THE ENERGY TRANSFORMATION SCENARIOS

AN OVERVIEW

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Scenarios help us make sense of what is happening in the world, and to make better, more resilient and potentially transformational decisions. Each of the three futures set out here is possible, but only one of them presents a truly desirable destination. **Sky 1.5** is that scenario. It imagines a world which has achieved the stretch goal of the Paris Agreement to limit global warming to under 1.5 degrees Celsius above pre-industrial levels this century.

Ben van Beurden,
Chief Executive Officer

This overview introduces three long-horizon scenarios[1] – **Waves**, **Islands** and **Sky 1.5**. The full report can be found at www.shell.com/transformationscenarios.

All three scenarios are possible pathways towards the future that have both attractive and challenging features. But of the three, only **Sky 1.5** has a pace and timing for energy decarbonisation that is fast enough to limit global warming to 1.5°C above pre-industrial levels by the end of this century.

Sky 1.5 is solidly built on lessons learned from previous energy transitions. During the past few decades, however, the pace of change in the policies and practices shaping the energy system has been relatively modest – the pace needed now must be faster and will be extraordinarily challenging. It requires practical actions to speed the mass deployment of cleaner technologies, to motivate new behaviours and investment choices and to remove emissions. New alignments, smart policies and pioneer leaders can accelerate this action.

THE ENERGY TRANSFORMATION SCENARIOS: FOUR CONCLUSIONS

1. **Energy needs will grow.**
   - A better life for all requires sufficient energy to provide everyone with a decent quality of life.[2]
   - The energy needs of growing populations seeking a decent quality of life will outstrip the significant capacity to improve energy efficiency.
   - A healthy planet requires a transition of the energy system from one that relies primarily on fossil fuels to one that increasingly uses sustainable sources of energy to achieve net-zero emissions.[3]

2. **The energy system will be transformed – the issue is speed.**
   - To meet all energy needs while decarbonising will require accelerating electrification of the economy through renewable power and will also still require the use of liquid and gaseous fuels in sectors that are hard to electrify; at the same time, these fuels will steadily transition from traditional fossil fuels to low- and no-carbon sources as end-use technologies evolve.
   - Such energy transitions are inevitable over time, but they will proceed at different paces in different places and in different sectors.
   - Sociopolitical choices affecting the shape of the economy, the energy system and the environment that are being made now will be significant for decades to come. Making these choices could be the most challenging part of energy transitions.

3. **Transformation will have costs and benefits.**
   - Taking steps towards the goal of the Paris Agreement could be rewarding both economically and environmentally, although the necessary actions involve costs.
   - These overall societal costs of investing in energy transitions are expected to be manageable.
   - Triggers like the current COVID-19 crisis provide opportunities to transform traditional approaches and apply new ones that are better tuned to the urgent needs ahead.

4. **Action accelerators are necessary to meet climate aspirations.**
   - Society is not currently on course to meet the goal of the Paris Agreement.
   - With sufficient *acceleration* along known pathways, it nevertheless remains technically possible, although extremely challenging, to achieve these climate aspirations.
   - Three fundamental *action accelerators* are needed for a timely and just transition to make Paris happen: alignments of policies, sectors and governments; smart policy rules and incentives; and pioneer leaders.

> “It is not the strongest of the species that survives, nor the most intelligent. It is the one that is most adaptable to change.”
>
> **From Darwin’s Origin of Species, paraphrased.**

RECOVERY, RESILIENCE AND TRANSFORMATION

The COVID-19 pandemic has generated significant turning points, with shifts across almost all societies and economies. It has exposed tensions and weaknesses in the global systems – but also shifted policy and behaviour in ways that open new possibilities for the future.

There will be different *recovery* objectives at the front of people's minds: the recovery of *economic strength*, the recovery of a sense of *security* and the recovery of a sense of *well-being*. These different objectives form the driving forces behind the scenarios in this report. To some extent, all societies will be seeking all three goals – material prosperity, security and health – but different circumstances and values will make one or another a greater priority in the mix.

Over time, attention will turn from short-term *recovery* to long-term *resilience* – the capacity to survive, adapt and grow in the face of change and uncertainty. The current crisis may provide a window of opportunity for the deep changes distinct to *transformative resilience* – the ability to transition deeply to thrive in new circumstances, characterised by cultures of experimentation, innovation and foresight.

