Economy-Wide Modeling in Analyses of Air Regulations at EPA

Presentation to Economy-Wide Modeling Science Advisory Board Panel

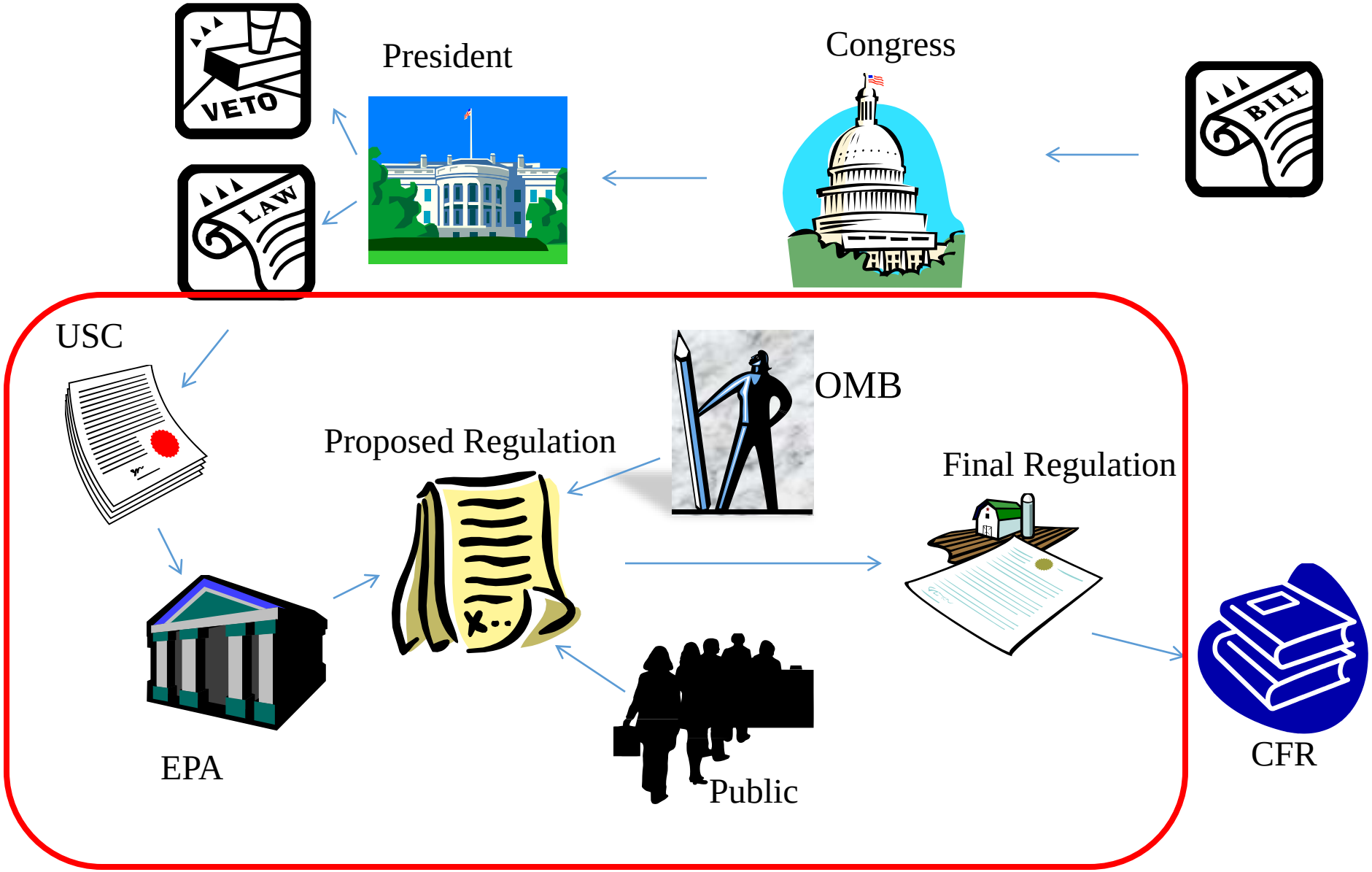
July 15, 2015

Outline

- Why EPA Conducts Economic Analysis
- Nature of Air Regulations
- Quick Overview of Regulatory Analytic Approaches
  - Guidance
  - Benefit-Cost Analysis
  - Economic Impact Analysis
- Examples Where CGE Models Have Been Used
- Overview of Charge and White Papers for SAB Process

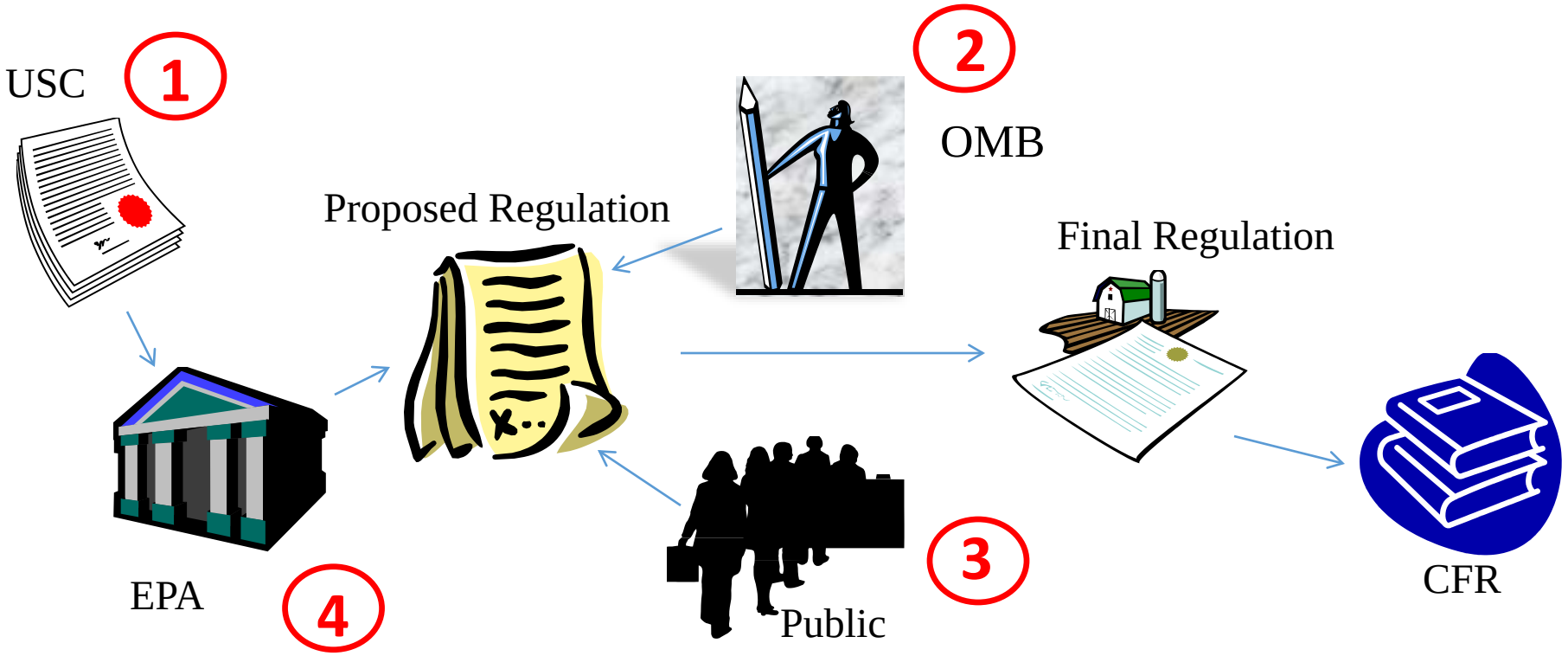
Why EPA Conducts Economic Analysis

The Regulatory Process



Why do Economic Analysis?

