# Progress and Challenges in Climate Change Mitigation since the Paris Agreement

Biying Yu[1], Shanglin Yang[1], Chengyao Zhang[1], Glen Peters[2], Monica Crippa[3], William Lamb[4], Klaus Hubacek[5]

[1] Center for Energy and Environmental Policy Research, Beijing Institute of Technology, Beijing, China
[2] Center for International Climate Research, Oslo, Norway
[3] Joint Research Centre, European Commission, Ispra, Italy
[4] Department of Climate Economics and Policy, Potsdam Institute for Climate Impact Research, Potsdam, Germany
[5] Faculty of Science and Engineering, University of Groningen, Groningen, the Netherlands

2026 marks the tenth anniversary of the Paris Agreement's entry into force. During this period, countries have adopted emissions reduction and net-zero targets, strengthened energy efficiency standards, and supported renewable energy deployment and vehicle electrification, aiming to slow fossil $CO_2$ emissions growth and ultimately meet global temperature goals. Yet the extent to which these efforts have translated into mitigation progress, and the elements that continue to constrain emissions reductions, remain insufficiently understood. This report applies an extended Kaya identity to examine the drivers of $CO_2$ emissions from fossil fuel combustion, namely population, economic growth (measured by GDP per capita), energy efficiency (by energy intensity), energy structure (by fossil fuel share), and fossil fuel carbon intensity. Using logarithmic mean Divisia index (LMDI) decomposition, we quantify each factor's contribution to emissions changes before (2006 - 2015) and after (2016 - 2025) the Paris Agreement, comparing global and regional totals alongside developments in energy systems, industry, buildings and transport. By identifying where mitigation has advanced and which drivers continue to sustain emissions growth, the analysis clarifies the progress achieved and the challenges that remain, providing an empirical basis for future climate policy.

**Table | Drivers of global, regional and sectoral fossil fuel combustion $CO_2$ emissions.** The standard Kaya identity is extended by splitting energy carbon intensity into fossil fuel share and fossil fuel carbon intensity to capture the replacement of fossil energy with non-fossil energy and shifts from higher-carbon to lower-carbon fossil fuels (Peters et al., 2017). Factor contributions are quantified using logarithmic mean Divisia index (LMDI) decomposition, as applied by Le Quéré et al. (2019). GDP per capita is defined as GDP/population, energy intensity as total energy/GDP, fossil fuel share (energy structure) as fossil energy/total energy, and fossil fuel carbon intensity as $CO_2$/fossil energy. The boundary for each sector follows Lamb et al. (2021), with emissions from industry, transport and buildings are direct emissions. The decomposition includes only $CO_2$ emissions from fossil fuel combustion to ensure consistency with the underlying energy data. Regional data are aggregated from national data, with regional definitions consistent with AR6 (IPCC, 2022). All sectoral decompositions use population and GDP totals for the corresponding region or the world, as these quantities cannot be meaningfully allocated to individual sectors(Lamb et al., 2021) Values in cells represent the compound annual growth rate (CAGR) calculated following IPCC (2022). The labels "$v < 0.1$" indicates a positive effect with a value below 0.1, and "$|v| < 0.1$" indicates a negative effect with an absolute value below 0.1. (All the results will be updated to 2025 when data is available.)

