Energy-efficient into the future

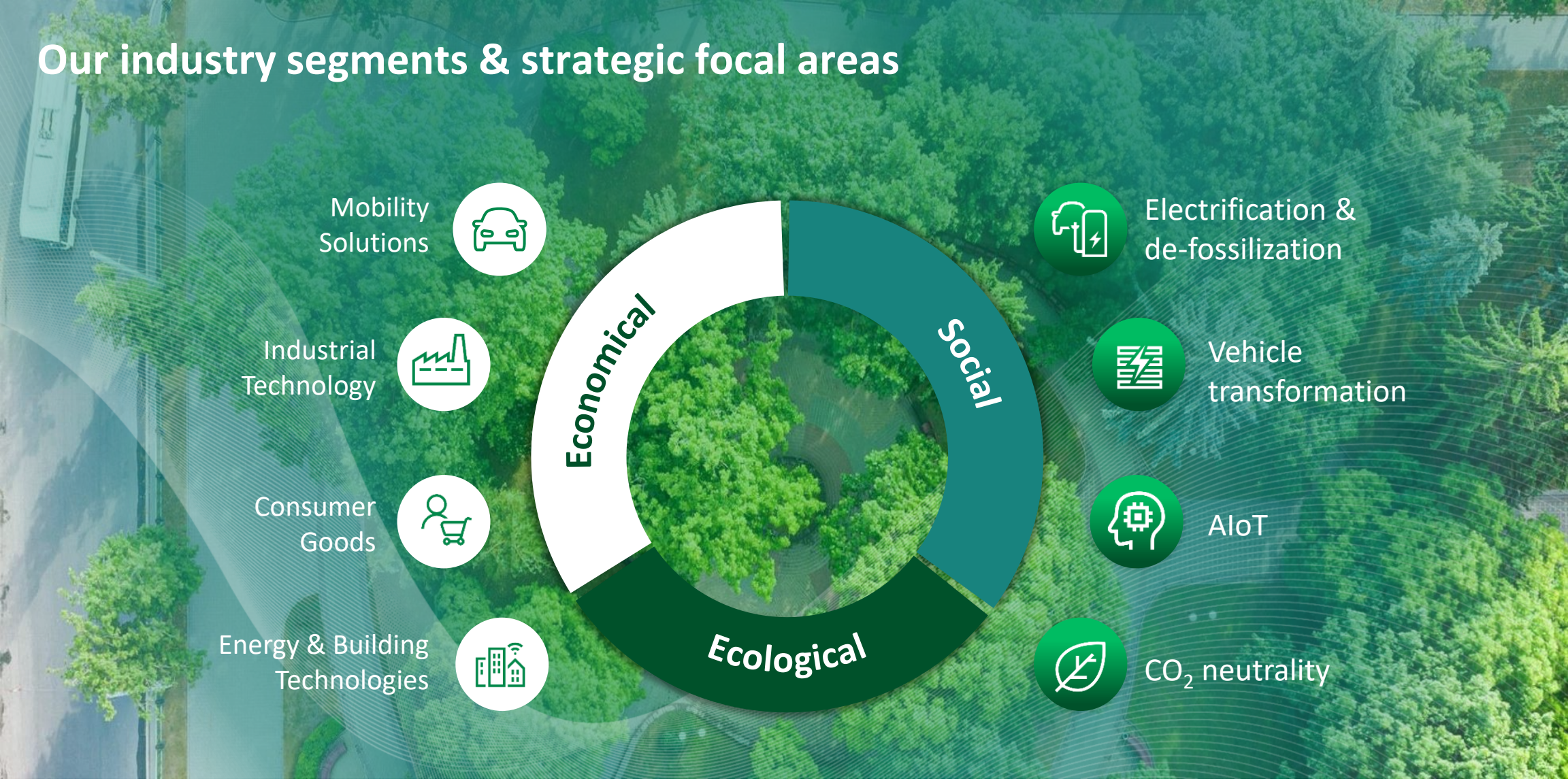
Fuel cell power by Bosch

Ben Richardson
UK&I Lead for Stationary Fuel Cells
Cranfield University Hydrogen Showcase

