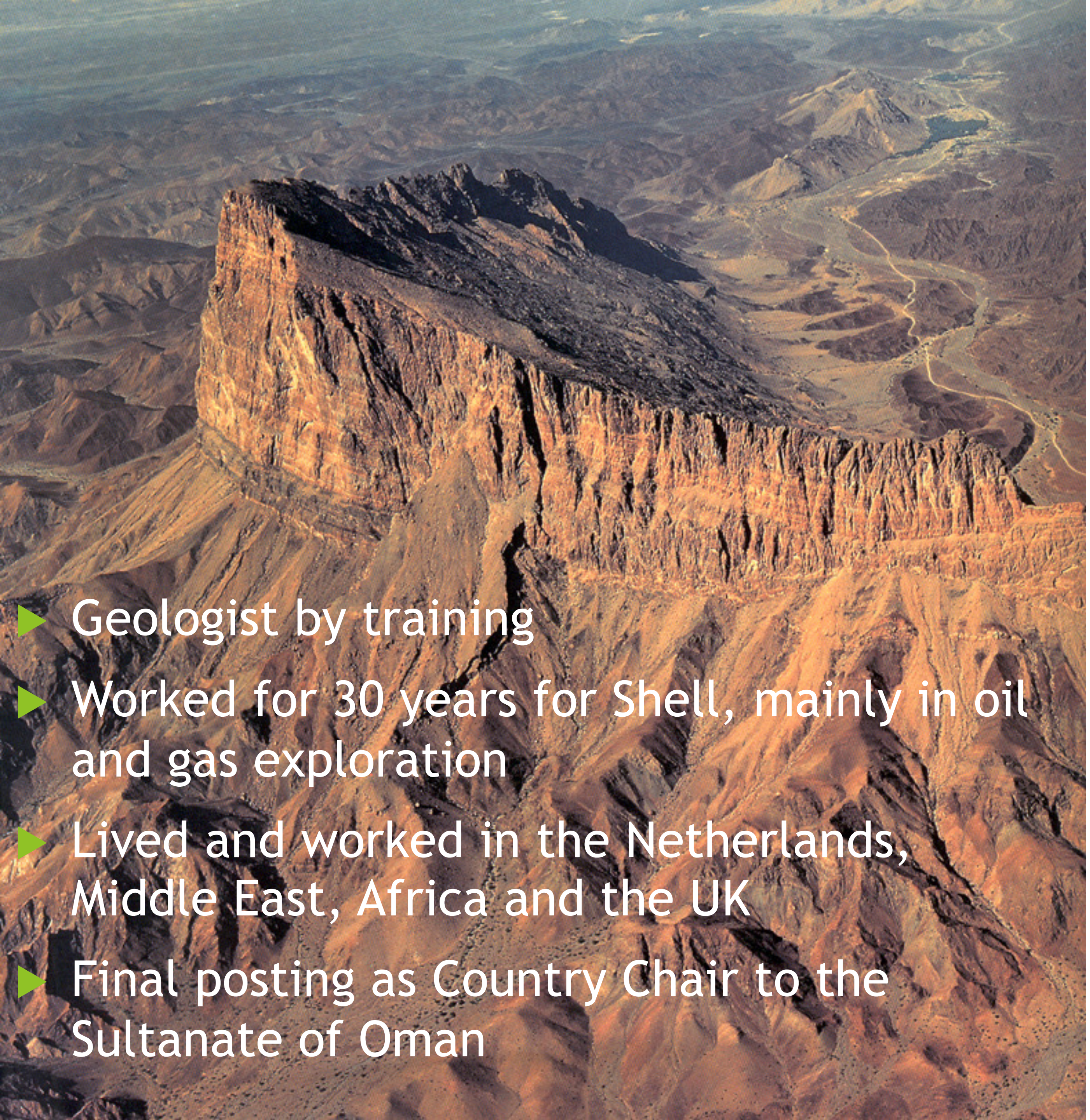
Is there still a place for fossil fuels in a zero-carbon world?

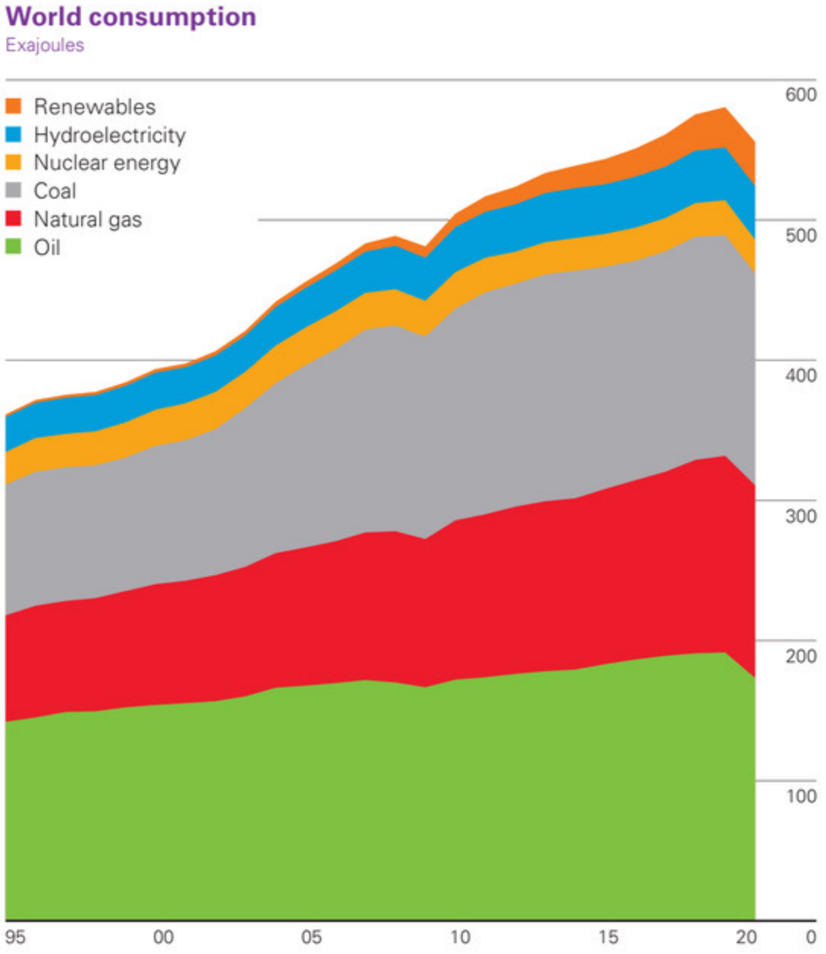
Dr Andrew Wood

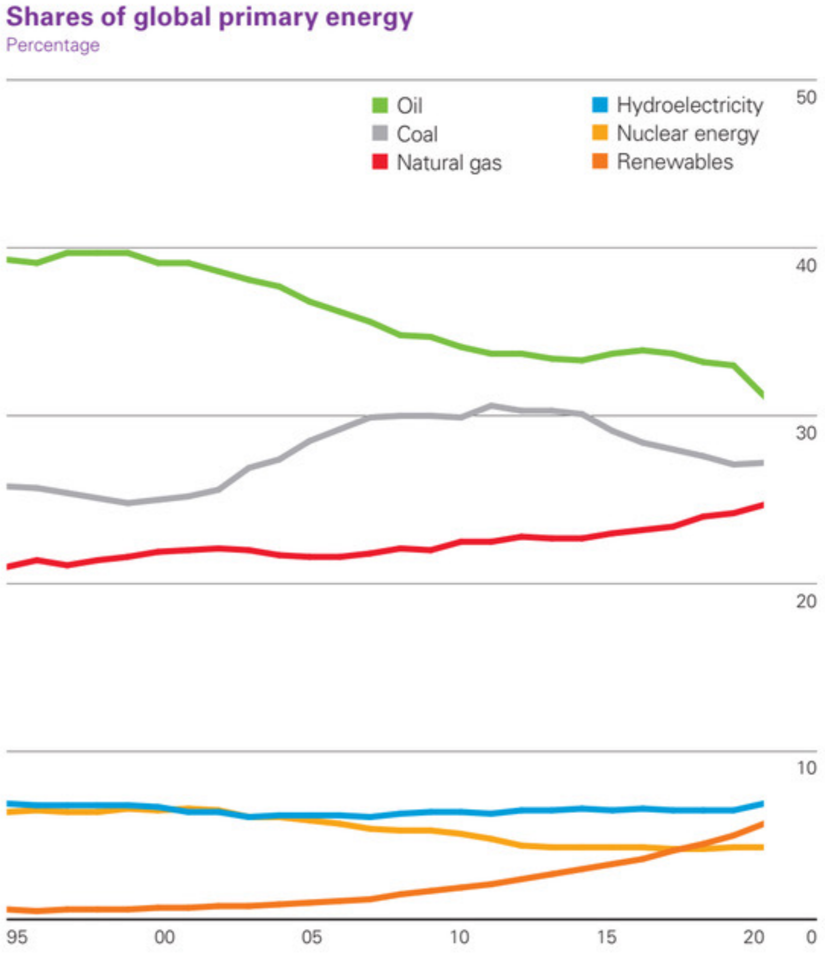
My background



- Geologist by training
- Worked for 30 years for Shell, mainly in oil and gas exploration
- Lived and worked in the Netherlands, Middle East, Africa and the UK
- Final posting as Country Chair to the Sultanate of Oman

How much of our energy currently comes from fossil fuels?



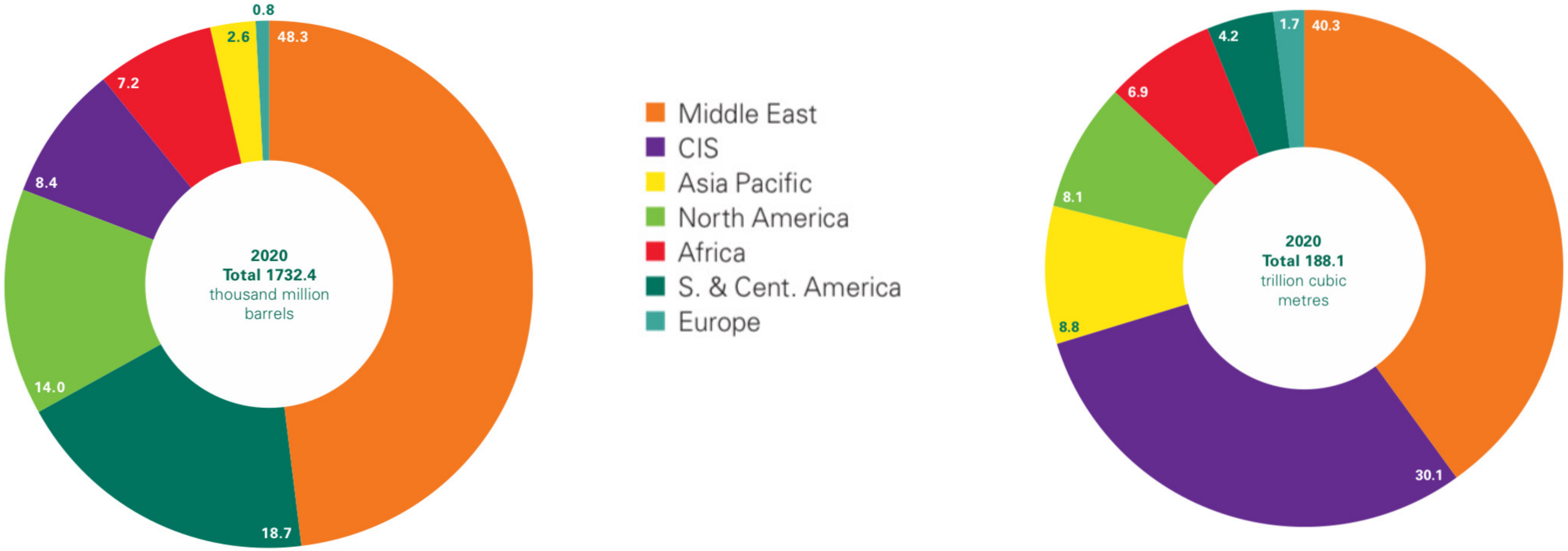


Source: BP Statistical Review of World Energy 2021

Where are the world's remaining proven oil and gas reserves located?

Oil

Gas

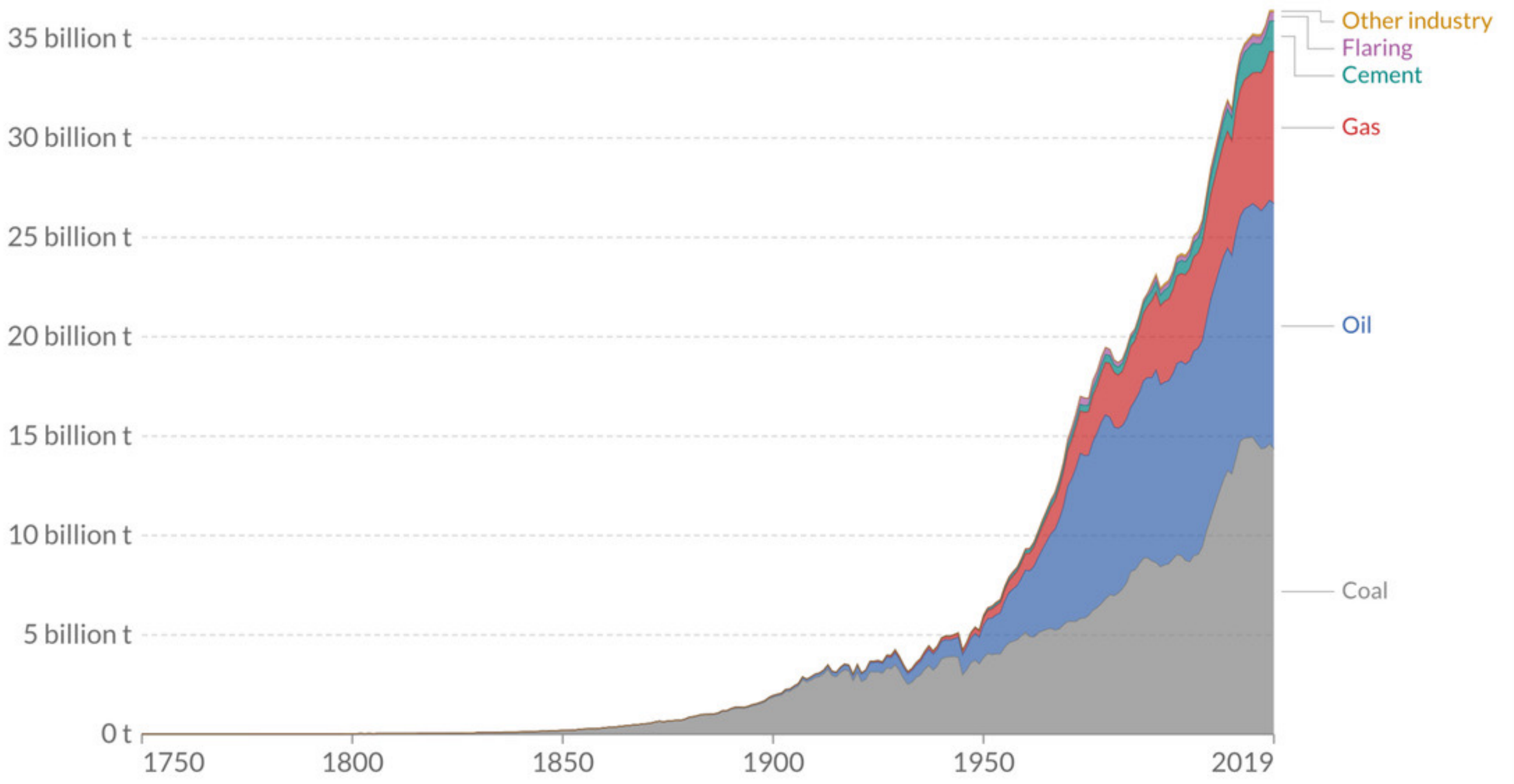


47 years

52 years

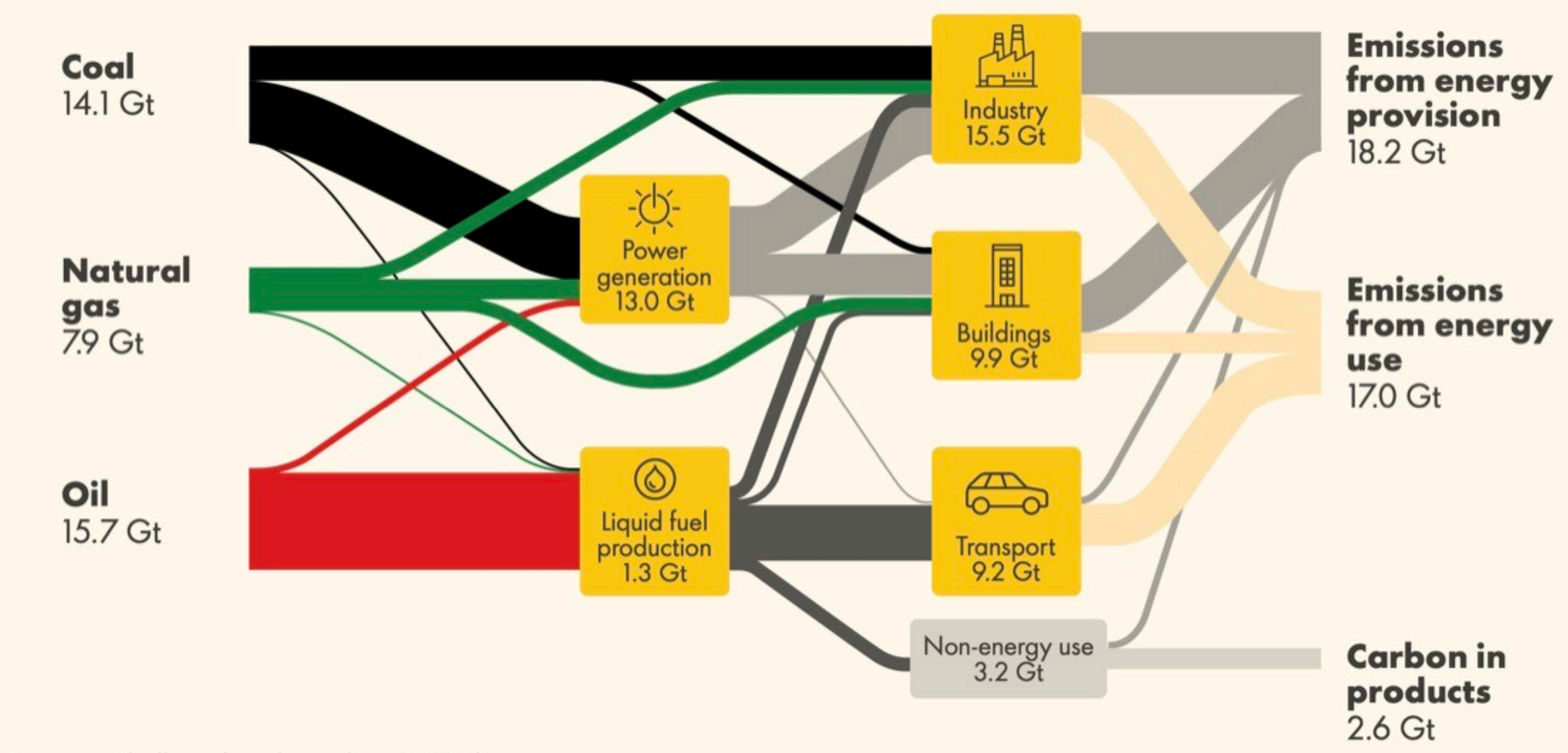
'The Stone Age did not end for a lack of stones'

