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US Power Market Future in a Carbon Constrained World

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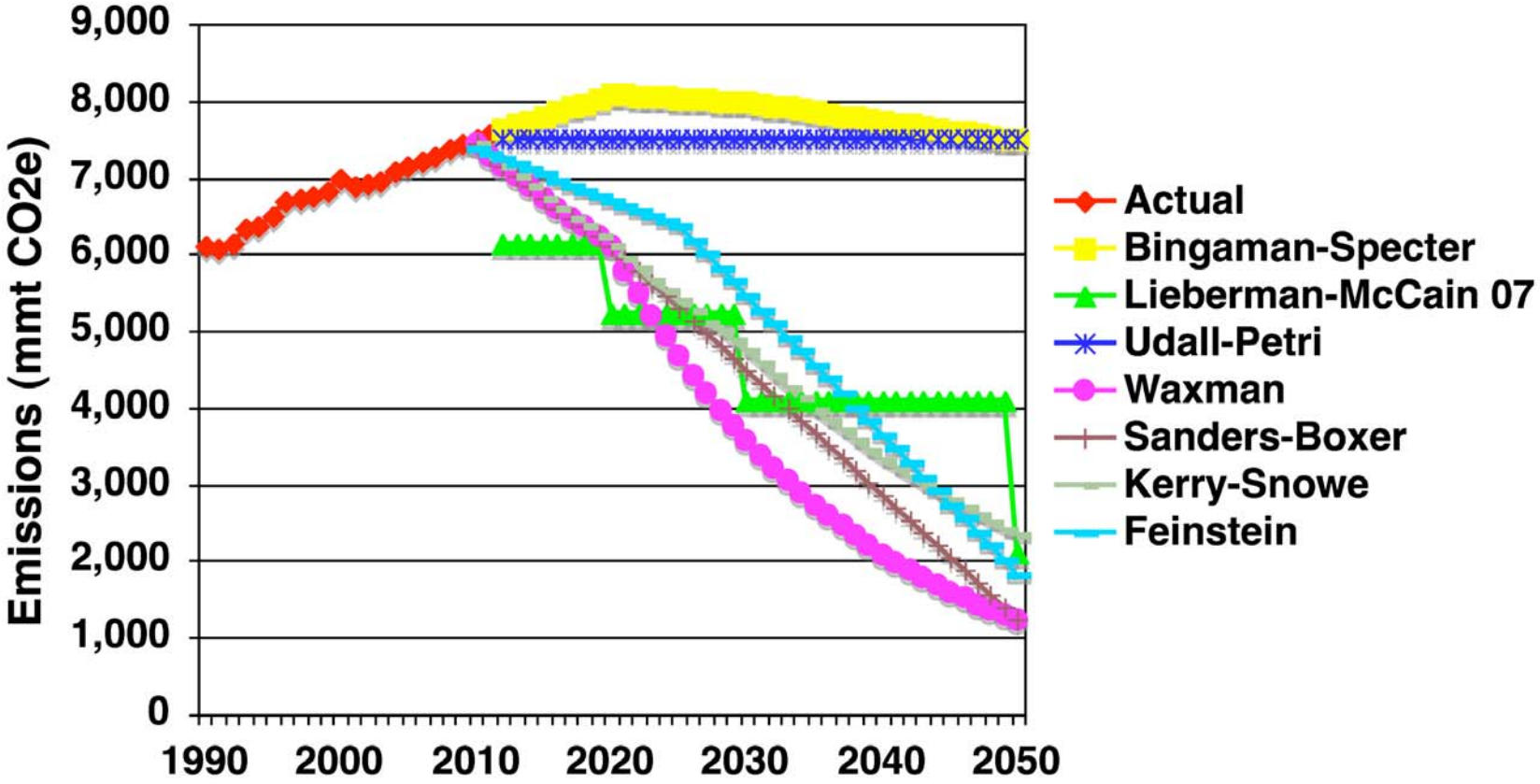
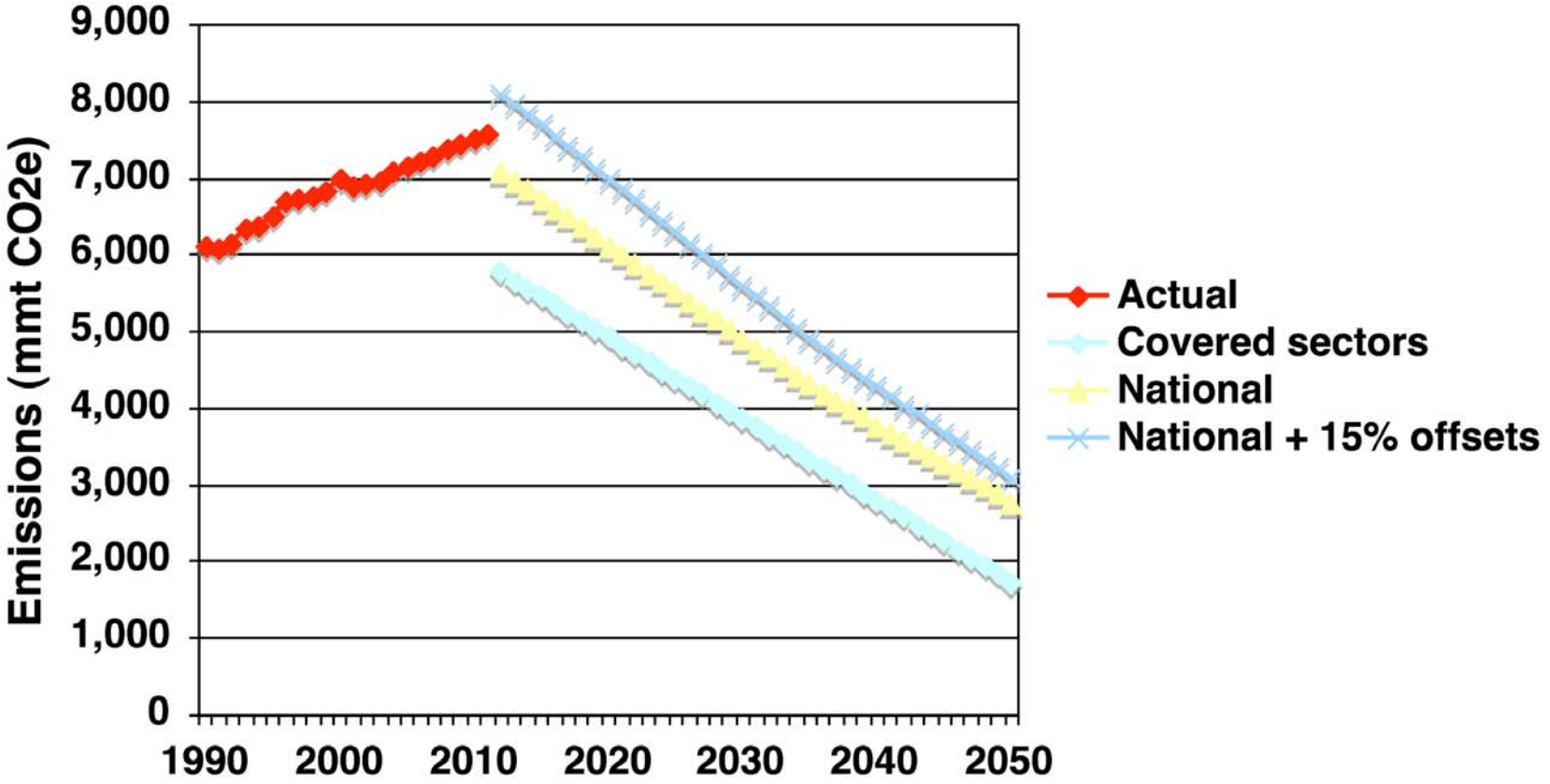
MIT's Joint Program on the Science & Policy of Global Change