Solid Oxide Fuel Cell Program

BOSCH

Our industry segments & strategic focal areas



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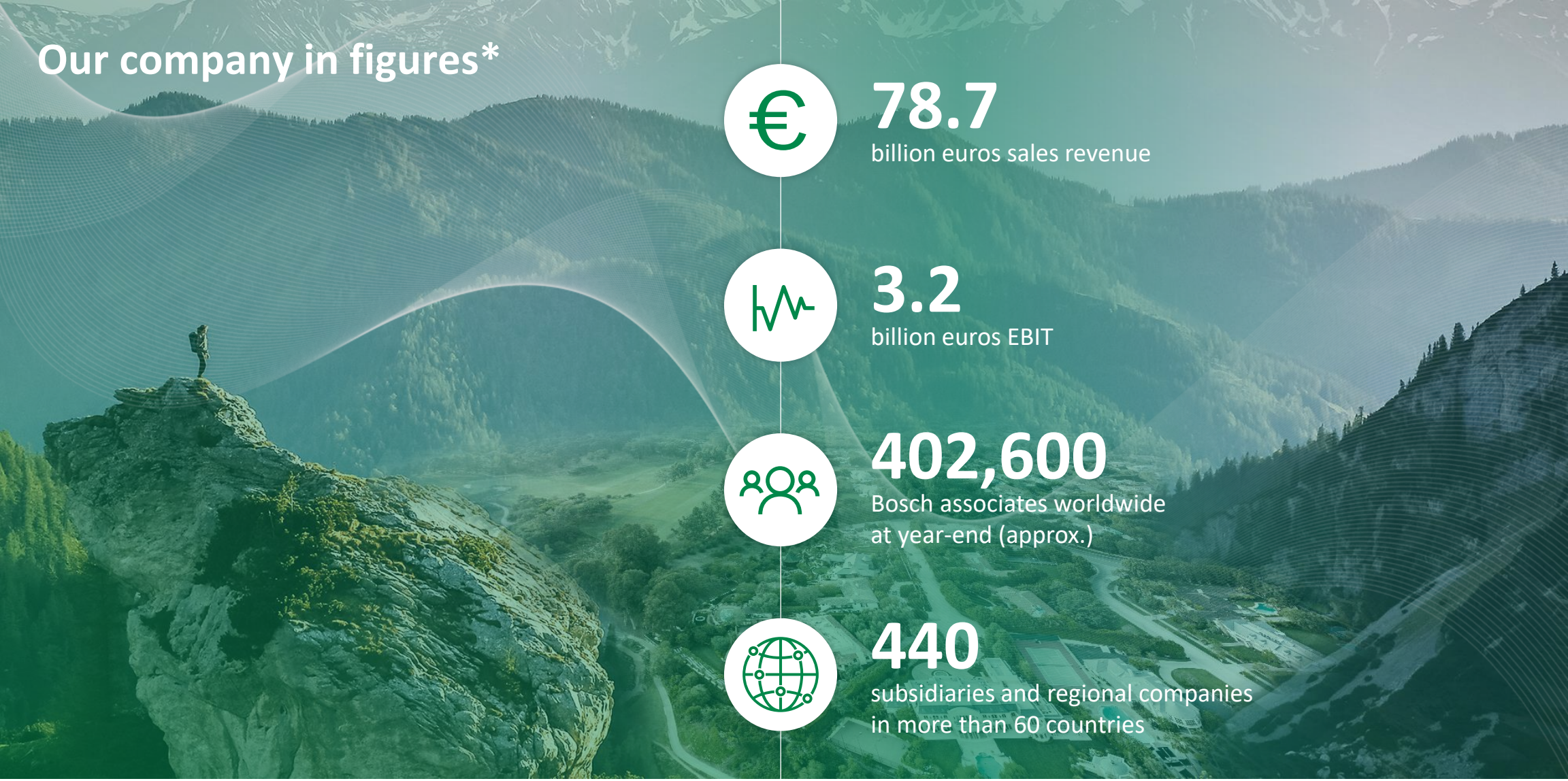
Our company in figures*



