



Australian Reduction Roadmap

Reduction Roadmap is initiated by:

EFFEKT

ARTELIA

C E B R A

Reduction Roadmap Australia is initiated by:



TERROIR

UTS



Acknowledgment of Country

We acknowledge the Traditional Owners of the unceded land on which we work, learn and live. We recognise the unique place held by Aboriginal and Torres Strait Islander peoples as the original owners and custodians of the lands and waterways across the Australian continent, with histories of continuous connection dating back more than 60,000 years.

We also acknowledge their enduring cultural practices of caring for Country, and recognise the deep and meaningful relationships with the subject of this work in particular: the lands, skies and waterways, and manifold flows and cultures of material, identity, space and place embedded and embodied in Country.

We pay respect to Elders past, present and future. As a community of practitioners in the built and living environment, as well as researchers and teachers, we are privileged to work and learn every day with Indigenous colleagues and partners. We will continue working to move beyond acknowledgment and towards reciprocal relationships with the Traditional Owners and First Nations people of this land.

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Denmark team

Based on the original Danish Reduction Roadmap, initiated by EFFEKT, Artelia and CEBRA. Denmark's data validation was conducted by BUILD, Aalborg University, Aarhus University, DTU, and the University of Southern Denmark, and their project was funded by Realdania and the Villum Foundation. A special thank you to **Dani Hill-Hansen** and **Kasper Benjamin Reimer**, then both at EFFEKT, who guided the Australian team through the original Danish Reduction Roadmap methodology that so inspired us, generously shared their knowledge and resources, and helped forge an ongoing meaningful link between Australian and Danish approaches.

Tak!

Key literature

Dixit, M. K. (2017). *Life cycle embodied energy analysis of residential buildings: A review of literature to investigate embodied energy parameters*. *Renewable and Sustainable Energy Reviews*, 79, 390-413.

Forster et al (2022). *Indicators of Global Climate Change 2022: annual update of large-scale indicators of the state of the climate system and human influence*. *Earth Syst. Sci. Data*, 15, 2295–2327

IPCC AR6 (2021). *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

Jones et al. (2024)—with major processing by *Our World in Data*. 'Annual greenhouse gas emissions including land use [dataset]. Jones et al., 'National contributions to climate change 2024.2' [original data].

Petersen, S. & Ryberg, M. & Birkved, M. (2022). *The safe operating space for greenhouse gas emissions*. Schmidt, M., Crawford, R. H., & Warren-Myers, G. (2020). *Quantifying Australia's lifecycle greenhouse gas emissions for new homes*. *Energy and Buildings*, 224, 110287.

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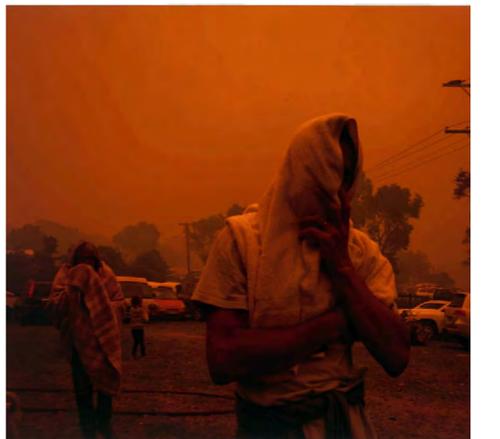
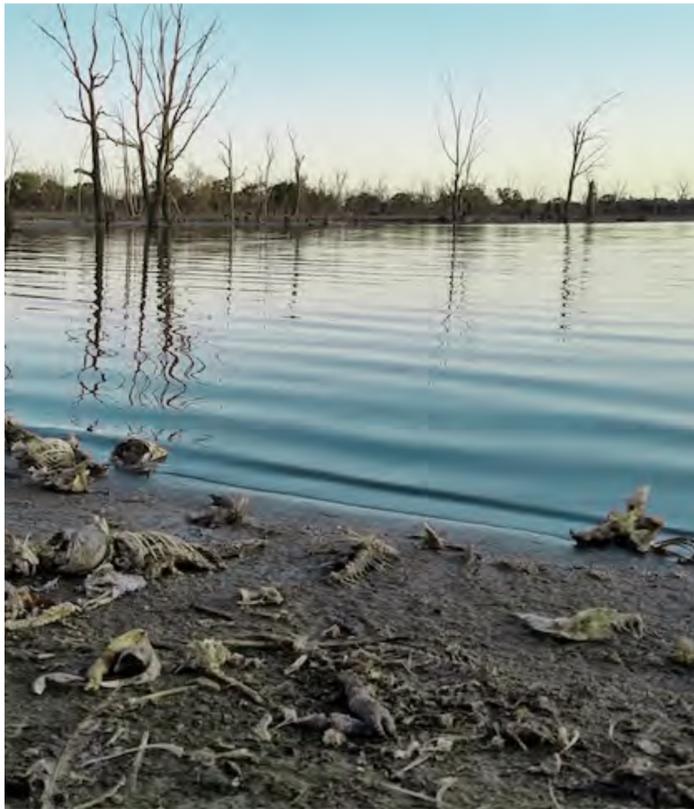
“What happens in the next 10 years will likely determine the state of the planet we hand over for future generations.”

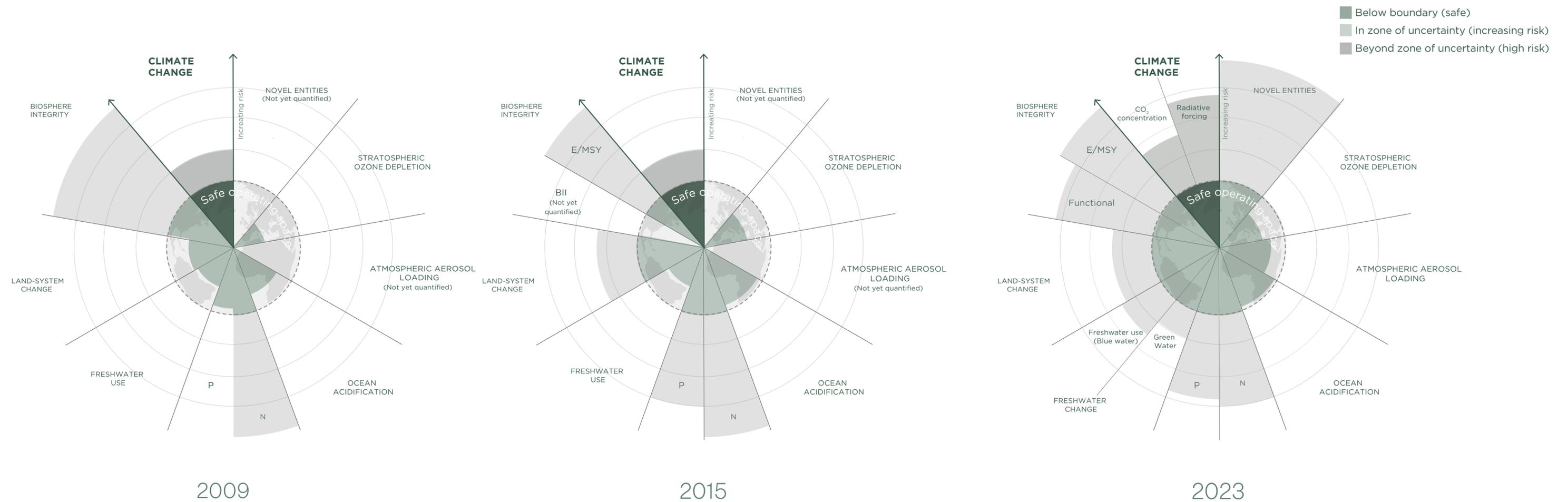
Johan Rockström, 2022

Professor in Earth System Science, University of Potsdam



Through 2023 and 2024, we saw record temperatures each month, adding up to the two hottest years on record.





In the latest update of the **planetary boundaries** work by Stockholm Resilience Centre, it is evident that we have now exceeded six out of the nine boundaries. With each update, it becomes increasingly clear that humanity's pressure on Earth's systems is pushing our planet closer to irreversible climate change.

