

SHELL SCENARIOS

# Sky



MEETING THE GOALS OF  
THE PARIS AGREEMENT

## AN OVERVIEW

2050

2055

2060

2065

2070

2075

20



# WELL BELOW 2°C: THE PARIS AMBITION

The December 2015 Paris Agreement on climate change is a remarkable document offering a pragmatic blueprint for resolving one of the toughest issues society faces.

2015 2020 2025 2030 2035 2040 2045

To hold the increase in the global average temperature to well below 2°C above pre-industrial levels, the Agreement calls for a “balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of the century.” This “balance”, or what is also referred to as “net-zero emissions” in the case of the energy system, is the critical outcome within the required transition. Our publication “**A Better Life with a Healthy Planet**” examines in detail what this requires.

Drawing lessons from previous Shell scenario work and additional analyses, we now present a possible pathway for achieving the goals of the Paris Agreement, including net-zero emissions from energy use by 2070 – a scenario called “**Sky**.”

**Sky** recognises that a simple extension of current efforts is insufficient. The relevant transformations in the energy and natural systems require the deployment of disruptive new technologies at mass scale within government policy environments that strongly incentivise investment and innovation. **Sky** relies on a complex combination of mutually reinforcing drivers being rapidly accelerated by society, markets, and governments.

The **Sky** booklet and dataset are available to download at [www.shell.com/skyscenario](http://www.shell.com/skyscenario)

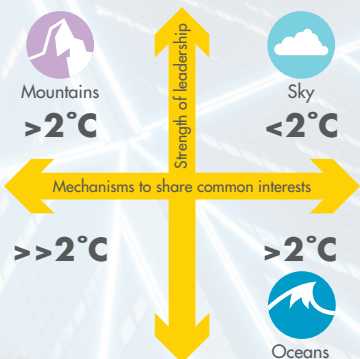


**Sky is a technologically and macro-economically possible route to achieving the goals of the Paris Agreement.**

2050      2055      2060      2065      **2070**      2075      2080

## FROM **MOUNTAINS** AND **OCEANS** TO **SKY**

In the original New Lens Scenarios, we explored two possible ways the 21<sup>st</sup> century could unfold, through our **Mountains** and **Oceans** scenarios.



The **Sky** scenario brings further to the surface the emerging possibility of multi-lateral collaboration to tackle climate and air-quality issues. It combines the most progressive elements of both **Mountains** and **Oceans**.

Leadership to create a shared vision was an essential element of the Paris Agreement, but so, too, was listening and responding to those most at risk from climate change. These developments introduce the notion of a framework for resolution of global issues within which various scenarios could be positioned.



## CHALLENGES AHEAD FOR **SKY**

Because we need energy for just about everything we make and do, achieving **Sky** essentially involves re-wiring the whole global economy to reach net-zero emissions in just 50 years. We face some major challenges.

- Population growth, development, new energy services, and the extended use of existing services will all contribute to energy demand growth. Demand growth can potentially be slowed through rapid efficiency gains, but efficiency tends to lower the cost of energy services, leading to increasing consumption by consumers - a double-edged sword.
- A stark reality of the early 21st century is the lack of a clear development pathway for an emerging economy that doesn't include coal. Coal is a relatively easy resource to make use of and offers a great deal, including electricity, heating, chemicals, and, very importantly, smelting to make iron. It remains an important energy resource.
- Some progressive regions may need to consider net-zero emissions as an objective for the 2050s, in part to balance countries that arrive at this point much later in the century. But net-zero emissions in almost any industrial economy is a tough ask due to the current lack of low-carbon substitutes for, e.g. aviation, shipping, road freight, cement manufacture, some chemicals processes, smelting and glass manufacture. Energy-dense portable fuels will be a continuing need.
- Wind and solar power can grow rapidly, but produce electricity which makes up less than 20% of final energy consumption today. Major contributions to decarbonisation and increased efficiency require deep electrification of the economy, but electrification has been slow and its market share is currently growing at only 2%-points per decade, which needs to triple.
- Some promising low-carbon technologies are currently stalled, with hydrogen, perhaps, being the most notable example. Progress in biofuels technology and Carbon Capture and Storage (CCS) have also been slower than originally anticipated.

Achieving net-zero emissions in just 50 years leaves no margin for interruption, stalled technologies, delayed deployment, policy indecision, or national back-tracking. Rather, it requires a broad process that is embraced by societies and led by public policy.

