Pricing Carbon

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CONTEXT: Major Lessons from the Fourth Assessment Report (2007)

- **Responding to climate change involves an *iterative risk management process* that includes *both adaptation and mitigation* and takes into account climate change damages, co-benefits, sustainability, equity, and attitudes to risk.**

The Fundamental Questions
Warming and Stabilization Targets

Evaluate how much risk is acceptable?
A value judgment (not addressed by the scientific community in its assessments).

What is at risk?
A science judgment (must be addressed as far as the scientific literature allows).

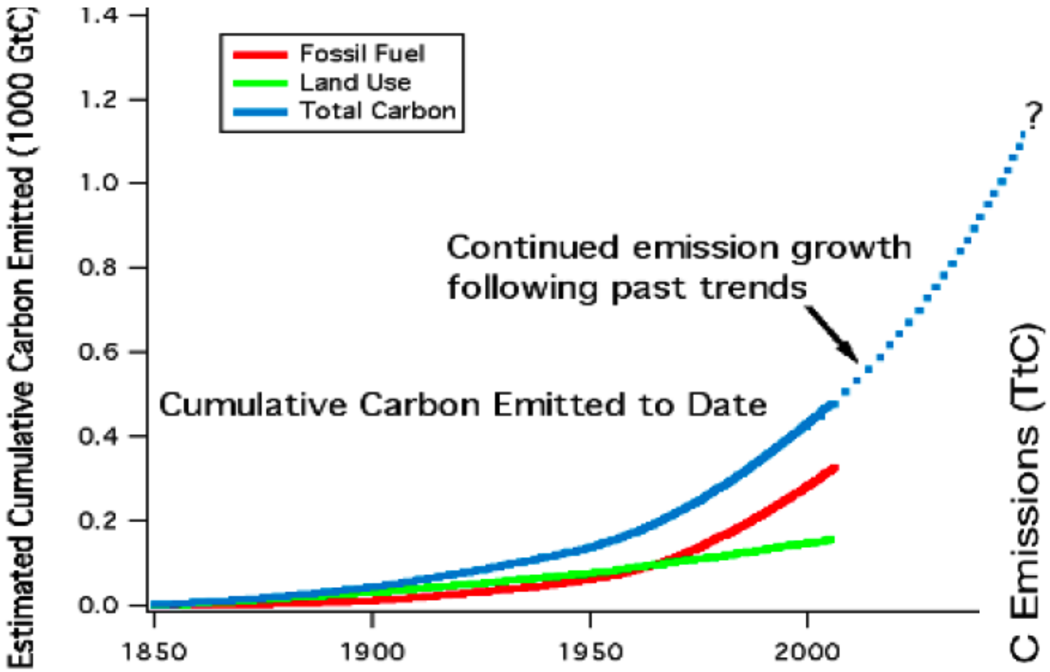
Climate Stabilization Targets:

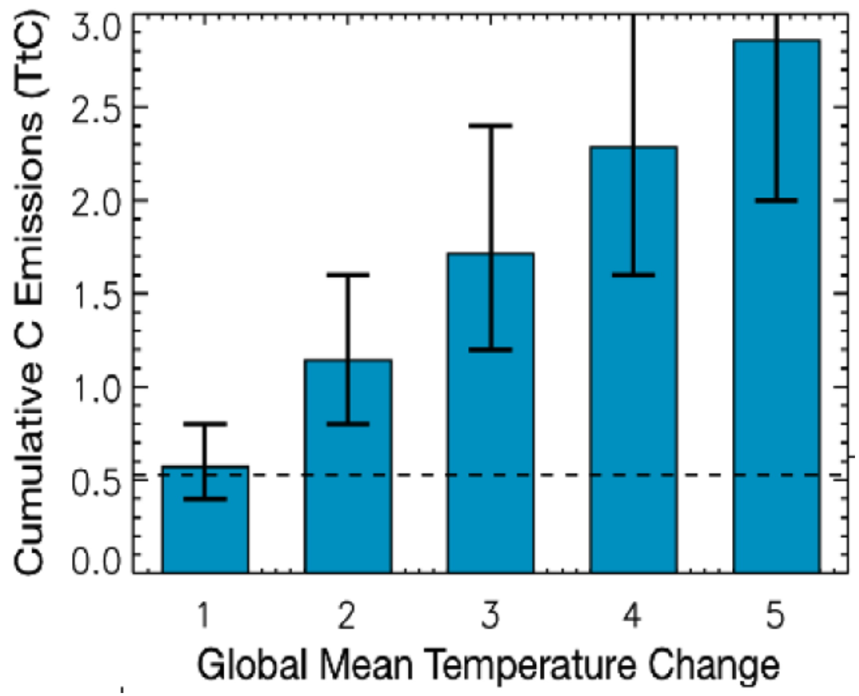
Emissions, Concentrations, and Impacts over Decades to Millennia

