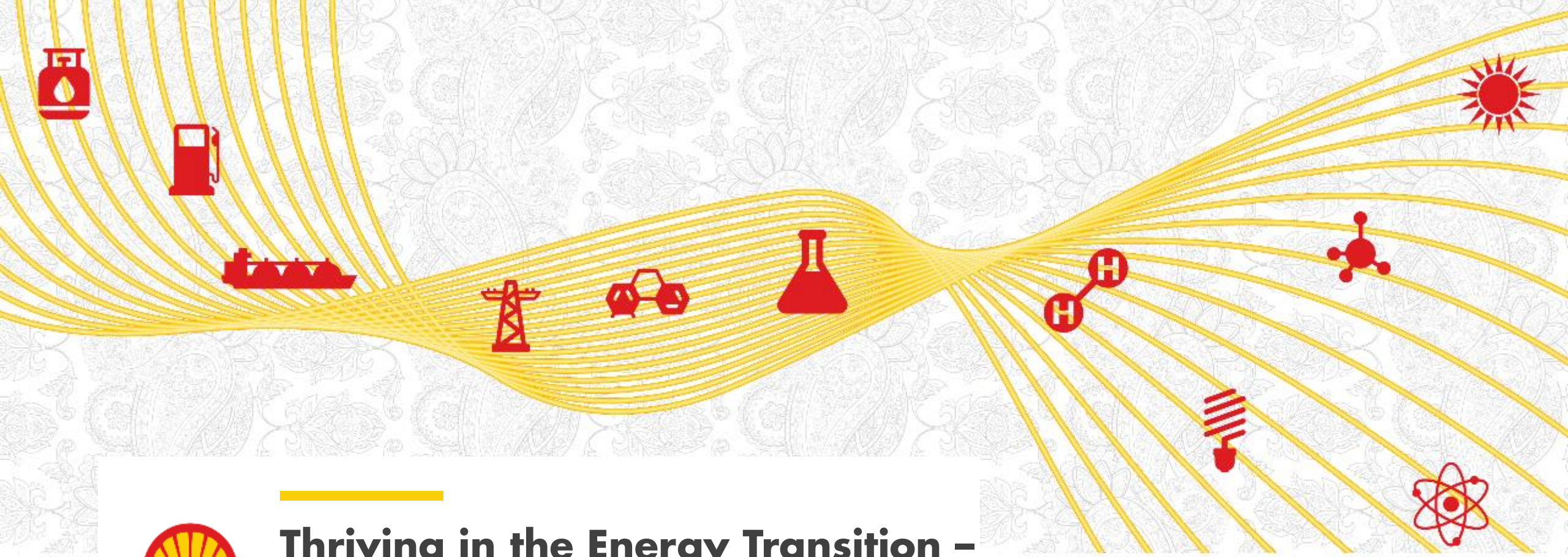

Thriving in the Energy Transition – Pathways to a Low Carbon Future

Ajay Mehta
GM Long Range Reserch & New Energy Technologies

UT Energy Week, Austin, TX, January 29, 2018

Definitions & cautionary note

Reserves: Our use of the term "reserves" in this presentation means SEC proved oil and gas reserves.

Resources: Our use of the term "resources" in this presentation includes quantities of oil and gas not yet classified as SEC proved oil and gas reserves. Resources are consistent with the Society of Petroleum Engineers 2P and 2C definitions.

Organic: Our use of the term Organic includes SEC proved oil and gas reserves excluding changes resulting from acquisitions, divestments and year-average pricing impact.

Shales: Our use of the term 'shales' refers to tight, shale and coal bed methane oil and gas acreage.

The companies in which Royal Dutch Shell plc directly and indirectly owns investments are separate entities. In this document "Shell", "Shell group" and "Royal Dutch Shell" are sometimes used for convenience where references are made to Royal Dutch Shell plc and its subsidiaries in general. Likewise, the words "we", "us" and "our" are also used to refer to subsidiaries in general or to those who work for them. These expressions are also used where no useful purpose is served by identifying the particular company or companies. ''Subsidiaries'', "Shell subsidiaries" and "Shell companies" as used in this document refer to companies over which Royal Dutch Shell plc either directly or indirectly has control. Companies over which Shell has joint control are generally referred to as "joint ventures" and companies over which Shell has significant influence but neither control nor joint control are referred to as "associates". The term "Shell interest" is used for convenience to indicate the direct and/or indirect ownership interest held by Shell in a venture, partnership or company, after exclusion of all third-party interest.

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Shell's Purpose

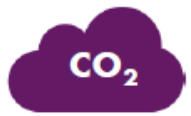
We power progress together by providing more and cleaner energy solutions

LET'S MAKE THE FUTURE

Underpinned by our people and a relentless drive for Goal Zero

Thrive in the energy transition

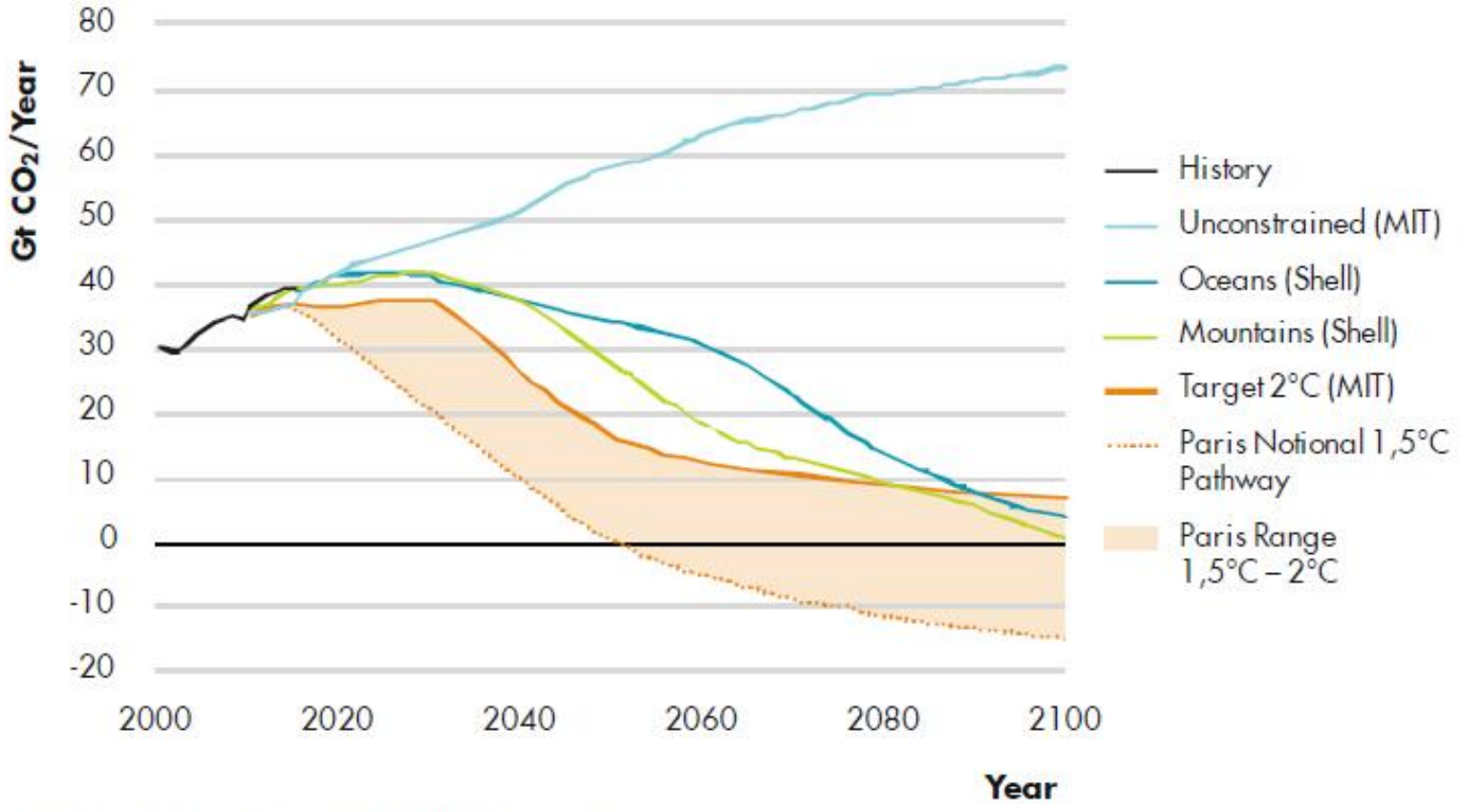
Societal challenge

2015		2070
	Increasing population	
7 billion		**>10** billion
	Increasing energy demand	
570 Exajoules		**1000** Exajoules
	Need to reduce CO_2 emissions	
32 gt CO_2e	 2040 **43** gt CO_2e current policies	Net Zero Emissions 

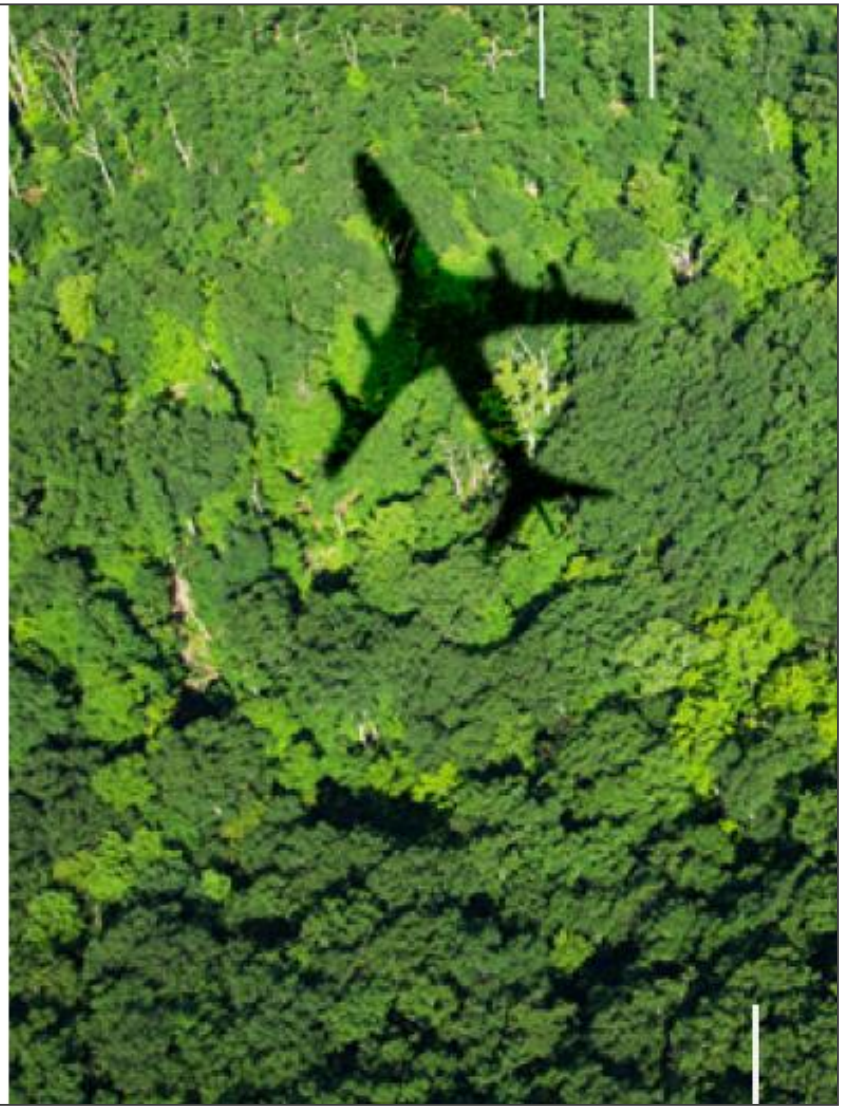
- Challenge for more and cleaner energy
- Reduction required in the carbon intensity of every unit of energy consumed

Sources: Population – UN World Population projections; Energy consumption: 2015 – IEA World Energy Outlook ("WEO") 2017; 2070 outlook – Shell scenarios analysis from A Better Life with a Healthy Planet
CO_2 emissions: 2015 – IEA WEO 2017; 2040 – IEA WEO 2017 Current policies scenario; 2070 – Shell scenarios analysis from A better life with a healthy planet.

