Investment Needs of a 1.5°C World

Projected energy investment requirements under IPCC decarbonization scenarios

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BloombergNEF

Executive summary

As policy makers endeavor to keep global CO2 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 potential dollar ranges in scenarios from the IPCC ‘Climate Change 2022: Mitigation of Climate Change’, Working Group III contribution released in April 2022.

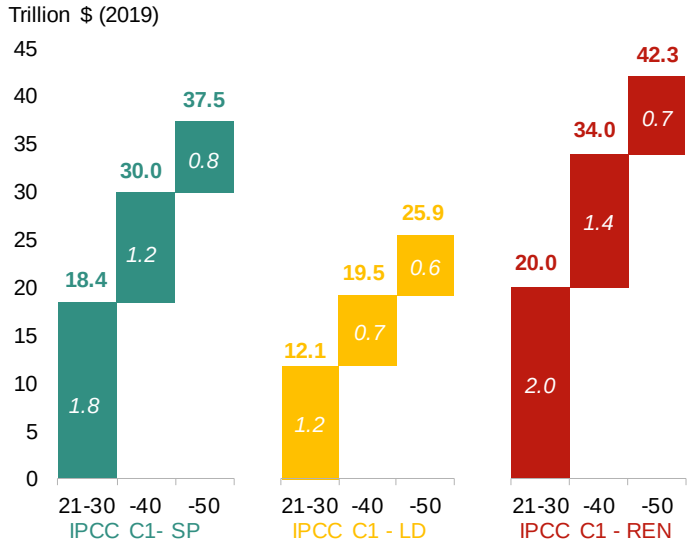
- This note evaluates three IPCC scenarios compatible with 1.5ºC rise from the recent Assessment Report 6. These are IPCC C1 – SP (Shifting Development), C1 – LD (Low Demand), and C1 – REN (Renewables) pathways. This is the sequel to an earlier note on other scenarios.
- Extrapolating from these three recent IPCC scenarios, BNEF pegs the required electricity and fossil fuel investment at $1.2-2.0 trillion per annum through 2030. Through 2050, capital needs range $1.1-1.4 trillion per year.
- Fossil fuel supply investment decelerates until 2050, although does not fully diminish. Oil stands to receive the most investment, followed by natural gas. Coal trails far, far behind. These trends follow those in previous IPCC pathways BNEF examined earlier.

$42.3 tr Projected 2021-2050 electricity and fossil fuel investments under the IPCC C1- REN scenario

$25.9 tr Projected 2021-2050 electricity and fossil fuel investments under the IPCC C1- LD scenario

$0.1-0.2tr Projected 2021-2050 investment for coal supply

Total electricity and fossil fuel supply investment 2021-2050



Source: BloombergNEF analysis of IPCC scenarios.

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Executive summary (continued)

- Under all scenarios analyzed, 2020-2030 fossil fuel investment remains similar to last decade's levels. Average annual investment in all scenarios stands around $0.2-0.9 trillion against an estimated $0.8 trillion across 2016-2020. However, the pathways diverge substantially post-2030. Under IPCC C1-LD, $0.1 trillion per annum is invested. Under IPCC C1-REN: $0.2-0.3 trillion.
- Investment in oil supply tracks at $0.6 trillion per annum to 2030 for C1-SP and C1-REN, up from $0.5 trillion/year from 2016-2020. It falls to $0.1-0.3 trillion/year to 2050.
- Investment in gas supply range $0.1-0.3 trillion per annum to 2030 across all scenarios, in line with the $0.2 trillion/year 2016-2020. It then declines to $0.1 trillion/year to 2050.
- Overall investment in coal supply falls close to $0.1-0.2 trillion after 2030, essentially stopping except for capital deployed to support maintenance of existing infrastructures.
- Renewables investment varies by scenario, but accounts for at least 75% of funds to be deployed in support of the electricity sector.
- Investment in renewable power ranges from $0.8 to $1.3 trillion per annum to 2030 across all scenarios. C1-REN leads the overall cumulative value to 2050 with $29.7 trillion, followed by $21.4 trillion by C1-SP.
- Overall electricity supply investment stands close to $1.0-1.3 trillion per annum for all the scenarios up until 2030. This falls to $0.5-1.1 trillion per annum until 2050.

June 21, 2022: Corrects fifth bullet point in executive summary (slide 2) to "up from $0.5 trillion/year" from "down from $0.5 trillion/year".

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 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".
- It does not seek to evaluate scenarios produced by non-intergovernmental bodies or those without delegated authority such as commercial organizations or universities.
- This work benefitted from correspondence with the IPCC. BNEF thanks them for their support but notes this reports is not endorsed by that organization.

