15.023J / 12.848J / ESD.128J Global Climate Change: Economics, Science, and Policy
Spring 2008

Climate Policy Analysis

- What long-term stabilization target?
- How strong a mitigation effort to undertake NOW?
  - Quantity target, say for 2008-2015?
  - Social cost of carbon?
- Need more information?
  - What specifically?
  - How to frame the issue for public/policy discussion?

Path for Today

- Structure of the assessment task
  - The handling of uncertainty
  - Representation of decision-making process
  - Areas of policy choice
- Examples under Certainty
  - Benefit-cost analysis
  - Cost-effectiveness analysis
  - Tolerable windows analysis
- Examples under Uncertainty (preview)
  - Probabilistic forecasts
  - Sequential decision

Certainty vs. Uncertainty

- Assuming certainty
  - Once-and-for-all decision now
    - Near-term choice (*e.g.*, Kyoto-type analyses)
    - Path over time (*e.g.*, B/C, stabilization studies)
- Considering uncertainty
  - Once-and-for-all decision now
    - Scenario analysis
    - With probability distributions
  - Sequential choice, with learning

How important to include uncertainty?

Representation of the Decision-Maker or Process

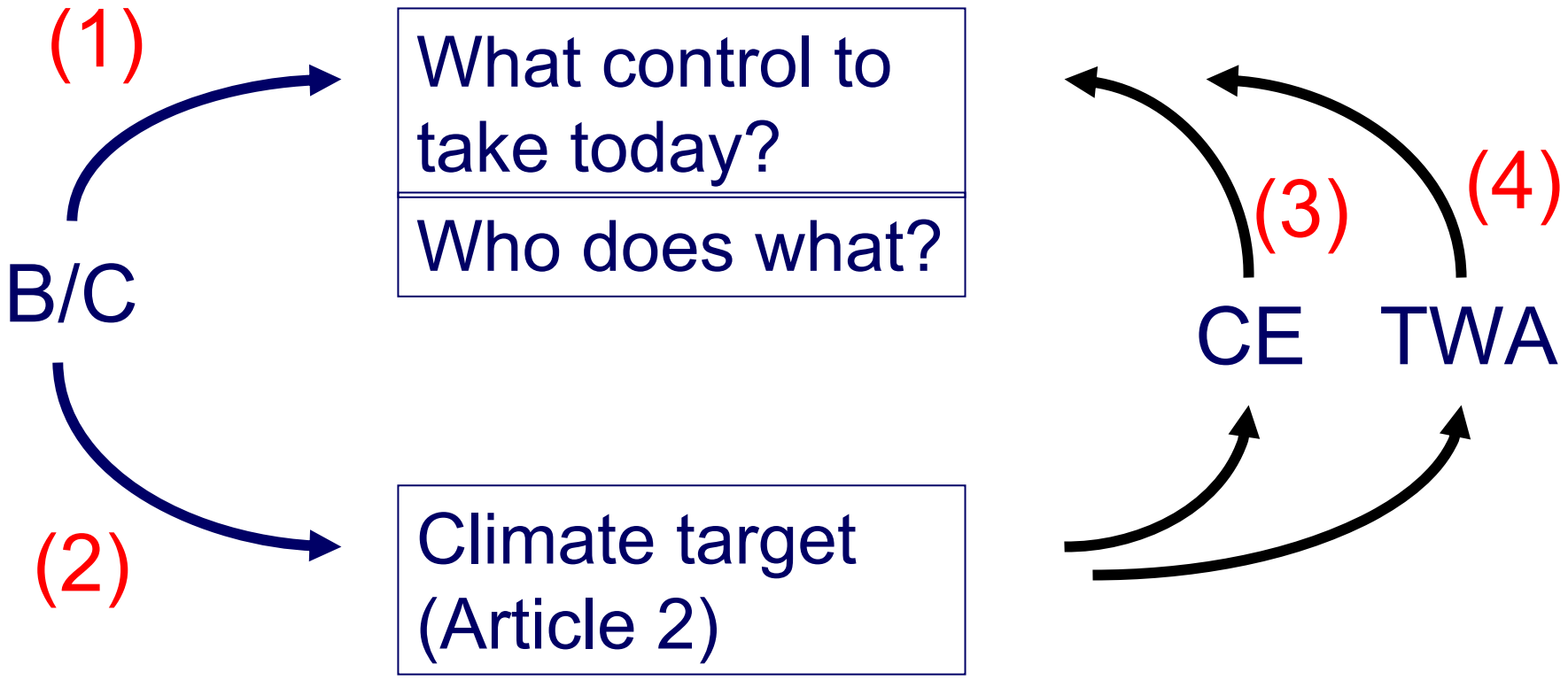
- Single decision-maker
- Multiple decision-makers and gaming behavior
- Negotiation among parties

What is the value/limits of single-actor analysis?

Areas of Policy Choice

- Emissions control (what to do now?)
  - Single decision-maker (global welfare)
  - [Multiple parties and negotiation]
- Anticipatory adaptation
- Actions to open options
  - R&D & technology push
  - “Architecture” of climate negotiations
- Geo-engineering

Examples under Certainty



Benefit-Cost Analysis

- Cost function & benefit relationship
- Alternative applications
  - Calculate optimal path, unconstrained
  - Constrain by long-term target
  - Apply policy scenarios (*e.g.*, burden sharing)
- Difficult issues
  - Valuation & aggregation
  - Discounting
  - Institutional assumptions

Example: Nordhaus DICE Model

- Growth, emissions, and ΔT
  - Like Homework's 2 & 3
- Climate change effects
  - A damage function of form in last lecture
- Forward-looking, optimizing model
- Policy assumptions
  - Optimal path (by their valuations)
  - Stabilize concentrations at $2xCO_2$
  - Hold ΔT to 2.5°C
  - Stabilize emissions at 1990 levels (E90)

Efficient Policies

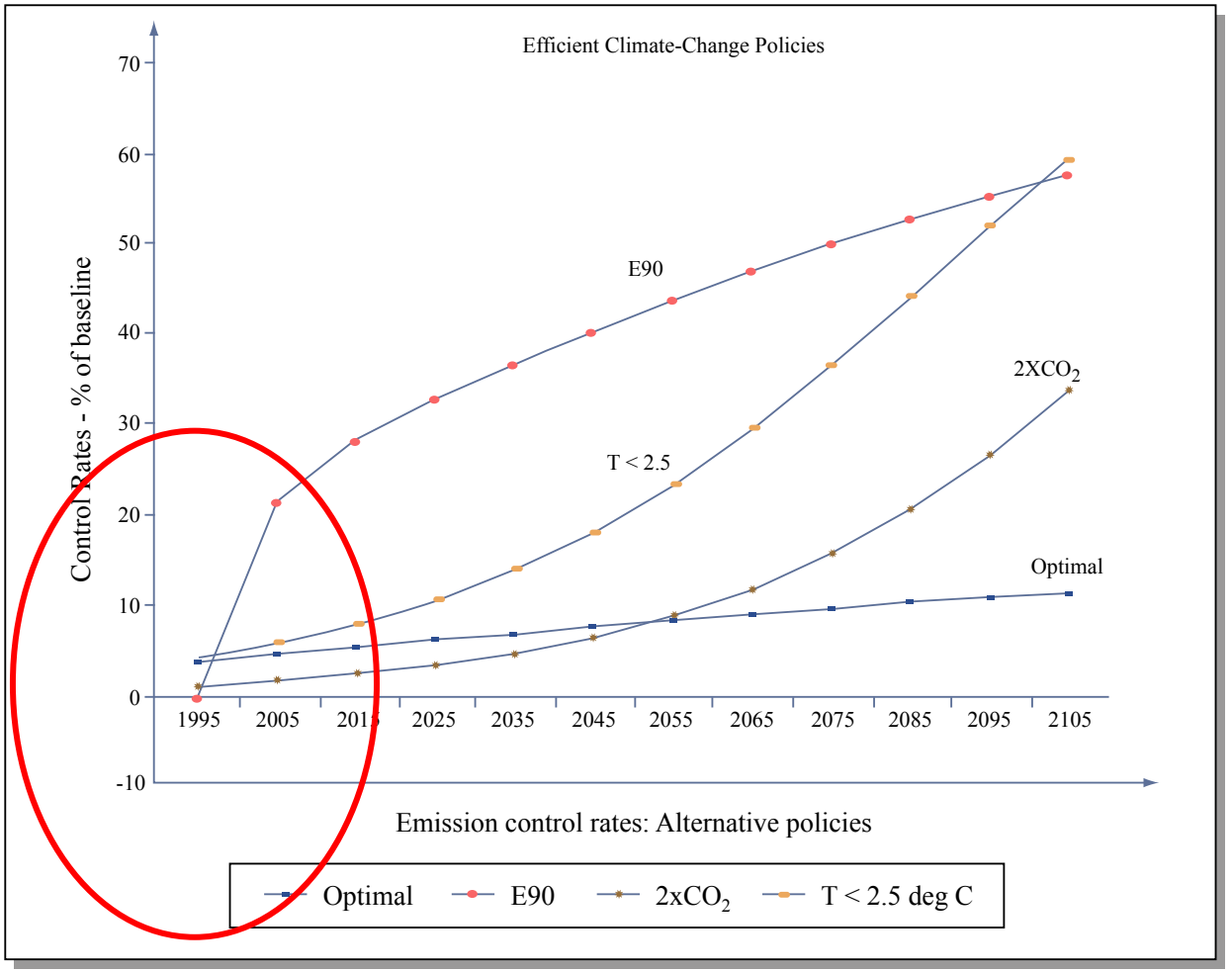


Figure by MIT OpenCourseWare.

