POLICY BRIEF

How can the EU transform its economy to meet the 1.5°C goal?

Main findings and recommendations:

1. 1.5°C compatible pathways for the EU27 show that the European Union can **cut its greenhouse gas emissions by 62-66% by 2030 relative to 1990** (excluding LULUCF), faster than the currently legislated 2030 target of 53.9% (excluding LULUCF).

2. In assessed pathways, non-biomass renewables such as wind and solar are deployed rapidly to reduce emissions. Coupled with limited biomass, nuclear and hydrogen generation, this sees **the EU27 achieve close to zero-emissions electricity generation by 2035**.

3. This rapid deployment of renewables is coupled with greater electrification of energy demand, as well as use of renewable heat and hydrogen. As a result, **renewables provide up to 52% of final energy demand in 2030**, rising to 93-95% by 2050, vs. 23% in 2019.

4. Fossil fuel demand falls rapidly in 1.5°C compatible pathways. In assessed scenarios for the EU27, **coal consumption is phased out by 2030**. Gas demand also falls rapidly, with gas phased out in electricity production in the mid-2030s, and in the industry and buildings sectors by the mid-2040s in the most ambitious pathways.

5. For the EU27 to take action compatible with the 1.5°C pathways assessed here, it should:
   a) Increase the ambition of its 2030 climate target to at least 62% (excluding LULUCF)
   b) Commit to achieving 100% clean power by 2035
   c) Increase investments in renewables and accelerate deployment by simplifying the permitting process
   d) Commit to phasing out coal by 2030 and fossil gas by 2050.

Introduction

Limiting global warming to 1.5°C will require rapid greenhouse gas emission reductions and achieving a net-zero energy system by mid-century. Such transformative change could be achieved in a range of ways, and there is scope to further assess the implications for different world regions and individual countries to guide policy interventions and investments. It is crucial that the EU27 takes the lead in combatting climate change. Long-term energy scenarios and emissions pathways can explore how different policy levers and low-carbon technologies can reduce emissions, while considering a range of future uncertainties. The Working Group III report of the IPCC's Sixth Assessment Report (AR6) provides the latest assessment of global climate pathways and pledges in relation to long-term emissions goals (IPCC 2022).

In this policy brief, we use the latest evidence assessed by the IPCC to explore what transformation may be necessary for the EU27 to fulfil the Paris Agreement goal. Using two technically feasible illustrative pathways produced by integrated assessment models (see Box 1 and Methodology), we explore how emissions and final energy demand evolve in the future for the EU27 in 1.5°C compatible pathways. This is then compared to the current set of targets and the underlying modelling.

What do 1.5°C compatible emissions trajectories look like for the EU?

The EU27 aims to reduce its GHG emissions by at least 55% below 1990 levels (including LULUCF) by 2030. A central objective in the European Green Deal is to make Europe first climate neutral continent by 2050. As a specific interim target, the EU27 has legally committed itself to enhancing the greenhouse gas (GHG) carbon sink from Land Use, Land Use Change and Forestry (LULUCF) (European Commission 2020c). This translates to a reduction of GHG emissions of at least 53.9% by 2030 relative to 1990, excluding LULUCF (Climate Action Tracker 2021). The 55% goal was an improvement over a previous target of a 40% cut by 2030, which had been deemed insufficient, following the adoption of the Paris Agreement.

However, several published 1.5°C compatible pathways are considerably more ambitious than current EU climate targets. In these pathways, emissions decline by **62-66%** below 1990 levels by 2030 (excluding LULUCF). Such pathways outline technically feasible routes to higher near-term decarbonisation.

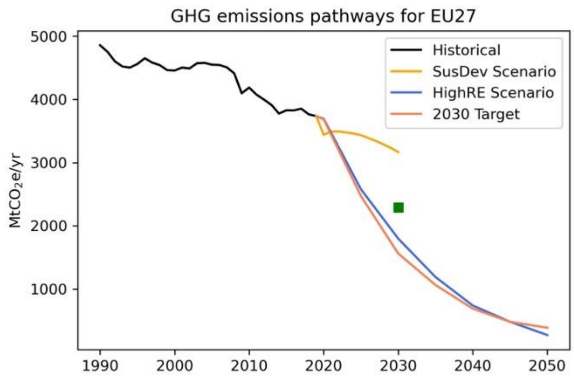

Figure 1: GHG emissions pathways for EU27 showing historical (1990-2019), 2030 target, and illustrative downscaled pathways from IPCC AR6 (2020-2050).