# A SCENARIO FOR SUCCESS

In **Sky**, governments respond positively to the rapid cycle of assessment, review, and improvement of national contributions, as set up under the Paris Agreement. Peer pressure, emerging from the Paris transparency framework, provides an additional push and the five-year ratchet mechanism works.

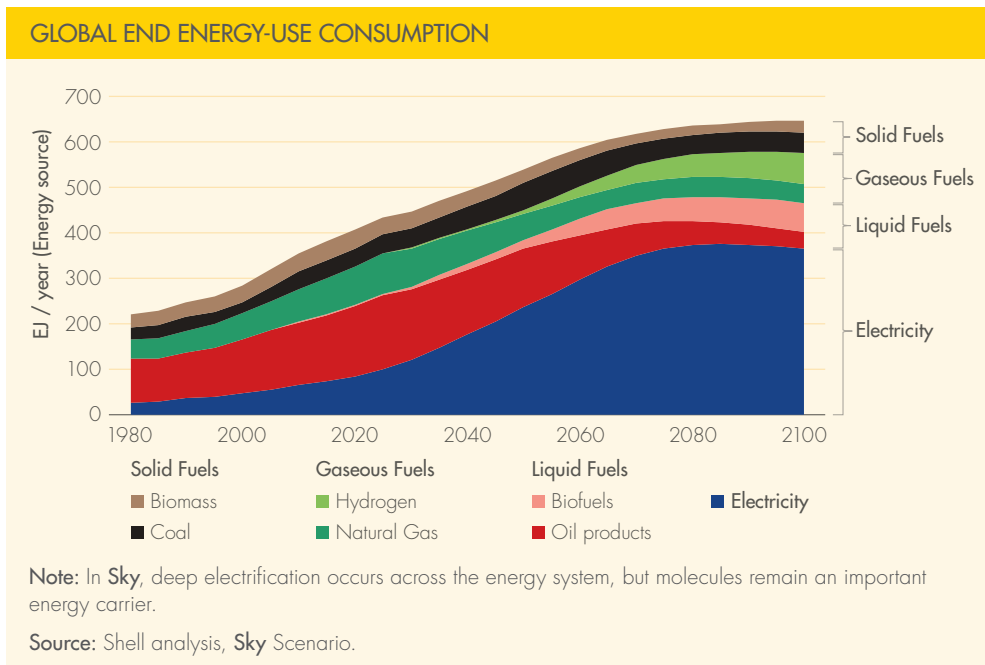
At national level in **Sky**, governments implement legislative frameworks to drive efficiency and rapidly reduce CO<sub>2</sub> emissions, both through forcing out older energy technologies and by promoting competition to deploy new technologies as they reach cost effectiveness. Government-led carbon pricing emerges in **Sky** as a suite of taxes, levies, and market mechanisms. By 2030, a common understanding is reached between governments as to the appropriate level of the cost of emissions.

The route to netzero emissions by 2070 involves change at every level of the economy and energy system. One of the most important trends is electrification – the increasing replacement of direct fossil fuel use (such as gasoline for mobility) by electricity.

In **Sky**, by the 2070s;

- Electricity exceeds 50% of end-use energy consumption, with the sector nearing five times the size of that seen in 2017.
- Fossil fuels are effectively absent from power generation with solar starting to dominate.
- Biomass generation has emerged, linked with CCS to offer an important carbon sink.

Electrification begins most clearly in the transport system through intergovernmental initiatives and pledges by countries and cities to phase out internal combustion engine passenger cars. As early as 2030, more than half of global car sales are electric, extending to all cars by 2050.



Across all other forms of transport, biofuels play a critical role in **Sky** due to continued reliance on liquid fuels as the high energy-density fuel of choice, but set against the need to reduce CO<sub>2</sub> emissions. Hydrogen also comes into the mix at scale in the 2030s.

The shift in industry required for net-zero emissions follows a more incremental path, responding to the ratcheting up of carbon prices by governments. The transformation follows three distinct routes in **Sky**:

- Efficiency improves continuously.
- Some processes shift towards electricity, with hydrogen also emerging as an important fuel in the 2030s, although not until after 2050 for heavy industry.
- Coal remains important in various processes with CCS applied to manage CO<sub>2</sub> emissions.

For fossil fuels in **Sky**, the first clear signs of the transition emerge in the 2020s;

- Oil demand peaks and begins to decline by the 2030s. By 2070, however, oil production

remains at 50 million barrels per day, albeit declining, due to the broad swathe of services that it still supplies. Biofuels increasingly supplement the liquid fuel mix.

