Introduction to Externalities: Early 1990's Methods and Results

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Motivation for the Externality Studies in the Early 1990's

- In the U.S., initiatives among state regulatory commissions to require electric utilities to account for external costs associated with power plant emissions in the utilities' long-term planning of power plant construction and operation.

- In Europe, growing requirement for policy analysts to take account of the environment in their decision making, as reflected in the European Union's 5th Environmental Action Programme.

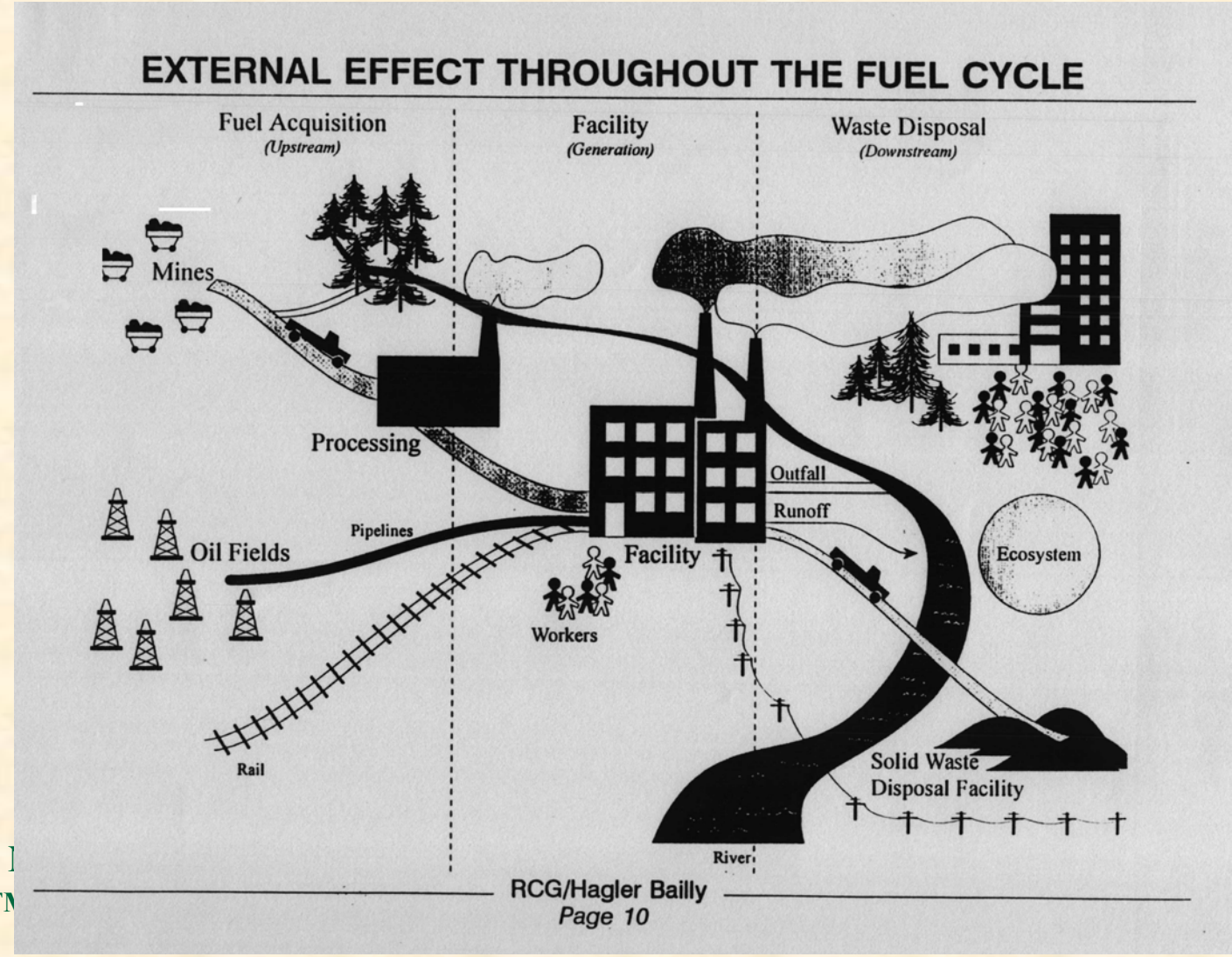
Overview of Presentation

- Methodology for estimating the health and environmental externalities from electricity generation
- Results of studies from the early 1990's
- Methodological issues and unanswered questions

