



# INNOVATION FOR OUR FUTURE ENERGY SYSTEM

**Chris Laurens**

Vice President Innovation and Future Energies



# DEFINITIONS AND 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.

**Resources plays:** Our use of the term ‘resources plays’ refers to tight, shale and coal bed methane oil and gas acreage.

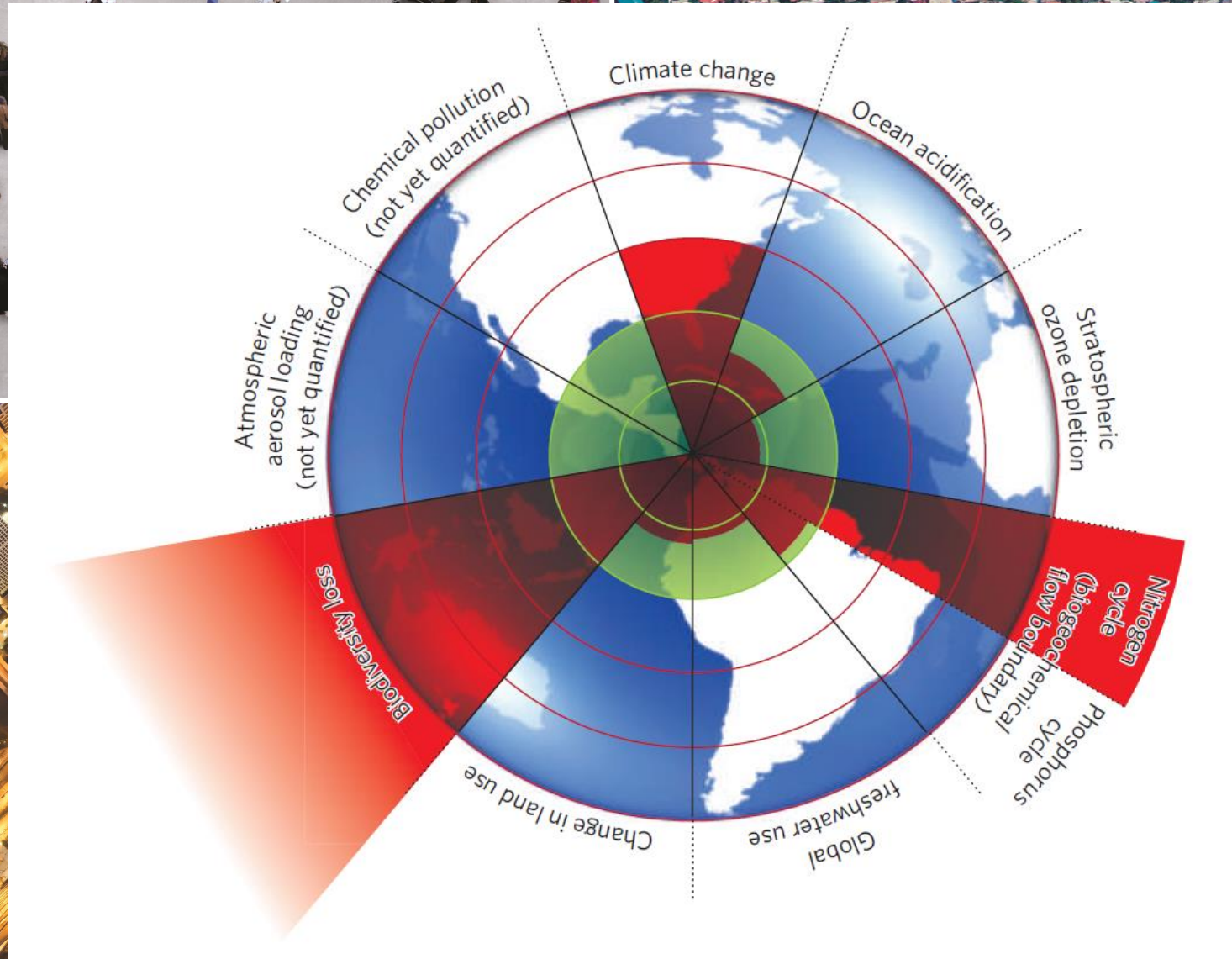
The companies in which Royal Dutch Shell plc directly and indirectly owns investments are separate entities. In this document “Shell”, “Shell group” and “Royal Dutch Shell” are sometimes used for convenience where references are made to Royal Dutch Shell plc and its subsidiaries in general. Likewise, 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.

