Chapter 11

Presentation of Analysis and Results

This chapter provides some general guidance for presenting analytical results to policy makers and others interested in environmental policy development. Economic analyses play an important role throughout the policy development process. From the initial, preliminary evaluation of potential options through the preparation of a final economic analysis document, economic analysts participate in an interactive process with policy makers. The fundamental goal of this process is to collect, analyze, and present information useful for policy makers.

Economic analysis is often motivated by a desire to find an optimal outcome, such as a degree of stringency in a regulation, or a level of provision of a public good that yields the largest possible net benefits. Environmental statutes sometimes mandate criteria other than economic efficiency, such as best available control technology or lowest achievable emission rate. Policy makers rely on quantitative analysis to promulgate these approaches. In particular they rely on analyses that delineate the costs, benefits, or other impacts of a wide range of control options.

This guidance for presenting inputs, analyses, and results applies at *all* stages of this process, not only for the final document embodying the completed economic analysis. Conveying uncertainty effectively and reporting critical assumptions and key unquantified effects to decision makers is critical at all points in the policy-making process.

This chapter begins by providing general guidance on how to present the results of economic analyses, with a particular emphasis on presenting benefits and costs, including those that cannot be quantified and/or put into dollar terms. The chapter then discusses the components, or inputs, of an economic analysis, and how their effect on the economic analysis can best be communicated.

11.1 Presenting Results of Economic Analyses

The presentation of the results of an economic analysis should be thorough and transparent. The reader should be able to understand:

- What the primary conclusions of the economic analysis are;
- How the benefits and costs were estimated;
- What the important non-quantified or non-monetized effects are;
- What key assumptions were made for the analysis;
- What the primary sources of uncertainty are in the analysis; and
- How those sources of uncertainty affect the results.

An economic analysis of regulatory or policy options should present all identifiable costs and benefits that are incremental to the regulation or policy under consideration. These should include directly intended effects and associated costs, as well as ancillary (or co-) benefits and costs.

Benefits and costs should be reported in monetary terms whenever possible. In reality, however, there are often effects that cannot be monetized, and the analysis needs to communicate the full richness of benefit and cost information beyond what can be put in dollar terms. Benefits and costs that cannot be monetized should, if possible, be quantified (e.g., expected number of adverse health effects avoided). Benefits and costs that cannot be quantified should be presented qualitatively (e.g., directional impacts on relevant variables). Section 11.1.2 contains more detailed guidance on presenting this information in EPA's economic analyses.

Agencies are also required to provide OMB with an accounting statement reporting benefit and cost estimates when sending over each economically significant rule. Analysts should rely upon these *Guidelines* and *Circular A-4* for developing these estimates. *Circular A-4* describes the accounting statement on pages 44-46 and contains a suggested format for this accounting statement.[1]

In addition to requirements under *Circular A-4*, the 2010 OMB *Annual Report to Congress on the Costs and Benefits of Federal Regulations* asks agencies to provide a "simple, clear table of aggregated costs and benefits" of each economically significant rule in the regulatory Preamble of the Federal Register Notice and in the Executive Summary of the RIA (OMB 2010a, p. 51). EPA's guidance for satisfying these criteria is described more fully in Section 11.1.2 as part of the Agency's general guidance on reporting the results of benefit-cost analysis (BCA).

The results of economic analyses of environmental policies should generally be presented in three sections.

- **Results from BCA.** Estimates of the net social benefits should be presented based on the benefits and costs expressed in monetary terms. Non-monetized and unquantifiable benefits and costs should also be included and described in the presentation.
- **Results from cost-effectiveness analysis (CEA).** Under OMB *Circular A-4*, CEA should generally be performed for rules in which the primary effect is human health or safety. Results of these analyses should also be presented when they are conducted.[2]
- **Results from economic impact analysis (EIA) and distributional assessments.** Results of the EIA should be reported, including predicted effects on prices, profits, plant closures, employment, and any other effects. Distributional impacts for particular groups of concern, including small entities, governments, and environmental justice populations should also be presented.

The relative importance of these three sections will depend on the policy and statutory context of the analysis.

