Counting Cash in Paris Aligned Pathways

Projected energy investment requirements under IEA and IPCC de-carbonization scenarios

May 2022

BloombergNEF

Executive summary

As policy makers endeavour to keep global CO_2 emissions in check, debate swirls over how much capital will be needed to transition swiftly but smoothly from fossil fuel reliance to cleaner sources. The financial, business and policy-making communities lack consensus over what fossil fuel investment is compatible with 1.5°C "pathways". This work examines potentially acceptable dollar ranges under four of the world's best publicized Paris aligned scenarios.

- While many have prepared long-term scenarios, we focus here on four pathways produced by major intergovernmental bodies the International Energy Agency (IEA) and the Intergovernmental Panel on Climate Change (IPCC). We will examine others in coming work.
- Extrapolating from three IPCC scenarios and one IEA scenario, BNEF pegs required investment at $1.1-1.8 trillion per annum through 2030. Through 2050, capital needs range $0.6-1.7tr/yr.
- The majority of fossil investment goes to maintaining delivery and consumption infrastructure required to ensure the world transitions smoothly to cleaner sources. Oil stands to receive most investment, followed by natural gas. Coal trails far, far behind.

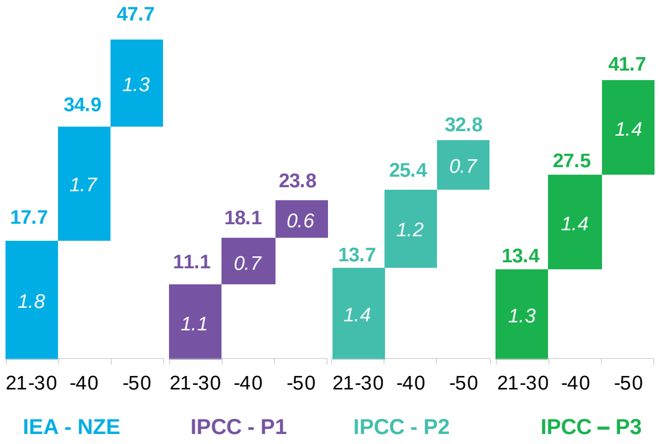
$47.7 tr Projected 2021-2050 energy investment under the IEA's Net Zero Emissions scenario

$23.8 tr Projected 2021-2050 energy investment under the IPCC "P1" scenario

$0.2-0.3tr Projected 2021-2050 investment specifically for coal supply (0.005-0.006% of total investment)

Total energy investment 2021-2050

Trillion $ (2019)



Source: BloombergNEF analysis of IEA, IPCC scenarios..

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Executive summary (continued)

- Under all scenarios analyzed, fossil investment 2020-2030 sinks below last decade's levels. Average annual investment falls in all scenarios to $0.4-0.6 trillion from an estimated $0.8 trillion across 2016-2020. However, the pathways diverge substantially post-2030. Under IPCC P1, $0.1-0.2 trillion per annum is invested. Under IPCC P3: $0.3-0.5 trillion.
- Investment in oil supply tracks at $0.3 trillion per annum to 2030 across all scenarios, down from $0.5 trillion/year 2016-2020. It falls further to $0.1-0.2 trillion/year to 2050.
- Investment in gas supply is at $0.2 trillion per annum to 2030 across all scenarios, in line with the $0.2 trillion/year 2016-2020. It then declines to $0.1-0.2 trillion/year to 2050.
- Investment in coal supply falls close to $0.1-0.3 trillion per annum after 2030, essentially stopping except for capital deployed to support maintenance of existing infrastructure.
- In the IEA NZE scenario investment in new, currently unlicensed oil and gas fields halts post-2030. Inherent in this scenario is a prioritizing of assets over emissions to limit price volatility. It also assumes global cooperation in global oil markets.
- Renewables investment varies by scenario but accounts for about 75% of funds expected to be deployed in support of the electricity sector. Investments to 2030 range from $0.7-1.0 trillion. To 2050 the range of annual investment in different scenarios varies from $0.3-1.0 trillion.
- IPCC P3 includes substantial nuclear investment of $0.3-0.6 trillion per annum after 2030.

About the analysis

Why scenarios?

- There is **uncertainty in the financial, business and policy making community** regarding **the level of energy investment and financing compatible with emissions pathways** published by the IEA and IPCC with no or limited overshoot of 1.5°C.
- This work is intended to offer insight on the range of energy investment outlined by the different scenarios.

Why these specific scenarios?

- There are a large number of scenarios prepared and disseminated by different organizations. This work focuses on those **that have been evaluated or produced by major intergovernmental bodies** such as the IPCC and IEA. In due course it will also include those produced by **networks of bodies with significant authority delegated by national governments** such as the Network for Greening the Financial System (NGFS).
- It focuses on those **scenarios with no or limited overshoot of 1.5°C.** This is in line with the Glasgow Financial Alliance for Net Zero (GFANZ) mission of "achieving the objective of the Paris Agreement to limit global temperature increases to 1.5°C from pre-industrial levels".
- The four scenarios assessed are:
  - The IEA's Net Zero Emissions by 2050 (NZE)
  - IPCC P1 – Lower Energy Demand Pathway
  - IPCC P2 – Shared Socioeconomic Pathway
  - IPCC P3 – "Middle-of-the-Road" Scenario
- Each of these is explored in greater detail on the next four slides.
- This work benefitted from correspondence with both the IEA and IPCC. BNEF thanks them for their support but notes this reports is not endorsed by either organization.

