National Research Council Report

Hidden Costs of Energy:
Unpriced Consequences of Energy Production and Use

Presentation by

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Study Origin and Task

Congress:

- Requested this study in the Energy Policy Act of 2005.
- Directed the Department of the Treasury to fund the study under the Consolidated Appropriations Act of 2008.

Study Task:

- Define and evaluate key external costs and benefits – related to health, environment, security, and infrastructure – that are associated with the production, distribution, and use of energy but not reflected in the market price or energy or fully addressed by current government policy.

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Committee Roster

Jared Cohon (Chair)	Carnegie Mellon University
Maureen Cropper (Vice Chair)	University of Maryland, College Park
Mark Cullen	Stanford University School of Medicine
Elisabeth Drake	Massachusetts Institute of Technology (retired)
Mary English	University of Tennessee, Knoxville
Christopher Field	Carnegie Institution of Washington
Daniel Greenbaum	Health Effects Institute
James Hammitt	Harvard University Center for Risk Analysis
Rogene Henderson	Lovelace Respiratory Research Institute
Catherine Kling	Iowa State University
Alan Krupnick	Resources for the Future
Russell Lee	Oak Ridge National Laboratory
H. Scott Matthews	Carnegie Mellon University
Thomas McKone	Lawrence Berkeley National Laboratory
Gilbert Metcalf	Tufts University
Richard Newell *	Duke University
Richard Revesz	New York University School of Law
Ian Sue Wing	Boston University
Terrance Surles	University of Hawaii at Manoa

* Resigned August 2, 2009 to accept appointment as Administrator of the U.S. Energy Information Administration.

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Study Approach

- Selected Areas
  - Electricity Generation
  - Transportation
  - Heat for Buildings and Industrial Processes
  - Climate Change
  - Infrastructure and National Security
- Considered full life-cycle
- Focused on air pollution effects for non-climate damages
- 2005 and 2030 reference years
- Did not present a point estimate of climate damages (per ton of CO2)
  - Identified how damages vary with key parameters of Integrated Assessment models

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Non-Climate Damage Approach

- Damage Function Approach:
  Emissions>>Ambient Concentration>>Exposure>>Effect>>
  Monetized Damages
- Effects of air pollution on human health, grain crop and timber yields, building materials, recreation, and visibility of outdoor vistas.
- Modeling used to estimate damages-- based primarily on SO_2, NO_x, and PM emissions across the 48 contiguous states.
- 94% of the damages are associated with human mortality
  – Each statistical life lost valued at $6 million (2000 USD)

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Electricity: Coal
406 coal-fired power-plants

Aggregate damages (2005): **$62 billion (non-climate damages)**

- 50% of plants with the lowest damages--which produced 25% of net generation of electricity--accounted for only 12% of the damages.
- 10% of plants with the highest damages--which produced 25% of net generation--accounted for 43% of the damages.
- Variation in damages primarily due to variation in tons of pollutants emitted.

Average damages per kilowatt hour (kWh):
3.2 cents/kWh (2005)
- Range of damages: 0.19 – 12.0 (5^{th} – 95^{th} percentile) cents/kWh.
- Variation primarily due to variation in pollution intensity (emissions per kWh) across plants.

1.7 cents/kWh (2030)
- Fall in damages per kWh in 2030 due to assumption that pounds of SO_2 per kWh hour will fall by 64% and that NO_x emissions per kWh will fall by 50%.

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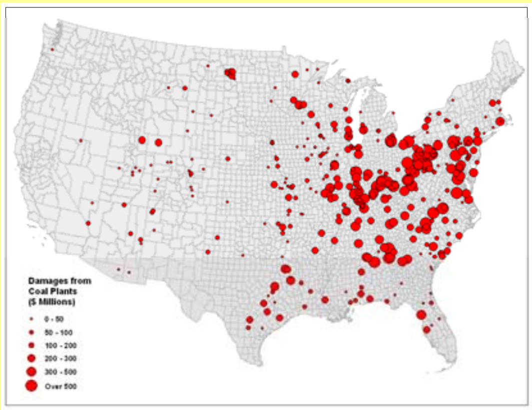
Electricity: Coal
Location of Sources of Damages

Damage Estimates based on SO_2, NO_x, and PM emissions



- Air Pollution Damages from Coal Generation for 406 plants, 2005
- Damages related to climate-change effects are not included

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Electricity: Natural Gas
498 Natural Gas-Fired Plants

Aggregate damages (2005): ≈ $740 million (non-climate damages)

- From plants that account for 71% of net generation from gas is lower than those for coal-fired power plants.
- 50% of plants with the lowest damages accounted for only 4% of aggregate damages.
- 10% of plants with largest damages accounted for 65% of damages.
- Each group generated 25% of electricity from gas.

Average damages per kilowatt hour:
0.16 cents/kWh (2005); Range of damages: 0.001 – 0.55 (5^{th} – 95^{th} percentile)

0.11 cents/kWh (2030)

Fall in damages per kWh in 2030 explained by an expected19% fall in NO_x emissions per kWh hour and 32% fall in $PM_{2.5}$ emissions per kWh.