11.1.1 Presenting the Results of Benefit-Cost Analyses

When presenting the results of a BCA, the expected benefits and costs of the preferred regulatory option should be reported, together with the expected benefits and costs of alternative approaches. OMB's *Circular A-4* requires that at least one alternative be more stringent and one less stringent than the preferred option, and the incremental costs and benefits would be reported for each increasingly stringent option. Separate time streams of benefits and costs should be reported, in constant (inflation-adjusted), undiscounted dollars. Per the discussion in

1 The accounting statement is on page 47 of *Circular A-4*, available at www.whitehouse.gov/sites/default/files/omb/assets/omb/circulars/a004/a-4.pdf (accessed on January 21, 2011).

2 The Institute of Medicine (IOM) (2006) recently issued recommendations to regulatory agencies on how to perform health-based CEA. Recent examples of CEA can be found in appendices of several recent RIAs including those for PM NAAQS [see Appendix G listed at http://www.epa.gov/ttn/ecas/ria.html (accessed March 13, 2011)] and the Ground Water Rule [see Appendix H listed at http://www.epa.gov/safewater/disinfection/gwr/regulation.html (accessed March 13, 2011)].

Chapter 6, appropriately discounted benefits and costs should be reported as well.

Ideally, all benefits and costs of a regulation would be expressed in monetary terms, but this is almost never possible because of data gaps, unquantifiable uncertainties, and other challenges. It is important not to exclude an important benefit or cost category from BCA even if it cannot be placed in dollar terms. Instead, such benefits and costs should be expressed quantitatively if possible (e.g., avoided adverse health impacts). If important benefit or cost categories cannot be expressed quantitatively, they should be discussed qualitatively (e.g., a regulation's effect on technological innovation).

Quantifiable benefits and costs, properly discounted, should be compared to determine a regulation's net benefits, even if important benefits or costs cannot be monetized. However, an economic analysis should assess the likelihood that non-monetized benefits and costs would materially alter the net benefit calculation for a given regulation.

Incremental benefits, costs, and net benefits of moving from less to more stringent regulatory alternatives should also be presented. If a regulation has particularly significant impacts on certain groups or sub-populations, the various options' incremental impacts on these subpopulations or source categories should be reported. This should include a discussion of incremental changes in quantified and qualitatively described benefits and costs.

Given the number of potential models presented in Chapters 7 and 8, the analyst should take care to clearly indicate the correspondence between the benefit and cost estimates. For example, the cost analysis may include results from a general equilibrium model but the benefit analysis may only include partial equilibrium effects.[3] In this case, the cost side of the equation includes general equilibrium feedback effects while the benefit side does not. This difference should be clearly presented and explained.

The tables at the end of this chapter contain templates for presenting information on regulatory benefits and costs, including those benefits that cannot be quantified or put into dollar terms. The analyst's primary goal, using these tables, is to communicate the full richness of benefit and cost information instead of focusing narrowly on what can be put in dollar terms. Some guiding principles for constructing these tables follow.

- *All meaningful benefit and costs are included in all of the tables* even if they cannot be quantified or monetized. Not only does this provide consistency for the reader, but it also maintains important information on the context of the quantified and monetized benefits.
- *The types of benefits and costs are described briefly in plain terms* to make them clearer to the public and to decision makers, and they should be well-defined and mutually exclusive, to the extent possible. Benefits should be grouped a manner consistent with the categories in Table 7.1 of Chapter 7, although the order and specific characterization can be expected to vary by rule as needed.
- *The benefits are expressed first in natural or physical units* (i.e., number) to provide a more complete picture of what the rule accomplishes. These units are not discounted as they would be in a CEA because the goal here is to describe what might be termed the "physical scope" of the rule's benefits. It may be the case that physical or natural units are not relevant for presenting costs.
- *Explanatory notes accompany each benefit and cost entry* and can be used to describe whatever the most salient or important points are about scientific uncertainty, the type of benefit or cost, how it is estimated, or the presentation.

The benefit categories in these templates (e.g., improved human health, improved environment, and other benefits,) will need to be revised to reflect the benefits categories for the rule under

3 While there have been some attempts to include benefit estimates in general equilibrium models, these efforts are nascent (Sieg et al. 2004, Yang et al. 2004, and Jena et al. 2008).

