Risks of Climate Change and Risks of Climate Change Solutions

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Modeling and Climate Change Policy
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Four World Views

		Are fossil fuels hard to displace?	
		NO	YES
Is climate change an urgent matter?	NO		
	YES		

Four World Views

		Are fossil fuels hard to displace?	
		NO	YES
Is climate change an urgent matter?	NO	A nuclear or renewables world unmotivated by climate.	Most people in the fuel industries and most of the public are here. **5°C.**
	YES	Environmentalists, nuclear advocates are often here. **2°C.**	OUR WORKING ASSUMPTIONS. **3°C, tough job.**

What happens when an irresistible force meets an immovable object?

Ten-year-olds love this paradox!

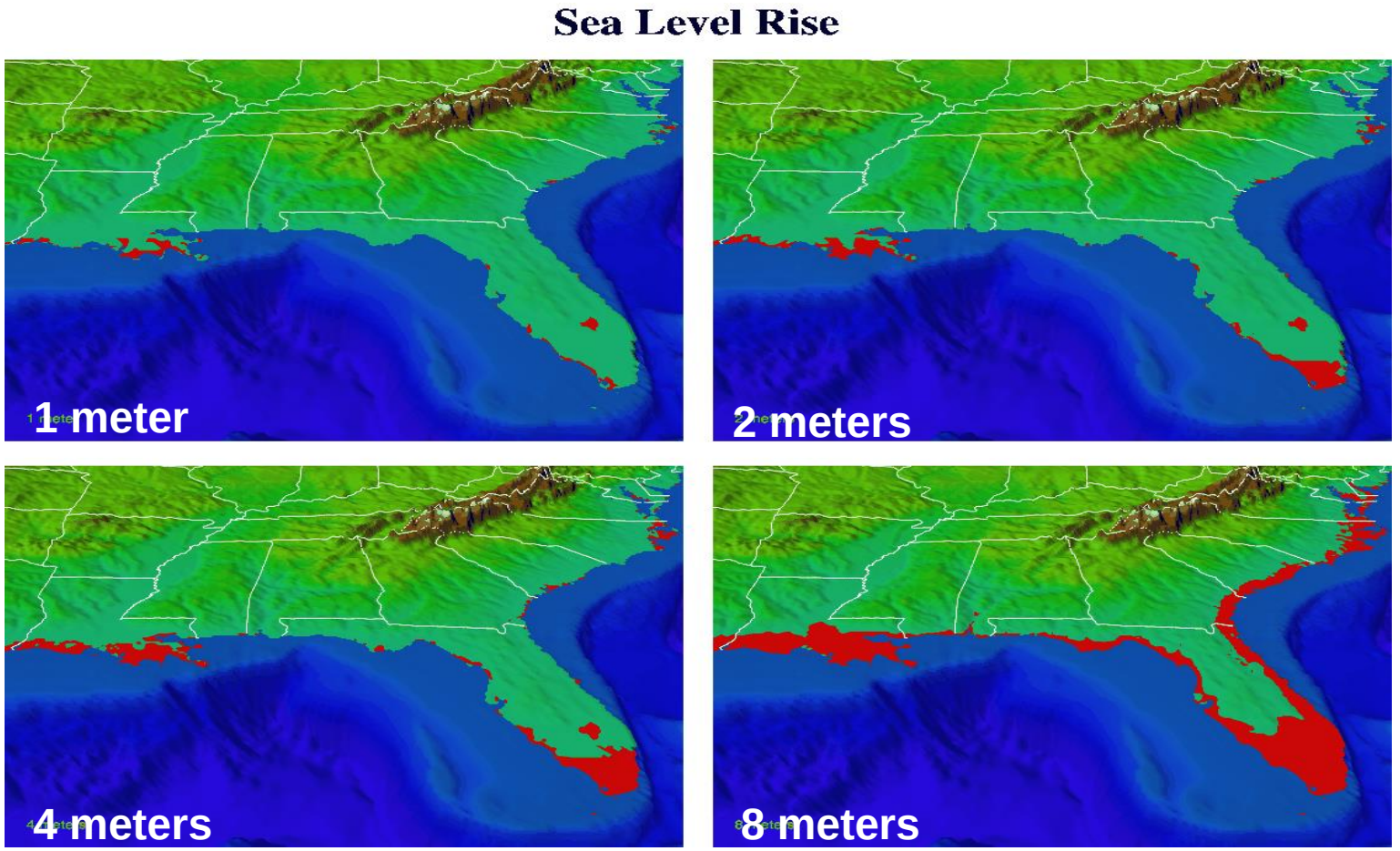
The irresistible force: Fossil fuels, as vital as ever.

The immovable object: Climate change, which looms ominously.

At some uncertain pace, but conceivably soon, the world will become seriously engaged with climate change.

Required: a two-sided view of risk and uncertainty – one that encompasses both problems and solutions.