- Report #146: Assessment of U.S. Cap-and-Trade Proposals
- Emissions Prediction and Policy Analysis (EPPA) model
- Reference vs. Cap

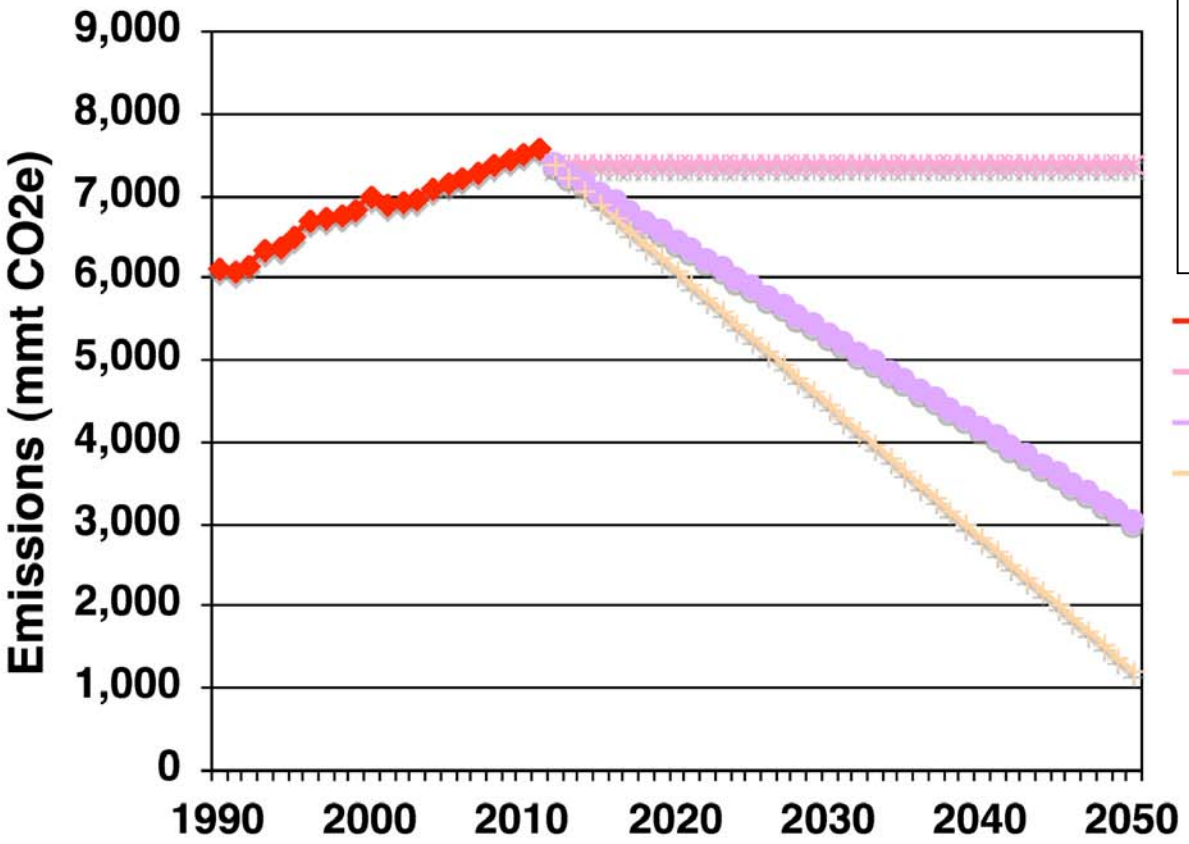
US Emissions & Alternative Cap Proposals



