The Challenges and Opportunities of Innovation for the Environment

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Why innovate?

Innovation plays a critical role in …

• Creating new products, services, jobs
• Economic development
• Raising standards of living
• Better health
• Mobility
• Improved “quality of life”

But technology and industrialization also have brought new problems

- Air Pollution
- Solid Wastes
- Urban Smog
- Water Pollution
- Conjestion
The problem of global climate change

Major “Greenhouse Gases”

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>Common Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
<td>Carbon Dioxide</td>
<td>Fossil fuel combustion, deforestation, cement production, etc.</td>
</tr>
<tr>
<td>CH₄</td>
<td>Methane</td>
<td>Landfills, production and distribution of natural gas &amp; petroleum, fermentation from digestive system of livestock, rice cultivation, fossil fuel combustion, etc.</td>
</tr>
<tr>
<td>N₂O</td>
<td>Nitrous Oxide</td>
<td>Fossil fuel combustion, fertilizers, nylon production, manure, etc.</td>
</tr>
<tr>
<td>HFC’s</td>
<td>Hydrofluorocarbons</td>
<td>Refrigeration gases, aluminum smelting, semiconductor manufacturing, etc.</td>
</tr>
</tbody>
</table>

GHGs trap heat and thus raise the global temperature. Unlike traditional air pollutants, they stay in the atmosphere for a very long time (decades to centuries).

Atmospheric GHG Levels

- Greenhouse gas (GHG) concentrations in the atmosphere have been increasing rapidly as a result of human activities
- CO₂ is the dominant greenhouse gas

Most CO₂ is from burning fossil fuels, the world’s primary energy source

1000 Mtoe = 42 EJ
~85% = fossil fuels
World energy-related CO₂ emissions are projected to grow

Source: EIA/IEO, 2011

Projections of Future Warming

Continued increases in GHG emissions are projected to raise Earth’s average temperature by 2.0°F to 11.5°F (1.1°C to 6.4°C) by the end of this century

Source: IPCC, 2007

The impacts of climate change are more severe with increasing warming

More extreme events are expected as atmospheric concentration rises
Mitigating Climate Change Requires Large Emission Reductions

The most recent IPCC and NAS studies indicate a need for large reductions by 2050 to avoid serious impacts (>2°C rise)

<table>
<thead>
<tr>
<th>Required change in global GHG emissions from 2000 to 2050</th>
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<tbody>
<tr>
<td>-50% to -85%</td>
</tr>
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</table>

Source: IPCC, 2007; NAS, 2010

Requires innovation and deployment of new technology on a massive scale!

Innovations Needed to Reduce Energy-Related GHG Emissions

- Technologies that reduce the demands for energy
- More efficient technologies for energy utilization (in all sectors of the economy)
- Technologies to produce and use alternative energy sources with low or no GHG emissions
- Technologies for CO₂ capture and sequestration at power plants and other industrial sources

Electricity + Vehicles emit ≈ 75% of all U.S. CO₂

How is this different from other areas of innovation?

Innovation and Entrepreneurship Topics for this Summit

- Internet Service & Cloud Computing
- Finance and Capital Markets
- Innovation & Entrepreneurship
- Healthcare
- Information & Digital Entertainment Technology
- Energy and Environment

How do we get a market for environmental technology?
**The Process of Technological Change**

- **Invention**
- **Innovation** (new or better product)
- **Adoption** (limited use of early designs)
- **Diffusion** (improvement & widespread use)

**R&D**

**Learning**
- By Doing
- By Using

**The critical role of government actions**

**“Technology Policy” Tools**

- **Direct Government Funding of Research and Development (R&D)**
  - R&D contracts with private firms
  - R&D grants and contracts with universities
  - Intramural R&D conducted at govt laboratories
  - R&D contracts with consortia (2 or more of the actors above)
  - Provide “carrots” to incentivize innovation & technological change
  - Policies influence different phases of the innovation process

- **Direct or Indirect Support for Commercialization and Production; Indirect Support for Development**
  - Patent protection
  - R&D tax credits
  - Production subsidies or tax credits to firms bringing new technologies to market
  - Tax credits or rebates for new technology buyers
  - Government procurement
  - Demonstration projects

- **Support for Learning and Diffusion of Knowledge and Technology**
  - Education and training
  - Codification and transfer of knowledge
  - Technical standard-setting (non-regulatory)
  - Technology and/or industrial extension services
  - Publicity and consumer information

- **COOL Colors Reduce Energy Demand**

- **COOL CARS**

  Cool Colors Reflect Invisible Near-Infrared Sunlight

  Source: A. Rosenfeld, CEC, 2007

  New (pitched, cool, colored)
Rechargeable LED Flashlights and Task Lights Improve Efficiency

Growth in Electricity Generation from Wind and Solar

Government incentives played the key role in this growth

Regulatory Policy Tools

- Economy-wide Measures and/or Sector or Technology-specific Regulations and Standards; e.g.,
  - Performance standards
  - Portfolio standards
  - Cap-and-trade program
  - Emissions tax
  - Fuels tax

  • Provide “sticks” to incentivize innovation & technological change
  • Also influence different phases of the innovation process

Corporate Average Fuel Economy (CAFE) Standards Raised MPG of New Vehicles

New CAFE rules will bring US fleet average (cars + light trucks) up to 34.1 mpg by 2016
Appliance Standards Reduced Refrigerator Energy Use

Power Plant Performance Standards Spurred Innovation and Lowered Cost

Key Barriers to Innovation for Climate Change Mitigation

- Policy
- Policy
- Policy

Without a policy requirement or incentive there is little or no reason to innovate and deploy new technologies

A path forward
Innovation Policies for Climate Change Mitigation

• A *combination* of incentive-based policies and regulatory policies can most effectively foster innovations favored or required by markets in a carbon-constrained world.

• *Energy policy* can further spur (or hinder) innovations that reduce GHG emissions.

The Economic Value of Innovation

```
\begin{center}
\begin{tikzpicture}
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    ytick={0, 50, 100, 150, 200, 250, 300, 350, 400, 450, 500},
    xticklabels={2005, 2020, 2035, 2050},
    yticklabels={0, 50, 100, 150, 200, 250, 300, 350, 400, 450, 500},
    legend entries={‘Known Technologies’, Advanced Technologies},
    legend pos=north east,
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\addplot[red,mark=*] coordinates {
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    (2020, 400)
    (2035, 600)
    (2050, 800)
};
\addplot[blue,mark=square] coordinates {
    (2005, 100)
    (2020, 300)
    (2035, 500)
    (2050, 700)
};
\end{axis}
\end{tikzpicture}
\end{center}
```

*Source: Kyle et al. 2009*

The availability of advanced technologies can greatly reduce the cost of mitigating climate change.

So What Will the Future Bring?

**Our Advanced Forecasting Model**

*Answer:* Look to US-China innovation & entrepreneurs!

Thank You

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