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The latest understanding on efforts required to achieve the 1.5°C goal

Expert Meeting on the Science of National Mitigation Efforts, different gases and 1.5°C – 22 June 2021 (virtual)

Dr Joeri ROGELJ

Halting global warming needs zero CO_2 emissions

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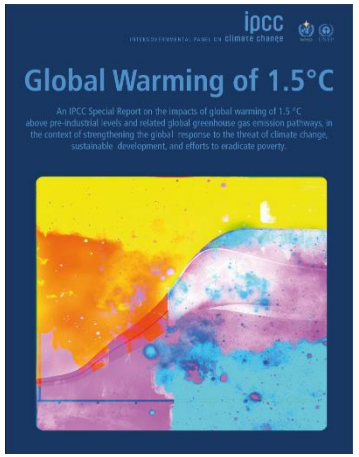

The remaining carbon budget for limiting warming to 1.5°C is small

insufficient emissions reductions in the past results in certainty of success not being an option anymore

Additional Warming since 2006–2015 [°C]*(1)	Approximate Warming since 1850–1900 [°C]*(1)	Remaining Carbon Budget (Excluding Additional Earth System Feedbacks*(5)) [$GtCO_2$ from 1.1.2018]*(2)			Key U	
		Percentiles of TCRE *(3)			Earth System Feedbacks *(5)	Non-CO_2 scenario variation *(6)
		33rd	*50th*	*67th*	*[$GtCO_2$]*	*[$GtCO_2$]*
0.3		290	160	80	Budgets on the left are reduced by about –100 on centennial time scales	±250
0.4		530	350	230		
0.5		770	530	380		
0.53	**~1.5°C**	**840**	**580**	**420**		
0.6		1010	710	530		
0.63		1080	770	570		
0.7		1240	900	680		
0.78		1440	1040	800		
0.8		1480	1080	830		
0.9		1720	1260	980		
1		1960	1450	1130		
1.03	**~2°C**	2030	1500	1170		

Source: IPCC SR1.5 (2018) – Table 2.2 https://www.ipcc.ch/sr15/

Carbon budgets critical for implied 1.5°C efforts

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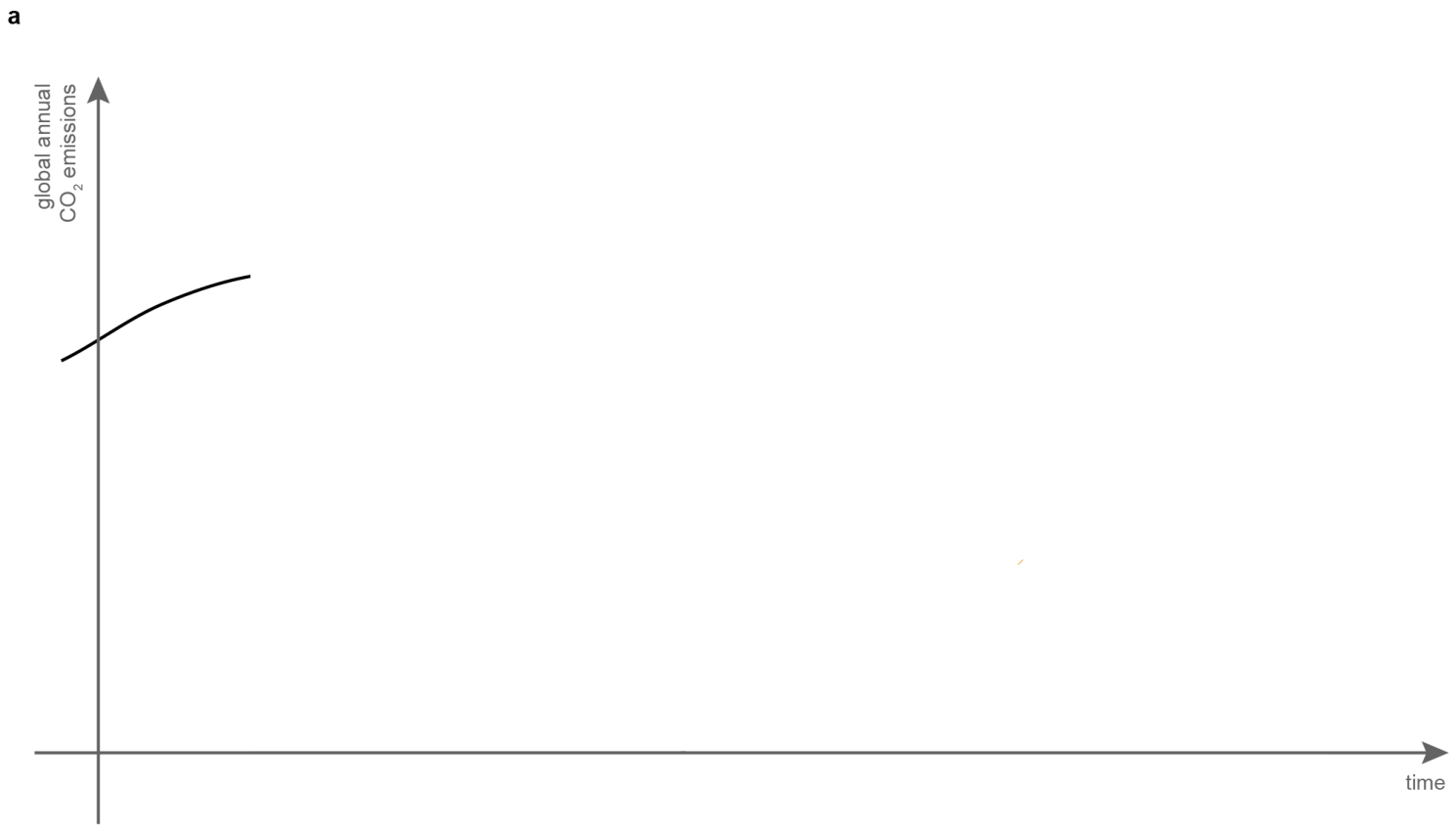

Source: Rogelj et al, Nature (2019) "A new scenario logic for the Paris Agreement long-term temperature goal "

Carbon budgets critical for implied 1.5°C efforts

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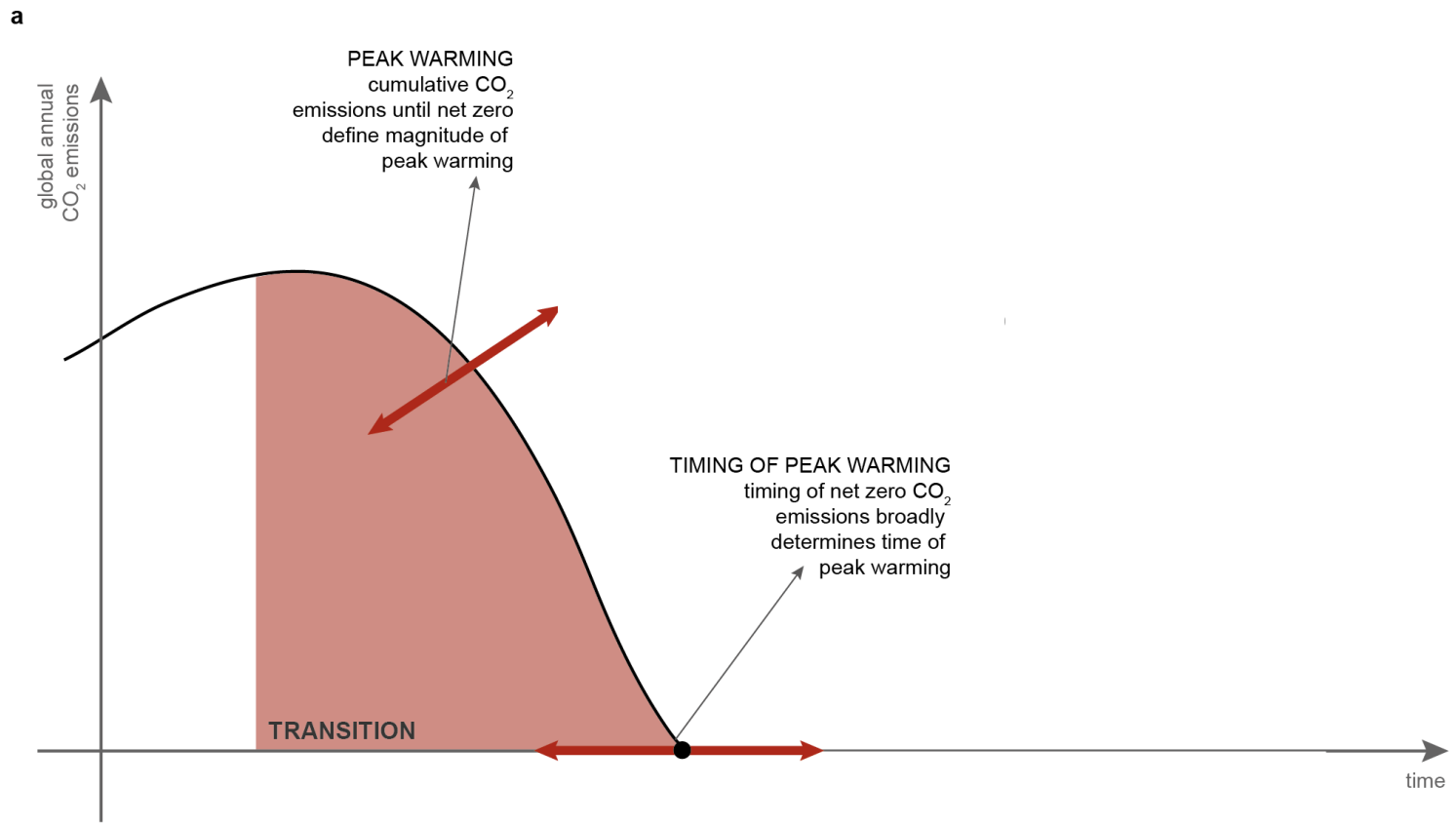

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Carbon budgets critical for implied 1.5°C efforts

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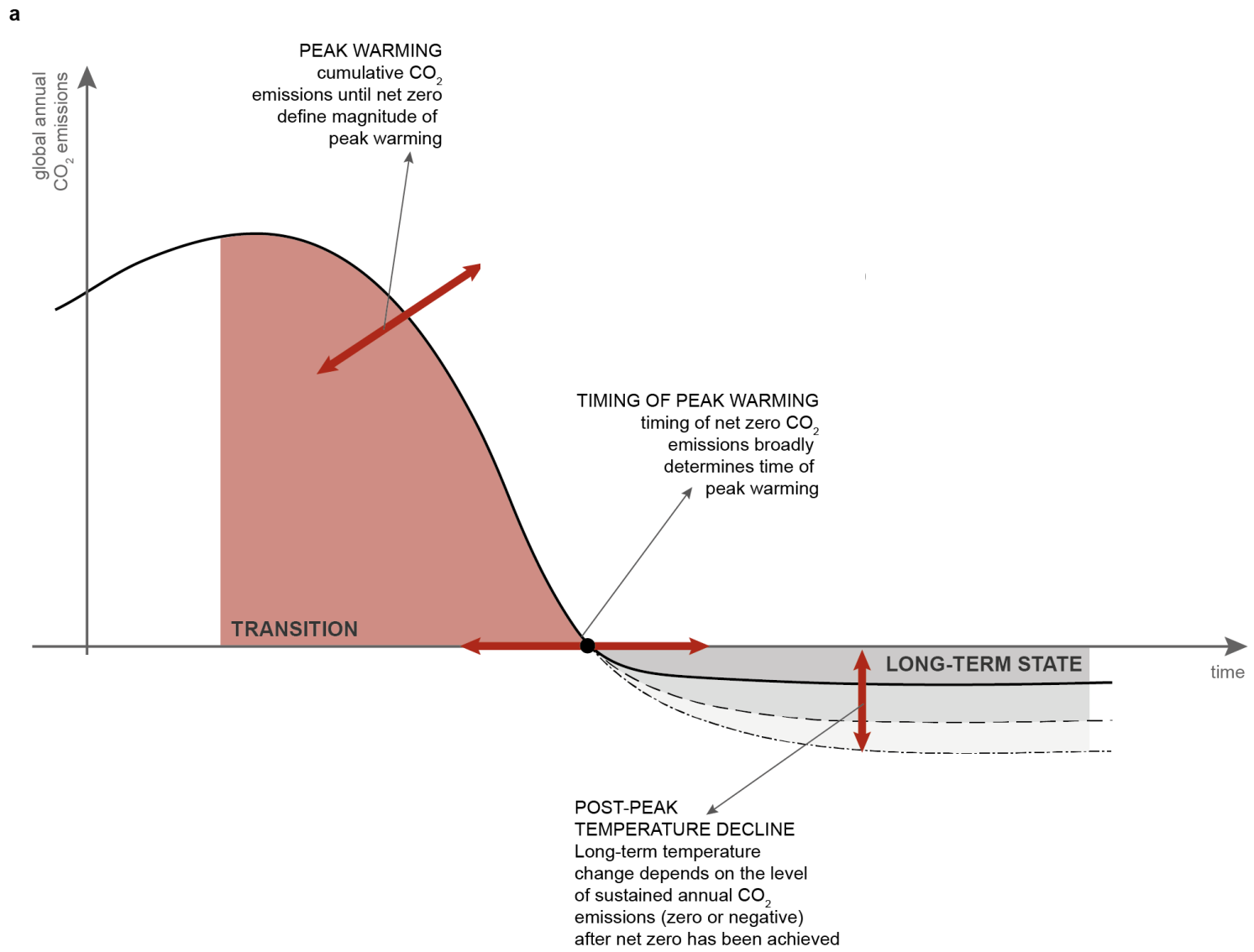

