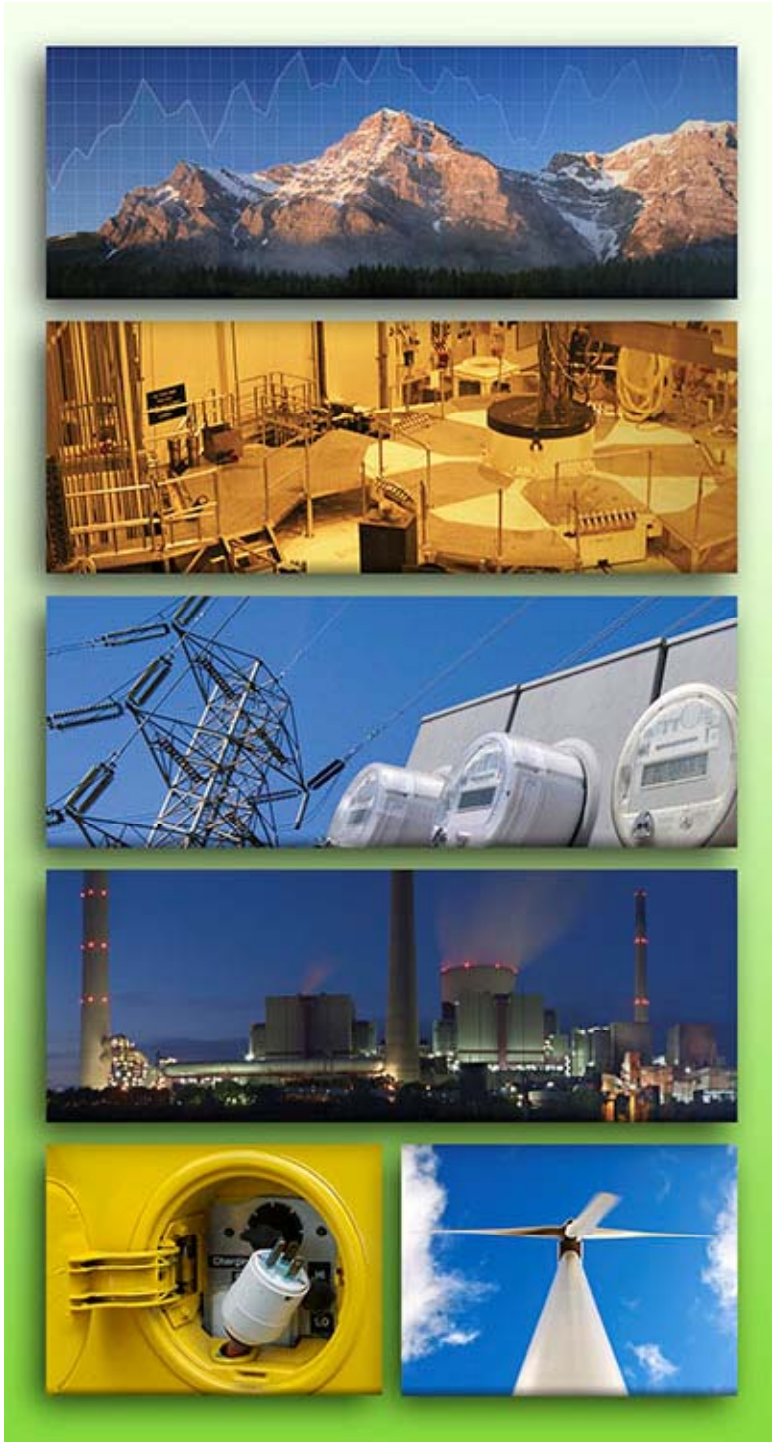

ELECTRIC POWER RESEARCH INSTITUTE

Financial Incentives for Deploying Carbon Capture and Storage:

How Much are they Worth?

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Background

- Carbon capture and storage (CCS) is a critically important technology for addressing climate change
  - IPCC estimates cost savings of trillions of dollars to meet global targets currently under discussion
- There are a number of barriers to early CCS deployment – this presentation deals with one, cost
- Government incentives for initial plants are essential to help deploy the technology:
  - Initial cost
  - Technical risk
  - Operation costs -- in the absence of sufficiently high CO_2 prices
- We estimate how companies might value potential incentives

EPRI analyzes policy proposals … we do not make them.

