Day 1:

Climate Change and Renewable Energy

S15658: Saving the World with the Science of Sustainability!

Instructor: Simo

Sunday, July 9th, 2022

1:00-2:30 PM

Our goals for today

1. Define light, energy, and the greenhouse effect.

2. Understand what gases are responsible for global warming and how they work.

3. Understand *why* global warming is such a serious problem.

4. Understand how **greenhouse gases** are produced.

5. Learn about how we can avoid producing greenhouse gases and the role thermal science plays in doing so.

LIGHT is an *electromagnetic wave*

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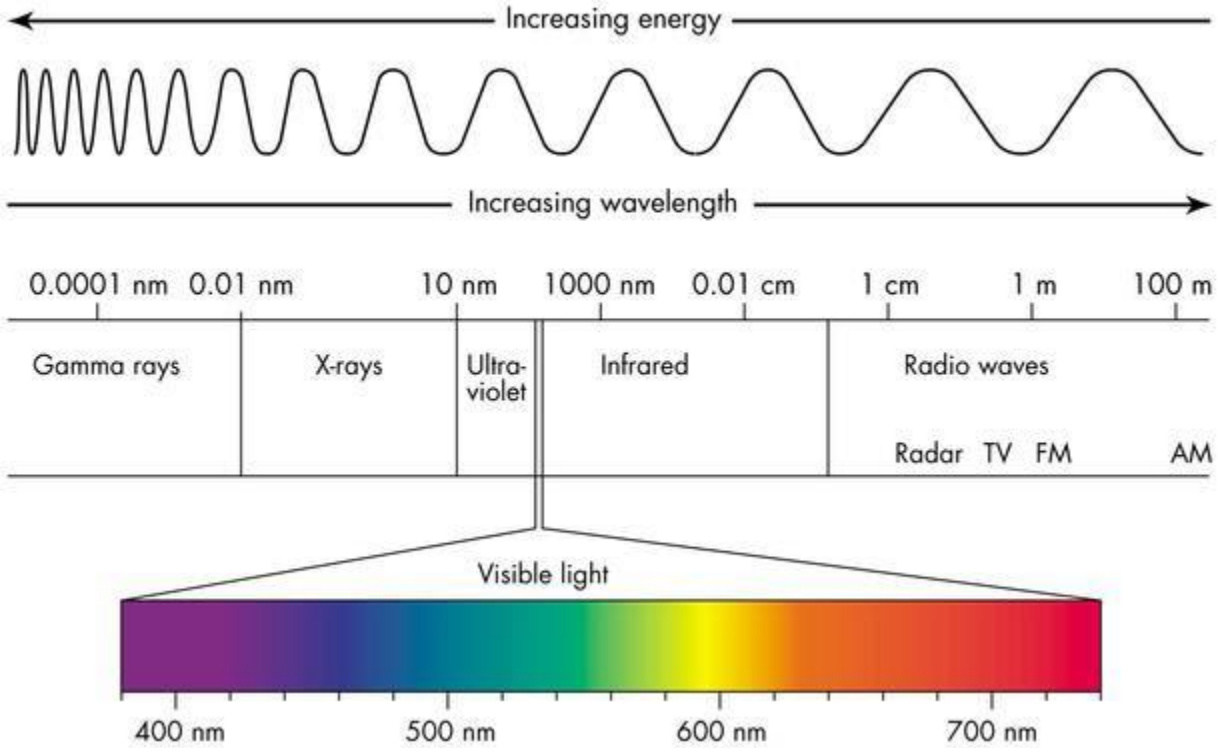
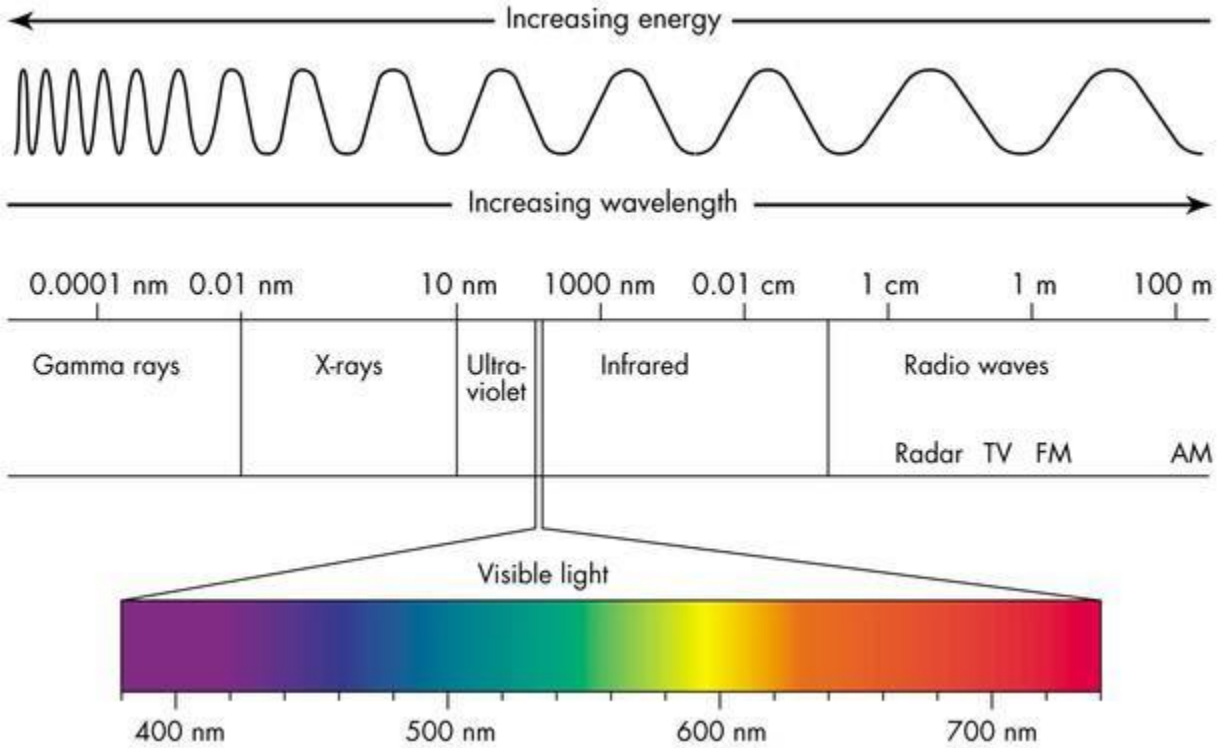
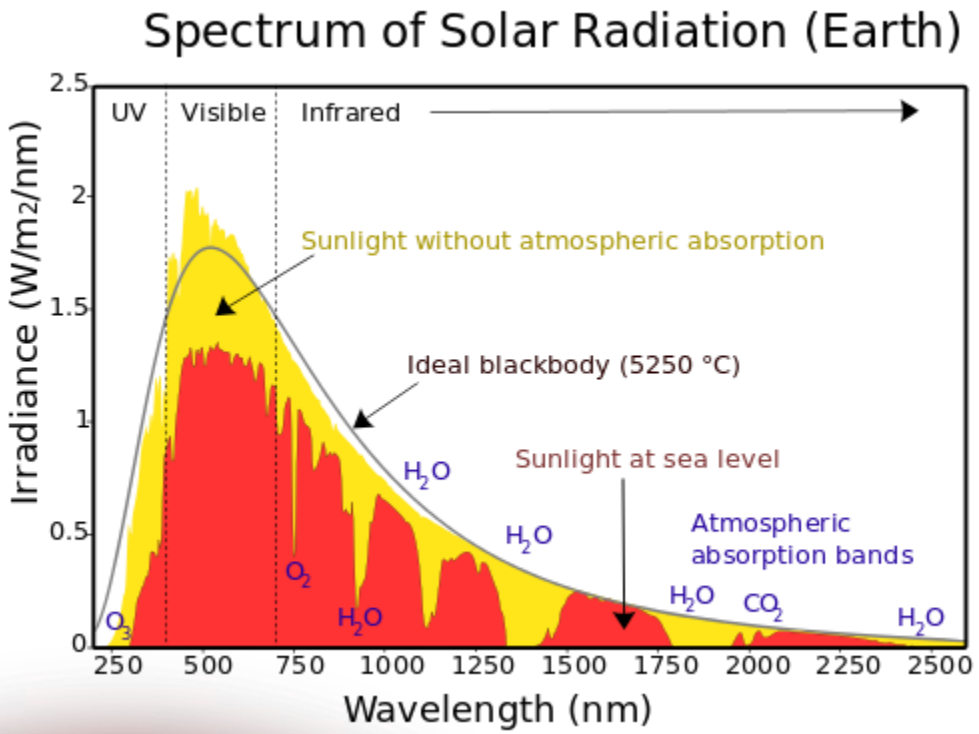


