

# **Economic and Energy Market Effects of S. 2191: MIT Analysis and Comparison with other Analyses**

Report @

[http://web.mit.edu/globalchange/www/MITJPSPGC\\_Rpt146\\_AppendixD.pdf](http://web.mit.edu/globalchange/www/MITJPSPGC_Rpt146_AppendixD.pdf)

John Reilly (jreilly@mit.edu)

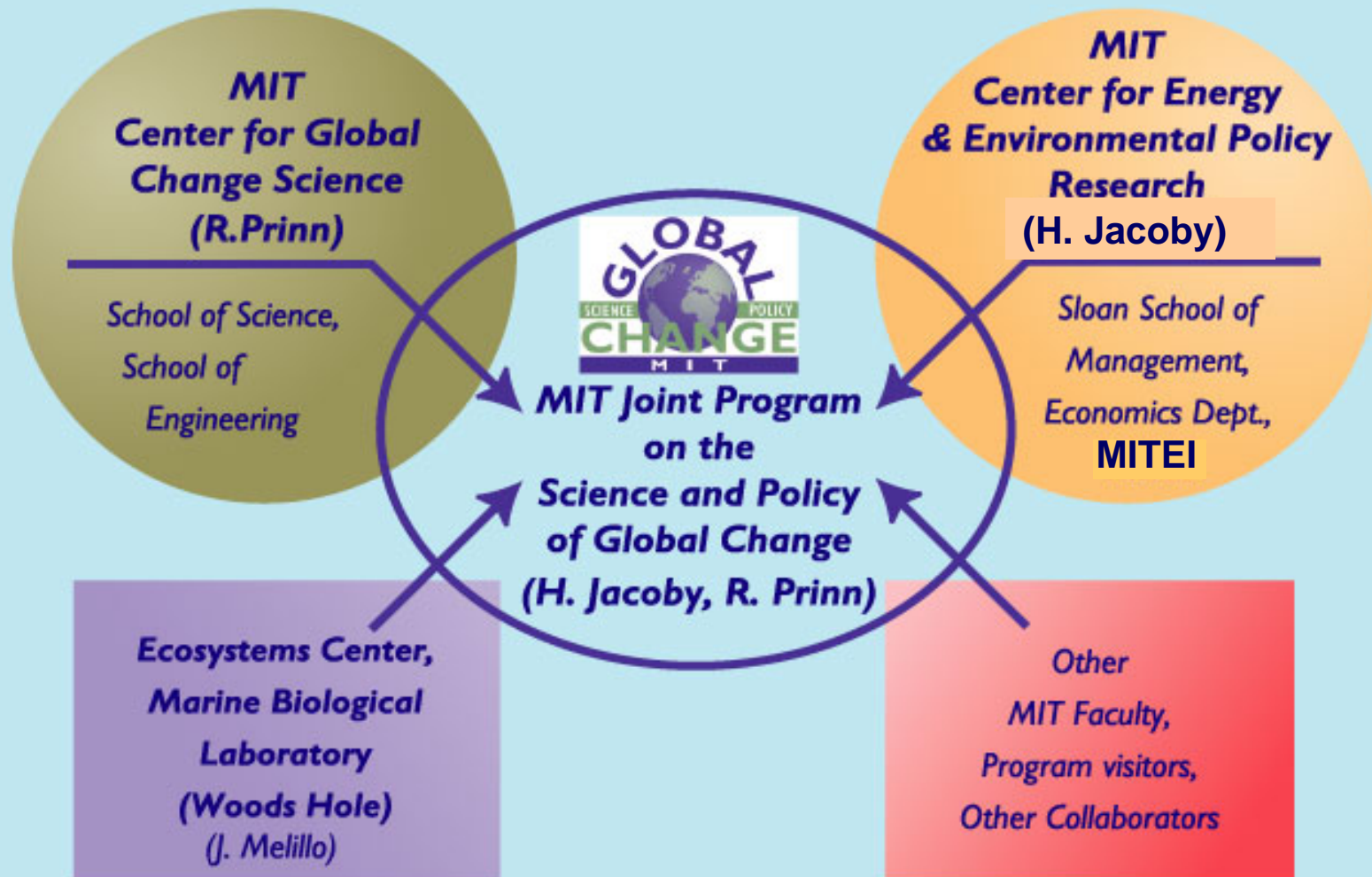
**Joint Program on the Science and Policy of Global Change  
Massachusetts Institute of Technology**