This presentation contains forward-looking statements concerning the financial condition, results of operations and businesses of Royal Dutch Shell. All statements other than statements of historical fact are, or may be deemed to be, forward-looking statements. Forward-looking statements are statements of future expectations that are based on management’s current expectations and assumptions and involve known and unknown risks and uncertainties that could cause actual results, performance or events to differ materially from those expressed or implied in these statements. Forward-looking statements include, among other things, statements concerning the potential exposure of Royal Dutch Shell to market risks and statements expressing management’s expectations, beliefs, estimates, forecasts, projections and assumptions. These forward-looking statements are identified by their use of terms and phrases such as “anticipate”, “believe”, “could”, “estimate”, “expect”, “intend”, “may”, “plan”, “objectives”, “outlook”, “probably”, “project”, “will”, “seek”, “target”, “risks”, “goals”, “should” and similar terms and phrases. There are a number of factors that could affect the future operations of Royal Dutch Shell and could cause those results to differ materially from those expressed in the forward-looking statements included in this presentation, including (without limitation): (a) price fluctuations in crude oil and natural gas; (b) changes in demand for Shell’s products; (c) currency fluctuations; (d) drilling and production results; (e) reserves estimates; (f) loss of market share and industry competition; (g) environmental and physical risks; (h) risks associated with the identification of suitable potential acquisition properties and targets, and successful negotiation and completion of such transactions; (i) the risk of doing business in developing countries and countries subject to international sanctions; (j) legislative, fiscal and regulatory developments including potential litigation and regulatory measures as a result of climate changes; (k) economic and financial market conditions in various countries and regions; (l) political risks, including the risks of expropriation and renegotiation of the terms of contracts with governmental entities, delays or advancements in the approval of projects and delays in the reimbursement for shared costs; and (m) changes in trading conditions. All forward-looking statements contained in this presentation are expressly qualified in their entirety by the cautionary statements contained or referred to in this section. Readers should not place undue reliance on forward-looking statements. Additional factors that may affect future results are contained in Royal Dutch Shell’s 20-F for the year ended 31 December, 2014 (available at [www.shell.com/investor](http://www.shell.com/investor) and [www.sec.gov](http://www.sec.gov)). These factors also should be considered by the reader. Each forward-looking statement speaks only as of the date of this presentation, 24 September, 2015. Neither Royal Dutch Shell nor any of its subsidiaries undertake any obligation to publicly update or revise any forward-looking statement as a result of new information, future events or other information. In light of these risks, results could differ materially from those stated, implied or inferred from the forward-looking statements contained in this presentation. There can be no assurance that dividend payments will match or exceed those set out in this presentation in the future, or that they will be made at all.

We use certain terms in this presentation, such as discovery potential, that the United States Securities and Exchange Commission (SEC) guidelines strictly prohibit us from including in filings with the SEC. U.S. Investors are urged to consider closely the disclosure in our Form 20-F, File No 1-32575, available on the SEC website [www.sec.gov](http://www.sec.gov). You can also obtain this form from the SEC by calling 1-800-SEC-0330.



