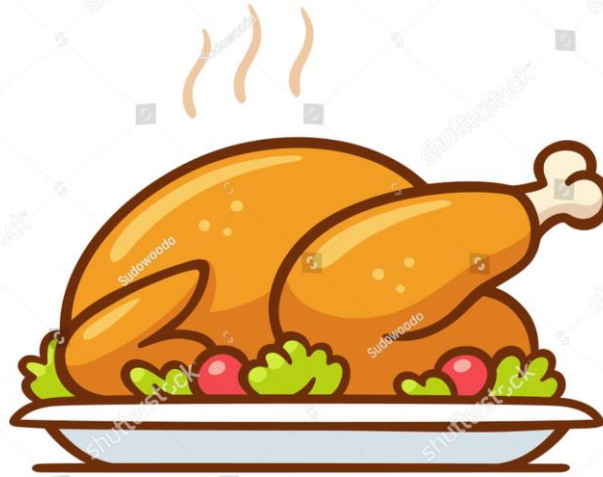


So, Is our goose (civilization) cooked?



# What is the Green New Deal and how would it work?

Pat Murray, MD, MS  
Dept of Physical Medicine and Rehabilitation

# Questions to be able to intelligently discuss after this talk

What is a carbon budget and how does it set the end line at mid-century (~2050)?

What are the components of the Green New Deal?

Is the Green New Deal technically feasible?

Can we afford the Green New Deal?

What are the easy parts of the Green New Deal?

What are the hard parts of the Green New Deal?

What role can we play in avoiding catastrophic climate change?

# What is a carbon budget?

Actually a bit of a misnomer

Usually think about budgets annually.

But in this situation there is a finite amount total dose of green house gas (GNG) that the world can tolerate while maintaining its temperature.

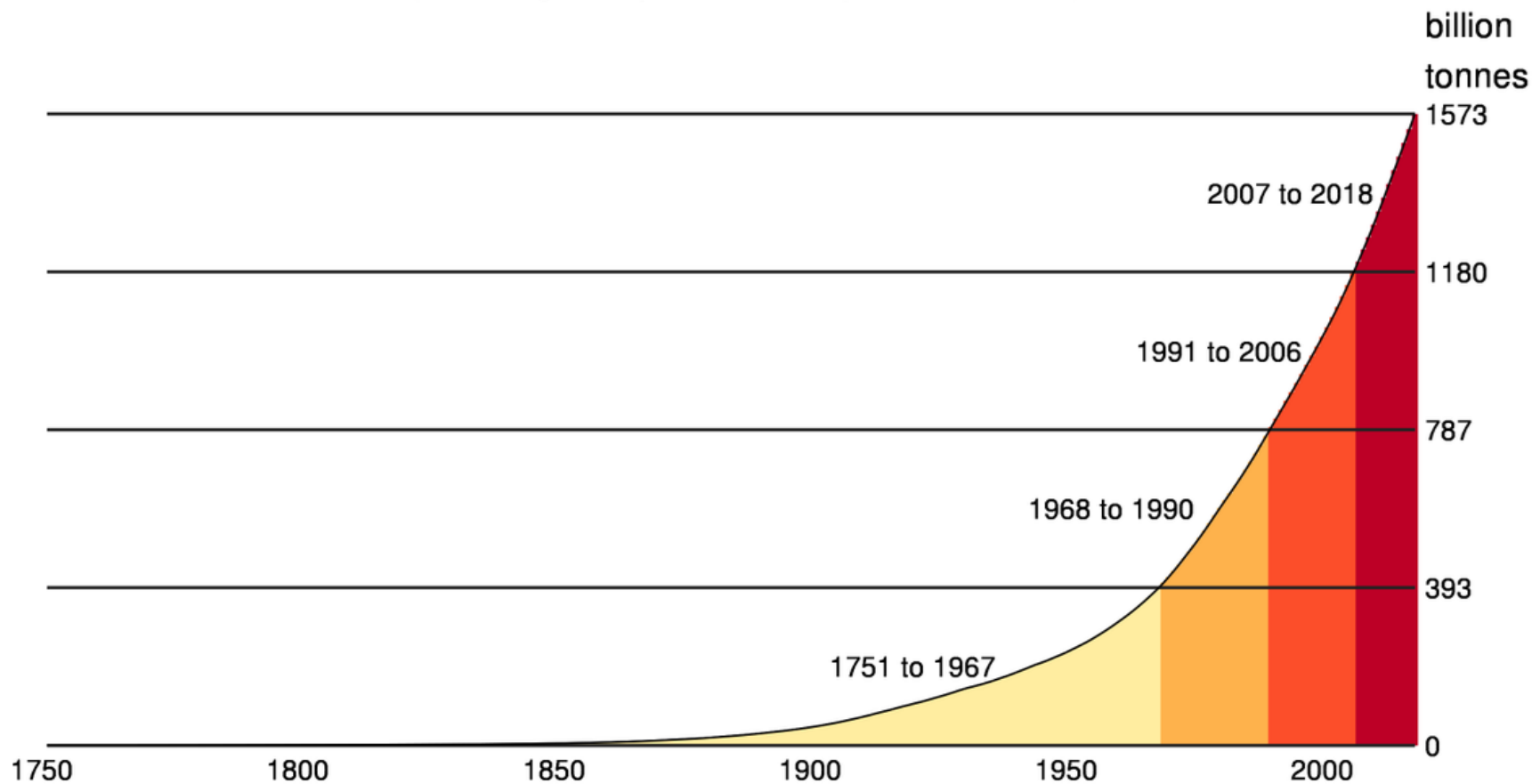
The natural elimination rate of CO<sub>2</sub> is very slow