Study Approach – Cost to Beat Coal w/o CCS … Also Have to Beat Gas, Nuclear, Wind …

- Compares a new supercritical pulverized coal (SPC) plant without capture to a new SPC with capture
  - Assumes you have to pay for storage
  - Sensitivity case with Enhanced Oil Recovery
- Calculates the cost of electricity (COE) for both and finds the cost gap
  - Note, this evaluation considers only the value of incentives and excludes project execution risk
- Calculates the value of incentives in COE terms
  - Accounts for interactions between incentives
- Shows how packages of incentives can bridge the COE gap

CAVEAT: Our analysis provides only a general guide to valuing incentives.

Key Cost and Performance Parameters: Supercritical PC with and without CCS (2010$)

	Conventional Supercritical PC	SPC with CCS
Capital Cost ($/kW) [a]	2,115	3,540 [b]
Dispatched Capacity Factor	92 %	65-88 % [c]
Heat Rate (MMBtu/kWh)	9000	12,650
Variable O&M (non-fuel – $/MWh)	8.50	24.66
Fixed O&M ($/kW/Year)	38	40
CO_2 emissions (tons/MWh)	0.860	0.124

a. Does not include 10% owner's cost or interest during construction.

b. Assumes an amine-based capture system.

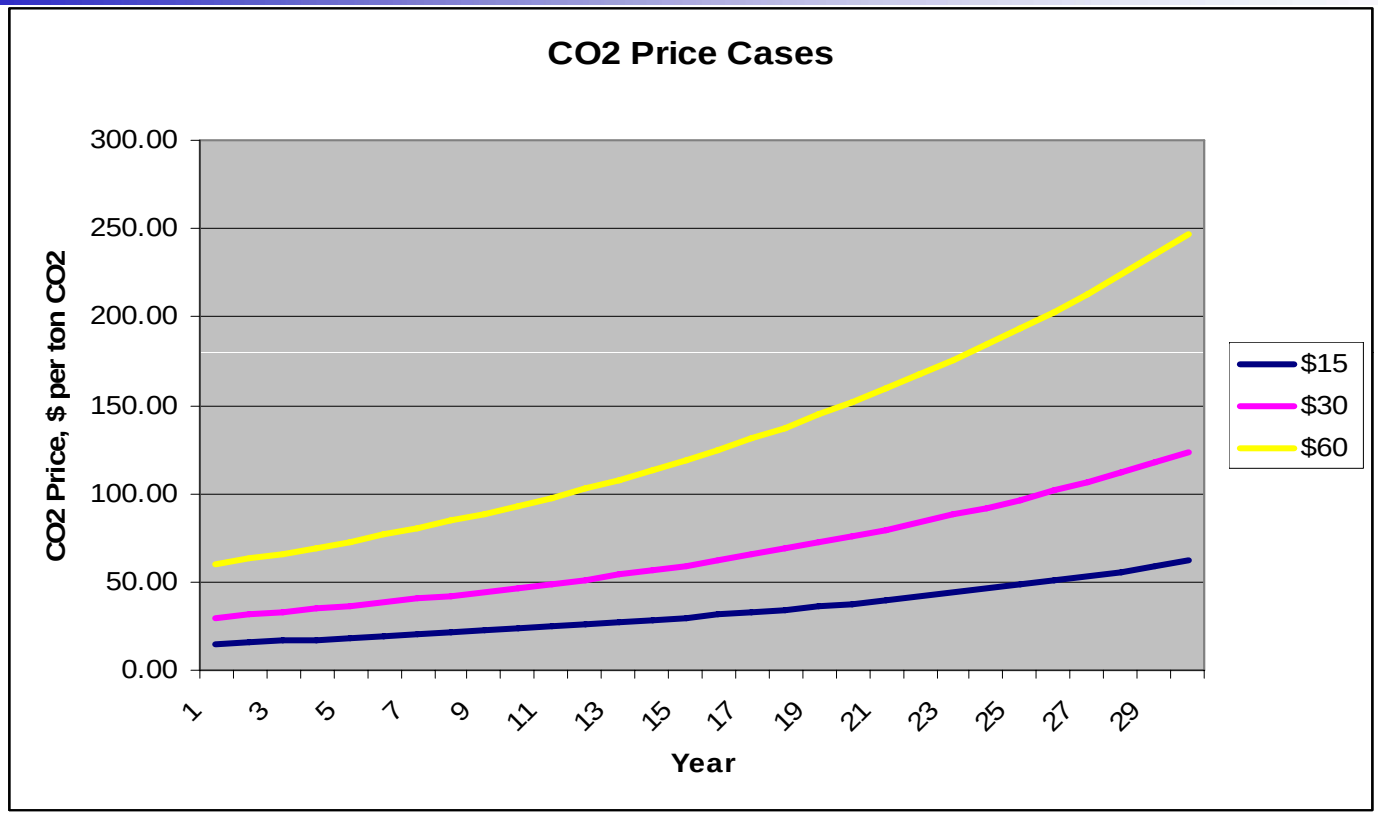
c. The base scenario assumes that the conventional PC plant is available 92% of the time. The PC+CCS plant is assumed to have 65% availability in year 1, 70% in year 2, 75% in year 3, 80% in year 4, 85% in year 5, and 88% in years 6-30. Both units are assumed to be dispatched whenever available.

