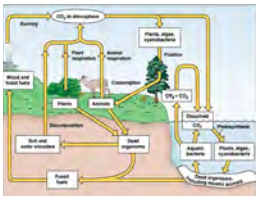
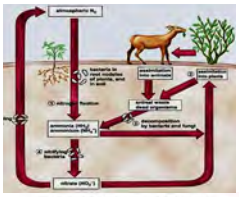
How Humans Caused Climate Change By Altering the Carbon (& Nitrogen) Cycles





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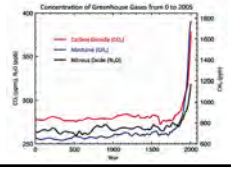
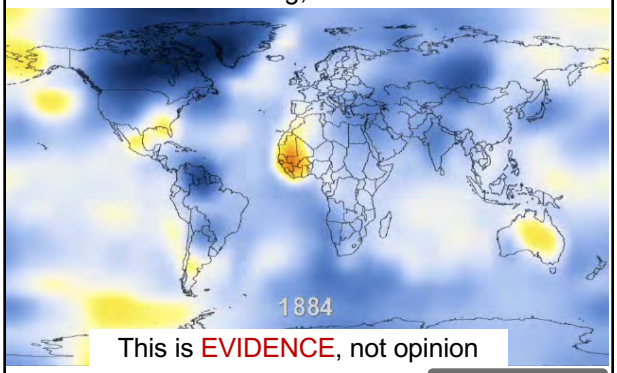


1

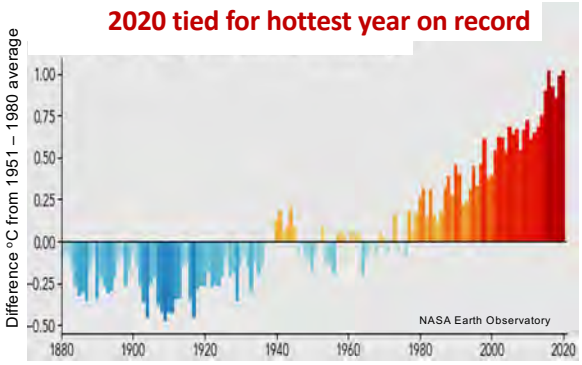
Global Warming, 1884 – 2011



This is EVIDENCE, not opinion

2

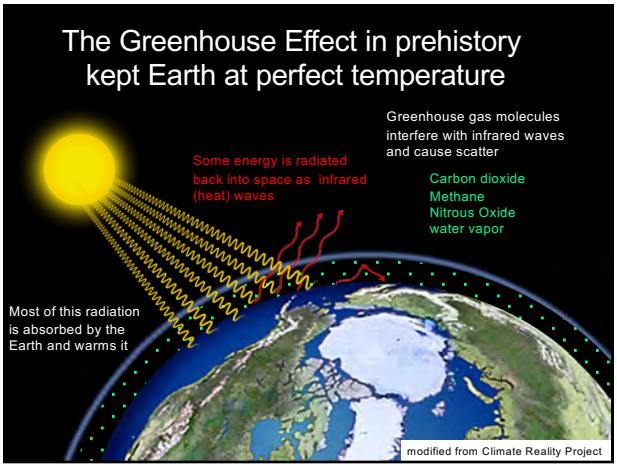
2020 tied for hottest year on record



Each decade hotter than the last … **WHY?**

3

The Greenhouse Effect in prehistory kept Earth at perfect temperature

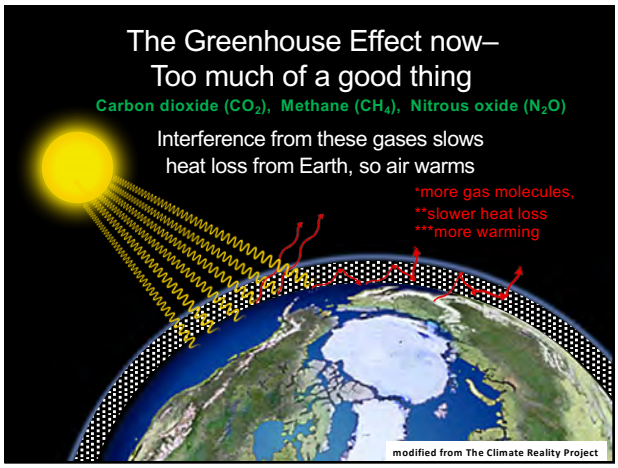


4

The Greenhouse Effect now– Too much of a good thing

Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O)

