Lessons from *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use*

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Outline

Background

Statement of task

Defining externality

Scope of study

Selected results

Background

Congress

- Requested study – Energy Policy Act of 2005
- Directed Treasury to fund – Consolidated Appropriations Act of 2008

Tight schedule

- First committee meeting (of six) Sept 11, 2008
- Report released Oct 19, 2009
  - 473 pages

Statement of Task (1/2)

An NRC committee will define and evaluate key external costs and benefits—health, environmental, security, and infrastructure—associated with the production, distribution, and consumption of energy from various selected sources that are not or may not be fully incorporated into the market price of such energy, or into the Federal tax or fee or other applicable revenue measures related to such production, distribution, or consumption.

Although the committee will carry out its task from a U.S. perspective, it will consider broader geographic implications of externalities when warranted and feasible.

The committee will not recommend specific strategies for internalizing observable externalities, because those choices will entail policy judgments that transcend scientific and technological considerations.

In carrying out its task, the committee will include the following activities:

Seek to build upon the results of the NRC study America's Energy Future: Technology and Transformations.

Identify key externalities to be assessed in the categories of human health, environment, security (including quality, abundance, and reliability of energy sources), and infrastructure (such as transportation and waste disposal systems not sufficiently taken into account by producers or consumers).

Consider externalities associated with producing, distributing, and consuming energy imported from foreign sources.

Define appropriate metric(s) for each externality category considered.

Identify state-of-the-science approaches for assessing external effects (actual or expected) and expressing their effects in economic terms.

Develop an approach for estimating externalities related to greenhouse gas emissions and climate change. Estimate externalities related to those changes.

Present qualitative and, to the extent practicable, quantitative estimates of externalities and associated uncertainties within a consistent framework that makes the discussion of externalities and uncertainties associated with energy production, distribution, and consumption more transparent.

When it is not feasible to assess specific externalities comprehensively, the committee will recommend assessment approaches and identify key information needs to inform future assessments.

Defining Externality (p. 29)

An externality, which can be positive or negative, is an activity of one agent (for example, an individual or an organization, such as a company) that affects the well-being of another agent and occurs outside the market mechanism.

In the absence of government intervention, externalities associated with energy production and use are generally not taken into account in decision making.

Text book definition – but what if economic models oversimplify real-world behavior?

- Non-market interactions?

Internalized externalities?

"An NRC committee will define and evaluate key external costs and benefits … that are not or may not be fully incorporated into the market price of such energy, or into the Federal tax or fee or other applicable revenue measures…."

Are some externalities fully internalized through 'conventional' regulation?

- 'Command & control'
- Excluding pollution taxes, cap & trade, deposit-refund, etc.

Internalized (efficient) externalities?

"A coal-fired electricity-generating plant, which is in compliance with current environmental regulations, releases various pollutants…. The damage from this pollution is … a 'social cost'. If these social costs were not adequately taken into account in selecting the plant's site or the air pollution control technology that it uses, the true costs … have not been reflected in these decisions." (Example 1, p. 30)

How can we know if 'adequately taken into account'?

What if knowledge about harm from pollution changes?

Report describes

- Total damage (compared with zero emissions)
- Marginal damage

Note: neither total nor marginal damage is sufficient for judging if externality is too large or small

- Need to know marginal cost of control

Scope of study

- Energy sources (and carriers)
  - Major
  - Rapidly growing
- Endpoints
  - Human health
  - Climate change
  - Infrastructure & security
  - Environmental & ecological largely omitted
    - Unable to quantify or monetize
- Time period: 2005 & 2030
  - I report 2005 results
- Life-cycle analysis

Scope (personal view)

Too much effort on well-understood damages

- Health effects of fossil-fuel combustion (PM, O_3)

Too little effort describing other externalities

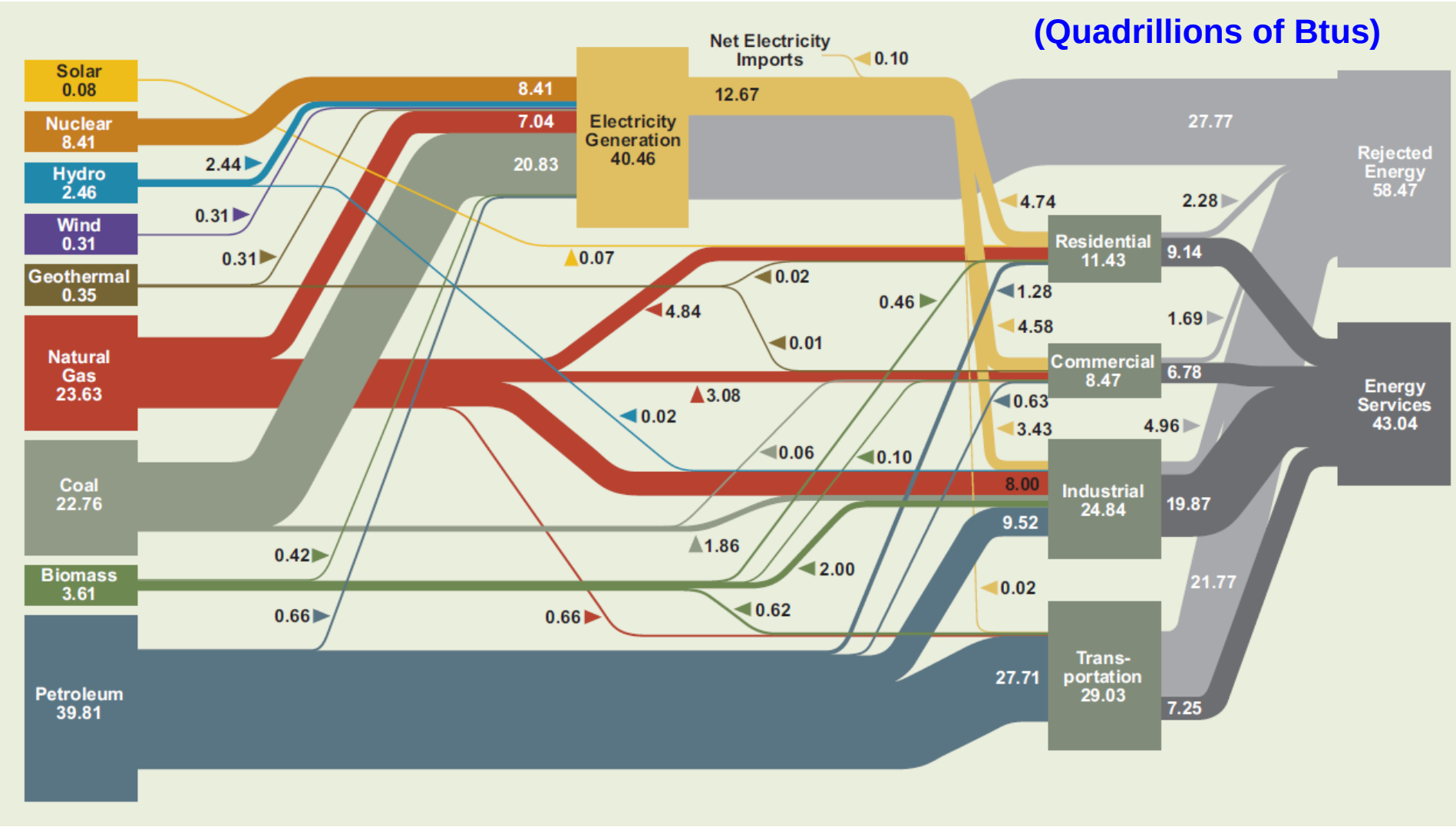
- Security & infrastructure
- Unconventional power (wind, solar, …)

