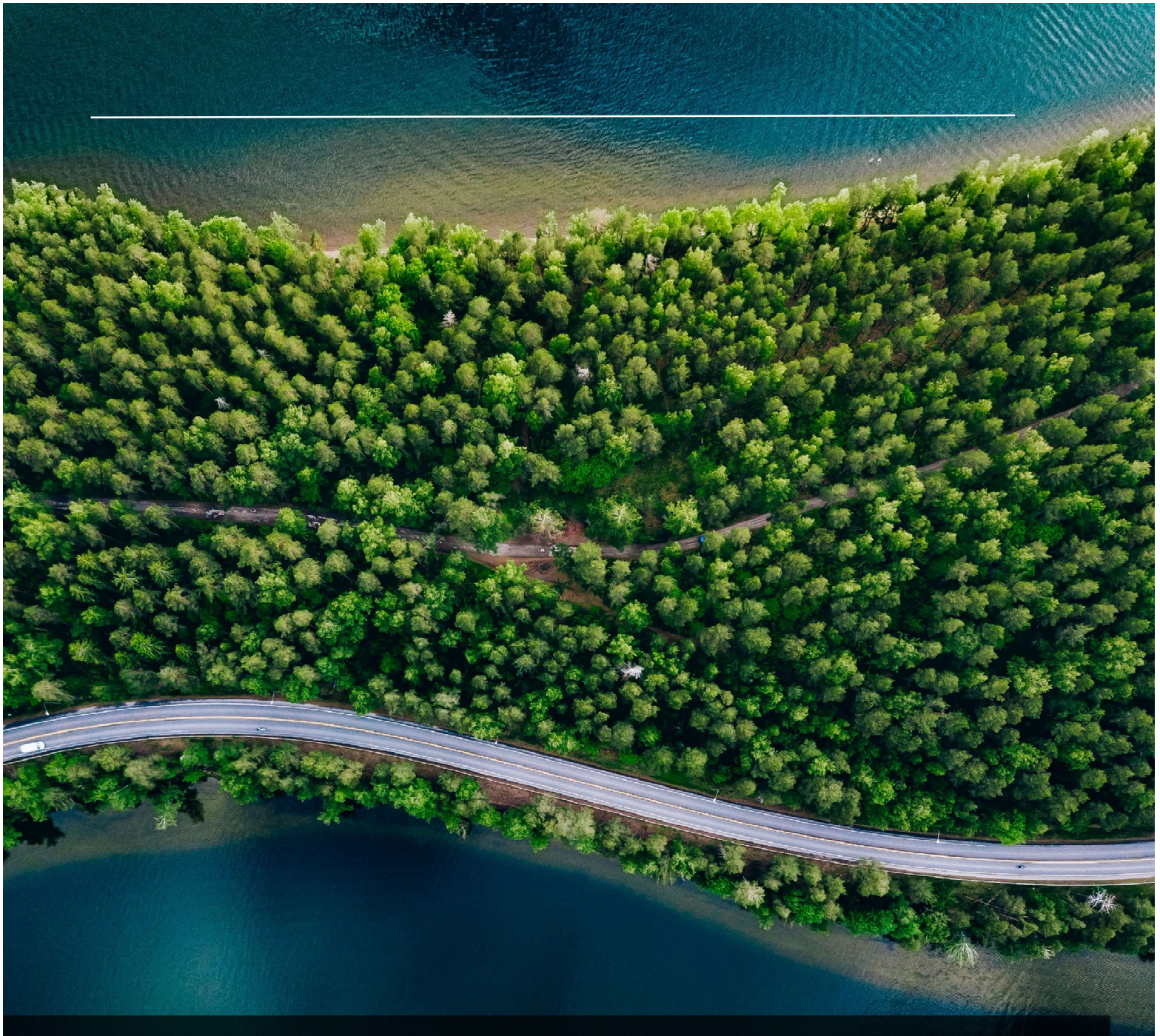

CLIMATE CHANGE MODELLING INFORMATION

Quarterly report – Q1 2021 report

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A report submitted by ICF S.A.
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High-level executive summary

This report under the "**Climate change modelling information**" series presents recent developments reported by key international climate modelling institutions. This issue sets an emphasis on the Covid-19 public health crisis and its effects, in addition to the regular sections on Nationally Determined Contributions, Mid-century strategies and the Sustainable Development Goals.