Scenario Narrative

Net Zero by 2050

IEA - NZE

"The Net-Zero Emissions by 2050 Scenario (NZE) is designed to show what is needed across the main sectors by various actors, and by when, for the world to achieve net-zero energy-related and industrial process CO2 emissions by 2050. It also aims to minimise methane emissions from the energy sector. In recent years, the energy sector was responsible for around three-quarters of global greenhouse gas (GHG) emissions. Achieving net-zero energy-related and industrial process CO2 emissions by 2050 in the NZE does not rely on action in areas other than the energy sector, but limiting climate change does require such action. The IEA therefore additionally examine the reductions in CO2 emissions from land use that would be commensurate with the transformation of the energy sector in the NZE, working in co-operation with the International Institute for Applied Systems Analysis (IIASA). In parallel with action on reducing all other sources of GHG emissions, achieving net-zero CO2 emissions from the energy sector by 2050 is consistent with around a 50% chance of limiting the long-term average global temperature rise to 1.5 °C without a temperature overshoot (IPCC, 2018).

The Net-Zero Emissions by 2050 Scenario is built on the following principles.

- *The uptake of all the available technologies and emissions reduction options is dictated by costs, technology maturity, policy preferences, and market and country conditions.*
- *All countries co-operate towards achieving net-zero emissions worldwide. This involves all countries participating in efforts to meet the net zero goal, working together in an effective and mutually beneficial way, and recognising the different stages of economic development of countries and regions, and the importance of ensuring a just transition.*
- *An orderly transition across the energy sector. This includes ensuring the security of fuel and electricity supplies at all times, minimising stranded assets where possible and aiming to avoid volatility in energy markets."*

Source: IEA, https://www.iea.org/reports/net-zero-by-2050

Scenario Narrative

A pathway of lower energy demand

IPCC - P1 (LED)

"The LED scenario narrative has five main drivers of long-term change in energy end-use: quality of life, which is the continued push for higher living standards, clean local environments, and widely accessible services and end-use technologies; urbanisation, referring to the continued rapid urbanisation particularly in mid-size cities in developing countries; novel energy services, which sees a continued historical trend of end users demanding novel, more accessible, more convenient, cleaner, and higher quality energy services; end-user roles, meaning the continued diversification of roles played by end-users in the energy system from consumer, to producer, trader, citizen, designer and community member; and information innovation, which involves continued rapid improvements in cost and performance of information and communication technologies (ICTs) supporting their widespread application. Each of these drivers is clearly evidenced as currently shaping energy-related developments.

These five drivers of change interact to generate five additional elements of the LED scenario narrative: granularity, referring to the proliferation of small scale, low unit cost technologies enabling experimentation, rapid learning and equitable access; decentralised service provision of energy generation, distribution and end-use, with piecewise expansion or adaptation of centralised infrastructure; use value from services, meaning a move away from ownership of single purpose goods to 'usership' with flexible, multi-purpose services delivered through digital platforms or sharing economies; digitalisation of daily life, describing the integration of sensors, processors, wireless communication, and control functionality into energy-using technologies and daily routines; and rapid transformation, which is the accelerated improvement demanded by end users in the changing form and quality of energy-service provision as incomes and aspirations rise.

The LED scenario narrative describes rapid social and institutional changes in how energy services are provided and consumed, in addition to technological innovation."

Source: IPCC, http://pure.iiasa.ac.at/id/eprint/15301/1/FINAL_LED_MS_REVISED_noTRCHNoComments_SUBMIT_newFig2.pdf

Scenario Narrative

Shared Socioeconomic Pathway
(Low challenges to mitigation and adaptation)

IPCC - P2 (S1)

“The world shifts gradually, but pervasively, toward a more sustainable path, emphasizing more inclusive development that respects perceived environmental boundaries. Increasing evidence of and accounting for the social, cultural, and economic costs of environmental degradation and inequality drive this shift. Management of the global commons slowly improves, facilitated by increasingly effective and persistent cooperation and collaboration of local, national, and international organizations and institutions, the private sector, and civil society. Educational and health investments accelerate the demographic transition, leading to a relatively low population. Beginning with current high-income countries, the emphasis on economic growth shifts toward a broader emphasis on human well-being, even at the expense of somewhat slower economic growth over the longer term. Driven by an increasing commitment to achieving development goals, inequality is reduced both across and within countries.

Investment in environmental technology and changes in tax structures lead to improved resource efficiency, reducing overall energy and resource use and improving environmental conditions over the longer term. Increased investment, financial incentives and changing perceptions make renewable energy more attractive. Consumption is oriented toward low material growth and lower resource and energy intensity. The combination of directed development of environmentally friendly technologies, a favorable outlook for renewable energy, institutions that can facilitate international cooperation, and relatively low energy demand results in relatively low challenges to mitigation. At the same time, the improvements in human well-being, along with strong and flexible global, regional, and national institutions imply low challenges to adaptation.”