Social Cost of Carbon

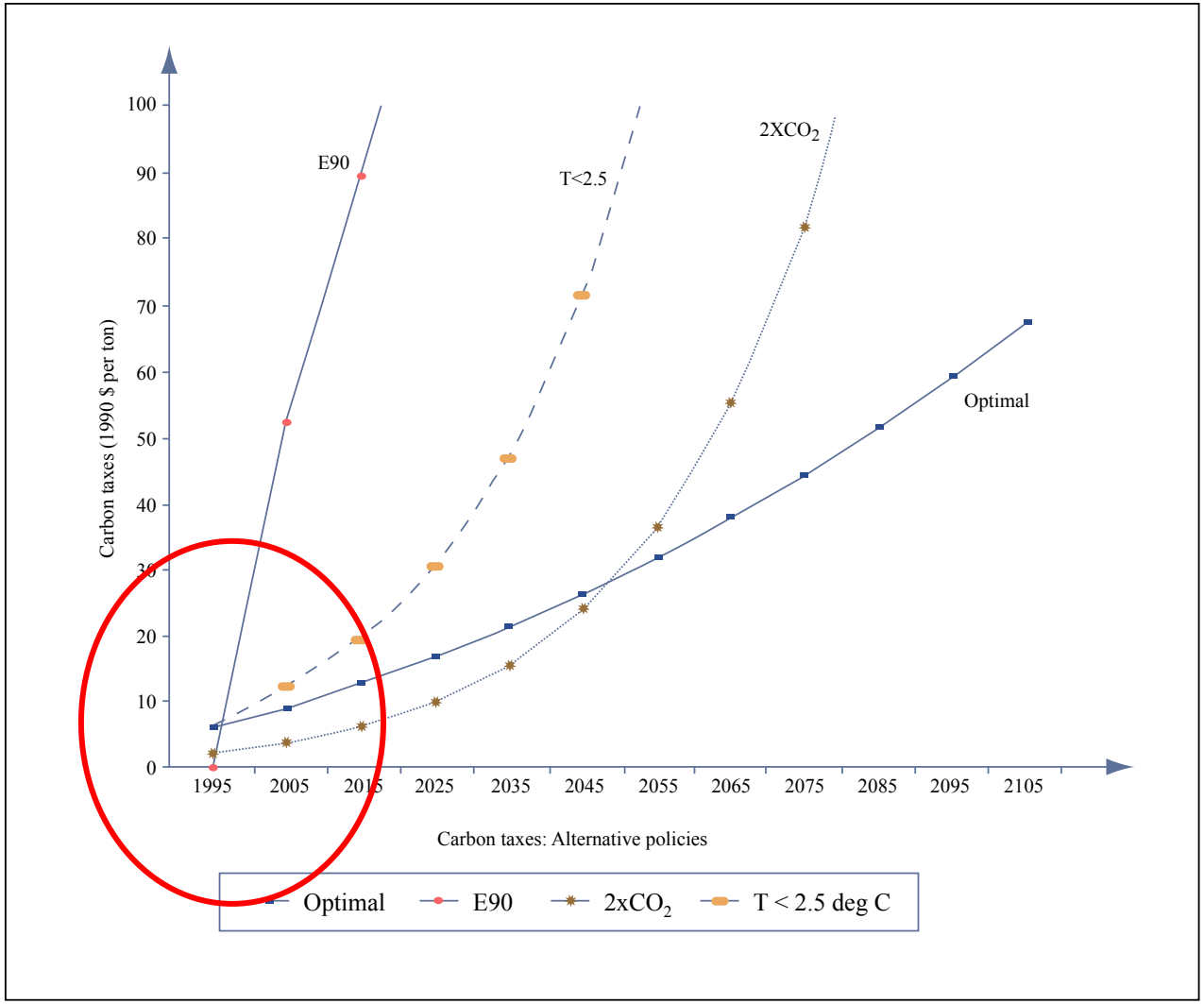
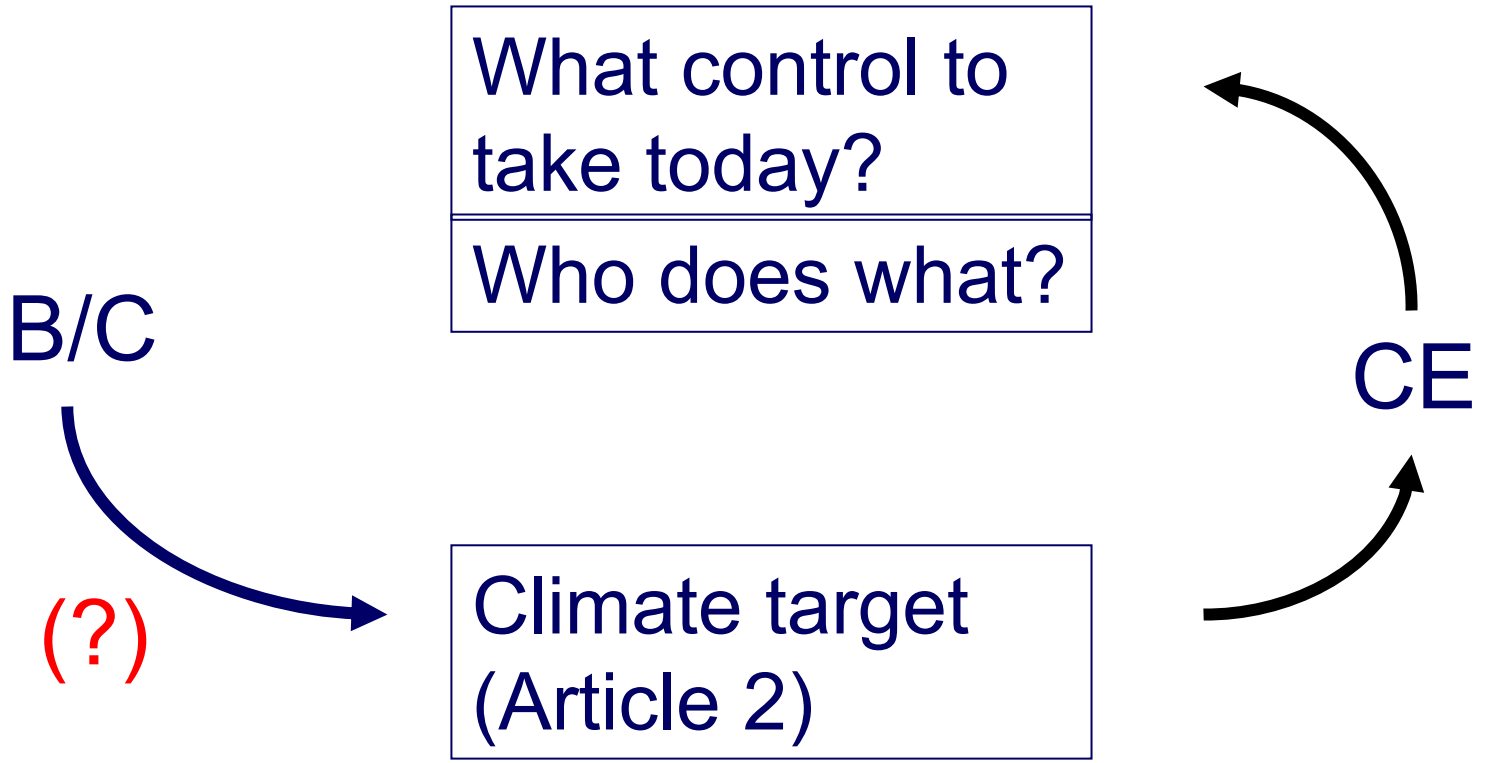