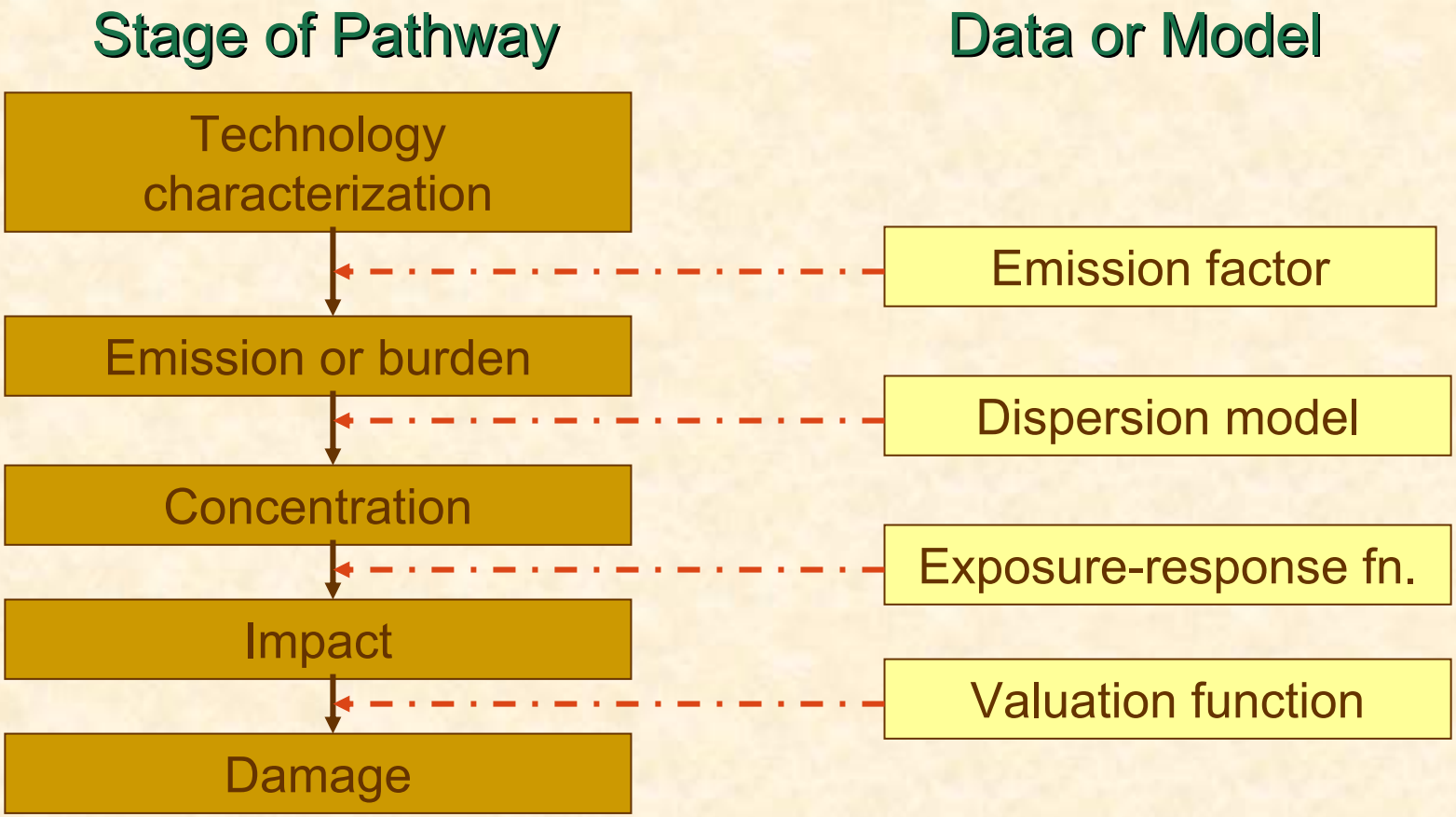
Part 1.

Methodology for Estimating Health and Environmental Externalities Associated with Electric Power Generation