Source: O’Neill et al., 2017 https://www.sciencedirect.com/science/article/pii/S0959378016300784#bib0155

Scenario Narrative

A “middle-of-the-road” scenario
(Medium challenges to mitigation and adaptation)

IPCC – P3 (S2)

“The world follows a path in which social, economic, and technological trends do not shift markedly from historical patterns. Development and income growth proceed unevenly, with some countries making relatively good progress while others fall short of expectations. Most economies are politically stable. Globally connected markets function imperfectly. Global and national institutions work toward but make slow progress in achieving sustainable development goals, including improved living conditions and access to education, safe water, and health care. Technological development proceeds apace, but without fundamental breakthroughs. Environmental systems experience degradation, although there are some improvements and overall the intensity of resource and energy use declines. Even though fossil fuel dependency decreases slowly, there is no reluctance to use unconventional fossil resources.

Global population growth is moderate and levels off in the second half of the century as a consequence of completion of the demographic transition. However, education investments are not high enough to accelerate the transition to low fertility rates in low-income countries and to rapidly slow population growth. This growth, along with income inequality that persists or improves only slowly, continuing societal stratification, and limited social cohesion, maintain challenges to reducing vulnerability to societal and environmental changes and constrain significant advances in sustainable development. These moderate development trends leave the world, on average, facing moderate challenges to mitigation and adaptation, but with significant heterogeneities across and within countries.”

Source: Grubler et al. http://pure.iiasa.ac.at/id/eprint/15301/1/FINAL_LED_MS_REVISED_noTRCHNoComments_SUBMIT_newFig2.pdf

Scenario overview

An orderly transition

IEA - NZE

- Emissions reduction routes are dictated by **costs, technology maturity, policy and market/country** conditions. Assumes **global cooperation.**
- An orderly transition ensures **security of fuel** and electricity supplies at all times. Universal access to sustainable energy is achieved by 2030.
- **Any economic 'hit' is minimized** at the expense of a faster reduction in CO2 emissions from fossil fuel extraction. Aims to **avoid volatility** in energy markets.

A pathway of lower energy demand

IPCC - P1 (LED)

- A continued push for **higher living standards. Rapid urbanization**. Very significant near-term fall in energy demand.
- Enabled by a **move away from ownership** of single-purpose goods to **'usership',** with flexible, multi-purpose services delivered through digital platforms or sharing economies.
- Lower energy demand allows for **swift decarbonization of the remaining energy system**. **Afforestation** is the only carbon dioxide removal option considered.

A shared socio-economic pathway

IPCC - P2 (S1)

- A gradual shift toward a more sustainable path. **Global cooperation** and **economic convergence**. Minimal challenges to adoption of technology.
- **Low population**, **high economic growth** and technological progress.
- Investment in environmental technology and changes in tax structures lead to improved, **resource-efficient** lifestyles.
- Energy demand remains relatively unchanged by 2050, oil plays a large role as renewables scale up. **Limited** societal acceptance for bioenergy with carbon capture and storage **(BECCS).**

A "middle-of-the-road" scenario

IPCC – P3 (S2)

- Social, economic, and technological **trends do not shift markedly** from historical patterns.
- **Uneven economic growth, human development,** technological progress. **Limited global cooperation** or economic convergence. **Resource-intensive** lifestyles.
- Emissions reduced by **changing the way in which energy and products are produced.** Fossil fuel dependency decreases slowly with no reluctance to use unconventional fossil resources.
- Energy demand remains relatively unchanged by 2050, gas plays a large role as biomass and nuclear scale up.

Source: BloombergNEF, IEA Net Zero Scenario, IPCC models P1(LED): MESSAGEix-GLO 1.0 LowEnergyDemand , P2(S1): AIM/CGE 2.0 SSP1-19 and P3(S2): MESSAGE-GLOBIOM 1.0 SSP2-19.