Inconsistency across sectors

- Quantified health damages from fossil fuels
- Did not quantify damages from nuclear power (accident, waste, proliferation), electric grid disruption, accidents/attacks on facilities
  - Too hard and/or fully internalized (arguably)

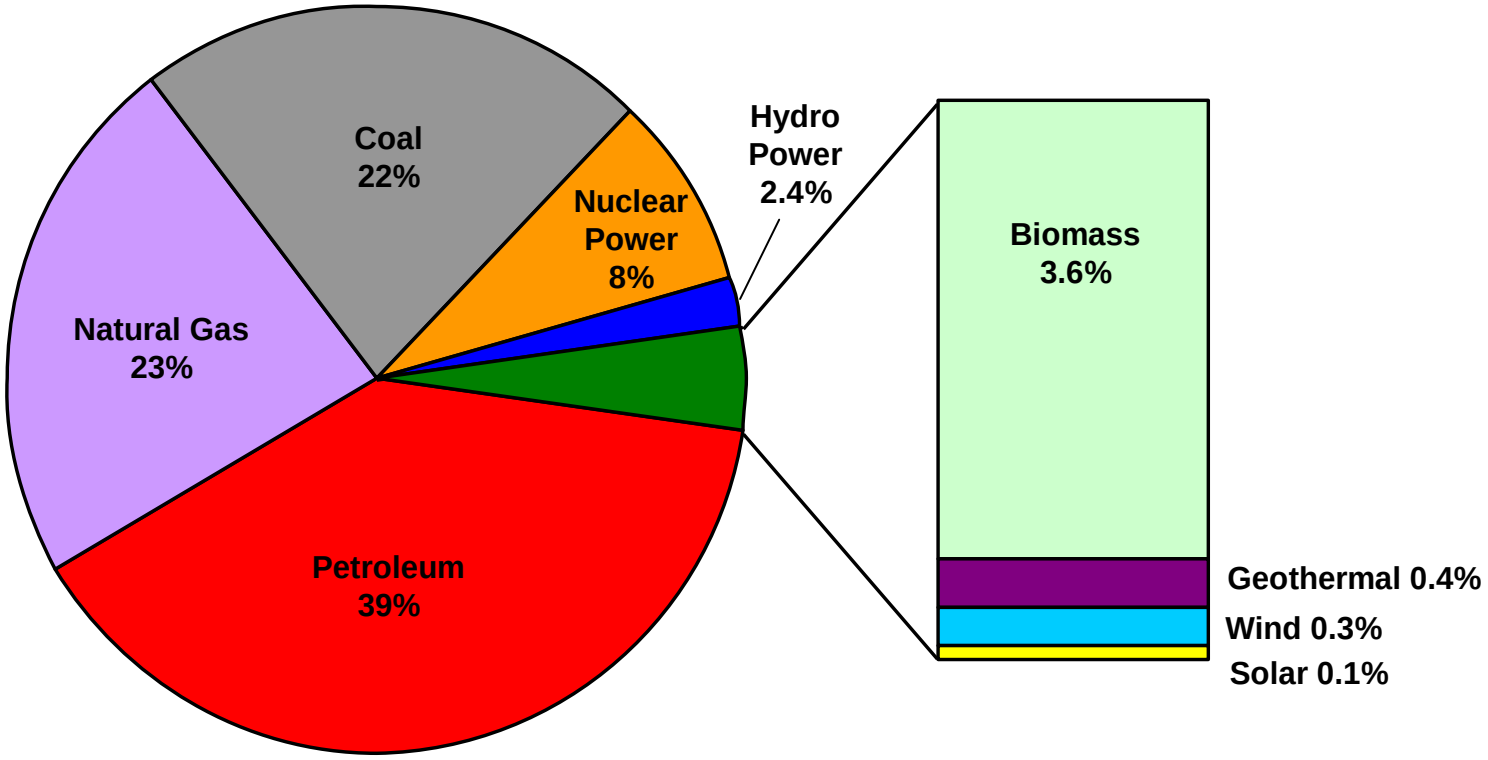
Do fossil-fuel health effects (and climate?) dominate, or are we missing important damages?