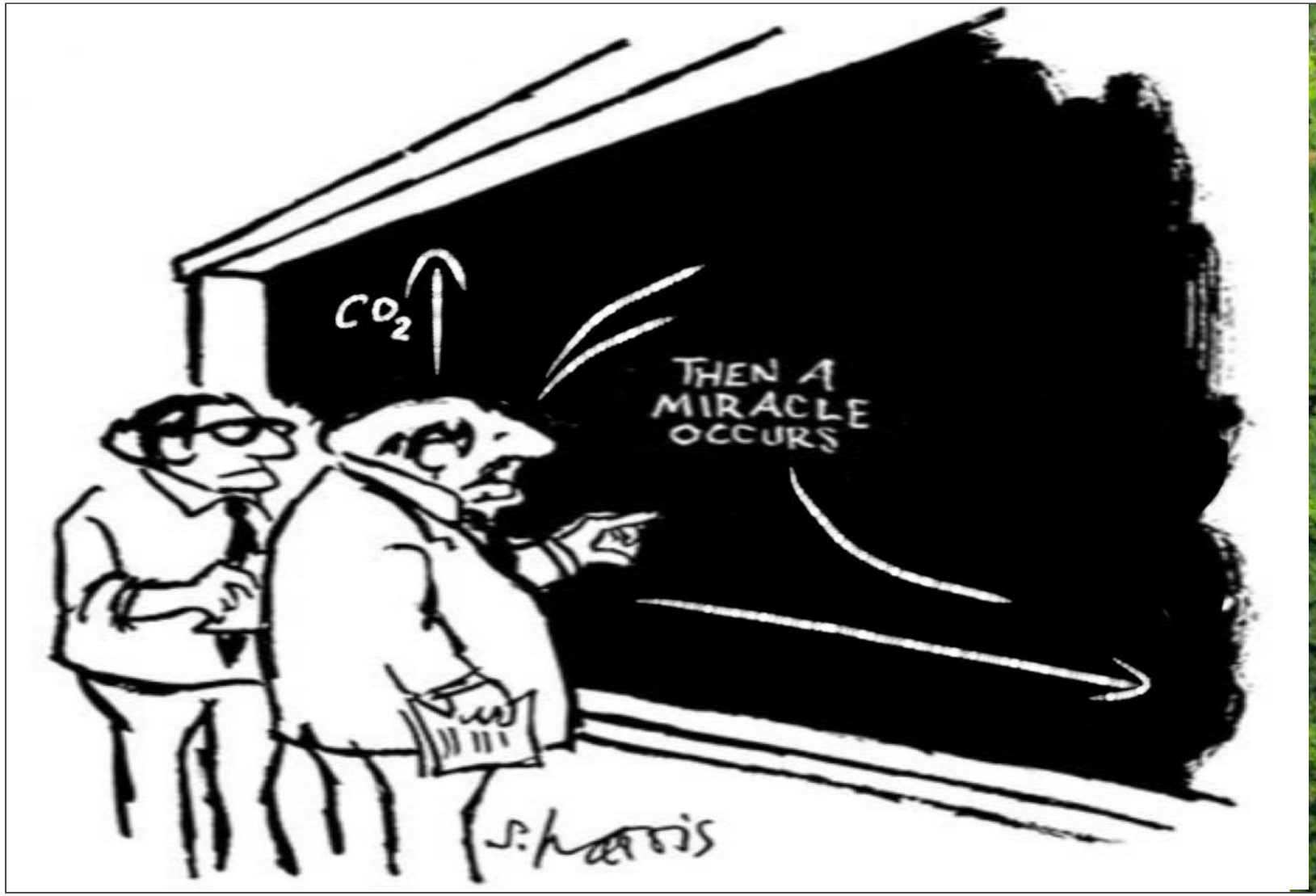
CO2 Emission Pathways

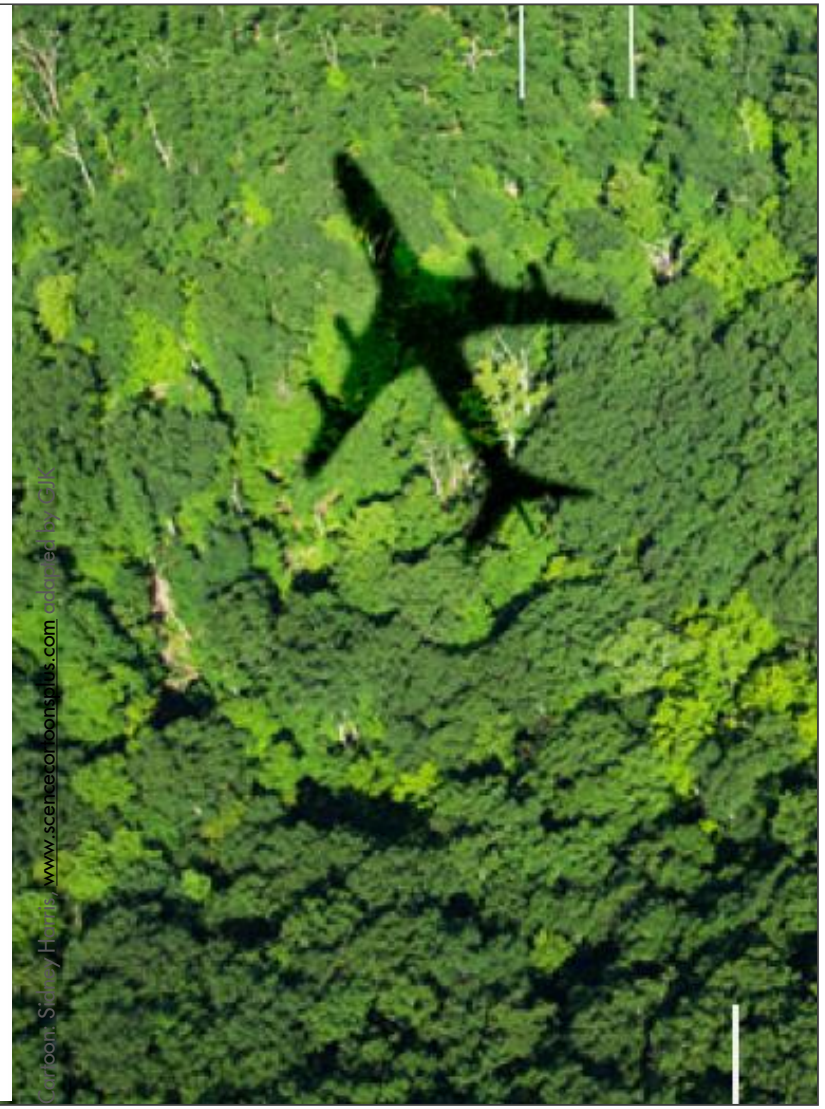


Source: Shell analysis - World Energy Model and MIT 2015 & 2016



CO2 Emission Pathways





Cartoon Stock, http://www.sciencecartoonsplus.com adapted by Gk

Thrive in the energy transition

Ambition – Net Carbon Footprint

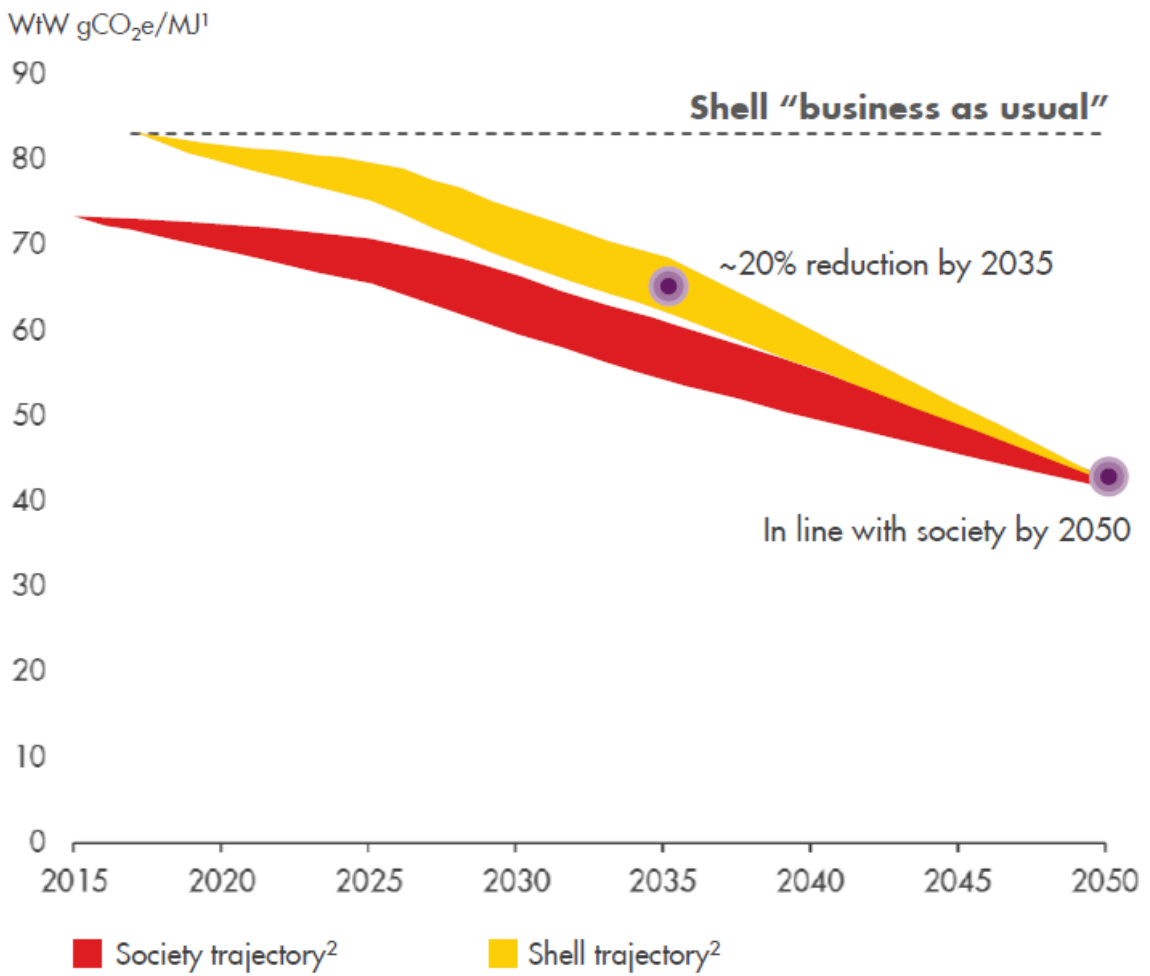
Ambition to reduce Net Carbon Footprint[1] of our energy products by around 20% by 2035

- Covers full range of emissions from energy products
- Aim to reduce overall intensity including production, supply chain, and customers
- Government policy, technology, and consumer choice will drive actual energy transition pace and outcomes
- Drive strategy over time in step with society
- 5-year reviews to ensure in line with societal progress

Ambitions:

- Reduce Net Carbon Footprint[1] of our energy products by ~20% by 2035
- Be in line with society Net Carbon Footprint by 2050

Ambition for Net Carbon Footprint[1]



1: Net Carbon Footprint measured on an aggregate "well to wheel" or "well to wire" basis, from production through to consumption, on grams of CO_2 equivalent per megajoule of energy products consumed; chemicals + lubricants products are excluded. Carbon Footprint of the energy system is modelled using Shell methodology aggregating lifecycle emissions of energy products on a fossil-equivalence basis. The methodology will be further reviewed and validated in collaboration with external experts.