Transforming the global energy system will involve many different types of organisation engaging with the future, supporting cultures of learning and experimentation and building transparent, inclusive, widely accepted and accountable institutions and systems of cooperation and governance.

SCENARIO SUMMARIES

The Energy Transformation Scenarios – **Waves**, **Islands** and **Sky 1.5** – explore different initial recovery responses to the crises of 2020 and how these responses develop into future pathways throughout the 2020s and beyond. *Scenario Energy Landscapes: A Graphic Exploration* goes deeper into the significance of the scenarios for the energy system by quantifying and comparing the different energy and environmental implications of the choices taken in each world.

Waves – *late, but fast decarbonisation*

In **Waves**, the initial response to the crises of 2020 caused by the COVID-19 pandemic is to repair the economy – wealth first. Self-interest is largely perceived in economic terms, and resilience is judged in terms of economic strength. Economic recovery is rapid, although at the cost of repeated waves of infection. There is a surge in the use of energy, fossil fuels and greenhouse gas emissions, but there are also underlying currents that eventually bring these waves crashing down. The apparent economic success disguises a deeper story of growing inequality, feeding social discontent and labour unrest. The public also begins to react to more frequent and more extreme weather events. The neglect of structural issues, ranging from public health to social welfare to climate change, is blamed for societal and environmental stresses. From an energy perspective, there is a societal and political backlash to climate change which forces rapid policy-driven reductions in fossil fuel use. The global use of coal and oil peaks in the 2030s, and natural gas not long afterwards. Moving quickly, but starting later than required to meet the goal of the Paris Agreement, global society achieves an energy system with net-zero emissions around 2100. The world must face long-term higher temperatures of around 2.3°C above pre-industrial levels – *late, but fast decarbonisation.*

Islands – *late and slow decarbonisation*

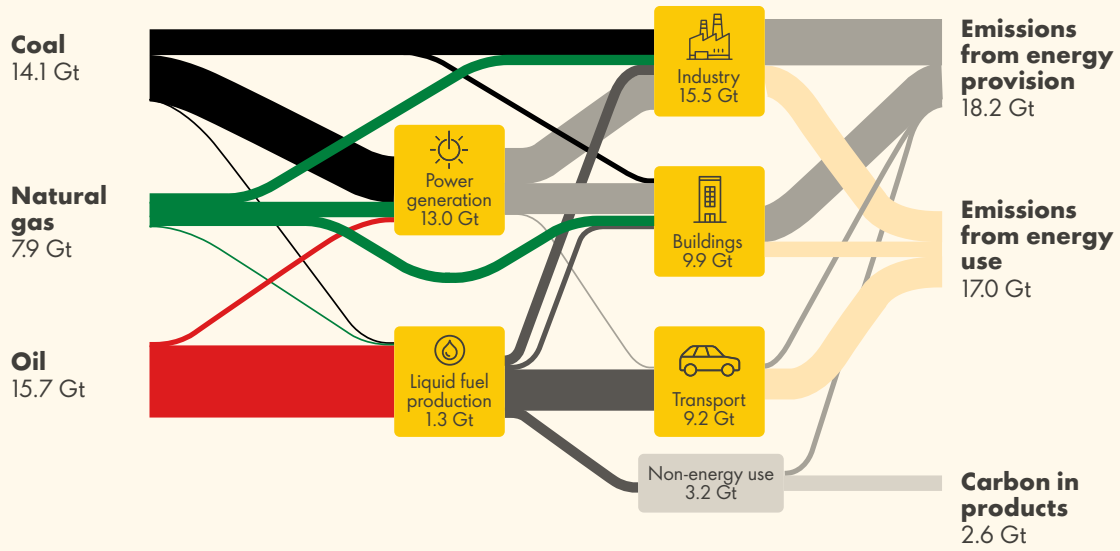
In **Islands**, governments and societies decide to focus on their own security first, with a new emphasis on nationalism threatening to unravel the post-war geopolitical order. There is an islands-mentality with resilience understood as autonomy and self-sufficiency. These internally focused recovery efforts have mixed results. Some countries do relatively well while others suffer from ineffective policies. There are frictions in international trade and collaboration, so growth in the global economy begins to stagnate, and international efforts to address the climate challenge slow. The Paris climate process unravels. Nations focused on their own short-term economic outcomes remain dependent on cheap fossil energy for a prolonged period, and global emissions decline only slowly. Extreme weather events eventually cause disruption and suffering, yet the 'blame' for this is largely placed on others rather than embraced in domestic politics. Although the normal course of equipment and infrastructure replacement and the deployment of cleaner technologies bring progress and eventually net-zero emissions beyond 2100, the world overshoots the timeline and does not achieve the goal of the Paris agreement. The transition that unfolds in **Islands** leads to atmospheric CO_2 levels consistent with an average temperature around 2.5°C above pre-industrial levels by 2100, and still rising slowly – *late and slow decarbonisation.*