| Geography / sector | $CO_2$ emissions | | Population | | GDP per capita | | Energy intensity | | Fossil fuel share | | Fossil fuel carbon intensity | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Global total** | 2006-2015 | 2016-2025 | 2006-2015 | 2016-2025 | 2006-2015 | 2016-2025 | 2006-2015 | 2016-2025 | 2006-2015 | 2016-2025 | 2006-2015 | 2016-2025 |
| World | +1.7 | +0.9 | +1.3 | +1.0 | +1.4 | +1.7 | −1.1 | −1.2 | v<0.1 | −0.3 | v<0.1 | −0.2 |
| **Global sectors** | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 |
| Energy systems | +1.8 | +1.8 | +1.3 | +1.0 | +1.4 | +1.7 | −0.9 | −0.3 | \|v\|<0.1 | −0.6 | \|v\|<0.1 | \|v\|<0.1 |
| Industry | +2.2 | −0.1 | +1.3 | +1.0 | +1.4 | +1.7 | −0.8 | −1.1 | −0.2 | −1.3 | +0.5 | −0.4 |
| Transport | +1.7 | +1.1 | +1.3 | +1.0 | +1.4 | +1.7 | −0.8 | −1.3 | −0.2 | −0.2 | \|v\|<0.1 | \|v\|<0.1 |
| Buildings | +0.2 | −0.4 | +1.3 | +1.0 | +1.4 | +1.7 | −1.8 | −1.7 | −0.5 | −0.9 | −0.2 | −0.5 |
| **Region total** | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 |
| Africa | +3.3 | +1.1 | +2.6 | +2.4 | +2.0 | +0.5 | −1.6 | −0.8 | +0.2 | −0.3 | v<0.1 | −0.7 |
| A. Pacific | \|v\|<0.1 | −2.0 | +0.2 | \|v\|<0.1 | +0.6 | +0.8 | −2.2 | −1.9 | +1.2 | −1.0 | +0.2 | v<0.1 |
| E. Asia | +4.6 | +2.3 | +0.6 | +0.2 | +7.7 | +5.1 | −3.4 | −1.7 | +0.2 | −0.4 | −0.2 | −0.7 |
| Eurasia | −0.5 | +1.2 | +0.3 | v<0.1 | +1.9 | +1.9 | −2.4 | −0.3 | −0.2 | v<0.1 | \|v\|<0.1 | −0.5 |
| Europe | −1.8 | −2.1 | +0.4 | +0.3 | +0.5 | +1.3 | −2.0 | −2.6 | −0.8 | −0.8 | +0.1 | −0.3 |
| Latin Am. | +2.5 | −0.6 | +1.1 | +0.8 | +1.6 | v<0.1 | −0.6 | −0.5 | v<0.1 | −0.8 | +0.4 | \|v\|<0.1 |
| Middle E. | +3.7 | +2.0 | +2.5 | +1.9 | +1.5 | +0.5 | \|v\|<0.1 | −0.2 | v<0.1 | −0.2 | −0.3 | v<0.1 |
| N. America | −1.3 | −1.2 | +1.0 | +0.7 | +0.5 | +1.7 | −2.0 | −2.2 | −0.3 | −0.2 | −0.5 | −1.1 |
| S.E. Asia | +4.3 | +4.0 | +1.3 | +0.9 | +3.9 | +2.9 | −2.2 | −0.2 | +0.4 | \|v\|<0.1 | +0.8 | +0.5 |
| S. Asia | +6.5 | +3.7 | +1.4 | +1.1 | +4.9 | +4.4 | −1.4 | −2.2 | +1.0 | v<0.1 | +0.5 | +0.5 |
| **Energy system by region** | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 |
| Africa | +3.0 | \|v\|<0.1 | +2.6 | +2.4 | +2.0 | +0.5 | −1.2 | −1.8 | −0.2 | −0.4 | −0.3 | −0.7 |
| A. Pacific | +1.5 | −2.6 | +0.2 | \|v\|<0.1 | +0.6 | +0.8 | −2.3 | −1.4 | +3.3 | −2.4 | −0.2 | +0.3 |
| E. Asia | +5.2 | +4.7 | +0.6 | +0.2 | +7.7 | +5.1 | −2.4 | +0.5 | −0.7 | −0.9 | +0.1 | −0.1 |
| Eurasia | −1.6 | +0.9 | +0.3 | v<0.1 | +1.9 | +1.9 | −2.9 | −0.9 | −0.5 | v<0.1 | −0.4 | −0.1 |
| Europe | −2.4 | −5.3 | +0.4 | +0.3 | +0.5 | +1.3 | −1.8 | −3.2 | −1.9 | −3.3 | +0.4 | −0.5 |
| Latin Am. | +4.2 | −2.1 | +1.1 | +0.8 | +1.6 | v<0.1 | +0.7 | −0.2 | +0.8 | −2.2 | −0.1 | −0.5 |
| Middle E. | +4.2 | +2.3 | +2.5 | +1.9 | +1.5 | +0.5 | +0.2 | +0.8 | v<0.1 | −0.5 | −0.1 | −0.4 |
| N. America | −2.3 | −3.1 | +1.0 | +0.7 | +0.5 | +1.7 | −2.1 | −3.0 | −0.8 | −1.0 | −0.9 | −1.5 |
| S.E. Asia | +6.6 | +5.8 | +1.3 | +0.9 | +3.9 | +2.9 | +0.3 | +1.8 | +0.2 | −0.6 | +0.8 | +0.7 |
| S. Asia | +6.5 | +4.5 | +1.4 | +1.1 | +4.9 | +4.4 | −0.4 | −0.9 | \|v\|<0.1 | −0.6 | +0.5 | +0.5 |
| **Industry by region** | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 |