Box 1 – Integrated assessment models, scenarios and feasibility

This policy brief uses integrated assessment models (IAMs) to explore transformation pathways for the EU27. IAMs are global models which explore how the energy, land and economic systems could evolve together to meet the Paris Agreement goals.

The policy brief uses two IAM scenarios, called **HighRE** and **SusDev**. The first focuses on rapid renewables deployment and electrification to reduce emissions. The second focuses on achieving the sustainable development goals alongside the 1.5°C temperature goal. For more detail, see (Luderer et al. 2021; Soergel et al. 2021) and the Methodology.

These scenarios are technically feasible and economically "optimal", meeting the geophysical and techno-economic constraints applied in the model, and optimising the distribution of costs across world regions over the 21st century. Technical considerations include regional potentials for renewables, constraints on the pace of technology deployment, and power sector dynamics such as storage requirements. IAMs do not assess the political feasibility of their pathways or identify the regulatory challenges to achieving transformative change. However, highlighting that technically feasible pathways to higher ambition exist can provide motivation to identify and address barriers to their political feasibility.

What do 1.5°C compatible pathways mean for different energy sectors?

In July 2021, the European Commission put forward a legislative package to revise existing and adopt new measures to deliver on the 55% GHG reduction target, referred to as the **Fit for 55 package** (European Council 2021). Negotiations are still ongoing at the time of writing (June 2022). In this context, the Commission proposed increased 2030 objectives for renewable energy (40% from 32%) and energy efficiency in line with the 55% GHG reduction.

The energy efficiency target put forward is a reduction in final energy demand by 36% in 2030, relative to the 2007 reference scenario projections (European Commission 2021c). This equates to an 11% reduction in final energy demand by 2030, relative to 2019.

In May 2022, the EU Commission launched the **REPowerEU** plan, aimed at rapidly reducing the EU's dependence on Russian fossil fuels and accelerating the energy transition. This plan proposes to further raise the target in the Renewable Energy Directive to 45% by 2030, (European Commission 2022a). Furthermore, the new plan also aimed to increase energy efficiency targets to a 13% reduction in final energy consumption by 2030, relative to 2019.

In the 1.5°C compatible pathways based on the selected IPCC AR6 scenarios, renewables provide 48-52% of final energy demand by 2030 and 93-95% by 2050. Final energy demand falls 8-14% by 2030 and 20-41% by

2050 relative to 2019 levels. This implies that greater EU ambition on deploying renewables would be feasible, even beyond the 45% target included in the REPowerEU plan.

Scenario/ Policy package	RE share in final energy (2030)	Final energy reduction in 2030 relative to 2019
Fit for 55 package	40%	11%
REpowerEU plan	45%	13%
SusDev Scenario	48%	14%
HighRE Scenario	52%	8%

Electricity sector

A climate-neutral power system for the EU would require rapid uptake in the renewable energy generation in its member states. In the REpowerEU plan, the European Commission proposed increasing the ambition of installed capacity of solar PV to almost 600 GW by 2030 – more than four times today's capacity (European Commission 2022a). Alongside this, the Strategy on Offshore Renewable Energy aims to increase the EU's offshore wind capacity by at least five-fold to reach 60 GW by 2030 (European Commission 2020a).

In the selected 1.5°C compatible scenarios from the IPCC's AR6 report, non-biomass renewables (mainly wind and solar) provide the vast majority of future electricity demand in Europe. In these pathways, the share of non-biomass renewables increases from nearly 30% today to **80-85%** by 2030 and **93-98%** by 2050. Both illustrative pathways demonstrate a diminishing role of nuclear in the future EU27 power mix. However, with limited contribution from biomass and nuclear, the EU would be able to achieve close to 100% clean power by 2035 (98-99%). Further innovation and

