DOE IAM Model Diagnostics Project Overview

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Stanford University
DOE Climate Change PI Meeting
Washington, DC
September 22, 2011

Outline

- Objectives
- Multiple Levels of Diagnostics
  - Individual Module Diagnostics
    - Socio-Economic Components
    - ESM Components-Mostly PCMDI Tests
  - Full Model Diagnostics
  - “Hind Casting” Exercises
- Co-ordination and Outreach
  - Our Team
  - US IAMs
  - IAMC Network
  - AMPERE (EC Meeting in Two Weeks)
  - Japanese LCS, etc.

Model Inter-comparisons, Diagnostics & Validation

- We do model comparisons for three basic reasons
  - See where models differ (and maybe why they do so)
  - Identify robust and believable conclusions (or not)
  - Identify gaps and opportunties in underlying research
- Why do we do model diagnostics?
  - Provide deeper insight into intermodel differences
  - Provide more evidence of realism
- How should we do model validation?
  - Model comparisons & diagnostics are quite useful
  - Well conceived hindcasting experiments can also help
  - But, is a model that produces the past well going to project the future well???
- In this project we focus on diagnostics & validation

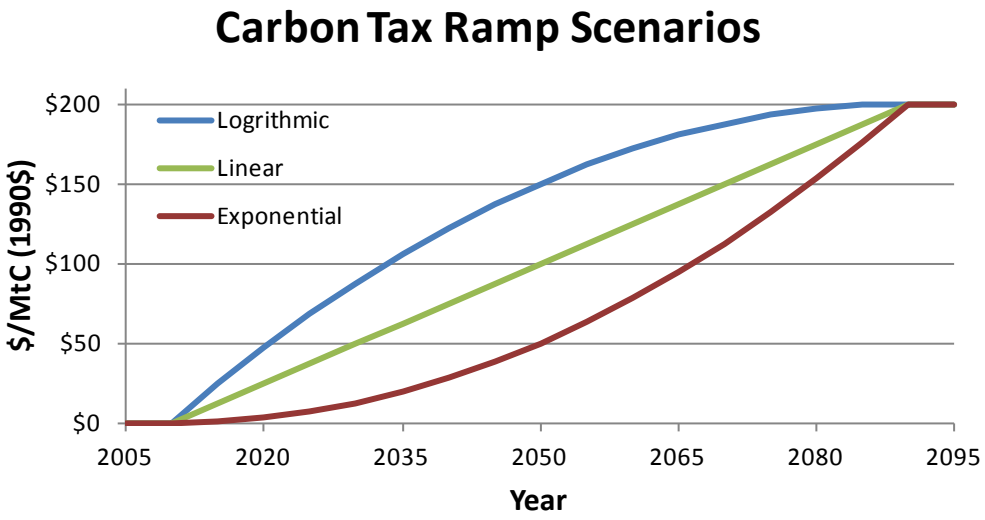
Our Core Team

- LLNL
  - Karl Taylor
  - Ben Santer
  - Clara Smith
- LBNL/UCBerkeley
  - Bill Collins
  - Jeff Chambers
  - Alan Di Vittorio
- Stanford
  - Noah Diffenbaugh
  - Chris Field
  - John Weyant
  - Jordan Wilkerson
  - Michael Delgado (Link to Sally Benson Technology Assessment Project)

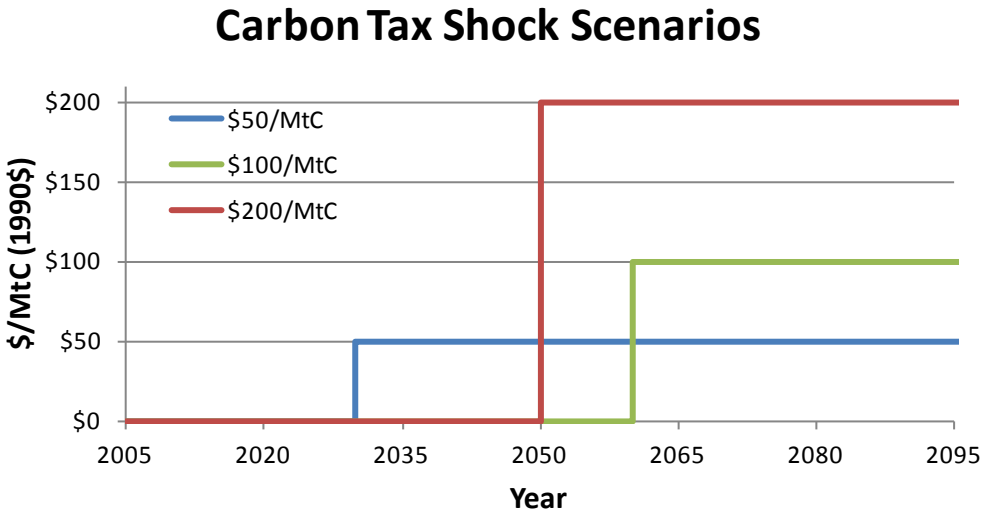
Socio-Economic Module Diagnostic Tests

Tax Scenarios

- Tax Ramps
  - Ramp to $200/MtC
  - Exponential, Linear, Logarithmic



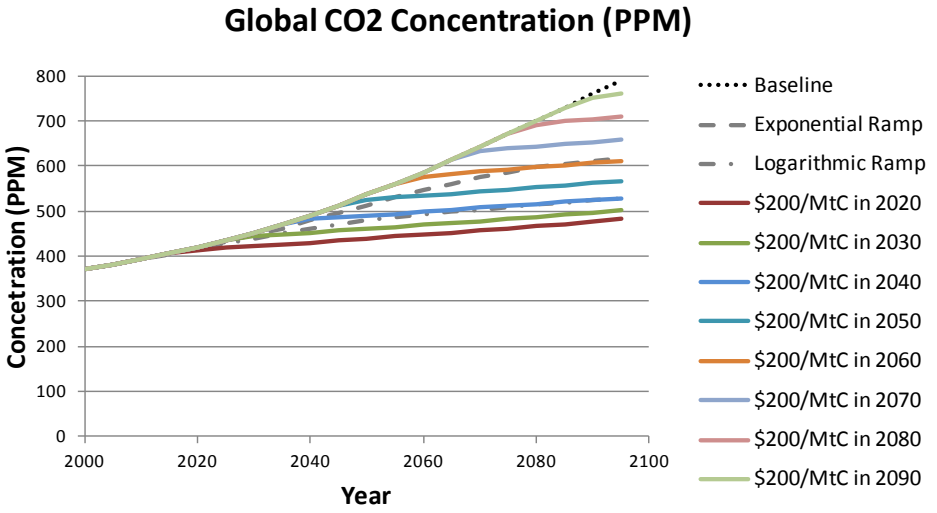
- Fixed tax shocks
  - Delayed policy
  - 50, 100, $200/MtC

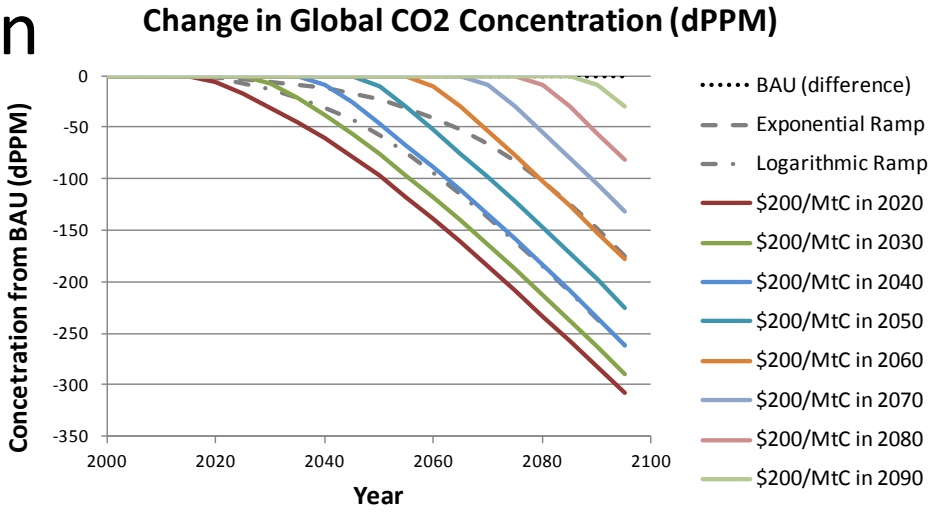


GCAM $200 Tax Shock Results: CO2

- Global CO2 concentration

- No reduction in emissions until shock occurs
- An immediate $200 tax can reduce concentration by 300ppm from the base case by 2095