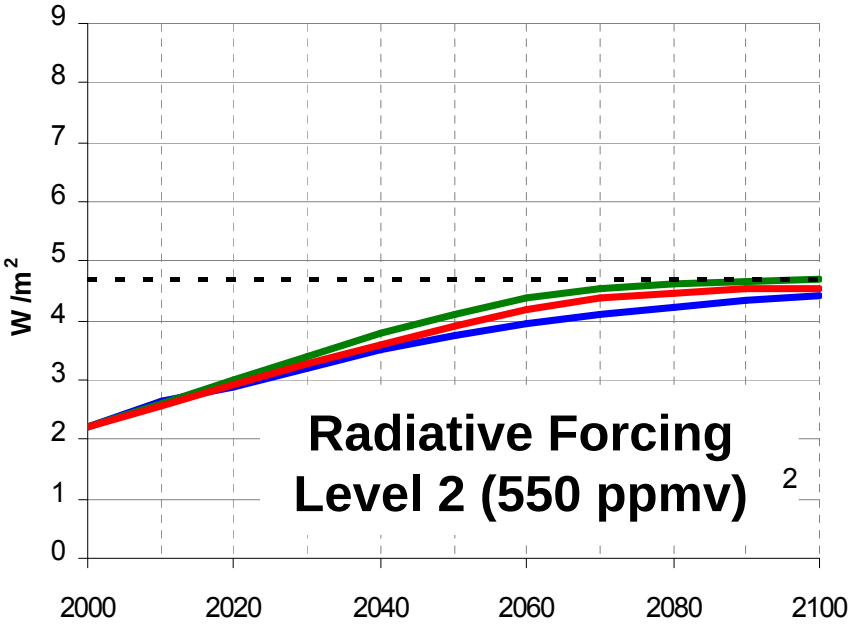
Figure by MIT OpenCourseWare.

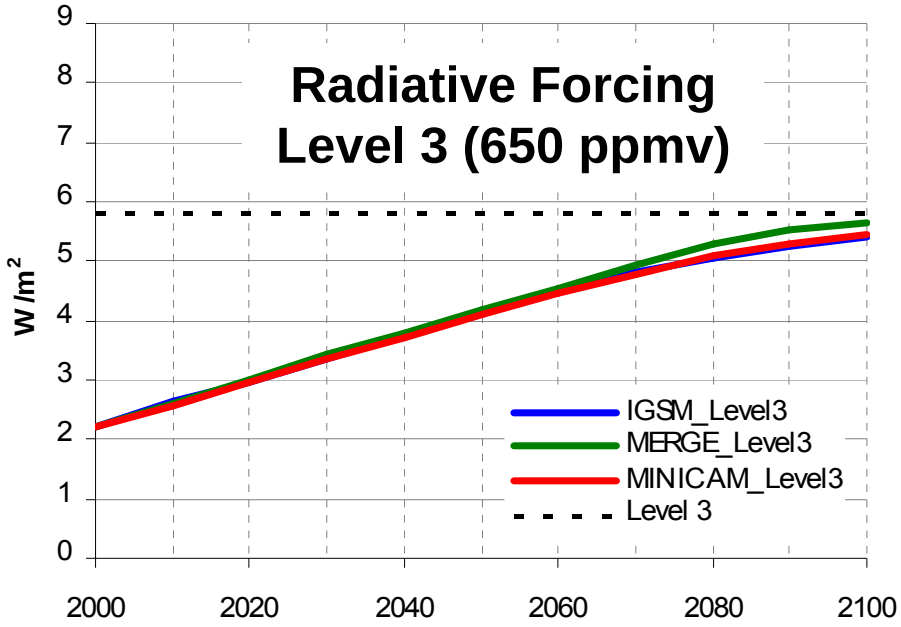
Insights/Evaluation?

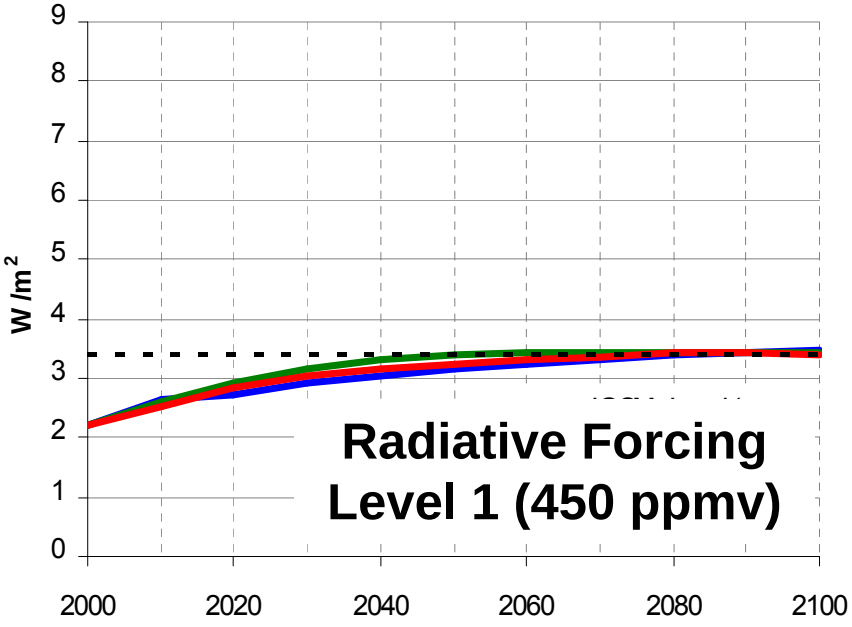
- What think of the analysis?
- Insights gained?
  - About paths of stringency?
  - Other?
- What assumptions dominate?
  -
  -
- What is missing?
  -
- US EPA task under Court ruling on CO_2
- Debates surrounding Warner-Lieberman