Think about a chemotherapy drug like adriamycin that has a maximum cumulative lifetime dose

The total dose of CO<sub>2</sub> is dependent on what temperature rise that is tolerable

Most scientists now think that 1.5 degrees C is the most we can tolerate.

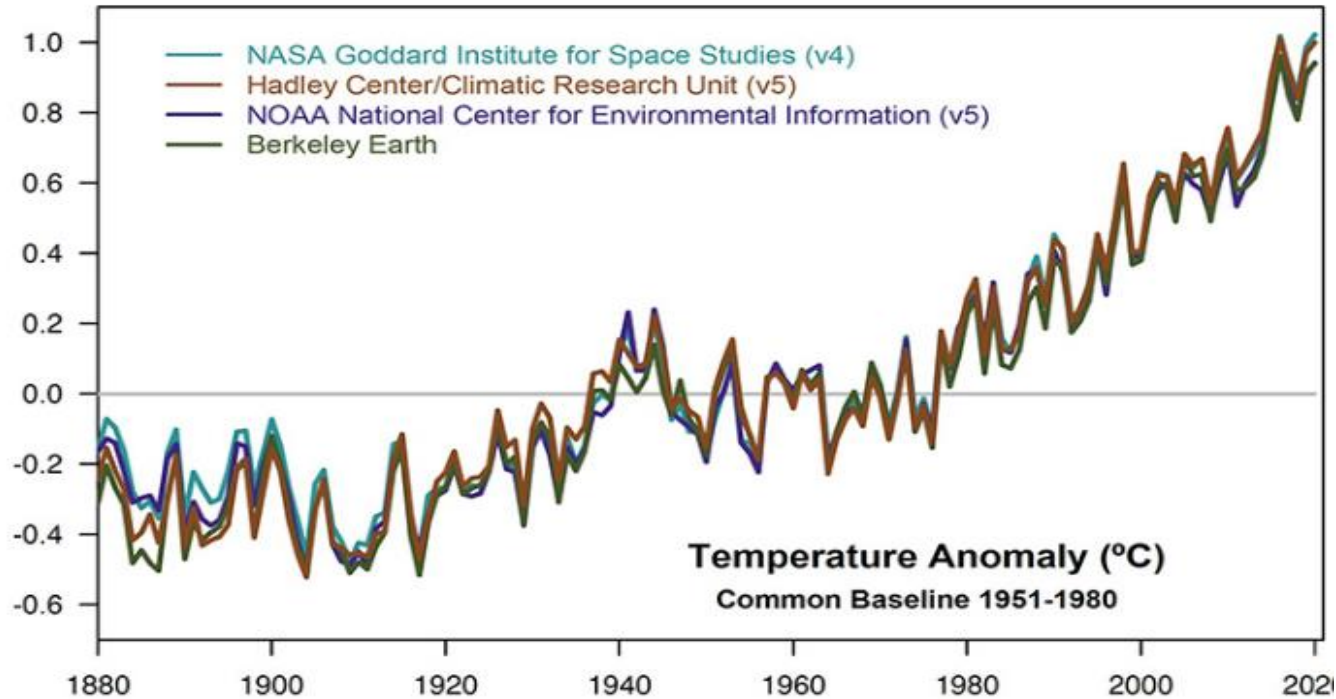
# Running total of global fossil fuel CO<sub>2</sub> emissions since 1751 (showing four periods of equal emissions)



Data source: CDIAC and [globalcarbonproject.org](http://globalcarbonproject.org)