LIGHT is an *electromagnetic wave*

Strictly speaking, light more like a "wavepacket" and has some particle-like characteristics…



The primary source of all light on Earth is the sun



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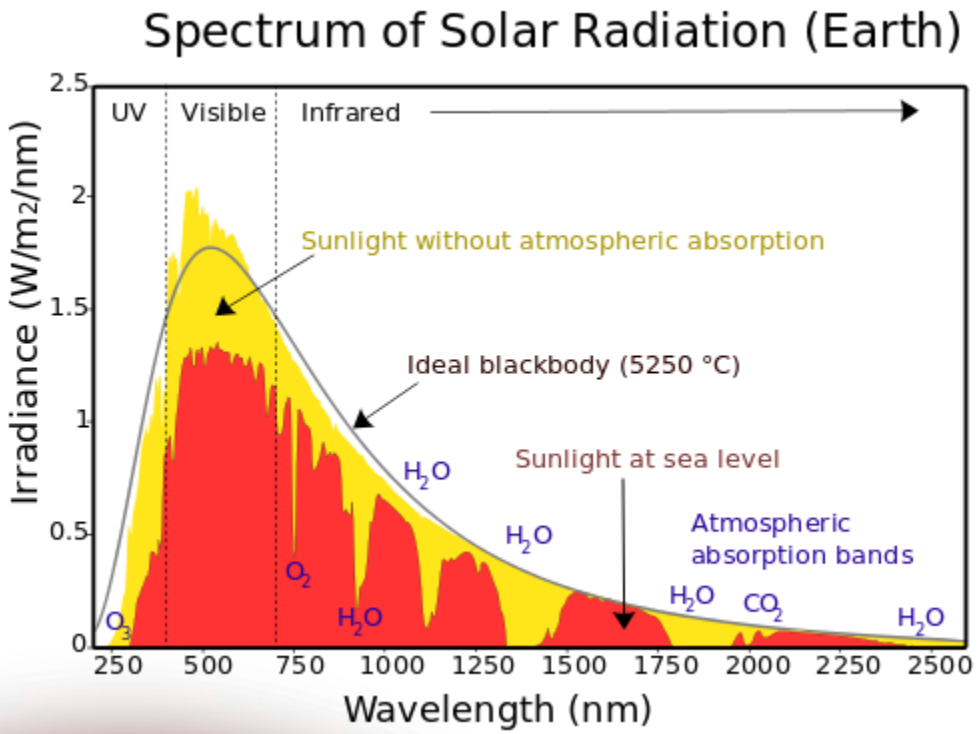
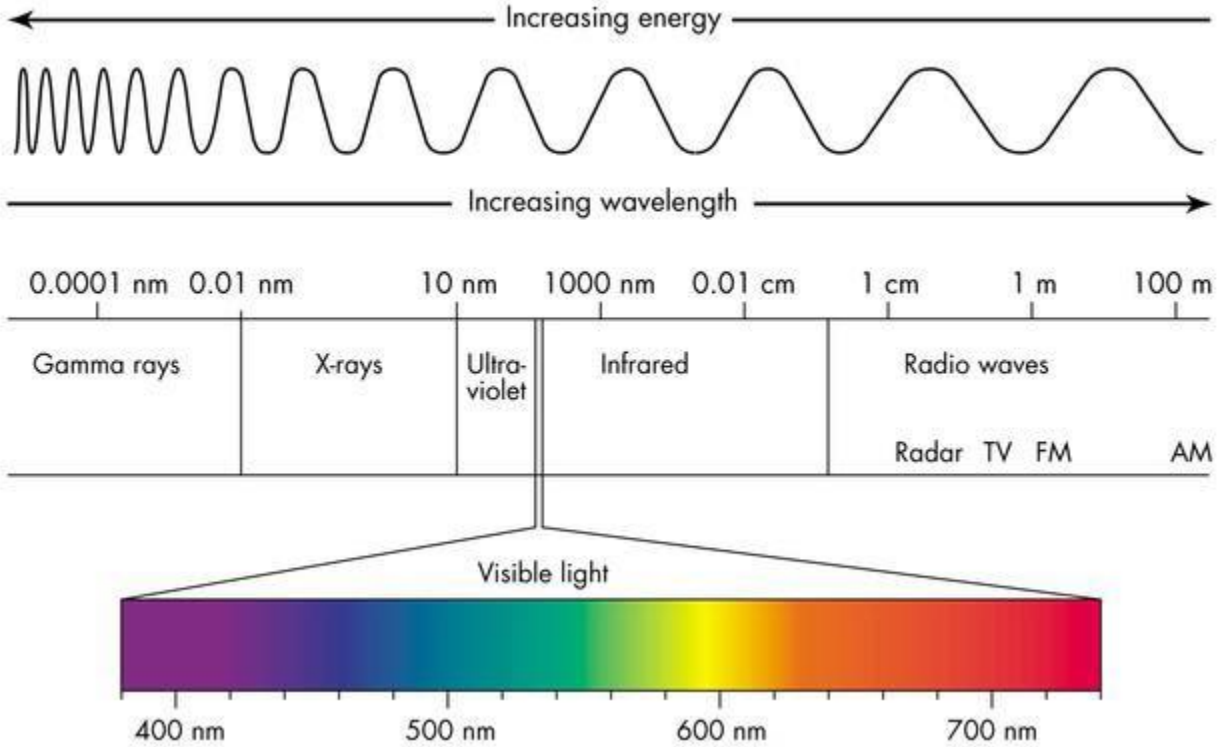


Where is solar radiation in this picture?



“Greenhouse effect”?

Pause for questions!

