# Policies and Economics for Low Carbon Pathways: The Role of Technology RD&D Policies

## ICLCS Inaugural Roundtable
## June 27, 2009

*Paul Friley*
*Brookhaven National Laboratory*
*PFriley@bnl.gov*

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## Climate Change Policy Options

- There are a wide variety of potential policies to combat climate change
  - Greenhouse gas taxes
  - Cap and trade policy (with/without permit price "safety valves" or emission credit banking)
  - Renewable portfolio standards (RPS) or clean energy tax credits/subsidies
  - Energy efficiency/appliance standards
  - Low carbon fuel or biofuel standards (LCFS)
  - Domestic and international emission offsets
  - Technology research, development and deployment (RD&D) investments
- This presentation focuses on the potential impact of technology RD&D as a key enabling policy for climate change legislation.
  - Technology RD&D has the potential to greatly reduce the economic cost of other climate change policies and can make those policies politically easier to enact and keep in place.

# Impact of Energy Technology RD&D on Carbon Emission Reductions

- Results are from a previous study using the U.S. Single Region MARKAL model.
  - Reference case based on U.S. Energy Information Administration's (EIA) Annual Energy Outlook 2007.
- Tested different sets of energy technology assumptions
  - Base "business-as-usual" technology set (with and without CCS)
  - U.S. Department of Energy (DOE) R&D goal technology sets (GPRA09 assumptions)
- Carbon prices ranging from $0 to $100 per ton of CO2.
- Examined wind turbine R&D goal technology set at different levels of success (100%, 75%, 50% and 25%).

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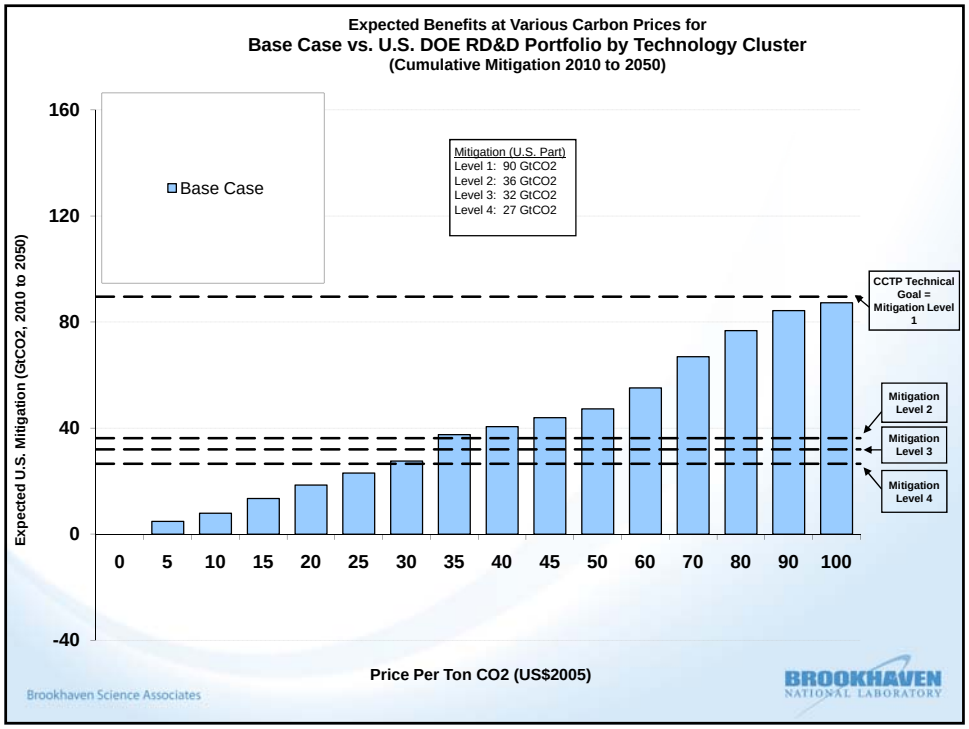