Table 11.1 - Template for Regulatory Benefits Checklist

Overview of Benefits			
Benefits	**Effect can be Quantified?** (put in numeric terms)	**Effect can be Monetized?** (put in dollar terms)	**More Information** (e.g., reference to section of the economic analysis)
Improved Human Health			
• **Reduced incidence of adult premature mortality** from exposure to $PM_{2.5}$	√	√	e.g., see Section 5.2 of the economic analysis
• **Reduced incidence of fetal loss** from reduced exposure to disinfection byproducts	√	--	*Notes and reference to section of the economic analysis*
• ***Unquantified human health benefit*** *with a brief description*	--	--	*Notes and reference*
Improved Environment			
• **Fewer fish killed** from reduced nutrient loadings into waterways	√	√	*Notes and reference*
• **Improved timber harvest** from lower tropospheric ozone concentrations	√	√	*Notes and reference*
• ***Other environmental benefit*** *with a brief description*	--	--	*Notes and reference*
Other Benefits			
• **Fuel savings** from improved efficiency in automobiles and light trucks	√	√	*Notes and reference*
• ***Other benefit*** *with a brief description*	--	--	*Notes and reference*

consideration. Simpler analyses may need only the overview (Table 11.1) and the final summary (Table 11.4).

Table 11.1 is a quick-glance summary of regulatory benefits and costs, the extent to which they could be quantified and monetized, and a reference to where they are more fully characterized or estimated in the economic analysis. Some benefits may be described only qualitatively.

Table 11.2 reports benefits in non-monetary terms along with the units and additional explanatory notes. The goal of this table is to communicate the physical scope of the regulation's benefits and costs rather than the dollar equivalent. Benefits here do not need to be discounted to present value, but the time associated with the quantities should be made clear (e.g., "annual" or "more than ten years").

Table 11.3 reports benefits in monetary terms along with a total for dollar-valued benefits. Here it is important to specify the reference year for the dollars (i.e., real terms), the discount rate(s) used, and the unit value and/or source.

Table 11.4 contains a template for bringing all this information together in summary that includes the type of benefit or cost, how it is measured, its quantity, and dollar benefits. When multiple regulatory options are included in this table, it is appropriate for including in the regulatory preamble as requested by OMB.

Consistent with recommendations in these *Guidelines* for communicating uncertainty, quantitative entries should generally include a central or best estimate in addition to a range or confidence interval. The ability to do this, of course, may be limited by data availability.

11.1.2 Presenting the Results of Cost-Effectiveness Analyses

When BCA is not possible, CEA may be the best available option. The cost-effectiveness of a policy

Table 11.2 - Template for Quantified Regulatory Benefits

Quantified Benefits			
Benefits	**Quantified Benefits** (confidence interval or range)	**Units**	**More Information** *(w/possible reference to section of the economic analysis)*
Improved Human Health			
• **Reduced incidence of adult premature mortality** from exposure to $PM_{2.5}$	estimate *(range)*	expected avoided expected premature deaths per year	e.g., range represents confidence interval
• **Reduced incidence of fetal loss** from reduced exposure to disinfection byproducts	estimate *(range)*	expected avoided fetal losses per year	e.g., confidence interval cannot be estimated. Range based on alternative studies
• ***Unquantified human health benefit*** *with a brief description*	*	*	e.g., data do not allow for quantification
Improved Environment			
• **Fewer fish killed** from reduced nutrient loadings into waterways	estimate *(range)*	thousands of fish per year	Notes *(reference)*
• **Improved timber harvest** from lower tropospheric ozone concentrations	estimate *(range)*	thousands of board feet per year	Notes *(reference)*
• ***Other environmental benefit*** *with a brief description*	*	*	Notes *(reference)*
Other Benefits			
• **Fuel savings** from improved efficiency in automobiles and light trucks	estimate *(range)*	millions of gallons of gasoline reduced per year	Notes *(reference)*
• ***Other benefit*** *with a brief description*	*	*	Notes *(reference)*

Note: * indicates the benefit cannot be quantified with available information

option is calculated by dividing the annualized cost of the option by non-monetary benefit measures. Options for such measures range from quantities of pollutant emissions reduced, measured in physical terms, to a specific improvement in human health or the environment, measured in reductions in illnesses or changes in ecological services rendered.

In the context of RIA, or other analyses of specific regulatory or policy options, CEA is most informative when several different options are analyzed. The analysis should include at least one option that is less stringent and at least one option that is more stringent than the preferred option. The incremental costs and non-monetary benefit yield of each option, in order of increasing stringency, should be reported.