1. ~~Define light, energy, and the greenhouse effect.~~

Next…

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Let's get gassy—a molecular view on the greenhouse effect

In the case of our planet, it's not plastic trapping heat—it's GAS

Let's get gassy—a molecular view on the greenhouse effect

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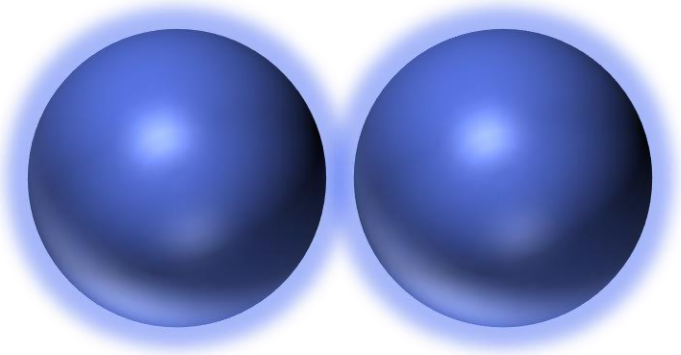
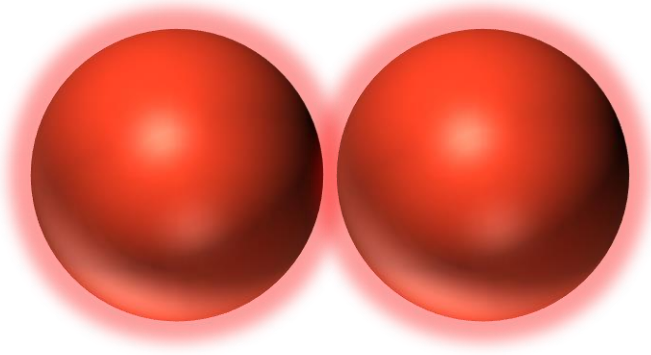
78%



Nitrogen (N_2)

21%



Oxygen (O_2)

The rest of it includes…

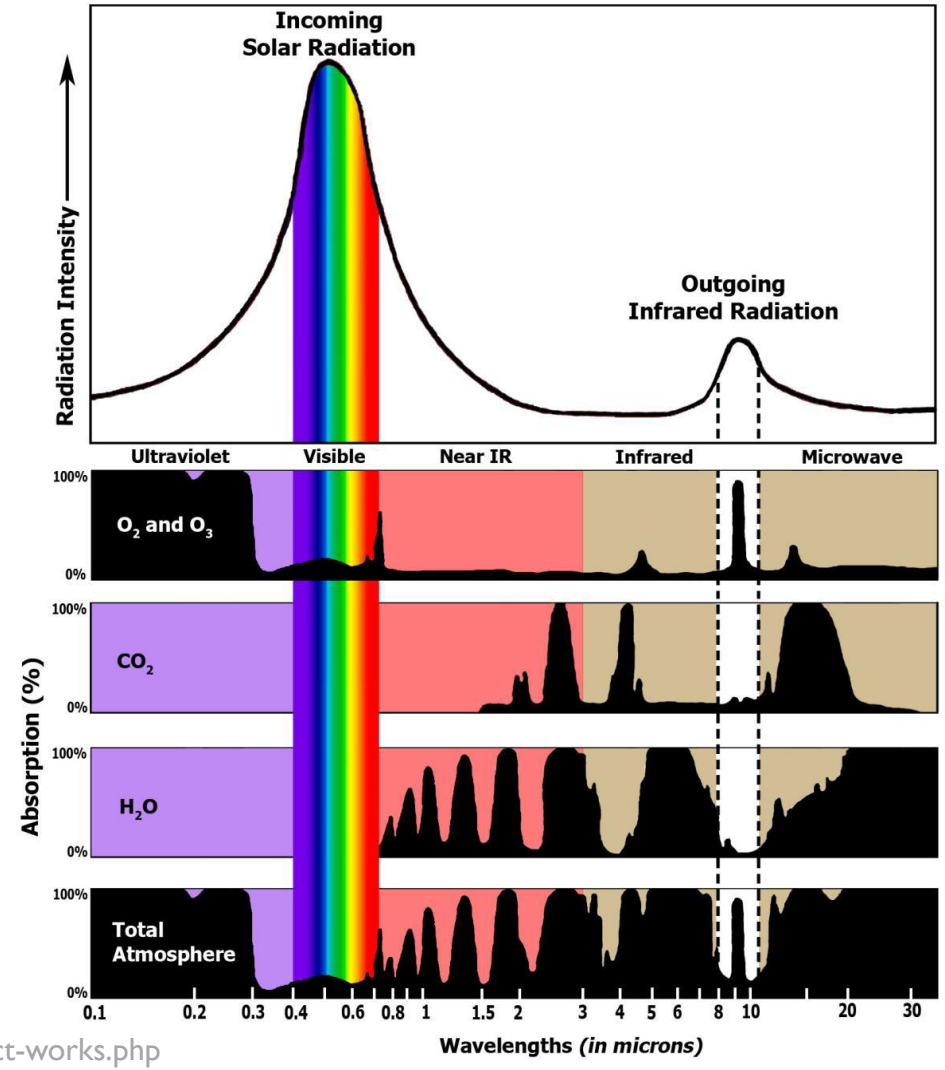
- Water vapor (H_2O)
- Carbon dioxide (CO_2)
- Argon (Ar)
- Neon (Ne)
- Helium (He)
- Methane (CH_4)
- Krypton (Kr)
- Hydrogen (H_2)

Gases in the atmosphere can be transparent or absorbing

Transparent

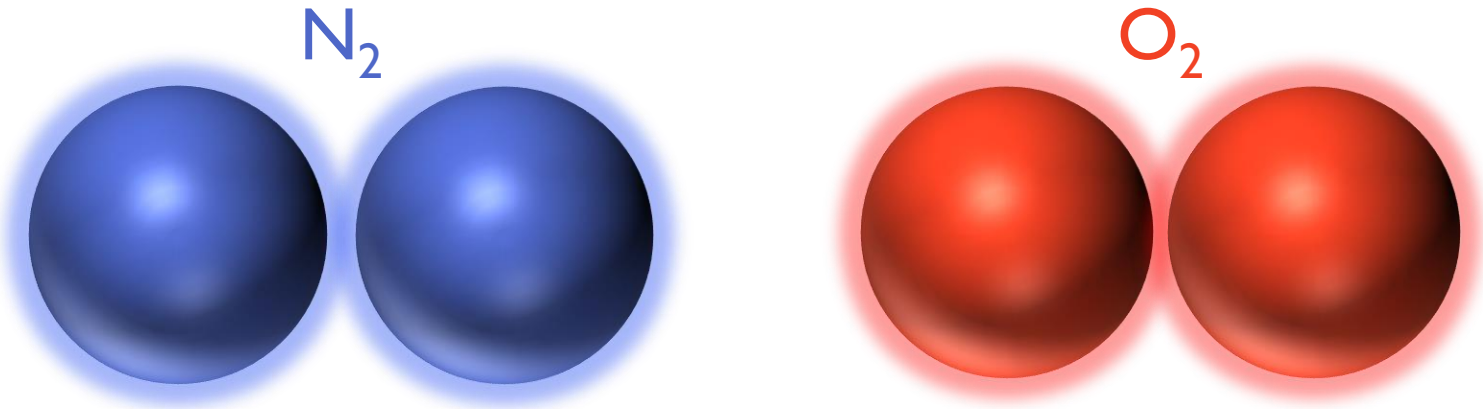
Absorbing

Gases in the atmosphere can be transparent or absorbing *at different wavelengths of light*



http://www.ces.fau.edu/nasa/module-2/how-greenhouse-effect-works.php

Each gas has its own problems



Except for these two—transparent in the visible and infrared!