Sky 1.5 – *fast decarbonization now*

In **Sky 1.5**, the initial response to the crises of 2020 is to focus on responding to the pandemic and related challenges to public well-being – health first. Following the successes of collaborative efforts and healthy competition among international medical and scientific communities in developing vaccines, there is deeper appreciation of

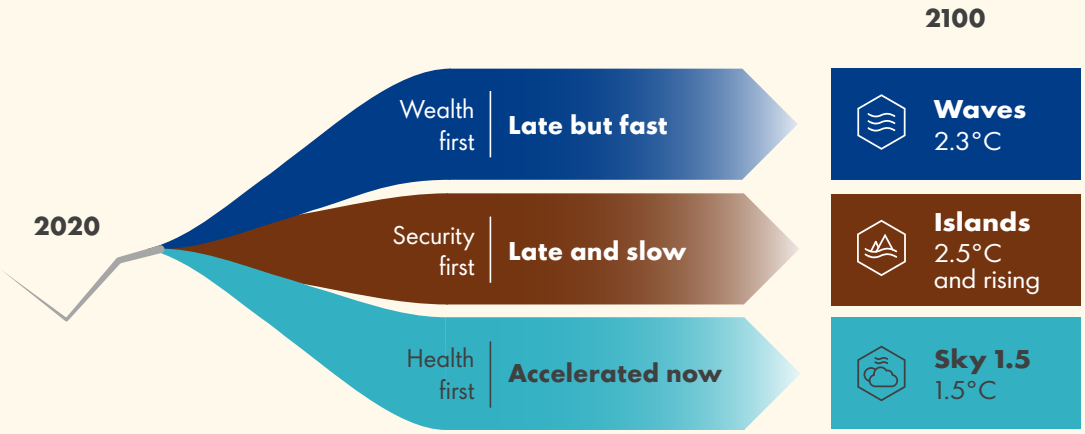
the value of alignments in addressing challenges more broadly. From an energy perspective, people learn from successful green policies and investment that support a steady economic recovery as well as emissions reduction. The USA, China and other technology-focused economies in Asia and Europe target the development and deployment of cleaner technologies as an economic goal that boosts domestic industrial and technological competitiveness. There is rapid and deep electrification of the global economy, with growth dominated by renewable resources. Global demand for coal and oil peak in the 2020s, and natural gas in the 2030s. In the economic sectors that are harder to electrify, liquid and gaseous fuels are progressively decarbonised through biofuels and hydrogen. Leading economies achieve the goal of net-zero CO_2 emissions by 2050. Globally, the world is proceeding towards achieving the stretch Paris ambition – temporarily rising above and then limiting average global warming to 1.5°C above pre-industrial levels before the end of this century – accelerated decarbonisation now.

Figure 1: Energy-related CO_2 emissions today and the key areas to be transformed



Source: Shell analysis based on 2019 data

Figure 2: Pace of decarbonisation in the three scenarios



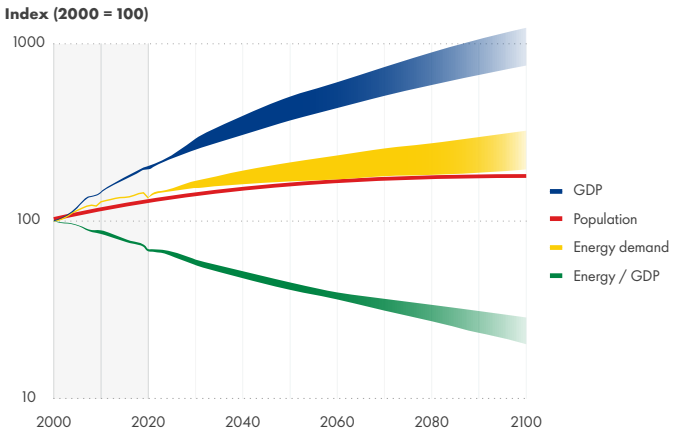
Source: Shell analysis, MIT Joint Program on Global Change