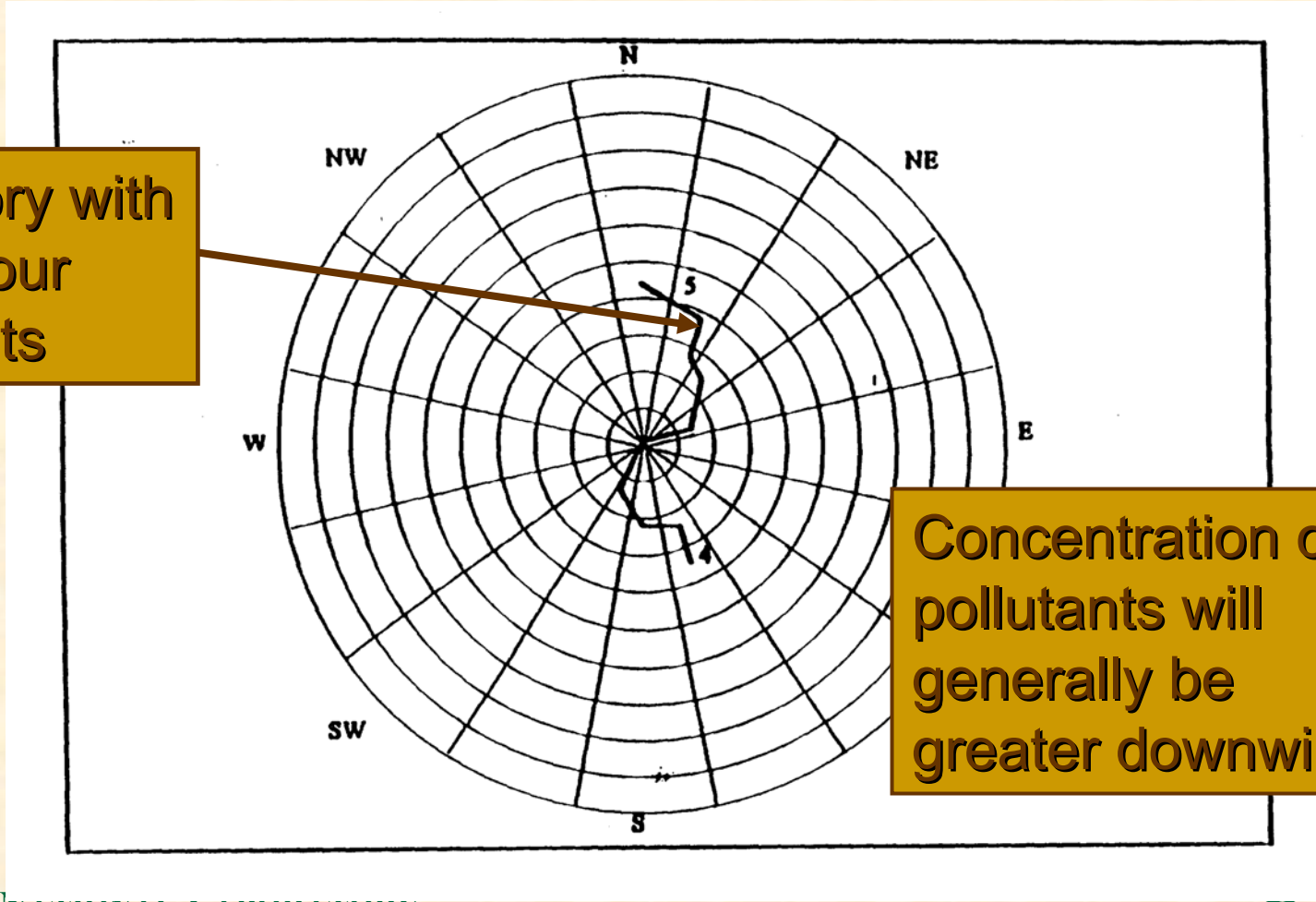
Fuel Chain Analysis Accounts for Important Sources of Pollutants From Activities of the Full Life Cycle



Impact Pathway/Damage Function Methodology Applied to Fuel Chains



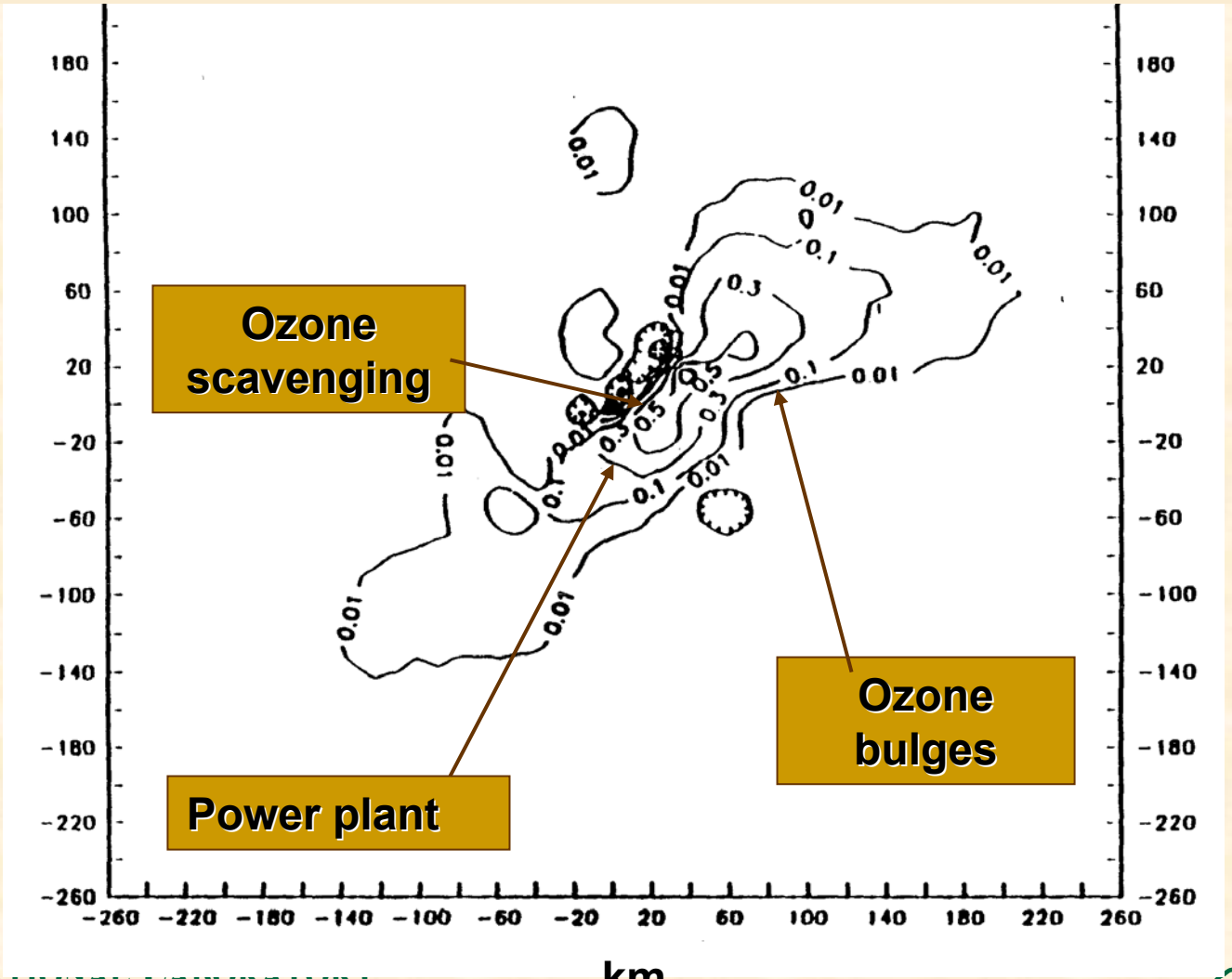
Airborne Dispersion of Pollutants Reflects Hourly Wind Velocities