Using what we know, let's scale up to Earth

Pause for questions!

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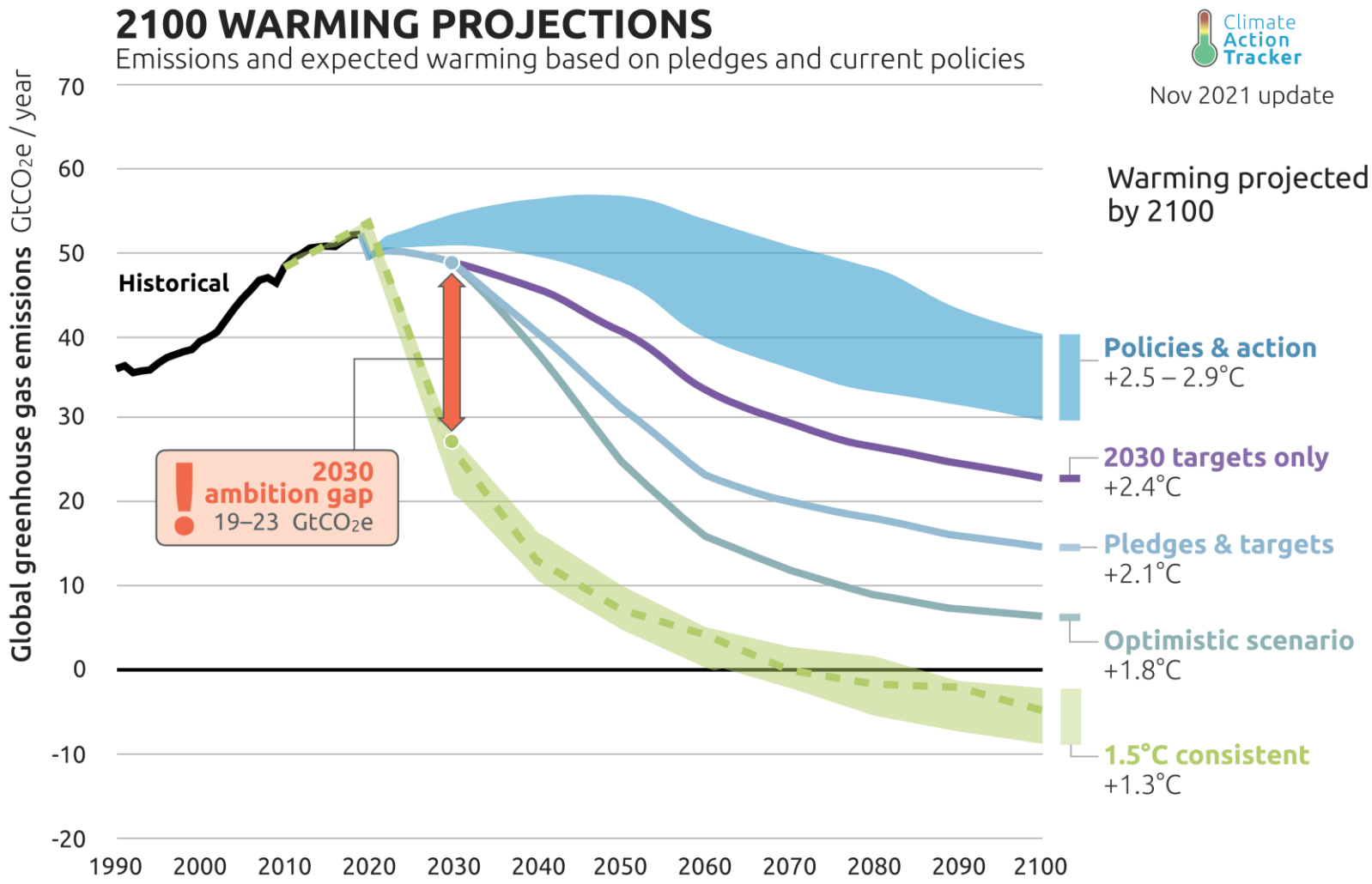
So we've got a bit of a problem…



Okay, uh, quite a few problems…

Rising sea levels

Sea levels projected to rise 1-8 ft by 2100, which could lead to 1 billion climate refugees by 2050

Wildfires

Australia 2020:

- > $100 billion in damages
- 25 people and 0.5 billion animals dead
- 20 million acres burned down

Okay, uh, quite a few problems…

Increased frequency
and intensity of storms

Hurricane Florence (NASA)

Extinction due to
ocean acidification

Bleached coral

Pause for questions and discussion

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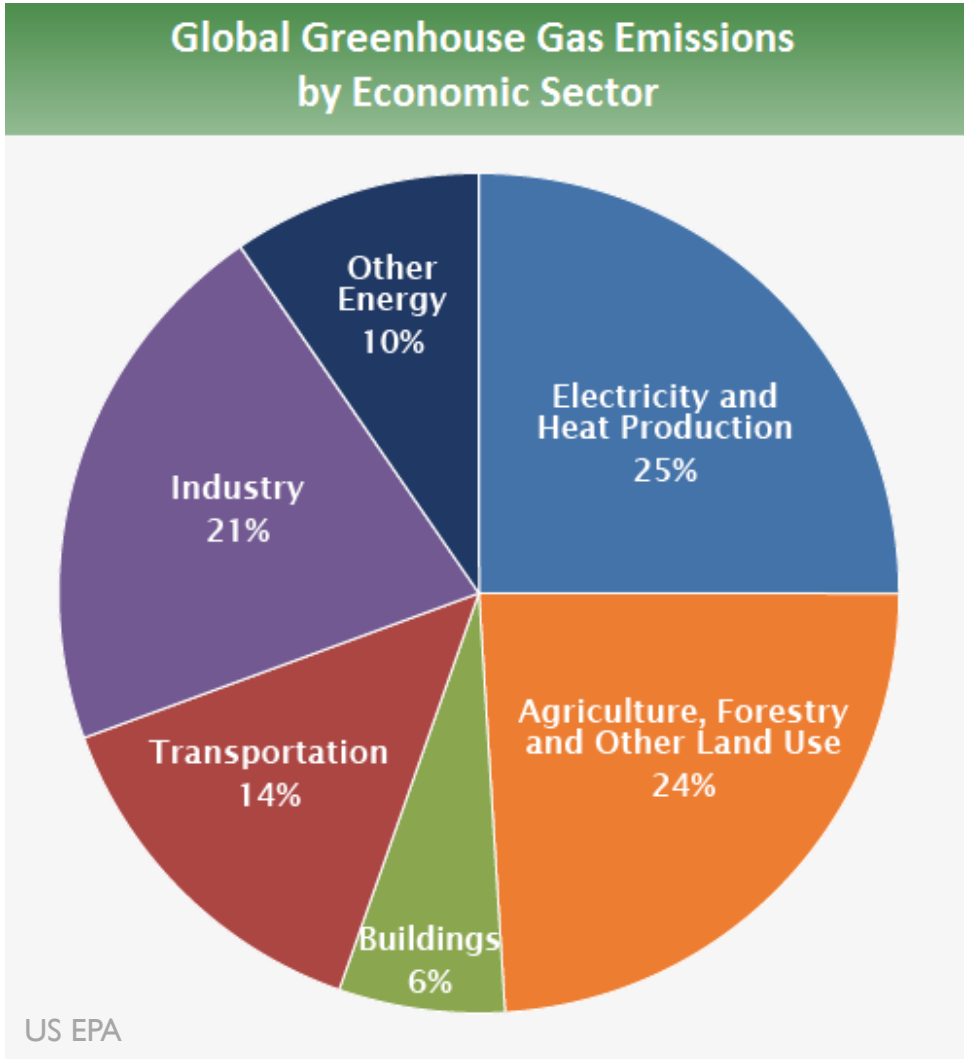
Where are greenhouse gases coming from?