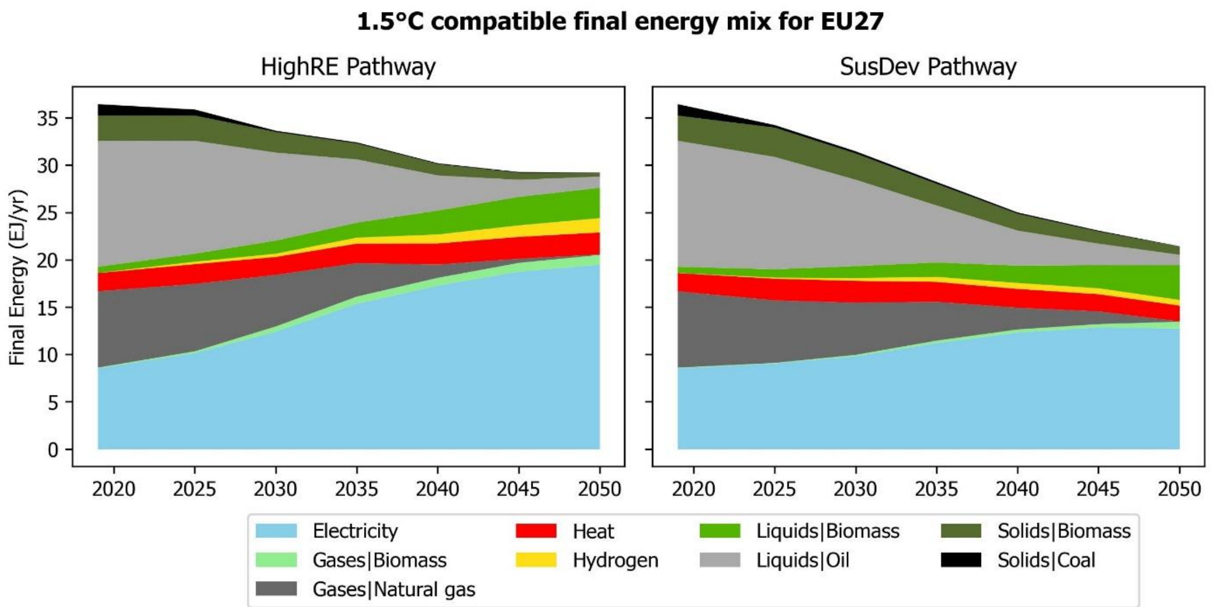

Figure 2 Final energy pathways for EU27 based on a) The HighRE pathway and b.) The SusDev pathway (2019-2050).

investment would be required to accommodate this high share of variable renewables in the power system, including for grid expansion and interconnection, storage technologies and sector coupling. Hydrogen plays a particularly important role in providing long-term energy storage.

According to the scenarios, there is no space for coal in the EU power mix after 2030. The assessed scenarios also project a rapid reduction in gas consumption in the power sector, with gas phased out by 2032-35 in the HighRE and SusDev scenario.

Final energy consumption by end-use sectors

Transport sector

As part of the Fit For 55 proposals, the European Commission aims for all new cars to be zero-emissions by 2035, and has also proposed to set up a new emissions trading system for the transport sector (European Commission 2021a). In the underlying Commission scenarios, the share of electricity in road transport reaches around **3%** in 2030, while the share of biofuels rises from 5% in 2019 to **8.7%** in 2030 (European Commission 2021b).

In the 1.5°C compatible pathways based on the transport sector is electrified much faster. Electricity provides **12-15%** of final energy by 2030 and **42-46%** by 2050.

Hydrogen could also become increasingly important in the transport sector decarbonisation. Based on the two assessed illustrative pathways, the share of hydrogen in the transport sector reaches **1-3%** by 2030 and **1-10%** by 2050. Hydrogen could be crucial for decarbonising long-distance transport such as aviation, shipping, and long-haul road freight, where electrification is a less competitive option.

In a scenario comparison exercise conducted by the Joint Research Centre of the European Commission in 2020, the share of biofuels in the