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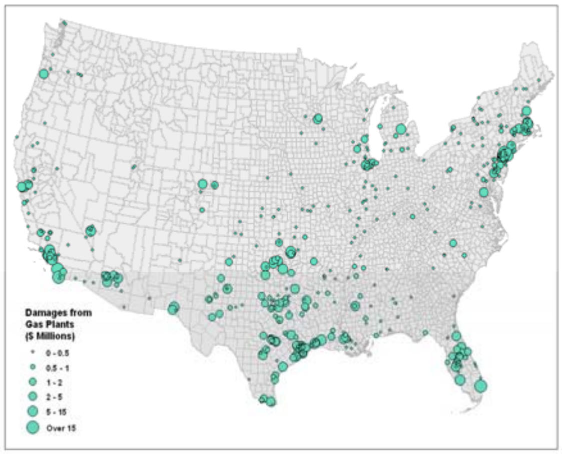
Electricity: Natural Gas
Location of Sources of Damages

Damage Estimates based on SO_2, NO_x, and PM emissions



- Air Pollution Damages from Natural Gas Generation for 498 plants, 2005.
- Damages related to climate-change effects are not included.

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Electricity: Other Sources

Nuclear Power:

– Other studies found that damages associated with normal operation of plants are low compared with those of fossil-fuel-based power plants.

– External costs of a permanent repository for spent fuel should be studied.

Wind and Solar Power:

– Electricity generation from wind and solar is a small fraction of the total U.S. electricity production. External effects, which are largely local (e.g. land use), are much smaller than those for fossil-fuel plants.

– As the use of renewable sources grows, their external effects should be reevaluated.

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Transportation

- Committee focused on highway vehicles, as they account for more than 75% of transportation-energy consumption in the U.S.
- Energy Sources: oil (petroleum/diesel), natural gas, biomass, electricity, and others
- Four life-cycle stages (well-to-wheel) were considered:
  (1) Feedstock: fuel extraction and transport to refinery
  (2) Fuel: fuel refining/conversion and transport to the pump
  (3) Vehicle: emissions from production/manufacturing of the vehicle
  (4) Operation: tailpipe and evaporative emissions

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Transportation

Aggregate non-climate damages: ≈ $ 56 billion (2005)

Light-duty vehicles: $36 billion

Heavy-duty vehicles: $20 billion

- Damages per vehicle-mile traveled (VMT) ranged from 1.2 cents to 1.7 cents.
  - 23-38 cents/ gasoline gallon equivalent
- Damage estimates did not vary significantly across fuels and technologies; caution is needed for interpreting small differences.
  - Some (electric, corn ethanol) had higher lifecycle damages
  - Others (cellulosic ethanol, CNG) had lower lifecycle damages

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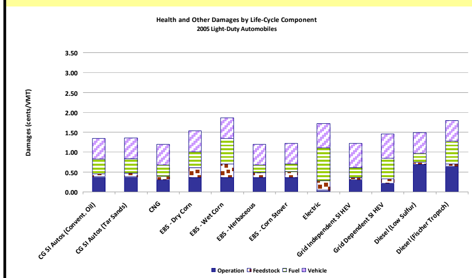
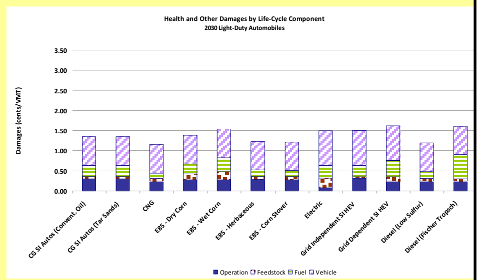
Light-Duty Vehicles: Health Damages in 2005 and 2030





CG SI = Conventional Gasoline Spark Ignition

- Damages in 2030 are similar to 2005, despite population and income growth
  - Fuel economy (CAFE) and diesel emission rules reduce 2030 damages
- Damages are not spread equally among the different lifecycle components.
  - *Vehicle operation* accounted in most cases for less than one-third of the total damage
  - Other components of the life cycle contributed the rest
  - Vehicle manufacturing is a significant contributor to damages

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How Can Health Damage Estimates Inform Policy?

To control current PM, SO2, NOx damages:

- Damages represent benefits of pollution control
- Damages should be compared with costs of control
- Possible control measures are pollution taxes or allowances (control pollution not output)
- Tax on electricity provides no incentive to reduce SO2 per se
- Tax on gasoline reduces miles traveled but not pollution per mile

To select among future fuel sources for electricity:

- Compare cost per kWh of different fuel sources, including health costs and other externalities (e.g., damages from CO2)

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How Can Health Damage Estimates Inform Policy?

To select among future transportation technologies:

- Compare cost per mile of different technologies
  - Add health costs and other externalities (e.g., damages from CO_2) to capital and fuel costs

To calculate the net costs of CO_2 reduction policies:

- Once have controlled local pollution (PM and ozone) remaining damages represent an additional benefit from CO_2 reduction
- Example:
  - Energy-saving technology reduces electricity use by 1 MWh
  - If electricity produced by a coal plant, save 1 ton CO_2
  - If the plant produces $30 per MWh of health damages these represent a co-benefit

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