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

Electrification of mobility

Urbanization

Digitalization

BOSCH

UK Trends
Business Drivers

Reduce Operating Costs

Increase Energy Resilience

Reduce Carbon

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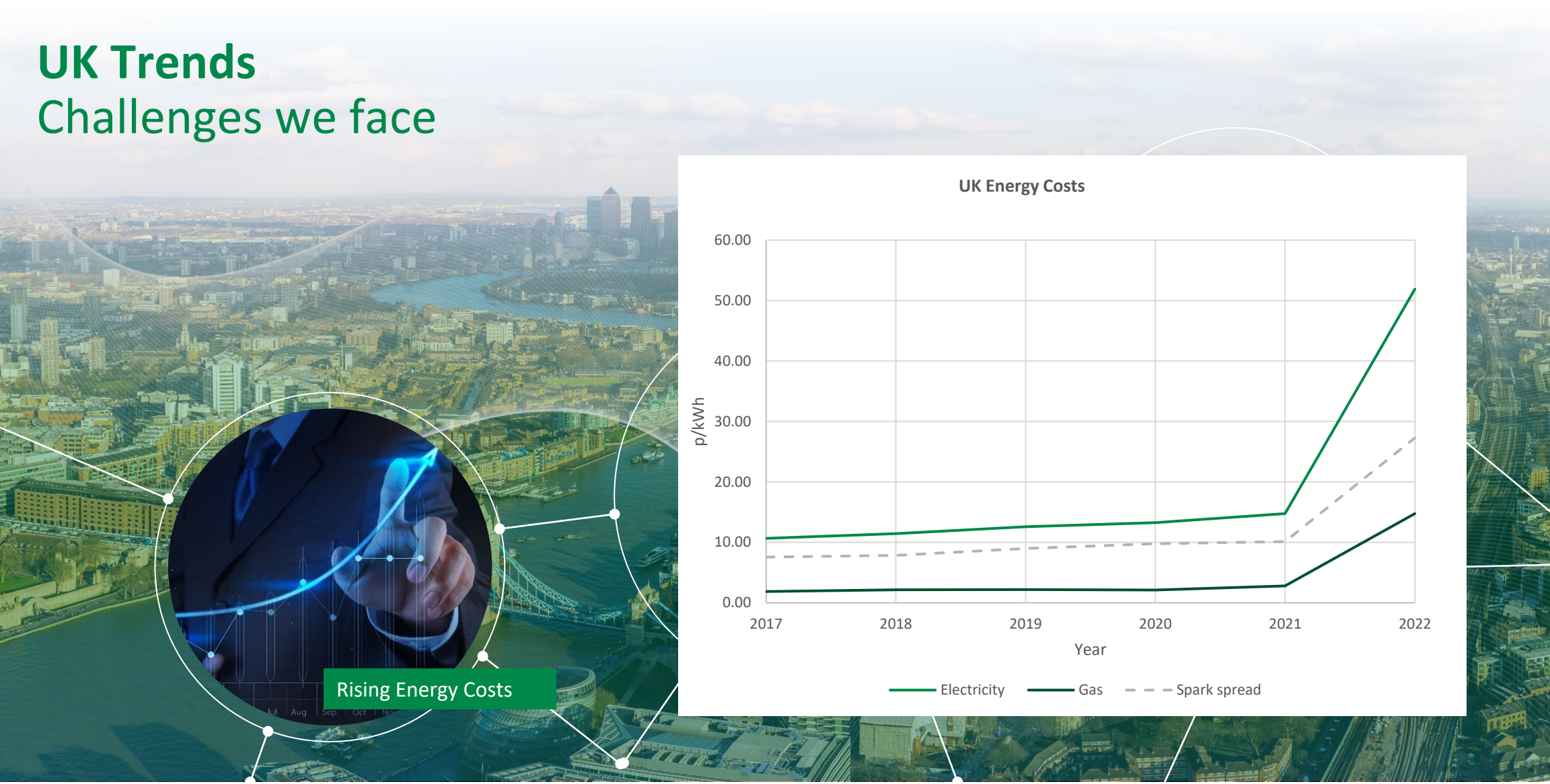
UK Trends
Challenges we face

UK Trends
Challenges we face



UK Trends
Challenges we face

Electricity: Lack of capacity 'holds back green energy'

By Dafydd Morgan
BBC News

30 August · Comments

Farmers and energy experts say a lack of capacity in the electricity network is preventing some renewable energy projects from seeing the light of day.

Infrastructure, Policy, Top Stories

UK relaxes permitting conditions for coal-fired power plants this winter

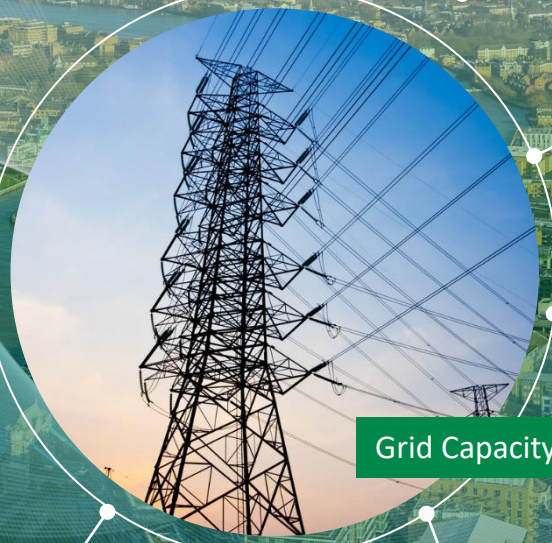
It will cover the period from 1st October 2022 to 31st March 2023 to address energy security issues if they arise, 'whilst aiming to limit unnecessary pollution'

The Telegraph

Power struggle with Europe as UK grid battles to keep the lights on

System under strain as renewable supply hit by weather conditions, while growing reliance on interconnectors exposes more frailties

Britain's power grid has repeatedly fallen below its targeted frequency level this year, raising fears that it is struggling to cope with intermittent energy supplies....