**Workshop on Understanding Cost Estimates of Climate  
Policy, Washington DC May 8, 2008**



# MIT Programs on Energy and Global Change



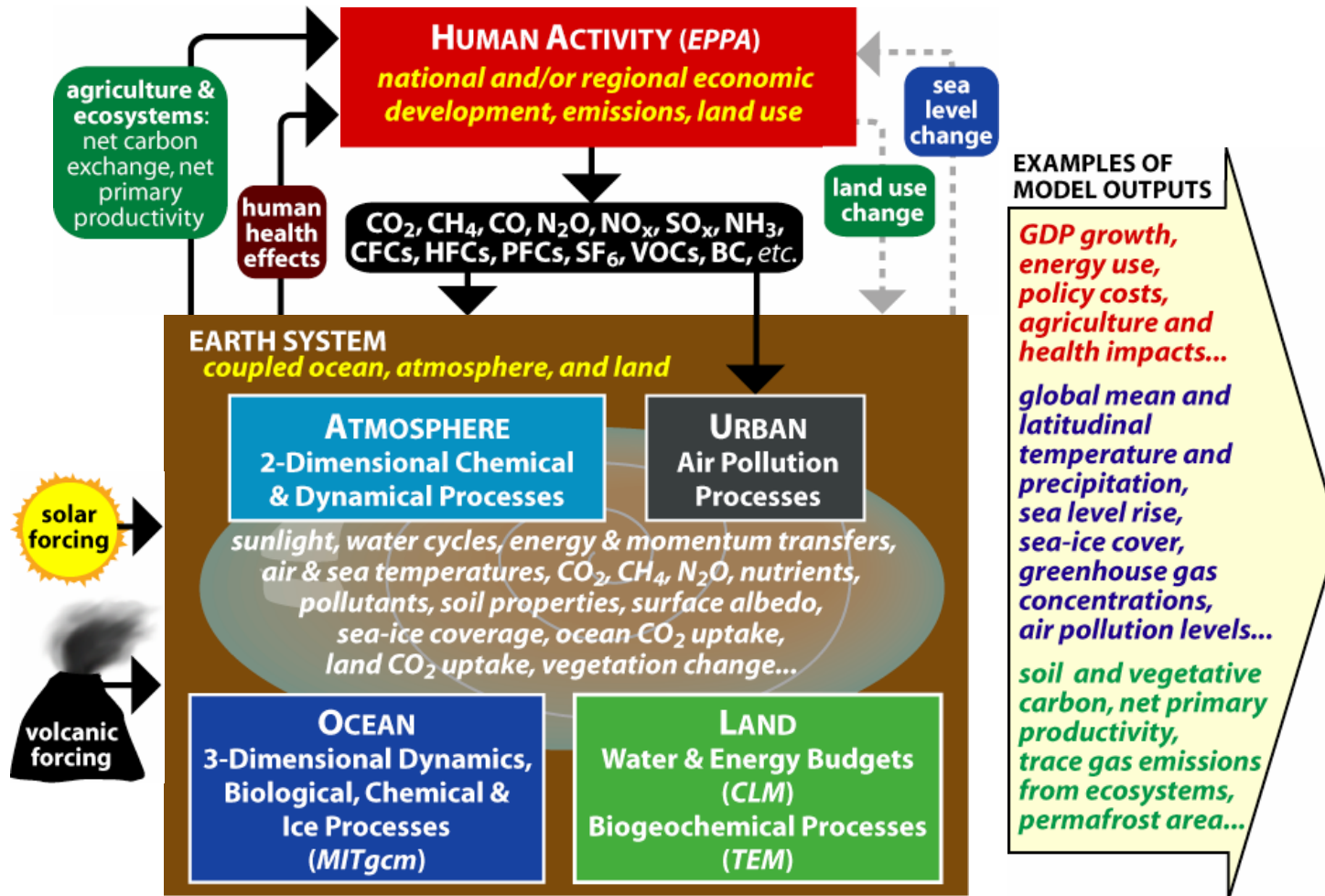
## Model Development and Policy Analysis is Possible Because of Joint Program Sponsors

