Shell scenarios, modelling and decision making

Royal Dutch Shell plc
September 8, 2017

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Georges Menane
VP Investor Relations Europe
Royal Dutch Shell
Summary

Re-shaping Shell - on track
- Divestments: >$25 billion completed, announced or advanced progress
- Projects delivery for 2018 on track
- Capital investment – discipline, efficiency and flexibility
- Operational excellence and driving down costs
Supporting Shell’s World Class Investment

IR Programme
- LNG Outlook
  - Provide information to demonstrate the robustness of our Integrated Gas cash engine
- Chemicals event
  - Raise the appreciation and understanding of our Chemicals business
- Scenarios, modelling and strategy presentation
  - Explain how different scenarios inform strategy

Task force on climate-related financial disclosure (TCFD)
- Shell supports TCFD
- Ongoing engagement with taskforce
- Challenges with regulatory perspective
- Considering next steps
- Modelling ability helps us understand qualitative risks

www.shell.com/investor
Exploring alternative futures

- Energy system was complicated
- Energy transition and digital: major disruptors
- Past does not predict the future
- Forecasts are inappropriate

- Radically uncertain future
- Complex future: needs agility
  - Scenario thinking
  - Decision-making
- Scenarios are a distinctive Shell capability

From complicated to complex
Scenarios are neither forecasts nor plans

- Scenarios are not forecasts; neither are they our business plan
- Shell considers multiple, bespoke scenarios relevant to decisions
- Scenarios usage ranges from evaluation of individual opportunities, to portfolio choices, to overarching strategy development

Multiple forces may push towards or pull away from the envisaged futures

Scenarios stretch our perspectives
Shell’s strategy
#makethefuture

Scenario thinking supports robust strategy + portfolio decision-making

Aspired Future
- World-class investment case
- Leader: value + influence
- Reducing our carbon intensity
- Shared value with society

Aspired Portfolio
- Cash Engines
- Growth Priorities
- Future Opportunities

Winning Capabilities
- Customer Centricity
- Commercial Value Delivery
- Technology Commercialisation
- Project Delivery
- Operational Excellence
Using scenarios
Recognising a range of uncertain outcomes

- Consider a range of plausible futures
  - Explore social, political + economic factors
  - Determine context for business environment
  - Model the Future World’s energy systems

- Consider existing and new energy value chains
  - Elements within the value chain
  - Assess investment attractiveness over time
  - Consider the Future Worlds

*This is an example diagram of graphic representations that are considered by the Board. Not based on Shell’s actual portfolio.*
Framework for decision making in uncertainty

- Build from ‘Future Worlds’ + value chain analysis
- Consider “minimise maximum regret”
- Make investment and portfolio decisions

External environment and disruptors

Consider multiple futures in decision-focused scenarios

Business environment/value chain understanding

Clarity of objectives

Strategy and aspired future

Analytic tools

Apply lenses to support the ‘hard’ input to decisions

Decisions based on ‘hard’ and ‘soft’ inputs

From individual decisions to shaping the aspired portfolio

Energy transition

Current portfolio

Aspired portfolio

Multiple lenses
Wim Thomas
Chief Energy Adviser
Royal Dutch Shell
Introduction
How scenarios inform modelling

- Scenarios explore “how the world will work” in the future, and is an essential front-end input in modelling
- Different parts of the world will develop in their own ways and at different paces
- Technology innovation enables new options
- Resource availability can be a constraint
- Deal with disruptions and non-linear relationships
- Modelling helps to demonstrate the plausibility of the scenarios

The future is not an extrapolation of the past
Models underpin scenarios and strategic analysis
World Energy Model (WEM): Estimates global energy demand dynamically

- Estimates energy demand holistically
- Underpinned by demand, choice and supply modules
- Uses resource constraints, build rates and prices to balance supply and demand
- Covers other elements such as efficiency and learning curves, and outcomes like CO$_2$ emissions from energy use