The first section of the report features results from macroeconomic and environmental modelling of the **Covid-19 public health crisis**. There is an increasing amount of modelling occurring in this area as the pandemic continues and datasets become available. In this quarter, over half of survey respondents are integrating Covid-19 into their policy scenarios and into economic recovery plans. Most of the modelling reported here focusses on recovery pathways and associated Green Recovery Packages. Green Recovery policies present key opportunities for countries to take advantage of reduced emissions due to the Covid-19 pandemic and maintain lower carbon emissions. Reduced use of transport during this time has opened a route to promoting greater use of public transport and electrification of transport. Overall, the pandemic has forced reduction of emissions across a number of sectors, opening the path to more aggressive climate and emissions policies to strengthen progress towards Nationally Determined Contributions and mid-century strategies.

Various developments linked to the implementation of **the Nationally Determined Contributions (NDCs)** are reported in the second section. A research team in China has published articles on allowance allocation in China's ETS and another on integrated modelling of India's clean energy transition. The study of China's ETS supports their recent 2030 target to reach peak emissions before this date, showing that emissions abatement is achievable with modest GDP and consumption impacts. Air quality and energy policies in India are shown to reduce pollution related deaths, supporting India's NDC to increase the non-fossil fuel share of power generation capacity to 40% by 2030.

In the third section, the report features research linked to long-term low greenhouse gas emission development strategies (**mid-century strategies)**. Japanese researchers have completed an integrated assessment of Japan's mid-century emissions pathways in a global and national context, showing a low-carbon-budget scenario is sufficient to meet Japans greenhouse gas (GHG) 2050 emission goal. A research team in the USA has found that the impact of biomass burning (BB) aerosols is overstated in most climate models indicating mid-century strategies may have overambitious BB aerosol reduction targets.

The fourth section of the report is dedicated to developments linked to the **Sustainable Development Goals (SDGs)**. An article from researchers in Switzerland examines regional impacts of electricity sector transition in 2035 for six central European countries highlighting how national energy and climate targets can influence local communities to achieve regional equality. A study from Canada uses an open modelling platform to investigate how cross-boundary and cross-sector cooperation could boost sustainable development across the water-energy-food nexus in the Indus Valley in South Asia. This shows the potential for international policy to address the impacts of climate change by considering the SDGs. Researchers in China looked at the co-benefits of China's carbon pricing policy on the reduction of pollutants and the improvement of public health. This study supports China's recent goal to achieve peak emissions by 2030, and highlights the environmental and public health benefits of a green recovery from Covid-19.

