

Impact case study (REF3)

Institution: University of East Anglia		
Unit of Assessment: 7 – Earth Systems and Environmental Sciences		
Title of case study: Global carbon budgets influence the design and implementation of Net-Zero emissions targets		
Period when the underpinning research was undertaken: 2006 - 2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Corinne Le Quéré	Royal Society Research Professor	2004 - present
Bob Watson	Emeritus Prof of Environmental Sciences	2007 - 2019
Dorothee Bakker	Reader in Ocean Biogeochemistry	1998 - present
Andrew Manning	Reader in Atmospheric & Ocean Science	2005 - present
Naomi Vaughan	Senior Lecturer in Climate Change	2006 - present
Charlie Wilson	Reader in Energy and Climate Change	2010 - present
Andy Jordan	Prof of Environmental Sciences	1992 - present
Ian Harris	Senior Research Associate	1996 - present
Period when the claimed impact occurred: 2013 – 2020		
Is this case study continued from a case study submitted in 2014? N		
1. Summary of the impact		
<p>Around the world, most countries have committed to pursue efforts to limit climate change to 1.5°C of warming, and to achieve a balance between the emissions and sinks of greenhouse gases as part of the landmark intergovernmental Paris Agreement on climate change. Our research contributed to enshrining these objectives into the Paris Agreement, demonstrating that they are possible and by what means. Our research further underpinned the translation of these objectives into national “Net-Zero” emissions targets in the UK and France, while supporting similar reflections in the European Union and worldwide. Our research and engagement with policymakers at national and international levels has been instrumental in setting carbon budget and climate change targets via international agreements and national laws.</p>		
2. Underpinning research		
<p>Researchers in the School of Environmental Sciences (ENV) have played prominent roles in establishing the current understanding of the balance between emissions and sinks of carbon dioxide (CO₂), and their evolution over recent decades (e.g. [R1, R2]). Only about 45% of the global emissions of carbon dioxide (CO₂) remain in the atmosphere every year; the remainder are absorbed by ocean and land “carbon sinks”. CO₂ is the anthropogenic greenhouse gas most responsible for climate change. To stop further warming of the planet, the emissions and sinks of CO₂ have to reach “Net-Zero”, meaning that residual emissions that cannot be totally eradicated need to be balanced by artificially enhanced carbon sinks.</p> <p>In 2004, Le Quéré instigated the publication of annual reports on the balance between emissions and sinks of CO₂, so-called “global carbon budgets”, under the umbrella of the Global Carbon Project, an international research project of the <i>World Climate Research Programme</i> and <i>Future Earth</i>, which she co-chaired between 2009 and 2013. Le Quéré led the first 13 editions of the annual updates up to 2018 (with major contributions to more recent editions), bringing together annual contributions from up to 80 scientists, with some editions including Bakker, Harris, Manning, and other UEA researchers. From the outset, these annual budget updates revealed increases in global CO₂ emissions beyond expectations and highlighted that carbon sinks were probably already responding to recent climate change [R1]. The subsequent reports [R2] demonstrated that the current understanding and data on CO₂ emissions and sinks could account for both the mean and trend in observed atmospheric CO₂ concentrations, even though some unaccounted variability remained evident.</p> <p>ENV faculty have also led on the monitoring of the oceans’ carbon sinks and their contribution to the global carbon budget [R2]. UEA’s Bakker is one of the champions of the Surface Ocean</p>		

CO₂ Atlas (SOCAT) data collection [R3], a synthesis of global observations that are used to verify the ocean sinks' estimate of the global carbon budget. SOCAT is also used for evaluation of sensor data and ocean biogeochemical models thus informing the IPCC (Intergovernmental Panel on Climate Change).

The 15 annual global carbon budget updates [R2] have become a key pillar of climate change science. They provide **exceptional exposure to the necessity to balance global emissions and global sinks of CO₂**. One key figure reproduced each year (Fig. 1) shows that emissions need to decrease to zero in the second half of this century to limit global warming to 1.5°C. These annual analyses are often published in high-impact journals (e.g., *Nature*, *Nature Geoscience*, *Nature Climate Change*) and have high visibility both within the climate research community and, via the media and researchers' engagement with Stakeholders, to policymakers and the public.