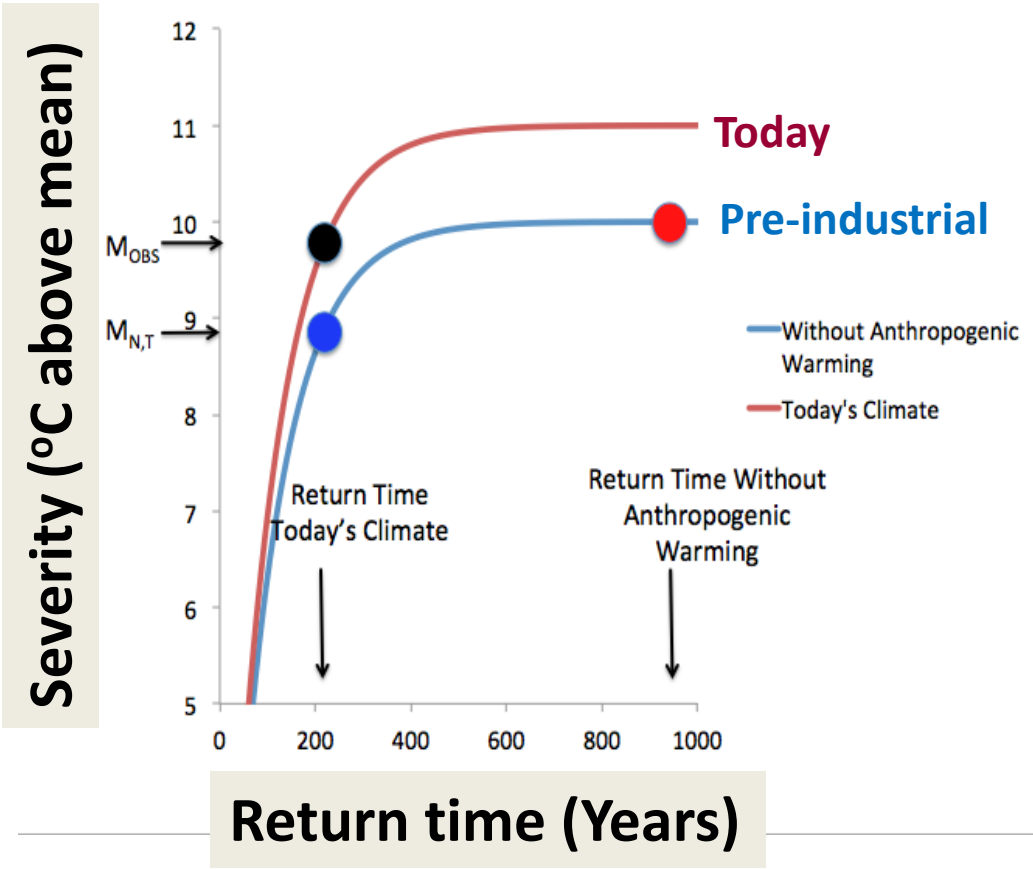
Uncertain risks of climate change: When?



Greenland ice sheet:	7 meters
West Antarctic Ice Sheet:	5 meters

Source: T. Knutson, Geophysical Fluid Dynamics Laboratory, NOAA. See:
http://www.gfdl.noaa.gov/~tk/climate_dynamics/climate_impact_webpage.html#section4

The Earth will gradually reveal how it works



Frequencies of extreme events will probably reveal human agency first. E.g., the nastiest heat waves will arrive much more frequently.

In general, frequencies of rare extremes will increase faster than frequencies of mild extremes.

Source: **S. Pacala**, private communication

Communicating uncertainty about climate science can enhance persuasion

Conventional wisdom holds that communicating uncertainty diminishes confidence in results and disempowers. Contrary findings in a new paper*.

Subjects are told that 5 million people in the U.S. could need to move their homes and businesses because of sea level rise during the next 100 years. They are told a) only this; b) that the number also could be 8 million; or c) that it could be either 1 million or 8 million. *Finding*: Subjects told *all three* estimates then rate the seriousness of climate change and their trust in scientists highest.

Conclusion: Uncertainty is not always detrimental to scientists' messages.

This is the first study to demonstrate that a representative sample of adults is influenced by expressions of uncertainty in a persuasive message.

**Source:* paper in progress by Bo MacInnis, Lauren Howe, Jon Krosnick, Ezra Markowitz, Robert Socolow

“Solutions” can bring serious problems of their own.

Every “solution” has a dark side.

Conservation	Regimentation
Renewables	Competing uses of land
“Clean coal”	Mining: worker and land impacts
Nuclear power	Nuclear war
Geoengineering	Technological hegemony

Risk management: We must take into account both the risks of disruption from climate change and the risks of disruption from mitigation. We must not privilege the atmosphere. Climate change is just one aspect of “fitting on the earth.”

Uncertain realizations of “emissions budgets”

Fossil fuels are so abundant that, for *any* carbon budget target, even a weak one, *attractive* fossil fuel will be left in the ground.

