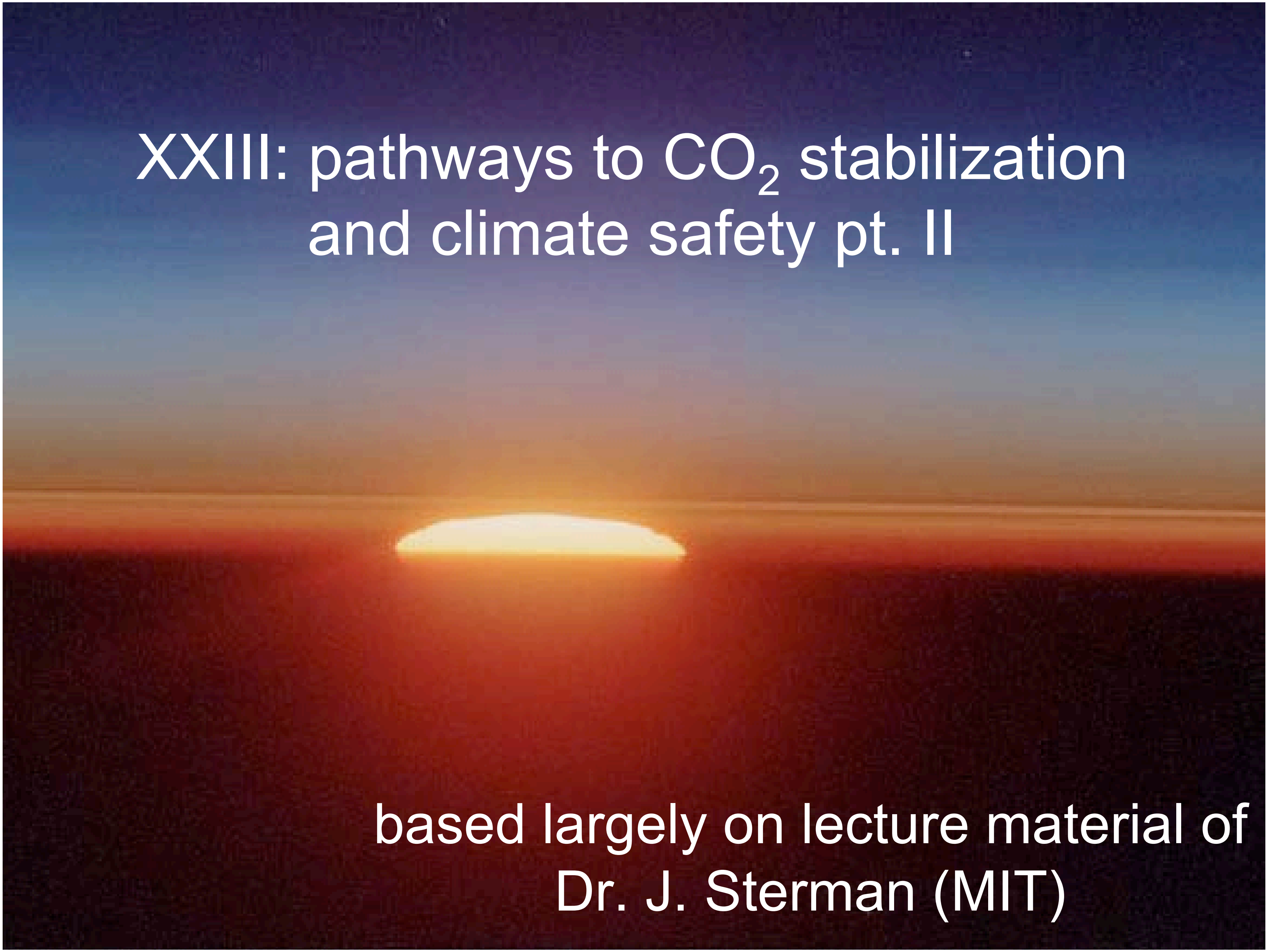

XXIII: pathways to CO_2 stabilization
and climate safety pt. II
based largely on lecture material of
Dr. J. Sterman (MIT)

review

- stabilization of the atmospheric CO_2 concentration at any level utlimately requires reduction and stabilization of C emissions at a level that matches net C sinks (i.e. must achieve *steady state*)
- any delay in reducing emissions requires steeper & deeper cuts later in order to achieve the same stabilization CO_2 conc.
- emissions reductions of ~60-80% by 2050 will be needed to stabilize CO_2 concentrations in the range of 4-500 ppm
- we can use a simple empirical approach to determine total allowable emissions for a given CO_2 stabilization cap (but this necessarily assumes no change in C-cycle feedback and may likely turn out to be too permissive)

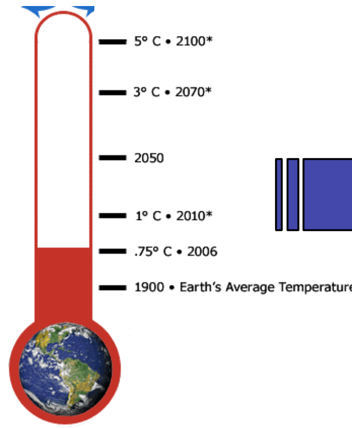
review

- Dr. Jim Hansen has proposed a prudent CO_2 cap of ~350 ppm, based largely on the fact that deleterious and possible irreversible impacts are already underway (at 385 ppm)
- phase-out of any coal power that does not include CCS by 2030 is necessary if we are to achieve CO_2 stablilization at or below 425 ppm
- other measures necessary to reach a lower target
- the wedge concept provides a piece-wise mechanism for filling the gap between BAU economic growth and a flat emissions that makes use of existing technologies (and upscaling) which buys 50 yrs in order to develop and deploy new energy technologies needed to stabilize CO_2 (at 500 ppm)
- *no matter what the cap, we know the necessary emissions trajectory! (that'd be downward…)*

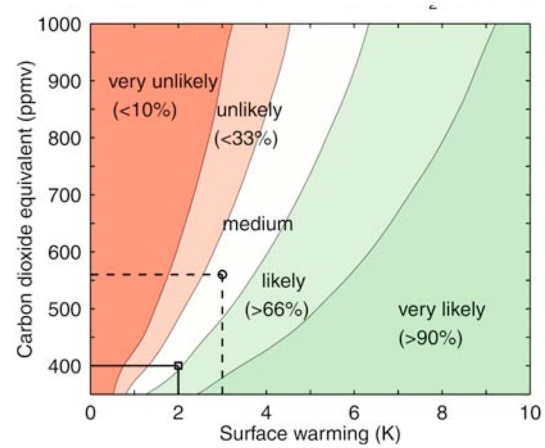
logical flow chart (according to me)

