Technology teach-in

Ceres Power Holdings plc

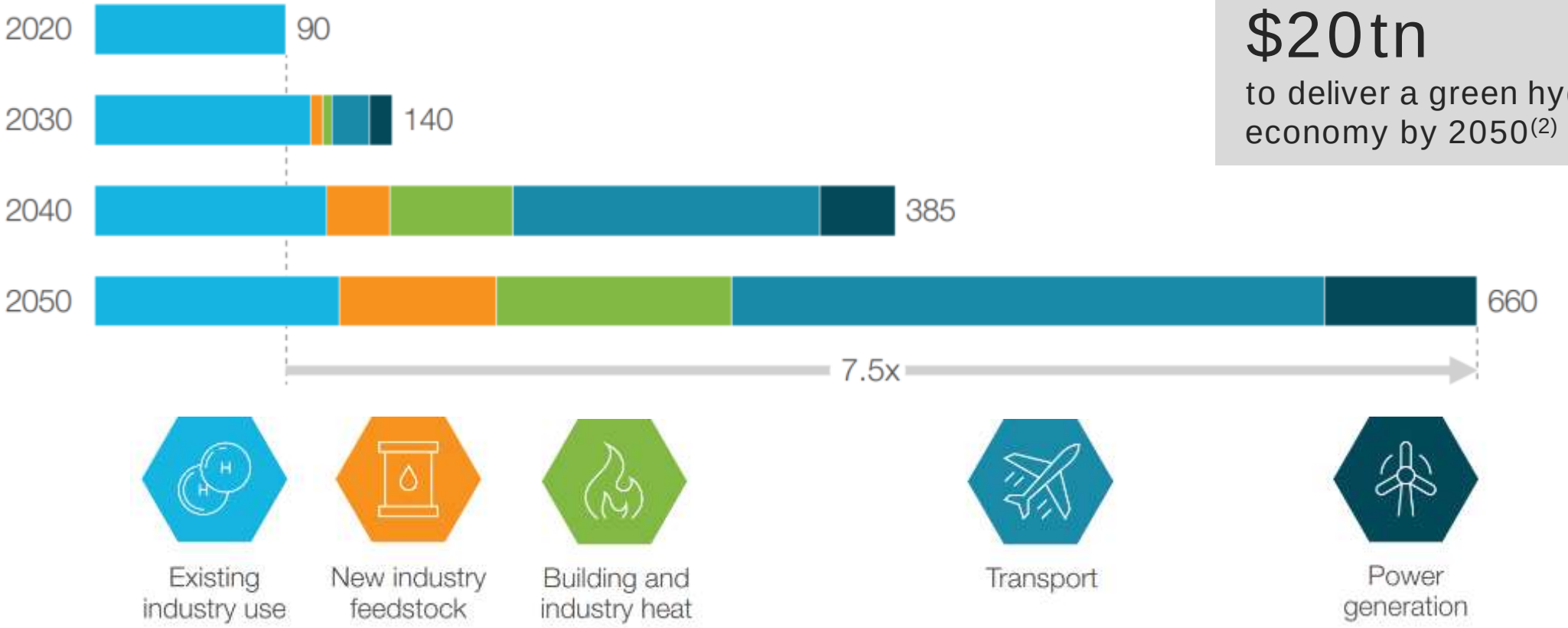
09 June 2023

Strategic overview

Phil Caldwell

2050 demand for hydrogen

Global hydrogen demand, MT[1]



22%

of global final energy demand in 2050[1]

$20tn

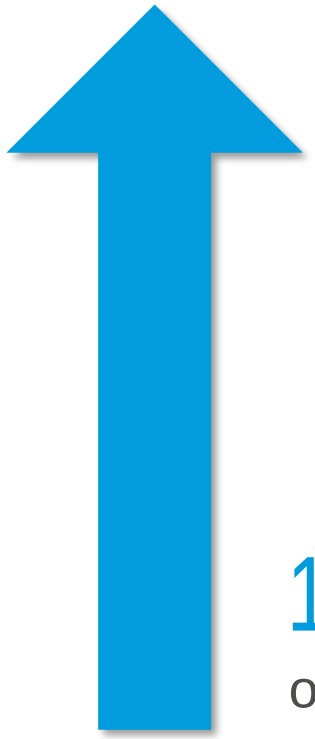
to deliver a green hydrogen economy by 2050[2]

(1): Global Hydrogen Flows, Hydrogen Council 2022
(2): The staggering cost of a green hydrogen economy, Financial Times May 2023

3,585GW

IEA estimate of electrolyser capacity needed by 2050

1GW cumulative installations today



100GW

of capacity every year

Indicative 2030 project costs for 1MT of green hydrogen

	Low temp	SOEC target	
	System Efficiency 50 kWh/kg*	System Efficiency 37 kWh/kg*	
Green hydrogen production Per year	1MT	1MT	Cost savings
Electrolyser capacity	6.3GW	4.7GW	-
Renewables capacity	12GW	8.9GW	$6.8bn
Electricity costs ($55/MWh) Per year	$2.75bn	$2.0bn	$0.75bn

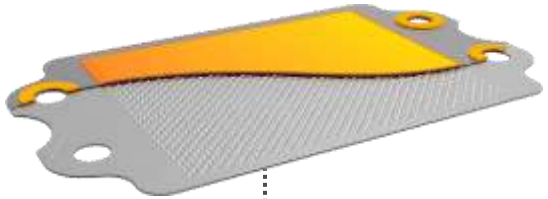
26% renewable capex reduction of $6.8bn

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

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); Green hydrogen cost reduction: Scaling up electrolysers to meet the 1.5C climate goal (irena.org)

Technology platform to address decarbonisation

Ceres technology enables high efficiency energy conversion at low cost



Stack

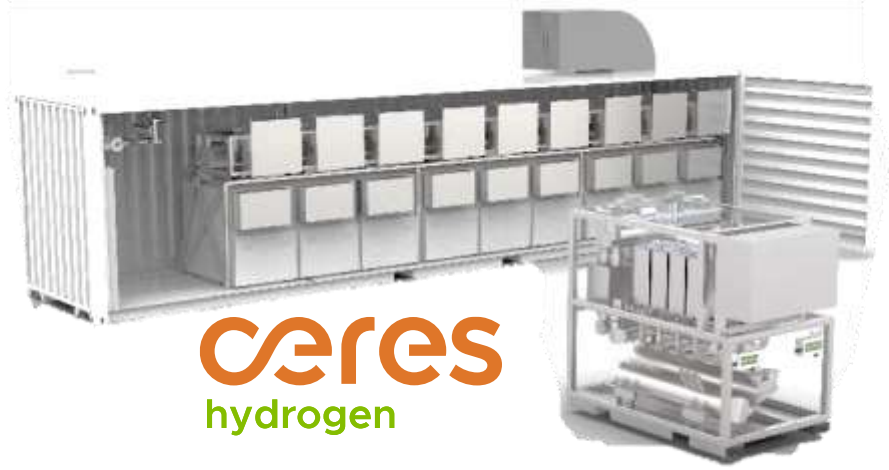
ceres power

MIURA

BOSCH

DOOSAN

WEICHAI

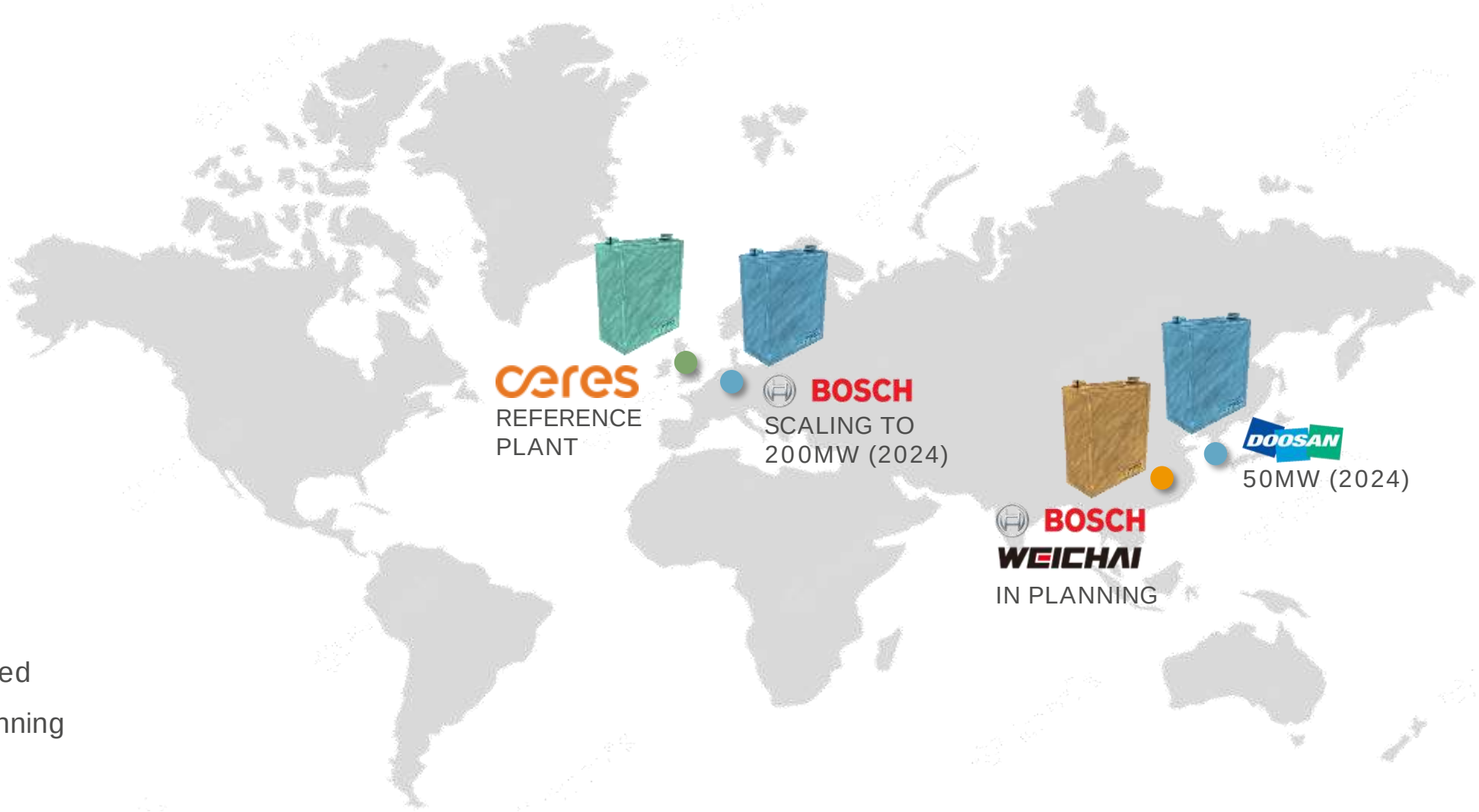


ceres hydrogen

BOSCH

Linde

Multi gigawatts of manufacturing capacity under licence with global partners by 2030