- **US Industry/Foundation**
  - Alstom Power
  - Cargill
  - Chevron
  - Chrysler
  - Electric Power Research Institute
    - American Electric Power
    - Duke Energy
    - Ogelthorpe Power
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  - ExxonMobil
  - Ford Motor Company
  - General Motors
  - Merrill Lynch
  - Murphy Oil
  - Schlumberger
  - Tennessee Valley Authority
  - Vetlesen Foundation
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  - J-Power (Japan)
  - APMoller-Maersk (Den)
  - Norway Pet. Ministry
  - RWE Power (Germany)
  - Shell Petroleum
  - StatoilHydro
  - Tokyo Electric Power
  - Total
- **U.S. government**
  - DOE
  - EPA
  - NASA
  - NOAA
  - NSF

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# MIT Integrated Global System Model



# EPPA Model

## Sectors

### Non-Energy

- Agriculture
- Energy Intensive
- Other Industry
- Services
- Industrial Transport
- Household Transport
- Other Household Consumption

### Energy

- Crude & Refined oil
- 2<sup>nd</sup> Gen. Biofuel
- Shale oil
- Coal
- Natural gas
- Synthetic gas (from coal)
- Electricity

EPPA is a global computable general equilibrium model with US one of 17 regions with trade in all goods. For this exercise it was solved recursively at 5 year time steps.

### Technologies Included

- Fossil (oil, gas & coal)
- IGCC with capture
- NGCC with capture
- NGCC without capture
- Nuclear
- Hydro
- Wind and solar
- Biomass

# Scenario Design

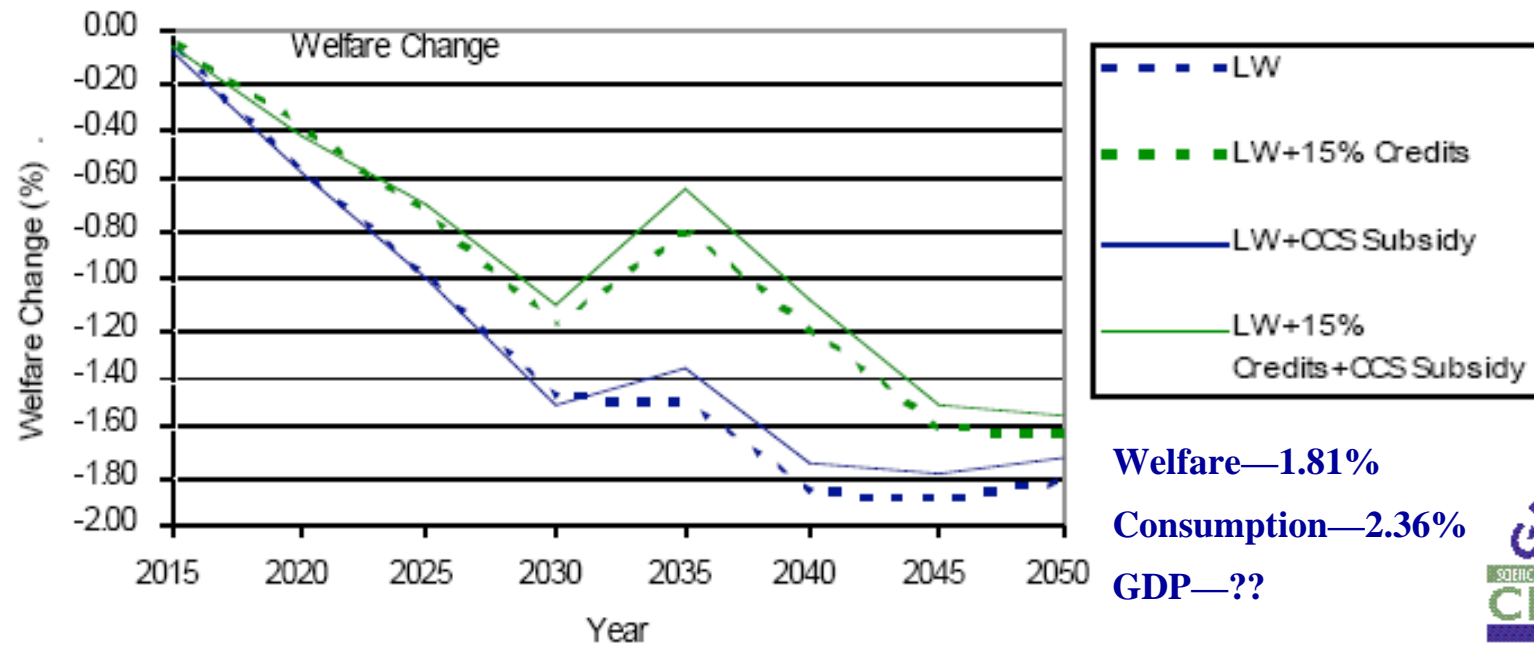
- Matched covered, uncovered, and separately covered activities fairly closely to specifications in the Bill.
  - Covered—most energy, some non-CO<sub>2</sub> GHGs—mainly High GWP industrial gases..
  - Non-covered—land use, many non-CO<sub>2</sub> GHGs especially agriculture, waste sources.
  - Separately covered—HFCs
- Reference Emissions benchmarked to EIA 2007
  - GDP, 3.2% : EIA AEO 2008 of 2.5%/yr. (1980-'07, 3%/yr)
  - EPPA 2030 emissions 8.5 GtCO<sub>2</sub>, AEO '08, 6.9 GtCO<sub>2</sub>.
    - Recent growth rate, 1%/yr; EPPA ~1.4%, AEO ~.5%
  - EPPA 2030 Energy 135EJ, AEO '08, 118EJ
- Scenarios—all with banking/borrowing
  - w/ & w/o 15% allowance for credits from non-covered sources
  - w/ & w/o bonus allowances for CCS (unrestricted amount)
  - Did not consider trade with foreign cap and trade systems.
  - Did not consider effects of bonus allowances to non-covered activities.
  - Did not consider use of revenue, R&D, other efficiency provisions