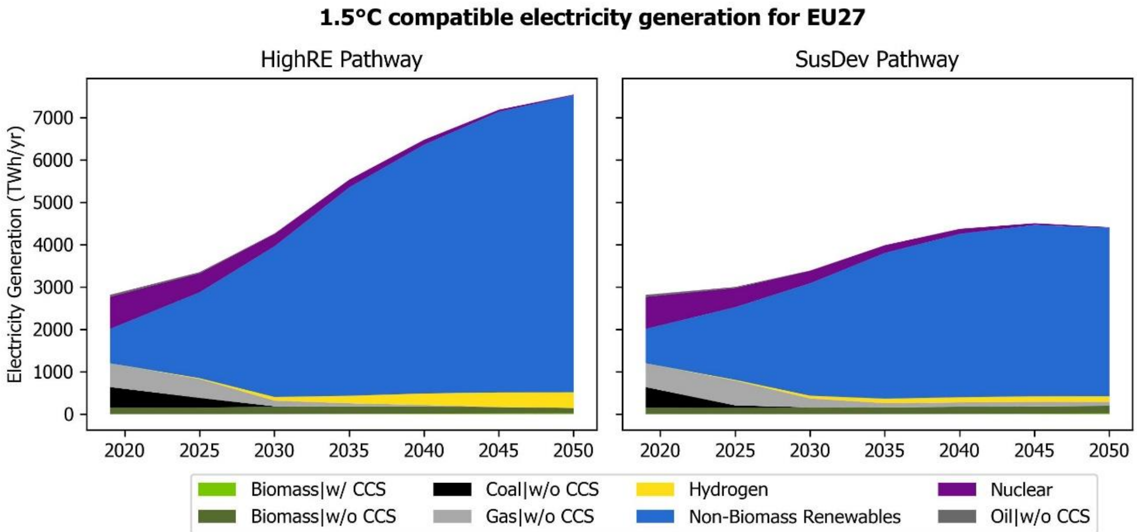

Figure 3 Electricity mix for EU27 based on a.) HighRE scenario and b.) SusDev scenario (2019-2050).

transport sector ranged between 6-18% by 2030 from the six scenarios in line with the ambition of the European Green Deal (Tsiropoulos et al. 2020). In the assessed scenarios based on IPCC AR6, the share of biofuels in the transport sector reaches **8-9%** by 2030, and **31-38%** by 2050. This share represents considerable reliance on biofuels for transport decarbonisation. It is, however, lower than in previously assessed scenarios from the IPCC's Special Report on 1.5°C. High-resolution energy system modelling also demonstrates that transport could be decarbonised without using biofuels via greater progress on electrification of the sector (Pickering, Lombardi, and Pfenninger 2022). Biofuel use is therefore an option, rather than a necessity, for reducing emissions. Any biomass used to support decarbonisation should be sourced sustainably, avoiding high land-use change emissions, competition with food crops and negative biodiversity impacts (Energy Transitions Committee 2021).

Due to the expansion of electricity, hydrogen and biofuels, the share of oil declines steeply in selected IPCC pathways to reach **75-77%** by 2030 and **14-17%** by 2050. Remaining oil demand is largely confined to the aviation sector and could be further reduced by the introduction of renewable-based synthetic fuels, which are not currently included in the assessed model pathways.

Industry sector

The EU aims to reduce industrial emissions by a combination of efficiency measures, electrification, and switching to renewable hydrogen and biofuels. The REPowerEU plan sets a target of 20 million tonnes of renewable hydrogen demand by 2030, while the Biomethane Action Plan aims to increase the production of biomethane to 35 bcm by 2030 in the EU (European Commission 2022b).

The electrification of industrial processes can reduce both energy intensity and industrial emissions. In the 1.5°C compatible pathways, the share of electricity in the industrial sector reaches up to **52%** by 2030 and **59-64%** by 2050.

In the selected 1.5°C compatible pathways, the share of hydrogen in industry use reaches up to **3%** by 2030 and **15%** by 2050. This share could be higher given recent policy developments in the EU, which envisage rapid deployment of hydrogen to drive decarbonisation. For example, one recent study suggested industrial demand for hydrogen in the EU27 could reach 420TWh by 2050 (FCH 2019), providing high-temperature heat, driving primary steel production and acting as a chemical feedstock. For comparison, hydrogen use in the EU27 industry sector in the HighRE scenario rises to 390 TWh by 2050. There is therefore the potential for more ambitious deployment of hydrogen to drive industrial decarbonisation.

In the selected 1.5°C compatible pathways, the share of biofuels in industry use grows from 9% in 2019 to **13-23%** by 2030. In 2050, there is a range of plausible biofuel consumption levels. In the HighRE scenario, hydrogen becomes the second largest energy source in industry, displacing biofuels, which fall to **11%** of industrial final energy. The SusDev scenario has slower scale-up of hydrogen production, and therefore displays greater biofuel reliance, with biofuels providing **31%** of industrial demand in 2050. In both cases, greater consumption of hydrogen or synthetic fuels, as often shown in detailed energy system modelling, could further reduce biofuel reliance (Pickering, Lombardi, and Pfenninger 2022).