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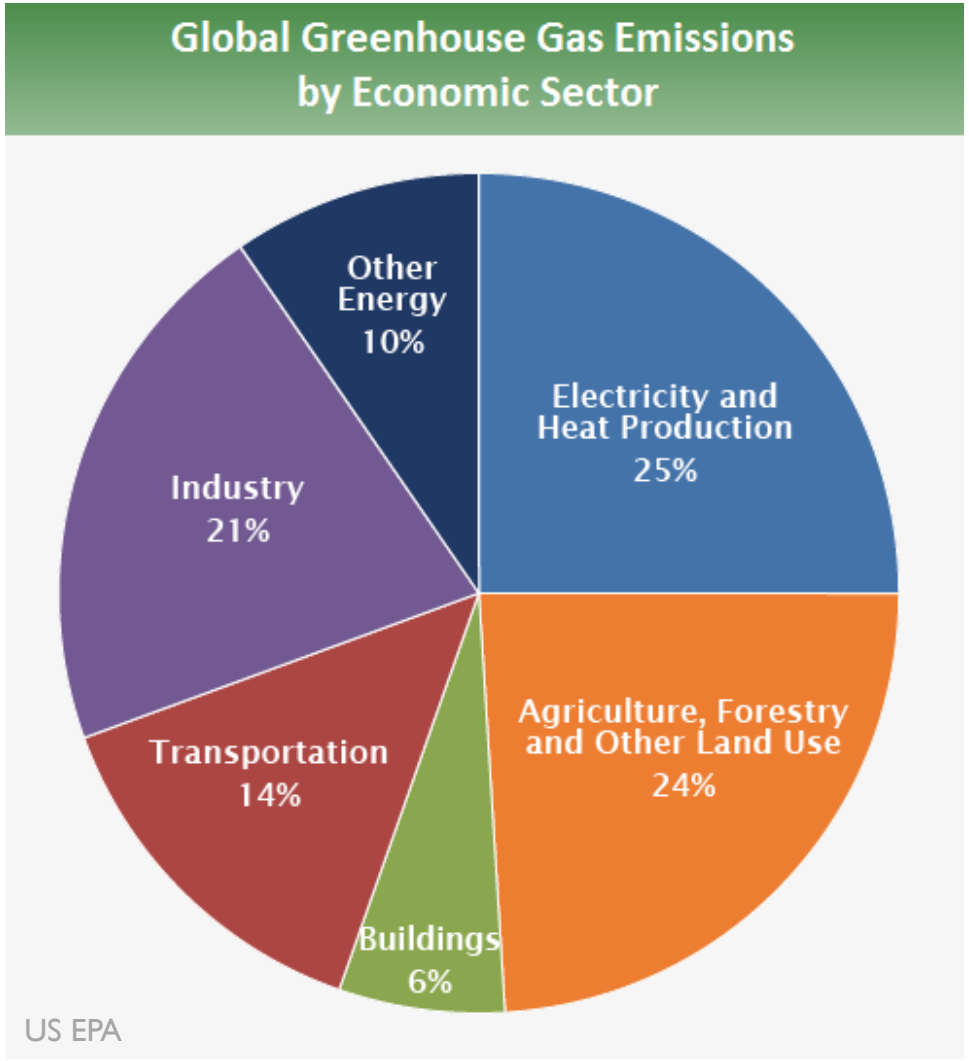

When we combust fossil fuels to extract their energy, GHGs are a byproduct

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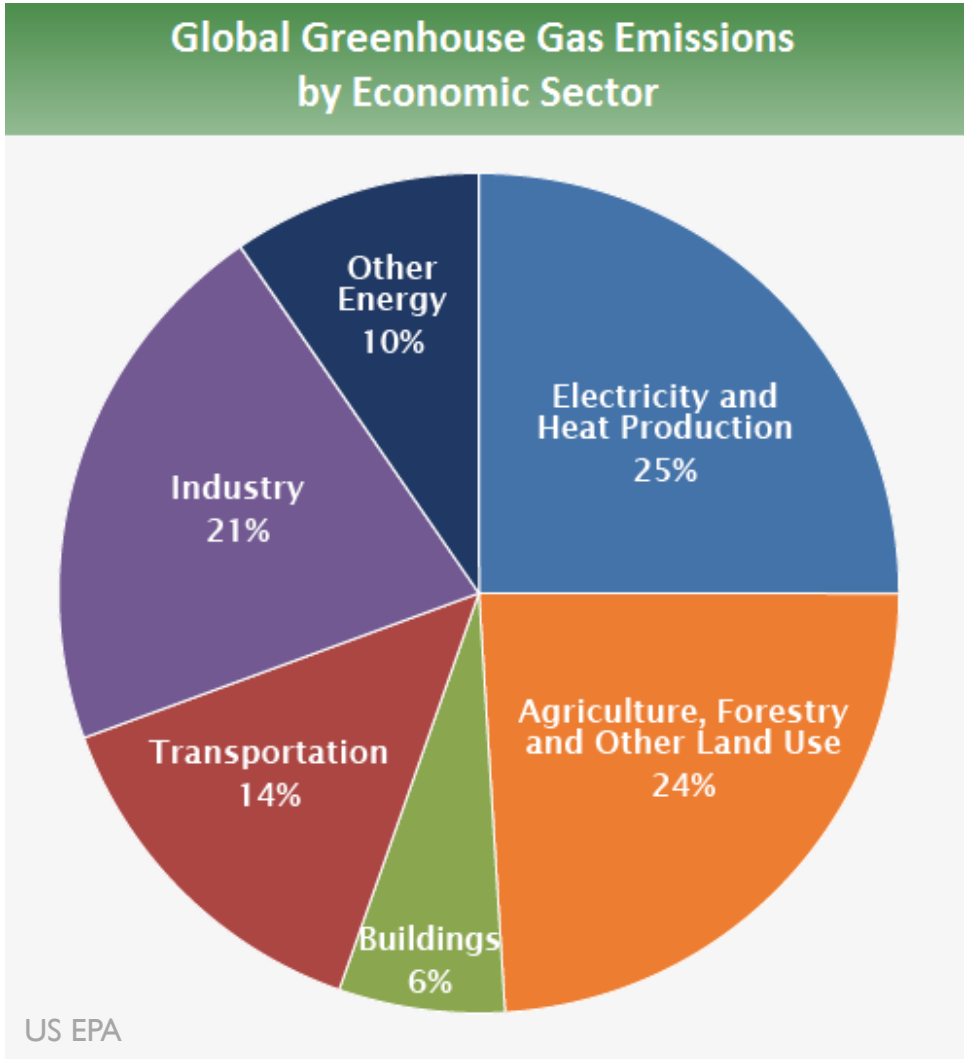