unacceptable impacts

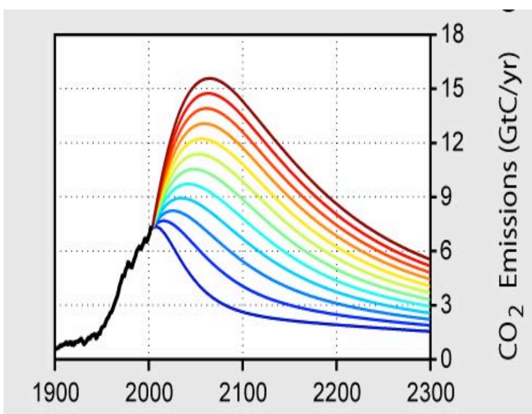
assoc. warming limit



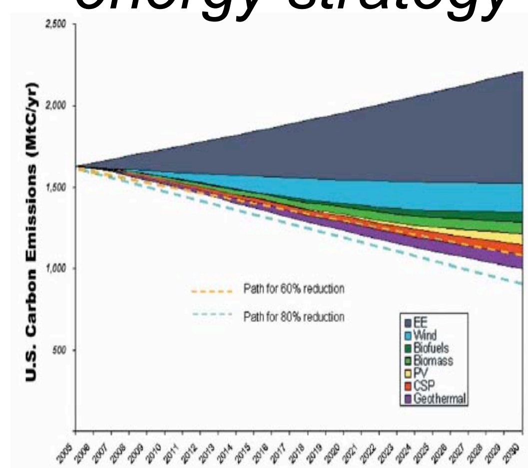
assoc. CO_2 cap



emissions pathway

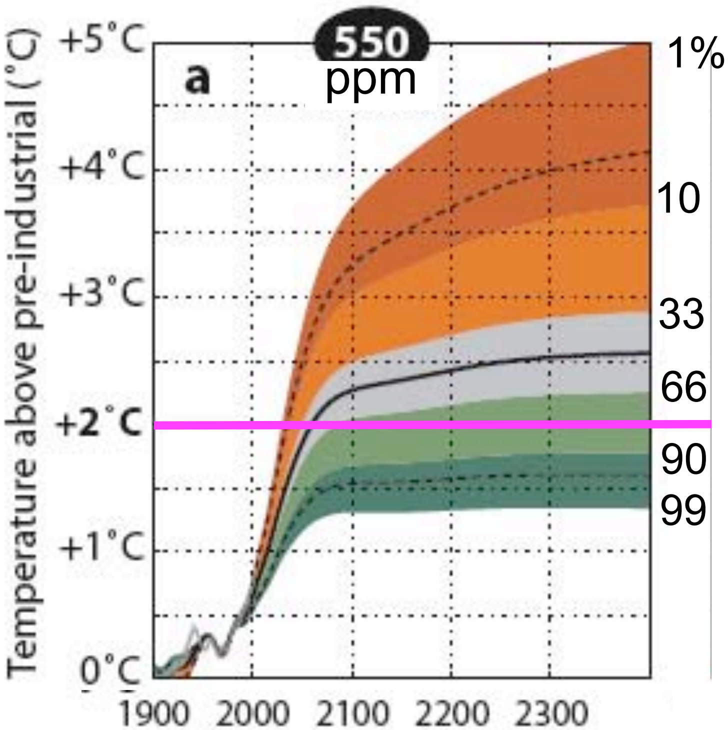


energy strategy



accommodates population and economic growth

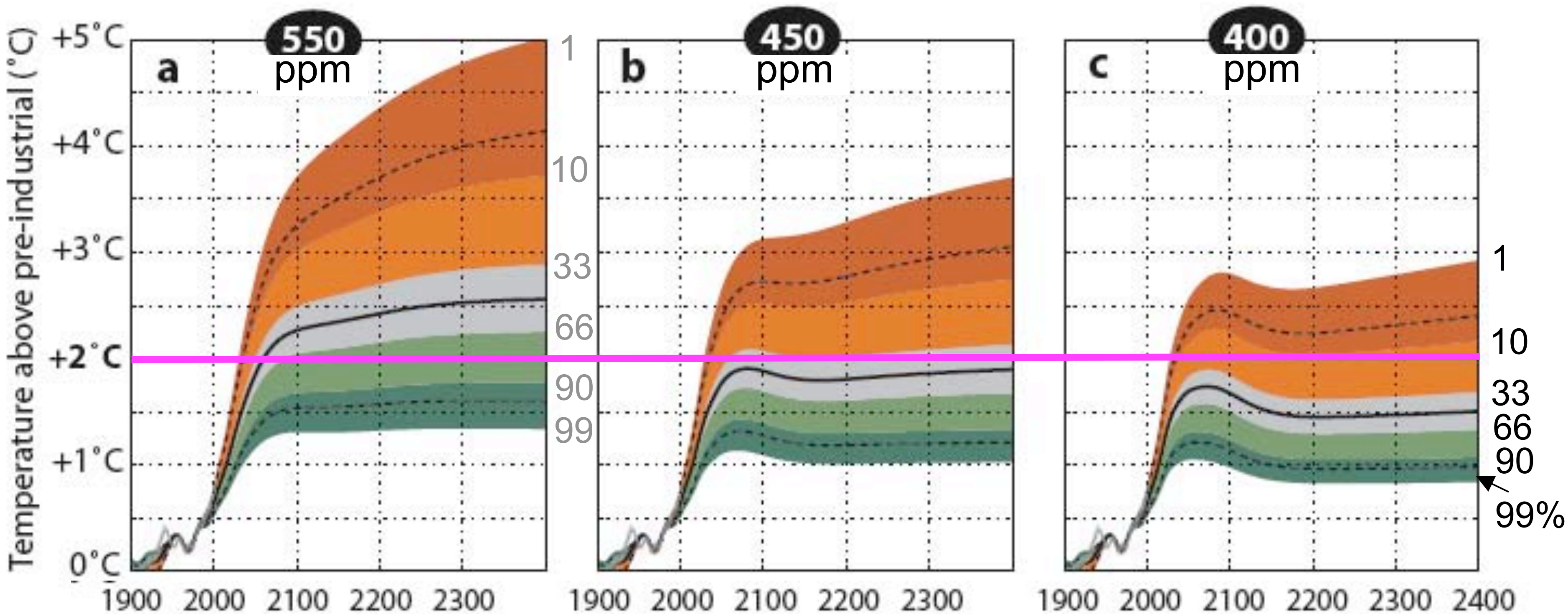
risk of overshooting 2 °C for given stabilization CO_2 concentration



this figure shows range of predicted temperatures and their probability of occurring for a CO_2 trajectory headed to stabilization at 550 ppm- risk of exceeding 2 °C is between 90 and 66%.... probability is based on multiple model runs with successful hindcasts...

Meinshausen et al. 05

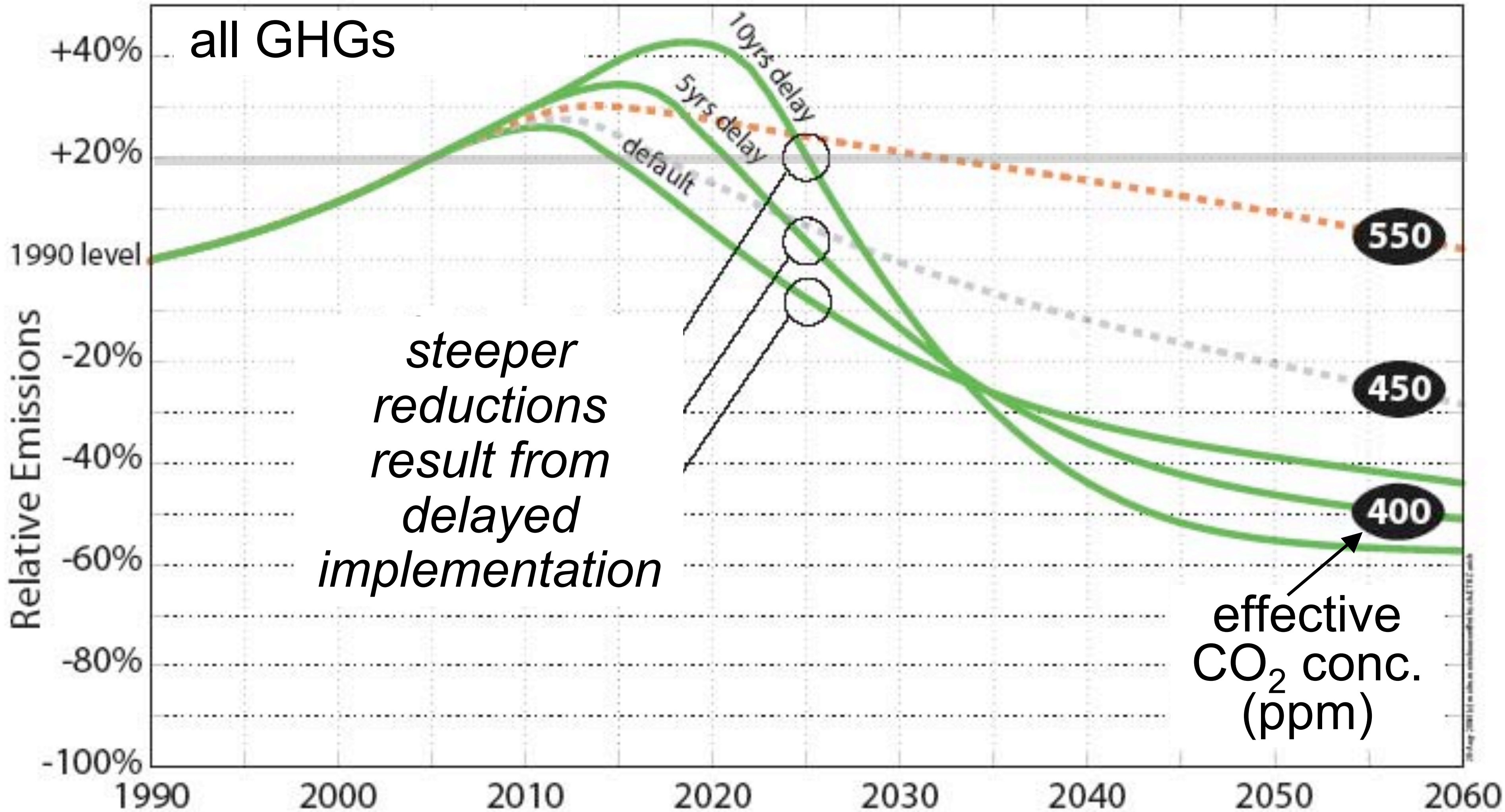
risk of overshooting 2 °C for given stabilization CO_2 concentration



same as preceding slide but with 2 additional CO^2 stabilization trajectories considered.... if 2 °C were to be taken as the global "harm threshold" then we might want to stabilize CO_2 at 400 ppm in order to avert harm with a high degree of certainty

Meinshausen et al. 05

emissions pathway to stabilize at +2°C



reductions of 60-80% (v. 2005) by 2050 needed to avoid 2 °C total warming with high confidence- any delay will eventually require steeper cuts

Meinshausen et al. 05

outline

- why the delay between acknowledgment of the climate problem and decisive action?
- Prof. J. Sterman, MIT lecture (first 10 mins.)
- over the tipping point (markets)
  - *finally a "positive" positive feedback*
- an "America leads" solution
  - *US has highest emissions so more and easier savings possible*
  - *technologies ready to be deployed at needed scale*
  - *meet global leadership obligation (China/India and others follow)*
  - *elevate world status ("Green Geopolitics")*
- discussion

the challenge

- satisfying the global energy demand while reducing emissions to a safe level is the science, engineering and social problem of the century (millennium?) (M. Hoffert), but…
- progress is hampered by public perception and lack of leadership
- “there is a gap between what is understood and what is known” (J. Hansen)
- the public view (“wait and see”) is not consistent with the real nature of the problem (J. Sterman)
  - “wait and see” OK if time delays in social and physical system are small
  - and damage is reversible (no inertia or tipping point behavior)

Prof. John Sterman lecture

- expert on dynamical systems theory at Sloan School of Management, MIT
- takes on some prevailing myths…
- (we'll see ~ first 10 mins. only)

lecture is here:

http://dotearth.blogs.nytimes.com/2009/01/28/the-greenhouse-effect-and-the-bathtub-effect/?hp