# THE ANTHROPOCENE





# THE WORLD IN 2060



**GLOBAL  
POPULATION  
9 BILLION**



**ENERGY  
DEMAND  
DOUBLES**



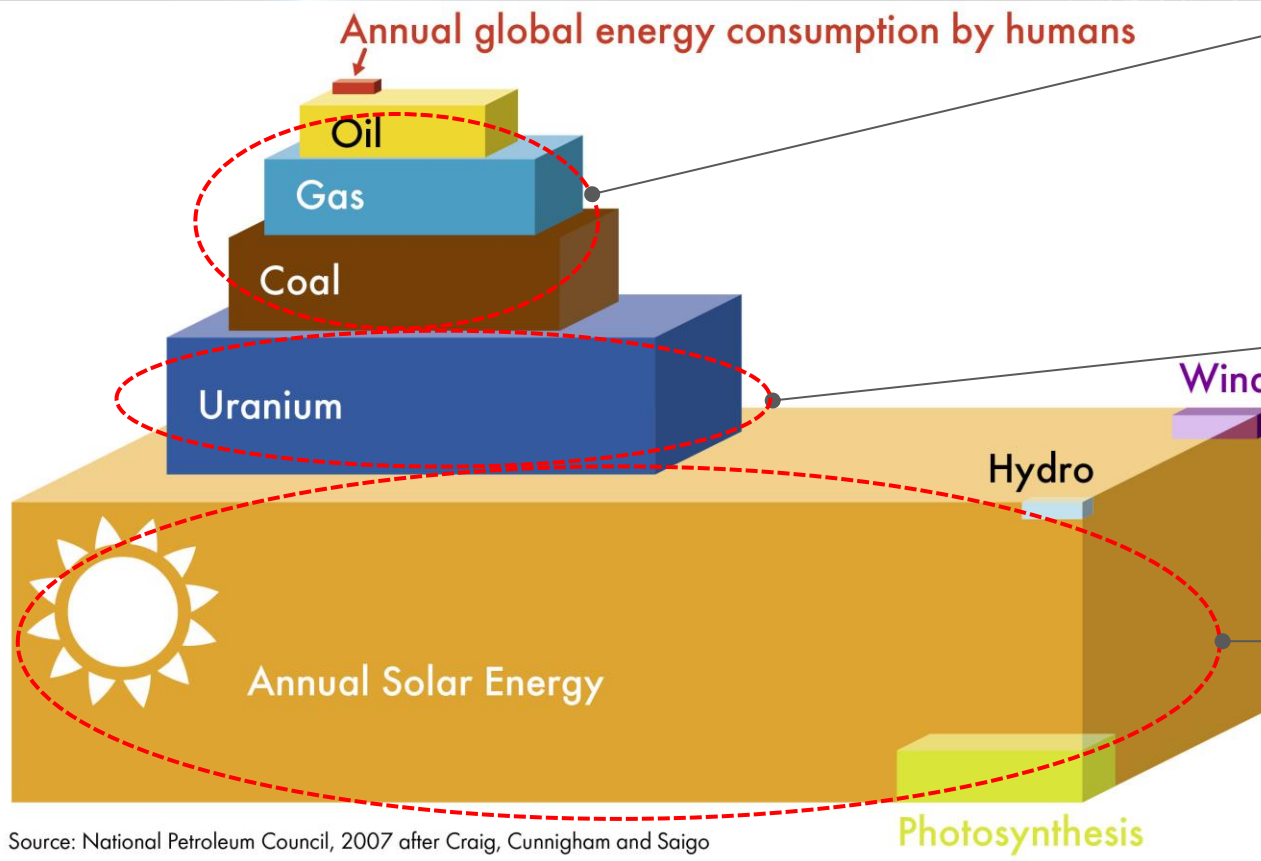
**PEOPLE  
IN CITIES  
75%**



**VEHICLES  
ON ROADS  
2 BILLION**

# IN PRINCIPLE, THERE IS ENOUGH ENERGY

## Energy resource



## Constraints

### Fossil fuels

- Atmospheric CO<sub>2e</sub>
- Other emissions and waste products
- (land, fresh water)

