Getting Serious about Carbon Mitigation

Opening Address
Conference on States and Climate Change
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Princeton University
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The UK and targets

Just before the 1997 elections, the UK government set a unilateral target of reducing CO₂ emissions by 20% by 2010, relative to 1990. As of 2006, they are down 5%. They were down 8% as of 2005, but rose 3% last year.

The main reason for the rise was a move from gas to coal for electricity generation. Environment Secretary David Miliband said it demonstrated the need for increased action on climate change.

The government admitted last year that it would fail to meet its unilateral target. Instead, it said existing policies would yield a 15-18% cut over the same period.

Mike Childs, campaigns director with Friends of the Earth UK, told the BBC News website: "The government dreams up estimates of what its policies can deliver without any external scrutiny; and as soon as there is any external scrutiny, they turn out to be dreams."

Data: 1990, 592 MtCO₂/hr; 2006 561 MtCO₂/hr. 2010 Goal: 473 MtCO2/hr.

Story from BBC NEWS: http://news.bbc.co.uk/go/pr/fr/-/2/hi/science/nature/6506223.stm
Why are we here?

We are here to support action, encourage and scrutinize analyses, and motivate ourselves to work together on an unfamiliar problem: living harmoniously on Earth within global environmental constraints.

This challenge is tractable, but it is one of the most difficult challenges human beings have ever faced.

At last, we can start with the presumption that there will be national CO$_2$ policy, and that NJ policy will be additive. The basic game has changed.
Corzine: “A coalition of leadership states”

I intend …to call for the formation of a Governors’ Climate Protection Leadership Council. A coalition of leadership states will provide a more effective voice of advocacy for a strong federal greenhouse gas regulatory program that acknowledges a role for states in its design and implementation.

Federal legislation should facilitate the role of the states as policy innovators by explicitly preventing federal preemption of state programs that go beyond federal minimum requirements, as well as preventing preemption of state programs outside the scope of federal initiatives.

Testimony, Senate Committee on Environment and Public Works, March 1, 2007
Antarctic Ice Core

Source: Gabrielle Walker, “Frozen time,” Nature; Jun 10, 2004; 429, 6992; Research Library Core, pg. 596
Past, present, and potential future levels of carbon in the atmosphere

Rosetta Stone: 2.1 billion metric tons of carbon added to the atmosphere as CO₂ raises its CO₂ concentration by one part per million.
The atmosphere as a bathtub, with current inputs and outputs of carbon

- **Ocean**: 2 billion tons go in
- **Land Biosphere (net)**: 1 billion tons added every year
- **Fossil Fuel Burning**: 7 billion tons go in
- **800 billion tons carbon**
- **4 billion tons added every year**

**Outputs:**
- **Ocean**: 2 billion tons go out
- **Fossil Fuel Burning**: 3 billion tons go out

**Equation:**
2 + 1 = 3 billion tons go out
Past Emissions

Billion of Tons of Carbon Emitted per Year

Historical emissions

2.0 →
The Stabilization Triangle

- **Billion of Tons of Carbon Emitted per Year**:
  - 1955: 2.0
  - 2005: 14
  - 2105: ~500 ppm

- **Currently projected path**
- **Stabilization Triangle**
- **Historical emissions**
- **Flat path**
- **Interim Goal**
- **Easier CO₂ target** ~850 ppm
- **Tougher CO₂ target** ~500 ppm
The Interim Goal is Within Reach

Reasons for optimism that global emissions in 2055 need not exceed today’s emissions:

• The world today has a terribly inefficient energy system.

• Carbon emissions have just begun to be priced.

• Most of the 2055 physical plant is not yet built
Billion of Tons of Carbon Emitted per Year

Historical emissions

Currently projected path

Flat path

14 GtC/y

Seven “wedges”

7 GtC/y

0 → 14

1955 → 2005 → 2055 → 2105
What is a “Wedge”?

A “wedge” is a strategy to reduce carbon emissions that grows in 50 years from zero to 1.0 GtC/yr. The strategy has already been commercialized at scale somewhere.

Cumulatively, a wedge redirects the flow of 25 GtC in its first 50 years. This is 2.5 trillion dollars at $100/tC.