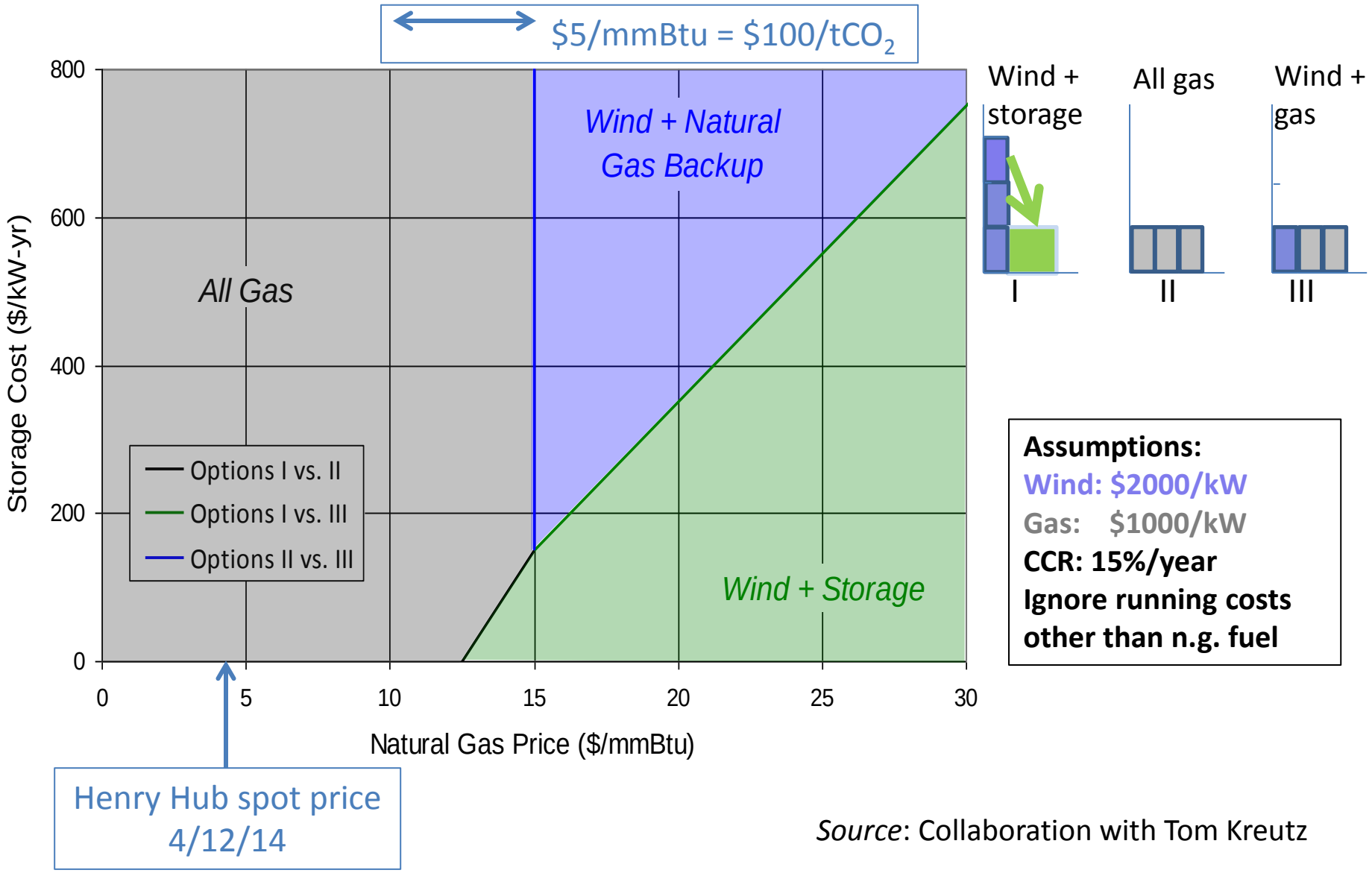
> The IPCC connected the carbon-budget idea to a 2^{o}C target. The idea is more general.

The budget concept leads inexorably to choices:

When?	Better options someday?
Whose?	Geopolitical stability
Used where?	“Fairness”
For what purpose?	Who judges?
Which fossil fuels?	Those with the highest H/C ratio?

Carbon dioxide capture and storage (CCS) expands the budget.