Report from The National Academies

Board on Atmospheric Sciences and Climate

Framing the Long Term: Cumulative Carbon ***Budgets***





Global mean temperature change is almost linearly related to cumulative carbon emission, and is independent of the time over which the emissions occur (because radiative forcing decreases logarithmically with increasing CO_2 concentrations, but this is balanced by weakening carbon sinks at higher CO_2).

Transient and Equilibrium Warming: What We Observe versus What Will Happen

CO_2-equlvalent concentration (ppmv)	Best estimate transient warming (°C)	Estimated likely range of transient warming (°C)	Best estimate equilibrium warming (°C)	Estimated likely range of equilibrium warming (°C)
350	0.5	0.4-0.7	1	0.7-1.4
450	1.1	0.9 -1.5	2.2	1.4-3.0
550	1.6	1.3-2.1	3.1	2.1-4.3
650	2	1.6-2.7	3.9	2.6-5.4
1000	3	2.4-4.0	5.9	3.9-8.1
2000	4.7	3.7-6.2	9.1	6.0-12.5

Wait to observe severe impacts? A future with about twice as much warming and double the impacts…..

Key Findings

•Observed climate changes as greenhouse gas emissions increase reflect only about half of the eventual total warming that would occur for stabilization at the same concentrations; deep emission reductions (>80%) would be required to stabilize carbon dioxide concentrations at any chosen target level (e.g., 450 ppmv, 550 ppmv, 650 ppmv, 750 ppmv, etc.).

• Scientific progress has resulted in increased confidence in understanding how global warming levels of 2, 3, 4, 5°C, or more would affect wildfire area, Arctic sea ice retreat, reduced crop yields, coral bleaching, streamflow, rainfall patterns, and eventual sea level rise, providing improved information for science and society.

