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CORDIS Results Pack on

the net-zero transition

A thematic collection of innovative EU-funded research results

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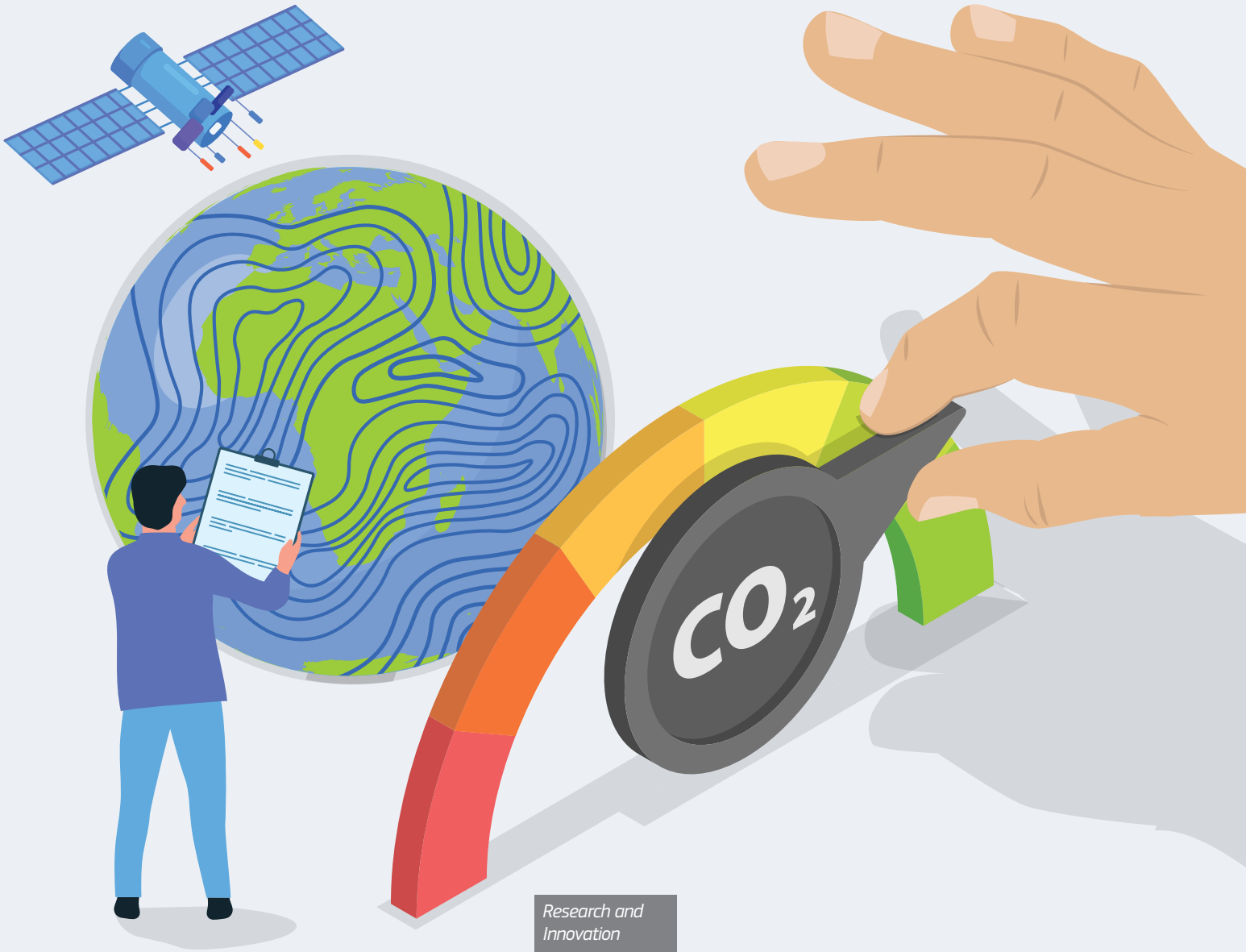
Accelerating climate action through science



Research and Innovation

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Editorial

The EU aims to become climate neutral by 2050, in line with its commitment to global climate action under the Paris Agreement. This Result Pack focuses on 10 EU-funded Horizon 2020 projects that are helping to pave the way for a climate-neutral economy and society by developing state-of-art knowledge.

In a landscape already feeling the heat of climate change, Europe is facing a myriad of challenges. Heatwaves and wildfires are becoming more common, while biodiversity and crop yields are decreasing. The repercussions extend beyond the environment. In the summer of 2022, low water levels disrupted riverine transport along the Rhine and other major rivers, impacting Europe's economy. A changing climate can also affect people's health, a fact highlighted in the COP28 climate summit.

The EU is a key player in UN climate talks and in 2015 it demonstrated its desire for action by signing the 2015 Paris Agreement. Under the agreement, the EU is committed to cutting greenhouse gas emissions by at least 55 % below 1990 levels by 2050.

This ambitious target is enshrined in the 2021 European Climate Law, and also forms part of the European Green Deal, the EU's roadmap for becoming climate neutral by 2050, which is crucial to achieving the objectives of the Paris Agreement. To reach this goal the EU is supporting more renewable energy, greater energy efficiency, cleaner transport, greener farming and a circular economy. Unavoidable emissions will be compensated by improved forest management, conserving ecosystems and investing in innovation and research to gather more and better data on climate-related risks and losses to push back the frontiers of knowledge on adaptation and mitigation.

Path to a low-carbon future

This new Results Pack highlights a wide range of aspects that support the low-carbon transition within the main sectors responsible for greenhouse gas (GHG) emissions, both at an EU and global level. It explores the technical feasibility, financial viability, social acceptance and potential co-benefits and trade-offs of low carbon transition pathways to achieve the Paris Agreement goals.

The 10 projects featured in this Pack offer recommendations to policymakers at national and EU level and identify strategies to significantly reduce GHG emissions in the coming decades. Their results will provide a better understanding of the feasibility and socio-economic impacts of an altered environment. They will also help avoid the worst effects of global warming while benefiting health and energy security, and competitiveness in green technologies while ensuring Europe remains a global leader in the fight against climate change.

Innovative phone app boosts low-carbon lifestyles

A scalable tool that collects data and incentivises change on a personal level enables behavioural transformation, predictive modelling and informed policymaking.

The EU is striving to become climate neutral by the year 2050. To achieve this, citizens must change the way they live. The EU-funded CAMPAIGNers project developed the Climate Campaigners phone app to educate and motivate citizens to change behaviours. The app also provides data analyses that can inform policy decisions and contribute to predictive modelling tools.

Climate Campaigners revolutionises lifestyle research

Too often, lifestyle research is driven by hypothesising how citizens might behave. When the many factors that conspire to drive individual choices appear, it is clear that the hypothetical citizen does not reliably represent human behaviour. This negatively impacts effective policymaking as well as the development of accurate predictive models.

The project addressed this challenge by collecting important demographic data from app users. For example, knowing how behaviour varies due to aspects of identity such as gender, age, education and income level gives scientists granular information pertaining to human choice.