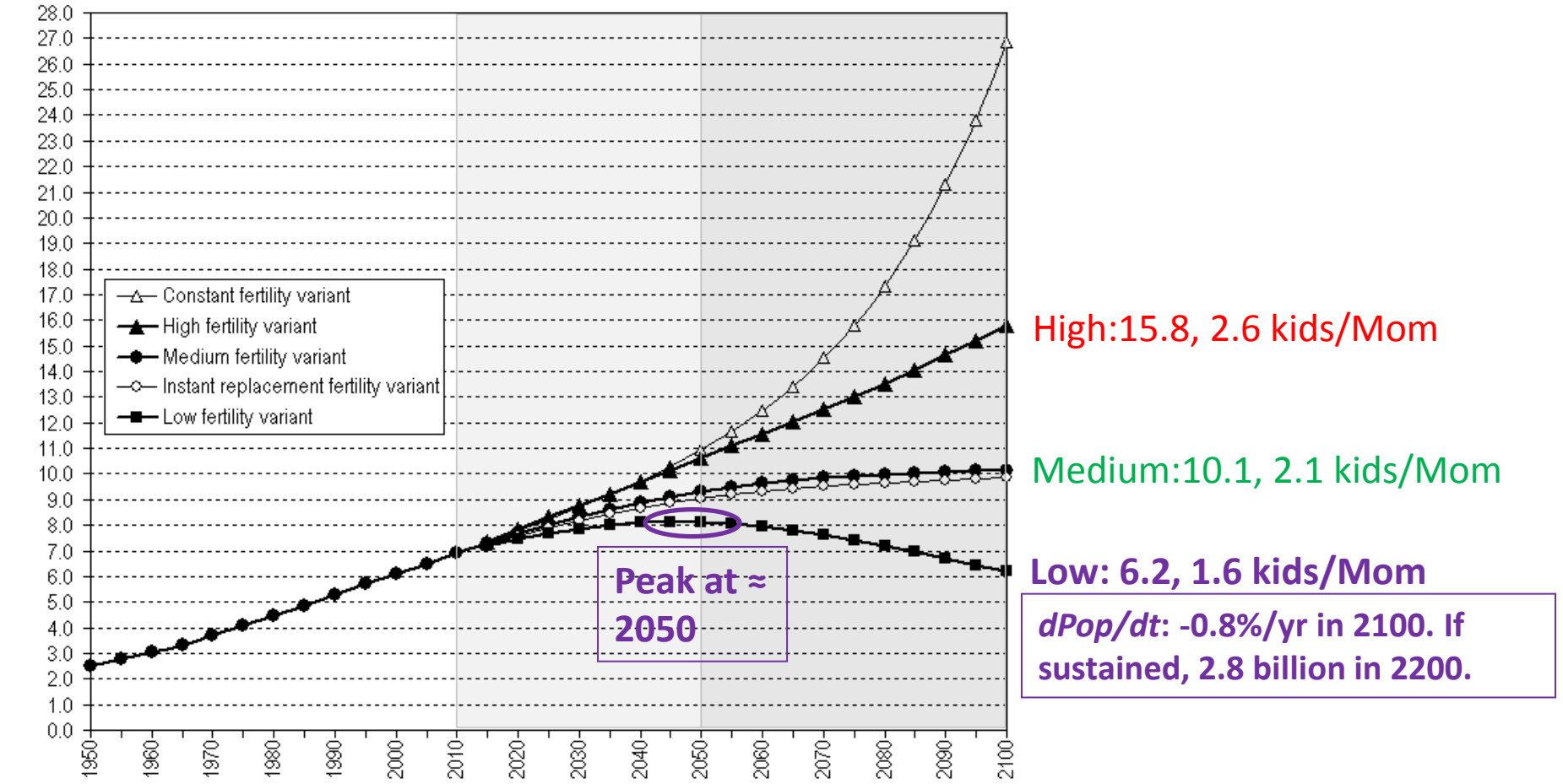
Very-low-carbon wind and solar requires expensive natural gas and cheap storage