1. Inform policy decision (required by statute for some regulatory decisions)
2. Required by Executive Order
3. Inform the public
4. Aid in decision-making



Why do Economic Analysis?

- Economic analysis can inform the policy decision (as allowed by statute) by answering:
  - Is it theoretically possible for the “gainers” from the policy to fully compensate the “losers” and still remain better off? (benefit-cost analysis shows positive net benefits)
  - Who are the gainers and losers from the policy and associated economic changes? (economic impact analysis)

Why do Economic Analysis?

- For regulatory actions expected to have an annual effect on the economy of $100 million or more, Federal agencies should:
  - "propose or adopt a regulation only upon a reasoned determination that its benefits justify its costs (recognizing that some benefits and costs are difficult to quantify);"
  - (to the extent permitted by law) "in choosing among alternative regulatory approaches, [select] those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts; and equity);"
  - "use the best available techniques to quantify anticipated present and future benefits and costs as accurately as possible."

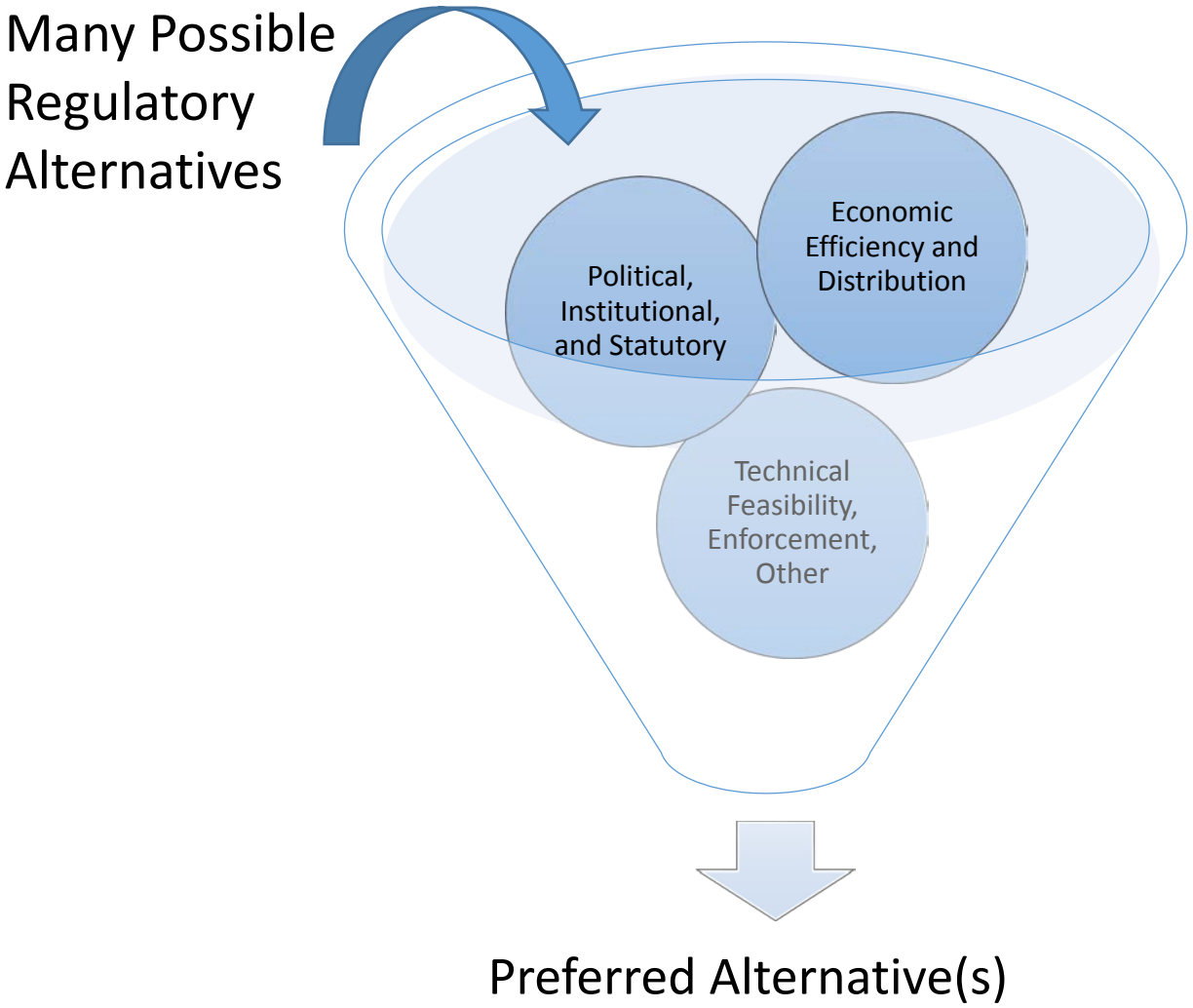
Executive Order 12866, as amended by EO 13563

Why do Economic Analysis?

- Economic analysis can inform the public even when it can't be used to set a standard
  - What are the positive and negative consequences and how important are they?
  - How does this regulation compare to others?
- Economic analysis can also be an organizing framework for decision-making
  - Enumerates positive and negative consequences, mutually exclusive and exhaustive
  - Even if we cannot estimate benefits in quantitative or monetary terms, impacts can be described coherently

Economic Analysis Is One of Many Decision Criteria

- Political Factors
- Statutory Instruction
- Institutional Feasibility
- Technical Feasibility
- Benefits and Costs (Economic Efficiency)
- Enforceability
- Distributional Concerns
  - Economic Impacts
  - Environmental Justice
- Ethics
- Sustainability



Nature of EPA Air Regulations

Total Annual Benefits and Costs of Major Federal Rules (FY 2003 – 2013 in billions in 2010 dollars)

Agency	Number of Rules	Benefits	Costs
Dept of Agriculture	4	1.0 to 1.4	1.0 to 1.4
Dept of Energy	14	11.0 to 20.1	4.7 to 7.0
Dept of Health and Human Services	18	19.6 to 45.2	2.9 to 6.2
Dept of Housing and Urban Development	1	2.8	1.1
Dept of Labor	8	8.9 to 25.8	2.7 to 6.2
Dept of Transportation	28	18.5 to 32.2	7.9 to 15.3
Environmental Protection Agency	**34**	**164.8 to 849.5**	**38.2 to 46.1**
Air	24	162 to 839.6	37.5 to 45.1
Water	4	1.1 to 4	0.4 to 0.5
Solid Waste & Emergency Response	4	0 to 0.3	(0.03) to (0.04)

Source: *2011 Report to Congress on the Costs and Benefits of Federal Regulations*