Trajectory with five 1-hour segments

Concentration of pollutants will generally be greater downwind

Ozone Concentrations are a Result of Complex Atmospheric Chemical Processes



Impacts Estimated from Exposure-Response Functions, Thresholds, Critical Loads

Health -- morbidity and mortality

Environment -- agriculture, natural (vegetation., aquatic, biodiversity, visibility), man-made infrastructure

Accidents -- occupational, transportation, severe, perceptions

Economic Valuation Used Valuation Functions from the Economics Literature

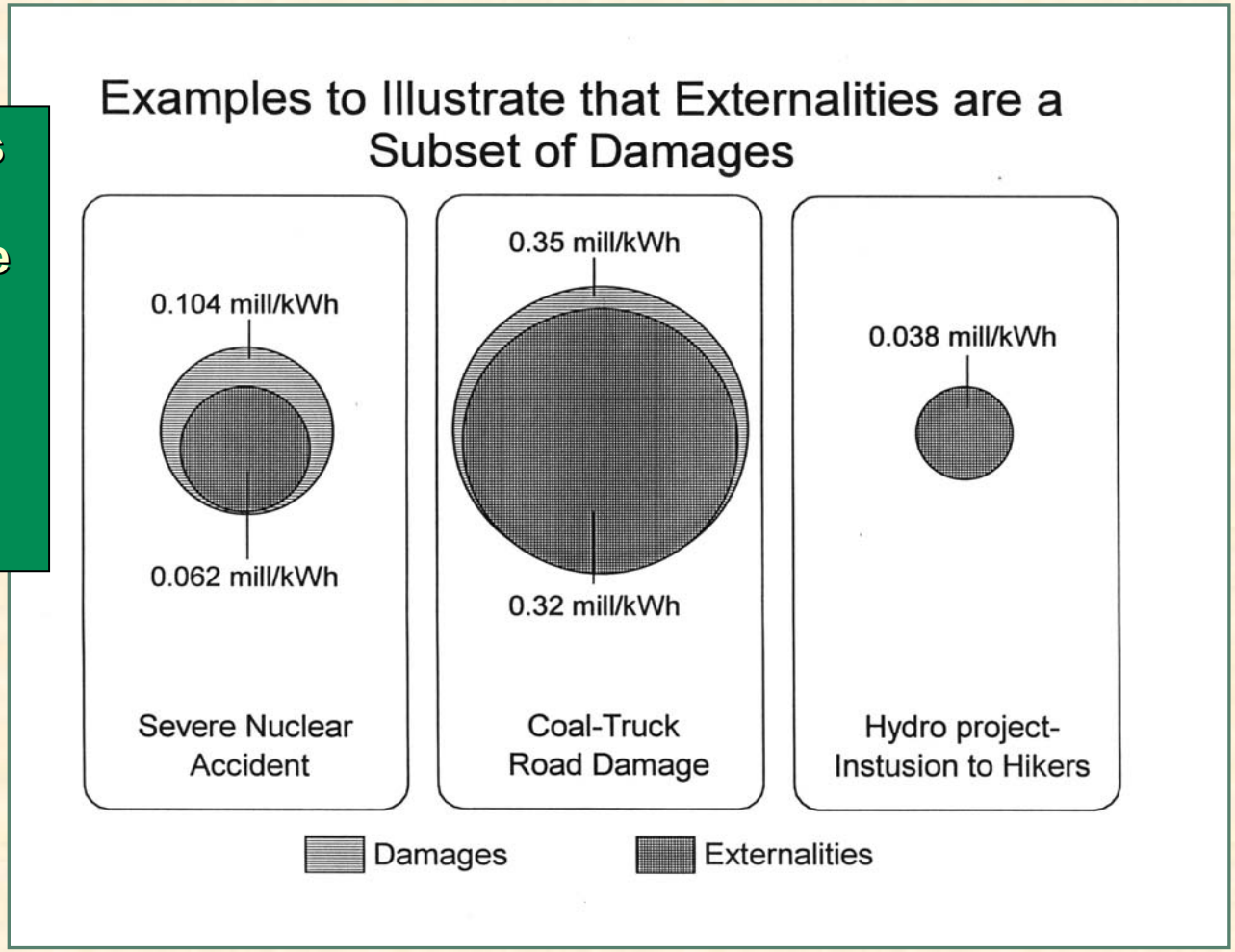
Economic value is based on evidence of individuals' willingness to pay (WTP) to avoid damaging impacts