BNEF has published research on three previous IPCC scenarios (P1, P2, and P3) and IEA Net Zero by 2050.

For more see (web | terminal).

Scenario Narrative

Shifting Development Pathway

IPCC C1 – SP

"The shifting development pathway aims to increase sustainability in the global society, by making strides to achieve the UN Sustainable Development Goals (SDGs) while meeting the 1.5 °C targets. This includes the interconnection of improved economic development, education, technological progress, less resource-intensive lifestyles, and most importantly climate policies. Policies will essentially shift the development pathway in pursuit of overall societal development objectives and additional sustainable development package, such as job creation, macro-economic stability, progressive redistribution of carbon pricing revenues, sufficient and healthy nutrition and improved access to modern energy.

Coordinated policy uptake however will require collaboration from multiple stakeholders, including individuals, groups and collectives, corporate actors, and institutions and infrastructure actors to deepen decarbonization initiatives and increase sustainability. Essentially, these interventions are grouped into six classes: development, resource efficiency and lifestyle change, ambitious climate change mitigation, international climate finance, national poverty alleviation programmes, and deepened shift in consumption patterns to include a more ambitious lifestyle shift in industrialized economies. Despite these targets, several gaps remain, including the eradication of extreme poverty."

Source: IPCC, Soergel et al., 2021

Scenario Narrative

Low Demand Scenario

IPCC C1 – LD

"This scenario offers a contrasting perspective to the others, which usually describes major growths in both the global energy supply and demand mixes. The narrative is based on observable trends that leads to a low energy demand, by quantifying changes in activity levels and energy intensity in the global North and global South through an integrated assessment modelling framework. Energy demand here reduces to 245 EJ per year by 2050, a 40% reduction than current levels, despite the population, income and activity levels increasing worldwide.

The down-sizing of the global energy system alleviates the prospect of low-carbon supply-side transformations and uptake, allowing to meet the 1.5°C climate target and many of the sustainable development goals, without depending on negative emission technologies."

Source: IPCC, Grubler et al., 2018

Scenario Narrative

High Renewables and Electrification

IPCC C1 – REN

"The cost of clean and sustainable energy technologies, such as photovoltaics, wind-power, and battery storage, will continue to fall faster than previously anticipated. The inclination of future climate policies to align with the Paris Climate targets will hike the cost of carbon-based fuels and reduce their supply. The narrative here lies in the rapid integration of solar and wind technologies, and carbon pricing to make the cost of electricity more feasible than its fossil fuels counterparts, and limit temperature rise to 1.5-2°C.

Simultaneously, the increased adoption of demand-side innovations such as e-mobility, and heat pumps, will lead to a global transformation of energy systems toward a dominance of electricity-based end uses. This scenario will incorporate electricity to account for 66% of its final energy by 2050, with limited reliance on bioenergy and carbon dioxide removal to reduce energy-related land and water requirements."

Source: IPCC, Luderer at al., 2021

Scenario overview

IPCC C1 – SP

- Below 1.5ºC with no or limited overshoot.
- **Ambitious climate policies**, as well as **economic development, education, technological progress and less resource-intensive lifestyles**.
- Gradual **fossil fuel phase-outs**.
- International climate finance, progressive redistribution of carbon pricing revenues, sufficient and healthy nutrition and improved access to modern energy.
- 180 million people **remain in extreme poverty** in 2030.

IPCC C1 – LD

- Below 1.5ºC with no or limited overshoot.
- Final energy demand by 2050 is **around 40% lower** than today, despite rising population, income and activity.
- **Down-sizing the global energy system** dramatically improves the feasibility of a low-carbon supply-side transformation.
- **Large reductions in future energy demand and rapid fossil fuel phase-outs** enabled by the use of best available technique and efficiency increase
- **Limited reliance** on negative emission technologies.

IPCC C1 – REN

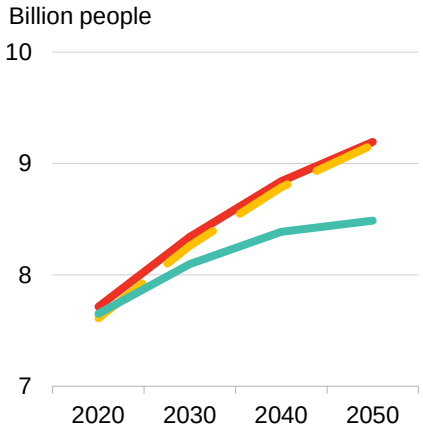
- Below 1.5ºC with no or limited overshoot.
- **Rapid phase out of fossil fuels, more moderate future energy demand** that is primarily met by renewables, plus more **limited deployment** of carbon direct removals (CDR).
- **Policy** to limit warming to 1.5–2°C will make carbon-based fuels scarce and expensive.
- **Demand-side innovation leads** to the dominance of electricity-based end uses, dominating 66% of final energy uses.
- **Low availability** of bioenergy and carbon removal technologies.