In addition to gathering information about identity, the app also provides choice with respect to what type of Lifestyle Challenge an individual wants to explore. Challenges are broken into four sectors: mobility, housing, food and other consumption. Which

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Challenges an individual chooses and how this connects to aspects of identity provide valuable information to researchers.

Lighthouse cities anchor goal-setting network

The most promising outcomes of the project are the collection of multidisciplinary knowledge and approaches in the field of behavioural change in real-world settings, as well as the acquisition of innovative communication strategies between cities and citizens for effective engagement in climate change mitigation.

The project launched Climate Campaigners in 14 cities around the world, with the potential to reach 20 million citizens. According to junior researcher Giulia Garzon: "The diversity in custom, environments, infrastructures, lifestyles and weather patterns between lighthouse cities meant that a 'one-size-fits-all' approach to creating Challenges was not feasible." Therefore, the project tailored Challenges specific to the needs of lighthouse cities.

Garzon states: "The most promising outcomes of the CAMPAIGNers project are the collection of multidisciplinary knowledge and approaches in the field of behavioural change in real-world settings, as well as the acquisition of innovative communication strategies between cities and citizens for effective engagement in climate change mitigation."

The empirical data collected, although not of the expected magnitude/scale, will inform policy makers at European, national and local levels in the development of targeted environmental policies. Such data will also advance integrated assessment models used to predict climate conditions in the coming decades.

Incentivising transformational behaviours

While a phone app can diversify the array of people included in a lifestyle transformation study, it is important to find ways to encourage citizens to take up the app and continue using it. To reach these goals, the project included scientific institutes, civil society organisations and consultant enterprises to optimise design.

Climate Campaigners leverages prosocial behaviour by integrating a sense of belonging and community into the app. Highlighting co-benefits such as improved health outcomes also motivates change in behaviour. Further, participation in many Challenges is linked to rewards, such as free credits in a bike-share programme.

Currently the number of app users is approaching 5 000. Development of the app will continue, with a focus on increasing accessibility and maintaining sustainability. Results of data analyses are shared through an interactive dashboard, and other dissemination avenues include policy briefs and workshops targeting various political levels.

Climate change is the greatest challenge facing humanity. Combating it requires the effort of every individual. By envisioning a solution built on that most ubiquitous of tools, the smartphone app, CAMPAIGNers has increased our chance of success.

PROJECT
CAMPAIGNers – Citizens Acting on Mitigation Pathways through Active Implementation of a Goal-setting Network

COORDINATED BY
Energy Institute at the Johannes Kepler University Linz in Austria

FUNDED UNDER
H2020-EU.3.5., H2020-EU.3.5.1.

CORDIS FACTSHEET
cordis.europa.eu/project/id/101003815

PROJECT WEBSITE
climate-campaigners.com/

Research project urges immediate action to save oceans

EU-funded research investigated the critical thresholds that, when surpassed, can lead to irreversible damages in the marine ecosystems.

Ocean warming, deoxygenation and acidification are consequences of human activities, primarily from the release of greenhouse gases into the atmosphere. This triple threat leads to changes in the ocean that are happening fast and abruptly. According to the EU-funded project COMFORT, the time to act is now.

The project gathered experts from Earth system science, oceanography, fisheries science and ecology to study these threats' "tipping points", which are critical thresholds that, when exceeded, can lead to significant and often irreversible changes in the marine ecosystems.

COMFORT took an integrative approach to analyse factors contributing to the thresholds in parallel. "We looked at a suite of different targets, including limits to warming, ocean acidification, biological organic carbon production and oxygen content," describes Christoph Heinze, COMFORT project coordinator. "Common to all metrics is that reducing greenhouse gas emissions and limiting reactive nitrogen input to the ocean upfront is better, more economical, and induces less environmental stress than fixing issues through geoengineering at a later stage."

Reducing greenhouse gas emissions and limiting reactive nitrogen input to the ocean upfront is better, more economical, and induces less environmental stress than fixing issues through geoengineering at a later stage.

Alarming findings

Coordinated by the University of Bergen, the project had alarming findings. Some thresholds have already been crossed and others are likely to be passed soon.

Some regions of the North Atlantic have already crossed tipping points resulting in regime shifts, namely sudden ecosystem changes. They are a consequence of factors such as overfishing, climate change and pollution.

"Climate change in combination with overfishing can trigger sudden changes in fish stocks. Some marine provinces that are characterised by certain environmental conditions and ecosystems are on the verge of vanishing," says Heinze.

The ocean absorbs about 25 % of the annual emissions of anthropogenic CO_2, reducing the impacts of climate change on the planet. However, it becomes more acidic the more it absorbs CO_2, bringing harmful consequences to many marine organisms. The ocean has also absorbed more than 90 % of the extra heat from global warming since 1970. Increased temperatures and nutrient pollution also reduce the ocean's oxygen.

The triple threat is already becoming reality in all European seas. In the Arctic Ocean, the acidification progresses 10 times faster and the warming advances two times faster than the rest of the globe.

"The sum of increasing regional non-linear changes, that is, the results of crossing certain thresholds, and regime shifts in the ocean are likely to happen with high probability and aggregate to a problem of global dimension," warns Heinze.

Mitigation strategies

Through statistical methods, COMFORT produced several model outputs for historical and future scenarios. The team

© Christoph Heinze

also gathered in situ observations, resulting in valuable ocean hydrography, biogeochemistry and biological data. The project suggested a series of mitigation strategies for policymakers and was an important contributor to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.

"We recommend urgent implementation of a drastic reduction of greenhouse gas emissions, which are the primary cause of global warming and ocean acidification, to avoid further stability loss of major Earth system tipping elements and long-lasting changes in ocean properties," states Heinze.

He also highlights the need for appropriate global resource management to achieve greenhouse gas emission reductions in line with the Paris Agreement. Furthermore, societies must engage in green energy production, as well as sustainable food production on land and in the ocean.