The illustrative pathways from IPCC AR6 envisage a **coal-free industrial sector by 2030 for the EU**. This would represent a transformative shift in coal-reliant industries such as steel production, which would move to greater use of hydrogen for primary steel production and greater steel recycling using electric arc furnaces.

There scenarios also project a rapid reduction in gas demand. Industrial gas demand falls 40% by 2030 relative to 2019 levels, and **gas use is phased out of industry by 2050**.

Oil consumption for energy use in the industrial sector is rapidly reduced – with a total phaseout between 2030 and 2046 in the 1.5°C compatible pathways. There is continued use of oil for non-energy consumption out to 2050, which could be replaced by bio-based or synthetic feedstocks.

Buildings sector

Buildings account for more than one-third of final energy consumption by the energy end-use sectors in the EU (International Energy Agency 2021). Rapid decarbonisation of buildings is therefore crucial to achieve the EU's climate objectives.

The EU's current policy framework for buildings decarbonisation includes substantial electrification driven by uptake of heat pumps and rooftop solar, as well as renewable heat from geothermal and solar – with an additional impetus in this direction given by REPowerEU (European Commission 2022b).

The EU has also placed more focus on energy efficiency. In 2020, the European Commission published a strategy to double the annual energy renovation rate of both residential and non-residential buildings by 2030 and to foster deep energy renovations (European Commission 2020b).

In the 1.5°C compatible pathways of the IPCC AR6, the direct electrification rate of buildings in the EU reaches **41-44%** by 2030 and **69-81%** by 2050. The share of biomass reaches **12-14%** by 2030 and **6-17%** by 2050. The total share of renewables, including direct electrification, biomass and renewable based heating reaches **58-62%** by 2030 and **96-99%** by 2050. These results are comparable with scenarios that explicitly align with the European Green Deal, in which the share of electricity, biofuels and total renewables ranged 26-43%, 5-15% and 61-73% by 2030 respectively (Tsiropoulos et al. 2020).

In selected 1.5°C compatible scenarios, oil and gas are replaced by electricity or renewables-based fuels **by 2050** in the buildings sector.

Fossil fuel phase-out dates

In the assessed pathways, fossil fuel consumption falls rapidly across all fuels and all sectors. The table below highlights effective phase-out dates for fossil fuel by sector for the selected scenarios. These are the dates when fossil fuels make a negligible contribution to final energy demand and therefore could be considered to have been effectively phased out. For more detail, see the Methodology. In all cases except for oil demand in transport, **fossil fuels are phased out prior to 2050** in 1.5°C compatible scenarios for the EU27.

Fossil fuel phase-out dates by sector

Sector	Coal	Gas	Oil
Power	2025-2029	2032-2035	N/A
Industry	2025-2027	2045-2049	2030-2046
Buildings	N/A	2045-2049	2043-2047
Transport	N/A	N/A	Post-2050

Source: AR6 Scenario Database, with analysis by Climate Analytics

What are the implications for EU policy?

Based on the analysis of the pathways analysed and the comparison with current EU policy (combining Fit For 55 and REPowerEU), the following insights can be summarised: it is technically feasible to reduce emissions in 2030 by 62-66% below 1990 levels by 2030, which is more than the currently proposed 53.9% (excluding LULUCF). Therefore, the EU could **be more ambitious regarding** its 2030 climate target.

In the pathways for the EU27, the share of electricity from clean power[1] approaches 100% by 2035. This could become a dedicated target for the EU. The date would also be in line with the USA and the UK, both of which have set targets for 100% clean electricity by 2035 (U.K. Government 2021; U.S. Government 2021).

In assessed pathways, there is a rapid expansion of renewable electricity generation, particularly wind and solar. This will require considerable investment, not only in generation capacity but in transmission and distribution systems to accommodate new renewable energy generation. The cumulative investment needs in the power sector alone would range from **3.4 to 7 trillion USD between 2025 and 2050** in the assessed scenarios from IPCC AR6. Achieving such levels will require shifting investment from fossil fuels to renewables, while simultaneously scaling up total investment. In addition, accelerating the permitting process for onshore renewables (particularly wind), can help achieve this rapid expansion of renewables to achieve deep decarbonisation (Bellona 2022).

