Politically founded, scientifically grounded

Can New Zealand's action on climate change be improved?

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Global Warming Potentials

2.2.7 A Global Warming Potential Concept for Trace Gases

In considering the policy options for dealing with greenhouse gases, it is necessary to have a simple means of describing the relative abilities of emissions of each greenhouse gas to affect radiative forcing and hence climate A useful approach could be to express any estimates relative to the trace gas of primary concern, namely carbon dioxide It would follow on from the concept of relative Ozone Depletion Potential (ODP) which has become an integral part of the Montreal Protocol and other national and international agreements for controlling emissions of halocarbons (e g UNEP 1989) The long lifetime of some greenhouse gases implies some commitment to possible climate impacts for decades or centuries to come, and hence the inclusion of potential in the formulation of the concept

Estimates of the relative greenhouse forcing based on atmospheric concentrations have been detailed in Section 2 2 3 these are relatively straightforward to evaluate Relative forcings based on emissions are of much greater intrinsic interest to policy makers but require a careful consideration of the radiative properties of the gases their lifetimes and their indirect effects on greenhouse gases Wuebbles (1989) has reviewed various approaches to the design of relative forcings based on emissions using past and current trends in global emissions and concentrations

It must be stressed that there is no universally accepted methodology for combining all the relevant factors into a single global warming potential for greenhouse gas emissions In fact there may be no single approach which will represent all the needs of policy makers A simple approach has been adopted here to illustrate the difficulties inherent in the concept, to illustrate the importance of some of the current gaps in understanding and to demonstrate the current range of uncertainties However, because of the importance of greenhouse warming potentials, a preliminary evaluation is made

The Global Warming Potential (GWP) of the emissions of a greenhouse gas, as employed in this report, is the time integrated commitment to climate forcing from the instantaneous release of 1 kg of a trace gas expressed relative to that from 1 kg of carbon dioxide

$$GWP = \frac{\int_0^n a_i c_i \, dt}{\int_0^n a_{CO_2} c_{CO_2} \, dt}$$

where a_i is the instantaneous radiative forcing due to a unit increase in the concentration of trace gas, i, c_i is concentration of the trace gas i remaining at time t after its release and
calculation is p
carbon dioxide a
Fisher et al (
a global warmin
CFC-11 In the
integration time
Early attempt
potentials (Lashof and Ahuja 1990, Rodhe, 1990, Derwent 1990) are based on the instantaneous emissions into the atmosphere of
trace gas concen
is present in th
warming If its
processes ther
generate an ad
emission scen
number of in
over an extended time period and some emission abatement scenarios can be evaluated using this concept

Particular problems associated with evaluating the GWP are

- the estimation of atmospheric lifetimes of gases (and in particular CO_2), and the variation of that lifetime in the future,
- the dependence of the radiative forcing of a gas on its concentration and the concentration of other gases with spectrally overlapping absorption bands
- the calculation of the indirect effects of the emitted gases and the subsequent radiative effects of these indirect greenhouse gases (ozone poses a particular problem),
- the specification of the most appropriate time period over which to perform the integration

The full resolution of the above problems must await further research The assumptions made in the present assessment are described below

For some environmental impacts, it is important to evaluate the cumulative greenhouse warming over an extended period after the instantaneous release of the trace gas For the evaluation of sea-level rise, the commitment to greenhouse warming over a 100 year or longer time horizon may be appropriate For the evaluation of short term effects, a time horizon of a few decades could be taken, for example, model studies show that continental areas are able to respond rapidly to radiative forcing (see e g , Section 6) so that the relative effects of emissions on such timescales are relevant to predictions of near-term climate change This consideration alone dramatically changes the emphasis between the different greenhouse

greenhouse gases, it is necessary to have a simple means of describing the relative abilities of emissions of each greenhouse gas to affect radiative forcing and hence climate A useful approach could be to express any

1989) The long lifetime of some greenhouse gases implies some commitment to possible climate impacts for decades or centuries to come, and hence the inclusion of potential in the formulation of the concept