Historic CO2 emissions by fuel type



Source: Our World in Data

CO_2 emissions by sector



Source: Shell analysis based on 2019 data

Possible scenarios for how the future might look like

WAVES

THE 2020s – *WEALTH* FIRST

ISLANDS

THE 2020s – *SECURITY* FIRST

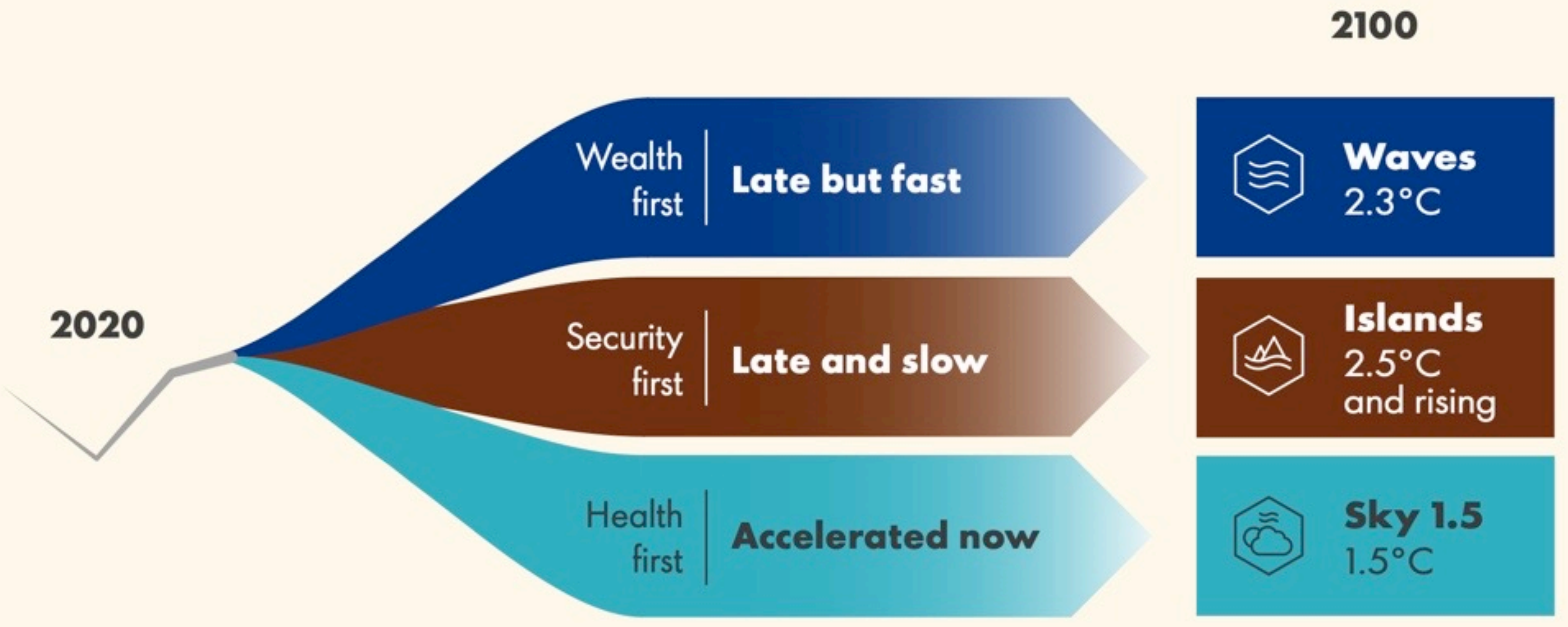
SKY 1.5

THE 2020s – *HEALTH* FIRST

Source: Shell Energy Transformation Scenarios 2021

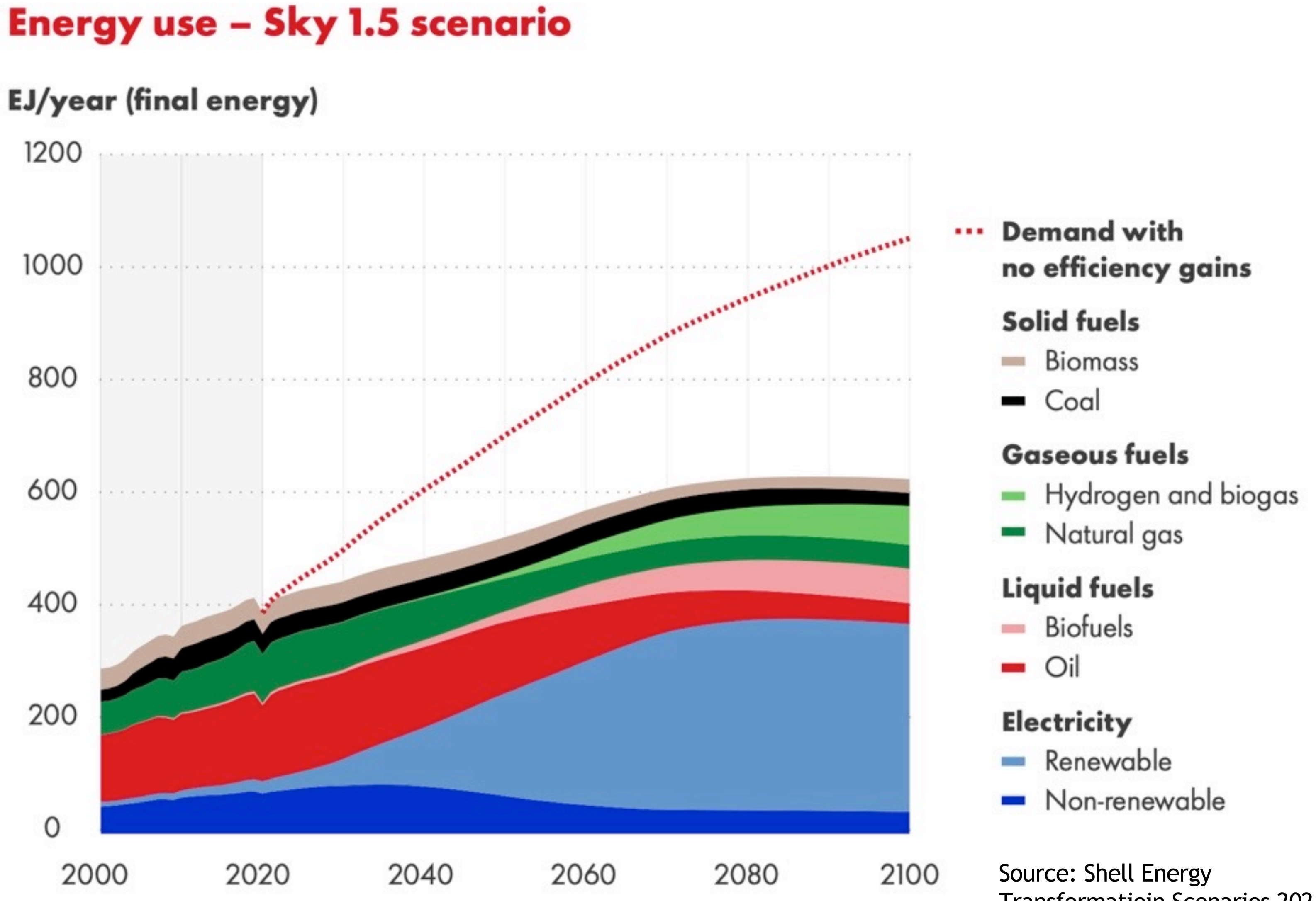
"Prediction is very difficult, especially if it's about the future" – Neils Bohr

Pace of decarbonisation



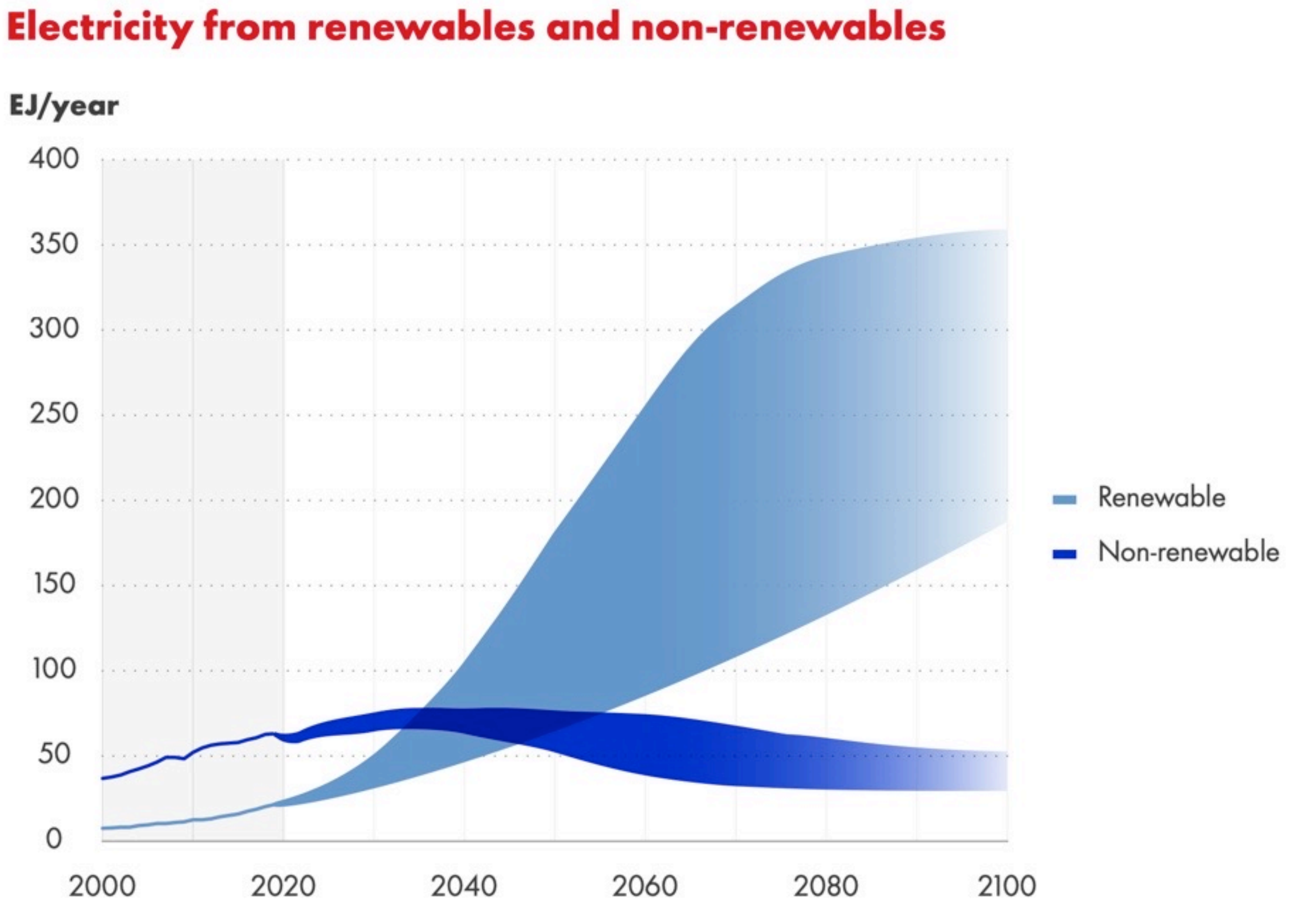
Source: Shell Energy Transformation Scenarios 2021

Electrification and decarbonisation of fuels will transform the global energy system



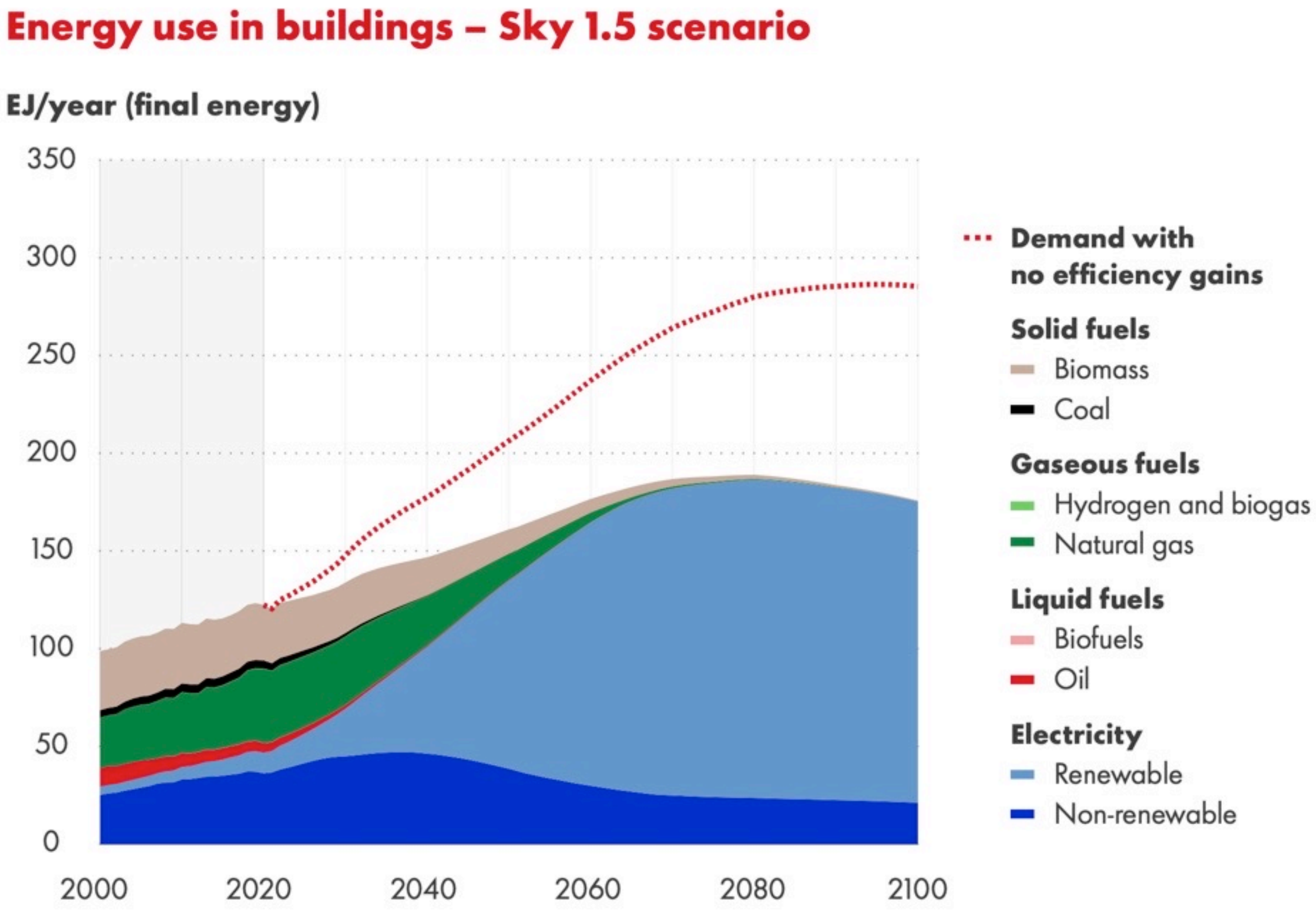
Source: Shell Energy Transformatioin Scenarios 2021