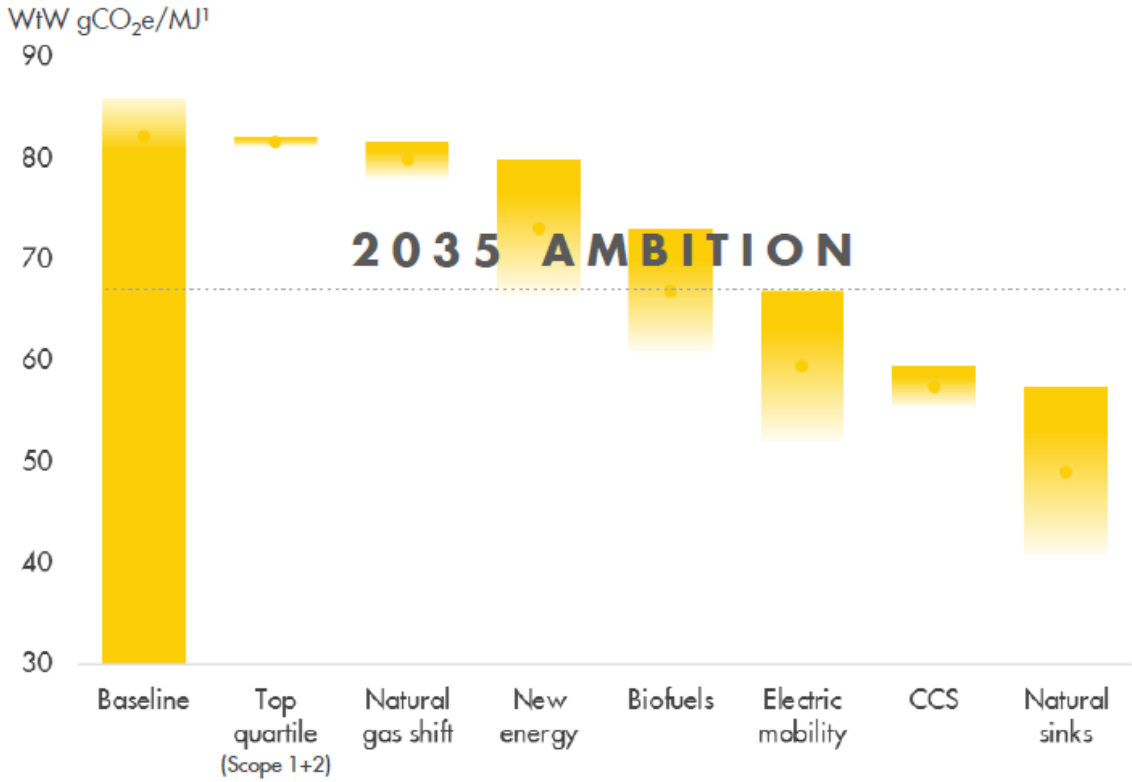
2: Potential society trajectory includes analysis from Shell scenarios estimate of Net Zero Emissions by 2070 and IEA Energy Technology Perspectives 2017; Potential illustrative Shell trajectory

Thrive in the energy transition

Ambition – Net Carbon Footprint

- Flexibility and mix of options to achieve ambition
  - Allows for oil and gas production growth offset by evolving product mix
- Changing product mix gives greatest opportunity
- Top-quartile scope 1 + 2 emissions has limited overall impact

Potential tools to achieve our 2035 Net Carbon Footprint[1] ambition



- Shell is active in each of these areas

Existing examples:


Flare reduction


Increased LNG


Wind power

Raizen biofuels


Shell Recharge + New Motion


Quest CCS


Nature based offsets

1: Net Carbon Footprint measured on an aggregate "well to wheel" or "well to wire" basis, from production through to consumption, on grams of CO_2 equivalent per megajoule of energy products consumed; chemicals + lubricants products are excluded. Carbon Footprint of the energy system is modelled using Shell methodology aggregating lifecycle emissions of energy products on a fossil-equivalence basis. The methodology will be further reviewed and validated in collaboration with external experts.

New Energies

- Build integrated value chains
- Exploit adjacencies to existing businesses
- Discipline and commerciality
- Not equipment manufacturing

Emerging Opportunities

New Fuels

Focus areas:

- Biofuels
- Hydrogen

Power

Focus areas:

- Trading, marketing and customer access
- Low-carbon generation and storage (solar, wind, gas)

Shell and Biofuels

Trading & Supply

One of the world's largest blenders and distributers of biofuels

Raízen JV

Production of low-carbon ethanol from Brazilian sugar cane

Advanced Biofuels

Investing in technologies using alternatives feedstocks such as waste

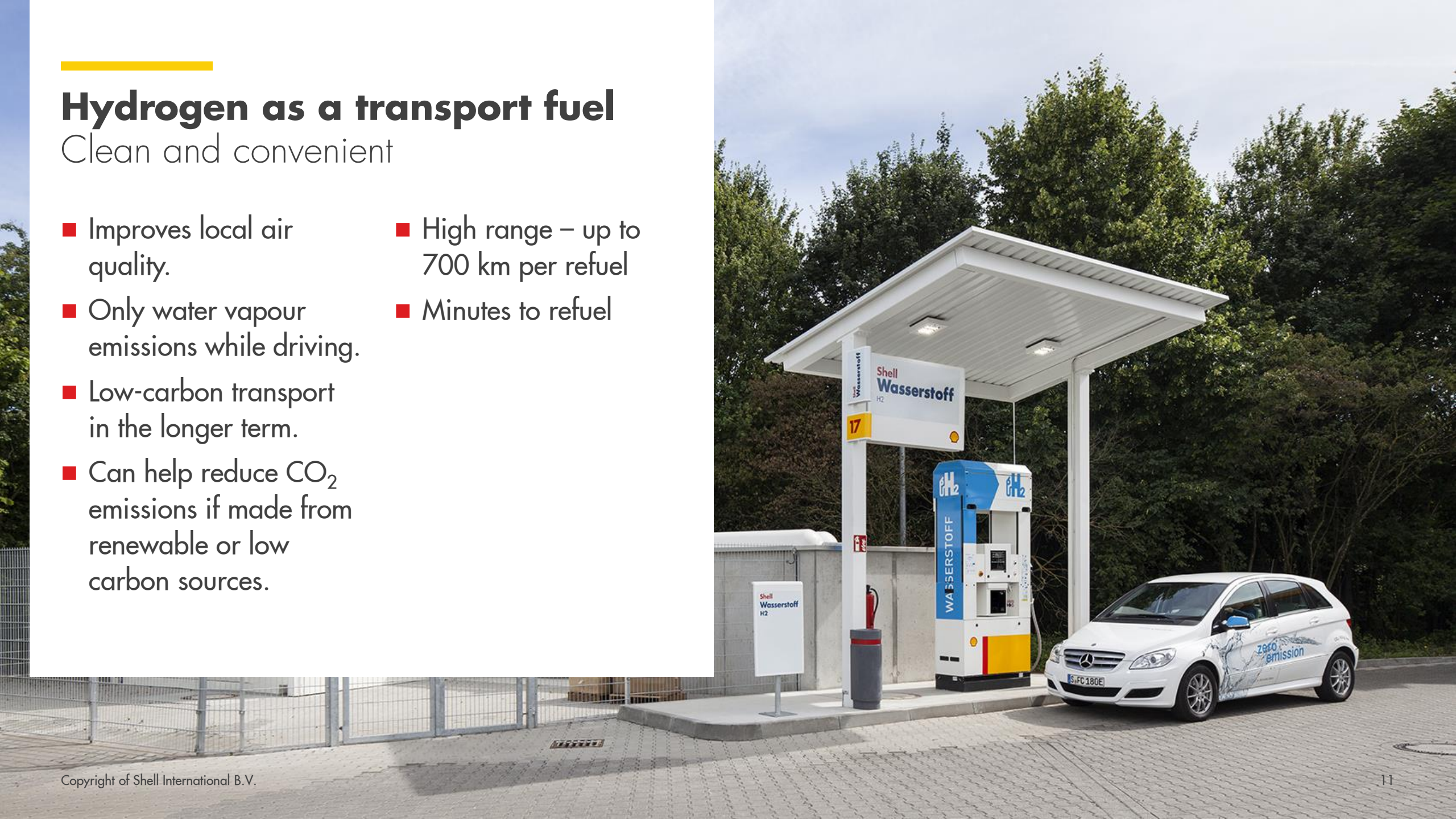
Sustainability

Commitment to the supply and development of sustainable biofuels

Hydrogen as a transport fuel

Clean and convenient

- Improves local air quality.
- Only water vapour emissions while driving.
- Low-carbon transport in the longer term.
- Can help reduce CO_2 emissions if made from renewable or low carbon sources.
- High range – up to 700 km per refuel
- Minutes to refuel



Shell and hydrogen

Germany

H2 Mobility Germany

- Industry consortium – 400 stations by 2023.

(230 Shell-branded)

California, USA

Shell Retail Stations

- Two Shell refuelling Stations – Torrance and Newport Beach.

Toyota Partnership

- Seven retail stations to be owned/operated by Shell.

UK

- First Shell hydrogen station in 2017 – London, UK.

Portfolio resilience through a

Power value chain

- Adjacencies to existing gas businesses
- Value chain integrator
- Demand-driven development

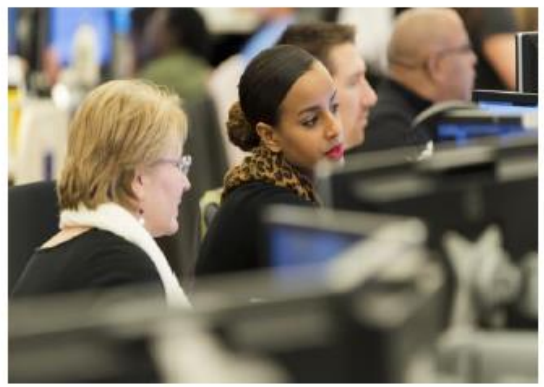
CUSTOMERS

Multiple parties are active on the demand side

- Secure demand in key markets
- Commercial, industrial, and residential

OPTIMISATION

Leverage portfolio flexibility and arbitrage opportunities



- Optimise intermittent demand and supply
- Trading opportunities

SUPPLY & GENERATION

Not all products are supplied by Shell; some are purchased from third parties

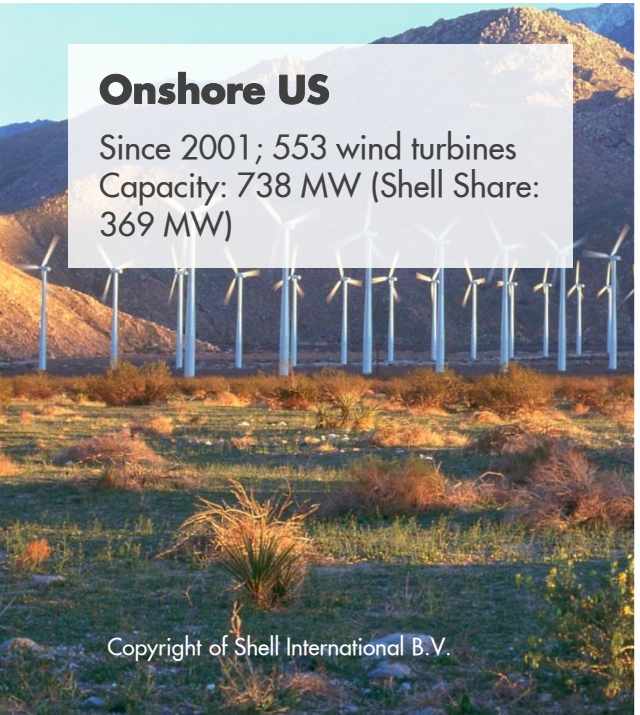
- Wind, solar, and selected gas and storage assets
- Selective capacity ownership to create portfolio flexibility

Wind

Experience and portfolio diversity

Wind is an increasingly prominent part of the evolving energy system

- More than 15 years' experience.
- Onshore and offshore projects operational in the USA and in Europe (50:50 joint ventures).
- Working to develop a diverse portfolio in offshore wind.