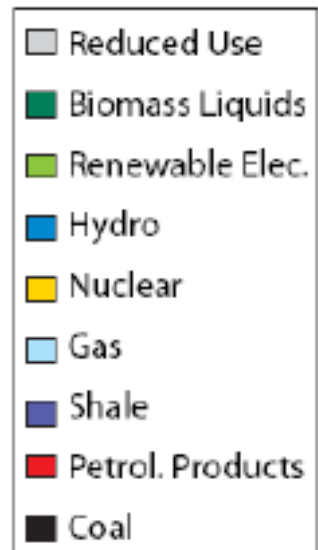
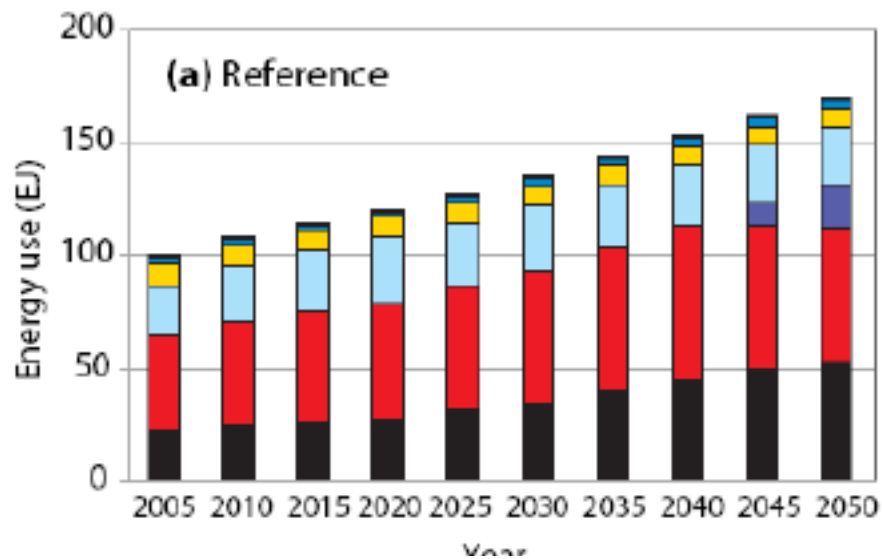


# Scenarios Results

Table D3. CO<sub>2</sub>-equivalent prices (ex HFCs).