PROJECT
COMFORT – Our common future ocean in the Earth system – quantifying coupled cycles of carbon, oxygen, and nutrients for determining and achieving safe operating spaces with respect to tipping points

COORDINATED BY
University of Bergen

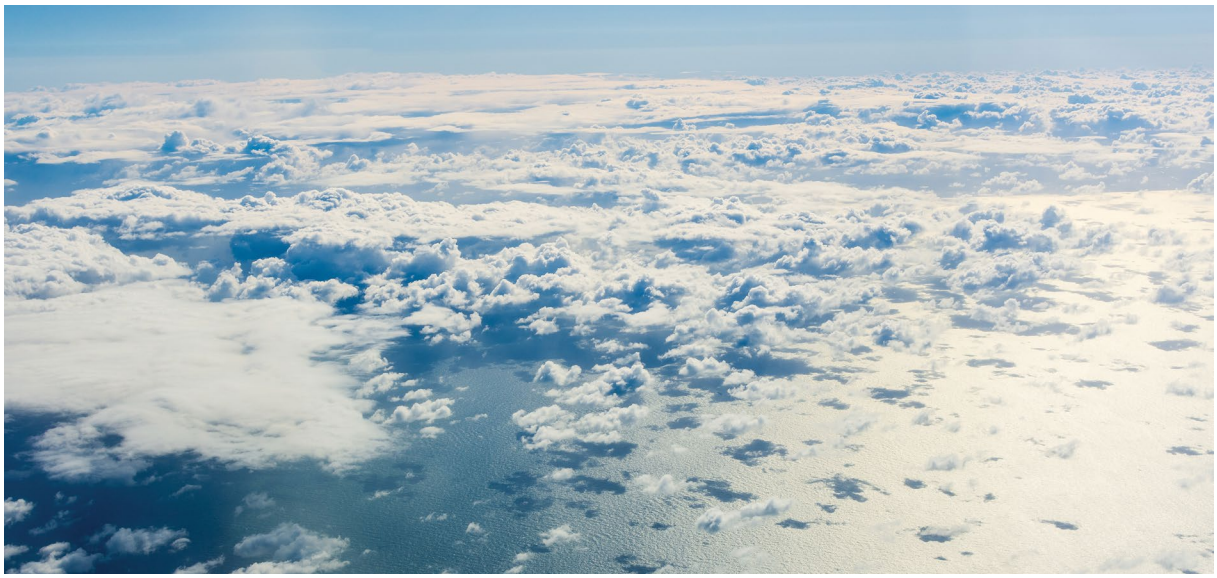
FUNDED UNDER
H2020-EU.3.5., H2020-EU.3.5.1.

CORDIS FACTSHEET
cordis.europa.eu/project/id/820989

PROJECT WEBSITE
comfort.w.uib.no/

Novel modelling tools yield up-to-date climate reports

Improved emulation and greater frequency of reporting provide governmental agencies with the necessary information to take on climate change.



Climate change is the most critical issue facing humanity, and several agencies address the causes of global warming. However, the rate of change is increasing, and policymakers need accurate and timely information. The EU-funded project CONSTRAIN targets recognised knowledge gaps in three areas: radiative forcing, cloud feedbacks, and the relationship between ocean variability and atmospheric change. The project also initiated a more frequent update of key climate information.

Paris Agreement goals

In 2015, the Paris Agreement was adopted by 196 parties. This multinational agreement is focused on constraining the rising average temperature of the planet. The Paris Agreement galvanised climate change initiatives, and led to the Intergovernmental Panel on Climate Change (IPCC) special report, *Global Warming of 1.5 ºC*.

The IPCC reporting cycle updates every 5 to 10 years, with the most recent (AR6) concluding in 2023. It provides comprehensive information to guide policy, but the long reporting cycle does not address the rapid developments in climate science. In 2023, the Indicators of Global Climate Change (IGCC) was formed to address this knowledge gap.

CONSTRAIN's work is closely aligned with the IGCC. According to project coordinator Piers Forster: "The intention of the IGCC is to update the indicators reported by the IPCC on an annual basis, thus helping to fill the knowledge gap between the

publication of IPCC's Sixth Assessment Report (AR6) and the next iteration, likely due in 2030." One of the major outcomes of the project was the publication of the first IGCC paper, which included a large body of CONSTRAIN research alongside a wider community effort.

New modelling tools address knowledge gaps

In addition to the publication of the first IGCC paper, another major project accomplishment was the development of various climate modelling tools, including Silicone, to support near-term climate modelling. Silicone enhances existing integrated assessment models by linking what is known about common emissions to rarer ones.

The project also involved the use, further development, and assessment of simple climate models known as emulators. A distinguishing feature of the emulators is their simplicity. Forster states: "Simple climate models capture the behaviour of more complex Earth system models, but at a much lower computational cost. This allows them to be calibrated to observations and make a more detailed exploration of climate projections and emissions pathways than would otherwise be possible."

Paving the path to policy

Creating accurate and detailed reports is essential to combating climate change, but unless it is translated into more accessible material, such information can often remain inert. CONSTRAIN has employed several avenues to connect with stakeholders, policymakers and citizens.

Simple climate models capture the behaviour of more complex Earth system models, but at a much lower computational cost. This allows them to be calibrated to observations and make a more detailed exploration of climate projections and emissions pathways than would otherwise be possible.

In addition to the first IGCC paper, the project also supported the development of the IGCC dashboard. The purpose of the dashboard is to make data on how the climate system is changing more accessible and user friendly. While its primary audience is policymakers, the dashboard can amplify the communication of climate data to a much wider audience.

Another avenue for communication is the *ZERO IN* report series that directly connects scientific updates from the project and beyond to the Paris Agreement. Additionally, there are hundreds of journal articles connected to the project, further broadcasting CONSTRAIN's contributions within the scientific community.

When it comes to climate change, humanity is on a dangerous course. We can't afford to take our eyes off the road, or our hands off the wheel. CONSTRAIN, by employing novel modelling tools and timely updates, is helping to steer Earth stewardship in the right direction.

PROJECT
CONSTRAIN – Constraining uncertainty of multi decadal climate projections

COORDINATED BY
University of Leeds in United Kingdom

FUNDED UNDER
H2020-EU.3.5., H2020-EU.3.5.1.

CORDIS FACTSHEET
cordis.europa.eu/project/id/820829

PROJECT WEBSITE
constrain-eu.org/

Institutional capacity building essential to rapid climate change mitigation

A comprehensive comparison of decarbonisation scenarios has identified feasible global and national actions that limit peak temperature in line with the Paris Agreement.

The United Nations' Intergovernmental Panel on Climate Change (IPCC) has issued very clear warnings regarding the multiple and concurrent hazards associated with an increase in the global average temperature (over conventional 20-to-30-year periods typically used to define climate) by 1.5 °C relative to pre-industrial levels. To avoid this, the overarching target of the Paris Agreement, a legally binding international treaty on climate change, is fast greenhouse gas emission reductions to achieve net-zero emissions.

The IPCC assessments also consider peak temperature constraints, namely to what extent pathways first overshoot the 1.5 °C increase and then return to 1.5 °C during the 21st century. The EU-funded ENGAGE project used integrated assessment models to identify pathways that explicitly limit peak temperature in line with the Paris Agreement, and the technical, social and political challenges that must be met to effectively implement them.

Meeting the peak temperature constraint: institutional capacity and international support

ENGAGE's elaborate stakeholder process relied heavily on societal partners to develop a new generation of scenarios that takes feasibility constraints into account. The results showed that traditional emissions pathways focused on end-of-century average global temperature lead to hazardous levels of mid-century peak-temperature overshoot, with substantially greater climate impacts and risks of reaching tipping points. In addition, the investments needed to reduce emissions in the short term bring long-term economic gains – end-of-century gross domestic product is higher in scenarios that avoid temperature overshoot.