Balances demand choices with supply

- 100 Years
- 100 Countries & Regions (Incl. 82 countries individually)
- 14 Sectors
- 10 Energy Carriers
- 18 Energy Sources
WEM:
Key drivers for demand

75 specific scenario-based inputs, considered by:
- Sector
- Carrier
- Energy source
- Geography

Population  Economic growth  Environmental pressures
Technology  Resource availability  People’s choices
**WEM: Energy Ladders**
Estimate energy service needs

- Different development curves by country, by sector
- Developing nations tend to use less energy due to more efficient technologies available now than in the past for developed nations
- Non-linear relationship between GDP growth and energy use
- Energy demand accelerates once industrialisation starts
- Demand growth eases as some uses approach saturation and the economy diversifies from industrial to service sector activity

**Logarithmic scale

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**The Energy Ladder 1960 – 2016**
The relationship between income and energy use

Primary energy/ (GJ/capita/year)

GDP (PPP) capita (2010 USD)**
WEM: Choice module
Determining the energy mix

- Acknowledges different user preferences for technologies and solutions
- Choices change in response to prices, taxes, subsidies, availability, convenience, values and energy security or policy considerations
- Not all choices will be based on lowest cost options
- Different energy choices are not perfect substitutes

- Consumers choose which energy carrier to deliver their service needs
- Producers decide which primary energy sources to use to satisfy consumer demand

### 14 Sectors
- Passenger transport
  - Ship
  - Rail
  - Road
  - Air
- Freight transport
  - Ship
  - Rail
  - Road
  - Air
- Residential
  - Heating & Cooking
  - Lighting & Appliances
- Industry & services
  - Heavy
  - Other
  - Services
  - Non-energy

### 10 Carriers
- Electricity (Centralised / Distributed)
- Liquid Fuels
- Heat (Centralised / Distributed)
- Gaseous Fuels
- Solid Fuels
- Biomass (Traditional / Commercial)
- Hydrogen

### 18 Energy Sources
- Oil
- Natural Gas
- Coal
- Nuclear
- Hydro-electricity
- Biofuels – 1st Gen
- Biofuels – 2nd Gen
- Biofuels – Marine
- Biofuels – Traditional
- Biofuels – Commercial
- Waste
- Geothermal – Hydrothermal
- Geothermal – Engineered
- Solar – Photovoltaic
- Solar – Thermal
- Wind
- Tidal
- Wave
WEM: Example outputs
A myriad of different “slices” through the output data set possible

- The WEM considers the global energy system as one
- What happens in China reverberates throughout the rest of the world

These are not forecasts, but example outputs of scenarios that have been modelled
Source: Shell New Lens Scenarios
WEM: Example outputs
Comparing two scenarios for consumer choices of what type of energy they want to use

Decarbonisation and efficiency go hand-in-hand with electrification of the energy system

Mountains explores the widespread success of shale gas and strong government policy to reduce oil use in transport and use of CCS to reduce CO₂ emissions

Oceans explores a highly economically efficient world and strong uptake of Renewables to reduce CO₂ emissions
WEM: **Example outputs**
Comparing two scenarios for primary energy mix as a result of different policy, GDP, resources and innovation assumptions

Of the New Lens Scenarios, Mountains’ drivers result in ‘earliest’ peak oil demand; Oceans’ drivers result in ‘latest’ peak oil supply

- Mountains explores the widespread success of shale gas and strong government policy to reduce oil use in Transport and use of CCS to reduce CO₂ emissions
- Oceans explores a highly economically efficient world and strong uptake of Renewables to reduce CO₂ emissions

These are not forecasts, but example outputs of scenarios that have been modelled
Global Energy Resources database
Essential for projecting the future energy mix

- Assessment as at 2015
  - Oil, gas and coal expected remaining resources
  - Renewables annual production potential
  - Used for Shell scenarios
  - Data will be available for download

Insights:
- Sufficient renewable resources, but unequal distribution
- Sufficient fossil resources for a decarbonised and efficient world, but potential for stresses otherwise

Note: Figures for fossil energy and renewables are not directly comparable. The figures for fossil energy are for the stock of resources in place, whereas the renewable figures represent an annual rate of production.