Grid Capacity Limitations

The Telegraph News Sport Business Opinion Ukraine Money Life Style Travel Culture PlusWord

Economy Companies Markets Tech Alex

No new homes in West London as electricity grid runs out of capacity

Housebuilders have been told it could take until 2035 to get new developments hooked up to the electricity network

PM Housing development in England under threat as electricity capacity nears limits | Financial Times

UK infrastructure

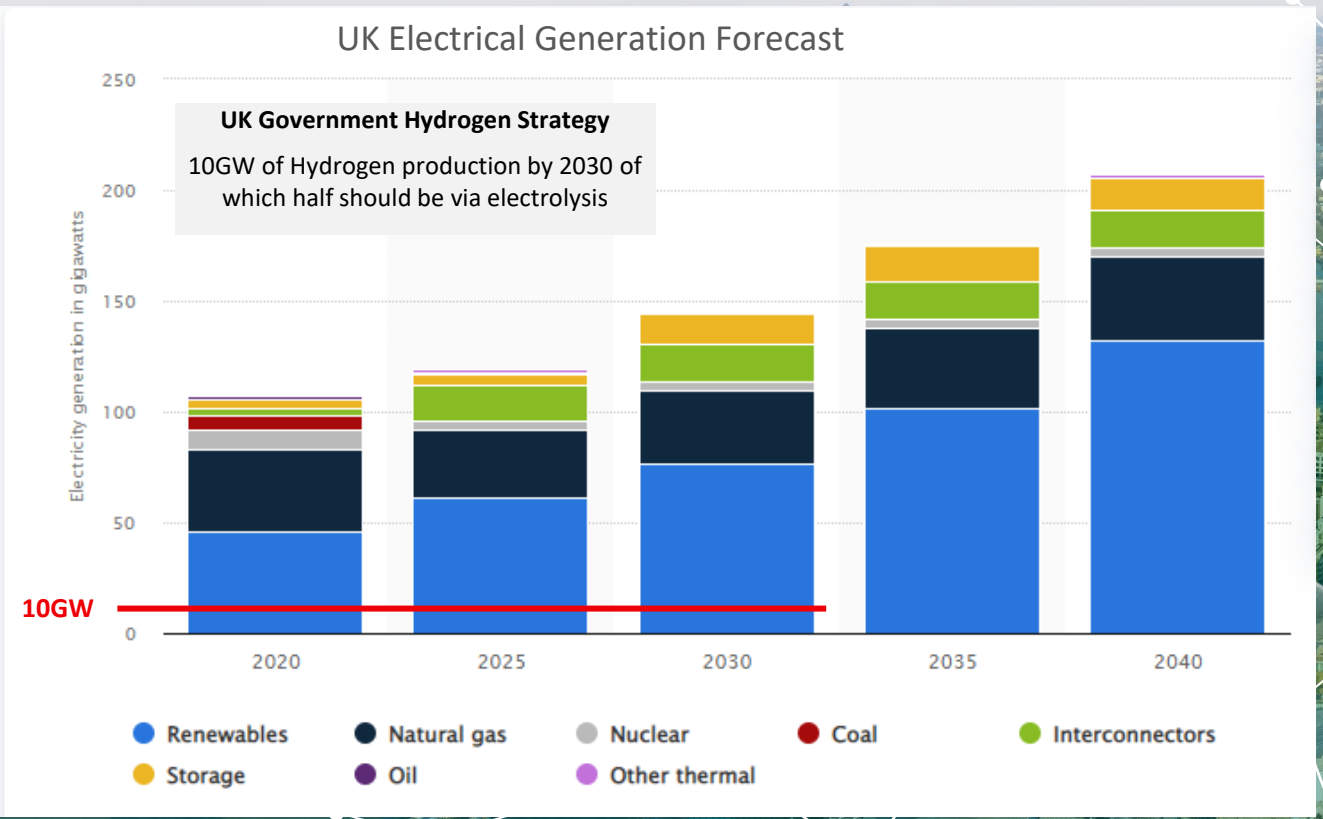
Housing development in England under threat as electricity capacity nears limits

Data centres, which can use as much energy as thousands of homes, put London and the south-east at particular risk

40°C heatwave pushed UK grid to the brink of blackouts with electricity demand close to outstripping supply

Searing temperatures caused cables to swell and power stations to struggle, almost sparking widespread power cuts

UK Trends
Challenges we face



H2 Availability and Price

Graph Source: https://www.statista.com/statistics/496283/total-electricity-generation-capacity-uk/

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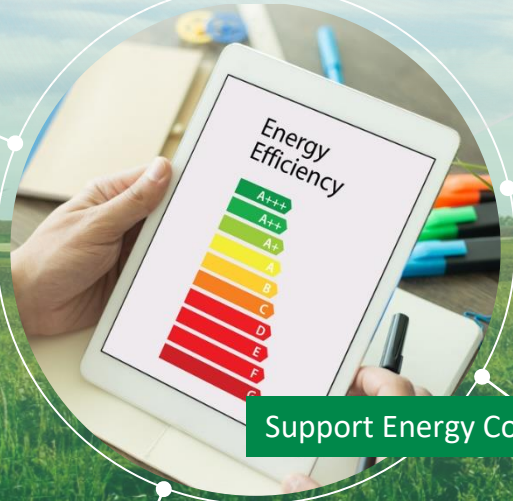
The Bosch Solid Oxide Fuel Cell

Paving the way to a sustainable future

Alternative Gases

H_2 READY

One Solution



Support Energy Cost Reduction*

Onsite Generation

* Correct as of 14/09/22 – Gas cost 17p/kW x SOFC efficiency 60% = 28.3p/kW of electricity produced vs grid at 52p/kW

