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

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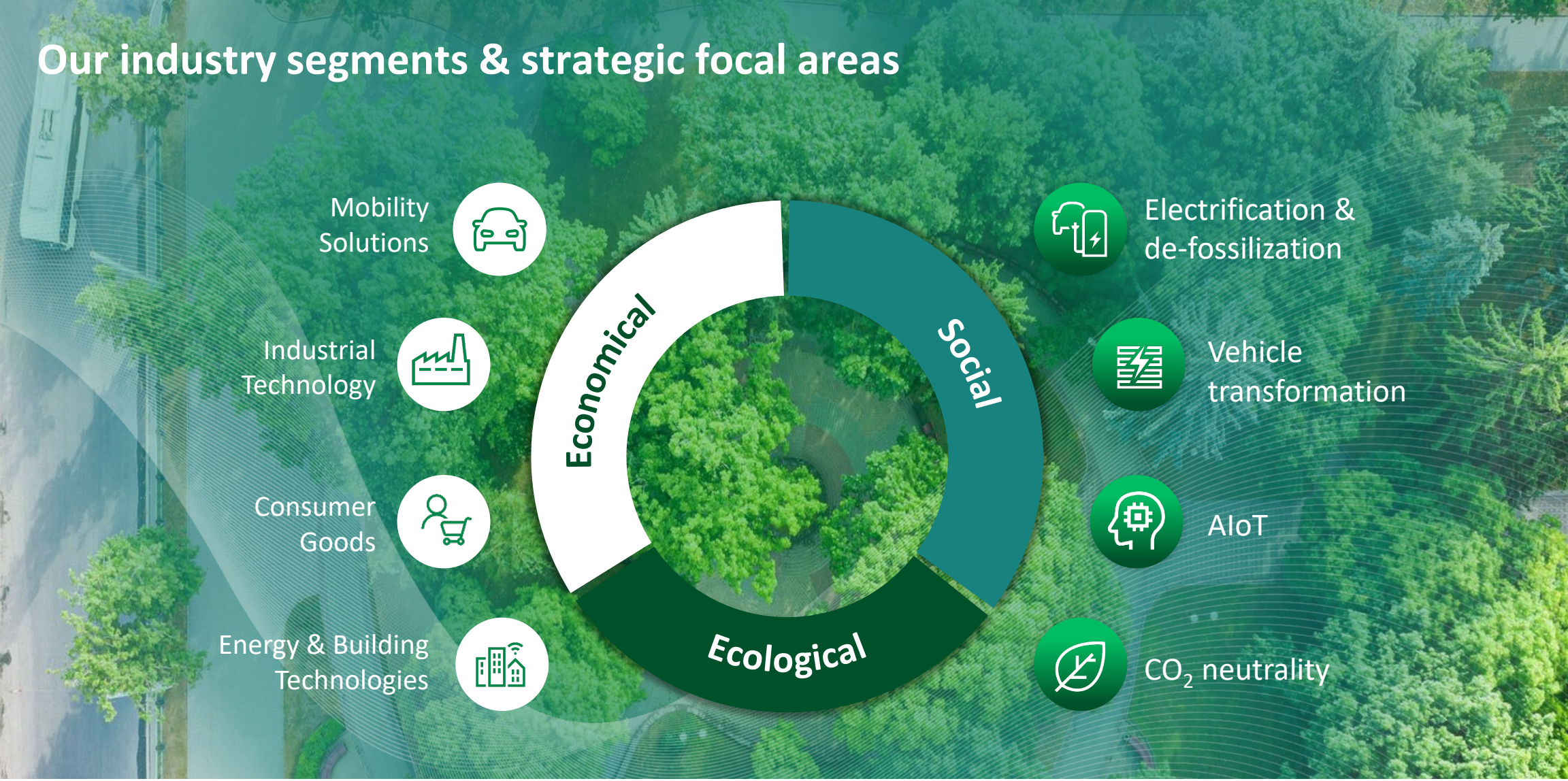
Our industry segments & strategic focal areas