Key Financial Assumptions for Different Project Owners

	Investor-owned Utility (IOU)	Independent Power Producer (IPP)	Public
Fraction Debt	**55 %**	**70 %**	**100 %**
Cost of Debt*	**6.5 %**	**8.0 %**	**4.5 %**
Cost of Equity	**11.5 %**	**13.0 %**	**N/A**
Tax Rate	**39.2 %**	**39.2 %**	**0 %**
Inflation Rate	**2% For All**		

* Assumes you can get a loan

Cost of Electricity (COE) Estimates Made for Two CO_2 Price Scenarios -- $15/ton CO_2 and $30/ton CO_2



- CO_2 price scenario named for first year price
- CO_2 price assumed to increase at 5% real per year
  - $15/ton scenario hits $62/ton after 30 years; levelized cost is $27/ton CO_2
  - $30/ton scenario hits $124/ton after 30 years; levelized cost is $54/ton CO_2

Cost of Electricity (COE) Estimates for SPC with and without CCS ($/MWh)

$15/ton CO_2 Case	IOU	IPP	Public
Supercritical PC	$ 97	$ 98	$ 85
SPC w/ CCS	$130	$131	$104
COE Gap @ $15/ton CO2	$ 34	$ 32	$ 20

$30/ton CO_2 Case	IOU	IPP	Public
Supercritical PC	$121	$122	$111
SPC w/ CCS	$134	$134	$108
COE Gap @ $30/ton CO2	$ 13	$12	-$ 3

Government Incentives Can Help Close the Gap

	Value of the Incentive, $ per MWh		
	IOU	IPP	Public
Loan Guarantee (w/ no fee)	$ 1	$ 3	$ 0
Direct Loan	$ 4	$ 8	$ 0
Cost Sharing (30% w/o repay)	$15	$15	$ 7
Investment Tax Credit (20%, without accelerated depreciation)	$ 6	$ 6	$ 0*
Production Tax Credit ($20 per MWh for 10 years)	$ 9	$ 9	$ 0*
Feed-in Tariff -- $15/ton CO2	$20	$20	$16
2 Bonus Permits/ton CO2 (for 10 years)			
• $15/ton CO2 Scenario	$20	$20	$16
• $30/ton CO2 Scenario	$39	$39	$33
COE Gap at $15/ton CO2	$34	$32	$20
COE Gap at $30/ton CO2	$13	$12	-$3

Threshold issue??

*Comparable incentive can be made available.