According to project coordinator Bas van Ruijven of the International Institute for Applied Systems Analysis: "The capacity of governments and other institutions to achieve what is required for rapid mitigation to limit peak temperature in line with the Paris Agreement is a key concern. Countries with high institutional capacity including the EU, Japan and the United States should take more responsibility for near-term mitigation. Focused international aid for capacity building and knowledge transfer is essential for achieving ambitious decarbonisation."

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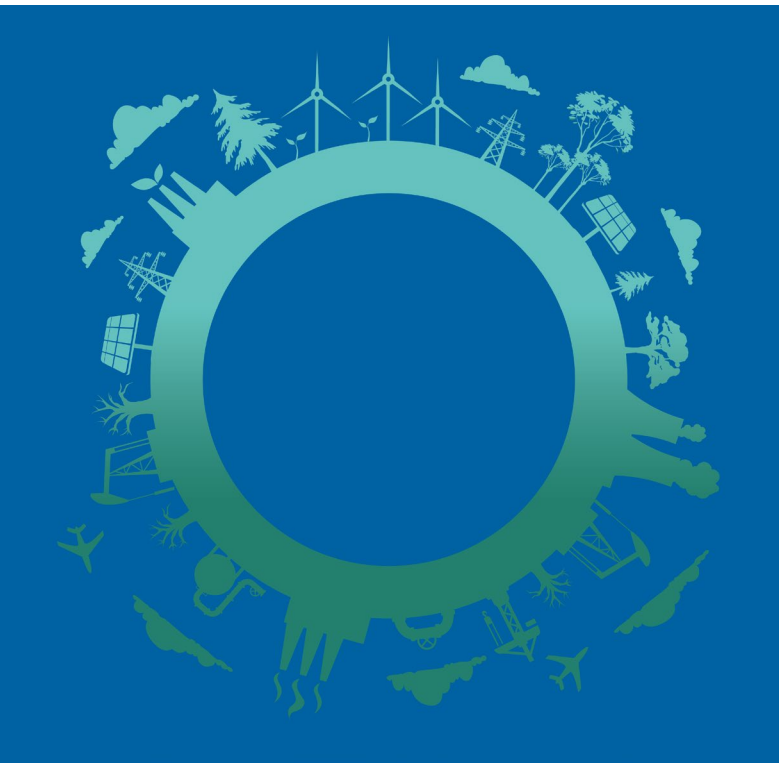
A comprehensive toolkit for climate stakeholders

The ENGAGE project developed a wealth of tools to support decision-making. These include: the Scenario Explorer with all the project's scenarios; the Multidimensional Feasibility Visualisation Tool to evaluate and compare decarbonisation pathways; and Dividing the Carbon Cake depicting allocation rules and regional emissions to keep the global average temperature increase below 2 °C.



"A key novelty of the Climate Solutions Explorer is the 'avoided climate impacts', those we will not experience if the world successfully mitigates global warming to 1.5 °C. The Impacts Explorer National Dashboards present the benefits of mitigation for close to 200 countries and 10 global macro-regions," explains van Ruijven.

Informed climate policymaking

ENGAGE also contributed more specifically to policymaking in many ways. Among these, the project directly informed and contributed to the conclusions of the IPCC Sixth Assessment Report. They produced eight topical policy briefs, combined in the ENGAGE Summary for Policymakers report and national policy scenarios that attempt to align national climate policies with global climate goals. Finally, the Climate Policy Database assimilates 6 028 policies covering 198 countries.

ENGAGE has delivered the information and data-driven tools needed for effective policymaking and decision-making. It is now in the hands of governments and stakeholders to realise their potential to limit the world's peak temperature in line with the Paris Agreement.

PROJECT
ENGAGE - Exploring National and Global Actions to reduce Greenhouse gas Emissions

COORDINATED BY
International Institute for Applied Systems Analysis in Austria

FUNDED UNDER
H2020-EU.3.5., H2020-EU.3.5.1.

CORDIS FACTSHEET
cordis.europa.eu/project/id/821471

PROJECT WEBSITE
engage-climate.org/

Heatwaves and air pollution combined: Europe's silent killer

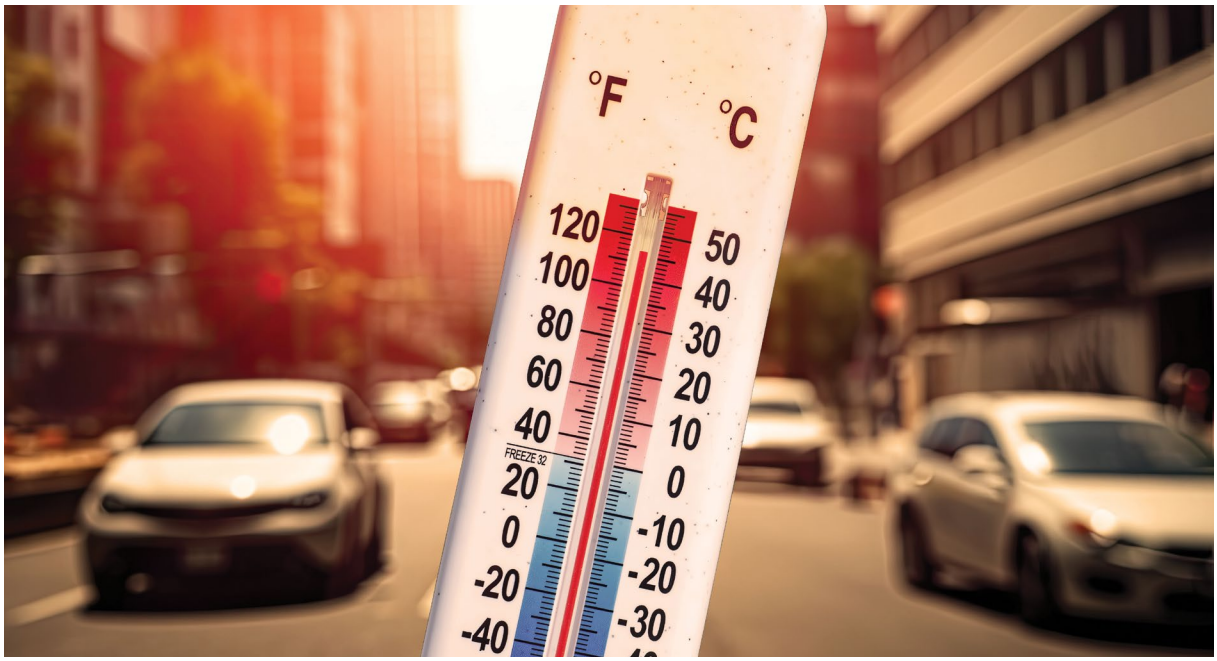
Air pollution and rising temperatures are creating a deadly combination in Europe, increasing mortality during heatwaves. To safeguard public health, urgent measures are needed.

Air pollution has become a pressing environmental challenge, leading to elevated mortality rates across Europe. This problem is further exacerbated by the rising occurrence of heatwaves due to climate change, which results in increased levels of ozone and particulate matter.