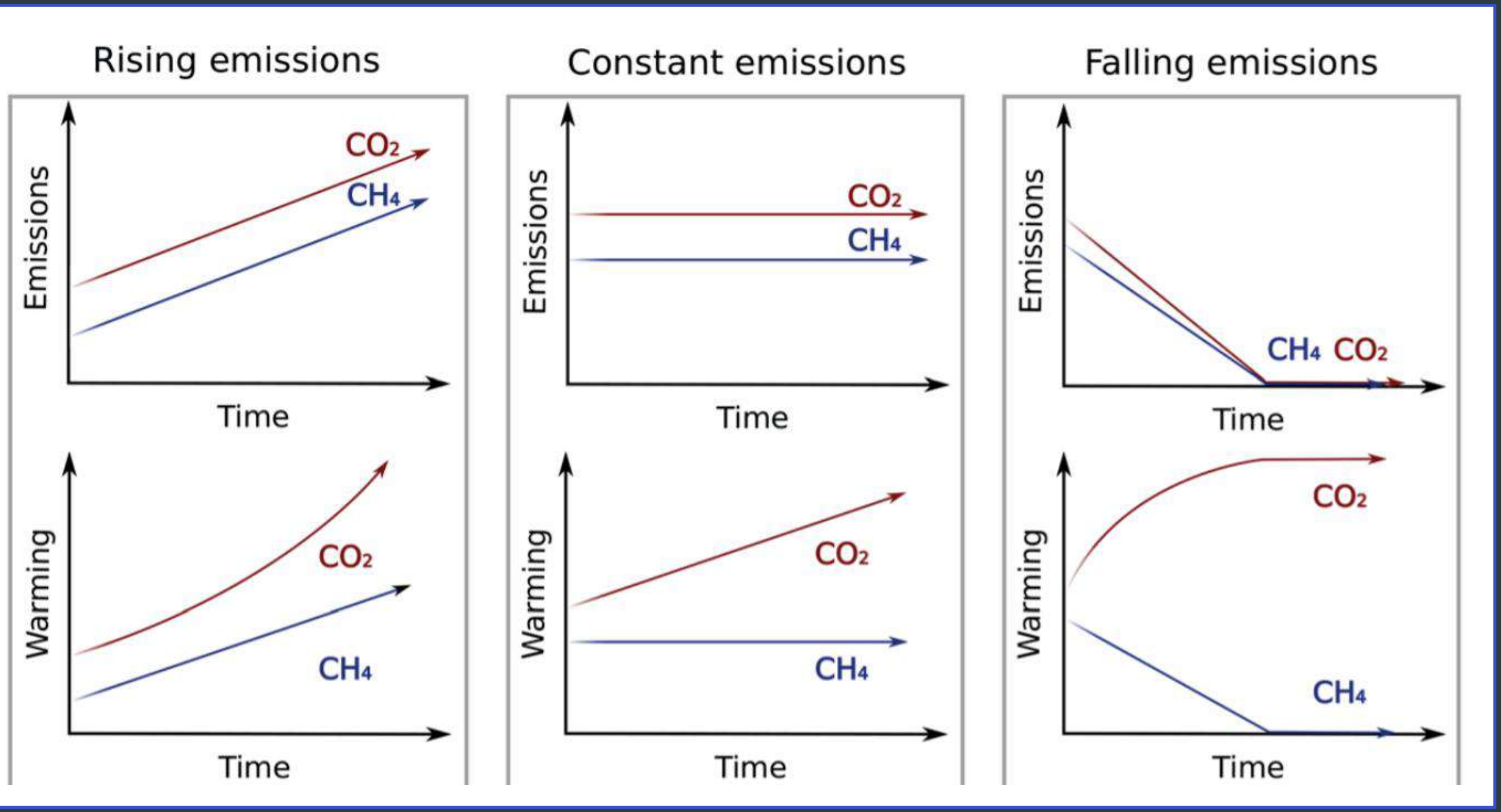
GWP: The amount of warming a gas will cause compared to the same amount of CO_2 over a particular period of time – can be used to calculated CO_2-e values

Chemical	Global Warming Potential (GWP)		Perturbation Lifetime
	GWP_{20}	GWP_{100}	
Methane (CH_4)	84	28	12.4 years
Carbon Dioxide (CO_2)	1	1	Up to thousands of years
Nitrous Oxide (N_2O)	264	265	121 years
Chlorofluorocarbon-13 (CFC-13)	10,900	13,900	640 years

GWP Values from the IPCC AR5 Report, adapted from Table 8.A.1 (Myhre et al., 2013, p731).

