutes; the project is managed by the Potsdam Institute for Climate Impact Research.

4. International collaboration

4-1 International alliance/networking development

The Fraunhofer-Gesellschaft cooperates with legally independent Fraunhofer affiliates in

Europe, North and South America and Singapore. Representative Offices and Senior Advisors worldwide form a bridge between the local markets and the Fraunhofer Institutes. Their activities are focused on marketing and business expansion. The Fraunhofer Brussels office serves as a platform for dialog with European policy makers, with the additional functions of issuing public/official statements and providing information services.

Fraunhofer holds Memoranda of Understanding with a broad range of research institutes, companies and organizations around the world.

Selected international collaborations:

- **Global Alliance for Solar Energy Research Institutes (GA-SERI):** Together with AIST and the National Renewable Energy Laboratory NREL (USA), Fraunhofer is member of the GA-SERI. This is an international group of scientific experts, which since 2016 discusses challenges related to the use of photovoltaics and other key technologies such as hydrogen to achieve global climate goals.
- **Fraunhofer Innovation Platform for the Water-Energy-Food Nexus at Stellenbosch University:** Stellenbosch University and the Fraunhofer-Gesellschaft have established a Fraunhofer Innovation Platform as part of a strategic partnership. The objective of this long-term cooperation is to jointly develop tailored technological and cross-sectoral solutions for water, energy and food security – for the benefit of people and the environment.
- **Fraunhofer Chile Research – Centro para Tecnologías en Energía Solar (FCR-CSET),** Santiago, Chile: Research in the field of solar generation of electricity, thermal solar energy, water purification and process heat.
- Among other memberships, Fraunhofer is a member of the European Research Alliance (EERA), the European Technology and Innovation Platform (ETIP) and the Association of European Renewable Energy Research Centers (EUREC).

4-2 International joint R&D activities

Selected international R&D activities:

- **AtaMoS-TeC:** photovoltaic technologies for the exceptional conditions of the Atacama Desert (Fraunhofer and Solar Energy Research Center (Chile))
- **CPV-India:** Concentrator Photovoltaics Targeted for highly efficient power production in India (Fraunhofer and NTCP NETRA (India))
- **AFLOAT:** Demonstration of high survivability cost competitive floating offshore wind (FOW) technology (Fraunhofer together with companies and research institutions from Ireland, France, Netherlands)
- **REStable:** Improvement of regenerative-based power grid systems and services (Fraunhofer together with companies and research institutions from France and Germany)
- **Solid State Battery (ICON Project:** Fraunhofer and EMPA (Switzerland))
- **DEKADE:** novel catalyst systems, electrodes and membranes are developed for automotive fuel cell applications (Fraunhofer and National Research Council, University of British Columbia and Simon Fraser University, Vancouver (Canada))

Furthermore, Fraunhofer is involved in many other international projects, for example Horizon 2020 projects.

5. Future perspectives (beyond 2030)

In order to reach Germany's ambitions renewable energy and climate goals, technological innovations are necessary, that also include new technologies for electricity grids, load management, energy storage and carbon recycling.

A meta-analysis of several German energy-related studies has identified the following major challenges for a successful energy transition in Germany, which also include societal and economic issues:

- Renewable energy technologies need to be developed and implemented faster
- Energy Consumption and power plant management need to get more flexible in order to ensure supply
- A new technology mix in transportation/mobility is necessary
- A comprehensive, energy-efficient and faster renovation of buildings must take effect
- Further reduction and avoidance of industrial emissions with more energy efficiency, renewable energies use and new processes is required
- A holistic control of the energy transition to facilitate investments is important
- Positive economic and societal conditions and incentives need to be conveyed

In the long term, a mayor challenge will be to achieve closed material cycles for all key technologies of a sustainable energy system. This has a substantial impact on the whole value chain of components and devices including a design and production that enables a maximum regeneration of involved materials.