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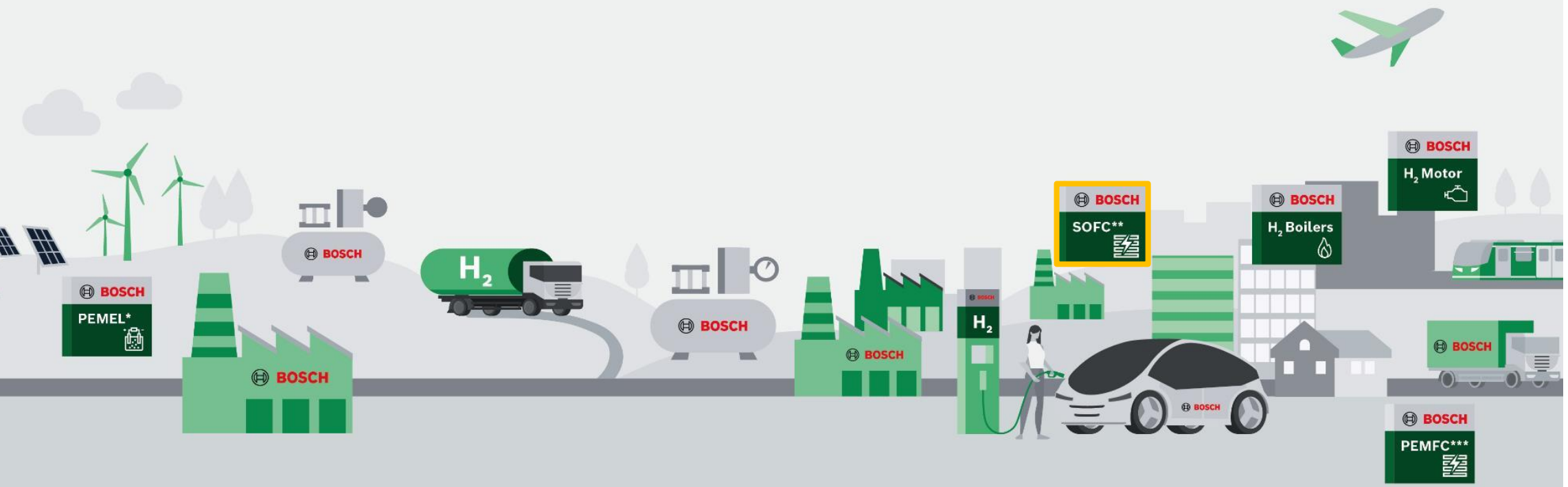
Bosch and the hydrogen economy



PRODUCTION

TRANSPORT & STORAGE

USAGE

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

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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**	