- Market price
- Contingent valuation
- Hedonic price
- Travel cost

Externalities are a Subset of Economic Damages

Define>>>

Externalities are effects on the well-being or profits of those who are not involved in a transaction, and which are not taken into account in the transaction.



Key Attributes of These Studies Are That They Were:

- ***Science-based*** →
  - Considered scientific evidence
  - Did not rely on regulations
- ***Damage-based*** in terms of estimating damaging impacts and individuals' willingness to pay (WTP) to avoid these impacts
  - Damage-based estimates should be compared against, and not approximated by, estimates of the ***cost of abatement***
- ***Bottom-up*** from the standpoint of an engineering analysis of source terms, modeling pollutant transformation and dispersion, estimating specific impacts, and valuing their damages

Part 2.

Results of Studies in the Early 1990's

Summary of Externalities Estimates for Selected Technologies Sited at a Rural Location

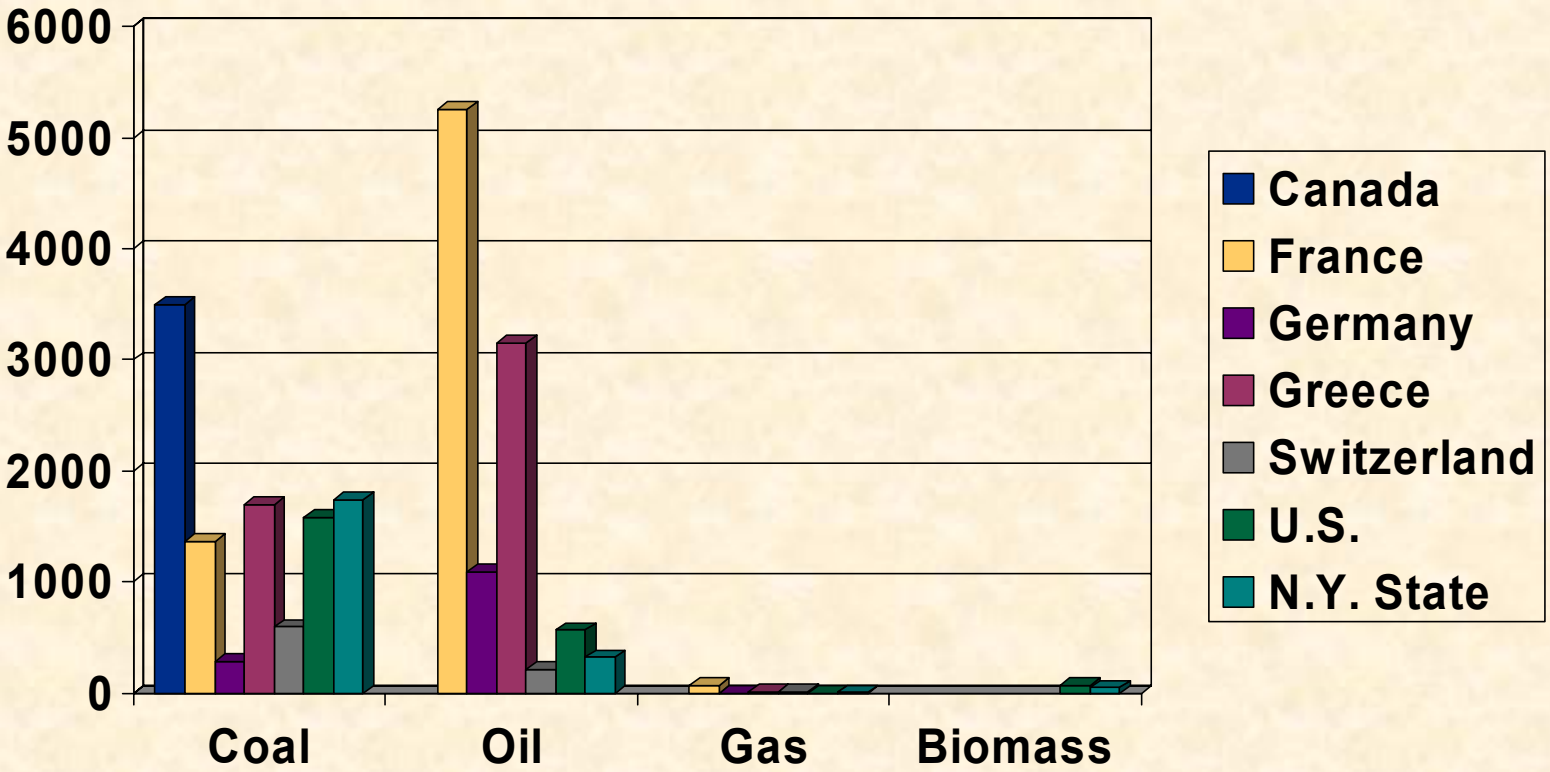
Impact	Externalities (mills/kWh)					
	Coal	Oil	Gas	Biomass	Hydro	Nuclear
Mining and milling - public healt	0	0	0	0	0	0.0145
Rail accidents - public injuries	0.4152	0	0	0	0	0
Particulates - health	0.28	0.031	0.054	0.86	0.002	0
Ozone - health	0.23	0.074	0.027	0.15	0.0014	0
Ozone - crops	0.12	0.06	0.06	0.088	0.0007	0
Lead - health	0.0109	0	0	0	0	0
Water use - fish loss	0.0031	0	0	0	0	0
SO2 - health	0.018	0	0	0.0014	0	0
CO2 - climate change impacts	6.8	5.14	3.9	0	0.037	0.0041
Crude oil spills - aquatic damag	0	0.0017	0	0	0	0
Refined oil spills - aquatic dama	0	0.0043	0	0	0	0
Truck traffic - highway damage	0	0.0921	0	0.122	0	0.0016
Reduced fishing benefits	0	0	0	0	0.097	0
Intrusion to hikers	0	0	0	0	0.038	0
Radionuclides, normal operatio	0	0	0	0	0	4E-05
Waste transportation - health	0	0	0	0	0	6E-05
Severe reactor accidents - healt	0	0	0	0	0	0.0249
Severe reactor accidents - other	0	0	0	0	0	0.0789
Transportation shipments - pub	0	0	0	0	0	0.0091
Transportation shipments - prop	0	0	0	0	0	0.0618