Source: Collaboration with Tom Kreutz

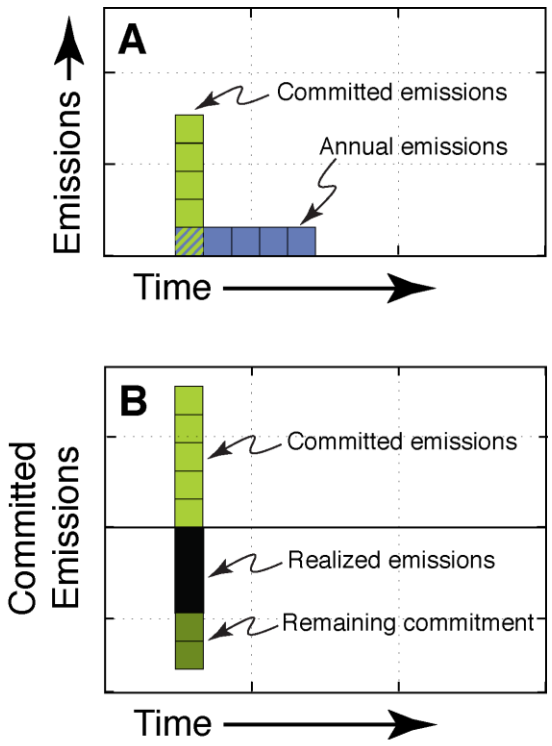
IAMs should include demography

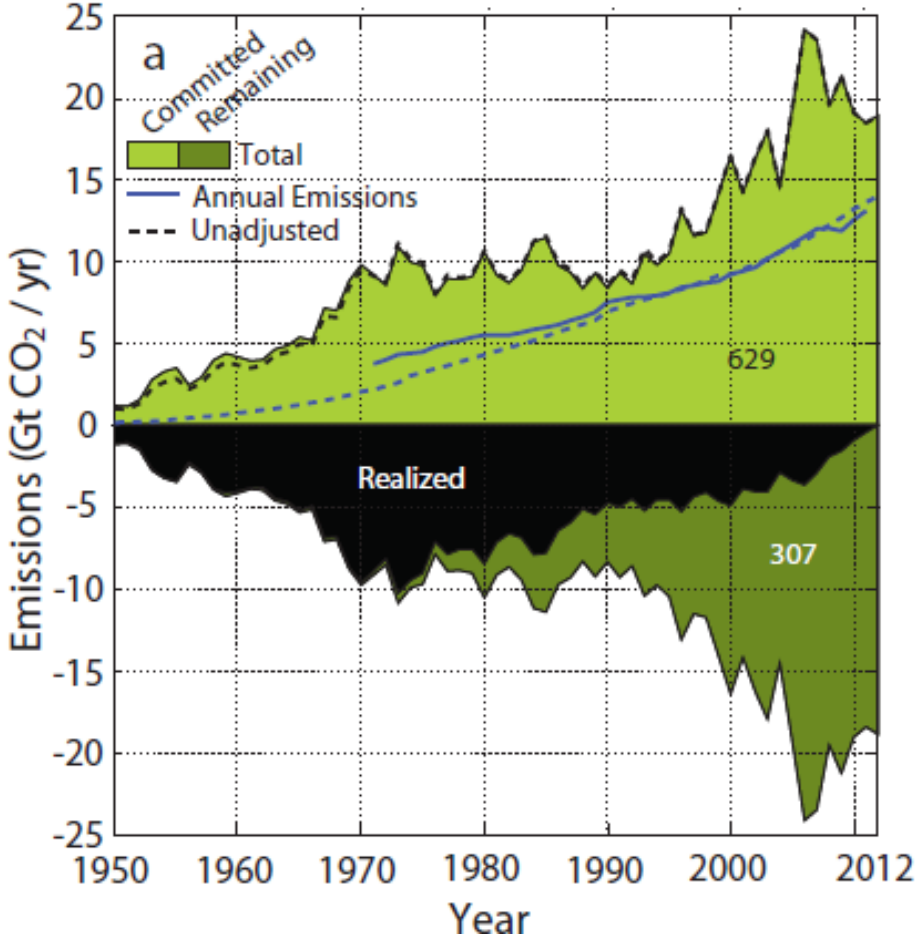
The UN's "low" population projection has almost 10 billion fewer people in 2100 than its "high" projection.



Source: United Nations. http://esa.un.org/unpd/wpp/unpp/panel_population.htm

IAMs should include “committed emissions”