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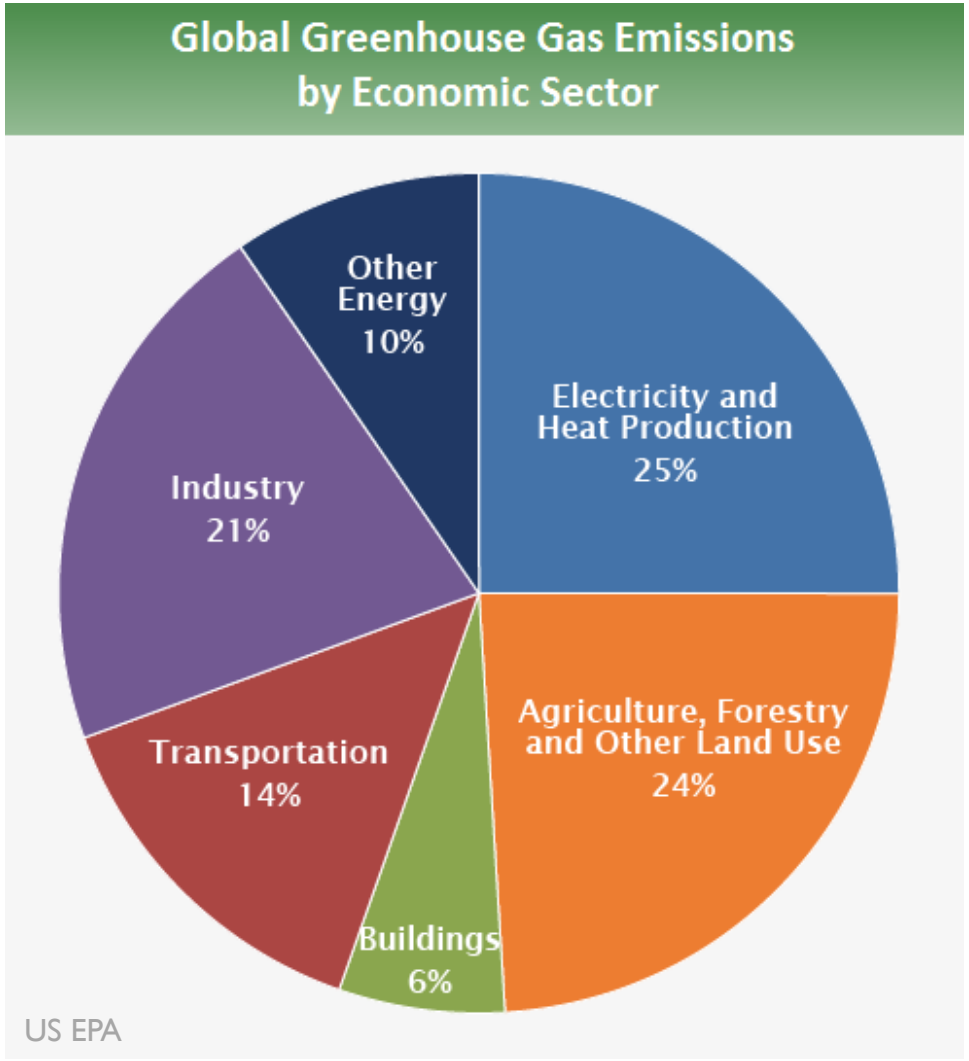
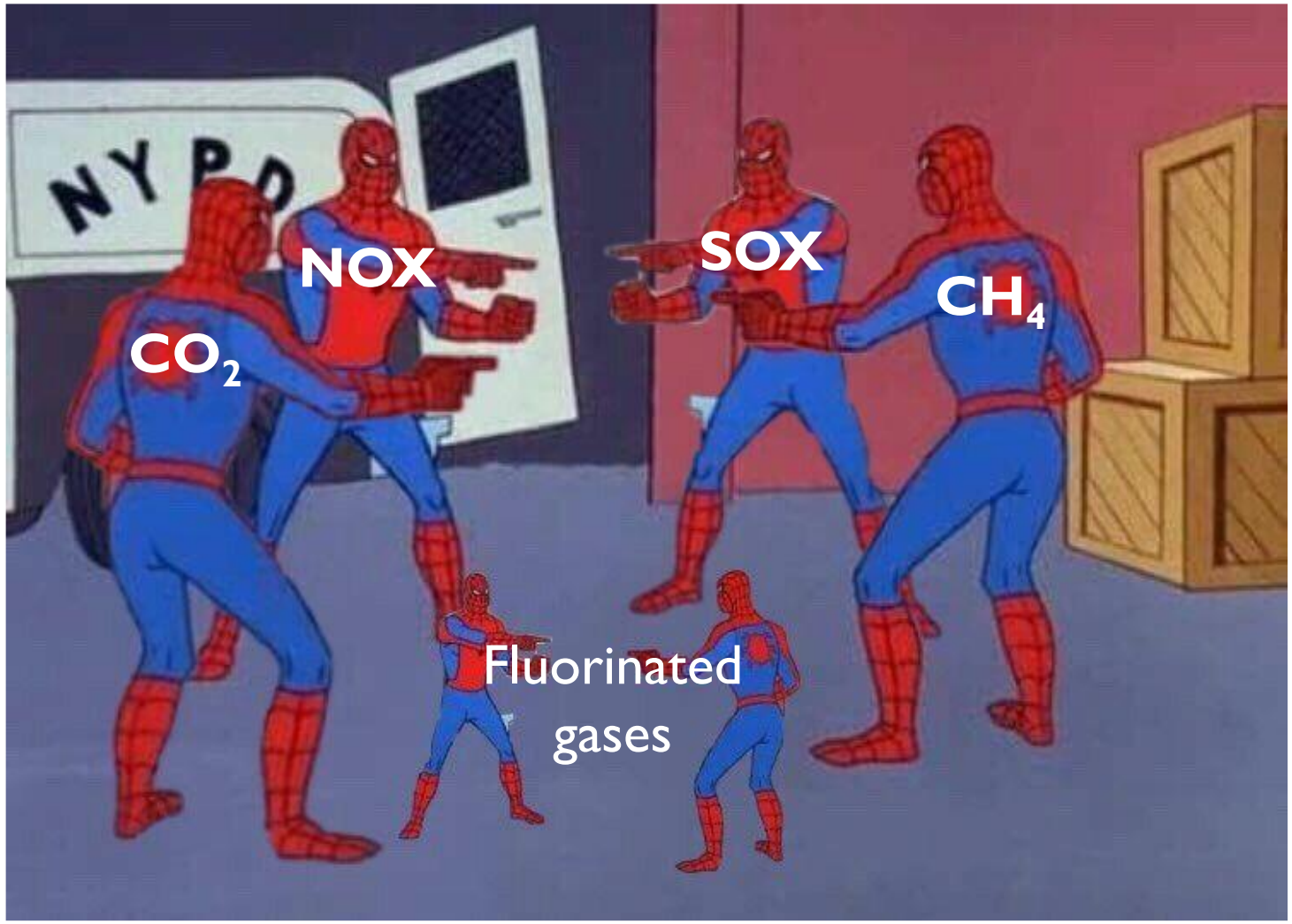


How much methane produced by cow farts/burps in a day?