Analyses as Allowed by Statute for Standard Setting

	Benefit-Related Factors			Cost Related Factors			
	Pollution Reduction	**Health**	**Welfare**	**Technical Fesibility**	**Affordability**	**Cost-Effectiveness**	**Benefit / Cost**
Clean Air Act (CAA)							
NAAQS/primary		Yes					
NAAQS/secondary			Yes				?
Hazardous air pollution		Marginal	Marginal	Marginal	Marginal	Marginal	Marginal
Automobile engines	Limited	Limited	Limited	Limited	Limited	Limited	Limited
Fuel standards	Limited	Limited	Limited			Limited	Limited
New source standards	Yes			Yes	Yes	Yes	Yes
Clean Water Act (CWA)							
Effluent guidelines, industrial sources	Yes	Yes	Yes	Yes	Yes	Yes	?
Safe Drinking Water Act (SDWA)							
Maximum contaminant levels		Yes	Yes	Yes	Yes	Yes	Yes
Toxic Substances Control Act (TSCA)		Yes	Yes	Yes	Yes	Yes	Yes
Resouce Conservation and Recovery Act (RCRA)		Yes	Yes	Yes	?	?	?
Federal Insecticide, Fungidice and Rodenticide Act (FIFRA)		Yes	Yes		Yes	Yes	Yes

Source: Mogenstern, Richard D., ed. 1997. *Economic Analysis at EPA*. Washington, D.C.: Resources for the Future.

EPA Air Regulations Vary Widely

Attribute	Key Questions that Inform Analytics
Form of the standard	Is it an emission rate or technology standard? Are limits applied at a sub-facility or facility level? Is trading/crediting allowed? Is it differentiated along particular attributes (e.g., age, plant or unit type, fuel, location)?
Methods of compliance	Are methods of compliance clearly identified? Is it expected that methods of compliance will vary across units, firms, sectors, locations?
Regulated sources	Is regulated universe readily identified? In which sector(s) are directly affected sources? How easy is it to map regulated sources to sectors?
Unit compliance costs	Are estimates of unit compliance costs available? Is decomposition of compliance costs by input available? Are some components of costs more uncertain or not available? Are some methods of compliance expected to result in changes that are difficult to capture (process change)?
Aggregate compliance costs	What is the expected magnitude of aggregate compliance costs? How does it compare to the size of the regulated sector?
Benefits	What are the expected sources of benefits? Is there an established approach to quantifying favorable effects from emission reductions? Are there ways to monetize these effects?
Implementation	Is implementation defined directly in the regulation or are key aspects left to the states or other government entities? What is time period over which compliance occurs?

For Example, Major Differences between Rules…

Key attribute	Ozone National Ambient Air Quality Standards	Mercury and Air Toxics Standard
Form of Standard	Implemented by states resulting in differentiated local emission targets; potentially applying to any stationary, mobile or area source	National sub-facility emissions rate or output standards for power plants over 25 MWs; vary by pollutant, plant vintage, fuel type, technology, and location; work practice standards for some EGUs
Methods of Compliance	Depend on state implementation	Flexibility in method of compliance(install control technology, switch fuels, or shut down units)
Regulated Sources	Expected to affect wide array of sectors but which entities and in which sectors is uncertain	Existing EGUs generally well known
Unit Compliance Costs	Estimated for illustrative control strategy	Capital costs; operation and monitoring costs; fuel costs due to shifts in fuel mix; reporting and record-keeping costs; labor cost for work practices
Benefits	Large mortality risk reductions, also expect reductions in asthma, missed work days, ER visits; monetize visibility benefits; some morbidity, ecosystem and deposition effects not quantified	Large mortality risk reductions, also expect reductions in asthma, missed work days, ER visits; some morbidity, visibility, ecosystem, and deposition effects not quantified
Implementation	States develop implementation plans detailing approach to achieving standard; generally implemented within 5-10 years of promulgation	Federally implemented; allow 3 years for existing sources to comply; states may offer additional year

…Affect Analytical Approach

Key attribute	Ozone National Ambient Air Quality Standards	Mercury and Air Toxics Standard
Approach	Analyze **illustrative** control strategies to demonstrate how target may be met	Analyze **expected method of** compliance
Sectors affected	Many	One
Analytic Challenges	Uncertainty about baseline air quality due to longer promulgation timeline; uncertainty regarding what sectors or sources are affected, how sources will choose to comply, and future availability of control technologies. Challenge of extrapolating costs for unknown controls to bring some areas into compliance once all known technologies are applied; established methods for monetizing many major health benefits	Relatively good information on which entities will be affected, technologies available for compliance, and engineering-based cost estimates. Cost estimates based on expected method to comply but facilities may choose alternative approaches, including changing production process. Established methods for monetizing many major health benefits
Role of cost/benefit analysis	Inform the public and satisfy E.O. 12866 requirements, but cost estimates cannot be considered when setting standards	Inform policy options, inform the public, and satisfy E.O. 12866

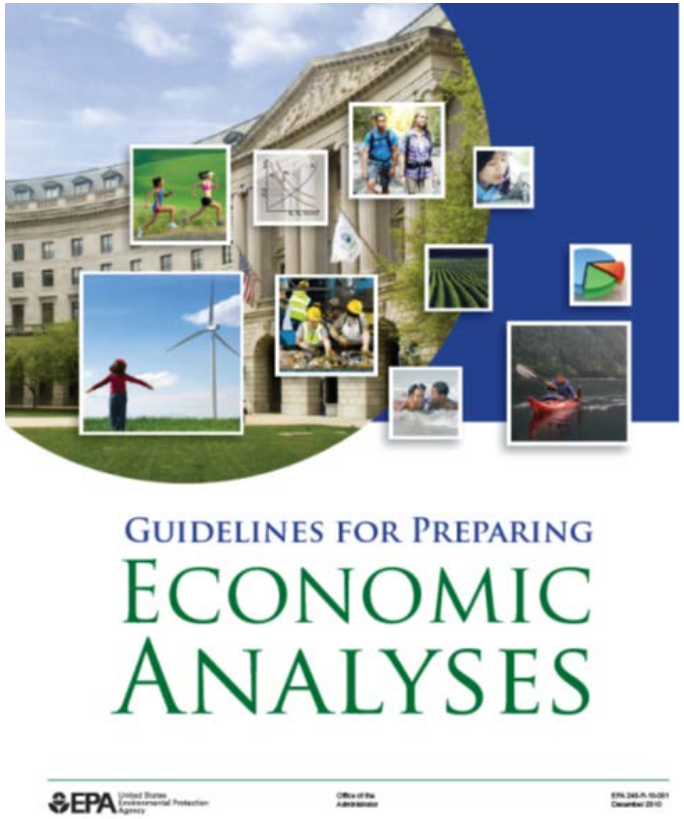
Note: Benefits and costs of NAAQS and technology standards are also non-additive: NAAQS assess hypothetical attainment many years before standards are implemented; technology-based rules implemented after the NAAQS may help ease attainment

Quick Overview of Regulatory Analytic Approaches and CGE

Estimating Economic Effects of Regulation

- Two main guidance documents on how to conduct economic analysis for major rules:
  - *Circular A-4* (OMB)
  - *Guidelines for Preparing Economic Analyses* (EPA)

- Main focus of guidance is benefit-cost and economic impact analysis
  - OMB guidance does not speak to use of CGE or other economy-wide models
  - EPA provides limited guidance on use of CGE models



EPA Economic Guidelines: Use of CGE for Estimating Economic Effects of Regulation

- EPA's Guidelines are recommendations; analysts have a lot of discretion regarding estimation approach utilized
- Use of CGE models for regulatory analysis is relatively less developed area of Guidelines
  - Only speaks to use of CGE to characterize social costs and some types of economic impacts (silent on including benefits)
  - While CGE approach is recognized as potentially useful, silent on how to determine what constitutes large number of sectors, or in which types of sectors a large change in a single market may matter
- Looking forward to SAB's response to charge as it may inform future updates

CGE models are particularly useful for "policies that have large economy-wide impacts, especially when indirect and interaction effects are expected to be significant …[and] generally more appropriate for analyzing medium- or long-term effects of policies or regulations."