- Coal declines rapidly with the peak already behind us.
- Natural gas plays an important early role in supplanting coal in power generation and backing up renewable energy intermittency. Demand then falls after 2040.

By the middle of the century the energy mix is starting to look very different, with solar the dominant primary energy supply source by around 2055. Energy system CO<sub>2</sub> emissions peak in the mid-2020s at around 35 Gt, and fall sharply thereafter.

Numerous other human activities have also changed the trace gas composition of the atmosphere, which have also contributed to warming. In **Sky**, however, significant changes are made in all the greenhouse-gas producing sectors.

## Introducing **Sky** – an ambitious scenario to hold the increase in the global average temperature to well below 2°C.

### From now to 2070 –

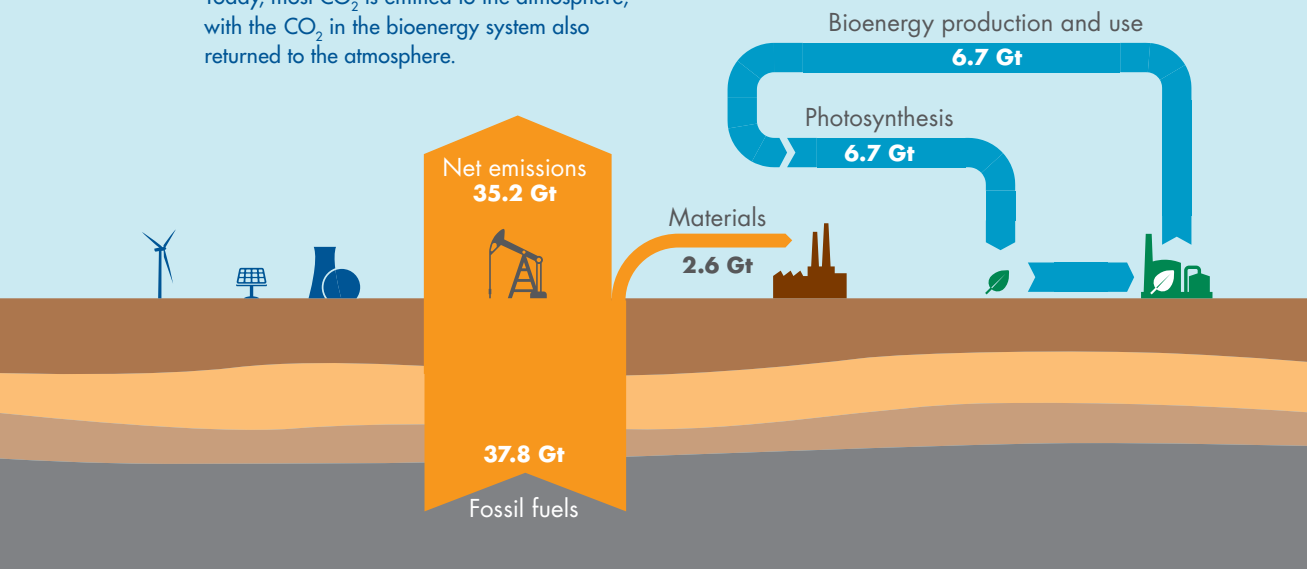
- A change in consumer mindset means that people preferentially choose low-carbon, high-efficiency options to meet their energy service needs.
- A step-change in the efficiency of energy use leads to gains above historical trends.
- Carbon-pricing mechanisms are adopted by governments globally over the 2020s, leading to a meaningful cost of CO<sub>2</sub> embedded within consumer goods and services.
- The rate of electrification of final energy more than triples, with global electricity generation reaching a level nearly five times today's level.
- New energy sources grow up to fifty-fold, with primary energy from renewables eclipsing fossil fuels in the 2050s.
- Some 10,000 large carbon capture and storage (CCS) facilities are built, compared to fewer than 50 operating in 2020.
- Net-zero deforestation is achieved. In addition, reforesting an area the size of Brazil offers the possibility of limiting warming to 1.5°C