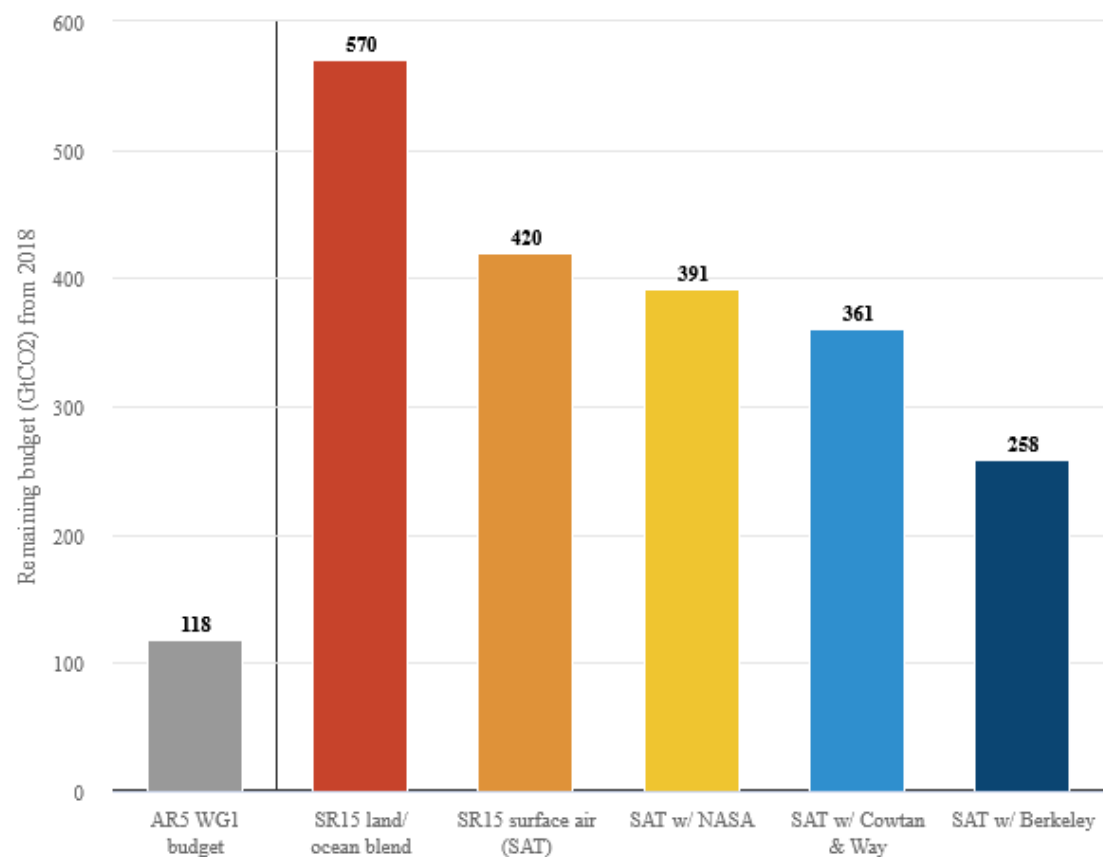
created by: @neilrkaye

# Where are we on the road to 1.5 Degrees C?

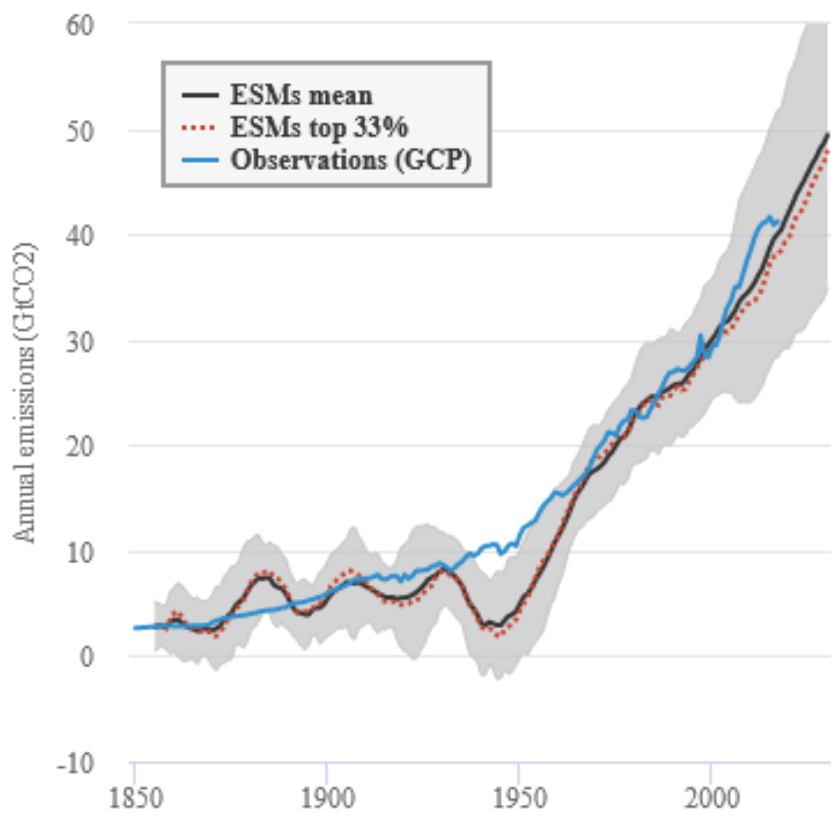


Temperature data showing rapid warming in the past few decades, the latest data going up to 2020. According to NASA data, 2016 and 2020 are tied for the warmest year since 1880, continuing a long-term trend of rising global temperatures. The 10 warmest years in the 141-year record have occurred since 2005, with the seven most recent years being the warmest. Credit: NASA's Goddard Institute for Space Studies.

## Different ways to define the carbon budget



## CO2 emissions: ESMs vs observations





The most largest (most optimistic) estimate of cumulative carbon is 2300 gigatons (We are at about 1650 now)

At 45 gigatons per year, we will reach our Maximum cumulative dose in 13 years if we continue with business as usual (BAU).