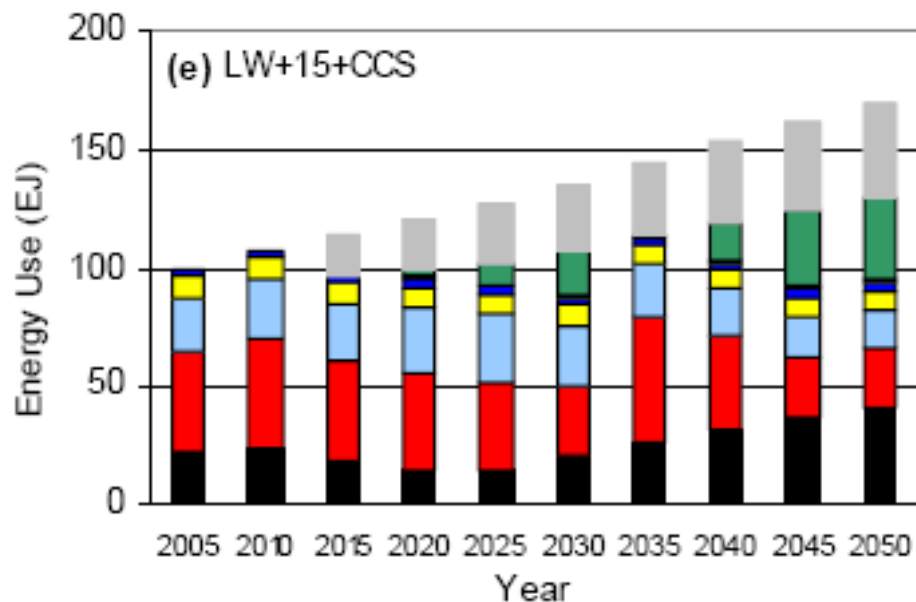
	CO <sub>2</sub> -e Price (\$/tCO <sub>2</sub> -e)			
	<i>LW</i>	<i>LW+CSS Subsidy</i>	<i>LW+15% Credits</i>	<i>LW+15% Credits + CCS Subsidy</i>
<b>2015</b>	56	55	48	48
<b>2020</b>	68	67	59	58
<b>2025</b>	83	81	71	71
<b>2030</b>	101	99	87	86
<b>2035</b>	123	120	106	105
<b>2040</b>	150	147	128	128
<b>2045</b>	182	178	156	155
<b>2050</b>	222	217	190	189





### Reference

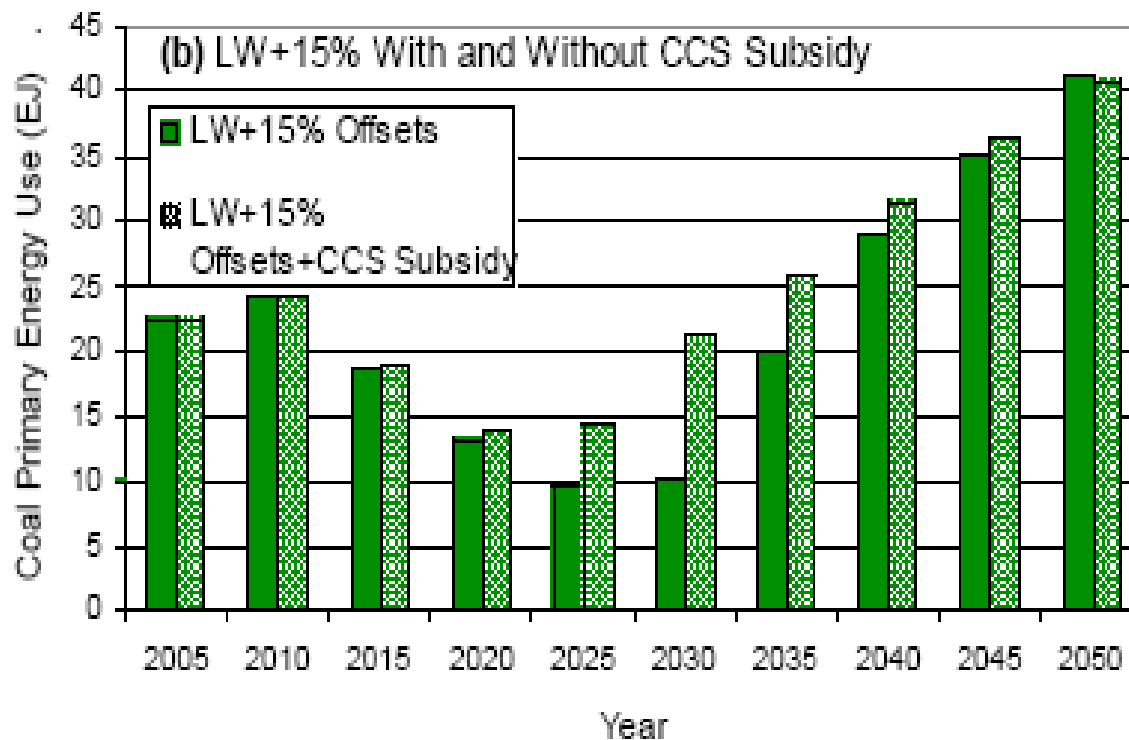
Heavy reliance on coal, petroleum use grows, shale oil enters, some renewable elec (while it does not show up in figure it rises to more than 1/2 current hydroelectric generation).