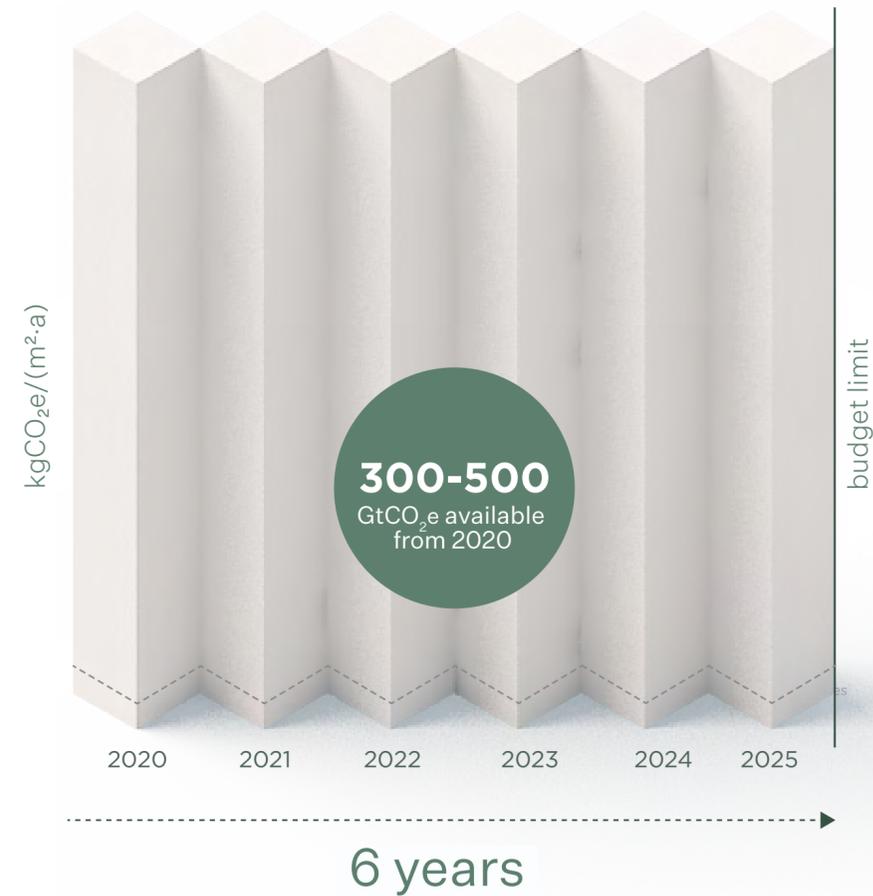
**Can we build within
planetary boundaries?**

What is the goal?

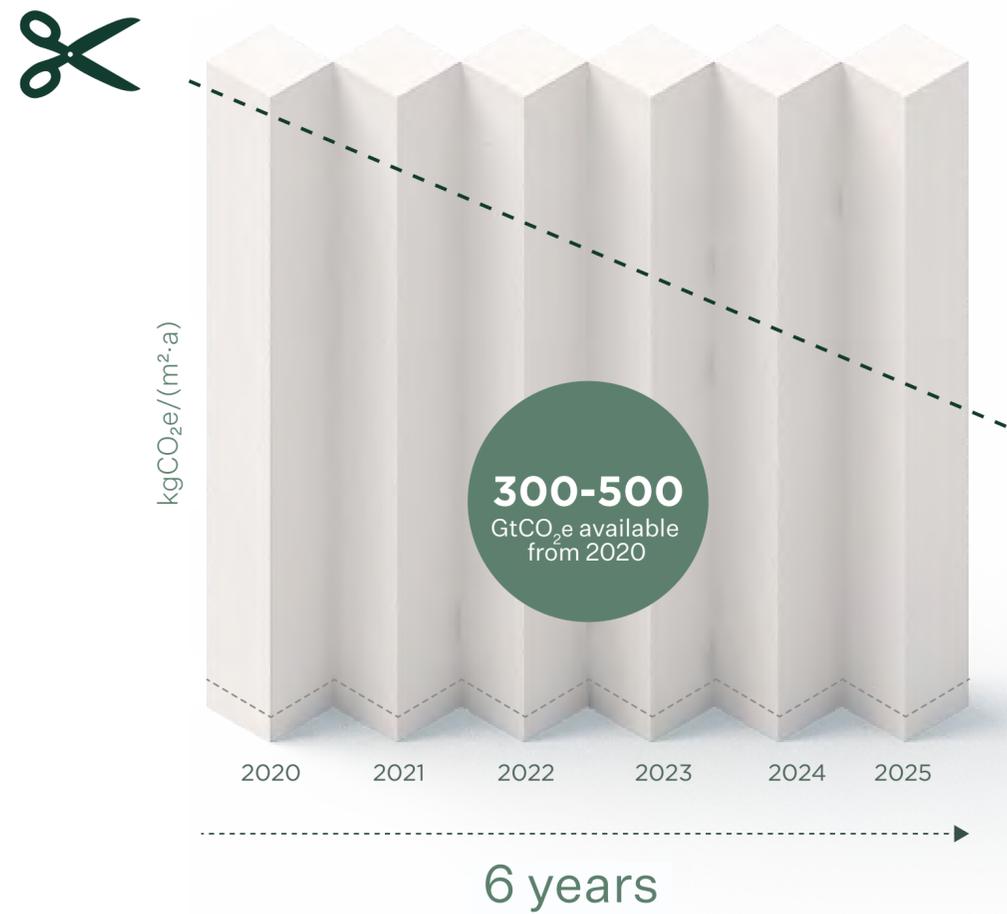
How do we get there?



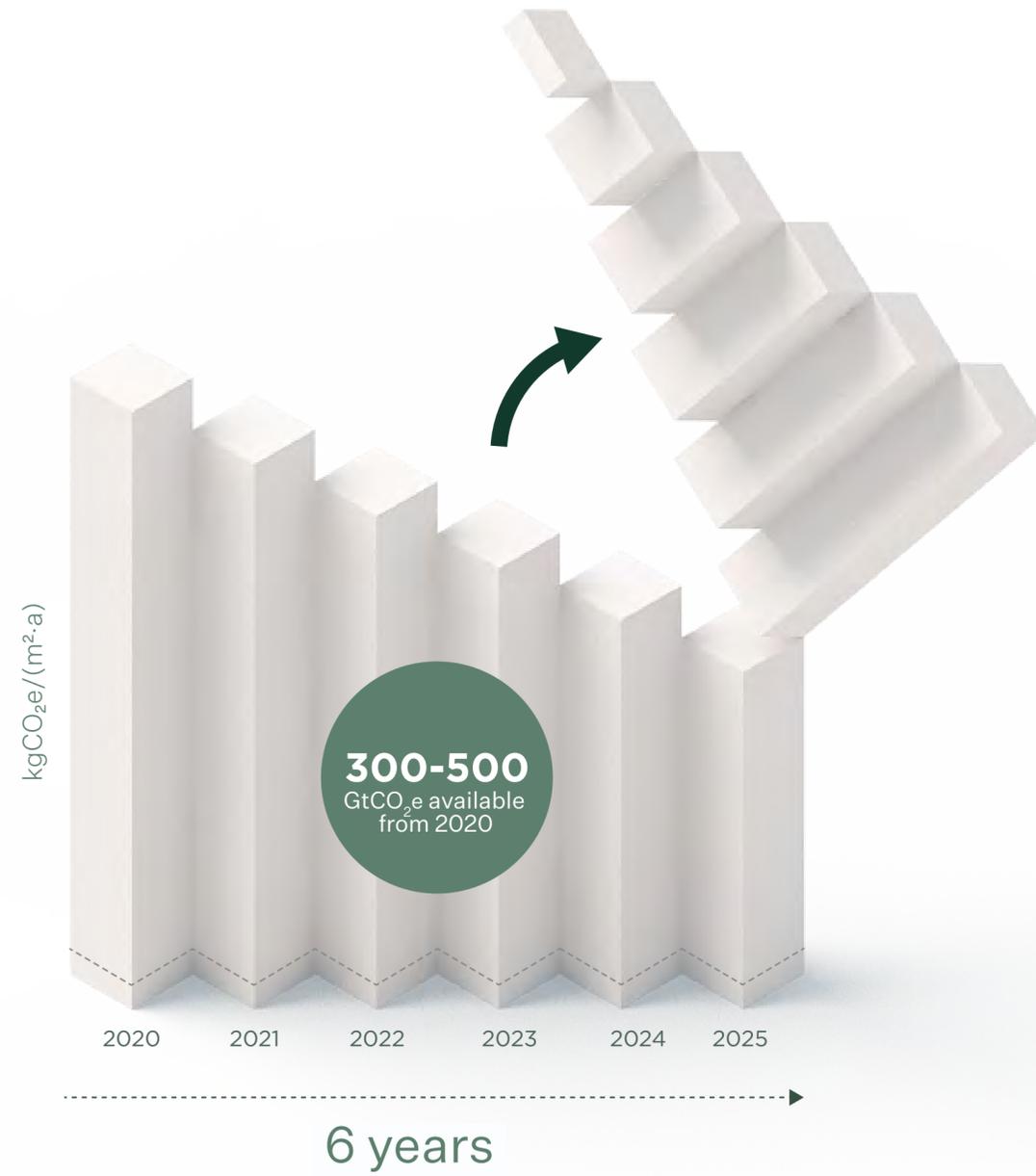
The Planetary Boundaries safe operating space for climate change as defined in the white paper *The safe operating space for greenhouse gas emissions* (Petersen, S. et al, 2022).