"[A]s the number of affected markets grows, it becomes less and less likely that partial equilibrium analysis can provide an accurate estimate of social cost. Similarly, it may not be possible to accurately model a large change in a single regulated market using partial equilibrium analysis."

Distinction Between Benefit Cost and Economic Impact Analyses

- When examining value of proposed policy, social costs compared against social benefits in benefit-cost analysis to understand effects on <u>overall economic efficiency</u>
  - Economy-wide models, particularly CGE models, are often used to evaluate social cost. Benefits are frequently not included.

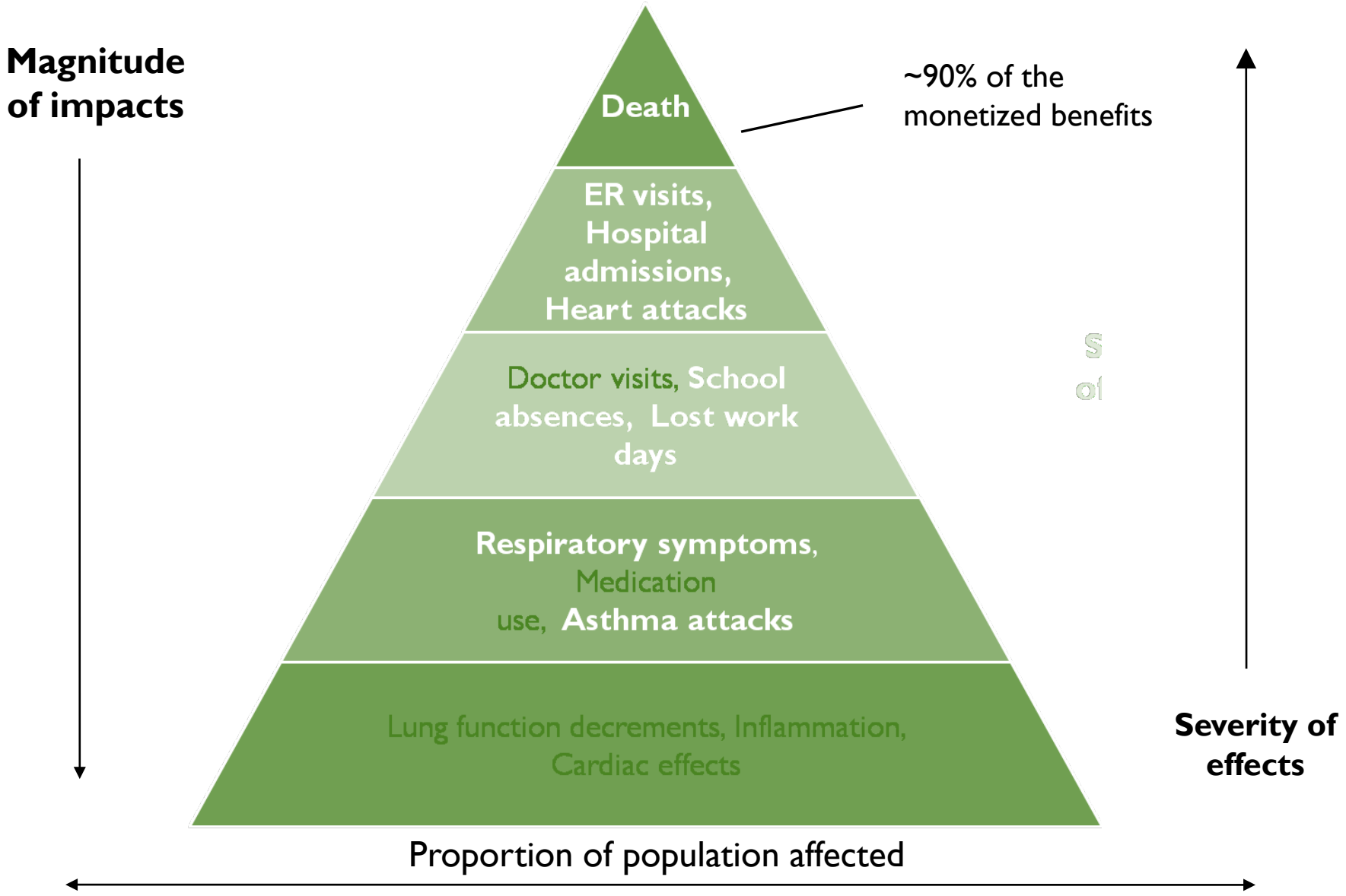
- Information on how social costs *and* benefits are distributed across households and economic sectors (who "wins" and "loses") also of interest
  - Impacts on specific sectors are generally subsumed within broader measure of social costs and benefits; transfers between economic actors netted out.
  - The degree to which economy-wide models speak to economic impacts may vary.
    - CGE models typically focus on long term implications of policy but may provide information on how costs are distributed by sector, region, or household income.