Cost Effectiveness Analysis



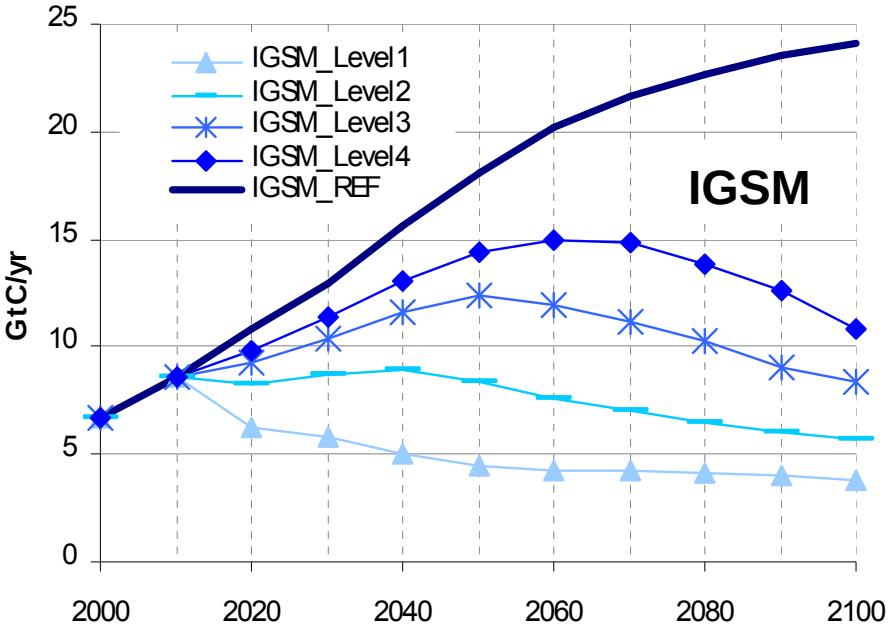


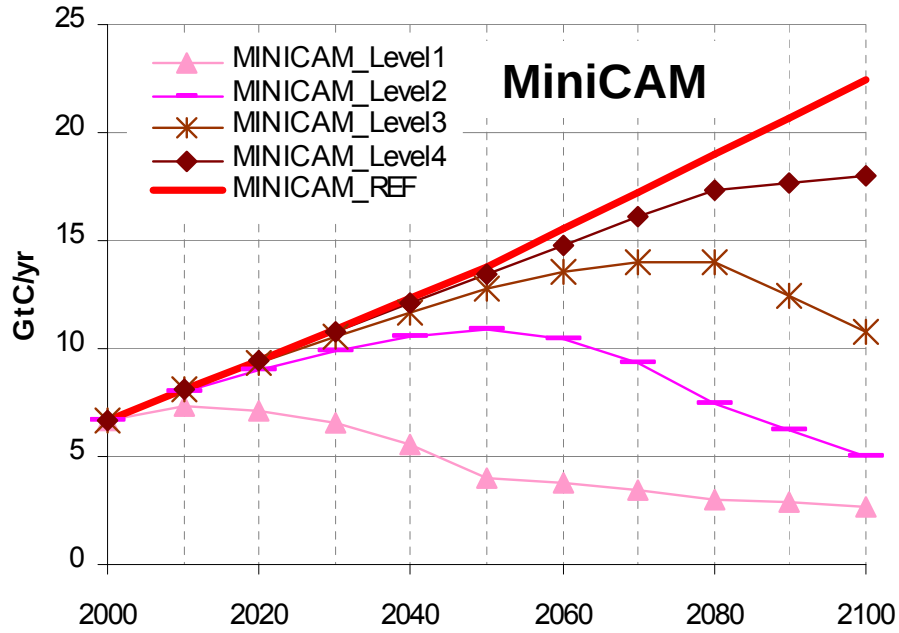


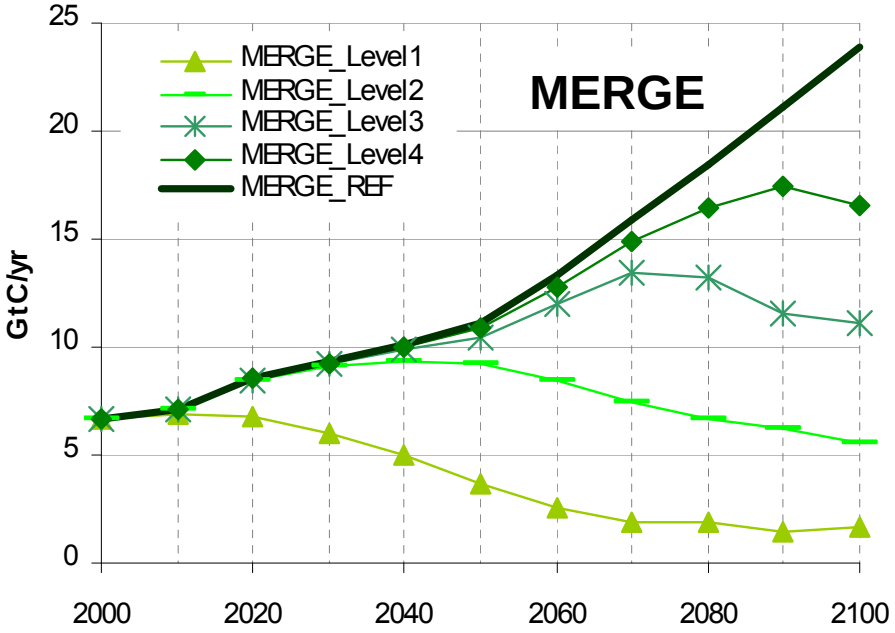


Stabilization

- Forcing trajectories are similar across the models
- 550 and 650 ppmv cases stabilize in next century
- 450 case must stabilize with 50 t0 75 years

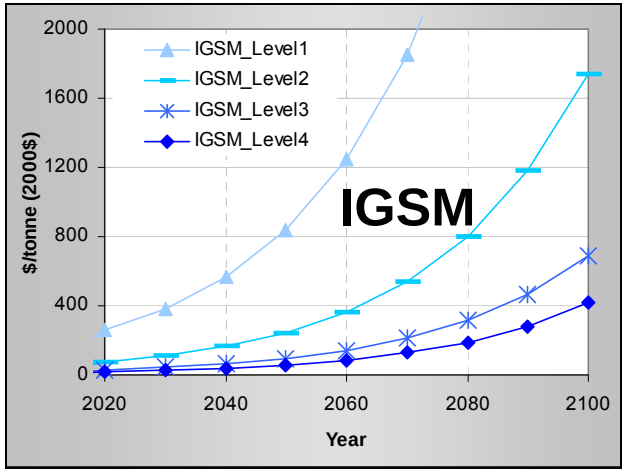


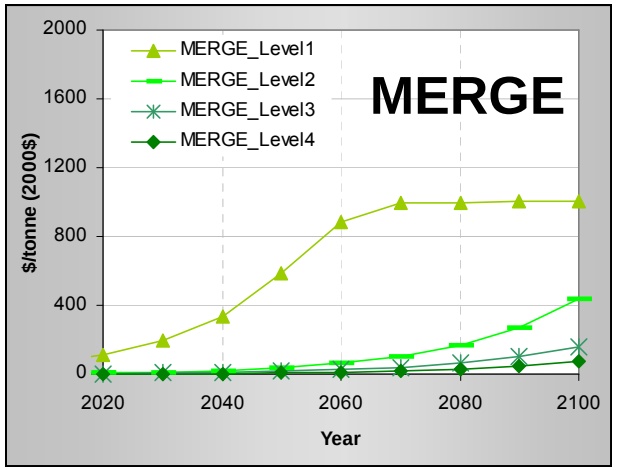


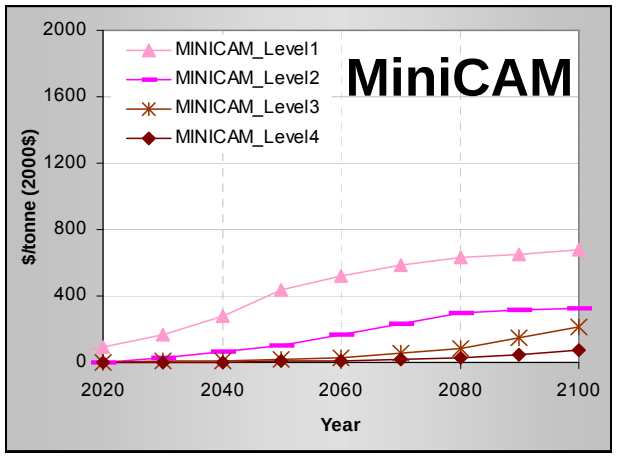


Required CO_2 Reduction

- To stabilize, emissions must decline to the rate of natural removal (E→0)
- Higher stabilization targets only delay this ultimate condition
- Monotonic increase in effort over time, with only technology to moderate

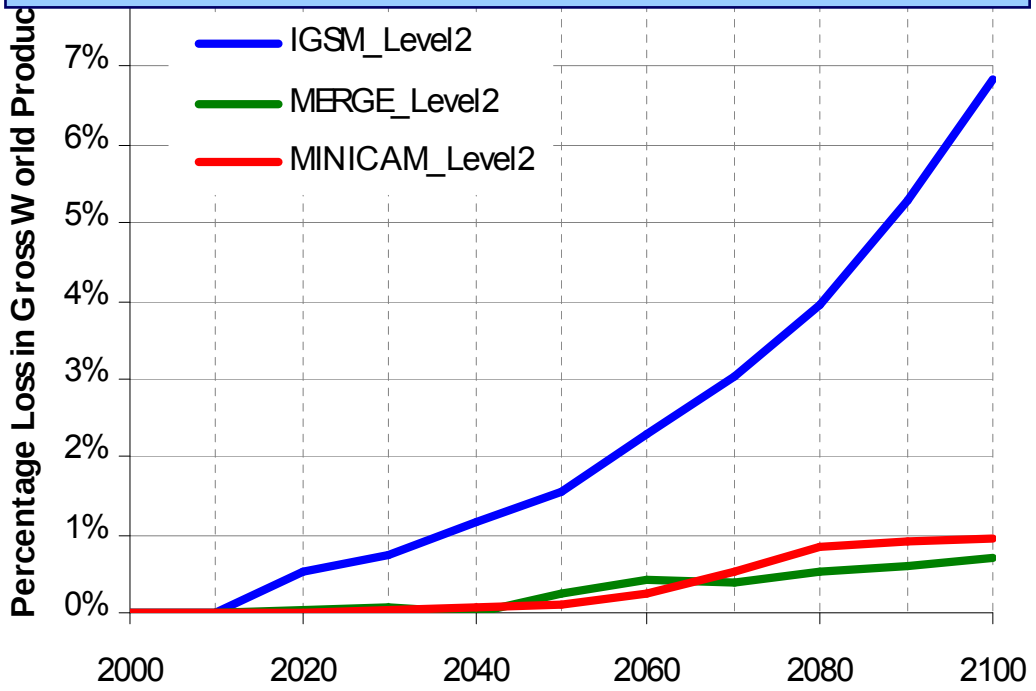






CO_2 Price Paths

% Loss in Global World Product 550 ppmv case (MER)