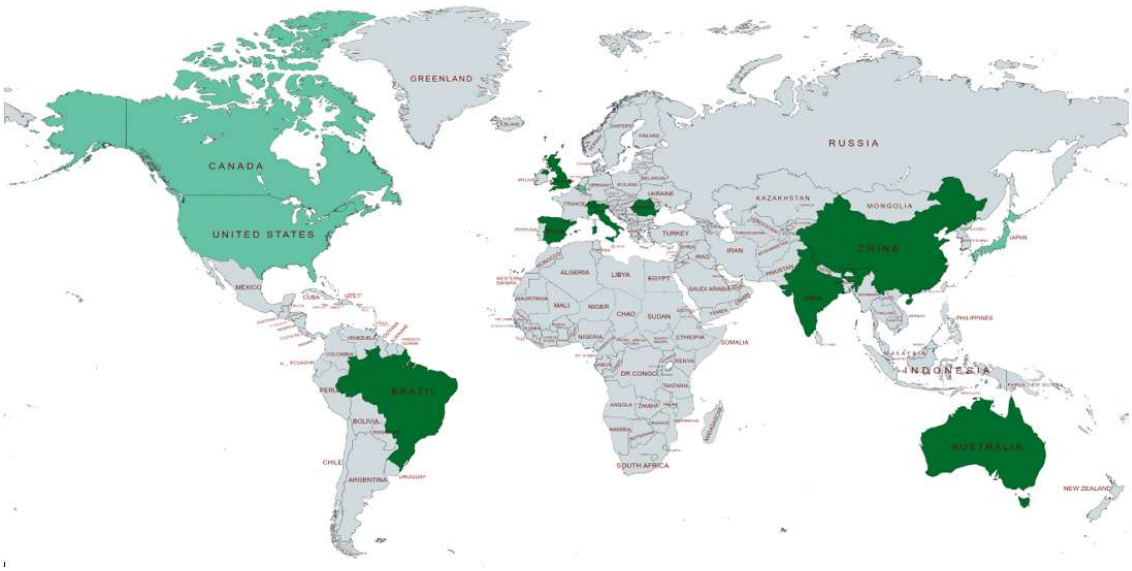
Introduction

This report is the first quarterly report of 2021 under the series 'Climate Change Modelling Information' financed by the European Commission. This project aims to provide the EU and global climate change modelling community and interested policy makers with up-to-date information about ongoing modelling developments and projected results, focussing in particular on economic assessments of policies to mitigate climate change, ways to combine climate action with other global priorities, and assessments of the impacts of climate change and how to adapt to it. The data presented in this report were collected through an open survey sent to more than 200 modelling teams worldwide and open from 15-29 January 2021.

The survey asked modellers to report relevant developments with a focus on the implementation of Nationally Determined Contributions (NDCs), mid-century strategies and Sustainable Development Goals (SDGs). Considering the Covid-19 crisis, an additional set of questions was asked about whether modellers are integrating the impact of Covid-19 in current policy scenarios and in economic recovery plans. Although the objective of this report is to present an extensive list of recent developments, it cannot be considered as exhaustive. For this quarterly report, responses came from 9 countries (see Figure 2.1), 13 organisations and covered 17 different modelling developments and projects.

Additional research was undertaken to complement the survey results.

Geographical coverage of climate change modelling developments reported through the online survey (dark green) and through additional research (light green).



Source: ICF, 2021. Climate change modelling information Q1 2021 survey.

The modelling developments discussed in this report are summarised below and further described in the coming chapters.

Modelling developments linked to the integration of the Covid-19 public health crisis:

- Potential for Green Recovery in Visegrad countries (UK)
- Impact of Covid-19 pandemic on transport (Belgium/Spain)
- The effects of the Covid-19 pandemic on global CO_2 emissions (China)
- Green recovery packages in TEA model (Brazil)

Modelling developments linked to nationally determined contributions (NDCs):

- Allowance allocation in China's ETS (China)
- Integrated modelling of India's clean energy transition (China)

Modelling developments linked to mid-century strategies:

- Integrated assessment of Japan's mid-century emissions pathway (Japan)
- The impact of biomass burning aerosols are overestimated in most climate models (USA)

Modelling developments linked to Sustainable Development Goals (SDGs):

- Regional impacts of electricity sector transition in 2035 for six central European countries (Switzerland)
- Energy-water-land development in the Indus Valley (Canada)
- The benefits of China's carbon pricing policy on the reduction of pollutants and the improvement of public health (China)