The non-monetary measure of benefits used in a CEA must be chosen with great care to facilitate valid comparisons across options. The closer the chosen measure is to the variable that directly impacts social welfare, the more robust a CEA will be. Consider the following steps that a typical environmental economic assessment follows:

- Changes in emissions are estimated (e.g., tons of emissions); then

Table 11.3 - Template for Dollar-Valued Regulatory Benefits

Dollar-Valued Benefits			
Benefit	**Dollar Benefits** (millions per year)	**Basis of Value**	**More Information** *(w/possible reference)*
Improved Human Health			
• **Reduced incidence of adult premature mortality** from exposure to $PM_{2.5}$	$ estimate *($ range)*	e.g., $X based on Agency guidance	Notes *(reference)*
• **Reduced incidence of fetal loss** from reduced exposure to disinfection byproducts	*	Not available	Notes *(reference)*
• ***Unquantified human health benefit*** *with a brief description*	*	*	e.g., data insufficient to quantify (reference)
Improved Environment			
• **Fewer fish killed** from reduced nutrient loadings into waterways	$ estimate *($ range)*	e.g., $X based on WTP for recreational fishing	e.g., range reflects two different valuation approaches *(reference)*
• **Improved timber harvest** from lower tropospheric ozone concentrations	$ estimate *($ range)*	e.g., change in consumer and producer surplus	e.g., estimated from market model across several species *(reference)*
• ***Other environmental benefit*** *with a brief description*	*	*	Notes *(reference)*
Other Benefits			
• **Fuel savings** from improved efficiency in automobiles and light trucks	$ estimate *($ range)*	e.g., $X, based on net-of-tax average per gallon price	e.g., there is debate on how well fuel savings represent consumer benefits *(reference)*
• ***Other benefit*** *with a brief description*	*	*Not available*	Notes *(reference)*
TOTAL Benefits that can be monetized ($millions per year)	**$ estimate** *($ range)*		

Note: * indicates the benefit cannot be quantified with available information.

- Changes in environmental quality (e.g., changes in ambient concentrations of a given air pollutant) are estimated; then
- Changes in human health or welfare (e.g., changes in illness or visibility) are estimated.

Each successive step in this sequence yields a better measure for CEA.

To illustrate, consider a typical air pollution scenario. Depending on where and when air pollutants are released into the atmosphere, a given ton of a particular pollutant can have widely divergent impacts on ambient air quality. Similarly, depending on when and where air quality changes, widely different levels of human health impacts may result. Particularly when different regulatory approaches are under consideration (e.g., regulation of different source categories in different locations), failing to standardize the analyses on the benefit measure that directly affects human health or welfare will significantly reduce

Table 11.4 - Template for Summary of Benefits and Costs

Benefits Notes: e.g., "annual average numbers; 2006 dollars annualized at 3% discount rate" Best estimate, with range							
	Option 1		Proposed Option		Option 3		***Source, limitations, or other key notes***
	Number	***$ Millions***	***Number***	***$ Millions***	***Number***	***$ Millions***	
Improved Human Health							
• **Reduced incidence of adult premature mortality** from exposure to $PM_{2.5}$	estimate *(range)*	$ estimate *(range)*	estimate *(range)*	$ estimate *(range)*	estimate *(range)*	$ estimate *(range)*	*highlight most important points, as needed*
• **Reduced incidence of fetal loss** from reduced exposure to disinfection byproducts	estimate *(range)*	*	estimate *(range)*	*	estimate *(range)*	*	e.g., no valuation data exist. Effects are sensitive to dose-response model.
• ***Unquantified human health benefit*** *with a brief description*	*	*	*	*	*	*	e.g., risk data insufficient for quantification
Improved Environment							
• **Fewer fish killed** from reduced nutrient loadings into waterways	estimate *(range)*	$ estimate *(range)*	estimate *(range)*	$ estimate *(range)*	estimate *(range)*	$ estimate *(range)*	*Notes*
• **Improved timber harvest** from lower tropospheric ozone concentrations	estimate *(range)*	$ estimate *(range)*	estimate *(range)*	$ estimate *(range)*	estimate *(range)*	$ estimate *(range)*	*Notes*
• ***Other environmental benefit*** *with a brief description*	*	*	*	*	*	*	*Notes*
Other Benefits							
• **Fuel savings** from improved efficiency in automobiles and light trucks	estimate *(range)*	$ estimate *(range)*	estimate *(range)*	$ estimate *(range)*	estimate *(range)*	$ estimate *(range)*	*Notes*
• ***Other benefit*** *with a brief description*	*	*	*	*	*	*	*Notes*
TOTAL Benefits that can be monetized *(annualized, millions $2006)*	**$ estimate** *(range)*		**$ estimate** *(range)*		**$ estimate** *(range)*		e.g., total range may be overstated because of aggregation *(See Section 8.1 of economic analysis)*