If we spread the carbon budget over 29 years then we need to decrease carbon emissions about 6% each year to reach this goal

If we set 6% as the target for decline, we have 11 years to cut global GHG emissions by half

The magnitude and the urgency of the change that caused the Green New Deal to be proposed

What the resolution proposed:

Appointment of a Select Committee to develop a plan for a Green New Deal and draft legislation for a national 10-year mobilization

There was nothing in it about hamburger or air travel!

# Five Goals of the Green New Deal

Achieve **net-zero greenhouse gas emissions** through a fair and **just transition** for all communities and workers;

Create **millions of good, high-wage jobs**

Invest in the **infrastructure and industry** of the United States

**Sustainable environment for all;**

**Promote justice and equity** in historically oppressed frontline and vulnerable communities.

# Focus today: high level view technical aspects of reaching goal one: net zero greenhouse gas emissions by 2050

## Five Pillars of Decarbonization

1. Zero carbon electricity and doubling of electricity production
  - a. Doubling is probably a significant underestimate
2. Electrification of end uses
3. Green synthetic fuels
4. Smart grid creation implementation
5. Energy and Material efficiency

## Sixth Issue: Agriculture

# Getting to zero carbon electricity is pretty easy

Capital cost of new infrastructure for wind, solar--

Levelized costs are now the same as fossil fuels

(Unaddressed issue is obsolete capital investment in fossil fuels infrastructure)

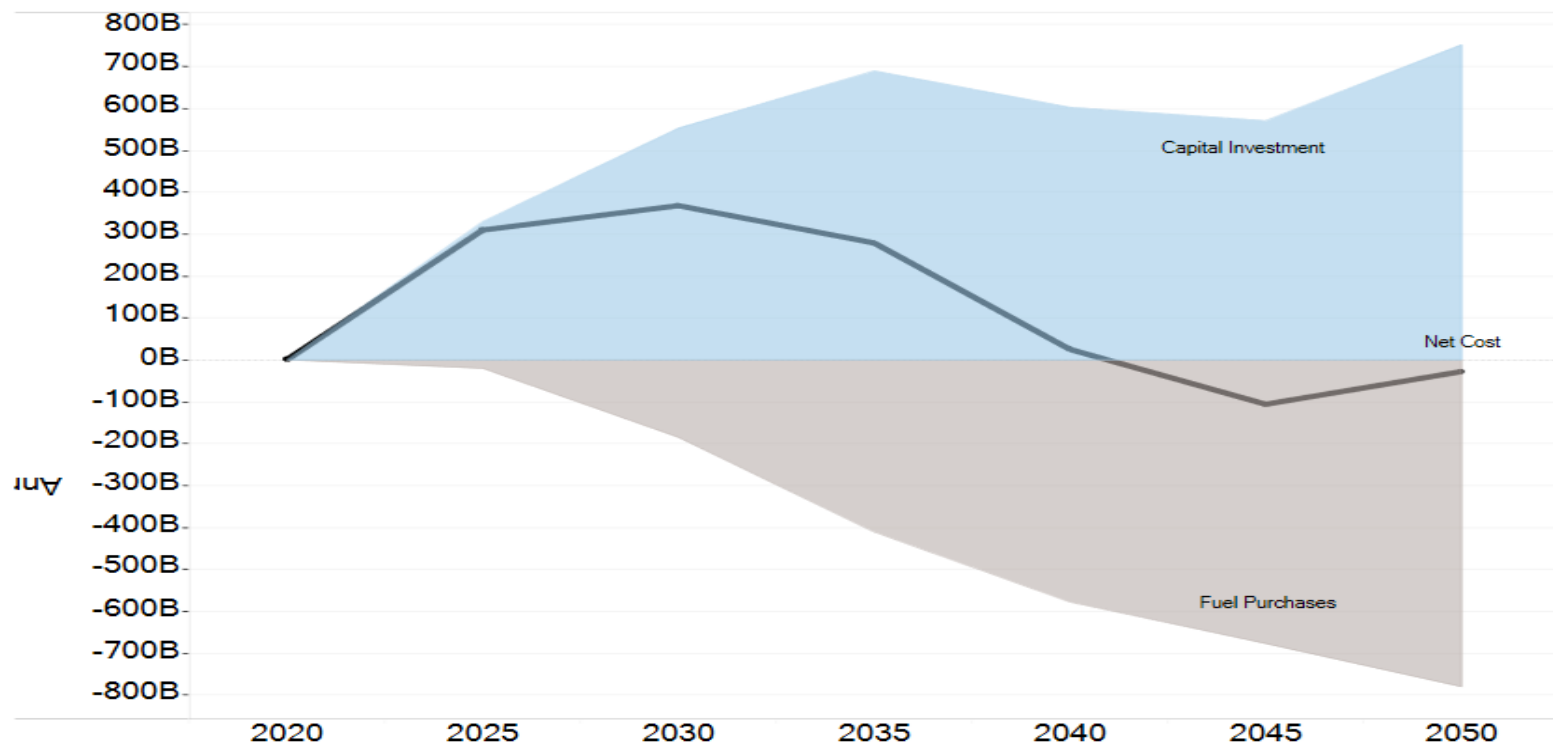
Intermittency of the renewables and limited dispatchability