•TEMPERATURE INCREASES DEPEND ON CONCENTRATIONS AND THEY DEPEND ON CUMULATIVE EMISSIONS

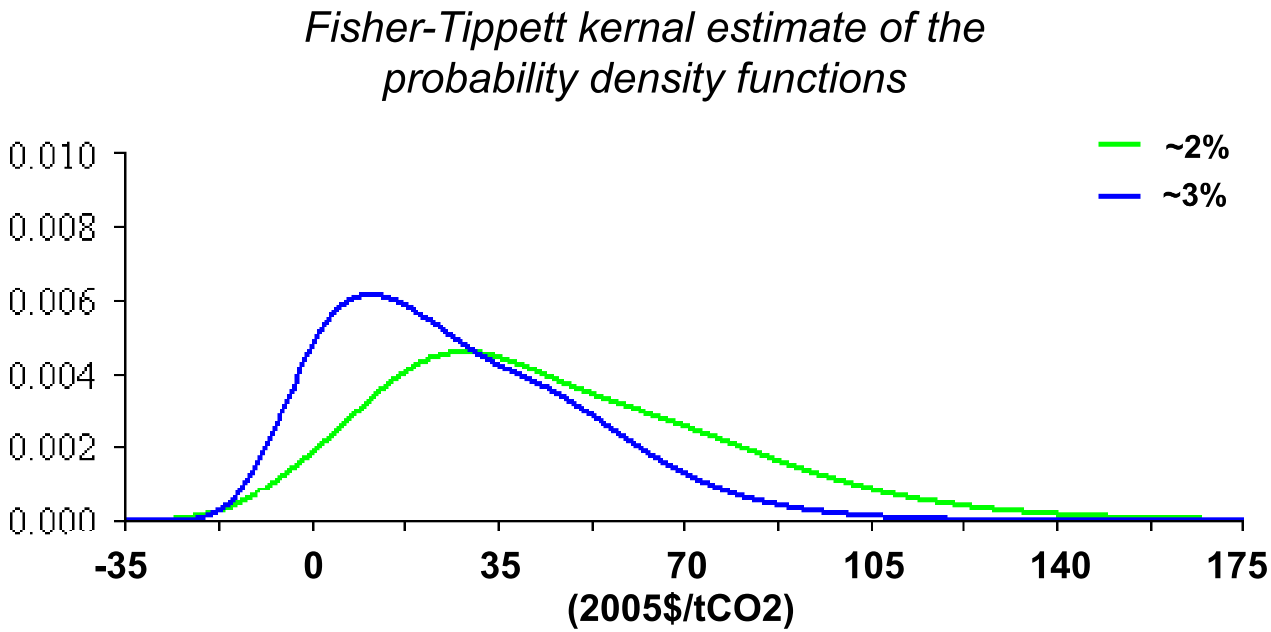
Reasons to Price Carbon

- The price of carbon can be a socially significant and economically important indication of the long-term objective.
- Appropriate (at least internally consistent) accounting of the carbon implications of other government policies and/or regulations must be quantified somehow.
- The price of carbon support economic incentives for R&D into carbon-saving and/or carbon sequestering technologies; it also portends their subsequent success in global market penetration.

The "Social Cost of Carbon" The Marginal Cost of Emissions

- An indication of long-term objective (at least partially)
- Very difficult to make operational because estimates are very dependent on normative assumptions and very dependent on uncertainties like "climate sensitivity".
- Could be a **normative** estimate of marginal cost.
- Important to note that every estimate is ***time specific and future dependent.***

Refined meta analysis range and discounting
(for emissions reductions in 2005)



Summary of EPA estimates

(various emissions years and discount rates, 2006$)

		~ 2%			~ 3%			~ 7%		
		Low	**Central**	**High**	**Low**	**Central**	**High**	**Low**	**Central**	**High**
Meta global	**2007**	-3	68	159	-4	40	106	n/a	n/a	n/a
	2017	-2	91	213	-3	53	142	n/a	n/a	n/a
	2022	-2	105	247	-2	62	165	n/a	n/a	n/a
	2030	-1	134	314	-2	78	209	n/a	n/a	n/a
	2040	-1	179	421	-1	105	281	n/a	n/a	n/a
FUND global	**2007**	-6	88	695	-6	17	132	-3	-1	5
	2017	-4	118	934	-4	23	178	-2	-1	7
	2022	-4	136	1083	-4	26	206	-2	-1	9
	2030	-3	173	1372	-3	33	261	-1	0	11
	2040	-2	232	1843	-2	44	351	-1	0	15
FUND domestic	**2007**	0	4	16	0	1	5	0	0	0
	2017	0	6	22	0	1	7	0	0	0
	2022	0	7	26	0	2	9	0	0	0
	2030	0	9	32	0	2	11	0	0	0
	2040	0	12	44	0	3	15	0	0	0

FUND estimates are preliminary

- Estimates for reductions in subsequent years are higher due to a larger marginal effect on net damages (IPCC suggests 2-4%/yr; 3% applied above)
- DOT and DOE proposed rule estimates: $7/tCO2 in 2011 (2006$), range $0 - $14

Other Determinants and Source of the Wide Range

- Mother nature:
  - Climate sensitivity – the temperature – cumulative emissions sensitivity
- Damage estimates and timing and downscaling and adaptation and…. Included in the future baseline:
- Normative values reflected in:
  - Pure rate of time preference
  - Relative risk aversion – elasticity of the marginal utility of consumption
  - Aversion to inequality – distributional weights

Plus ---

What

Is

Missing

	Uncertainty in Valuation →			
Uncertainty in Predicting Climate Change ↓		**Market**	**Non Market**	**Socially Contingent**
	Projection (e.g., sea level Rise)	**I** Coastal protection Loss of dryland Energy (heating/cooling)	**IV** Heat stress Loss of wetland	**VII** Regional costs Investment
	Bounded Risks (e.g. droughts, floods, storms)	**II** Agriculture Water Variability (drought, flood, storms)	**V** Ecosystem change Biodiversity Loss of life Secondary social effects	**VIII** Comparative advantage & market structures
	System change & surprises (e.g. major events)	**III** Above, plus Significant loss of land and resources Non-marginal effects	**VI** Higher order Social effects Regional collapse	**IX** Regional collapse