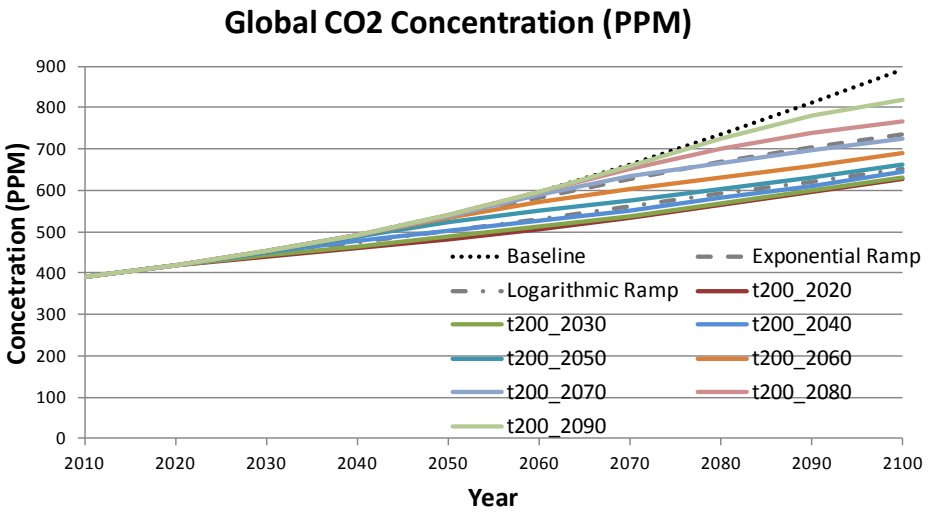


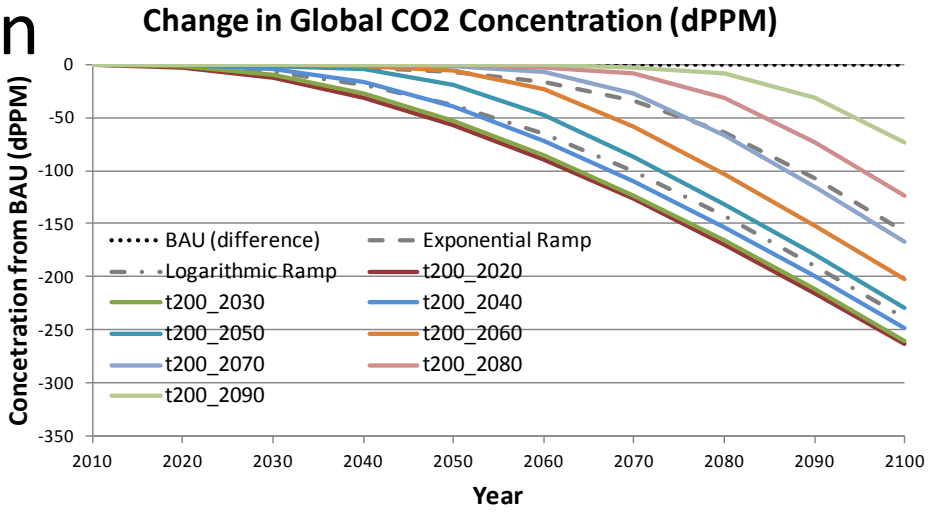


MERGE $200 Tax Shock Results: CO2

- Global CO2 concentration

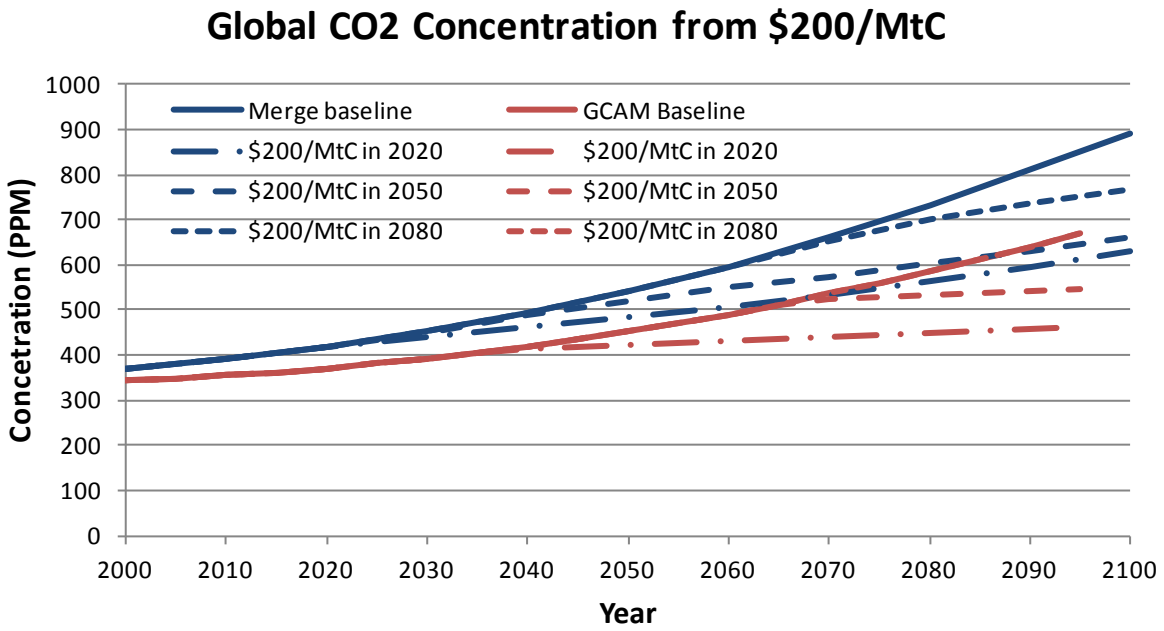
- No reduction in emissions until shock occurs
- An immediate $200 tax can reduce concentration by 260ppm from the base case by 2100





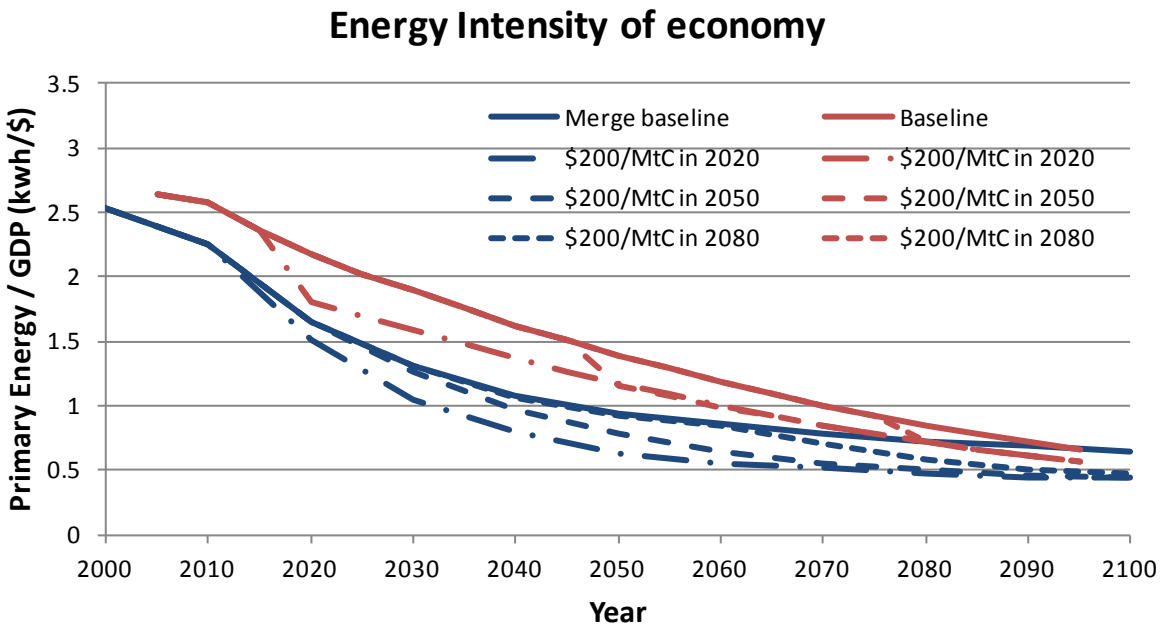
CO2 Concentrations Comparisons

- Resulting CO2 concentrations from $200/MtC tax beginning in various years.



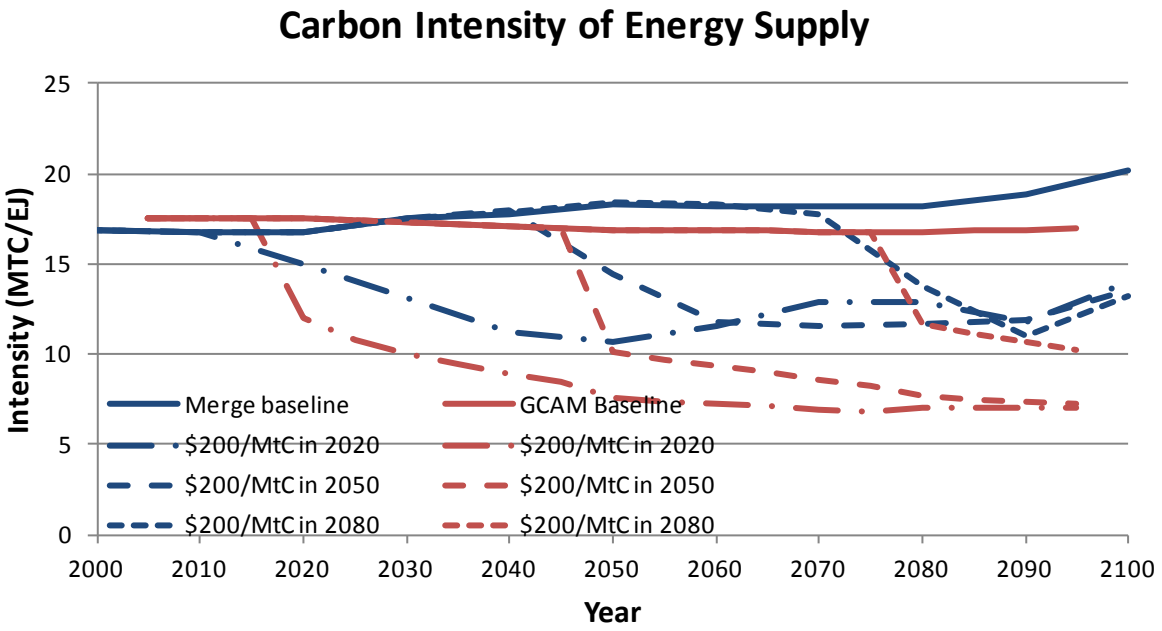
Energy Intensity Comparisons

- PE/GDP
- Merge anticipates the tax and starts with ‘clean tech upgrades’ before the tax.