Energy storage (batteries, hydrogen, and pumped storage)

Grid expansion and diversification

# Energy Economy in Low Carbon Transition

## Capital Costs Replace Fuel Costs

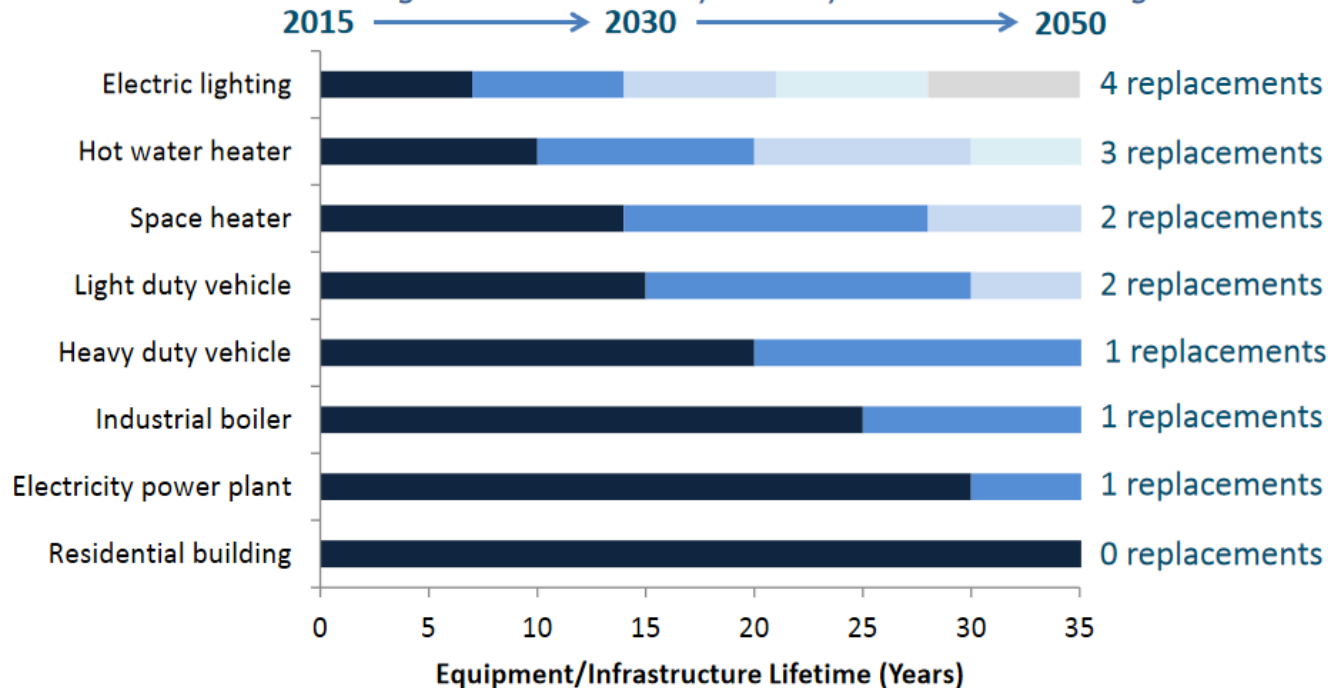


Source: Haley, et al. 350 ppm Pathways for the United States. (2019)

# Energy infrastructure typically has long lifetimes

## Decarbonization strategy must account for this

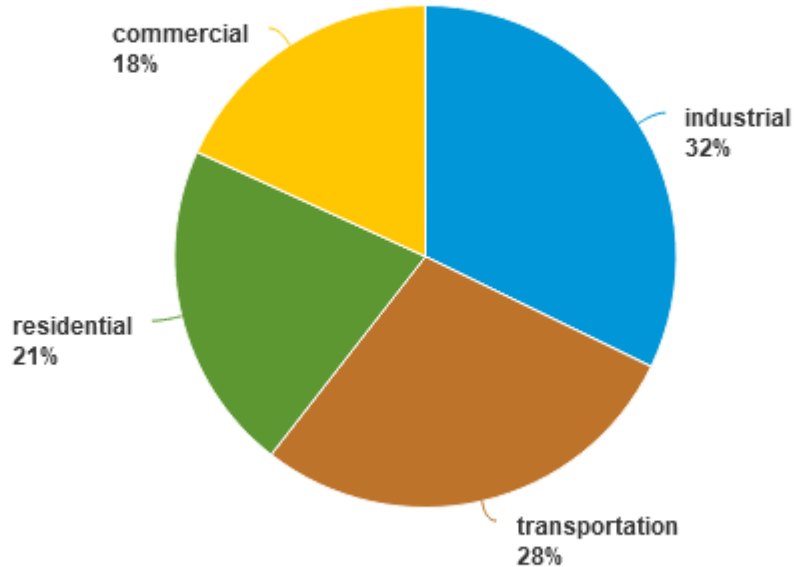
- A car purchased today is likely to be replaced at most 2 times before 2050.  
A residential building constructed today is likely to still be standing in 2050.