Renewable electricity demand will grow rapidly in all scenarios, increasing power generation by up to four times by 2100



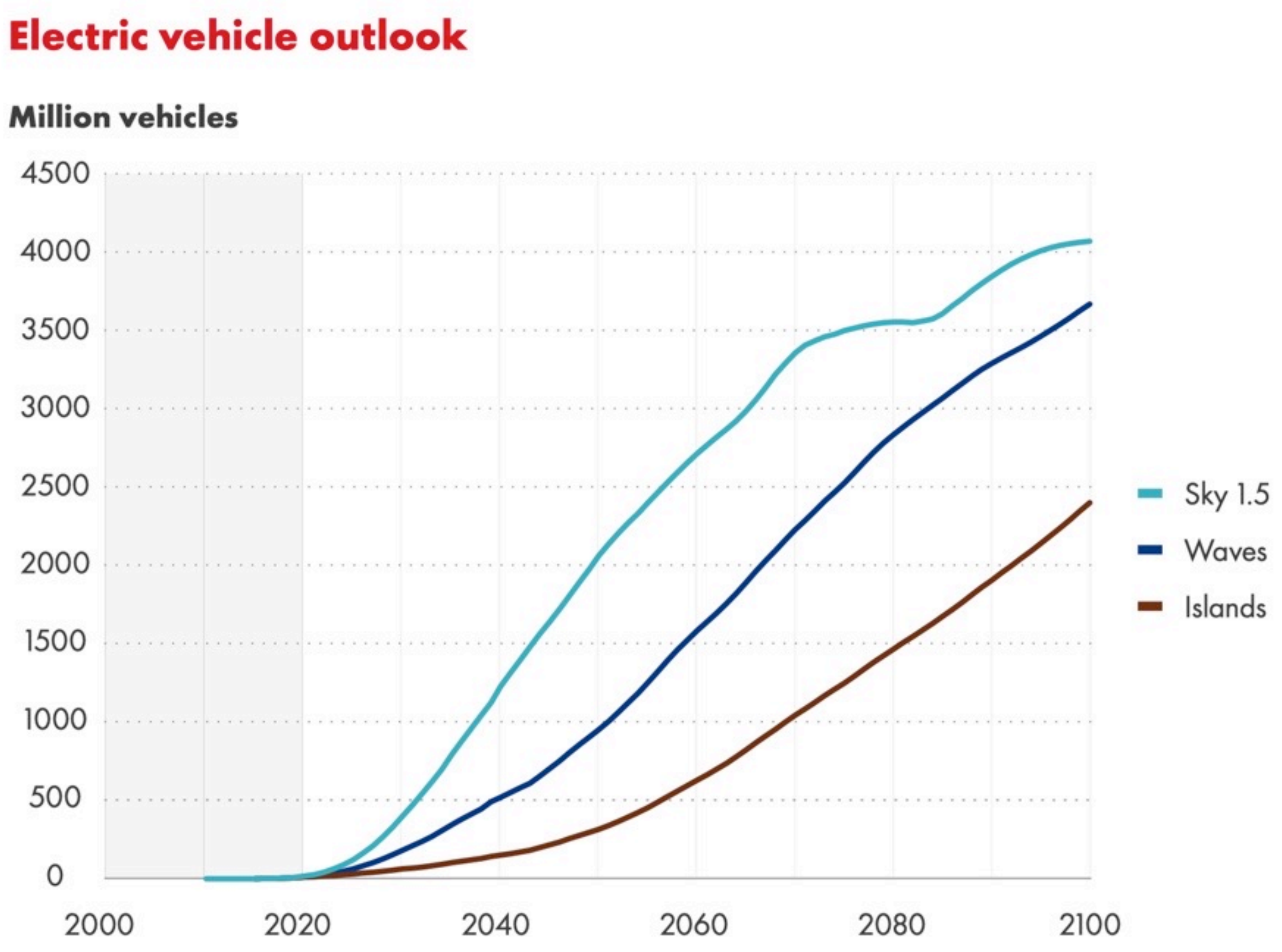
Source: Scenario ranges from Shell analysis based on data from the IEA (2020) World Energy Balances (Link), all rights reserved

Buildings are expected to be largely electrified by the 2060s



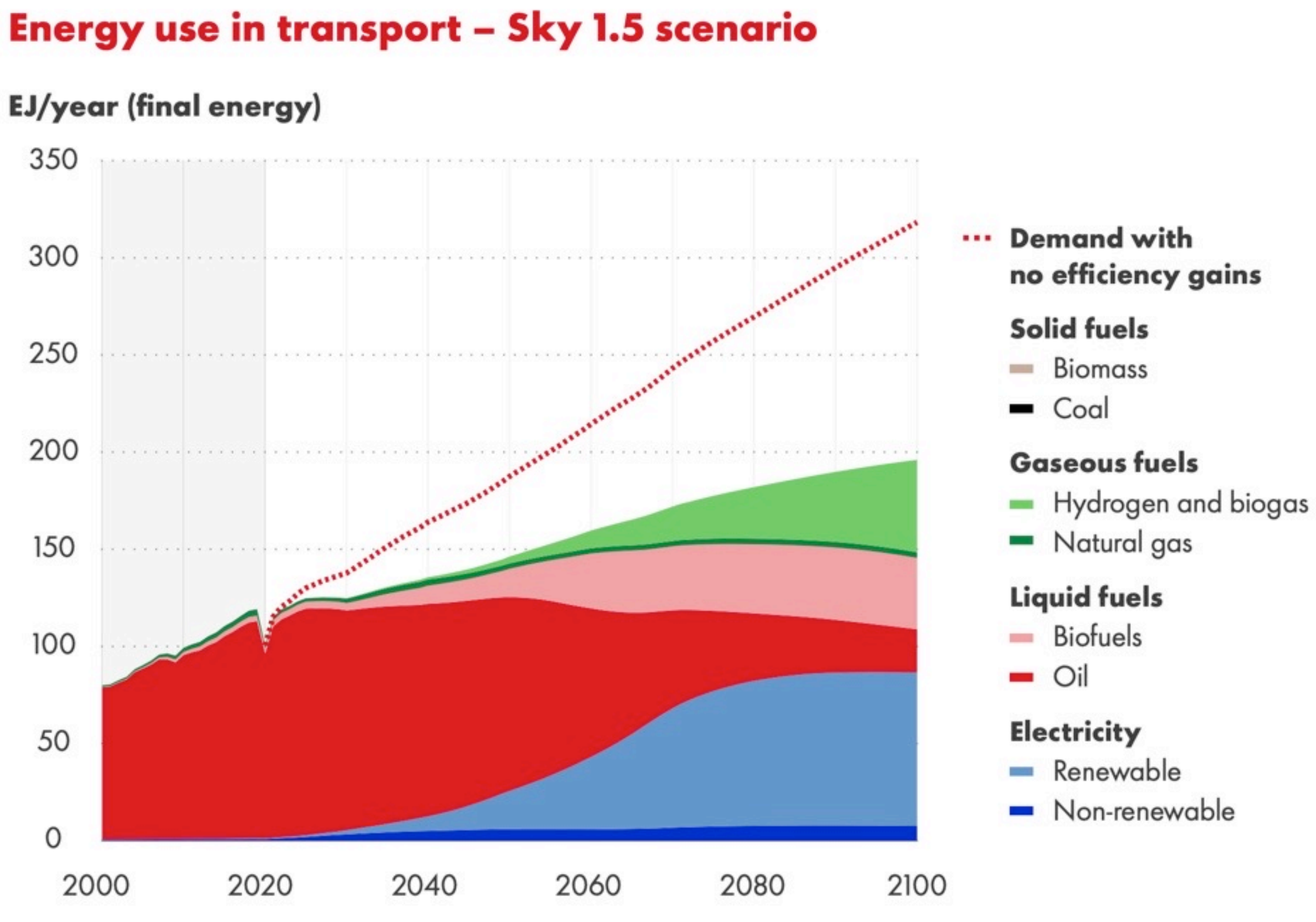
Source: Shell analysis based on data from the IEA (2020) World Energy Balances (Link), all rights reserved

The rise of electric vehicles is vital to decarbonising road transport



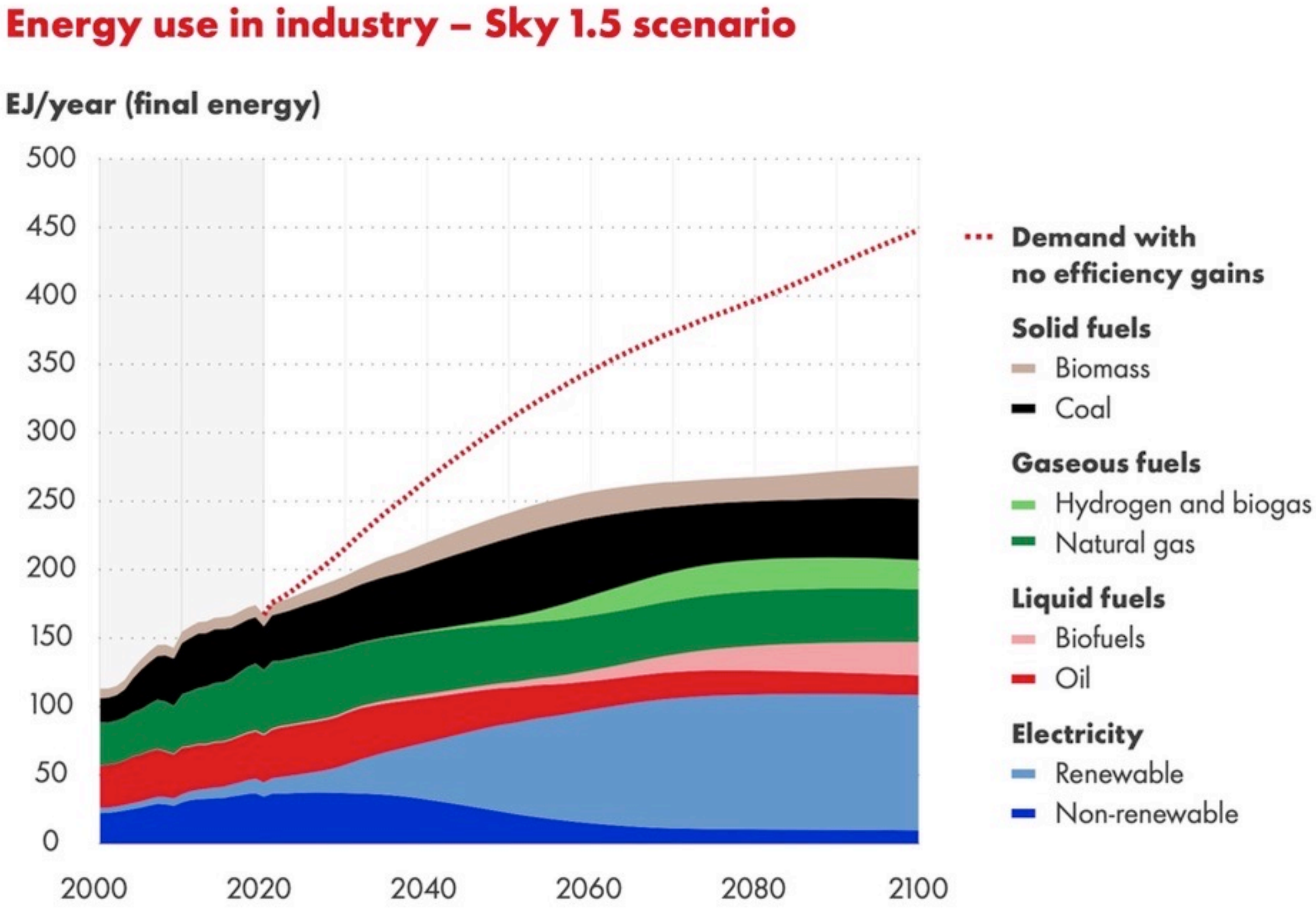
Source: Shell analysis based on data from the IEA (2020) World Energy Balances (Link) and Global EV Outlook (Link), all rights reserved

Light-duty vehicles will electrify, but heavy-freight, aviation and marine sectors will need increasingly decarbonised gaseous and liquid fuels



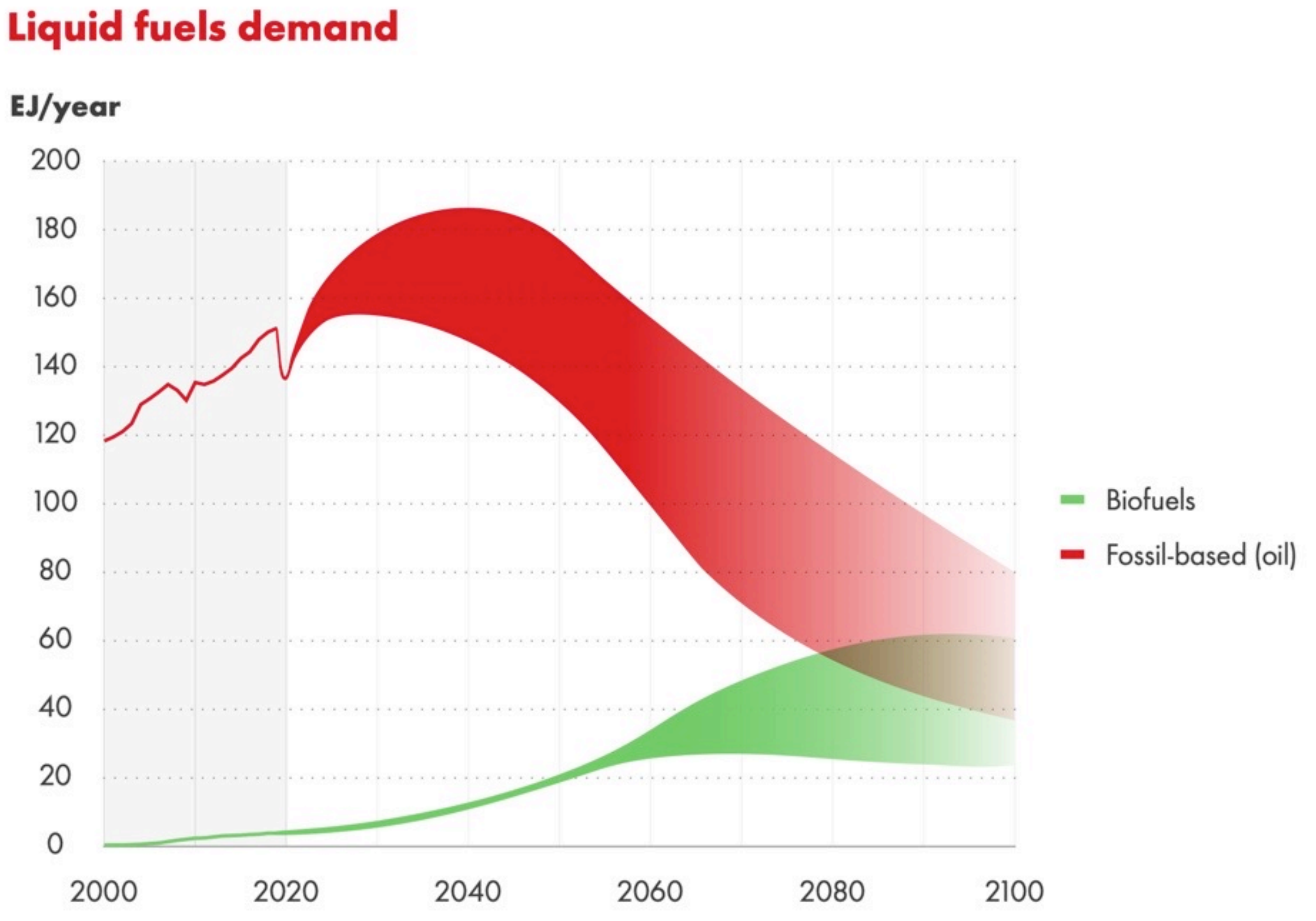
Source: Shell analysis based on data from the IEA (2020) World Energy Balances (Link), all rights reserved

In industry significant electrification is possible, but molecular fuels and feedstocks will still be needed



