Fraunhofer Institute for Solar Energy Systems ISE

Director:
Prof. Eicke R. Weber

Staff: 490

Budget: 32.5 Mio EUR (2006)

Founded: 1981
Fraunhofer Gesellschaft

- leading organisation for applied research in Germany
- conducts commissioned research for the industrial, tertiary and public sector
- prepares readily applicable solutions to technical and organisational problems for private-sector clients, rapidly and cost-effectively
- 58 research institutes at 40 locations in Germany
- affiliate institutes in Europe, the USA and in Asia
- 12,500 employees, the majority of whom are qualified scientists and engineers
- annual research budget of around 1 billion Euro
Exemplary path, global primary energy

- geothermal
- other renewables
- solar thermal (heat only)
- solar power (PV and solar thermal generation)
- wind
- biomass (advanced)
- biomass (traditional)
- hydroelectricity
- nuclear power
- gas
- coal
- oil

![Graph showing energy consumption over time](graph.png)
Reasons for the installation of a global sustainable energy system

- Protection of the natural life-support system
- Eradication of energy poverty in developing countries
- Promote peace by reducing dependence upon oil reserves
Sustainable potentials of selected renewable energy sources, examples

- modern biomass: 100 EJ/a
- wind: 140 EJ/a
- hydro: 15 EJ/a
- solar: quasi unlimited

* higher potential with extensive off-shore wind energy conversion

Source: German Advisory Council on Global Change (WBGU), 2003, www.wbgu.de
## Personnel Fraunhofer ISE

<table>
<thead>
<tr>
<th>Department</th>
<th>Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research and Development</td>
<td>116</td>
</tr>
<tr>
<td>Commercial and Technical Services</td>
<td>28</td>
</tr>
<tr>
<td>Press and Public Relations</td>
<td>4</td>
</tr>
<tr>
<td>Doctoral Students *</td>
<td>54</td>
</tr>
<tr>
<td>Diploma Students*</td>
<td>45</td>
</tr>
<tr>
<td>Scientific Assistants, Practical Trainees, etc.</td>
<td>173</td>
</tr>
<tr>
<td><strong>Sum of the Employees</strong></td>
<td><strong>420</strong></td>
</tr>
</tbody>
</table>

*some with contracts at universities
Revenue structure Operation 2006

Operation: 28,0 Mio Euro
Investment: 4,5 Mio Euro
Total: 32,5 Mio Euro

Industry 36%
Federal Government Projects 33%
Regional Government Projects 1%
European Union 7%
Others 3%
Special Programs, FhG 5%
Basic Funding* 15%

* 90% Federal Government
  10% Regional Government
Development total budget

- Investment costs
- Operational costs

* ohne Investitionsprojekt Gelsenkirchen (2,7 Mio. Euro)
** ohne Erstausstattungsinvestitionen Neubau
*** ohne BMU Investitionsprojekt PV-TEC (10,7 Mio. Euro)
Fraunhofer ISE Areas of Business

Buildings and Technical Building Services

Optical Components and Systems

Solar Cells

Off-Grid Power Supplies

Grid-Connected Renewable Power Generation

Hydrogen Technology
Buildings and Technical Building Components

Building Concepts, Simulation and Control

Façades and Windows

Heating, Ventilation and Air-conditioning Technology

Solar Thermal Systems

Monitoring and Demonstration Projects

Natural vein structures (as in leaves or blood vessels) for solar absorbers

Lighting Technology
Energy Demand Residential Buildings

End Energy Use in kWh/m²a

- Old
- Code 1995
- EnEV 2002
- 3-Liter House
- Passive house
- PV

- Heating
- Hot water
- Elec. for ventilation
- Personal use

With solar systems
Zero emission

End Energy Use in kWh/m²a

0 50 100 150 200 250 300

Fraunhofer ISE
Institut Solare Energiesysteme
Heating, Ventilation and Air-conditioning technology

Technology for energy efficient residential buildings

- Simulation
- Technology development
- Test stand
Technology Development

Compact ventilation device and electrical heat pumps for solar passive houses

Industry Partners
- Maico
- EnBW
Building Concepts and Simulations

Energy efficiency and solar technology in commercial buildings

www.solarbau.de
Primary Energy Saving: Offices

Primary Energy Equivalent in kWh/m²a

Artificial Light
Air Conditioning
Cooling
Heating
Total 85 kWh/m²a

Conventional Buildings
New Fraunhofer ISE building
Need
Supply

Fossil Energy
PV

Primary Energy Saving: Offices
Facades and Windows

Development of energy-efficient sunshade systems

»s_enn«, Clauss Markisen
Solar Thermal Systems

Biometric approach to optimise the energy efficiency of absorbers for solar collectors
Ventilation and Air-Conditioning Technology