Soergel et al. 2021. Grubler et al. 2018 Luderer et al. 2021

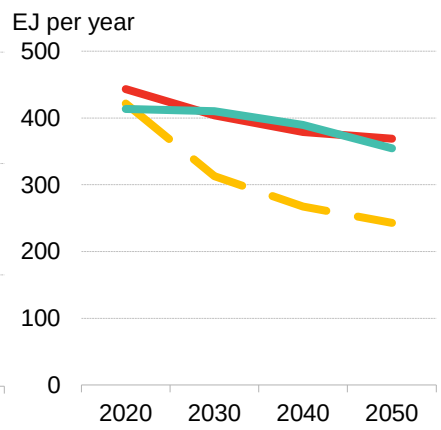
*Source: BloombergNEF, IPCC models **C1 SP:** REMIND-MAgPIE 2.1-4.2 SusDev_SDP-PkBudg1000, **C1 LD:** MESSAGEix-GLOBIOM 1.0 LowEnergyDemand_1.3_IPCC, **C1 Ren:** REMIND-MAgPIE 2.1-4.3 DeepElec_SSP2_ HighRE_Budg900*

Scenario assumptions

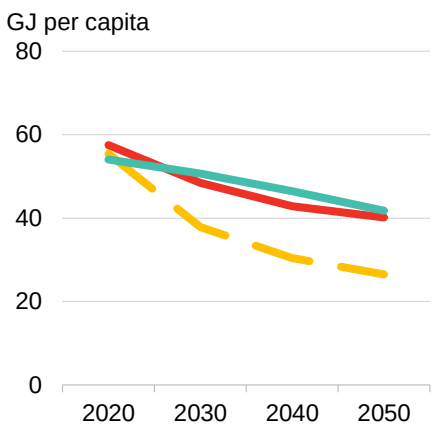
Population



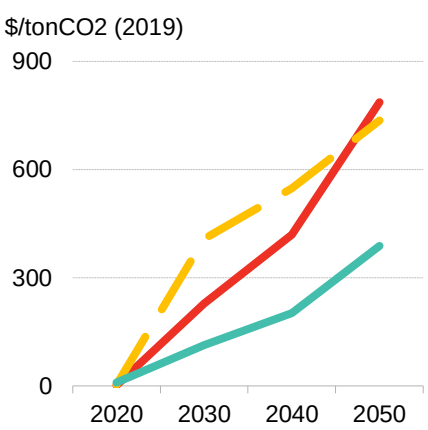
Energy demand



Energy demand per capita



Carbon price



Source: BloombergNEF, IPCC

IPCC - C1 Shifting Development (SP)

IPCC - C1 Low Demand (LD)

IPCC - C1 Renewables (REN)

- Population increases past 9 billion people in 2050 for C1-LD and C1-REN. C1-SP lags, with a population of 8.5 billion by 2050.
- Energy demand is relatively similar for C1-SP and C1-REN at 355-370 EJ per year, however C1-LD falls to 245 EJ per year by 2050, as the narrative focuses on demand reduction. Similar trends are observed for energy demand per capita.
- Carbon prices are highest for C1-REN and C1-LD, with a sharp increase for the former post 2040.