Benefit-Cost Analysis

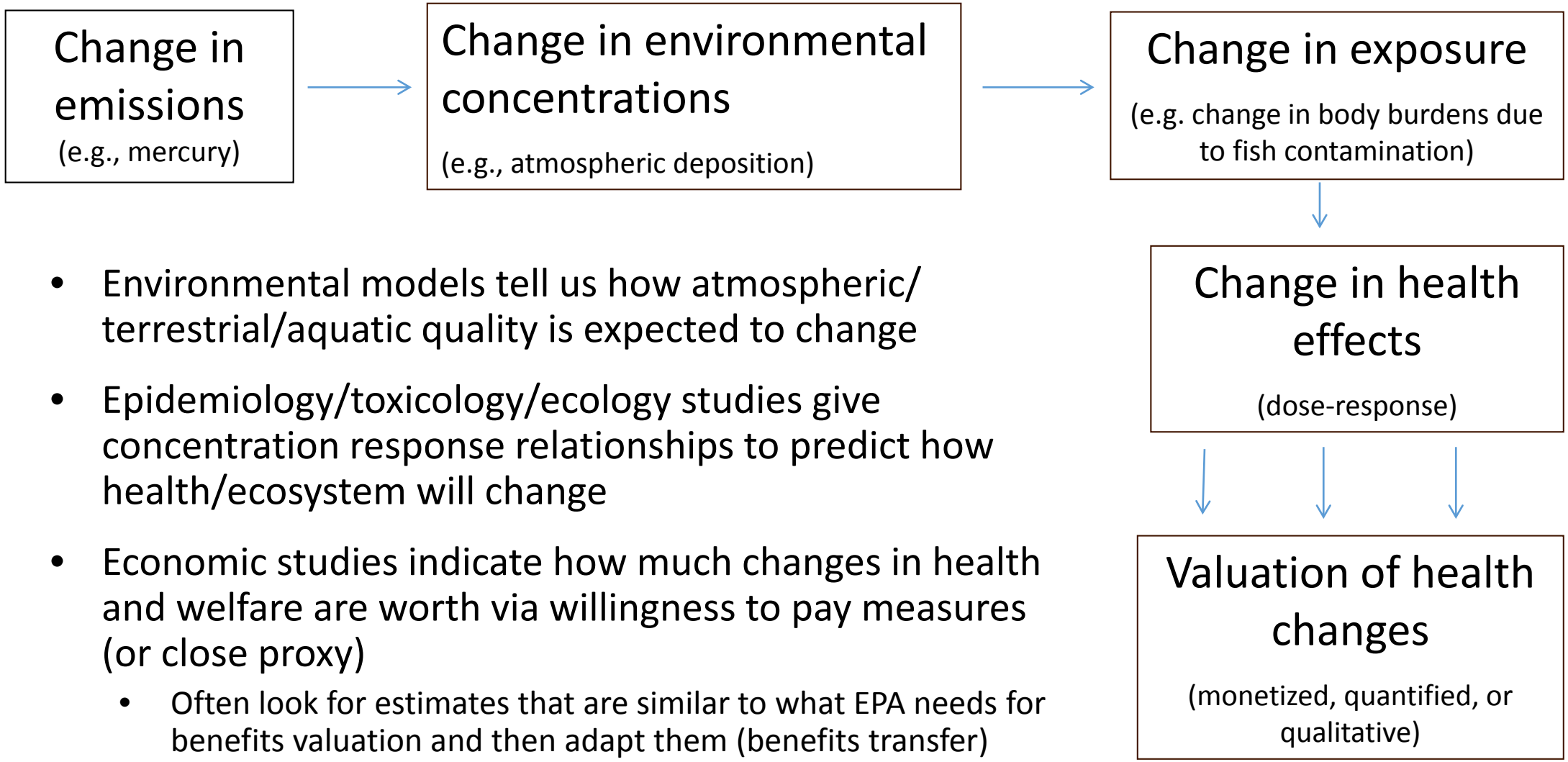
- Goal: to account as completely as possible, given time, resource and other constraints, for major benefits and costs of main regulatory alternatives

- Benefits: sum of favorable effects society gains due to a new regulation or policy
  - I.e., changes in individual well-being; willingness-to-pay measures provides full accounting of individual preferences across trade-offs between income and these benefits
- Social cost: sum of opportunity costs incurred by society because of new regulation or policy (total burden a regulation or policy will impose on the economy)
  - I.e., value of goods and services lost by society due to use of resources to comply with and implement the regulation, and from reductions in output

Health Benefits from Air Pollution



Damage Function Approach to Benefits Estimation



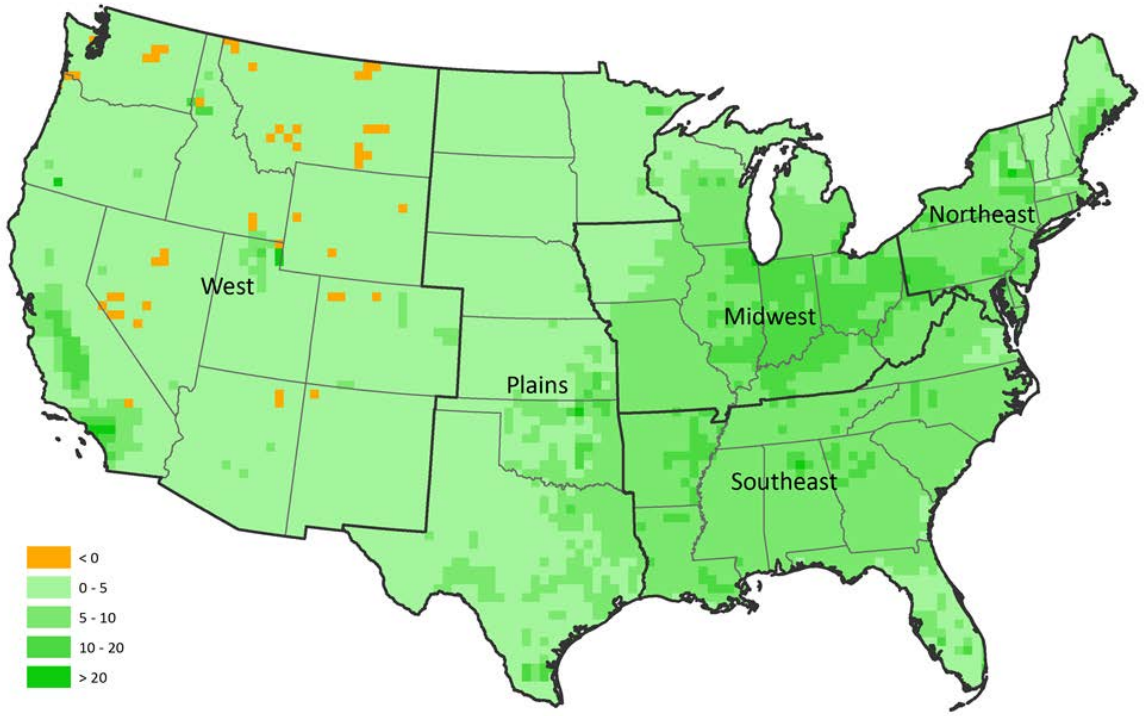
- Environmental models tell us how atmospheric/ terrestrial/aquatic quality is expected to change
- Epidemiology/toxicology/ecology studies give concentration response relationships to predict how health/ecosystem will change
- Economic studies indicate how much changes in health and welfare are worth via willingness to pay measures (or close proxy)
  - Often look for estimates that are similar to what EPA needs for benefits valuation and then adapt them (benefits transfer)

Not all benefits are easy to quantify and monetize

- Best case: well quantified, WTP estimates are well matched and recent
  - Example: Mortality risk reductions, some morbidity risk reductions
- More difficult: well quantified, proxies for WTP, e.g. cost of illness, are available
  - Example: Many morbidity risk reductions, e.g. cardiovascular hospitalizations, non-fatal heart attacks
- Most difficult: Challenges in quantifying impact, little availability of WTP proxies
  - Example 1: Reductions in mercury deposition impacting fish mercury levels and IQ in exposed children
  - Example 2: WTP for recreational fishing due to changes in lake acidification
- Additional considerations:
  - May require complex air quality modeling
  - May require complex economic modeling (e.g., agriculture and forestry)

Spatial variation also makes quantifying benefits challenging

- Regulations can have effects that differ significantly across space when:
  - Affected sources not distributed uniformly and change in emissions not uniform across sources
  - Changes in air quality not always associated with directly emitted pollutants but secondary processes depend on dispersion and transport of these pollutants
  - Ultimate impact depends on correlation between spatial distribution of air quality changes and spatial distribution of populations
- As a result, estimated impacts of air regulations often require relatively fine spatial scale
- The more spatially resolved the impact, the more difficult to value using existing regional or national scale information