US Emissions & Lieberman-Warner Cap Proposal



In a System with Banking, What Matters is the Aggregate Cap



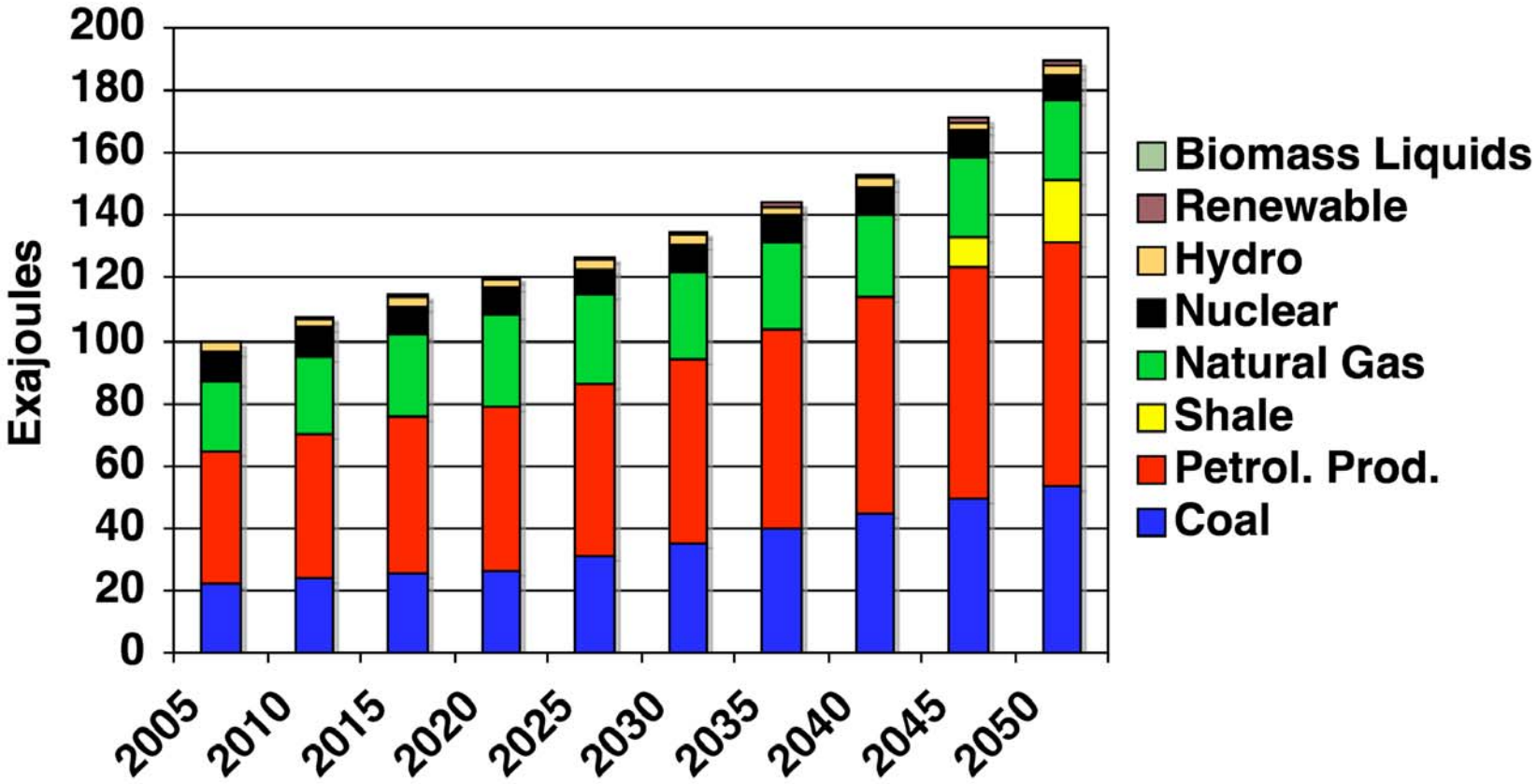
JP Report models 3 cases based on cumulative allowances between 2015-2050.

These slides focus on the 203 case.

Key Assumptions

- **Action in the rest of the world.**
  - Europe/Japan/Australia/Canada
  - Developing Countries
  - Comprehensive coverage except land use & agricultural sequestration
- **Other US energy policies**
- **US trade policies re biofuels**
- **New Technologies**
  - CCS
  - Next generation biofuels
  - Wind
  - Solar
  - Plug-in hybrids / Hydrogen