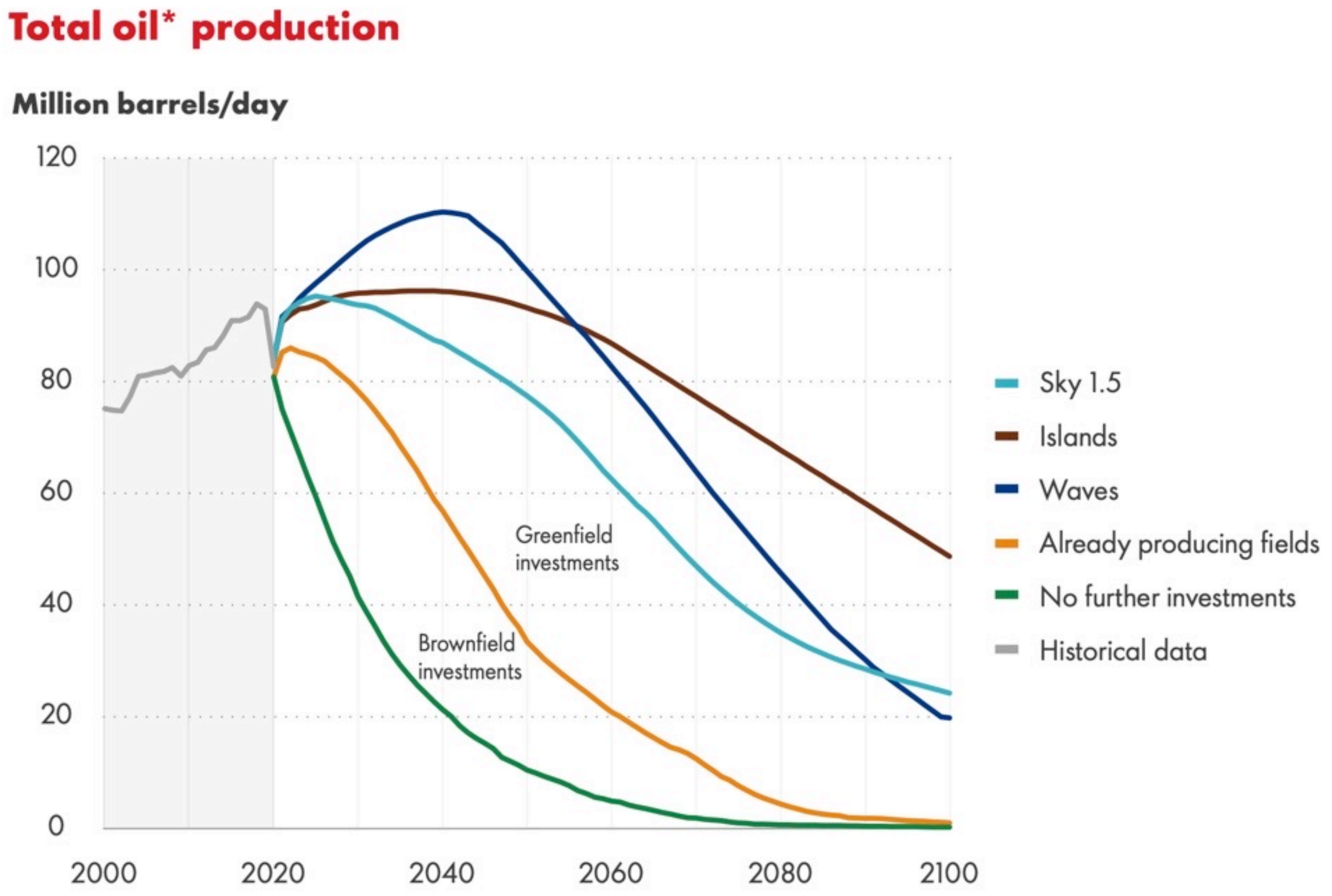
Source: Shell analysis based on data from the IEA (2020) World Energy Balances (Link),

Oil demand will peak in the next two decades, then decline as it is replaced by electricity and biofuels



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

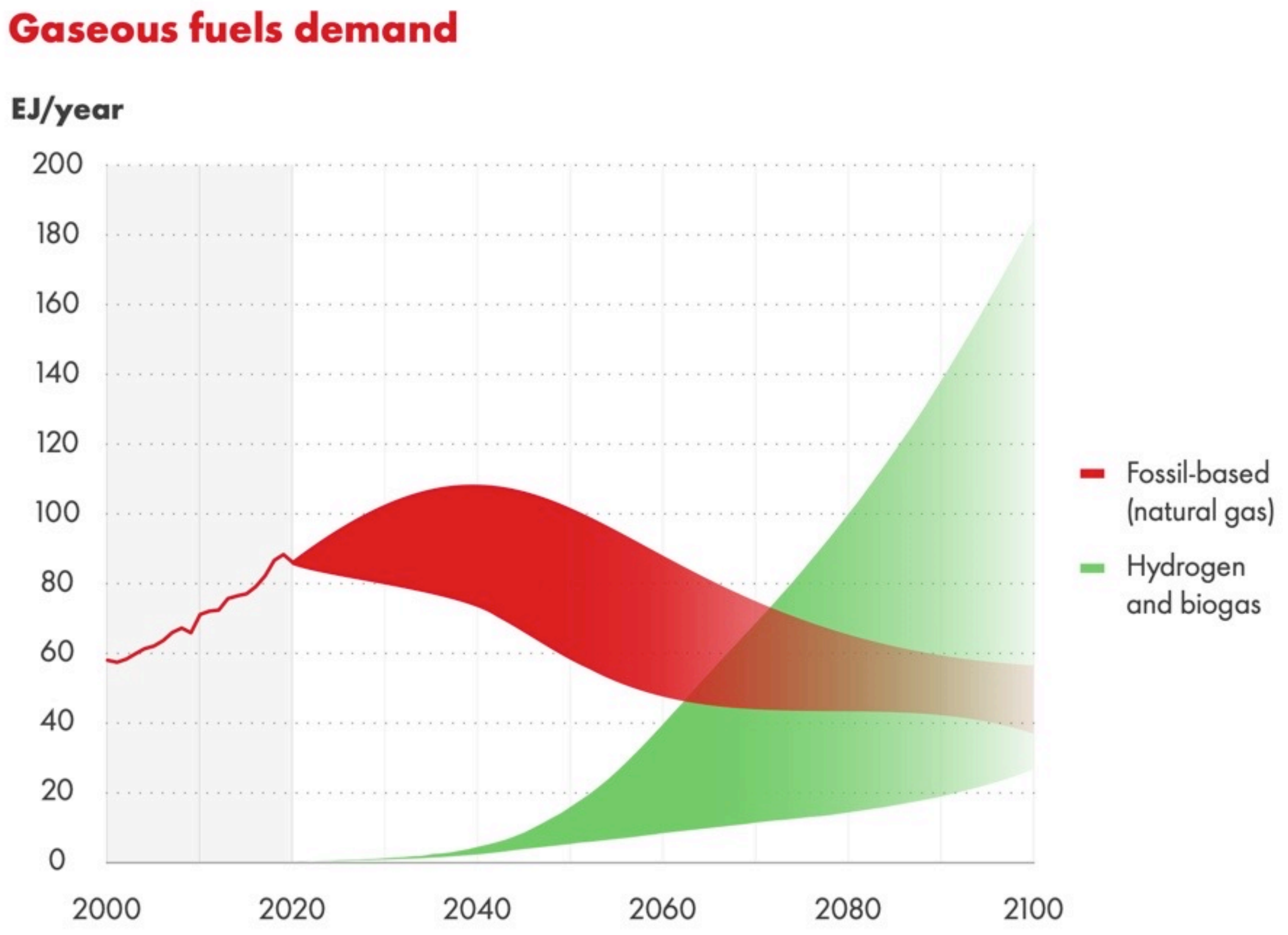
Investment in oil production will continue to be required to offset underlying decline



Source: Shell analysis based on data from Rystad Energy

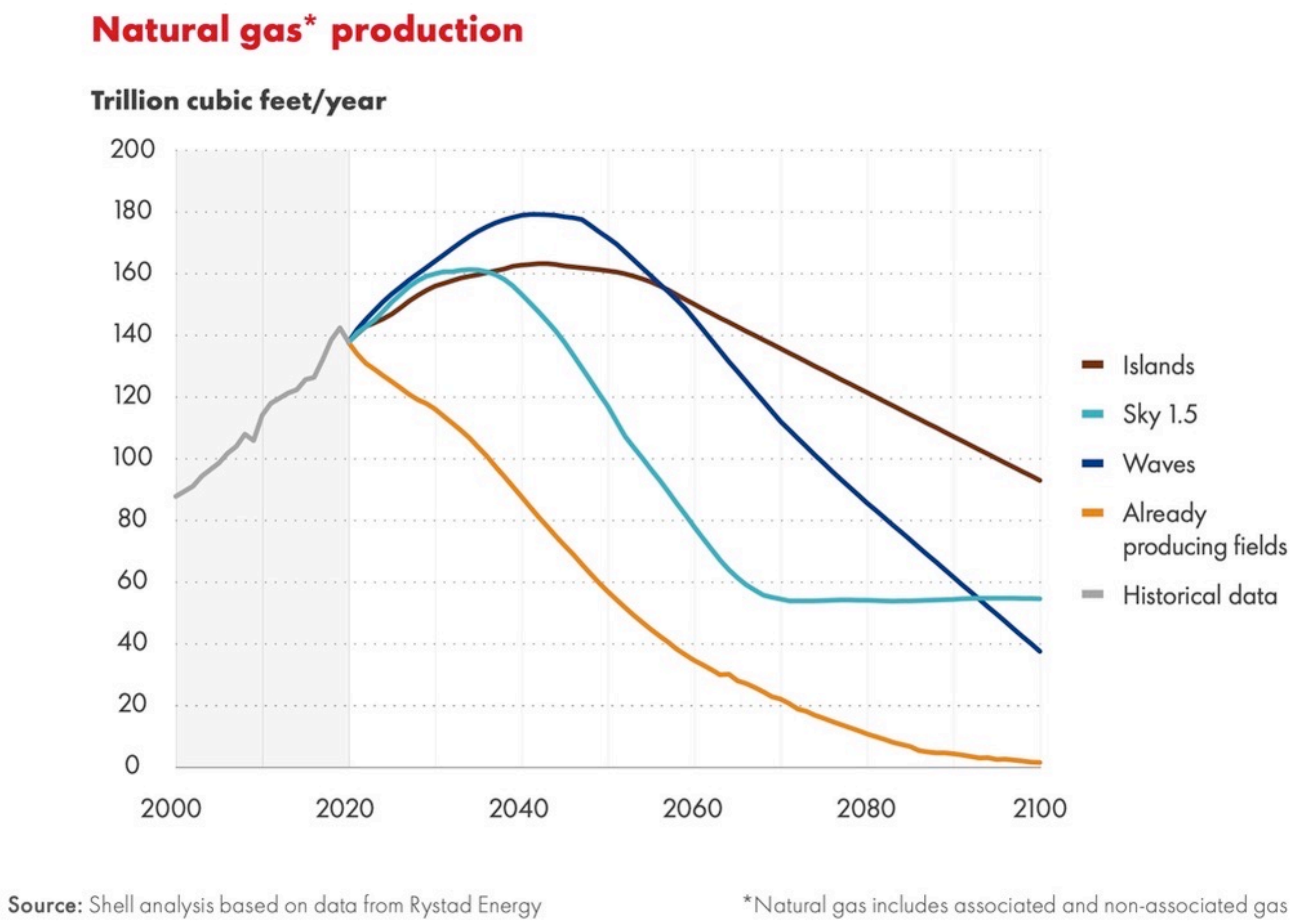
*Oil includes condensate and natural gas liquids

Gaseous fuels will remain important for longer as they are decarbonised with hydrogen and biomethane

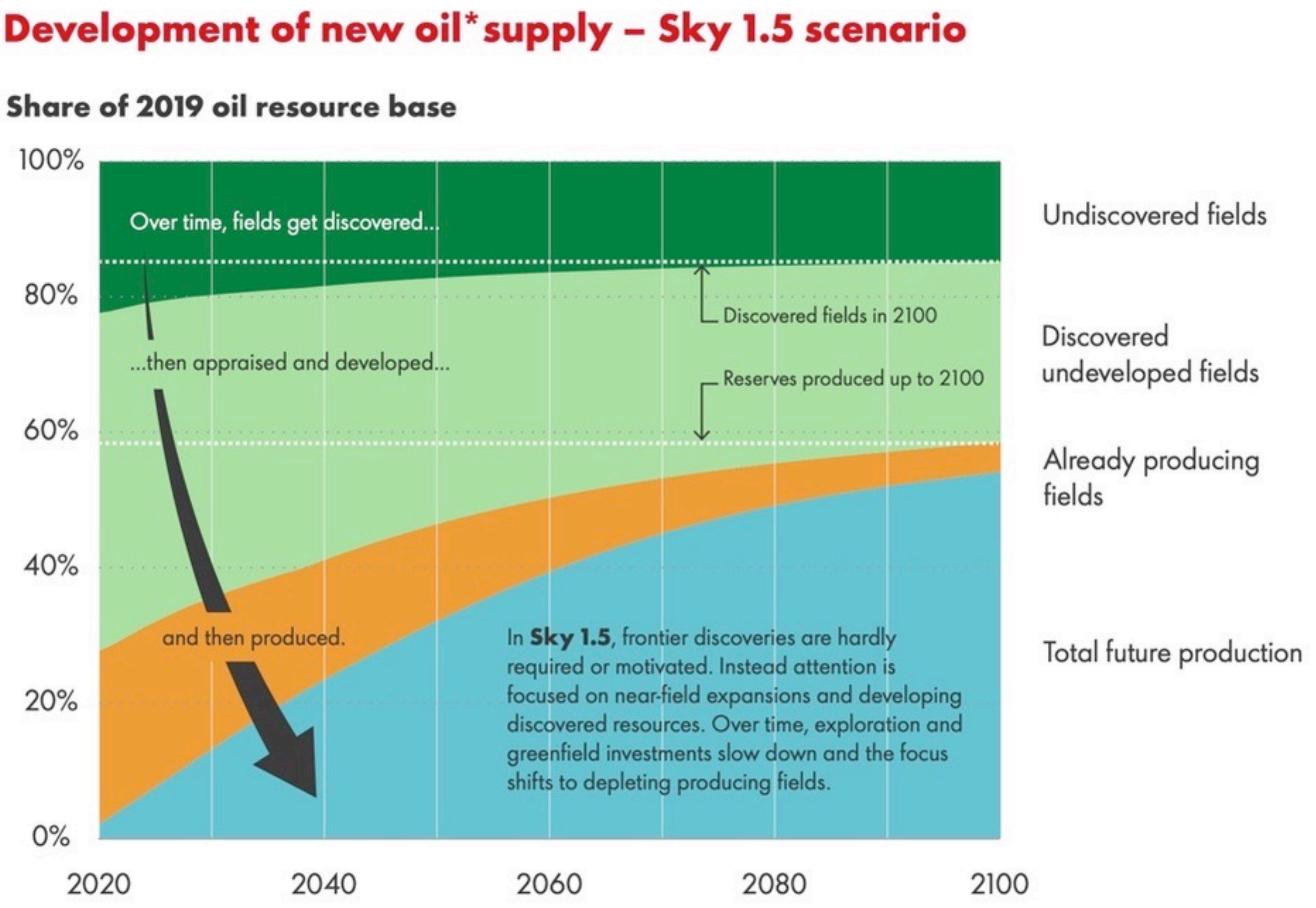


Source: Scenario ranges from Shell analysis based on data from the IEA (2020) World Energy Balances (**Link**), all rights reserved

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



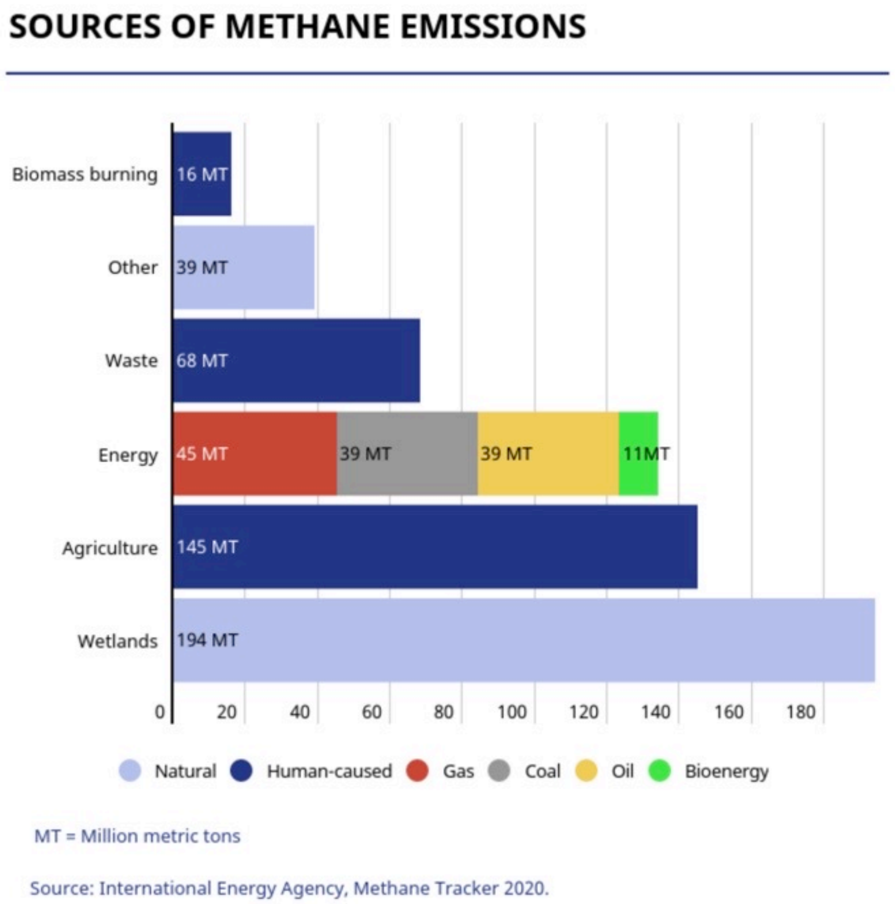
Upstream activity will shift away from exploration to appraising and developing already discovered fields