1.5°C compatible pathways for the EU27 involve substantial electrification of demand. Up to 67% of the final energy demand is electrified in 2050, which is almost three times the current level. Further policies will be required to support closer integration of the power sector and the demand sectors of buildings / transport / industry, including around smart grids, digitisation, electric vehicle charging infrastructure, and system flexibility.

While many of the technologies required to reach climate neutrality in the EU27 exist at scale today, such as solar and wind, others require further innovation support. Hydrogen plays an important role in the assessed 1.5°C compatible scenarios in the power, industries (ammonia production, methanol production, steel, etc.) and transport (shipping/aviation) sectors. Continued innovation support in these

[1] Including renewables and nuclear

sectors will be essential to enabling renewable hydrogen to contribute to decarbonisation.

Assessed pathways show a rapid reduction in fossil fuel consumption. They demonstrate the feasibility of a total phase-out of coal by 2030 and gas by 2050, and substantially reducing oil demand. The EU would therefore need to set clear targets to phase out coal and gas consumption, and substantially reduce oil consumption to be aligned with 1.5°C.

If the EU27 is to play its part in achieving the 1.5°C target, the ambition of EU climate policy must be further increased, and this ambition must be delivered on. Approving the Fit for 55 and building on it further are therefore priority tasks.

Methodology

This policy brief uses the latest evidence from pathways consistent with the Paris Agreement's long-term temperature goal, as assessed by the IPCC in the 6th Assessment Report (IPCC 2022). AR6 provides an ensemble of 97 scenarios produced by IAMs which limit warming to 1.5°C with no or low overshoot (Byers et al. 2022). The ensemble was further filtered to select scenarios which limit carbon dioxide removal to within sustainable levels, as assessed by Fuss et al. (2018), provide the necessary data for analysis, and which reduce EU27 emissions by at least 60% in 2030 relative to 1990 levels, excluding LULUCF sinks. This filtering ensures that selected scenarios show a transformative pathway towards a decarbonised energy system. A set of 11 scenarios were then obtained for consideration. From this, two illustrative pathways were taken – the '**HighRE**' and the '**SusDev**' pathways. For more detail, see Box 1.

These pathways are produced by a global integrated assessment model, REMIND-MAgPIE (Baumstark et al. 2021). This model produces global decarbonisation pathways, showing how different regions can contribute towards the collective goal of limiting warming to 1.5°C. This is valuable, as it ensures EU27 pathways are part of a globally consistent pathway that limits warming to 1.5°C. These pathways are produced by cost-optimisation, and do not explicitly account for effort-sharing or equity considerations, under which the EU27 would likely need to cut emissions faster still (van den Berg et al. 2019). Key to the EU27 contributing its fair share to climate action will be supporting ambitious decarbonisation in other countries, particularly via upscaling climate finance, which is currently at insufficient levels (Climate Action Tracker 2022).

REMIND-MAgPIE provides results for the European region, which includes non-EU27 countries such as the UK. We downscale the results from the European region to the EU27 using SIAMESE (Sferra et al. 2019). SIAMESE allocates energy consumption to individual countries within the European region by equating marginal fuel prices across all regions. This is equivalent to maximising welfare in each region, providing a cost-effective allocation of energy demand and emissions across the underlying regions. This mirrors the internal logic of integrated assessment models. To downscale total emissions to the EU27 level, we use an intensity convergence algorithm which assumes that the ratio of emissions to GDP across the EU27 will converge by 2100 (Gidden et al. 2019).

IAMs often display a bias against complete decarbonisation and so fossil consumption does not always reach absolute zero (Climate

Analytics 2019). Therefore effective phase-out dates are calculated on the basis of when fossil fuels provide under 2.5% of final energy demand or electricity generation. At this low level, gas will be relegated to the role of a 'peaking technology', operating only to meet demand on limited occasions, and could likely be entirely replaced by zero-carbon alternatives. These phase-out dates are driven by carbon pricing in the model, which does not actively model fossil fuel phase-out dates in the scenarios. However, they show the date, given effort consistent with the 1.5°C target, that fossil fuels would effectively exit the energy system.

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Authors

Aboumahboub, Tina; Climate Policy Analyst; Climate Analytics (CA)*
Shrestha, Himalaya Bir; Climate Policy Analyst; CA
Grant, Neil; Climate Policy Analyst; CA
Schaeffer, Michiel; Lead Science Advisor; CA
Waldmann, Clare; Project Manager; CA
*E-Mail: tina.aboumahboub@climateanalytics.org

Date

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