Carbon Intensity Comparisons

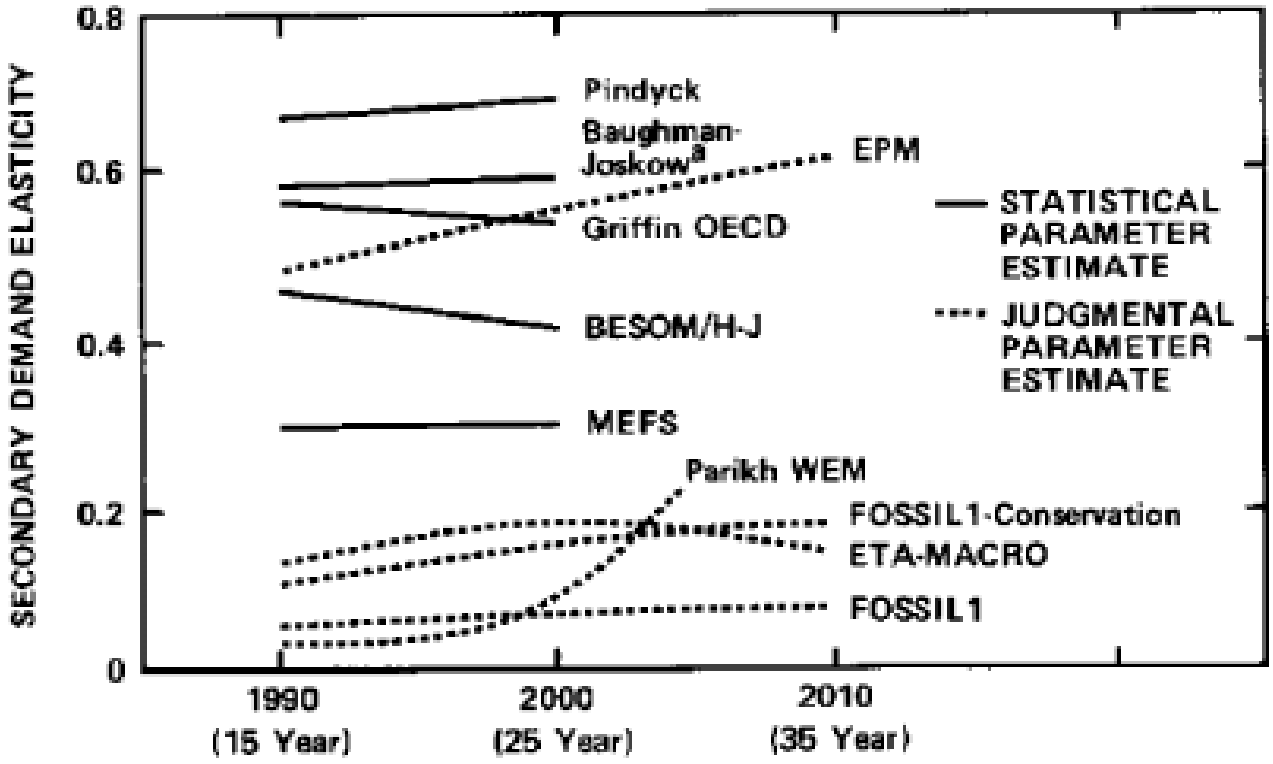
- Anticipation of the tax is more apparent here.



Proposed Hindcasting Experiments

- Parameters by parameter
- Module by module
- Full IAM experiments
  - Use actual economic growth and oil prices to start
  - Learn by doing (e.g., difference between unforeseen shocks and things that should be more predictable)

The EMF 4 Experiment(s)

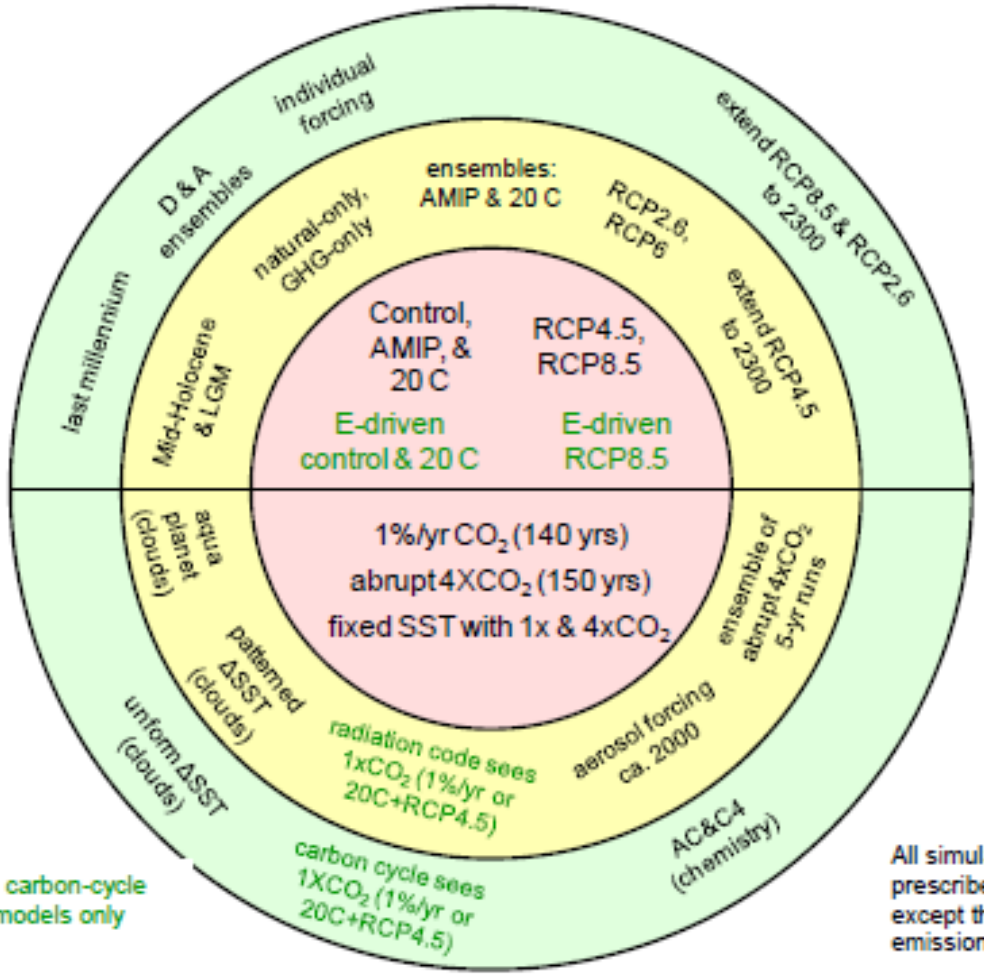


Note: The Paasche index was used to calculate these estimates.
[a]Does not include transportation demands

Figure 5. Aggregate total demand elasticity estimates.

Natural Science Module Diagnostic Tests

Schematic Summary of CMIP5 Long-Term Experiments (Taylor, Stouffer & Meehl)

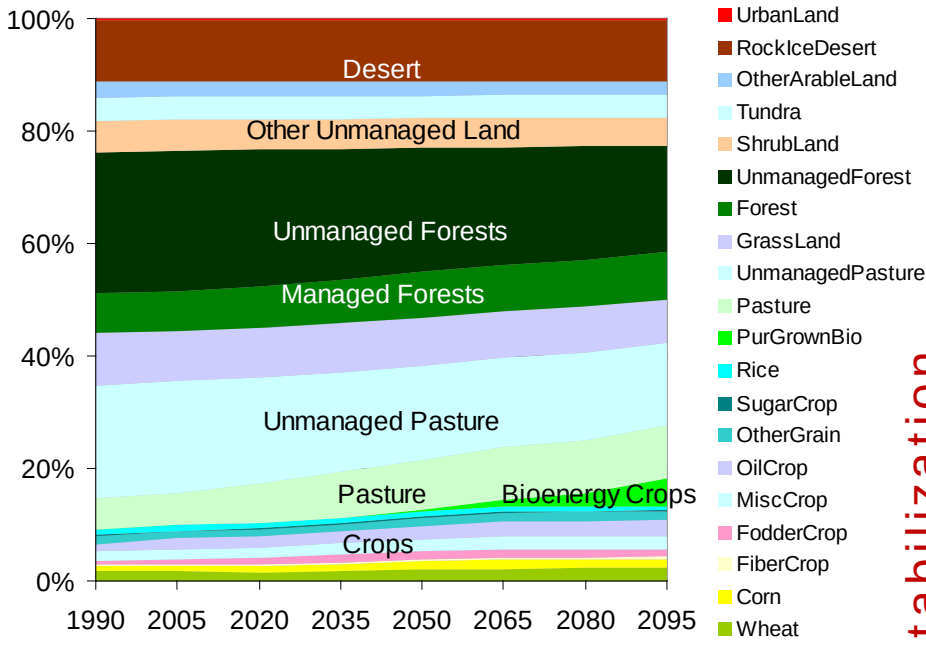


Coupled carbon-cycle climate models only

All simulations are forced by prescribed concentrations except those "E-driven" (i.e., emission-driven)