Source: ORNL/RFF (1994-1998) Estimating Externalities of Fuel Cycles. Washingto

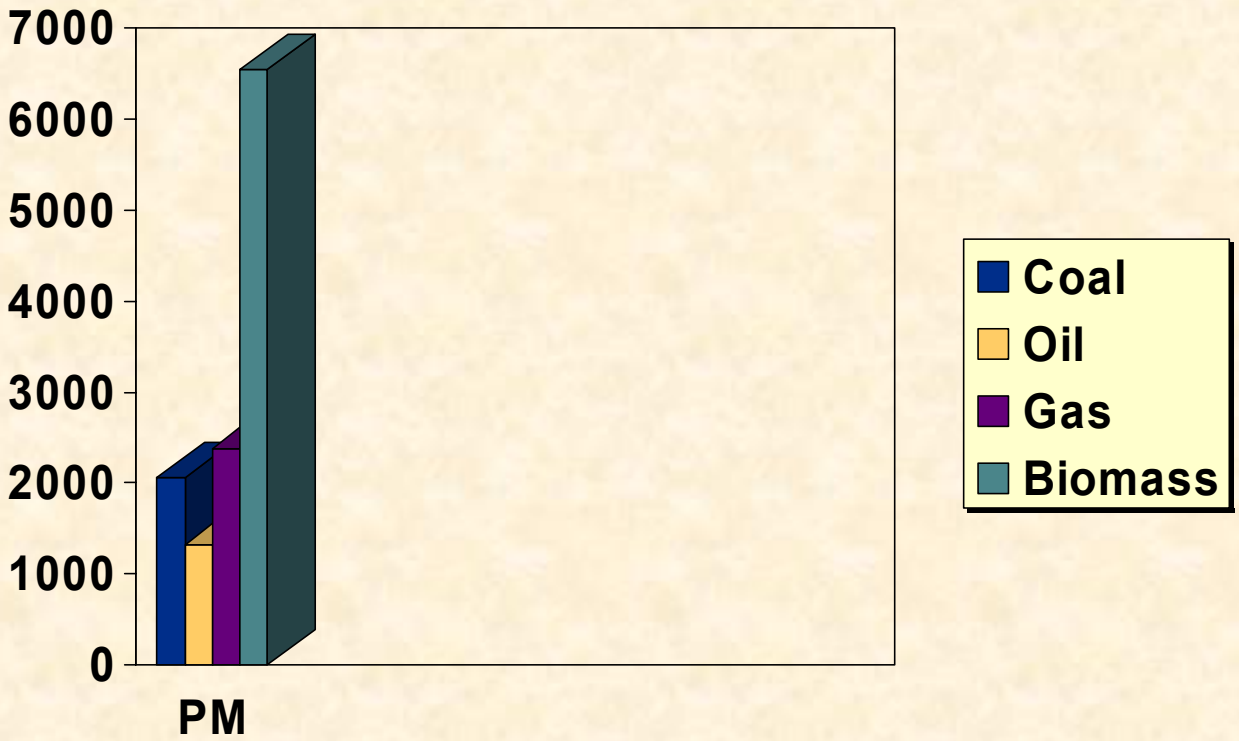
Many Possible Impacts but Most Important Appeared to be --