Predicted change in 2020 $PM_{2.5}$ concentrations

Source: EPA CAA Prospective Study (2011)

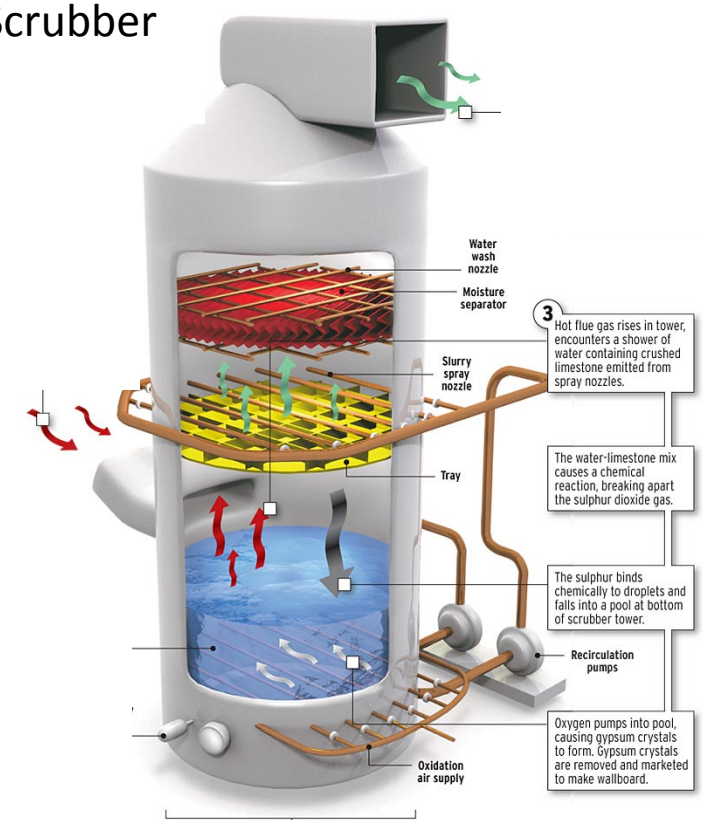
Example: Monetized Health Benefits for a NAAQS

Health Endpoint	Alternative 1	Alternative 2	Alternative 3
Premature deaths avoided	66 to 170	320 to 810	3,900 to 10,000
Other health effects avoided			
Non-fatal heart attacks	9 to 79	40 to 350	520 to 4,400
Respiratory and cardiovascular hospital admissions	51	230	3,100
Emergency room visits	36	220	2,800
Acute bronchitis	100	580	6,500
Lower and upper respiratory symptoms	2,300	13,000	150,000
Minor restricted activity days	18,000	310,000	3,400,000
Work loss days	8,600	52,000	580,000
Asthma exacerbation	1,900	11,000	290,000
Total Monetized Health Benefits (3% discount rate)	**$540 to $1,400 million**	**$2.6 to $6.6 billion**	**$32 to $82 billion**
Total Monetized Health Benefits (7% discount rate)	**$490 to $1,300 million**	**$2.3 to $6 billion**	**$29 to $74 billion**

Abatement Cost Estimation

- Engineering or model plant costs
  - Purchase, installation, operation, and maintenance of equipment; productivity changes; changing inputs; waste management
- EPA Air Pollution Control Cost Manual:
  - Engineering costs to build/install and operate many types of add-on controls (e.g., incinerators, baghouse, condensers)
- CoST (Software for Control Strategy and Cost Analysis):
  - Estimates emissions reductions and costs associated with future year National Ambient Air Quality Standards (NAAQS) emission control strategies for point (primarily non-EGU), area, and mobile sources of target pollutant
  - Also, useful for examining co-impacts on other criteria pollutants

Scrubber



Social Cost Estimation

- Social cost is a broader economic concept than just what it costs in terms of operating and capital costs to comply with an air regulation

- Social cost is the total burden a regulation imposes on the economy;
- It is the sum of all opportunity costs incurred as a result of regulation
  - Both opportunity cost of current consumption foregone as a result of regulation, and also loss if regulation reduces capital investment and thus future consumption.
  - (Opportunity cost is value lost to society of all goods and services that will not be produced and consumed if firms comply with the regulation and reallocate resources away from production activities toward pollution abatement)

Social Cost Estimation

- Choose model(s) to match most salient aspects of expected effects
- Depending on magnitude of costs and/or benefits and length of time for rule implementation may use one or more modeling approach:
  - Engineering or model plant, single-sector market (e.g., partial equilibrium), and/or multi-sector modeling approach (e.g., computable general equilibrium)
  - Abatement cost estimates possible inputs into partial and general equilibrium models
- Engineering, model plant approaches used when only a few directly regulated sectors expected to be affected with minimal effects on price or quantity
- Detailed partial equilibrium industry models used (when available) when impacts limited to few sectors but behavioral changes may result in price and quantity, quality, product mix, or productivity changes
- When changes in behavior expected to result in price and quantity effects in many markets may use CGE models to estimate consumer and producer surplus changes
- Partial and general equilibrium modeling approaches can be combined by linking CGE to detailed sector model but raises additional challenges and complications

Example: Social Cost Analysis for NAAQS

Abatement Cost

- For counties that exceed proposed standard, identify and apply control measures using CoST to estimate costs
- For example,
  - Dry and wet electrostatic precipitators applied to stationary sources in iron & steel, mineral products, industrial boilers, cement, chemical manufacturing
  - Wet scrubbers applied to stationary sources in industrial boilers, coke manufacturing, cement, petroleum refining
  - Area source controls such as fireplace inserts or low-sulfur home heating oil
  - Mobile source controls such as diesel retrofits and continuous inspection & maintenance for on-road vehicles

Social Cost

- Depends on scope of projected nonattainment (# of counties, degree of exceedance) and magnitude of annualized costs
  - Limited nonattainment – costs allocated by industry, limited economic analysis
  - Extensive nonattainment – more extensive economic analysis; CGE model occasionally used in the past
- When known control measures do not reduce emission enough to attain the proposed standard, extrapolate
  - These additional emission reductions and costs are not tied to specific technologies; therefore not distributed by industry
  - Social cost analyses have not included extrapolated costs

Economic Impact Analysis

- Complements benefit-cost analysis by examining who gains and who loses from a regulation, and by how much?
- Provides information to decision-maker and public about who will be affected by policy
  - Certain groups, industries or types of businesses may warrant special consideration due to cost burden
  - Knowing who is affected by a policy action is essential for determining when such consideration should be granted
- May include:
  - Geographic distribution of effects
  - Environmental justice (income and demographic distribution)
  - Effects on small businesses
  - Effects on employment
  - Effects on tax revenues
  - Energy price effects, etc.

