Shell in Advanced Biofuels

Technology Maturation Process as Applied to IH²® Technology

Dr. Alan Del Paggio
Business Manager, IH²® Technology, Shell Catalysts & Technologies
This presentation contains data from Shell’s new Sky Scenario. Unlike Shell’s previously published Mountains and Oceans exploratory scenarios, the Sky Scenario is targeted through the assumption that society reaches the Paris Agreement’s goal of holding global average temperatures to well below 2°C. Unlike Shell’s Mountains and Oceans scenarios which unfolded in an open-ended way based upon plausible assumptions and quantifications, the Sky Scenario was specifically designed to reach the Paris Agreement’s goal in a technically possible manner. These scenarios are a part of an ongoing process used in Shell for over 40 years to challenge executives’ perspectives on the future business environment. They are designed to stretch management to consider even events that may only be remotely possible. Scenarios, therefore, are not intended to be predictions of likely future events or outcomes and investors should not rely on them when making an investment decision with regard to Royal Dutch Shell plc securities.

Additionally, it is important to note that Shell’s existing portfolio has been decades in development. While we believe our portfolio is resilient under a wide range of outlooks, including the IEA’s 450 scenario (World Energy Outlook 2016), it includes assets across a spectrum of energy intensities including some with above-average intensity. While we seek to enhance our operations’ average energy intensity through both the development of new projects and divestments, we have no immediate plans to move to a net-zero emissions portfolio over our investment horizon of 10-20 years. Although, we have no immediate plans to move to a net-zero emissions portfolio, in November of 2017, we announced our ambition to reduce our net carbon footprint in accordance with society’s implementation of the Paris Agreement’s goal of holding global average temperature to well below 2°C above pre-industrial levels. Accordingly, assuming society aligns itself with the Paris Agreement’s goals, we aim to reduce our net carbon footprint, which includes not only our direct and indirect carbon emissions, associated with producing the energy products which we sell, but also our customers’ emissions from their use of the energy products we sell, by 20% in 2035 and by 50% in 2050.

The companies in which Royal Dutch Shell plc directly and indirectly owns investments are separate legal entities. In this presentation “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 presentation refer to companies over which Royal Dutch Shell plc either directly or indirectly has control. Entities and unincorporated arrangements over which Shell has joint control are generally referred to as “joint ventures” and “joint operations” respectively. Entities 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”, “goals”, “intend”, “may”, “objectives”, “outlook”, “plan”, “probably”, “project”, “risks”, “schedule”, “seek”, “should”, “target”, “will” 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 web page, 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 regulatory measures addressing climate change; (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. No assurance is provided that future dividend payments will match or exceed previous dividend payments. 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 risk factors that may affect future results are contained in Royal Dutch Shell’s Form 20-F for the year ended December 31, 2017 (available at www.shell.com/investor and www.sec.gov). These risk factors also expressly qualify all forward-looking statements contained in this presentation and should be considered by the reader. Each forward-looking statement speaks only as of the date of this presentation October 10th 2018. Neither Royal Dutch Shell plc 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 web page. We may have used certain terms, such as resources, in this presentation that United States Securities and Exchange Commission (SEC) strictly prohibits us from including in our 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. You can also obtain this form from the SEC by calling 1-800-SEC-0330.
Discussion topics

- Shell New Energies
- IH$^2$® process technology maturation
New Energies

- Selective and opportunity driven investment
- Capital investment $1-2 billion per annum average

Focus areas:
- Biofuels
- Hydrogen
- Electric mobility
- Work in partnerships and consortia
- Target downstream returns high teens %

New Fuels

Power

- Focus areas:
  - Trading, marketing and customer access
  - Low-carbon generation and storage
  - Investment in customer access
  - Selective asset ownership
  - Target equity returns of 8-12%

NoordzeeWind, The Netherlands
New Fuels

Biofuels
Conventional & advanced biofuels

Hydrogen
Active in hydrogen electric

Electric Mobility
Exploring a role in the charging of EVs

Gas for transport
Offering gas to liquids (GTL) and liquefied natural gas (LNG)
Shell and biofuels

Trading & Supply
One of the world’s largest blenders and distributors 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
Different fuels will have different applications