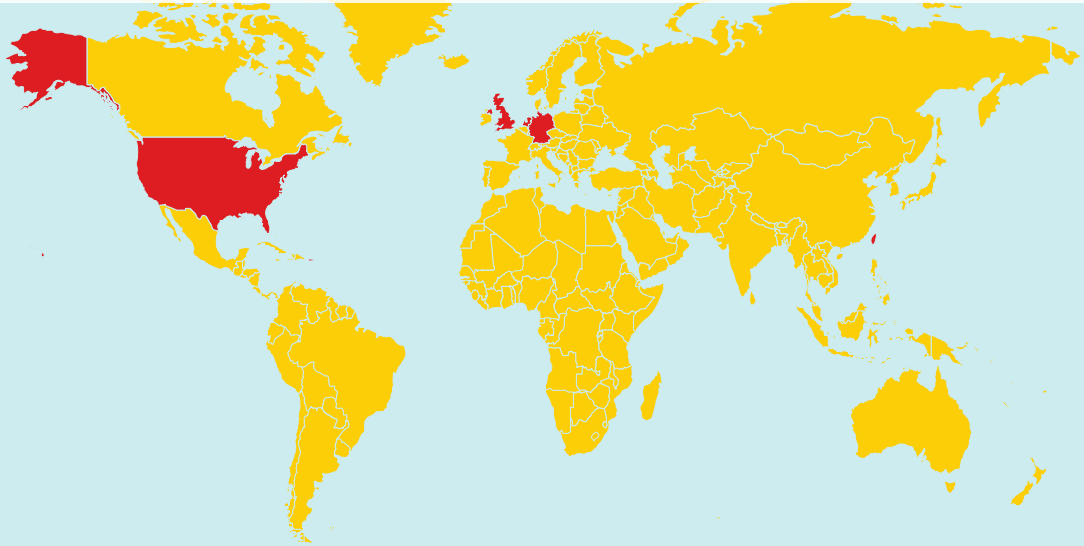
Onshore US

Since 2001; 553 wind turbines
Capacity: 738 MW (Shell Share: 369 MW)

Offshore Europe

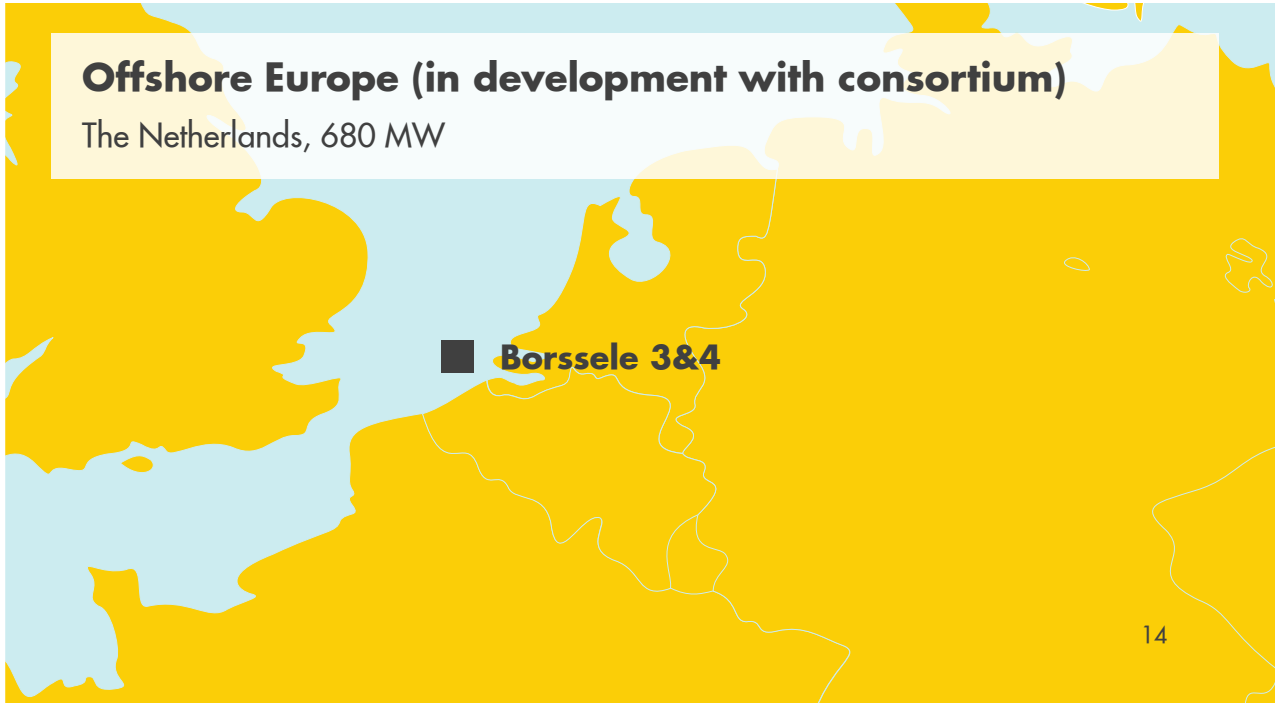
Since 2007; 36 wind turbines
Capacity: 108 MW (Shell Share: 54 MW)

Locations of our wind teams



Offshore Europe (in development with consortium)

The Netherlands, 680 MW



Solar

Providing tailored, integrated solutions for our customers

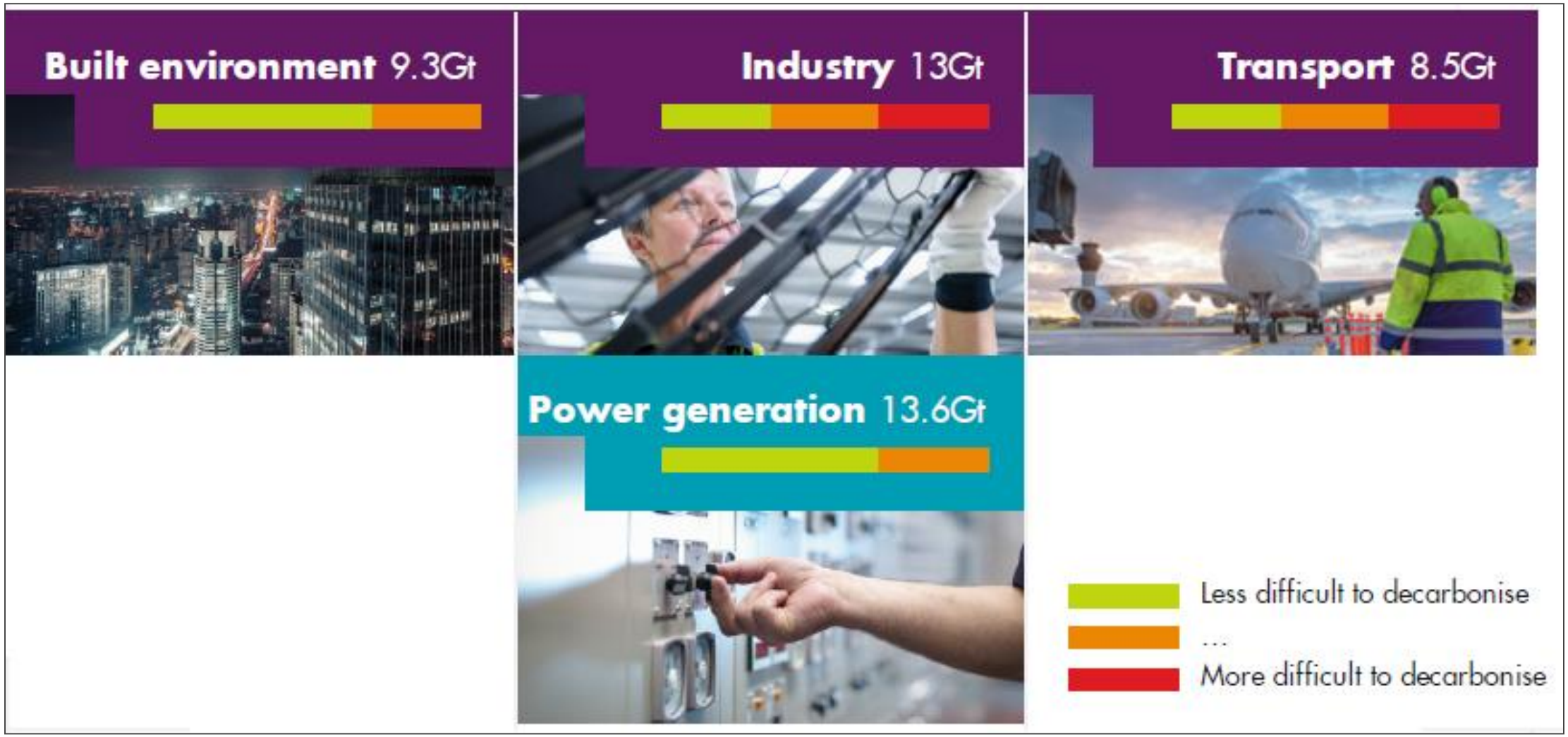
Investing in those opportunities where we:

See the potential for scale

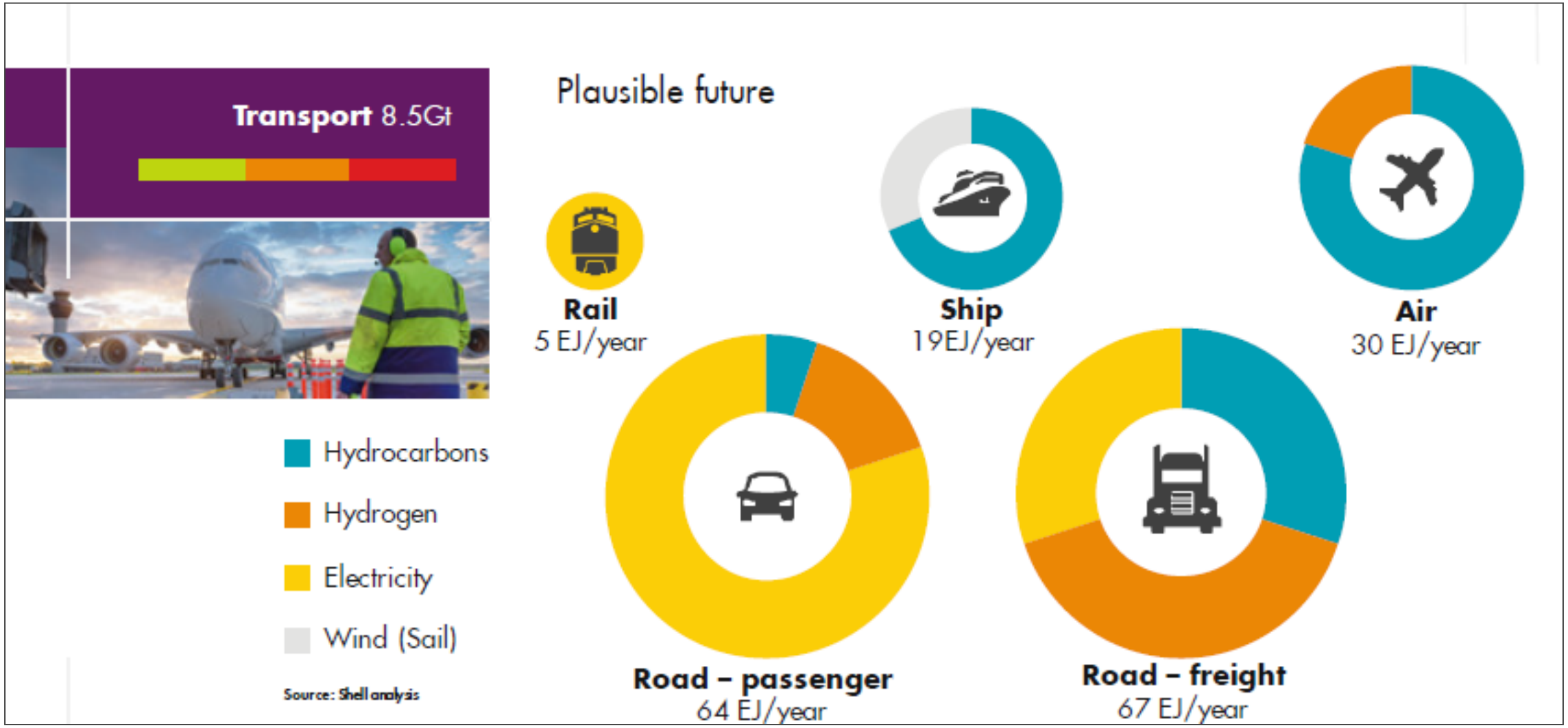
Have line of sight to profitability

Can leverage Shell's existing footprint and capabilities

The Pace of Energy Decarbonization will vary by Industry Sector

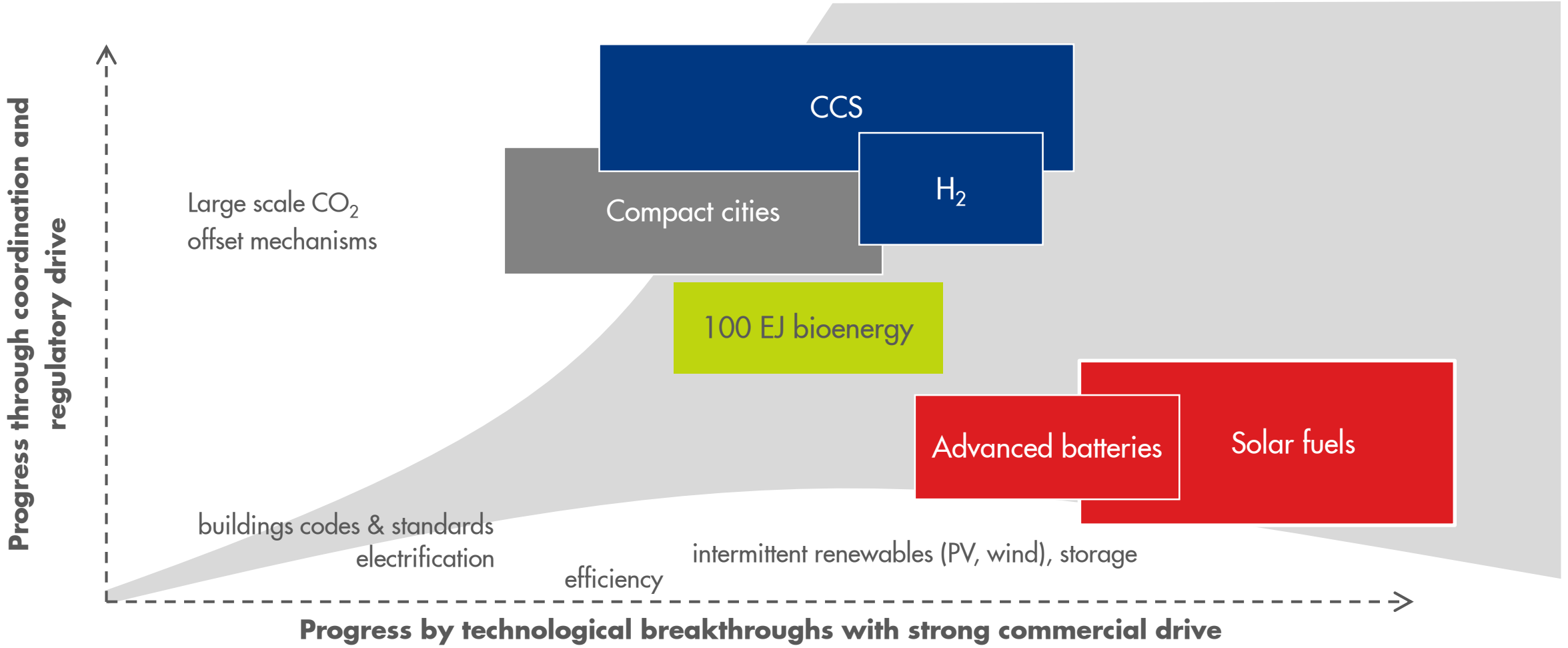


Aviation, Shipping & Long Distance Transport will still need Liquid Fuels



Policy coordination vs technology

A journey to net-zero emissions



Source: Shell FET analysis

Long Range Research (LRR) – Back to Basics and Fundamental R&D

New Energy

- Develop a radically better energy carrier using low cost solar energy combined with novel technologies for energy storage and conversion

Chemicals

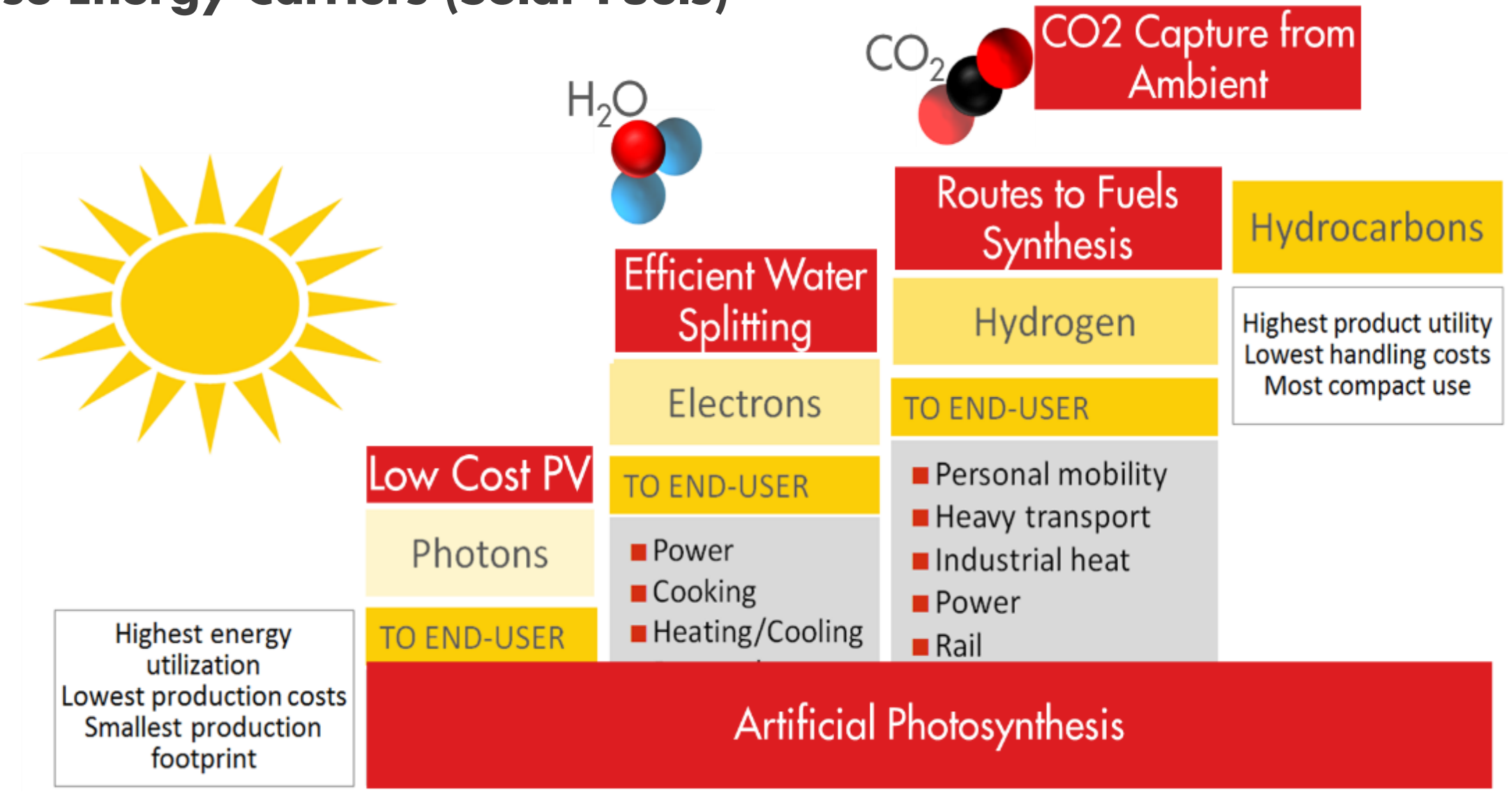
- Find new pathways to convert methane to products

Enabling sciences

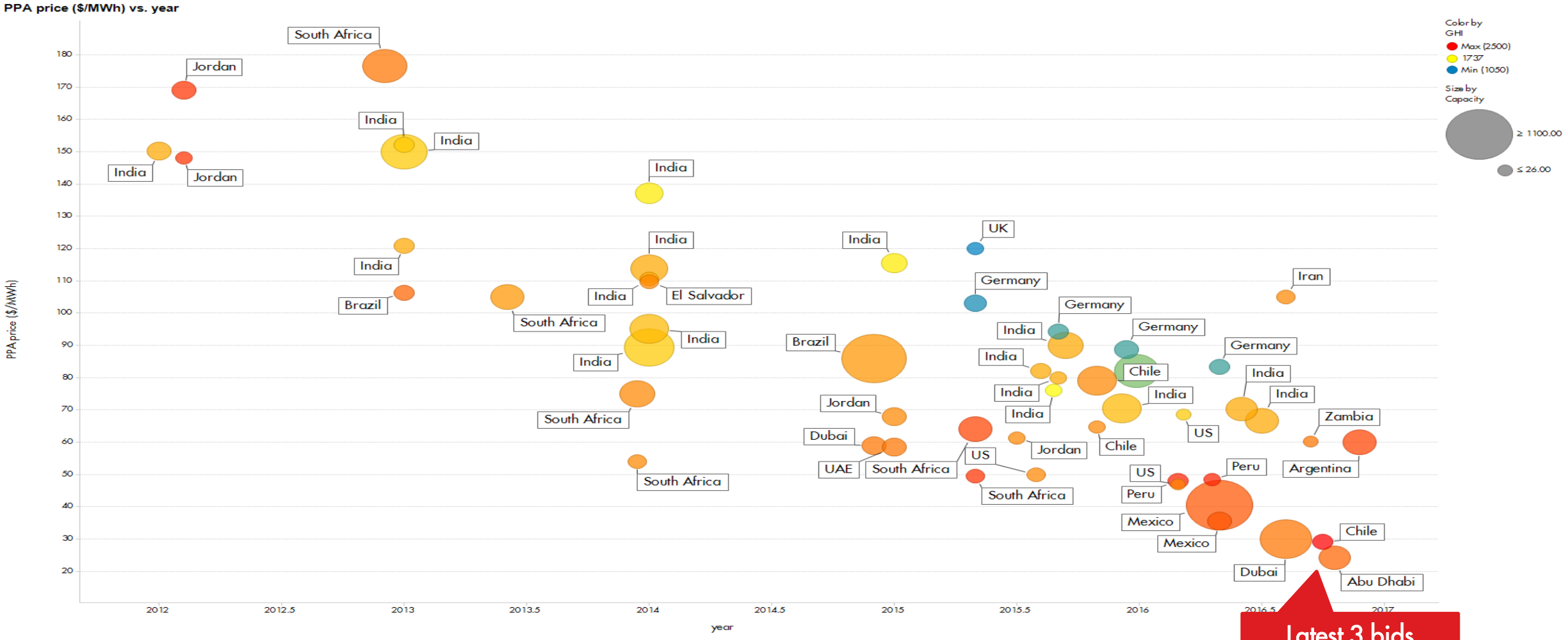
- Electrochemistry
- Materials science
- Structured catalysts & interfacial phenomena
- Transport phenomena
- Computational material science & chemistry
- Biosciences

Emphasis on scientific areas where: (i) we want to build capability; (ii) there is significant innovation headrooom; (iii) it has impact across multiple applications

Dense Energy Carriers (Solar Fuels)