Example: Employment Analysis

- Theory does not predict regulation's net impact on labor demand for regulated firms
  - Output effect: By affecting marginal cost of production, regulation affects profit-maximizing quantity of output. All else equal, a decrease in output decreases labor demand
  - Substitution effect: "end of pipe" pollution control technology may require more workers, while changes to the production process may require fewer workers to produce a given output quantity
  - Sum of two effects = net employment impact to a <u>regulated industry</u> but sign is ambiguous
- EPA estimates employment impacts directly related to compliance requirements based on bottom-up assessment of labor requirements for one or more of these effects:
  - Estimated employment effects directly related to compliance requirements:
    - E.g., Associated with construction and installation of new control equipment, and with monitoring, testing, and recordkeeping requirements
  - Employment effects in environmental protection sector
  - May also examine employment effects in key related economic sectors
    - E.g., effects on coal-mining employment based on change in coal demand from electricity sector model
- To-date, EPA has not attempted to estimate net effects on overall U.S. employment from an individual air regulation
  - No estimated effects on labor productivity and/or supply, or of economy-wide employment effects

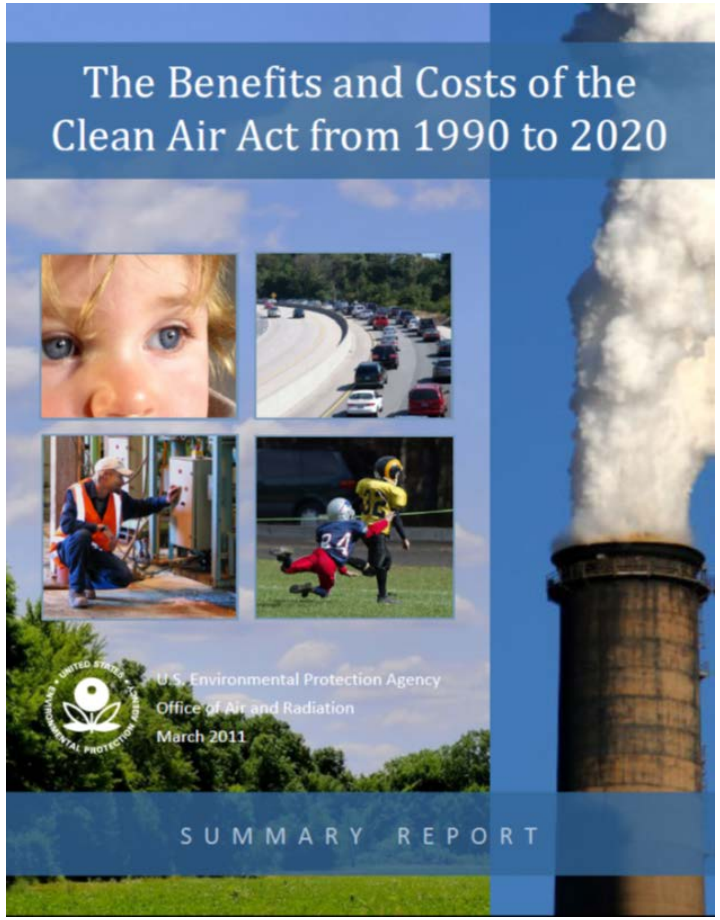
Examples Where CGE Models Have Been Used

Economy-Wide Approaches at EPA

- CGE models have been valuable tools in some EPA applications and may be useful in the future, but there are challenges to using them in regulatory context (e.g., lack of benefits in most cases)
  - Have been used by EPA to analyze large-scale policies (Clean Air Act, proposed climate legislation) but are less common when analyzing individual regulations
- Other economy wide modeling approaches are used even less by EPA and bring their own set of technical challenges
  - May not characterize changes in economic welfare (e.g., macro-econometric model)
  - Potentially useful for evaluating other effects such as short run impacts?
- Even when economy wide models are otherwise used appropriately, possible to misuse their outputs (e.g., effects on overall employment)

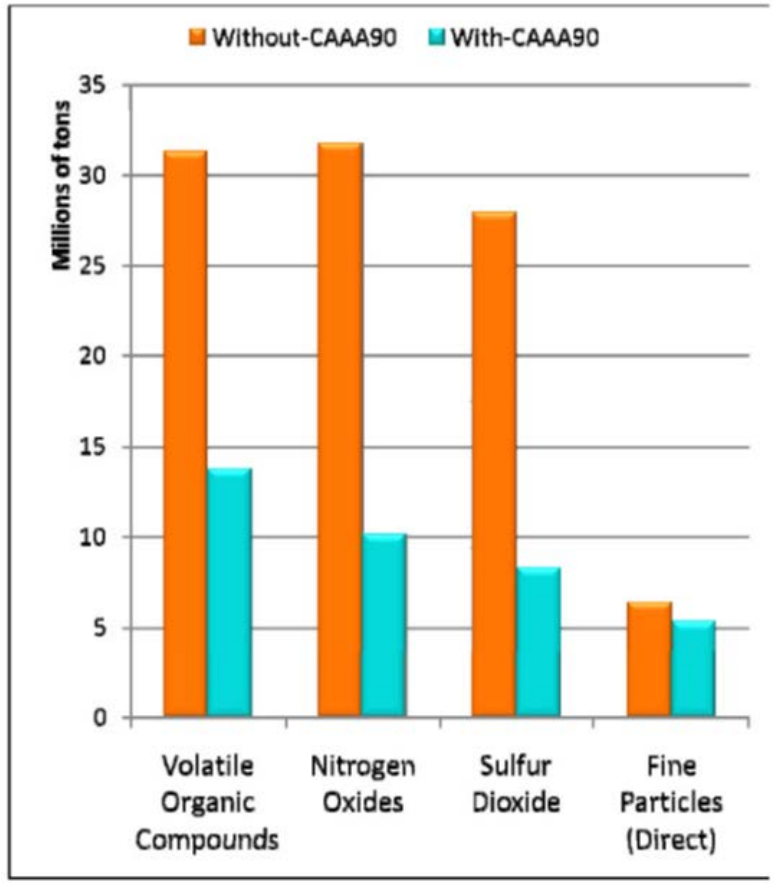
Prospective Analysis of Economy-Wide Impacts of the Clean Air Act

- Retrospective (1997) and prospective (2011) analyses of benefits and costs of the <u>entire</u> Clean Air Act (not just specific regulations)
  - Use CGE models to examine economy-wide effects
- In prospective study, reductions in premature mortality and morbidity-related work-loss days improve labor productivity in CGE model
  - Resources no longer spent on health care for air pollution-related illnesses returned to the economy
- For more information, see: http://www.epa.gov/cleanairactbenefits/prospective2.html