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Carbon budgets critical for implied 1.5°C efforts

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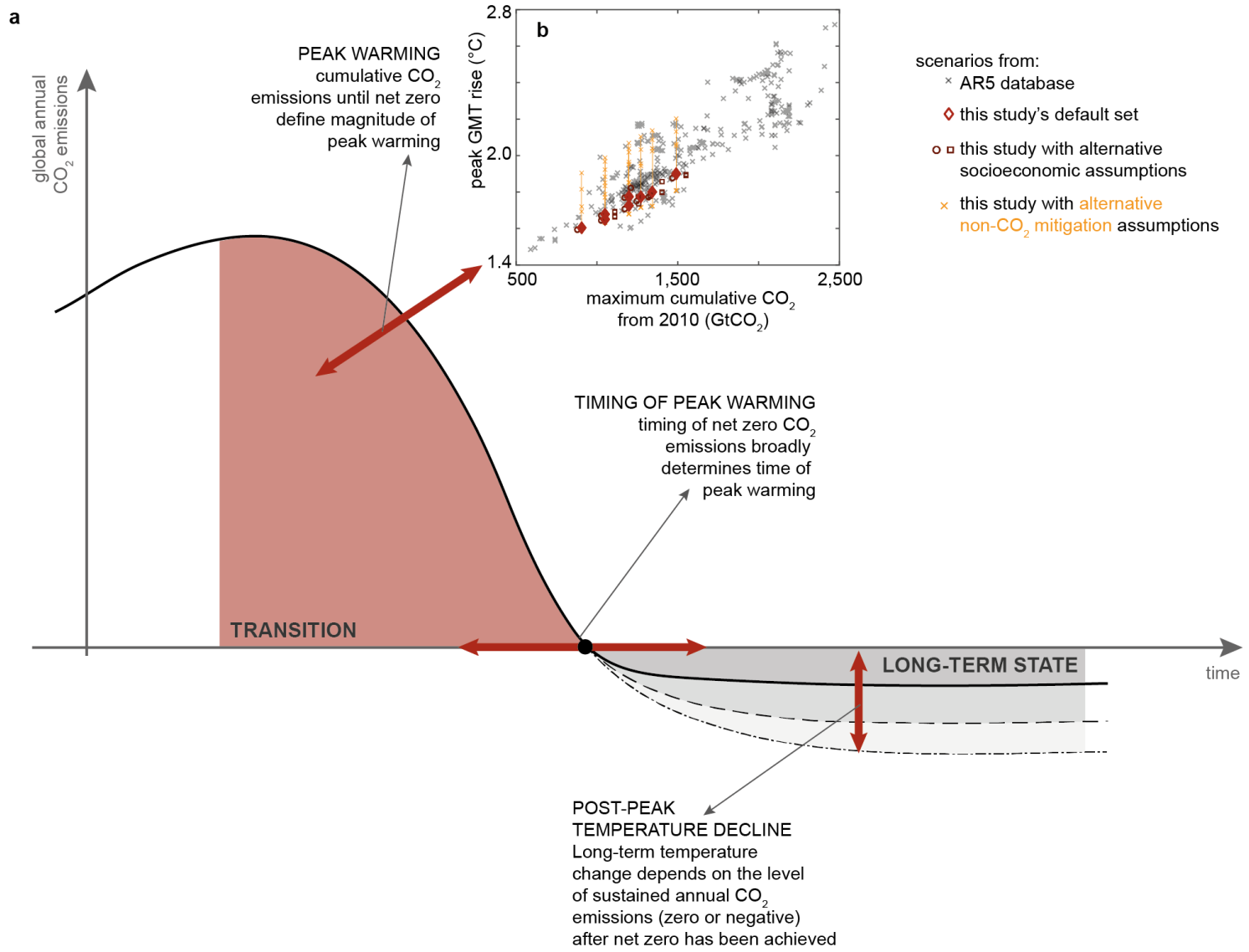

Source: Rogelj et al, Nature (2019) "A new scenario logic for the Paris Agreement long-term temperature goal "

Estimated near-term efforts increase sharply to 1.5°C

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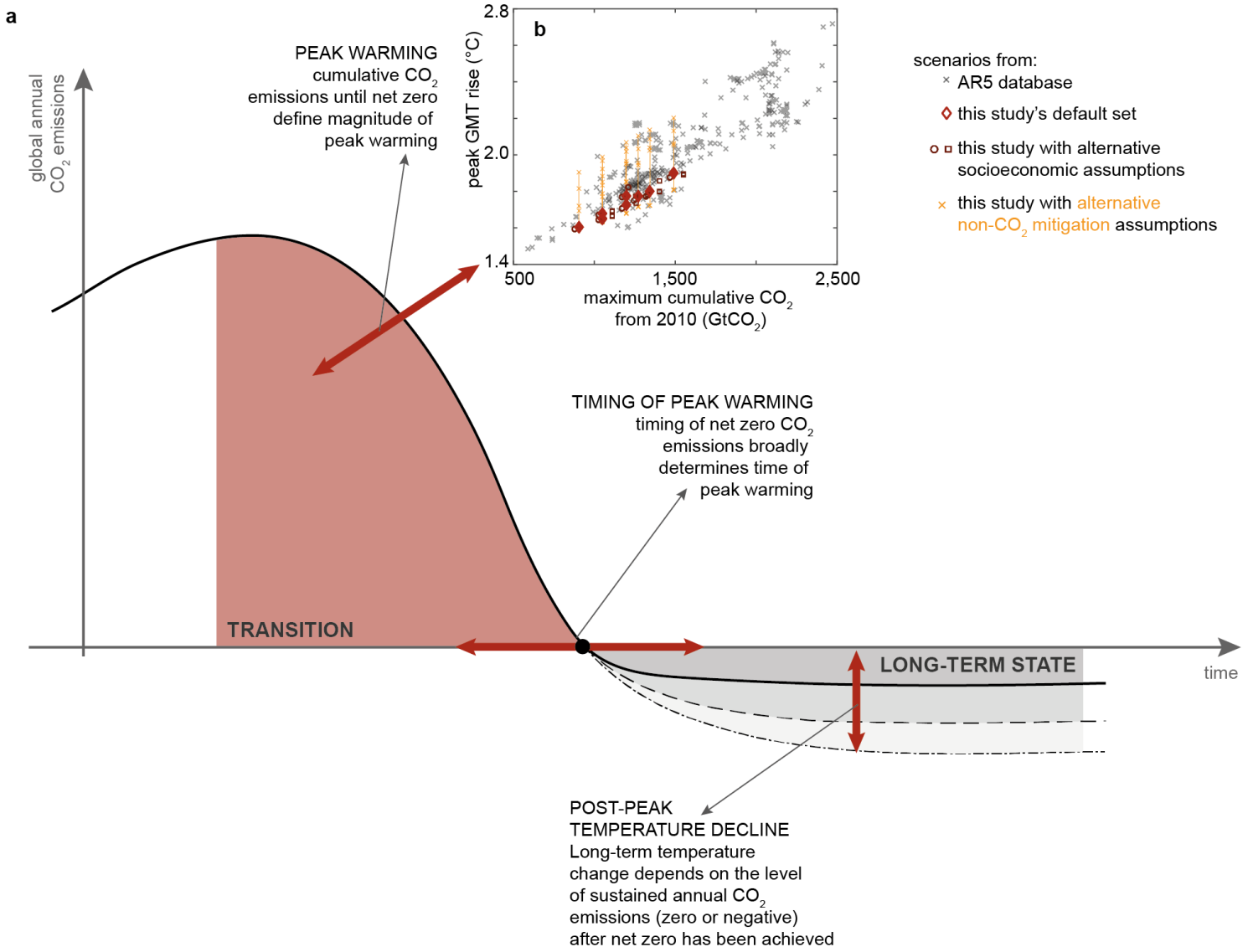

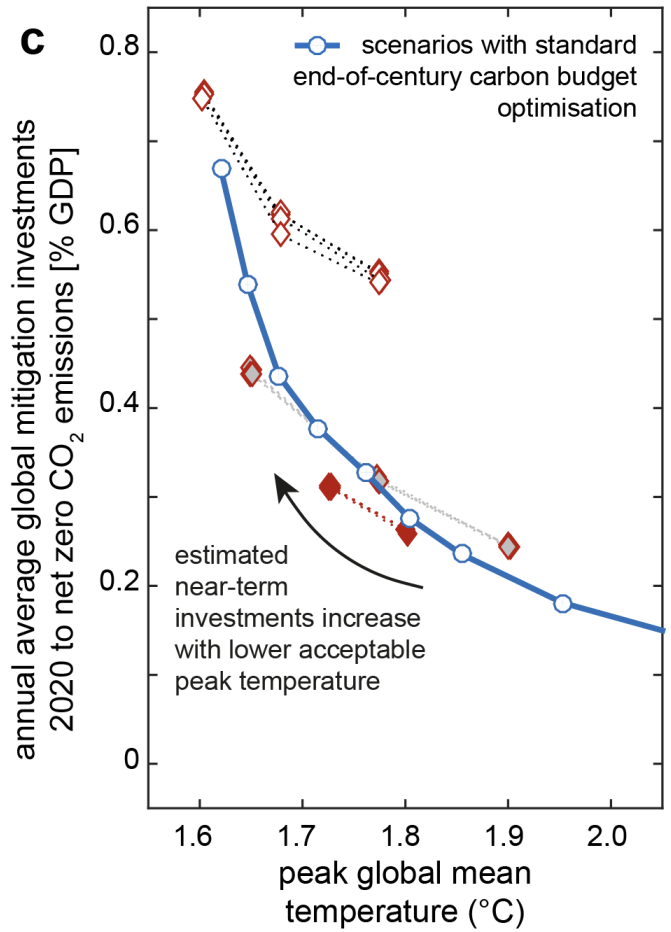

Source: Rogelj et al, Nature (2019) "A new scenario logic for the Paris Agreement long-term temperature goal "