ENABLE LICENCE PARTNERS TO SUCCEED

PHOTO: Doosan Fuel Cell

BUILD COMMERCIAL SCALE

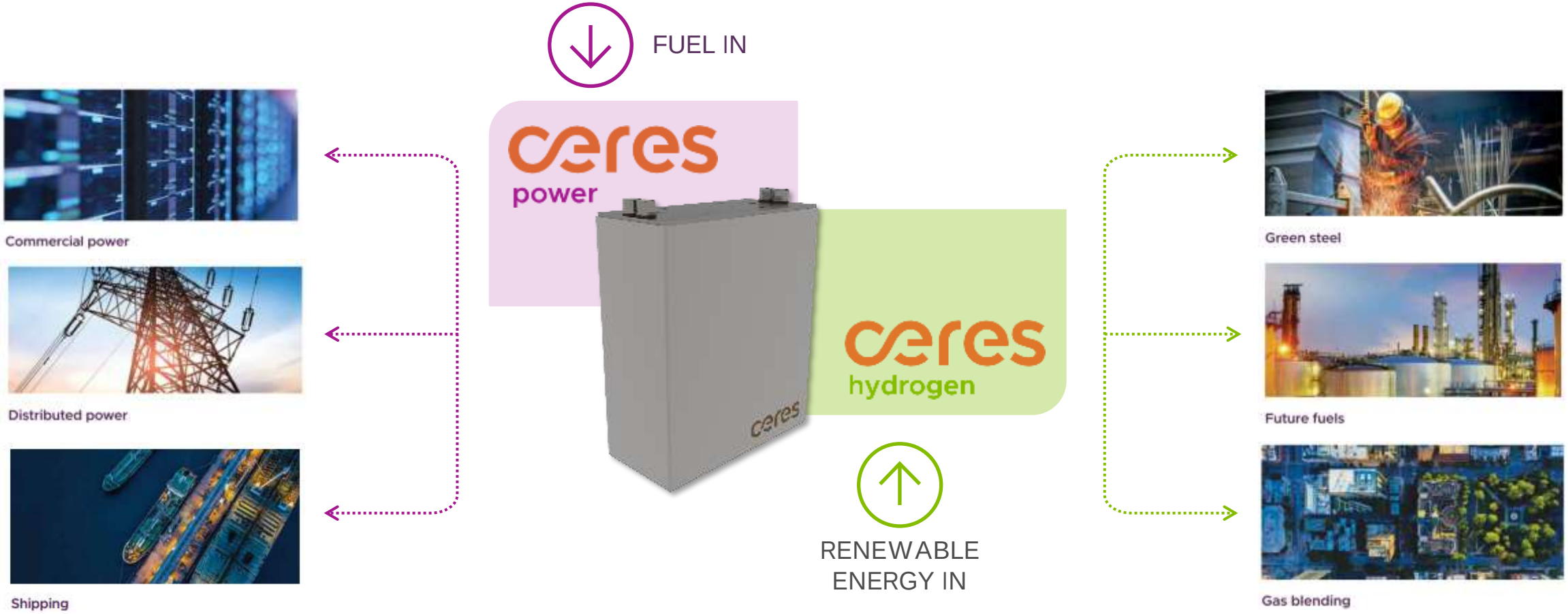
MAINTAIN TECHNOLOGY LEADERSHIP

Future focused technology organisation

Caroline Hargrove


Vodafone

Fuel cells for power and electrolysers for green hydrogen



Technology platform to address decarbonisation

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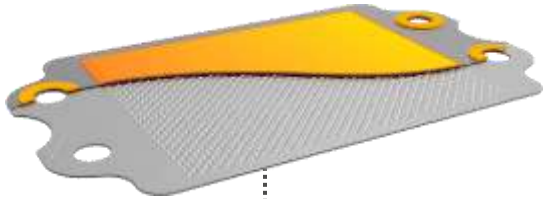

Stack

ceres power

MIURA

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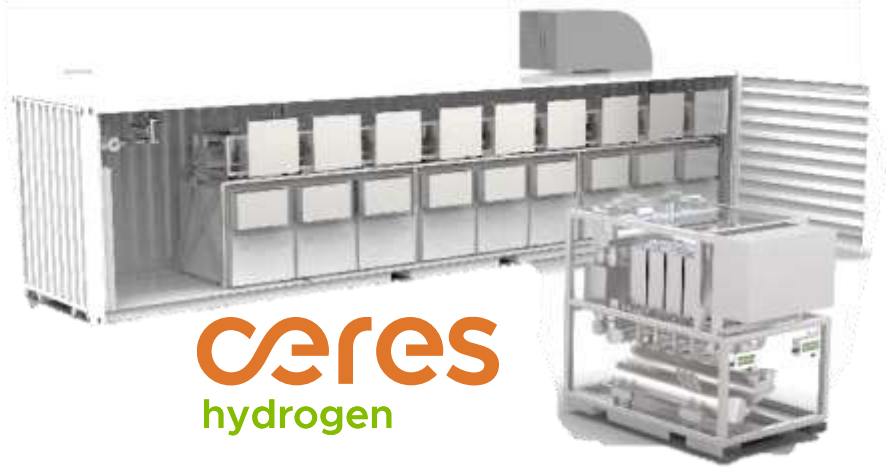


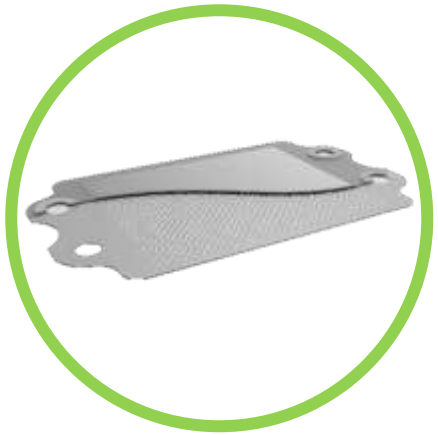
ceres hydrogen

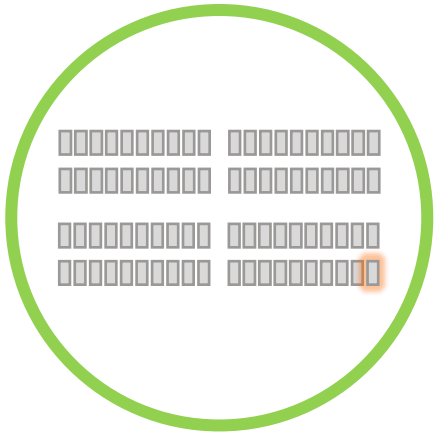
BOSCH

Linde

Modular scale-up concept

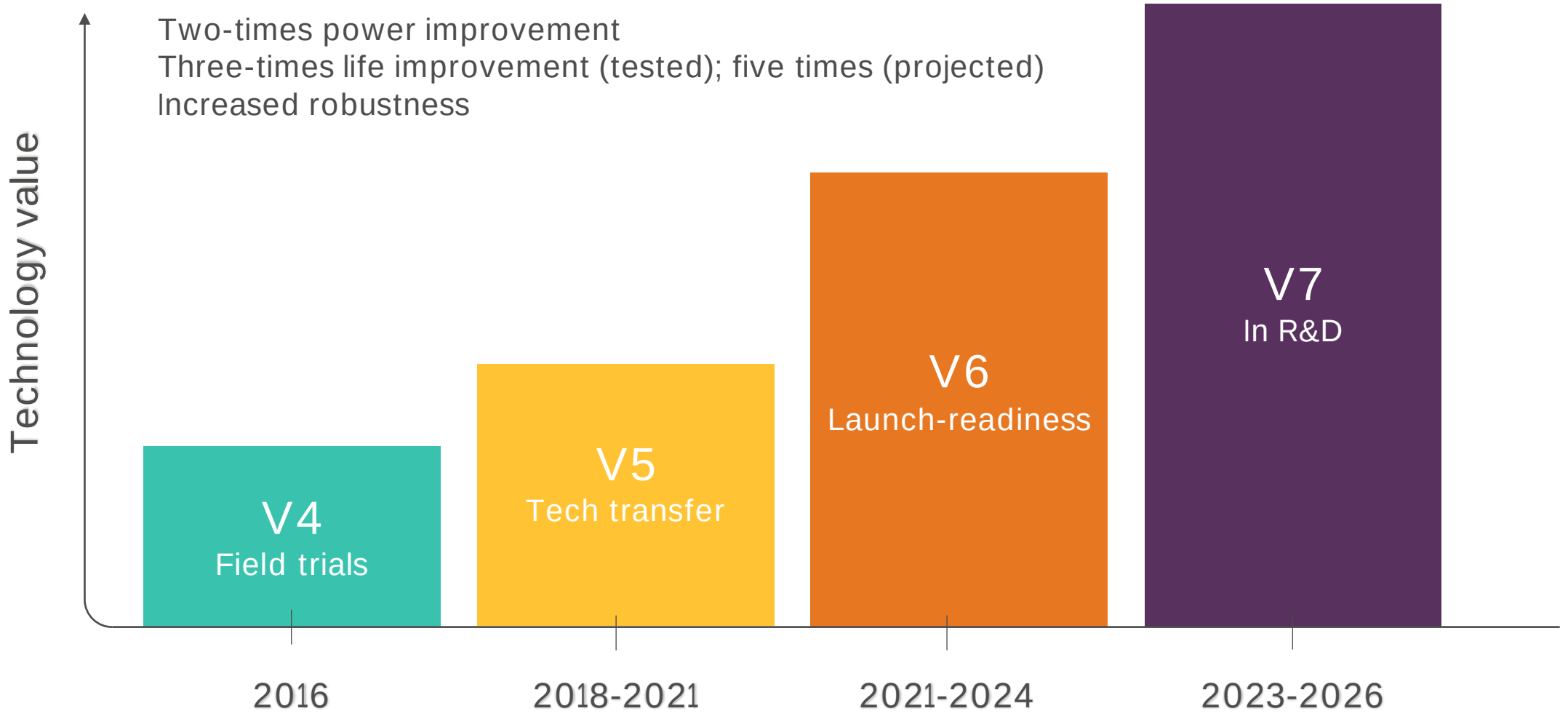
Cell	Stack	Stack array	Module	Plant
30-150W	10-50 kW	100-500 kW	1-5 MW	GWs



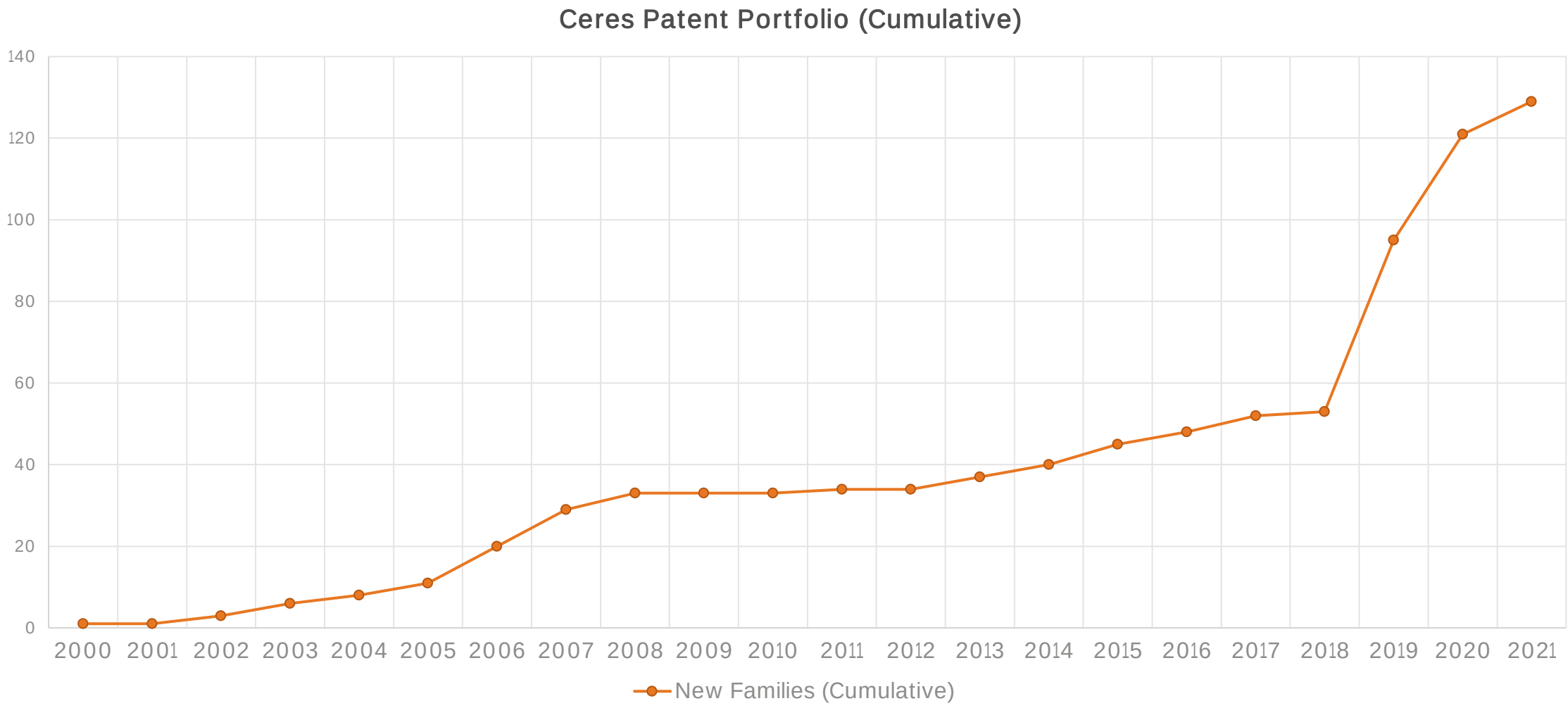


Industrial de-carbonisation of green steel, green ammonia, e-fuels. Chemicals, oil and gas