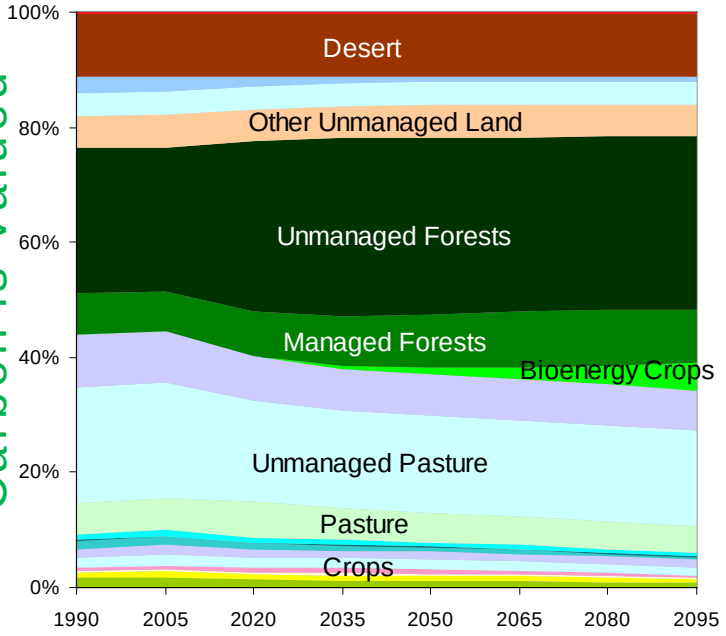
Full IAM Model Diagnostic Tests

The Land Use Implications of Stabilizing at 450 ppm When Terrestrial Carbon is Valued

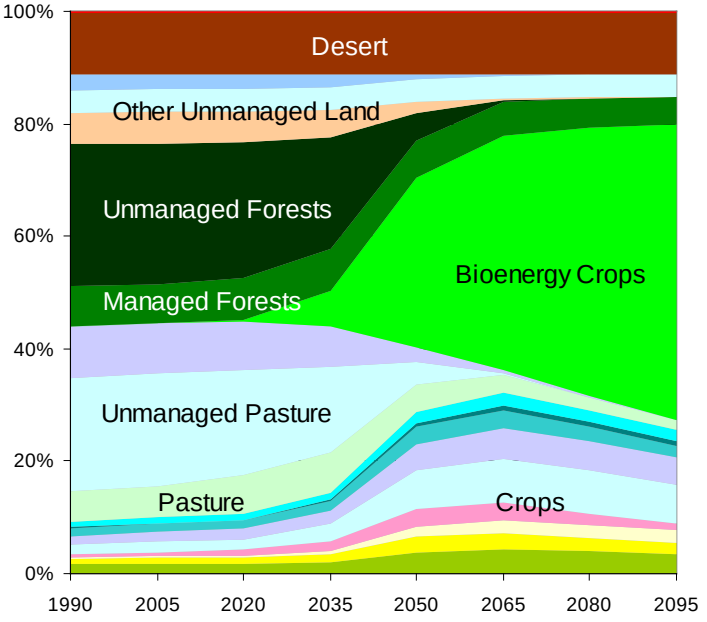


Reference Scenario

450 ppm Stabilization Scenario When ALL Carbon is Valued



450 ppm Stabilization Scenario When Terrestrial Carbon is NOT Valued



Co-ordination and Outreach

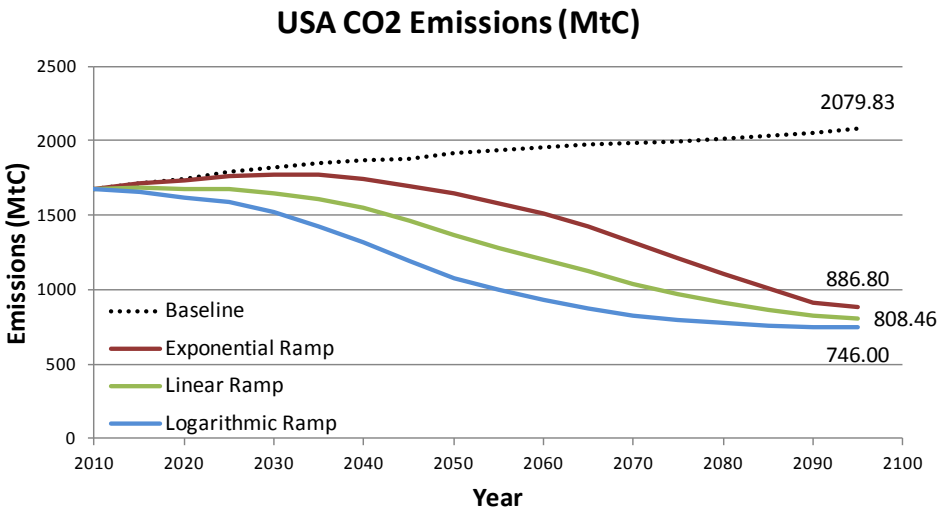
- US IAMs - Can run and ask teams to run
- IAMC Network (Meeting in Two Weeks)
  - 50 Members
  - Scientific Steering Committee
  - Data base management system at IIASA @data templates
  - Scientific Working Group on Model Validation
- AMPERE (EC Meeting in Two Weeks)
  - Weyant & Fisher-Vanden on Scientific Advisory Council
  - Karl Taylor Keynote Speaker

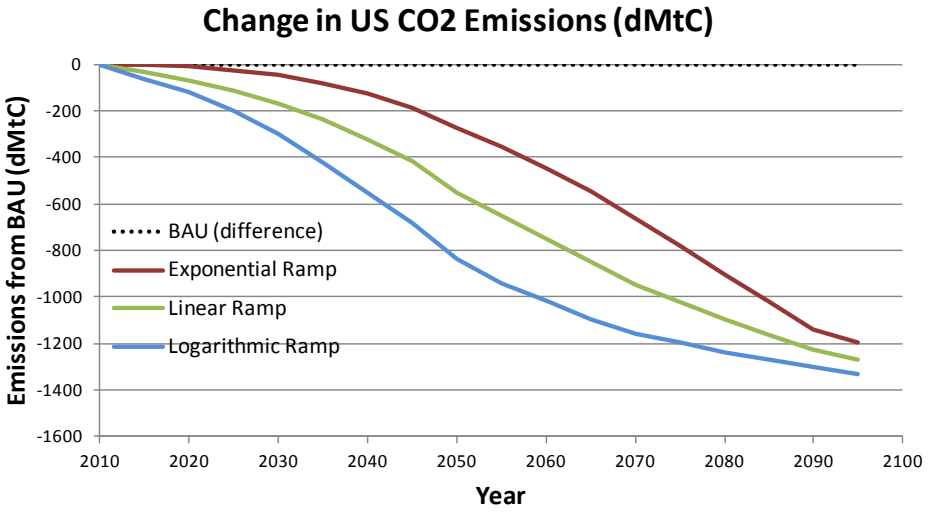
Thank You

GCAM Tax Ramp Results: CO2

- US CO2 emissions

- All three scenarios reduce emissions
- Exponential ramp responds slowest, representative of lower initial tax increments
- Scenarios approaching similar end point

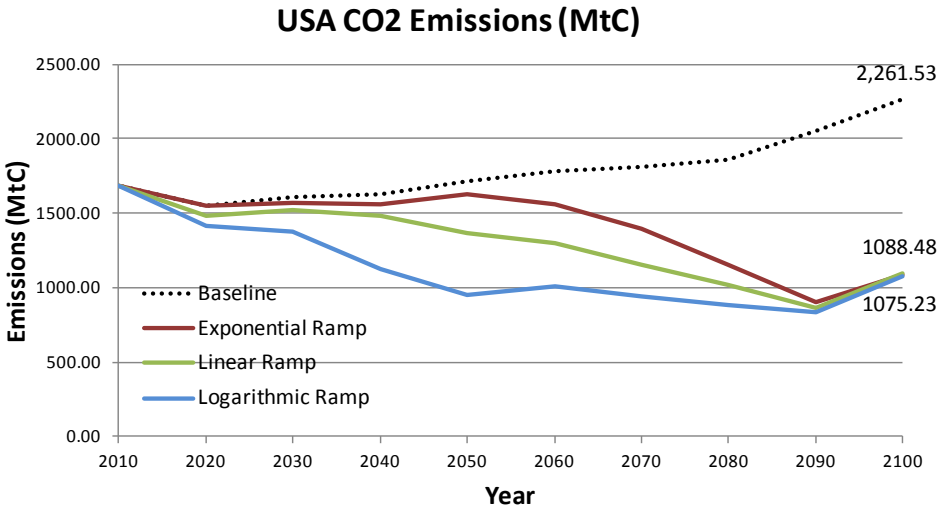


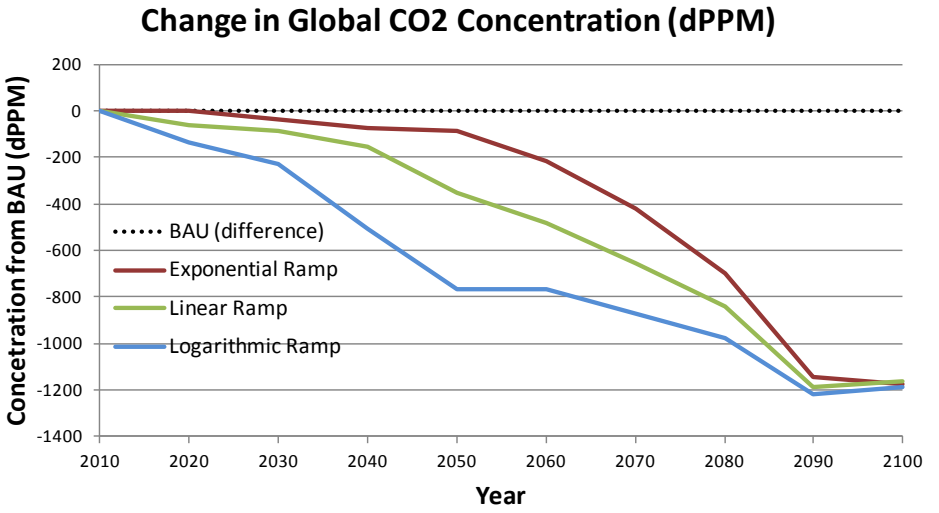


Merge Tax Ramp Results: CO2

- US CO2 emissions

- All three scenarios reduce emissions
- Exponential tamp responds slowest representative of lower initial tax increments
- Scenarios approaching similar end point
- Tracks baseline when ramp becomes constant at $200 in 2100