SOFC: Complete value stream covered at Bosch

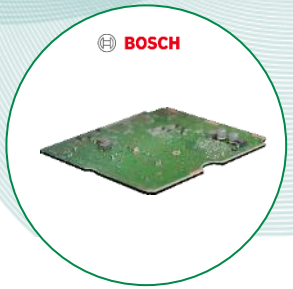
Cell

Stack

Hotbox

Unit

Decentralized energy supply system



Control unit

* 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

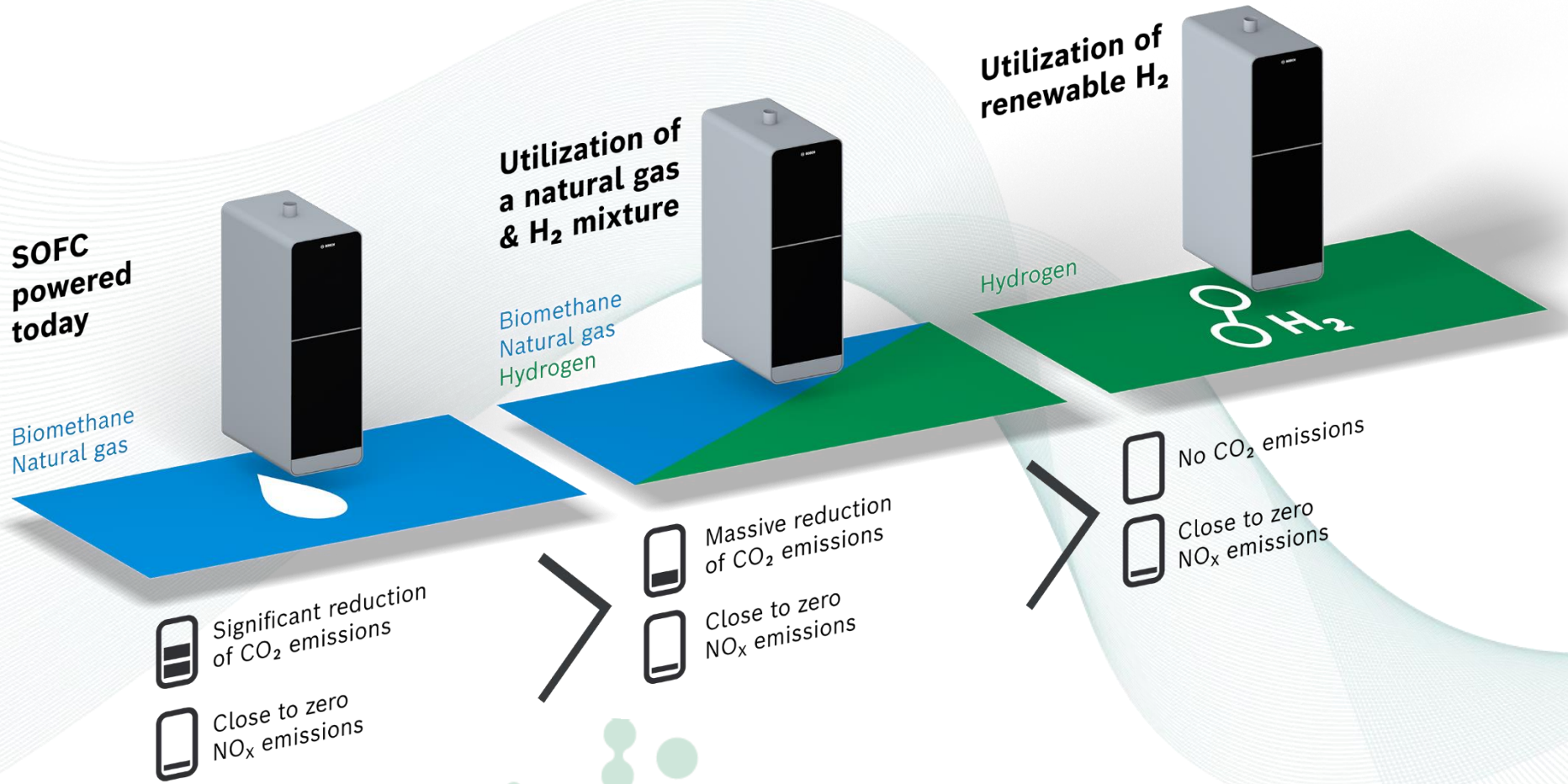
Fuel Flexible
Natural gas, biomethane or hydrogen or a blend of fuels

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

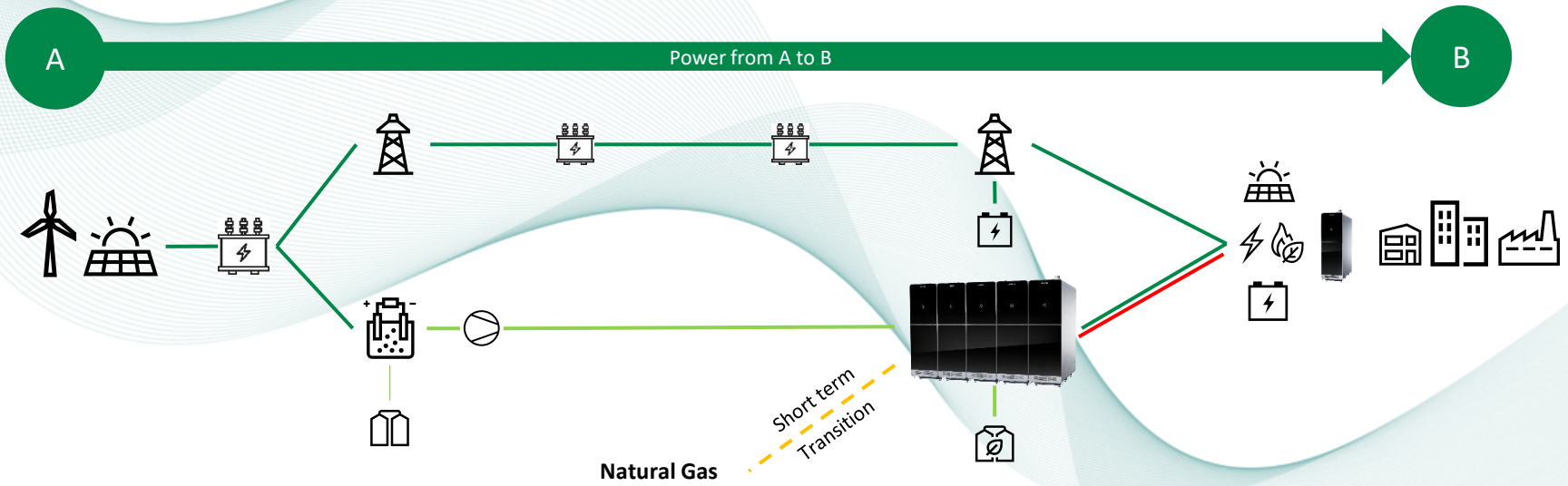
Transformation towards H_2



UK Energy System

Increasing resilience, security and availability

Energize
#LikeABosch



- **Increased** power **resiliency**
- **Increased** power **availability**
- **Long-term** energy **storage**
- Utilize **biofuels**
- **Reduce** electrical **infrastructure cost** burden on consumers