Modelling developments linked to the integration of the Covid-19 crisis

- Cambridge Econometrics published results from analysing the potential for Green Recovery in Visegrad countries (V4: Czechia, Hungary, Poland, Slovak Republic) in November 2020. Using their E3ME macroeconomic model they simulated the effect of a Green Recovery Programme (GRP) on employment, economic activity and CO_2 emissions. The model contains two scenarios, comparing the impact of a post-virus GRP with a virus-free scenario. The GRP scenario is based on estimates of the annual 2020 impacts of Covid-19, as the data is still largely unavailable and V4 governments were assumed to have implemented certain 'green policies'. Results differ substantially between countries. In Czechia, Poland, and Hungary the GRP produces long-term recovery of employment beyond 2030. This is not the case in the Slovak Republic, where there is limited renewables up-take, despite subsidies, and employment drops after 2023 when support ends. In all countries CO_2 emissions are severely reduced due to policy implementation, however rebound is seen in Poland from 2025. This demonstrates the importance of policies to phase out coal to limit continued investment in the sector.
- The Joint Research Centre recently published the Global Energy and Climate Outlook 2020, featuring special insight into the impact of Covid-19 on the transport sector, and how the pandemic can affect the transition to a low GHG economy. The Integrated Energy-System Simulation Model considers a New Normal scenario against a No Covid-19 Baseline and 1.5°C and 2°C warming scenarios in line with the Paris Agreement. In the New Normal scenario, the total emissions gap from Baseline to 2°C is reduced by about 35% by 2030, stressing the need for more ambitious collective action to keep warming below 2°C (**Figure 1**). Covid-19 has significantly altered the structure of the transport sector, with a more pronounced transport emissions reduction than for total emissions. In 2030, New Normal covers 80% of the transport emissions gap from Baseline to 2°C (**Figure 2**). Reduced use of private cars and aviation are significant contributors to this projection. It is suggested that policies promoting electrification of transport and the introduction of low carbon fuels could further decouple emissions from transport. From this work, JRC is also building a dataset of input-output tables to

use as a benchmark when assessing international climate policy pledges.

Figure 1: Global greenhouse gas emissions, Global Energy and Climate Outlook 2020

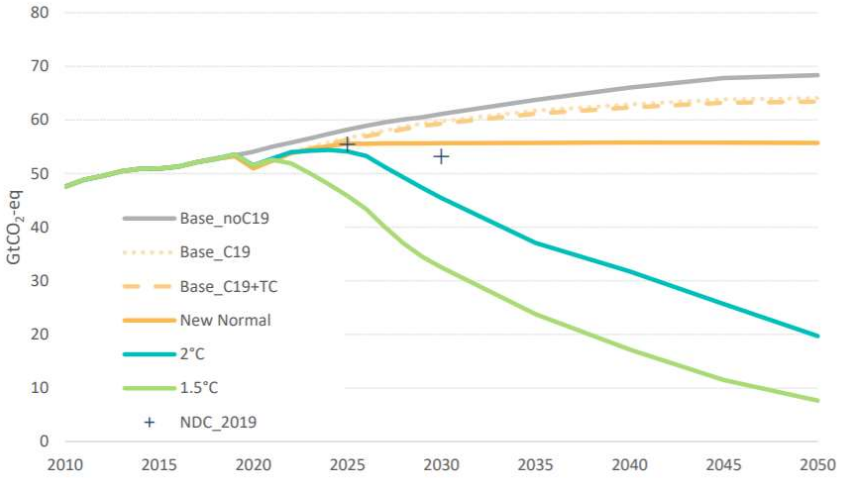
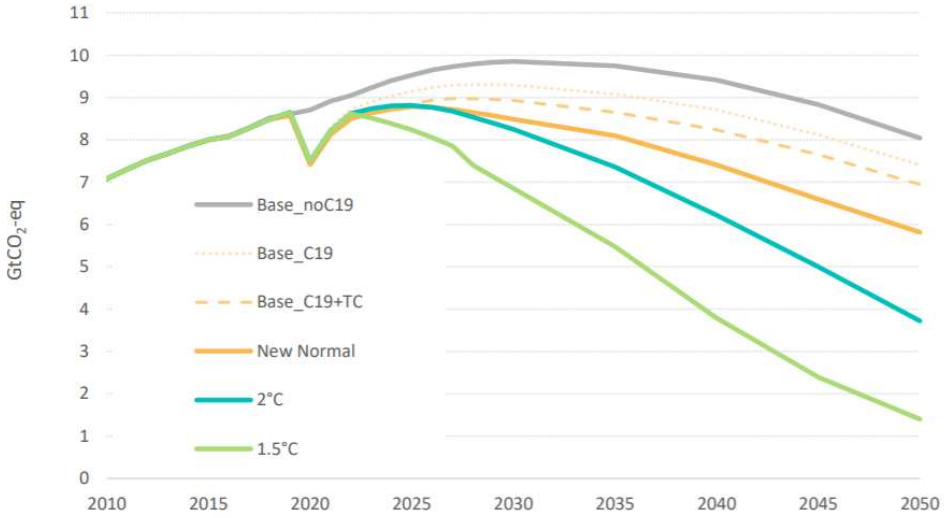