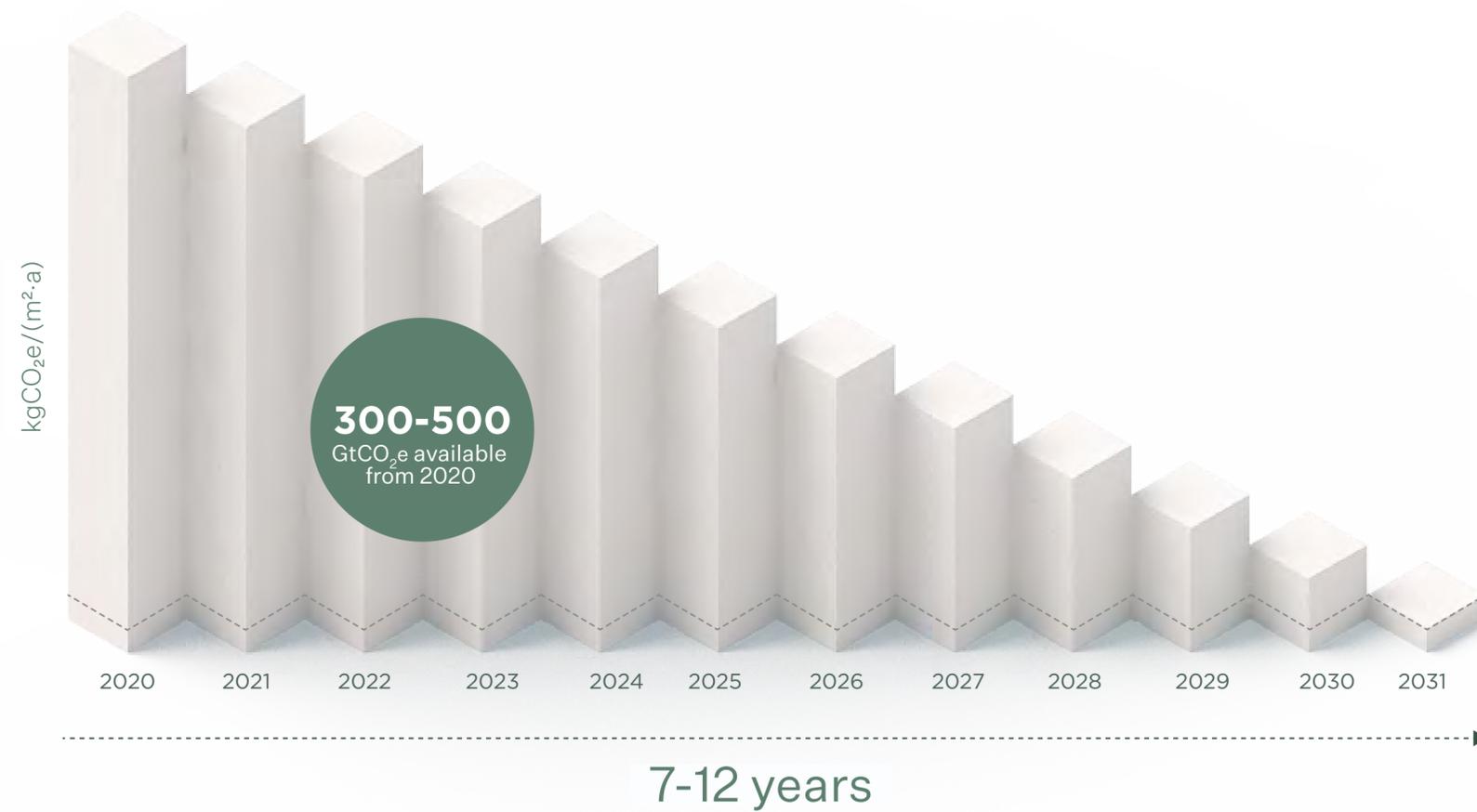
In 2020, the authors of the Danish Reduction Roadmap asked a question:
“If we continue with ‘business-as-usual,’ the remaining global climate budget, according to IPCC AR6, would be depleted within 6-12 years, but...



...if we had started reducing emissions at that point...

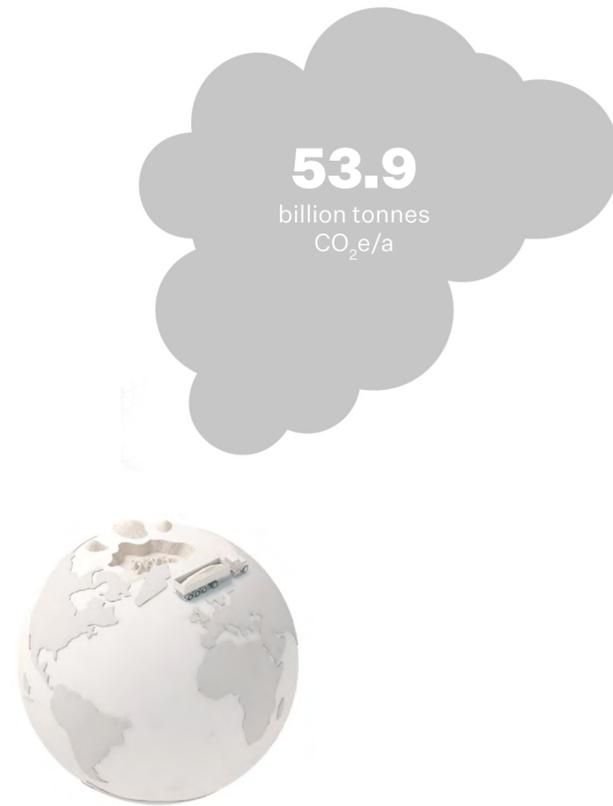


... and spread them out over the forthcoming years ...



... could we stretch the climate budget over 7-12 years and provide a pathway for carbon reduction?"

**How do we translate those
global goals into *local* targets?**



Global emissions

53.9 billion tonnes of CO₂e are emitted globally on an annual basis, based on 2022 emissions. (Jones et al, 2024).



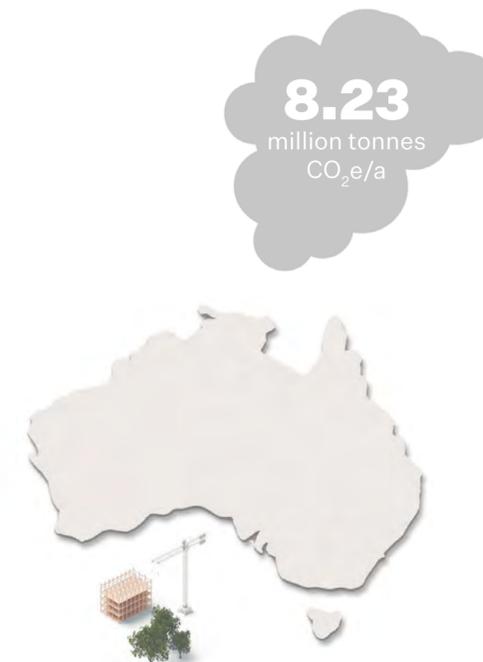
Global limit

The global carbon budget is 2.51 billion tonnes of CO₂e/a (Petersen et al, 2022). This is just low enough to keep us within the global carrying capacity—but not enough to bring down CO₂e levels in the atmosphere.



National emissions

Australia emitted 574 million tonnes of CO₂e in 2022 (<https://ourworldindata.org/greenhouse-gas-emissions>)



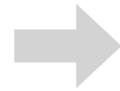
National limit

The Paris Agreement allots Australia 0.33% of the global carbon budget (Paris Accord, 2015). This equates to a national carbon budget for the period 2013–2050 of 8.23 Mt CO₂e per year for all carbon-producing activity in Australia. The current emissions, at 574 MtCO₂e per year, exceeds this national budget nearly 70 times over.



Housing industry emissions

New housing accounts for 3.0% of all Australian greenhouse gas emissions, which is equivalent to 17,206,419 tonnes CO₂e/a.



Housing industry limit

New housing in Australia is allocated 3.0% of the total Australian emissions allowance, equivalent to 248,490 tonnes CO₂e/a.

Drawing on Australian research, at this point we take a different route to the original Danish approach, recognising that embodied emissions are produced in the atmosphere during construction processes, and *cannot* be ‘spread out over time’ (50 years, in the case of Danish regulation).

We have confirmed the validity of our approach with our Danish colleagues, whilst recognising their imperative to influence their local regulatory context.



Current housing emissions

The annual greenhouse gas emissions per square metre of housing in Australia is calculated as such: initial embodied greenhouse gas emissions + annualised recurrent embodied greenhouse gas emissions (for replacing materials over 50 years) + annualised heating and cooling greenhouse gas emissions (over 50 years) for the average size of a new dwelling: 186m² (noting that Australia's predominant dwelling type, the detached house, is 232m² on average).

Initial embodied greenhouse gas emissions are sourced from Schmidt et al, 2020. Recurrent embodied greenhouse gas emissions are based on figures from Dixit, 2017. Heating and cooling greenhouse gas emissions are based on data from NatHERS. All greenhouse gas emissions are reduced by relevant factors over a 50 year period, to reflect the decarbonisation of the energy mix and improving technology.



Housing emissions limit per m²

In order to operate within planetary boundaries, the estimated greenhouse gas emissions intensity of 461.8 kgCO₂e/(m²·a) needs to be reduced by 98.57%, resulting in a limit of 6.63 kgCO₂e/(m²·a) for new housing.