Interference from these gases slows heat loss from Earth, so air warms



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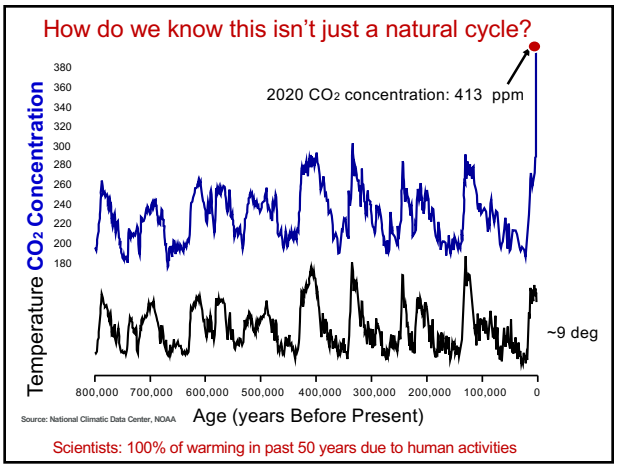
How do we know this isn't just a natural cycle?



Scientists: 100% of warming in past 50 years due to human activities

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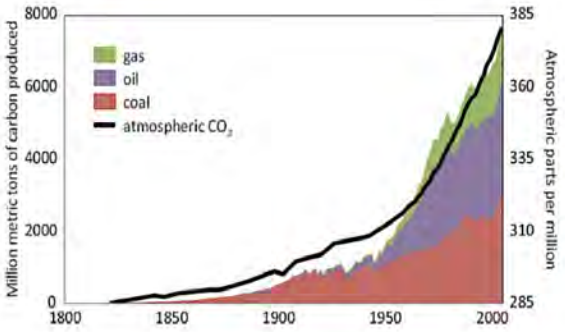
How do we know humans are responsible?

Increasing atmospheric CO_2 closely tracks known carbon emissions from fossil fuels.



data from Carbon Dioxide Information Analysis Center, DOE

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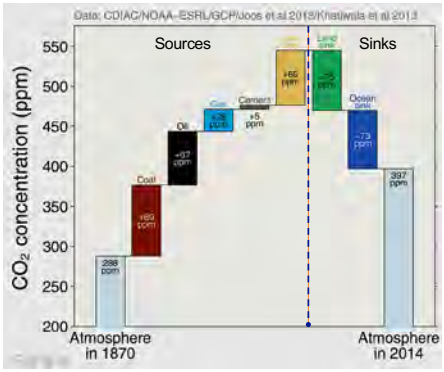
Where is the extra CO_2 going?



SOURCE: Le Quéré et al., 2016, Fig. 1.1 in NAS. 2019. NET & Reliable Sequestration.

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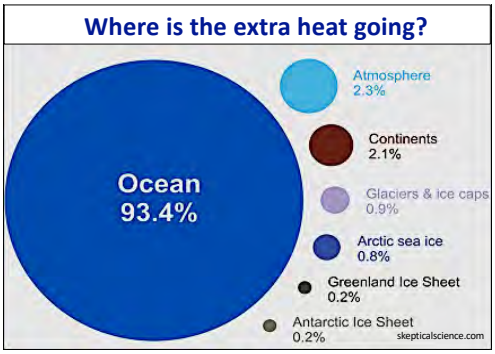
Where is the extra heat going?