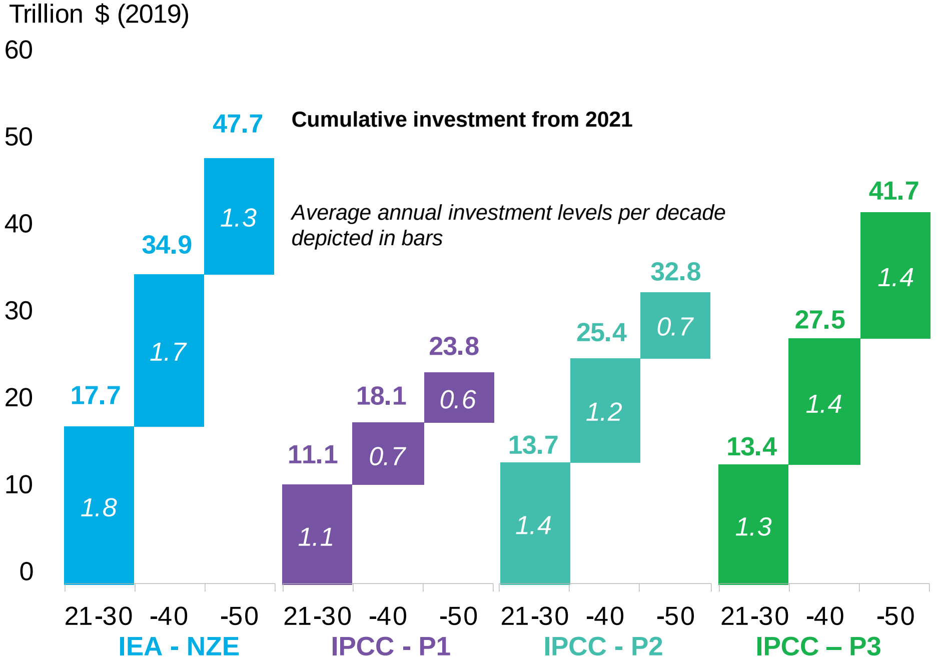
Methodology - investment

- Fossil fuel investment
  - **IEA NZE**: Data is provided by the IEA report for investment in $ 2019 terms.
  - **IPCC P1, P2 & P3**: Investment levels are derived based on $ per joule of total fuel supplied. The $ value per joule is based on a proxy marginal cost of production, derived from the IEA NZS. This value is mapped to primary fuel demand to reflect the variations in demand levels across scenarios over different time periods. For example higher demand levels from 2031-40 in the P2 and P3 scenarios lead to a different $ per joule investment versus the IEA NZS or the P1 scenarios over the same period - reflecting a different marginal cost of producing at that demand level.
- Renewable investment
  - **IEA NZE**: Data is provided by the IEA report for investment in $ 2019 terms.
  - **IPCC P1**: Data is provided in the IPCC report for investment in $ 2010 terms and converted to $ 2019 terms based on BloombergNEF data.
  - **IPCC P2 & P3**: The change in generation capacity by fuel type is translated into investment based on BloombergNEF's New Energy Outlook (NEO) 2021 costs. This method accounts for the net change in capacity, and does not account for the impact of technology retirements, as such will underestimate investment levels.

Source: BloombergNEF

Total energy investment is in a narrow band to 2030 but varies significantly out to 2050

Total fossil fuels and electricity supply investment



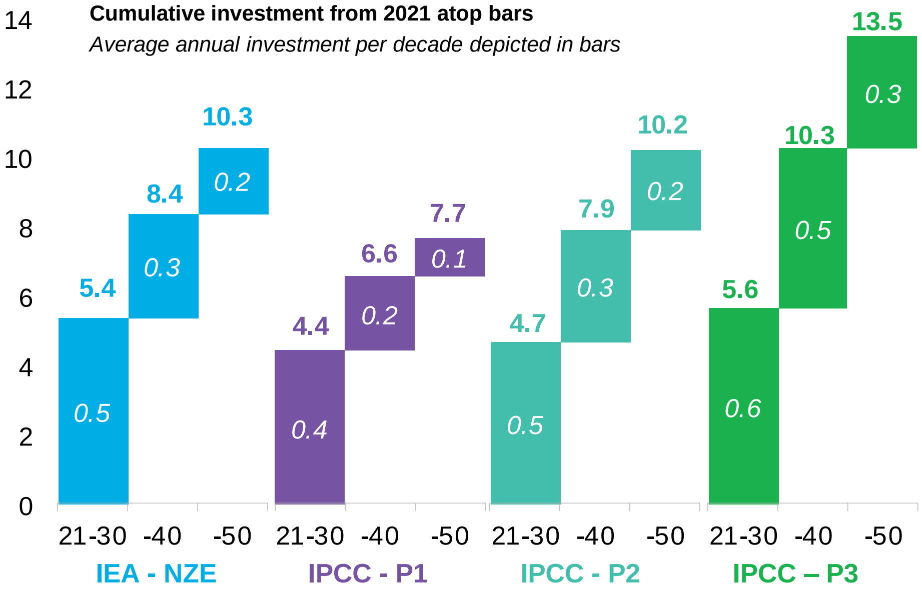
- Total annual investment in fossil fuels and electricity supply is projected to range from $1.1-1.8 trillion 2021-2030 under the four scenarios.
- As actual funds deployed averaged $1.3 trillion per year 2016-2020, such investment is actually expected to remain flat to slightly up for 2020-2030 under three of the four scenarios analyzed (IPCC P1 being the exception).
- The IEA scenario requires more investment than any other. This could be explained by its high level of energy demand – and a more significant pivot away from fossil fuels than in the P3 scenario.
- Investment in fossil fuels and electricity supply decelerates in the IEA, P1 and P2 scenarios after 2030.
- Both the P1 and P2 scenarios see the largest declines in investment in supply from 2030 onward as demand declines and energy intensity improves.

Source: BloombergNEF, IEA, IPCC. Note: IPCC investment numbers are based on BloombergNEF estimates using IEA data.