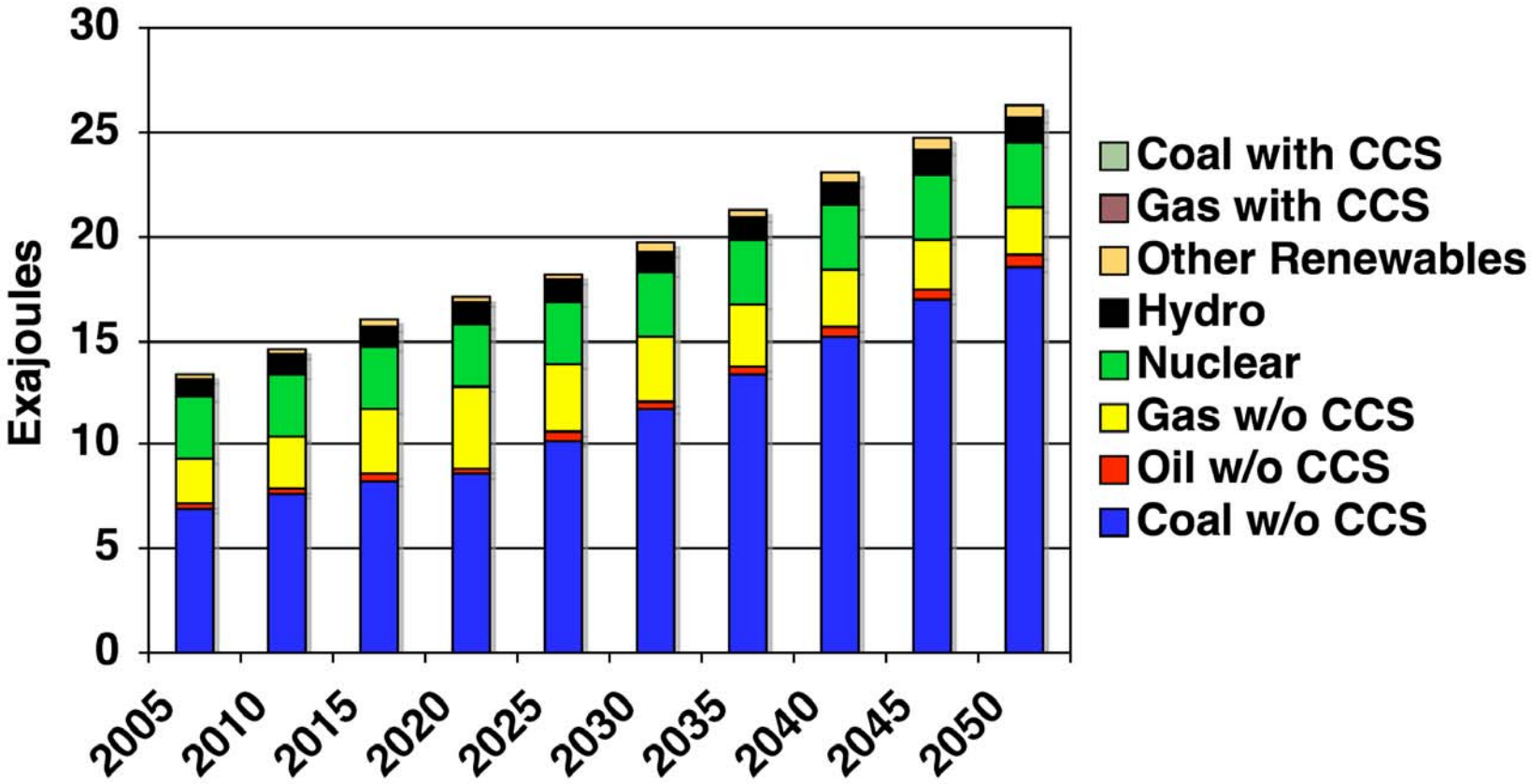
Reference Forecast: Energy Use



Reference Forecast: Energy Use

- Nuclear is held fixed
- Energy use in 2010, 2015 and 2020 grows 8%, 7% and 5% above the previous 5 year level; avg annual rate to 2050 is 1.4%; nonetheless this incorporates on-going improvements in efficiency.
- Coal grows 8%, 6%, 3%, avg annual 1.9%
- Oil grows 10%, 8%, 6%, avg annual 1.4%
- Gas grows 10%, 9%, 8%, avg annual 0.2%
- Renewables grows 17%, 14%, 25%, avg annual 2.2%