Continued improvement of cell and stack technology



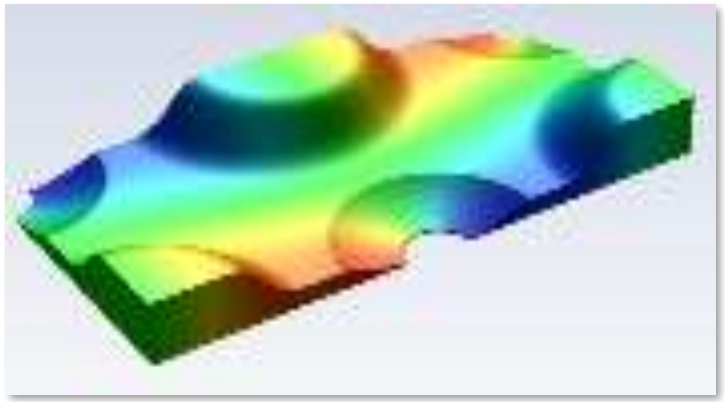
Ceres building a protected patent portfolio

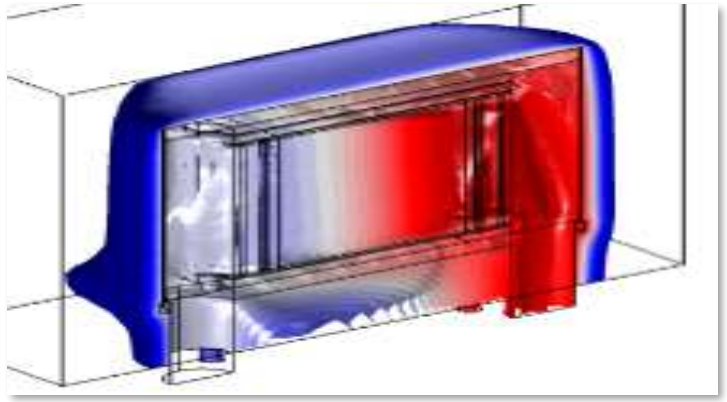


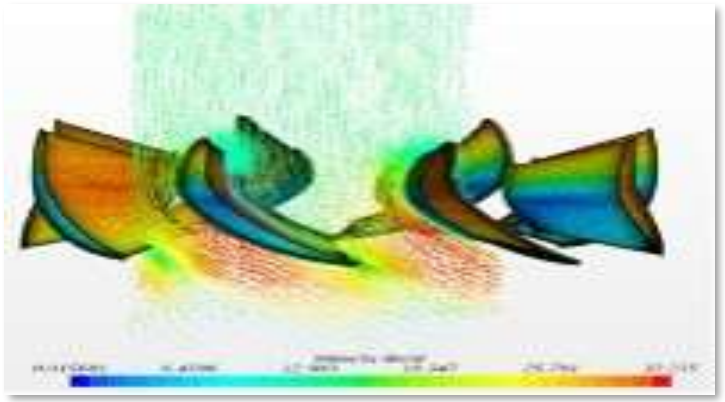
Technology innovation at cell, stack and system