Scenarios agree on investment in fossil fuels until 2030 then diverge

Total fossil fuels supply investment

Trillion $ (2019)



Source: BloombergNEF, IEA, IPCC. Note: Includes upstream, midstream, downstream and transport. IPCC investment numbers are based on BloombergNEF estimates derived from IEA data.

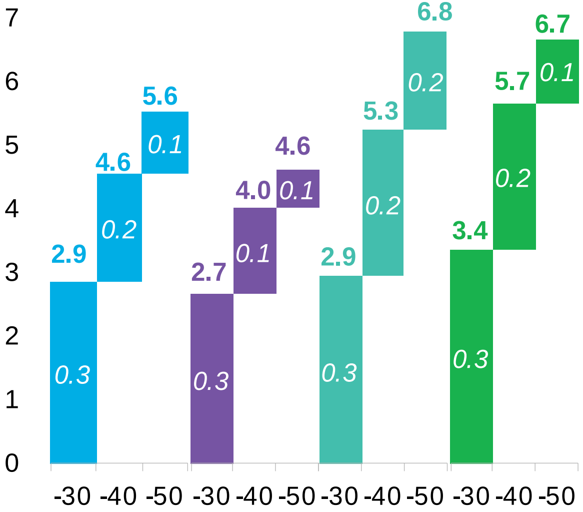
- Looking specifically at capital to be deployed in support of fossil fuel supply and infrastructure, average annual investment **drops under all four scenarios to $0.4-0.6 trillion.** That is down from an estimated **$0.8 trillion across 2016-2020**.
- The P3 scenario sees more investment into fossil fuels than any other – with natural gas and oil production accounting for roughly half of investment.
- Oil investment declines faster than gas from 2030 onward in almost all scenarios and across all decades.
- The IEA states that in the NZE scenario “no exploration for new resources is required and, other than fields already approved for development, no new oil fields are necessary.”

Gas investment stays in line with recent years to 2030; oil declines; coal investment dries up

***Average annual investment 2016-2020:** oil 0.5 trillion \$, gas 0.23 trillion \$, coal 0.07 trillion \$*

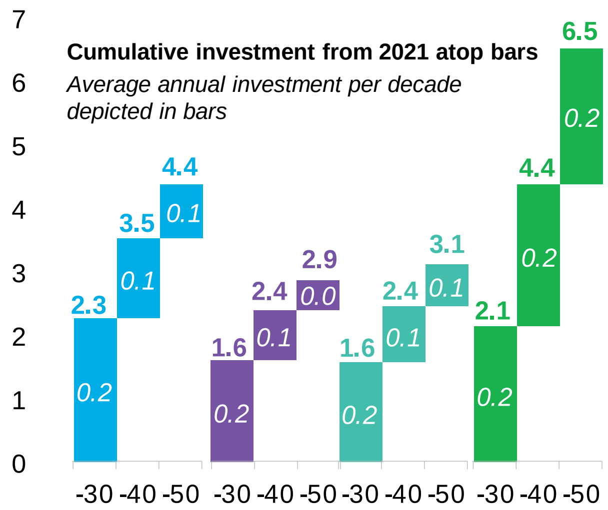
Oil supply investment

Trillion \$ (2019)



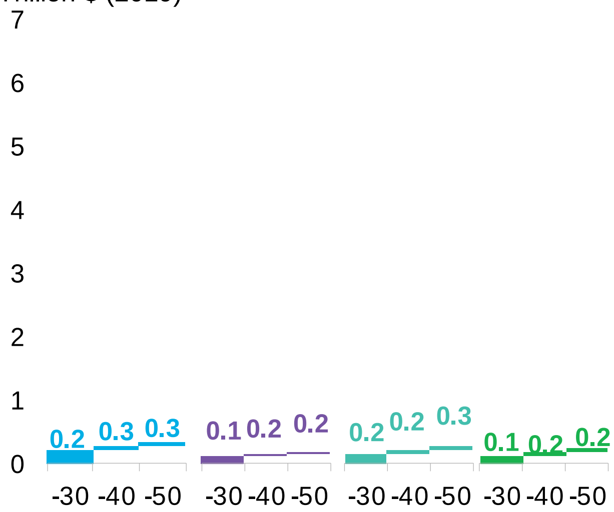
Gas supply investment

Trillion \$ (2019)



Coal supply investment

Trillion \$ (2019)