Figure 2: Global CO2 emissions of transport (including international aviation and maritime), Joint Research Centre Global Energy and Climate Outlook 2020



- Researchers from Tsinghua University in China have investigated the effects of the Covid-19 pandemic on global CO_2 emissions via near-real-time monitoring. Using data from the international research initiative, Carbon Monitor, they were able to track daily, weekly and seasonal dynamics of CO2 emissions before and after the Covid-19 pandemic. The global and sectoral impacts were then examined. Results show an 8.8% decrease (1551 Mt CO2) in global CO_2 emissions due to Covid-19 between 1st January 2020 and 30th June 2020. There had been some recovery of daily global emissions since their lowest point (-16.9%) in April, however, the decrease in mobility-related emission was more persistent (-13% in July). The timing of emissions decreases corresponds to initiation of lockdown in different countries. This interplay is seen in Europe and China: As lockdowns are enforced in Europe, economic activity slows down and emissions decrease. As China has relaxed restrictions and economic activity picks up, emissions begin to rise once more. The article and details of the method can be found online in Nature Communications.

- Researchers at COPPE UFRK in Brazil have further developed the TEA model. They have re-framed the rationale behind the IIASA Shared Socioeconomic Pathway 2 (SSP2), a 'middle-of-the-road' development scenario compared to other SSPs, by applying short-term regional GDP growth shocks based on projections of the Covid-19 pandemic from the World Economic Outlook (IMF, 2020). This will allow researchers to estimate the extent to which different regions' economic responses to the Covid-19 pandemic hinder progress towards their climate targets.

Modelling developments linked to Nationally Determined Contributions (NDCs)

- Researchers at Peking University in China have investigated allowance allocation in China's carbon emissions trading scheme (ETS) using the IMED/CGE (Integrated Model of Energy, Environment and Economy for Sustainable Development/Computable General Equilibrium) model. The study simulated a national ETS across ten carbon-intensive sectors with mass-based, output-based allocation (OBA) of emission allowances. The impacts of the ETS were evaluated by comparing abatement behaviours of each sector across different policy scenarios with varying allocation schemes and numbers of benchmarks. The results show that the simulated ETS achieves China's NDCs with modest macroeconomic losses. ETS participating sectors display evenly distributed emissions reduction efforts. The results also showed a reduction in emissions trading volumes and a modest impact on sectoral output, especially for upstream sectors. OBA with fewer benchmarks enhance emissions abatement, however this leads to relatively 'cleaner' sectors being subsidies by the ETS with a slightly greater impact on the macroeconomy. The article is available online in *Energy Economics*.
  Policy Implications: In September 2020, China announced that it would strengthen its 2030 target to reach peak emissions before 2030. Implementation of an ETS would strengthen this goal with significant emission abatement efforts across participating sectors, with modest GDP and consumption losses.