### Policy Case

Significant reduction in energy use, greater use of gas in mid-years, less post 2030, biofuels replace much of petroleum use, coal use drops but recovers as CCS plants are built.





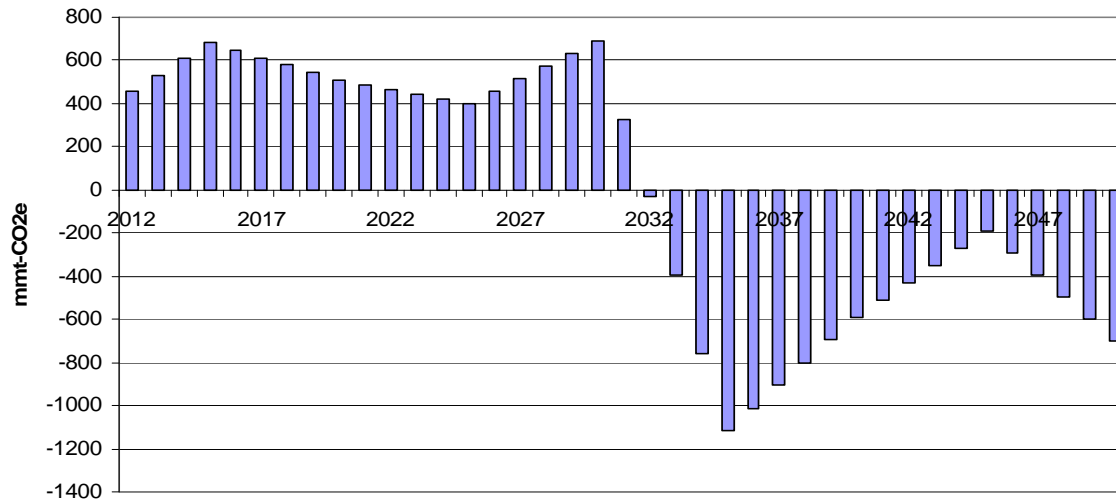
Coal use shows big impact, partly offset with CCS bonus allowance.