Energy Flows in the U.S. Economy 2007

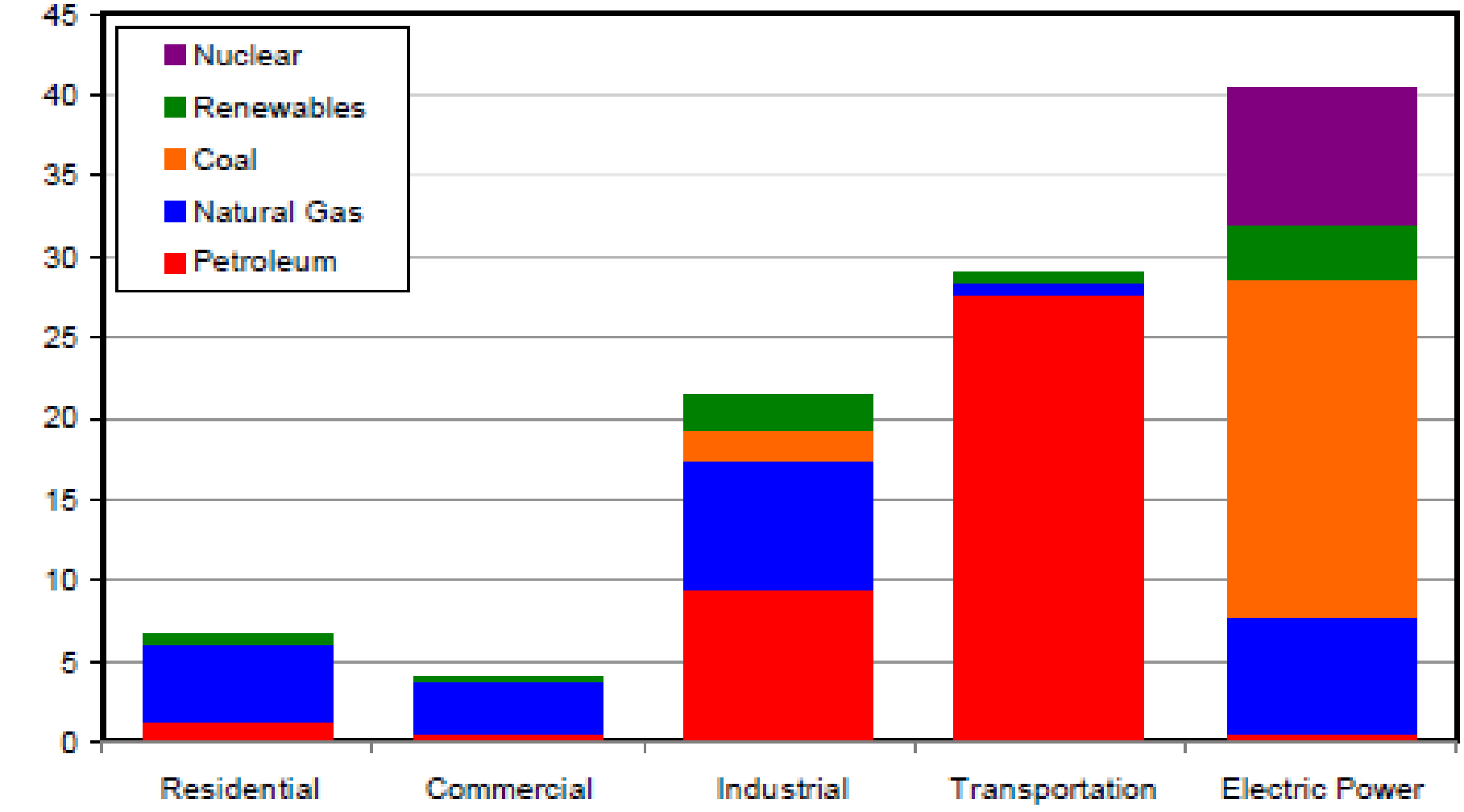


2007 U.S. Energy Consumption by Energy Source

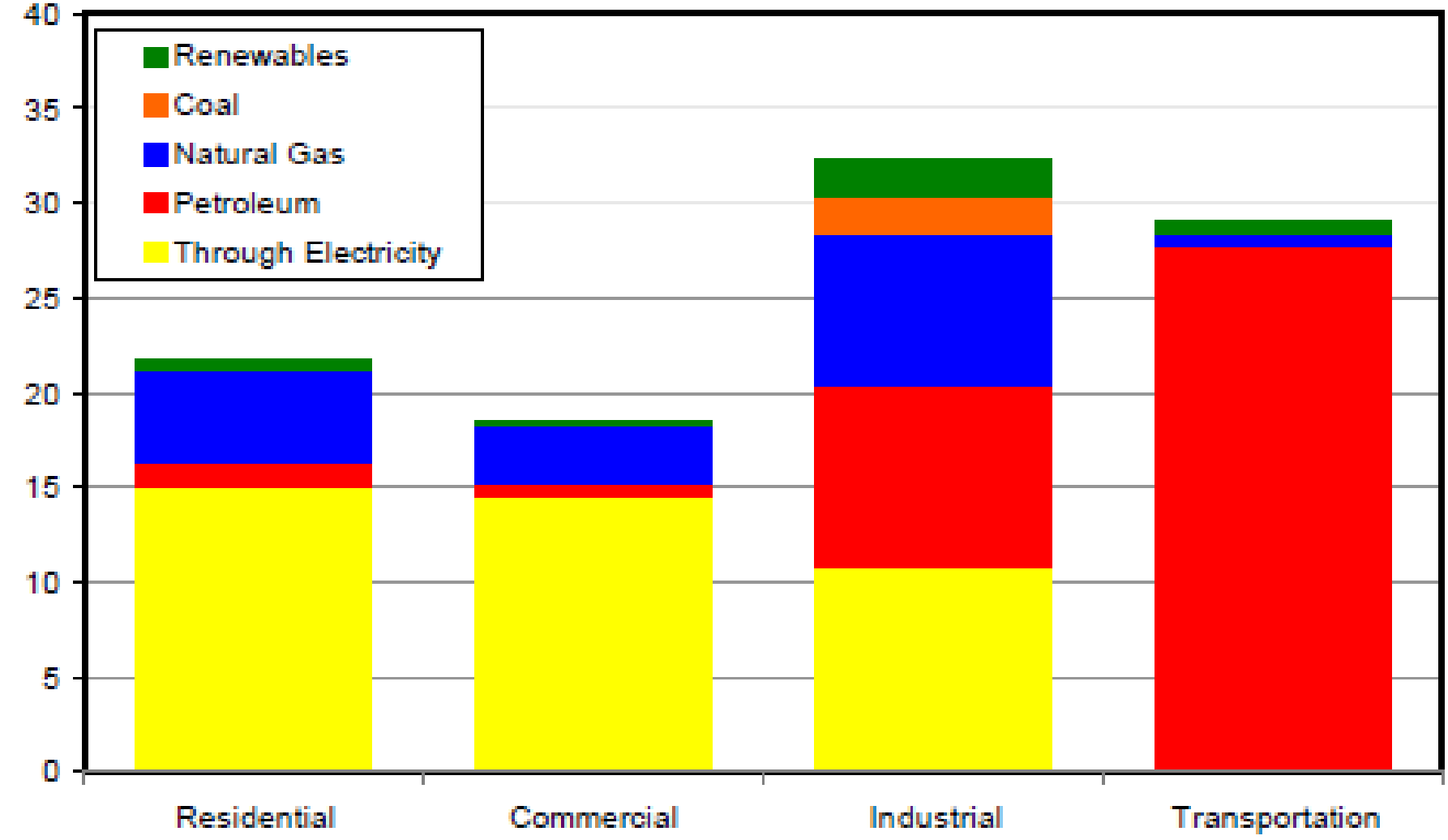
Total Consumption = 101.5 Quadrillion Btu