Warmer oceans: more evaporation, more humidity higher sea level, changes in currents

With warmer air: changes in winds

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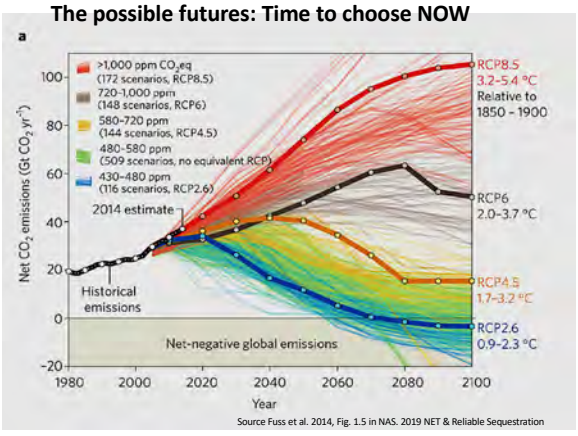
The possible futures: Time to choose NOW



Source Fuss et al. 2014, Fig. 1.5 in NAS. 2019 NET & Reliable Sequestration

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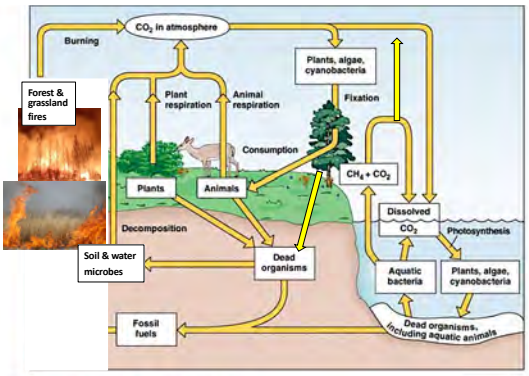
The Prehistoric Carbon Cycle



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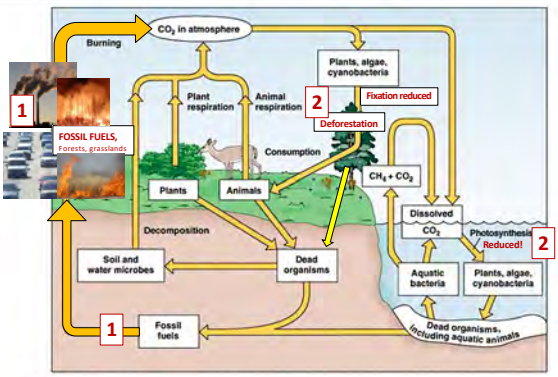
The Carbon Cycle Now



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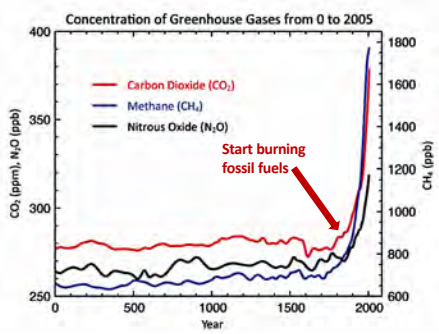
Carbon Dioxide (CO_2)



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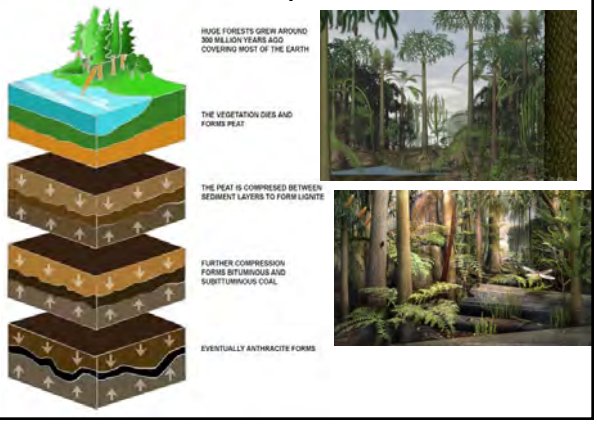
Coal came from fossilized plants