# THE EVOLVING ENERGY SYSTEM

## CO<sub>2</sub> BALANCE IN SKY

### 2020

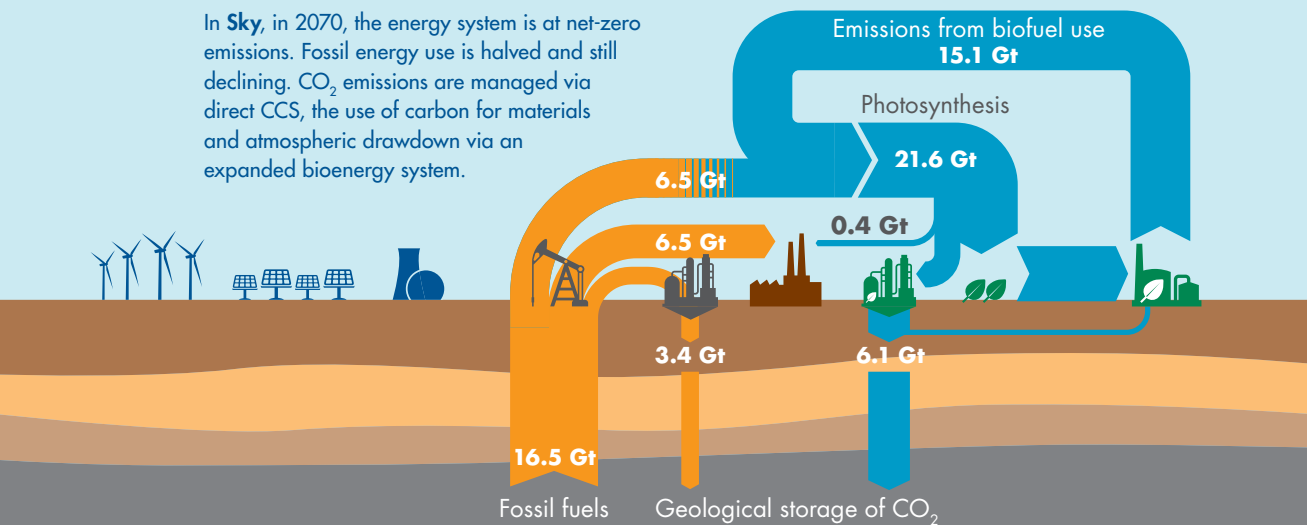
Today, most CO<sub>2</sub> is emitted to the atmosphere, with the CO<sub>2</sub> in the bioenergy system also returned to the atmosphere.



Fossil fuel production
 CCS
 Biofuel production
 Bioenergy with CCS
 Carbon in products
 Growing biomass

### 2070

In **Sky**, in 2070, the energy system is at net-zero emissions. Fossil energy use is halved and still declining. CO<sub>2</sub> emissions are managed via direct CCS, the use of carbon for materials and atmospheric drawdown via an expanded bioenergy system.



# ACHIEVING THE BALANCE

By 2070 in **Sky**, remaining fossil fuel use from hard-to-mitigate applications equates to some 16 Gt CO<sub>2</sub> per year in potential emissions, albeit continuing to decline. The Paris Agreement recognises this reality when it calls for a balance between emissions by sources and removals by sinks of greenhouse gases.

To achieve a balance in the energy sector, **Sky** utilises three mechanisms that either prevent the release of CO<sub>2</sub>, or remove CO<sub>2</sub> from the atmosphere. Over the course of the century one trillion tonnes of CO<sub>2</sub> are handled in this way.

- CCS applied in large point source emitting facilities such as cement plants.
- CCS applied in power plants operating with a sustainably produced biomass feedstock, resulting in net removal of CO<sub>2</sub> from the atmosphere.
- The production of various products, such as synthetic fibres, from fossil fuels or biomass.

In **Sky**, deforestation also reaches net-zero by 2070. Large-scale reforestation could accompany this, offering the opportunity to further limit warming. This scale of change in the land-use sector will require action by governments. Cooperative mechanisms, such as those within the Paris Agreement, can trigger private sector involvement, which in turn could accelerate the necessary activities.



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Delivering **Sky** will be challenging. Achieving long-term public goals requires long-term public policy to initiate and guide developments that the private sector will need to deliver and the public will need to choose or accept.





## THE PARIS AMBITION REALISED

By 2100, warming of the climate system is held to around 1.75°C according to independent expert analysis (MIT Joint Program on the Science and Policy of Global Change) of the energy system emissions trajectory described by **Sky**. Reforesting globally an area the size of Brazil offers the possibility of reaching the stretch Paris goal of 1.5°C.

The Paris Agreement has sent a signal around the world; climate change is a serious issue that governments are determined to address. By 2070, there is the potential for a very different energy system to emerge. It can be a system that brings modern energy to all in the world without delivering a climate legacy that society cannot readily adapt to. That is the essence of the **Sky** scenario.

Scenarios 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. Please read the full cautionary note in [www.shell.com/skyscenario](http://www.shell.com/skyscenario).

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