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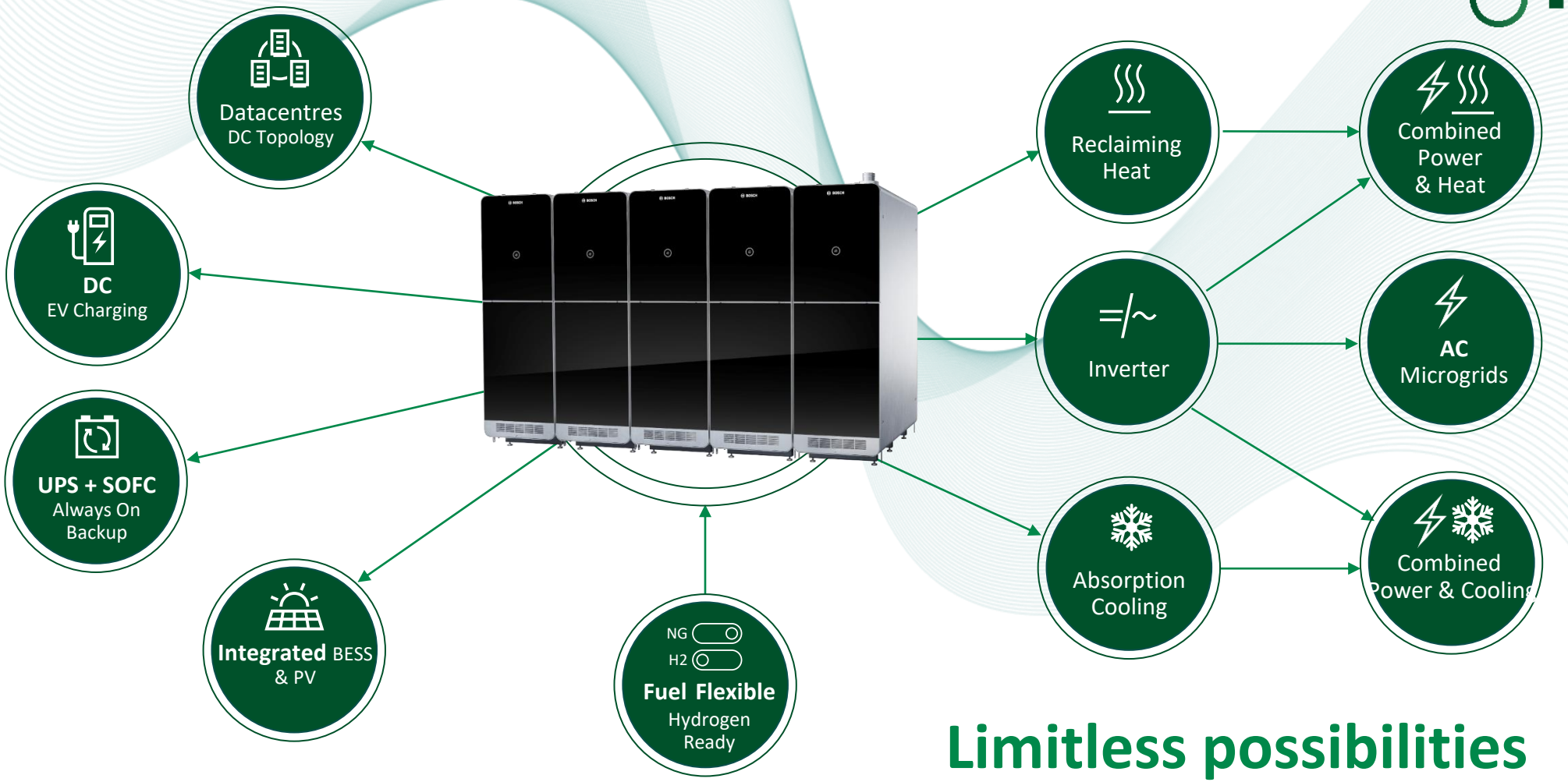
Flexible by design



Limitless possibilities

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

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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

6
SOFC manufacturing sites, offices and test labs

About **50 SOFC**
systems in internal and external pilot operation

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

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

PASM*

Wernau

*Power and Air Condition Solution Management GmbH (PASM), a Deutsche Telekom subsidiary