# How energy use is divided by sector today

## Share of total U.S. energy consumption by end-use sectors, 2019

Total = 100.2 quadrillion British thermal units



Note: Sum of individual percentages may not equal 100 because of independent rounding.



## 2nd pillar is electrification of end use

Some of these sectors are relatively easy and not requiring a lot of new capital expense

Personal and Local transportation: EVs and charging stations

Heating and cooling of new residential properties: Heat pumps

New commercial buildings: Heat pumps

Industrial

Light manufacturing

Much of agricultural production

# Some sectors are technically not hard, but expensive

Relatively hard or costly

Retrofitting existing residential properties

Retrofitting existing commercial facilities

Primary issue is heating as old buildings are expensive to upgrade

Energy efficiency

Heat production

Large investment by owner

## THE BIGGEST CHALLENGE IN MEETING THE PARIS AGREEMENT LIES IN THE MAJOR HARDER-TO-ABATE SECTORS

### HEAVY INDUSTRY



CEMENT



STEEL



PLASTICS

### HEAVY-DUTY TRANSPORT



HEAVY ROAD TRANSPORT



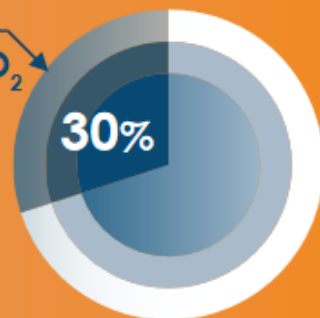
SHIPPING



AVIATION

10GtCO<sub>2</sub>

of total annual carbon emissions from energy and industry...



...and their share of remaining emissions will grow as other sectors, like power, buildings and light-duty transport get decarbonized.

## REACHING NET-ZERO CO<sub>2</sub> EMISSIONS FROM HARDER-TO-ABATE SECTORS BY MID-CENTURY IS POSSIBLE

TECHNICALLY



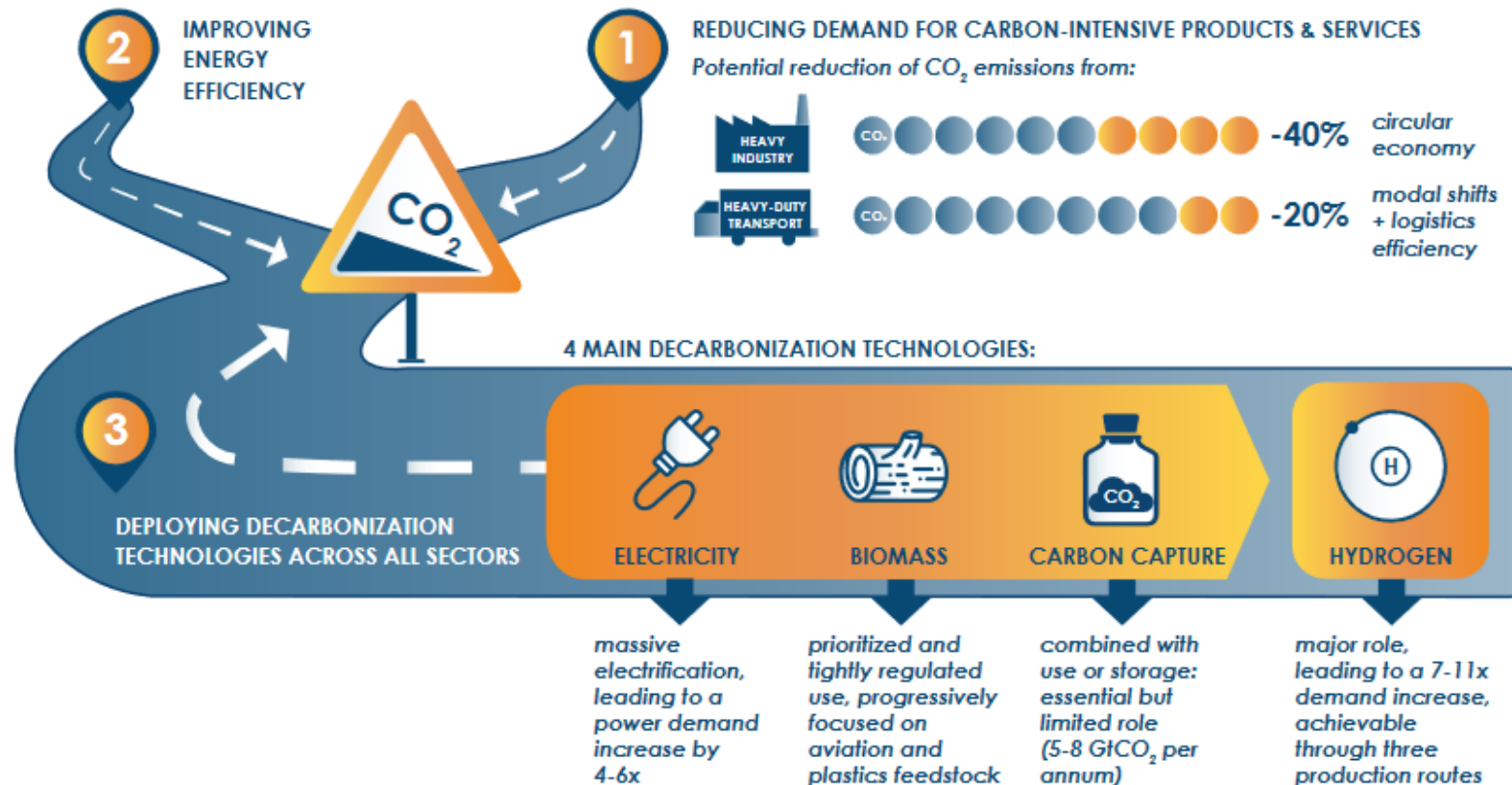
*Technologies are commercially ready or at research phase.*