Myth no. 1

public perception

Wait and see is prudent, ***if:***

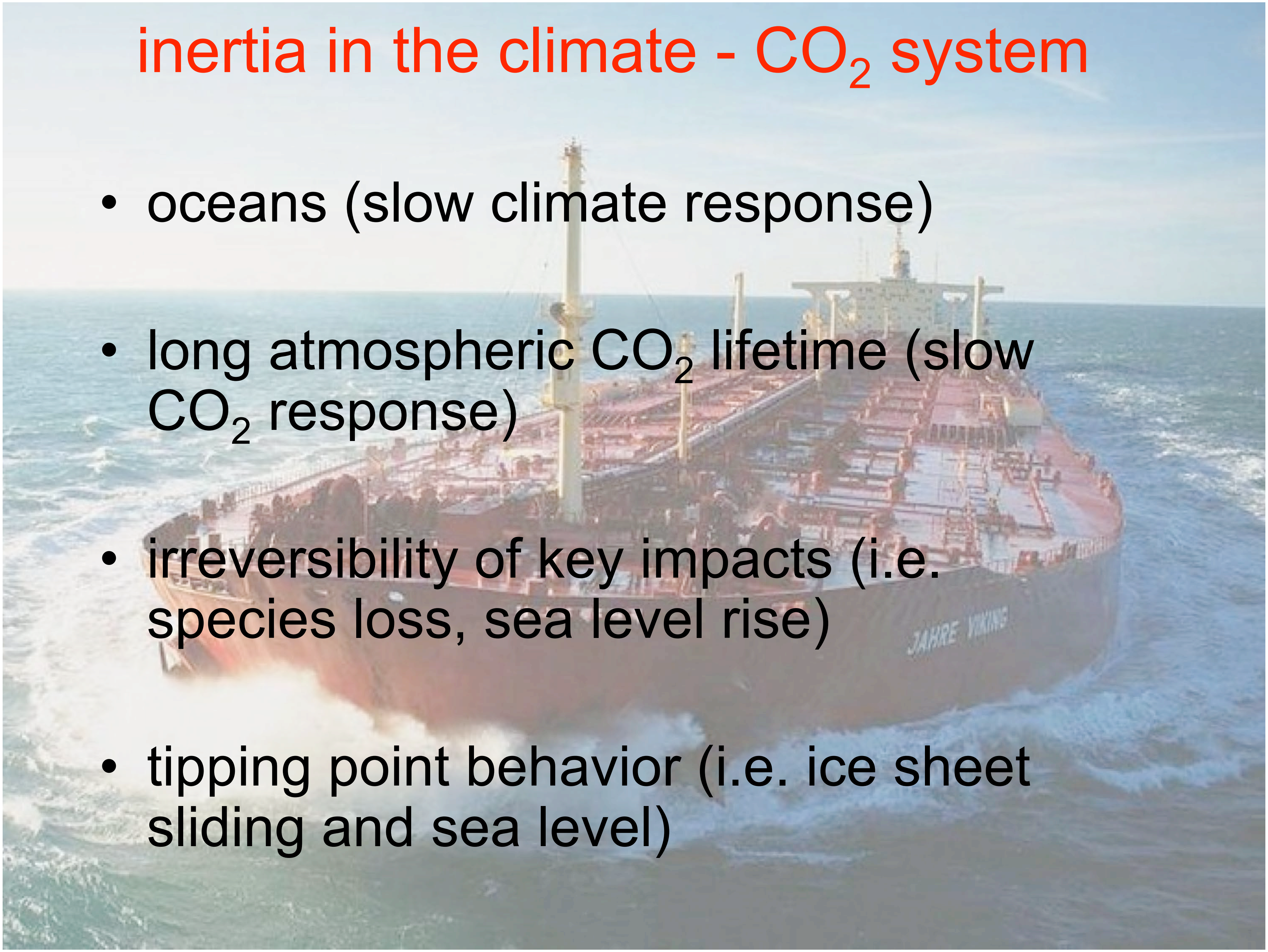
- Short delays between
  - scientific knowledge of the threat and public pressure for action
  - public pressure and policy change
  - policy change and emissions reductions
  - emissions reductions and climate response
- Damage is readily reversed

"But absolutely none of this is true.."

Prof. John Sterman, MIT

inertia in the climate - CO_2 system

- oceans (slow climate response)
- long atmospheric CO_2 lifetime (slow CO_2 response)
- irreversibility of key impacts (i.e. species loss, sea level rise)
- tipping point behavior (i.e. ice sheet sliding and sea level)



Tipping Point Definitions

1. **Tipping Level**

   - Climate forcing (greenhouse gas amount) reaches a point such that no additional forcing is required for large climate change and impacts

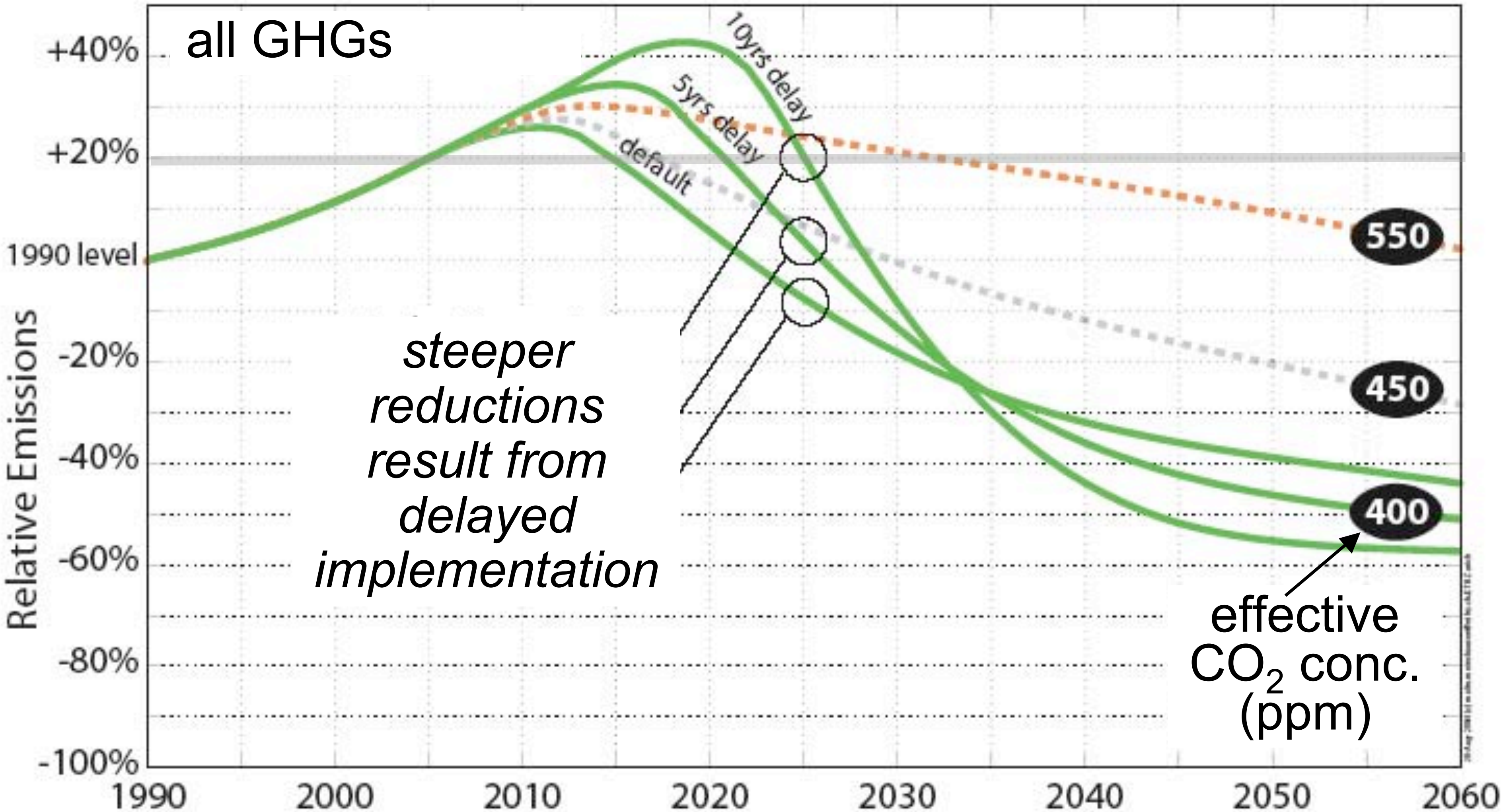
2. **Point of No Return**

   - Climate system reaches a point with unstoppable irreversible climate impacts (irreversible on a practical time scale) Example: disintegration of large ice sheet

from J. Hansen

Myth no. 2

emissions pathway to stabilize at +2°C



reductions of 60-80% (v. 2005) by 2050 needed

looks difficult and expensive…

Meinshausen et al. 05

important to do
but won’t it hurt the economy?

- “responding to climate change is just too expensive”
- “it will slow economic growth and cost jobs”
- “it will put our country at a competitive disadvantage”

(true?)