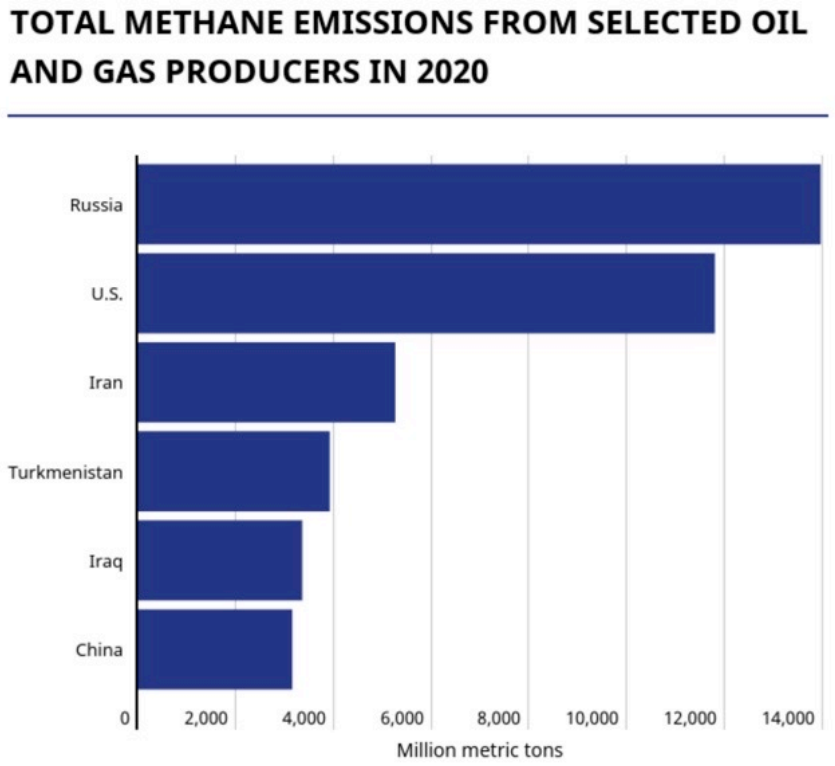


Source: Shell analysis based on data from Rystad Energy

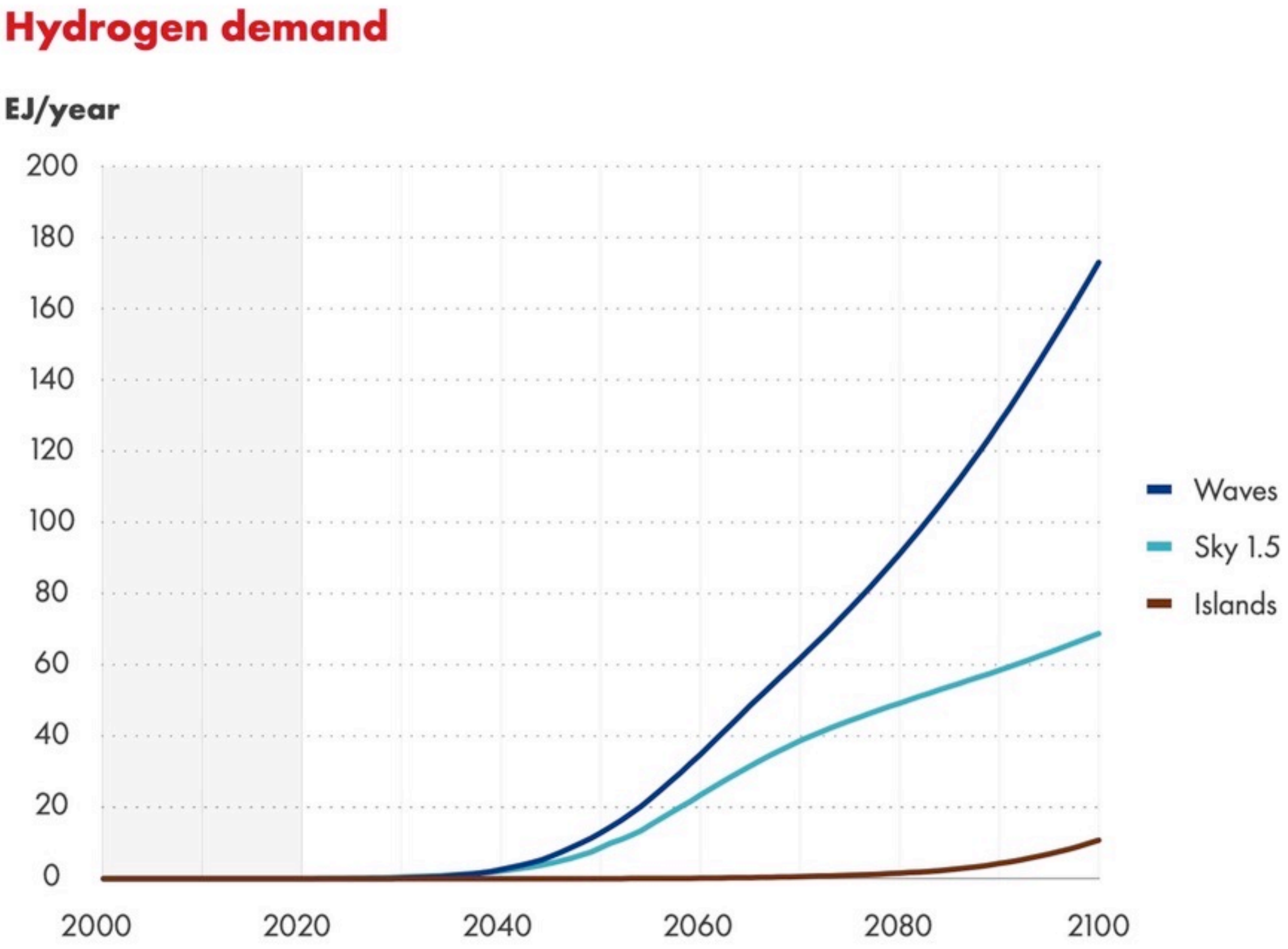
*Oil includes condensate and natural gas liquids

Methane


SOURCES OF METHANE EMISSIONS
Biomass burning
16 MT
Other
39 MT
Waste
68 MT
Energy
45 MT
39 MT
39 MT
11MT
Agriculture
145 MT
Wetlands
194 MT
0
20
40
60
80
100
120
140
160
180
Natural
Human-caused
Gas
Coal
Oil
Bioenergy
MT = Million metric tons
Source: International Energy Agency, Methane Tracker 2020.


TOTAL METHANE EMISSIONS FROM SELECTED OIL AND GAS PRODUCERS IN 2020
Russia
U.S.
Iran
Turkmenistan
Iraq
China
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
Million metric tons

Hydrogen could become a significant energy carrier beyond 2040

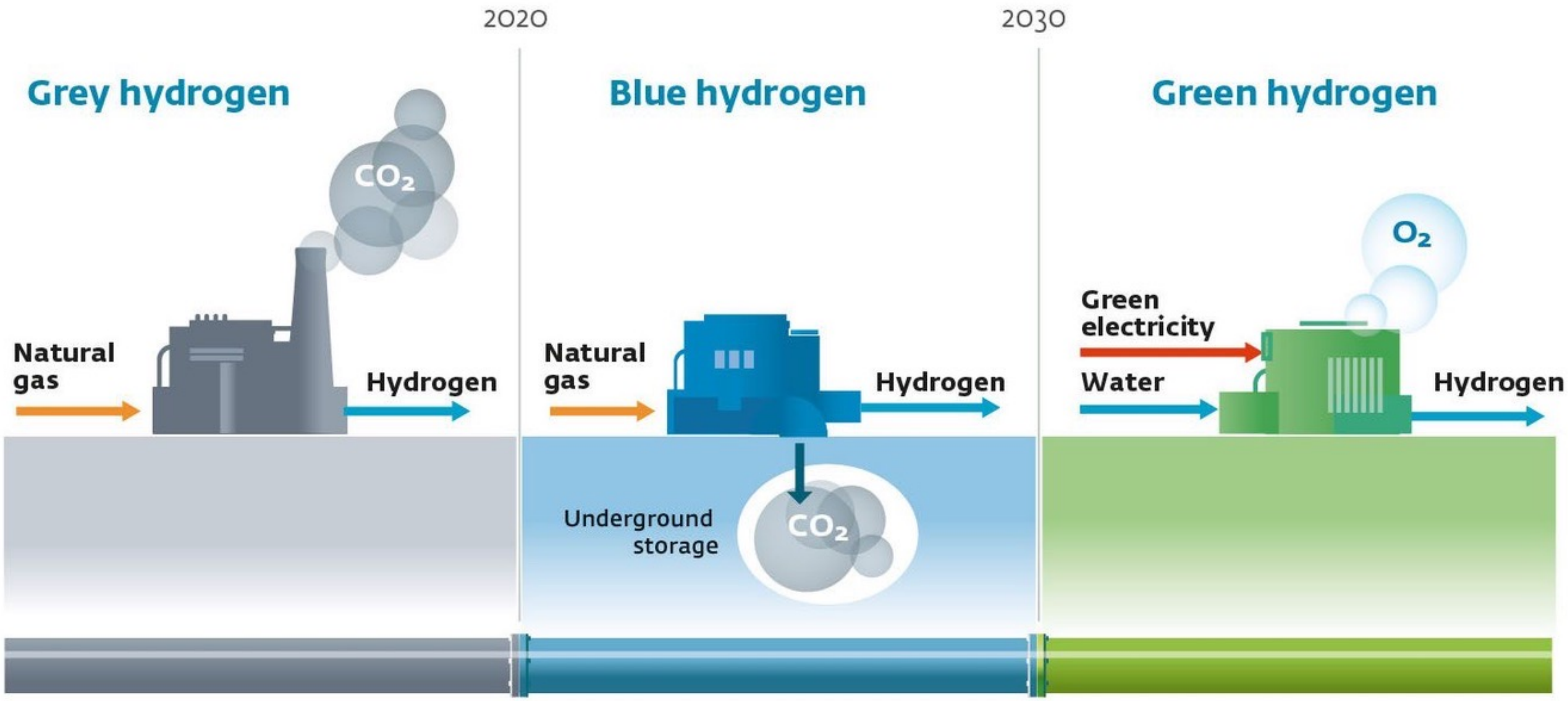


Source: Shell analysis based on data from the IEA (2020) World Energy Balances (**Link**),

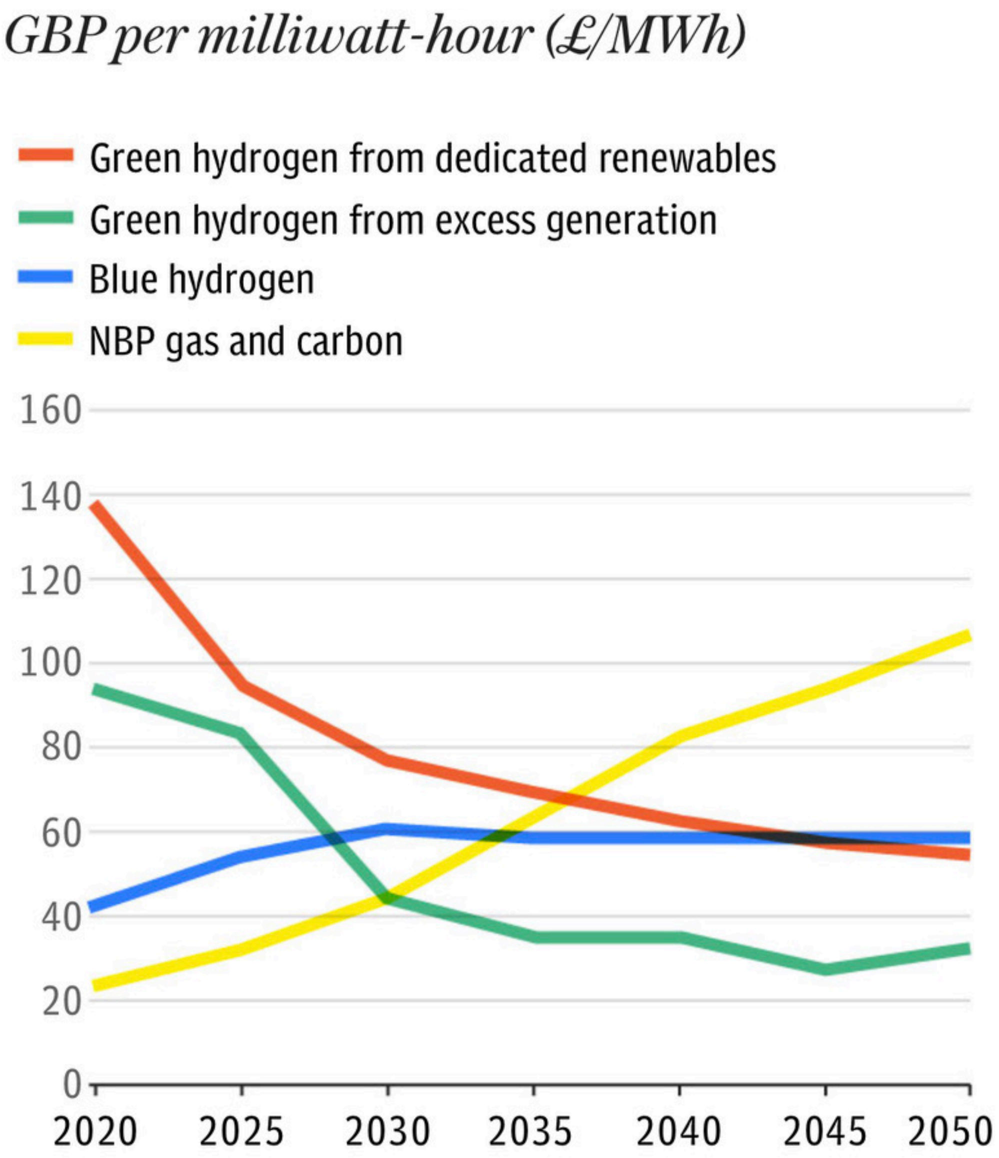
Pros and cons of hydrogen

- Hydrogen best thought of as an energy carrier and means of storage
- It is flammable and bulky
- Converting primary energy into hydrogen and then hydrogen into power leads to waste
- Less suited to light vehicles than batteries
- Opportunities for switching home heating from gas to hydrogen limited
- Best suited to niches;
  - Complex chemical and high temperature processes hard to achieve with electricity (e.g. steel, cement)
  - Commercial transport (HGVs, trains, shipping and aviation)
  - Storage medium for peak-shaving