### Nuclear fission, fusion

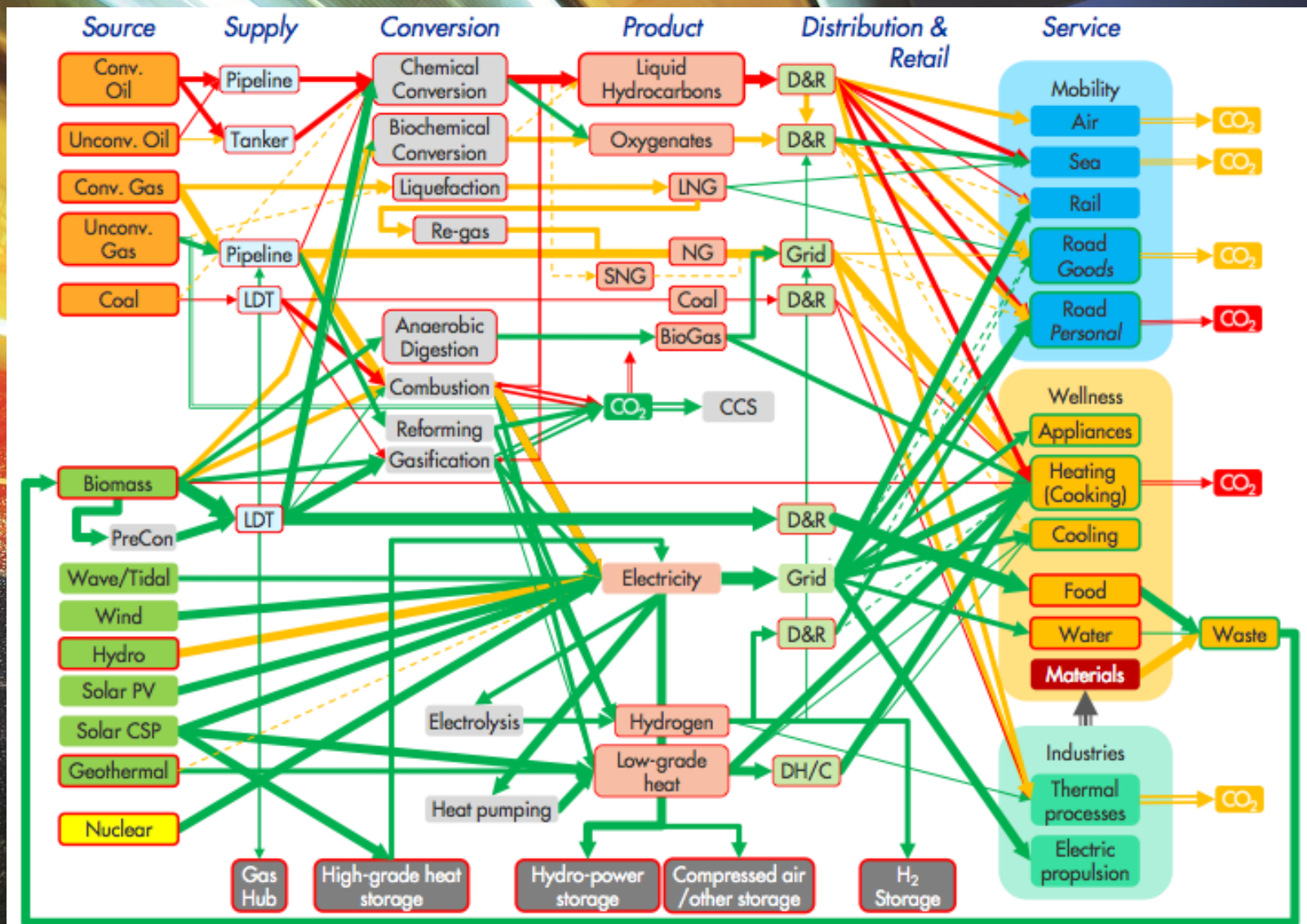
- Process containment
- Waste storage

### Solar based energies

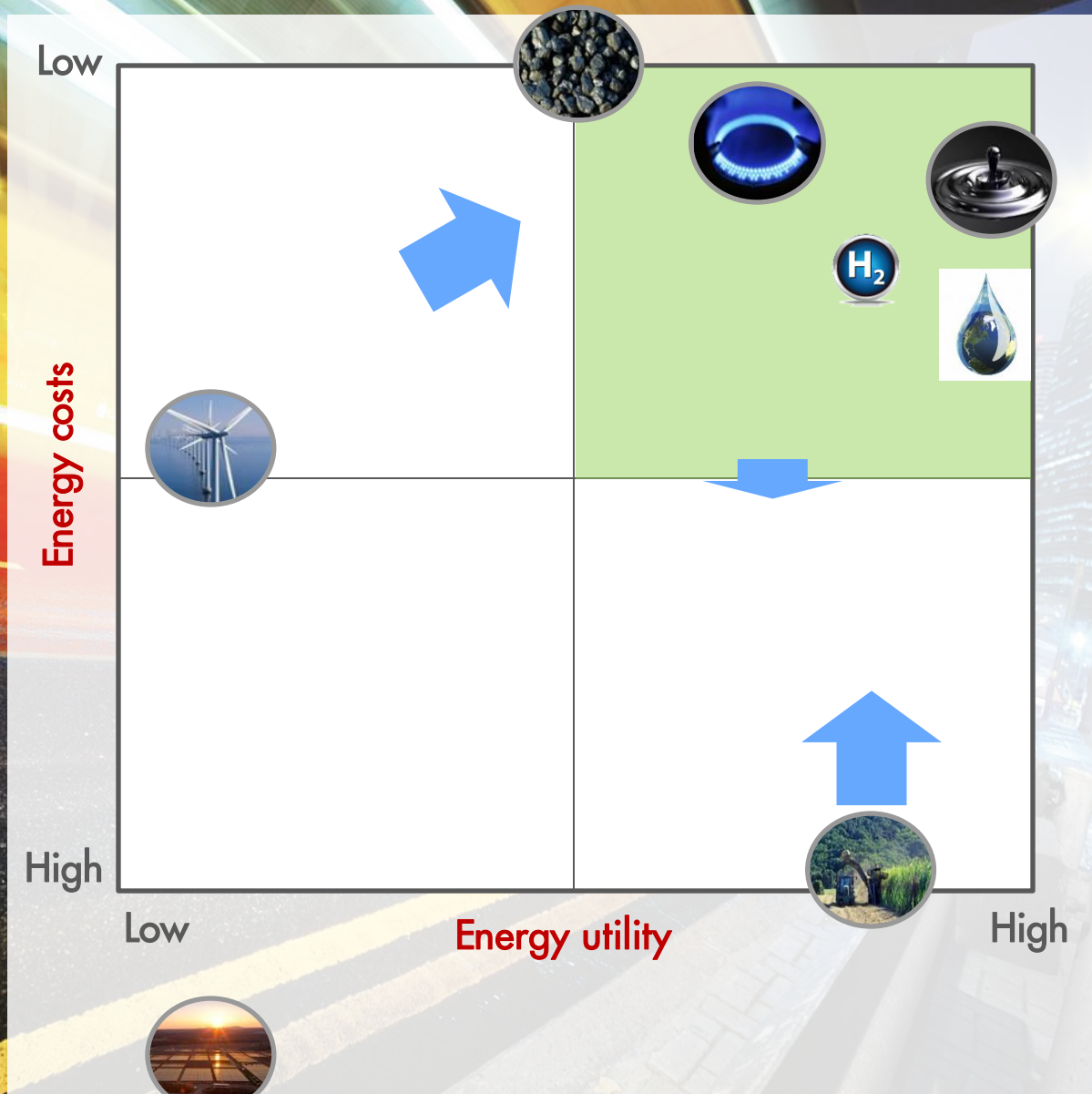
- Land use
- Intermittency
- Minerals



# DE-CARBONISATION REQUIRES A SYSTEM APPROACH

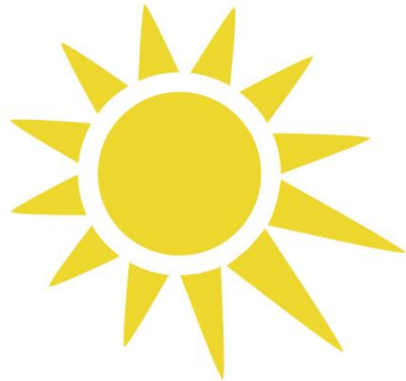


# FUTURE ENERGY DYNAMICS





# FUTURE ENERGY SOURCES AND MARKETS



**Photons**  
**0\$/GJ**

TO END-USER

- Heating
- Lighting

Highest energy utilization  
Lowest production costs  
Smallest production footprint

**Electrons**  
**5 – 10 \$/GJ**

1,5 – 3,5 ct/kWh

TO END-USER

- Power
- Cooking
- Heating/Cooling
- Personal mobility
- Rail

**Hydrogen**  
**10 – 20 \$/GJ**

10 – 20 \$ mmbtu

TO END-USER

- Personal mobility
- Heavy transport
- Industrial heat
- Power
- Rail
- Cooking
- Heating/Cooling

Highest product utility  
Lowest handling costs  
Most compact use

**Hydrocarbons**  
**20 – 40 \$/GJ**

0,6 – 1,2 \$/l

\$/GJ = estimated primary energy costs 2050



# SHELL IN THE ENERGY TRANSITION

- 3G bio-fuels
- Solar fuels
- Carbon utilization
- Energy storage
- Smart homes
- Energy Transitions

Research

Technology  
commercialization

New business  
incubation and  
growth

- 2G bio-fuels
- Carbon capture and storage
- H2Mobility
- LH<sub>2</sub> shipping