The influence of wildland fires and smoke further compounds the impact on European populations, increasing premature death and hospitalisation due to lung and heart diseases. Understanding the primary vulnerability factors within different communities and regions is crucial for shaping effective climate change policies.

Assessing the health impacts due to extreme heat and air pollution

The EU-funded EXHAUSTION project sought to quantify shifts in cardiopulmonary disease (CPD) mortality and morbidity due to extreme heat combined with air pollution. Researchers considered various climate scenarios and identified strategies for mitigating adverse effects.



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Utilising epidemiological methods, the study established the relationship between temperature and daily number of deaths across Europe and estimated the health burden. Moreover, it examined the impact of concurrent air pollutants such as particulate matter and ozone, on the heat-health relationship.

"We observed air pollution to be a significant modifier for the impact of heat on health, with a higher increase in deaths from respiratory diseases when air pollution levels were high," highlights project coordinator Kristin Aunan.

EXHAUSTION also assessed a range of vulnerability factors across European cities, both community level characteristics and individual parameters.

Key project findings reveal an elevated risk of up to 60 % of CPD mortality and morbidity during heat exposure, with a stronger heat effect observed for respiratory mortality/morbidity compared to cardiovascular causes. The elderly and females were more vulnerable to heat, with temperature effects demonstrating geographical and seasonal variations, including more pronounced heat effects in southern Europe.

Moreover, urban environment-related factors affected the risk of heat-related mortality, especially from respiratory diseases. Thus, people living in urban areas with dense populations, high air pollution levels and low coverage of green spaces demonstrated greater vulnerability to heat.

Heat and air pollution projections: the role of wildfires

EXHAUSTION projected health-relevant heat stress indicators for rising heatwave duration and intensity, and associated changes in air pollution levels.

Although air pollution surface concentrations are projected to decrease, the contribution from wildfire emissions is increasing, making it more difficult to reach air quality targets. Wildfires are emerging as a key source of particulate matter pollution, especially in eastern Europe.

Implications for climate change policies and public health

In the future, even with lower emissions, more people may die from heat than will be saved from cold-related deaths, leading to an overall increase in temperature-related fatalities.

In conclusion, the EXHAUSTION project's work underscores the critical importance of revamping urban environments and enhancing living conditions across European cities to combat the compounding effects of air pollution and rising temperatures.

It is becoming more and more evident that air quality and climate change are intertwined challenges and must be tackled together.

"It is becoming more and more evident that air quality and climate change are intertwined challenges and must be tackled together," emphasises Aunan.

Alignment of the EU air pollution mitigation measures with the World Health Organization's new Air quality guidelines is expected to bring clear health benefits, alongside resilience and sustainable development. To succeed, these measures must prioritise the protection of the most vulnerable population groups.

The findings from EXHAUSTION shape forthcoming studies, including the new PLANET4HEALTH project that will investigate the combined heat stress and air pollution in the African continent. Together, these efforts aim to create a safer and healthier future for Europe and beyond.

PROJECT
EXHAUSTION – Exposure to heat and air pollution in EUrope – cardiopulmonary impacts and benefits of mitigation and adaptation

COORDINATED BY
Center for International Climate Research in Norway

FUNDED UNDER
H2020-EU.3.5., H2020-EU.3.5.1.

CORDIS FACTSHEET
cordis.europa.eu/project/id/820655

PROJECT WEBSITE
exhaustion.eu/

Research advances means to expand the role of land in climate change strategies

EU-funded researchers dug deep into land-based mitigation technologies, which reduce and remove greenhouse gases from the atmosphere using land as a carbon sink.

Land-based mitigation technologies and practices (LMTs) are crucial strategies to combat climate change, representing around 30 % of the nationally determined contributions under the Paris Agreement. Although LMTs aim at reducing greenhouse gas emissions from land use and removing them from the atmosphere using land as a carbon sink, there are still uncertainties and barriers regarding their effectiveness.

To improve the assessment of these practices and to provide more detailed insights that can contribute to decision-making in the private sector and by policymakers, the EU-funded project LANDMARC was born.

The global and regional scaling potential of LMTs, despite the risk of reversal, is substantial both in terms of emission reduction and carbon removal in nature-based practices.

"The global and regional scaling potential of LMTs, despite the risk of reversal, is substantial both in terms of emission reduction and carbon removal in nature-based practices," argues Jenny Lieu, LANDMARC's co-coordinator.

Advances to expand LMTs

"It is vital to verify whether an LMT solution delivers its climate promise. Better and more reliable measurements are needed to be able to quantify the factual CO_2 emissions and the amount of carbon stored," says Eise Spijker, LANDMARC's other co-coordinator.

LANDMARC has developed more robust methods, called carbon measurement and monitoring tools, to measure LMTs in different contexts. Traditionally used in microbiology, agronomy and other disciplines, these techniques can now be used to obtain credible values of carbon content in soil or biomass and to validate the mitigation potential for different LMTs. They also ultimately offer cost-effective methods that land use owners can apply without resorting to expensive consulting partners.

The project also carried out experiments that combine remote sensing and in situ monitoring tools and methods in 14 countries.

LANDMARC brought together not only multidisciplinary experts from academia but real practitioners of LMTs and stakeholders from different parts of the world. It organised more than 716 stakeholder activities, such as workshops and interviews, to jointly develop knowledge narratives for models that can facilitate LMT pathways and collect data on the ground for monitoring and measuring CO_2.

Unique insights

The integrated approach of LANDMARC was essential to identify important elements for the implementation of LMTs. For instance, the research found that local and indigenous knowledge and practices, although of high value for LMTs, are often underrepresented or ignored. Gaps of knowledge regarding specific LMT solutions and costs were also identified among stakeholders.

The project further recognised that climate change cannot be the only reason for implementing LMTs. This is because these practices must also provide social and economic benefits, which can make them valuable in the long term.

Benefits for society

LANDMARC's policy analysis can provide information that helps the EU initiative to develop a carbon removal certification mechanism and complements other policies that can encourage land managers to engage in more sustainable LMT practices.

According to the research, a combination of LMT portfolios is the right approach. In Europe, depending on the region, this includes integrated soil fertility management, forest management practices, wildfire management, peatland rewetting, and bio-energy carbon capture and sequestration.

Lieu and Spijker maintain that "Our focus on a more integrated valuation of LMT practices benefits local communities and societies to become more resilient to climate change and other external shocks. Scaling up LMTs is not just about CO_2 removal or emission reduction, but mainly about other social and environmental impacts that matter."

PROJECT
LANDMARC – LAND-use based MitigAtion for Resilient Climate pathways

COORDINATED BY
Delft University of Technology in the Netherlands

FUNDED UNDER
H2020-EU.3.5., H2020-EU.3.5.1.

CORDIS FACTSHEET
cordis.europa.eu/project/id/869367

PROJECT WEBSITE
landmarc2020.eu/

An improved multidimensional sustainability modelling tool

A new open-source integrated assessment model will help policymakers, academia, NGOs and the public chart our path to a sustainable future.