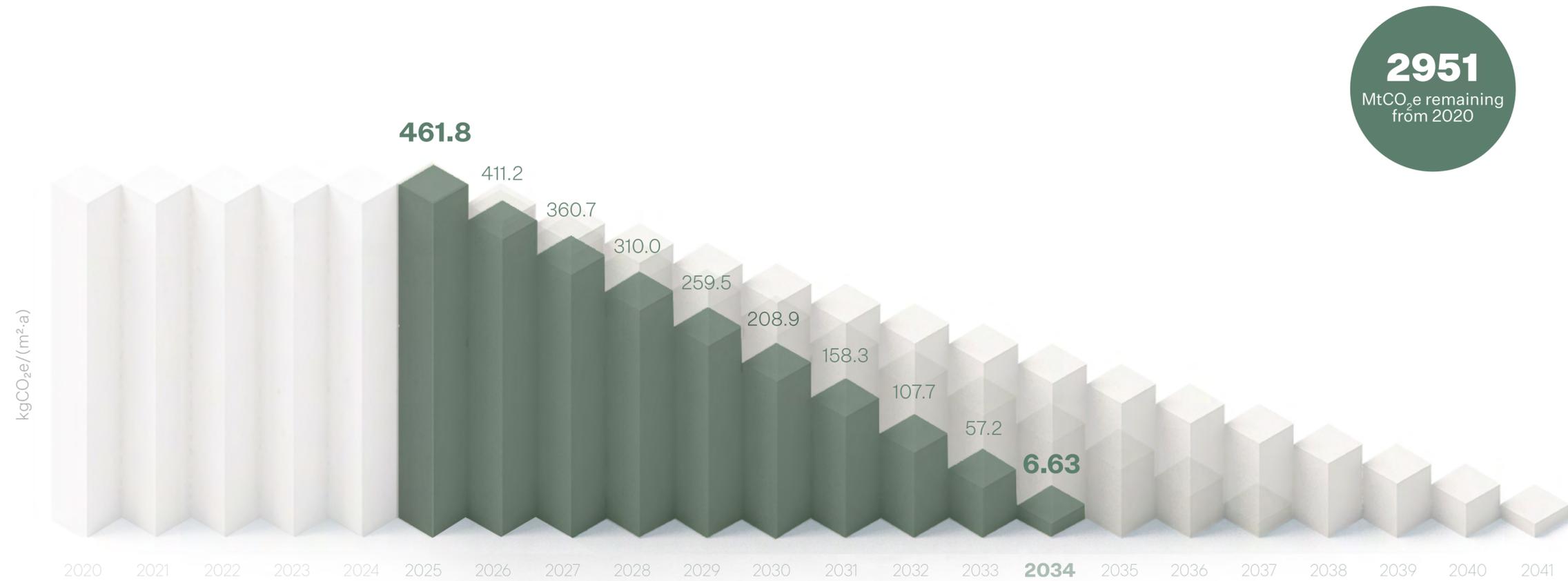
**How long do we have to
reach this emissions limit?**

Global Budget	Approximate global warming relative to 1850-1900 until temperature limit (°C)	Additional global warming relative to 2010-2019 until temperature limit (°C)	Estimated remaining emissions budgets from the beginning of 2020 (GtCO ₂ e)				
			17%	33%	50%	67%	83%
1.5	0.43		900	650	500	400	300
1.7	0.63		1,450	1,050	850	700	550
2.0	0.93		2,300	1,700	1,350	1,150	900

Data from 2019 indicates that globally we have 300-500 gigatonnes of CO₂e remaining to stay within the 1.5-degree scenario (IPCC AR6, 2021). However, fossil fuel consumption since that period means that we are headed for 1.5 degrees of warming. While staying under 2 degrees is becoming a new benchmark, there are grave consequences for our planet once 1.5 degrees is exceeded.

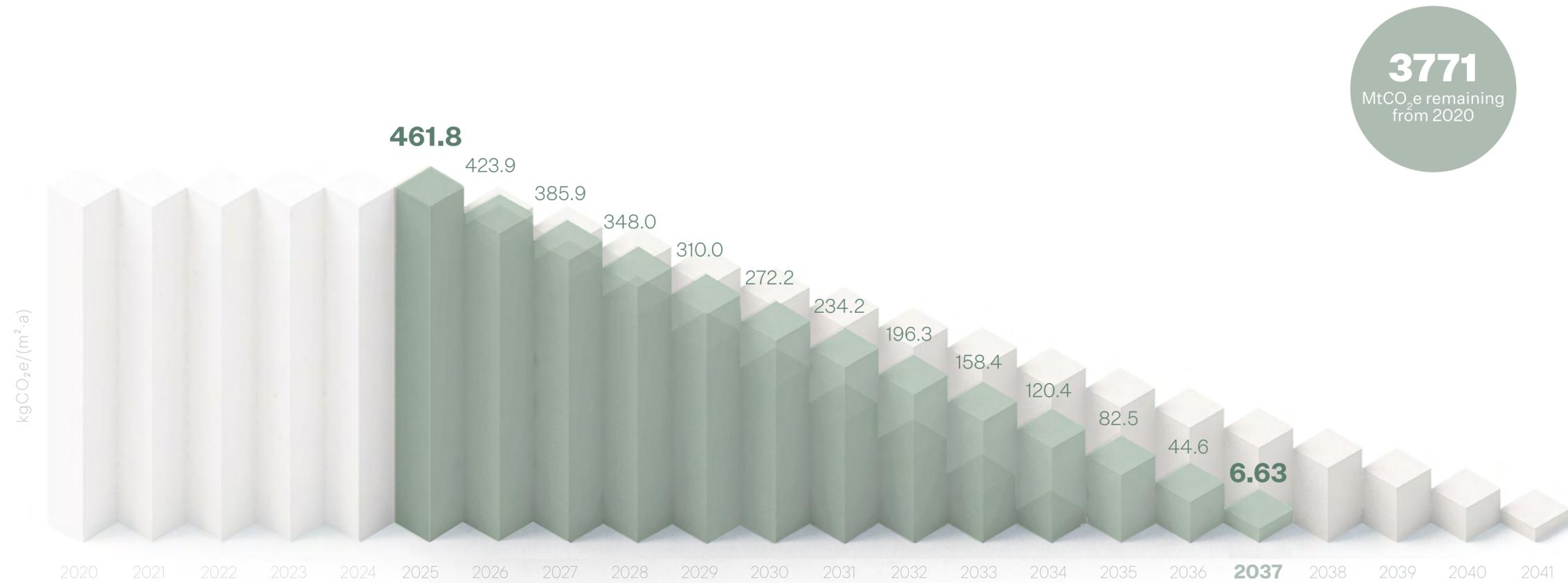
Australian Budget	Approximate global warming relative to 1850-1900 until temperature limit (°C)	Additional global warming relative to 2010-2019 until temperature limit (°C)	Estimated remaining emissions budgets from the beginning of 2020 (MtCO ₂ e)				
			17%	33%	50%	67%	83%
1.5	0.43		2,951	2,131	1,640	1,312	984
1.7	0.63		4,755	3,443	2,787	2,295	1,803
2.0	0.93		7,542	5,574	4,427	3,771	2,951

Therefore, while data from 2019 indicated that in Australia we had 984–1,640 megatonnes of CO₂e remaining to stay within the 1.5-degree scenario (IPCC AR6, 2021), and in this context the original Danish Reduction Roadmap targeted a 1.5 degree temperature limit - at this point we have no choice but to target a 2.0 degree limit, noting the consequences of this are significant.

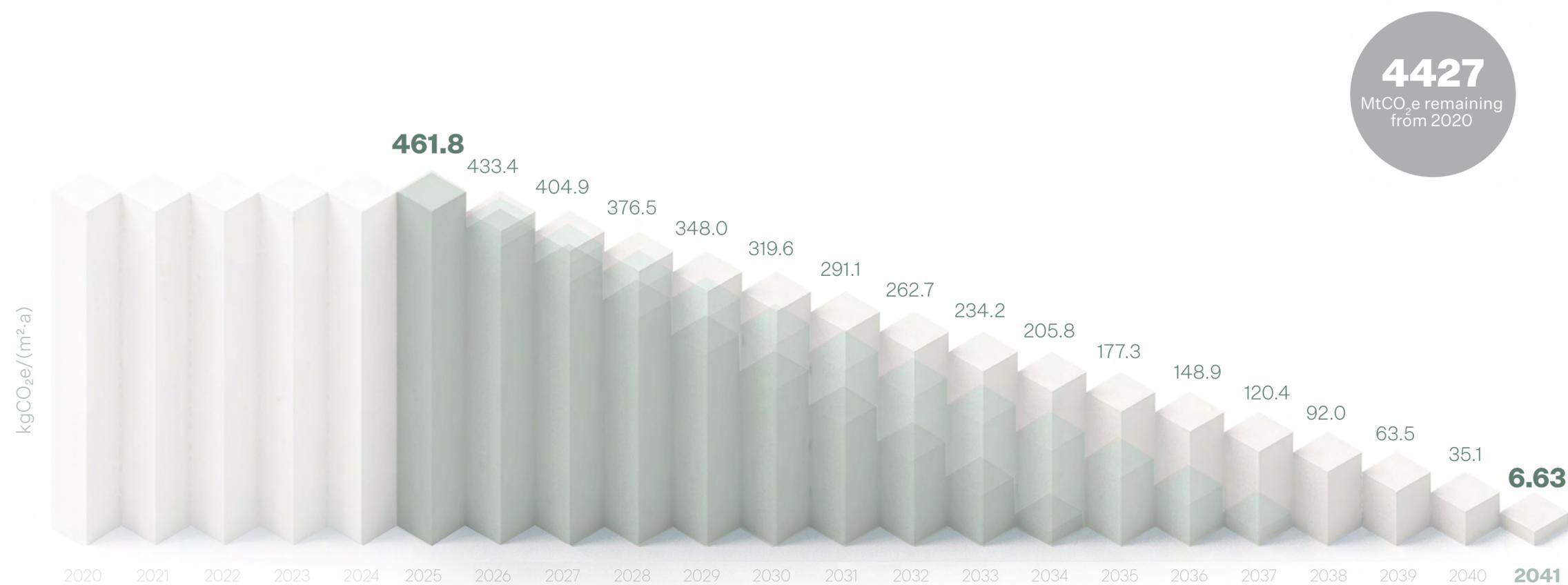


● **83%** ○ 67% ○ <50%

From this Australian budget a linear reduction path can be drawn with different scenarios with different risk levels.