- Researchers from China and Austria have published an article in Environmental Science and Technology examining the role of policy enforcement in achieving health, air quality and climate benefits from India's clean electricity transition. In this work they integrated the IMED/HEL (Integrated Model of Energy, Environment an Economy for Sustainable Development/Health Impact Assessment) model, WRF-CMAQ (Weather Research and Forecasting – Community Multiscale Air Quality) model, and the GAINS (Global Air Pollution Information and Simulation) model from IIASA to assess emission scenarios, air quality simulations and health impact assessments. Various air quality and energy policies are considered. The results show that limited enforcement of air pollution control policies leads to worse future air quality and health damages (14,200-59,000 more PM2.5 related deaths in 2040) compared to successful implementation. Conversely, there are fewer deaths when energy policies are not successfully implemented than when air quality policies are not implemented (5,900-8,700 more PM2.5 related deaths in 2040), since coal generation plants with end-of-pipe controls emit limited air pollution. The effect of unsuccessful low-carbon and clean coal policies is substantial, with 400-800 million tons more CO_2 in 2040. These results show the importance of effectively implementing existing clean air and energy policies to achieve air pollution, health and carbon mitigation goals in India.
  Policy Implications: India's current NDC under the Paris Agreement aims to reduce GDP's emissions intensity by 35% and increase the non-fossil fuel share of power generation capacity to 40% by 2030. The world has recently experienced cleaner air, as

Covid-19 has supressed economic activity, resulting in a dramatic drop in pollution levels. This has launched discussions around strengthening ambient air quality standards in India, which would be driven by a transition away from coal to renewable energy sources and increased uptake of electric mobility. This would improve progress towards India's current NDC goals, with additional benefits of reducing PM2.5 deaths.

Modelling developments linked to Mid-century strategies

- A research team from Kyoto University in Japan has assessed Japan's mid-century low-emissions pathway using both national and global integrated assessment models. In both cases, high and low carbon budgets are examined corresponding to the 2°C goal. The impacts of near-term policy assumptions, including implementation and enhancement of Japan's NDC are also considered. The most recent national policies in Japan, including the implementation of the NDC and other related energy mix policies, were taken into consideration to inform the global stocktake procedure. Results show that low-carbon-budget scenarios are essentially on track for mid-century and are close to Japans previous GHG emissions 2050 goal of reducing greenhouse gas emissions by 80%. In the near term, Japan's NDC is set to meet the high-carbon-budget scenario. There is variation across models in the decarbonisation fuel mix required to meet the low-budget scenario, but in general by 2050 low-carbon energy represents 44-54% of primary energy in the high-budget scenario and 86-97% of electricity supply in the low scenario. The model also examines economic implications of the transition. The article was published in *Climactic Change* and is available online.
  Policy Implications: Japan's NDC policies are consistent with the high-carbon budget scenario. The low-carbon-budget scenario suggests that mid-century strategy to reduce GHG emissions by 80% is an effective milestone, however greater mitigation action is required after 2030. These policies require a high rate of national decarbonisation, only experienced by Japan's economy during the oil crisis and global recession.

- Researchers at the University of Wyoming, US, have investigated the representation of biomass burning (BB) aerosol composition and optical properties in climate models. Results from 12 observational datasets applied to nine state-of-the-art Earth system models (ESM) and chemical transport models (CTM) show that absorptivity of BB aerosols is overestimated in most climate models. Therefore, BB contributes less to global warming than previously thought (a global change in BB direct radiative effect of $-0.07 Wm^{-2}$). These results may impact modelling analysis underlying decarbonisation pathways and mid-century strategies incorporating the effects of BB aerosols. The article is available online in Nature Communications.
  Policy Implications: Modelling underlying mid-century strategies may overestimate the warming effect of BB aerosols. This may result in over ambitious reduction targets of aerosol use and release by 2050.