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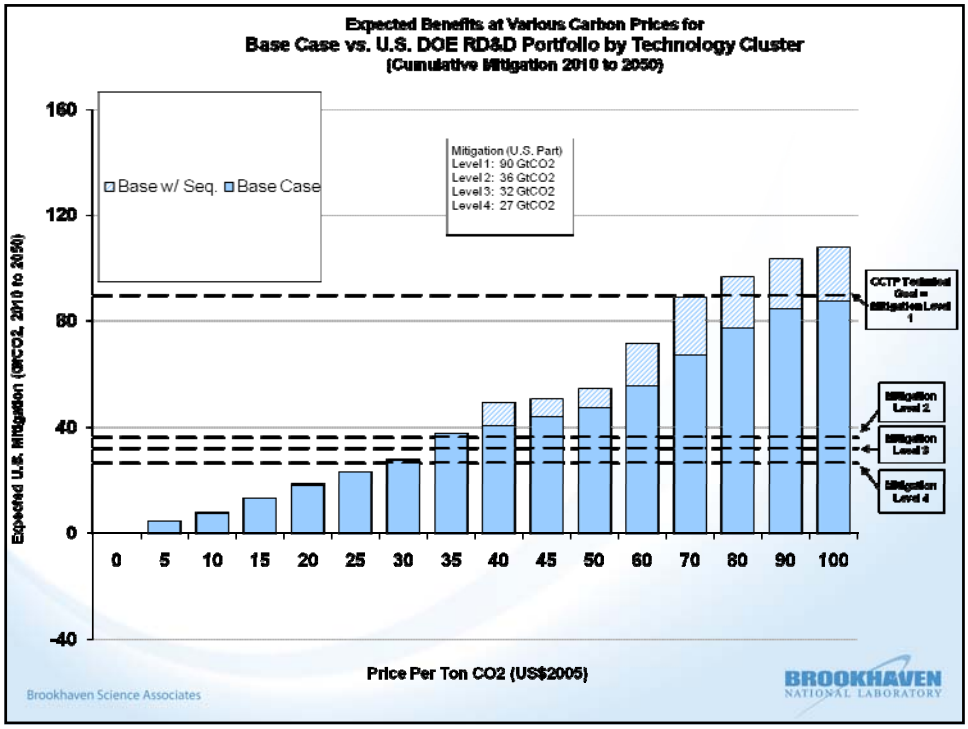
Expected Benefits at Various Carbon Prices for
Base Case vs. U.S. DOE RD&D Portfolio by Technology Cluster
(Cumulative Mitigation 2010 to 2050)
Base w/ Seq.
Base Case
Mitigation (U.S. Part)
Level 1: 90 GtCO2
Level 2: 36 GtCO2
Level 3: 32 GtCO2
Level 4: 27 GtCO2
Expected U.S. Mitigation (GtCO2, 2010 to 2050)
160
120
80
40
0
-40
0 5 10 15 20 25 30 35 40 45 50 60 70 80 90 100
Price Per Ton CO2 (US$2005)
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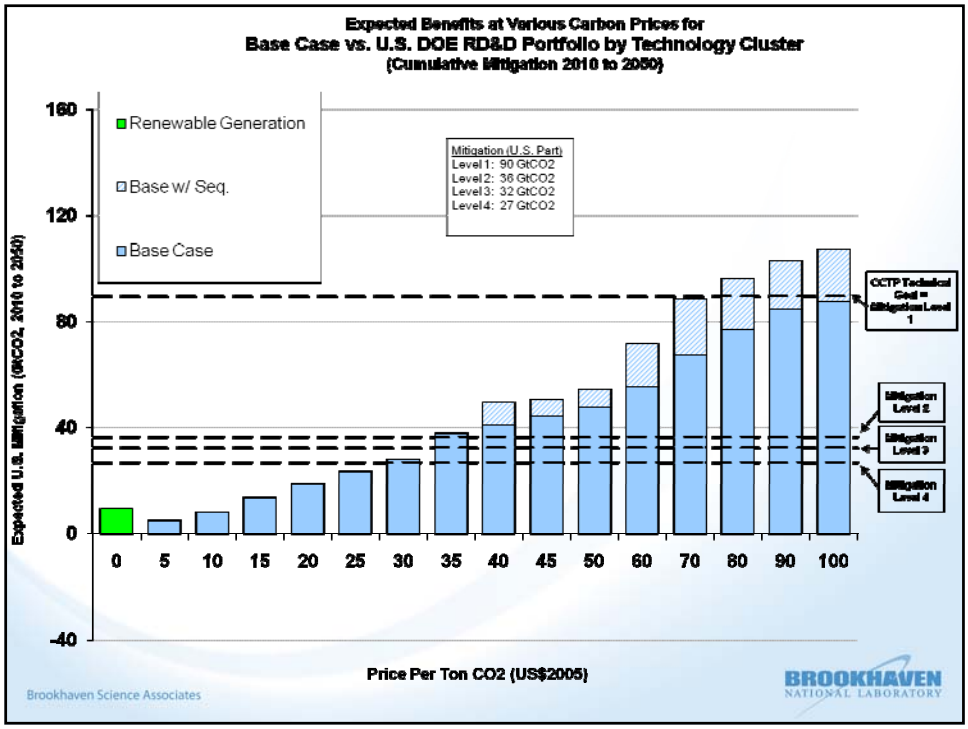
Expected Benefits at Various Carbon Prices for