Methodology - investment

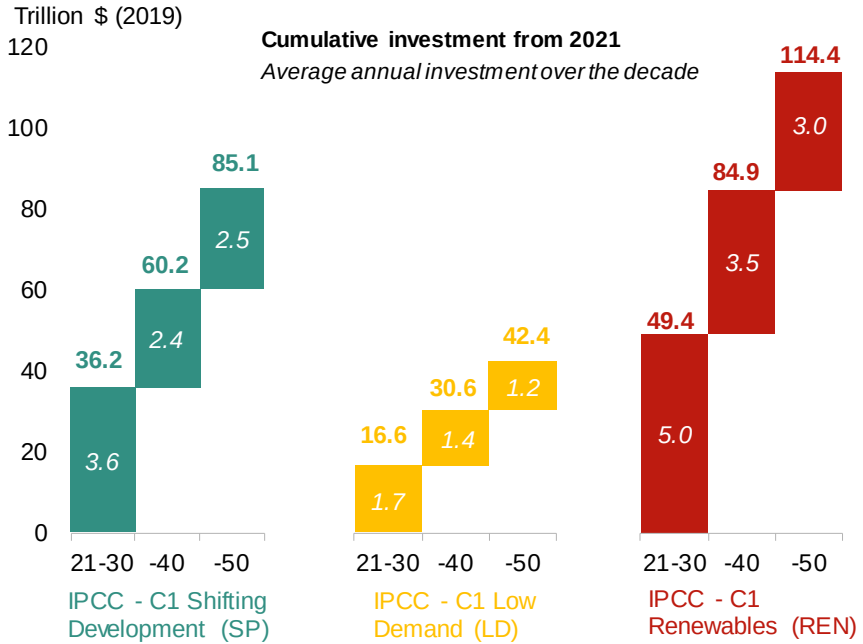
- Fossil fuel investment
  - **IPCC C1-LD**; Data is provided by the IPCC report for investment in $ 2010 terms. Values have been brought to $ 2019 terms based on historic and forecasted inflation levels from the IMF and BloombergNEF data.
  - **IPCC C1-SP and C1-REN**: Investment levels are derived based on dollars per joule of total fuel supplied. The $ value per joule is based on a proxy marginal cost of production, derived from the IEA Net Zero Emissions (NZE) scenario. 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 2041-50 in the C1-SP scenario lead to a different $ per joule investment versus the IEA NZE or the C1-LD scenarios over the same period - reflecting a different marginal cost of producing at that demand level.

- Renewable investment
  - **IPCC C1-LD** : Data is provided in the IPCC report for investment in $ 2010 terms. Values have been brought to $ 2019 terms based on historic and forecasted inflation levels from the IMF and BloombergNEF data.
  - **IPCC C1-SP and C1-REN** : The change in generating capacity by fuel type is translated into investment based on the respective IPCC scenario capital expenditures. Average annual capital expenditures were obtained through linear extrapolation for the decade. This method accounts for the net change in capacity, and does not account for the impact of technology retirements, and as such will underestimate investment levels. Values have been brought to $ 2019 terms based on historic and forecasted inflation levels from the IMF and BloombergNEF data.

Source: BloombergNEF, IEA, IPCC, IMF

C1-REN investment leads the way pre-2030 driven by rapid electrification, followed by C1-SP