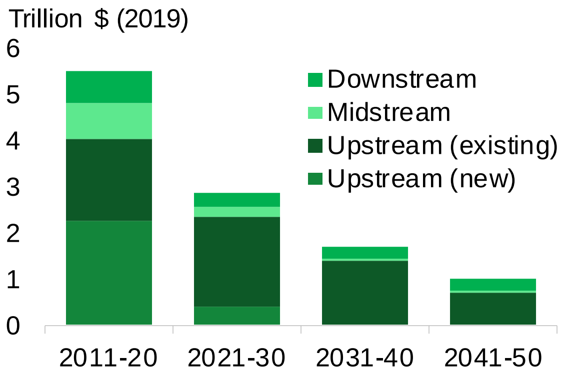


IEA - NZE IPCC - P1 IPCC - P2 IPCC – P3

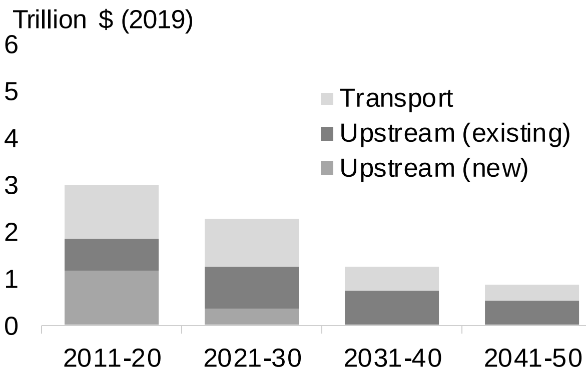
Source: BloombergNEF, IEA, IPCC. Note: Includes upstream, midstream, downstream and transport. IPCC investment numbers are based on BloombergNEF estimates.

New upstream investment halts post-2030 in IEA scenario

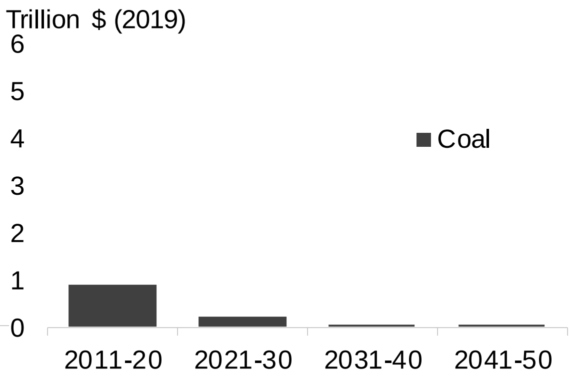
Oil investment



Gas investment



Coal investment

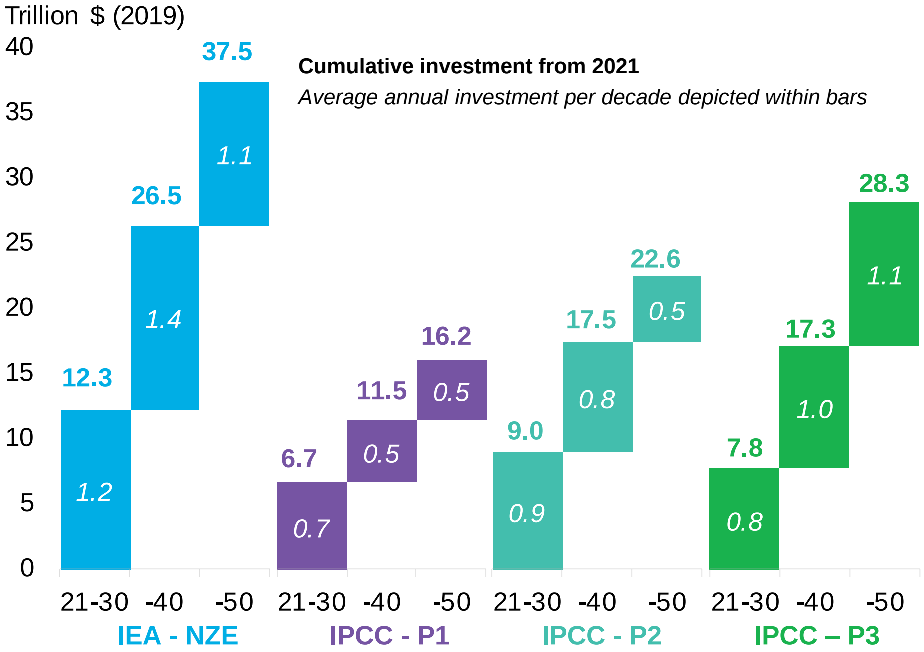


- In the IEA scenario, if all investment in existing oil fields were to cease, this would lead to a loss of more than 8% of supply each year. Continued investment in existing oil fields stems this loss of supply to about 4.5%. This reduction in supply is slightly higher than the decline in demand in the IEA scenario.
- The oil price would be sufficient in principle to cover the cost of developing new fields for the lowest cost producers, including those in the Middle East, but it is assumed that major resource holders do not proceed with investment in new fields in order to avoid downward pressure on prices. It could also be the case that new, more carbon-efficient fields remain undeveloped.
- The scenario also sees many LNG liquefaction facilities under construction - or at the planning stage - become underutilized as more than 50% of gas use in 2050 is focused on hydrogen production.
- The downstream segment also requires a significant pivot toward petrochemical feedstocks, with runs down 85% in the IEA scenario by 2050.

Source: BloombergNEF, IEA Net Zero scenario.