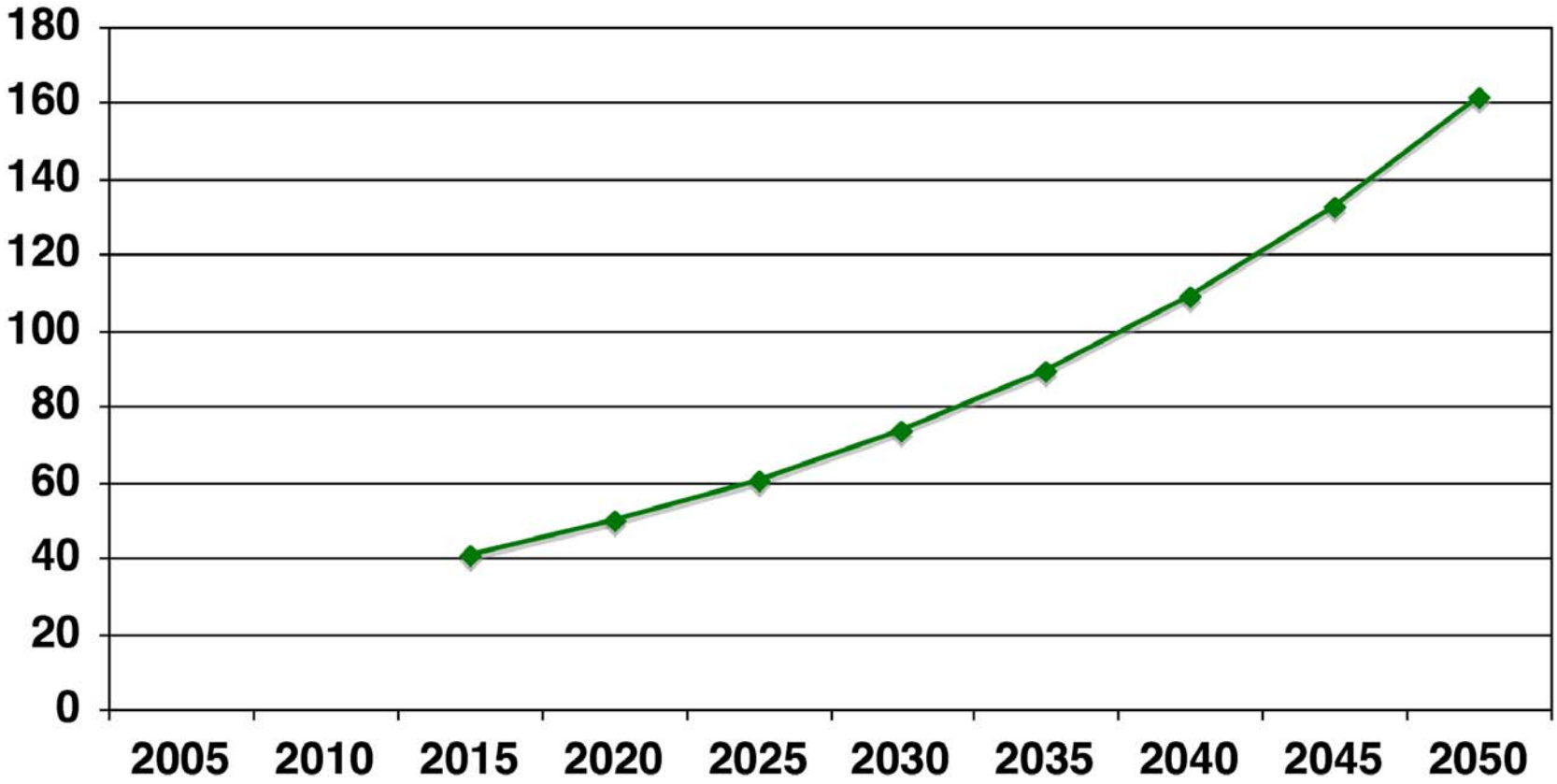
Reference Forecast: Electricity



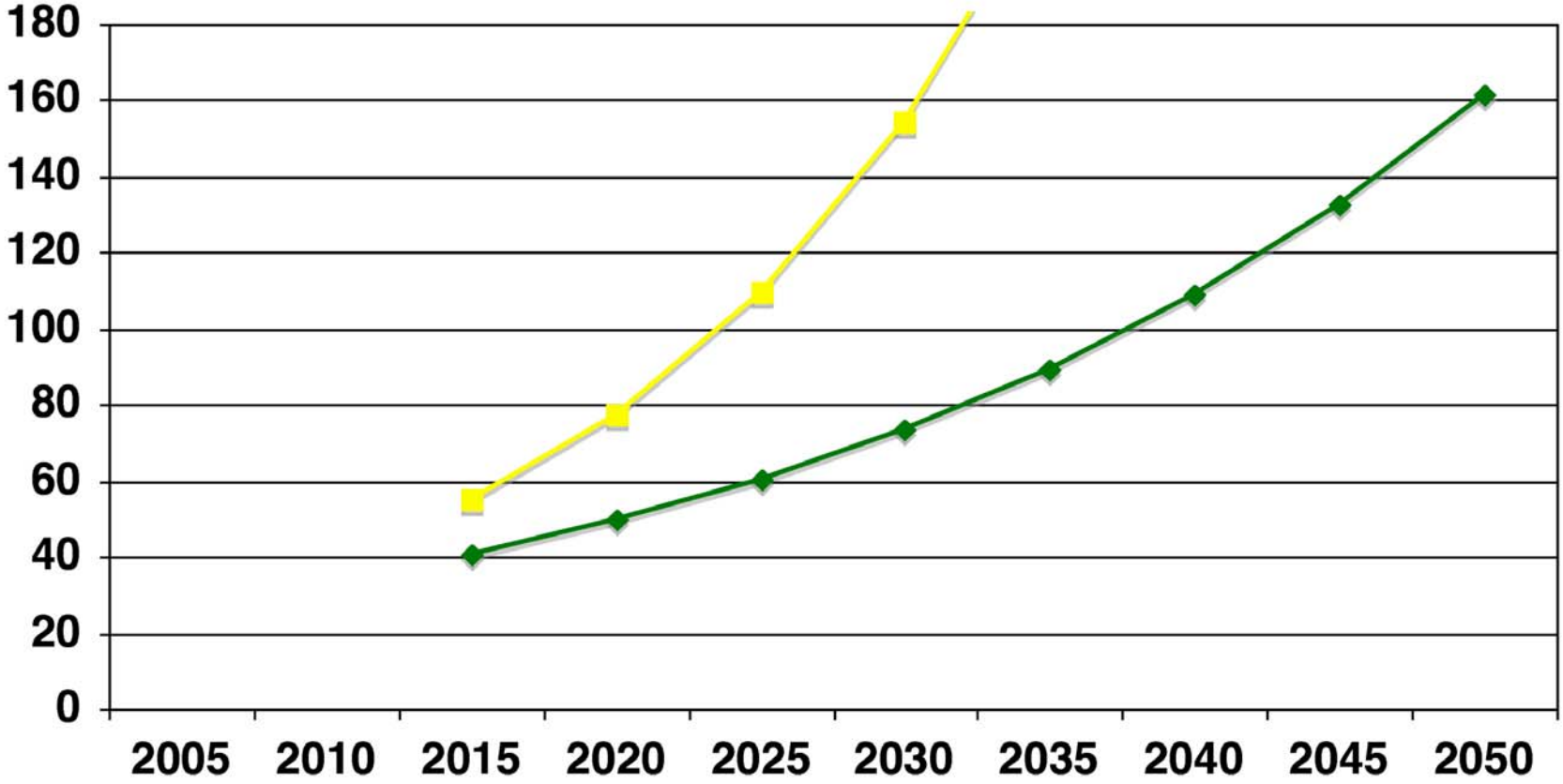
Reference Forecast: Electricity

- Electricity use in 2010, 2015 and 2020 grows 9%, 10% and 4% above the previous 5 year level; avg annual rate to 2050 is 1.5%.
- Coal grows 10%, 9%, 4%, avg annual 2.2%
- Gas grows 19%, 24%, 26%, avg annual 0.2%
- Renewables grows 0%, 50%, 0%, avg annual 2.5%

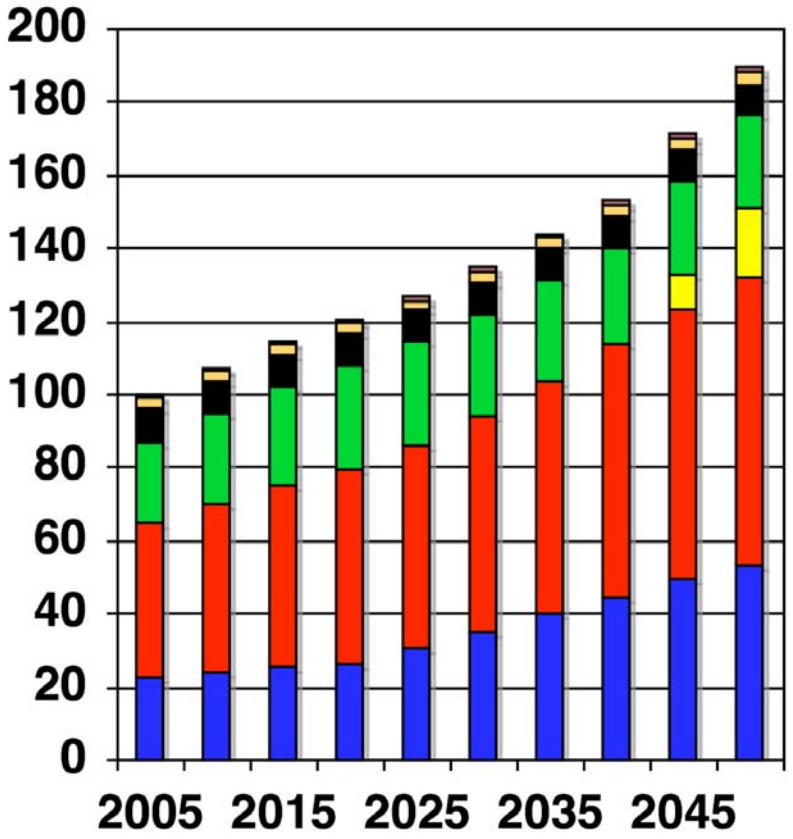
Policy Effect: CO2 Real Price ($2005)