Base Case vs. U.S. DOE RD&D Portfolio by Technology Cluster
(Cumulative Mitigation 2010 to 2050)
Renewable Generation
Base w/ Seq.
Base Case
Mitigation (U.S. Part)
Level 1: 90 GtCO2
Level 2: 36 GtCO2
Level 3: 32 GtCO2
Level 4: 27 GtCO2
Expected U.S. Mitigation (GtCO2, 2010 to 2050)
160
120
80
40
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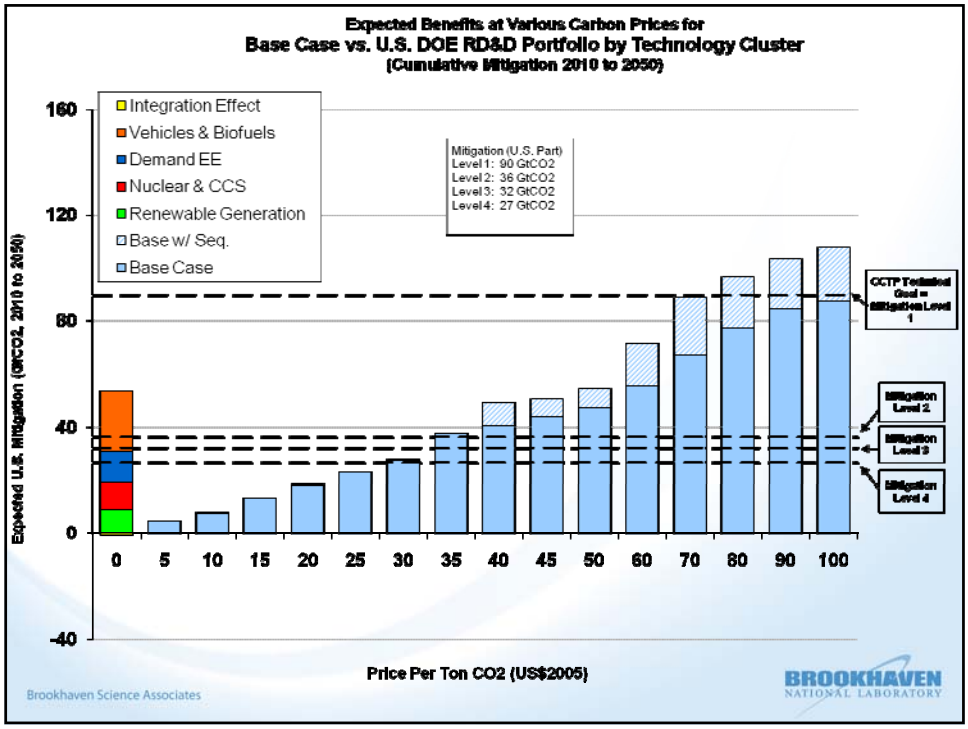
Expected Benefits at Various Carbon Prices for
Base Case vs. U.S. DOE RD&D Portfolio by Technology Cluster
(Cumulative Mitigation 2010 to 2050)
Integration Effect
Vehicles & Biofuels
Demand EE
Nuclear & CCS
Renewable Generation
Base w/ Seq.
Base Case
Mitigation (U.S. Part)
Level 1: 90 GtCO2