| Africa | +0.8 | +2.6 | +2.6 | +2.4 | +2.0 | +0.5 | −3.6 | −1.2 | −0.3 | +0.8 | +0.2 | \|v\|<0.1 |
| A. Pacific | −1.5 | −1.7 | +0.2 | \|v\|<0.1 | +0.6 | +0.8 | −2.4 | −2.0 | −0.3 | −0.4 | +0.4 | −0.2 |
| E. Asia | +3.8 | −1.2 | +0.6 | +0.2 | +7.7 | +5.1 | −3.7 | −3.1 | −1.1 | −2.6 | +0.6 | −0.6 |
| Eurasia | +2.2 | +0.3 | +0.3 | v<0.1 | +1.9 | +1.9 | −2.5 | −1.2 | +2.0 | −0.7 | +0.5 | +0.2 |
| Europe | −2.6 | −0.6 | +0.4 | +0.3 | +0.5 | +1.3 | −2.4 | −2.2 | −1.1 | −0.4 | −0.1 | +0.4 |
| Latin Am. | +0.2 | −1.3 | +1.1 | +0.8 | +1.6 | v<0.1 | −1.8 | −0.2 | −0.4 | −1.2 | −0.1 | −0.7 |
| Middle E. | +5.4 | +1.7 | +2.5 | +1.9 | +1.5 | +0.5 | +1.9 | −0.5 | +0.2 | −0.5 | −0.7 | +0.3 |
| N. America | −1.3 | +0.3 | +1.0 | +0.7 | +0.5 | +1.7 | −2.5 | −1.8 | +0.5 | +0.2 | −0.8 | −0.5 |
| S.E. Asia | +0.7 | +3.1 | +1.3 | +0.9 | +3.9 | +2.9 | −3.4 | −0.3 | −1.2 | −1.0 | +0.1 | +0.6 |
| S. Asia | +7.1 | +2.7 | +1.4 | +1.1 | +4.9 | +4.4 | −0.7 | −1.3 | +0.6 | −1.2 | +0.7 | −0.2 |
| **Buildings by region** | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 |
| Africa | +2.5 | +0.6 | +2.6 | +2.4 | +2.0 | +0.5 | −2.1 | −0.6 | +0.4 | −0.7 | −0.4 | −1.0 |
| A. Pacific | −2.1 | −2.4 | +0.2 | \|v\|<0.1 | +0.6 | +0.8 | −1.7 | −2.0 | −1.2 | −1.2 | \|v\|<0.1 | \|v\|<0.1 |
| E. Asia | +2.5 | −2.3 | +0.6 | +0.2 | +7.7 | +5.1 | −6.2 | −3.1 | +1.8 | −3.0 | −0.9 | −1.3 |
| Eurasia | −0.3 | +2.3 | +0.3 | v<0.1 | +1.9 | +1.9 | −1.8 | \|v\|<0.1 | \|v\|<0.1 | +0.6 | −0.6 | −0.2 |
| Europe | −2.0 | −1.8 | +0.4 | +0.3 | +0.5 | +1.3 | −1.6 | −2.4 | −1.3 | −1.0 | \|v\|<0.1 | v<0.1 |
| Latin Am. | +1.6 | +0.1 | +1.1 | +0.8 | +1.6 | v<0.1 | −0.7 | +0.4 | −0.8 | −0.6 | +0.4 | −0.4 |
| Middle E. | +0.5 | +3.2 | +2.5 | +1.9 | +1.5 | +0.5 | −0.8 | +0.6 | −1.6 | −0.1 | −1.2 | +0.4 |
| N. America | −0.2 | −0.6 | +1.0 | +0.7 | +0.5 | +1.7 | −1.1 | −2.2 | −0.3 | −0.3 | −0.4 | −0.3 |
| S.E. Asia | +0.7 | +0.3 | +1.3 | +0.9 | +3.9 | +2.9 | −4.3 | −2.1 | −0.6 | +0.3 | +0.5 | −1.6 |
| S. Asia | +2.7 | +2.4 | +1.4 | +1.1 | +4.9 | +4.4 | −3.9 | −3.9 | +1.0 | +1.0 | −0.7 | \|v\|<0.1 |
| **Transport by region** | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 | 2006-2015 | 2016-2024 |
| Africa | +5.6 | +2.0 | +2.6 | +2.4 | +2.0 | +0.5 | +0.8 | −0.8 | v<0.1 | v<0.1 | v<0.1 | −0.2 |
| A. Pacific | −0.9 | −0.7 | +0.2 | \|v\|<0.1 | +0.6 | +0.8 | −1.7 | −1.6 | \|v\|<0.1 | \|v\|<0.1 | v<0.1 | +0.1 |
| E. Asia | +6.6 | +2.6 | +0.6 | +0.2 | +7.7 | +5.1 | −1.4 | −2.0 | \|v\|<0.1 | −0.3 | −0.2 | −0.1 |
| Eurasia | +0.5 | +2.1 | +0.3 | v<0.1 | +1.9 | +1.9 | −1.9 | −0.5 | v<0.1 | v<0.1 | +0.2 | +0.6 |
| Europe | −0.4 | +0.3 | +0.4 | +0.3 | +0.5 | +1.3 | −1.1 | −1.1 | −0.3 | −0.2 | v<0.1 | \|v\|<0.1 |
| Latin Am. | +2.8 | +0.5 | +1.1 | +0.8 | +1.6 | v<0.1 | +0.7 | v<0.1 | −0.6 | −0.3 | \|v\|<0.1 | \|v\|<0.1 |
| Middle E. | +3.8 | +1.0 | +2.5 | +1.9 | +1.5 | +0.5 | −0.2 | −1.2 | \|v\|<0.1 | \|v\|<0.1 | \|v\|<0.1 | \|v\|<0.1 |
| N. America | −0.6 | \|v\|<0.1 | +1.0 | +0.7 | +0.5 | +1.7 | −1.6 | −2.0 | −0.4 | −0.3 | \|v\|<0.1 | −0.1 |
| S.E. Asia | +5.2 | +2.3 | +1.3 | +0.9 | +3.9 | +2.9 | +0.3 | −0.5 | −0.3 | −0.7 | −0.1 | −0.3 |
| S. Asia | +8.1 | +3.5 | +1.4 | +1.1 | +4.9 | +4.4 | +1.7 | −1.4 | v<0.1 | −0.3 | \|v\|<0.1 | −0.2 |