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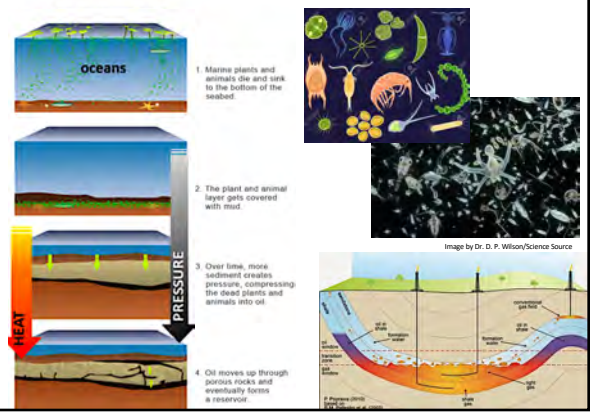
Oil & natural gas came from marine plankton



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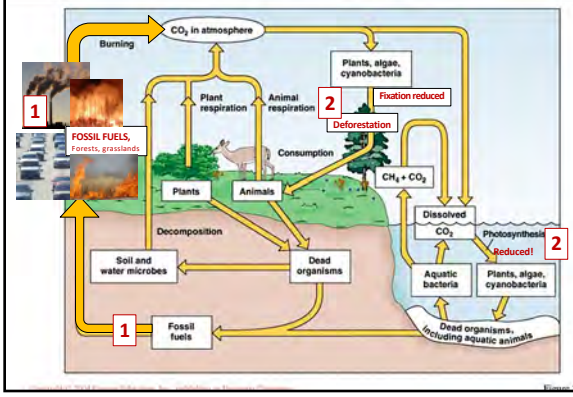
The Carbon Cycle Now



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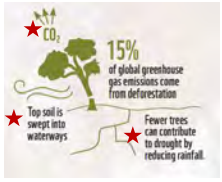
Deforestation: Less CO_2 removed by photosynthesis



1978-now, 1M ac Amazon rainforest lost to logging & burning

- Land mostly used for cattle and soybeans

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Deforestation: Less CO_2 removed through photosynthesis

Indonesia – rainforest & peatland destruction makes Indonesia world's 3rd largest GHG emitter
- pulp for paper
- palm oil plantations

https://qz.com/1711172/the-global-demand-for-palm-oil-is-driving-the-fires-in-indonesia/

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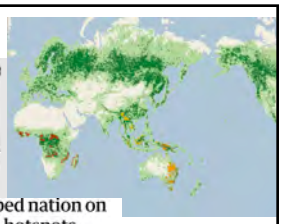
Deforestation:

2 Australia has lost 25% rainforest, 45% of open forest, 32% woodland forest and 30% of mallee forest in 200 years[1]

3 The effect of these changes has been considerable. Around 20% of Australian mammals, 7% of reptiles, 13% of birds are listed as Extinct, Endangered or Vulnerable.

4 More than 100 species have gone extinct in NSW in the last 200 years[2]



WWF

Australia the only developed nation on world list of deforestation hotspots

WWF report finds area six times the size of Tasmania has been cleared globally since 2004

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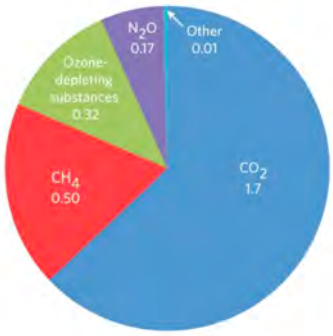
Relative impact of different GHG on climate change, 2008



Ripple, W., Smith, P., Haberl, H. *et al.* Ruminants, climate change and climate policy. *Nature Clim Change* **4,** 2–5 (2014).

