Shell Scenarios

Sky

Meeting the Goals of the Paris Agreement

May 2018
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Scenarios for the pathway ahead

Scenarios are not predictions or forecasts, they are a way of exploring alternative futures.
## The energy system today

- **Primarily fossil fuels**
- **Final energy is less than 20% electricity; so more than 80% of the energy we use is not electricity**
- **Continuing to grow as population increases and economies expand**
- **Current energy system has been evolving over the last 150 years**
- **A person from London or New York in 1920 visiting today would recognise much of what they see (in the energy system)**

### Energy Sources

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil Fuels</td>
<td>81%</td>
</tr>
<tr>
<td>Oil</td>
<td>32%</td>
</tr>
<tr>
<td>Coal</td>
<td>27%</td>
</tr>
<tr>
<td>Gas</td>
<td>22%</td>
</tr>
<tr>
<td>Renewable</td>
<td>14%</td>
</tr>
<tr>
<td>Wind</td>
<td>0.61%</td>
</tr>
<tr>
<td>Solar PV</td>
<td>0.19%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>5%</td>
</tr>
<tr>
<td>Hydro</td>
<td>2.5%</td>
</tr>
<tr>
<td>Biomass</td>
<td>5%</td>
</tr>
<tr>
<td>Wood</td>
<td>5%</td>
</tr>
<tr>
<td>Other (Solar water heaters, tidal etc.)</td>
<td>0.26%</td>
</tr>
<tr>
<td>Geothermal</td>
<td>0.57%</td>
</tr>
</tbody>
</table>

### Data Source

The goals of the Paris Agreement

...aim to reach global peaking of greenhouse gas emissions as soon as possible;

...achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century.

Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels
Challenges for the 21st century: Development and decarbonisation

Human Development Index: energy supports a better life

- 1.0: United Kingdom, Germany, Australia, Canada, USA, South Korea, France, Japan, Spain/Italy
- 0.9: Canada, USA, South Korea, USA, China, Russia, Germany, France, Japan
- 0.8: United Kingdom, USA, South Korea, USA, China, Russia, Germany, France, Japan
- 0.7: United Kingdom, USA, South Korea, USA, China, Russia, Germany, France, Japan
- 0.6: China, Russia, Germany, France, Japan, Spain/Italy
- 0.5: China, Russia, Germany, France, Japan, Spain/Italy
- 0.4: China, Russia, Germany, France, Japan, Spain/Italy
- 0.3: China, Russia, Germany, France, Japan, Spain/Italy
- 0.2: China, Russia, Germany, France, Japan, Spain/Italy
- 0.1: China, Russia, Germany, France, Japan, Spain/Italy

Decarbonisation: sector-specific perspective is key

- Industry: Less difficult to decarbonise, ... More difficult to decarbonise
- Built environment: Less difficult to decarbonise, ... More difficult to decarbonise
- Power generation: Less difficult to decarbonise, ... More difficult to decarbonise
- Transport: Less difficult to decarbonise, ... More difficult to decarbonise

Source: Shell analysis, UN Human Development Index 2016


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The New Lens Scenarios Family
Looking beyond Mountains and Oceans...

Mountains
> 2°C

Sky
< 2°C

Mechanisms to share common interests

Mountains
> 2°C

Oceans
> 2°C

>> 2°C

>> 2°C

...to Sky
Sky Scenario: A possible primary energy mix for a net-zero emissions world

The size of the pie chart indicates growth of the energy system

Source: Shell analysis, Sky scenario
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Sky Scenario: Navigating 21st century turbulence

- Demand growth
- Abundant coal
- Efficiency rebound
- Difficult sectors
- Stalled technologies
- Time

“A Better Life with a Healthy Planet”
Sky begins in today’s economic & policy realities, ratchets up action, then goal-seeks within techno-economic possibilities

Source: Shell analysis, Sky scenario
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Sky Scenario: Seven essential elements

- Electrification of final energy
- Grow new energy systems
- Energy efficiency
- Carbon pricing
- Carbon capture and storage
- End deforestation

Underpinned by changing consumer mind-set
Sky Scenario: A major ramp-up in electrification
Current trends are not sufficient

Electricity as a % of final energy use

The transition in Sky is at least triple the historic rate

Historic electrification trend is ~2% points per decade

Source: Shell analysis, Sky scenario, May 2018
Sky Scenario: Deep electrification
But molecules remain important

World total final energy consumption, EJ/year

- **Solid fuels**: Coal, Biomass
- **Gaseous fuels**: Natural gas, H₂
- **Liquid fuels**: Oil, Biofuel
- **Electricity**: Renewables, Nuclear

Source: Shell analysis, Sky scenario
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Sky Scenario: Energy efficiency is key
Step-change leads to gains above historical trends

World total final energy consumption, EJ/year

- Rising incomes in developing regions drive global energy demand
- This is moderated by significant energy efficiency improvements

Source: Shell analysis, Sky scenario
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Sky Scenario: Essential policies are established
Governments rapidly adopt carbon-pricing mechanisms

Carbon equivalent price, \$/tonne CO₂

Unwavering acceleration and coordination:
- Market & fiscal mechanisms
- Standards & mandates
- Investments in infrastructure & technology

Source: Shell analysis, Sky scenario
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Sky Scenario: Major shifts in primary energy
By mid-century, renewables dominate

World total primary energy by source, EJ/year

- Natural gas is a transition fuel as wind and solar deployment ramps-up
- Solar PV passes oil as the largest energy source in the 2050s

Source: Shell analysis, Sky scenario
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Sky Scenario: Fossil fuel demand peaks
Needs continue where substitution is difficult

World total primary energy, EJ/year

Source: Shell analysis, Sky scenario
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Sky Scenario: Carbon capture and storage (CCS) as a man-made sink
Sky Scenario: Bioenergy with CCS has an important role to play

- Combustion
- Fermentation
- Aerobic Digestion
- Gasification
- Heat
- Biohydrogen
- Biomethane
- Synthetic biofuels
- Electricity
- Energy products
- Energy crops
  - High biomass yield
  - Extensive availability
- Biomass residues
- Capture
  - Compression
  - Transport
- Geological storage
- Saline aquifers
  - Depleted oil and gas fields
- Non-energy by-products

Source: Shell schematic
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Sky Scenario: Achieving the balance

Net emissions:
- 37.8 Gt (Fossil fuels)
- 35.2 Gt (all emissions are Gt of CO₂)

Bioenergy production and use:
- 6.7 Gt

Photosynthesis:
- 6.7 Gt

Source: Shell analysis, Sky scenario
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Sky Scenario: Achieving the balance

Emissions from biofuel use: 15.1 Gt
Emissions: 21.6 Gt

Fossil fuels: 16.5 Gt
Geological storage of CO₂: 6.1 Gt

Source: Shell analysis, Sky scenario

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Sky Scenario: Achieving the balance

Source: Shell analysis, Sky scenario
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Sky Scenario: An end to deforestation by 2070
In addition, increasing global forest coverage by an area the size of Brazil offers potential to deliver the stretched 1.5°C ambition of the Paris Agreement.
Meeting the Paris ambition = re-wiring the global economy in 50 years

Governments
- Promoting critical new pre-commercial technologies
- Developing key infrastructures
- Framing new market structures

Private sector
- The engine for commercial innovation and scaling
- Mass-deployment and integration of new technologies
- Providing customers with new possibilities

Acceleration is achieved through policy and technology uptake, and unprecedented degrees of cross-boundary collaboration
“The future depends on what we do in the present”

Mahatma Gandhi
Read more about Sky and download the data-set
www.shell.com/skyscenario