U.S. Primary Energy Use by Sectors (2007)



U.S. Delivered Energy Use by Sectors (2007)



Organization (Contents)

1. Introduction
2. Electricity
3. Transportation
4. Heat
5. Climate change (not included above)
6. Infrastructure & security
7. Conclusions

Energy Source	Electricity (Chapter 2)	Transportation (Chapter 3)	Industry – heat (Chapter 4)	Buildings – heat (Chapter 4)
Oil		MA	QE	QE
Coal	MA			
Natural Gas/Liq	MA	MA	QE	MA
Uranium	QL			
Biomass	QL	MA		
Wind	QL			
Solar Power	QL			QE
Other Fuels		MA		
Electricity	-	MA	QE	QE

MA = modeling analysis; QL = quantitative information from literature;
QE = qualitative evaluation

Non-Climate Damages

Damage Function Approach

- Emissions → Ambient concentrations → Exposures → Effects → Monetary values

Effects of air pollution

- Primarily PM, SO_2, NO_x

on

- human health, grain & timber yields, building materials, recreation, visibility

94% of damages are associated with human mortality

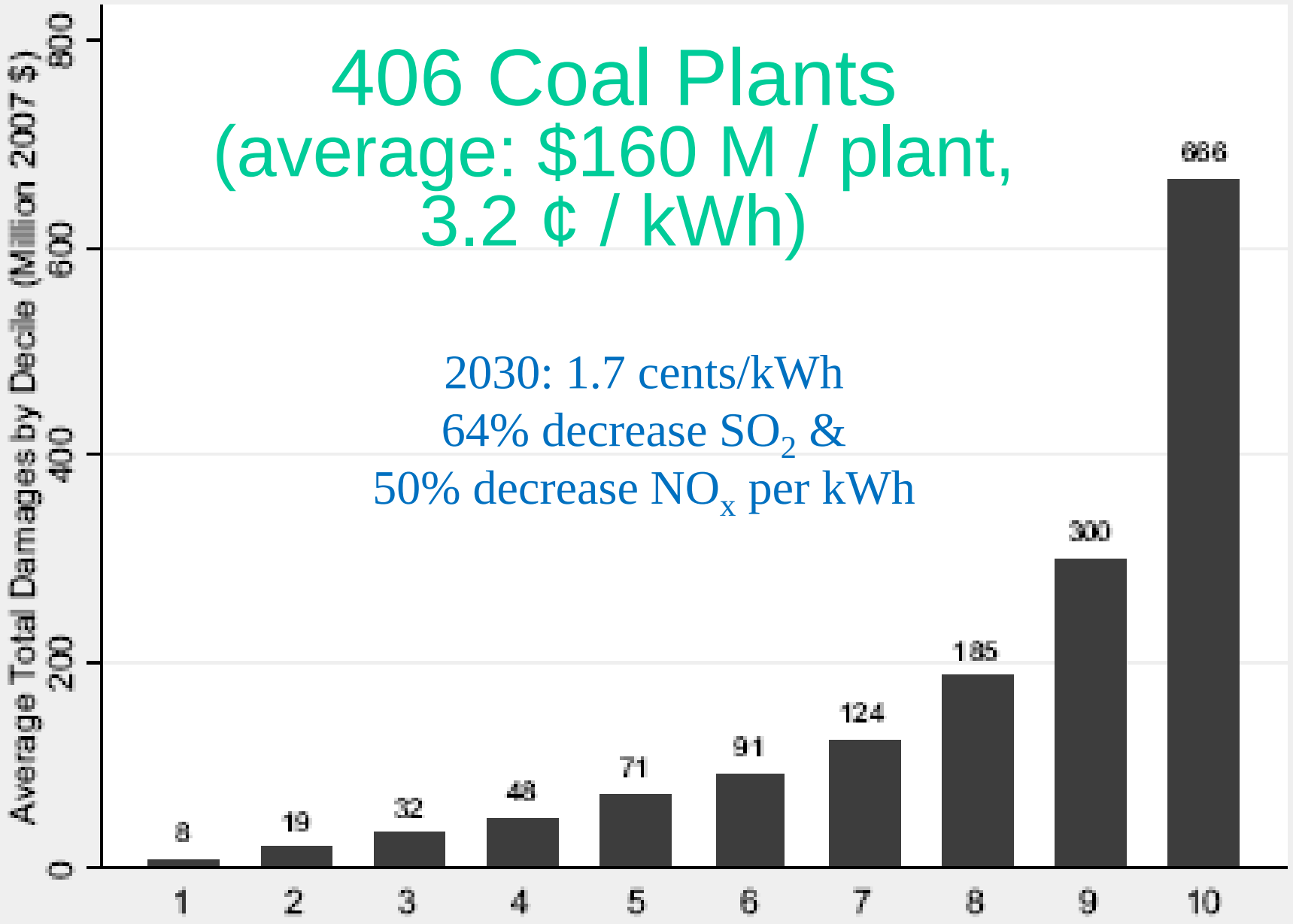
- Value per statistical life (VSL) = $6 million (2000 USD)

