



Ceres technology for Clean Power and Green Hydrogen

Dr. Subhasish Mukerjee
Chief Scientific Officer

Innovate UK KTN Hydrogen showcase event

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My intro:

Dr. Subhasish Mukerjee

- Chief Scientific Officer at Ceres
- Visiting Professor at Imperial College, London
- 25+ years of experience in fuel cells, hydrogen and electrochemical technologies for green energy
- Long term association with KTN and Innovate UK



Ceres is a leading developer of clean energy technology, for power and green hydrogen

Our licensing model enables us to partner with some of the world's most progressive companies to decarbonise at scale and pace



A leading developer of clean energy technology

c. **600**
experts in-house

Our values

- We commit wholeheartedly
- We are creative collaborators
- We pioneer with precision

Our operating businesses



Leading technology position in solid oxide fuel cells, being demonstrated in multiple applications and geographies through established global partnerships. Growing demand for higher-power systems and broadening applications in hard-to-abate sectors such as maritime.

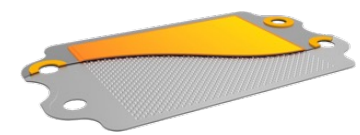


Now addressing the potentially even greater market for electrolysis through a differentiated offering for hydrogen, with distinct advantages in efficiency, coupling with industrial processes that are high emitters of carbon dioxide today.

Our scalable technology

Solid oxide cell

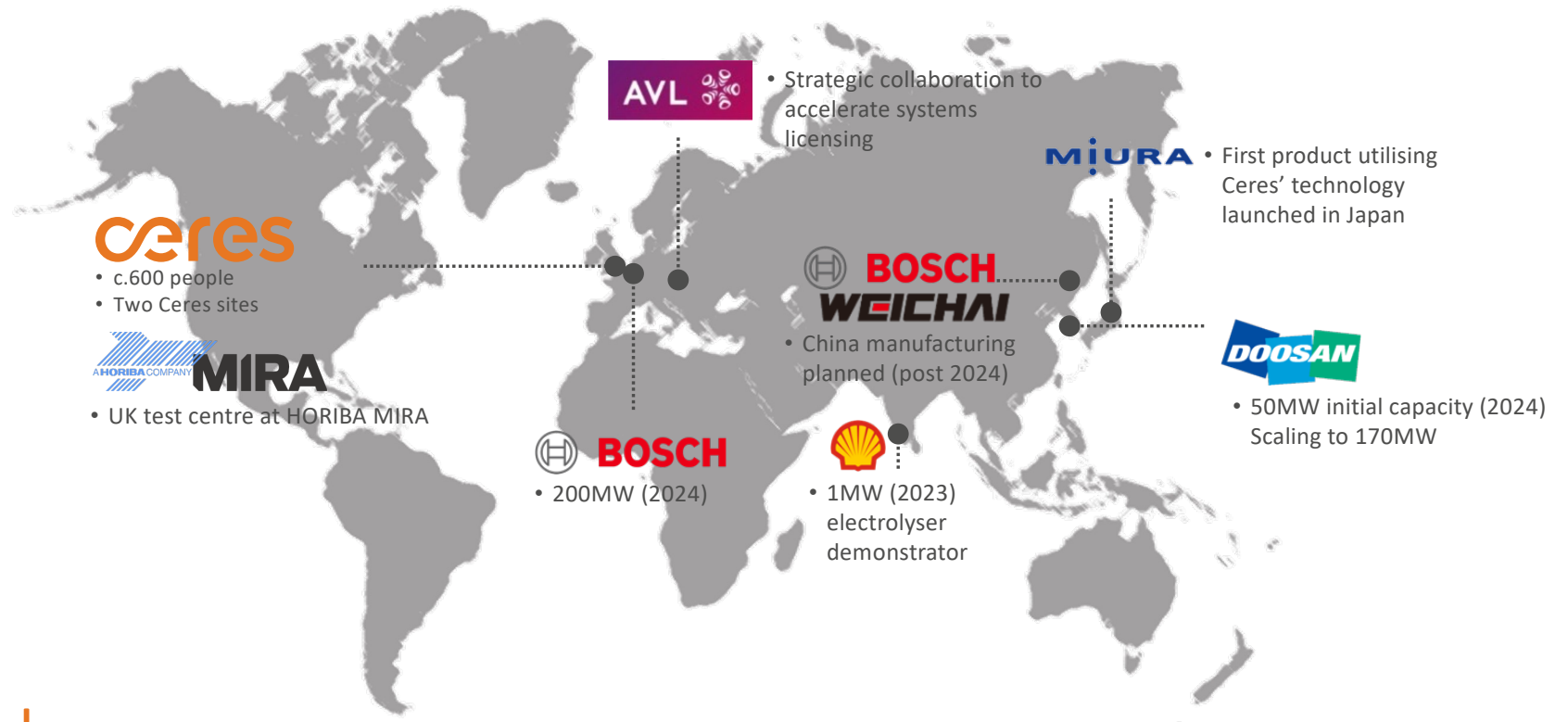
Ceres' core cell is based on low-cost materials: a ceria ceramic electrolyte and a stainless-steel substrate and interconnect.