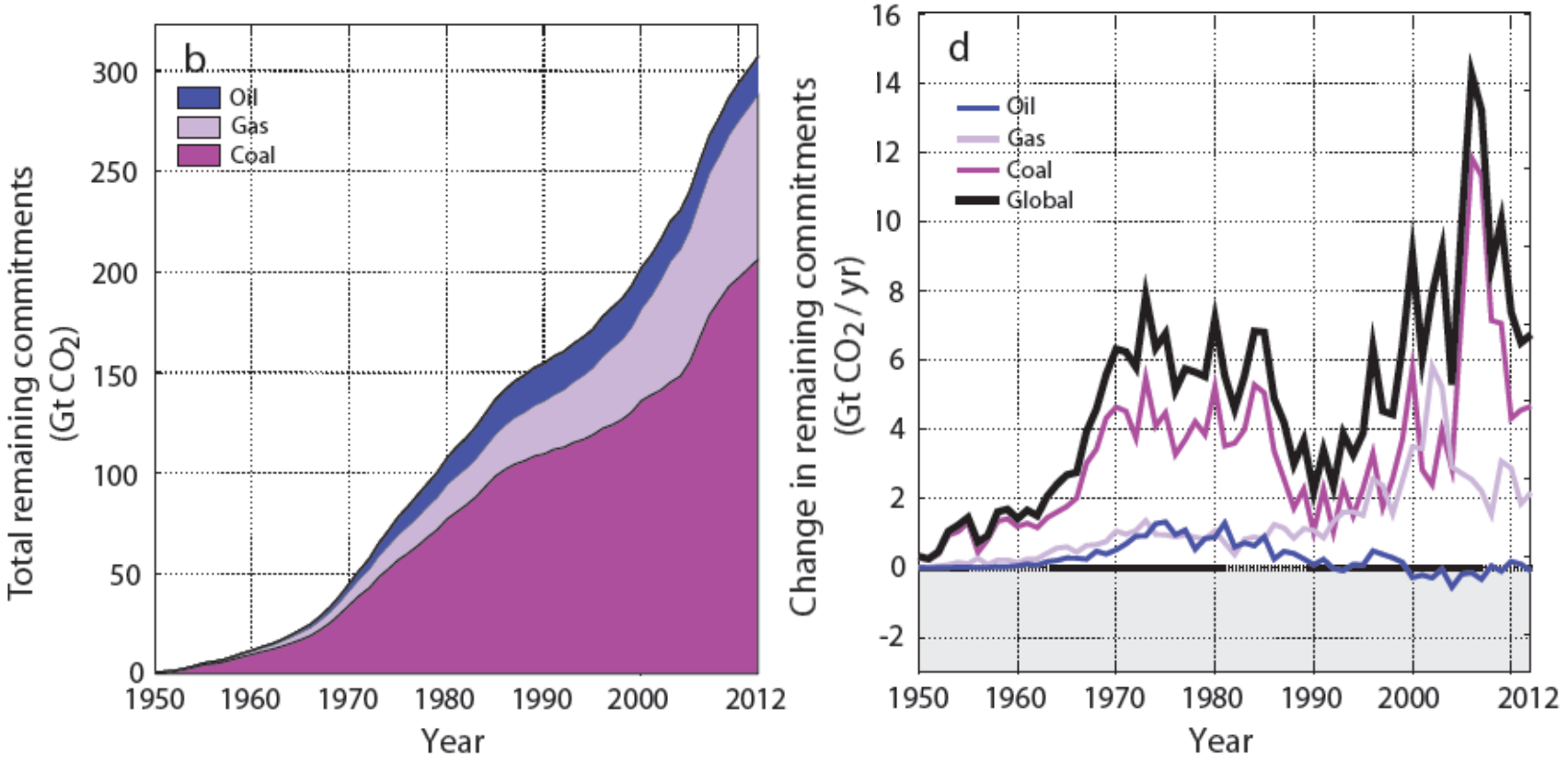




Global view of electric power from 2012 view. Assumed 40-year life for power plants, updated for retirements and plant-life extensions. Remaining emissions are 307 $GtCO_2$.

Source: **Davis** and Socolow, to be published

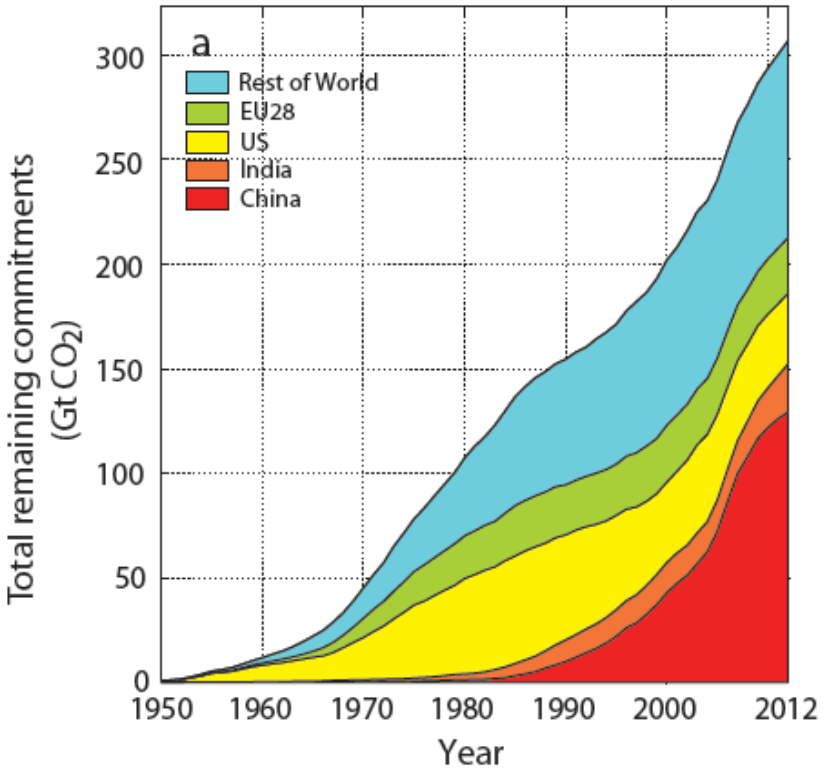
Committed emissions as of each year, 1950-2012, by fuel, power sector only