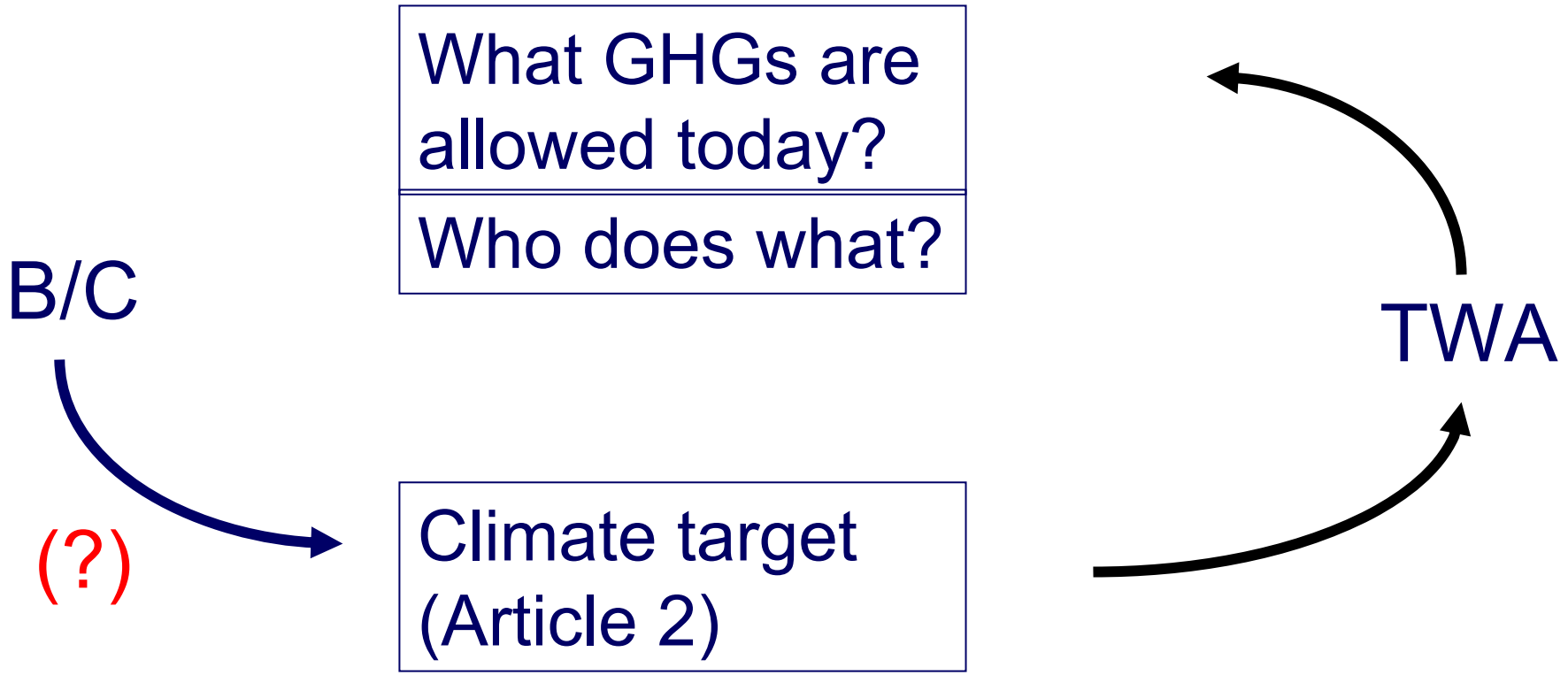
Origin of the Differences

- Required CO_2 reduction
- Assumptions about post-2050 technology

Cost-Effectiveness Analysis

- Maybe no direct benefit estimate
  - Least-cost path in stabilization studies
  - Examples: CCSP & HW #3
- Explore what, where & when flexibility
- Input to “meta” benefit-cost analysis
  - Combine with benefits of stabilization level
  - Example: Stern Review
- Difficult issues
  - Aggregation
  - Discounting
  - Institutional assumptions

Tolerable Windows



Tolerable Windows

- No explicit benefit function
  - Represented in form of constraints
- No explicit cost function
  - Represented by some limit on effort
- Question: what must we do to preserve the option of some future climate state?
  - Capable of multiple attributes

