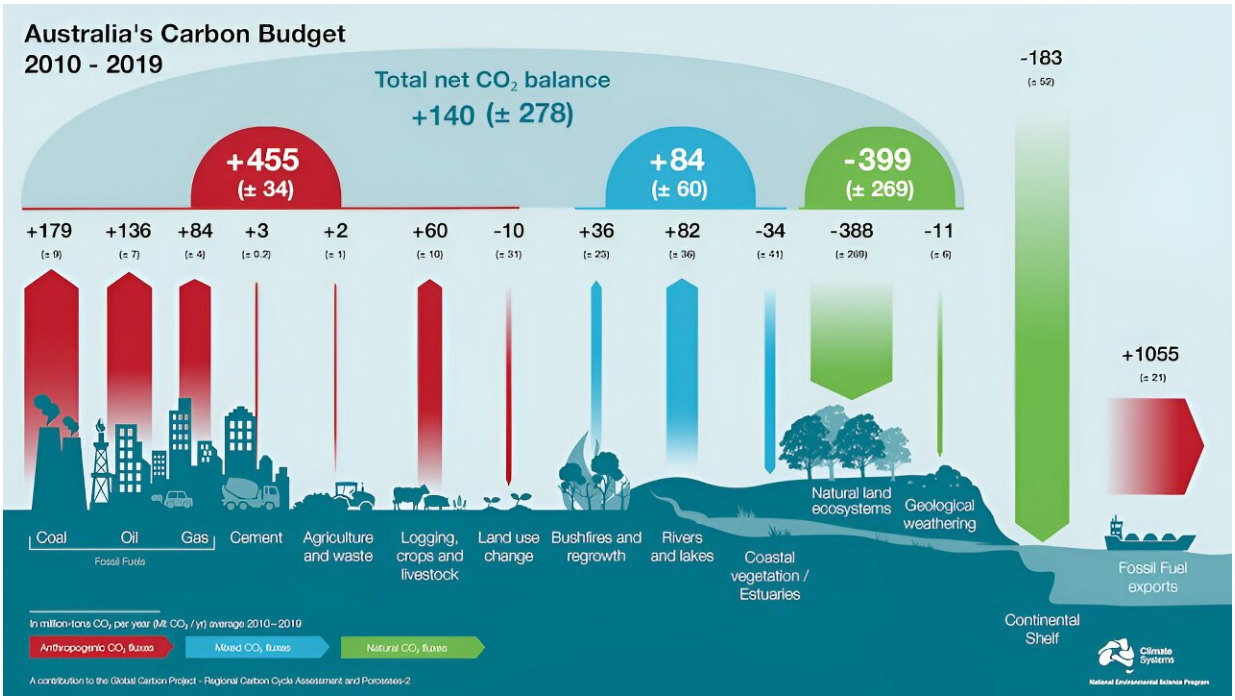
Carbon in, carbon out: Australia's 'carbon budget' assessment reveals astonishing boom and bust cycles

December 20 2023, by Yohanna Villalobos, Benjamin Smith, Pep Canadell and Peter Briggs



Australia's Carbon Budget 2010-2019. A product of the National Environmental Science Program - Climate Systems Hub; and a contribution to the Global Carbon Project - Regional Carbon Cycle Assessment and Processes-2. Credit: NESP-2

If you really want to know how much Australia contributes to the amount of carbon dioxide (CO_2) in the atmosphere, you have to study all the "sources" and "sinks."

Sources release CO_2 into the atmosphere, while sinks take it out. There are sources from human activities, such as burning fossil fuels, and there are natural sinks such as plants absorbing CO_2. You can tally it all up on a balance sheet to find the net result. Are we adding to CO_2 levels in the atmosphere, overall? And if so, by how much?

It's an enormous undertaking, but not impossible. We have just published the most comprehensive assessment of Australian CO_2 sources and sinks. It covers the decade from 2010 to 2019, and it reveals some surprising features.

Astonishingly, we found the net annual carbon balance of the entire continent switches from year to year. Australia can be a large net source of CO_2 one year and a large net CO_2 sink the next, in response to our increasingly variable climate. That makes it harder to detect long-term trends and understand whether our natural carbon sinks are growing or decreasing.