TECHNOLOGY

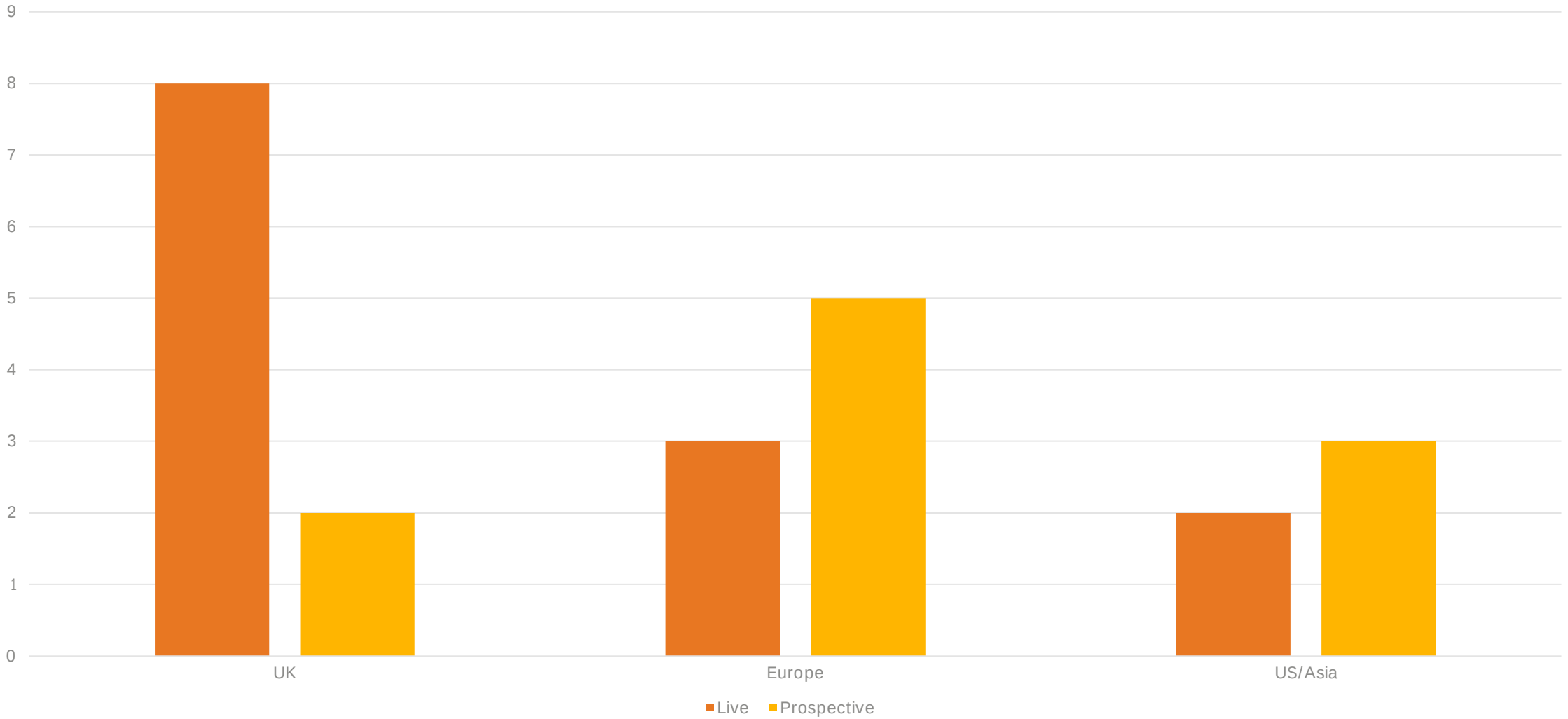
DIGITALISATION







University partnerships support cutting edge research

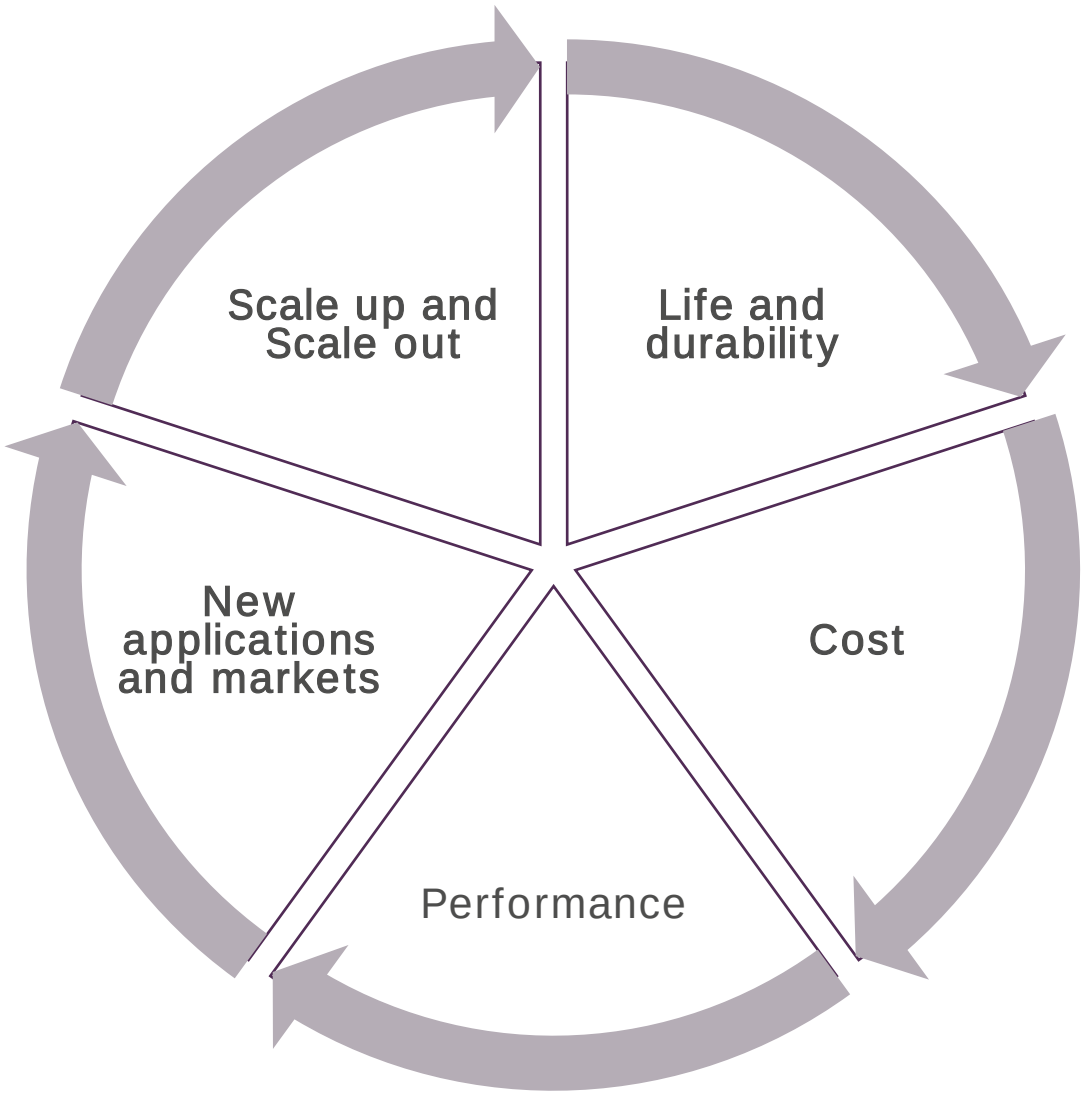


Technology innovation by design

Research and innovation

Technology maturation

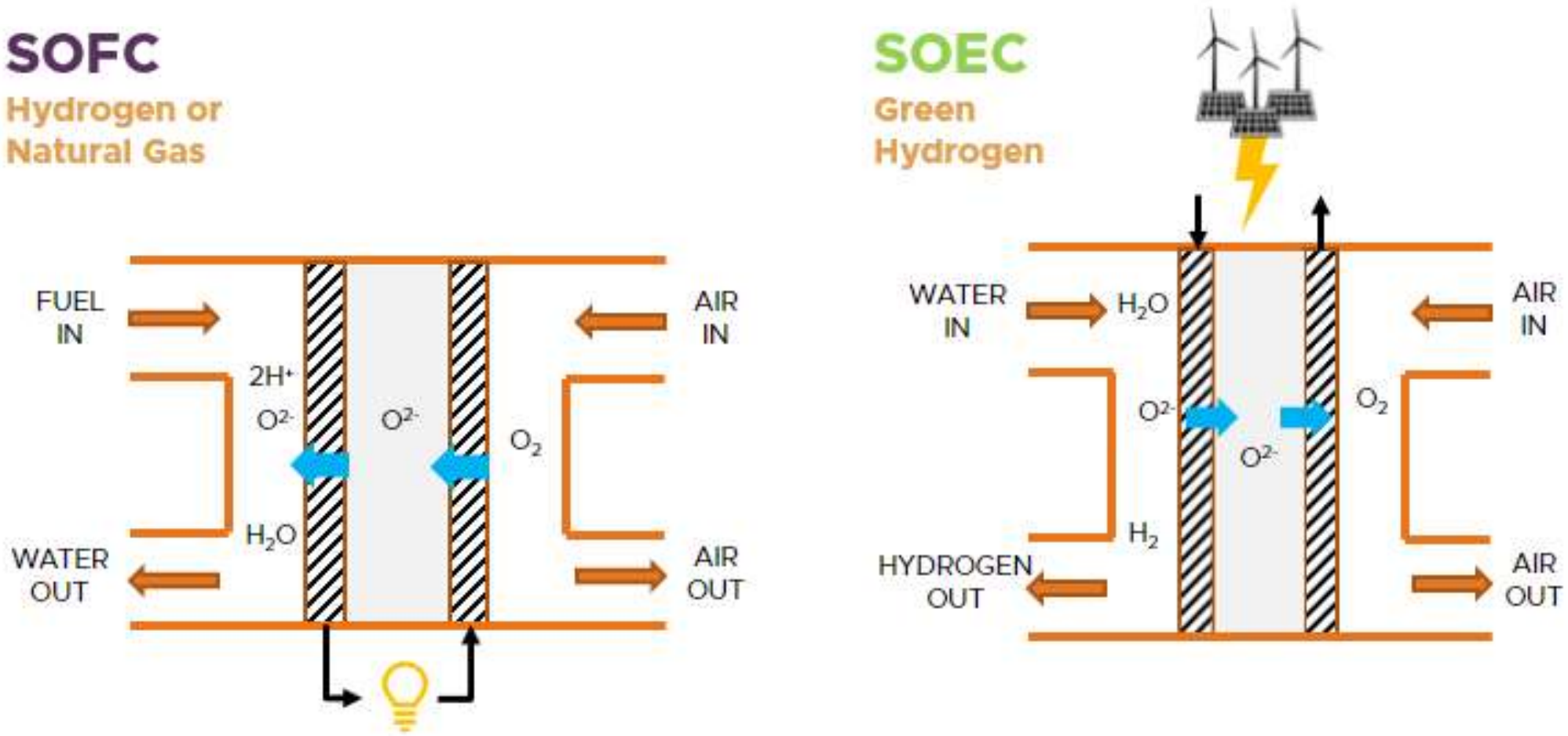
New product introduction



Highly differentiated technology

Subhasish Mukerjee

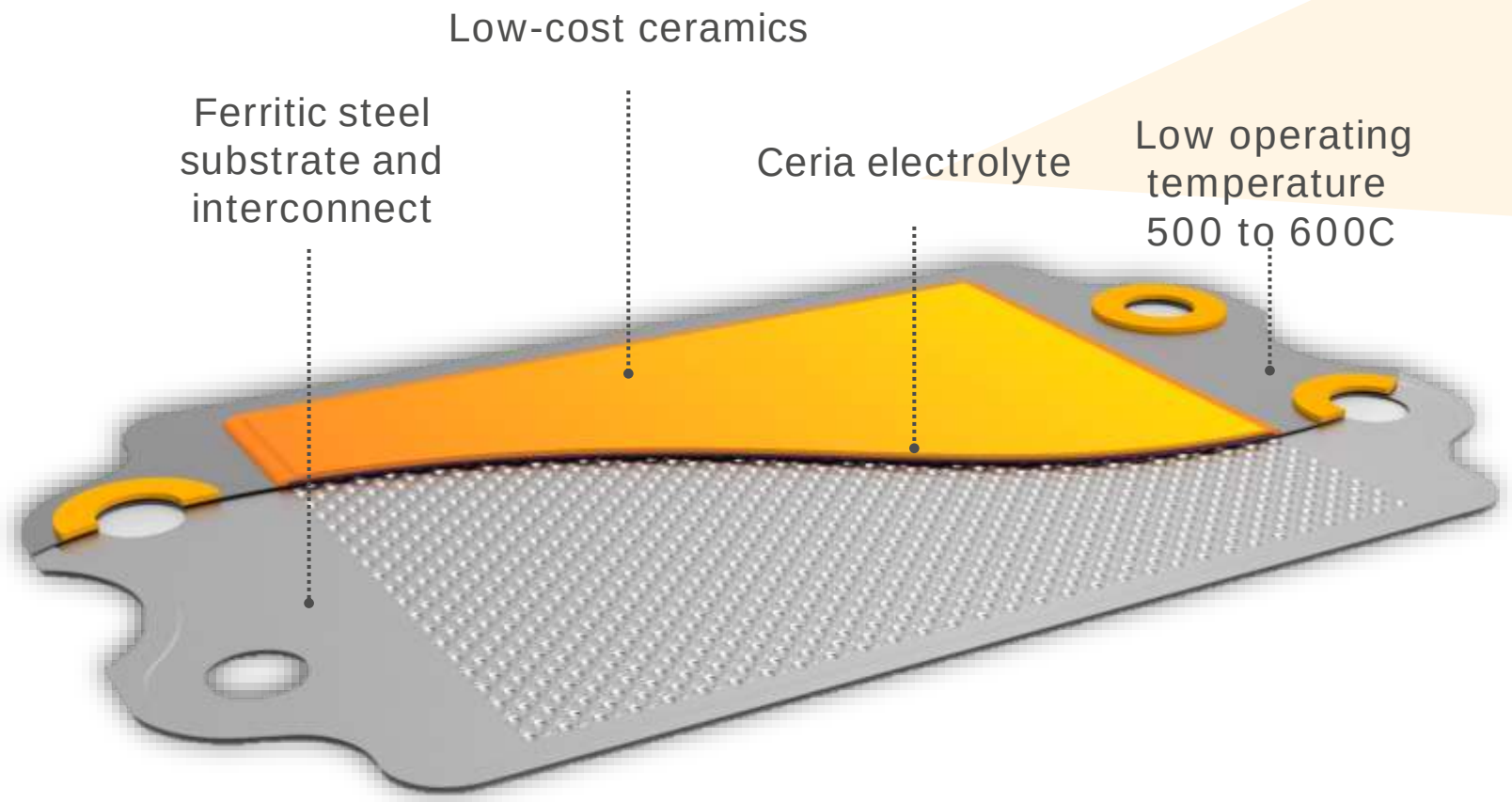
Solid oxide is a fully reversible technology



World-class performance

Highest efficiency
Most durable
Most robust
Fuel flexible

Low-cost, sustainable materials



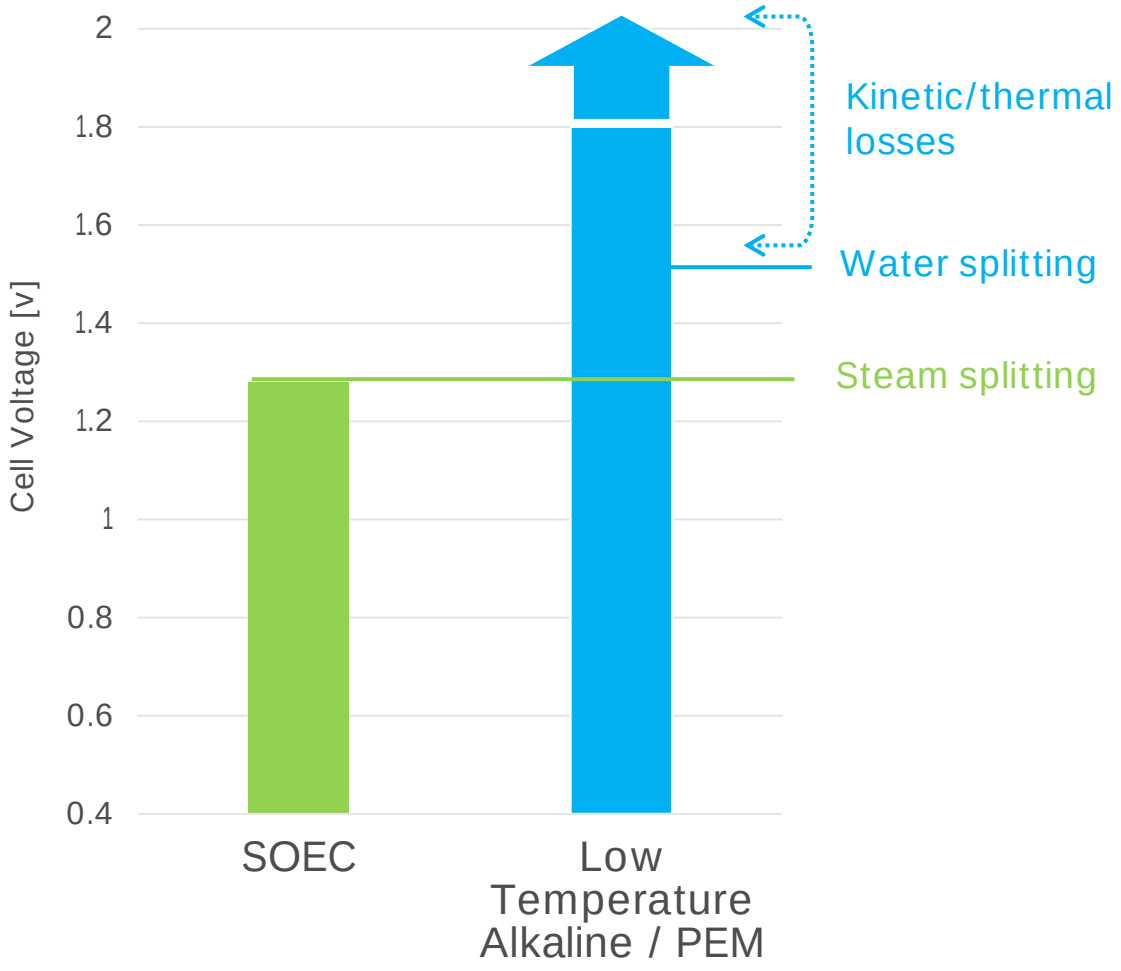
Ceria costs

1/1,000th platinum
1/70,000th iridium
1/10th nickel

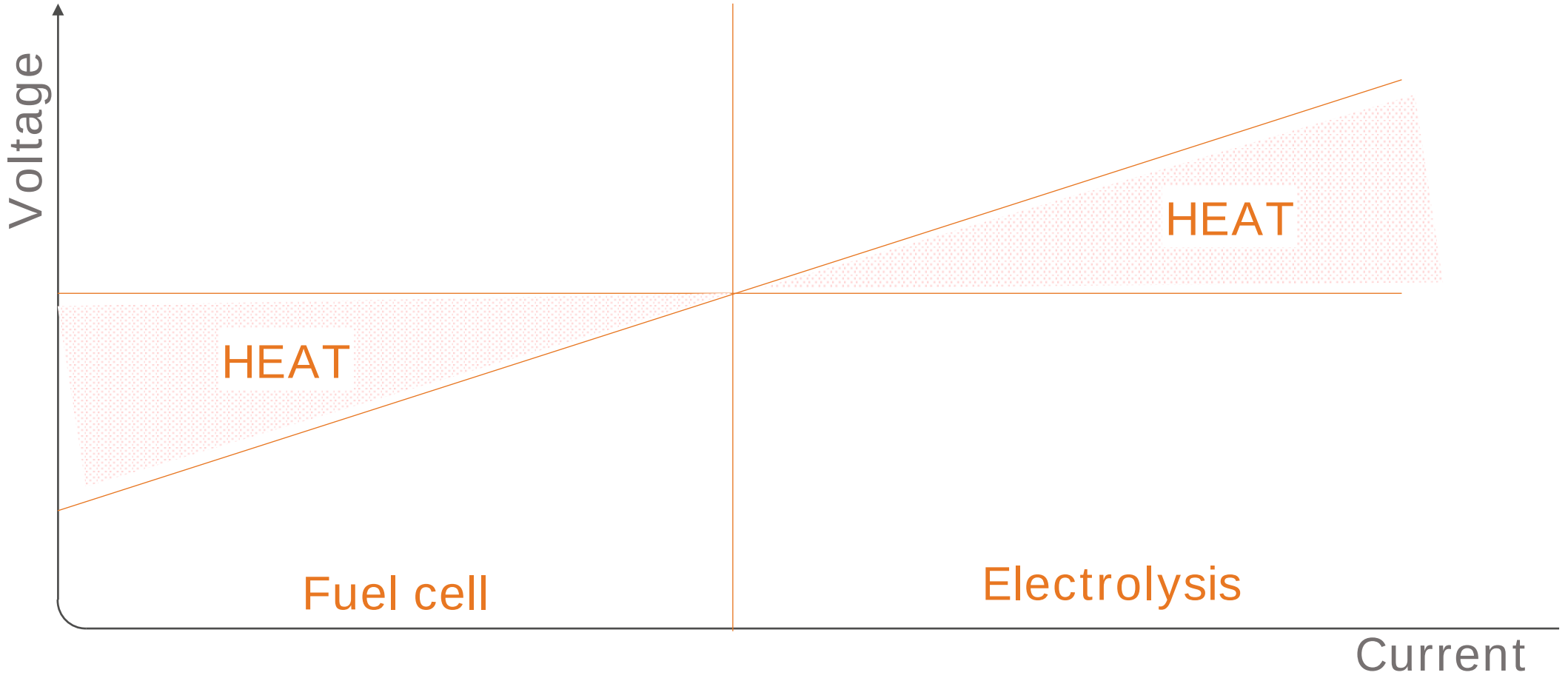
Why solid oxide offers the highest efficiency