Which gases are to blame?



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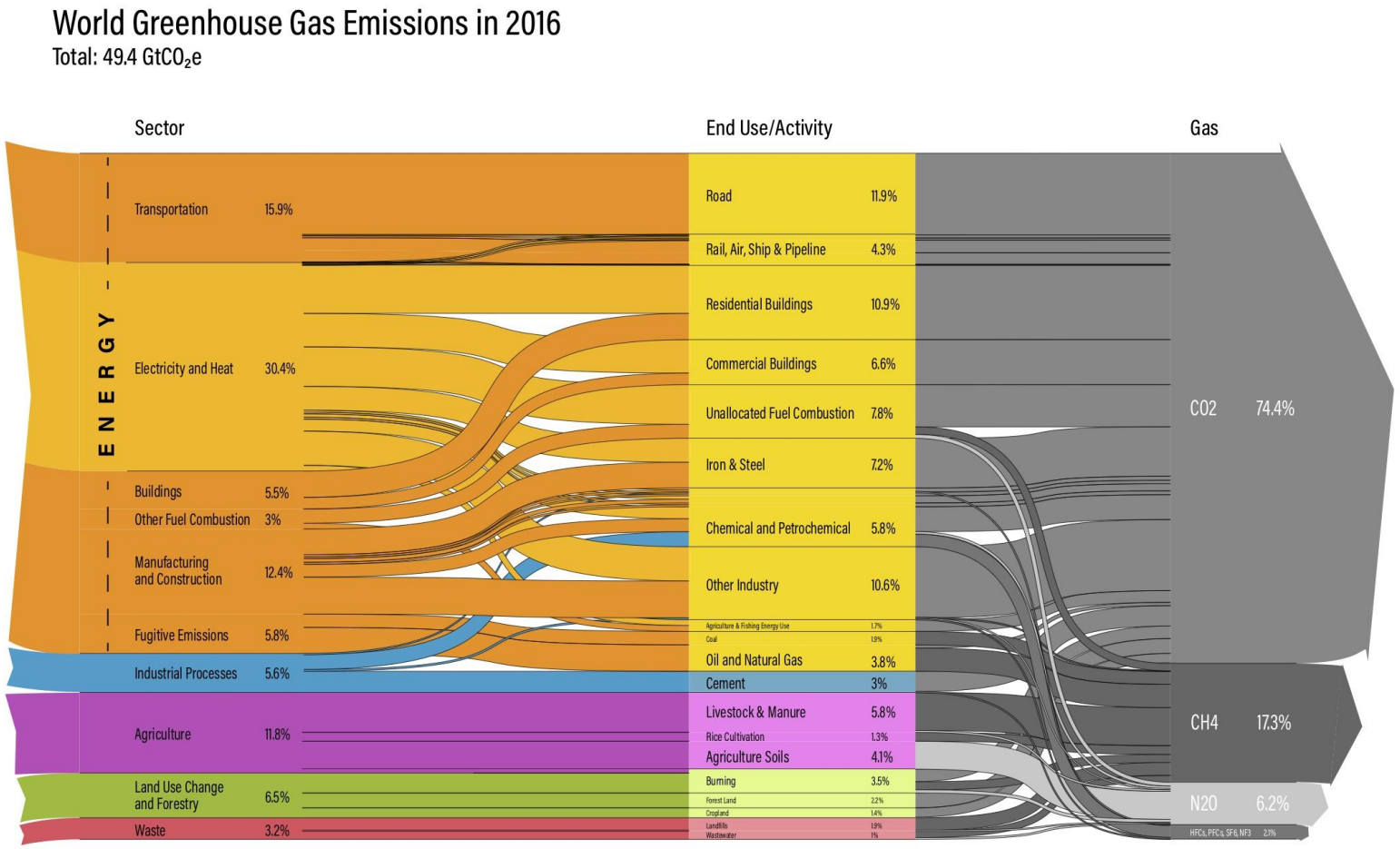


Source: Greenhouse gas emissions on Climate Watch. Available at: https://www.climatewatchdata.org

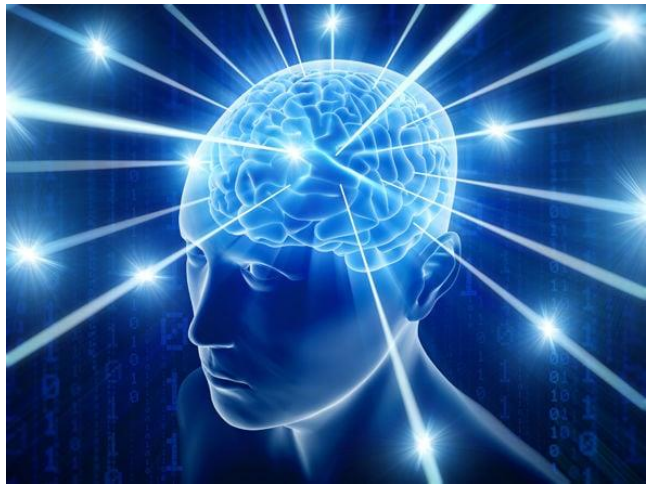
WORLD RESOURCES INSTITUTE

Global Warming Potential (GWP)

Greenhouse Gas	Atmospheric Concentration		Atmospheric Lifetime (Years)	100-Year Global Warming Potential
	Pre-Industrial (1000-1750)	Recent (2019)		
CO_2	280 ppm	410 ppm	50-200	1
CH_4	0.7 ppm	2 ppm	12	23
N_2O	0.270 ppm	0.330 ppm	114	296
CF_4	40 ppt	80 ppt	> 50,000	5700
SF_6	0	10 ppt	3200	22,200

US EPA

Pause for questions!