Modelling developments linked to SDGs

- A research team at the University of Geneva, Switzerland, has quantified the regional impacts of electricity sector transition in 2035 for six central European countries using Dynamic Energy Optimisation models Exploration of Patterns in Near-Optimal Energy Scenarios (EXPANSE) and Python for Power Systems Analysis (PyPSA). Using a Modelling to Generate Alternatives (MGA) method they searched for cost-optimal and near-optimal solutions at a high spatial resolution of 650 NUTS-3 regions (where NUTS is a common classification of territorial units for statistics, Regulation (EC) No 1059/2003)). The study was published in Nature Communications (October 2020) and considered

three distinct scenarios to highlight trade-offs: a scenario with minimum system costs, maximum regional equality of system costs, and maximum renewable generation capacity. These were compared to a frozen generation capacity where the generation capacity in 2035 is the same as it was in 2018. The dataset is based on existing electricity infrastructure, allowing the model to accurately account for future investments. The results show that the scenario with minimum system costs is characterized by relatively high centralized electricity generation, suggesting that these technologies improve cost efficiency. This results in an increased system cost per capita in coastal regions due to high wind speeds and land availability. The scenario with maximum regional equality of system costs has comparatively high decentralized electricity generation. Here, the increase in system costs are regionally even and less extreme. The maximum renewable technology scenario has high renewable generation supported by nuclear and above-average lignite generation. This support mix enables renewable electricity integration by keeping total system costs within the near-optimal range in 2035. A high increase in systems costs is seen in both coastal areas and inland due to the mix of generation technologies.
Policy Implications: National energy and climate targets can be linked with impacts on local communities to achieve regional equality and distribution of systems cost increases. Maximum deployment of renewables, a key strategy proposed in the European Green Deal, could result in uneven distribution of job creation based on the optimal locations for solar PV and on-/off-shore wind installation.

- IIASA recently published an article in Nature Sustainability investigating how unique cross-boundary and cross-sector cooperation could boost sustainable development in South Asia. The authors used the open modelling platform Nexus Solutions Tool (NEST) v1.1 to integrate multi-scale energy-water-land optimisation with distributed hydrological modelling. The energy-water-land nexus is central to the solutions to address climate change. These sectors already face significant challenges, and climate change will place further stress on them. Countries in the Indus River Basin could lower costs of development and reduce soil pollution and water stress through cooperation on management and development of water, electricity and food production. Results show increased investments to US$10 billion per year are required to mitigate water scarcity issues exacerbated by climate change and ensure improved access to resources by 2050. These costs could drastically reduce to US$2 billion per year if countries pursue more collaborative policies. The study is of interest to those looking at the impacts of climate change beyond carbon emissions and was conducted as part of the Integrated Solutions for Water, Energy and Land (ISWEL) project.
Policy Implications: Covid-19 has multiplied the vulnerability of people who are at risk of displacement by storms, floods and other climate disasters. International and cross-sectoral cooperation to address the effects of climate change and the SDGs should be incorporated into Green Recovery plans.

- Researchers from Tsinghua University in China have applied the Regional Energy Emission Air-quality Climate Health (REACH) model to quantify the co-benefits of China's carbon pricing policy on the reduction of pollutants and the improvement of public health. Results published in August 2020 showed that the national carbon pricing policy can effectively reduce national and regional CO_2 emissions and promote structural transformation of the energy sector. This leads to a reduction in pollutants due to a reduction in fossil fuel consumption. The study show that a scenario consistent with the 2◦C target that peaks China's emissions before 2025 could avoid around 190 thousand premature deaths in 2030. The extent to which benefits are felt is distributed unevenly across different regions. It is also shown that a stronger low-carbon policy gives greater health benefits than the current NDC scenario, with 270,000 premature deaths avoided in 2035 due to reduced PM2.5 concentration. Finally, the health co-

benefits can partially offset policy costs depending on the assumed value of a statistical life. The article was published in *Climate Change Economics* and can be found online.
Policy Implications: This study supports the action China took in December 2020 to strengthen its 2030 NDC, aiming for peak emissions before 2030, and to achieve climate neutrality before 2060. Incorporation of low-carbon policies into a Covid-19 green recovery strategy would lead to further health benefits and reduced air pollution.