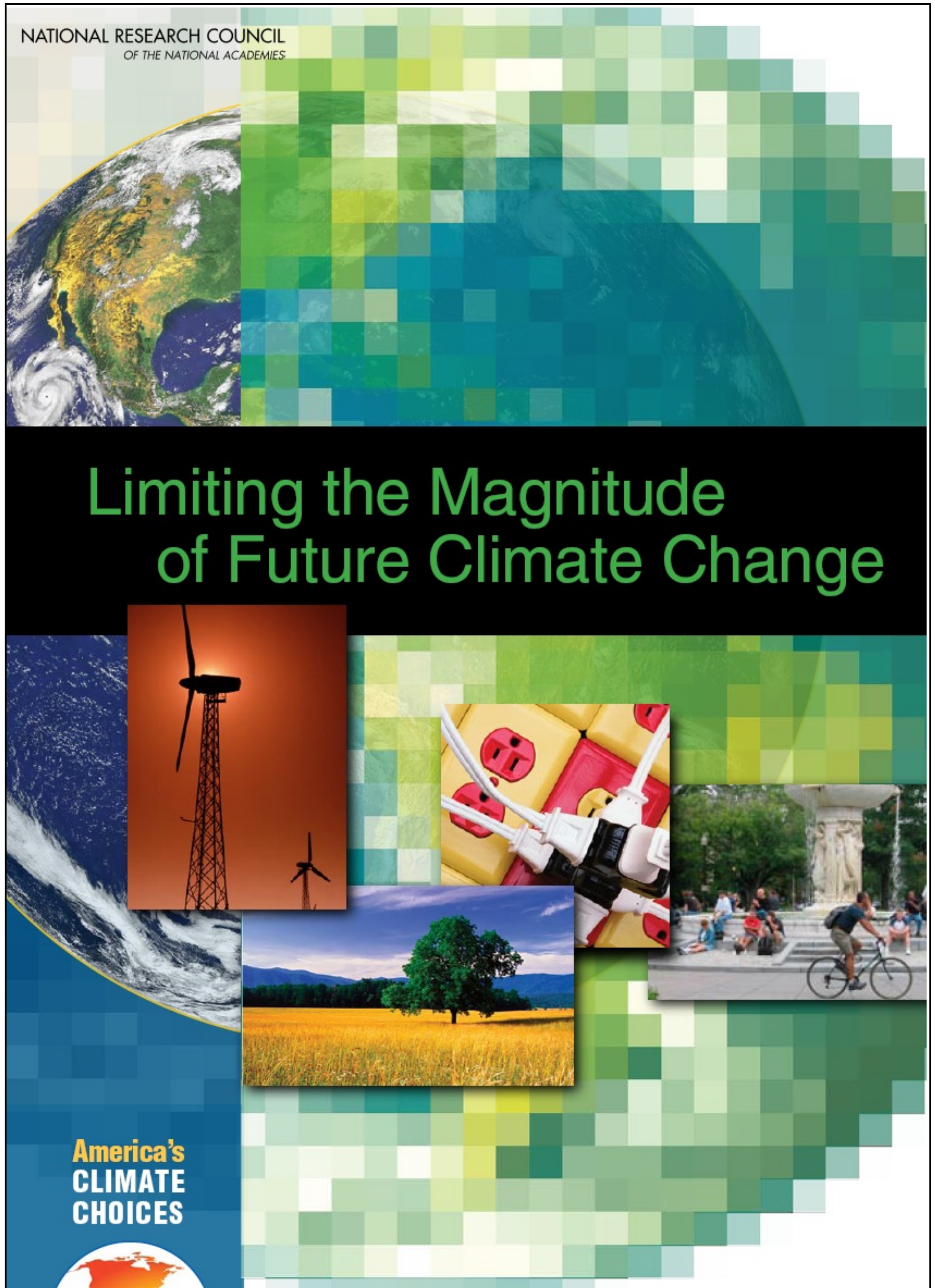
Source: Yohe and Tirpak (2008), derived from Downing and Watkiss (2003).

So…

- SCC is an ambiguous lower bound that….
- Can be set to any number you want by adjusting normative parameters or making assumptions about climate science or socio-economic response efficacy.
- Thus… a Slow Moving Target
- It is informative that AR4 and AR5 and ACC did not opt to emphasize or even report SCC.

RETURNING TO THE CONTEXT: Major Lessons from the Fourth Assessment Report (2007) adopted by ACC

- **Responding to climate change involves an *iterative risk management process* that includes *both adaptation and mitigation* and takes into account climate change damages, co-benefits, sustainability, equity, and attitudes to risk.**


NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES
Limiting the Magnitude of Future Climate Change
America's
CLIMATE
CHOICES

Setting Goals

Target: limiting global mean temperature increase
(e.g., 2 deg, 3 deg)

↓

What is a 'safe' amount of climate change?