Total energy infrastructure investment

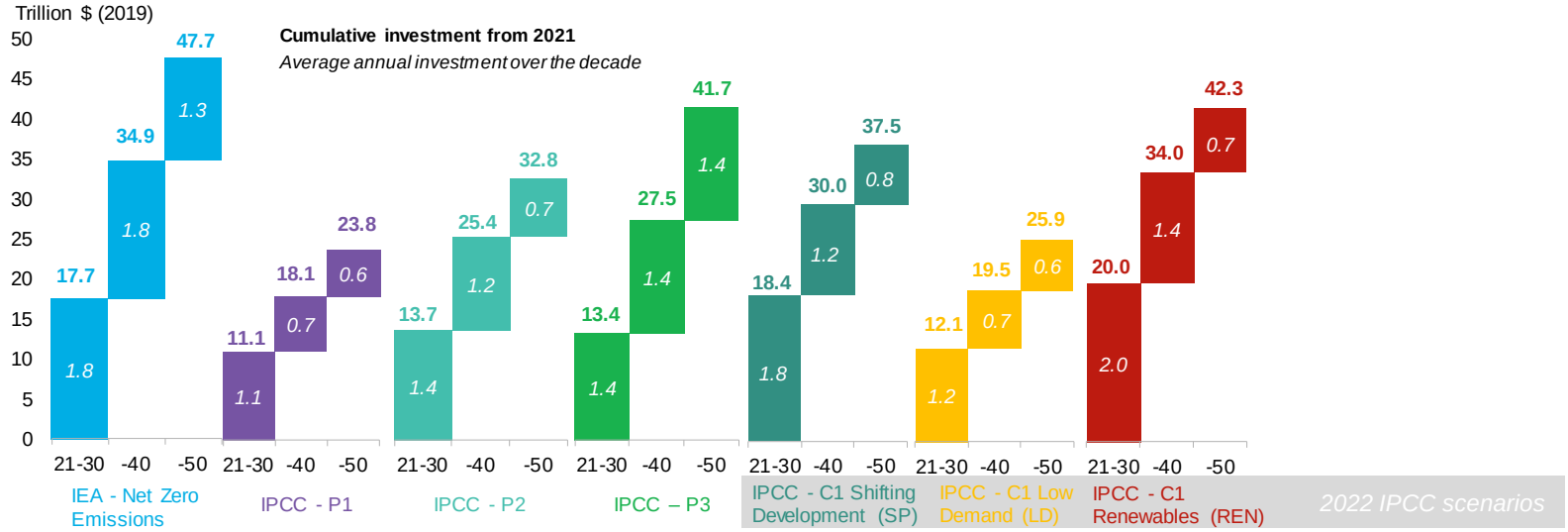


- Total annual investment in overall **energy supply, transmission and distribution is projected to range from $1.7 – 5.0 trillion per year from 2021-2030** across the three scenarios. Investment slows in the later years.
- The C1-REN scenario requires more investment than any other, due to the projected high level of energy demand and the significant focus on renewables in the near term, before costs decline.
- Overall investments in energy supply for C1-REN and C1-LD decelerates after 2030.
- Annual investment marginally increased from 2040 onwards for C1-SP, which focuses more on society making a greater shift toward sustainability.
- C1-LD has the lowest average annual investment and the lowest cumulative investment by 2050, as demand and the required generation capacity reduces by then. C1-LD has the lowest overall energy demand by 2050.

Source: BloombergNEF, IPCC. Note: Figures above includes electricity, storage, transmission and distribution (T&D), CCUS, hydrogen, and fossil fuel infrastructures data.

Electricity + fossil fuel investment remains in a narrow band to 2030

Total electricity and fossil fuel supply investment

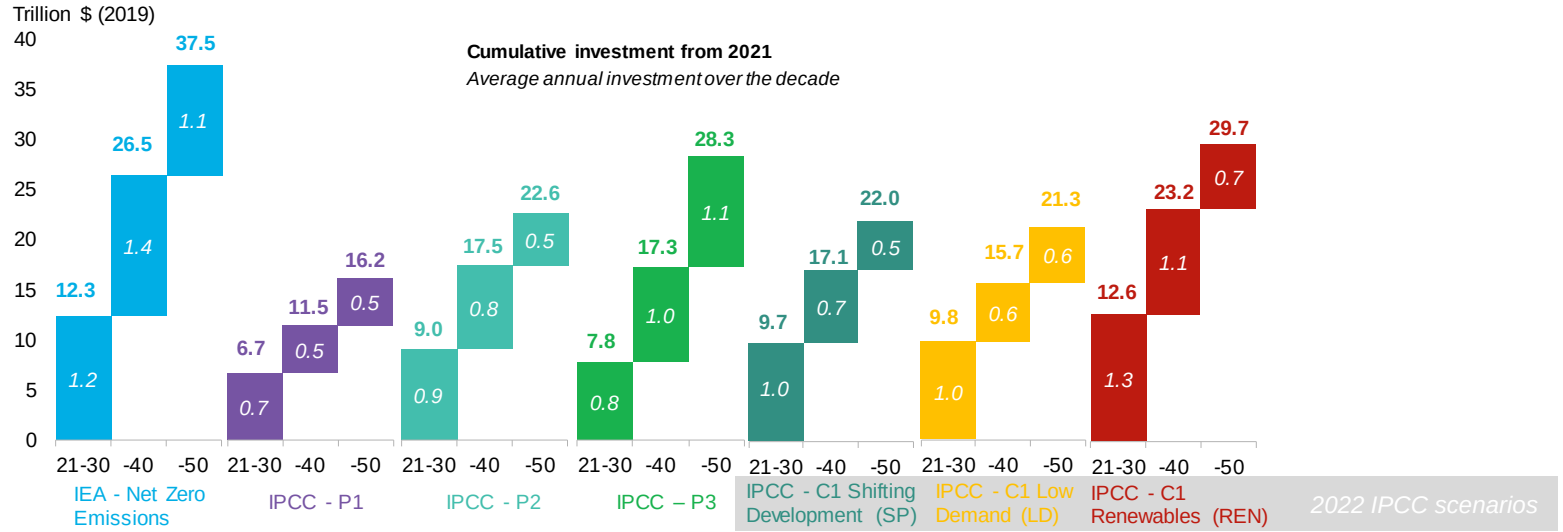


Source: BloombergNEF, IEA, IPCC. Note: C1-SP and C1-REN investment values are based on BloombergNEF estimates.

- Total annual investment in fossil fuels and electricity supply for the new IPCC scenarios is projected to range from **$1.2 – 2.0 trillion** from 2021-2030.
- As actual funds deployed averaged $1.3 trillion per year 2016-2020, such investment is expected to increase slightly for 2020-2030.
- C1-REN requires more investment than the other two C1 counterparts due to the high level of renewable technologies integrated into energy systems.
- Investment in fossil fuels and electricity supply decelerate after 2030, especially for C1-SP and C1-REN.