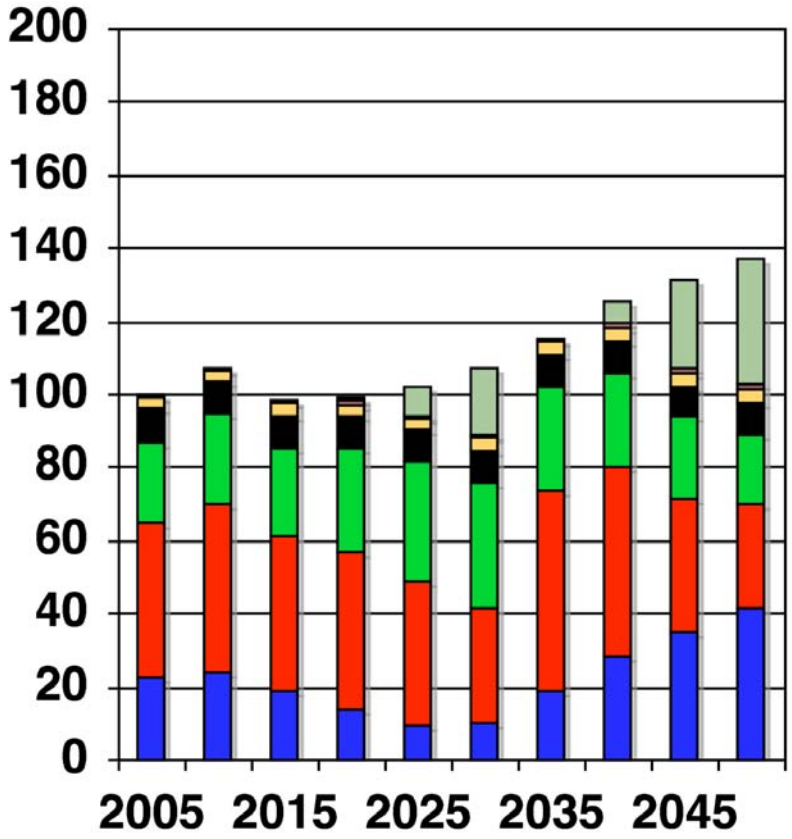


Policy Effect: CO2 Price, Real & Nominal



Policy Effect: Energy Sources

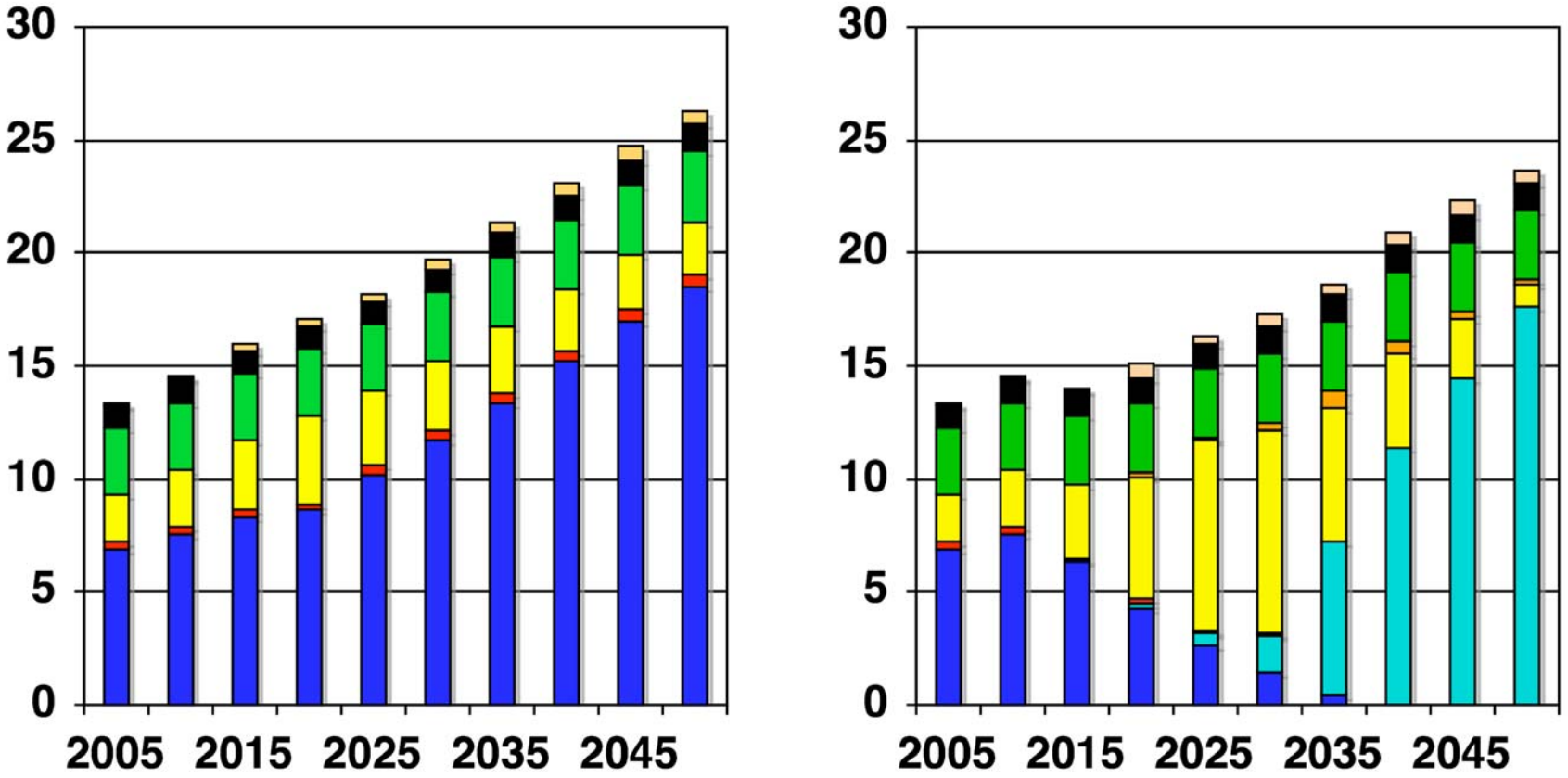




Policy Effect: Energy Use

- **Demand reduction:**
  - 2015 and 2020, cap v. reference lower by 15.8 and 21.1 Exajoules, or 14% and 17%, respectively.
- **Coal's valley of death**
  - Use declines absolutely from 2010 to 2015 and 2020,
  - Therefore cap v. reference is lower by 48% in 2020,
  - Although coal use increases absolutely through 2050, due to CCS.
- **Gas use…**
  - 2015 and 2020, cap v. reference lower by 2.8 and 0.6 Exajoules, or 10% and 2%, respectively,
  - Still increases absolutely to 2050.