© LOCOMOTION H2020 project

Climate change risks and impacts are becoming increasingly complex and difficult to manage. Moving towards a low-carbon, zero-emissions future requires an equally complex integration of socioeconomic, energy and environmental considerations.

Integrated assessment models (IAMs) do precisely this. The EU-funded LOCOMOTION project developed WILIAM, a new IAM that addresses key limitations of current models. It is a fully open source and it can model both global and regional scenarios with all model variables separated into nine world regions. The European Union is one, although some modules model the 27 EU Member States separately.

Modelling realistic and detailed socioeconomic, energy and environmental interactions

"WILIAM models the economy dynamically with detailed representation of production (based on input-output tables for 62 sectors) and consumption (including 60 household types in the EU) as well as government, investment, labour, international trade and finance," explains project manager Nathalie Wergles of the University of Valladolid, Group of Energy, Economy and Systems Dynamics. WILIAM captures interactions among energy, the economy, materials and land use, with changes in the physical models affecting the economic model and vice versa.

WILIAM also includes modules for demography, society and climate. It computes the energy return on investment (EROI) (the ratio of usable energy returned to the energy invested to make it over a system's lifetime) considering the material requirements of green technologies.

"In contrast to current models that assume very high renewable and non-renewable energy potentials, WILIAM considers constraints on biophysical systems, geography, natural resources and EROI when assessing the techno-sustainable potential of renewables," adds scientific project coordinator Iñigo Capellán Pérez, also of the University of Valladolid, Group of Energy, Economy and Systems Dynamics.

Finally, WILIAM addresses the challenges of systems based on 100 % renewables. It keeps track of sub-annual timescale effects on annual energy balances depending on the generation and flexibility capacities and contains hydrogen-based energy capabilities.

A groundbreaking IAM for all stakeholders

LOCOMOTION developed three versions of the software, all open source, to enable easy use by those not familiar with modelling software. The most complex, the Model Analyser, targets policymakers and academia and enables detailed model parametrisation for customised scenarios.

The Model Explorer is a simple, user-friendly application to provide environmental NGOs or similar organisations with data to support their arguments. The Global Sustainability Crossroads II Game is designed to help educators and NGOs raise awareness among young people about the difficult political and societal choices required to achieve global sustainability.

Data-backed policy scenarios and more

"WILIAM is a complex, new IAM rather than an extension of the MEDEAS model as originally planned," notes Capellán Pérez. The WILIAM model is already producing relevant results of policy scenario simulations, for example, on the decarbonisation of passenger transport, dietary shifts, the potential hydrogen use in the energy system, raw materials required for the green transition, the integration of high shares of renewables and the effect of introducing a universal basic income in the EU. It has also been used to explore the techno-sustainability limits of renewables for biofuels and electricity.

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As the team continues to improve and validate modules and incorporate them into the highly comprehensive model, all updates are published as they become available. The LOCOMOTION tool assists global decision makers in designing a successful path to sustainable energy systems.

PROJECT
LOCOMOTION – Low-carbon society: an enhanced modelling tool for the transition to sustainability

COORDINATED BY
University of Valladolid in Spain

FUNDED UNDER
H2020-EU.3.5., H2020-EU.3.5.1.

CORDIS FACTSHEET
cordis.europa.eu/project/id/821105

PROJECT WEBSITE
locomotion-h2020.eu/

Negative emissions technologies and practices: the way forward

An analysis of technical, environmental, social and commercial aspects of carbon dioxide removal strategies identifies the realistic potential for negative emissions.

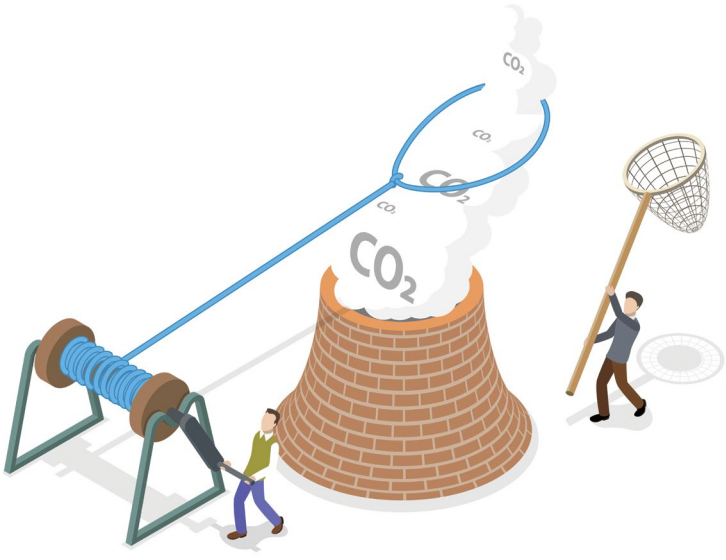
According to the United Nations' Intergovernmental Panel on Climate Change, the world must transform in complex and interconnected ways to limit global warming to 1.5 °C relative to pre-industrial levels. Emissions reductions and carbon dioxide removal (CDR) both reduce the amount of atmospheric greenhouse gases. As the urgency to mitigate climate change escalates and the speed with which the world adopts low-carbon processes lags behind, negative emissions technologies and practices (NETPs) are needed to complement the emission reductions.

Negative emissions are created when more CO_2 is removed from the atmosphere than is emitted and its storage is permanent. To be adopted and thus effective, NETPs must go beyond technological potential. The EU-funded NEGEM project, ending in May 2024, is evaluating the realistic potential of seven classes of NETPs in the context of their technical, environmental, social and commercial potential and challenges. The project's science policy brief summarises the results to date and delivers key recommendations for EU climate policy.

Engineered and nature-based solutions for CDR

Engineered solutions abound. They include direct air capture and storage of CO_2, bioenergy or other biomass-based processes combined with CO_2 capture and storage, enhanced weathering and ocean-based solutions such as ocean liming. Nature-based solutions (NBS), a phrase put forth in the late 2000s and now enshrined in climate change dialogues, include afforestation, reforestation, biochar CDR, soil carbon sequestration, and ocean-based CDR including seaweed cultivation and sinking.

The NEGEM project is studying all of these. According to Kati Koponen of the VTT Technical Research Centre of Finland: "Engineered solutions with storage on geological timescales provide permanent CDR and are necessary to reach climate neutrality. NBS are essential because they provide strong synergies between climate change mitigation and international targets for nature restoration and broader sustainable development goals."



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NETPs: technical, environmental, social and commercial aspects

The NEGEM analysis framework combines land use modelling, life-cycle assessment (LCA), cost optimisation and social acceptance evaluation. Essential new insight on NETPs deployment is emerging from combined modelling approaches, for example land use modelling and energy system modelling, and integrated assessment modelling that included the full portfolio of NETPs.

The LCA results for more than 20 NETP cases revealed that none of the NETPs comes without trade-offs between different environmental goals. The social licence to operate varies across sectors and geographical regions for different NETPs. For example, NGOs and companies sometimes have opposing views on the acceptability of certain NETP solutions. In addition, tension exists in balancing CDR goals against other high-priority social or environmental goals.