A “solution” to the CO₂ problem should provide at least one wedge.
U.S. Wedges

Sectoral emissions: NJ and USA, 2002

NJ, 120 MtCO₂/yr
USA: 6400 MCO₂/yr

Does not include CO₂ emissions from 28% imported power

NJ CO₂ emissions to 2025

120 MtCO₂/yr = 33 MtC/yr, 0.5% of world

(33 MtC/yr)/8.7 M people = 3.8 tC/capita-yr, 2/3 of U.S. average, 4x world average

Corzine on Offsets

[Federal climate change legislation should]

•Limit the use of emissions offsets, to ensure that a majority of emissions reductions are achieved from the capped sector or sectors. Emissions offsets should be incorporated as a flexibility mechanism that is designed to be *supplemental* to on-system emissions reductions.

•Design robust requirements to ensure that emissions offsets are of high quality and represent incremental emissions reductions beyond business-as-usual reductions…Quantification and verification protocols should be rigorous and detailed, and apply conservative assumptions when appropriate.

We are going to need to discuss offsets with care today!

Testimony, Senate Committee on Environment and Public Works, March 1, 2007
Priority #1: Energy Efficiency

The post-industrialized age features unprecedented private consumption: Life, liberty, and the pursuit of mobility and comfort. In industrialized countries more than 60% of oil is used in vehicles, more than 60% of electricity in buildings.

Curbing global CO₂ emissions will require major changes in the post-industrial social envelope. Examples:

- Property-tax systems that reinvigorate cities and discourage sprawl.

- New norms of business and professional face-to-face contact that enable reduced work-related travel.
Dominance of transport in NJ

Sectoral CO$_2$ emissions, 2002

- Transportation: 52%
- Residential: 13%
- Electricity: 16%
- Industrial: 11%
- Commercial: 8%

2 tC/capita-yr

Efficient Use of Fuel

Effort needed by 2055 for 1 wedge:

Note: 1 car driven 10,000 miles at 30 mpg emits 1 ton of carbon.

2 billion cars driven 10,000 miles per year at 60 mpg instead of 30 mpg.
2 billion cars driven, at 30 mpg, 5,000 instead of 10,000 miles per year.

NJ issue: Reversing the hollowing out of the cities.
Efficient Use of Electricity

Effort needed by 2055 for 1 wedge:

- 25% reduction in expected 2055 electricity use in commercial and residential buildings

NJ issue: Incentives to overhaul commercial and multifamily buildings.
### Five ways to cut 1 tonC/yr in half

<table>
<thead>
<tr>
<th></th>
<th>1 ton carbon/yr</th>
<th>Cut in half</th>
<th>How?</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Drive</td>
<td>10,000 mi, 30 mpg</td>
<td>60 mpg</td>
<td>Lighter, less power(?)</td>
</tr>
<tr>
<td>b) Drive</td>
<td>10,000 mi, 30 mpg</td>
<td>5,000 miles</td>
<td>Live closer to work</td>
</tr>
<tr>
<td>c) Fly</td>
<td>10,000 miles</td>
<td>5,000 miles</td>
<td>Video-conference</td>
</tr>
<tr>
<td>d) Heat home</td>
<td>Nat. gas, av. house, av. climate</td>
<td>Insulate, double-pane windows, fewer leaks, condensing furnace,</td>
<td></td>
</tr>
<tr>
<td>e) Lights</td>
<td>16 100W bulbs, 6hr/day, coal power</td>
<td>2/3 compact fluorescents (¼ as much electricity for same lumens)</td>
<td></td>
</tr>
</tbody>
</table>
Priority #2: Fight the rush to coal

Incremental new coal capacity by decade
Projected Net Generation of Electricity by Power Source, New Jersey, 2025

Today:

\[ \approx 75,000 \text{ GWh/yr} = 8600 \text{ kWh/cap-yr} \]

U.S. Power Plant Capacity, by Vintage

Capacity, total by source

Issues: Retirement, relicensing, grandfathering

Source: EIA
Corzine on safety valves and grandfathering

Avoid the use of safety valves or price caps.