Policy Effect: Electricity Production



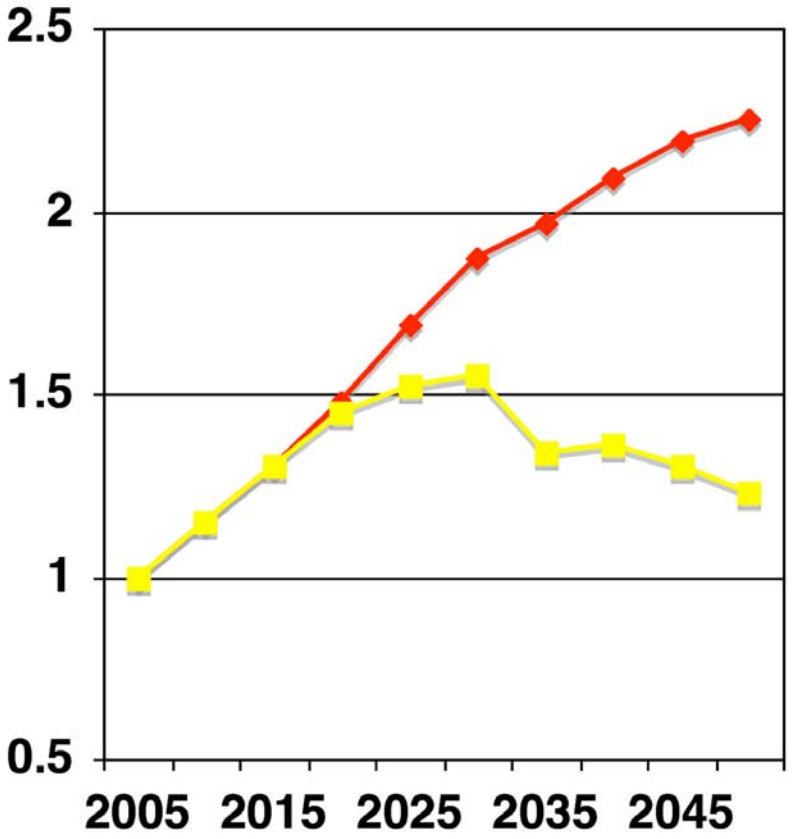
Policy Effect

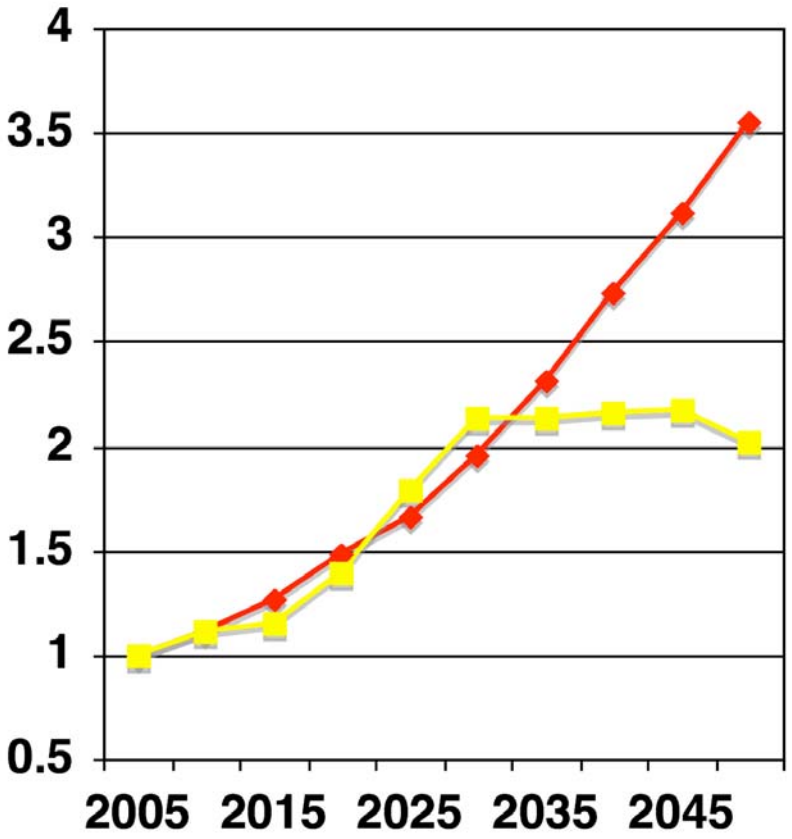
- **Demand reduction:**
  - 2015 and 2020, cap v. reference lower by 2 and 2 Exajoules, or 13% and 12%, respectively.
- **Coal's resurrection…**
  - is due to CCS beginning in 2020;
  - involves ALL electricity generation from coal incorporating CCS
- **Gas use…**
  - 2015 and 2020, cap v. reference HIGHER by 0.1 and 1.5 Exajoules, or +3% and +38%, respectively,
  - Essentially tied to coal's trajectory; gas replaces coal without CCS, but is replaced in turn by coal with CCS.

Comparison of $40 Carbon Price to Fuel Prices

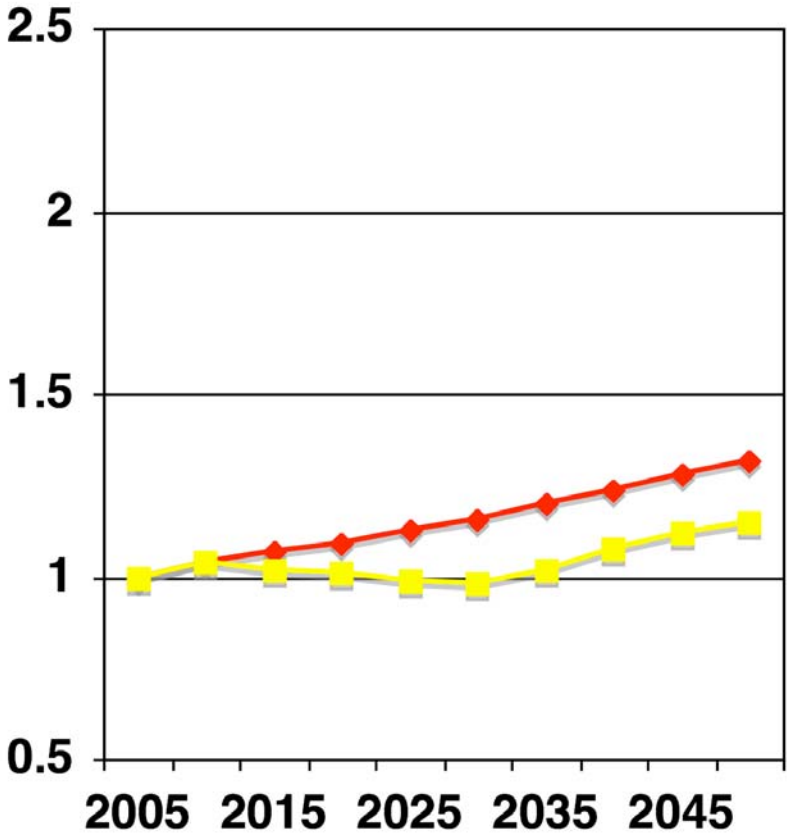
	Base Price Avg '02-'06	Carbon Charge ($2005)	% Added
Crude Oil ($/bbl)	40.00	18.07	45%
Regular Gasoline ($/gal)	1.82	0.39	21%
Heating Oil ($/gal)	1.35	0.43	32%
Wellhead Natural Gas ($/tcf)	5.40	2.21	41%
Residential Natural Gas ($/tcf)	11.05	2.22	20%
Utility Coal ($/short ton)	26.70	81.93	307%