Level 2: 36 GtCO2
Level 3: 32 GtCO2
Level 4: 27 GtCO2
Expected U.S. Mitigation (GtCO2, 2010 to 2050)
160
120
80
40
0
-40
0 5 10 15 20 25 30 35 40 45 50 60 70 80 90 100
Price Per Ton CO2 (US$2005)
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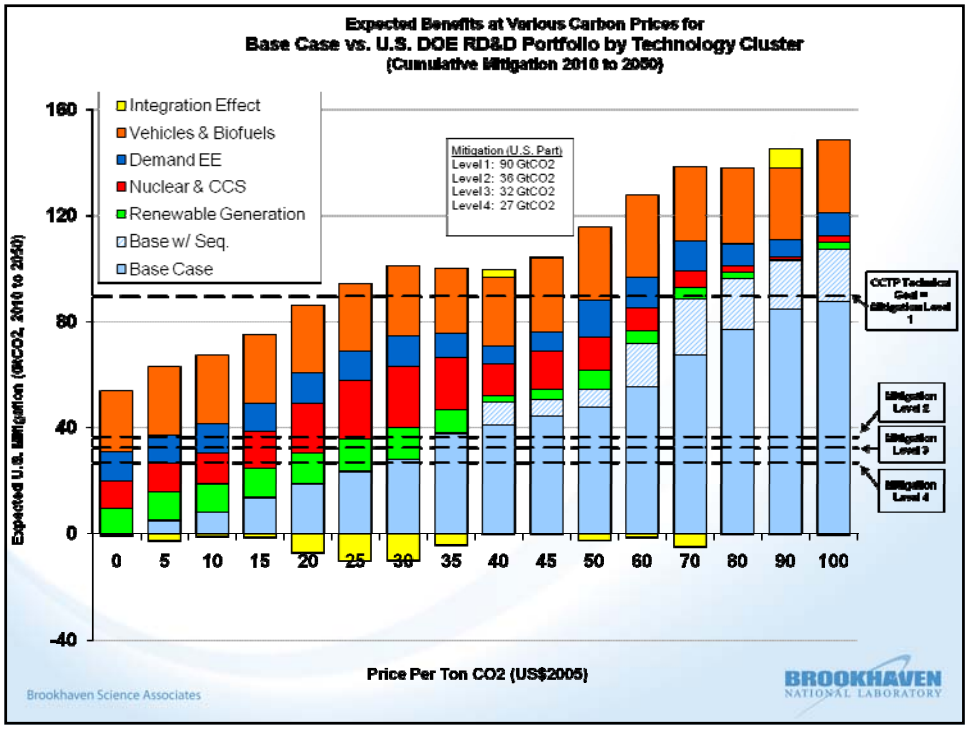
Expected Benefits at Various Carbon Prices for
Base Case vs. U.S. DOE RD&D Portfolio by Technology Cluster
(Cumulative Mitigation 2010 to 2050)
Integration Effect
Vehicles & Biofuels
Demand EE
Nuclear & CCS
Renewable Generation
Base w/ Seq.
Base Case
Mitigation (U.S. Part)
Level 1: 90 GtCO2
Level 2: 36 GtCO2
Level 3: 32 GtCO2
Level 4: 27 GtCO2