Target: limiting global atmospheric GHG concentrations
(e.g., 450ppm, 550 ppm)

↓

How does GHG concentration translate into global temperature change and other key impacts?

Target: limiting global GHG emissions
(e.g. global emission budget, or percent reduction)

↓

How does a given level of emissions translate into atmospheric GHG concentrations?

Target: limiting U.S. GHG emissions
(e.g. national emission budget, or percent reduction)

What is a 'reasonable' share of U.S. emission reductions relative to the global targets?

My “Bridge too Far” Comment

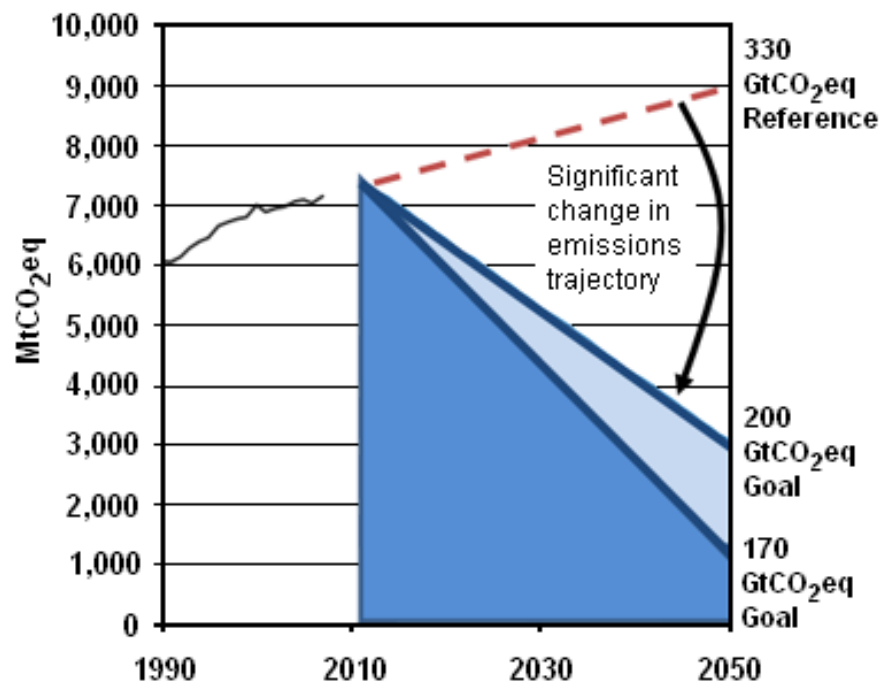
- Is the top-down / bottom up synthesis worth the effort for informing step one? Or is it a “bridge too far?”.
- Juan Carlos and had a conversation, and recalled my vacation to Sicily.
- Think about the proposed bridge from Sicily to the mainland of Italy – it has been designed many times as various barriers were incrementally accommodated, but has been on the table for 50 years; costs (effort) have been estimated repeatedly; but it is no closer to being built than in the 1960’s .
- We do not have that kind of time, …
- ***And we don’t know what to do on either end of the span to take advantage of the bridge.*** *SO YES… TOO FAR*

Emissions Budget – NRC Limiting Panel

We suggest that the U.S. establish a 'budget' for cumulative GHG emissions over a set period of time (through 2050) and plan to iterate (on science, cost, participation etc….)

We do not recommend a specific budget number, but offer a 'representative' budget range of: 170 - 200 gigatons (Gt) of CO_2-eq for 2012 - 2050.

Perhaps a midcourse correction In 2030 … mini-iteration on the price of carbon.



Core Recommendations

1. Adopt a mechanism for setting an economy-wide carbon pricing system.

2. Complement the carbon price with policies to:

- realize the practical potential for energy efficiency and low-emission energy sources in the electric and transportation sectors;
- establish the feasibility of carbon capture and storage and new nuclear technologies;
- accelerate the retirement, retrofitting or replacement of GHG emission-intensive infrastructure.

3. Create new technology choices by investing heavily in research and crafting policies to stimulate innovation.

Alternatives Mechanism for the Pricing Carbon

- Calculate the shadow price of accepted approaches based on risk evaluations (assuming cost minimization and efficiency in the first order?
- The ACC worked on economic feasibilities of alternative available technologies in their application along the two trajectories.
- The price of carbon could be calculated to make anticipated technologies economically viable when they needed (use Hotelling for a first order approximation.