Signal that new conventional coal-fired power plants constructed from this day forward will not be grandfathered under a federal cap-and-trade system, and will need to purchase allowances on the open market.

Testimony, Senate Committee on Environment and Public Works, March 1, 2007
Wind Electricity

Effort needed by 2055 for 1 wedge:

One million 2-MW windmills displacing coal power.

Today: 50,000 MW (1/40)

Prototype of 80 m tall Nordex 2.5 MW wind turbine located in Grevenbroich, Germany
(Danish Wind Industry Association)
Effort Needed by 2055 for one wedge:

2000 GW_{peak} (700 times current capacity)

2 million hectares

Solar thermal power via concentrators (troughs and dishes) is produced at high efficiency, like PV.

NJ issue: Integrate with buildings
Electricity

Effort needed by 2055 for 1 wedge:
700 GW (twice current capacity) displacing coal power.

Nuclear

Graphic courtesy of NRC

Phase out of nuclear power creates the need for another half wedge.

NJ issue: Relicensing

Graphic courtesy of NRC
Output of Wabash gasifier: CO + H₂. Gases go directly to turbine.

Add for CCS power: CO + H₂O $\rightarrow$ CO₂ + H₂; then CO₂ - H₂ separation; then H₂ to turbine, and CO₂ handoff from coal industry to oil and gas industry.

Same technology can produce H₂ or synthetic fuels.

NJ issue: CO₂ emissions constraint on imported power

Effort needed by 2055 for 1 wedge:

Carbon capture and storage at 800 GW coal power plants.

Graphics courtesy of DOE Office of Fossil Energy
The Future Fossil Fuel Power Plant

Shown here: After 10 years of operation of a 1000 MW coal plant, 60 Mt (90 Mm³) of CO₂ have been injected, filling a horizontal area of 40 km² in each of two formations.

Assumptions:
• 10% porosity
• 1/3 of pore space accessed
• 60 m total vertical height for the two formations.

• Note: Plant is still young.

Note: Injection rate is 150,000 bbl(CO₂)/day, 3 billion barrels over 60 years.
Carbondioxide charges in the neighborhood of $100/tC can enable scale-up of most of the wedges, if supplemented with sectoral policy to facilitate transition.

<table>
<thead>
<tr>
<th>Form of Energy</th>
<th>Equivalent to $100/tC or $30/tCO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural gas</td>
<td>$1.50/1000 scf</td>
</tr>
<tr>
<td>Crude oil</td>
<td>$12/barrel</td>
</tr>
<tr>
<td>Coal</td>
<td>$65/U.S. ton</td>
</tr>
<tr>
<td>Gasoline</td>
<td>25¢/gallon (ethanol subsidy: 50¢/gallon)</td>
</tr>
<tr>
<td>Electricity from coal</td>
<td>2.2¢/kWh (wind and nuclear subsidies: 1.8 ¢/kWh)</td>
</tr>
<tr>
<td>Electricity from natural gas</td>
<td>1.0¢/kWh</td>
</tr>
</tbody>
</table>

$100/tC was the approximate EU trading price for a year ending April 2006, when it fell sharply.
Recommendations to U.S. Congress

- Policies should be prescriptive for a decade or more.
  - Periodic revision is desirable, but not “foot in the door” for two or three years followed by unspecified ratchets.
- Policies should be stringent enough to be technology-forcing.
  - “Mitigation Lite” is a tax-collection mechanism.
- Any Cap-and-trade policy should be supplemented with sectoral policies: “Carbon Price, Plus.”
  - Examples: efficiency standards, renewable portfolio standards, CCS portfolio standards,…
- Policies should reach far upstream.
  - No unregulated refinery emissions, while paying for CO$_2$ at the gas pump. No flaring, while paying for CCS.
Can We Do It?

People (we!) are becoming increasingly determined to lower the risk that we and our children will experience major social dislocation and environmental havoc as a result of rising CO₂ in the atmosphere.

…and we are learning that there are many ways of changing how we live, what we buy, and how we spend our time, that will make a difference.

We are in the midst of a discontinuity:

**What once seemed too hard has become what simply must be done.**

Precedents include abolishing child labor, addressing the needs of the disabled, and mitigating air pollution.