- *Coal*: climate change, acid aerosols, primary particulates, ozone, transportation accidents, truck road damage, mining accidents
- *Oil*: climate change, energy security(?), aerosols and particulates, ozone, spills (internalized in costs?)
- *Gas*: climate change, particulates, pipeline leakage and accidents (vary considerably)
- *Nuclear*: severe accident and waste storage issues, long-term risks of reprocessing (where done)
- *Biomass*: primary particulates, transportation impacts
- *Hydro*: change in local environment
- *Wind*: noise if in populated area

Estimates of Emissions of SO_2 Vary Among Studies (t/TWh)

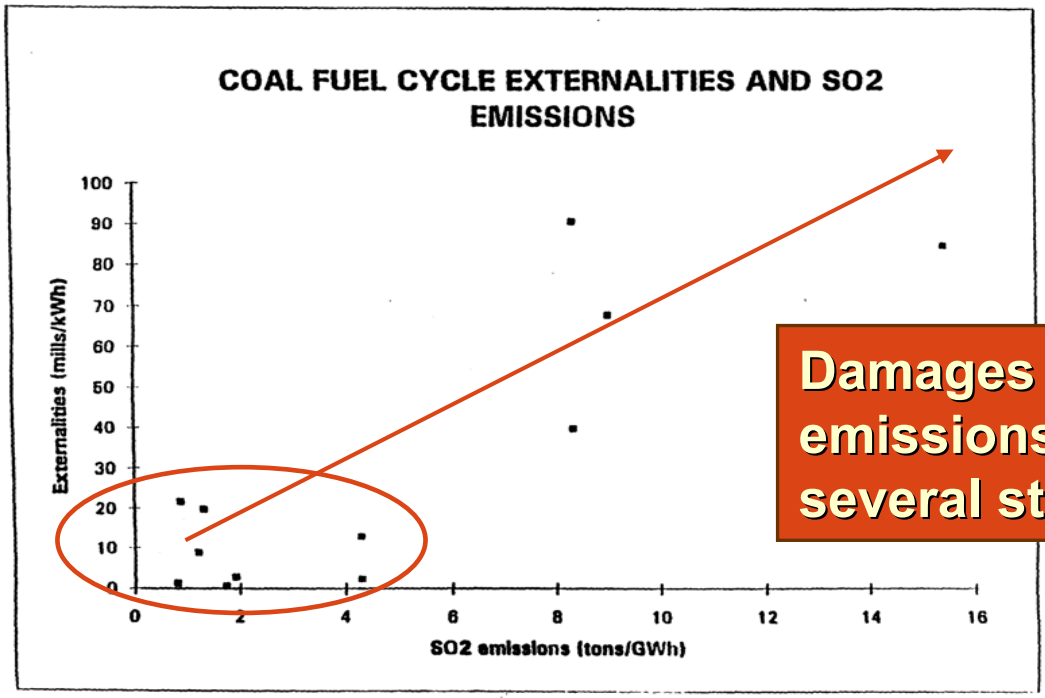


For Given Level of Emissions, Externalities Depended on *Type* of Power Plant (1989 $/metric ton)



Impacts are Directly Related to Quantity of Emissions of SO_2 and to the Pathways and Dose-Response Functions Used