Model Comparison charts

- Evaluate projections of carbon emissions under various carbon tax scenarios
  - Increased tax with time (tax ramp)
  - Fixed-value tax (tax shock)

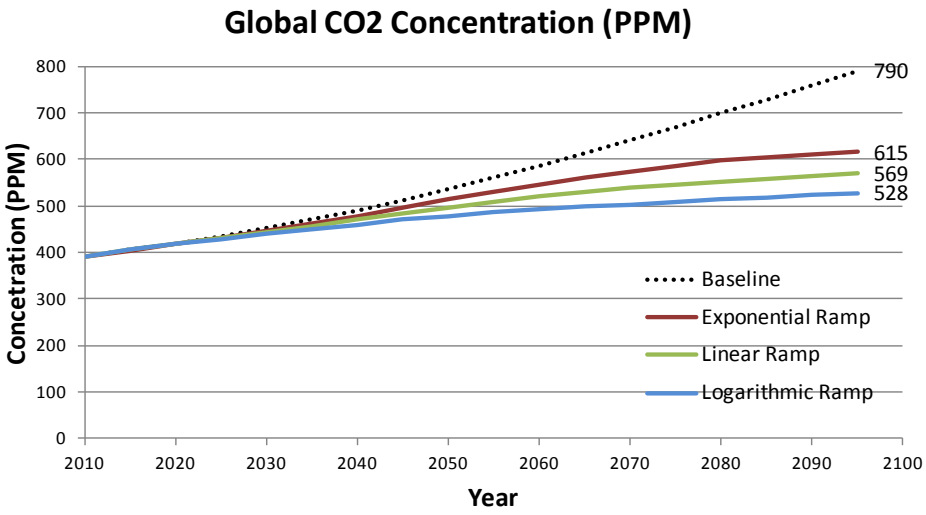
- Compare results from different models
  - GCAM
  - MERGE

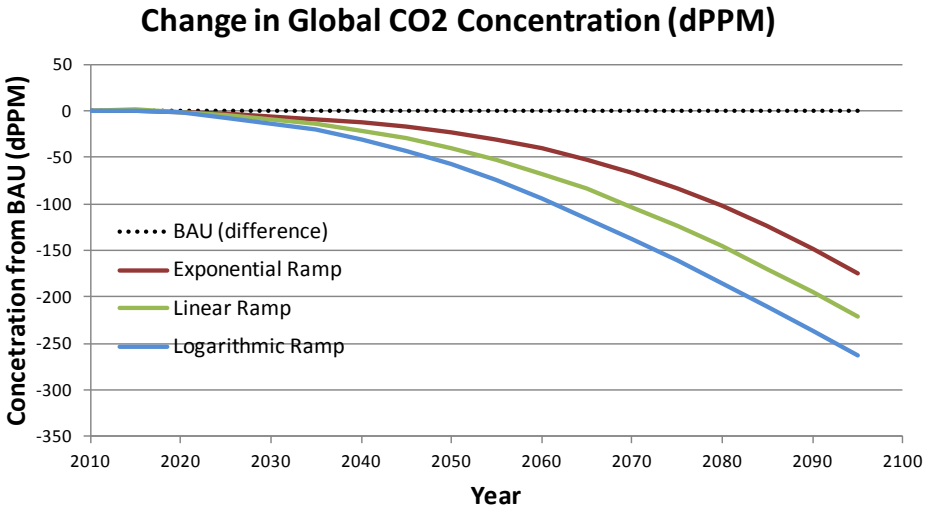
GCAM

GCAM Tax Ramp Results: CO2

- Global CO2 concentration

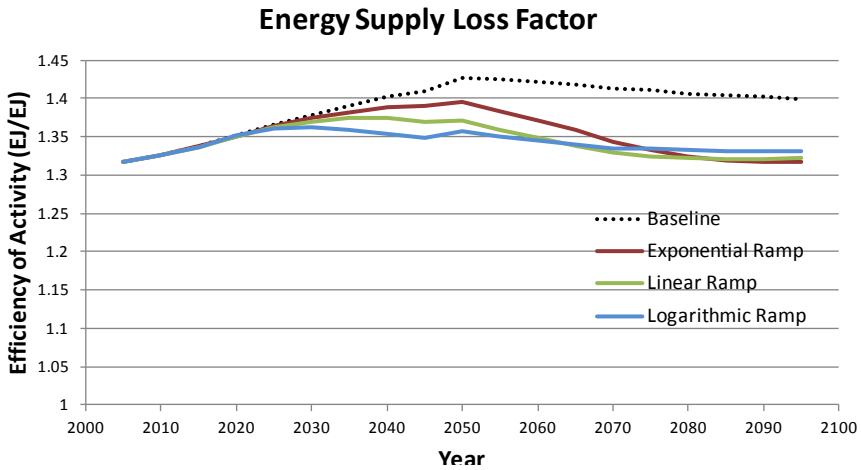
- Logarithmic scenario drives emissions down sooner
  - significant benefit to global concentration