Solid oxide stack

Highly differentiated stack technology platform with strong and growing intellectual property and distinct advantages of robustness, efficiency and cost.



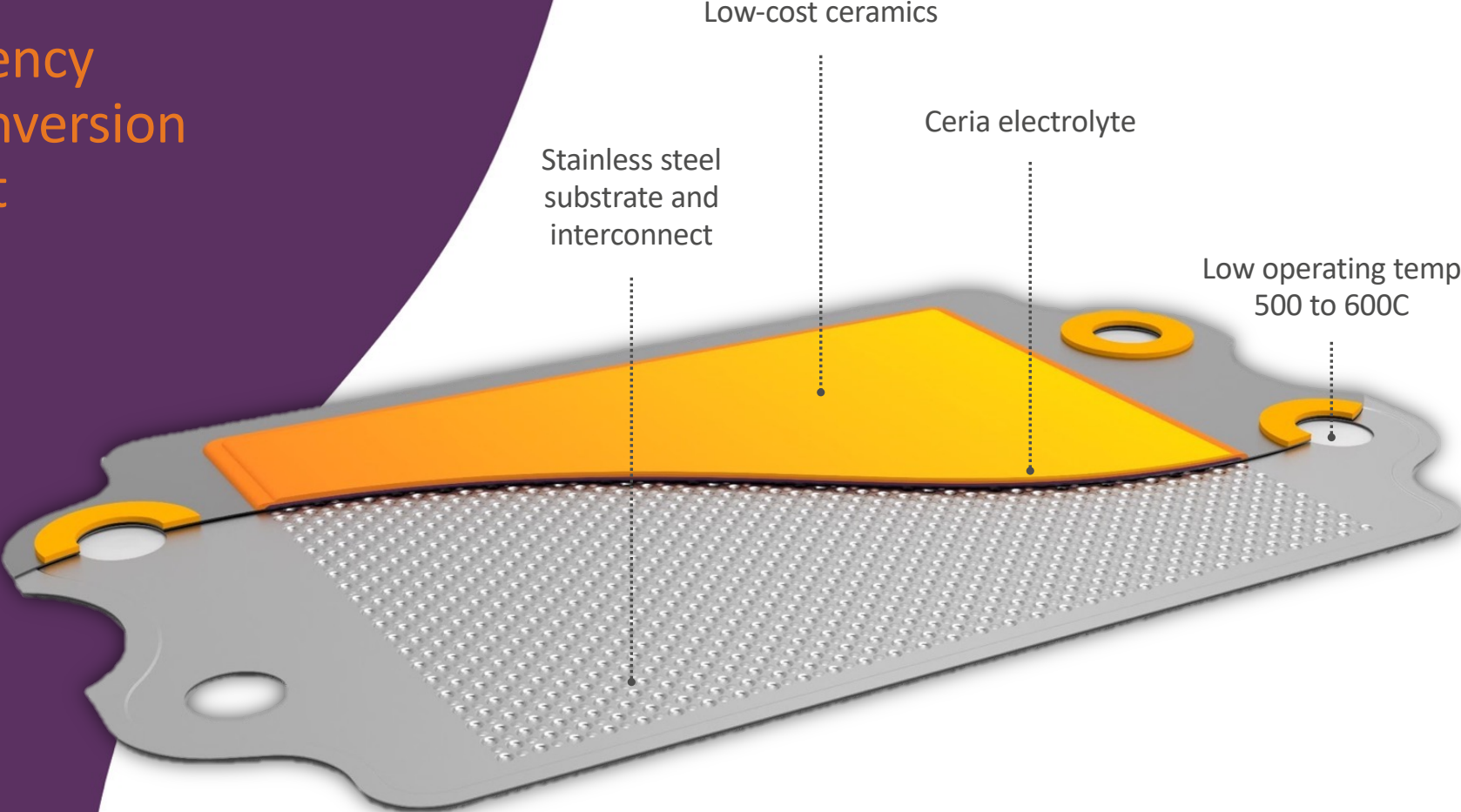


Global reach through strategic partnerships

3 Ceres locations and multiple customer and partner sites



Ceres SteelCell[®] technology enables high efficiency energy conversion at low cost



Ceres SteelCell® highly differentiated

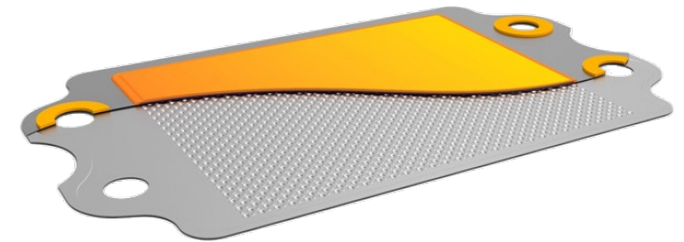
Ceres SteelCell® solid oxide cell

- Highly efficient, c.60%
- Fuel flexible
- Robust and scalable
- Made from widely available materials
- Cost-efficient
- Suitable for a wide range of applications
- Operates in either fuel cell or electrolysis mode

ceres
power

ceres
hydrogen

Technology Family	PEM	SOFC	Ceres SteelCell®
Efficiency		✓	✓
Fuel	Hydrogen only	Nat Gas Liquid fuels Bio fuels Hydrogen	Nat Gas Liquid fuels Bio fuels Hydrogen
Cost	✓		✓
Robust	✓		✓
Applications	Transport	Stationary	Both