Different net zero targets

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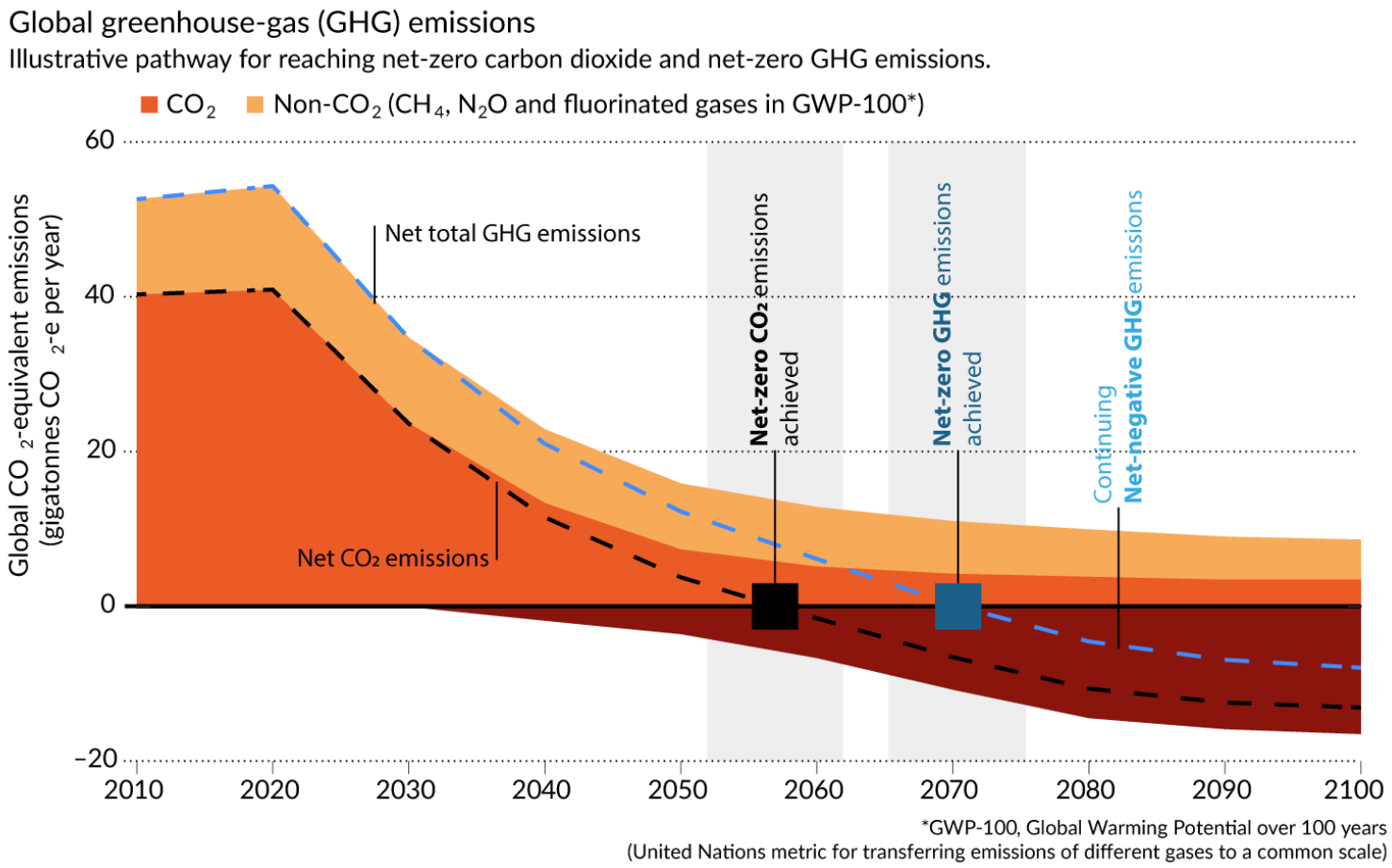

Source: Rogelj et al, Nature (2021) "Three ways to improve net-zero emissions targets"

Different net zero targets and their climate outcome

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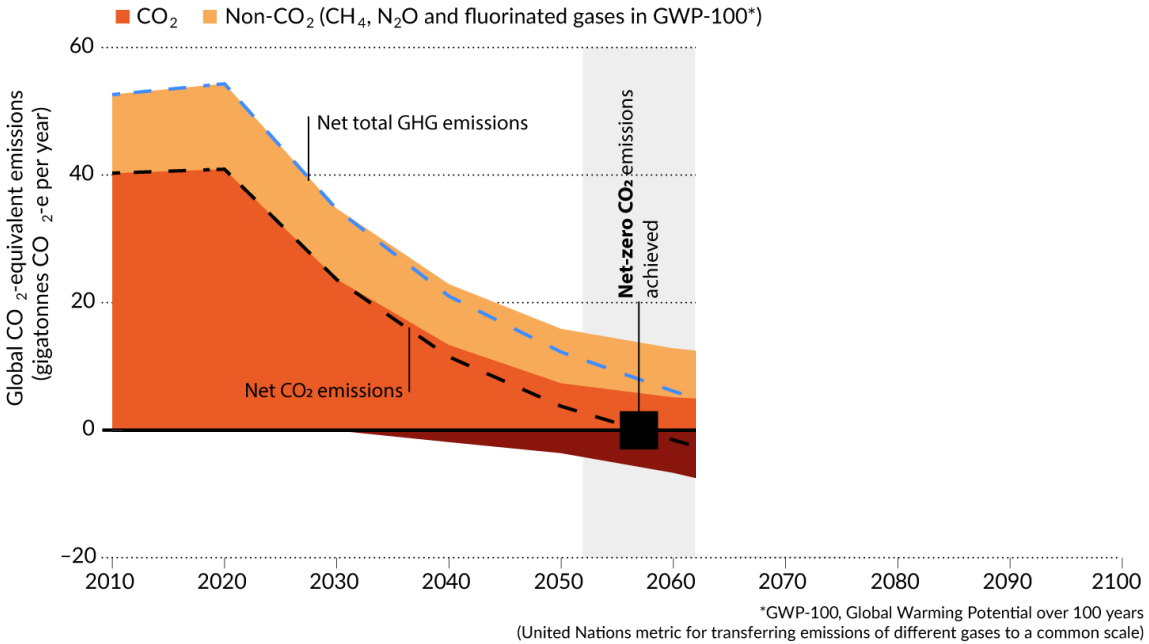
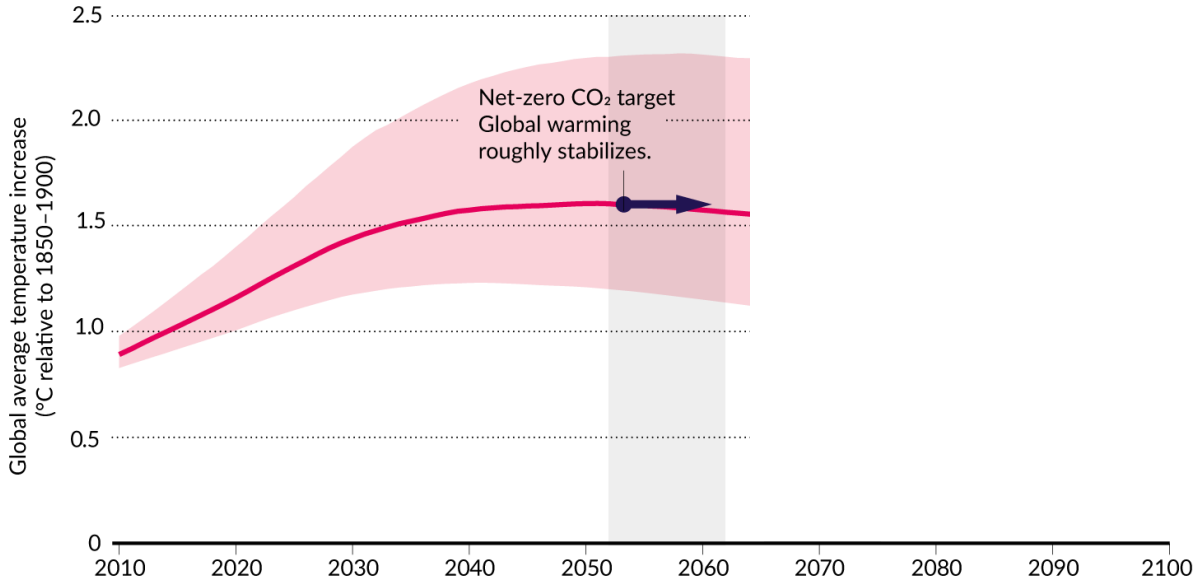
Global greenhouse-gas (GHG) emissions
Illustrative pathway for reaching net-zero carbon dioxide and net-zero GHG emissions.



*GWP-100, Global Warming Potential over 100 years
(United Nations metric for transferring emissions of different gases to a common scale)

Global-warming implications
Estimated global temperature peaks (in pink) and declines (arrows) under net-zero GHG emissions.



Source: Rogelj et al, Nature (2021) “Three ways to improve net-zero emissions targets”

Improved understanding of key components determining carbon budget size

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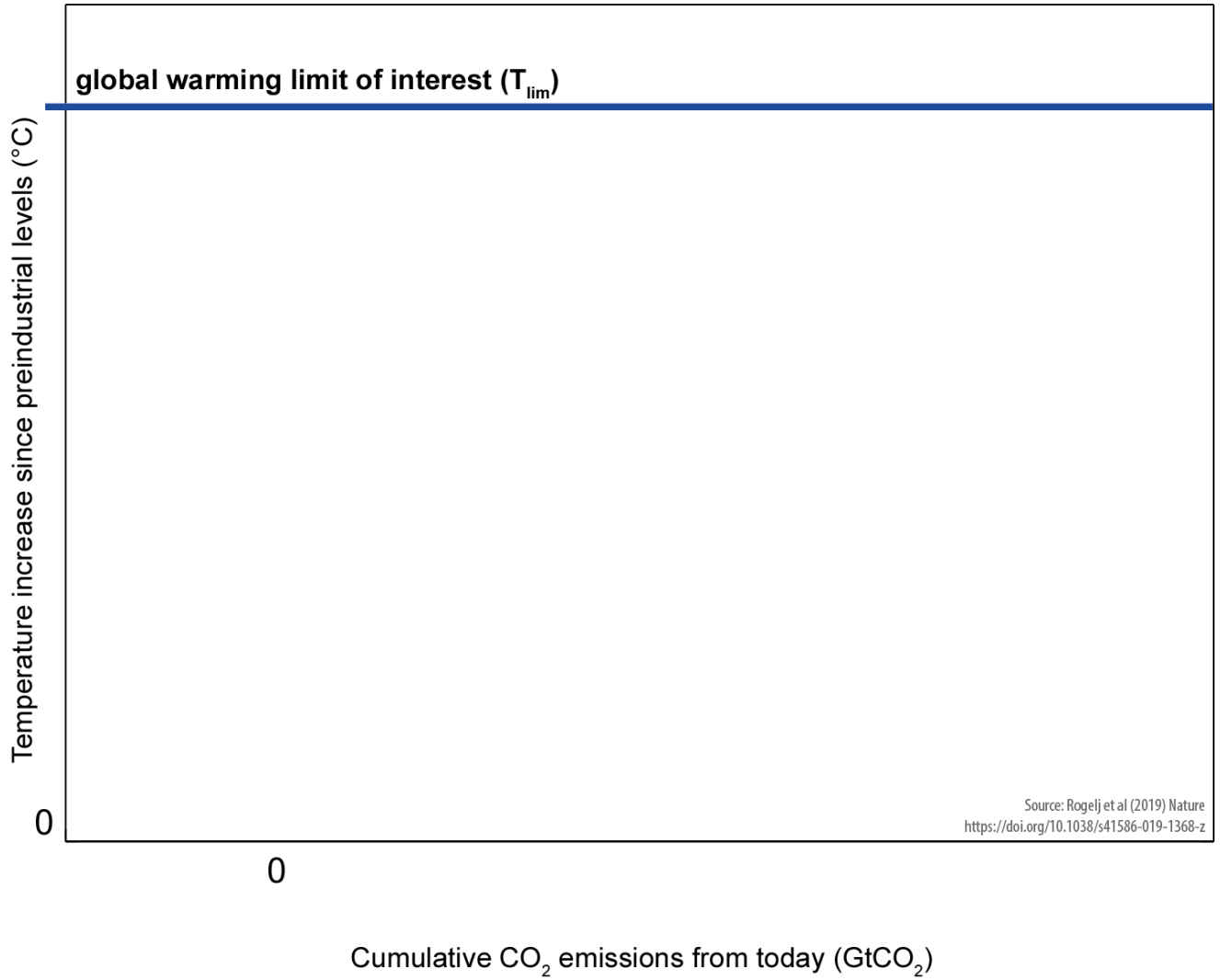
Five components:



Source: IPCC SR1.5 (2018)

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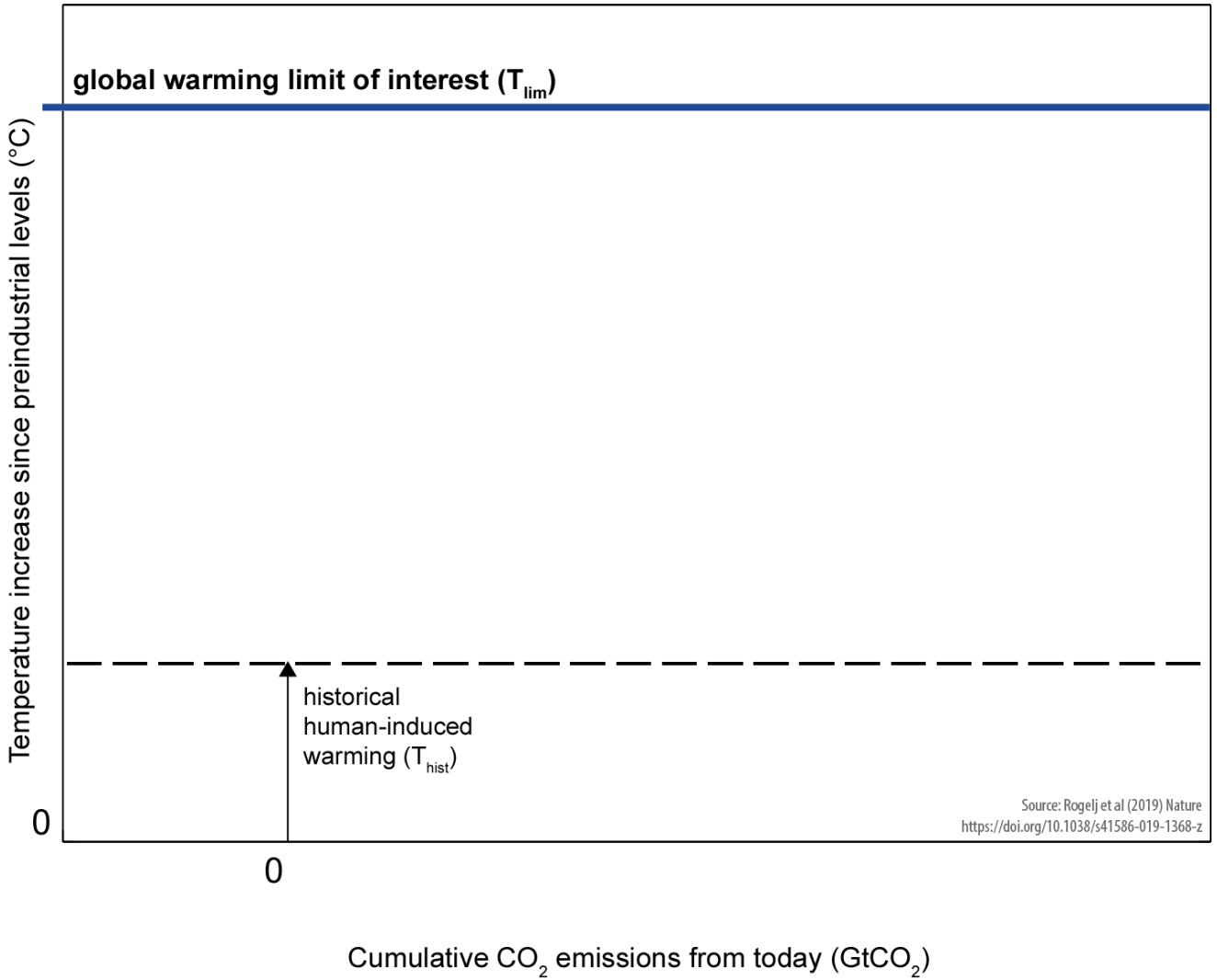
Five components:

- Historical warming to date



Source: IPCC SR1.5 (2018)

Improved understanding of key components determining carbon budget size

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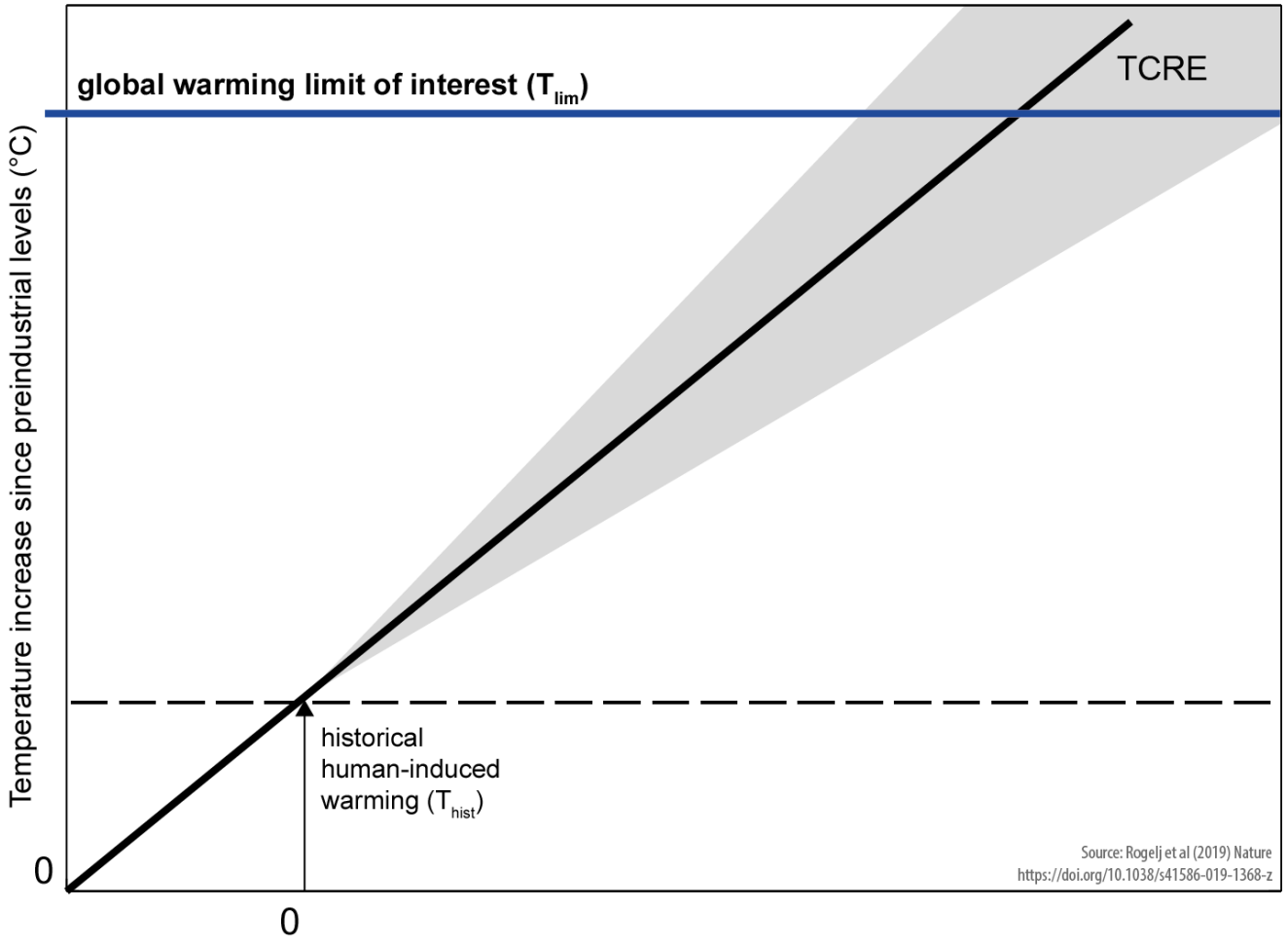
Five components:

- Historical warming to date
- Transient climate response to cumulative emissions of carbon dioxide (TCRE)



Source: IPCC SR1.5 (2018)

Improved understanding of key components determining carbon budget size

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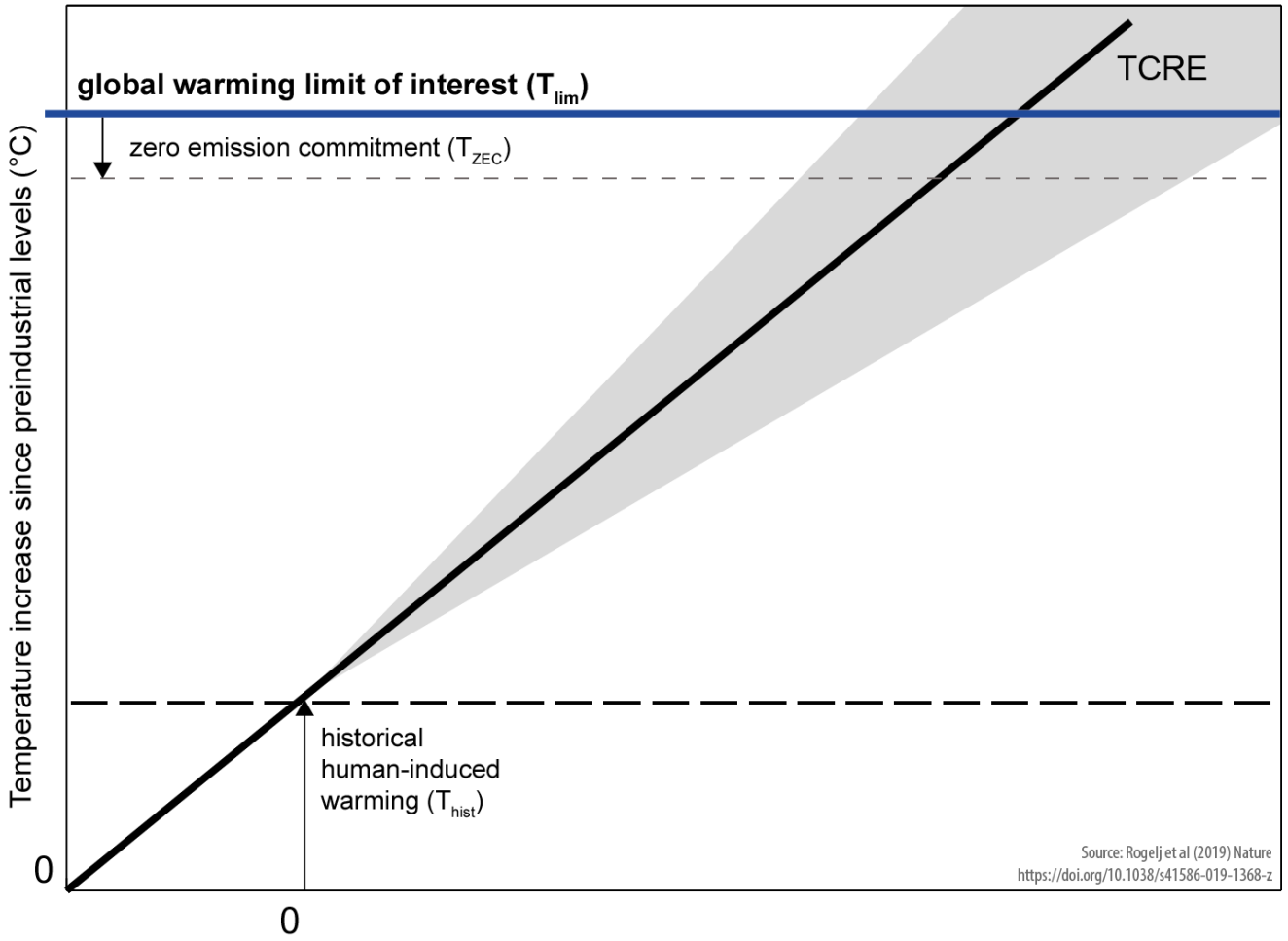
Five components:

- Historical warming to date
- Transient climate response to cumulative emissions of carbon dioxide (TCRE)
- Zero emission commitment (ZEC)



Source: IPCC SR1.5 (2018)

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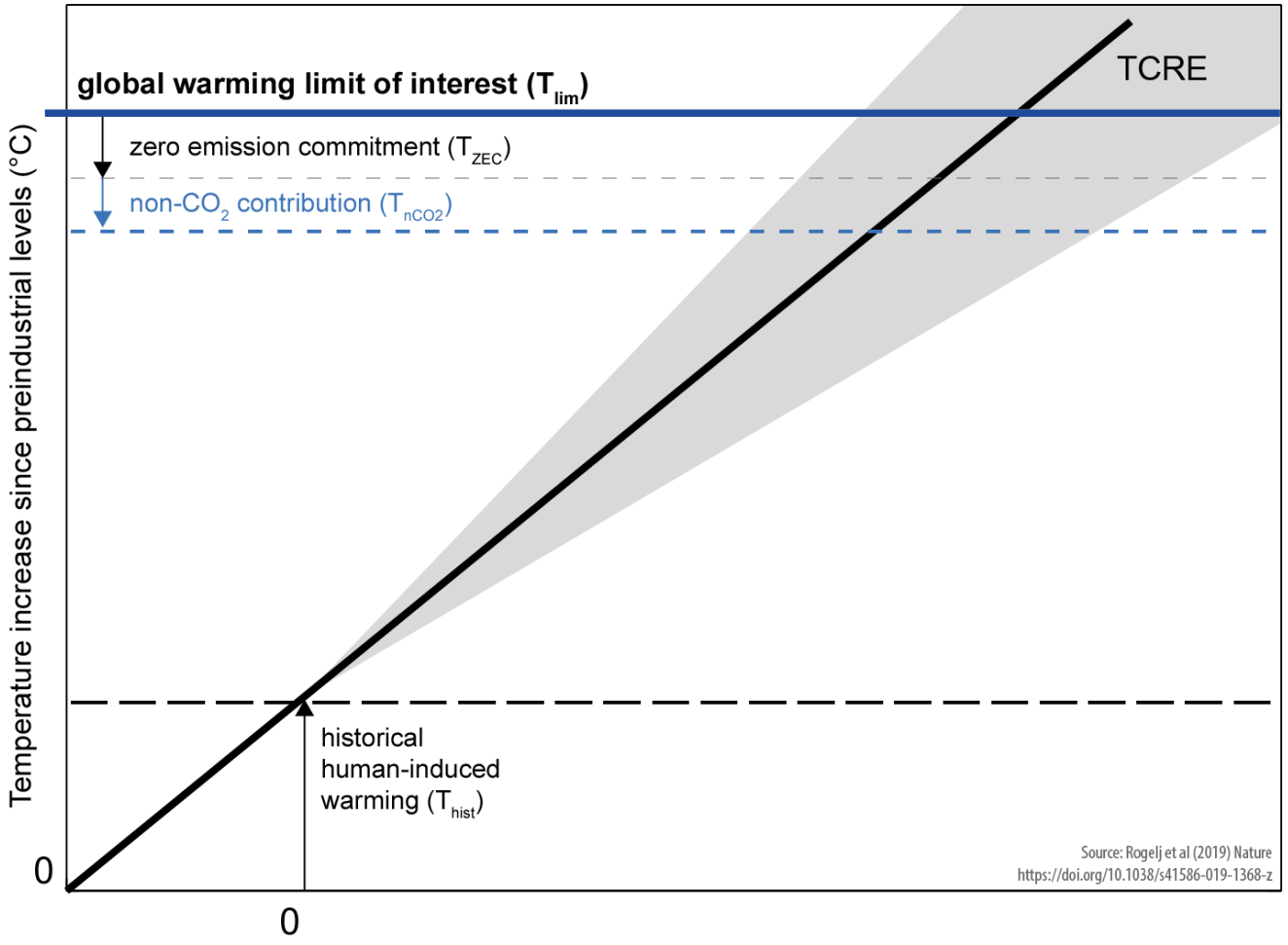
Five components:

- Historical warming to date
- Transient climate response to cumulative emissions of carbon dioxide (TCRE)
- Zero emission commitment (ZEC)
- Projected future non-CO_2 temperature contribution



Source: IPCC SR1.5 (2018)

Improved understanding of key components determining carbon budget size

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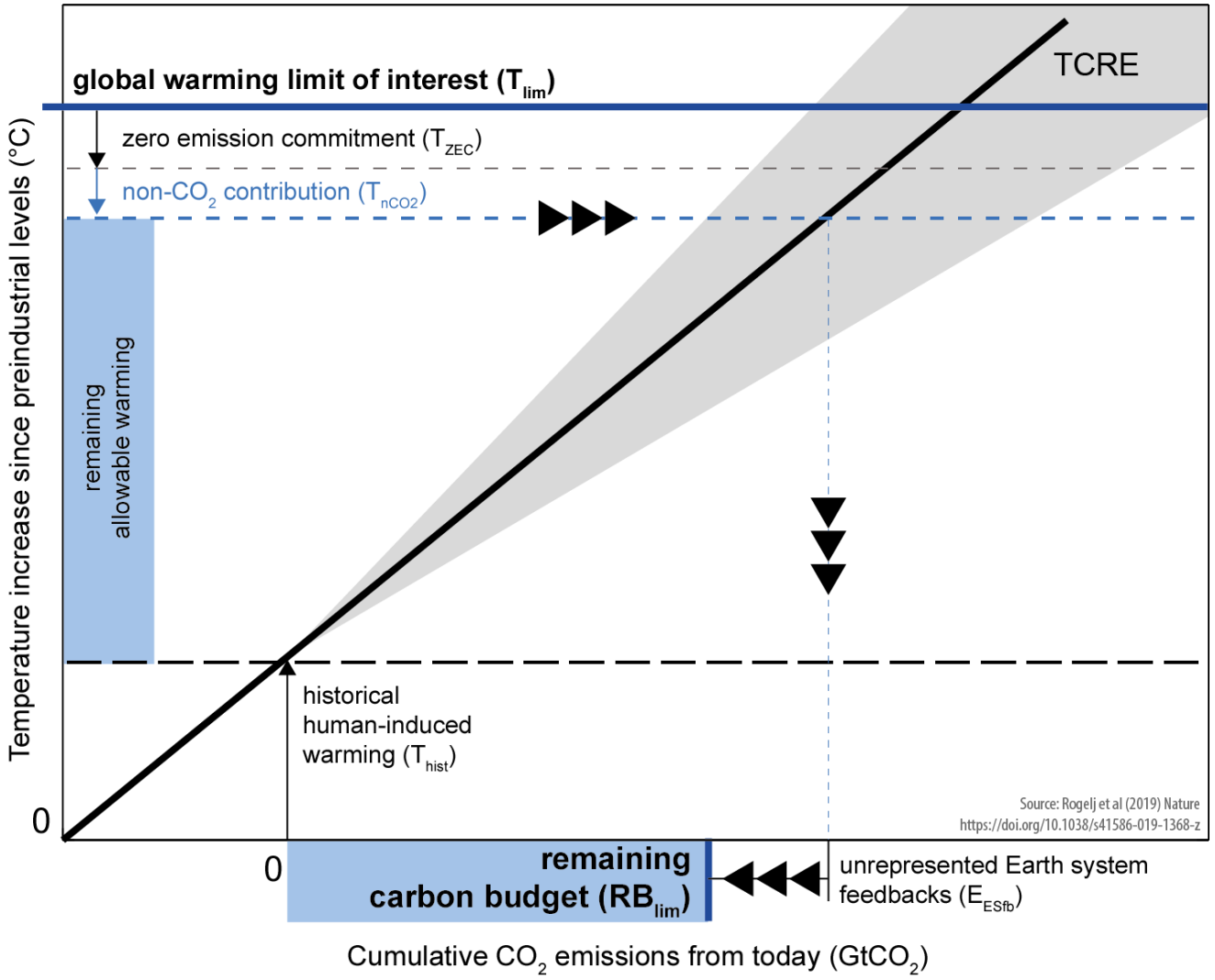
Five components:

- Historical warming to date
- Transient climate response to cumulative emissions of carbon dioxide (TCRE)
- Zero emission commitment (ZEC)
- Projected future non-CO_2 temperature contribution
- Unrepresented Earth system feedbacks



Source: IPCC SR1.5 (2018)

Dedicated studies of the “warming in the pipeline” suggest no marked additional warming

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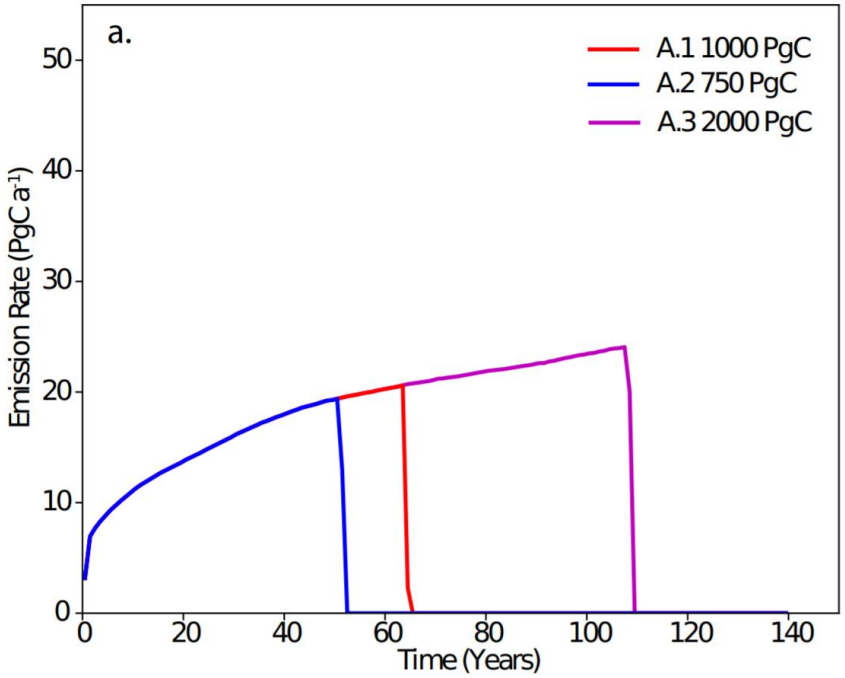