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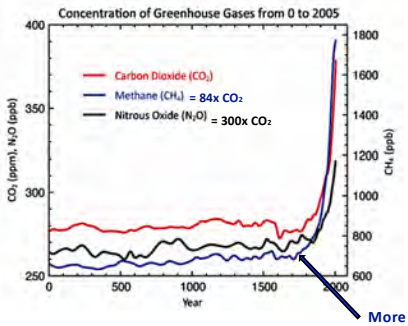
Methane, CH_4



More people: More waste, more domesticated animals

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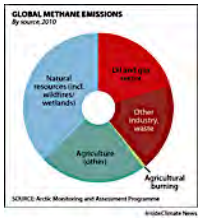
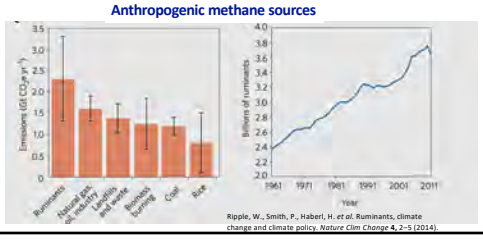
Sources of Methane



Anthropogenic methane sources



Ripple, W., Smith, P., Haberl, H. *et al.* Ruminants, climate change and climate policy. *Nature Clim Change* **4,** 2–5 (2014).

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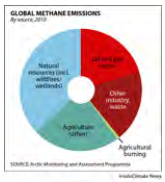
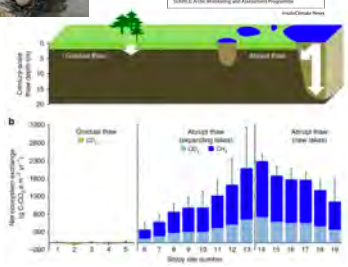
Methane from thawing permafrost



Methane from rapid thaw in Artic lakes:

Bigger mid-century threat than permafrost



Walter et al. 2018.NATURE COMMUNICATIONS | (2018) 9:3262 | DOI: 10.1038/s41467-018-05738-9

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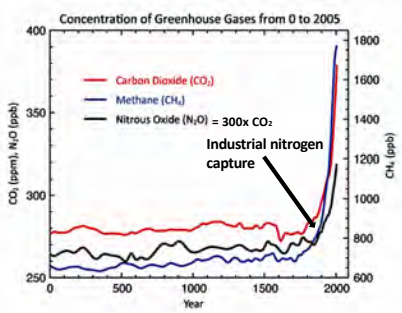
Nitrous Oxide, N_2O



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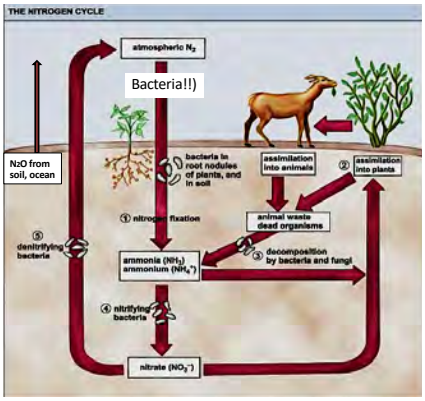
The Prehistoric Nitrogen Cycle



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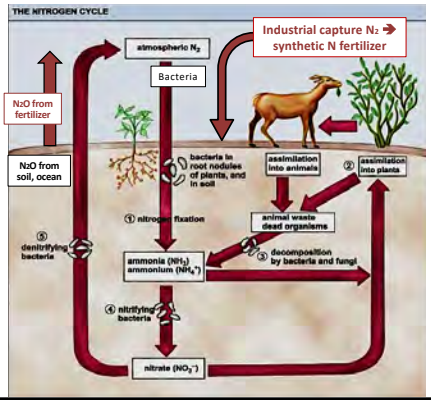
The Nitrogen Cycle Now



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What can we do about it?

Reduce emissions

AND

Increase Carbon Uptake by Plants & Sequester

There are no magic bullets – We need to do everything we can

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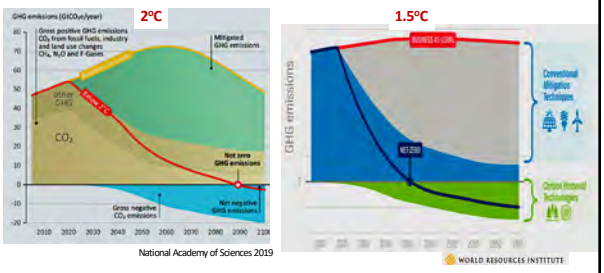
What can we do about it?
The uncertain path to NET-ZERO



National Academy of Sciences 2019

Reduce GHG emissions as much as possible, but some are "too hard" or "too disruptive" to reduce (air travel, dietary change…)

Net zero = when remaining emissions balanced by "negative emissions"

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What can we do about it?
The uncertain path to NET-ZERO

Uncertain path??