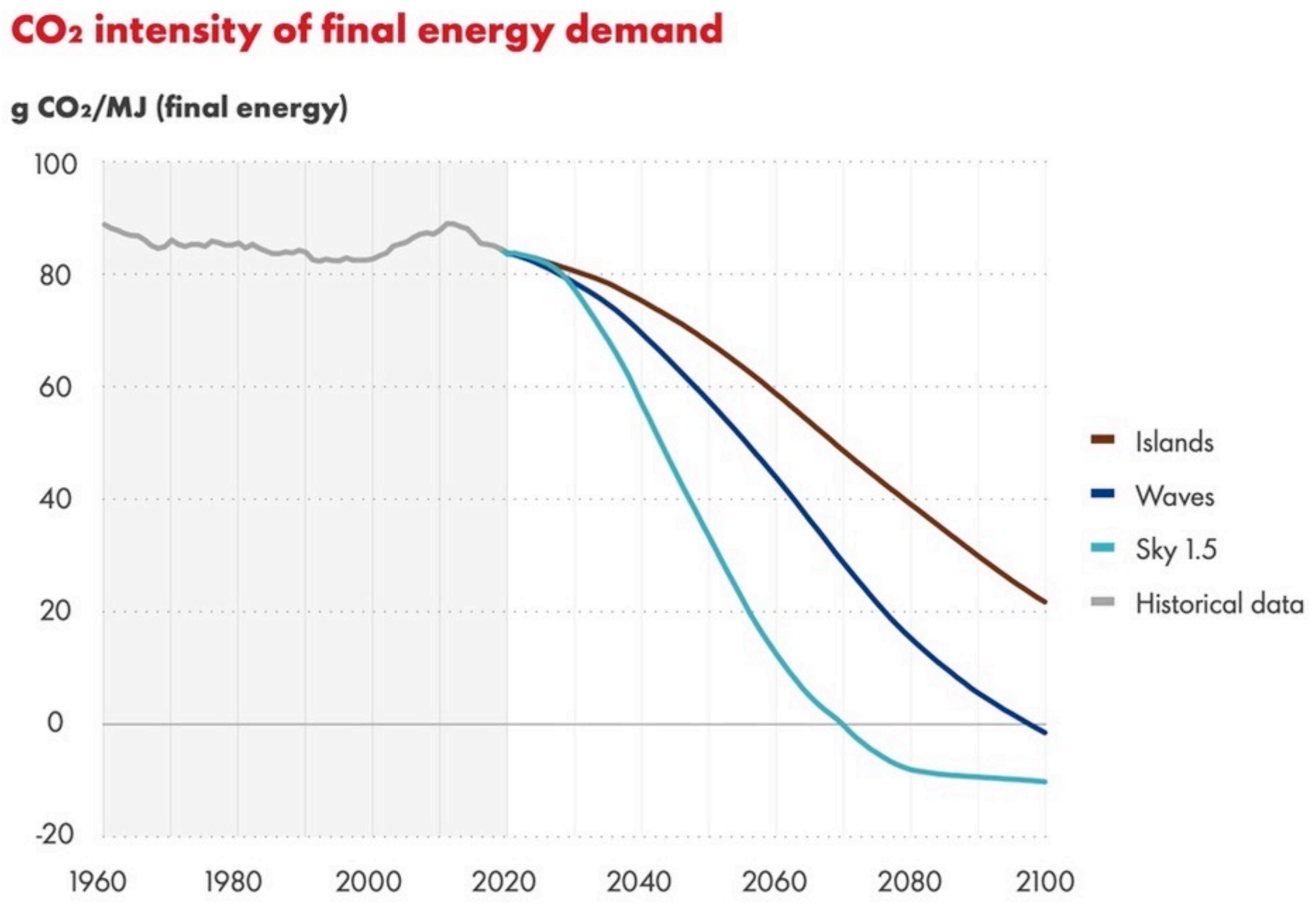
Hydrogen comes in different shades



Levelised cost of hydrogen

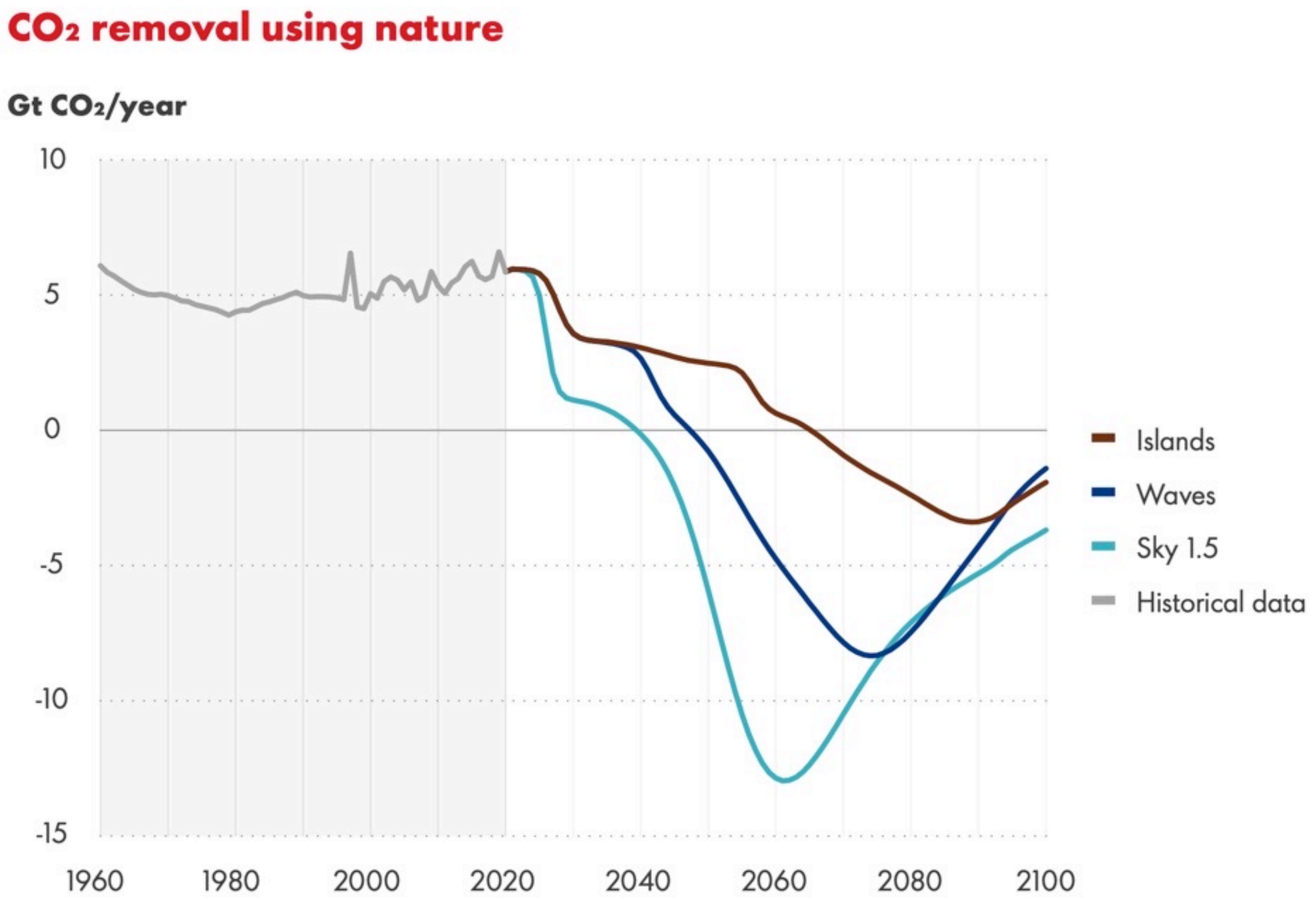


The CO2 intensity of final energy consumed has been flat for decades, but is about to decline



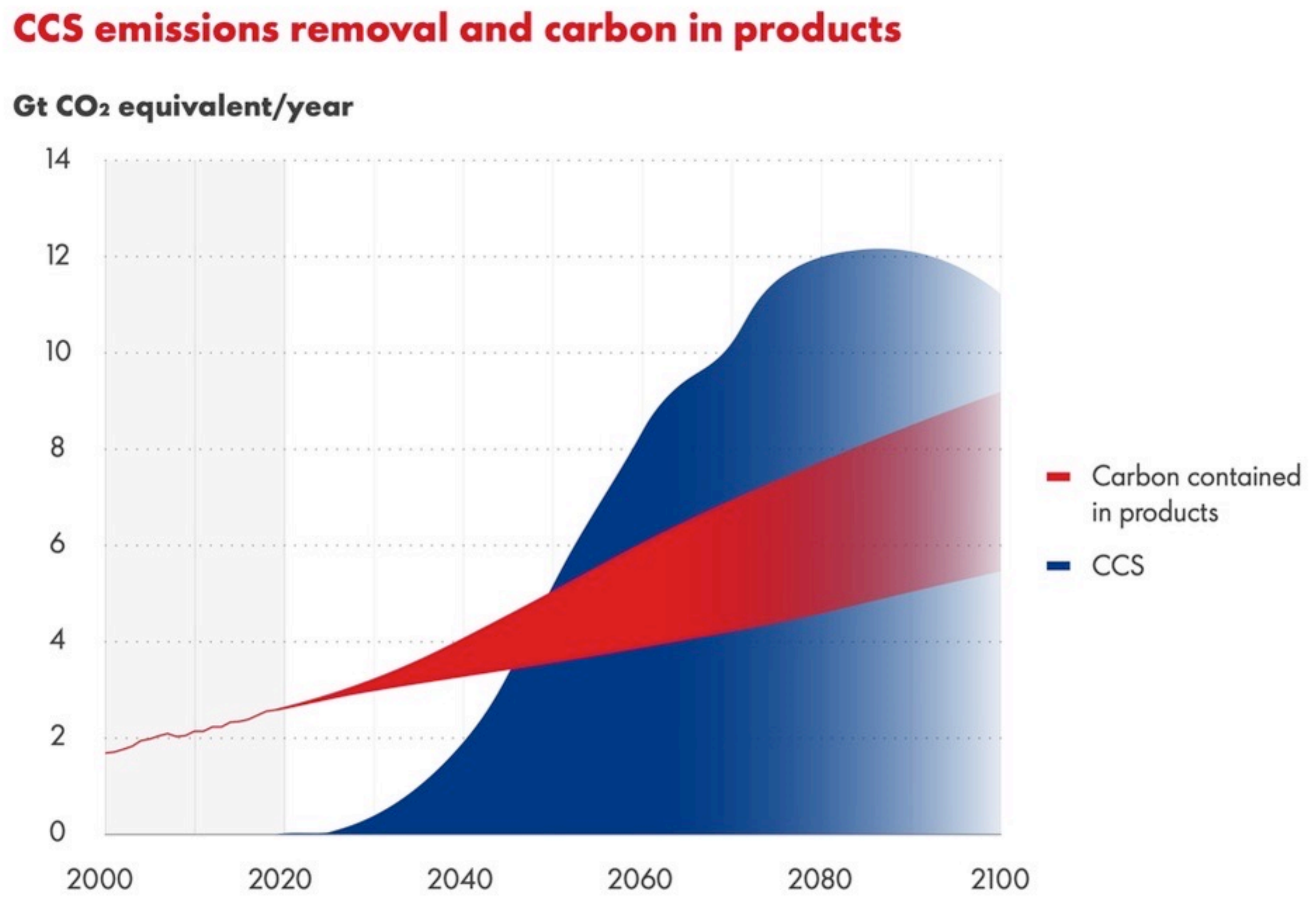
Source: Shell analysis based on data from the IEA (2020) World Energy Balances (**Link**), all rights reserved

Natural capture of CO2 emissions will be key to meeting the Paris goal



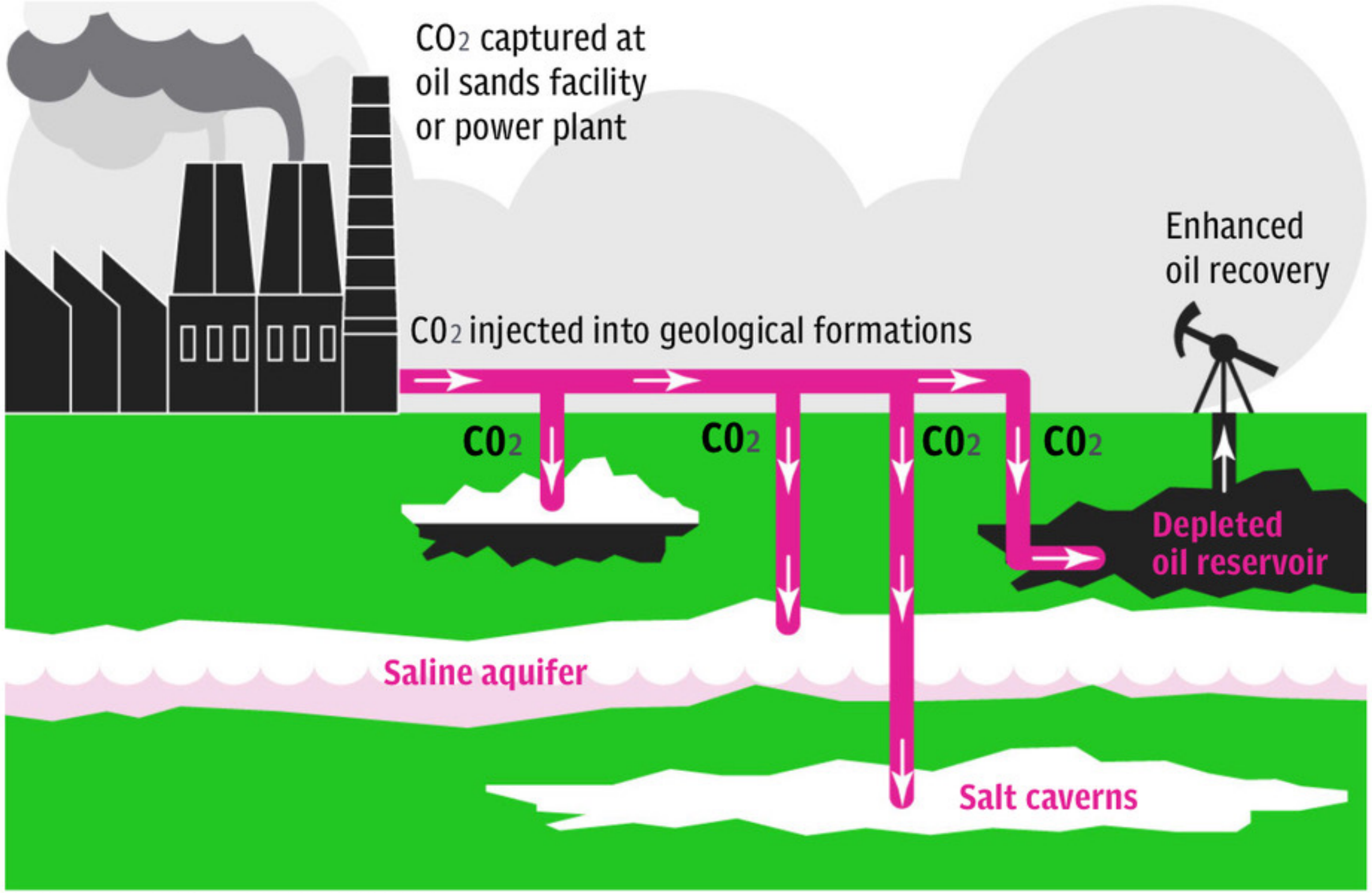
Source: Shell analysis, Global Carbon Project (2020)

Removing CO2 emissions with carbon capture and storage (CCS) will be key to meeting the Paris goal



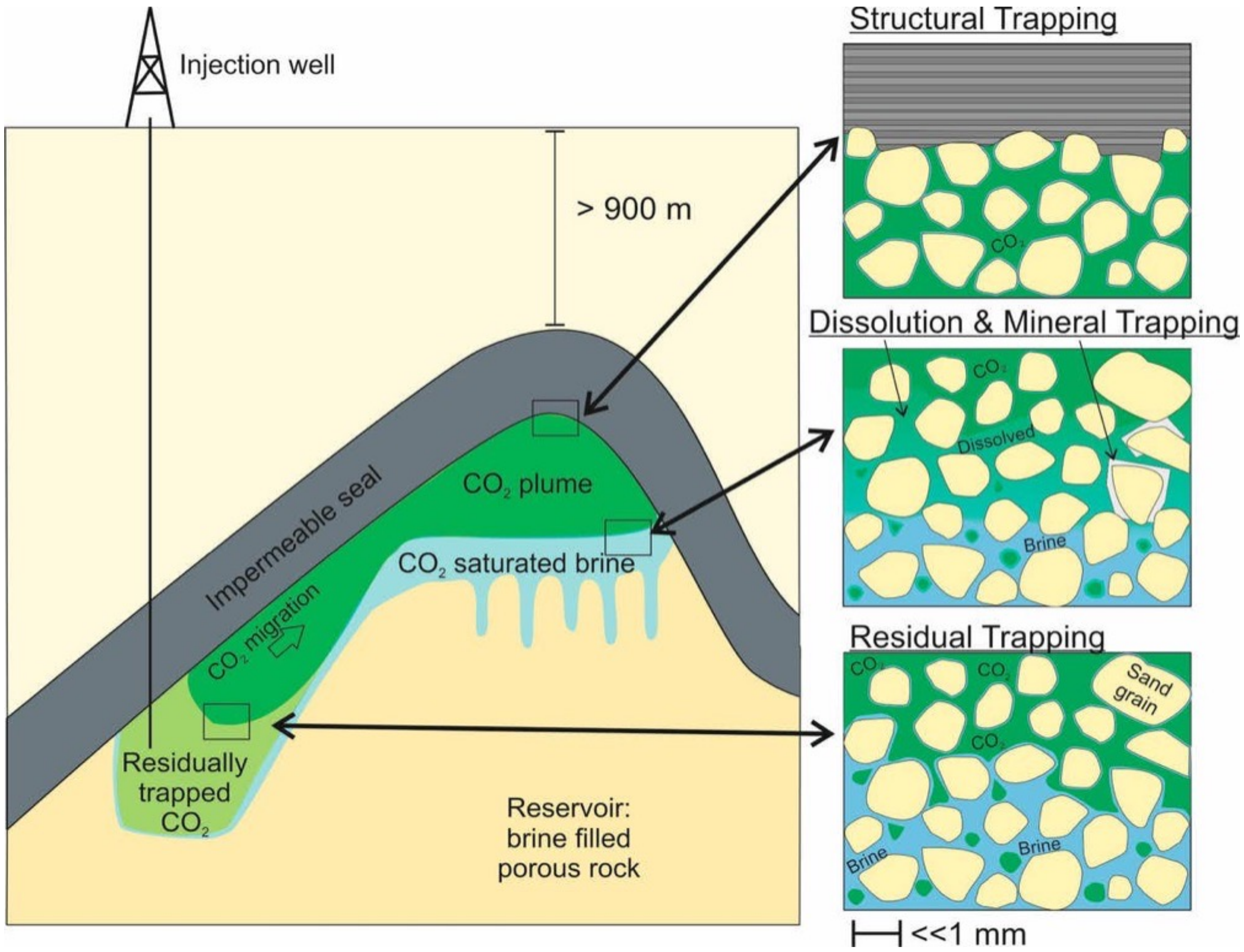
Source: Scenario ranges from Shell analysis

How Carbon Capture and Storage (CCS) works



SOURCE: CCS ASSOCIATION

How is CO2 stored and is it safe?