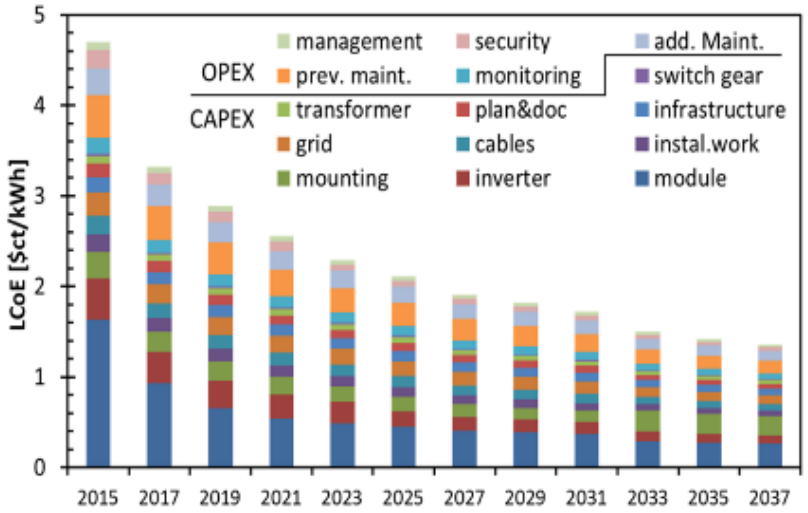
PV Auction Database: PPA prices decline



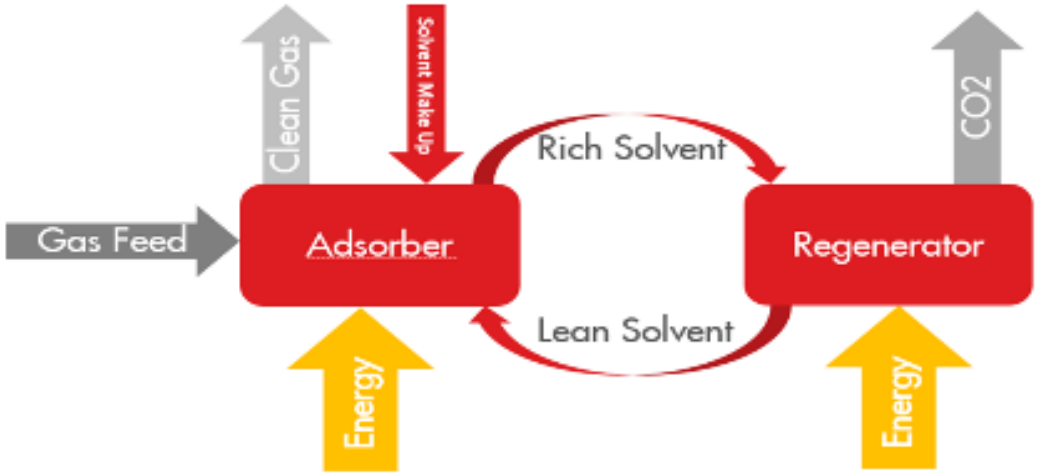
Source: Official government publications, World Bank, IFC, BNEF, various news sources

Dense Energy Carrier – recent insights

Solar PV <2 cents/kWh feasible by 2025



Cost of CO_2 direct Air Capture < $150/ton by 2030

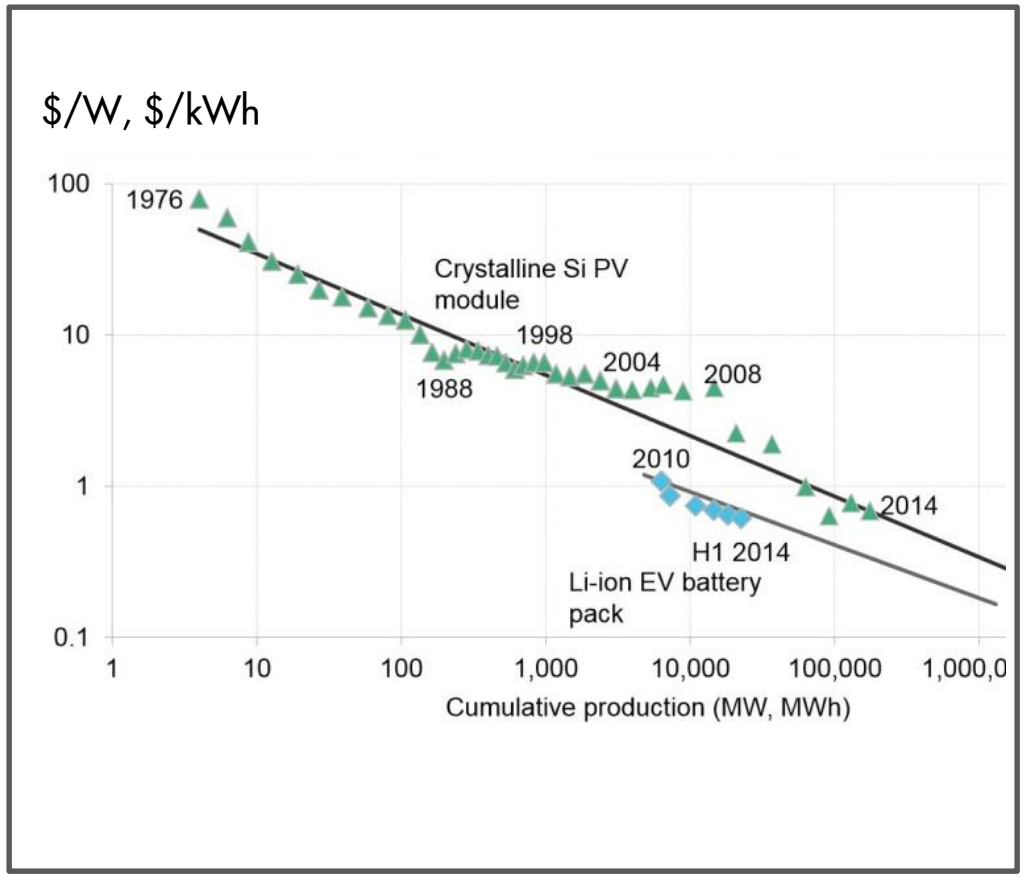


Electrolytic hydrogen may be produced at ~ $ 1/kg by 2035; I.E. cost competitive to H_2 from SMR (With CCS)

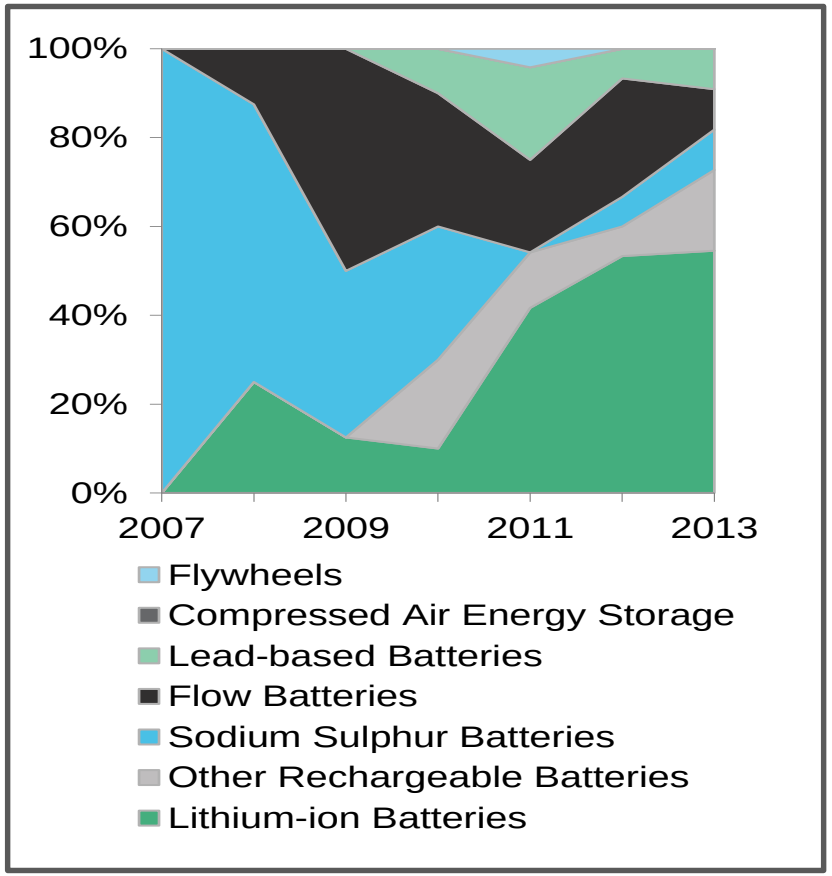
But… will we be able to create an End-to-End solution for an affordable, safe and ubiquitous energy carrier that challenges the convenience of liquid hydrocarbons?

Li-ion is ahead in the adoption game and "improved Li-ion" may become leading technology for increasing number of applications

Technology learning curves make deployment pace a competitive advantage ('winner takes all')



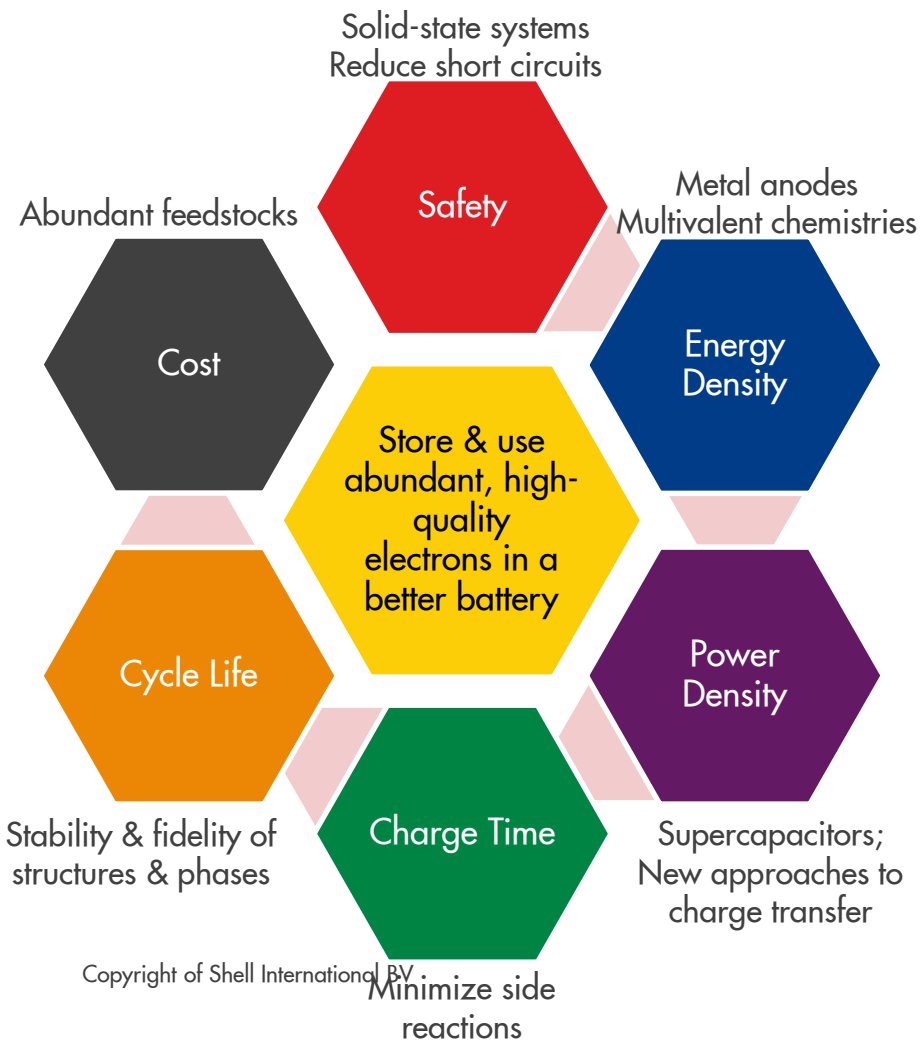
Energy storage deployment over time



Source: BNEF, April 2015

Advanced Energy Storage (AES)