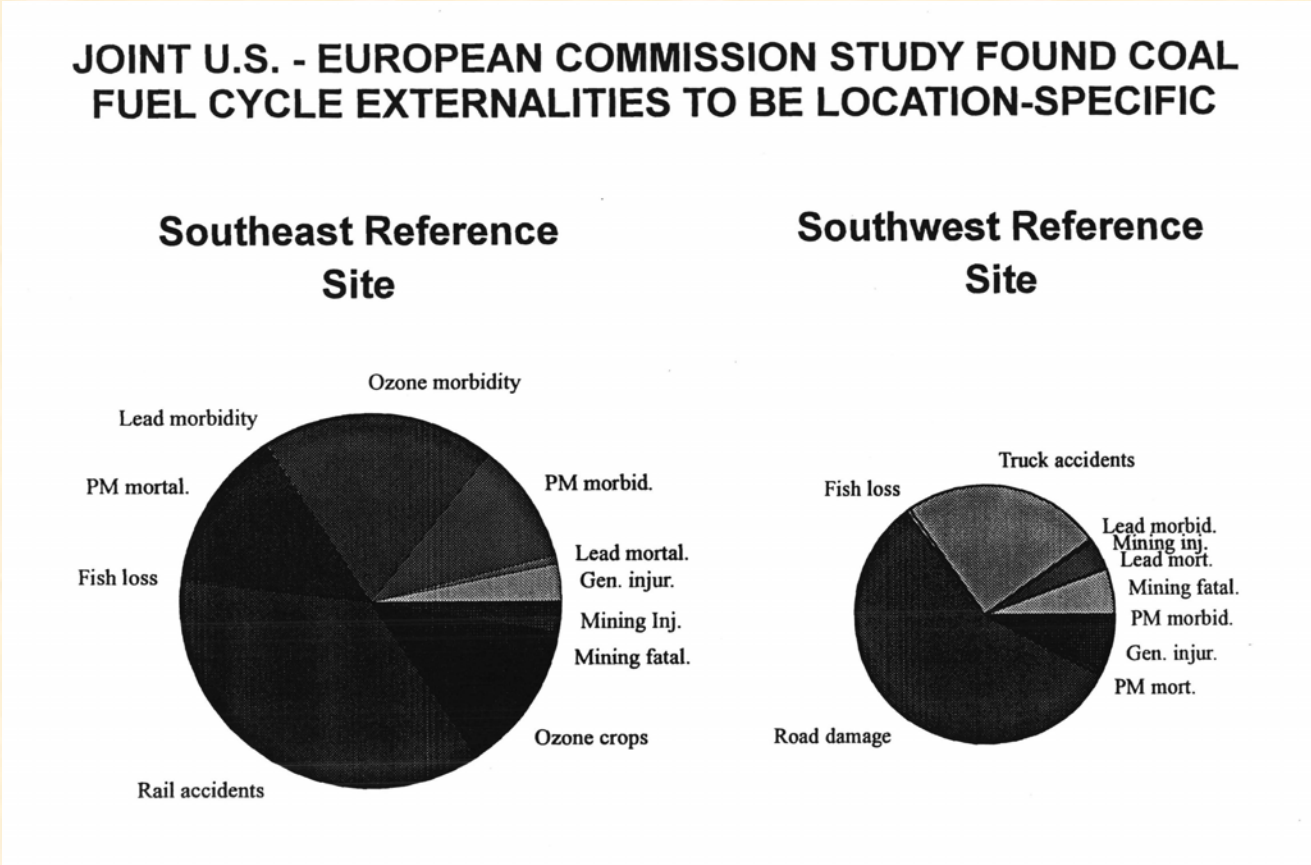
QUANTITY OF EMISSIONS HAS DIRECT BEARING ON THE ASSOCIATED HEALTH AND ENVIRONMENTAL IMPACTS



Estimates of damages depend on ***pathways*** considered and ***damage functions*** used

Damages vs. emissions from several studies

Except for CO_2, Externalities Vary by Site in Terms of Type and Magnitude



The Most Important Factors Affecting the Magnitude of Impacts and Damages:

- Quantity of emissions
- Impact pathways and damage functions used (especially for health effects of exposure to sulfates)
- Geographic distribution of population
- Boundary and scope of study
- Economic valuation of increased risk of premature mortality
- Treatment of global warming
- Treatment of risk of severe accidents
- Existence of highly valued ecosystems

Other Factors Affecting the Magnitude of Impacts and Externalities

- Source parameters (e.g. stack height and diameter, exit velocity)
- Background levels of pollutants and atmospheric chemistry
- Meteorology
- Local topography
- Background levels of pollutants and atmospheric chemistry
- Thresholds in impacts
- Valuation functions

Part 3.

Methodological Issues

Challenges Abound

- Health effects of particulate matter, particularly sulfates
- Complexities in modeling mercury transport and fate
- Valuing increased risk of premature mortality
- Estimating externalities associated with climate change
- Impact pathways for other emissions and impacts
- Quick-response policy applications on a national scale

Acknowledgements

Material in this presentation is taken in part from

Guidance for Comparative Assessment of the Health and Environmental Impacts of Electricity Generation Systems, Vienna: International Atomic Energy Agency, 1999, which I co-authored with Stephen Hirschberg, Paul Scherrer Institute; Corinne Boone, Ontario Hydro; Richard Dutkiewicz, University of Capetown; and Richard Wilson, Harvard University. Yoshio Matsuki of the IAEA was Scientific Officer of the Coordinated Research Programme that produced this book.

Estimating Fuel Cycle Externalities, Washington: McGraw-Hill/Utility Data Institute, 1992-1998, co-authored with colleagues from Oak Ridge National Laboratory and Resources for the Future.

Presentation to the Joint Colloquium of the School for Public and Environmental Affairs and the Department of Economics, Indiana University, October 1, 1998

Presentation to the Fourth Coordinated Research Meeting of the International Atomic Energy Agency's Co-ordinated Research Programme on "Comparative Health and Environmental Risks of Nuclear and Other Energy Systems," Vienna, Austria, 19-23 October 1998

"Environmental Impacts of Energy Use," chapter 3 in *Energy: Science, Policy, and the Pursuit of Sustainability*, Robert Bent, Lloyd Orr and Randall Baker (eds.) Washington, DC: Island Press, 2002.