If action is not rapid and immediate, the chance of staying within the target temperature limit reduces accordingly, as more emissions are produced over time.



4427
MtCO₂e remaining
from 2020

○ 83% ○ 67% ● <50%

If emissions reduction occurs over a longer period, more total emissions are produced and the percentage chance of staying within the target temperature limit is significantly reduced. While a 50% chance appears promising, it is deeply concerning when the impacts of a 2.0 degree warming are understood and should not be considered a viable pathway.

**The science is changing rapidly,
and so is our target.**

Indicators of Global Climate Change 2022: annual update of large-scale indicators of the state of the climate system and human influence

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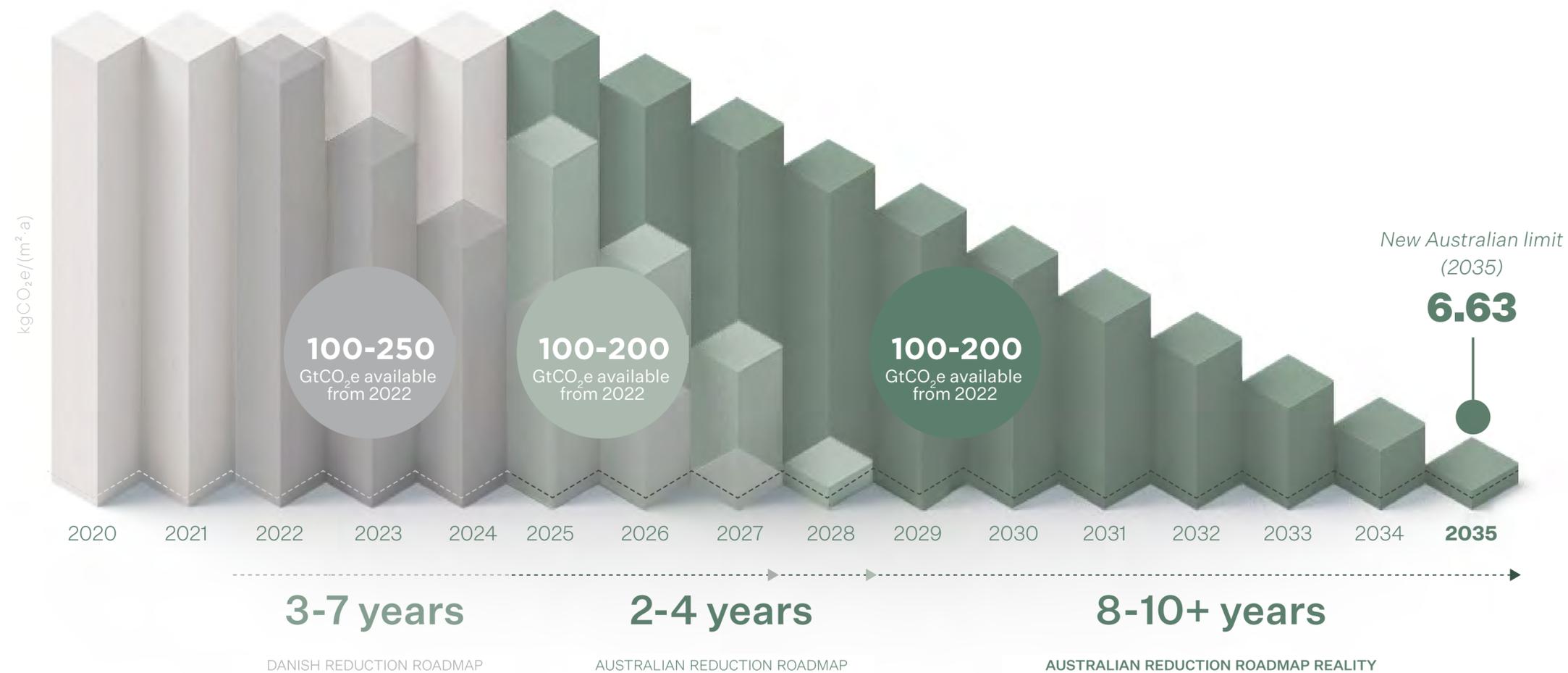
Data from 2023 indicates that globally we have 100-200 gigatonnes of CO₂e remaining to stay within the 1.5–2.0°C scenario (Forster et al, 2023).
The remaining share for Australia must be lowered accordingly.

The Danish Reduction Roadmap, targets a reduction to the New limit in 2-7 years, with an emissions budget of 100-200 GtCO₂e starting from 2022.

On a global scale, there haven't been any significant reductions in the past four years. As a result, the global emissions budget has been more than halved, and we have less time to reach a safe operating space.



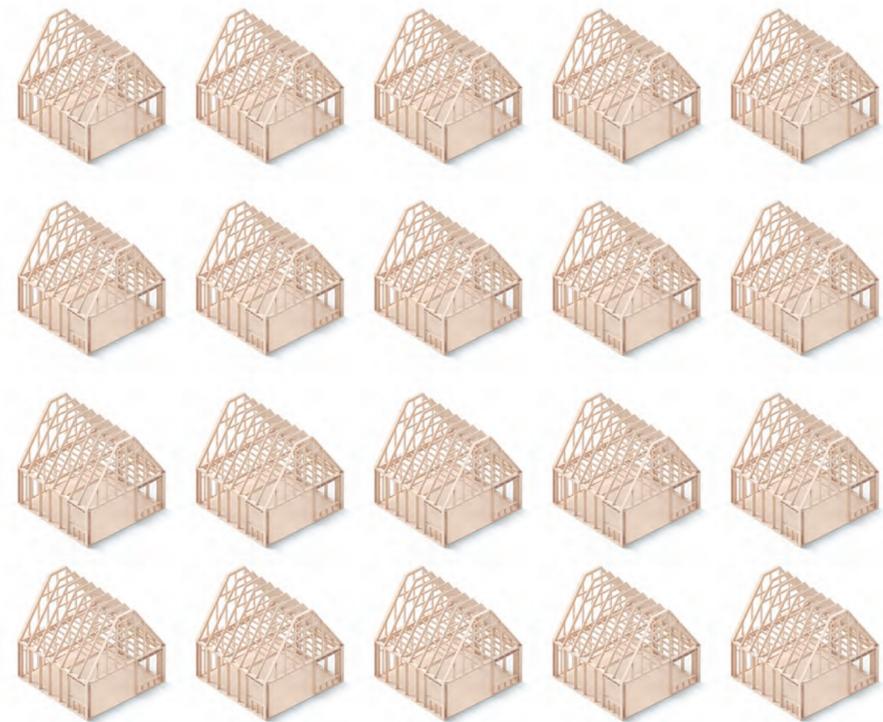
Instead of six to twelve years to reach the target, which the original Reduction Roadmap started with, we now have two to four years, in theory.