# BIOFUELS – RAIZEN JV + 2G INNOVATION

**MOST EFFICIENT** ETHANOL PRODUCING COUNTRY

BRAZILIAN SUGAR CANE **LESS CO<sub>2</sub> & COMPETITIVE**

**2 BILLION+ LITRES** PRODUCTION CAPACITY PER YEAR

**RAIZEN 2G** PLANT BUILT IN BRAZIL, IN OPERATION CO-LOCATED WITH EXISTING 1G OPERATION

SHELL IS INVESTIGATING **DIFFERENT 2G TECHNOLOGIES** - INCLUDING DEMONSTRATION PLANT INVESTMENTS IN US

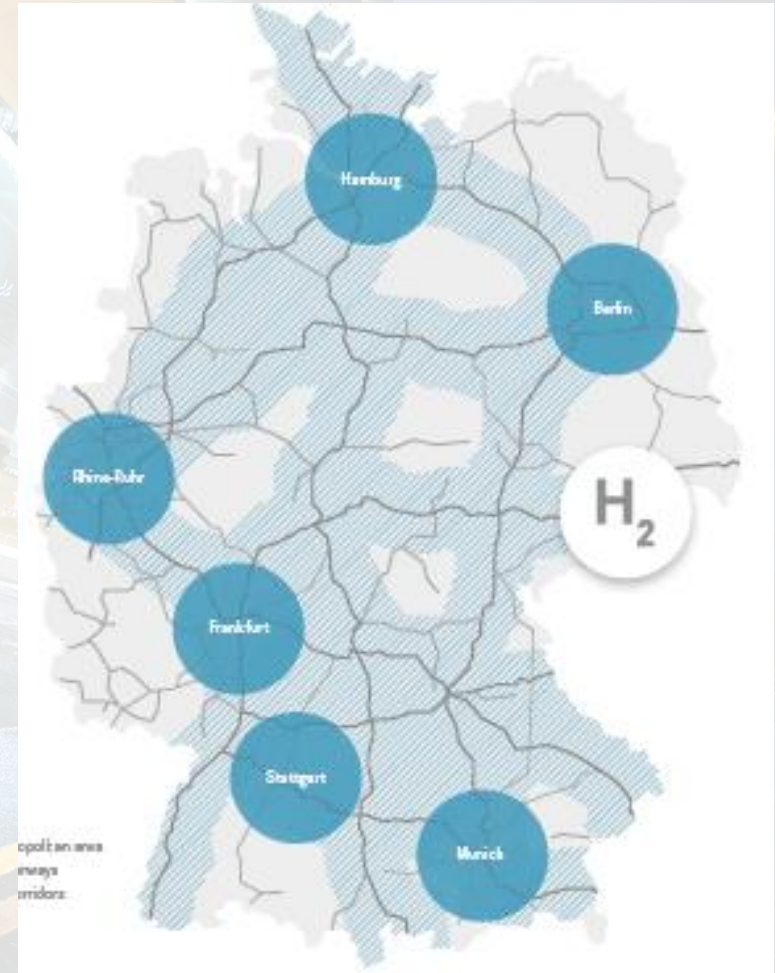




# HYDROGEN TO MOBILITY



Aim to develop a network of 400 stations by 2023 and 100 stations by 2018





# SOLAR THERMAL POWER IN OMAN

Miraah: largest solar plant in the world (1021 MW)



شركة تنمية نفط عُمان  
Petrochem Development Oman



# CARBON CAPTURE AND STORAGE

Feed: syngas  
Start-up: Q3 2015  
1 mtpa  
Capture: amine



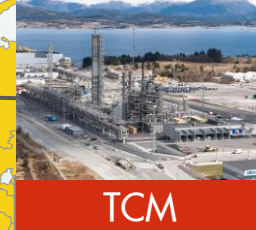
Quest

Feed: gas power flue gas  
FID to be taken,  
Start-up potentially 2019  
1 mtpa  
Capture: amine



Peterhead

Feed: dual streams (gas and coal flue gas specs)  
Operating since 2012,  
Up to 200 ktpa  
Capture: various technologies for testing