PEM

Grid balancing and
refuelling stations

50 kWh/kg

Challenger:
dynamic response

Alkaline

Industrial / bulk production

48 kWh/kg

Most mature:
lowest scale, lowest cost
today

SOEC

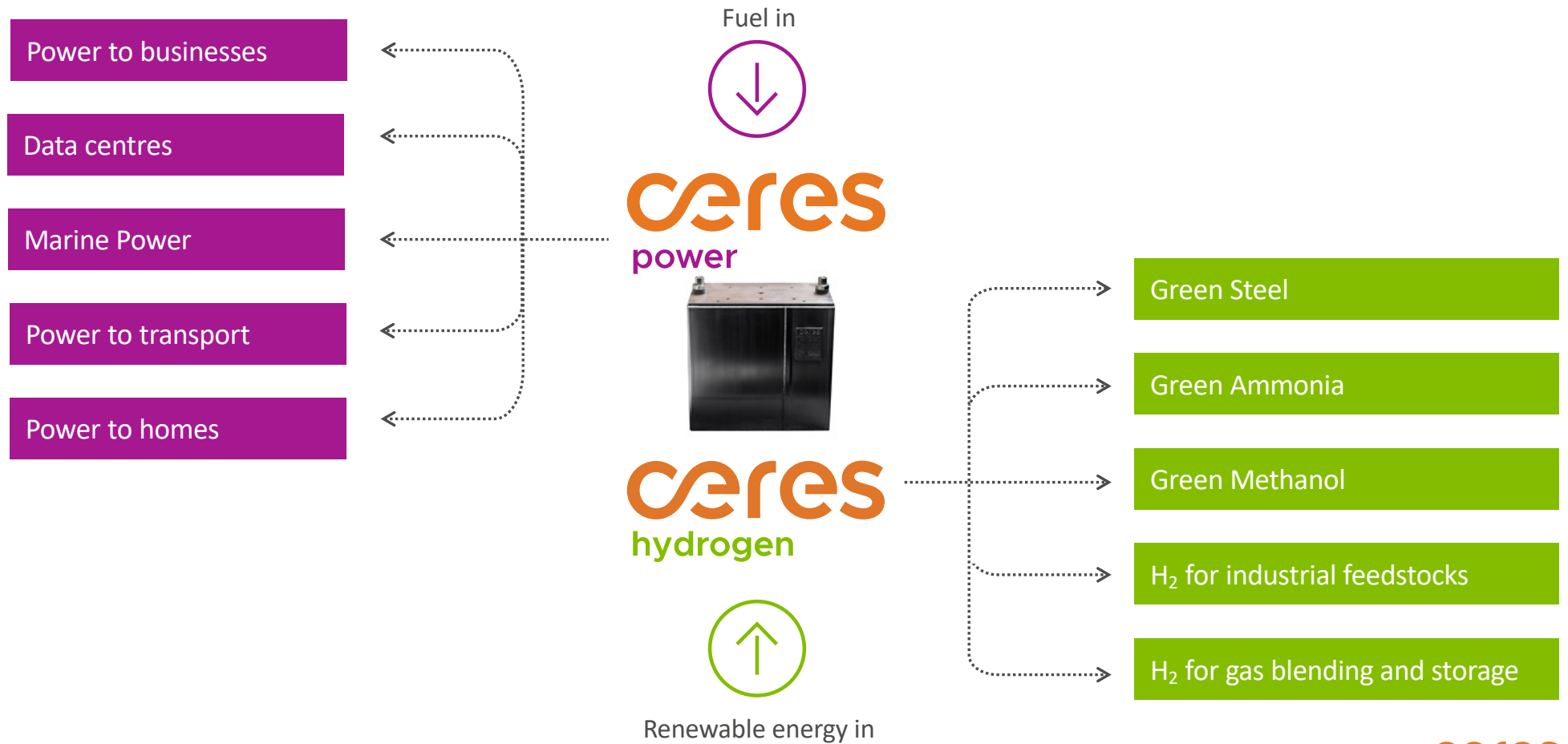
Industrial uses, steel and e-fuels

37 kWh/kg

Potential:
highest efficiency due to lower electrical
energy input

Solid oxide
electrolysis
is highly
differentiated

Fuel cells for power generation and electrolysers for green hydrogen



Technology platform for high power applications



Developing a 600kW solution for marine SOFC auxiliary power unit



100kW SOFC plug and play solution for edge data centres



120kW stationary power system for distributed power



Bosch decentralised SOFC 'power plants'

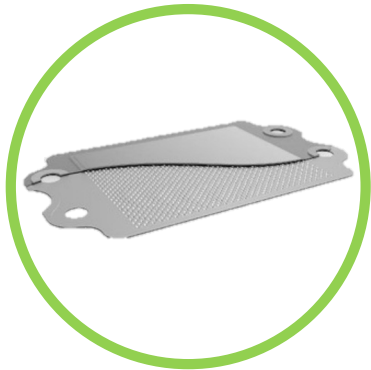
- Series production commences in 2024, by which time Bosch will have invested ~€500m
- Approved by the European Commission as one of the first Important Projects of Common European Interest (IPCEI)
- Eligible for funding in Germany, where more than €8 billion is available for the development of hydrogen and other green technologies



SOURCES: BMWK - [European Commission approves 41 large-scale hydrogen projects – Tailwind from Brussels for four initial projects from Germany](#) and www.bosch-sofc.com
PHOTO: Bosch SOFC