# Technology...

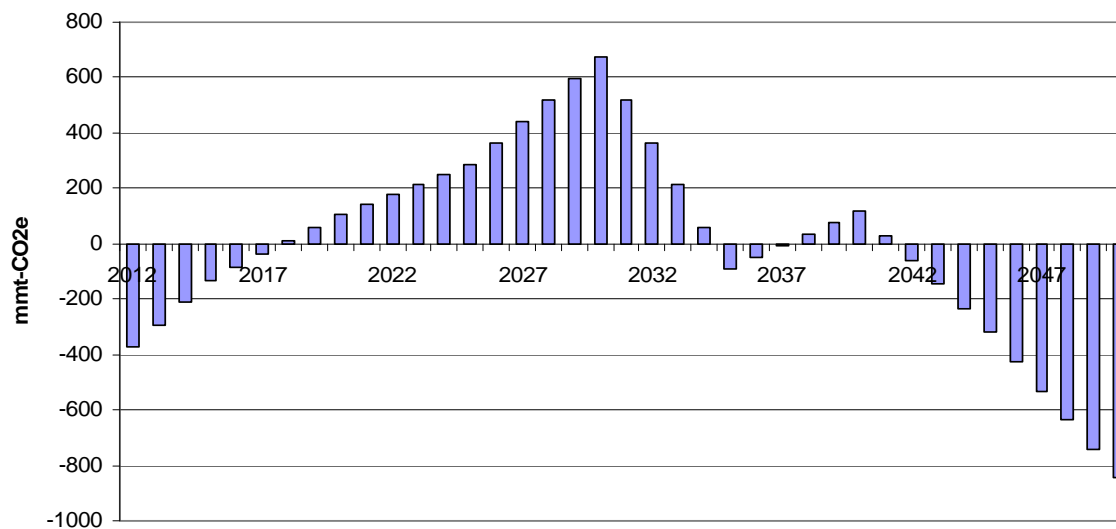
- To decarbonize to this level will require novel technologies at very large scales, overcoming barriers to siting, scaling up of production, unexpected problems, new regulations and rules, industry models, engineers/managers/construction crews.
- EPPA-like models depends on estimates of costs once these things are sorted out.
  - Some characterization of adjustment costs.
  - Learning... Will we learn that the costs are higher than we estimated?
- Electricity
  - Nuclear, CCS—cost uncertainty, not sure which is cheaper, regulatory structure—better the devil you know or the devil you don't.
  - Renewables—intermittency, storage, siting, cost, scaling up. Optimistic cost estimates often don't deal with these other issues or assume complex issues of managing the grid/storage are also solved.
- Biofuels, PHEVs, hybrids, EVs.
- Will one dominate? Or will they be close enough so that different situations will favor a portfolio
  - maintaining a portfolio of options is a good thing but that doesn't necessarily mean that all options will be exercised.
- Models give you answers but sensible people need to realize that details on technologies that are yet to be fully developed are informed guess work
  - that is why economists favor price signals to let market participants choose what is best.



**Banking and Borrowing: Offsets**



**Banking and Borrowing: No Offsets**



**Banking & borrowing can change a lot with slightly different assumptions.**



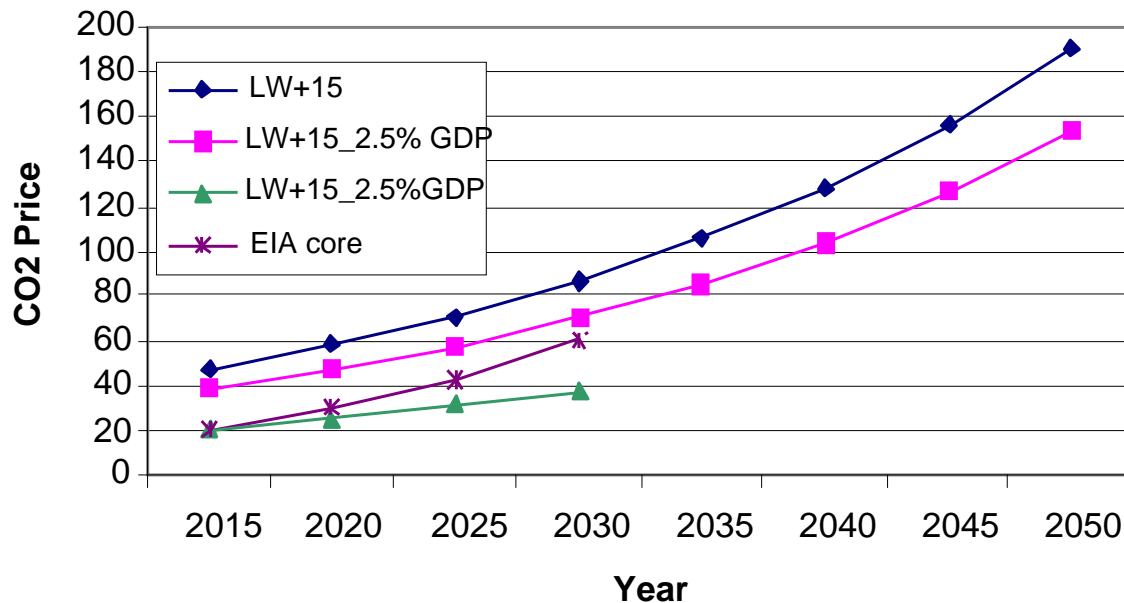
## Why are estimates from different models so different?