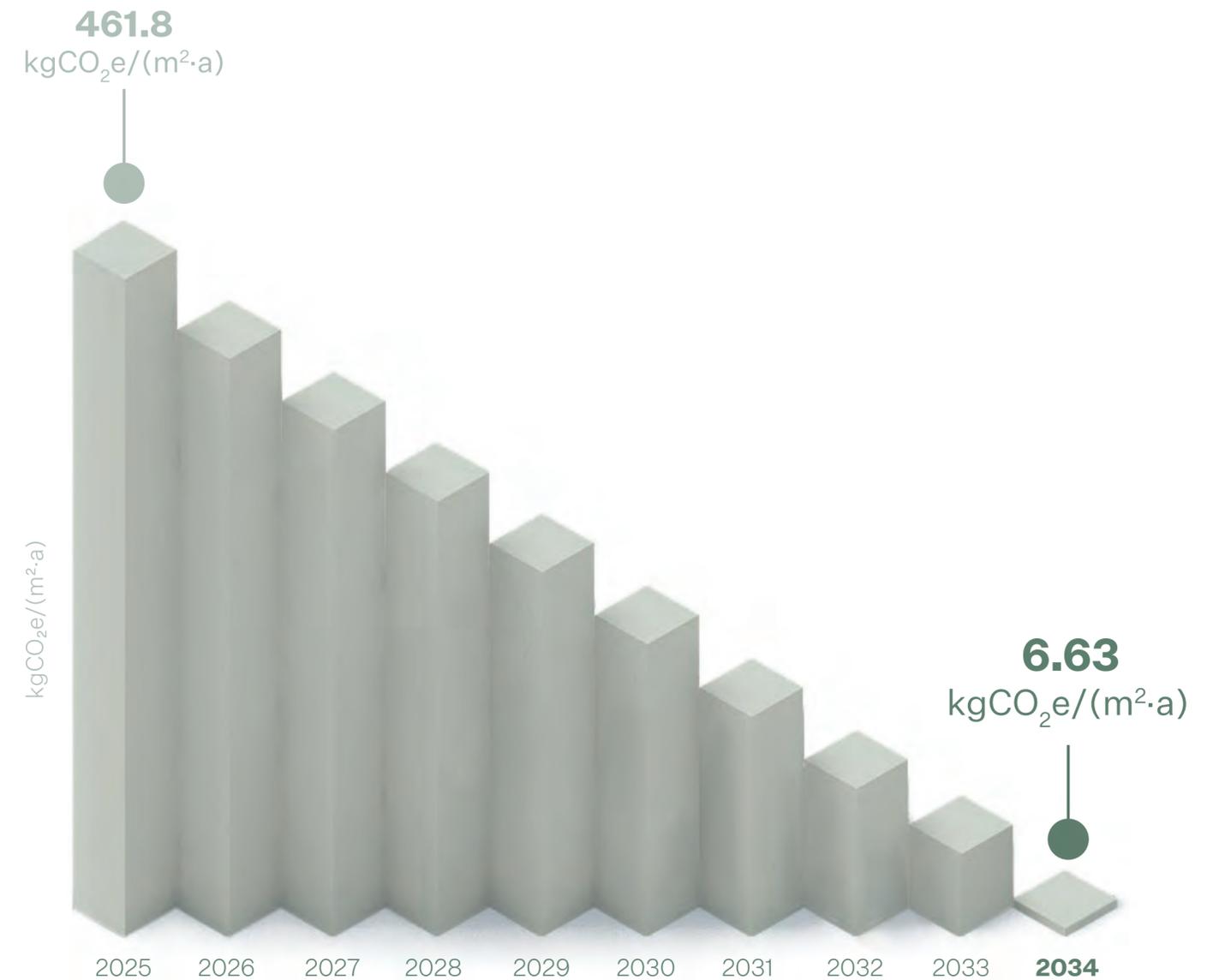
In reality, given the scale of transformation required, the time to the target will have to be much longer. But it cannot be *that* much longer.

Using housing as an example, Australia's targets for new housing, if delivered 'business-as-usual', would consume around 200% of our national emissions budget for everything.

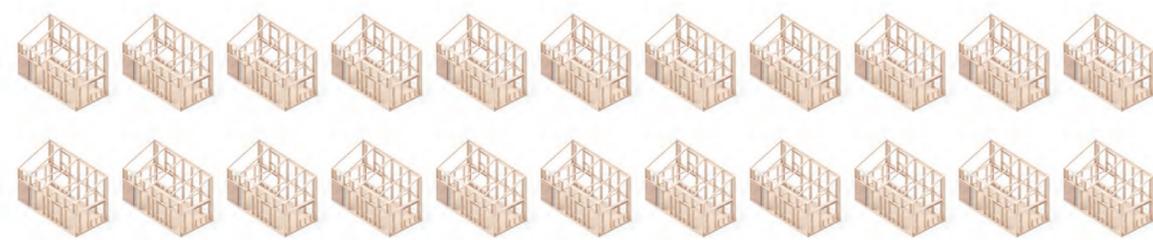
So what can we do?



200,000 housing units of 186m²



Current Australian housing targets vary by state/territory, but the total goal approximates to 200,000 housing units annually. The average floor area of a new dwelling is 186m²—though note the most common Australian type, the detached house, averages 232m², the largest in the world. If we don't reconcile housing policy with climate policy, we are left with an unachievable target.