ECONOMICALLY



*It will cost less than 0.5% of global GDP.*

## THERE ARE THREE MAIN ROUTES TO DECARBONIZATION



# COST TO THE END CONSUMER

THE COST TO CONSUMERS OF DECARBONIZING HEAVY INDUSTRY  
AND HEAVY-DUTY TRANSPORT WILL BE SMALL

## HEAVY INDUSTRY



## HEAVY-DUTY TRANSPORT



## Decarbonization of the harder-to-abate sectors would have a significant impact on the price of intermediate products

		Impact on intermediate product cost	
		US\$ / % price increase	
Industry	Cement	+\$100 per tonne of cement (+\$30 per tonne of concrete)	+100% (+30%)
	Steel	+\$120 per tonne of steel	+20%
	Plastics	+\$500 per tonne of ethylene	+50%*
Transport	Heavy road transport	No price impact	None
	Shipping	+\$4 million on typical bulk carrier voyage cost per annum	+110%
	Aviation	+\$0.3-0.6 per liter of jet fuel equivalent	+50-100%

\*Assuming an initial price of US\$1000/tonne for ethylene, although the price of ethylene is very volatile.  
Source: SYSTEMIQ analysis for the Energy Transitions Commission (2018)

# SIX INNOVATION AREAS



## TO FULLY DECARBONIZE HARDER-TO-ABATE SECTORS OF THE ECONOMY

### ELECTRIFICATION



Cheaper and more efficient batteries

Electric furnaces for cement and chemicals

Electrochemical reduction of iron for steel production

### MATERIALS EFFICIENCY AND CIRCULARITY



New designs for consumer products

Materials traceability, collection, sorting and recycling technologies

New business models: product-as-a-service, sharing...

### HYDROGEN



Cheaper electrolysis (targeting \$250/kWh)

Cheaper hydrogen fuel cells and hydrogen tanks

Long-distance transport of hydrogen

### NEW MATERIALS



Low-carbon cement and concrete chemistries

Biomaterials for construction

Cellulose-based fibers as a substitute for plastics

### BIOCHEMISTRY AND SYNTHETIC CHEMISTRY



Increased efficiency in biomass transformation

Bioenergy and bio-feedstocks from lignocellulosic sources and algae

Synthetic chemistry, including direct air capture of CO<sub>2</sub>

### CARBON CAPTURE AND CARBON USE



More efficient carbon capture, especially for cement

Use of carbon in concrete, aggregates and carbon fiber

# Timeline of the change will influence the cost of the transition

How to deal fairly with capital investments made now obsolete property

Least-cost solution in each case is to retire the existing capital at the end of its normal life



# National Policy Framework

- Timelines for phasing out fossil fuel–related capital stocks
  - a. Natural gas, coal, and oil
- R&D outlays for the hard technologies
  - a. Focused on plastics, cement, steel
  - b. Aviation, ocean shipping
  - c. Carbon sequestration
- Public investments
  - a. Interstate transmission of electricity, charging stations, catenary lines
  - b. government fleets and buildings, and other public infrastructure
- Financing for a fair transition for those displaced
  - a. Job retraining, income supplements, regional development
- Public financing for building retrofits
  - a. Housing
  - b. Industry

# Up for discussion

- Allocations of responsibilities among federal, state, and local governments
- Carbon pricing, including carbon taxes, feed-in tariffs
- How to incentivize/pay for transition
  - a. Carbon price management (tax carbon or incentivize carbon free alternatives)
    - i. For difficult sectors where solutions aren't clear
    - ii. Phase in carbon pricing on future costs to avoid social disruption
  - b. Manage quantities
    - i. For sectors where solutions are clear and already cost effective, e.g., Electric cars, new building standards for heating, cooking

## Some caveats

I have talked today as though all greenhouse gases are carbon dioxide

They aren't-- methane, nitrous oxide, and refrigerants are important and management of these is needed as well.