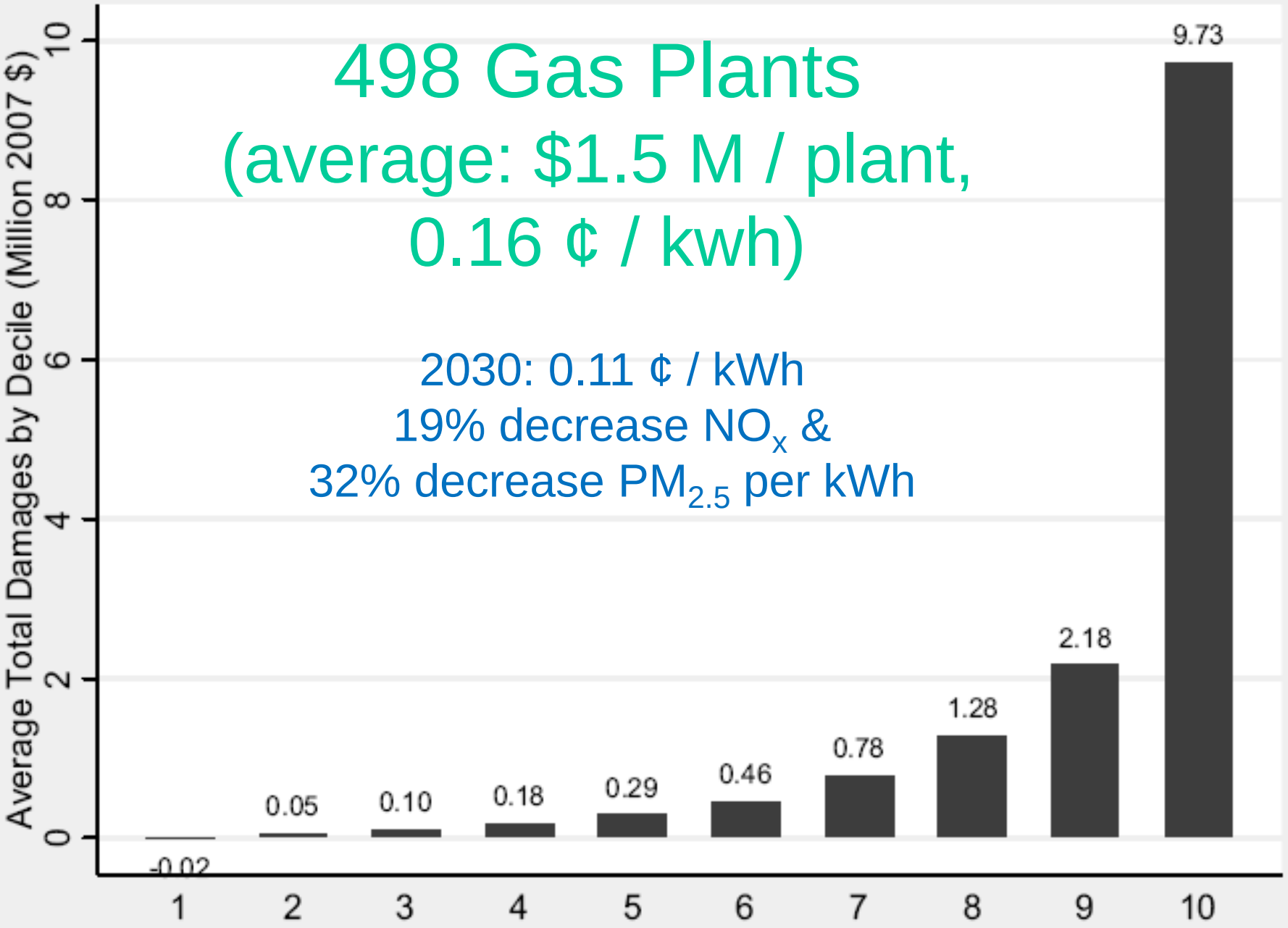
Electricity

- Detailed modeling of air pollution mortality from coal & gas plants
  - APEEP (Muller & Mendelsohn)
  - County-level source-receptor matrix derived from Gaussian model, adjusted to fit CMAQ
  - PM, SO_2, NO_x
- Damages dominated by emissions from generating plants (coal, gas)
  - Great heterogeneity (dominated by composition of emissions, not effects)

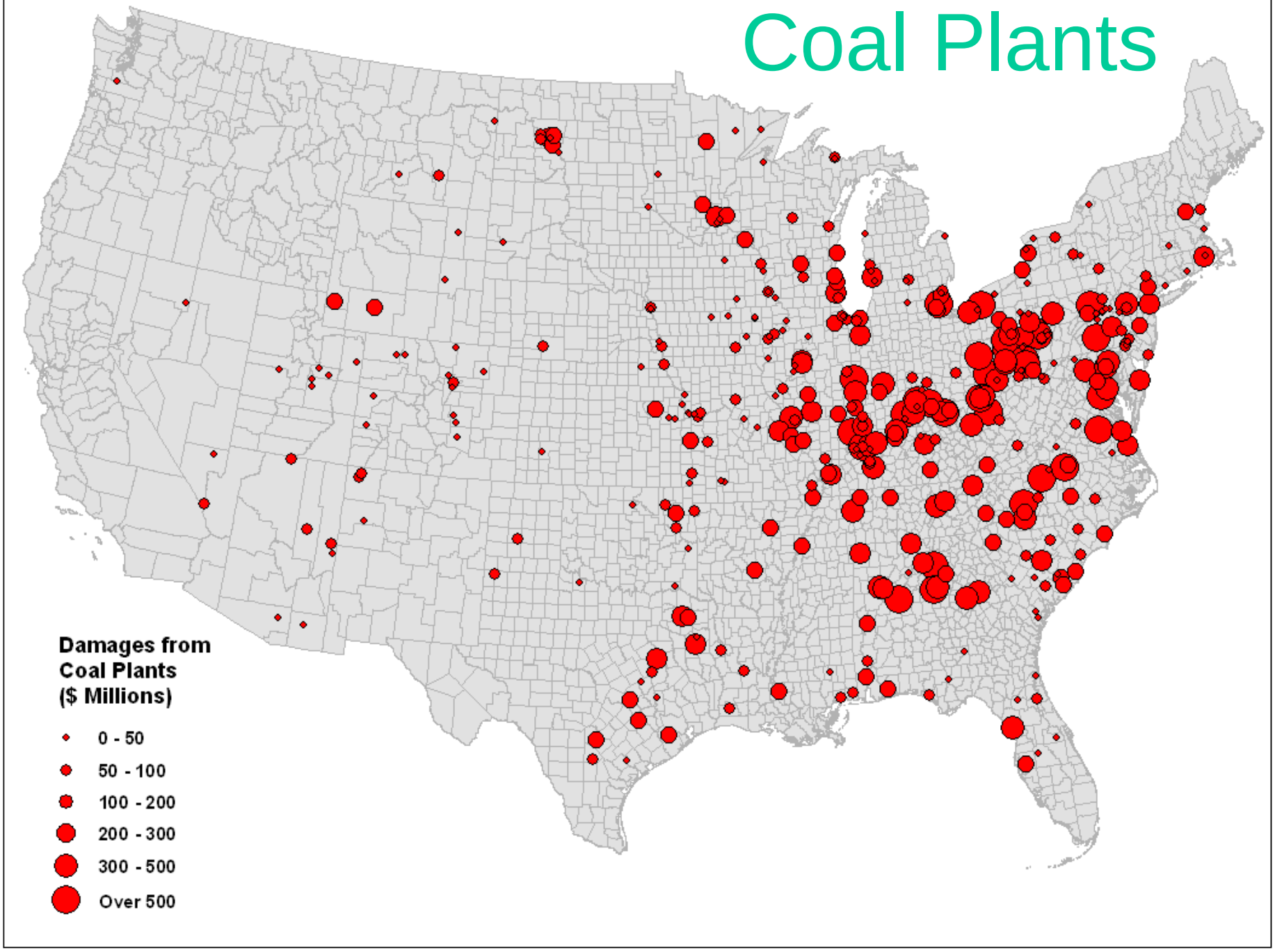
406 Coal Plants (average: $160 M / plant, 3.2 ¢ / kWh)