- Actually the different models give shockingly similar results when presented with the exact same scenario.
- Various analyses have different assumptions.
  - Reference/baseline emissions.
  - Horizon.
  - Discount rate for banking.
  - Price/supply of external credits to system
- The more models benchmark to standard assumptions the more we should be concerned that we are not fully representing possible range of outcomes.
- There is a tremendous amount of interaction among the modeling groups which is a very healthy thing.



# EIA and MIT

## Understanding Differences in MIT and EIA Analyses

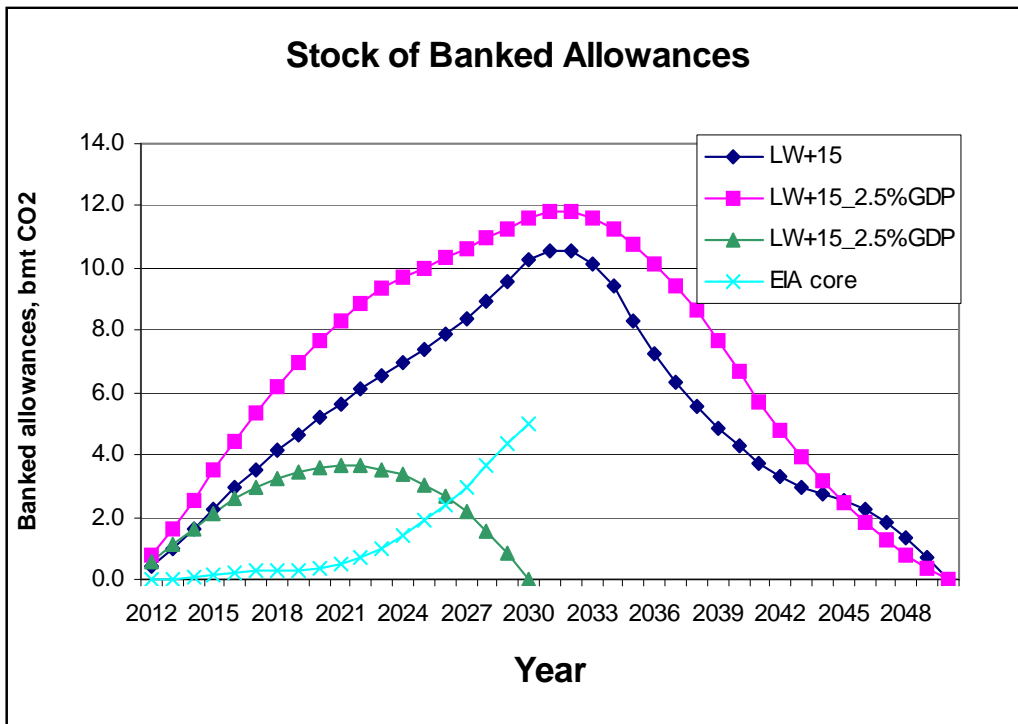


**Bottom line: If MIT ran only to 2030, with a 5bmt bank to carry to post-2030, and assumed 7.4% discount rate for banking decision the results would be almost exactly the same as EIA**

**EIA sharper slope is due to discount rate( 7.4%) compared to MIT (4.0%)**

**MIT2030** uses all allocated allowances through 2030, EIA assumes a bank in 2030 for future of 5bmt; **MIT2050** bank in 2030 is 11.6 bmt. If MIT2030 also banked 5 bmt it would raise price to very close to EIA average.





Post 2030 period is when the policy really tightens, especially the way the credit provision is interpreted.

Illustrates why shorter horizon gives much lower costs.

# Summary

- Different models themselves appear to give very similar results at least in terms of CO<sub>2</sub> price when poised with exact same conditions.
- Spread in results is a good thing—the world is not certain, nor is the exact way in which any legislation will be implemented.
- Details of which technologies will be favored are highly uncertain and depend on educated guesses about how still novel technologies will evolve.