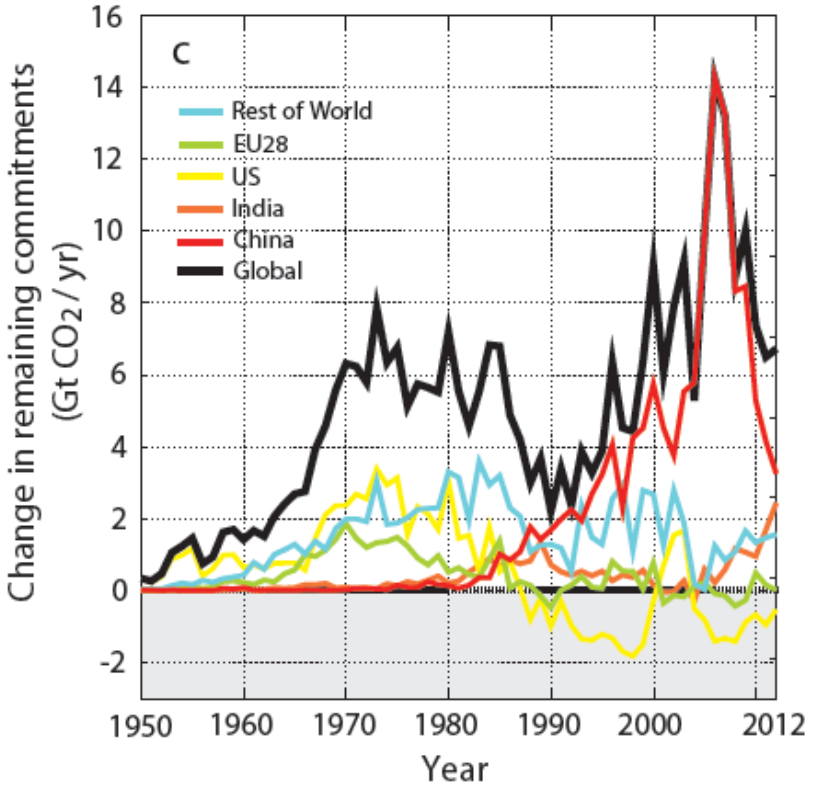


The China-coal peak in 2005 is distinctive, but annual net new commitments of 6 to 10 $GtCO_2$ are seen throughout 2000-2102.

Source: **Davis** and Socolow, to be published

Committed emissions as of each year, 1950-2012, by region, power sector only

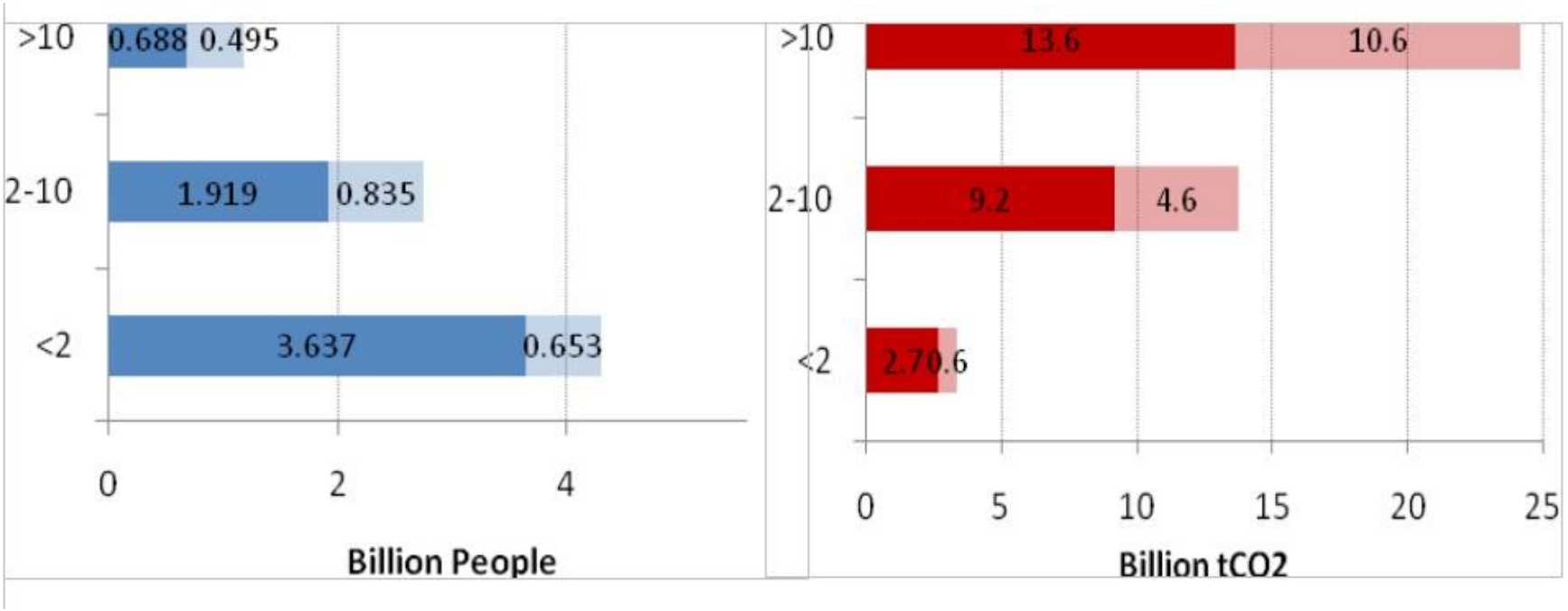




In 2012 China had half of the world's commitments, other developing countries had more than half, and the U.S. was disinvesting. Note the U.S. "rush to gas," 1998-2002.

Source: Davis and Socolow, to be published

Beyond per capita: the world's individual emitters



Population (left panel) and emissions (right panel). The dark and light parts of a bar shows 2003 emissions and additions from 2003 to 2030. Bin boundaries at 2 tCO_2/yr and 10 tCO_2/yr are approximately the 2003 per capita values for Brazil and the EU, respectively.

Totals	Billion people	$GtCO_2$
2003	6.2	26
2030	8.2	41

Source: Chakravarty, Socolow, and Tavoni, 2009. Figure 1.
http://www.climatescienceandpolicy.eu/2009/11/afocus-on-individuals-can-guide-nations-towards-a-low-carbon-world/

Post-post-colonial IAMs

The 1992 United Nations Framework Convention on Climate Change (UNFCCC), like many post-colonial international institutions, created two-tier behavior. "Annex I" expresses guilt and entitlement.