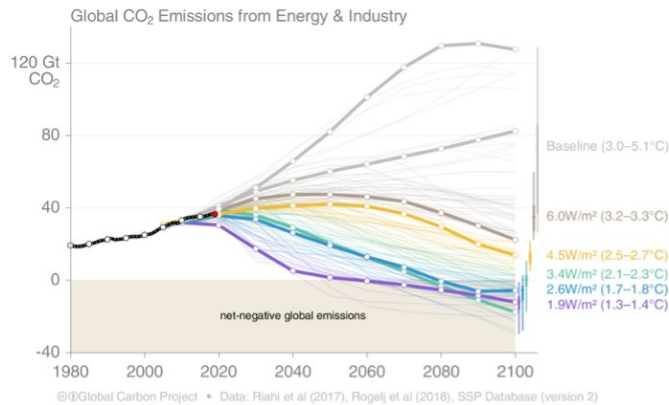


Figure 1 Global CO₂ emissions compared to emissions scenarios that limit climate change to 1.5°C and other temperature targets [updated from R2].

ENV faculty have also helped to establish the scientific evidence on *how to deliver reductions in emissions*. **Le Quéré, Wilson** and **Jordan** carried out an analysis of the success behind the decarbonisation of 18 developed economies which identified, for the first time, a link between energy and climate policies and reductions in emissions; suggesting that policies work to reduce emissions largely through the displacement of fossil fuels by renewable energy and a decrease in energy use [R4]. **Wilson's** 'Low Energy Demand' scenario [R5] was prominently featured as one of four marker scenarios in the IPCC *Special Report on Global Warming of 1.5°C*, the only one not reliant on large-scale negative emissions. At the onset of the COVID-19 pandemic, **Le Quéré** led a team that published the first peer-reviewed estimate of the impact of confinement measures on global and national CO₂ emissions [R6], innovating on methodology as well as clarifying the temporary nature of this event on emissions, and the large potential of economic recovery stimulus to address climate change.

3. References to the research

Underpinning research: The underpinning research outputs have all been published in competitive, international, peer-reviewed journals and form part of a larger body of such published work. [Citations from Google Scholar]. **UEA authors** in bold.

[R1] Trends in the sources and sinks of carbon dioxide.

Le Quéré, C., ... U. Schuster et al.

Nature Geoscience, **2009**, 2, 831-836. DOI: 10.1038/ngeo689 [1174 citations]

[R2] The Global Carbon Budget 1959–2011,

Le Quéré, C., et al.

Earth System Science Data, **2013**, 5, 165-186. DOI: 10.5194/essd-5-165-2013 [Updated each year as part of the Living Data format, with 3,107 citations across the paper collection.]

[R3] An update to the Surface Ocean CO₂ Atlas (SOCAT version 2).

Bakker, D. C. E., et al.

Earth System Science Data, **2014**, 6, 69-90 DOI: 10.5194/essd-6-69-2014. [Four Living Data updates with two led by Bakker, with 417 citations across the paper collection]

[R4] Drivers of declining CO₂ emissions in 18 developed economies.

Le Quéré, C., J.I. Korsbakken, C. Wilson, J. Tosun, R. Andrew, R. Andres, J. Canadell, A. Jordan, G. Peters, D. van Vuuren

Nature Climate Change, **2019**, 9, 213-217. DOI: 10.1038/s41558-019-0419-7 [62 citations]

[R5] "A Low Energy Demand Scenario for Meeting the 1.5°C Target and Sustainable Development Goals without Negative Emission Technologies."
Grubler, A., C. **Wilson**, *et al.*
Nature Energy, **2018**, 3: 515-527. DOI: 10.1038/s41560-018-0172-6 [177 citations].

[R6] Temporary reduction in daily global CO₂ emissions during the COVID-19 forced confinement.
Le Quéré, C., R.B. Jackson, **M.W. Jones**, **A.J.P. Smith**, S. Abernethy, R.M. Andrew, **A.J. De-Gol**, **D.R. Willis**, Y. Shan, J.G. Canadell, P. Friedlingstein, F. Creutzig, G.P. Peters.
Nature Climate Change, **2020**, 10, 647-653. DOI: 10.1038/s41558-020-0797-x [193 citations]

4. Details of the impact

Our research has helped shape responses to the global carbon budget and climate change in three complementary ways. First it significantly influenced the content of the Paris Agreement on climate (signed in December 2015). Second, it has provided insights and advice for translating Paris Agreement objectives into national Net-Zero emissions targets in the UK and France, while also supporting similar reflections in the European Union and worldwide. Third, it has underpinned global awareness of the necessity to balance CO₂ emissions and sinks, helping establish a background of knowledge and acceptability for this challenge. Furthermore, the inclusion of the ambition to limit climate change to 1.5°C was influenced by a report Chaired by **Watson** and requested by the Alliance of Small Island States (AOSIS), to assess its feasibility. The report was presented to UN General Secretary Ban Ki Moon (2014) and formed the basis of the position of AOSIS to 'keep the politically agreed 1.5-2°C goal within reach'.