Comprehensive overview of all available primary and renewable energy resources per country
Global Supply Model (GSM)  
Estimates oil and gas production

- Estimates production at resource category and country level until 2100
- Each resource category develops through its own resource maturation chain
- Cost of supply curves control how much resource is economic to mature at a given price
- Includes an environmental footprint module

Includes:
- Top down analysis for yet-to-find resources
- Bottom-up analysis for undeveloped and developed resources
- Depletion of existing production and
- Reserves growth due to technology
GSM: Example outputs
Projecting oil and gas supply by type, region and resource category

These are not forecasts, but example outputs of scenarios that have been modelled

Production varies with oil price, technology progress and (geo)political assumptions
**Example outputs:**

**Modelling disruption potential of Electric vehicles (EV)**

An aggressive EV scenario

**Key assumptions:**

- Battery costs continue to decline
- Regulation strengthens (e.g. ban internal combustion engine (ICE) vehicles in cities)
- OEM vehicle manufacturers assumed to continue to develop ICE efficiencies

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**Global vehicle sales**

<table>
<thead>
<tr>
<th>Year</th>
<th>Million vehicles/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>120</td>
</tr>
<tr>
<td>2020</td>
<td>140</td>
</tr>
<tr>
<td>2025</td>
<td>120</td>
</tr>
<tr>
<td>2030</td>
<td>140</td>
</tr>
<tr>
<td>2035</td>
<td>120</td>
</tr>
<tr>
<td>2040</td>
<td>140</td>
</tr>
</tbody>
</table>

**Global vehicle fleet**

<table>
<thead>
<tr>
<th>Year</th>
<th>Million vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>2,000</td>
</tr>
<tr>
<td>2020</td>
<td>1,500</td>
</tr>
<tr>
<td>2025</td>
<td>1,000</td>
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<tr>
<td>2030</td>
<td>500</td>
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<tr>
<td>2035</td>
<td>500</td>
</tr>
<tr>
<td>2040</td>
<td>2,000</td>
</tr>
</tbody>
</table>

- Yellow: Internal combustion engine (ICE)
- Orange: Plug-in hybrid EV (PHEV)
- Green: Battery EV (BEV)

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EV share in new sales may grow from 1% today to reach 10% by 2025, displacing less than 0.8 mboe/d

This is not a forecast, this is one example scenario
Example outputs:

**Oil demand context**

An aggressive EV scenario

- Passenger road transport makes up around a third of global oil use
- Oil demand has fallen in OECD since 2005
- Non-OECD oil demand growth 2.5 times the impact of OECD demand decline

- EV mainly impacts passenger road transport (a third of total oil demand)
- ICE efficiency has a much bigger impact over this period
- Overall demand continues to grow underpinned by non-OECD growth

Source: Shell WEM Disruption example

This is not a forecast, this is one example scenario
Summary

- ‘Complicated to complex’ context
- Understand multiple futures to frame decision-making
- Scenario thinking and holistic modelling is key
- Use multiple lenses, including ‘minimise maximum regret’
- Agile decision-making needed through energy transition
Materials available online

www.shell.com/scenariosenergymodels
Questions and Answers

Guy Outen
EVP Strategy & Portfolio

Wim Thomas
Chief Energy Adviser
Biographies
Guy Outen was appointed Executive Vice President, Strategy & Portfolio for Royal Dutch Shell plc in 2014.

Guy has worked in various commercial, new business and finance roles across all parts of Shell’s business. From 2009 to 2013 he was the EVP Commercial, New Business & LNG. LNG became part of the separate Integrated Gas business from 2013. Before 2009 Guy was EVP, EP Strategy & New Business and before that he was the Chief Financial Officer for Gas & Power, Shell Group Chief Internal Auditor, the CFO for Shell Development Australia and has also been responsible for Retail operating processes, split off and merged Shell Australia’s chemical operations into the Montell JV, worked in Crude Oil Trading and a Coal JV.