Incentives Can Close the Gap

- Loan guarantees or direct loans
  - Provide only a small benefit … **unless** needed to get a loan
  - Low-cost to the government
- Tax credits
  - Provide significant value to companies with tax liability, but none to public power
  - Cost to government is same as benefit to company
- Everyone can use $$ …
  - Cost sharing, free permits, and feed-in tariff benefit all
  - "Availability insurance" may provide targeted value, but the concept needs more refinement

  … but government may want "return" of funds if CO_2 prices rise

Packages of Incentives Could Reduce or Eliminate the COE Gap

- Packages of incentives can address specific risks, e.g.,
  - Cost share can provide initial capital
  - Availability insurance can provide cash if the technology fails to operate
  - Production tax credit can reward CCS operation when CO2 price is not sufficient

	Value of Incentive Package, $/MWh		
	IOU	IPP	Public
20% ITC + Accelerated Depreciation	$12	$12	$ 0
30% Cost Share + $20 PTC	$15	$15	$ 7
40% Cost Share + $30 PTC	$33	$34	$10
30% Cost Share + $20 PTC + Enhanced Availability Insurance	$29	$30	$ 8
COE Gap at $15/ton CO2	$34	$32	$20
COE Gap at $30/ton CO2	$13	$12	-$ 3

What Difference Does "Claw Back" Make? e.g. for an IOU

Cost Sharing with "Claw Back"

- 30% government cost sharing,
- "profit" = after tax profit plus depreciation plus value of CO2 reduction
- pay back government with 33% of "profit" after capital investment is recovered

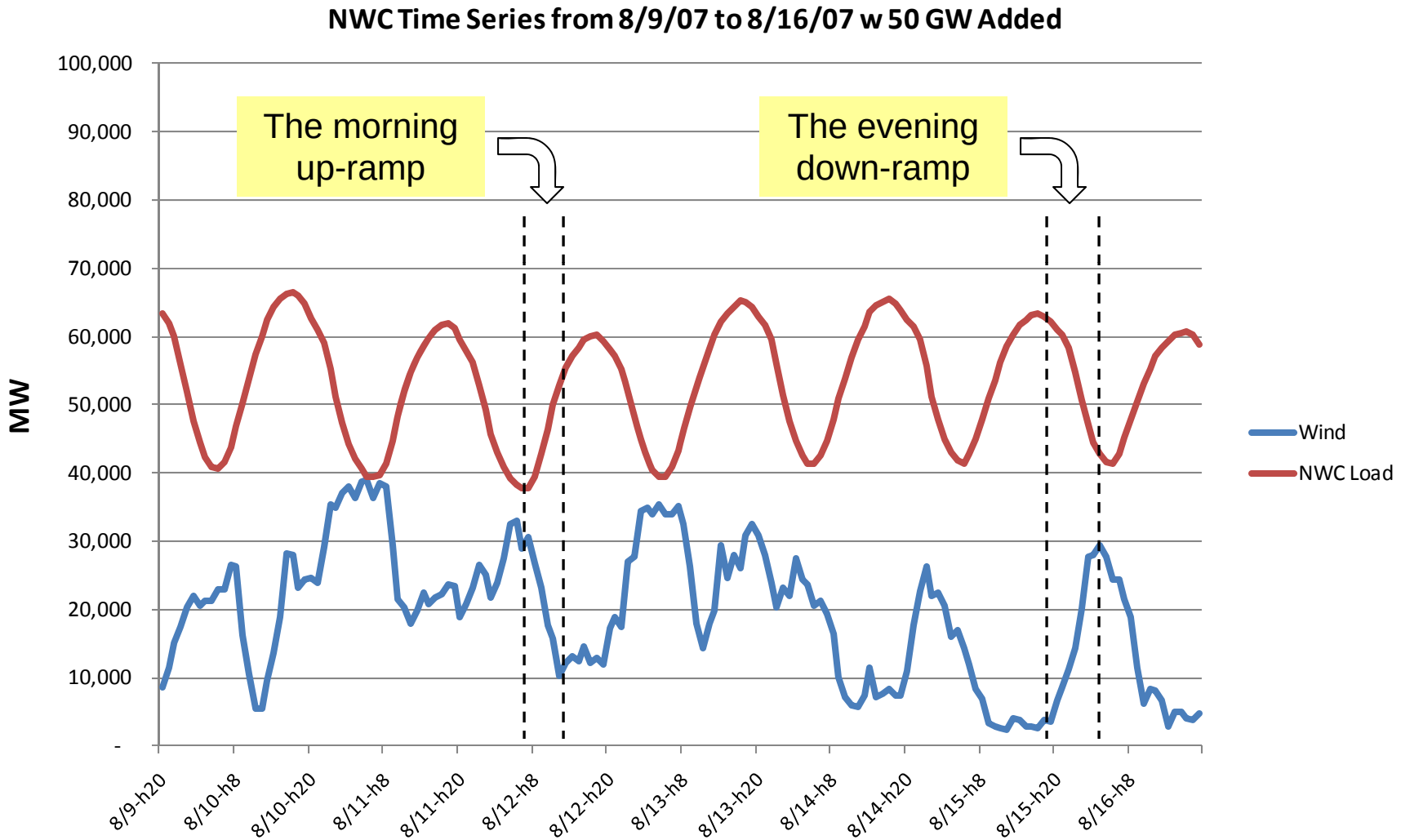
	$15/ton CO2	$30/ton CO2
Value of Incentive w/o Claw Back ($/MWh)	$15	$15
Year pay back starts	8	7
Year pay back ends	13	10
Value of Incentive w/ Claw Back ($/MWh)	$10.26	$9.54
COE Gap	**$34**	**$13**