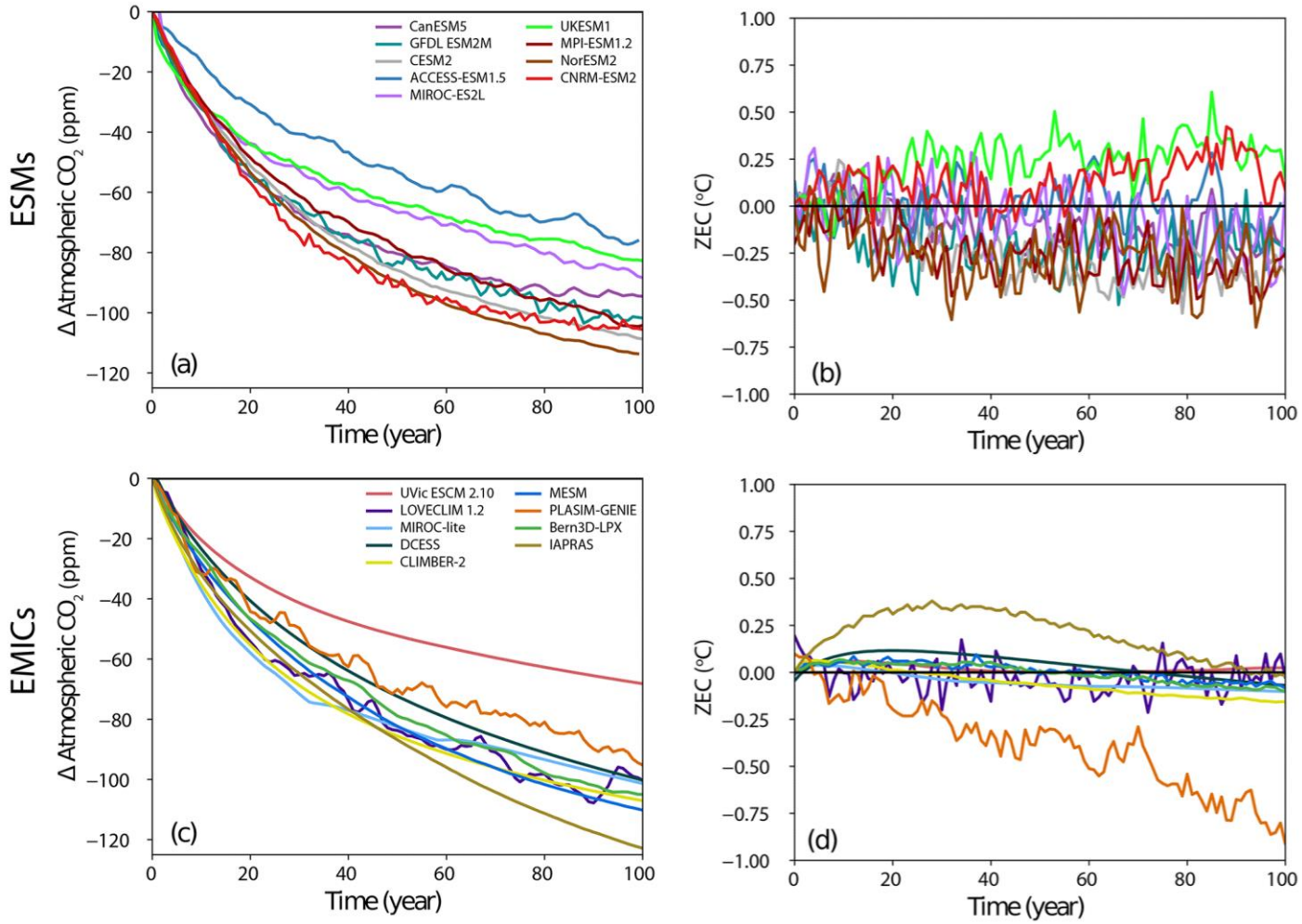

Source: MacDougall et al (2020)

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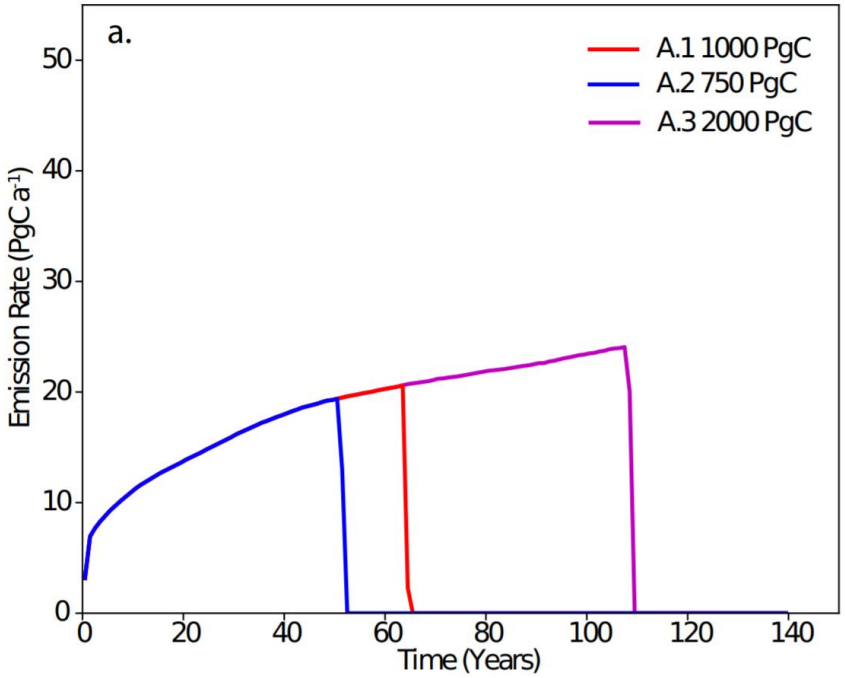


Model	ZEC_{25} (°C)	ZEC_{50} (°C)	ZEC_{90} (°C)
Mean	-0.01	-0.06	-0.11
Median	-0.01	-0.05	-0.08
Standard Deviation	0.15	0.19	0.23

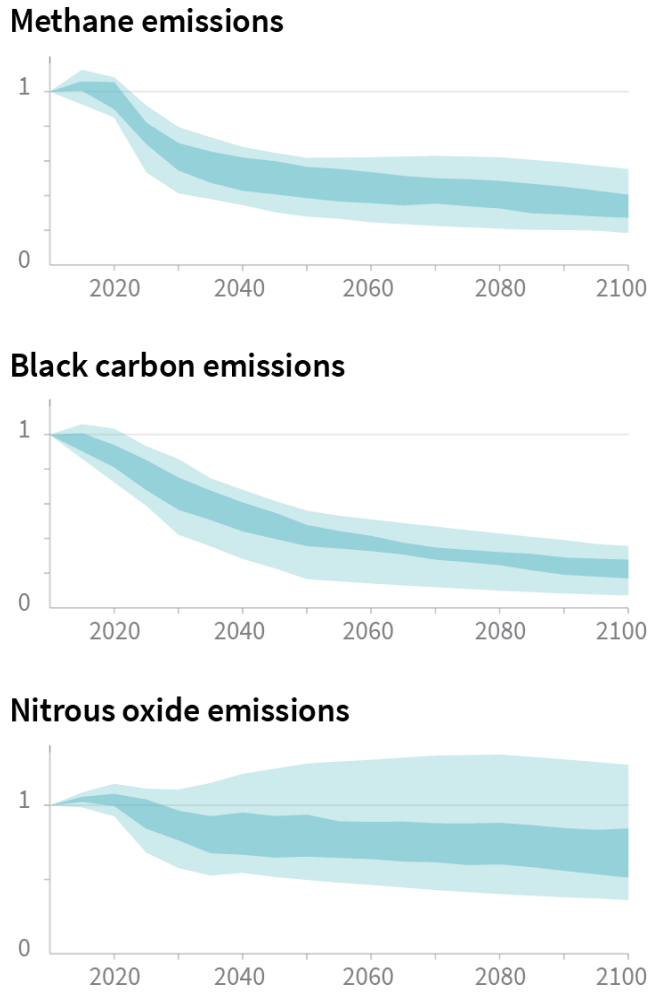
Source: MacDougall et al (2020)

Impact of past and future non-CO_2 emissions

Carbon budget assessment for 1.5°C uses consistent reductions in non-CO_2 greenhouse gases to counter effect of reducing aerosols

Despite deep reductions in CH_4, N_2O and other greenhouse gases net effect by mid-century = 0.1 to 0.2°C warming due to non-CO_2

Global CH_4 emissions reductions are essential:
Around a 50 to 60% reduction over the next 2 decades



Source: IPCC SR1.5 (2018)

Impact of past and future non-CO_2 emissions **focus on methane**

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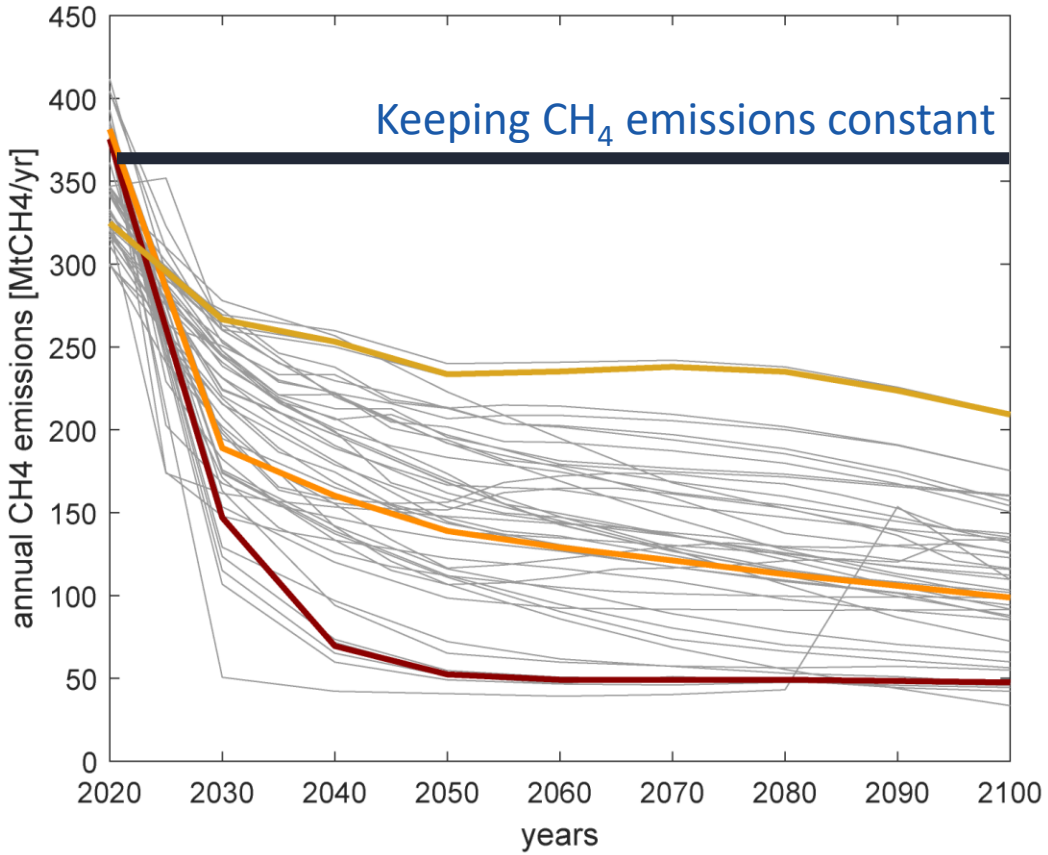
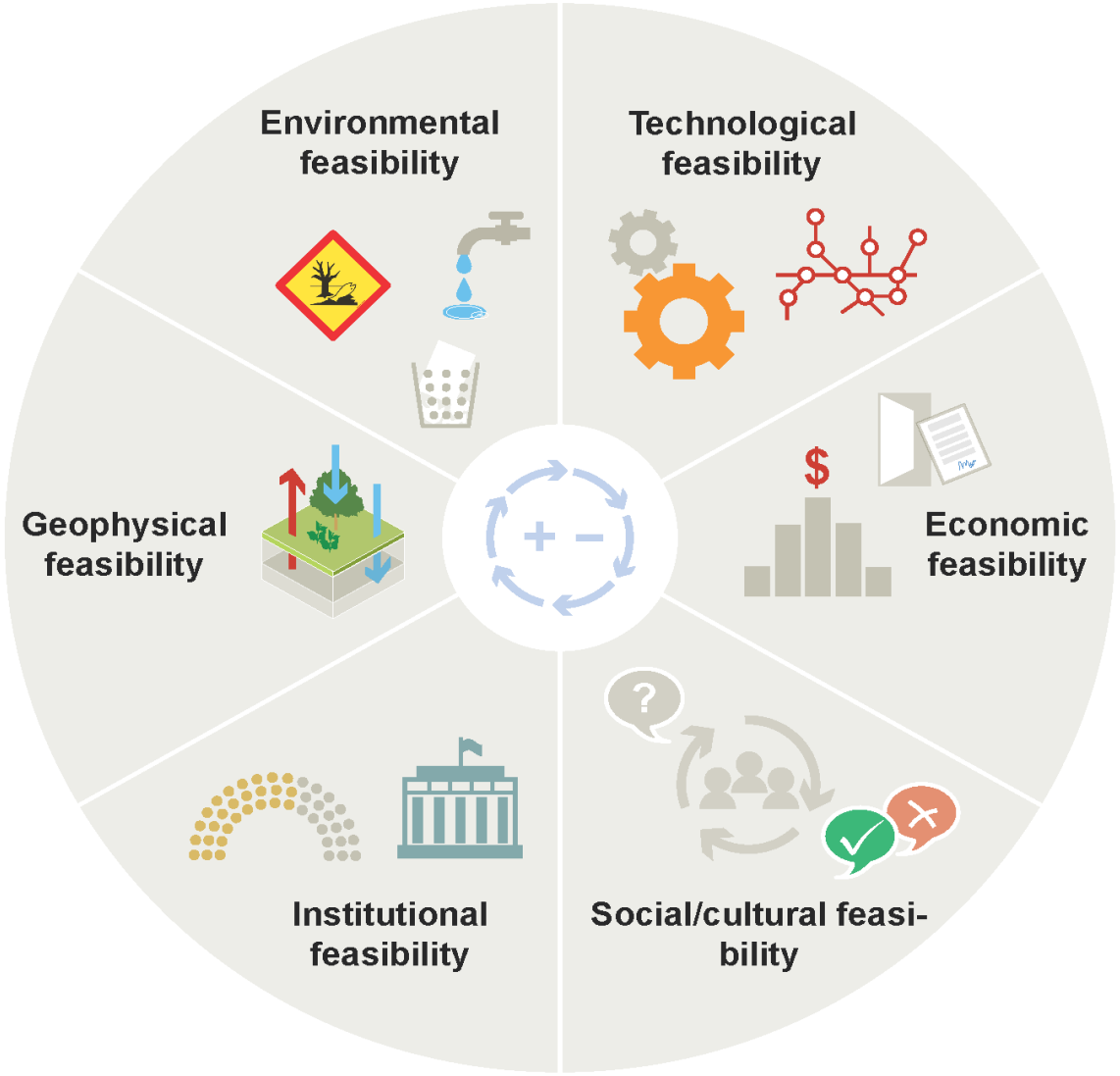