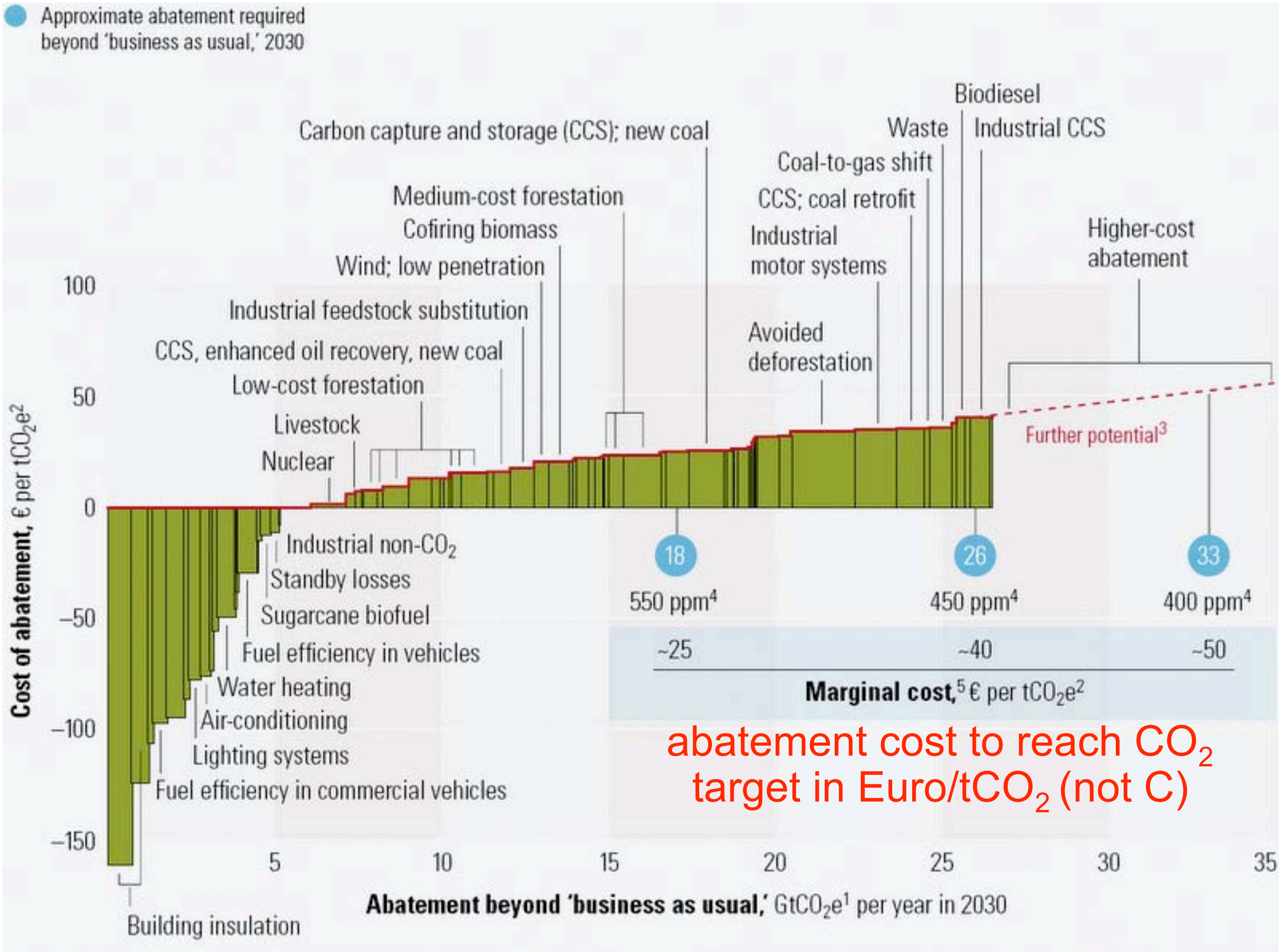
Prof. John Sterman, MIT

the climate dividend

- cutting GHGs puts $$$ in our pockets
  – cuts oil imports ($500 billion/yr @ $90/barrel)
  – reduce need to defend insecure supplies
  – reduce other harmful pollutants and their health costs, saving lives and $$$ while improving quality of life
- investing in emissions reductions
  – stimulates innovation and new businesses that enhance competitiveness and create jobs
  – creates opportunity for global leadership in emerging critical technologies
  – getting cheaper every day

Prof. John Sterman, MIT

cost of GHG abatement

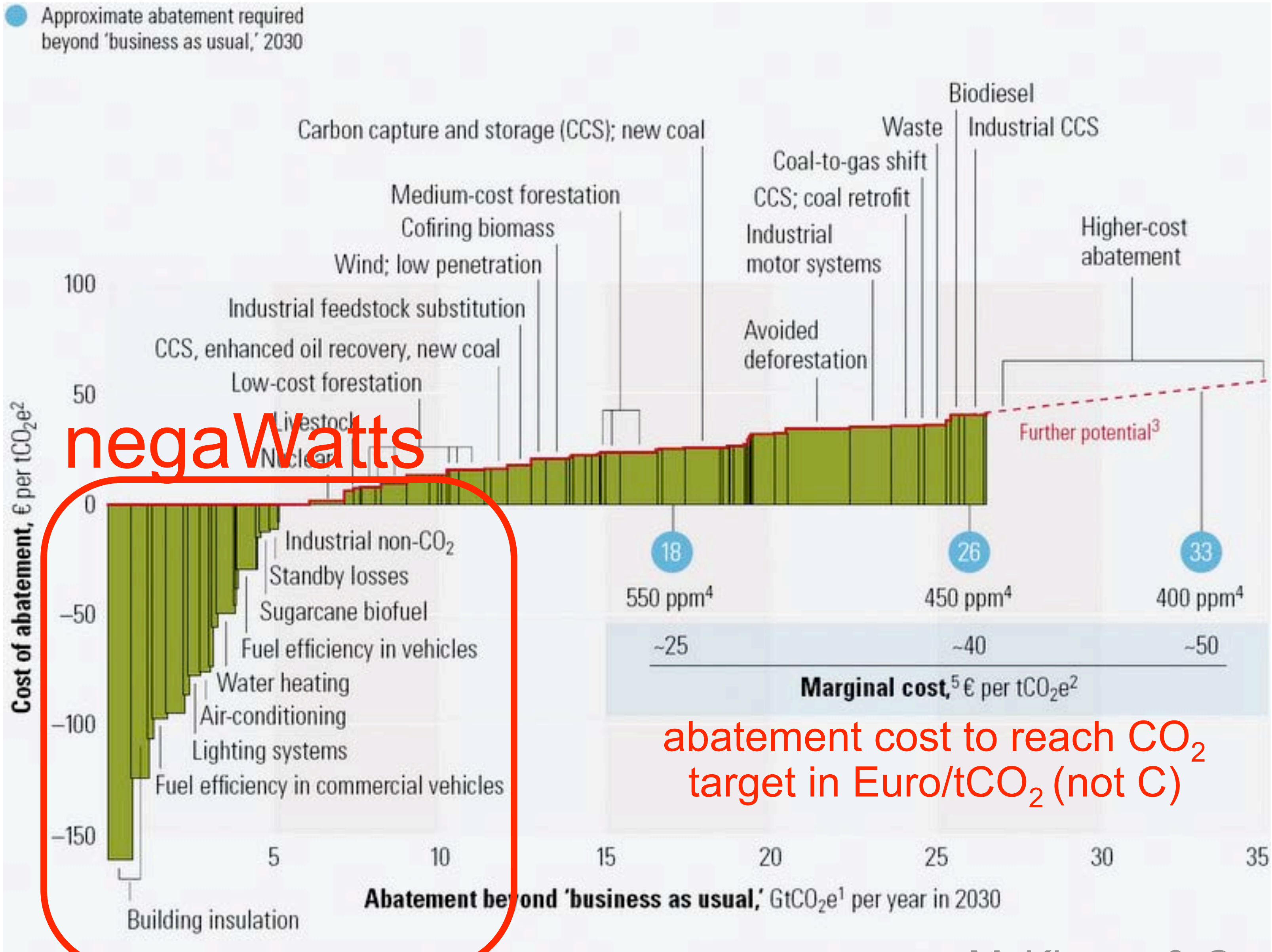


abatement cost to reach CO_2 target in Euro/tCO_2 (not C)

considers mechanisms up to ~40 euro/tCO2

McKinsey & Co. 2007
J. Sterman lecture

cost of GHG abatement



many examples of negative abatement cost

McKinsey & Co. 2007
J. Sterman lecture

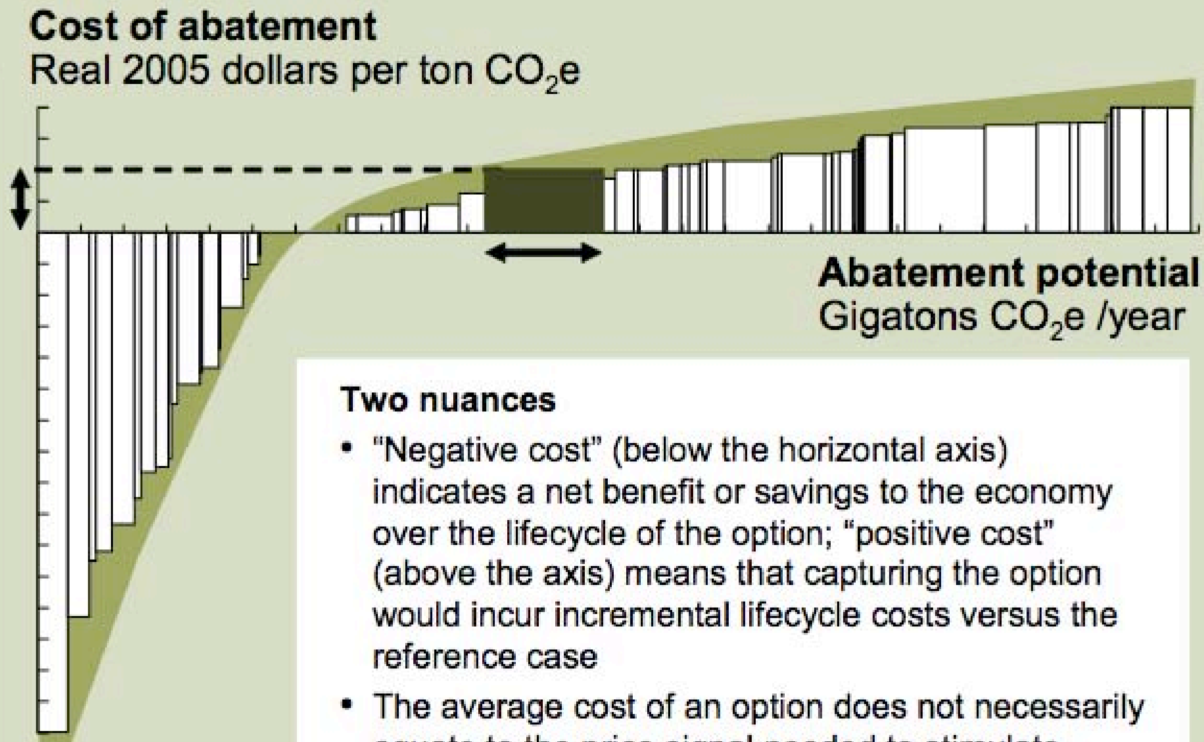
cost of GHG abatement

How to read an abatement curve

Two dimensions

Each bar represents one option or a group of closely related options (e.g., "improvements to residential buildings")

- Width: amount of CO_2e that can be reduced annually by means of this option
- Height: average cost of avoiding 1 ton CO_2e with this option, as measured against emissions reference case. Cost is averaged across sub-options, regions, and years