Enhanced Oil Recovery (EOR) Can Make A Huge Difference

- For CO_2 used for EOR, assume \$20/ton CO_2 rising at 3% real per year

	Value in $/MWh		
	IOU	IPP	Public
EOR @ $20/ton CO2 + 3% real	$31	$31	$ 33
COE Gap at $15/ton CO2	$34	$32	$20
COE Gap at $30/ton CO2	$13	$12	-$ 3

CCS Will Likely Need to Operate Flexibly:
Anti-correlation of Wind with Load Creates a Ramping Challenge (e.g., 50GW of wind in Northwest Central US)



Final Thoughts on Financing CCS

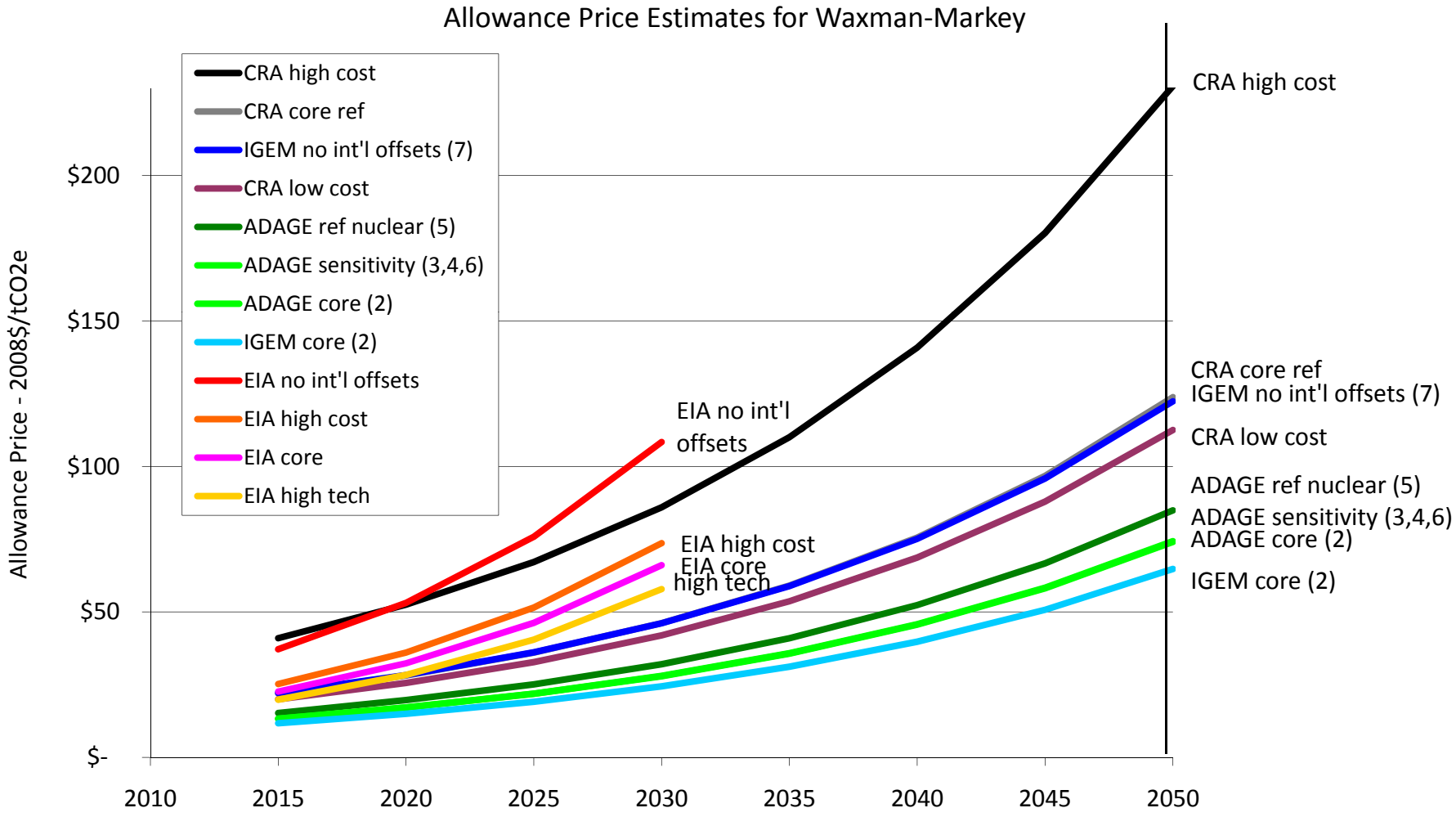
- The financing gap between a plant with CCS and one without is large and very sensitive to CO_2 price
  - CO_2 price is uncertain; lenders may/will assume it will be low or at the "floor"
- Incentive packages can address a range of risks – initial cost, poor operatation, operation when CO2 price is low
- Incentive packages likely must find balance between insufficient incentive to build and excess revenues
  - Incentives can be designed to address excess revenues
- Ultimately, CCS will compete with nuclear, renewables, and natural gas in supplying lower-carbon electricity
- Flexible operation of CCS will likely be key

Government incentives provide value only if

they work for enough companies to get initial plants built

Together…Shaping the Future of Electricity

Cost of Electricity Depends on CO_2 Price …
E.g., Allowance Price Estimates for Waxman-Markey



Note: Allowance prices could approach $100/ton if offsets do not materialize in large quantities at costs assumed