(1) Our research has provided instrumental evidence that was critical to the content of the Paris Agreement. The multiple statements on the importance of balancing the emissions and sinks of greenhouse gases were greatly influenced by results of the global carbon budget [R1, R2], particularly following the presentation of the global carbon budget results by **Le Quéré** at the June 2015 Structured Expert Dialogue of the United Nations Framework Convention on Climate Change (UNFCCC), the UN body tasked with supporting the global response to the threat of climate change. The multiple mentions of the ocean and land "sinks" in the meeting report primarily referred to the presentation of **Le Quéré** at that meeting [S1]. The UNFCCC June 2015 meeting report was then used by the UNFCCC as a basis to draft the scientific text of the Paris Agreement that was eventually adopted in December 2015. Furthermore, the global carbon budget findings are extensively cited in the IPCC 5th Assessment report, WGI (Ch. 6) and WGIII (Ch. 5), and in the UNEP (United Nations Environment Programme) Emissions Gap Reports of 2013 and 2014 (and every report since), all of which were core to the scientific basis of the 2015 Paris Agreement [S2].

(2) Our research has provided evidence and expert advice to help translate the worldwide ambition of the Paris Agreement into meaningful national targets and accompanying policy for reaching 'Net-Zero' emissions in the UK and France, as well as influencing reflections in the European Union and worldwide.

The UK Net-Zero target for year 2050 was passed into law in 2019, adopting the recommendation of the **Climate Change Committee** (CCC) whose report includes multiple contributions from UEA authors, and was authored by **Le Quéré** [S3]. **Vaughan** was member of the advisory group on UK Net-Zero that informed the CCC report, with contributions from **Wilson** acknowledged. The global carbon budget analysis (2018 update of [R2]) is cited in the main report, and the low energy demand scenario [R5] in the technical report. Our research also played an important role ahead of the CCC recommendation for Net-Zero by providing multiple briefings to policymakers. For example, in 2018, the Department for Business, Energy and Industrial Strategy (BEIS) received our advice on how to respond to the Paris Agreement, providing UEA with funding through a competitive call, from which we delivered [R4] and other similar analysis. This effort included **Le Quéré**, **Vaughan**, **Watson**, **Wilson**, and many others in ENV and ended in a training day for 75 senior civil servants and political advisors [S4].

The French Net-Zero target for 2050 was strengthened in November 2019 in response to a report led by **Le Quéré** in June that year. **Le Quéré** became the first Chair of the new French **Haut**

conseil pour le climat (HCC, Fig. 2), an independent advisory body inspired by the UK CCC. She presented the recommendations of the first HCC report to the 'Conseil de Défense Écologique' in July 2019, an inter-ministerial group Chaired by President Macron including 9 Ministers. The French government later detailed the numerous actions they have undertaken in response to the HCC 2019 report, including the inclusion in law of a target for international transport and for consumption emissions, and the evaluation of laws, which were direct recommendations of the HCC [S5]. The HCC has published six reports so far, all of which have led to substantial responses by the French Government, most recently the recommendation to frame the economic stimulus response of the Government within the limits of the climate, resulting in a EUR30,000,000,000 green investment (of the EUR100,000,000,000 announced in September 2020), and published after an HCC report citing **Le Quéré's** assessment of the effect of COVID-19 on CO₂ emissions [R6] made the case for the importance to align the economic stimulus with climate targets [S6].



Figure 2 Members of the French Government including President Macron (middle-left), the Prime Minister and several ministers, at the launch of the Haut conseil pour le climat, Chaired by UEA Professor Le Quéré (middle-right). Paris, 27 November 2018.

The European Union used our work in a 2018 policy document detailing its strategy for achieving a climate neutral economy, citing the 2017 global carbon budget led by **Le Quéré** [R2; S7]. The EU has now agreed a goal of reaching carbon neutrality in 2050.