2030: 1.7 cents/kWh
64% decrease SO_2 &
50% decrease NO_x per kWh

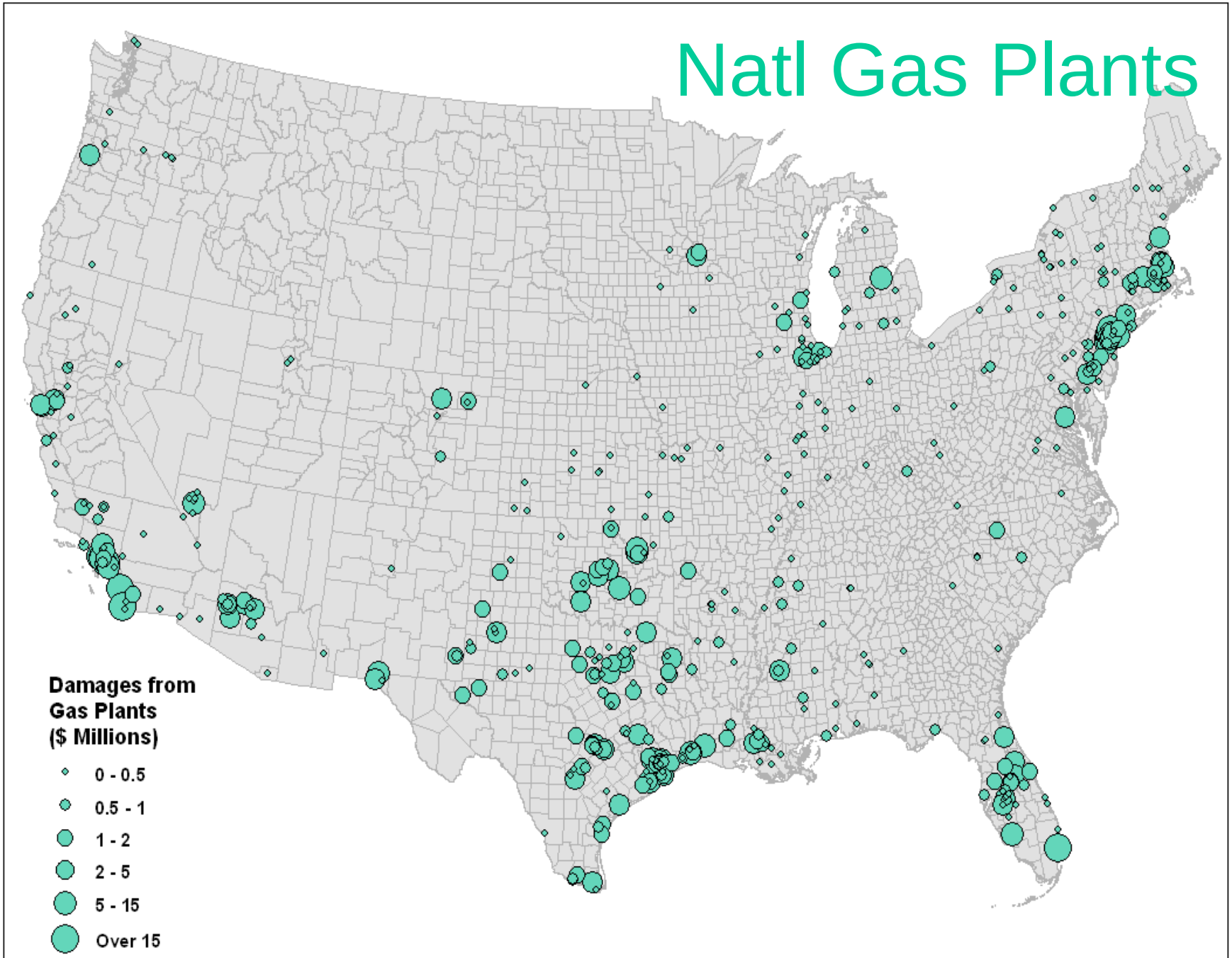



498 Gas Plants
(average: $1.5 M / plant,
0.16 ¢ / kwh)
2030: 0.11 ¢ / kWh
19% decrease NO_x &
32% decrease $PM_{2.5}$ per kWh
Average Total Damages by Decile (Million 2007 $)
0
2
4
6
8
10
-0.02
0.05
0.10
0.18
0.29
0.46
0.78
1.28
2.18
9.73
1
2
3
4
5
6
7
8
9
10

Coal Plants


Damages from
Coal Plants
($ Millions)
0 - 50
50 - 100
100 - 200
200 - 300
300 - 500
Over 500

Natl Gas Plants



Transportation (on-road)