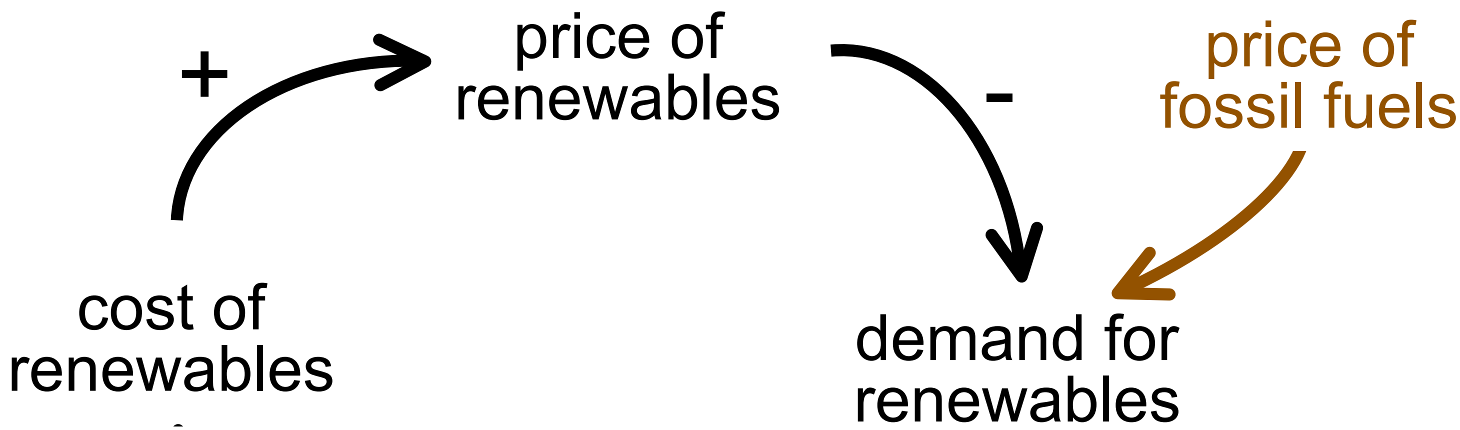


Two nuances

- "Negative cost" (below the horizontal axis) indicates a net benefit or savings to the economy over the lifecycle of the option; "positive cost" (above the axis) means that capturing the option would incur incremental lifecycle costs versus the reference case
- The average cost of an option does not necessarily equate to the price signal needed to stimulate capture of that option

McKinsey & Co.

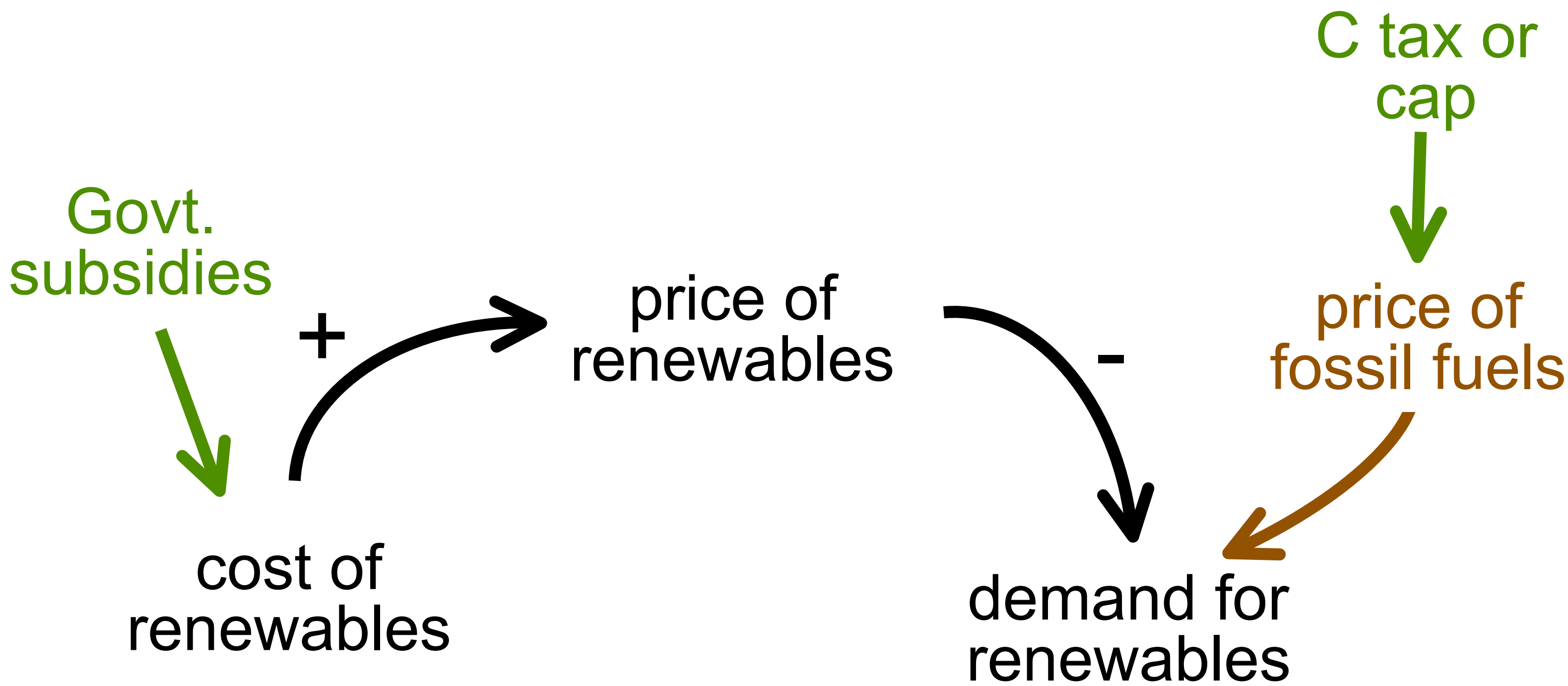
over the tipping point



“demand for renewable energy is low because it ought to be”, i.e. because of cost competition from fossil fuels (which are improperly priced…)