- We know what to do, though schemes differ
- BUT many aspects are untested, not to scale and/or require major social adjustment & buy-in

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Different report, different scheme
We know WHAT to do, but how to do it??

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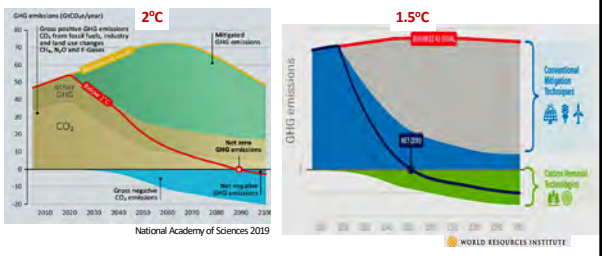
What can we do about it?
The uncertain path to NET-ZERO



What are "negative emissions"?

- direct removal of CO_2 from air, Carbon Capture & Storage (after burning fossil fuel or biomass (BECCS)
- carbon sequestration in soil or forests, adsorption to rock dust (this requires very high level of adoption by farmers & landowners)

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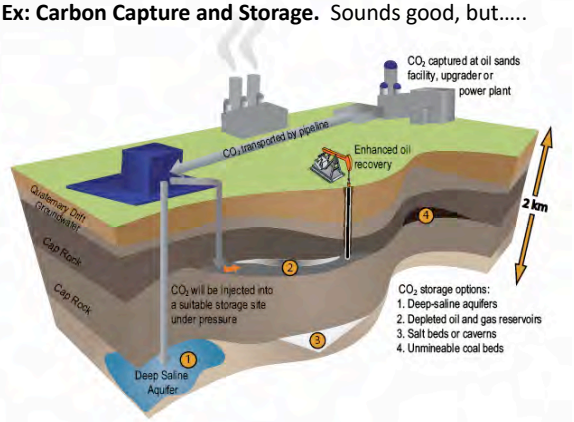
Ex: Carbon Capture and Storage. Sounds good, but…..



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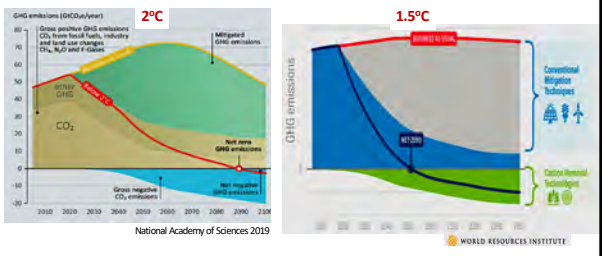
What can we do about it?
The uncertain path to NET ZERO



Uncertain path??

- Solution requires MANY fundamental changes, need to start NOW (or yesterday…)
- Do we have either the social or political will??

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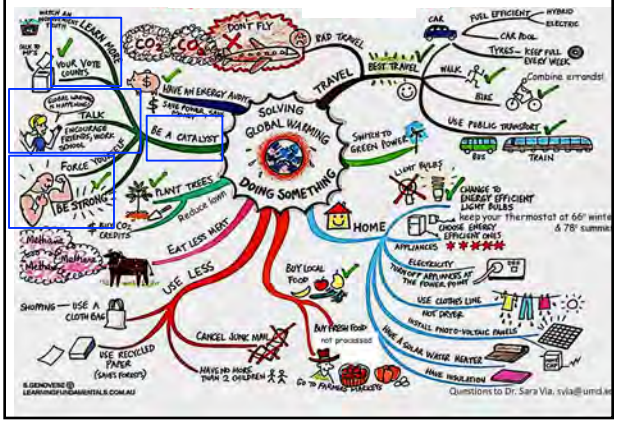
What can we each do??



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