TCM



Boundary

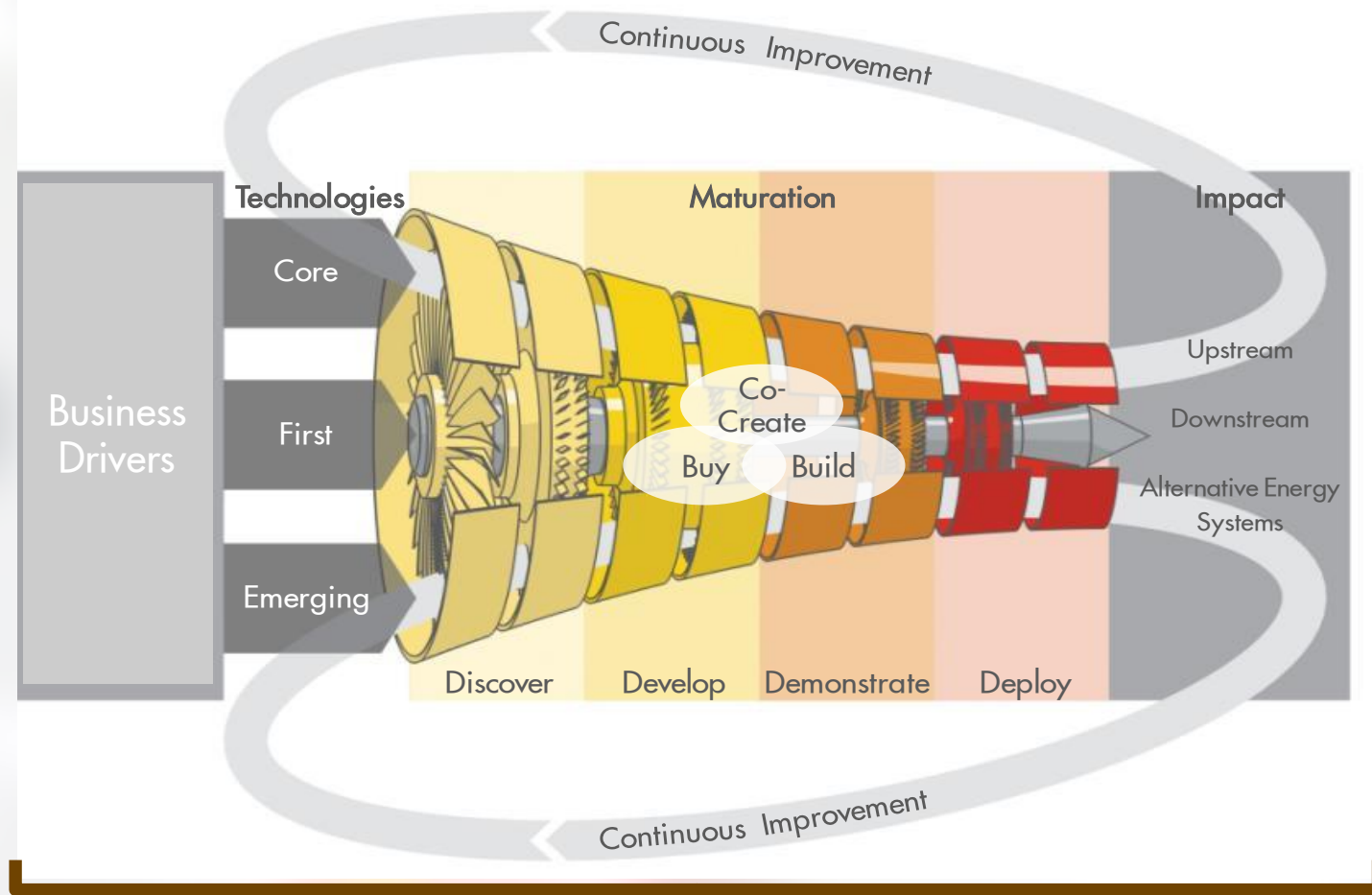
Feed: coal power flue gas  
Operating since 2014  
1 mtpa  
Capture: amine  
Shell has no equity in this project



Gorgon

Feed: natural gas  
LNG start-up: 2016  
CO<sub>2</sub> injection start-up: 2017  
Capture: amine  
3-4 mtpa