Failure to reduce CH_4 emissions: Reduction of remaining carbon budget
Implications: 1.5°C carbon budget effectively zero

Source: IPCC SR1.5 (2018); Huppmann et al (2018); own calculations using GWP*

1.5°C efforts and feasibility



Source: IPCC SR1.5

Shifting efforts and transition risks in 1.5°C pathways

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Table 1. —Indicators selected for the five feasibility dimensions. In this table we indicate the general approach to derive the thresholds and point to the specific section in the SM, where more details and citations can be found. All indicators are defined at the decadal level. Please refer to the visual tool to explore the sensitivity of results to the selection of different thresholds: https://data.ece.iiasa.ac.at/climate-action-feasibility-dashboard/. The framework includes both demand and supply side mitigation measures, and focuses on sectors where rapid decarbonization is required.

Indicator	Computation	Medium concern threshold	High concern threshold	Sources
Geophysical constraints *Indicators measuring technical potentials (not accounting for desirability considerations) (SM section 2)*				
1.1 Wind energy generation	Total secondary energy generation from wind in a given decade (EJ)	830	2000	Deng *et al* (2015), Eurek *et al* (2017)
1.2 Solar energy generation	Total primary energy generation from solar in a given decade (EJ)	1600	50 000	Moomaw *et al* (2011)
1.3 Biomass energy generation	Total primary energy generation from biomass in a given decade (EJ)	300	600	Slade (2011)
Economic constraints *Indicators measuring economic mitigation efforts or costs (SM section 3) or costs (SM section 3)*				
2.1 Carbon price	Carbon price levels (NPV) and decadal increases	60$	120$ and 5×	Own analysis (based on World Bank data)
2.2 GDP losses	Decadal percentage difference in GDP in mitigation vs baseline scenario	5%	10%	Analogy to current COVID-19 spending Andrijevic *et al* (2020b)
2.3 Energy investments	Ratio between investments in mitigation vs baseline in a given decade	1.2	1.5	Various reports and related studies
2.4 Stranded coal assets	Share of prematurely retired coal power generation in a given decade	20%	50%	Own analysis based on the current fleet of coal power plants (Global Energy Monitor 2021)
Technological constraints *Indicators assuming ideal conditions for technological growth (SM section 4)*				
Electricity sector				
Established technologies				
3.1 Wind scale-up	Decadal percentage point increase in the wind share in electricity generation	10 pp	20 pp	Own analysis; Wilson *et al* (2020)
3.2 Solar scale-up	Decadal percentage point increase in the solar share in electricity generation	10 pp	20 pp	Own analysis; Wilson *et al* (2020)
3.3 Nuclear scale-up	Decadal percentage point increase in the nuclear share in electricity generation	5 pp	10 pp	Own analysis; Markard *et al* (2020), Wilson *et al* (2020)

(Continued.)

Source: IPCC SR1.5; Brutschin et al (2021)

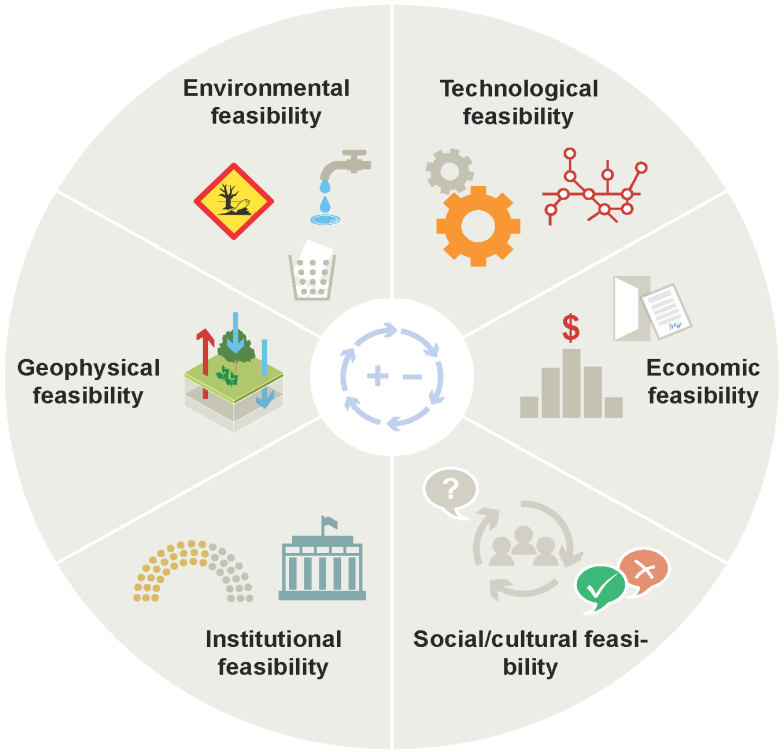
Shifting efforts and transition risks in 1.5°C pathways

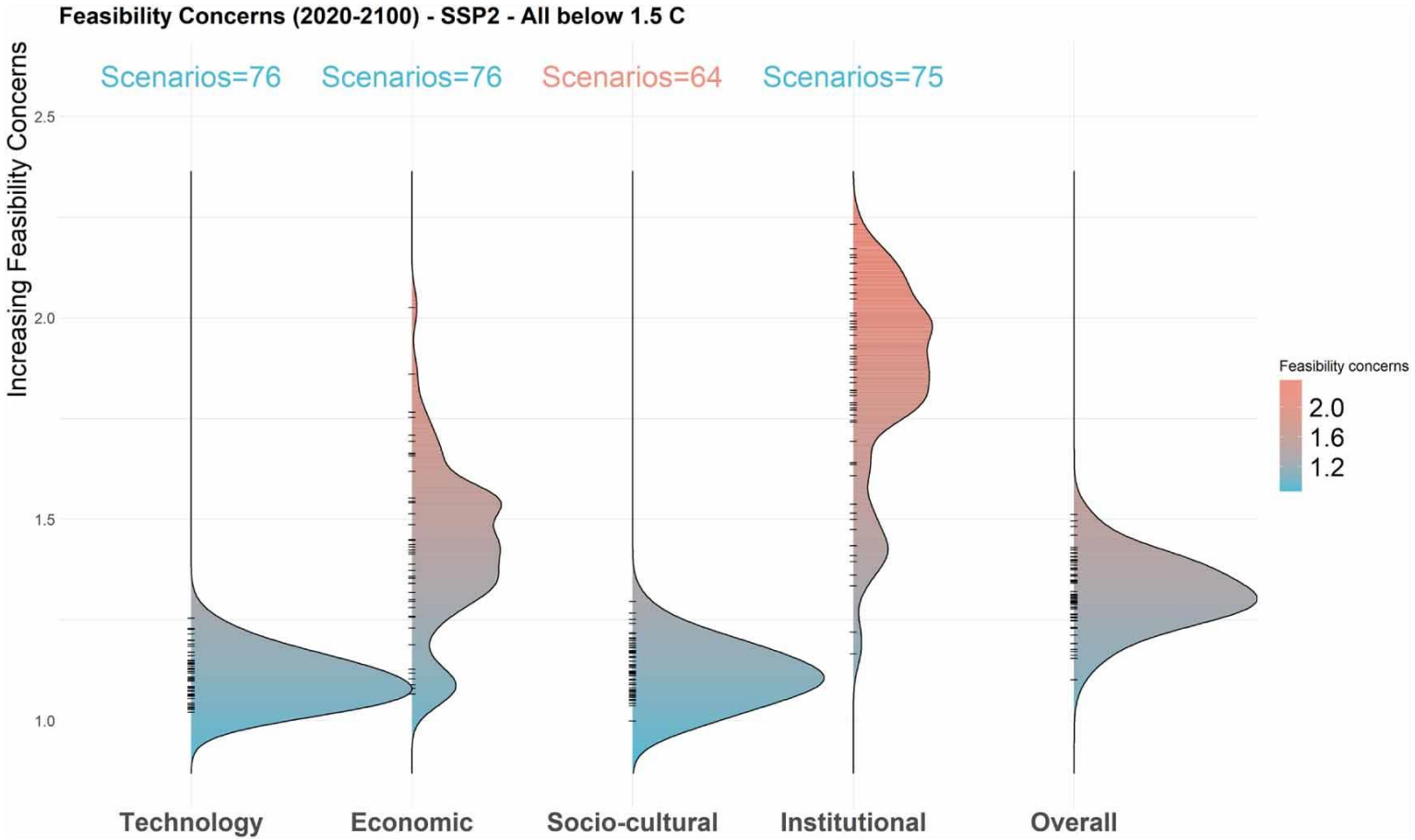
Table 1. (Continued.)