Modular scale-up concept

Cell
30-150W



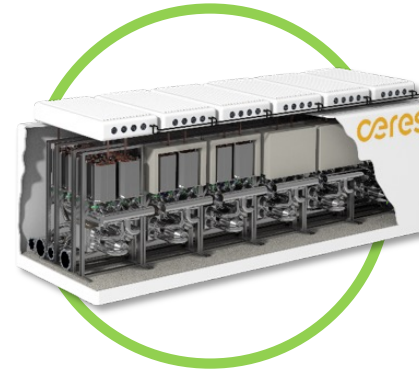
Stack
10-50 kW



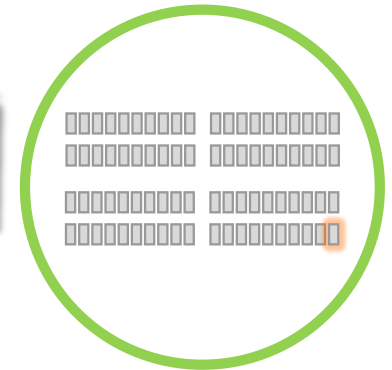
Stack array
100-500 kW



Module
1-5 MW



Plant
GWs



Industrial de-carbonisation of green steel, green ammonia, e-fuels. Chemicals, oil and gas

First prototype system at 1MW – future plants at 100MW

Specification	Target Value	Future plant scale
Hydrogen Production	~600kg / day	>60tn / day
System Efficiency	<40kWh/kg	37-40kWh/kg



Measured Efficiency 38kWh/kg

Specification	Target Value
Electrical Power Input	~100kW
Hydrogen Production	65kg / day
Module Efficiency	38kWh/kg
Steam input	150°C