Ceres stacks operate at:

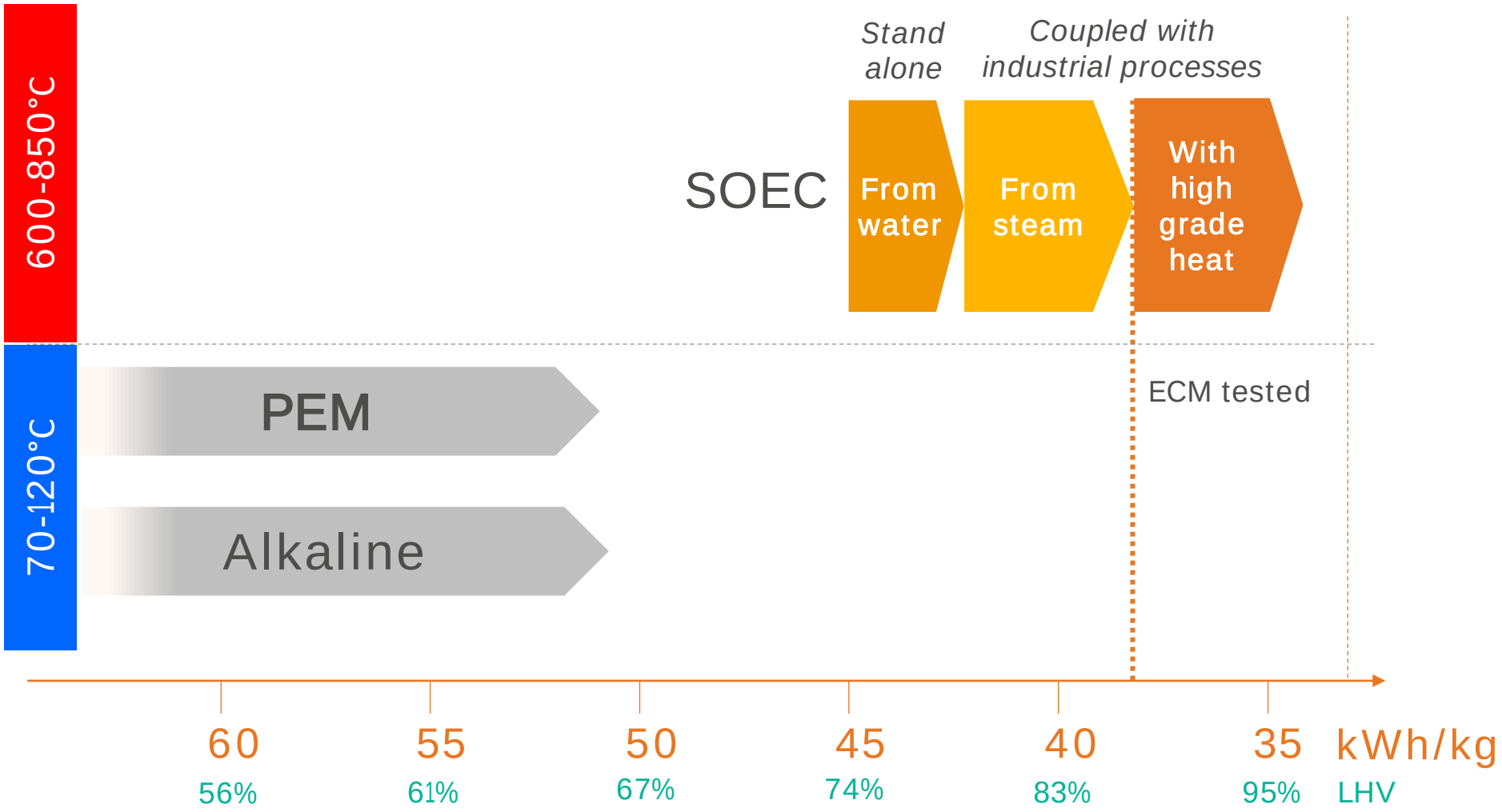
- **100%** electrical efficiency
- Using **a third less energy** compared to low temperature electrolysers



Heat drives efficiency in electrolyser mode

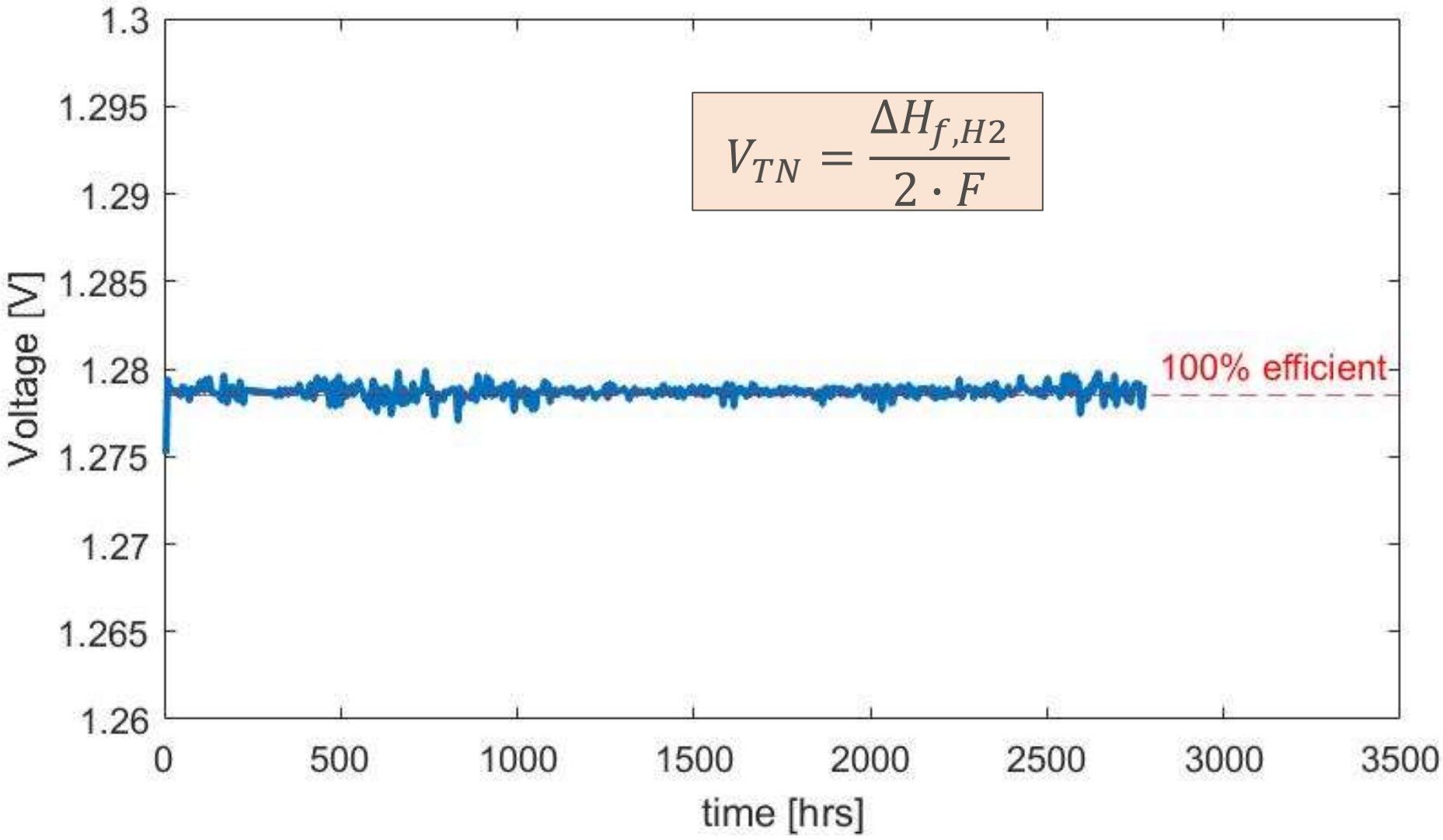


SOEC intrinsic thermodynamic advantage

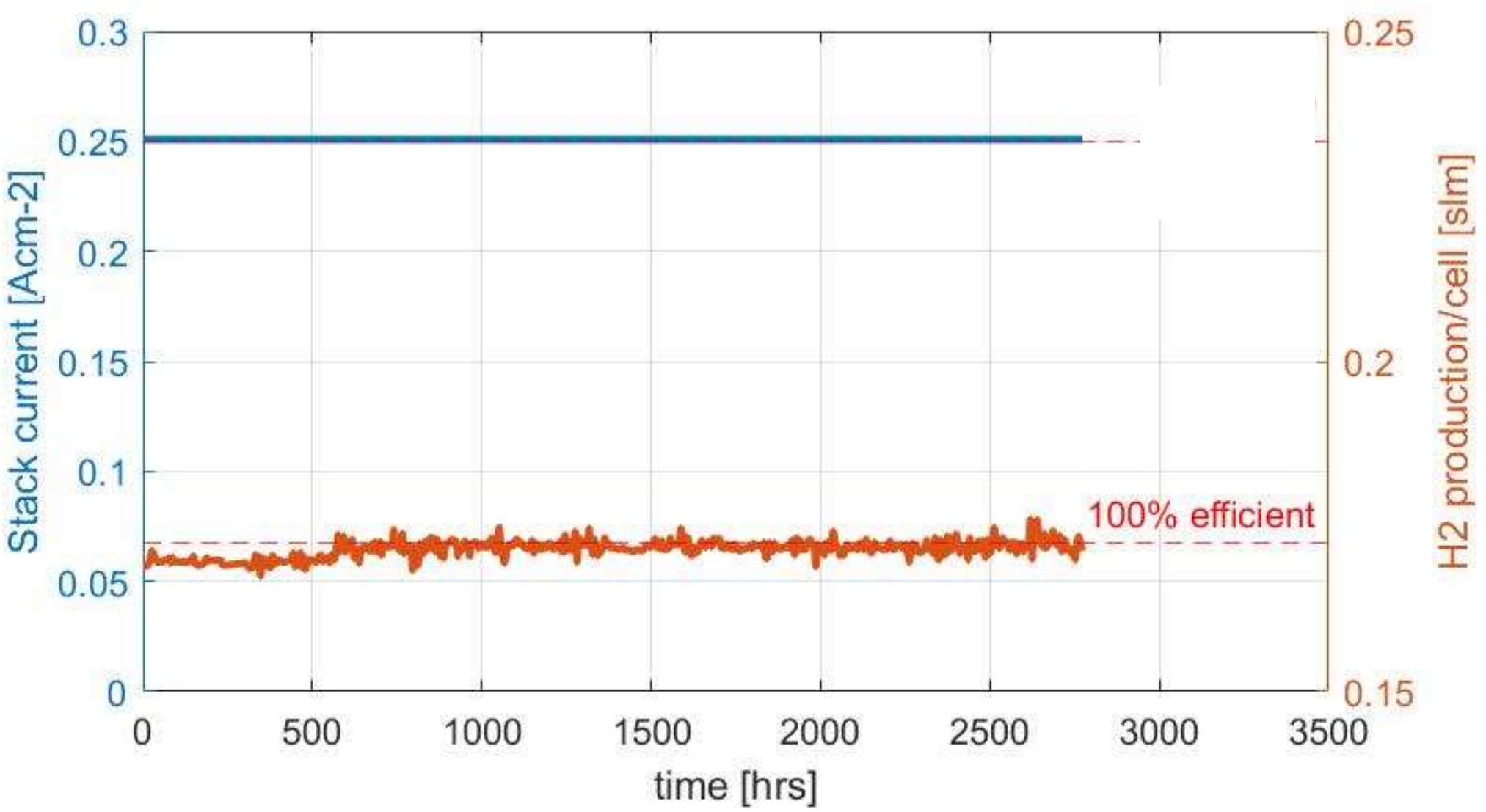


Green Hydrogen Cost Reduction –Scaling up Electrolysers to Meet the 1.5°C Climate Goal
International Renewable Energy Agency, 2020, Abu Dhabi