SCENARIO ENERGY LANDSCAPES: A GRAPHIC EXPLORATION

1. The world will become much more energy-efficient, but energy consumption will still grow

Structural changes and efficiency improvements will allow the global economy to grow 2-3 times more than energy demand

World trends

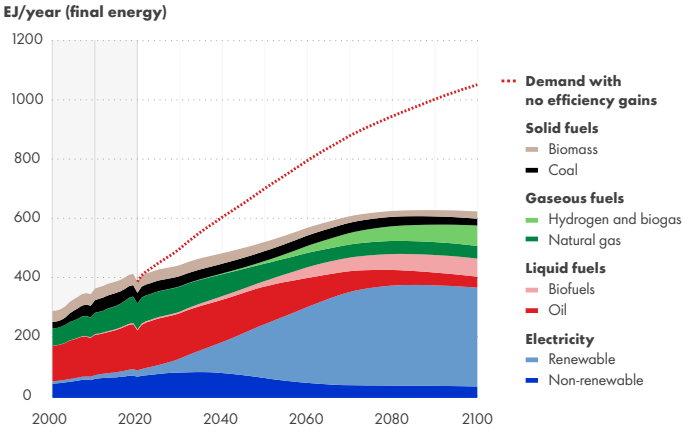


Source: Scenario ranges from Shell analysis based on data from UN Population Division (2019), US Conference Board (GDP) and the IEA (2020) World Energy Balances (**Link**), all rights reserved

2. The energy system will be decarbonised through electrification and low-carbon fuels

Electrification and decarbonisation of fuels will transform the global energy system

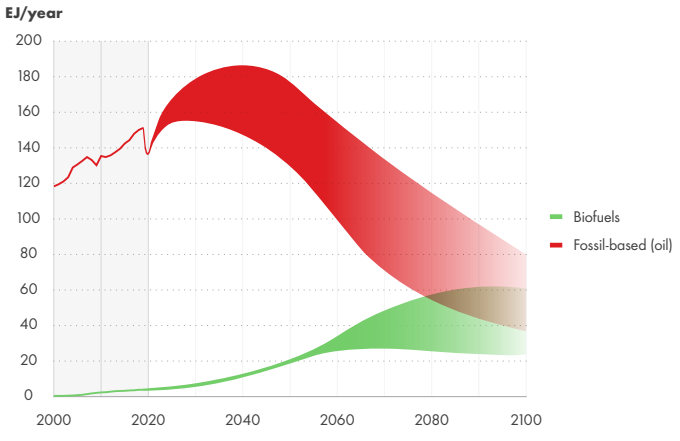
Energy use – Sky 1.5 scenario



Source: Shell analysis based on data from the IEA (2020) World Energy Balances (**Link**), all rights reserved

Consequently, oil demand will peak in the next two decades, then go into decline as it is replaced by electricity and biofuels

Liquid fuels demand

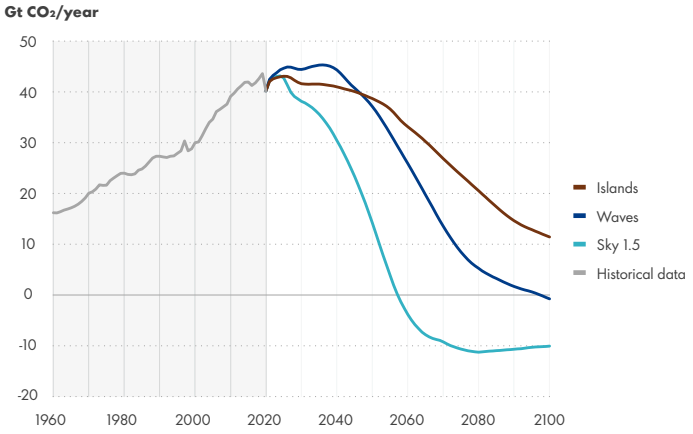


Source: Scenario ranges from Shell analysis based on data from the IEA (2020) World Energy Balances (**Link**), all rights reserved