Sequence of Windows

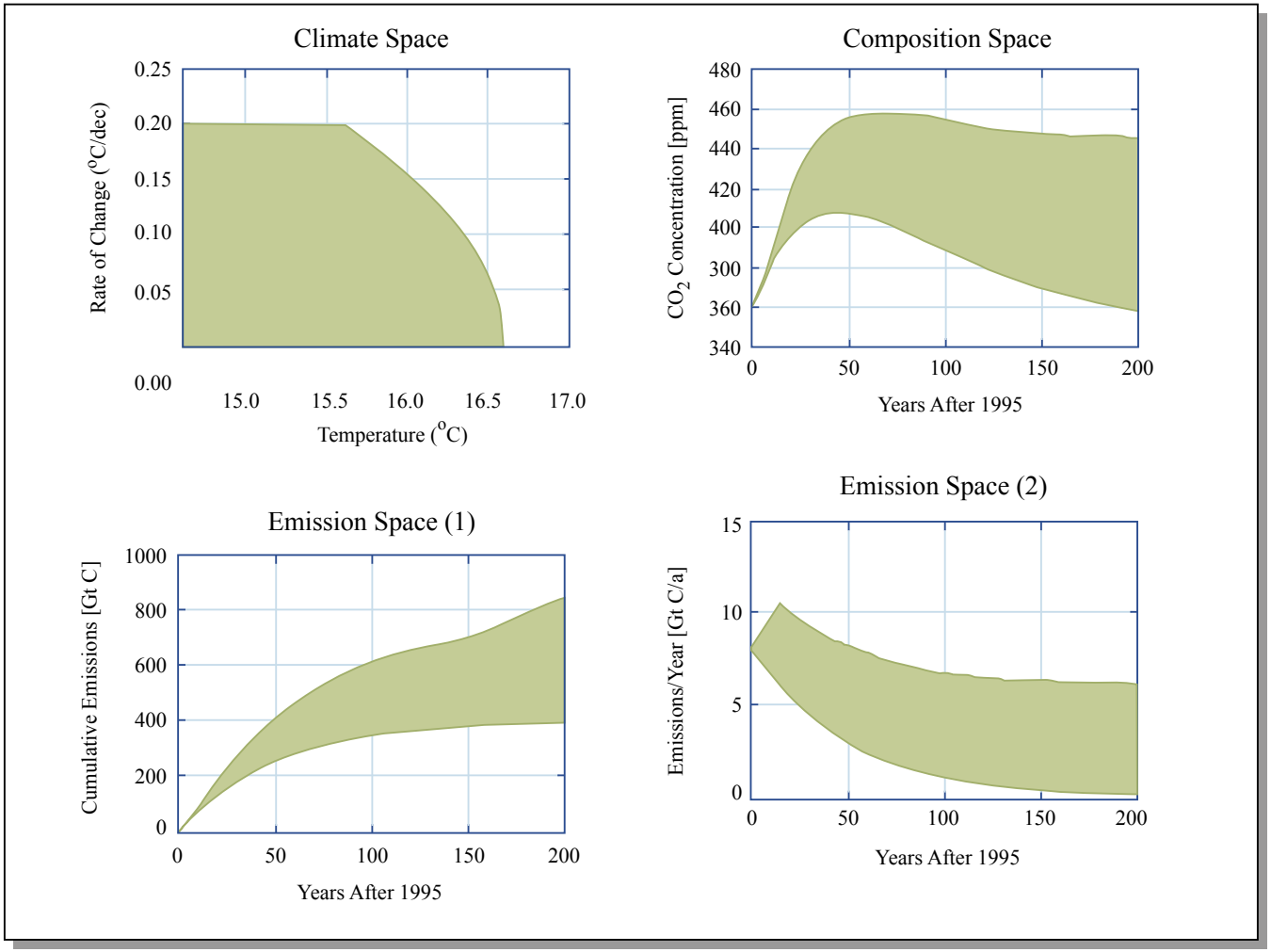
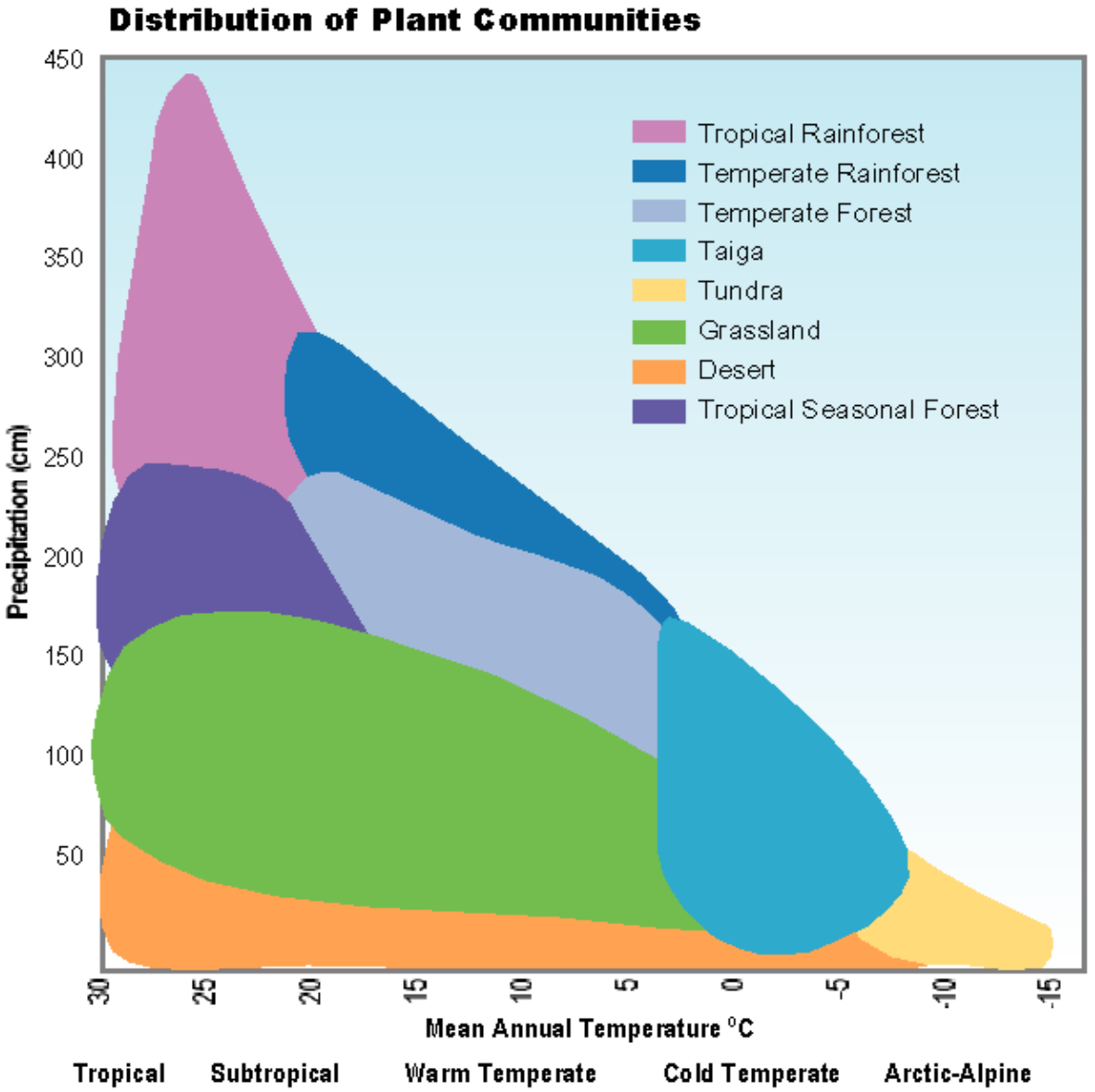


Figure by MIT OpenCourseWare.

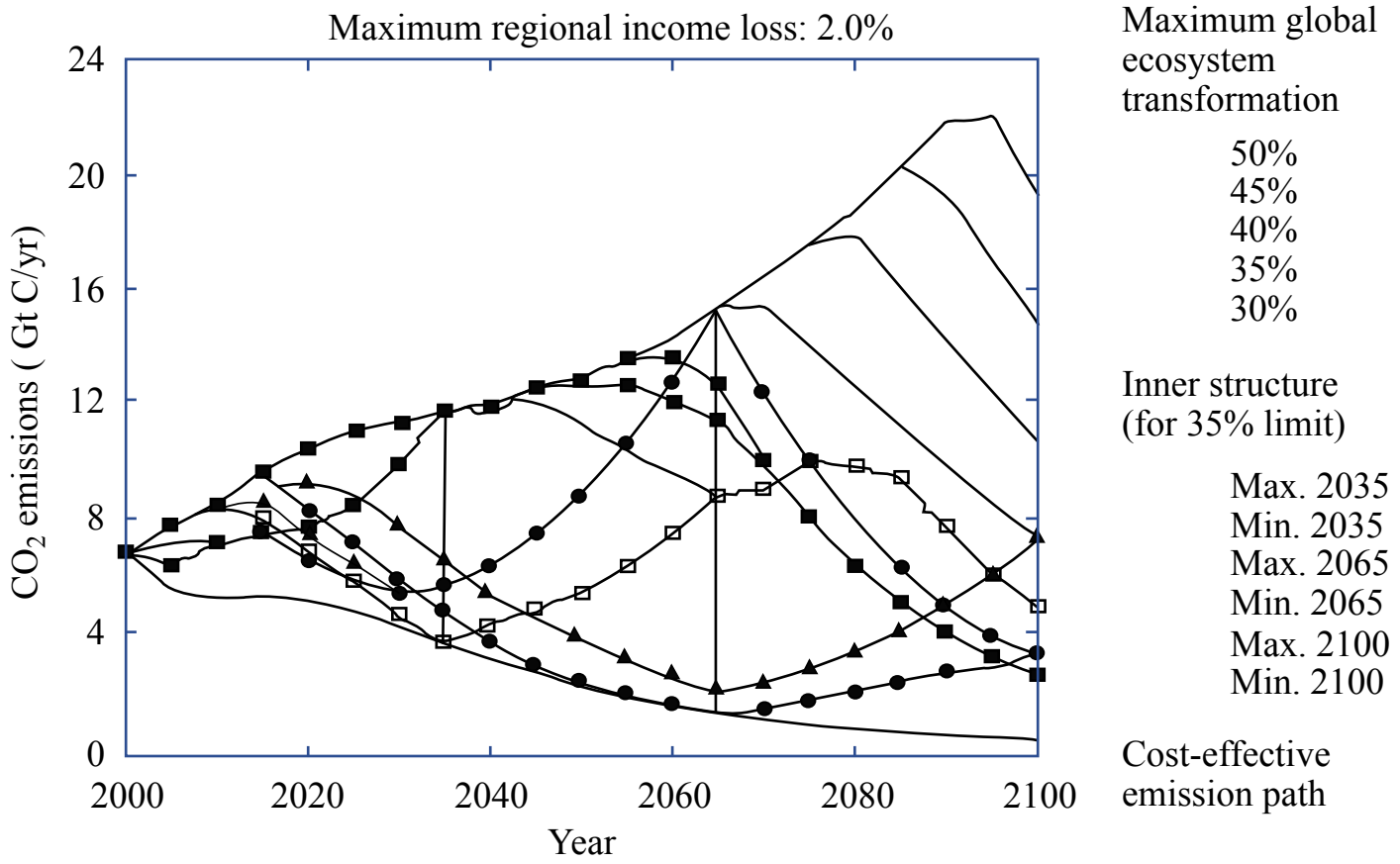


National Assessment Overview, Chapter 2

National Assessment Synthesis Team, Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change (Washington, DC: U.S. Global Change Research Program, 2000). Courtesy of The U.S. Global Change Research Program (USGCRP). Used with permission.