NEGEM also studied the market-based mechanisms for CDR. They found that the current mechanisms mainly support afforestation and soil carbon sequestration with minimal support for geological CDR. Overall, they are under-funded and provide too little incentive to enable a CDR portfolio that can achieve climate neutrality.

Climate policy requires a portfolio of solutions

Koponen summarises: "Based on the results of the scenario analyses, drastic and immediate emission reductions are needed to reach the 1.5-2.0 °C mitigation goals. In addition, NETPs will be needed as a complementary measure. A large portfolio of NETPs can help to respond to the environmental and social challenges. NETPs deployment should begin by the 2030s, underscoring the urgency to develop clear policies and regulations in the EU and globally." To assist stakeholders, the NEGEM tools and data sets can be found on the project website that will continue to be updated throughout the project's duration.

Based on the results of the scenario analyses, drastic and immediate emission reductions are needed to reach the 1.5-2.0 °C mitigation goals. A large portfolio of NETPs can help to respond to the environmental and social challenges.

PROJECT
NEGEM - Quantifying and Deploying Responsible Negative Emissions in Climate Resilient Pathways

COORDINATED BY
VTT Technical Research Centre of Finland in Finland

FUNDED UNDER
H2020-EU.3.5., H2020-EU.3.5.1.

CORDIS FACTSHEET
cordis.europa.eu/project/id/869192

PROJECT WEBSITE
negemproject.eu/

New tools offering unbiased insights into manmade and natural influences unveil our climate reality

Advanced tools are refining our ability to differentiate between anthropogenic and natural greenhouse gas emissions, helping us better understand the scale of their impact on climate change.

For millions of years, Earth has maintained a balanced climate system, adeptly managing natural emissions from plant uptake and organic matter decomposition as well as events such as volcanic eruptions. Recent human activities have tipped this balance. The burning of fossil fuels such as coal, gas and petroleum and various industrial processes have added a significant burden to our atmosphere.

Distinguishing between human and natural greenhouse gas (GHG) emissions is crucial for effective climate change action. Despite the numerous efforts by national governments, regional authorities and private stakeholders to reduce GHG emissions, measuring the effectiveness of related policies remains a challenge. "Current national GHG inventories report to the United Nations Framework Convention on Climate Change (UNFCCC)

each year, but these reports are often plagued by substantial uncertainties and cannot easily be independently verified," states Philippe Peylin, coordinator of the EU-funded VERIFY project.

Natural vs anthropogenic GHG emissions

VERIFY, a collaborative effort amongst 40 partners, sought to provide a more accurate assessment of carbon stocks and GHG emissions including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

"Creating a precise characterisation of the spatiotemporal variations of GHG fluxes is complex: it requires distinguishing between anthropogenic and natural components and their corresponding drivers," states Peylin. The team tackled this challenge through advanced modelling approaches. Their strategy included using atmospheric GHG measurements, tracer transport inversions and a diverse range of land observations – both in situ and from space.

"Our approach is unique as it incorporates independent observations in support of inventories that primarily rely on statistical data," highlights Peylin. "The wealth of knowledge generated by VERIFY will be harnessed to improve national GHG inventories. In collaboration with national inventory agencies, this information should help track the progress of EU mitigation efforts towards meeting the targets set out in the Paris Agreement on climate."

New products filtering out data uncertainties and biases

Project members have fostered synergies between the scientific and inventory communities through networking meetings and contributions to international programmes. They have developed process-based and statistical model simulations of terrestrial ecosystem GHG fluxes over Europe, creating high-resolution CO_2 maps across areas spanning around 11 km. VERIFY has also been successful in developing high-resolution maps spanning areas of around 6 km to study CO_2 emission correlations between humans and co-emitted species across Europe.

Researchers have also created a community inversion framework for future GHG monitoring systems. "Another significant achievement has been the development of a framework to provide yearly updates of the CO_2, CH_4 and N_2O flux synthesis for all EU countries. The data covers the past two decades up to 2022," notes Peylin.

VERIFY has successfully developed scientifically robust methods to help assess the accuracy and potential biases in national greenhouse gas inventories reported by various parties through independent operational frameworks.

Additionally, a database has been established to host VERIFY datasets and user-friendly visualisation tools to explore recent trends in GHG fluxes.

All products developed throughout VERIFY can be found on the official project website.

"VERIFY has successfully developed scientifically robust methods to help assess the accuracy and potential biases in national GHG inventories reported by various parties through independent operational frameworks," notes Peylin. "The basic idea has been to offer estimates based on various observations of both natural and anthropogenic GHG emissions and sinks, along with their associated uncertainties."

PROJECT
VERIFY – Observation-based system for monitoring and verification of greenhouse gases

COORDINATED BY
French Alternative Energies and Atomic Energy Commission, France

FUNDED UNDER
H2020-EU.3.5., H2020-EU.3.5.1.

CORDIS FACTSHEET
cordis.europa.eu/project/id/776810

PROJECT WEBSITE
verify.lsce.ipsl.fr/

New tools boost understanding of the perpetual interactions between climate and carbon cycle

The ongoing climate crisis underlines how changes in the carbon cycle can drastically affect our climate. An EU-funded project sheds light on their complex interplay and feedback mechanisms.

Climate-carbon cycle feedbacks, resulting from interactions between the climate and carbon cycle, can amplify global warming. Burning fossil fuels increases atmospheric CO_2, causing warming. In return, the warming disrupts the carbon cycle. For example, warmer temperatures accelerate organic matter decomposition, releasing more CO_2. Moreover, as Earth warms, natural carbon sinks such as forests and oceans may absorb less CO_2, creating a feedback loop that exacerbates climate change.

Novel tools tracking CO_2 variability and near-term predictions

The EU-funded 4C project was dedicated to enhancing quantitative understanding of carbon-climate interactions and feedbacks. This has been achieved by integrating models and observations, providing new land- and ocean-constrained carbon fluxes on carbon-climate interactions and drawing new climate projections.

We developed new tools and methods to predict, for the first time, the evolution of global carbon cycle variability over the coming decade including atmospheric CO_2, land and ocean carbon sinks, and climate response.

"We developed new tools and methods to predict, for the first time, the evolution of global carbon cycle variability over the coming decade including atmospheric CO_2, land and ocean carbon sinks, and climate response," notes Kerry Hope, 4C project coordinator. "This should help track the overall progress towards the goal of the Paris Agreement."

A significant feat has been the development of three European Earth system models (ESMs) utilised to develop and continually improve initialisation techniques. These techniques have been validated against new observational products for near-term CO_2 predictions. "The best-performing initialisation technique was used to perform near-term predictions. These predictions assume that anthropogenic emissions follow the nationally determined contributions (NDCs) as defined by the Paris Agreement," explains Hope. "This allows us to anticipate the near-term evolution (from 2020 to 2030) of atmospheric CO_2 increase as well as the response of land and ocean sinks to climate change and variability."