3. CO_2 emissions can be brought under control – the issue is when

In **Sky 1.5** total CO_2 emissions reach net-zero emissions by the late-2050s, but in **Waves** and **Islands** net-zero emissions isn't reached until 2100 or beyond

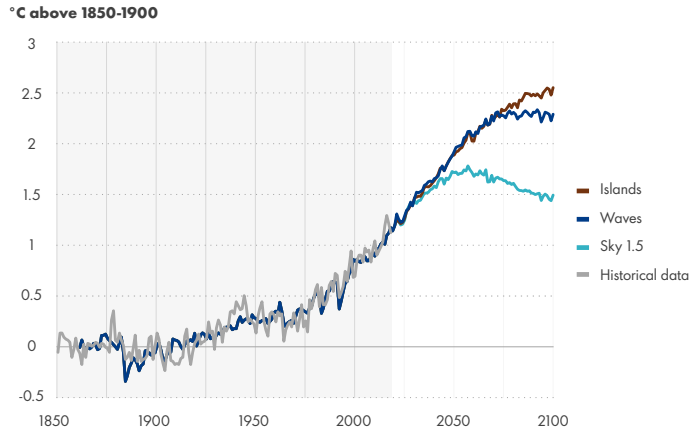
CO_2 emissions



Source: Shell analysis based on data from Global Carbon Project (2020) and the IEA (2020) World Energy Balances (**Link**), all rights reserved

The implications for global warming are significant. Temperature increases could be halted in the 2060s, but could equally continue to rise until the end of the century and beyond

World average surface temperature



Source: Shell analysis, Met Office Hadley Centre (2020) (temperature history, HadCRUT5), MIT Joint Program on Global Change (scenarios)

Sky 1.5 is ambitious, with decarbonisation milestones generally achieved 10-20 years earlier than in the other scenarios

Decarbonisation milestones

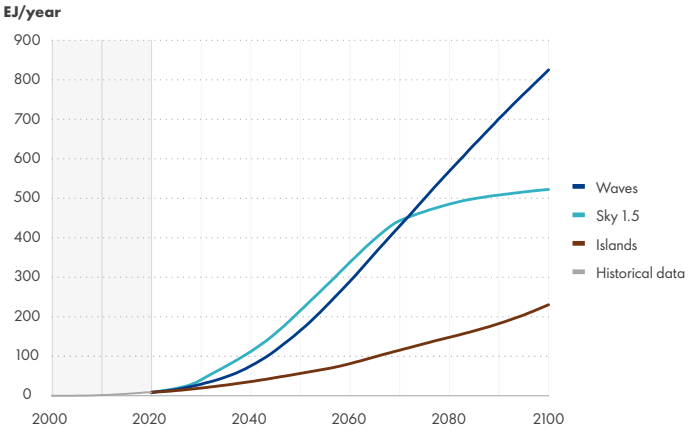
	Sky 1.5 ▼	Waves ▼	Islands ▼
Peak coal	2014	2031	2028
Peak oil	2025	2037	2037
Peak natural gas	2034	2043	2046
30% electrification of global economy	2035	2046	2066
50% electrification of global economy	2061	2080	>2100
20% of electricity from solar and wind	2029	2031	2035
50% of electricity from solar and wind	2043	2053	2068
20% of passenger vehicle km on electricity	2030	2042	2068
50% of passenger vehicle km on electricity	2046	2059	2086
10% of passenger aviation demand on hydrogen	2082	2057	>2100
20% of passenger aviation demand on hydrogen	2095	2066	>2100
50% CO_2 emissions reduction vs 2019	2046	2064	2078
Net-zero total CO_2 emissions	2058	2098	>>2100

Source: Shell analysis

4. Acceleration of renewables, biofuels and hydrogen, as well as nature-based and technological carbon removal, are necessary to meet climate aspirations

The supply of solar and wind energy varies between scenarios, but is vital to decarbonisation goals