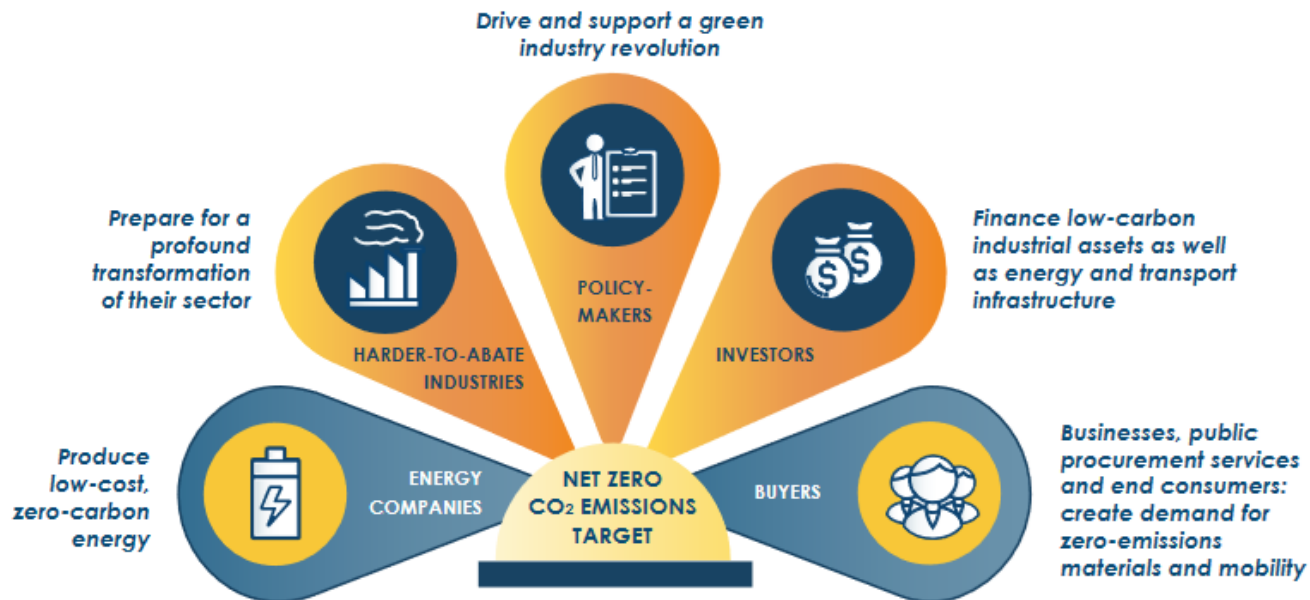
I have not discussed the carbon impact of our present food system

What most scientists suggest is that after we reach these goals we begin a period of development where we drawdown greenhouse gases. There is an excellent book on this topic, called Drawdown, edited by Paul Hawken that points the path to do this. Good place to learn about food issues among other things.











# WINNING THE CLIMATE WAR

*With immediate collective action, reaching net-zero CO<sub>2</sub> emissions from harder-to-abate sectors of the economy – in heavy industry and heavy-duty transport – is technically and economically feasible.*

## OUR RESPECTIVE RESPONSIBILITIES



CHANGE DRIVER	WHO	WHAT
---------------	-----	------

- |  |  |  |
|--|--|--|
| <b>1</b> SET AMBITIOUS CARBON-INTENSITY TARGETS        |   | <i>Enforce tight carbon-intensity mandates on industrial processes, heavy-duty transport and the carbon content of consumer products.</i>      |
| <b>2</b> PUT A PRICE ON CARBON                         |   | <i>Pursue international agreements while setting prices which are differentiated by sector, domestic, downstream &amp; defined in advance.</i> |
| <b>3</b> SHIFT FROM A LINEAR TO A CIRCULAR ECONOMY     |     | <i>Increase collaboration across the value chain to improve materials efficiency and recycling, supported by tight regulation.</i>             |
| <b>4</b> INVEST IN GREEN INDUSTRY                      |    | <i>Invest in and support R&amp;D projects and commercial deployment of decarbonization technologies for harder-to-abate sectors.</i>           |
| <b>5</b> CREATE DEMAND FOR GREEN PRODUCTS AND SERVICES |   | <i>Make voluntary commitments to "green purchasing" of e.g. trucks, flights, industrial components, building materials.</i>                    |
| <b>6</b> DRIVE DOWN THE COST OF RENEWABLE ENERGY       |     | <i>Drive down the cost and ramp up production of zero-carbon power, zero-carbon hydrogen and truly sustainable bioenergy.</i>                  |

# The problem is primarily political

How to sell these ideas to the American people?

Things to avoid--

Emphasis on raising taxes (carbon)

Emphasis on personal sacrifice

Things to emphasize

Benefits to all (Interstate highway example)

Emphasize concrete plans and their method of implementation

Importance for the nation and future generations

Every congressman, indeed every voter, should have a specific idea of what a Green New Deal would mean for their district and region. Without such a plan, climate activists will continue to win the battle over climate science but still lose the war over climate action.