High renewables investment required by 2030 to decarbonize power supply

Total electricity supply investment



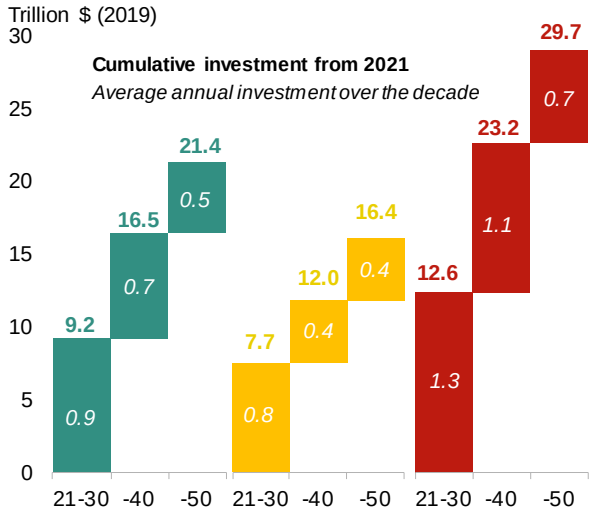
Source: BloombergNEF, IEA, IPCC. Note: C1-SP and C1-REN investment values are based on BloombergNEF estimates

- Average annual investment jumps in all scenarios from $0.5 trillion across 2016-2020.
- C1-REN has the highest cumulative investment by 2050 at $29.7 trillion, relying heavily on solar, especially until 2040. The annual **levelized cost of energy for solar drops 38% 2031-2040** versus the previous decade. Extensive electrification sees annual investment remain relatively high 2021-2040 before slowing.
- **C1-SP continuously employs gas**, although it prioritizes wind and solar later in the outlook as prices fall.
- **C1-LD sees high investment by 2030** as wind and solar capacities scale. Wind's levelized cost is 2.6 times higher than solar's 2021-2030. C1-LD's reliance on wind in the 2020s means overall investment almost matches C1-SP despite having far less energy demand in 2050.

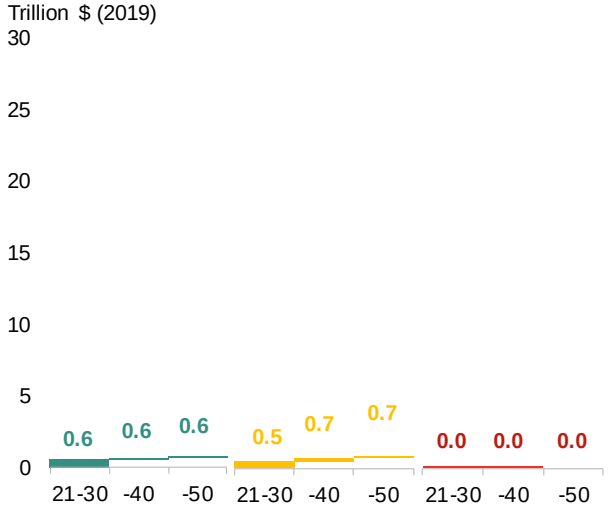
Renewables are the focus of electricity supply investment. Fossil fuel investment remains minimal