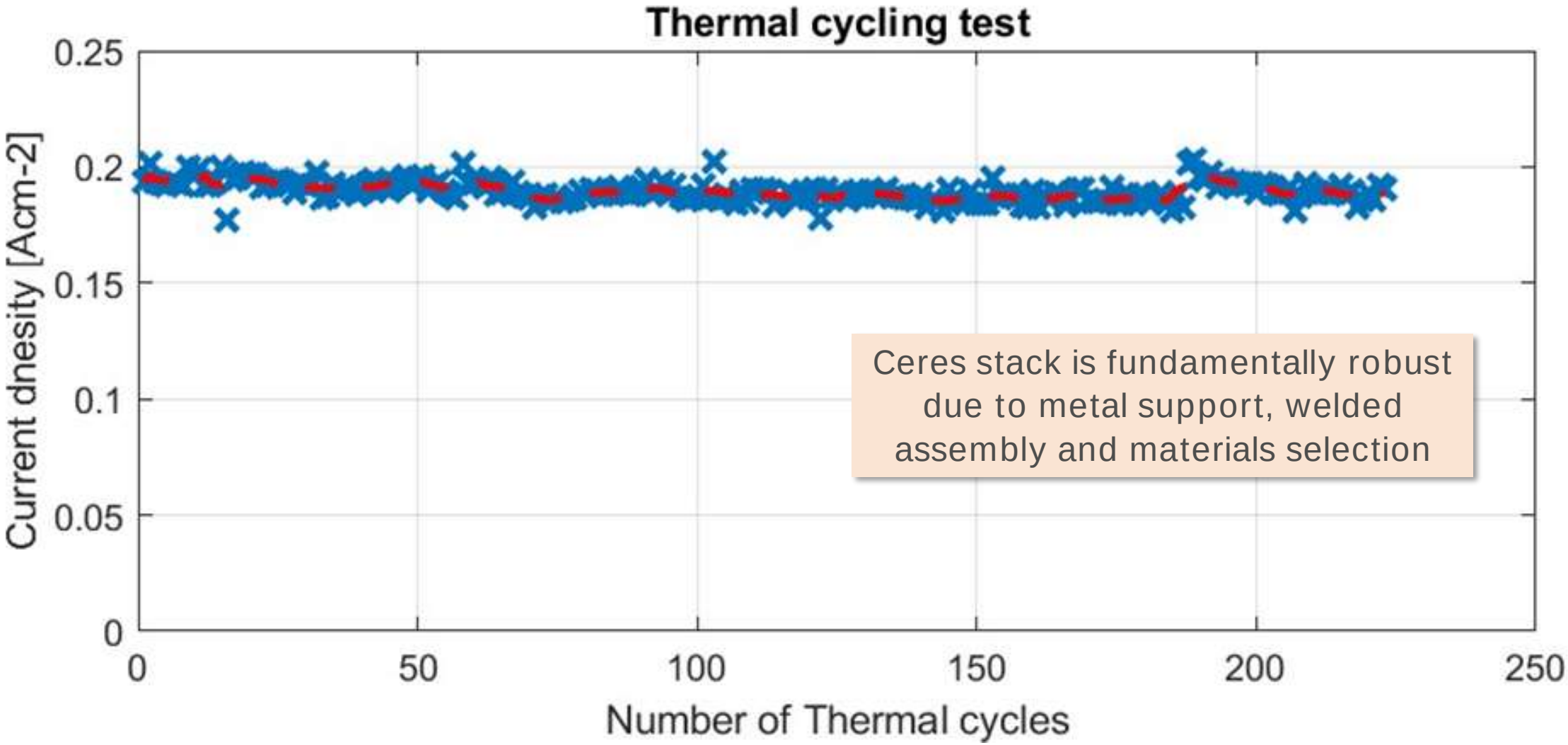
Thermoneutral operation offers maximum efficiency



Constant hydrogen output by increasing temperature through life

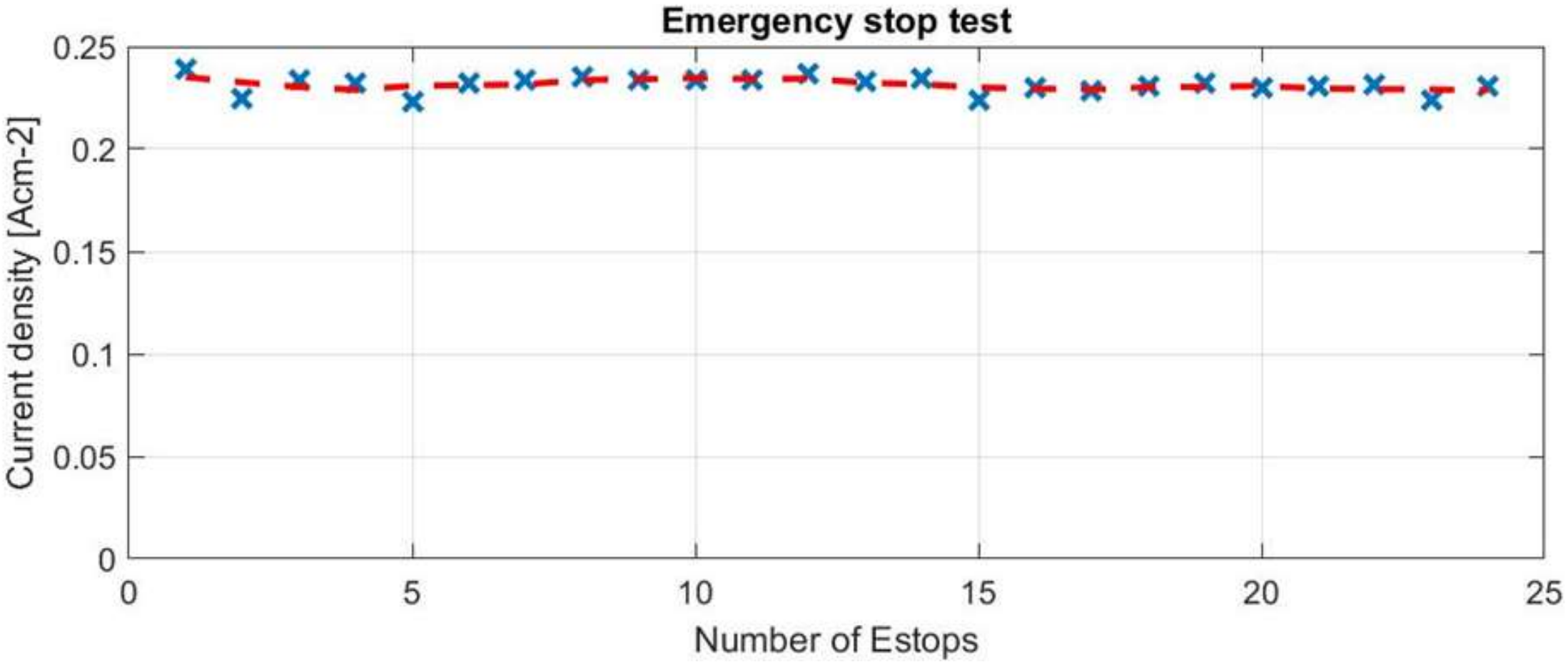


Robustness to thermal cycling



Ceres stack is fundamentally robust due to metal support, welded assembly and materials selection

Robust due to metal support, electrode and low temperature



Metal supported technology highly differentiated

Highest efficiency

Cost-efficient

Durable and robust

Scalable solution

Modular design that scales up to market

Jon Harman

SOEC technology maturation and demonstration approach

Cell and stack development

Electrolysis module development

x8

8 stacks

SOEC system development

x9

72 stacks

SOEC module demonstrated at 38kWh/kg

Specification	Target value
Electrical power input	~100kW
Hydrogen production	65kg per day
Module efficiency	38kWh/kg
Steam input	150°C

MW-class SOEC system installed at test site in Germany

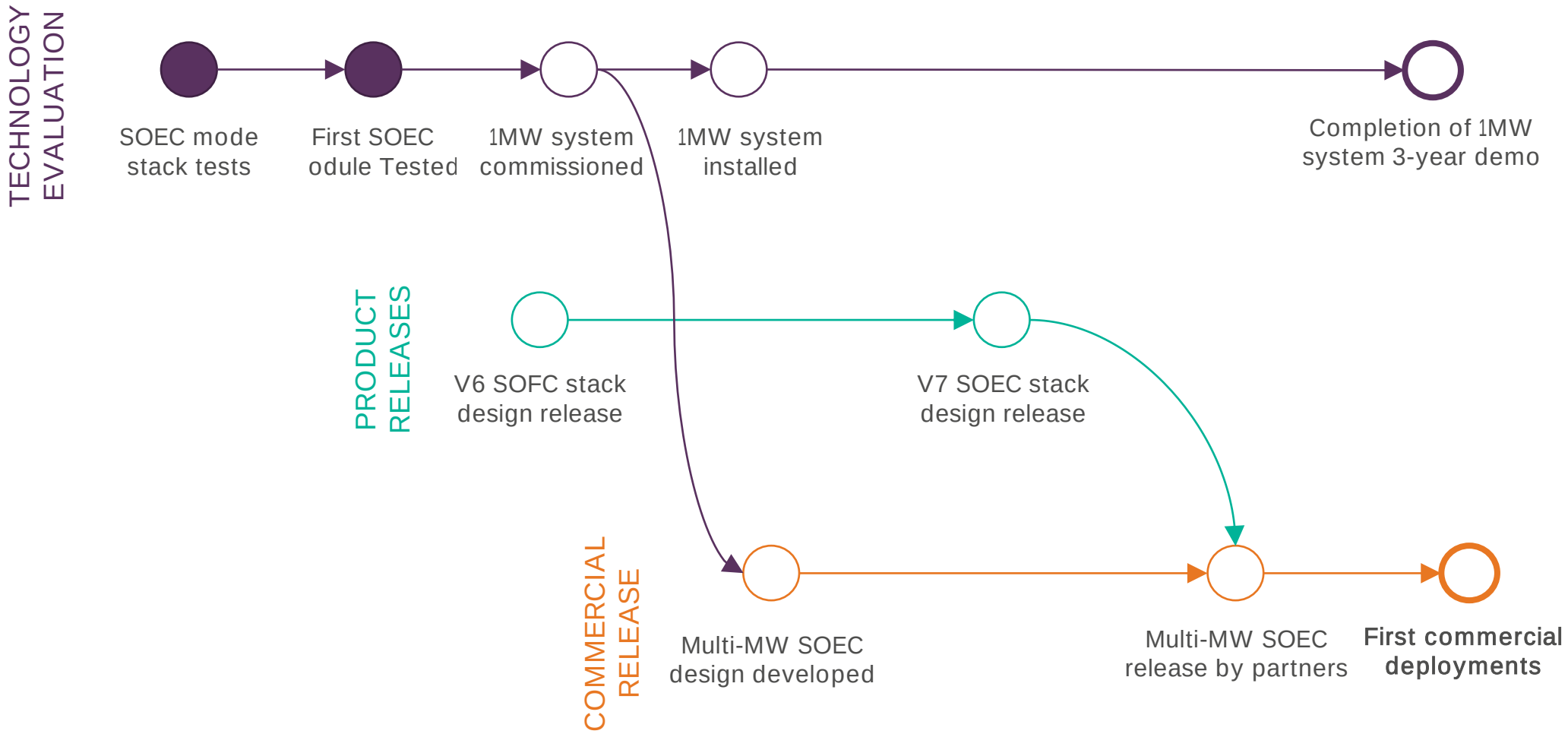
Tech focus: SOEC

Collaboration with Bosch and Linde Engineering

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.