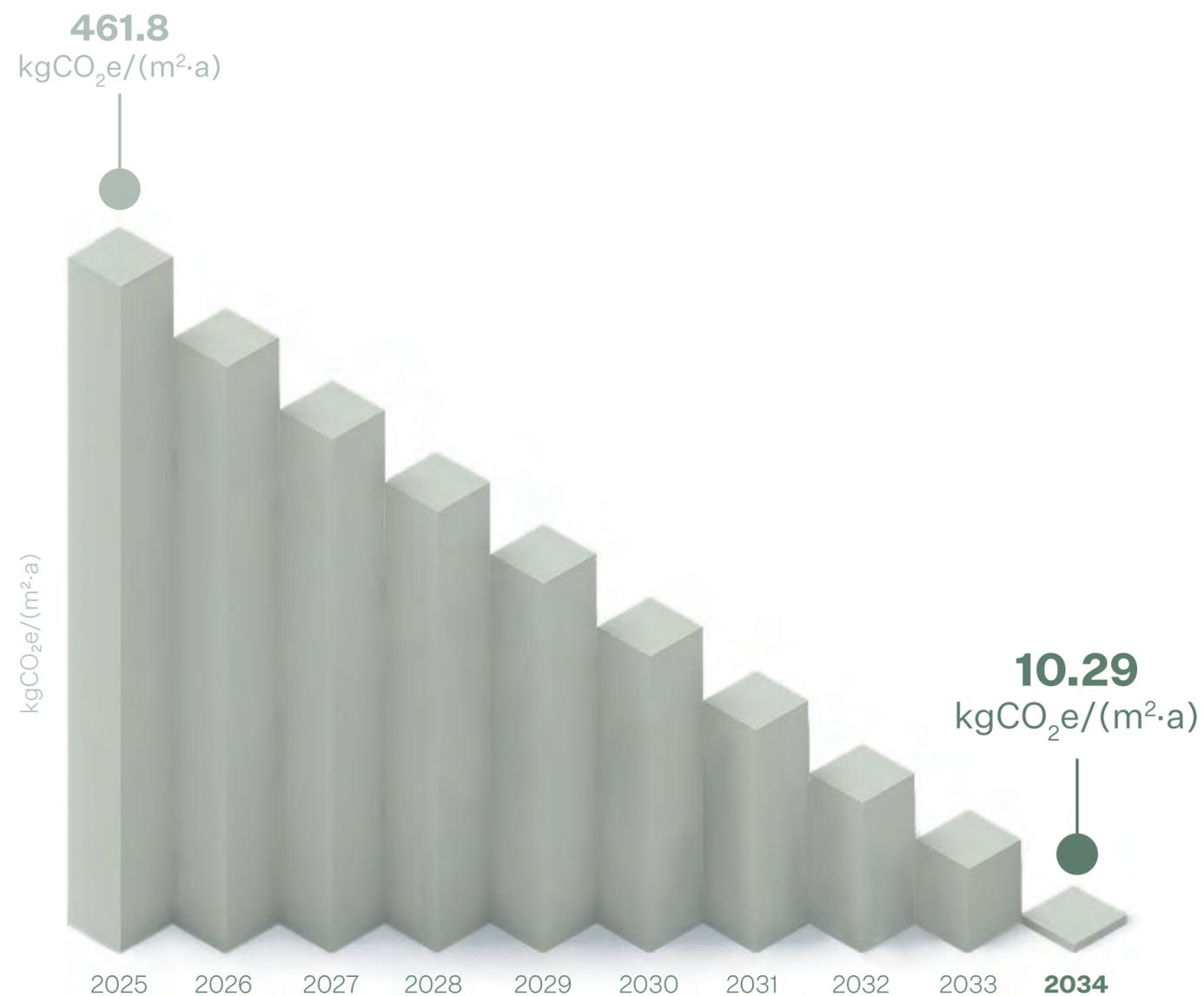


200,000 housing units of 120m²

or



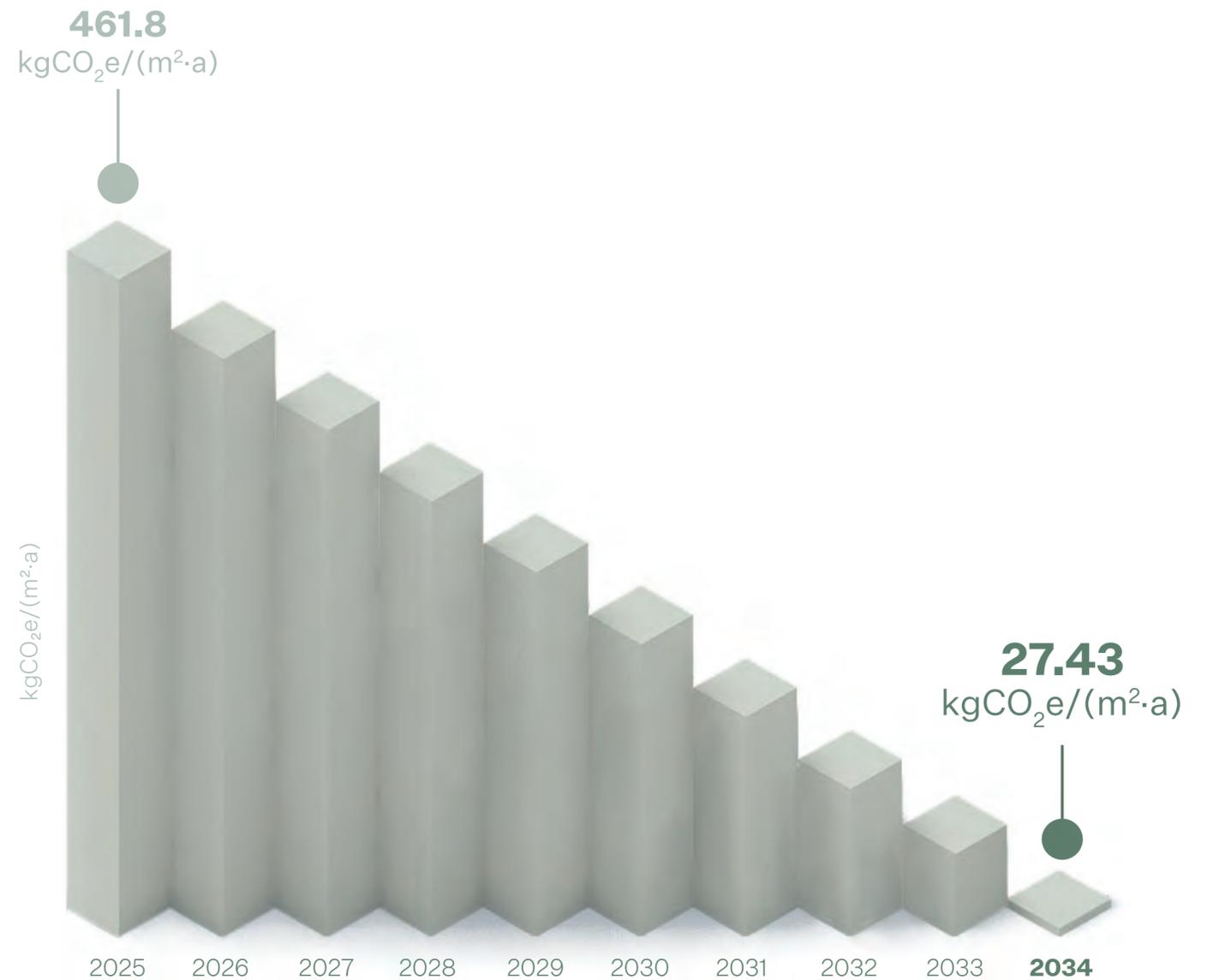
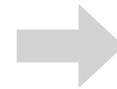
100,000 housing units of 186m²



An alternative would be to reduce the average size of homes built e.g. to 120m². This was the approximate average size of a new house in 1970—noting that we now have much smaller households than in 1970. **Or** we might reduce the total number of homes built. We must transform design and construction in both cases. (NB. These are simplifications: different house sizes have different emissions profiles and space provision.)



75,000 housing units of 120m²



Or, we could both reduce the average size of homes built **and** reduce the total number of homes built, making greater use of existing housing space—again, whilst also transforming design and construction. We would have more ‘budget’ to work with, within the same time frame.

These numbers feel almost impossible. Nor can numbers tell us *what to do*. They are only numbers.

But they do give us an idea of the gap we have to close, between what we do now and what we need to do.

We can imagine a diversity of inventive, inspiring responses to achieving this goal.

As each requires sectoral transformation, we encourage regulation and policy to help set an equitable, shared agenda for collective action.

Mass retrofit

As Australia has a surplus of housing space—ABS data suggests ~13 million unused bedrooms—prioritise careful, equitable and imaginative retrofit of existing places.

Architectural invention

Reorient practice around inventive retrofit and material innovation, re-using existing built fabric as well as new/old materials that are low emissions, biogenic and locally sourced.

A fair go fiscally

Remove financial and other incentives which currently increase greenhouse gas emissions and extractive practices, reversing the flow of finance towards the common good.

Renewable future

Australia's possible future as a 'renewable energy superpower' can be reinforced by prioritising renewable energy in both the construction industry as well as in buildings themselves.

Regenerative materials

Rebuild construction around biogenic materials from regenerative sources and existing buildings, as local as possible, with lifecycle thinking as the starting point for reducing emissions.

Less but better

Incentivise equitable downsizing, enabling retrofit of large houses into multiple units and smaller yet higher-quality new-build, living beautifully within planetary boundaries.

Public leadership

As the gap in the Australian market is in public and shared ownership housing, use the power of public procurement and delivery as well as legislation and planning to drive innovation.

Fab building

Rework construction innovation, with an industrial policy for circular and regenerative material supply chains via design and fabrication innovation, creating new tools, trades and crafts.

But rather than suggest specific solutions, we want to set a shared frame. We want to see whole life cycle emissions, including embodied emissions limits, meaningfully represented in Australian building regulations.

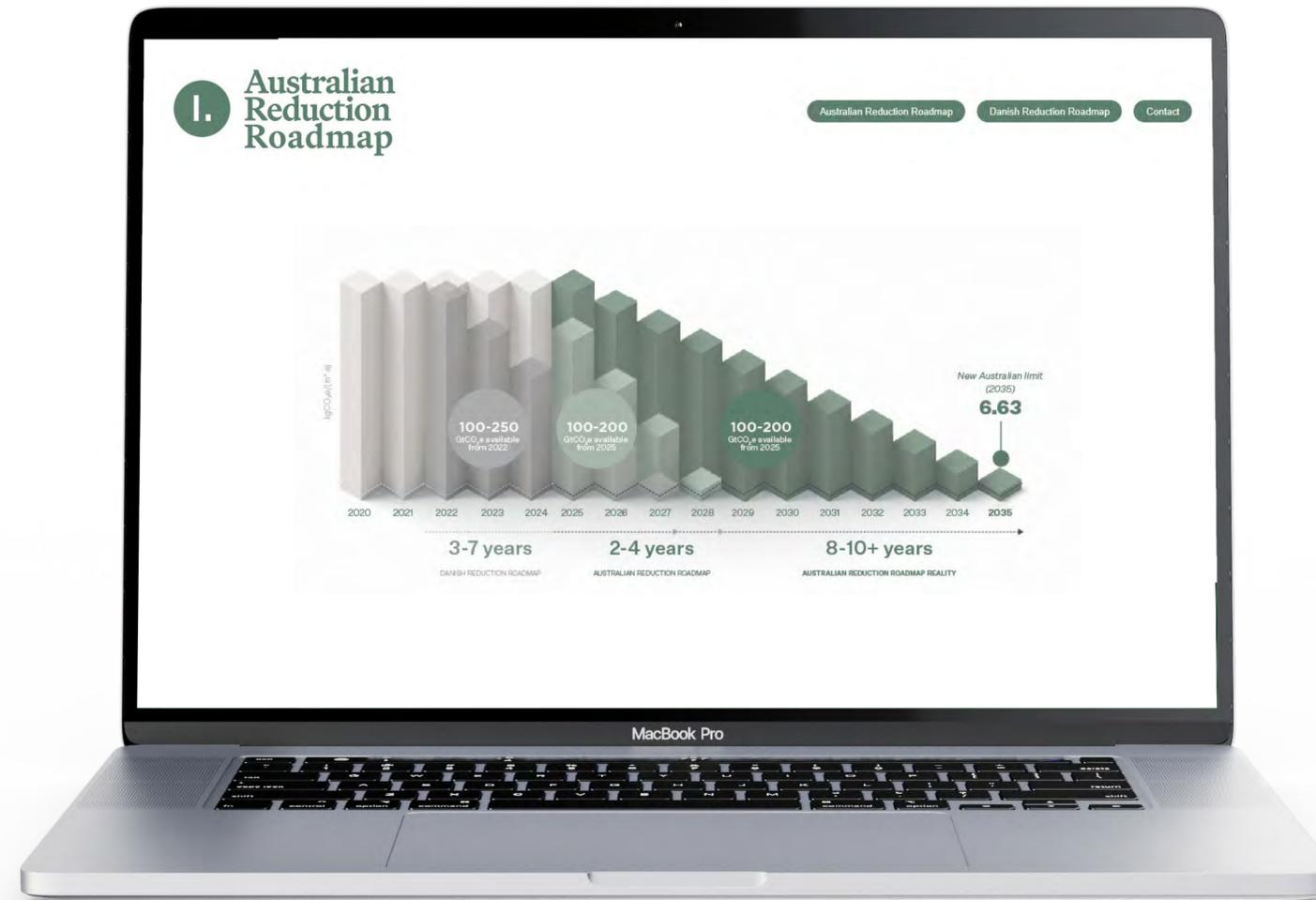
Given that, the sector will respond with shared purpose.

An ask:

According to the Australian Reduction Roadmap, the emissions limit for new housing should be set at an average maximum of $6.63 \text{ kgCO}_2\text{e}/(\text{m}^2\cdot\text{a})$ by 2028.

We encourage your organisation to share this message and show your support within your network.

In light of this, and with your backing, we aim to ensure the National Construction Code's emission limits align with climate science, working within planetary boundaries via cascading targeted reductions, thus contributing to Australia's commitment to the Paris Agreement's goals.



Join us!
reductionroadmap.au

Visit reductionroadmap.au today

Frequently asked questions

What do you commit to if you support the Reduction Roadmap initiative?

When your organisation supports the Reduction Roadmap initiative, you are not obliged to take any specific actions. By offering support, we ask for permission to add your organisation's name to the list of supporters, which we may publicly share on the Roadmap website and social media during the campaign. The publicly available list of supporting organisations is used as leverage to influence legislation and demonstrate to policymakers that the construction industry is ready to stand together and accelerate the green transition in alignment with climate science and the Paris Agreement.

According to the Australian Reduction Roadmap's data, the emissions limit for new housing should be set at an average maximum of 6.63 kgCO₂e/(m²-a) by 2028. We encourage your organisation to share this message and show your support within your network.