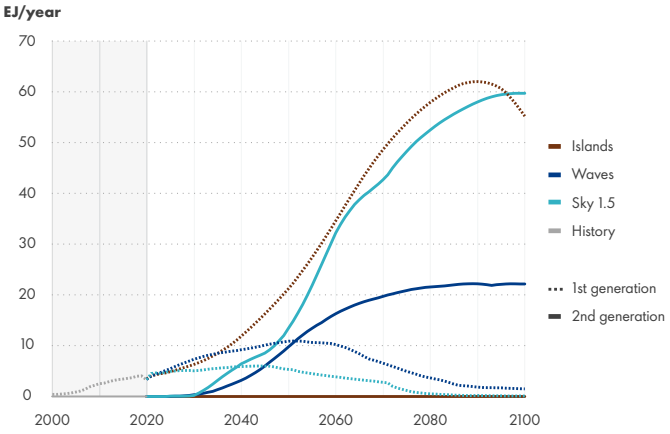
Wind and solar energy supply



Source: Shell analysis based on data from the IEA (2020) World Energy Balances (**Link**), all rights reserved

Biofuels are required to decarbonise liquid fuels

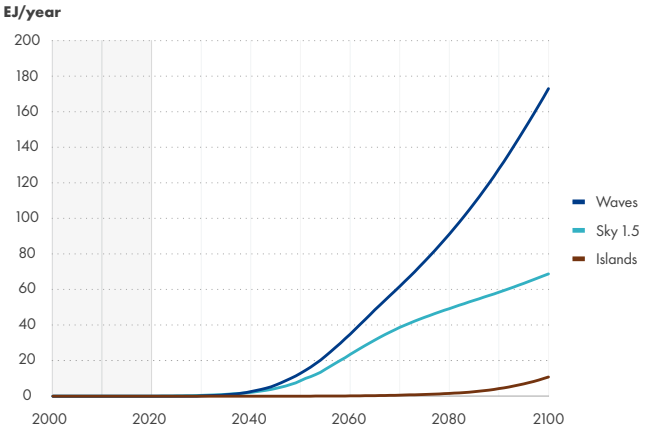
Biofuels demand



Source: Shell analysis based on data from the IEA (2020) World Energy Balances (**Link**), all rights reserved

Hydrogen could become a significant energy carrier beyond 2040 depending on policy support, alignment and timing

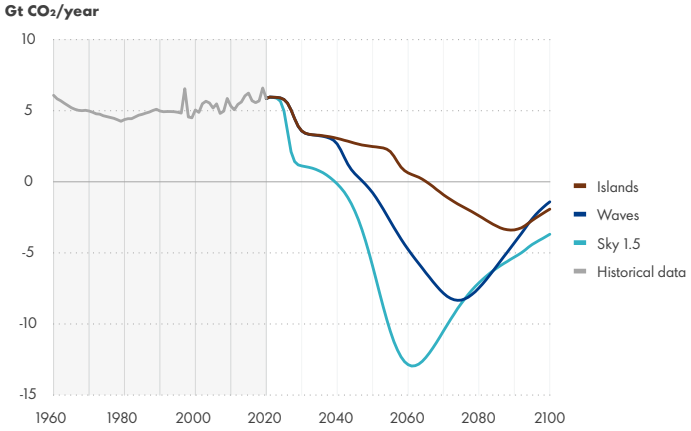
Hydrogen demand



Source: Shell analysis based on data from the IEA (2020) World Energy Balances (**Link**), all rights reserved

Natural capture of CO_2 emissions will be key to meeting the Paris goal, but differs across scenarios

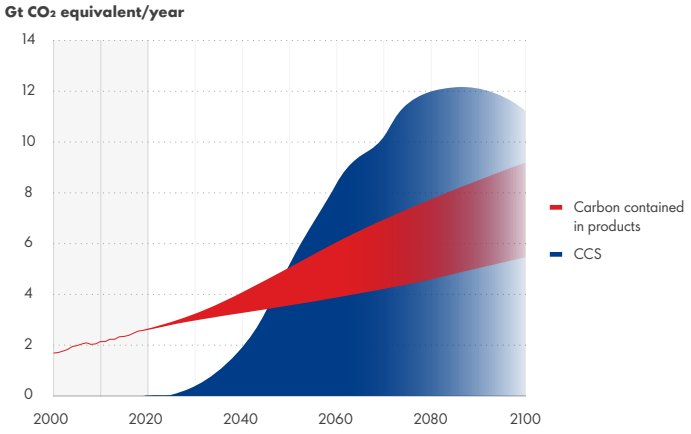
CO_2 removal using nature



Source: Shell analysis, Global Carbon Project (2020)