Note: * indicates the benefit cannot be quantified with available information.

Table 11.4 - Template for Summary of Benefits and Costs (continued)

Costs 2006 dollars annualized at 3% discount rate Best estimate, with range				
	Option 1	Proposed Option	Option 3	***Source, limitations, or other key notes***
	$ Millions	***$ Millions***	***$ Millions***	
• **Initial capital costs** *with any brief description and units.*	$ estimate *(range)*	$ estimate *(range)*	$ estimate *(range)*	*e.g., estimated from engineering cost models*
• **Type of cost** *with a brief description and units.* (This could include non-monetized costs.)	$ estimate *(range)*	$ estimate *(range)*	$ estimate *(range)*	*Notes*
• **Type of cost** *with a brief description and units.* (This could include non-monetized costs.)	$ estimate *(range)*	$ estimate *(range)*	$ estimate *(range)*	*Notes*
TOTAL Costs that can be monetized *(annualized, millions $2006)*	**$ estimate** *(range)*	**$ estimate** *(range)*	**$ estimate** *(range)*	
TOTAL Net Benefits that can be monetized *(annualized, millions $2006)*	**$ estimate *(range)***	**$ estimate *(range)***	**$ estimate *(range)***	

the value of the analysis to decision makers (and the public).

When presenting the results of a CEA, the rationale for the selection of the non-monetary benefit measure must be described in detail. The presentation of results should also include a discussion of the limitations of the analysis, especially if an inferior measure, such as cost per ton of pollutant, must be used.

CEA is most useful when the policy or regulation in question affects a single endpoint. When multiple endpoints are affected (e.g., cancer and kidney failures), combining endpoints into a single effectiveness measure is impossible unless appropriate weighting factors exist for the multiple endpoints. The theoretically correct weights to apply are the dollar values associated with each endpoint, but generally it is the absence of these values that necessitates CEA. Therefore, it is not possible to compare a policy or regulation that reduces relatively more expected cancers, but fewer expected cases of kidney failure, with one that has the opposite relative effects. When this occurs, the effects of each option for each endpoint should be reported. A single endpoint may be selected for calculating cost-effectiveness, while other endpoints can be listed as ancillary benefits (or, if possible, their monetary value should be subtracted from the option's cost prior to calculating its cost-effectiveness) (OMB 2003).

The most cost-effective option — i.e., the option with the lowest cost per unit of benefit — is not necessarily the most economically efficient. Moreover, other criteria, such as statutory requirements, enforcement problems, technological feasibility, or quantity and location of total emissions abated may preclude selecting the least-cost solution in a regulatory decision. However, where not prohibited by statute, CEA can indicate which control measures or policies are inferior options.

11.1.3 Presenting the Results of EIA and Distributional Analyses

EIA and distributional outcomes focus on disaggregating effects to show impacts separately for the groups and sectors of interest. If costs and/or benefits vary significantly among the sectors affected by the policy, then both costs and benefits should be shown separately for the different sectors. Presenting results in disaggregated form will provide important information to policy makers that may help them tailor the rule to improve its efficiency and distributional outcomes.

The results of the EIA should also be reported for important sectors within the affected population — identifying specific segments of industries, regions of the country, or types of firms that may experience significant impacts or plant closures and losses in employment.

Reporting the results in distributional assessments may include the expected allocation of benefits, costs, or both for specific subpopulations including those highlighted in the various mandates. These include minorities, low-income populations, small businesses, governments, not-for-profit organizations, and sensitive and vulnerable populations (including children). Where these mandates specify requirements that depend on the outcomes of the distributional analyses, such as the Regulatory Flexibility Act, the presentation of the results should conform to the criteria specified by the mandate.