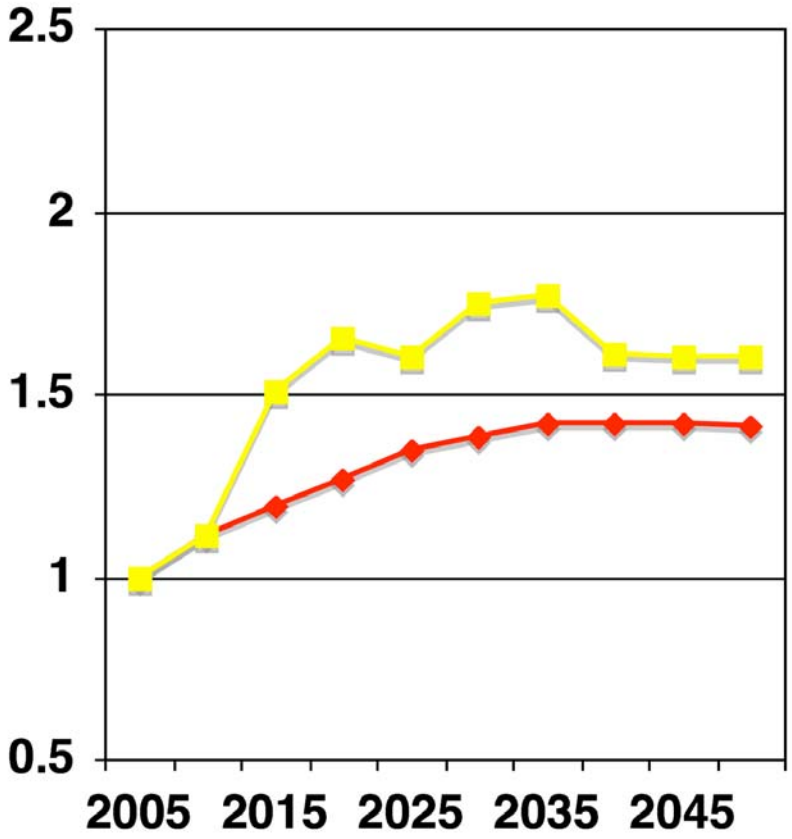
Policy Effect: Petroleum and Natural Gas Prices





Policy Effect: Coal and Electricity Prices





Revenue -- auction vs. allocation

Table 6. Potential CO_2-e auction or tax revenue.

	2015	2020	2025	2030	2035	2040	2045	2050
Total Potential Auction/Tax Revenue (billions $/yr)								
287 bmt	130	159	193	235	286	348	423	515
203 bmt	287	321	356	391	425	455	477	489
167 bmt	366	392	413	425	423	399	346	250
US Pop.	321	334	347	359	369	379	388	397
Potential Tax disbursement/family of 4 ($/yr)*								
287 bmt	1,630	1,900	2,230	2,620	3,100	3,670	4,360	5,190
203 bmt	3,580	3,850	4,100	4,360	4,600	4,800	4,920	4,920
167 bmt	4,560	4,700	4,760	4,740	4,580	4,210	3,560	2,520
CO_2 Revenue as a Percentage of Non-CO_2 Federal Tax Revenue (%)								
287 bmt	7	7	7	8	8	9	9	10
203 bmt	15	14	14	13	12	11	11	10
167 bmt	19	17	16	14	12	10	8	5

*Rounded to nearest $10.

New Elements in Energy

- **Sharply higher construction costs**
  - Existing facilities and retrofit gain
- **Reconsideration of nuclear energy**
  - But economics is still the main hurdle
- **High oil and coal(!) prices**
  - Supply and demand response takes time
- **Recognition of limits on renewables/biofuels**

Construction Costs

- +50% increase in construction costs in past few years
- Affects all large projects: coal, gas, and nuclear power plants, oil platforms, etc.
- Obvious effect on longer-term product prices
- More important effect on value of existing facilities
  - Longer to replace existing facilities
  - Retrofit life extension and pollution control is more attractive

Revival of Nuclear Power?

- Higher construction costs don't help, but…
- Evident reconsideration motivated by climate policy
  - US: re-licensing done, federal permitting simplified, and first new applications
  - Europe: New plants in Finland and France, active reconsideration in the UK, murmurs of such in Germany
- Still unresolved waste problem affects public perception of safety.
- Licensing reform is being tested.

High Oil & Coal Prices

- 6 years for price effects from last similar oil price peak to be felt
  - Probably faster this time, but how much will be irreversible?
- Eastern coal prices have doubled in past year in response to export demand
  - Good news for natural gas and previously stranded CC capacity

Renewables & Biofuels

- **Bloom is off biofuels**
  - The ethanol backlash
  - Food and biodiversity consequences
  - Long-term is a complicated global one involving autos, land-use, and international trade
- **Exploring renewable (wind/solar) limits**
  - High prices increase attractiveness
  - What are limits imposed by intermittency?
  - Are the subsidies sustainable?

Old Problems Persist

- Electricity restructuring stalled
- Demand flexibility remains unfulfilled promise
- Transmission investments difficult

The End

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