

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”

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But technology and industrialization also have brought new problems



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The problem of global climate change

Major "Greenhouse Gases"

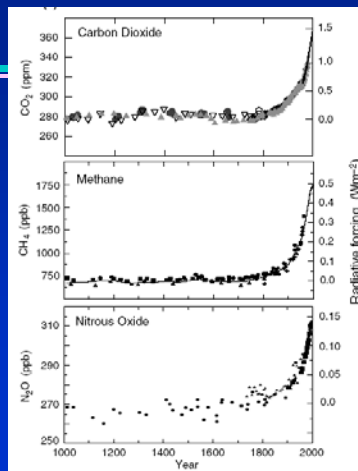
Symbol	Name	Common Sources
CO ₂	Carbon Dioxide	Fossil fuel combustion, deforestation, cement production, etc.
CH ₄	Methane	Landfills, production and distribution of natural gas & petroleum, fermentation from digestive system of livestock, rice cultivation, fossil fuel combustion, etc.
N ₂ O	Nitrous Oxide	Fossil fuel combustion, fertilizers, nylon production, manure, etc.
HFC's	Hydrofluorocarbons	Refrigeration gases, aluminum smelting, semiconductor manufacturing, etc.

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)

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Atmospheric GHG Levels

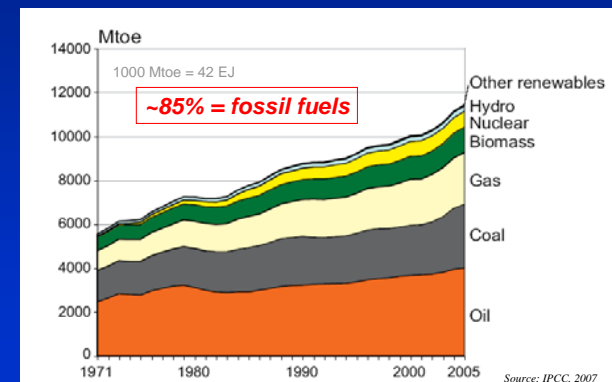
- Greenhouse gas (GHG) concentrations in the atmosphere have been increasing rapidly as a result of human activities
- CO₂ is the dominant greenhouse gas



Source: IPCC, 2001

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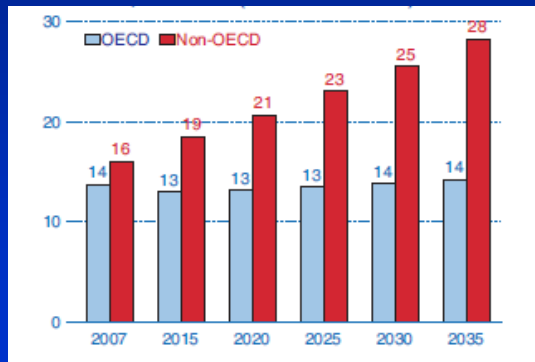
Most CO₂ is from burning fossil fuels, the world's primary energy source



Source: IPCC, 2007

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World energy-related CO₂ emissions are projected to grow

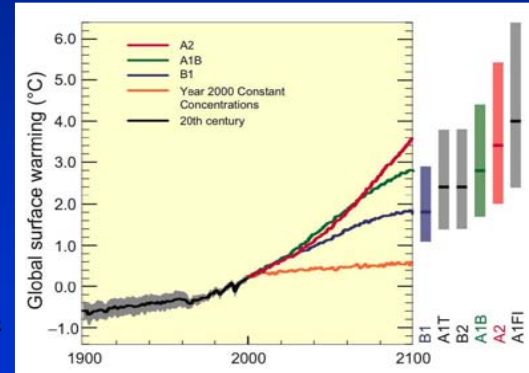


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Source: EIA/IEO, 2011

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



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Source: IPCC, 2007

The impacts of climate change are more severe with increasing warming

Category	Impacts
WATER	<ul style="list-style-type: none"> Increased water availability in moist tropics and high latitudes Decreasing water availability and increasing drought in mid-latitudes and semi-arid low latitudes Hundreds of millions of people exposed to increase water stress
ECOSYSTEMS	<ul style="list-style-type: none"> Up to 30% of species at increasing risk of extinction Significant extinctions around the globe Increased coral bleaching Most corals bleached Widespread coral mortality Terrestrial biosphere tends toward a net carbon source as: <ul style="list-style-type: none"> -15% of ecosystems affected -40% of ecosystems affected Ecosystem changes due to weakening of the meridional overturning circulation Increasing species range shifts and wildlife risk
FOOD	<ul style="list-style-type: none"> Complex, localised negative impacts on small holders, subsistence farmers and fishers Tendencies for cereal productivity to decrease in low latitudes Productivity of all cereals decreases in low latitudes Tendencies for some cereal productivity to increase at mid- to high latitudes Cereal productivity to decrease in some regions
COASTS	<ul style="list-style-type: none"> Increased damage from floods and storms About 10% of global coastal wetlands lost* Millions more people could experience coastal flooding each year*
HEALTH	<ul style="list-style-type: none"> Increasing burden from malnutrition, diarrhoeal, cardio-respiratory, and infectious diseases Increased morbidity and mortality from heat waves, floods, and droughts Changed distribution of some disease vectors Substantial burden on health services

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Source: IPCC, 2007



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)

Required change in global GHG emissions from 2000 to 2050

-50% to -85%

Source: IPCC, 2007; NAS, 2010

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

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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

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How is this different from other areas of innovation?