Corridors for energy-related CO_2 emissions

(a) Variation of the impact constraint



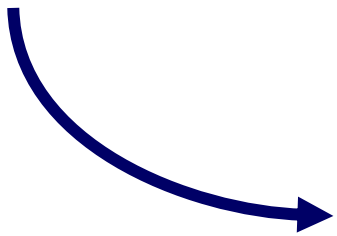
Insights/Evaluation?

- What think of the analysis?
- Insights gained?
  -
  -
- What assumptions dominate?
  - Structure of solution algorithm
  -
- What is missing?
  -
  -

Assessing an Atmospheric Target Under Uncertainty

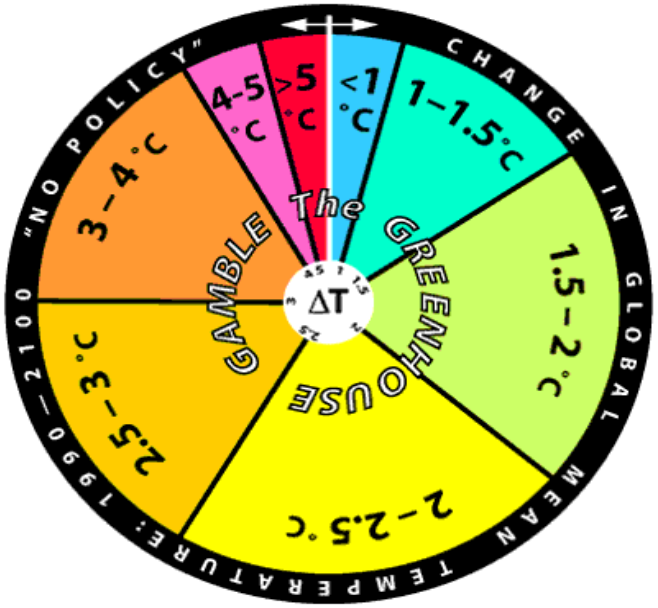
What control action today?

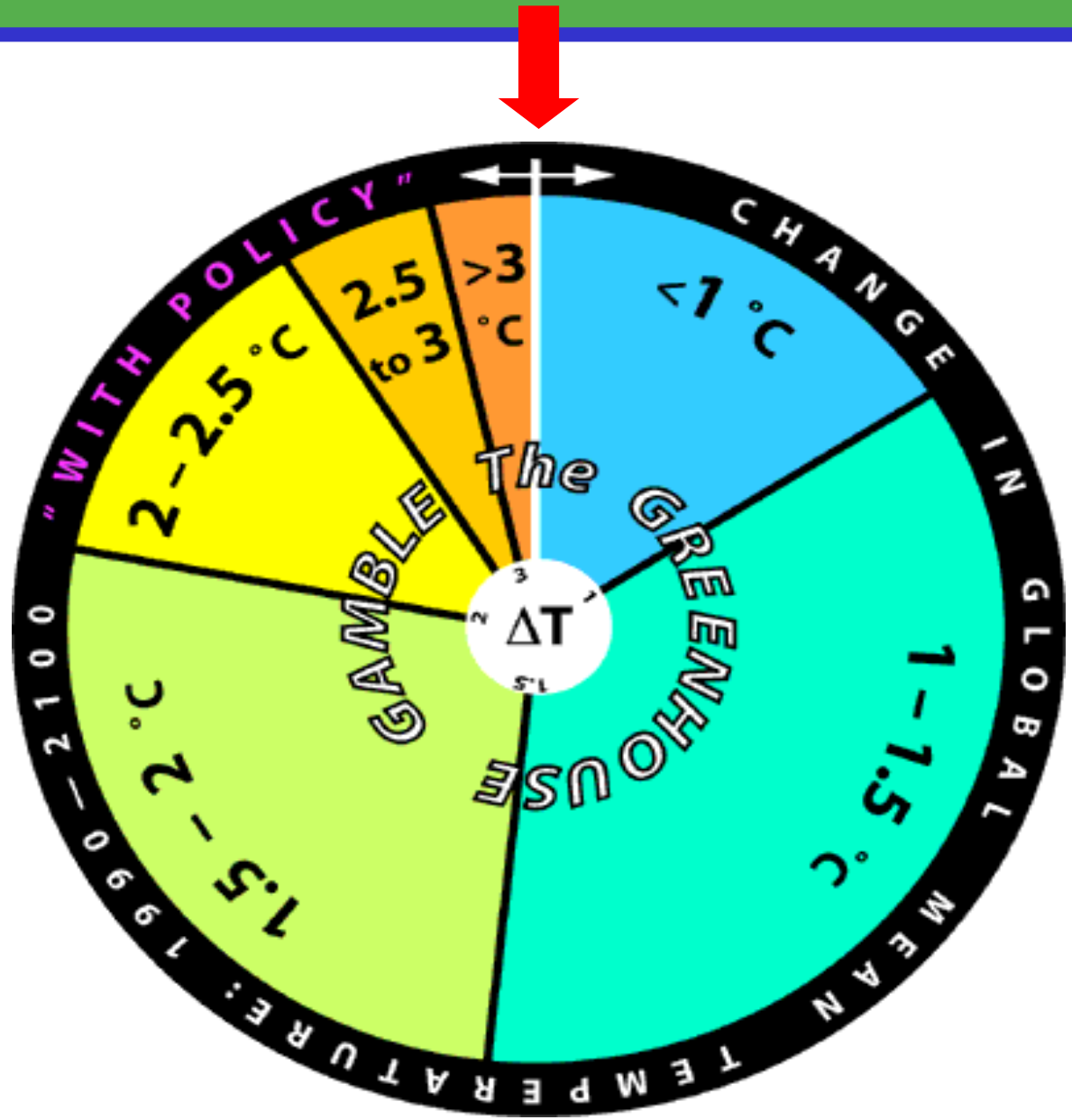
Meta B/C



Climate target (Article 2)

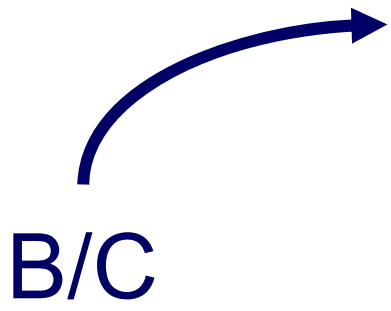
What would we gain with stabilization & 550 ppm?





Low probability, high consequence events?

Benefit-Cost Under Uncertainty



What control action today?

Climate target (Article 2)