It is time for *post-post-colonial* institutions, which express the reality that all of humanity is in the same boat.

It is time for "authentic" analysis, rather than analysis that provides answered desired by sponsors in the industrialized world.

It is time for everyone to work incredibly hard to understand the potential for leapfrogging.

IAMs must confront constraints on pace

Every IAM must deal with the question of "pace" – how quickly change can occur.

History is useful: How quickly did automobiles to displace horses, and why neither faster nor slower?

Looking ahead: How quickly will we increase our understanding of how the earth works (climate science)? How quickly will human values change (diet, consumerism)?

*Modelers need to learn about, and model, what goes wrong when change is attempted too quickly.**

* In one mainstream IAM, in 2015–2020 a uniform price on biological and fossil fuel carbon of $\$16/tCO_2$ is imposed. As a result, in the same time step, forest area increases by one billion hectares (predominantly, in the tropics). Is such a pace credible?

IAMs must confront the price of biocarbon when food, oil and carbon are one system

Stock

Flow

If climate change matters most, a single price will apply to biocarbon and fossil carbon – with profound consequences. Uncertainties include yields, water demands, diet preferences, land tenure rights.

IAMs are remarkably casual about land-energy couplings.

The engineered earth

There are important uncertainties about the features of a fully engineered world. Serious risks are inherent in a world where:

- The well-being of every non-human species is subordinated.
- Extreme events are minimized.
- Instrumental values dominate completely.

IAMs must not hide the fact that we have no idea how technologies compete and how societies set priorities at $600/t$CO_2$

Increment from adding $600/t$CO_2$

Natural gas	**$33/1000scf**
Crude oil	**$260/barrel**
Coal	**$1400/U.S. ton**
Gasoline	**$5.20/gallon**
Electricity from coal	**48¢/kWh**
Electricity from nat. gas	**21¢/kWh**

"Indirect" CO_2 emissions associated with production and with transmission and distribution (or transport) are not included.

Disciplining future time

The durability of buildings, roads, pipelines, waste disposal facilities, managed forests and parks – all involve distant time horizons.

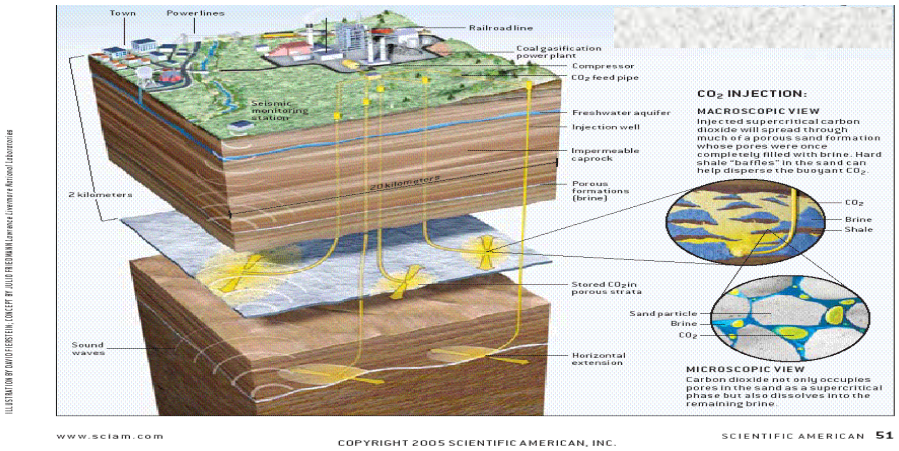
At present, there is little capacity to distinguish between our grandchildren's generation and more distant future generations.

What rate of leakage of sequestered CO_2 into the atmosphere is too fast? How about 0.1%/year?

First and third paragraphs: Socolow, *Vanderbilt Law Review,* 2012

Incoherence about future time

Dry-cask storage: a 100-year solution.



Permissible CO_2 leakage rate from a storage formation?

In a quest for ethically responsible nuclear waste disposal, policy-makers often use the half-lives of isotopes to establish the relevant time frames – notably, the half-life of plutonium-239, 24,100 years. Is this logic relevant for CCS?

Site: Surry station, James River, VA; 1625 MW since 1972-73,. *Credit*: Dominion.

Unknowability demands iteration

Given how much will be learned, bit by bit, it makes absolutely no sense that an optimal path will be one that is prescribed at *t = 0* and followed for a century.

The optimal task, surely, is *iterative risk management*. Modeling must explore what it means to revise frequently and to expect to be revising frequently.

Modelers need to learn about, and model, what goes wrong when change is attempted too quickly.

"Perfect foresight" is the single most wrong-headed assumption in IAMs.

Destiny Studies

In the past 50 years we have become aware of the history of our Universe, our Earth, and life.

Can we achieve a comparable understanding of human civilization at various future times: 50 years ahead – *vs.* 500 years and *vs.* 5000 years? Destiny Studies will address planning horizons, infrastructure, waste management….

IAMs will be key tools of Destiny Studies.