Research Directions

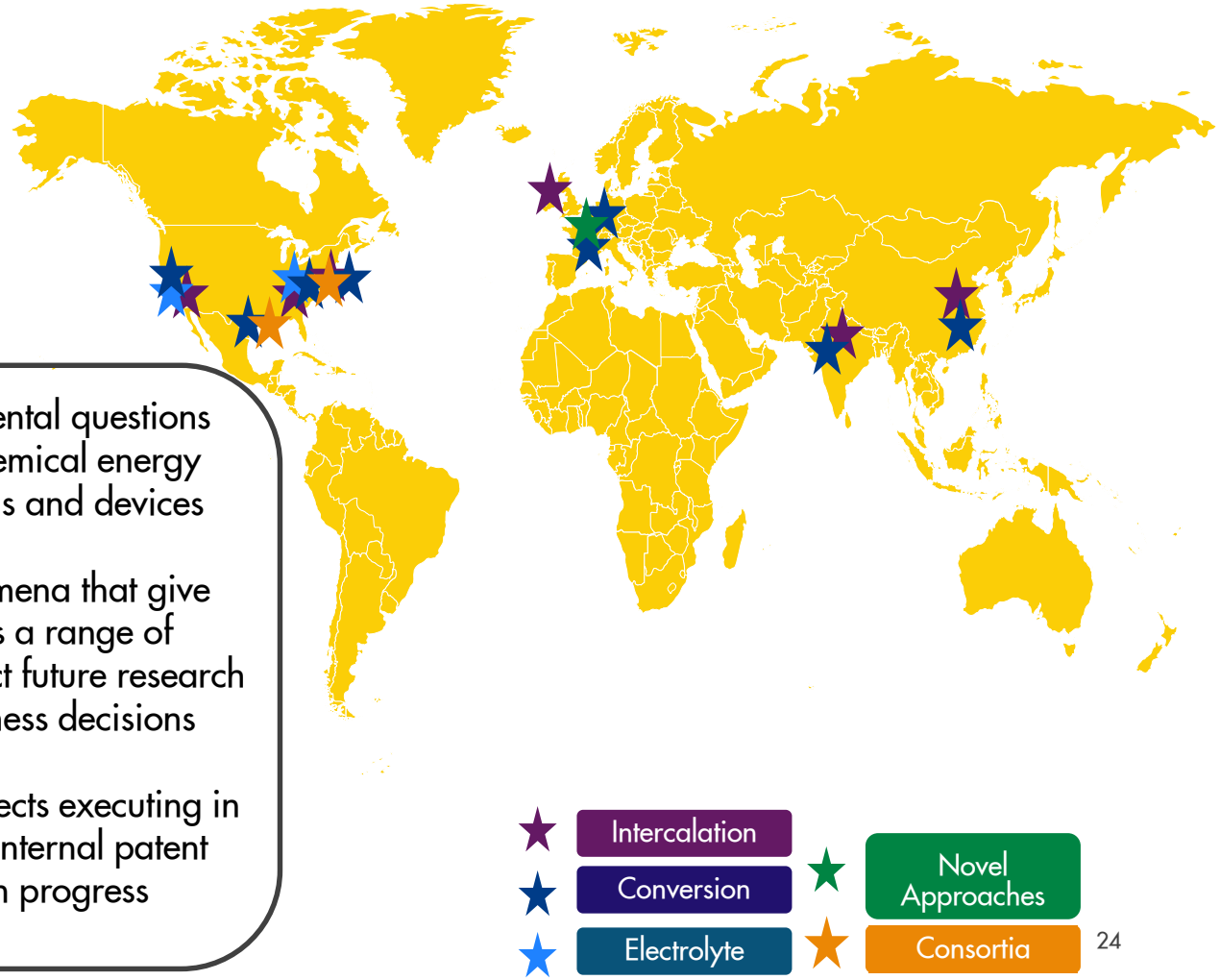


Answer fundamental questions about electrochemical energy storage materials and devices

Focus on phenomena that give insights across a range of chemistries to direct future research & support business decisions

Collaborative projects executing in US, UK, & NL; internal patent filings also in progress

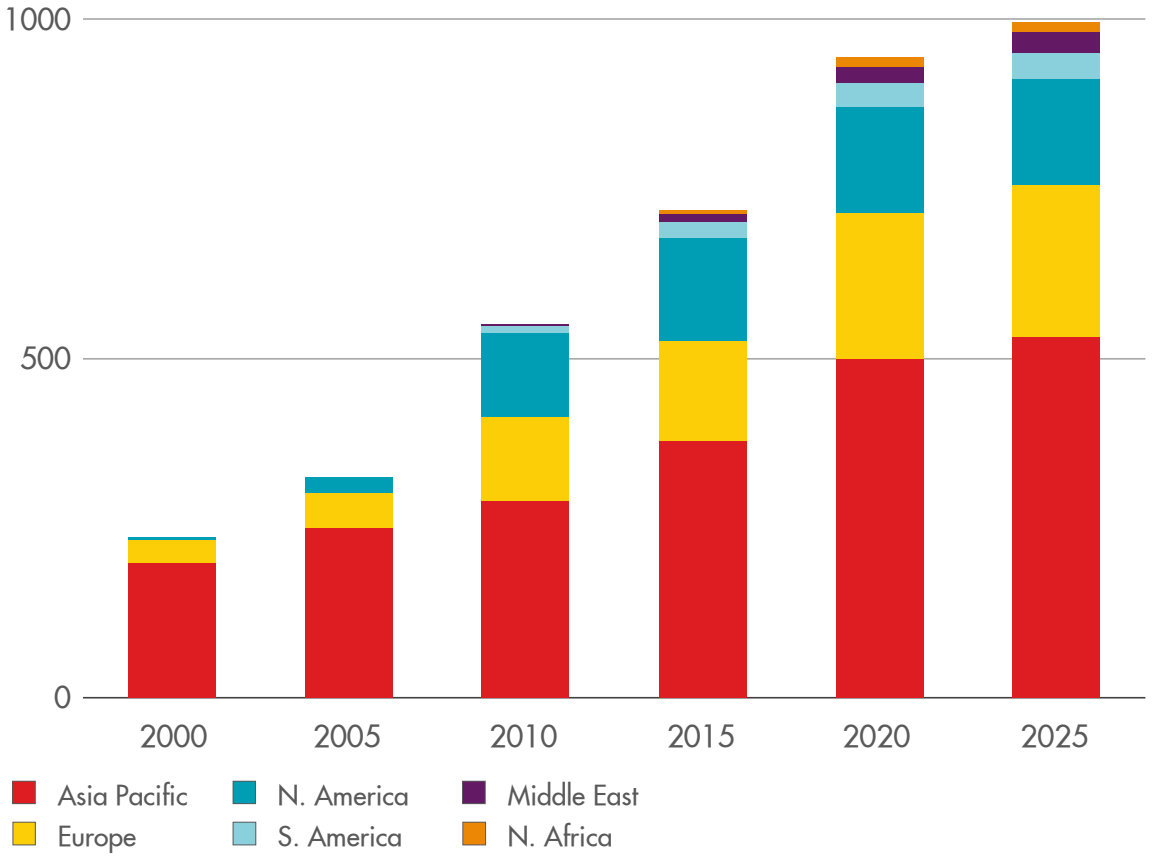
Global Partners



The Global Market for Chemicals Continues to Grow

LNG regasification capacity

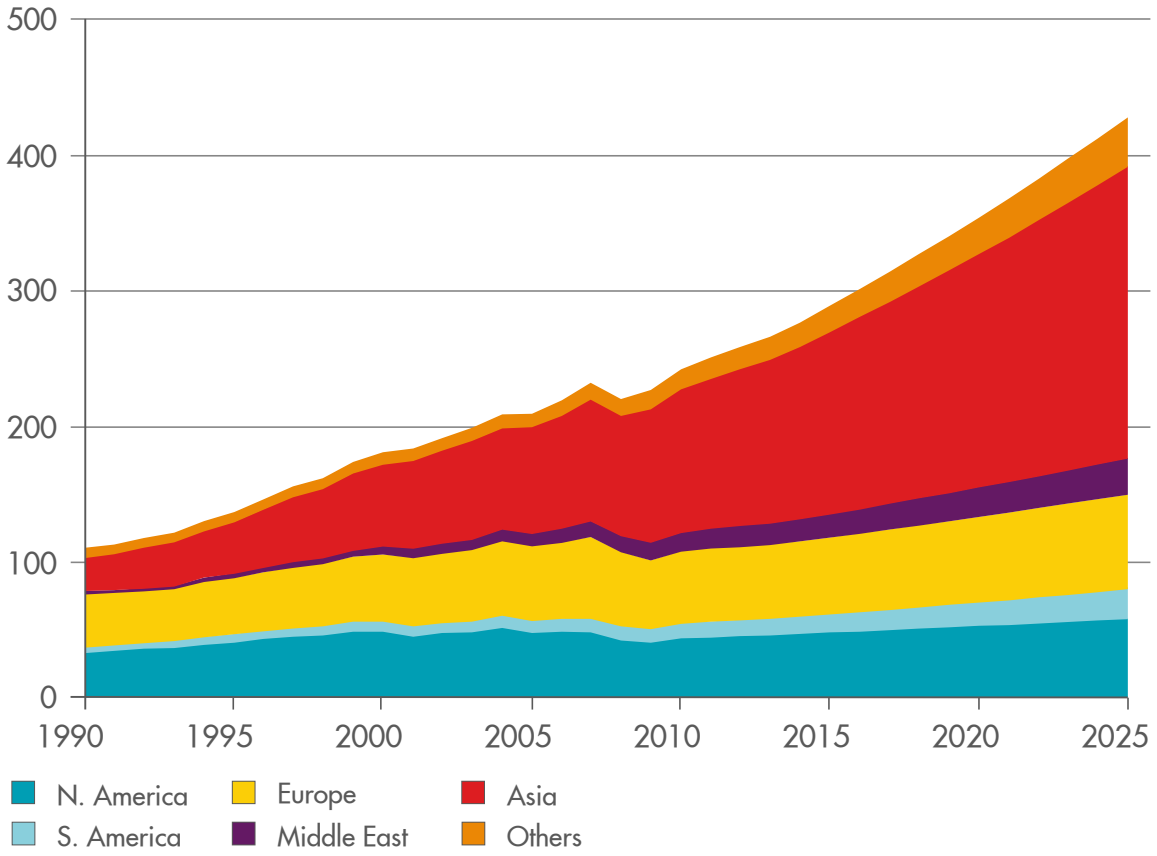
mln tonnes p.a.