Prof. John Sterman, MIT

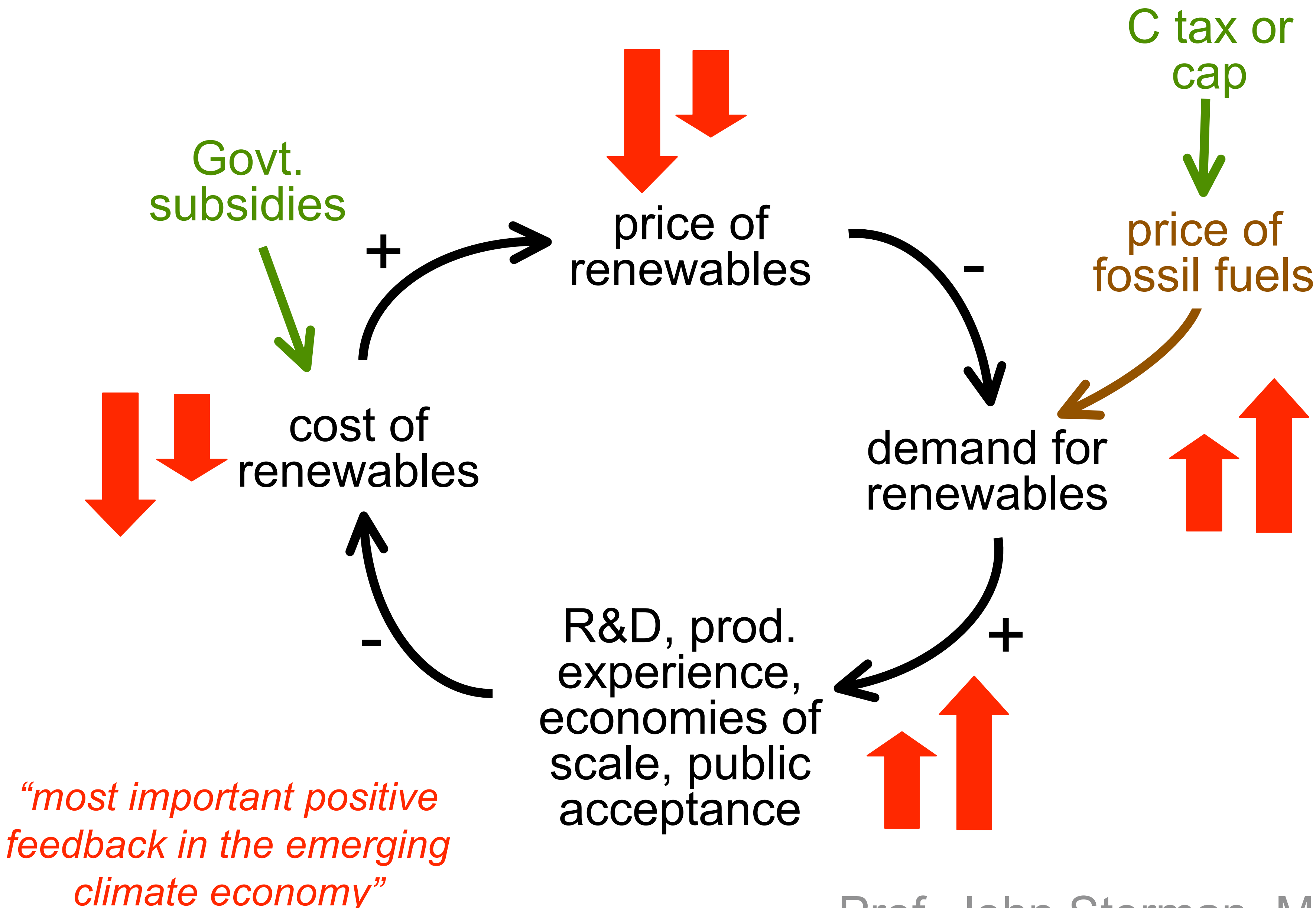
over the tipping point



There are two options available to relieve what is otherwise a market failure…

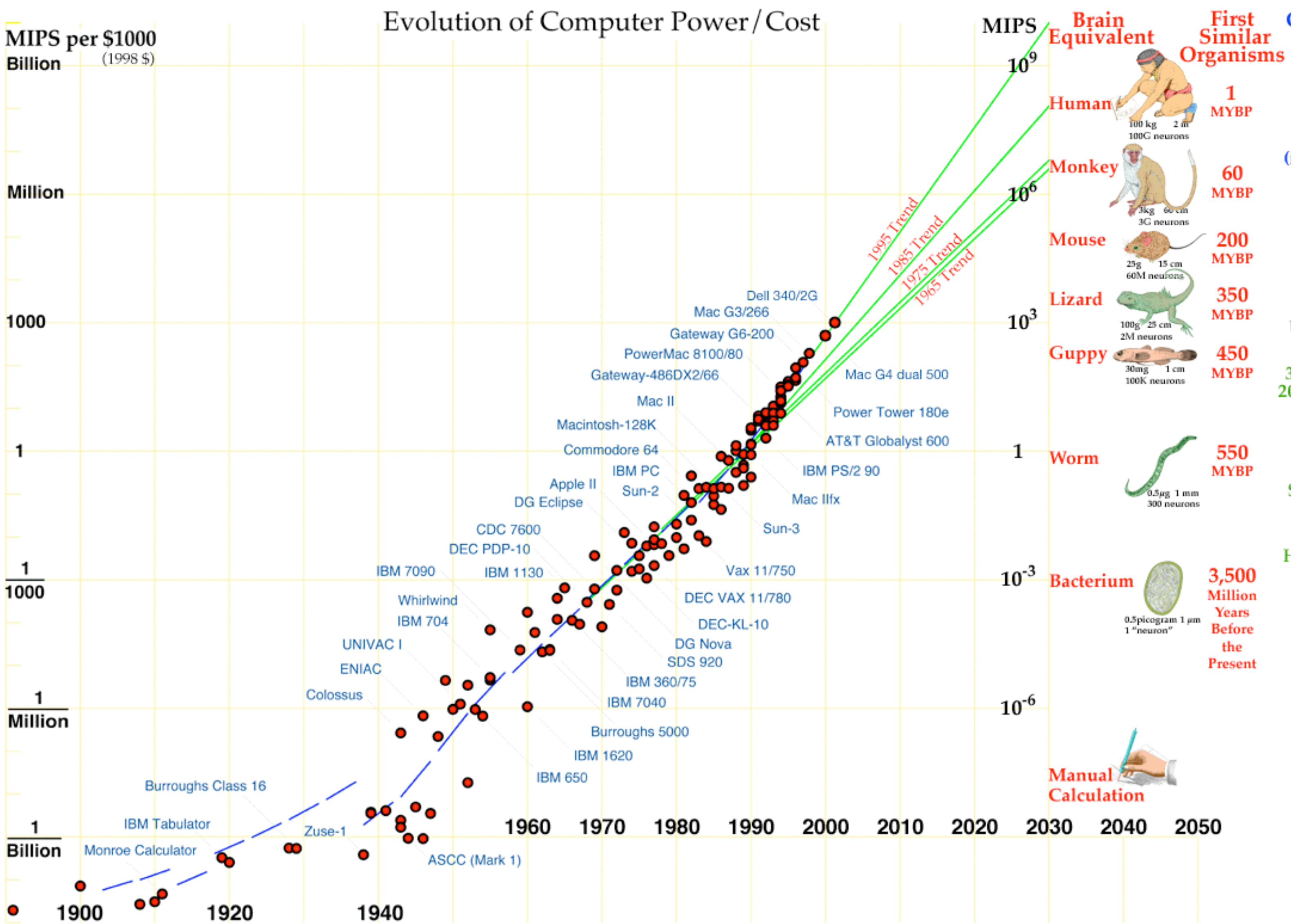
Prof. John Sterman, MIT

over the tipping point



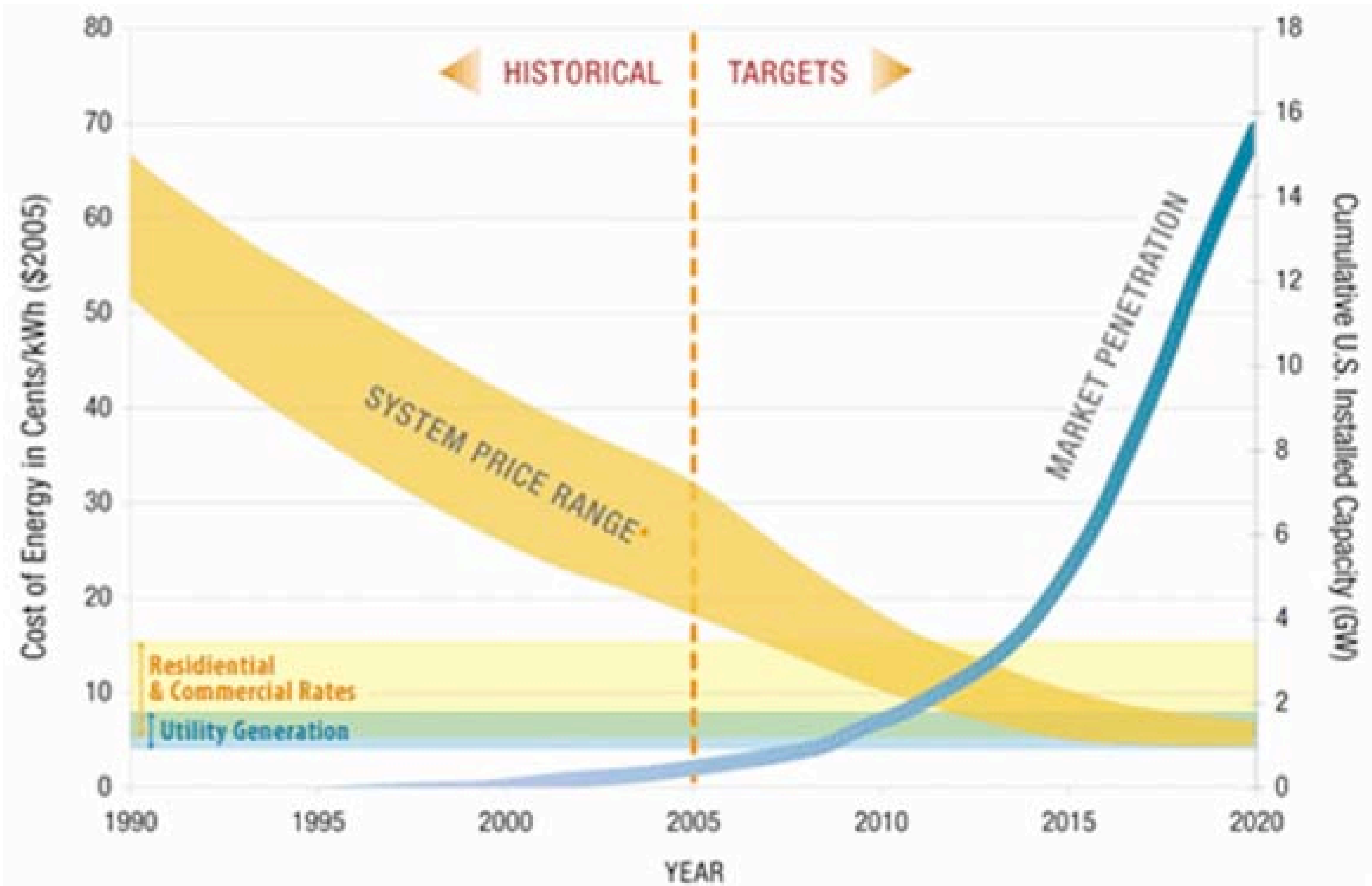
Prof. John Sterman, MIT

over the tipping point



example of logarithmic growth in available computing power (per $)

cost of solar electricity (PV)



analogous reduction of cost and increase in market penetration for PV can be expected?

and besides…..

- we will need to move beyond fossil fuels anyway…

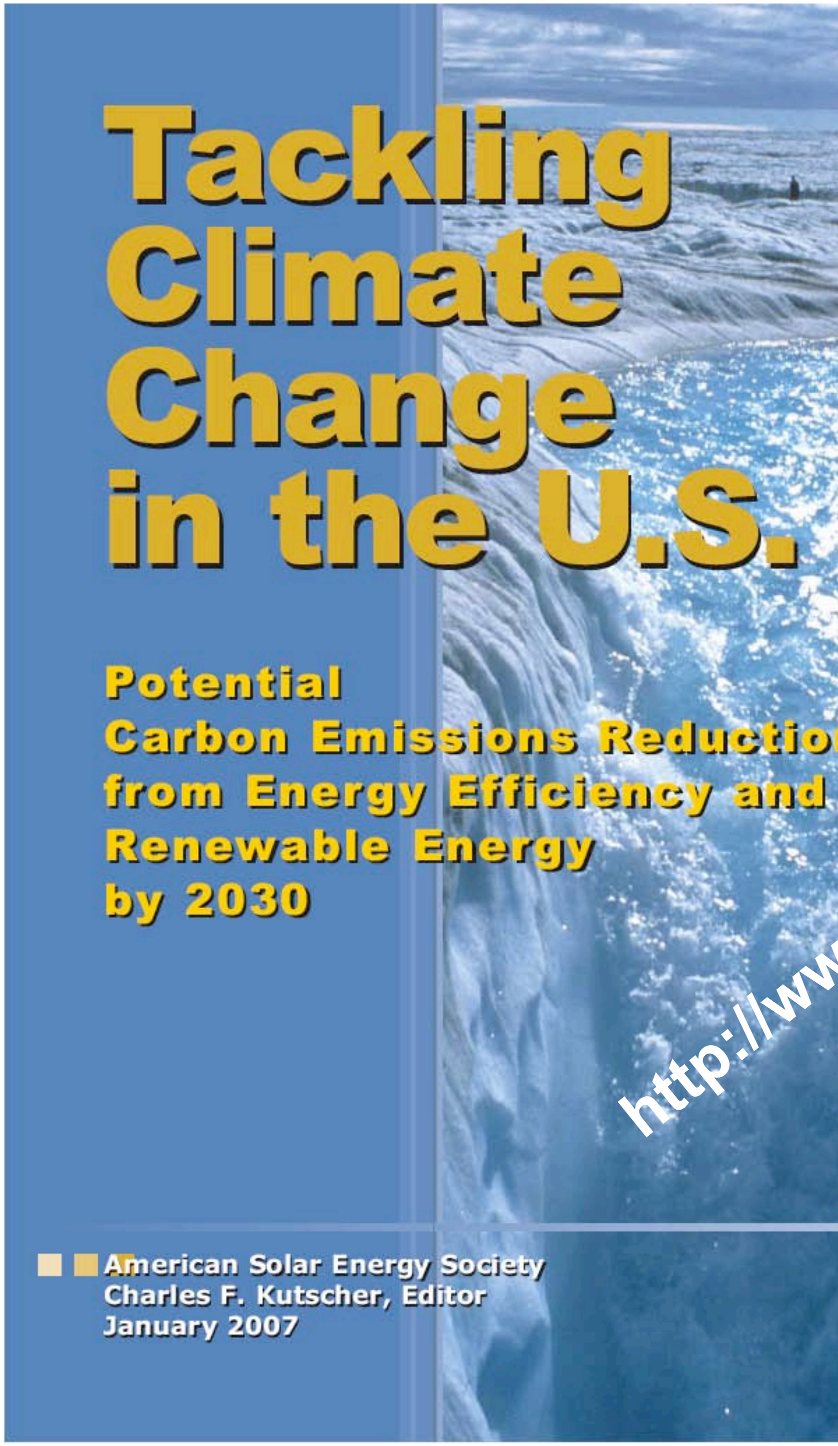
- why not do it now?