Roadmap to first commercial deployments



Modular scale-up concept

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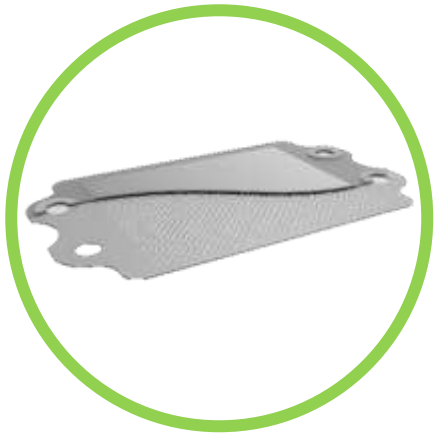
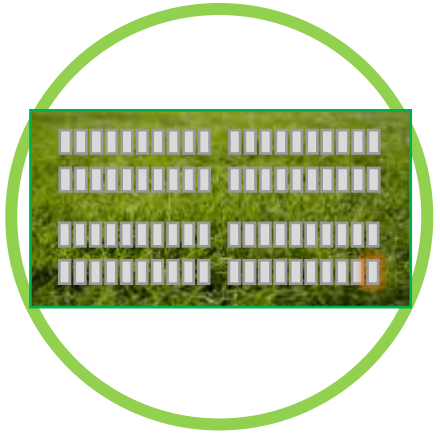
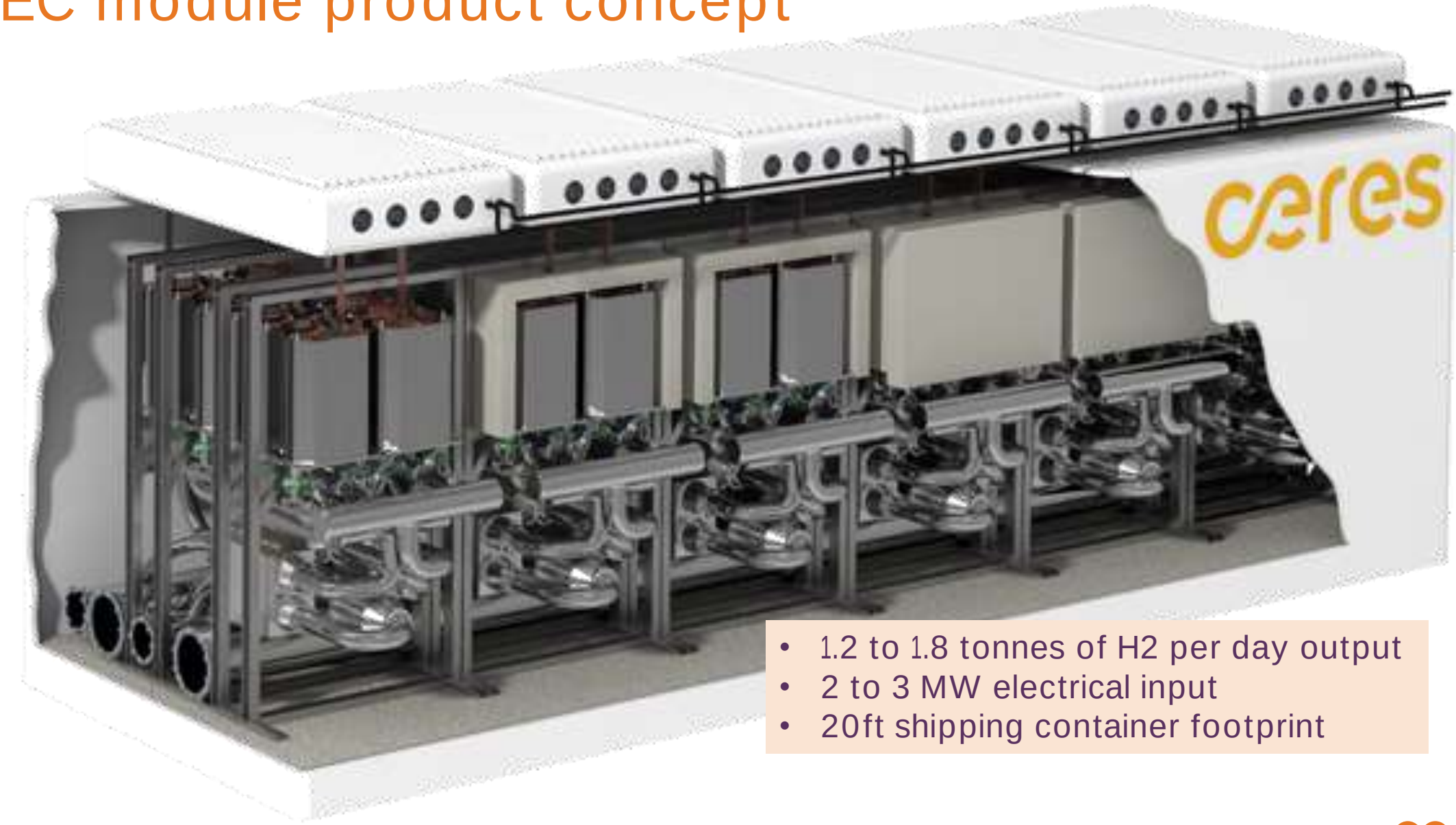




Industrial decarbonisation of green steel, green ammonia, e-fuels. Chemicals, oil and gas

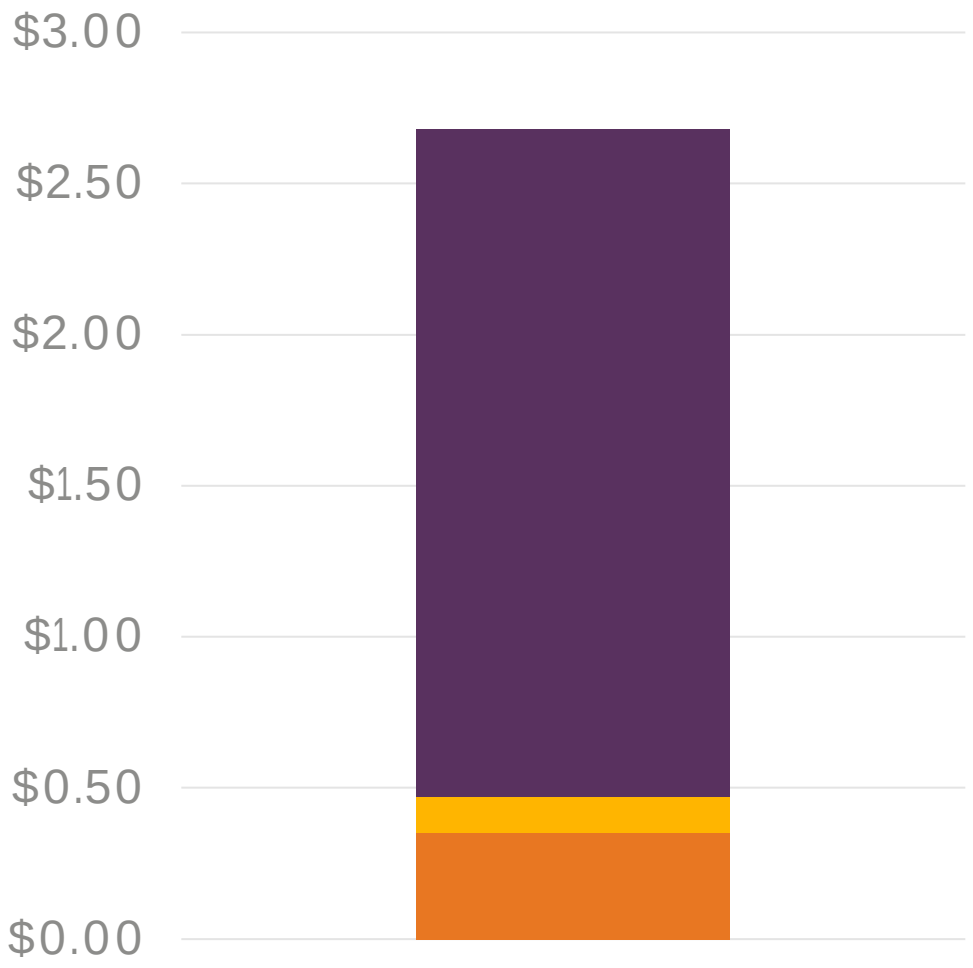
SOEC module product concept



- 1.2 to 1.8 tonnes of H2 per day output
- 2 to 3 MW electrical input
- 20ft shipping container footprint

Levelised cost of hydrogen

USD/kg



ENERGY

Electrical power at $55/MWh

O&M

Stack replacement cost, assuming conservative life of five years

CAPEX

Electrolyser system costs, including stacks, $600/kW

Indicative 2030 project costs

For 1MT of green hydrogen

	Low temp	SOEC target	
	System Efficiency 50 kWh/kg*	System Efficiency 37 kWh/kg*	
Green hydrogen production Per year	1MT	1MT	Cost savings
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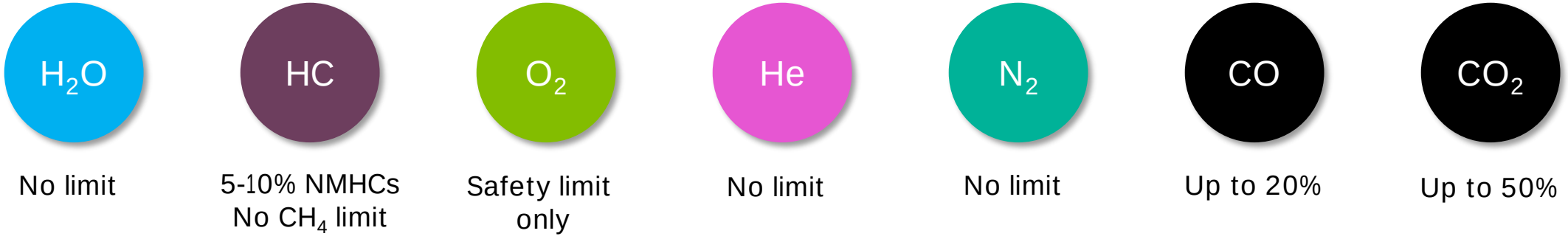
Ceres SOFC efficient and fuel agnostic