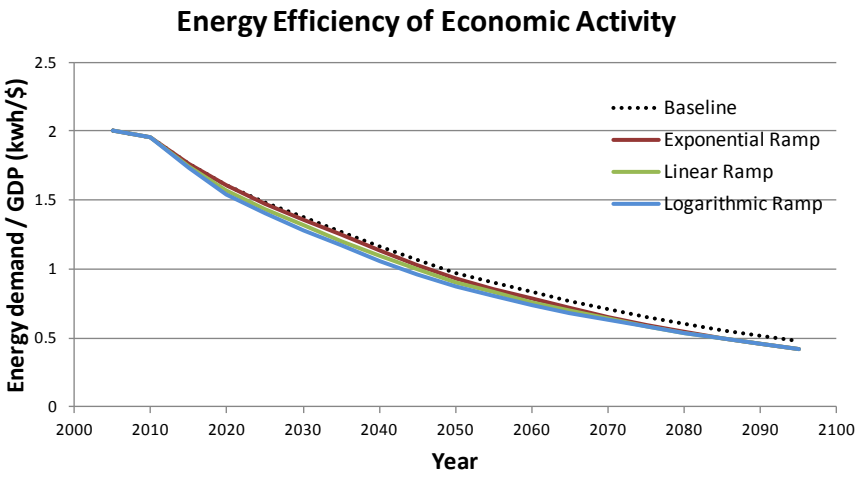


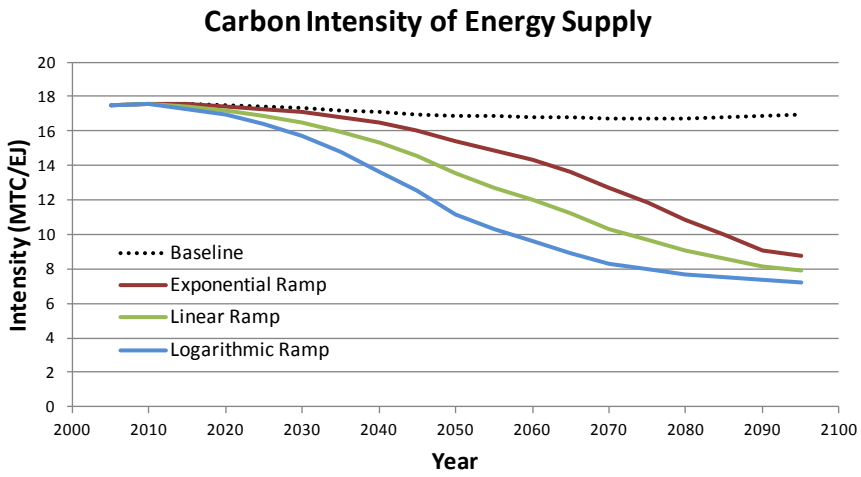


GCAM Tax Ramp Results: Kaya Terms

- P * GDP/P * FE/GDP * PE/FE * C/PE
  - Population and GDP exogenous



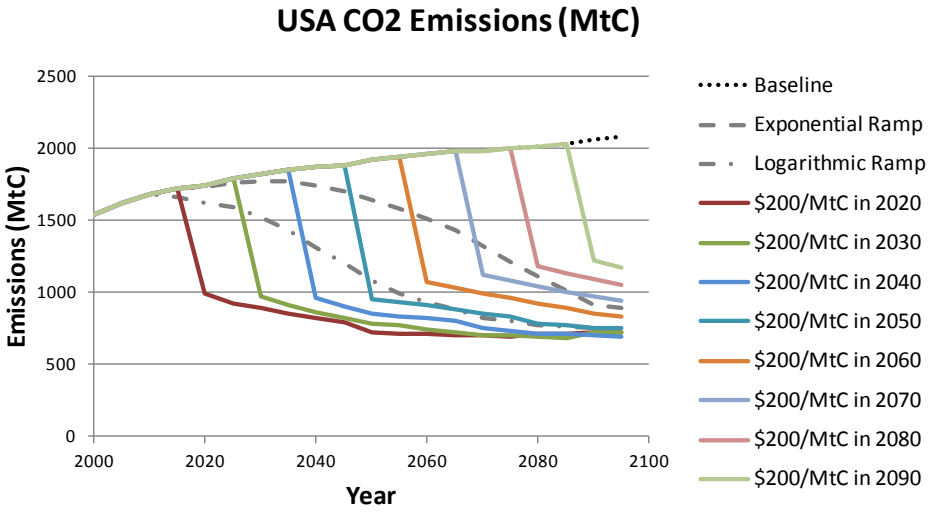


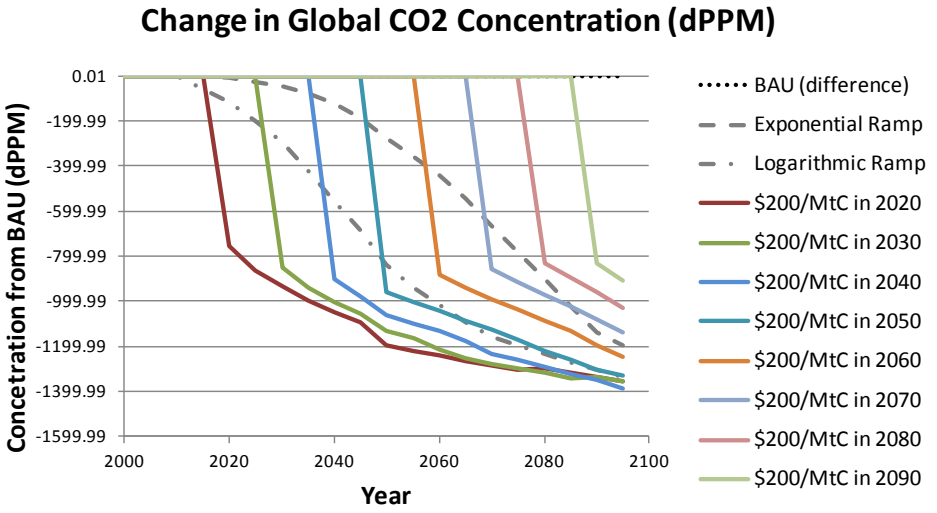


GCAM $200 Tax Shock Results: CO2

- US CO2 emissions

- Spurs dramatic change in emissions, followed by only modest reductions
- A delayed $200 tax has similar effect as the ramp cases
  - 2050 ~ Logarithmic
  - 2060 ~ Exponential





GCAM $200 Tax Shock Results: Kaya

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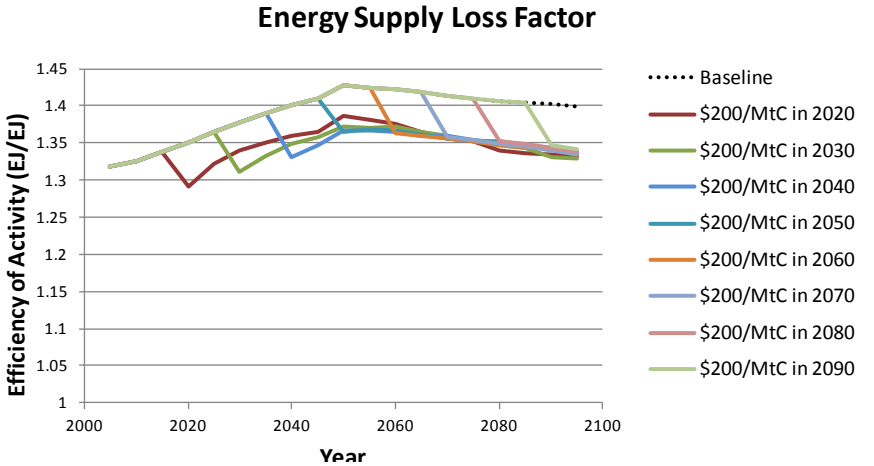
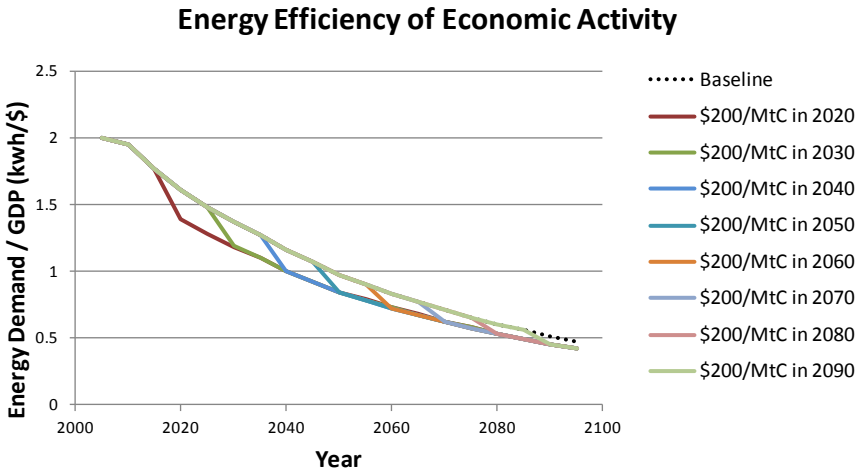
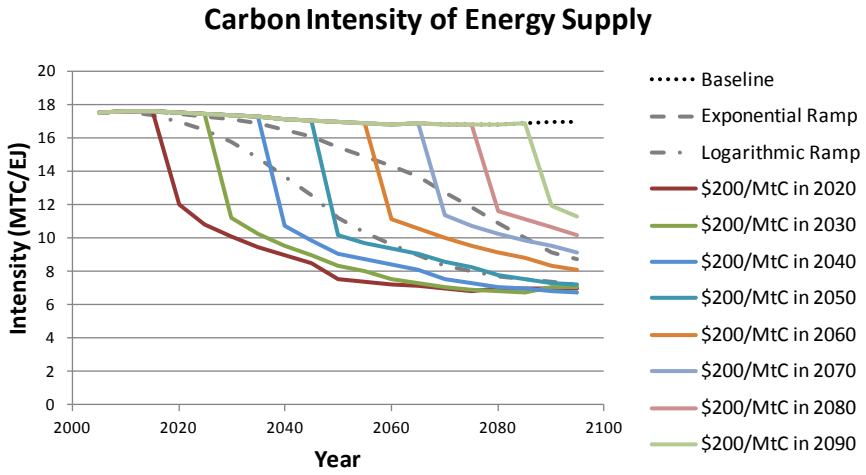
  - Population and GDP exogenous