Electricity supply investment peaks 2030-2040 as end-use sectors electrify, led by transport and buildings

Total electricity supply investment

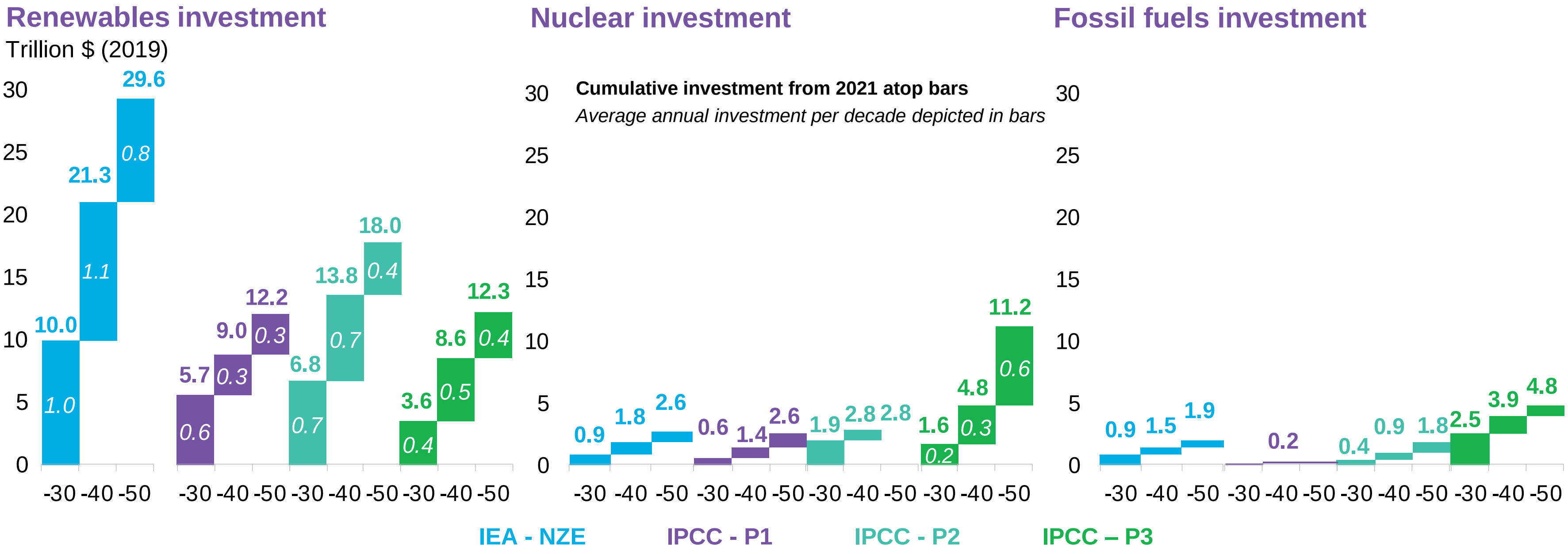


- Average annual investment jumps in all scenarios from **$0.5 trillion across 2016-2020**.
- The vast majority of investment in the supply of electricity is focused on renewables – with wind and solar technologies dominating the electricity mix in all scenarios.
- The P3 scenario is the only scenario to see a marked increase in investment into nuclear generation. It also registers the most investment into fossil fuel power generation – namely natural gas generation – by 2050.

Source: BloombergNEF, IEA, IPCC. Note: Includes investment in renewables, nuclear, fossil fuel and storage. IPCC P1 investment data over the interval are estimated based on data provided for a single year. IPCC P2 and P3 investment numbers are based on BloombergNEF estimates. Investment estimates are based on net additions and as such may underestimate investment levels.

Renewables investment varies but accounts for about 75% of investment in electricity supply

Average annual investment 2016-2020: Renewables $0.33 trillion, nuclear $0.04 trillion, fossil fuels $0.13 trillion



Source: BloombergNEF, IEA, IPCC. Note: Renewables includes solar, wind, hydro, biomass, geothermal and hydrogen. Fossil fuels include generation with and without CCS. IPCC P1 investment data over the interval are estimated based on data provided for a single year. IPCC P2 and P3 investment numbers are based on BloombergNEF estimates. Investment estimates are based on net additions and as such may underestimate investment levels.

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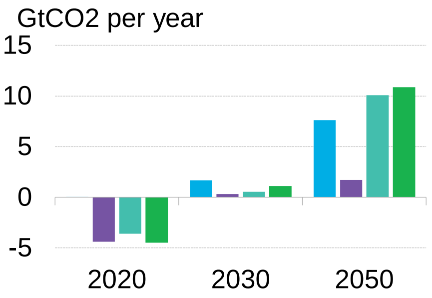
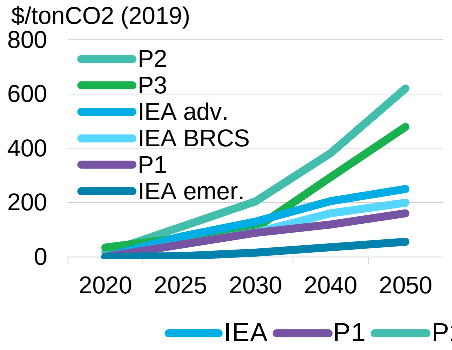
Reliance on carbon sequestration varies by scenario in magnitude and tech, but carbon price impacts the feasibility