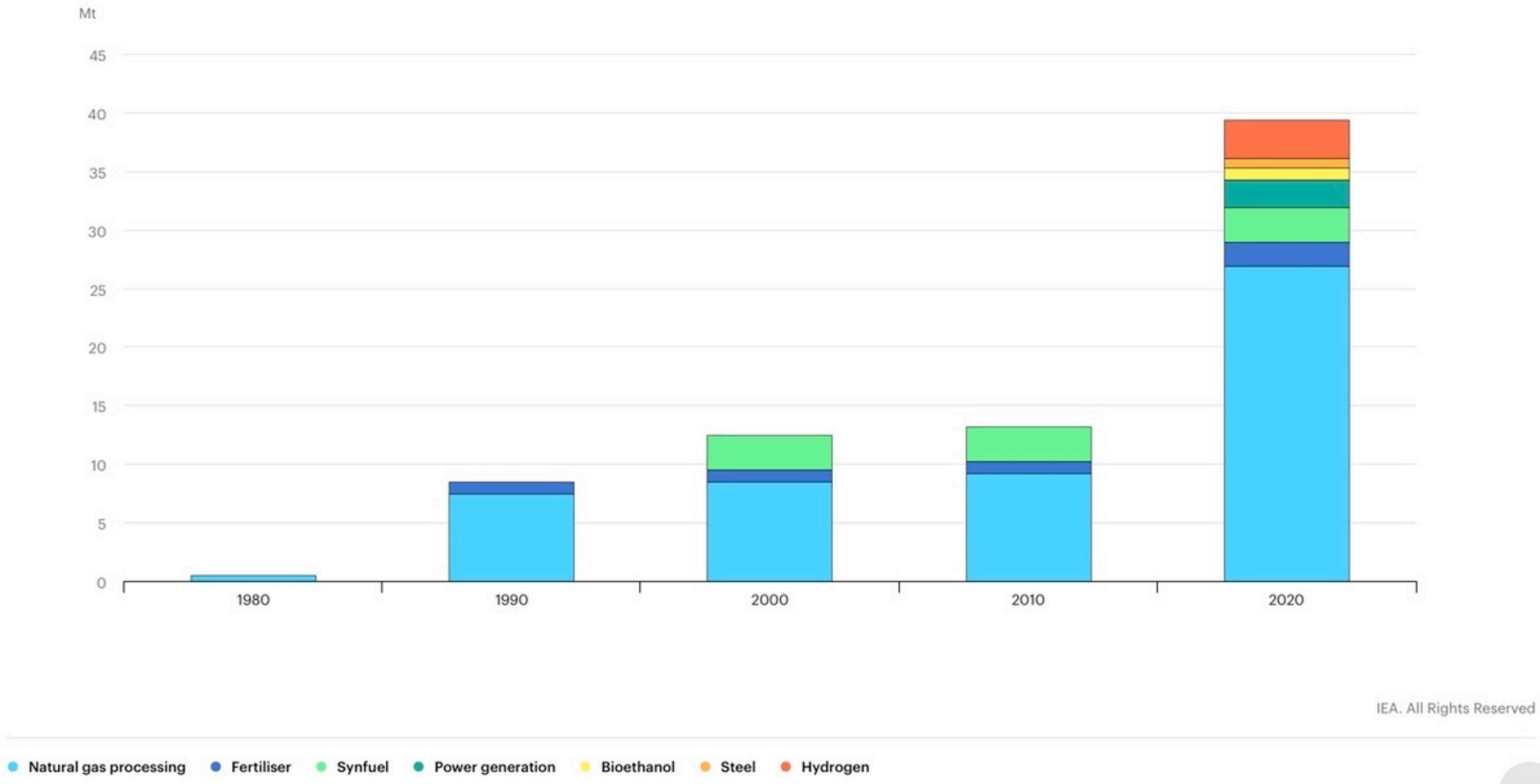


Mineral carbonation represents an intriguing - if currently largely theoretical - possibility for capturing CO_2 in rocks in ophiolite rocks.

Existing CCS projects

- 20 commercial projects operational, many linked to enhanced oil recovery
- >40 announced plans, largely involving industrial hub developments

Global CO2 capture capacity 1980-2020



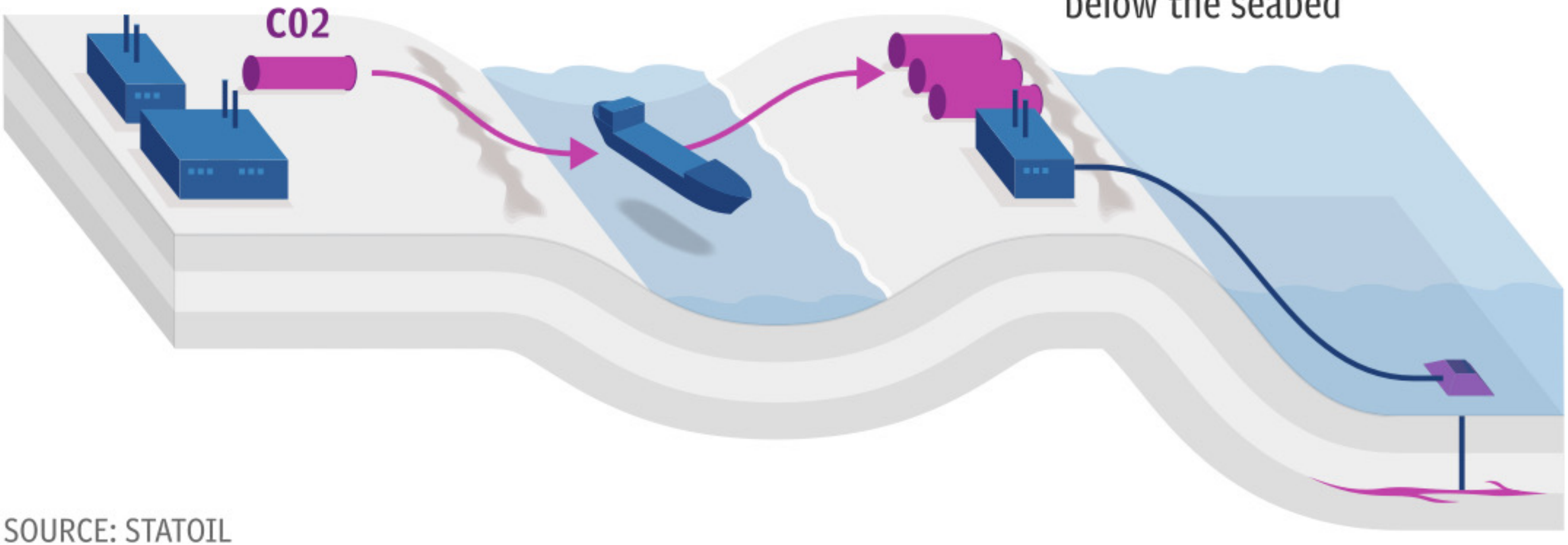
- 40 Mtpa CO_2 captured (0.1% of total global emissions)
- Majority linked to natural gas processing

A full-scale CCS value-chain

Capture
C02 is captured at industrial plants before being compressed and stored temporarily on site

Transport
Compressed C02 is transported by ship to a coastal storage site equipped with pipelines

Storage
The C02 is temporarily stored at the second site before it is piped via undersea pipelines and injected into a permanent reservoir around one mile below the seabed

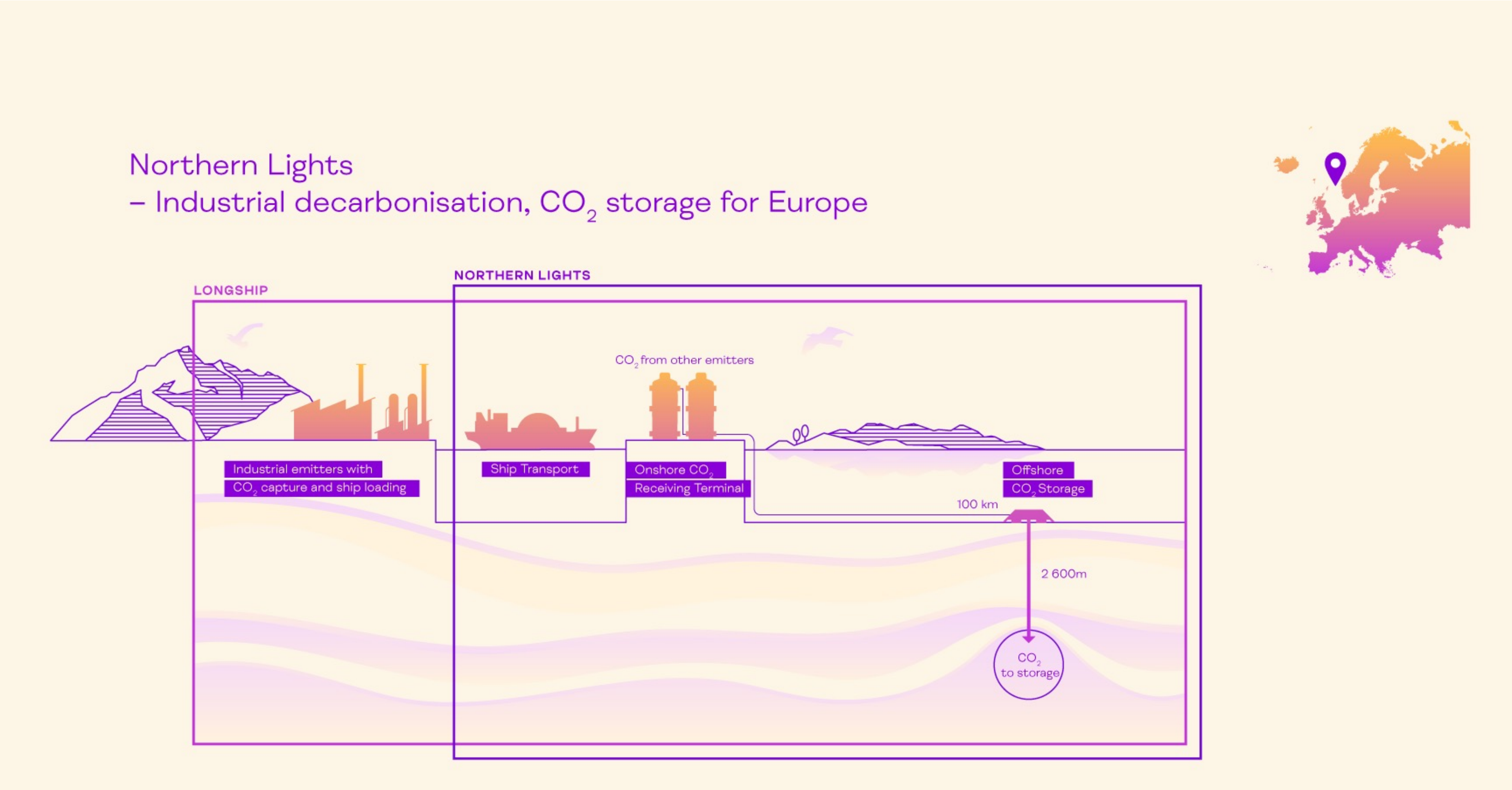


SOURCE: STATOIL

Project Acorn

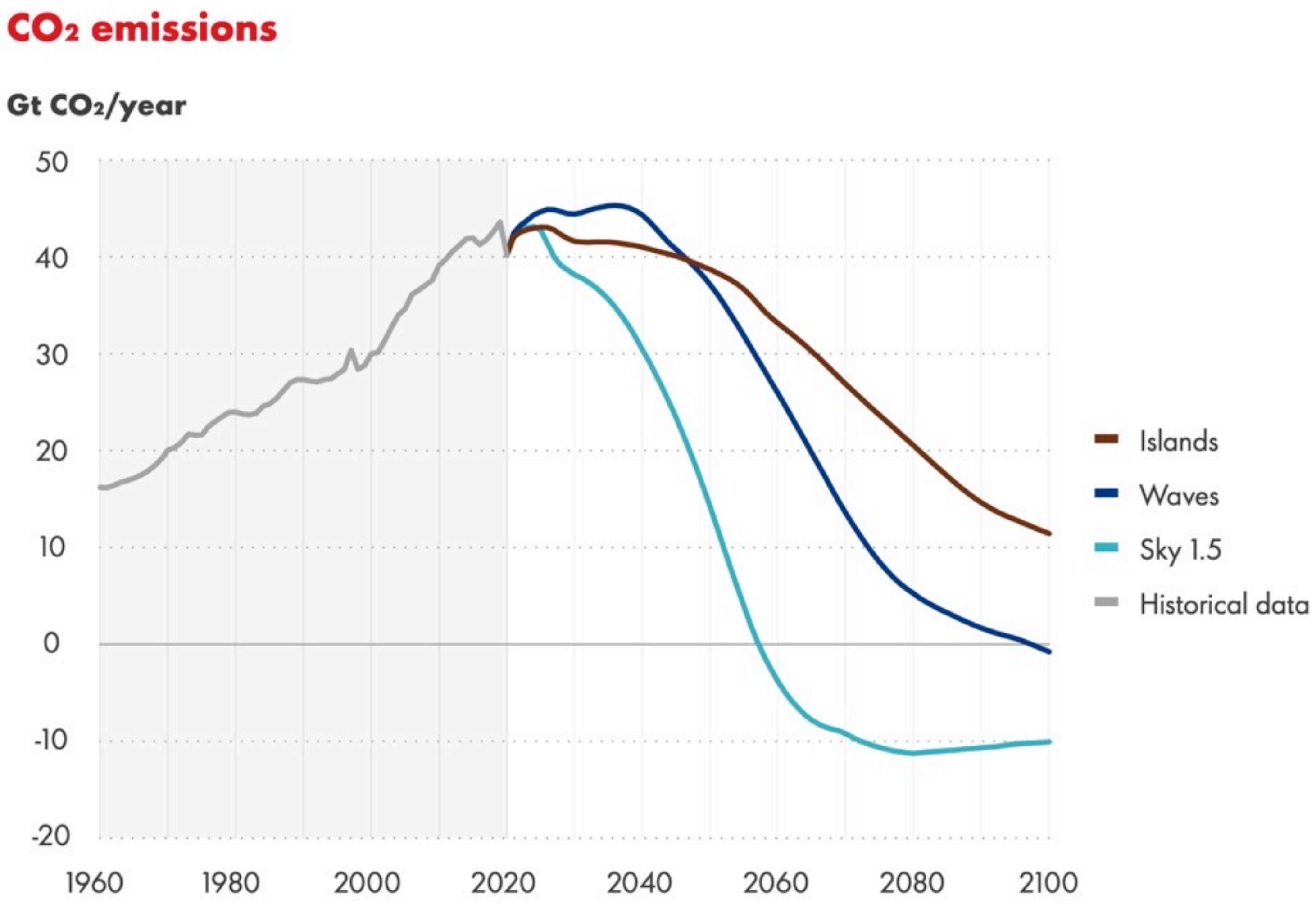
- Low capital cost CO_2 capture project
  - Re-purposed existing pipelines
  - 5-10 Mt by 2020
- Large offshore storage sites
  - 30% of UK's gas storage lies within 50km of St Fergus
- Gas access
  - 35% of UK gas processed at St Fergus
  - Import potential through Peterhead port
  - Potential for hydrogen blending with existing natural gas supply
- Benefits for local economy