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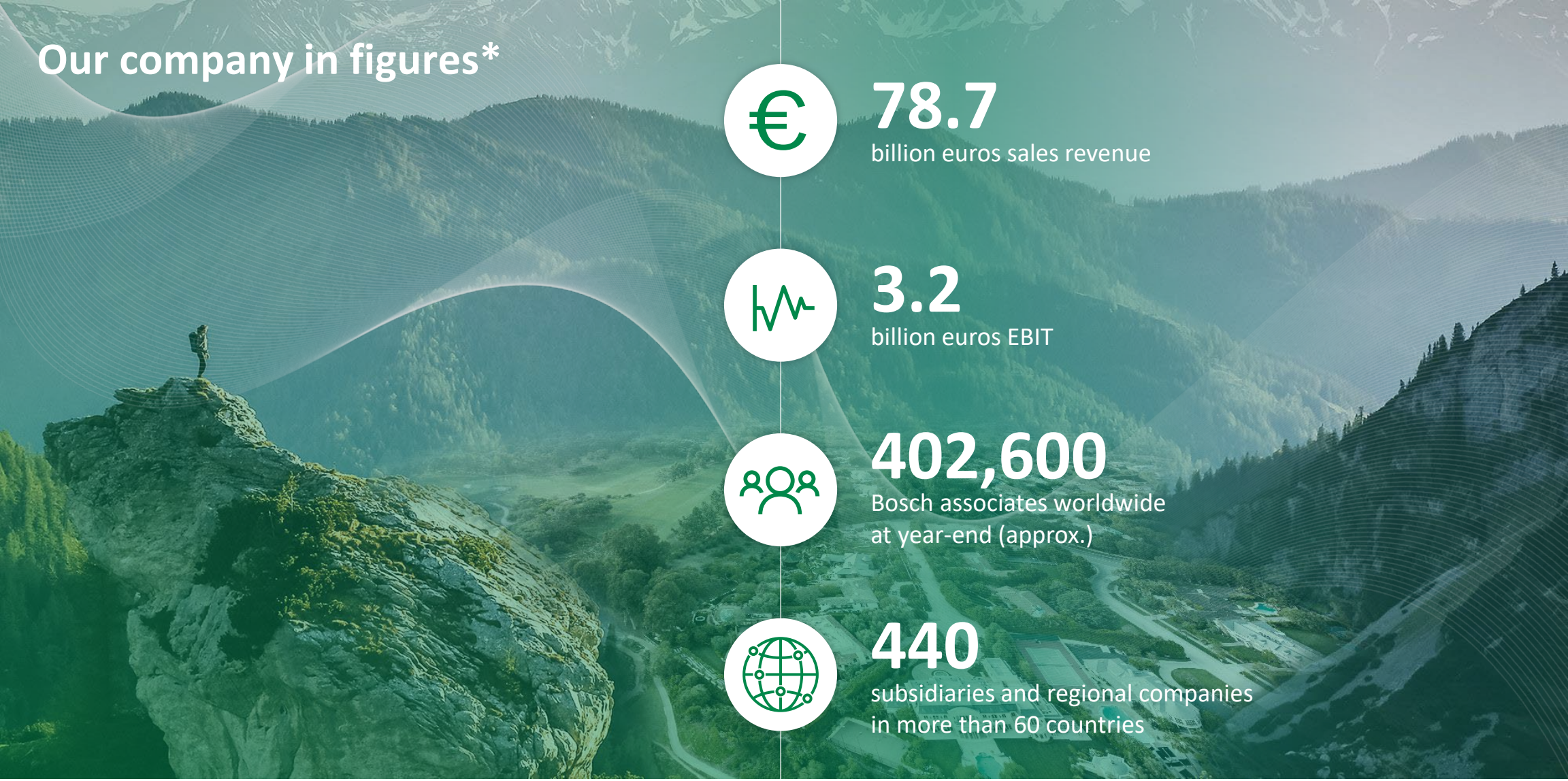
Our company in figures*



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

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Global mega trends
Balancing rising energy demand and climate change