- cars
- trucks, vans, buses
- marine
- aviation

- oil, biofuel
- electricity
- gases, RNG, H₂
Current Projects

- **Canada** SBI Bioenergy Technology & licensing agreement
- **Brazil** Raízen Production of sugarcane ethanol
- **Brazil** Raízen Production of cellulosic ethanol from sugar cane residues
- **India** IH2® Demo plant - Drop-in fuels
- **UK** Velocys Waste to renewable jet fuel
- **US** Junction City Biomethane Oregon, 2007
- **California, US** Codexis 2007
- **Wisconsin, US** Virent 2008
- **Hawaii, US** Cellana 2007
- **Germany** Choren 2005
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**IH²® Technology**
*a conversion technology for residual biomass*

- Technology invented by US-based Gas Technology Institute (GTI) and further developed in collaboration with CRI Catalyst Company (SC&T) since 2010

- Efficient conversion route for forestry, agricultural and other residues (e.g. sorted MSW) allowing the production of cleaner transportation fuels

- 5 tpd demonstration plant commissioned in October 2017 at Shell’s new Technology Centre in Bangalore, India has operated below 5 tpd capacity, modifications nearly complete for restart

*IH² is a trademark of Gas Technology Institute*
IH²® technology
Simplified schematic emphasizes flexibility

Flexibility
- Feed
- Location
- Integration
- Product

Refinery (upgrading, blending/distribution)
IH²® process - two modes of operation
Road vs Aviation fuel mode

Road Transport Mode
- Cut point varies 150-200°C
- Petrol 50-55%
- Diesel 45-50%

Jet Mode
- Cut points 120-280°C
- Naphtha 30-35%
- Jet 45-50%
- Marine Distillate 15-25%

Cycloparaffinic Kerosene (CPK)
**IH²® products: road transport fuels are high quality ‘drop in’**

**GASOLINE / PETROL**
- Meets ASTM D4814-16d
  - E10 blend for regular grade
- EN 228: Petrol – Jan 2009
  - E10 blend for regular grade
- BS VI compliant (BS IV in place)
  - E6 blend for regular grade

E10 petrol blends are currently undergoing qualification processes

**DIESEL**
- Meets ASTM D975-15c
- BS VI compliant
- BS VI compliant

Diesel is currently undergoing qualification processes
**IH2® products: jet mode fuels are high quality ‘drop in’**

Suitable components for:
- Solvents
- Steam cracker feed
- Reformer feedstock – bioBTX
- Gasoline blending

**NAPHTHA**

**JET FUEL**

Matches the Table 1 Performance Criteria for:

- World-wide Civil Jet Fuel Grade Jet A/A-1
  (e.g. ASTM D1655 & DEF STAN 91-091)

- US Military Jet Fuel Grade
  JP-8 and F-34
  (e.g. MIL-DTL-83133 & DEF STAN 91-87)

Fuel is currently in ASTM D4054 approval process with UDRI, NJFC etc having samples

**MARINE DISTILLATE**

Meets ISO 8217 2017 specs
- Very low S content (<5 ppm)
- High on DMA/DFA density (fixable)
- High on DMB/DFB density (fixable)
- Exceeds Residual Fuel Spec

US Navy F-76
- High on density (fixable)
- High cetane (value give-away)

Fuels are currently being evaluated
Technology maturation at demo scale
illustrative ‘spider chart’ provided for discussion

- Shell uses D gates to describe stage of development and an adapted form of NASA TRL for technology readiness
- IH2® technology, invented by GTI in 2009 is currently in D3 with various subsystems operating in the TRL ranges 5-8
- FEED is at FEL-2 stage/FEL-3 may begin as early as 1/20
Summarizing IH²® technology

IH²® technology…

- a location- and feedstock-flexible continuous catalytic thermochemical process under development by Shell using commercial refinery hardware to economically convert forestry, agricultural and sorted municipal wastes into clean-burning ‘drop in’ renewable hydrocarbon transportation fuels with up to 72% bio-energy recovery and up to 92% GHG reduction.

- invented by Gas Technology Institute in 2009
- developed by SC&T (CRI) with GTI from 2010 onward at Shell’s Technology Center in Bangalore, India (STCB)
- flexible with regard to feed and design — stand alone or mill/refinery integrated (build where biomass is)
- designed to meet all fuel specifications of the host country, including ASTM specifications for Jet A/A-1
- economics based upon FEL-2 accuracies are attractive >1000tpd scale. Opex (feed cost) dominates capex in ROI
- at demonstration scale at Shell Tech Center Bangalore
Advanced Biofuels Success Criteria

Right policies and financial support from governments,
- providing stable price signal for investments

Achievement of improved efficiencies by the industry, in both:
- manufacturing technologies
- sustainable feedstocks

Developments in infrastructure:
- vehicle compatibility
- distribution and retail networks
Acknowledgements
Thank You