Expected U.S. Mitigation (GtCO2, 2010 to 2050)
160
120
80
40
0
-40
0 5 10 15 20 25 30 35 40 45 50 60 70 80 90 100
Price Per Ton CO2 (US$2005)
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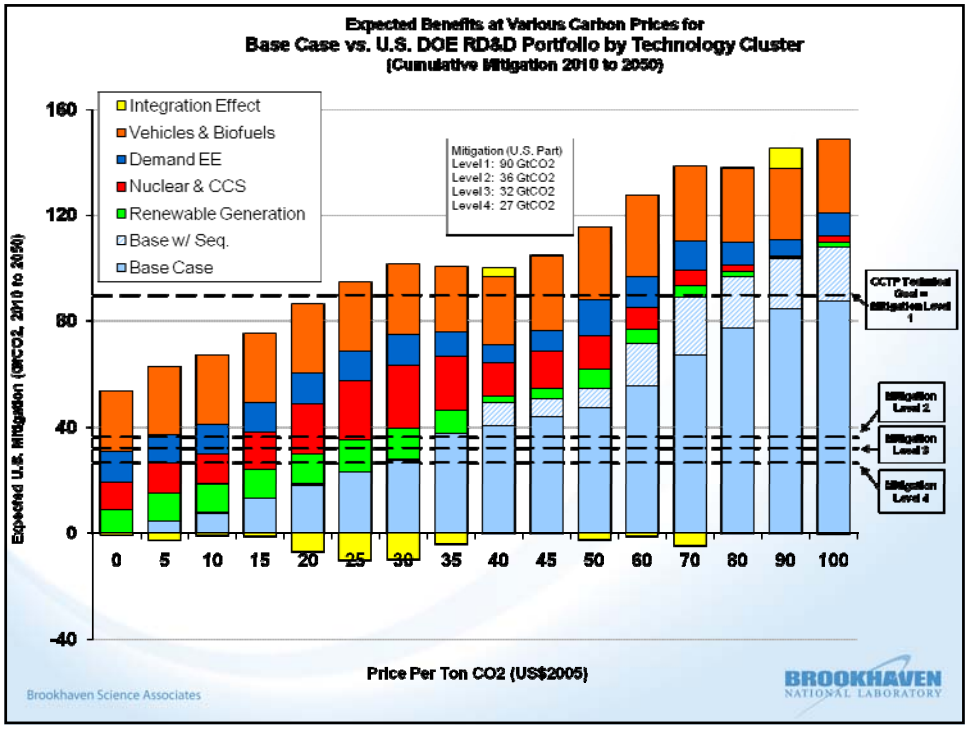
Expected Benefits at Various Carbon Prices for
Base Case vs. U.S. DOE RD&D Portfolio by Technology Cluster
(Cumulative Mitigation 2010 to 2050)
Integration Effect
Vehicles & Biofuels
Demand EE
Nuclear & CCS
Renewable Generation
Base w/ Seq.
Base Case
Mitigation (U.S. Part)
Level 1: 90 GtCO2
Level 2: 36 GtCO2
Level 3: 32 GtCO2
Level 4: 27 GtCO2
Expected U.S. Mitigation (GtCO2, 2010 to 2050)
160
120
80
40
0
-40