11.1.4 Reporting the Effects of Uncertainty on Results of Economic Analyses

Estimates of costs, benefits and other economic impacts should be accompanied by indications of the most important sources of uncertainty embodied in the estimates, and, if possible, a quantitative assessment of their importance. OMB requires formal quantitative analysis of uncertainties for rules with annual economic effects of $1 billion or more.

In economic analysis, uncertainty encompasses two different concepts:

- Statistical variability of key parameters; and
- Incomplete understanding of important relationships.

Economic analyses of environmental policies and regulatory options will frequently have to accommodate both concepts. The importance of statistical variability is commonly assessed using Monte Carlo analyses (see U.S. EPA 1997). Delphic panels, or expert elicitation techniques, can help close knowledge gaps surrounding key relationships (see IEc 2004).

Ideally, an economic analysis would present results in the form of probability distributions that reflect the cumulative impact of all underlying sources of uncertainty. When this is impossible, due to time or resource constraints, results should be qualified with descriptions of major sources of uncertainty. If at all possible, information about the underlying probability distribution should be conveyed. (A forthcoming section of these *Guidelines* will more fully address uncertainty issues.)

As recommended in Chapter 6, many EPA analyses will employ more than one discount rate to reflect different underlying approaches to discounting. When the choice of discount rate affects the outcome of the analysis, analysts should take extra care to convey the underlying theory and assumptions to decision makers. See Chapter 6 for more information.

11.2 Communicating Data, Model Choices and Assumptions, and Related Uncertainty

An economic analysis of an environmental regulation should carefully describe the data used in the analysis, the models it relies on, major assumptions that were made in running the models, and all major areas of uncertainty in each of these elements. Presentations of economic analyses should strive for clarity and transparency. An analysis whose conclusions can withstand close scrutiny is more likely to provide policy makers with the information they need to develop robust environmental policies.

11.2.1 Data

An economic analysis should clearly describe all important data sources and references used. Unless the data are confidential business information or some other form of private data, they should be available to policy makers, other researchers, policy analysts and the public. Providing documentation and access to the data used in an analysis is crucial to the credibility and reproducibility of the analysis.

EPA Order 5360.1 A2 (U.S. EPA 2000a) and the applicable federal regulations established a mandatory quality system for EPA. As required by the quality system, all EPA offices have developed quality management plans to ensure the quality of their data and information products.

Until recently, federal quality assurance (QA) requirements only applied to measurement and collection of *primary* environmental data. This meant that QA requirements often did not apply to economic analyses, which usually rely on the use of secondary data. However, this changed with the introduction of QA requirements regarding use of secondary data. In 2002 the Agency released QA guidelines regarding use of secondary data, and released Agency guidance, *Guidance for Quality Assurance Project Plans,* that includes procedures for documenting secondary data (U.S. EPA 2002f).

In any economic analysis, there should be a clear presentation of how data are used and a concise explanation of why the data are suitable for the selected purpose. The data's accuracy, precision, representativeness, completeness, and comparability should be discussed when applicable. When data are available from more than one source, a rationale for choosing the source of the data should be provided.

11.2.2 Model Choices and Assumptions

An economic analysis of an environmental regulation should carefully describe the models it relies on, the major assumptions made in running the models (to be discussed more fully below), and any areas of outstanding uncertainty. The analyst should take particular care to explain any results that might be viewed as counter-intuitive. In particular, analysts should be careful not to accept model output blindly. Any model that is used without proper thought given to both its input and output may become a "black box" insofar as nonsensical results may result from a misspecified scenario, a coding error, or any of a number of other causes.

In the process of conducting an economic analysis, it is sometimes necessary to bridge an information gap by making an assumption. Analysts should not simply note the information gap, but should also justify the chosen assumption and provide a rationale for choosing one assumption over other plausible options. The analyst should take care not to overlook information gaps that are filled with a piece of information that is only slightly related to the desired information. Analysts are advised to keep a running list of assumptions. This will make it easier to identify "key assumptions" for the final report. The likely impact of errors in assumptions should be characterized both in terms of direction and magnitude of effect when feasible.

Maintaining a list of assumptions can benefit the analysis in several ways. In the short run, a list can serve to focus analysts' attention on those assumptions with the greatest potential to affect net benefits, possibly leading to new approaches to bridging an information gap. In the long run, highlighting information gaps may encourage EPA or others to devote attention and resources to generating that information.