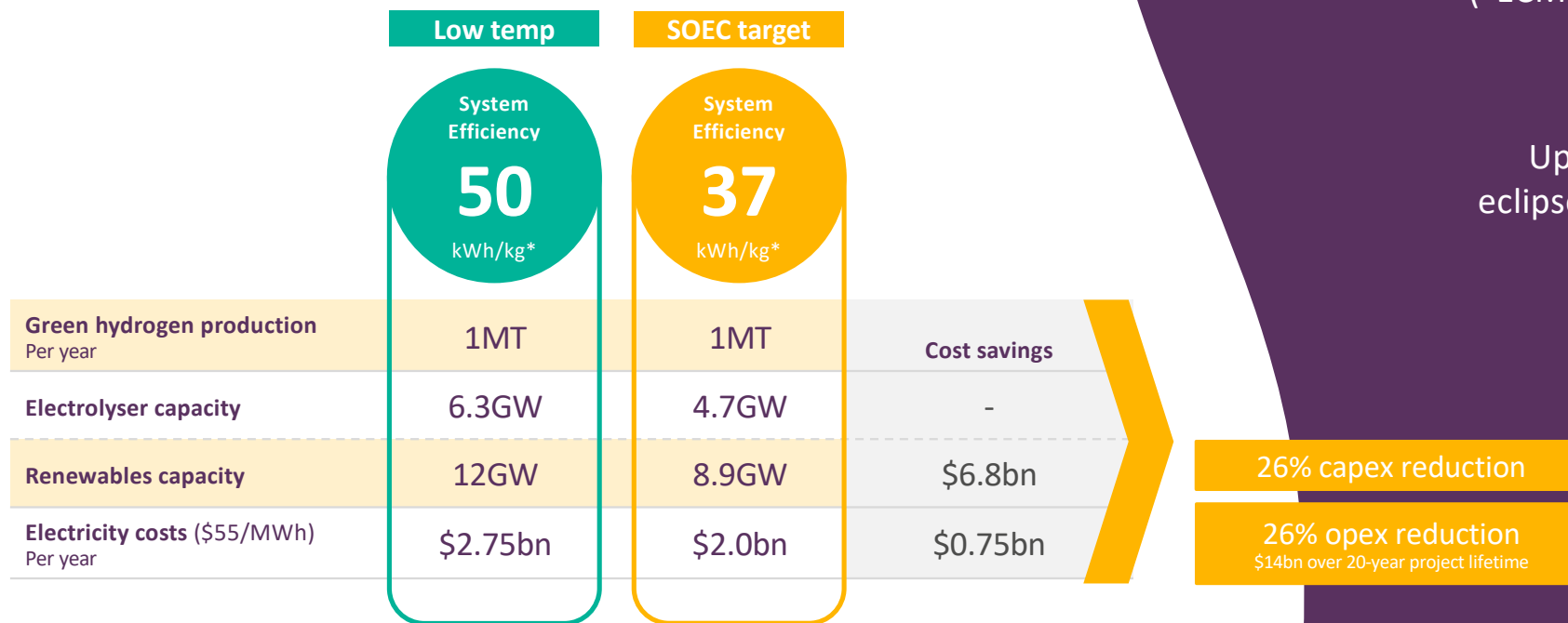




MW-class SOEC system installed at test site in Germany



Indicative 2030 project costs for 1MT of green hydrogen



26% capex reduction
26% opex reduction
\$14bn over 20-year project lifetime

Ceres' SOEC

First electrolyser cell module ("ECM") on test delivering **<40kWh/kg**

Upstream cost savings eclipse electrolyser capex

Assumptions used in calculations: Electrolyser System Installed CapEx: \$600/kW; Wind:Solar ratio: 67:33; Renewable Capacity factor: 53%; Electrolyser Capacity Factor: 90%;
***References for renewable energy cost and efficiencies:** [Renewable power generation costs in 2021 \(irena.org\)](https://www.irena.org/); [Green hydrogen cost reduction: Scaling up electrolysers to meet the 1.5C climate goal \(irena.org\)](https://www.irena.org/)

Shell collaboration for green hydrogen

- SOEC technology evaluation programme progressing well for deployment later this year
- First-of-a-kind 1MW demonstrator in build (far right) to accommodate up to nine electrolyser cell modules (“ECMs”)
- Pilot starts in 2023 and will run for three years – hydrogen will be used in industrial processes at Shell’s R&D centre in Bangalore, India
- 25% more efficient than incumbent lower temperature technologies



Collaboration with Bosch and Linde Engineering

- Assessment of Ceres' solid oxide electrolysis (SOEC) technology for large scale industrial applications