The "Wait to Learn" Debate April 23 & 28

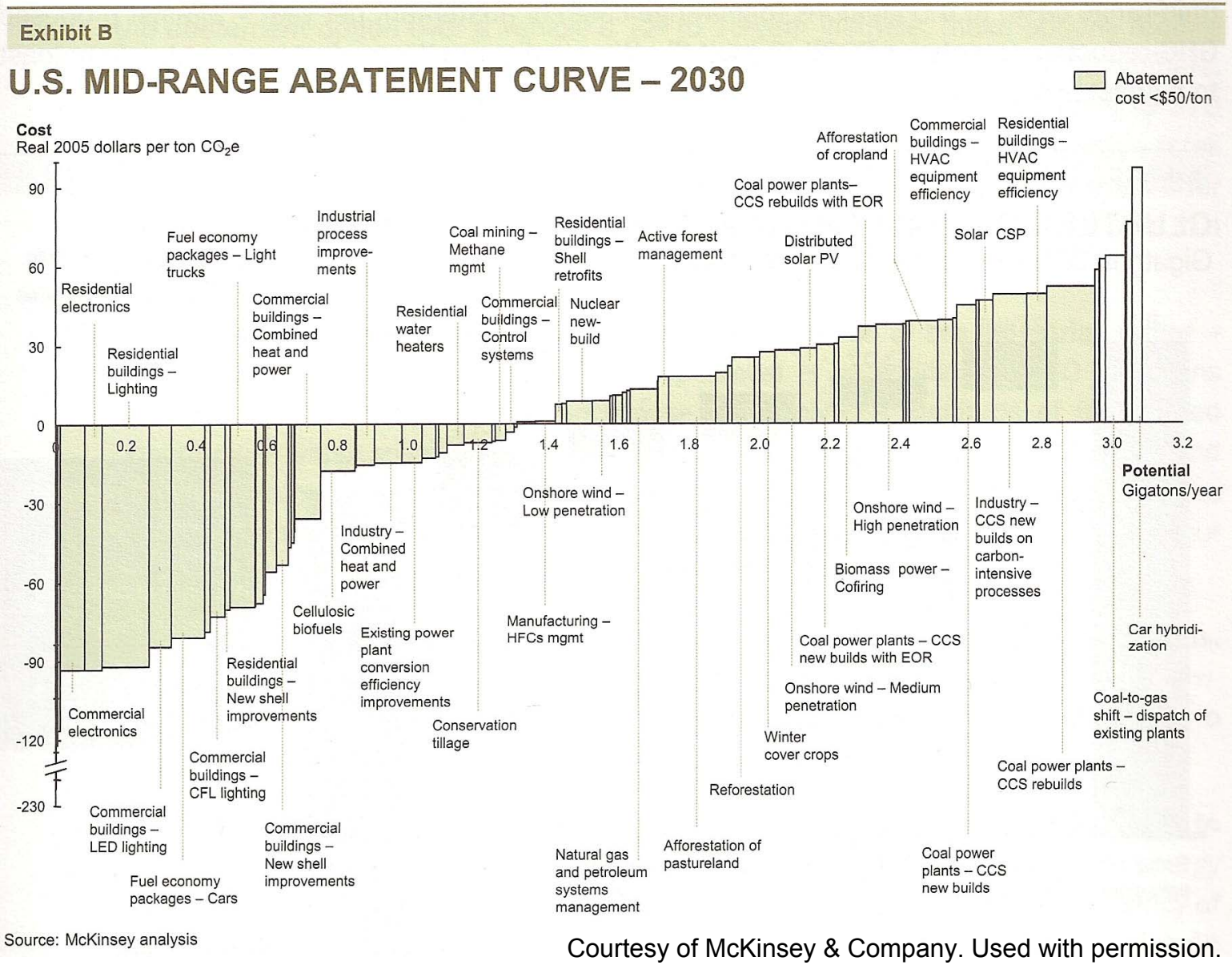
Ongoing Research

- Upper tail the distribution of outcomes
  - Missing (extreme) events
- Methodology
  - Elicitation of parameter PDFs
  - Cascading uncertainties through models of several stages of the climate issue
- The real (sequential) decision problem
  - Partial learning
  - Institutions and path dependency
  - Capturing risk aversion (precaution)
  - Multiple players & “who does what?”
- Lay communication

Final Thoughts

- At best, gain rough insight to today's decision
  - Damage functions are inadequate to the task
  - Necessary simplification of choices
  - Thus far: single decision-maker model, or very simple decision theory representations
- Much work needed to do better, even for "expert" understanding
- Lay audiences deserve our sympathy

McKenzie - 2007



Courtesy of McKinsey & Company. Used with permission.

Cost basis

Discount rate

What is in baseline?

What use?

Explaining Why Technologies Are Not Used

- Market failures: decision-makers don't see correct price signals
  - Lack of information
  - Principal-agent problems (e.g., landlord-tenant)
  - Externalities & public goods
- Market barriers
  - Hidden costs (*e.g.*, transactions costs)
  - Disadvantages perceived by users
  - "High" discount rates

Alternative Views of the Options

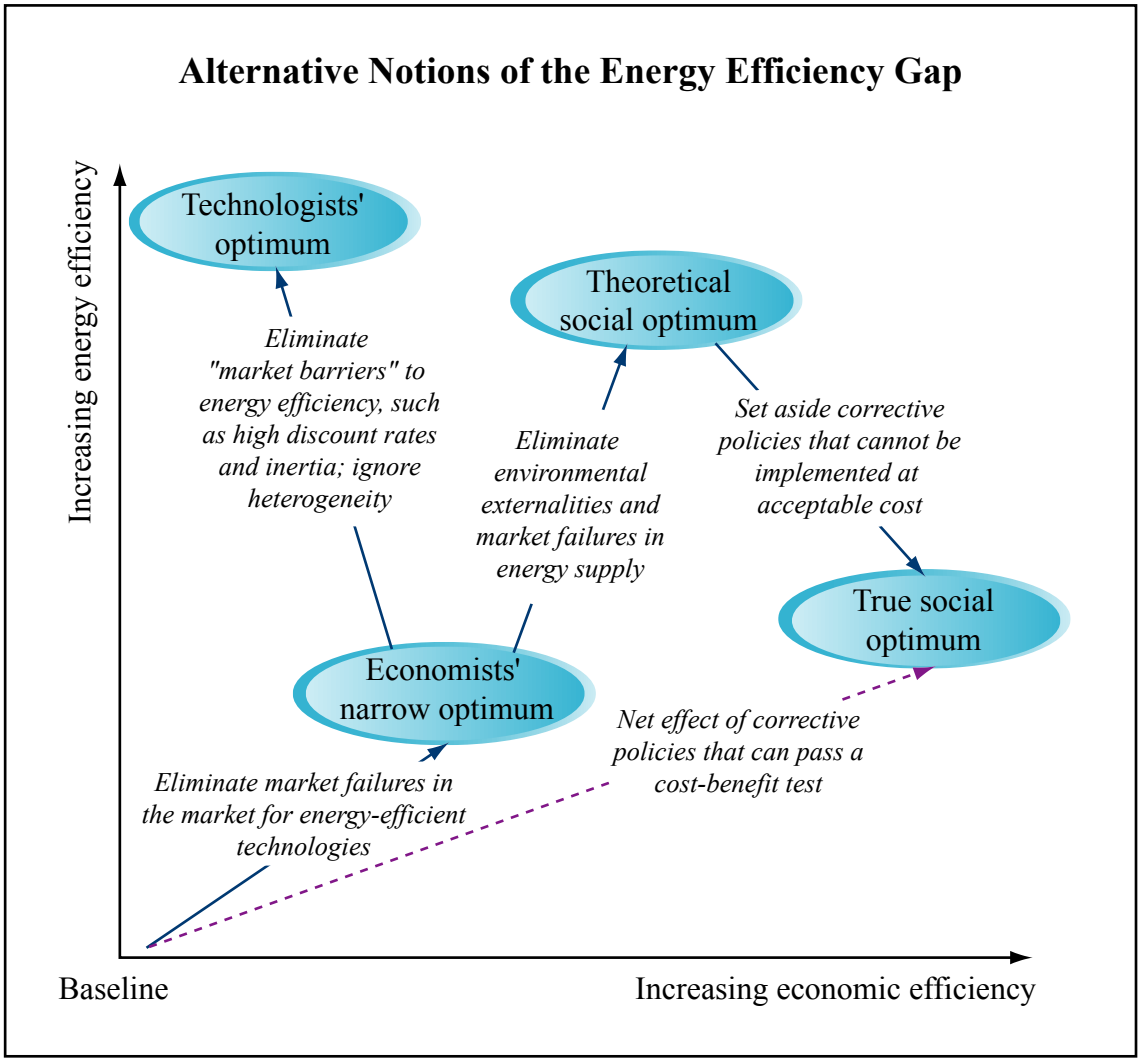
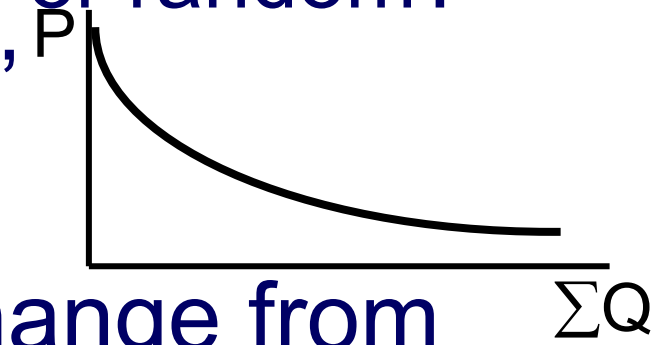


Figure by MIT OpenCourseWare, adapted from Resources for the Future.

Thinking about Technology

- What is technology, and tech. change?
- What leads to change?
  - Does change tend to economize on one factor or another, in response to prices?
  - What is the role of R&D expenditure?
  - To what degree is it *ad hoc* or random?
- Role of "learning by doing"



- How to distinguish tech change from
  - Change in inputs (in response to price)
  - Economies of scale

"New" Technologies

- Carbon capture and storage
  - From electric power plants
  - From the air
- Renewables
  - Wind & solar
  - Biomass
  - Tidal power
  - Geothermal
- New generation of fission, and fusion
- Solar satellites
- Demand-side technology
  - Fuel cells and H_2 fuel
  - Other? (lighting, buildings, ind. process, etc.)

What determines the likely contribution of each?