The global stampede to adopt net-zero climate goals continues unabated. As a goal net-zero is achieved when any residual carbon emissions are counter-balanced fully by dedicated carbon removal. Delivered at a global level, this would stabilise global temperatures. Almost 70% of states (accounting for 90% of the world's economic activity) have adopted net-zero goals, as have 40% of the world's largest companies. Does this mean climate procrastination is finally coming to an end?

A lot depends on what net-zero really means. In Which Net Zero, a new paper in Ethics and International Affairs, Chris Armstrong and I argue that there are critical ambiguities in net-zero policy. We highlight the scale of residual emissions, and the distribution of impacts and benefits associated with both residual emissions and counterbalancing removals. These ambiguities create loopholes, vulnerable to exploitation by carbon trading and offsetting approaches.

The scale of residual emissions really matters. Despite the hype associated with both nature-based and engineered forms of removals, scientific analysis indicates that potential sustainable levels of carbon removal may be as little as 2-5Gt of CO_2 per year (a gigatonne (Gt) is a thousand million tonnes). To give a sense of the amounts involved, the world produces around 2Gt of steel, 2.7Gt of grain (all cereal crops) and 4.5Gt of concrete each year. But total emissions of greenhouse gases are around 50Gt of CO_2 'equivalents'. Removing 2-5Gt of CO_2 each year is still a big undertaking. Yet if that is to balance residuals in a net zero world, emissions must be cut by 90-95%.

Limits on sustainable removals arise primarily in requirements for land, water, materials and clean energy. Many climate model scenarios involve residual emissions of 10-20 Gt-pa. To balance such levels, removals based on bioenergy with carbon capture and storage (BECCS) would require up to 1000 million hectares or three times India's land area. But other techniques create similar challenges. Achieving the same removals through direct air capture, for example, would require up to nine times India's primary energy consumption.

Loose or tight convergence?

Such a 'loose', or 'broad' convergence, with lots of removals balancing high remaining emissions, creates problems analogous to those of trying to balance two elephants on a seesaw or teeter-totter. Not only is it difficult to put elephants on a seesaw, but even if we were to succeed, we would likely end up with a broken seesaw. In other words, trying to achieve broad convergence would put

unmanageable stresses on society. Both elephants would impose serious harms, typically distributed unfairly. Delivering large removals would likely drive up costs of food and energy, exacerbating food insecurity and fuel poverty. Leaving large residuals would mean continued harms to health from air pollution and continued impacts from fossil fuel extraction and production.

For these reasons, and more, a ‘tight’ or ‘narrow’ convergence – instead balancing two mice on the seesaw – is far preferable. Recent empirical research has confirmed serious reasons to worry in this regard. Analysis of countries’ plans submitted under Paris accord by Holly Buck and colleagues found that projected residuals averaged almost 20% (or around 10 Gt-pa at a global level). Detailed examination of the claims on land involved in national climate plans published as the Land-Gap Report (pdf) found these exceed even the worst scenarios for BECCS – already demanding 1200 million hectares (closer to four times the area of India). And many corporations have also laid claim to carbon removals in their net zero plans, often promising to offset high levels of residual emissions. One analysis found that fewer than half of company plans cut residual emissions to less than 10%. Even worse, many use emissions-intensity targets that would actually allow total emissions to *grow*.

So future expectations of removals are sky-high. However, the new State of CDR report from Oxford University and partners reports very limited progress in delivering removals. Annual dedicated removals are now just 2.3Mt-pa (based on some rather optimistic assumptions), and set to grow to 11.75Mt-pa by 2025 if all current plans are fulfilled. This is still several orders of magnitude below even the minimum needed for balancing residuals alone in a net-zero world.

Recent policy debate has highlighted the need for strong quality and accountability standards for carbon removals. It matters that removals are additional, permanent and properly account for consequential emissions. The European Union has published a legislative proposal on certification of removals, albeit with some critical reactions regarding the role foreseen for impermanent land-based removals or ‘carbon farming’. We might hope that the lessons in recent revelations regarding the shortcomings of certification schemes for carbon offsets can be learnt as the Commission turns this proposal into legislation. At COP27 proposed rules for carbon removals in carbon markets were sent back to the supervisory body for more detailed revision, following criticism especially regarding the lack of human and indigenous rights protections. In the private sector a new guide from Shopify on buying carbon removals, sets non-negotiable standards on additionality, verifiability

and sustainability.

Legitimate residuals?

But achieving tight convergence means that tough standards will be needed on *both sides* of the net-zero balance. On the one side we must ensure that removals are real, durable, additional, sustainable and fair. But on the other we must also ensure that the residual emissions 'legitimated' as counterbalanced by removals (whether through credit trading or other mechanisms) are genuinely unavoidable and socially necessary.

At COP27 such issues were finally broached, not least as a result of the UN's High Level Expert Group report on net-zero claims. The report rejected the idea that companies might claim net-zero compliance based on poor quality credits (such as those from non-durable, or non-additional removals). It also highlighted the incompatibility of net zero with new fossil fuel investment, lobbying against climate action and intensity based targets.

Nonetheless there is a desperate need to translate such recommendations into law and policy. Ensuring quality removals is one thing, but given the limits to sustainable removals, it would be deeply unfair and problematic if that capacity was dedicated to offseting luxury emissions for air travel, or other high consumption by global elites. Quality removals need to be matched only to 'legitimate residuals'.

The Science Based Targets Initiative (SBTI) suggests a global cap on legitimate residuals, compatible with Paris, at no more than 5-10% of current emissions. But this still leaves the prospect that businesses perfectly able to completely decarbonise might claim 10% residuals and removals; while other businesses creating real social value, but unable to reduce emissions by 90%, might then be treated as not legitimate users of removal 'offsets'. We need a more sophisticated approach to defining 'legitimate residuals'.

Achieving tight convergence around net-zero, and fairly matching legitimate residuals with quality removals is a key challenge for climate policy in the coming years. Otherwise the loopholes in net-zero will be exploited in continued climate procrastination. Policy makers cannot afford to leave the delivery of net-zero to carbon markets, where the commercial incentives are for more trading (and a broader convergence with more residuals), lower standards, and for profits before fairness.