- to preserve “creation”…

J. Hansen

an “America leads” action plan

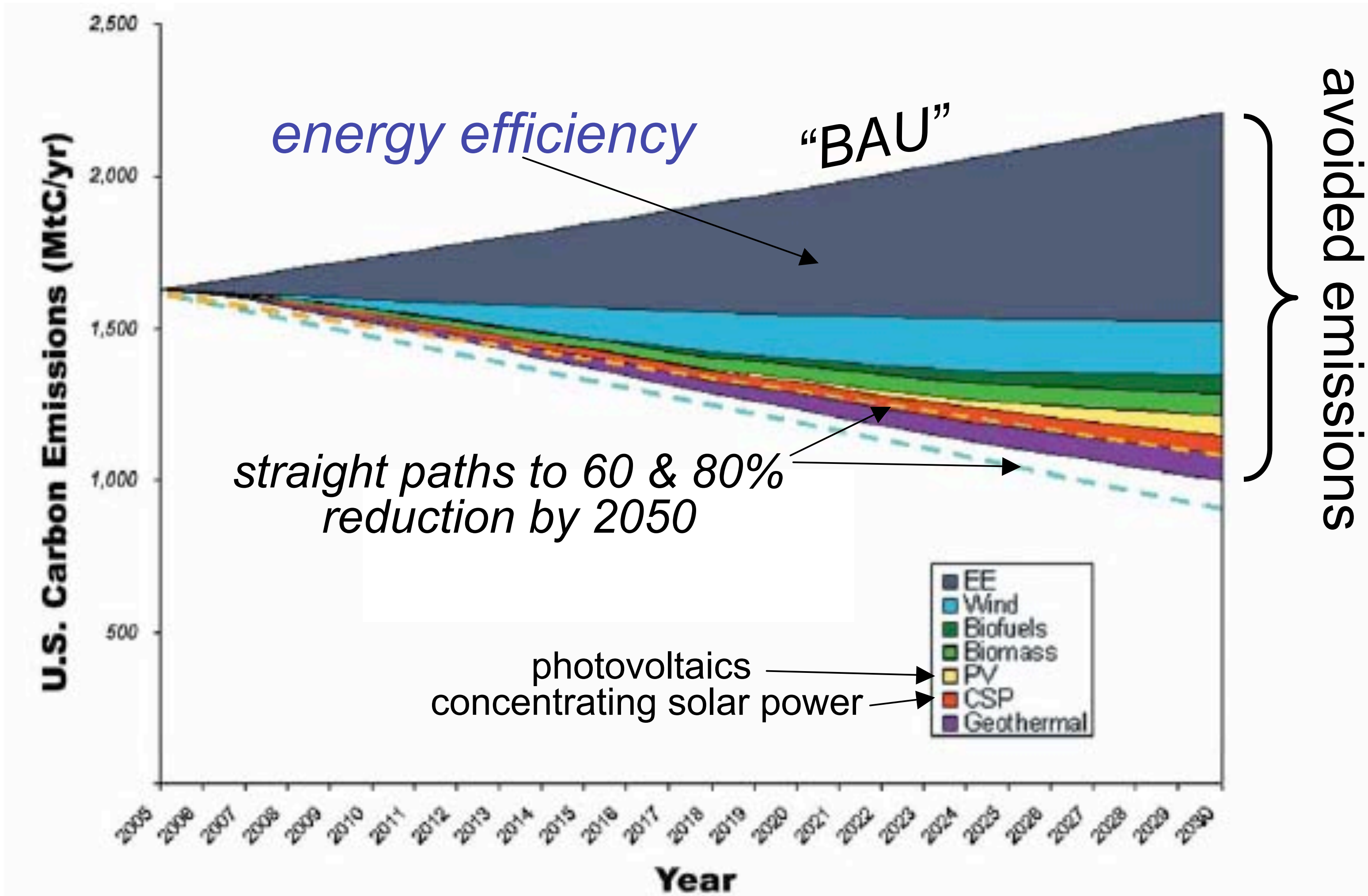
- ***US leads by reducing its emissions 60-80% by 2030 (that is, we share in meeting the global target)***



http://www.ases.org/climatechange/

Energy efficiency and renewable energy technologies have the potential to provide most, if not all, of the U.S. carbon emissions reductions that will be needed to help limit the atmospheric concentration of carbon dioxide to 450 to 500 ppm.

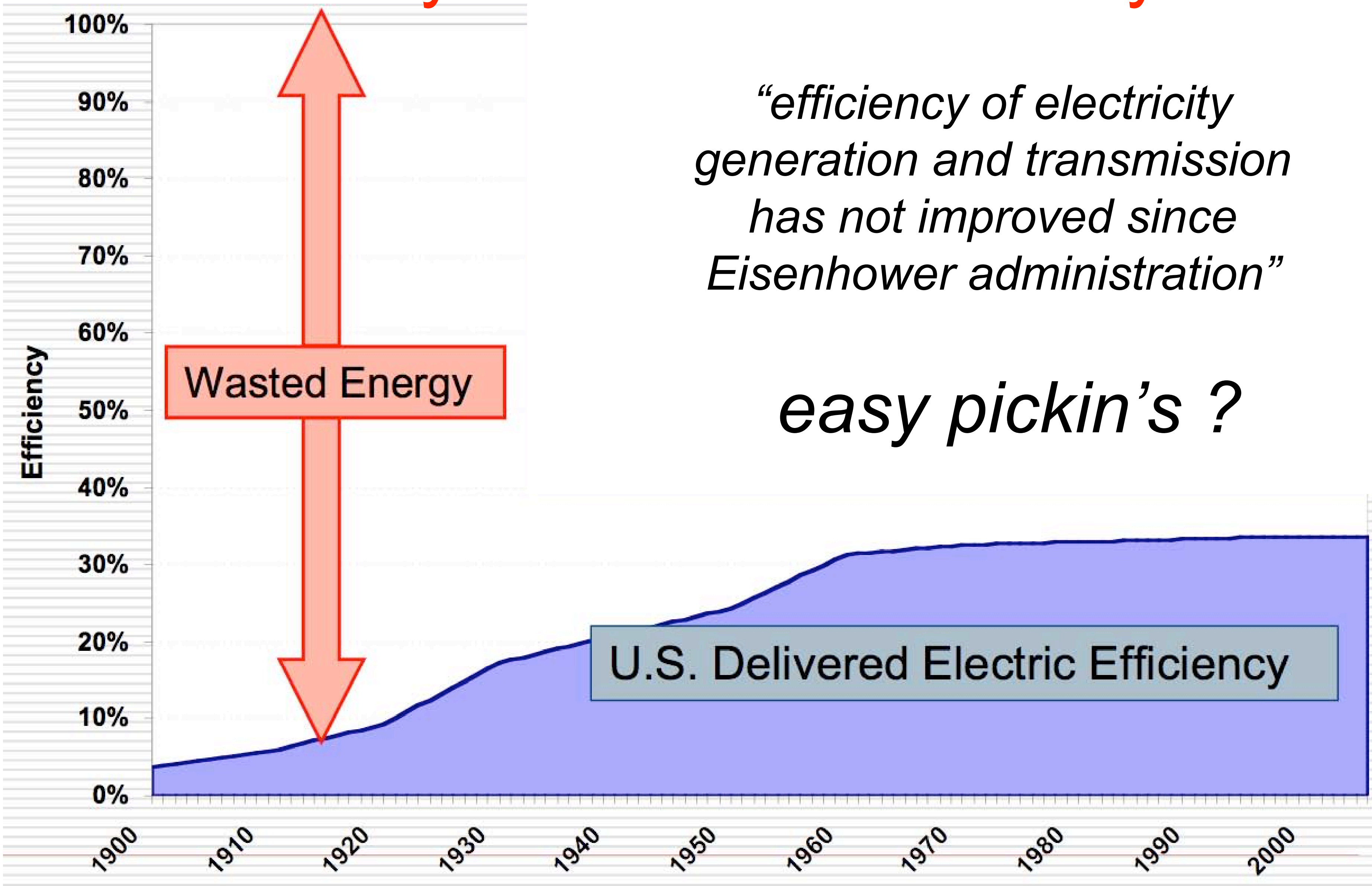
an "America leads" action plan



deployable US technologies and efficiencies compared to path for 60% and 80% reduction in US emissions