Issues with GWP

- Inconsistent reporting (changing values and separation of methane into biogenic and fossil)
- CO_2-e values misrepresent the temperature impact of short-lived gases



How global mean temperatures respond to different emissions trends in carbon dioxide (CO_2) and methane (CH_4) (Allen et al., 2017)

Issues with GWP

- Inconsistent reporting (changing values)
- CO_2-e values misrepresent the temperature impact of short-lived gases
  - In reality, GWP_{100} only represents a 20-30 year time horizon for methane
  - By the end of the 100-year period, warming from CO_2 would be just as potent whereas that of methane would be much less (PCE report - residual warming)
  - Implications for predicting future temperature responses based on emission scenarios, especially important for NZ given the large proportion of methane in our emissions profile (around one third) – implications for agriculture?

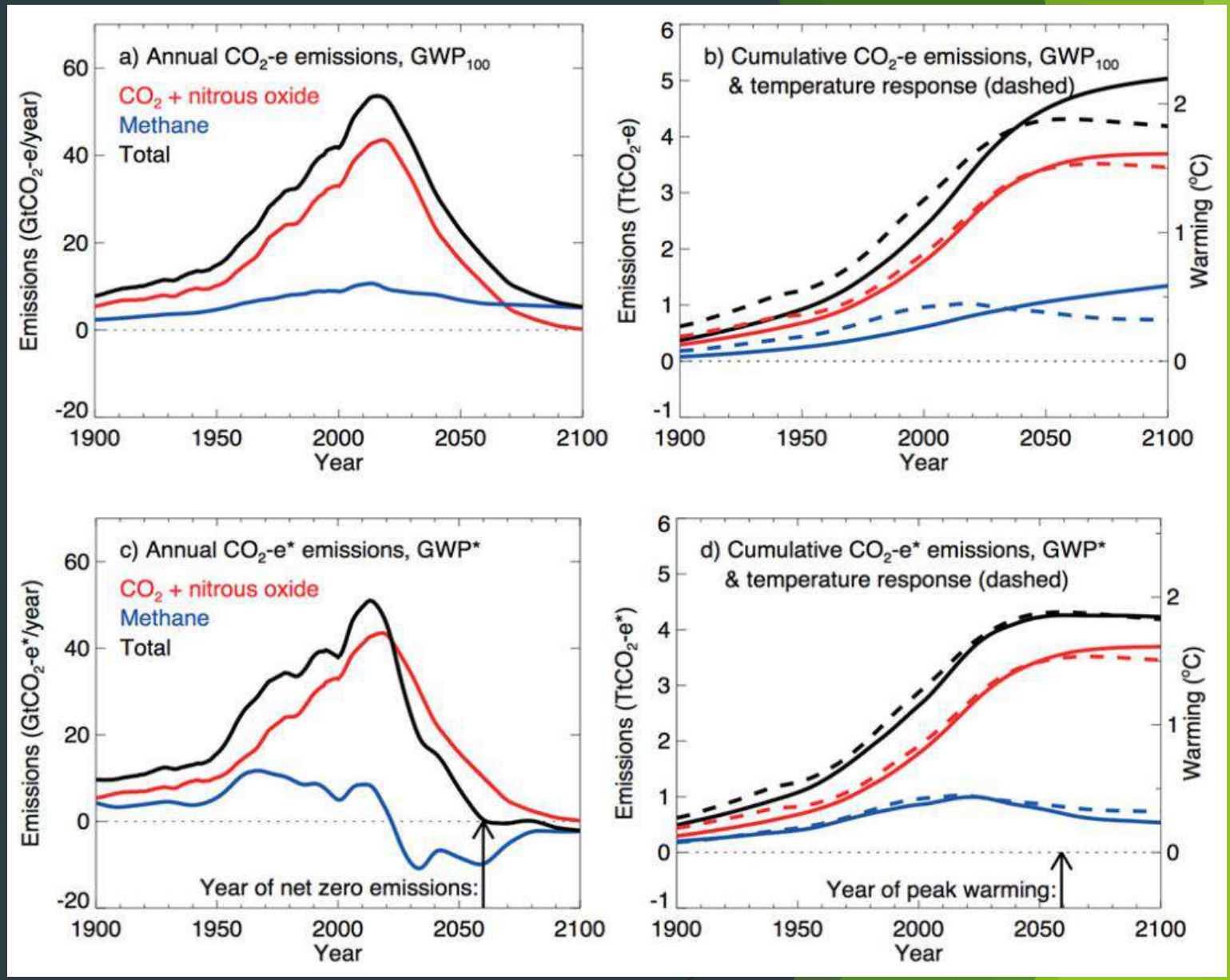
What ever will we do?