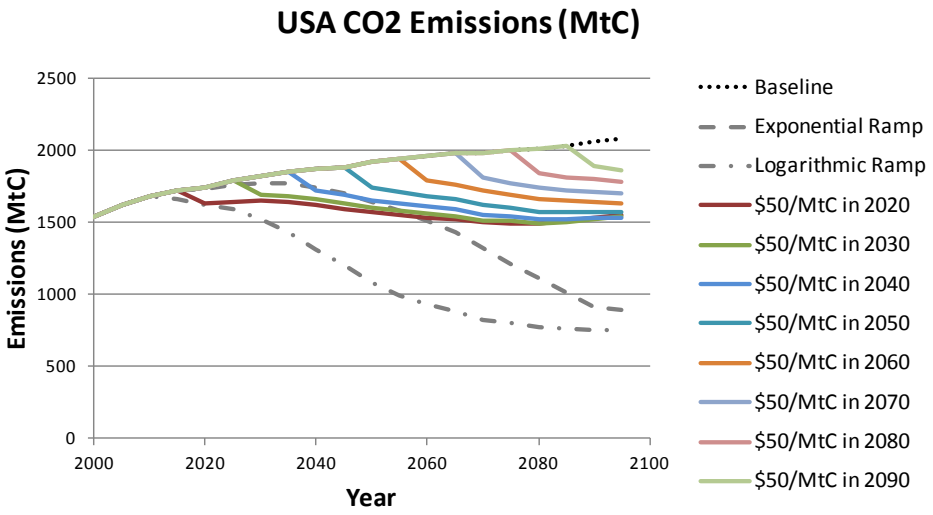


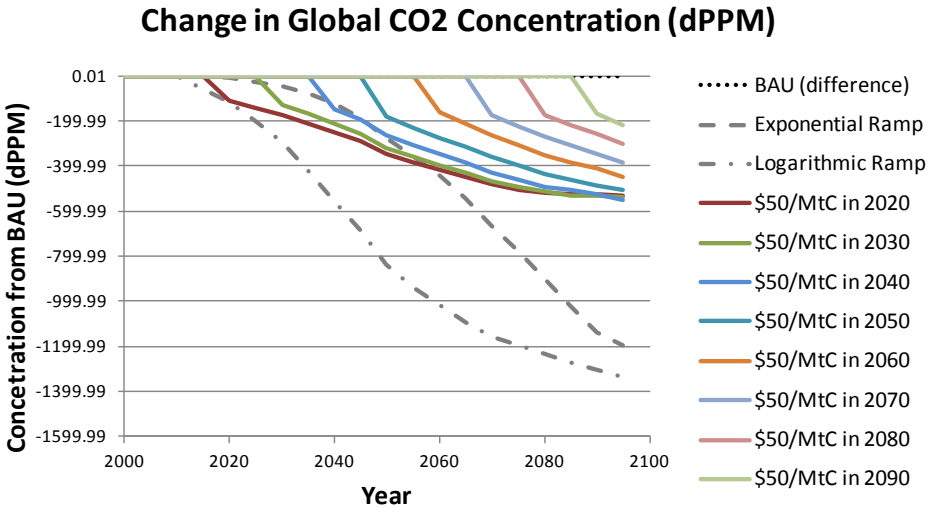




GCAM $50 Tax Shock Results: CO2

- US CO2 emissions
- $50 constant tax similar but smaller response as $200 tax



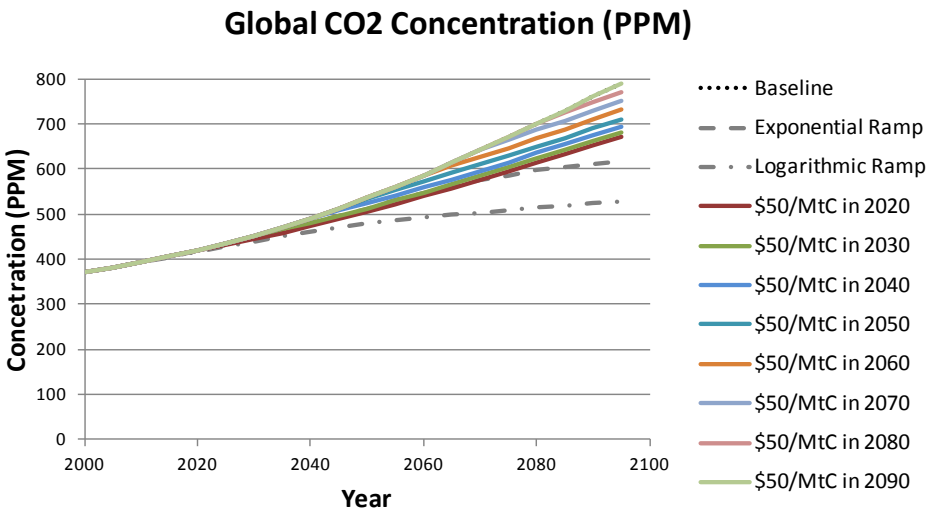


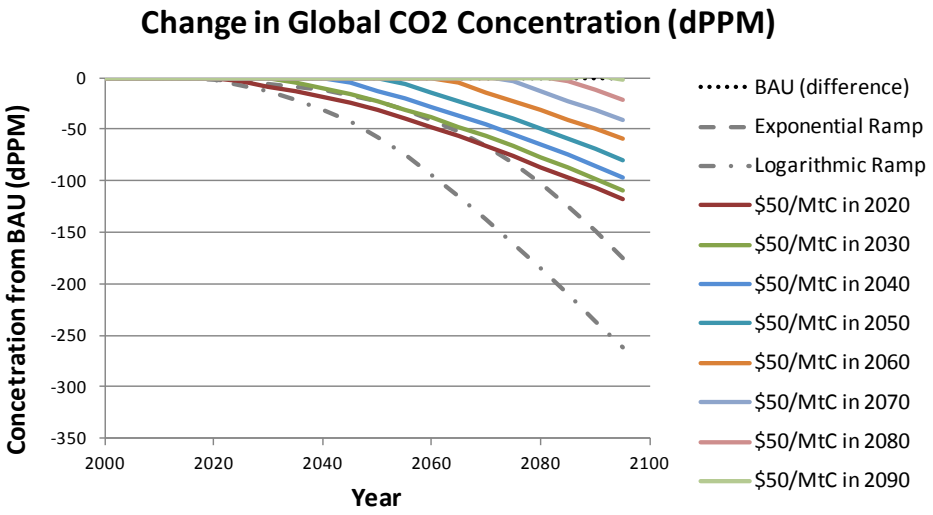
GCAM $50 Tax Shock Results: CO2

- Global CO2 concentration

- An immediate $50 constant tax will only reduce global concentration by 120ppm from the base case by 2095

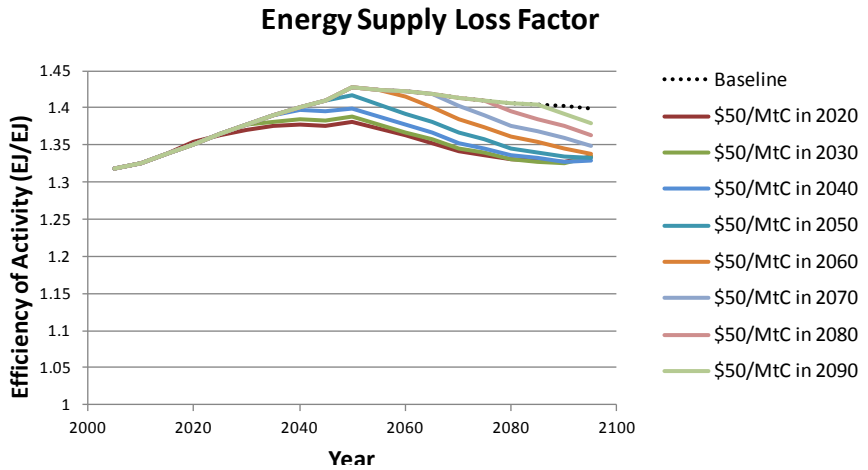
- $100 tax (not shown) can reduce concentration by 200ppm by 2095