from Tackling Climate Change in the US 2007

efficiency of delivered electricity

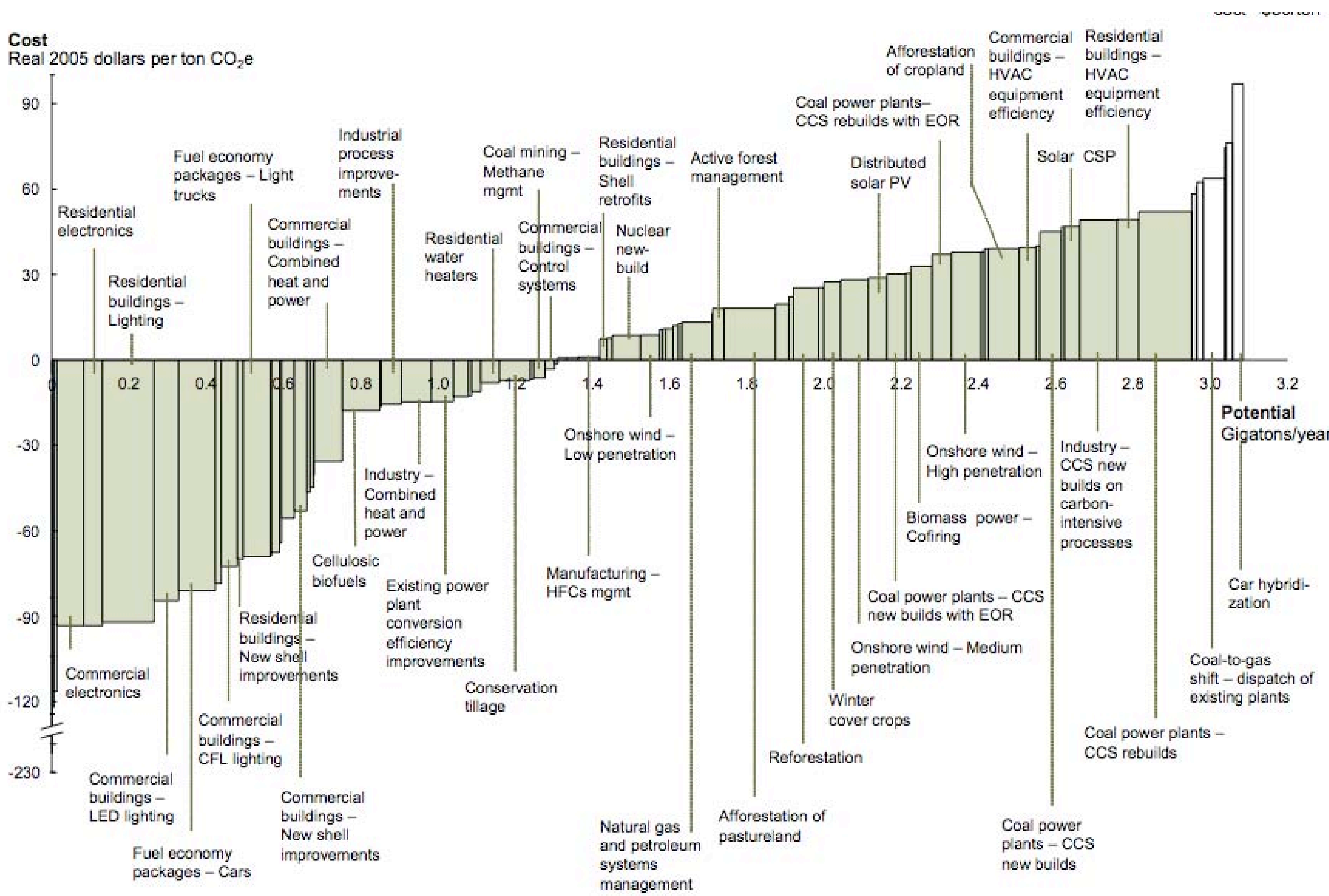


"efficiency of electricity generation and transmission has not improved since Eisenhower administration"

easy pickin's ?

slide from T.R. Casten in J. Sterman lecture

US mid-range abatement curve 2030



This mid-range case is for "concerted action across the economy" and considers abatement measures costing up to \$50/ton CO_2. The first ~1.5 Gt CO_2 per year by 2030 have negative abatement costs.

McKinsey & Co.

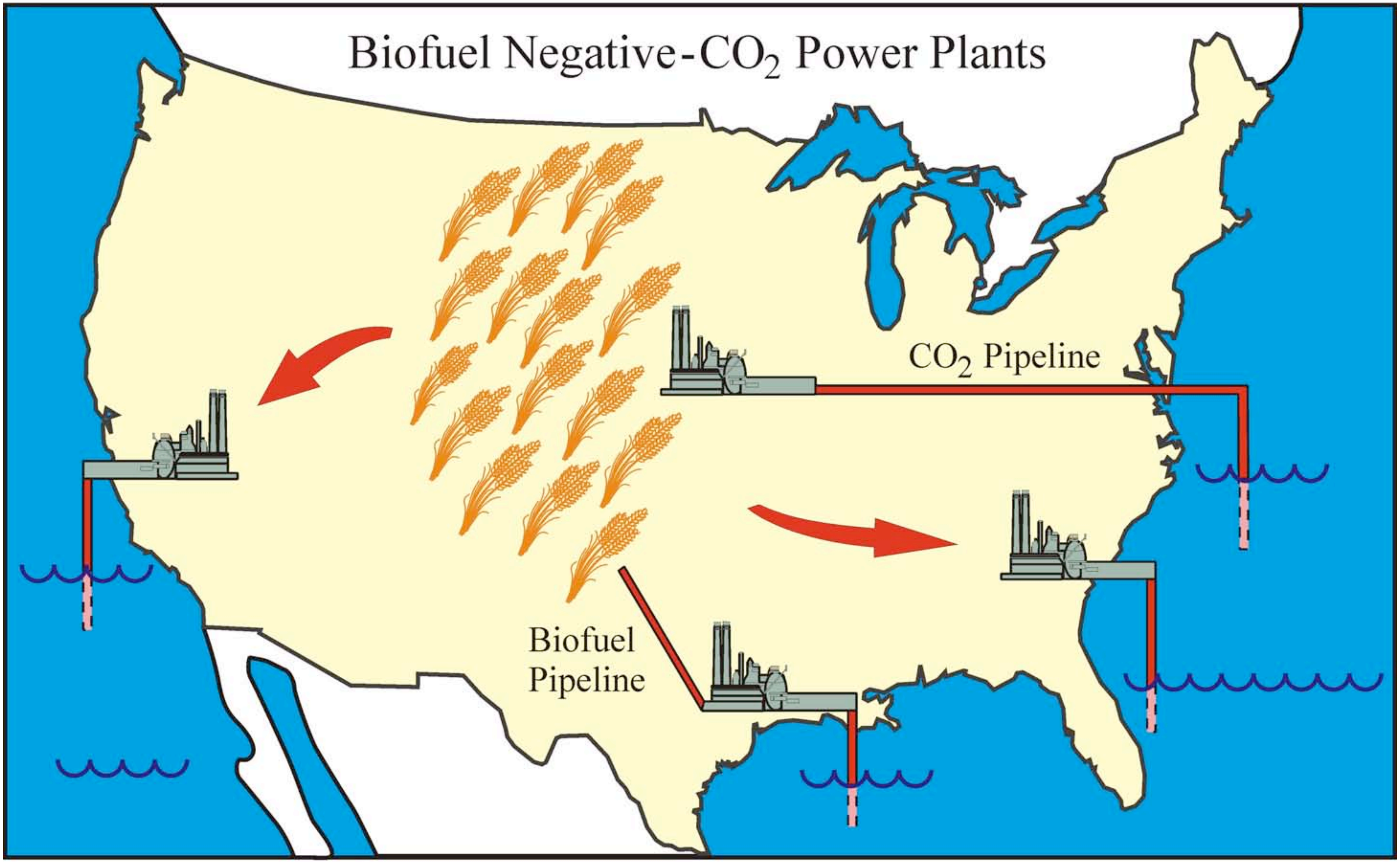
an “America leads” action plan

US leads by reducing its emissions 60-80%

why should America lead?

- because only we can (world will not follow otherwise)
- high emissions now translate to large, rapid initial reductions thru efficiency alone (pain-free)
- needed technologies developed and available
- serves many interests
  - environment
  - security
  - good for business long term (according to GE, Dupont, Alcoa *et al.* ....)
  - standing in global community
- developing economies looking for leadership, “leap-frog” technology (and financing)

Red, White & Blue Solution



Cellulos ic Biofuels Electrical Power Generation
Fail-Safe CO_2 Sequestration in Deep-Sea Sediments

J. Hansen

key points

- there is widespread agreement that stabilization of the atmospheric CO_2 concentration at any "safe" level requires reduction (and then stabilization) of C emissions
- despite this understanding, and the known urgency of the climate change problem, there has been little meaningful policy or regulatory response
- delay in policy response is symptom of weak leadership on the issue and a widely held public view that tackling the climate change problem will hurt the economy
- MIT's John Sterman argues that this has led public to "wait and see" approach to climate change problem
- Sterman argues that this is only reasonable if there are small delays between understanding, policy actions, emissions reductions, and CO_2 and climate responses, and that damage is reversible
- the public needs to understand that none of this is true
- a number of economically viable emissions abatement options are available (given as "abatement cost curves")
- the US can reduce its emissions substantially via (largely cost-saving) efficiency measures alone
- this is a leadership opportunity

learning goals

- be able to describe an emissions pathway to CO_2 stabilization at 400 or 500 ppm and the consequences of delayed action on the pace of emissions reductions required later on
- be able to explain the origin of the delays in the climate system between the start of any emissions reductions and the eventual CO_2 and climate responses
- be able to describe tipping point behaviors
- be able to describe some opportunities for emissions abatement and their costs (i.e. whether positive or negative) and be able to read an emissions abatement cost curve
- be able to describe a positive feedback in the market place that might assist an abatement effort

next

- *deconstructing the "Great Global Warming Swindle" (in 2 acts)*
- *carbon policy discussion*