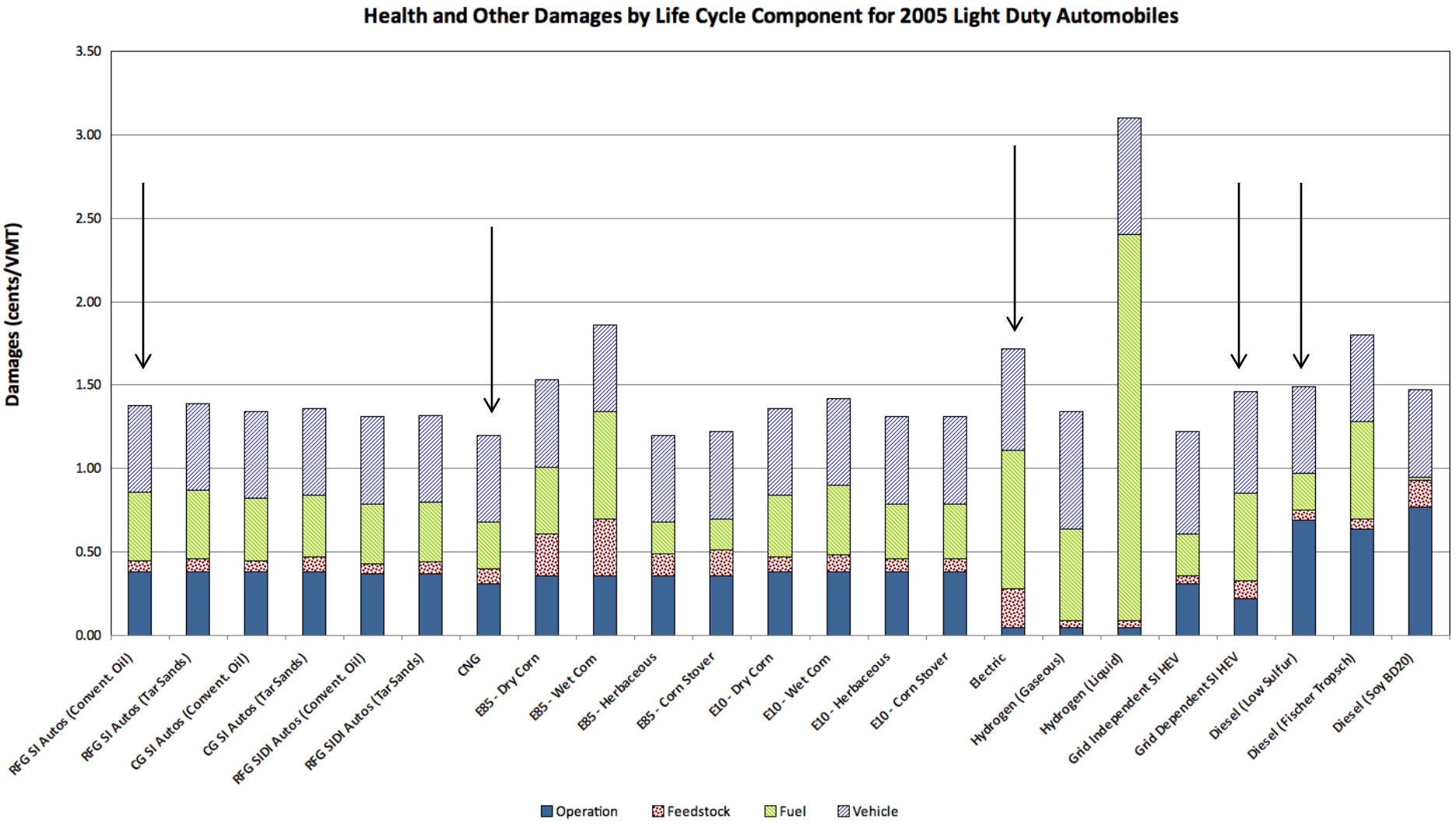
Analyzed many fuel / engine technologies

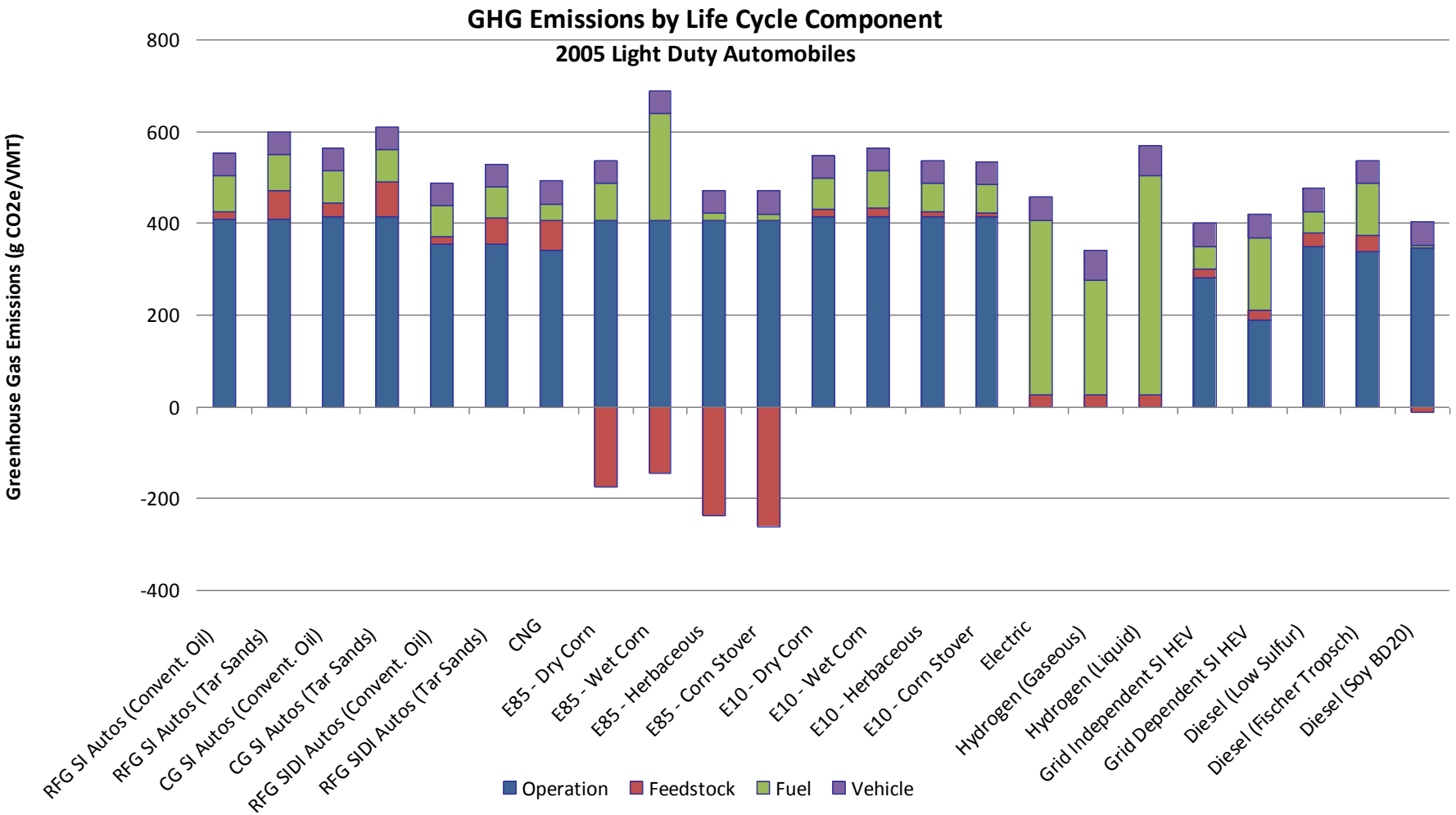
LCA using GREET (Argonne National Lab)