CAGR (% $yr^{-1}$) −7 −4 0 +4 +9

During 2016 - 2025 (post-Paris), growth in global fossil $CO_2$ emissions slowed markedly, with the average annual growth rate declining to 0.9% from 1.7% in 2006-2015. Economic growth (measured as GDP per capita) remained the strongest upward driver of fossil $CO_2$ emissions in the last decade, with intensified impact on $CO_2$ emissions growth compared to 2006-2015. Over the same period, the population effect on emissions growth declined by 0.3% $yr^{-1}$. Global energy intensity continued to improve, decreased by 1.2% $yr^{-1}$ between 2016 – 2025. Meanwhile, the effects of energy structure and carbon intensity shifted from increasing emissions in 2006 – 2015 to decreasing emissions in 2016 – 2025, contributing 1.1Gt and 0.7Gt reductions over this period, respectively. Together, the three emissions reducing factors offset about two-thirds of the emissions increase caused by population and economic growth, indicating stronger decoupling between emissions and economic activity (*high confidence*). Rapid renewable energy expansion due to improving cost competitiveness accelerate these shifts: the combined share of wind and solar PV of global electricity generation increased from about 5% in 2015 to 17% in 2025 (IEA, 2026), while global weighted-average levelized costs of electricity for new utility-scale solar PV and onshore wind fell by 90% and 70%, respectively, between 2010 and 2024 (IRENA, 2025). Global cost reductions were driven by economies of scale and sustained innovation across the entire supply chain, with China's rapid expansion of manufacturing capacity and technology improvement serving as key contributing factors (Helveston et al., 2022; IEA, 2022).

Regionally, energy intensity declined across all regions; in contrast, changes in energy structure and carbon intensity varied in the targeted two periods (*high confidence*). Although fossil $CO_2$ emissions continued to increase in Africa, East Asia, Middle East, South-East Asia and South Asia during 2016 - 2024, growth rates declined substantially relative to 2006–2015. The largest slowdown occurred in South Asia and East Asia. East Asia recorded the fastest energy structure shift among regions with increasing emissions, driven by the rapid deployment of renewables, especially in China (IRENA, 2025). Its coal share in fossil fuels also accelerated to decline, together with increased energy efficiency. The slower emissions growth in South Asia is manly driven by the improvement in energy efficiency and the decelerated growth in fossil fuel share. In Africa, private clean energy investment rose by more than 2 times since 2019 (IEA, 2025b), and this expansion provides context for its more diversified emissions reducing drivers, with improvement of energy structure and carbon intensity together contributing a reduction of 104 Mt over the period, compared with 78 Mt from energy intensity reduction. Declining fossil fuel share also supported slower emissions growth in the Middle East and South-East Asia. Eurasia shifted from net emissions reductions in the previous period to emissions growth due to more fossil energy consumption and slower improvements in energy intensity. All other regions not mentioned above achieved net emissions reductions. Notably, Australia, Japan and New Zealand showed the most pronounced improvement in energy structure, transitioning from net contributors to emissions growth to net enablers of emissions reduction. With a substantial hydropower base and continued renewable expansion led by solar deployment (IEA, 2024), Latin America and the Caribbean showed a clear transition from emissions growth to decline. In Europe and North America, the emissions reduction was dominated by accelerated decline of energy intensity, while the energy structure improvement stabilized in Europe and decelerated in North America.