Whenever the likely errors in a particular assumption can be characterized numerically or statistically, the factor is a good candidate for sensitivity analysis or uncertainty analysis, respectively. In many cases, only a narrative description of the impact of errors in assumptions is possible. The analyst should include a table that clearly lays out all of the key assumptions and the potential magnitude and direction of likely errors in assumptions in the summary of results.

11.2.3 Addressing Uncertainty Driven by Assumptions and Model Choice

Every analysis should address uncertainties resulting from the choices the analyst has made. For example, many economic analyses performed at EPA include assessments of economic impacts expected to occur decades into the future. Estimates of the future costs and benefits of a regulation will be sensitive to assumptions about growth rates for populations, source categories, economic activity, and technological change, as well as many other factors. Sensitivity analyses on key variables in the baseline scenario should be performed and reported when possible. This allows the reader to assess the importance of the assumptions made for the central case. Some of these variables may be affected by a regulation, particularly the assumed rate of technological innovation. (Please see Chapter 5 for additional guidance on specifying baselines.)

The impact of using alternative assumptions or alternative models can be assessed quantitatively in many cases.

- **Alternative analysis.** An analysis of alternative assumptions or "alternative analysis" is the substitution of one of the key assumptions with another. In presenting the results, the alternative analysis is presented with equal weight as the primary analysis and is presented alongside of the primary analysis, even if the probability of the alternative assumption differs from that of the primary analysis. Because performing an alternative analysis on all the assumptions in an analysis is prohibitively resource intensive, the analyst should focus on the assumptions that have the largest impact on the final results of the particular analysis. Thus, keeping a running list of the "key assumptions" in an analysis is recommended.
- **Sensitivity analysis.** A sensitivity analysis is used to assess how the final results or other aspects of the analysis change as input parameters change, particularly when only point estimates of parameters are available. A regulatory impact analysis benefits from knowing how the cost-effectiveness of a particular technology changes as fuel prices change, or how the net benefits of a BCA change as one of the model coefficients change. Typically, a sensitivity analysis measures how the model's output changes as one of the input parameters change. Joint sensitivity analysis (varying more than one parameter at a time) is sometimes useful as well.
- **Model uncertainty.** In addition to explaining the uncertainty in a model's parameters, analysts should discuss the uncertainty generated by the choice of model. Multiple models are often available to the analyst, and choosing among them is similar to making an assumption. Implicit in the choice of a model are many factors. For example, one model may take long-run effects into account while another model does not. When possible, presenting results of an alternate model can inform the reader. When resource limitations prevent the use of an alternative model, it is still often possible to predict the direction and likely magnitude of the use of an alternate model, and the analyst should present this information to the reader.

11.3 Use of Economic Analyses

The primary purpose of conducting economic analysis is to provide policy makers and others with detailed information on a wide variety of consequences of environmental policies. One important element these analyses have traditionally provided to the policy-making process is estimates of social benefits and costs — the economic efficiency of a policy. For this reason, these *Guidelines* reflect updated information associated with procedures for calculating benefits and costs, monetizing benefits estimates, and selecting particular inputs and assumptions.

Determining which regulatory options are best even on the restrictive terms of economic efficiency is often made difficult by uncertainties in data and by the presence of benefits and costs that can be quantified but not monetized, or that can only be qualitatively assessed. Even if the criterion of economic efficiency were the sole guide to

policy decisions, social benefit and costs estimates alone would not be sufficient to define the best policies.

A large number of social goals and statutory and judicial mandates motivate and shape environmental policy. For this and other reasons, these *Guidelines* contain information concerning procedures for conducting analyses of other consequences of environmental policies, such as economic impacts and equity effects. This is consistent with the fact that economic efficiency is not the sole criterion for developing good public policies.

Even the most comprehensive economic analyses are but part of a larger policy development process, one in which no individual analytical feature or empirical finding dominates. The role of economic analysis is to organize information and comprehensively assess the economic consequences of alternative actions — benefits, costs, economic impacts, and equity effects — and the trade-offs among them. Ultimately statutory requirements dictate if and how the analytic results are used in standard setting. In any case, these results, along with other analyses and considerations, serve as important inputs for the broader policy-making process and serve as important resources for the public.