- Feedstock (extraction, transport to refinery)
- Fuel (refining, transport to pump)
- Vehicle production
- Operations (in-use)

Total damages remarkably similar

- Allocation differs across life cycle
- Diesel anticipated to improve with new regulations


Health and Other Damages by Life Cycle Component for 2005 Light Duty Automobiles
Damages (cents/VMT)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
RFG SI Autos (Convent. Oil)
RFG SI Autos (Tar Sands)
CG SI Autos (Convent. Oil)
CG SI Autos (Tar Sands)
RFG SIDI Autos (Convent. Oil)
RFG SIDI Autos (Tar Sands)
CNG
E85 - Dry Corn
E85 - Wet Corn
E85 - Herbaceous
E85 - Corn Stover
E10 - Dry Corn
E10 - Wet Corn
E10 - Herbaceous
E10 - Corn Stover
Electric
Hydrogen (Gaseous)
Hydrogen (Liquid)
Grid Independent SI HEV
Grid Dependent SI HEV
Diesel (Low Sulfur)
Diesel (Fischer Tropsch)
Diesel (Soy BD20)
Operation
Feedstock
Fuel
Vehicle


GHG Emissions by Life Cycle Component
2005 Light Duty Automobiles
Greenhouse Gas Emissions (g CO2e/VMT)
800
600
400
200
0
-200
-400
RFG SI Autos (Convent. Oil)
RFG SI Autos (Tar Sands)
CG SI Autos (Convent. Oil)
CG SI Autos (Tar Sands)
RFG SIDI Autos (Convent. Oil)
RFG SIDI Autos (Tar Sands)
CNG
E85 - Dry Corn
E85 - Wet Corn
E85 - Herbaceous
E85 - Corn Stover
E10 - Dry Corn
E10 - Wet Corn
E10 - Herbaceous
E10 - Corn Stover
Electric
Hydrogen (Gaseous)
Hydrogen (Liquid)
Grid Independent SI HEV
Grid Dependent SI HEV
Diesel (Low Sulfur)
Diesel (Fischer Tropsch)
Diesel (Soy BD20)
Operation
Feedstock
Fuel
Vehicle

Climate Change

Marginal damages ($ / ton CO_2-eq) taken from review of integrated-assessment models

- Nordhaus, Tol, Hope (Stern)

Sensitive to discount rate, damage function

- Used 10, 30, 100 for illustration
- Could update with social cost of carbon report

Summary – Health & Climate

Electricity

- Coal: $62 B
  - 3.2 [< 0.5 – 12] ¢ / kwh
  - Climate: 3 [1 – 10] ¢ / kwh
- Gas: $0.74 B
  - 0.16 [< 0.05 – 1] ¢ / kwh
  - Climate: 1.5 [0.5 – 5] ¢ / kwh

Heat

- Gas: $1.4 B
  - 11 ¢ / MCF
  - Climate: 0.7 [0.07 – 7] ¢ / MCF

Transportation (on road)

- Light-duty: $36 B [1.2 – 1.7] ¢ / VMT
  - Climate: 0.5 [0.05 – 5] ¢ / VMT
  - (Gasoline, diesel, E85 corn, grid-dependent HEV or EV)
- Heavy-duty: $20B

Infrastructure & Security

Many effects, few externalities, hard to quantify, marginal externality may be negligible

Electric grid disruption

- Internalized through regulation?

Nuclear waste & security

- Hard to quantify
- Internalized through regulation?

Facility vulnerability to attack or accident

Dependence on foreign oil

Facility Vulnerability to Attack or Accident

LNG

- Unlimited liability (internalized)
- Subsidy (CG spends $60k to shepherd tanker to Everett)

Oil spills (ship, facility)

- < 1 ¢ / bbl (probability x damage / spill)
- Internalized?

Oil & gas pipelines

- < 1 ¢ / bbl (historical fatalities x VSL)
- Internalized?

Nuclear plants

- Required to carry $300 M liability ($0.005 / kWH)
- At risk for supplemental assessment (never levied)
- Exempt from liability above ~10 B / accident (externality)

Dependence on Foreign Oil

- US can exert monopsony power to reduce world oil price
  - Not an externality (works through market, creates deadweight loss or mitigates loss from oligopoly distortion)
- Oil supply disruption / price shock
  - Not an externality (works through market)?
  - Marginal effect on probability is negligible?
- Foreign policy, national security, military expenditures
  - Energy imports constrain US actions, enrich other states
  - Some constraints are externalities, but hard to estimate
  - Marginal effect is negligible?

Conclusion

"In aggregate, the damage estimates presented in this report for various external effects are substantial. Just the damages from external effects the committee was able to quantify add up to more than $120 billion for the year 2005….

- Coal-fired electricity 62 B
- On-road transportation 56 B
- Gas heat & electricity 2 B

"[T]here is little doubt that this aggregate total substantially underestimates the damages, because it does not include many other kinds of damages that could not be quantified …, such as damages related to climate change, ecosystems, infrastructure and security.

For policy, need to consider costs of control & other factors