0 5 10 15 20 25 30 35 40 45 50 60 70 80 90 100
Price Per Ton CO2 (US$2005)
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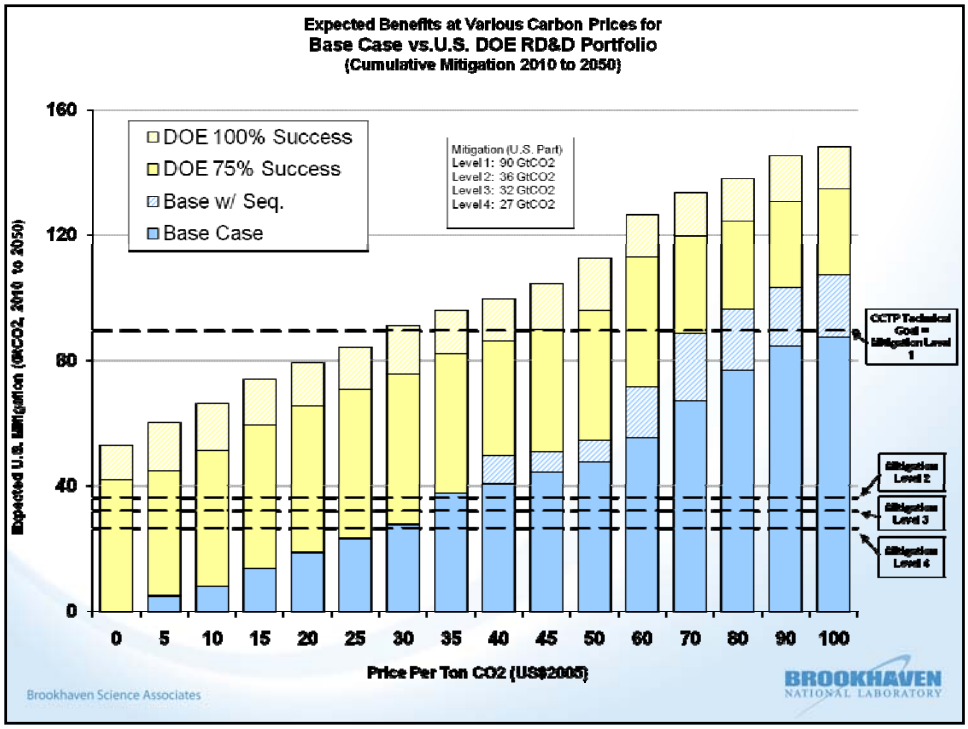
Expected Benefits at Various Carbon Prices for
Base Case vs.U.S. DOE RD&D Portfolio
(Cumulative Mitigation 2010 to 2050)
DOE 100% Success
DOE 75% Success
Base w/ Seq.
Base Case
Mitigation (U.S. Part)
Level 1: 90 GtCO2
Level 2: 36 GtCO2
Level 3: 32 GtCO2
Level 4: 27 GtCO2
Expected U.S. Mitigation (GtCO2, 2010 to 2050)
160
120
80
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Price Per Ton CO2 (US$2005)
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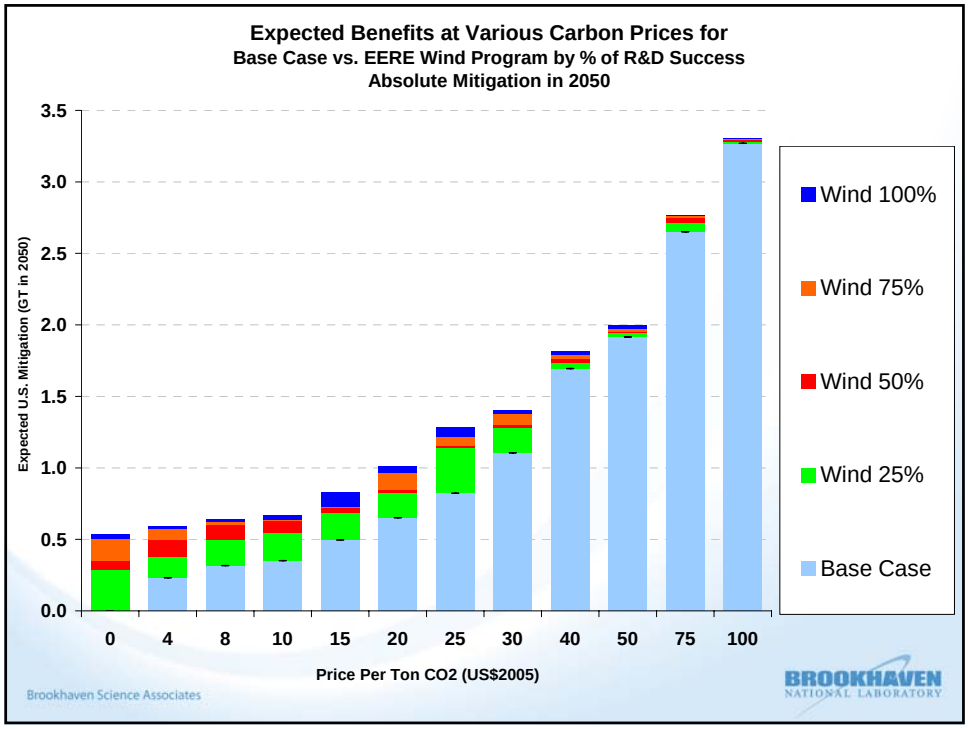