Worldwide, the work of **Wilson** on scenarios that focus on demand-led measures [R5] was used to influence strategies for businesses and governments, including **Mission Innovation**, an inter-governmental clean energy innovation initiative launched alongside the Paris Agreement, and the **Exponential Carbon Roadmap**, an initiative of the global science network, Future Earth. **Wilson** authored the '1.5°C Compatible Pathfinder Framework' published by **Mission Innovation** [S8a], advised the Mission Innovation secretariat on strategy, and presented results at the Ministerial Meeting in Vancouver (May 2019) and Saudi Arabia (Sep 2020). **Wilson** also co-authored the 'Meeting the 1.5 Climate Ambition' report launched at the 2019 UN Climate Action Summit by the **Exponential Carbon Roadmap** [S8b], setting out measures for halving emissions every decade to 2050, as well as a chapter in **UNEP's Emissions Gap** 2019 report [S8c], advising on critical interactions between climate targets and UN Sustainable Development Goals.

(3) Our research has helped to raise awareness amongst the public, thought leaders, UN bodies, and businesses, of the necessity to balance emissions and sinks of CO₂, providing background knowledge and acceptability for Net-Zero targets.

The reach of our public engagement truly stands out. Its influence is demonstrated through the extended use of our data, figures and commentaries by others.

Influential leaders and top UN bodies use the global carbon budget as a reference on the state of carbon emissions. **Former Governor of the Bank of England, Mark Carney**, now UN envoy for climate change action, used Fig. 1 in a report where he concluded that climate change risks are "far-reaching in breadth and magnitude" (2018; [S9a] Table A, page 9). Popular author **Naomi Klein's** book 'This changes everything' (2014) heavily cites the global carbon budget and broader research by the UEA-led Tyndall Centre [S9b]. The **UN Secretary General** talked about the global carbon project results in his opening presentation at COP22 (Bonn, 2017) [S9c]. **Former UNFCCC Chief Christiana Figueres** set out a six-point plan for turning the tide on climate change using global carbon project data and invited **Le Quéré** to co-author a *Nature Commentary* in 2018 [S9d].

The Global Carbon Budget publications [R1, R2] systematically and repeatedly achieve worldwide coverage in the media, reaching >2 billion people each year [S10a], equivalent to advertising spend approaching USD25,000,000. The use of the Global Carbon Atlas - set up by a team including Le Quéré (overseeing the emissions component) to facilitate access to carbon emissions data - is growing, with peak use correlated to events related to climate change (see Figure 3). The COVID-19 analysis of CO₂ emissions of Le Quéré [R6] also achieved unprecedented media coverage [S10b] and was in the top 1% of all research outputs scored by Altmetric and ranked in 12th position of the Altmetric top 100 research papers that most captured the public imagination [S10c]. This provided mass exposure to its conclusion that economic stimulus post-COVID will influence the course of CO₂ emissions in the long-term.



Figure 3 Weekly sessions of the globalcarbonatlas.org web site from Google Analytics (December 2020).

5. Sources to corroborate the impact

- [S1] UNFCCC minutes of the Structured Expert Dialogue report with details of Le Quéré's presentation.
- [S2] Held on file at UEA: a) IPCC 5th Assessment report; b) WGI (Ch. 6); c) WGIII (Ch. 5); d) UNEP (United Nations Environment Programme) GAP report 2013; e) UNEP GAP Report 2014
- [S3] The CCC advice on Net-Zero emissions authored by Le Quéré cites UEA's work and acknowledges contributions from Vaughan and Wilson:
- [S4] a) Briefings prepared for BEIS upon their request; b) Training programme
- [S5] Report by the French Prime Minister in response to HCC report Chaired by Le Quéré:
- [S6] a) HCC 2020 COVID report; b) HCC 2020 Annual Report; c) Announcement of the 30bi investment in September; d) Press dossier, Ministère de la Transition Écologique.
- [S7] European report on strategy to curb long-term emissions cites global carbon budgets
- [S8] a) Mission Innovation Compatibility Pathfinder Framework, 2019; b) *Meeting the 1.5 Climate Ambition*, 2019, The Exponential Roadmap co-authored by Wilson; c) Emission Gap Report 2019.
- [S9] Held on file at UEA: a) Bank of England 2018. Transition in thinking, reproduces Fig. 1 (p. 10); b) Naomi Klein's book, *This Changes Everything: Capitalism vs. the Climate* (2014); c) Mention of the Global Carbon Project by UN Secretary General; d) Christiana Figueres Nature Commentary
- [S10] a) Media coverage reports for the 2018-2020 Global Carbon Budgets; b) COVID emissions media coverage report, 2020; c) Altmetric analysis of attention received by research paper [R6]