Guy has an economics and commerce background, B.Com (Hons), M.Com, and is a Fellow CPA Australia.

Guy is married with three sons and enjoys sport, music and motorcycling.
Wim Thomas
Chief Energy Adviser

Wim Thomas is Chief Energy Adviser and leads the Energy Analysis practice in Shell.

His team is also responsible for Shell’s long-term global energy scenarios, informing Group Strategy. He has been with the Shell Group for some 33 years, with prior positions in drilling operations, subsurface reservoir management and commercial and regulatory affairs in gas.

Wim is chairman of the UK national committee of the World Petroleum Council and is a former chairman of the British Institute of Energy Economics. He holds a postgraduate degree in Maritime Technology from Delft University in The Netherlands.

Wim has been in his current role for the past 14 years. He advises Shell companies on a wide range of energy issues, including global supply and demand, regulations, energy policy, markets, pricing and industry structure.
### Board and future business environment

Diverse input in Board meetings to stretch thinking and inform decision making

<table>
<thead>
<tr>
<th>Mega Trends</th>
<th>Beliefs</th>
<th>Uncertainties</th>
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<tbody>
<tr>
<td>Energy Transition</td>
<td>Macroeconomics</td>
<td>Example:</td>
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<tr>
<td></td>
<td></td>
<td>■ Sustained era of transition &amp; volatility</td>
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<tr>
<td></td>
<td></td>
<td>■ Emerging markets drive Global GDP increases</td>
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<td></td>
<td>Market</td>
<td>Example:</td>
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<tr>
<td></td>
<td></td>
<td>■ Hydrocarbon demand growth + supply required</td>
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<tr>
<td></td>
<td></td>
<td>■ Renewables contribution increases significantly</td>
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<tr>
<td></td>
<td>Industry</td>
<td>Example:</td>
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<tr>
<td></td>
<td></td>
<td>■ Technology &amp; scale alone insufficient</td>
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<tr>
<td>Digitalisation</td>
<td></td>
<td>Example:</td>
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<tr>
<td></td>
<td></td>
<td>■ Political tensions &amp; regional instability</td>
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<tr>
<td></td>
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<td>■ Impact of digital technology</td>
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<tr>
<td></td>
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<td>■ Key pricing mechanisms</td>
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<tr>
<td></td>
<td></td>
<td>■ Energy transitions impact</td>
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<tr>
<td></td>
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<td>■ Winning business models &amp; capabilities</td>
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</tbody>
</table>
Shell scenarios
Identifying emerging challenges to guide us through change

Scenarios stretch our perspectives and help us to make crucial choices in uncertain times

Globalisation, liberalisation, technology diffusion; environmental pressures; Asian growth

Social fragmentation & cohesion dilemmas; re-emergence of State impact

Era of volatile energy transitions

Changing sources of influence & decision making power

Trends

Publications

1965-1980
First scenarios

‘92: Global Scenarios ‘92–20
‘95: Global Scenarios ‘96–20
‘95: Long Term Energy Scenarios
‘98: Global Scenarios ‘98–20

‘01: Energy Needs, Choices and Possibilities: Scenarios to 2050

‘02: People and Connections Scenarios

‘05: Global Scenario’s to 2025

‘07: Signals & Signposts

‘08: Shell energy scenarios to 2050

‘11: Signals & Signposts

‘13: New Lens Scenarios

‘14: New Lenses on Future Cities

‘16: A Better Life with a Healthy Planet: Pathways to Net-Zero Emissions

Internal unpublished scenarios focused on specific developments and challenges
WEM: Countries modelled

Darker-coloured countries are modelled individually. Lighter-coloured countries are modelled collectively as ‘Rest of’ regions, such as ‘Rest of West Africa’.