IHK Südlicher Oberrhein, Freiburg
First autonomous solar air-conditioning system in Germany
First autonomous solar air-conditioning system in Germany

Function

Solar Air Collector

Sorption Wheel

Heat Exchanger

Heater

Humidifier

warm, humid

cool, dry
Latent Heat Storage for Air-Conditioning

Plaster with PCM
(phase change materials)
Testing Center Solar Thermal Systems

DIN CERTCO certified according to European standards EN 12975
Optical Components and Systems

Facades and Windows

Solar Thermal Systems

Solar Power Plants

Lighting Technology

Display Technology

Nano-structured test substrate for organic photodetectors
Facades and Windows

Gaschromic switchable windows
Solar Thermal Power Plants

Absorber for solar thermal power plants

Sputtering
Solar Thermal Power Plants - Technologies

Solar Tower (California 10 MWₑ)

Dish-Stirling (Almería à 10 kWₑ)

Parabolic Systems (Californien 30-80 MWₑ)

Fresnel Collector (Belgium, Prototype)
Optically Functional Surfaces

Micro-structures on large areas (up to 120x120 cm²) produced with interference lithography
Optically Functional Surfaces

»Moth eye structures« for anti-reflective surfaces
Solar Cells

- Crystalline Silicon High-Efficiency Solar Cells
- Crystalline Silicon Thin-Film Solar Cells
- Solar Cells Production Technology
- III-V Solar Cells and Epitaxy
- Dye Solar Cells and Organic Solar Cells
- Characterisation of Solar Cells and Materials
- Wafer Technology
- Photovoltaic Modules

Photovoltaics Technology Evaluation Center PV-TEC
Monocrystalline Silicon Solar Cells

Highly efficient thin (100-150 μm) and ultra thin (<50μm) flexible crystalline silicon solar cells
Multicrystalline Silicon Solar Cells

World record efficiency 20,3%

July 2004
Photovoltaic Modules

Development of new module concepts to increase long-term reliability
III-V Solar Cells and Epitaxy

FLATCON® Modules

Fresnel Lens All-Glass Tandem Cell Concentrator
Dye Solar Cells

- Base Line Test Cells with $\eta=7\%$
- Sealing Techniques with Glass Solder
- Module 30 cm x 30 cm
- Integration in Façades

Fraunhofer Institut Solare Energiesysteme
Organic Solar Cells

Close cooperation with Freiburger Materialforschungszentrum
Photovoltaics Technology Evaluation Center PV-TEC

Accelerated technology transfer

Service center for producers:
- wafers
- solar cells
- modules
- production equipment
Off-grid Power Supplies

Systems for Grid-independent Electricity Supplies

Power Electronics and Controls Technology

Electric Storage Systems

Micro-Energy Technology: Fuel Cells, Device-integrated Solar Cells, Thermophotovoltaics

Rural Electrification: partly automated data acquisition programs for PV power supply for villages

Distributed Water Purification
Systems for Grid-Independent Electricity Supply

Rappenecker Hof
21st century
Systems for Grid-Independent Electricity Supply

Rappenecker Hof

Fuel Cell
Systems for Grid-Independent Electricity Supply

Rural electrification:
including socio-economic aspects

Solar home system in Argentina

PV pumping station for drinking water in Morocco
Systems for Grid-Independent Electricity Supply

Water Pumping and Purification System
Fraunhofer ISE and Solar-Fabrik Freiburg

Drinking water purification
Grid-connected Renewable Power Supply

Distributed Generation

Power Electronics and Controls Technology

Electric Storage Systems

Monitoring and Demonstration Projects

Solar Power Plants

Quality assurance for PV systems
Technical management allows economical and energy saving use of electricity production and storage.
Power Electronics and Control Systems

Platform for next generation inverters
Monitoring and Demonstration Projects

Quality assurance for PV systems

- yield measurement
- module measurement
- system inspection
- monitoring system quality
Hydrogen Technology

Membrane Fuel Cell Systems and Hydrogen Generation

Micro-Energy Technology: Fuel Cells, Device integrated Solar Cells, Thermophotovoltaics

Direct methanol fuel cell system
up to $35 \ W_{el}$
Reforming

APU (Auxiliary Power Units) for application in cars, boats or aircrafts

Kerosene reformer
Fuel Cell Systems

Prototype of a fuel cell system for professional TV camera

Fraunhofer Institut Solare Energiesysteme
Fuel Cell Systems

Planar Fuel Cell

PEM fuel cell stack
Outdoor applications