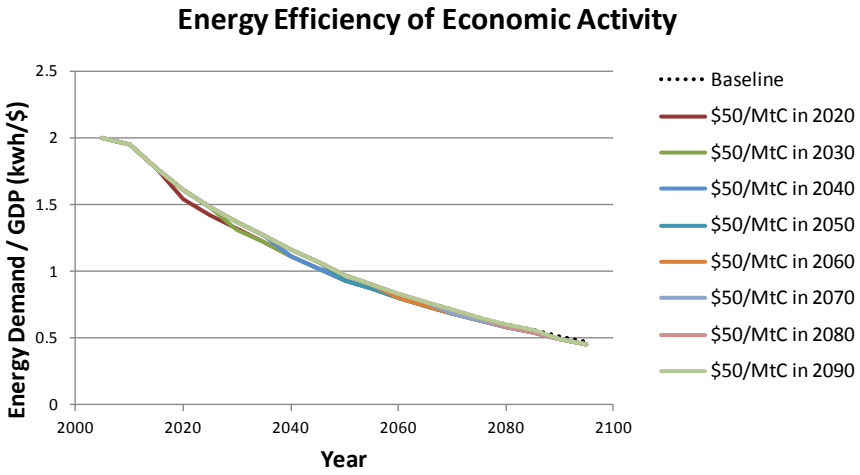


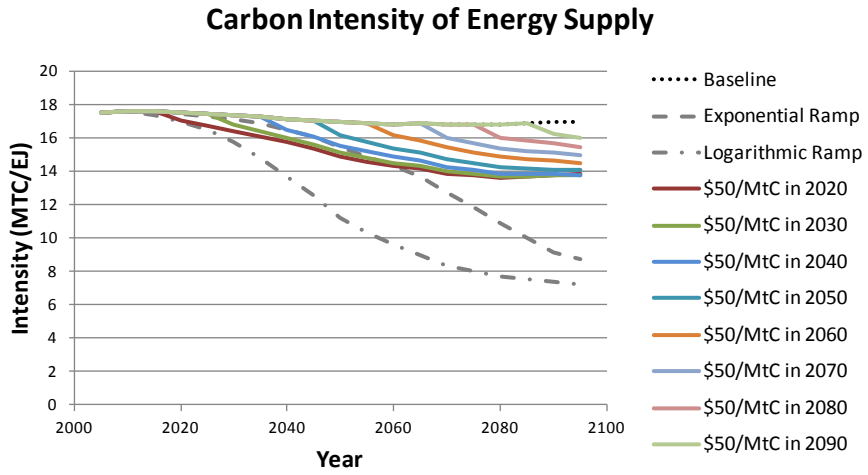


GCAM $50 Tax Shock Results: Kaya

- P * GDP/P * FE/GDP * PE/FE * C/PE
  - Population and GDP exogenous



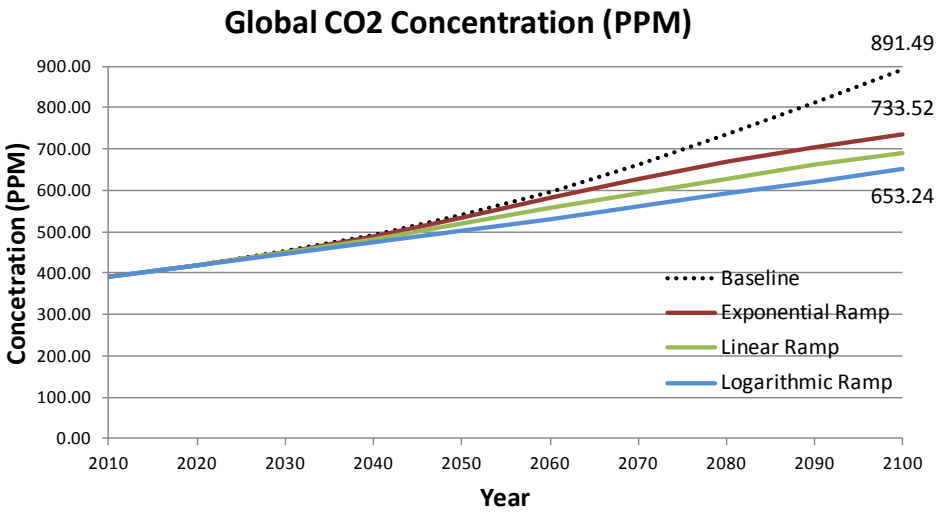


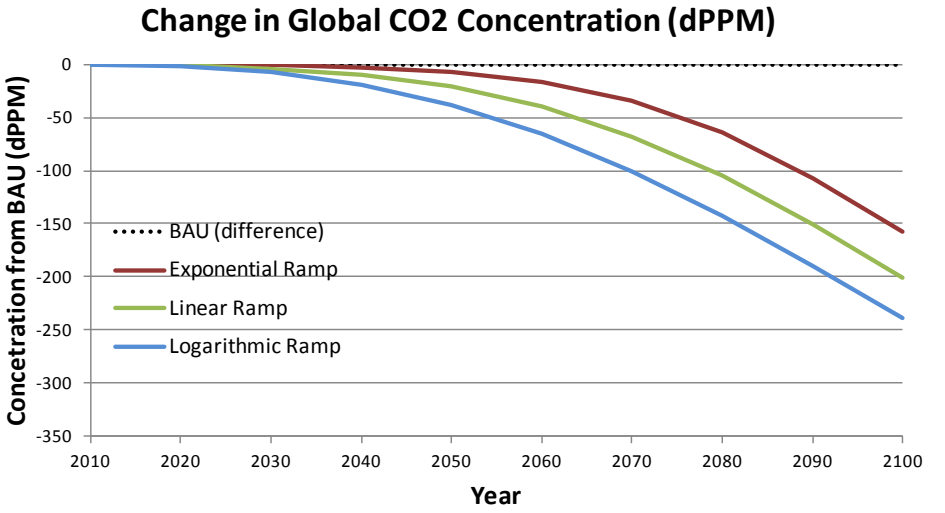


MERGE

Merge Tax Ramp Results: CO2

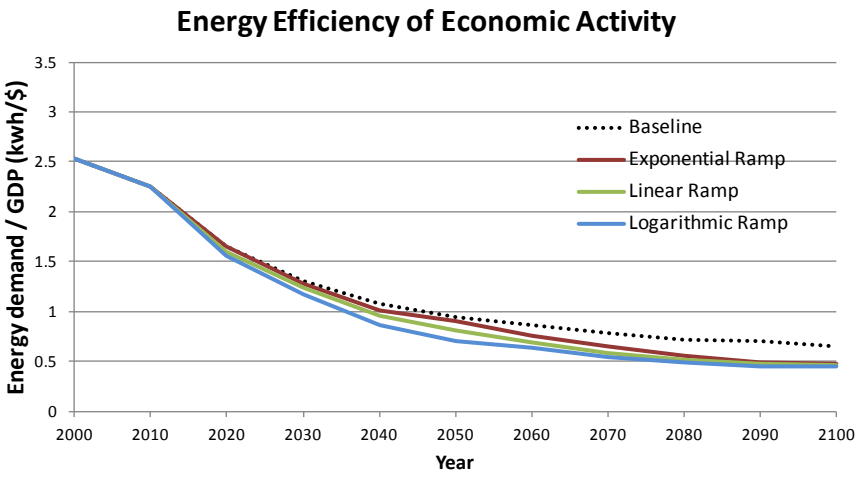
- Global CO2 concentration
- Logarithmic scenario drives emissions down sooner
  - significant benefit to global concentration

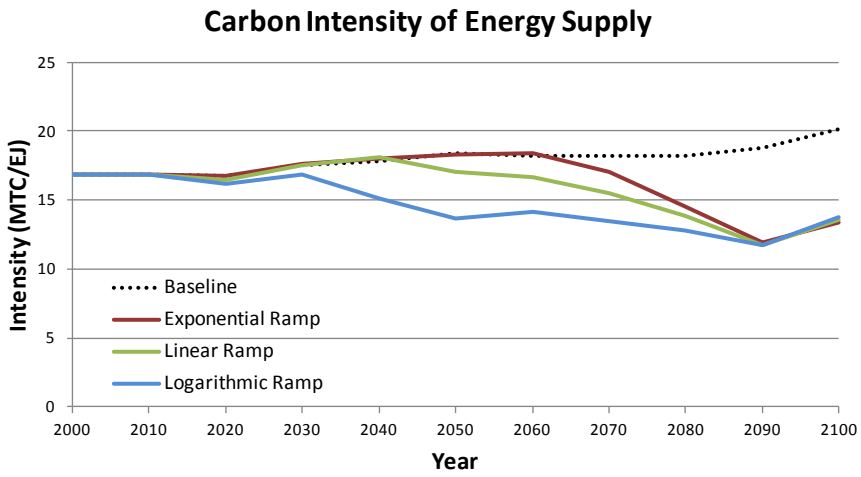




Merge Tax Ramp Results: IPAT

- P * GDP/P * FE/GDP * PE/FE * C/PE
  - Population and GDP exogenous
  - No final energy
  - Difficult to tease out CCS

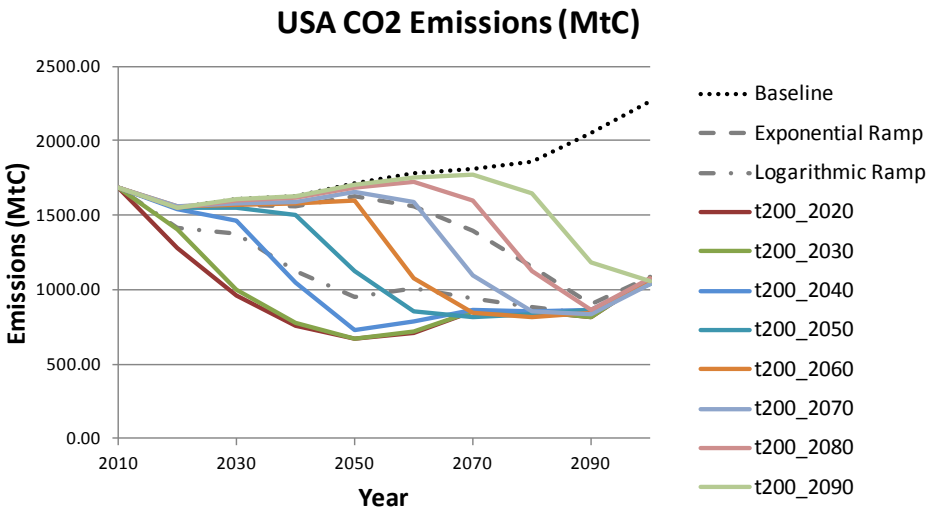


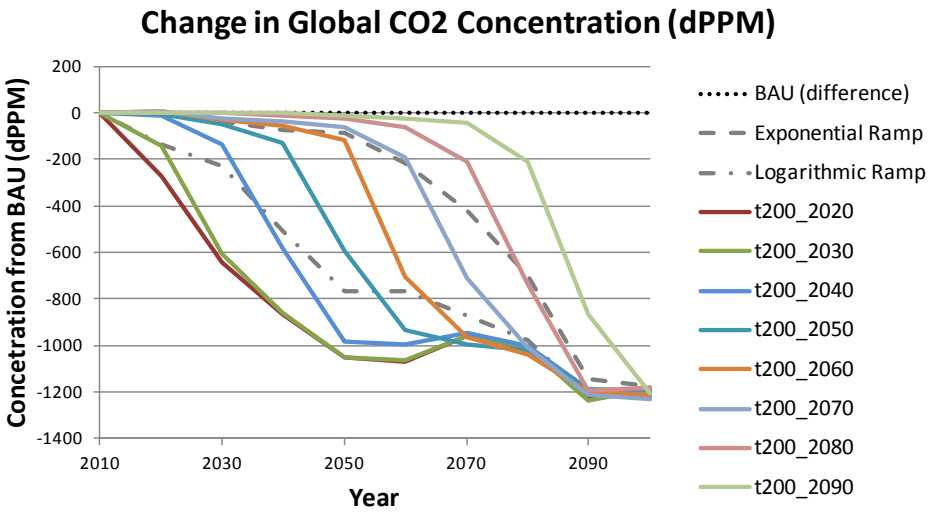


MERGE $200 Tax Shock Results: CO2

- US CO2 emissions

- Spurs dramatic change in emissions, followed by only modest reductions
- A delayed $200 tax has similar effect as the ramp cases
  - 2070 ~ Logarithmic
  - 2080 ~ Exponential





MERGE $200 Tax Shock Results: IPAT

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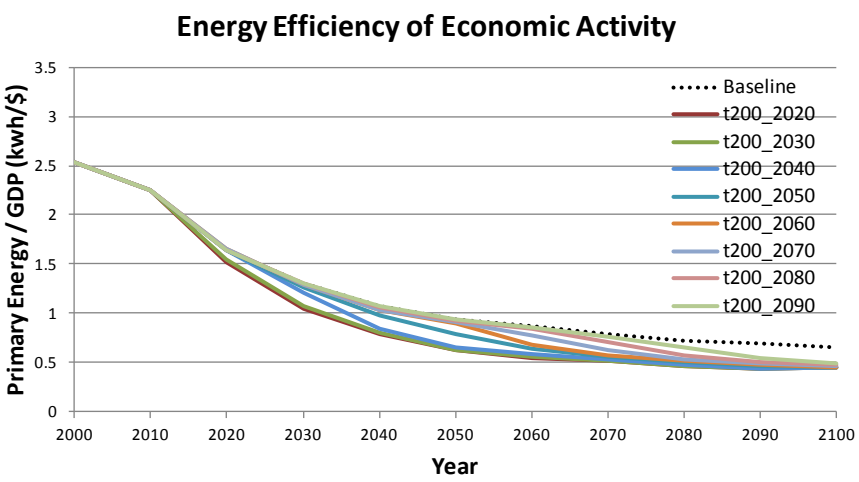

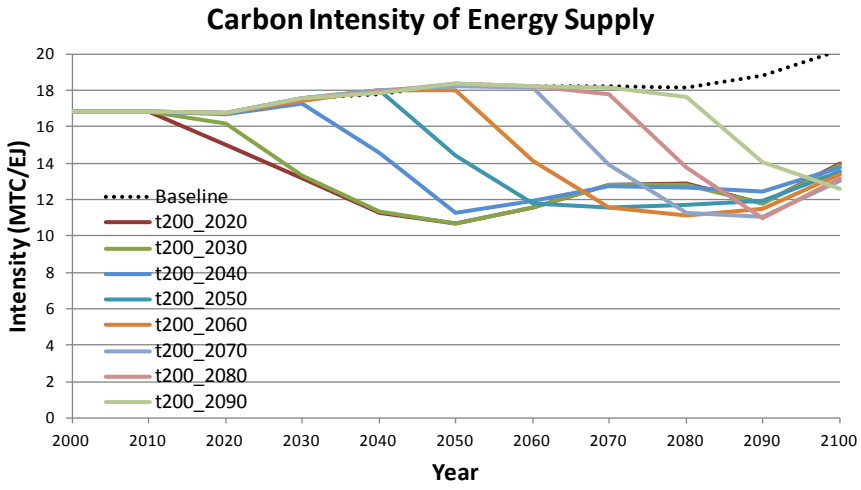

You believe, but what you see.
You receive, but what you give.

CO2 concentrations

- Resulting CO2 concentrations from $200/MtC tax beginning in various years.