Emerging Energy Technologies  Powering the energy transition with Bosch Fuel Cell technology

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Our industry segments & strategic focal areas

- Mobility Solutions
- Industrial Technology
- Consumer Goods
- Energy & Building Technologies
- Economical
- Social
- Ecological
- Electrification & de-fossilization
- Vehicle transformation
- AIoT
- CO₂ neutrality
- CO₂ neutrality
Our company in figures*

- **78.7** billion euros sales revenue
- **3.2** billion euros EBIT
- **402,600** Bosch associates worldwide at year-end (approx.)
- **440** subsidiaries and regional companies in more than 60 countries
Global mega trends
Balancing rising energy demand and climate change

Urbanization
Electrification of mobility
Digitalization
Transformation factors
Paving the way to a sustainable future

Decentral solutions
Grid reliability
Clean energy carriers
Energy efficiency
Hyper scaling demand for green hydrogen
Bosch and the hydrogen economy

PRODUCTION

TRANSPORT & STORAGE

USAGE

*PEMEL = Proton exchange membrane electrolysis; **SOFC = Solid Oxide Fuel Cell; ***PEMFC = Polymer electrolyte fuel cell
We believe in fuel cell technologies

- **€1BN** investments in mobile fuel cells by 2024
- About **50 SOFC** systems in internal and external pilot operation
- About **700** associates work in SOFC team by the end of 2022
- Decentralized SOFC fuel cells: investment of **€500M** by 2024
- Investment of **€500M** in hydrogen electrolysis by 2030
- **6** SOFC manufacturing sites, offices and test labs

Investments by Bosch
Bosch fuel cell portfolio

<table>
<thead>
<tr>
<th>Type</th>
<th>Mobile fuel cell</th>
<th>Stationary fuel cell</th>
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<tbody>
<tr>
<td>Fuel</td>
<td>Hydrogen</td>
<td>Biomethane</td>
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<tr>
<td></td>
<td></td>
<td>Natural gas</td>
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<tr>
<td>Power per module</td>
<td>Up to 130 kW</td>
<td>10 kW up to several MW</td>
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SOFC: Complete value stream covered at Bosch
Impressive performance

- **10 kW_{el}** Nominal AC power
- > 60% AC net electrical efficiency
- \( \approx 4.2 \text{ kW}_{th} \) Thermal power dependent reclamation method
- \( \approx 25\% \) Thermal net efficiency
- \( \approx 85\% \) Total net efficiency when reclaiming heat

**Energy Independence**
Resilient localized power generation reducing dependence and loading on the grid.

**High Grade Heat**
High exhaust temperatures of \( \approx 230\^\circ\text{C} \) provide flexible usage of heat.

**Flexible Integration**
By design the module can fit many different applications.

**Fuel Flexible**
Can run on natural gas, biomethane, hydrogen or a blend.

A stack of several hundred cells – the heart of the unit

- 1. Recirculation Fan
- 2. Heat exchanger
- 3. Inverter
- 4. Reforming
- 5. Inverter

![Image of fuel cell system](image-url)
Impressive features

- **Modulating**
  30–100% of power output

- **Flat Efficiency Curve**
  While modulating - no reduction in efficiency

- **CO₂ Reduction**
  Up to 50% reduction vs natural gas ICES and zero when running on H₂. No carbon emissions from oil

- **Low Maintenance**
  Once per year. Few moving parts, no oil or urea needed. Leads to greater uptime.

- **Connected Device**
  Cloud connected benefits such as, FOTA, SOTA updates, remote monitoring, diagnostics and predictive maintenance become possible

- **AC/DC Power**
  DC power modules allow for greater flexibility in applications

- **Fuel Flexible**
  Natural gas, biomethane or hydrogen or a blend of fuels

- **Near Emission-free**
  Near zero NOx, SOx and particulate matter without exhaust after-treatment

- **Low Noise & No Vibrations**
  Without the need for acoustic equipment or dampeners

- **Greater Power Availability**
  Through cascading modules total system downtime is reduced. Lower single point of failure nodes

Performance characteristics subject to change anytime without notice due to ongoing development.
Fit for the future
Meeting demands with combined power and heat

State of the art today:
Combined heat and power (CHP)

Increasing power demand
- Electrification of city life
- Electrification of mobility
- Digitalization in industry and private sector

Decreasing heat demand
- More efficient house heating thanks to better insulation
- Utilization of heat pumps

Impacts of global mega trends

New technology for the future:
Combined power and heat (CPH) = SOFC

SOFC providing optimal fit for future power and heat demand in buildings
Transformation towards H₂

SOFC powered today

- Biomethane/Ecogas
- Natural gas
- Significant reduction of CO₂ emissions
- Close to zero NOₓ emissions

Utilization of a natural gas & H₂ mixture

- Biomethane/Ecogas
- Natural gas
- Hydrogen
- Massive reduction of CO₂ emissions
- Close to zero NOₓ emissions

Utilization of renewable H₂

- Hydrogen
- No CO₂ emissions
- Close to zero NOₓ emissions
SOFCs Digital Twin – collecting and semantically linking data

- **Integration** with energy management systems
- **Faster product development**
- **Predictive** maintenance and services & **remote** monitoring and diagnostics
- **Improvement** of manufacturing processes & **optimization** of plant operation
- **FOTA & SOTA** updates
Applications and pilot projects

Wide range of applications

Buildings & urban quarters

Industries

Data centers

Bamberg

Stadtwerke Bamberg

Feuerbach

H₂ hub Homburg

Renningen

Salzgitter

Schwieberdingen

Telekom Berlin

Wernau
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