Optional 13

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Transformation factors

Paving the way to a sustainable future

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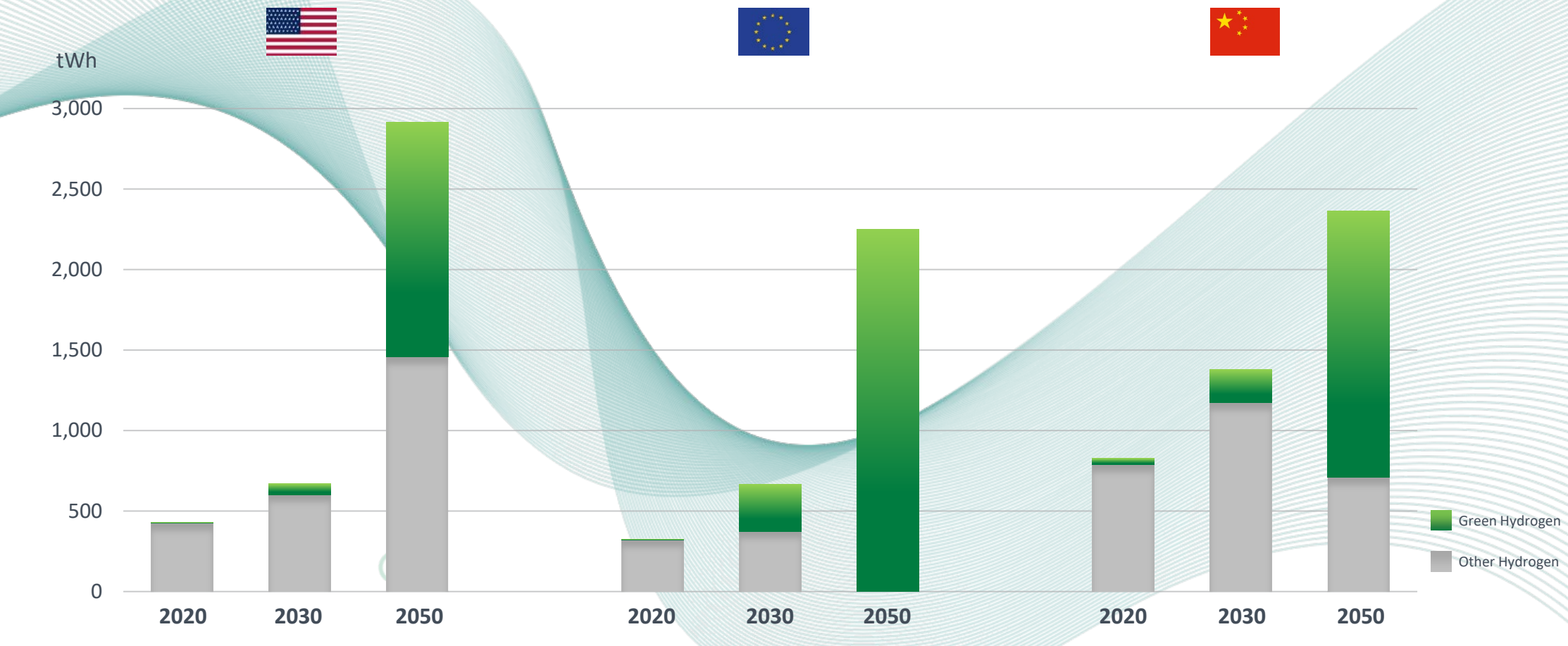
Hyper scaling demand for green hydrogen



Sources: Department of Energy (US), H_2 strategy (EU), Five-year plan 2021 (CN)

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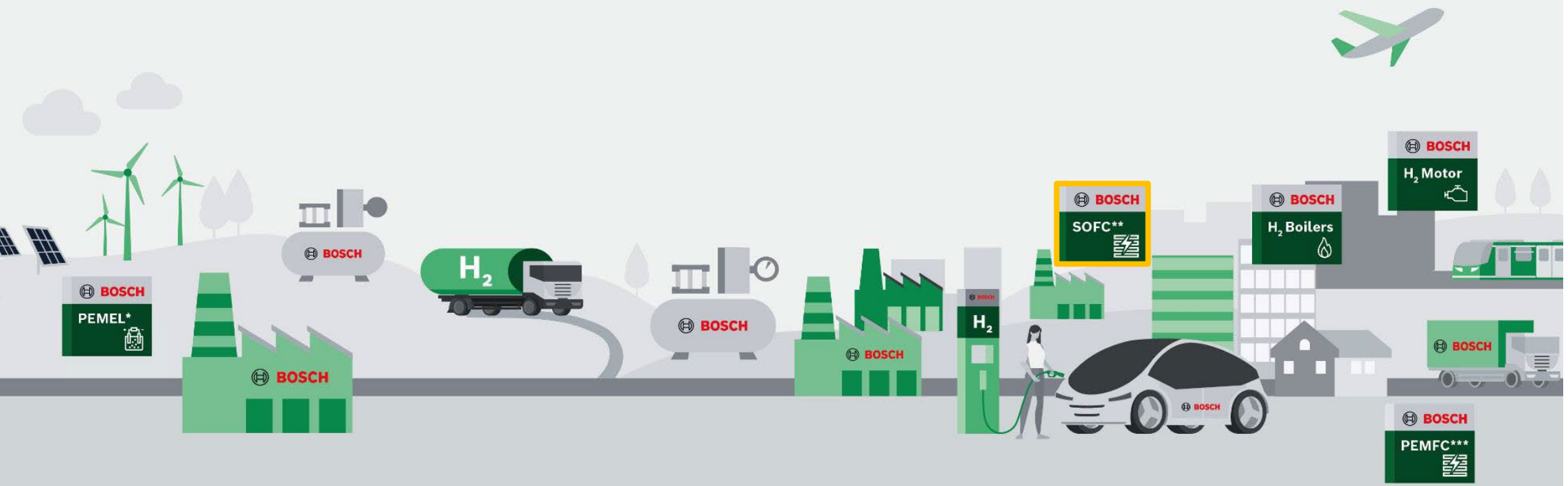
Bosch and the hydrogen economy