Source: Shell Management Day Nov 2015

Domestic demand for base chemicals

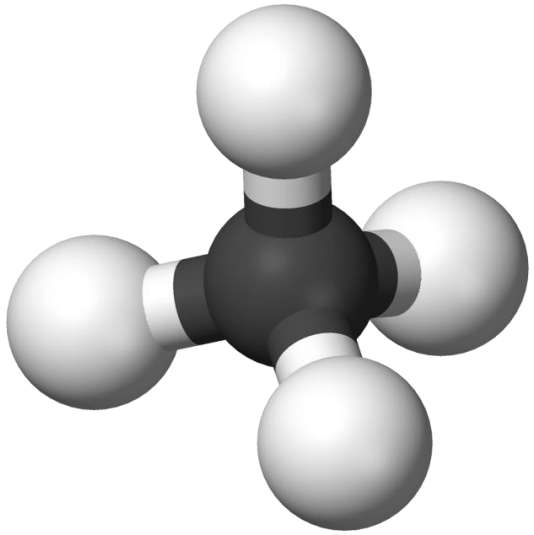
mln tonnes p.a



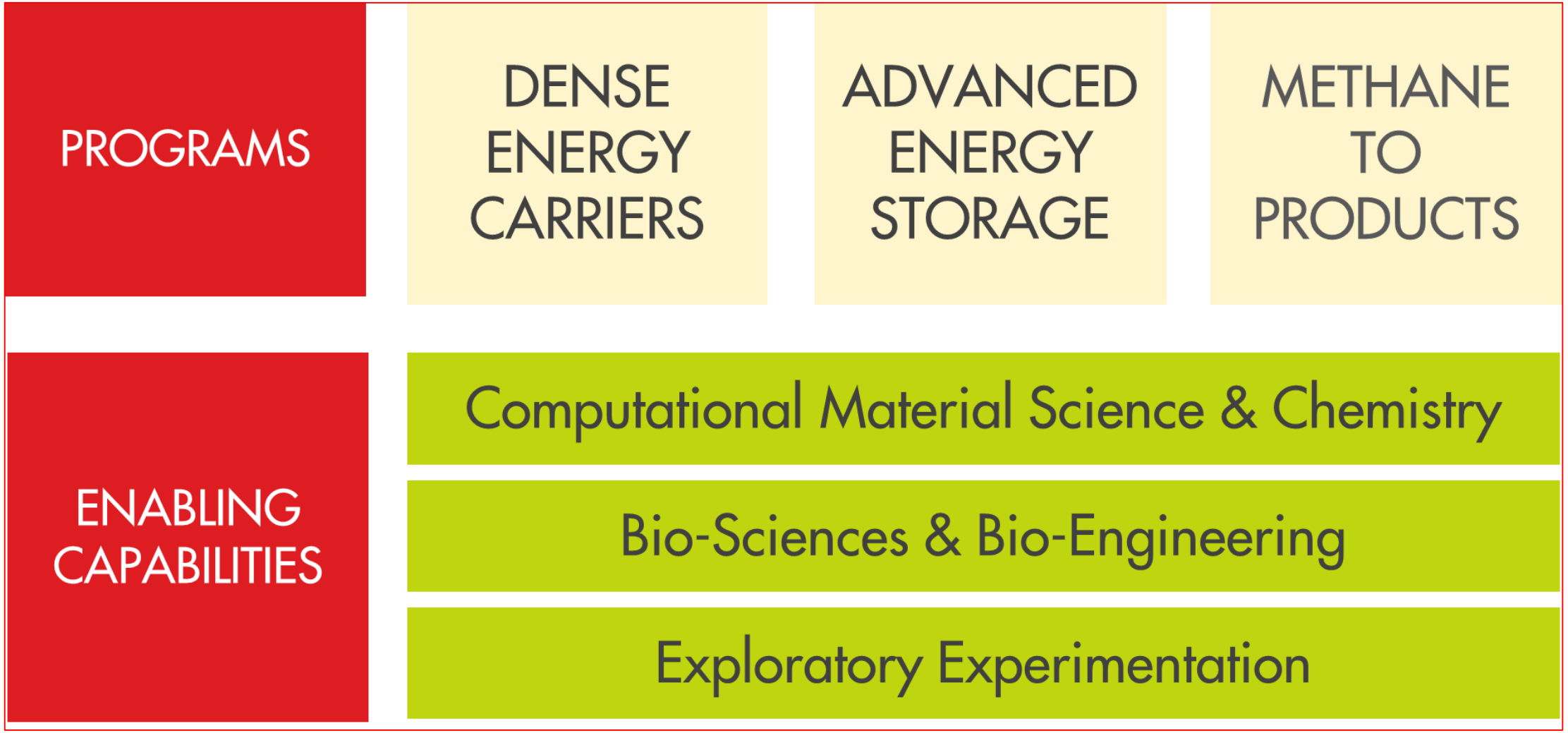
Source: IHS

Methane to Products (M2P)

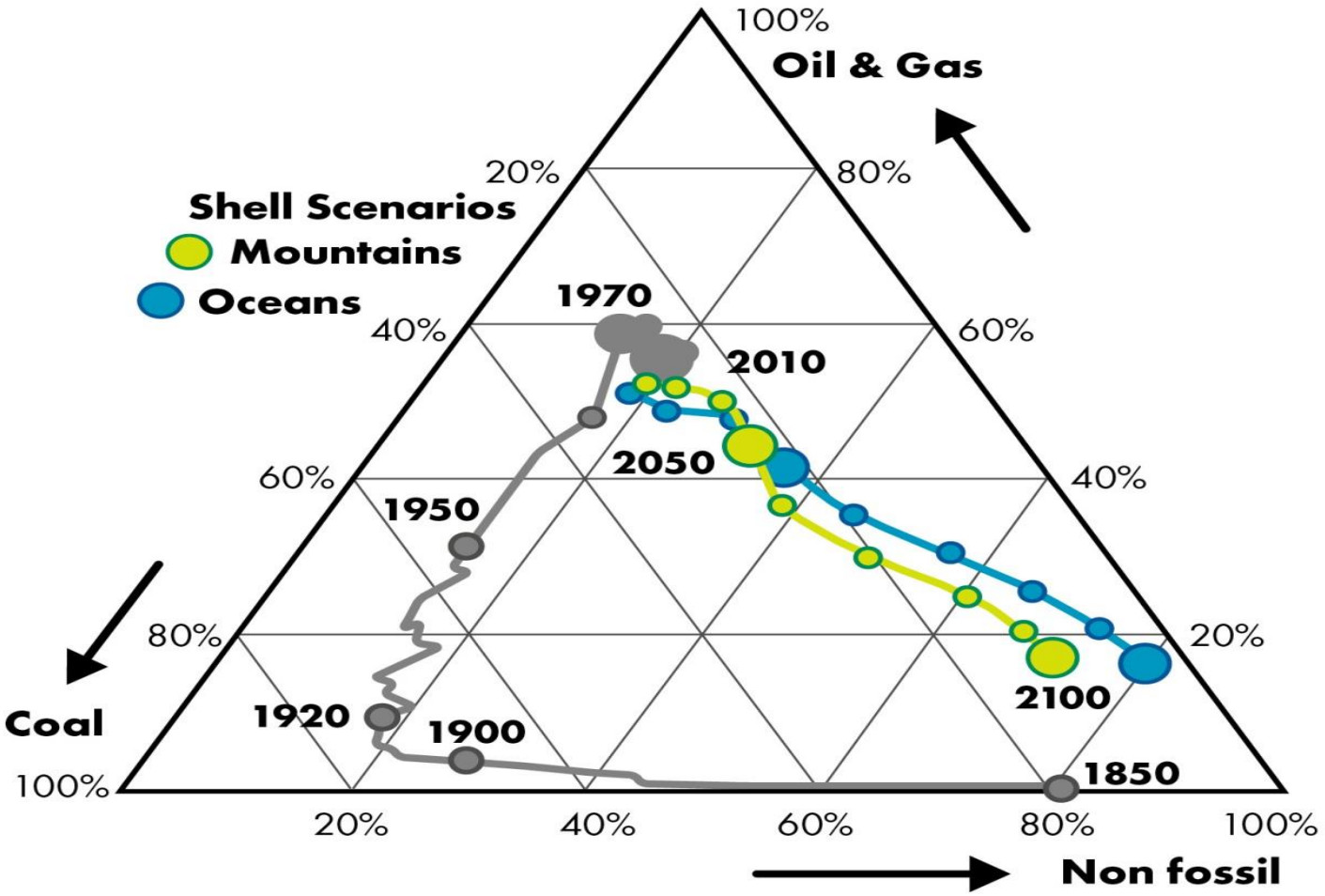
- Current markets for methane/natural gas is dominated by its calorific value (energy content)
- Find new routes for monetizing natural gas reserves
  - Bulk chemicals ('advanced feedstock')
  - Carbon as construction material (and H_2)
- Assume increased CO_2 taxation, instead of no penalty (for DEC/AES)
  - Ideally products with long life-time (reducing CO_2 penalty)
- Explore new scientific developments within catalysis, materials, physics
- Time-line: decades, but probably shorter



Long Range Research Technology Platform

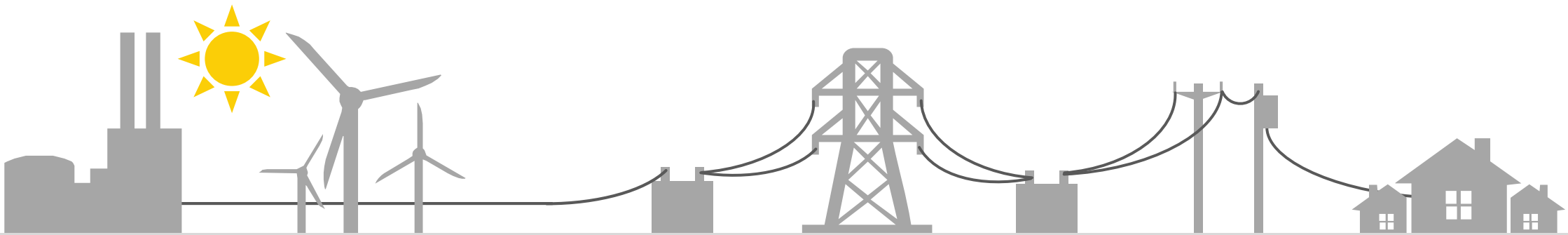


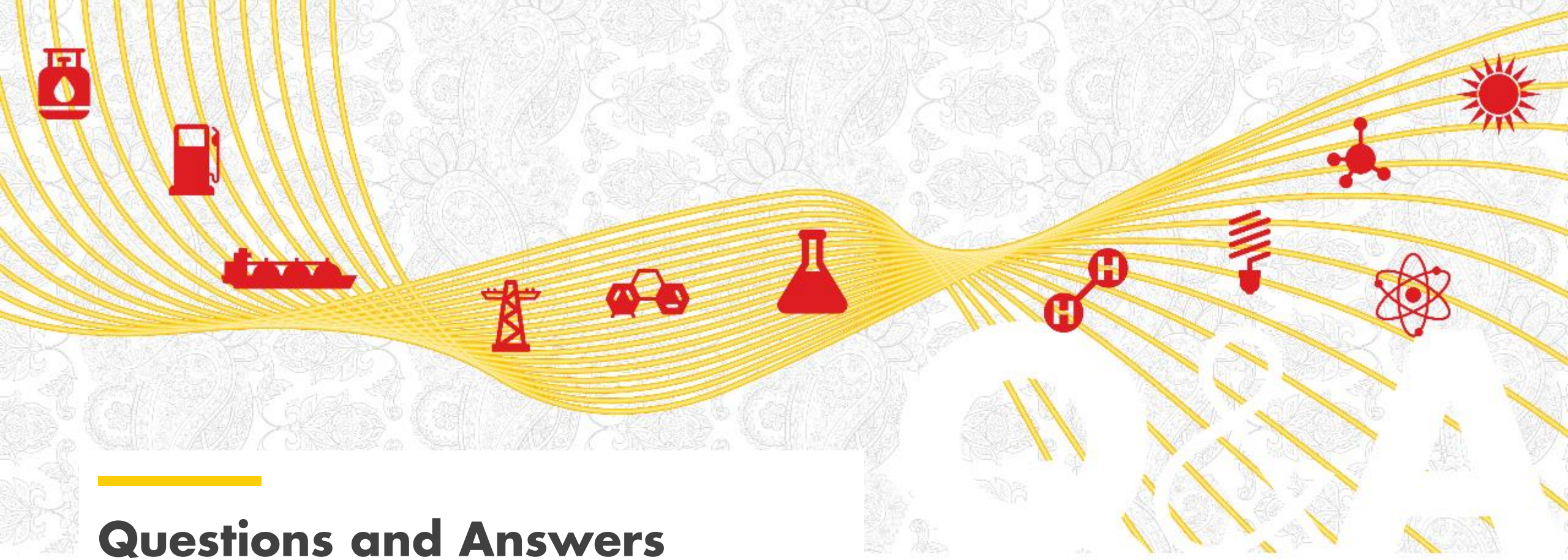
The Energy Transition ..... Coming Full Circle in the Near Future



Summary

- Energy systems are becoming ever more decentralised and interconnected.
- Shell aims to become a global leader in cleaner power generation, taking advantage of our global footprint and experience with large-scale power infrastructure.
- Natural gas and energy storage solutions must integrate with renewables to meet customers' new energy needs.
- Our integrated approach explores and expands wind and solar; ways to connect customers with new business energy models; access to energy; and the digitalisation of businesses.





Questions and Answers