Progress in fossil $CO_2$ emissions reduction varied across sectors. Relative to the 2006–2015 period, the most pronounced improvement in emissions performance occurred in the industrial sector, followed by the buildings sector, both of which shifted from emission increase to decrease. Improvement of energy intensity, energy structure and carbon intensity all contributed to emissions reductions. Emissions in energy and transport sectors are still increasing at 1.8% $yr^{-1}$ and 1.1% $yr^{-1}$, respectively. Slower emission growth in transport sector relied mainly on energy intensity improvement. For energy systems, non-fossil energy penetration speeded up, but economic growth continued to drive substantial emissions increases, limiting the emission reductions from this substitution.

For energy systems, during 2016 - 2024, Europe and North America sustained absolute emissions reductions with accelerated improvement of energy intensity, energy structure, and carbon intensity. Africa, Australia, Japan and New Zealand, and Latin America and the Caribbean shifted from emissions growth to decline, with declining energy intensity and a shift away from fossil fuel as common drivers. Emissions growth slowed in East Asia, the Middle East, South Asia and South-East Asia by 0.5 - 2.0%

$yr^{-1}$ relative to 2006 - 2015. In East Asia, energy intensity rebounded by 0.5% $yr^{-1}$, which was chiefly attributable to an expansion of renewable energy use, but improvements in energy structure and carbon intensity offset the emissions impact of this rebound. In South-East Asia and the Pacific, rising energy intensity partly counteracted the benefits of a declining fossil fuel share. South Asia, by contrast, experienced improvements in both energy intensity and energy structure, but increasing carbon intensity weakened their combined effect on emissions reduction. Eurasia shifted from net emissions reductions in the previous period to emissions growth mainly due to the increased fossil energy consumption and decelerated improvement in energy intensity and carbon intensity.

For industry, East Asia showed the largest improvement among all regions, with its annual direct emissions growth rate declining from 3.8% $yr^{-1}$ during 2006-2015 to -1.2% $yr^{-1}$ during 2016 - 2024. Accelerated electrification and switch from coal to gas is the main driver. Latin America and the Caribbean also shifted from growth to decline, driven by similar factors as East Asia. The direct industrial emissions reduction in Europe slowed, due to faster growth of GDP per capita, weaker improvements in energy structure, and a rebound of carbon intensity. North America shifted from emission reducing region in 2006-2015 to emission increasing region in 2016 – 2024, driven by economic growth and increasing fossil fuel consumption. Industrial emissions continued to grow in South Asia, the Middle East, and Eurasia, however, growth rates slowed. In South Asia, the improvement of energy efficiency accelerated, and energy structure and fossil energy carbon intensity shifted from contributing to emissions growth to emissions reductions in post-Paris period. In the Middle East, both energy intensity and energy structure shifted from net drivers of increasing industrial emissions to net contributors to their reduction; however, this progress was counterbalanced by a rise in carbon intensity. Emissions growth also accelerated in Africa and South-East Asia.

For buildings, the improvement was the most pronounced in East Asia, where direct emissions shifted from growth of 2.5% $yr^{-1}$ in 2006-2015 to a decline of 2.3% $yr^{-1}$ in 2016 - 2024. Europe and Australia, Japan and New Zealand maintained the trends of emission reduction. Among regions where emissions continued to grow, Africa, and Latin America and the Caribbean made good progress, with annual emissions growth rates declining by about 1.9% and 1.5%. In Africa, improvement of energy structure and carbon intensity contributed nearly three-quarters of the emissions reduction; and the slowdown in Latin America and the Caribbean is mostly due to the decelerated economic growth and declining carbon intensity. South-East Asia made progress in reducing carbon intensity, but its fossil fuel share increased. South Asia is still experiencing a high emission growth in buildings, mostly driven by the increasing fossil fuel share and rebounded carbon intensity. By contrast, direct emissions in buildings accelerated to grow in the Middle East and is rebounded in Eurasia relative to 2006-2015.