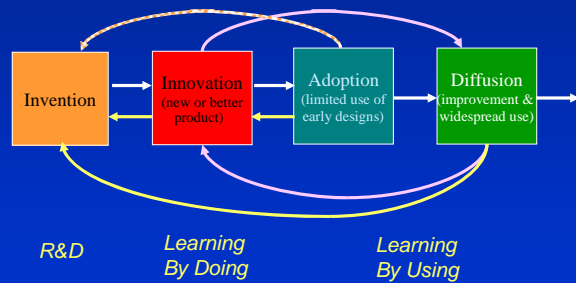
Innovation and Entrepreneurship Topics for this Summit

- 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?

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The Process of Technological Change



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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 gov't laboratories
- R&D contracts with consortia (2 or more of the actors above)

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

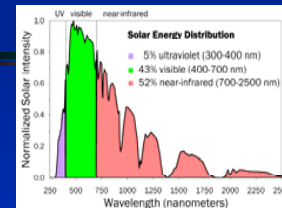
Support for Learning and Diffusion of Knowledge and Technology

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

- Provide “carrots” to incentivize innovation & technological change
- Policies influence different phases of the innovation process

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Cool Colors Reduce Energy Demand



Cool Colors Reflect Invisible Near-Infrared Sunlight



COOL CARS



COOL ROOF TECHNOLOGIES

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Source: A. Rosenfeld, CEC, 2007

Rechargeable LED Flashlights and Task Lights Improve Efficiency



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Source: A. Rosenfeld, CEC, 2007

Growth in Electricity Generation from Wind and Solar



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Source: EIA, 2010

Regulatory Policy Tools

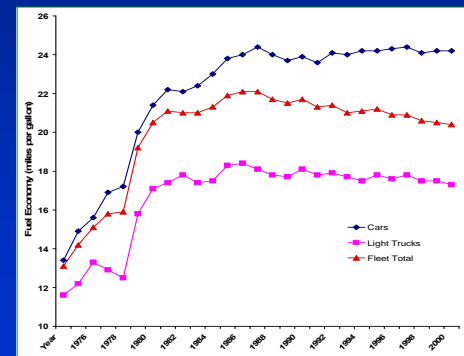
Economy-wide Measures and/or Sector or Technology-specific Regulations and Standards; e.g.,

- 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

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

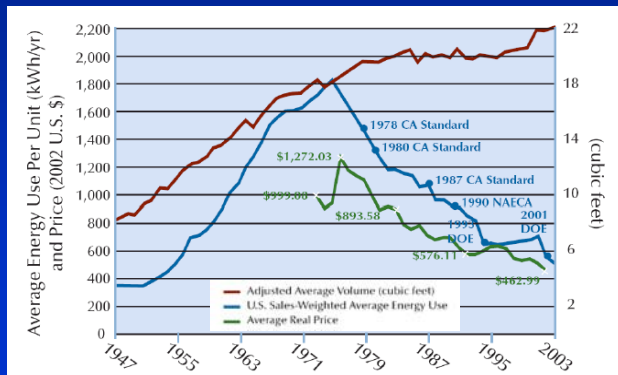


Source: USEPA, 2003; L. Love, 2007

New CAFE rules will bring US fleet average (cars + light trucks) up to 34.1 mpg by 2016

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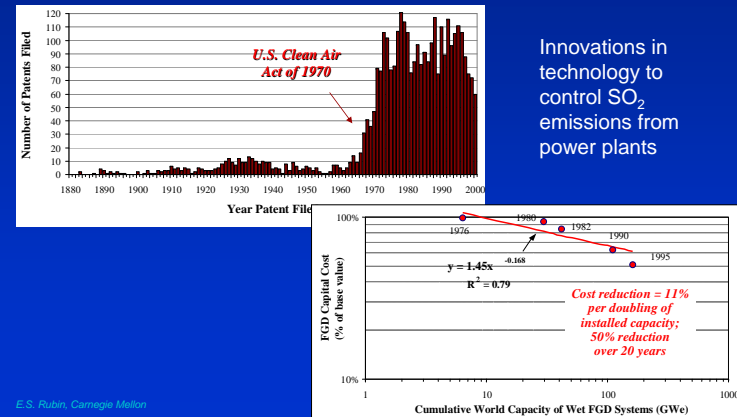
Appliance Standards Reduced Refrigerator Energy Use



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Source: A. Rosenfeld, CEC, 2007

Power Plant Performance Standards Spurred Innovation and Lowered Cost



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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

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A path forward

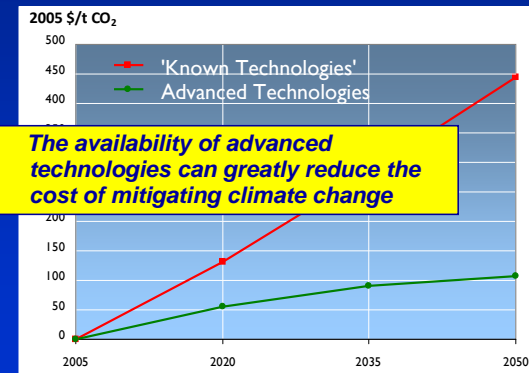
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Innovation Policies for Climate Change Mitigation

- 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

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The Economic Value of Innovation



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

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Source: Kyle et al. 2009

So What Will the Future Bring ?

Our
Advanced
Forecasting
Model

Answer:

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



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Thank You

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