# TECHNOLOGY MATURATION & GOVERNANCE



## GOVERNANCE

Chief Technology  
Officer (CTO) Board

Technology Platform Maturation  
and Performance Plan

Integration in Company  
Plan and Budget



# GAS-TO-LIQUIDS: A 40 YEAR JOURNEY OF TECHNOLOGY AND PRODUCT INNOVATION



1973

- Laboratory Amsterdam grams/d



1983

- Pilot plant Amsterdam 3 bbl/d



1993

- Bintulu Malaysia current capacity 14,700 bbl/d

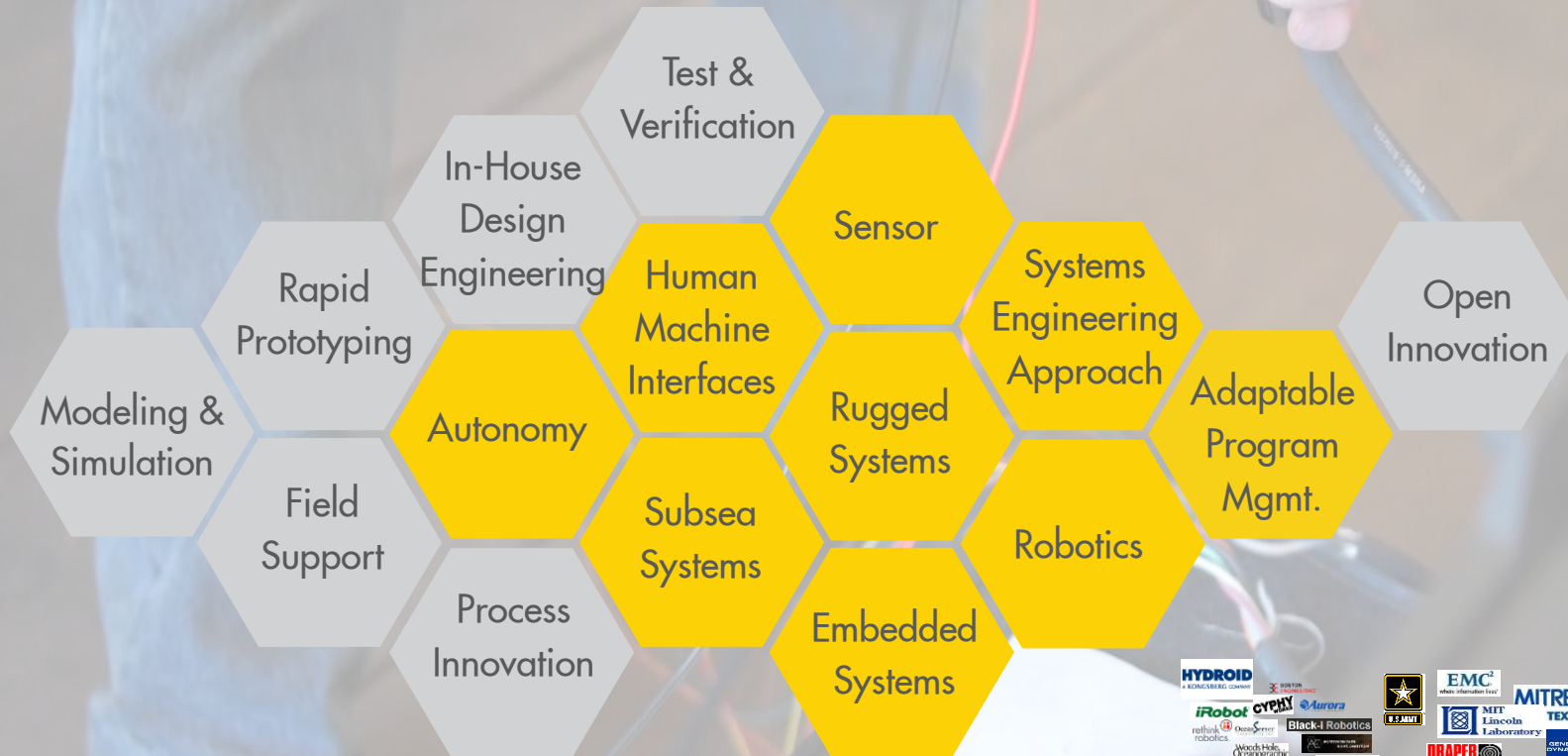


TODAY

- Pearl GTL Qatar 140,000 bbl/d

# SHELL TECHNOLOGY WORKS – BOSTON

Driven by a sense of urgency and armed with a systems engineering approach and adaptive program management, **Shell TechWorks** works with the business to solve critical challenges by adapting de-risked technologies while leveraging entrepreneurial and innovative people with non-traditional backgrounds.





# SHELL TECHNOLOGY VENTURES



## + CATHODE

Manganese Oxide  
spinel structure hosts  
intercalation reaction

## + SEPARATOR

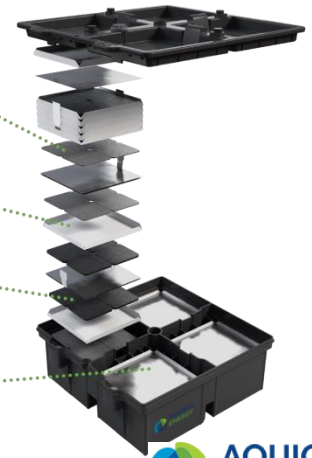
Non-woven cellulosic material

## + ANODE

Activated carbon composite  
with pseudocapacitive and  
intercalation reactions

## + ELECTROLYTE

Sodium sulfate in an  
aqueous solution



**AQUION  
ENERGY**



**Q&A**