Fuels supported

Impurities in hydrogen and reformates can be tolerated to a high level

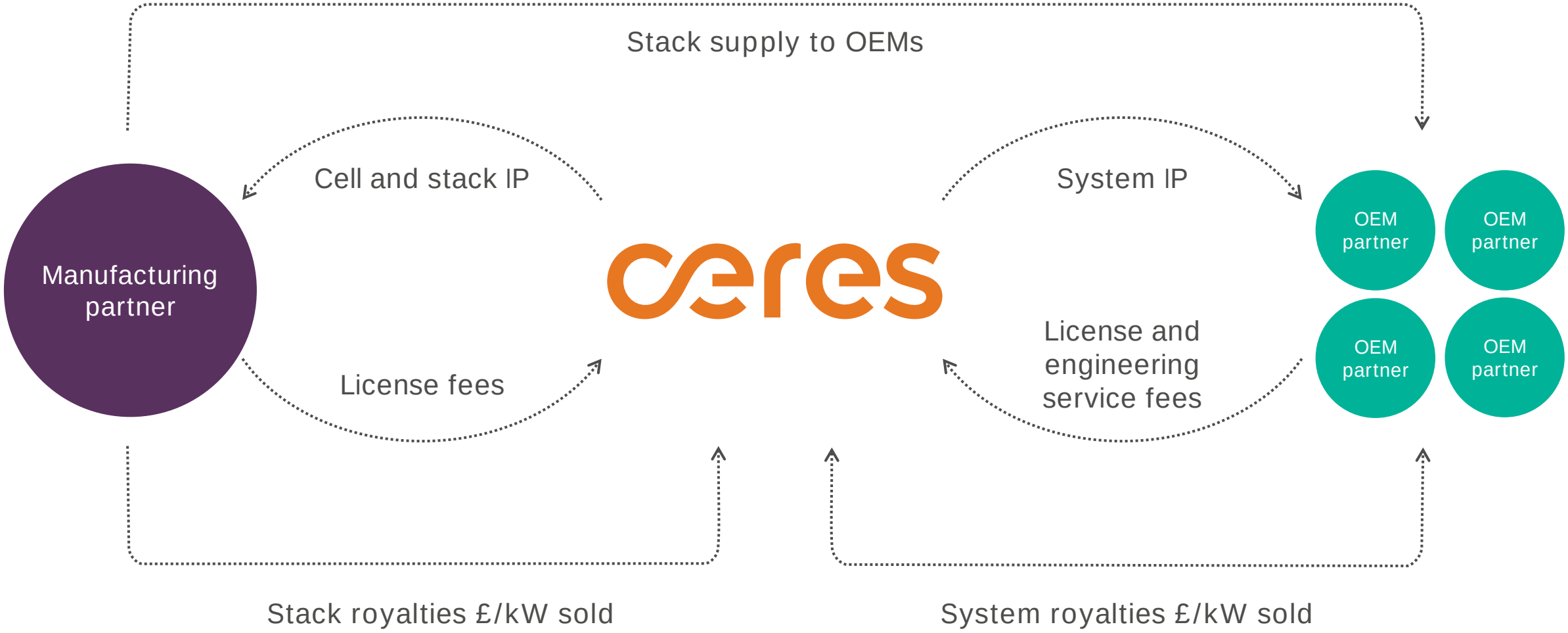


Q&As

Engagement through the hydrogen value chain

Tony Cochrane

Asset-light, licensing business model for SOFC and SOEC

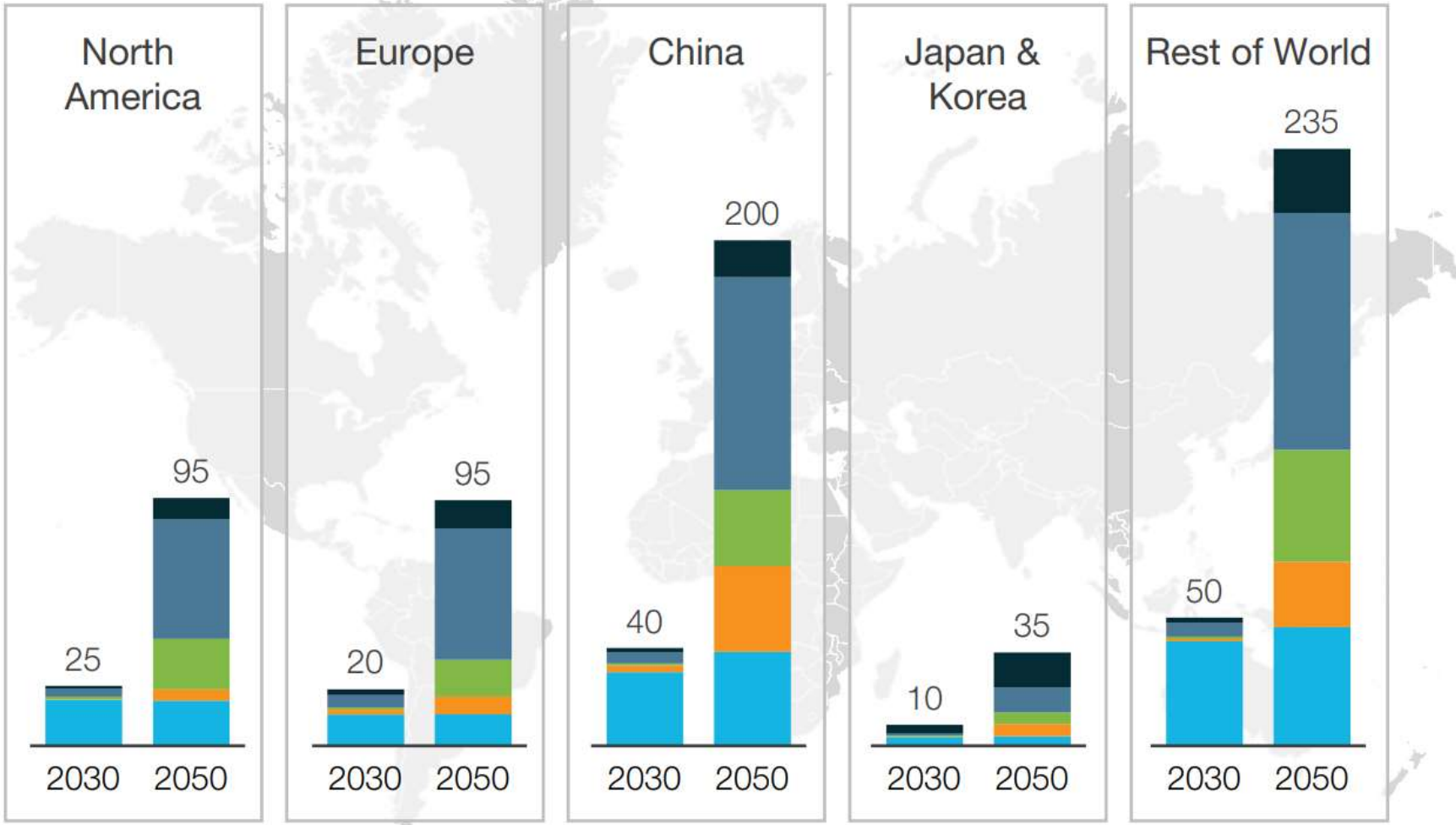


Engagement through the hydrogen value chain


TOR 3

Hydrogen end-use demand by region

MT hydrogen p.a.



Source: Hydrogen for net Zero, Hydrogen Council 2021.

IEA net-zero scenario with 340EJ final energy demand in 2050. HHV assumed. Excluding power.

- Power
- Mobility
- Heating
- New industry uses
- Existing industry use

Electrolysis builds on mature fuel cell capability

Both uses of our core technology have the:

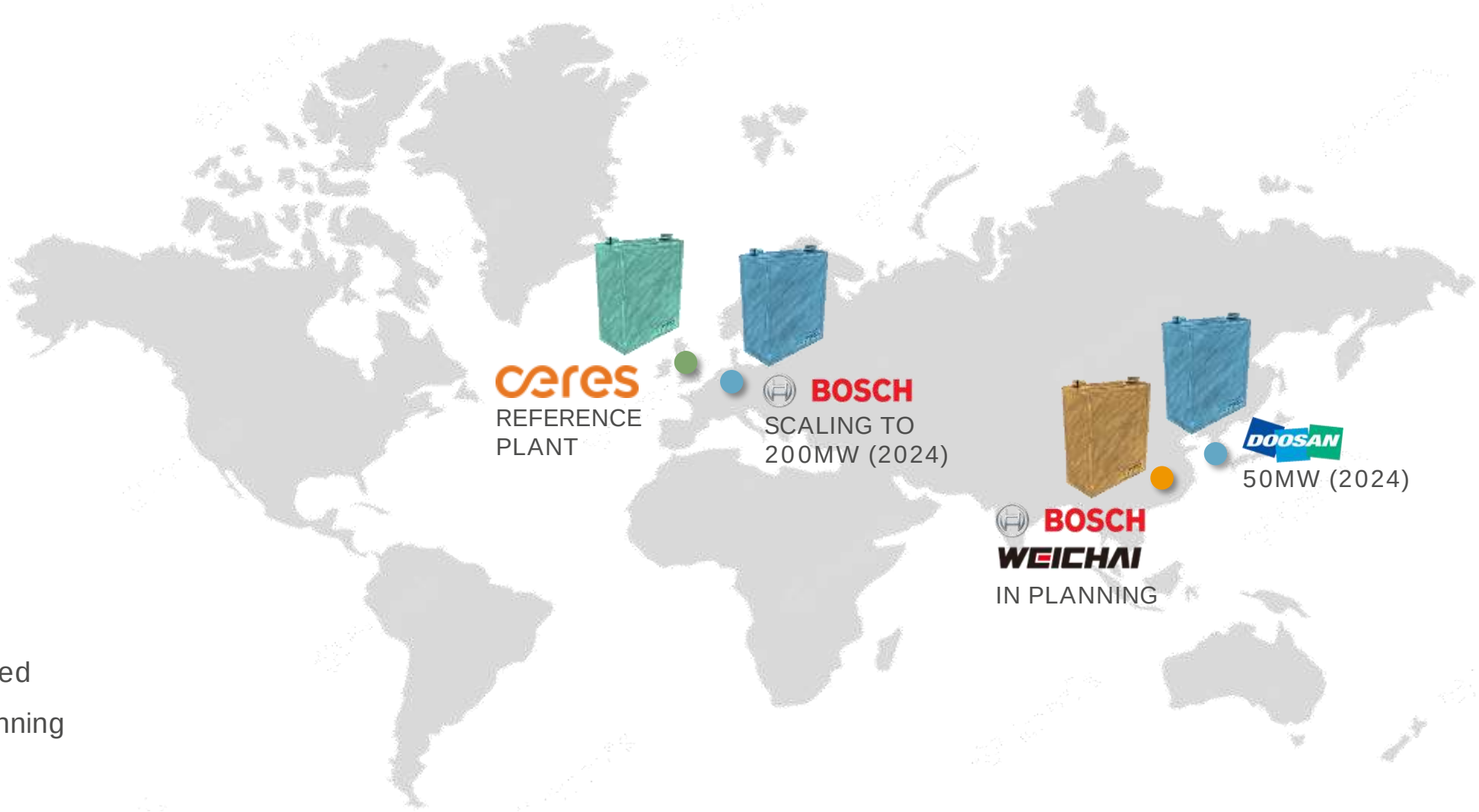
Same core cell and **stack technology platform**

Same **IP portfolio** covering SOEC and SOFC

Same **manufacturing process and supply chain**

Same **partnering** model providing scale

Ceres partners building manufacturing scale globally



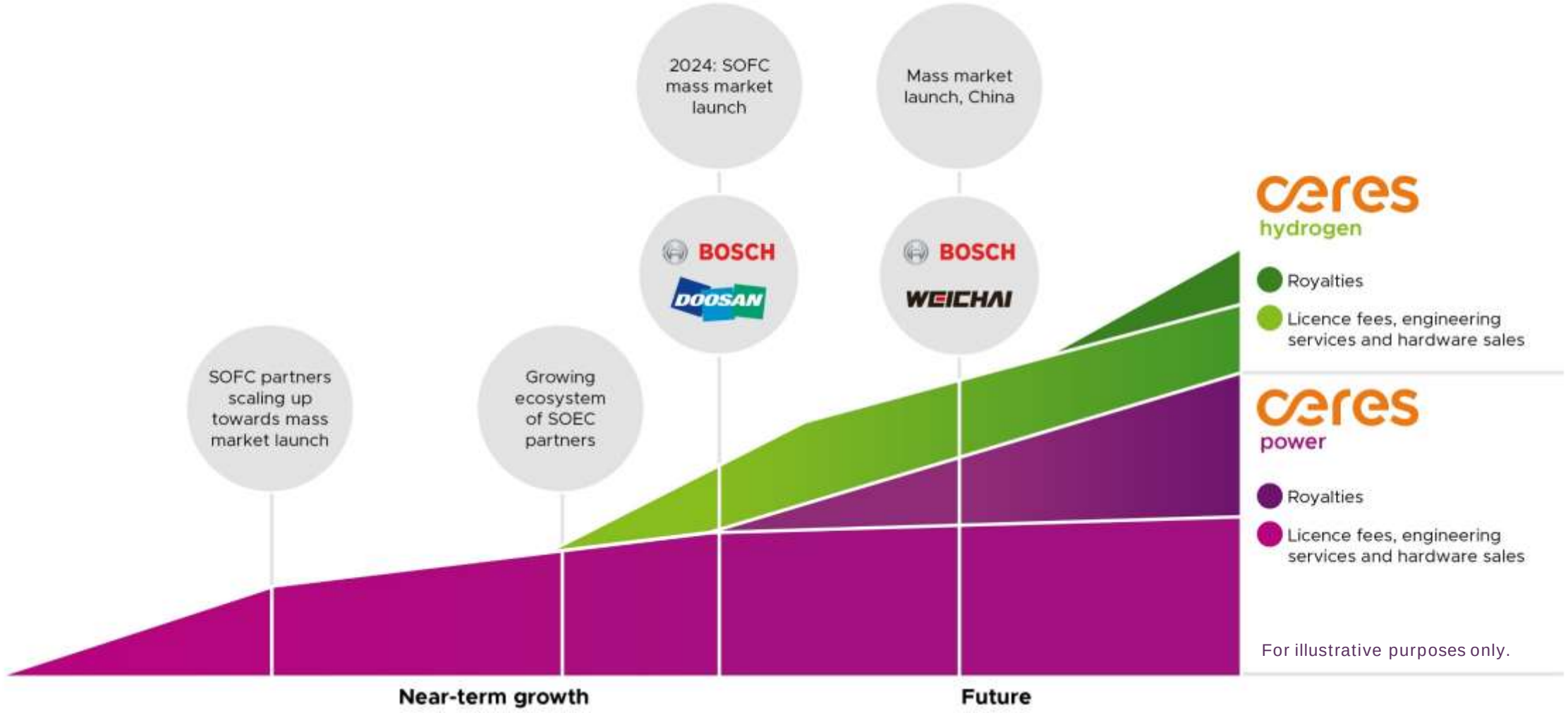
Same partnership progression as fuel cells

1. Joint product development
Engineering services

2. Licence: system/ manufacturing
Fees for tech transfer

3. Royalties from products sold
Royalties per kW

Growing visibility of future royalty revenue



Q&As