Removing CO_2 emissions with carbon capture and storage (CCS) will be key to meeting the Paris goal; carbon will still be required in product manufacturing, but does not contribute to emissions

CCS emissions removal and carbon in products

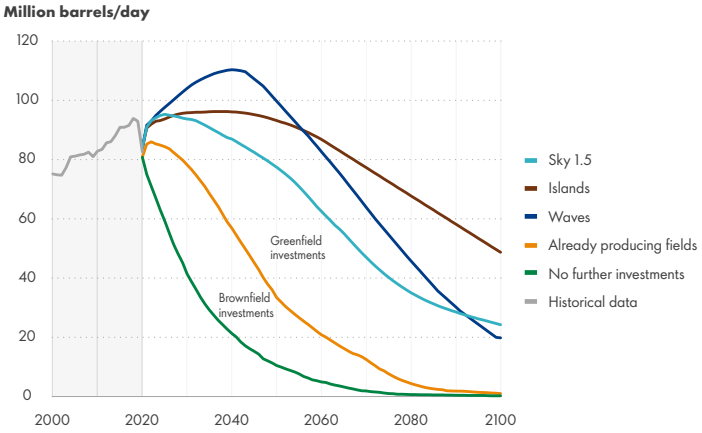


Source: Scenario ranges from Shell analysis

5. There needs to be continued investment in oil and gas supply

The future trajectory of oil consumption differs substantially across the scenarios, but investment continues to be required to offset underlying decline

Total oil* production

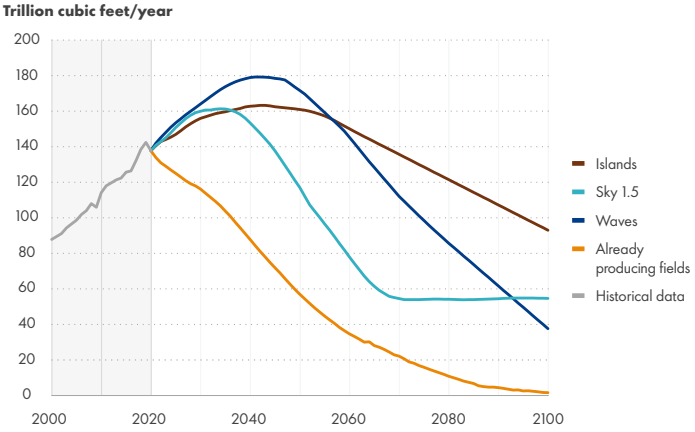


*Oil includes condensate and natural gas liquids

Source: Shell analysis based on data from Rystad Energy

Demand for natural gas is robust in the 2020s, but uncertainties grow after that

Natural gas* production



*Natural gas includes associated and non-associated gas

Source: Shell analysis based on data from Rystad Energy

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THE ENERGY TRANSFORMATION

A better life for all with a healthy planet requires a transformation of the energy system. But the world is not yet taking the necessary actions.

Simply summarised, the practical requirements for achieving this vision are:

- mass deployment of cleaner technologies;
- changes in behavioural and investment choices; and
- removing emissions that would otherwise accumulate in the atmosphere.

Action accelerators

Three powerful accelerators could push the pace of action towards the mass deployment of cleaner technologies beyond the natural or sequential evolution of market forces: alignment, smart policy and pioneer leaders.

1. Alignment – policies, sectors, governments

All sectors share the same three ways to make progress:

1. improve energy productivity by making more energy-efficient choices;
2. make changes to enable the use of lower-carbon energy products; and
3. remove or store emissions that cannot be avoided.

Alignments occur when different actors respond to common pressures. Climate pressures can lead to societal pressures, leading to political pressures, leading to commercial pressures and leading to investor pressures – and thus to emerging alignments.