Longship/Northern Lights



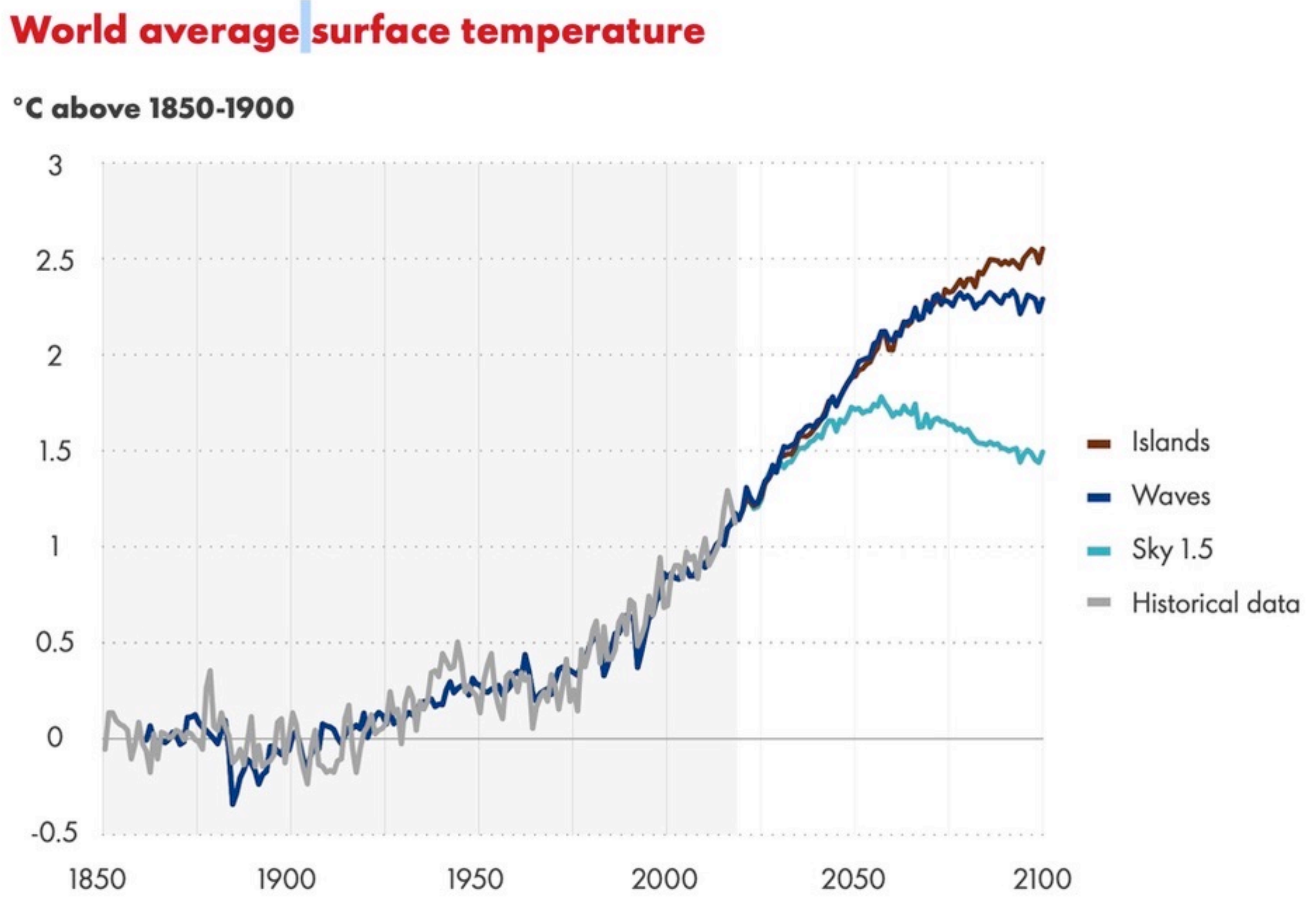
- CO_2 capture from onshore industrial plants (Cement & Waste-to-energy plants)
- Transport by ship to receiving terminal in west Norway
- CO_2 piped offshore for re-injection and storage in reservoirs 2,600 m below sea-bed
- Phase I will sequestrate 1.5 Mtpa
- Operational from 2024

In Sky 1.5 total CO2 emissions reach net zero by the late-2050s, but in Waves and Islands net zero is not reached until 2100 or beyond



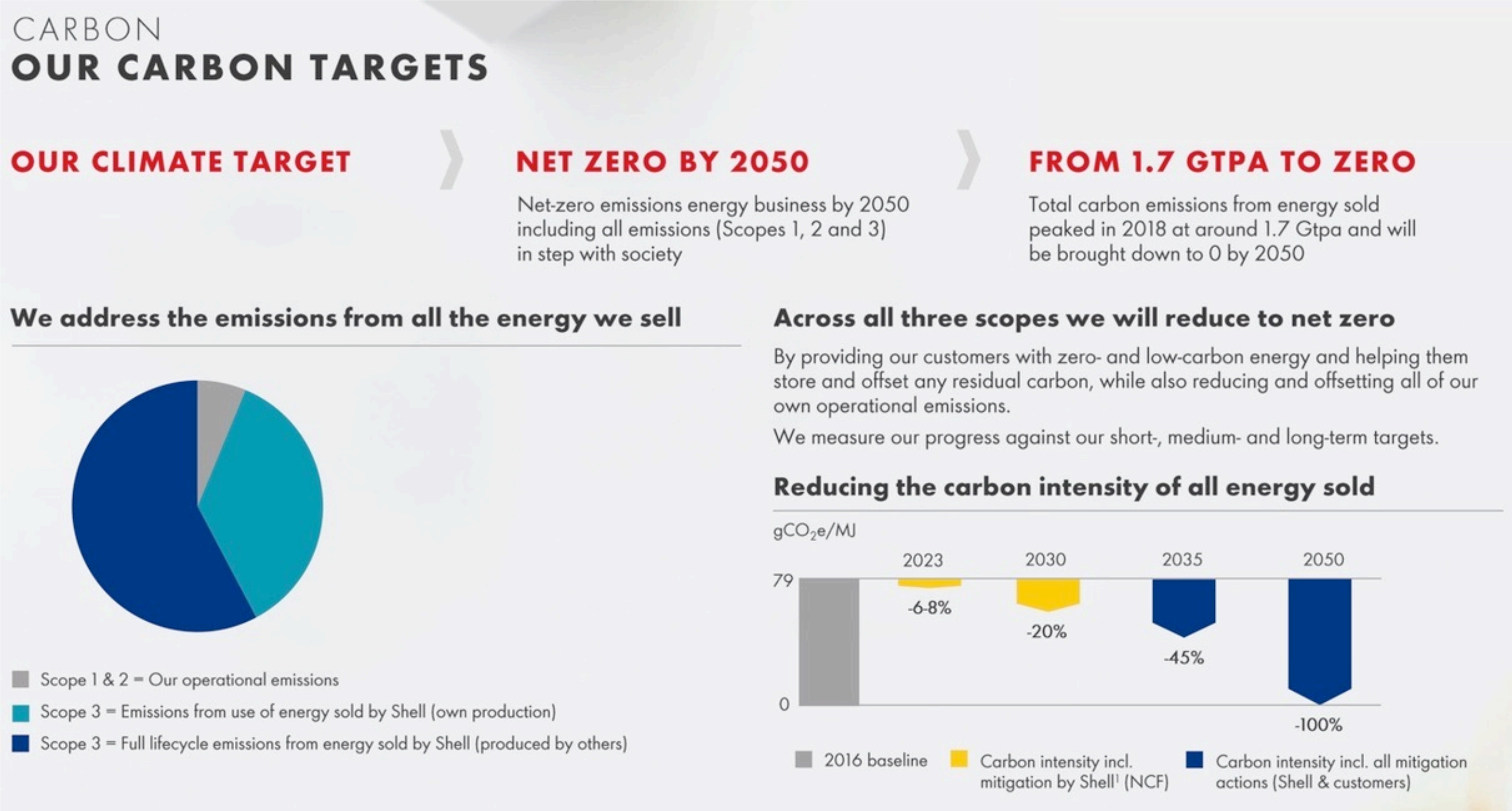
Source: Shell analysis based on data from Global Carbon Project (2020) and the IEA (2020) World Energy Balances (**Link**),

Temperature increases can be halted in the 2060s, but could equally continue to rise until the end of the century and beyond



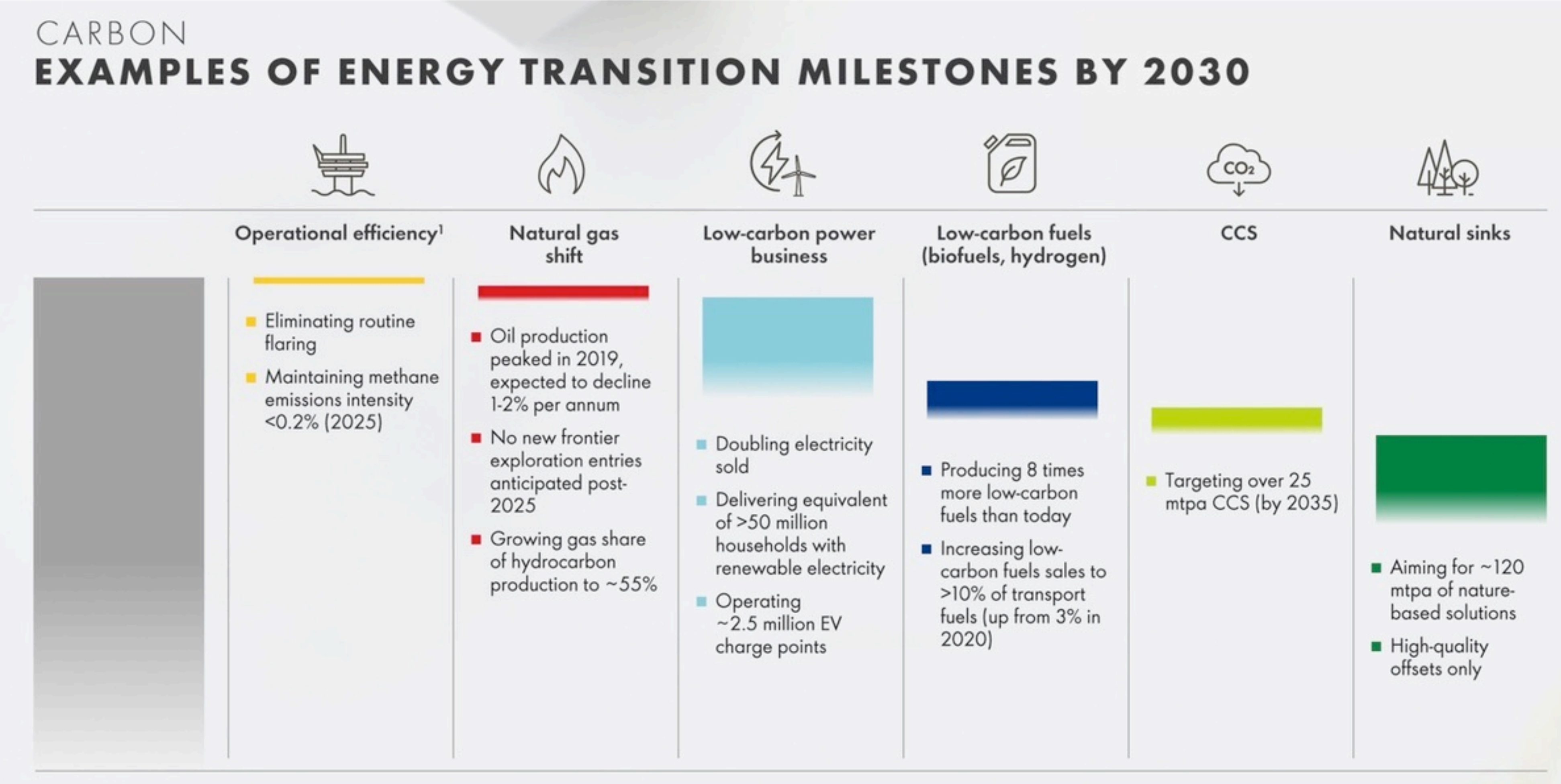
Source: Shell analysis, Met Office Hadley Centre (2020) (temperature history, HadCRUT5), MIT joint program on Global Change (scenarios)

Setting Targets



Source: Shell Energy Transition Strategy 2021

What role for the industry?



Source: Shell Energy Transition Strategy 2021

Oman – how a MENA oil and gas producer is transitioning to a low carbon world

A New Energy Era: Hydrocarbons & Renewables in the Sultanate – HE Salim al-Aufy, Undersecretary at Ministry of Energy & Minerals

https://www.ao-soc.org/podcasts

- Limited oil and gas reserves
- Already focusing upon improving the efficiency of existing oil and gas operations
- Government perceives an opportunity to become a major global player in the hydrogen business, initially blue and then green
- Numerous recent project announcements, including 25 gW integrated green fuels mega-project
- Combined wind and solar, producing green hydrogen and ammonia
- Capitalising upon abundant natural resources and strategic Indian Ocean location

The oil industry – the problem or part of the solution?


hell
WE'RE TURNING OUR
CARBON EMISSIONS
GREEN FOR EARTH DAY

‘The complex middle ground of transition investment’ – IEA World Energy Outlook 2021

- ‘The idea that all energy sector investments divide neatly into “clean” and “dirty” does not survive contact with the realities of energy transition’
- ‘A large portion of investments (will) go towards sectors, technologies and infrastructure that do not immediately deliver zero emissions energy or energy services, but do enable such investments or provide incremental emissions reductions’
- ‘Some of these investments can also help to deliver zero emissions energy over time, but are contingent on actions elsewhere in the system’
- ‘In the net zero emissions (scenario) around half of investment over the next decade will fall in (this) complex middle ground of spending’
- ‘In practice, this middle ground of actions that “make dirty cleaner” is crucial in determining the speed and scope of energy transitions, and (will) deliver the largest share of emissions reductions in getting … to a net zero trajectory

‘The key challenge is how to ensure that adequate financial channels remain open to support these “contingent” and “transition” investments without this becoming a loophole for investments that are not aligned with the Paris Agreement, or that allow for greenwashing.’

Back-up slides

Societal challenge

	2015		2070
	7 billion	Increasing population	>10 billion
	570 exajoules	Increasing energy demand	1,000 exajoules
■ Challenge for more and cleaner energy ■ Reduction required in the carbon intensity of every unit of energy consumed	32 gigatonnes CO_2e	Need to reduce CO_2 emissions CO_2	Net Zero Emissions

Sources: Population – UN world population projections, energy consumption. 2015 – IEA World Energy Outlook (WEO) 2017, 2070 outlook – Shell scenarios analysis from A Better Life with a Healthy Planet CO_2 emissions: 2015 – IEA WEO 2017: 2040 – IEA WEO 2017 Current policies scenario; 2017 – Shell scenario analysis from A Better Life with a Healthy Planet.

WAVES

- Initial response to 2020 COVID-related crisis is to repair the economy – wealth first.
  - Self-interest largely perceived in economic terms; resilience judged in terms of economic strength
  - Economic recovery is rapid, although at the cost of repeated waves of infection
- Surge in energy use, fossil fuel production and greenhouse gas emissions
- Underlying currents eventually bring these waves crashing down
  - Apparent economic success disguises growing inequality, feeding social discontent and labour unrest.
  - Public reacts to more frequent and more extreme weather events.
  - Neglect of structural issues, ranging from public health to social welfare to climate change, is blamed for societal and environmental stresses.
- Societal and political backlash to climate change
  - Rapid policy-driven reductions in fossil fuel use; global use of coal and oil peaks in the 2030s, and natural gas not long afterwards.
- Starting later than required to meet PA goals, 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

- Governments and societies focus on their own security first
  - New emphasis on nationalism threatens to unravel post-war geopolitical order
  - Islands-mentality with resilience seen as autonomy and self-sufficiency.
- Internally-focused recovery efforts have mixed results
  - Some countries do relatively well while others suffer from ineffective policies
  - Frictions in international trade and collaboration; global economic growth begins to stagnate
  - International efforts to address climate challenge slow; Paris climate process unravels.
- Nations focused on their own short-term economic outcomes remain dependent on cheap fossil energy for a prolonged period
  - Global emissions decline only slowly
  - Extreme weather events eventually cause disruption and suffering, yet 'blame' largely placed on others rather than embraced in domestic politics.
- Normal course of equipment and infrastructure replacement and deployment of cleaner technologies bring progress and eventually net-zero emissions beyond 2100
- World overshoots the timeline and does not achieve PA goal
  - Atmospheric CO_2 levels consistent with an average temperature around 2.5°C and still rising slowly

Late and slow decarbonisation.

SKY 1.5

- Initial response to the crises of 2020 is focus on responding to pandemic and related challenges to public well-being – health first.
  - Successful collaborative efforts and healthy competition among international medical and scientific communities in developing vaccines leads to deeper appreciation of the value of alignments in addressing challenges more broadly
- From an energy perspective, successful green policies and investment emerge that support steady economic recovery as well as emissions reduction
  - USA, China and other technology-focused economies in Asia and Europe target cleaner technologies as an economic goal that boosts domestic industrial and technological competitiveness
  - Rapid and deep electrification of global economy; growth dominated by renewables.
- Global demand for coal and oil peak in the 2020s, and natural gas in the 2030s
  - In economic sectors 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.
- World proceeds towards achieving the stretch Paris ambition
  - Temporarily rising above and then limiting average global warming to 1.5°C before the end of this century

Accelerated de-carbonisation now

Energy Transformation Scenarios – Four Main Conclusions

1. **Energy needs will grow**
   - Energy needs of growing populations will outstrip the significant capacity to improve energy efficiency
   - Transition of energy system required from reliance upon on fossil fuels to increasing use of sustainable
2. **The energy system will be transformed – the issue is speed**
   - Meeting energy needs while decarbonising will require accelerating electrification of the economy
   - Over time these fuels will steadily transition from fossil fuels to low- and no-carbon sources
   - Such energy transitions will proceed at different paces in different places and in different sectors.
   - Socio-political choices being made now will be significant for decades to come.
3. **Transformation will have costs and benefits.**
   - Taking steps towards Paris Agreement goals could be rewarding both economically and environmentally.
   - 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.
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 remains technically possible, though challenging.
   - Three fundamental action accelerators are needed for a timely and just transition:
     - alignments of policies, sectors and governments
     - smart policy rules and incentives
     - pioneer leaders

Making low carbon hydrogen