For transport, during 2016 - 2024, the direct emissions in majority of regions are still increasing. Australia, Japan and New Zealand and North America represent two exceptions; however, decelerated emissions reduction relative to the 2006-2015 are observed, especially North America (near to zero). Europe transitioned from being a net enabler of transport emissions reduction during 2006–2015 to a net contributor to emissions growth during 2016–2024, most due to the accelerated economic growth and decelerated fuel shift. The largest progress was saw in South Asia and East Asia, where annual growth rates declined by about 4.6% $yr^{-1}$ and 4.0% $yr^{-1}$ compared with the previous period, respectively. These regions show greater fuel efficiency improvement and expanding vehicle electrification. For example, China's new energy vehicle fleet had reached 31.4 million by 2024 (National Bureau of Statistics of China, 2025), with electric passenger-car sales exceeded 11 million in 2024, accounting for nearly half of domestic new passenger-car sales and almost two-thirds of global electric car sales (IEA, 2025a). India tightened passenger-car fuel consumption standards in 2022, while electric models accounted for 57% of new three-wheeler sales in 2024 (IEA, 2023, 2025a). Africa and South-East Asia also shifted from energy intensity rise to decline, and the Middle East accelerated its energy intensity improvement from 0.2% to 1.2% $yr^{-1}$. By contrast, emissions growth accelerated in Eurasia due to increasing carbon intensity and a markedly slower decline in energy intensity.

**References**


Helveston, J. P., He, G., & Davidson, M. R. (2022). Quantifying the cost savings of global solar photovoltaic supply chains. *Nature*, *612*(7938), 83–87. https://doi.org/10.1038/s41586-022-05316-6

IEA. (2022). *Solar PV Global Supply Chains*. https://www.iea.org/reports/solar-pv-global-supply-chains

IEA. (2023). *Transitioning India's Road Transport Sector*. https://www.iea.org/reports/transitioning-indias-road-transport-sector

IEA. (2024). *World Energy Investment 2024*. https://www.iea.org/reports/world-energy-investment-2024

IEA. (2025a). *Global EV Outlook 2025*. https://www.iea.org/reports/global-ev-outlook-2025

IEA. (2025b). *World Energy Investment 2025*. https://www.iea.org/reports/world-energy-investment-2025

IEA. (2026). *Global Energy Review 2026*. https://www.iea.org/reports/global-energy-review-2026

IPCC. (2022). Annex II: Definitions, Units and Conventions. In *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 1821–1840). Cambridge University Press. https://doi.org/10.1017/9781009157926.021

IRENA. (2025). *Renewable power generation costs in 2024*. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2025/Jul/IRENA_TEC_RPGC_in_2024_2025.pdf

Lamb, W., Wiedmann, T., Pongratz, J., Andrew, R., Crippa, M., Olivier, J., Wiedenhofer, D., Mattioli, G., Al Khourdajie, A., House, J., Pachauri, S., Figueroa, M., Saheb, Y., Slade, R., Klaus, H., Sun, L., Ribeiro, S., Khennas, S., Can, S., & Minx, J. (2021). A review of trends and drivers of greenhouse gas emissions by sector from 1990 to 2018. *Environmental Research Letters*, *16*. https://doi.org/10.1088/1748-9326/abee4e

Le Quéré, C., Korsbakken, J. I., Wilson, C., Tosun, J., Andrew, R., Andres, R. J., Canadell, J. G., Jordan, A., Peters, G. P., & van Vuuren, D. P. (2019). Drivers of declining CO2 emissions in 18 developed economies. *Nature Climate Change*, *9*(3), 213–217. https://doi.org/10.1038/s41558-019-0419-7

National Bureau of Statistics of China. (2025). *Statistical Communiqué of the People's Republic of China on the 2024 National Economic and Social Development*. https://www.stats.gov.cn/english/PressRelease/202502/t20250228_1958822.html

Peters, G. P., Andrew, R. M., Canadell, J. G., Fuss, S., Jackson, R. B., Korsbakken, Jan I., Le Quéré, C., & Nakicenovic, N. (2017). Key indicators to track current progress and future ambition of the Paris Agreement. *Nature Climate Change*, *7*(2), 118–122. https://doi.org/10.1038/nclimate3202