A solution to the misrepresentations of CO_2-equivalent emissions of short-lived climate pollutants under ambitious mitigation

Myles R. Allen ✉, Keith P. Shine, Jan S. Fuglestvedt, Richard J. Millar, Michelle Cain, David J. Frame & Adrian H. Macey

GWP*

- Equates a one-off emission of CO_2 with a permanent increase in the emission rate of methane, both of which cause a permanent increase in concentration and hence temperature
- CO_2-e* values lower than CO_2-e values
- More representative of warming, therefore a more realistic approach to meeting Paris Agreement goals

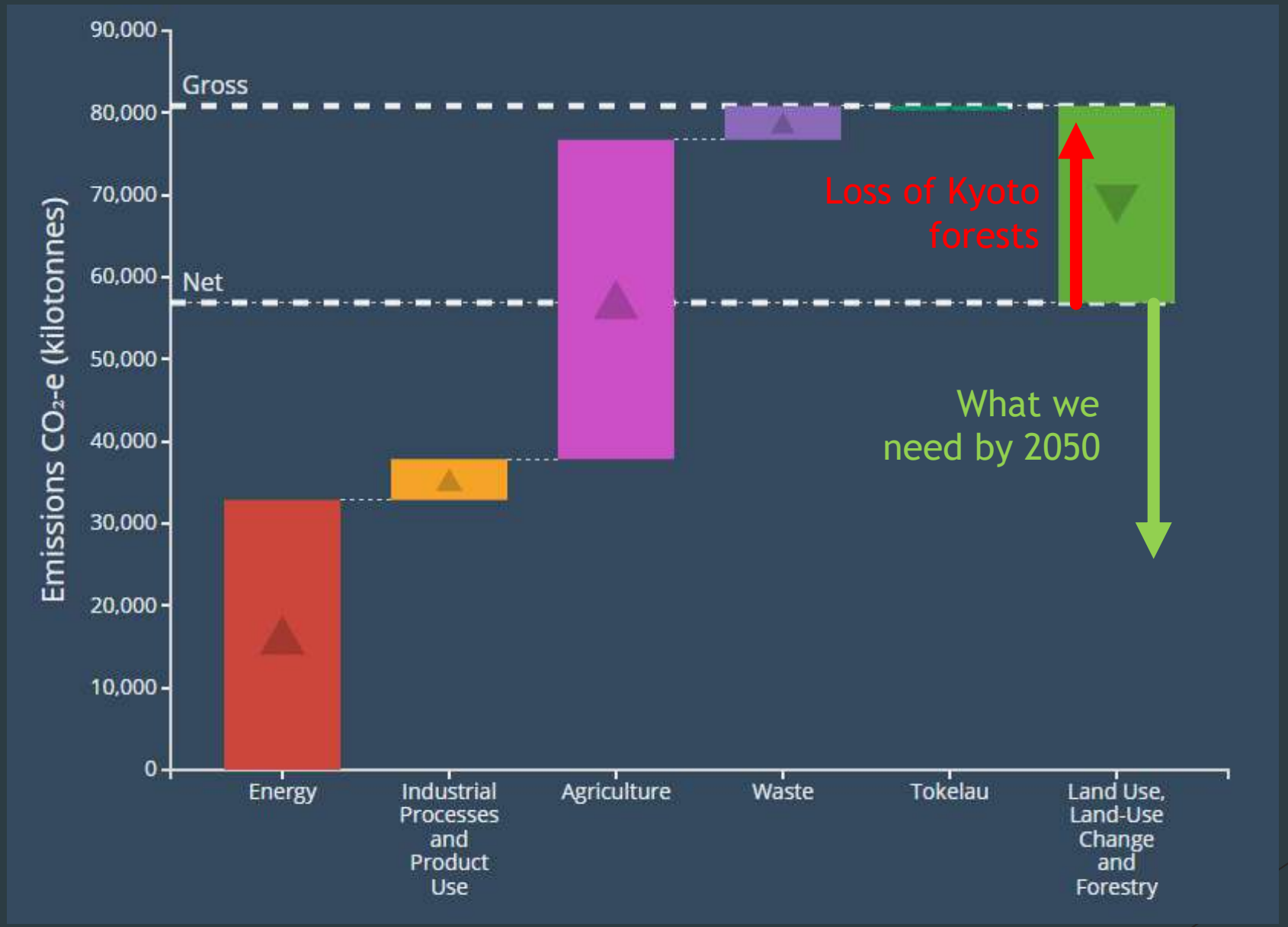


Emissions of long-lived CO_2 and nitrous oxide (red), short-lived methane (blue) and their sum (black) for the main ambitious mitigation scenario in the IPCC SR15 report (Allen et al., 2017)

Future?

- GWP* has been acknowledged nationally and in the IPCC SR15 report (p66)
- Two-baskets approach of the Zero Carbon Act reflects the need to treat short-lived and long-lived gases separately
- Findings of NZAGRC in PCE report says methane emissions must fall by 10-22% to prevent any future warming – contradicts notion that constant emissions result in constant temperature
- Will this be achieved at the expense of agriculture? In the absence of proven technology, this must be mainly achieved by reducing livestock numbers
- Should efforts be more focused on CO_2?

Native vs Exotic Forests


90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Gross
Net
Emissions CO_2-e (kilotonnes)
Loss of Kyoto forests
What we need by 2050
Energy
Industrial Processes and Product Use
Agriculture
Waste
Tokelau
Land Use, Land-Use Change and Forestry

Te Uru Rākau
Forestry New Zealand

The One Billion Trees Programme

Our future, our billion trees