In light of this, and with your backing, we aim to ensure the National Construction Code's emission limits align with climate science, working within planetary boundaries via cascading targeted reductions, thus contributing to Australia's commitment to the Paris Agreement's goals.

By showing support, an organisation does not commit to following the Reduction Roadmap's reduction pathway or to building within the limit of 6.63 kgCO₂e/(m²-a) in future projects—only to supporting a legislative change that ensures equal conditions for all, including the environment itself. Importantly, it indicates that a cascading set of reductions allows industry to innovate towards the target over a number of years. Of course, the number of years taken affects the likelihood of adhering to the Paris Agreement's goals, and living within planetary boundaries.

Are organisations obliged to follow the reduction pathway when they express support?

No. Organisations supporting the Reduction Roadmap initiative are not required to follow the reduction pathway or to build within the safe operating space.

The Reduction Roadmap solely focuses on aligning the emission limit in building regulations with the latest scientific knowledge and data, such as from UN climate reports. Only time will tell how much of the emissions budget remains when new policy goals for the emission limit are set in the near future. Therefore, the Reduction Roadmap does not take a position on future political targets for the emission limit in 2028, 2029, etc.

The Reduction Roadmap will be updated as scientific research changes. Equally, future versions will build a compendium of 'next practice' projects indicating possible ways forward, as well as targeting related aspects of extractive practice, such as biodiversity degradation.

How does the Reduction Roadmap translate the Paris Agreement's 1.5°C target into a specific emission limit, in kgCO₂e/(m²-a), for Australian new construction?

The goal of the Reduction Roadmap is to reduce greenhouse gas emissions to a level the planet can handle without the risk of climate change. This level is called the 'safe operating space' and, based on new knowledge from the UN climate report IPCC AR6 (2021), has been recalculated in the study *The Safe Operating Space for Greenhouse Gas Emissions* by Petersen, S. et al. (2022).

This recalculation has shown that global greenhouse gas emissions must be reduced by 95% to prevent further exceeding the planetary boundary for climate change. To achieve this reduction within the 1.5°C target, according to UN climate scientists' defined CO₂ budget in 2020, we had between 7 and 14 years to reduce global climate impact from 47 GtCO₂-eq to 2.54 GtCO₂-eq, assuming a linear reduction.

In June 2023, the article *Indicators of Global Climate Change 2022* (Foster, M. et al, 2023) stated that despite ambitious efforts, global greenhouse gas emissions had not decreased since the release of IPCC AR6. Within just three years, the global emissions budget had been halved, reducing the time frame to achieve the safe operating space to between 3 and 7 years (2026-2030).

Following the Danish precedent, the Australian Reduction Roadmap translates this global 'safe operating space' and the remaining emissions budget into national data for Australia. The scaling from global to national numbers follows an equal per capita distribution principle, which assumes that all people worldwide have an equal right to emissions. Thus, the Paris Agreement allots Australia 0.33% of the global emissions budget. The authors recognise the difficulty in finding an appropriately equitable allocation of budgets—do get in touch if you have better alternatives.

Is 6.63 kgCO₂e/(m²-a) the emission limit for all building types?

No. 6.63 kgCO₂e/(m²-a) should be taken as an overall average, and for housing. The Reduction Roadmap model

recognises the need for differentiated emission limits for different building types, considering their respective reduction potentials. For example, single-family houses have a greater reduction potential than office buildings. We are focusing on housing for this reason, and also due to the largely supply-side policies driving housing production in Australia, irrespective of existing housing space and other quantitative and qualitative aspects of new housing.

Over the past 60 years Australian homes have more than doubled in size, going from an average of approximately 100m² in 1950 to 232m² by 2022. During this period household size has been declining—for example, from 3.6 people per household in 1961 to 2.6 people in 2016. Larger houses have much higher running costs, from heating and cooling and other energy, and of course they use far more materials in construction and ongoing renovation. There is considerable room for improvement here.

We have used an average floor area size for all new dwellings of 186m², drawn from 2022 ABS data. This is drawn from the floor area for new detached residential dwellings (232m²) and 'other residential dwellings'—apartments and townhouses, essentially—at 137m².

The Danish regulation recognises different emissions targets for different buildings, whilst maintaining the principle of progressively reducing targets over time for each type. Read more at <https://www.nordicsustainableconstruction.com/news/2024/june/tillaegsaftale-paa-engelsk>.

What role does renewable energy play in future lifecycle calculations?

For Denmark, new regulations included new emission limits for buildings but also updated emission factors for electricity, district heating, and pipeline gas. These updates, based on projections from the Danish Energy Agency, have been accounted for in the lifecycle analysis, recognising the possibility of the green transition in energy supply.

A similar approach is taken with the Australian numbers, recognising the potential for reduction in emissions over time. This data is worked through on a state by state basis, recognising different Australian states have different heating and cooling needs. More information is available from the University of Melbourne's team: <https://msd.unimelb.edu.au/research/projects/current/environmental-performance-in-construction>. As we also note, as Australia has the potential to be a 'renewable

energy super-power' rather than a leading fossil-fuel emitter, the country has considerable possibility to drive construction industry innovation via renewable energy in production.

Will 6.63 kgCO₂e/(m²-a) slow down new construction?

No. We already have the tools, technologies and practices to build under this limit—they are just not evenly distributed. The challenge is rather an economic, political, and cultural question—and thus concerns design.

Climate risk is the biggest challenge for the construction sector, as it is for other sectors. The overshoot of global greenhouse gas emissions beyond the Paris Agreement's 'budget' will lead to increases in construction costs and timelines, insurance and valuation, material availability and economic viability. The best way to ensure future material access is to mitigate global warming immediately and re-imagine, rebuild and secure local supply chains. As Australia is both a major contributor to climate change, and at one of the front lines of the climate crisis, it should understand this better than most.

Australia can choose to lead this transition or lag behind. As Australian scientist Tim Flannery says, 'Australia is a harbinger of what is going to happen in other places in the world.' We can take this possibility positively or negatively. We choose to take it positively. If Australia helps to lead the industry's transition, it can create resilient, thriving places at home, whilst attracting new forms of investment and paving the way for sustainable construction solutions, knowledge, and products worldwide. However, such a transformation requires political, industrial and societal leadership.

Fact Box

Reduction Roadmap is a research-based tool that, based on climate science, sets specific annual emissions targets for new construction in Australia, using housing as a reference point. It follows Denmark's original Reduction Roadmap project and reworks the model, and associated data, for the Australian context. It indicates how much the construction sector typically emits today, where it needs to go, and at what pace emissions must be reduced to stay within the Paris Agreement's 1.5°C–2°C temperature limit. It is an open movement, allowing organisations to indicate their support for legislative change, placing pressure on regulators and policymakers to ensure that climate science is meaningfully incorporated into the national construction regulations.

Image credits for page 4

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Firefighters battling the blaze in Tara, Fri 27 Oct 2023 Image: Queensland Fire and Emergency Services /ABC

Clouds of toxic gas are blasted out of open-cut coalmines in NSW Image: Robert Rough

Sydney CBD flooding, 2015 Image: Getty Images/Mark Snodgrass

Mallacoota Bushfires, 2015. Image: Matthew Abbot for the New York Times

A turtle swimming over bleached coral near Heron Island, in the southern Great Barrier Reef. Image: XL Catlin Seaview Survey

Residents cleaning up the damage after devastating floods hit the central NSW town of Molong. Image: AAP

Smoke haze from bushfires in New South Wales blankets the CBD in Sydney, Friday, December 6, 2019. Picture: AAP Image/Bianca De Marchi

Smoke haze from bushfires in New South Wales blankets the CBD in Sydney, Friday, December 6, 2019. Image: AAP Image/Bianca De Marchi

The ADF says it now has 2,500 personnel helping with the clean-up in northern NSW. Image: AAP Image/Jason O'Brien

The town of Menindee, on the Darling River has suffered through two major fish kill events. Image: Jamie Pittock

Dark roofs banned in Wilton - ABC listen. An aerial photo of a new housing estate, Cecil Hills, in western Sydney. Image: Getty Images/Andrew Merry

Koala in aftermath of SA bushfires. Image: Brad Fleet

Flooding through Torwood Street in Auchenflower, Thursday, March 3, 2022. Image: Richard Walker

Flooding through Torwood Street in Auchenflower, Thursday, March 3, 2022. Image: Richard Walker

Sackville, NSW, Australia - 9 March 2022. Aerial view of the Hawkesbury River in flood over roads and farmland in outer rural Sydney. Image: Alamy Stock Photo/Harley Kingston

A photograph of a bushfire-affected community. The sky is red with smoke. A man wears a towel over his face. On New Year's Eve 2019, fire reached Mallacoota, forcing residents to flee to the beach. Image: QAGOMA/Rachel Mounsey

Lismore floods 2022. Image: AAP Image/Supplied by the Department of Defence, Bradley Richardson

Lifecycle emissions data

The University of Melbourne
<http://epicdatabase.au>

Graphics

TERROIR and University of Melbourne, based on an original scheme by EFFEKT, Artelia and CEBRA for the Danish Reduction Roadmap. Typefaces are Martina Plantijn and Untitled Sans, by klim.co.nz

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