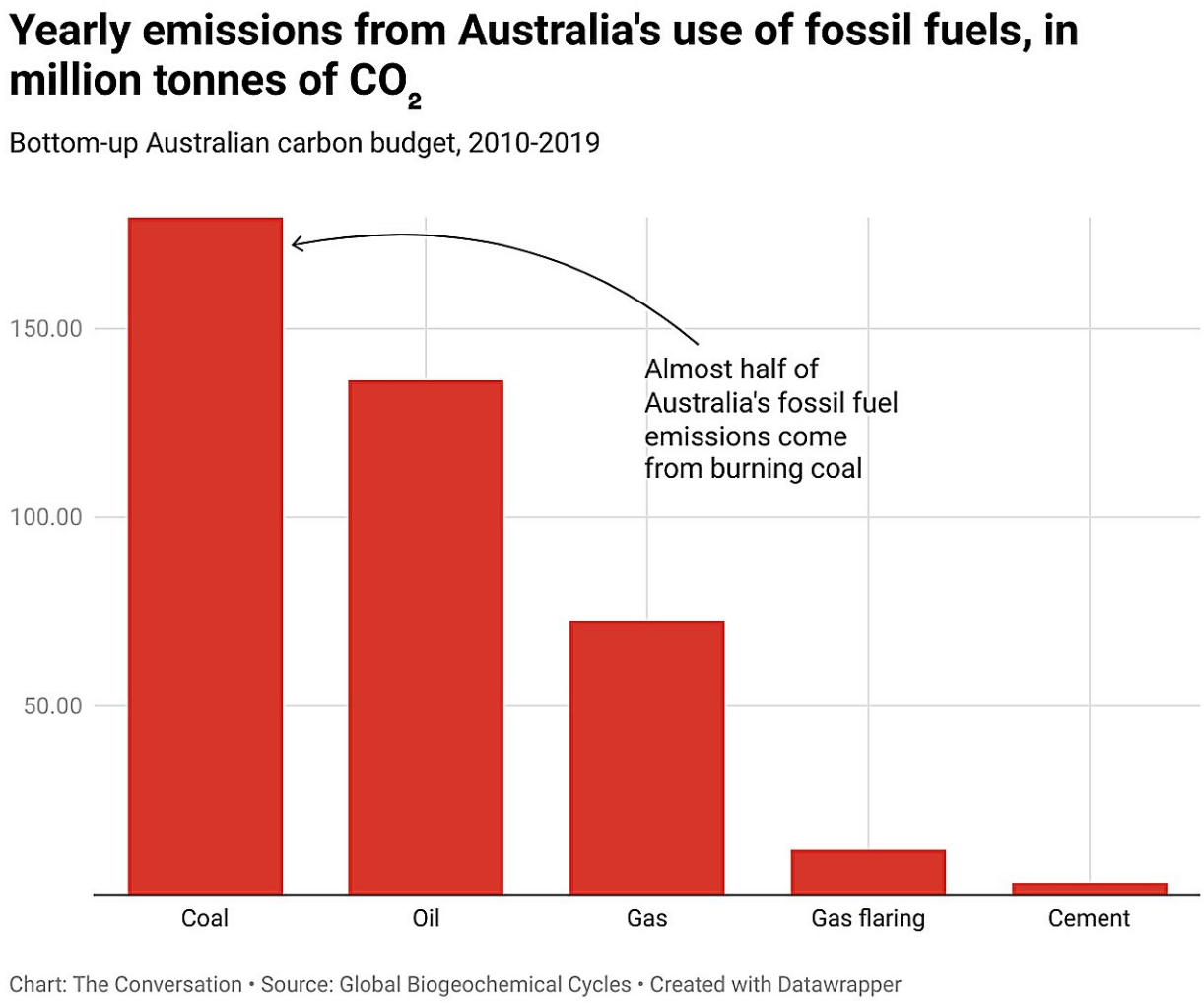
What is the contemporary carbon budget?

Our research reveals what we call the "contemporary carbon budget" for Australia.

This budget is different from the "remaining carbon budget," which refers to the CO_2 that can still be emitted before we exceed a certain level of warming.