Electricity supply investment by fuel

Renewables investment



Fossil fuels investment



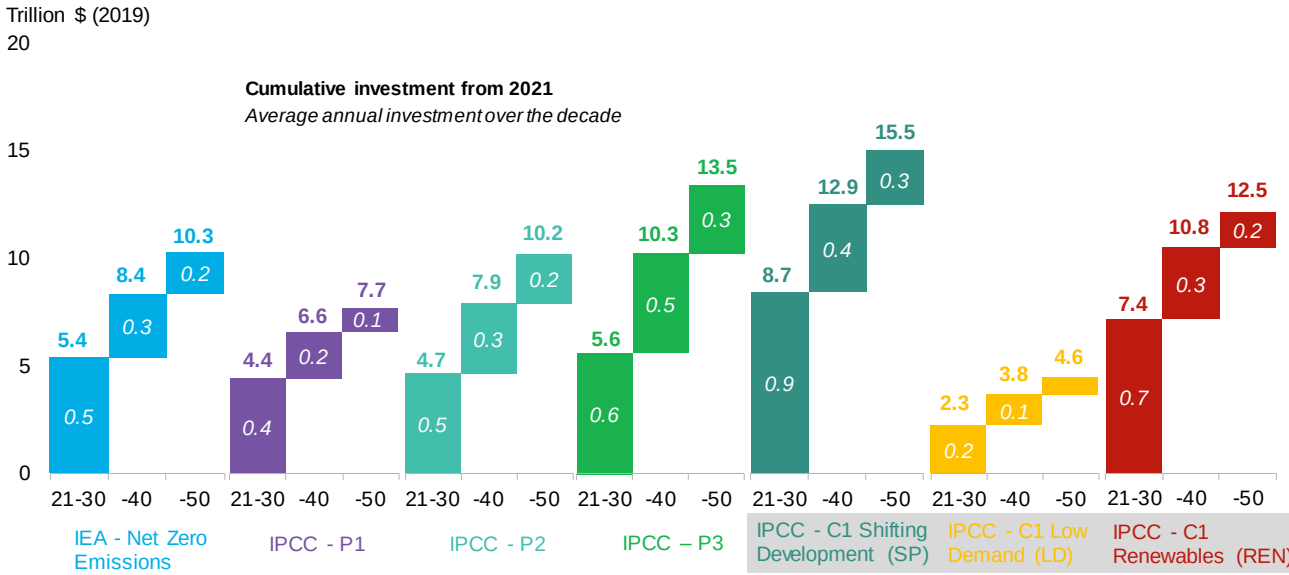
- Renewables account for over 95% of the total electricity supply investment under C1-SP and C1-REN, reaching cumulative values of **$21.4 and $29.7 trillion** respectively.
- C1-REN fossil fuel-based electricity investment nears zero by 2050.
- The average annual investment in renewable-based electricity stays relatively constant from 2030 to 2050 for C1-LD, totalling **$16.4 trillion** by 2050. This is due to fast changes in the main end-use sectors like transport, shifting to electricity.

IPCC - C1 Shifting Development (SP) | IPCC - C1 Low Demand (LD) | IPCC - C1 Renewables (REN)

Source: BloombergNEF. IPCC. Note: Investment values has been adjusted to 2019 values from 2010 values. Renewables includes hydro, geothermal, biomass, wind, and solar. Nuclear and storage investments are not shown here. Investment estimates are based on net additions and as such may underestimate investment levels.

Fossil fuel extraction requires investment but declines sharply post-2030

Total fossil fuels supply investment



- C1-SP sees the highest total investment in fossil fuel extraction, with a cumulative **$15.5 trillion invested** by 2050, due to its heavy reliance on oil and gas.
- Oil supply investment accounts for more than half of overall fossil fuel investment across all C1 scenarios, ranging from **$2.5 trillion to $10.3 trillion** by 2050.
- Coal investment declines in all scenarios, but does not disappear, ranging from **$0.1 to $0.2** trillion by 2050.
- Investment diverges across scenarios, but **investment pre-2030 accounts for the largest share across all scenarios.**

Source: BloombergNEF, IEA, IPCC. Note: C1-SP and C1-REN investment numbers are based on BloombergNEF estimates derived from IEA data. Includes upstream, and midstream (liquids)

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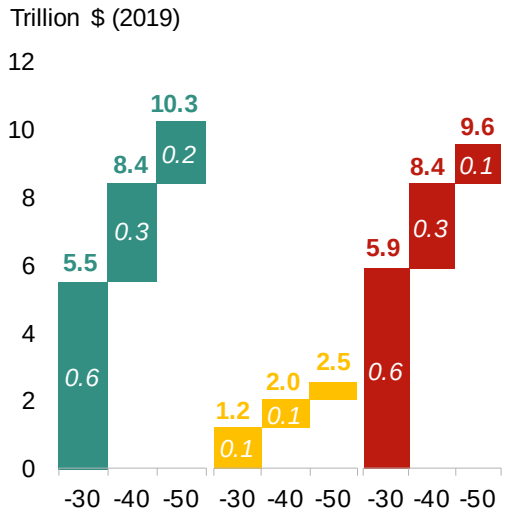
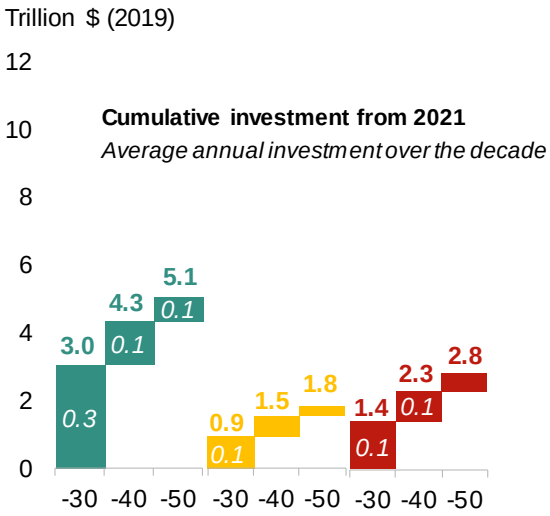
Oil supply dominates fossil fuel investment. Coal investment dries up in all scenarios