PRODUCTION

TRANSPORT & STORAGE

USAGE

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

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We believe in fuel cell technologies

Investments by Bosch

€1BN
investments in mobile fuel cells by 2024

Decentralized SOFC fuel cells: investment of
€500M
by 2024

Investment of
€500M
in hydrogen electrolysis by 2030

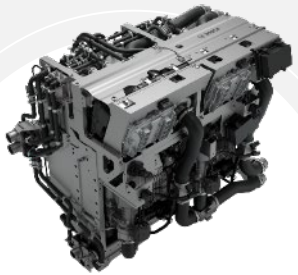
Partner-ships

About
50 SOFC
systems in internal and external pilot operation

6
SOFC manufacturing sites, offices and test labs

About 700
associates
work in SOFC team by the end of 2022

Bosch fuel cell portfolio



Polymer electrolyte membrane fuel cell (PEMFC)

Automotive

Data centers

Buildings & urban quarters

Solid oxide fuel cell (SOFC)

Industries

Wide range of applications

Type	**Mobile fuel cell**	**Stationary fuel cell**	
Fuel	**Hydrogen**	**Biomethane**	**Natural gas**
Power per module	**Up to 130 kW**	**10 kW up to several MW**	

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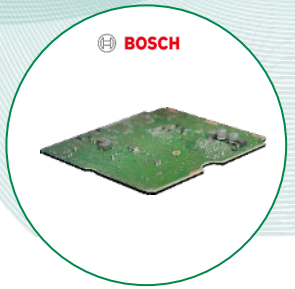
SOFC: Complete value stream covered at Bosch

Cell

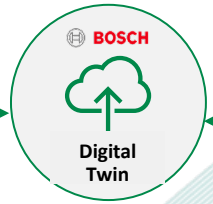
Stack

Hotbox



Control unit

Unit



Decentralized energy supply system

* Bosch focus on industrialization
Ceres focus on development

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Impressive performance

1. A stack of several hundred cells – the heart of the unit
2. Recirculation Fan
3. Reformer
4. Heat exchanger
5. Inverter

- **10 kW_{el}** Nominal AC power
- **> 60 %** AC net electrical efficiency
- **≈ 4.2 kW_{th}** Thermal power dependent reclamation method
- **≈ 25 %** Thermal net efficiency
- **≈ 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 ≈230°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.

Performance characteristics subject to change an anytime without notice due to ongoing development.

Impressive features

Modulating
30–100% of power output

Flat Efficiency Curve
While modulating - no reduction in efficiency

CO_2 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

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Fit for the future

Meeting demands with combined power and heat

State of the art **today**:

Combined heat and power (CHP)

Main output: heat

Impacts of global mega trends

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

New technology for the **future**:

Combined power and heat (CPH) = SOFC

Main output: electricity

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

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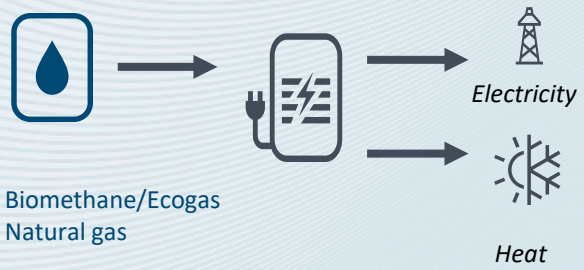
Transformation towards H_2

SOFC powered today



Significant reduction of CO_2 emissions

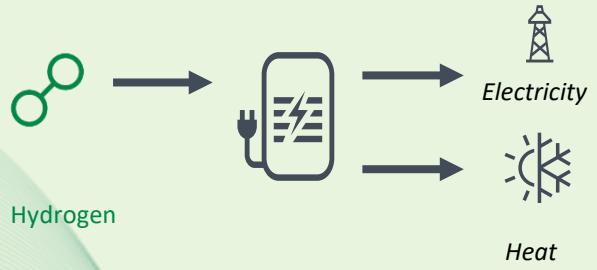
Close to zero NO_x emissions

Utilization of a natural gas & H_2 mixture

Massive reduction of CO_2 emissions

Close to zero NO_x emissions

Utilization of renewable H_2



No CO_2 emissions

Close to zero NO_x 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

Buildings & urban quarters

Industries

Data centers

Wide range of applications

Bamberg

Stadtwerke Bamberg

Feuerbach

H_2 hub Homburg

Renningen

Salzgitter

Schwieberdingen

Telekom Berlin

Wernau

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