We constructed the contemporary budget using a wide variety of data and modeling approaches. We needed to estimate the carbon "fluxes"

(sources and sinks) of land-based ecosystems, freshwater bodies, and of human activities such as the combustion of fossil fuels and changes in land clearing and revegetation.



Credit: The Conversation

We also used global assessments, Australia's National Greenhouse Gas Inventory, and trade statistics. And we used atmospheric and satellite CO_2 information to constrain the dynamics of the Australian carbon

balance, as well as other satellite-based data to estimate Australia's fire emissions.

We developed this carbon budget with the best available data and scientific tools. However, large uncertainties such as data gaps and model limitations remain for some of the estimates. We report all uncertainties in the research paper.

Carbon in, carbon out

The biggest CO_2 source from Australia's human activities is fossil fuels, with an average of 403 million tons of CO_2 for the decade 2010–19. That can be broken down into coal (44%), oil (34%), gas (18%), gas flaring (3%) and cement (1%).

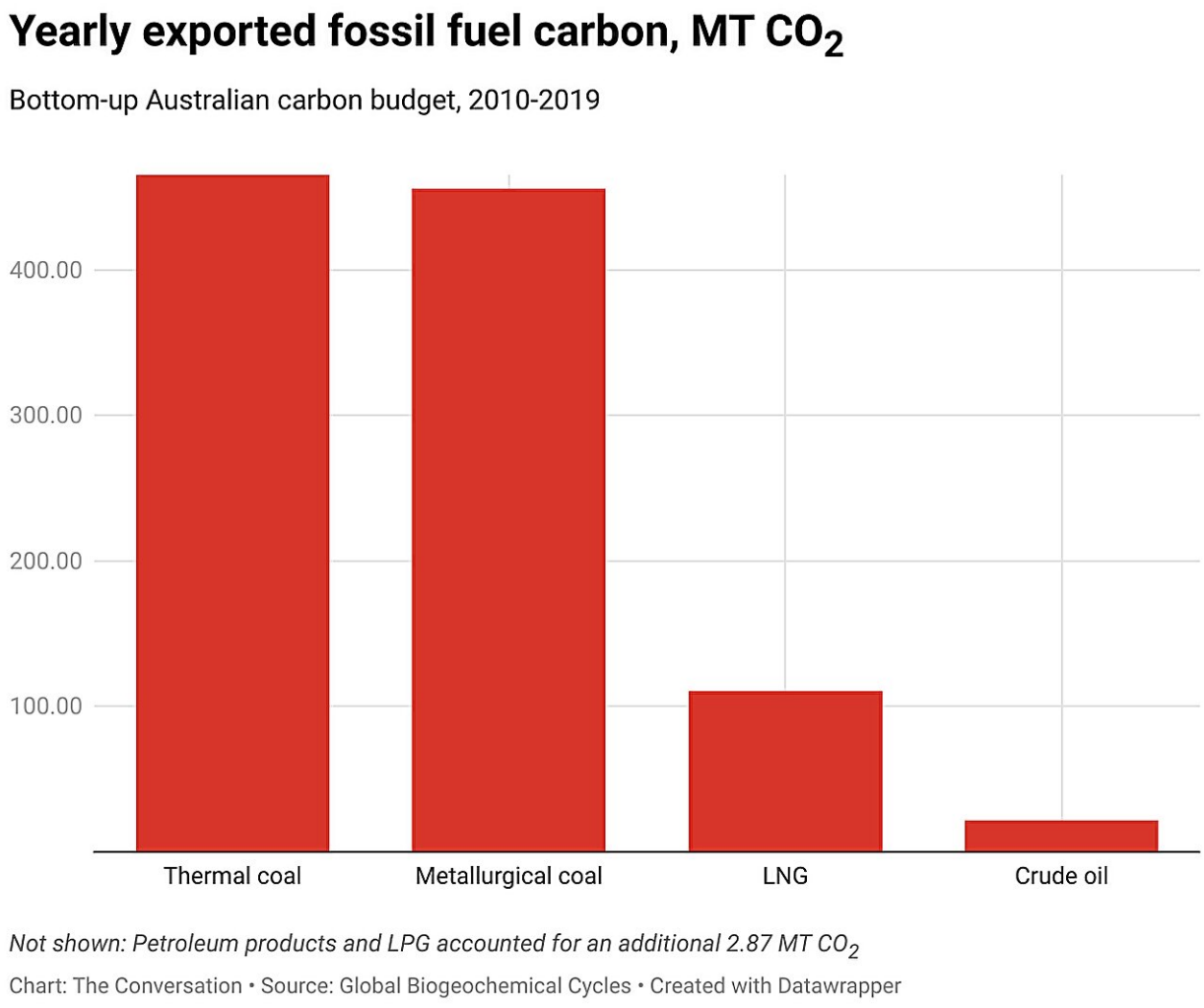
Emissions from wildfires (natural) and prescribed burning (human-caused) were 568 million tons of CO_2 a year which, unlike fossil fuels, are largely offset by subsequent vegetation regrowth. This led to a net CO_2 accumulation in the atmosphere of 36 million tons a year. CO_2 emissions from the Black Summer fires in 2019 were exceptionally high at 951 million tons, much of which has already returned to vegetation after three years of above-average rainfall.