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Emergent constraints and model skills have been combined to reproduce the historical climate projection records. This combination provides more accurate weighting of multi-model and large ensemble climate and carbon cycle projections. "Our Climate Model Intercomparison Project (CMIP6+) ESMs have been used to explore original adaptive scenarios. These scenarios start with one that aligns with NDCs for the first decade (2020-2030). After this, we implement an adaptive mechanism: every 5 years we simulate climate change, and the model tells us to what extent we need to adjust our emission reduction plan. The goal is to keep global warming below 1.5 or 2 degrees Celsius," highlights Hope.

Disseminating findings to the broader public

4C has made significant contributions to major international scientific assessments, such as the Intergovernmental Panel on Climate Change Sixth Assessment Report. It has supported the ScienceBrief platform, which synthesises rapidly evolving science on the global carbon cycle. The 4C team has also been strongly involved in the reports included in the Global Carbon Budget project.

"By confronting ESMs with novel observations and developing new emergent constraints and model weighting approaches, we sought to increase confidence in climate change projections," states Hope. "Overall, we provided added value to decisionmakers and policymakers in a bid to sustain Europe's leadership in climate science."

PROJECT
4C – Climate-Carbon Interactions in the Current Century

COORDINATED BY
University of Exeter in the United Kingdom

FUNDED UNDER
H2020-EU.3.5., H2020-EU.3.5.1.

CORDIS FACTSHEET
cordis.europa.eu/project/id/821003

PROJECT WEBSITE
4c-carbon.eu/4c-project

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CINEA manages the Connecting Europe Facility 2 (Transport and Energy), the LIFE programme, the Innovation Fund, the European Maritime, Fisheries and Aquaculture Fund, the Renewable Energy Financing Mechanism and the Public Sector Loan Facility under the Just Transition Mechanism. CINEA is also managing and implementing the Climate, Energy and Mobility Cluster of Horizon Europe and three of the five missions under the Horizon Europe framework programme. These missions are: Adaptation to Climate Change, Restore our Ocean and Waters by 2030, and 100 Climate-Neutral and Smart cities by 2030.

CINEA also implements two societal challenges of the Horizon 2020 programme: Secure, clean and efficient energy, and Smart, green and integrated transport. CINEA provides technical and financial management services at all stages of the programme and project life cycle – from the calls for proposals, evaluation of projects and the award of financial support, to the follow-up of project implementation and control of the use of funds allocated.

CINEA provides visibility for EU funding opportunities and project results – and supports potential applicants and beneficiaries, allowing them to benefit from the Agency's long-standing experience of programme implementation with a high level of performance and seeks to promote synergies between the programmes in order to benefit EU citizens and promote economic growth.

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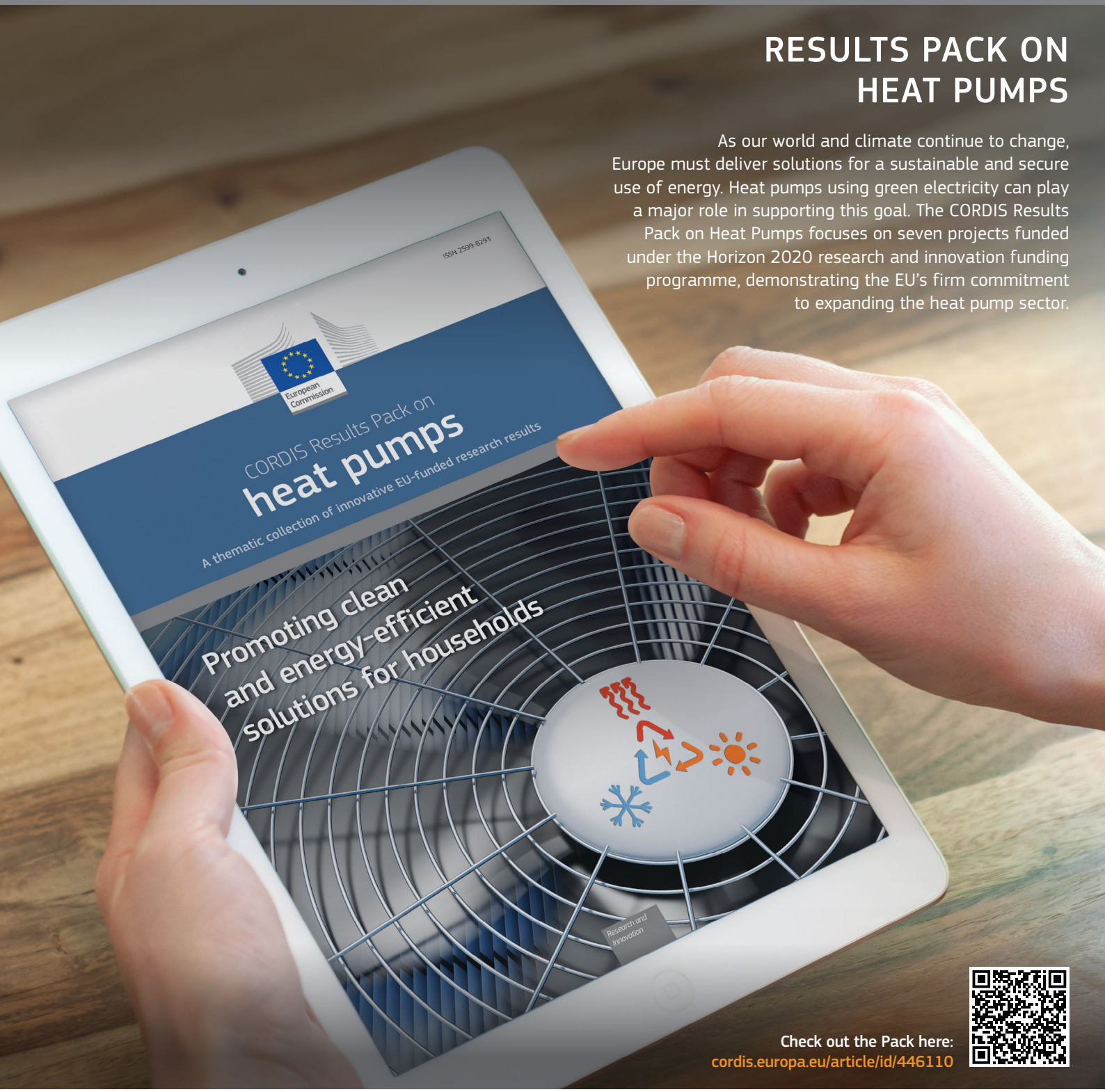
RESULTS PACK ON HEAT PUMPS

As our world and climate continue to change, Europe must deliver solutions for a sustainable and secure use of energy. Heat pumps using green electricity can play a major role in supporting this goal. The CORDIS Results Pack on Heat Pumps focuses on seven projects funded under the Horizon 2020 research and innovation funding programme, demonstrating the EU's firm commitment to expanding the heat pump sector.



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