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Extra Slides





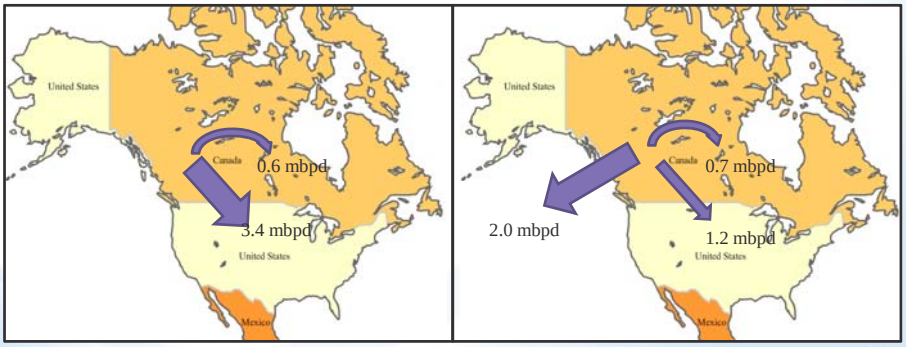
## DOE U.S.-India-China Cities Partnerships

- Share the lessons learned from every city's experience to augment capabilities of participating cities on mutual issues of interest on energy and environment
- Collaborate on programs like: green and zero energy buildings, codes, energy efficiency in industries and infrastructure, green and renewable power, alternative fuel vehicles, green government purchasing, consumer rebates, eco clubs, consumer education, awards/recognition, and others.
- Promote dialogues involving city agencies, businesses, professionals, citizens, and research and academic institutions.
- Participating Indian cities: Delhi, Mumbai, Chennai, Bangalore, Ahmedabad, Surat, Bhubaneswar and Vadodara
- Participating U.S. cities: Chicago, Atlanta, Denver, Columbus, Los Angeles, Edison NJ, Philadelphia and San Francisco
- Participating Chinese cities: Shanghai, Guangzhou, Hefei, Kunming, Nanjing, Tianjin, Beijing

# Alberta Oil Sands

- The US LCFS limits flow of oil sands to the USA, but only marginally reduces overall oil sands production.

Reference case 2025 LCFS case 2025

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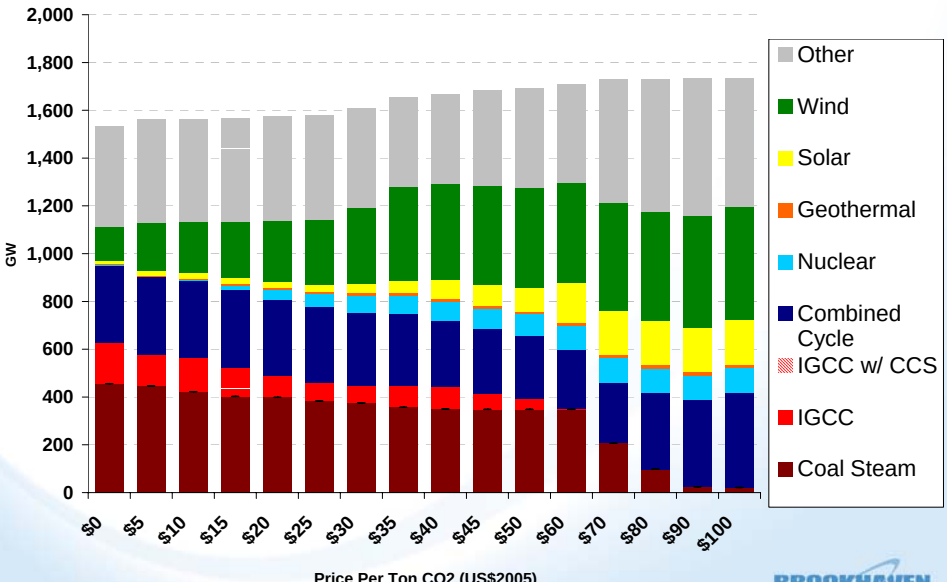
**Selected Generation Capacity for 2050**
**Base Case Technology Set (without CCS)**