2. Policy frameworks and incentives

Policies are needed to systematically address barriers to change and any lack of coordination between key players – especially in sectors that are harder to electrify and hence to abate. This requires coordination of sector-specific policies, the sequencing of these policies to create markets and generate demand for lower-carbon energy products, and time-limited financial support to make those products commercial and bring them to market. Long-term policy clarity and legal certainty, both around decarbonisation targets and the processes for monitoring and ensuring progress towards those targets, will help to incentivise the large upfront capital investment needed. Achieving climate neutrality will require policy frameworks that are:

- comprehensive and economy-wide;
- coherent within and across sectors; and
- credible and predictable over time.

3. Pioneer leaders

Establishing successful coalitions that reach beyond national borders requires pioneer governments, businesses, cities and civic groups to lead the way and encourage others to join.

Developed and developing nations will be expected to have different climate targets and to progress along the pathways to net-zero emissions at different rates – but there can be pioneer leaders among both types of nations.

> “The costs of transition at the macro level, which are manageable, do not hold back progress in energy transitions. It is the distribution of the costs... that can be a barrier.”

CONCLUSION: CRISIS AS AN OPPORTUNITY

A deadly pandemic, deeply disrupted economies globally and climate change – the need for transformative resilience has never been greater. This current crisis offers the opportunity to arouse the sense of urgency the world needs to catalyse action across a broad front.

Because almost everyone will benefit from reducing the impacts and risks of increasing global climate change, the type of developments described in **Sky 1.5** are likely to be in the interests of most people. Everyone makes choices – global society can pursue transformative resilience more broadly and influence which type of pathway the world will face. The required pace of change to meet the stretched goal of the Paris Agreement is extremely challenging, but technically and economically feasible if action accelerates decisively. History has shown that crises can galvanise people into action. The future health of the planet requires that societies grasp that challenge right now.

> Global societies may need to be prepared for any of the scenarios with a focus on their own resilience, but no one can be a passive spectator.

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Shell's scenarios are not intended to be projections or forecasts of the future. Shell's scenarios, including the scenarios contained in this report, are not Shell's strategy or business plan. When developing Shell's strategy, our scenarios are one of many variables that we consider. Ultimately, whether society meets its goals to decarbonise is not within Shell's control. While we intend to travel this journey in step with society, only governments can create the framework for success. The **Sky 1.5** scenario starts with data from Shell's **Sky** scenario, but there are important updates. First, the outlook uses the most recent modelling for the impact and recovery from COVID-19 consistent with a **Sky 1.5** scenario narrative. Second, it blends this projection into existing **Sky** (2018) energy system data by around 2030. Third, the extensive scale-up of nature-based solutions is brought into the core scenario, which benefits from extensive new modelling of that scale-up. (In 2018, nature-based solutions required to achieve 1.5°C above pre-industrial levels by the end of this century were analysed as a sensitivity to **Sky**. This analysis was also reviewed and included in the IPCC Special Report on Global Warming of 1.5°C (SR15).) Fourth, our new oil and natural gas supply modelling, with an outlook consistent with the **Sky 1.5** narrative and demand, is presented for the first time. Fifth, the **Sky 1.5** scenario draws on the latest historical data and estimates to 2020 from various sources, particularly the extensive International Energy Agency energy statistics. As with **Sky**, this scenario assumes that society achieves the 1.5°C stretch goal of the Paris Agreement. It is rooted in stretching but realistic development dynamics today, but explores a goal-oriented way to achieve that ambition. We worked back in designing how this could occur, considering the realities of the situation today and taking into account realistic timescales for change. Of course, there is a range of possible paths in detail that society could take to achieve this goal. Although achieving the goal of the Paris Agreement and the future depicted in **Sky 1.5** while maintaining a growing global economy will be extremely challenging, today it is still a technically possible path. However, we believe the window for success is quickly closing.

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ENDNOTES

1. Shell scenarios, including these scenarios, are not the Shell strategy or business plan. When developing Shell's strategy, our scenarios are one variable among many that we consider. Ultimately, whether society meets its goals to decarbonise is not within Shell's control.

2. A Better Life with a Healthy Planet, Shell, 2016: **Link.**

3. **Sky** scenario, Shell, 2018: **Link.**

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