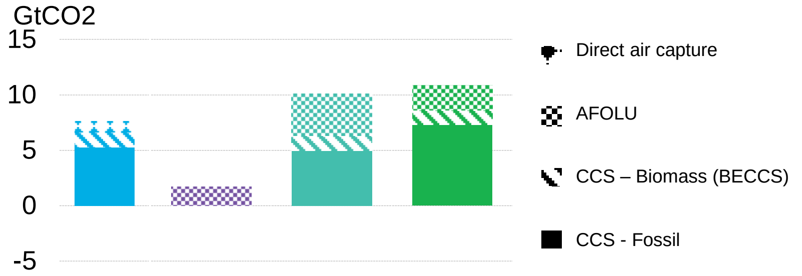
Total CO2 captured



Carbon price



By mode/technology in 2050

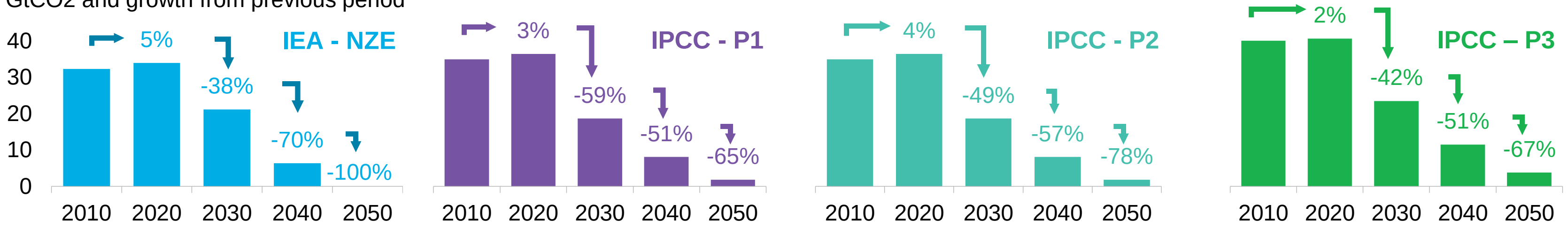


- The role of carbon sequestration varies greatly by scenario. The IEA does not rely on action in areas other than the energy sector, and as such does not employ agriculture, forestry or other land use (AFOLU) to sequester carbon. While in scenario P1 – AFOLU is the only form of sequestration included. The IEA scenario is the only scenario to explore the use of direct air capture (DAC).
- About 40% of the bioenergy used today is for the traditional use of biomass in cooking, such as wood or charcoal. This results in emissions – reflected here as a negative sequestration. The use of traditional biomass is phased out rapidly from 2020 to 2030 in all scenarios apart from P3.
- With the highest carbon prices of all scenarios, both P2 and P3 rely on carbon sequestration more than other scenarios.

Source: BloombergNEF, IEA, IPCC. Note: Negative sequestration comes from land use of Agriculture, Forestry and Other Land Use (AFOLU) -- a source of emissions due to solid biomass in 2020.

Summary

GtCO2 and growth from previous period



Investment from 2021 to 2030/ to 2050

IEA - NZE

- Fossil fuel supply: $5.4/ 10.3 trillion
- Renewable power: $10.0/ 29.6 trillion
- Transmission and distribution (T&D): $5.2/ 21.1 trillion
- Efficiency: $6.1/ 19.8 trillion

IPCC - P1

- Fossil fuel supply: $4.4/ 7.7 trillion
- Renewable power: $5.7/ 12.2 trillion
- T&D: $3.9 / 15.4 trillion

IPCC - P2

- Fossil fuel supply: $4.7/ 10.2 trillion
- Renewable power: $6.8/ 18 trillion

IPCC – P3

- Fossil fuel supply: $5.6/ 3.5 trillion
- Renewable power: $3.6/ 12.3 trillion

Fundamentals

IEA - NZE

- The largest population growth, and net zero by 2050. The second-best improvement in energy efficiency.
- Solar, biomass and wind lead supply. A significant role for nuclear.
- Relatively reliant on carbon sequestration, including DAC.

IPCC - P1

- The largest decline in demand, yet not net zero by 2050.
- Best improvement in CO2 per capita, but worst CO2 profile per joule.
- Solar, wind and biomass lead supply.
- Not reliant on carbon sequestration.

IPCC - P2

- Low population and high wealth rates.
- Not net zero by 2050, the second-worst improvement in CO2 per capita.
- Wind, oil and biomass lead supply.
- Heavily reliant on carbon sequestration - namely reforestation.

IPCC – P3

- The highest outright and per capita final energy demand level in 2050.
- Not net zero by 2050, second-best improvement in energy efficiency.
- Gas, biomass and wind lead supply.
- Heavily reliant on carbon sequestration – namely CCS for fossil fuels.

Source: BloombergNEF, IEA, IPCC. Note: Historic CO2 emissions vary by scenario. Investments are in 2019 $ terms. Fossil fuel investment includes upstream, midstream, downstream and transport. Renewables includes solar, wind, hydro, biomass, geothermal and hydrogen electricity generation capacity.

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Our expert coverage assesses pathways for the power, transport, industry, buildings and agriculture sectors to adapt to the energy transition.

We help commodity trading, corporate strategy, finance and policy professionals navigate change and generate opportunities.

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