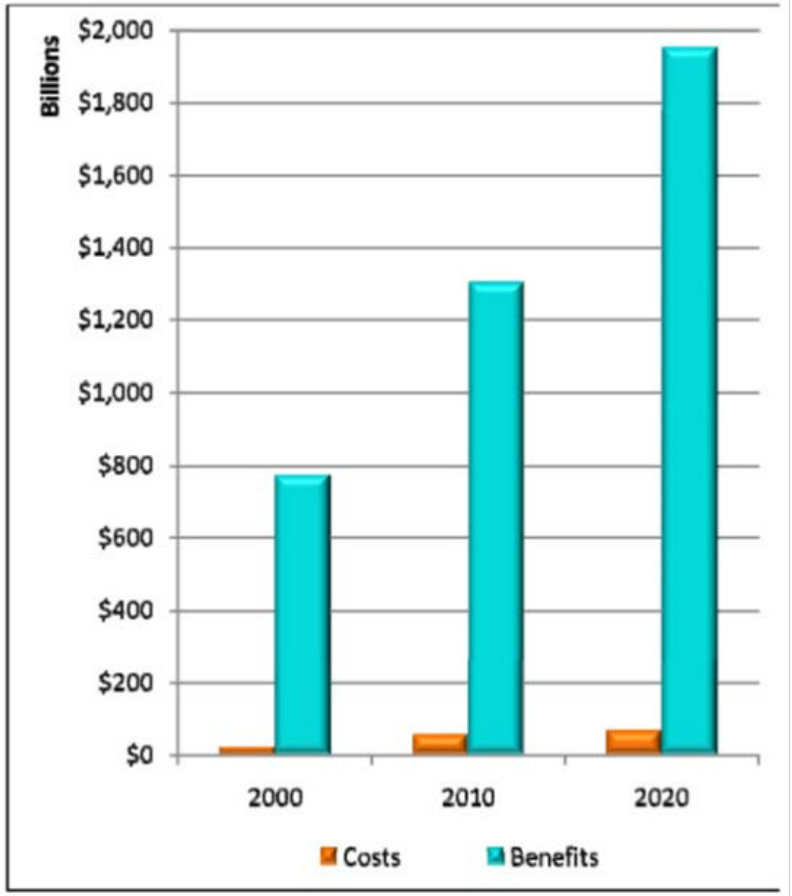


Prospective Study: 1990 - 2020

Forecast Emissions - 2020

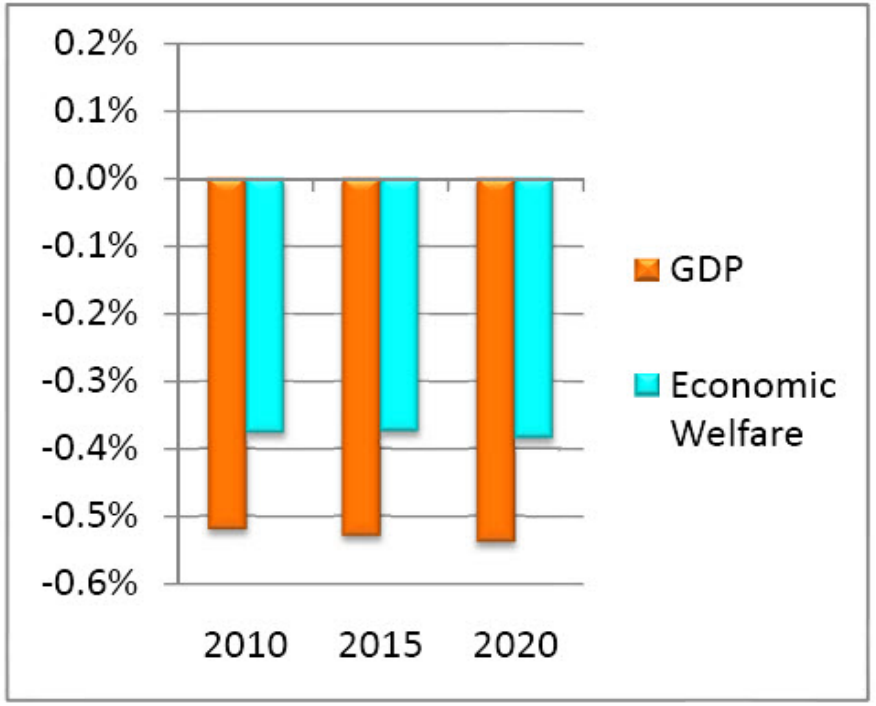


Benefits and Costs

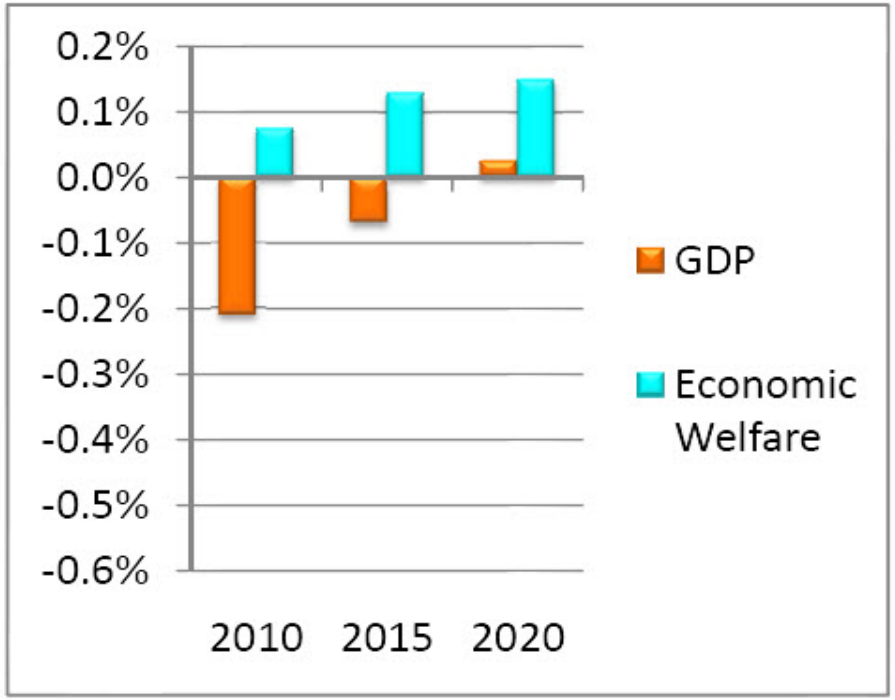


Prospective Study: 1990 - 2020

Without Health Benefits



With Health Benefits



- When a subset of CAA benefits are included in the CGE model, economic welfare measures are positive (even when initial impact on GDP is negative)

EPA Analysis of Proposed Climate Legislation

- CGE models often used by EPA to analyze social costs of proposed climate legislation
  - While a relatively large policy change, predict a modest impact (average annual household consumption declines by 0.1 - 0.2% for APA)
  - Many EPA regulations more targeted and result in smaller aggregate compliance costs than predicted for climate legislation.

- CGE models are designed with economic instrument in mind
  - Proposed climate legislation is based on cap-and-trade, though some specifics of are still very complicated
  - Most EPA regulations do not operate through price

- For more information, see: http://www.epa.gov/climatechange/EPAactivities/economics/legislativeanalyses.html

CGE Models in EPA Regulatory Analyses

- CGE models used for a few large regulations
- Used for analysis of social costs only
  - Sometimes linked to electricity sector model
- Challenging to represent a regulation in a CGE model
  - Typically emission-rate and/or technology-based standards
  - Unlike taxes, does not simply introduce wedge between unregulated and regulated market price; often treated as a negative productivity shock for affected firms
  - Difficult to adequately represent some compliance options and costs (e.g., extrapolated costs in NAAQS regulations)
- EPA analyses to-date have found that:
  - Effects of regulation are often quite small in terms of changes in household consumption or industry output
  - Social cost estimates are sometimes higher, sometimes lower than partial equilibrium estimate
- Outside organizations are using CGE models to analyze EPA air regulations, too
  - Key challenge has been how to evaluate and interpret analyses from others

Thank You