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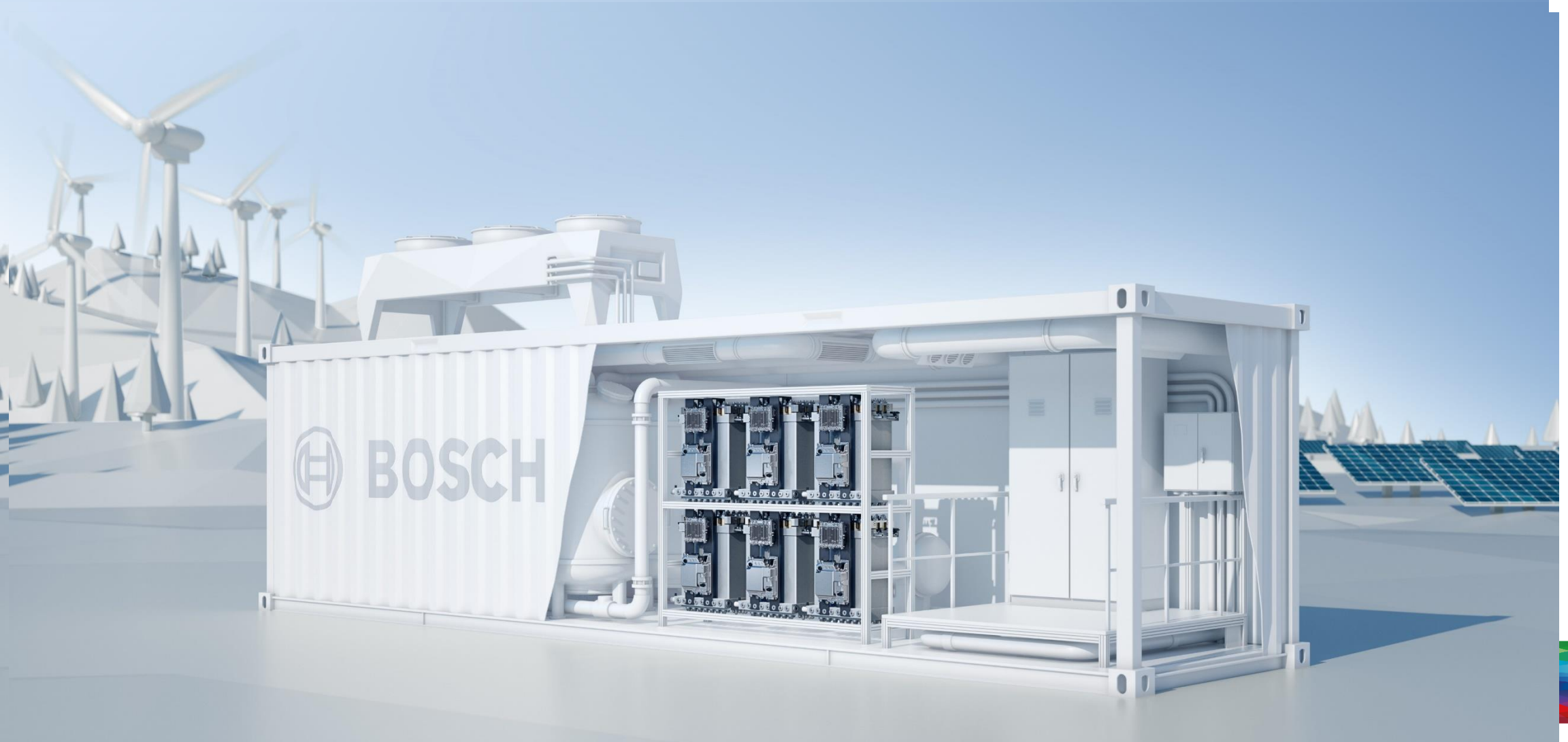
Pushing Green H2 Production in the Future with Electrolyzer Technology & Services from Bosch

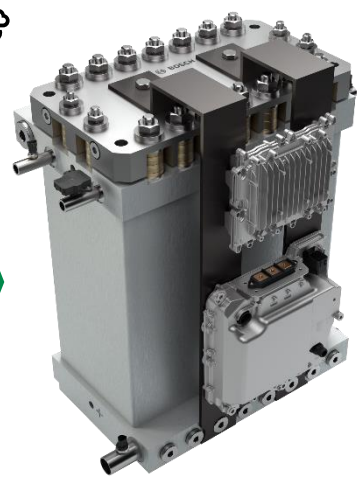


Bosch Electrolyzer Technology & Services
Product Portfolio

Benefits

- Compact system unit easy to integrate
- Online Monitoring of operation for extended lifetime
- Maximum efficiency and thus reduced hydrogen production costs
- Good price performance ratio due to aligned single components for a system optimum
- High quality due to mass production technologies

ELY Smart Module*



Content of Bosch Smart Module

Stack | Control Unit | Power Electronics | Sensors

Target values

- Rated Power: 300 kW up to 1.000 kW
- Temperature range: +20°C up to +80°C
- Pressure level: 1 bar / 40 bar
- Volumetric flow H2: 63 Nm³/h up to 208 Nm³/h
- Module efficiency: >70 %, ≈ 4,8 kWh / Nm³ H2 @ +70°C
- Lifetime: 40.000 h

1st Sample	12/2023
High volume series	12/2024

* visualization of the principle


Join us in shaping the energy supply of tomorrow
BOSCH
Technik fürs Leben
Energize
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