Number of natives under one billion trees anyone's guess

How many of the one billion trees planted in the next decade will be native species? Government tree planting agency Te Uru Rakau has clarified that it can't hazard an estimate.

Benefits

Natives

- Biodiversity
- Cultural value
- Soil and water conservation
- More fire-resistant
- Permanent status ensures slope stability

Pines

- Higher rate of carbon sequestration
- Not all carbon returned to atmosphere when harvested (long-lived wood products)
- Good for making money

Lots of uncertainty

- Native forests may be sequestering up to 60% more carbon than previously thought (mostly in Fiordland) – not counted as a permanent sink under the ETS
- In the time frame between now and 2050, pines sequester more – should we be thinking longer term?
- Use of pines as nursery – would have to be permanent (similar thing has been done with gorse)
- Growing rates and therefore sequestering ability highly variable throughout the country
- **We need more information**

Some bedtime reading

GWP Stuff:

- IPCC (1990) First Assessment Report - https://bit.ly/342rBXl
- IPCC (2013) Fifth Assessment Report: The Physical Science Basis - https://bit.ly/2CZZpIE
- Michelle Cain Summary (easy read and contains links to work of Allen *et al.*) - https://bit.ly/2KBkaP6
- Muñoz and Schmidt (2016) *Methane oxidation, biogenic carbon, and the IPCC's emission metrics. Proposal for a consistent greenhouse-gas accounting* - https://bit.ly/2Ot2fv6
- PCE Report - https://bit.ly/2CXtKrp

Forest Stuff:

- Steinkamp *et al.* (2017) *Atmospheric CO2 observations and models suggest strong carbon uptake by forests in New Zealand* - https://bit.ly/37ekywu (NIWA Summary - https://bit.ly/2OxguPh)
- Summary of different debates concerning pine forestry - https://bit.ly/35fsnAj