Backup Slides – Definition of the Incentives

- Loan Guarantee – Government guarantees a loan for 80% of the capital cost. Interest rates drop 0.7% (IOU), 1.1% (IPP), and 0.0% (Public).
- Direct Loan Government lends 80% of the capital cost at its borrowing rate. Interest rates drop 2.0% (IOU), 3.5% (IPP), and 0.0% (Public).
- 30% Cost Sharing - Government (or other entity) contributes 30% of the capital cost of the plant. There is no repayment of the contribution.
- 30% Cost Sharing with Payback - Government contributes 30% of the capital cost of the plant. The owner pays back the cost sharing over 20 years..

Definition of the Incentives

- 20% ITC - Government grants an investment tax credit equal to 20% of the plant capital cost to the plant owner.
- $20 Production Tax Credit – Government gives a $20 per megawatt hour (for the electric industry) or per ton of CO2 avoided (for the petroleum sector) production tax credit (PTC) to the plant owner for a period of ten years.
- Accelerated Depreciation – Government reduces the period for depreciating the capital investment for tax purposes from 20 years to 5 years.
- Availability Insurance – – Government guarantees the interest on and repayment of debt on any shortfall in plant output below a negotiated target plant capacity factor for ten years. The target is 88% and the payment is the fraction shortfall from this target times the debt service.