Total fossil fuels supply investment by fuel

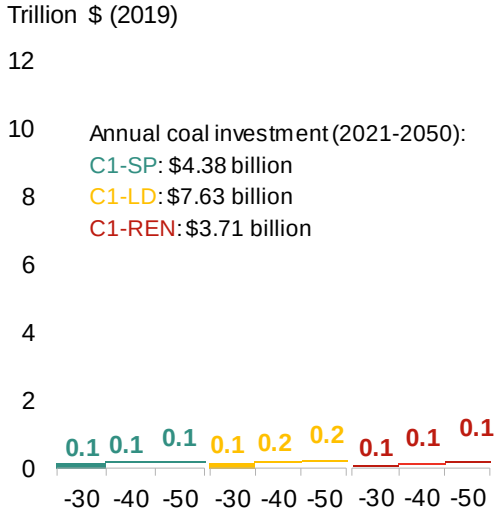
Oil supply investment



Gas supply investment



Coal supply investment



IPCC - C1 Shifting Development (SP) | IPCC - C1 Low Demand (LD) | IPCC - C1 Renewables (REN)

Source: BloombergNEF, IEA, IPCC. Note: C1-SP and C1-REN investment numbers are based on BloombergNEF estimates derived from IEA data. Includes upstream, and midstream (liquids)

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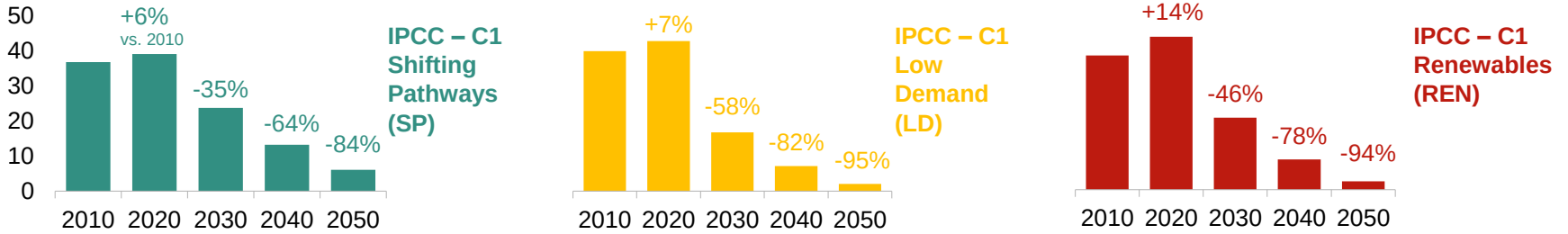
Summary

GtCO2 and change indexed to 2010



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

Investment from 2021-2030/ 2021-2050

- Oil supply: $5.5/ 10.3 trillion
- Gas fuel supply: $3.0/ 5.1 trillion
- Coal fuel supply: $0.1/ 0.1 trillion
- Renewable power: $9.2/ 21.4 trillion

- Oil supply: $1.2/ 2.5 trillion
- Gas fuel supply: $0.9/ 1.8 trillion
- Coal fuel supply: $0.1/ 0.2 trillion
- Renewable power: $7.7/16.4 trillion
- T&D: $4.5/ 15.5 trillion

- Oil supply: $5.9/ 9.6 trillion
- Gas fuel supply: $1.4/ 2.8 trillion
- Coal fuel supply: $0.1/ 0.1 trillion
- Renewable power: $12.6/ 29.7 trillion

Fundamentals

- Highest emissions per year by 2050.
- Oil plays a major role in total energy supply, alongside solar and wind after 2030.
- Solar capacity accounts for more than 60% of 2050's overall capacity.
- Solar and wind dominate electricity mix by 2050.

- The largest decline in demand, yet not net zero by 2050.
- Lowest final energy demand and energy intensity by 2050.
- Wind, solar and biomass lead total energy supply, as oil's role decline.
- Wind, solar, nuclear and hydro dominate 2050's electricity mix.

- The highest total energy supply by 2050.
- Solar capacity accounts for more than 60% of 2050's overall capacity.
- High emphasis on solar for energy supply, followed by wind and biomass.
- Highest total consumption from 2020-2050.

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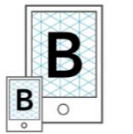

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