Rivers, lakes and reservoirs—both natural and human-made—are also sources of CO_2, contributing 82 million tons.

Natural forests, savannas and the large expanses of rangelands all contributed to removing vast amounts of CO_2 from the atmosphere at a rate of more than 388 million tons a year.

Coastal ecosystems "blue carbon" such as mangroves, tidal marshes and seagrasses soaked up 61 million tons of CO_2 a year, further adding to Australia's CO_2 sinks. However, estuaries, including tidal systems, deltas

and lagoons, released 27 million tons of CO_2 into the atmosphere.



Credit: The Conversation

The oceans surrounding Australia are also strong CO_2 sinks, removing about 183 million tons of CO_2 a year. This highlights the important role of the oceans, in addition to the land sink, in slowing the buildup of atmospheric CO_2 due to human emissions.

Exported carbon

Every year, about 1 billion tons of CO_2 are exported in the form of fossil fuels, primarily coal and natural gas.

A further 22 million tons of embedded CO_2 are exported every year in products such as wheat, wood pellets and livestock.

When these exported fossil fuels and products are consumed overseas, they release their carbon content into the atmosphere as CO_2.

However, the UN Framework Convention on Climate Change and rules supporting the Paris Agreement only require nations to report emissions released from their own territory. Emissions from exports are counted by the countries where the fossil fuels and products are eventually consumed.

The flip-flop carbon dynamics

We have long known about the "boom and bust" dynamics of Australia's vegetation growth as it responds to periods of above-average rainfall and drought.

But we never imagined the entire nation could flip-flop so quickly from being a very strong and globally significant CO_2 sink, as in the La Niña of 2010–11, to being a major source of CO_2. But that's precisely what happened as drought and fire changed the carbon accounts of Australia, during the southeast drought of 2018–19 and the following Black Summer fires in 2019.

What this tells us about the path to net zero

When we put all of the land-based CO_2 sources and sinks together, overall Australia was a net source to the atmosphere of 200 million tons of CO_2 a year during 2010–19. This drops to 140 million tons of CO_2 a year if we count the sinks from coastal ecosystems.

This means CO_2 sinks are partially offsetting fossil fuel emissions. This is something we have also estimated at the global scale, where about one-third of global fossil fuel emissions are removed by terrestrial land-based CO_2 sinks.

While this highlights the important role natural CO_2 sinks play in slowing climate change, it does not imply we have less work to do to reach the net zero emissions target.

That is because natural CO_2 sinks are already accounted for in estimates of the remaining carbon budgets and decarbonization pathways to stabilize the climate. Accordingly, the Paris Agreement calls for achieving a balance between anthropogenic emissions and removals by sinks of greenhouse gases, the so-called net zero target.

The large year-to-year variability of Australia's non-anthropogenic carbon dynamics also underscores the need for a comprehensive and long-term monitoring and modeling observatory system to track the evolution of sources and sinks. We need high quality data supplementing the National Greenhouse Accounts to support decisions around how to use Australia's natural assets to mitigate climate change.

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