- Validate performance of a high-efficiency pathway to low-cost green hydrogen
- Two-year demonstration of a 1MW SOEC system, starting in 2024 at Bosch's site in Stuttgart, Germany

Three-way collaboration

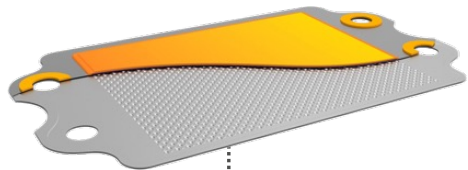
Bosch has significant expertise in product industrialisation and mass manufacturing.

Linde Engineering has world-leading capabilities in hydrogen process technology and a global customer footprint in industrial facilities.



Platform technology to address decarbonisation

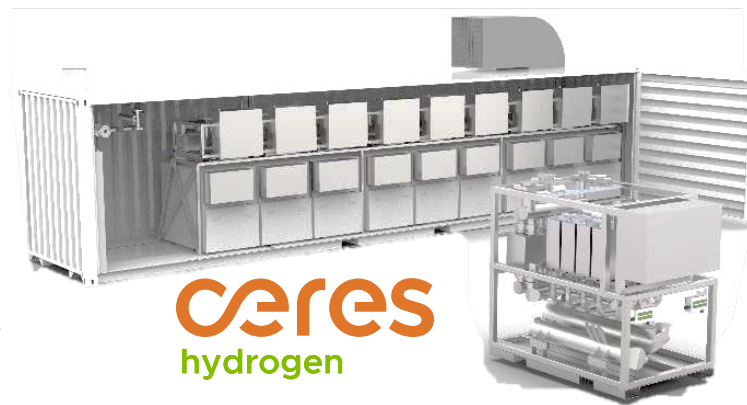
Ceres technology enables high efficiency energy conversion at low cost



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power



Stack



Summary and outlook

- **Urgency for climate action continues to drive the global demand for clean energy**
- Ceres has a world leading SOC technology which continues to mature for multiple product platforms
- Strategy of licensing to global partners, with a leading position in their products and markets, continues to be highly successful
- Accelerating activities in key new areas such as electrolysis for green hydrogen and expansion of our power systems business into new applications and markets

World class most robust, cost effective SOC technology continuing to grow

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THANK YOU

Dr Subhasish Mukerjee, CSO

Subhasish.Mukerjee@cerespower.com

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