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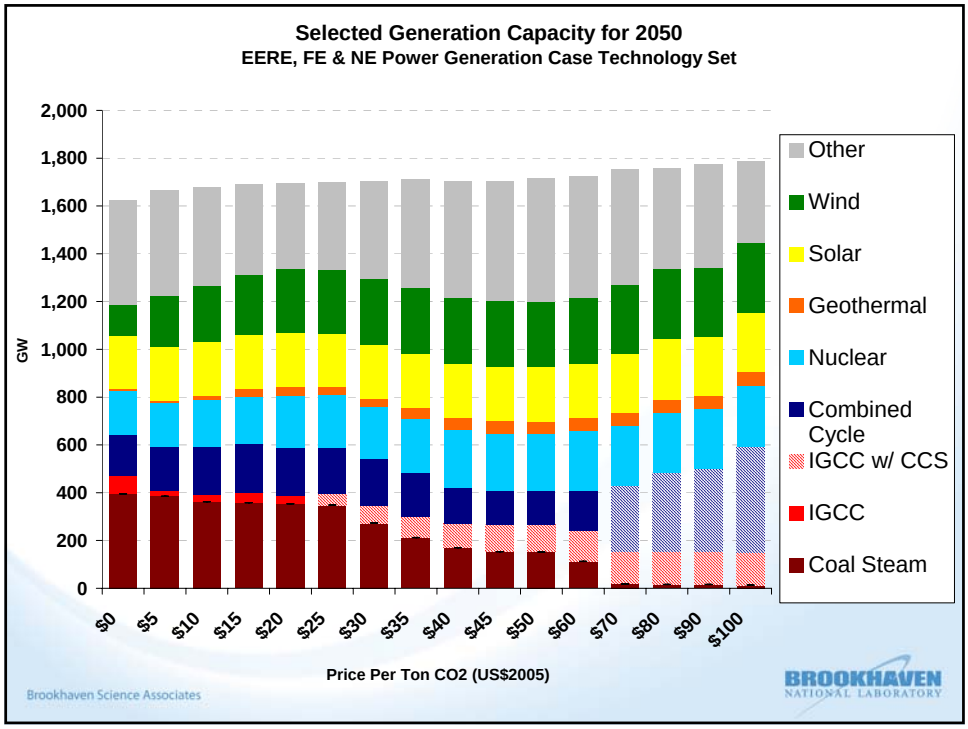
Selected Generation Capacity for 2050
EERE, FE & NE Power Generation Case Technology Set
GW
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
$0
$5
$10
$15
$20
$25
$30
$35
$40
$45
$50
$60
$70
$80
$90
$100
Price Per Ton CO2 (US$2005)
Other
Wind
Solar
Geothermal
Nuclear
Combined Cycle
IGCC w/ CCS
IGCC
Coal Steam
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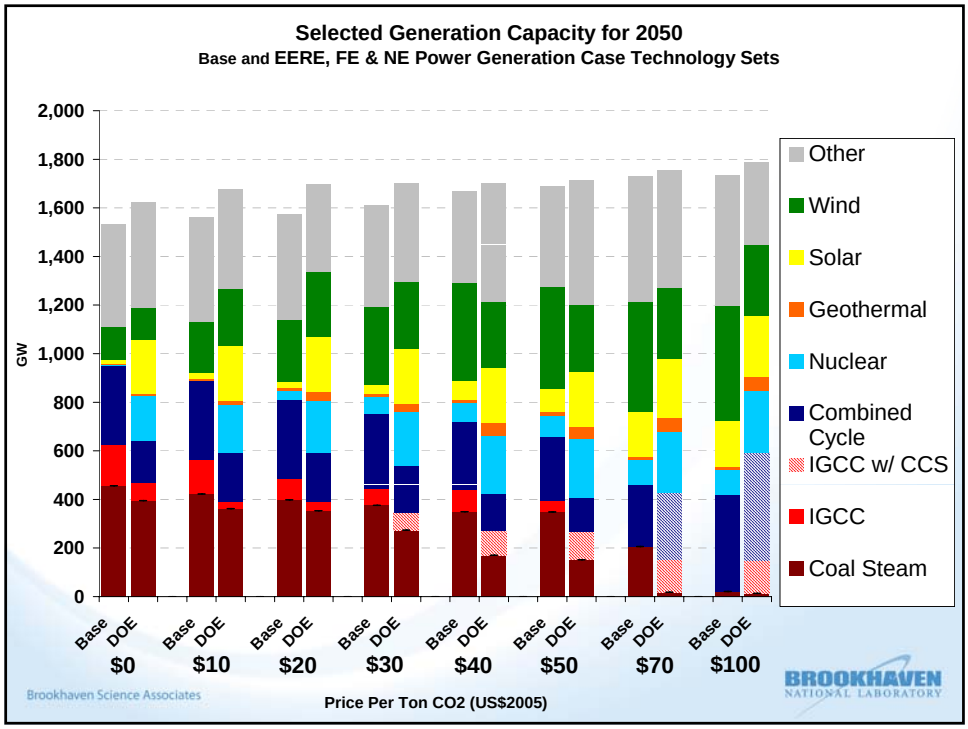
Selected Generation Capacity for 2050
Base and EERE, FE & NE Power Generation Case Technology Sets
GW
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
Base
DOE
$0
$10
$20
$30
$40
$50
$70
$100
Price Per Ton CO2 (US$2005)
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