Indicator	Computation	Medium concern threshold	High concern threshold	Sources
Emerging technologies				
3.4 Biomass scale-up	Decadal percentage point increase in the biomass share in electricity generation	2 pp	5 pp	Analogies and related studies
3.5 CCS with coal scale-up	Decadal percentage point increase in the share of coal with CCS in electricity generation	2 pp	5 pp	Analogies and related studies
3.6 BECCS scale-up	Decadal percentage point increase in the share of BECCS in electricity generation	2 pp	5 pp	Analogies and related studies
Transport sector				
3.7 Biofuels in transport scale-up	Decadal percentage point increase in the share of biofuels in the final energy demand of the transport sector	10 pp	15 pp	Various reports and related studies
3.8 Electricity in transport scale-up	Decadal percentage point increase in the share of electricity in the final energy demand of the transport sector	10 pp	15 pp	Various reports and related studies
Socio-cultural constraints *Indicators assessing shifts in demand associated with attitudinal and behavioral changes (SM section 5)*				
Energy sector				
4.1 Total energy demand decline	Decadal percentage decrease in energy demand	10%	20%	Grubler *et al* (2018)
4.2 Energy demand decline in transport sector	Decadal percentage decrease in energy demand	10%	20%	Grubler *et al* (2018)
4.3 Energy demand decline in industry sector	Decadal percentage decrease in energy demand	10%	20%	Grubler *et al* (2018)
4.4 Energy demand decline in residential sector	Decadal percentage decrease in energy demand	10%	20%	Grubler *et al* (2018)
Land sector				
4.5 Decline of livestock share in food demand	Decadal percentage decrease in the livestock share in total food demand	0.5 pp	1 pp	Various reports
4.6 Forest cover increase	Decadal percentage increase in forest cover	2%	5%	Own analyses based on FAO data
4.7 Pasture cover decrease	Decadal percentage decrease in pasture cover	5%	10%	Own analyses based on FAO data
Institutional constraints *Indicator measuring the institutional capacity to decarbonize (SM section 6)*				
5.1 Governance level and decarbonization rate	Governance levels and per capita CO_2 emission reductions over a decade	>0.6 and <20%	<0.6 and >20%	Own analysis using data from Andrijevic *et al* (2019)

Source: IPCC SR1.5; Brutschin et al (2021)

Shifting efforts and transition risks in 1.5°C pathways

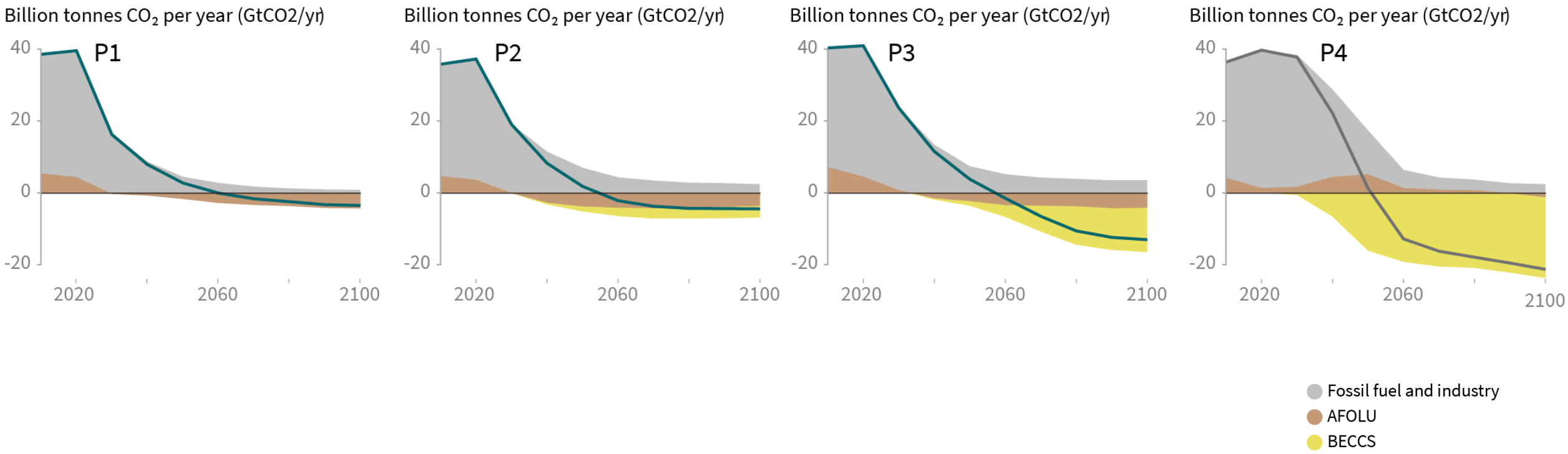




Source: IPCC SR1.5; Huppmann et al (2018); Brutschin et al (2021)

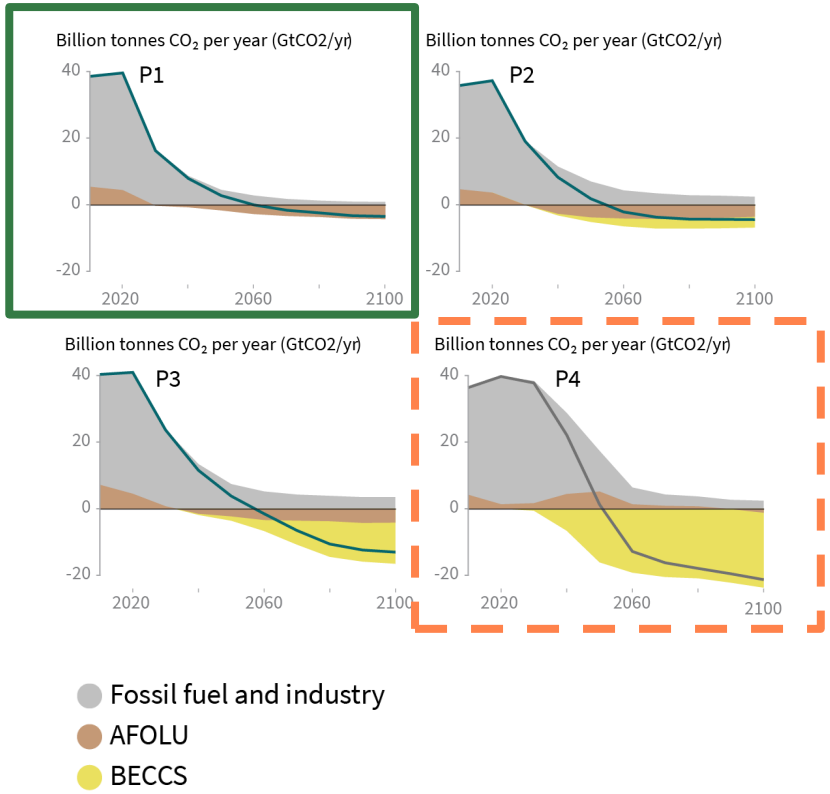
Shifting efforts and transition risks in 1.5°C pathways

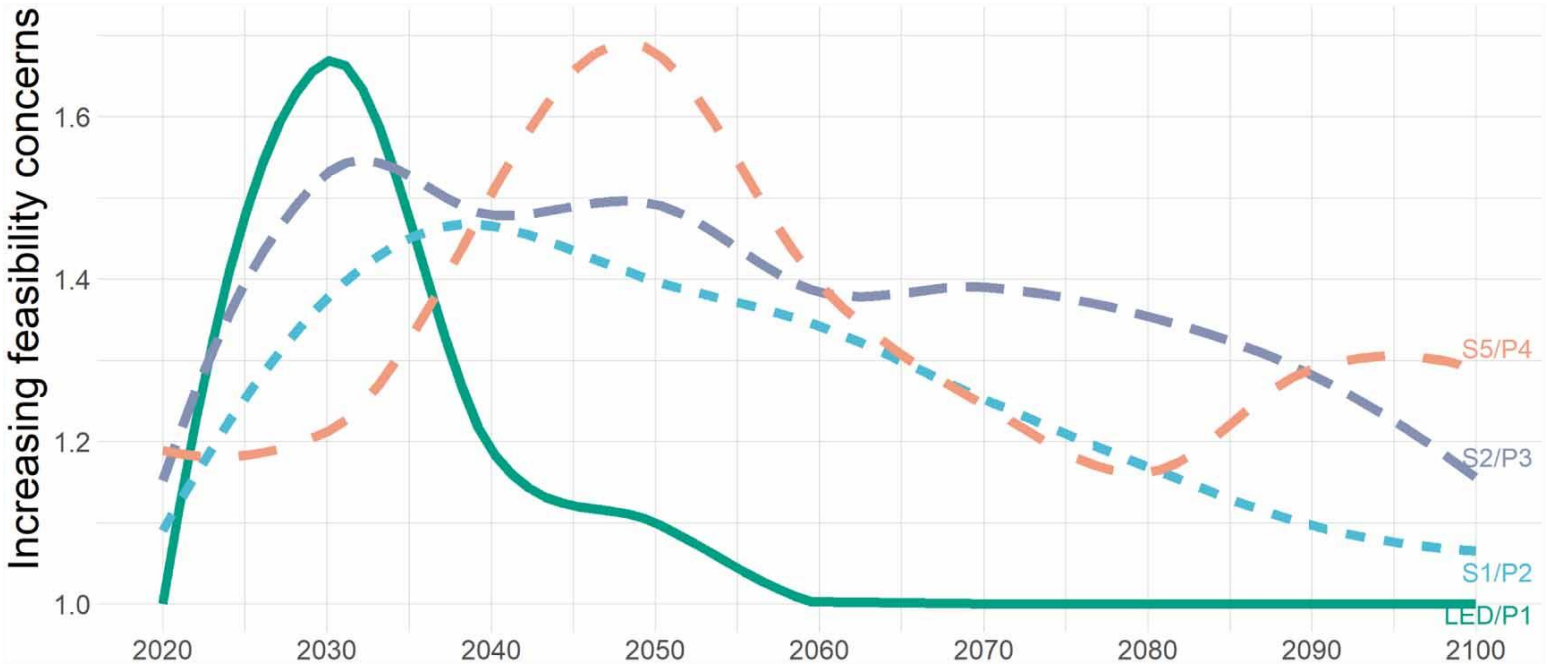
Similar cumulative CO_2 until net zero, but different strategies



Source: IPCC SR1.5

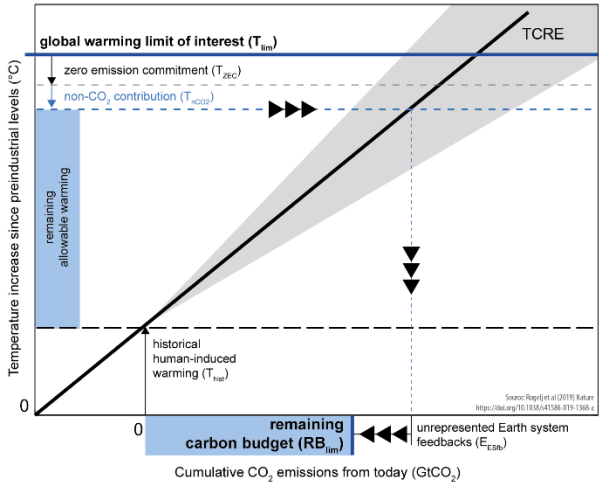
Shifting efforts and transition risks in 1.5°C pathways

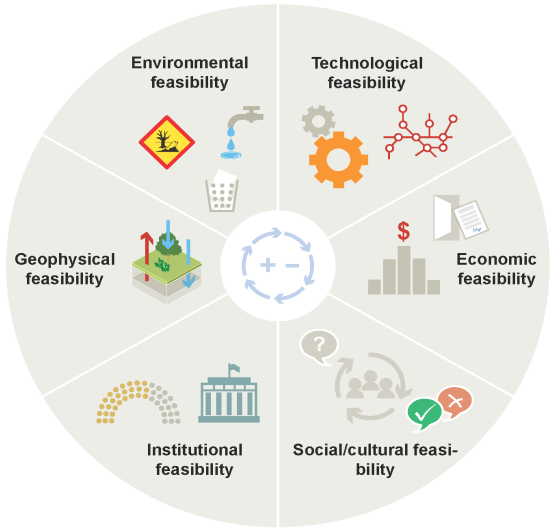




Source: IPCC SR1.5; Huppmann et al (2018); Brutschin et al (2021)

The latest understanding on efforts required to achieve the 1.5C goal





Thank you
Joeri ROGELJ