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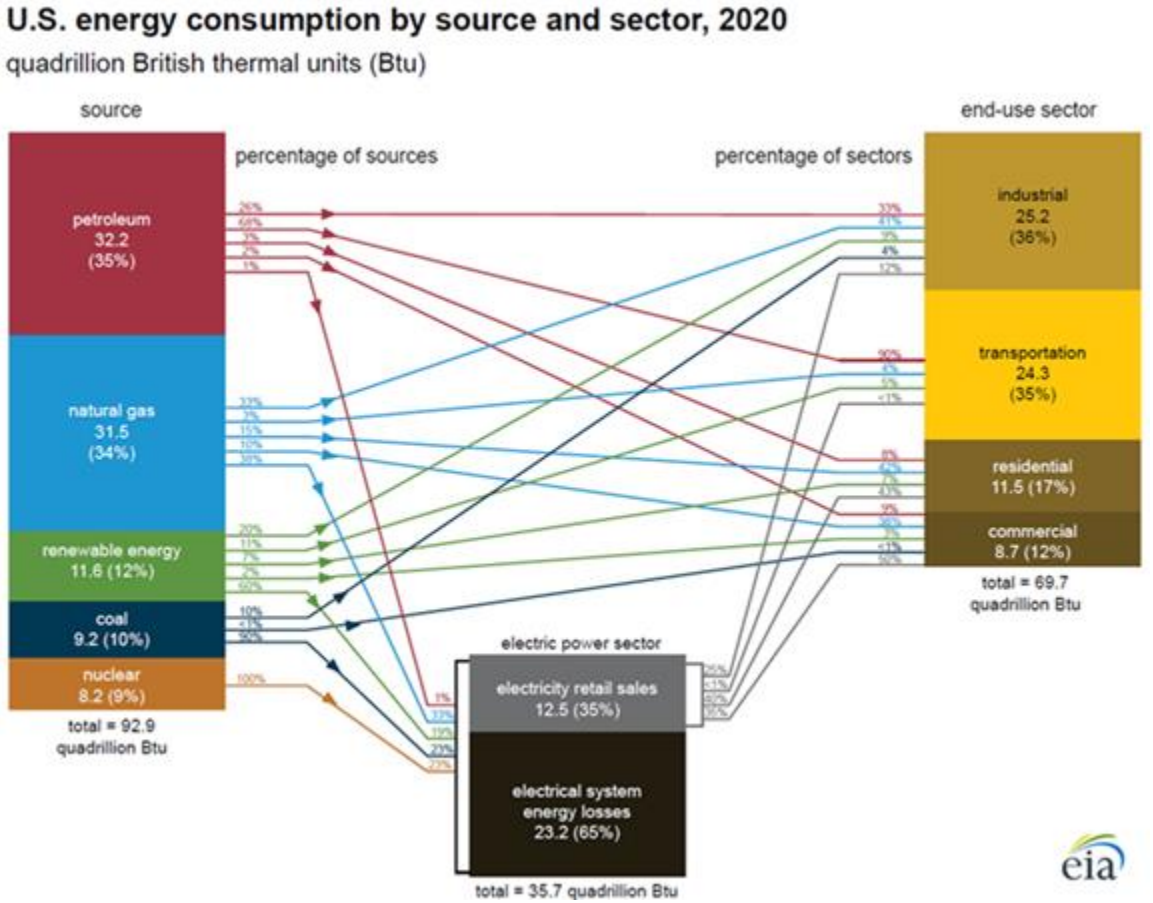
Thermal science can help by reducing waste heat

Back to the coal power plant example…

We waste heaps of energy!

"It is estimated that between **20 to 50%** of industrial energy input is lost as waste heat in the form of hot exhaust gases, cooling water, and heat lost from hot equipment surfaces and heated products."

—US Office of Energy Efficiency and Renewable Energy



US Energy Information Administration (EIA)

Ways we can minimize waste heat

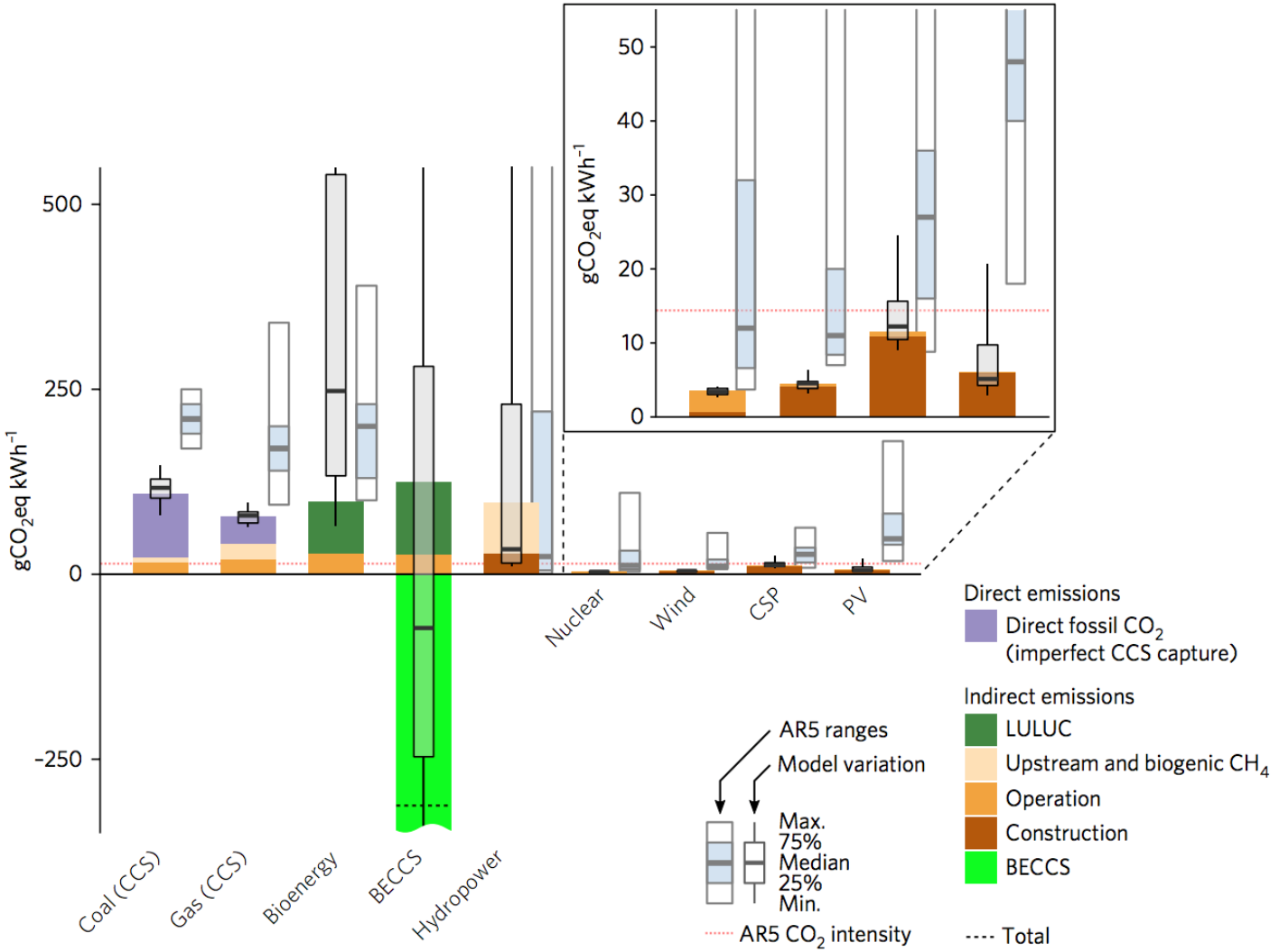
Regeneration

Cogeneration

Using low-grade waste heat

Energy storage

Options *that aren't burning fossil fuels!*



M. Pehl *et al.* Nat. Energy **2**, 939 (2017). https://doi.org/10.1038/s41560

Two kinds of solar energy: solar photovoltaic and solar thermal

Solar photovoltaic

Solar thermal

We can also extract energy from fluids already flowing in nature!

Hydropower

Wind power

All done!

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So what did we learn today?

Next time…