PART TWO
CHAPTER 1

Quantifying the Benefits: An Overview of the Analytic Framework

DOCUMENT MAP

PART ONE
The Multiple Benefits of Energy Efficiency and Renewable Energy

PART TWO
Quantifying the Benefits: Framework, Methods, and Tools

CHAPTER 1
Quantifying the Benefits: An Overview of the Analytic Framework

CHAPTER 2
Estimating the Direct Electricity Impacts of Energy Efficiency and Renewable Energy

CHAPTER 3
Assessing the Electricity System Benefits of Energy Efficiency and Renewable Energy

CHAPTER 4
Quantifying the Emissions and Health Benefits of Energy Efficiency and Renewable Energy

CHAPTER 5
Estimating the Economic Benefits of Energy Efficiency and Renewable Energy

CHAPTER 1 CONTENTS

ABOUT THIS CHAPTER

This chapter presents a four-step framework for quantifying the multiple benefits of energy efficiency and renewable energy, and provides an overview of the general process for assessing benefits, which is described in more detail in subsequent chapters.

1.1. OVERVIEW: A FRAMEWORK FOR QUANTIFYING THE MULTIPLE BENEFITS OF ENERGY EFFICIENCY AND RENEWABLE ENERGY

Analysts can use the framework, methods, and tools described here to quantify the electricity system, emissions, health, and economic benefits of energy efficiency and renewable energy. Part Two of this *Guide* presents key considerations for analysts and the steps they can follow to quantify and incorporate benefits into policy analyses and decision-making. These steps include:

1. Determine the scope of and strategy for the analysis.
2. Determine the expected or actual direct electricity impacts of the initiative(s).
3. Quantify the electricity system, emissions, health, and/or economic benefits of interest.
4. Use information to support a balanced comparison of costs and benefits during decision-making processes.

Figure 1-1 illustrates how these steps relate to the overall policy planning and evaluation process depicted in Figure I-1 of Part One.

This overview chapter introduces each step of the overall framework, as shown in Figure 1-2. The rest of Part Two describes methods, tools, and resources analysts can use to implement Steps 2 and 3, and includes examples and case studies.

IMPORTANT NOTES ON THE SCOPE OF THIS *GUIDE*

Because the practice of quantifying the costs of policies is widely understood, the focus of this *Guide* is on describing the practice of quantifying the *benefits* of policies.

This *Guide* focuses on methods and tools to quantify the electricity system, emissions, health, and economic benefits from energy efficiency and renewable energy programs. Energy efficiency and renewable energy programs can have other energy-related benefits (e.g., from combined heat and power) and other environmental benefits (e.g., to water quality), but they are not covered in detail here.

The *Guide* also focuses on benefits in the electricity sector as opposed to the energy sector in general. It does not consider other sectors such as transportation (where, for example, electric vehicles may be able to provide grid services when not in use). Consideration and inclusion of these other types of benefits and sectors could further enhance the comprehensiveness of an analysis.

1.1.1. Step 1: Determine the Scope of and Strategy for the Analysis

Step 1 identifies the goals and boundaries of the analysis, narrowing the areas of focus for subsequent steps.

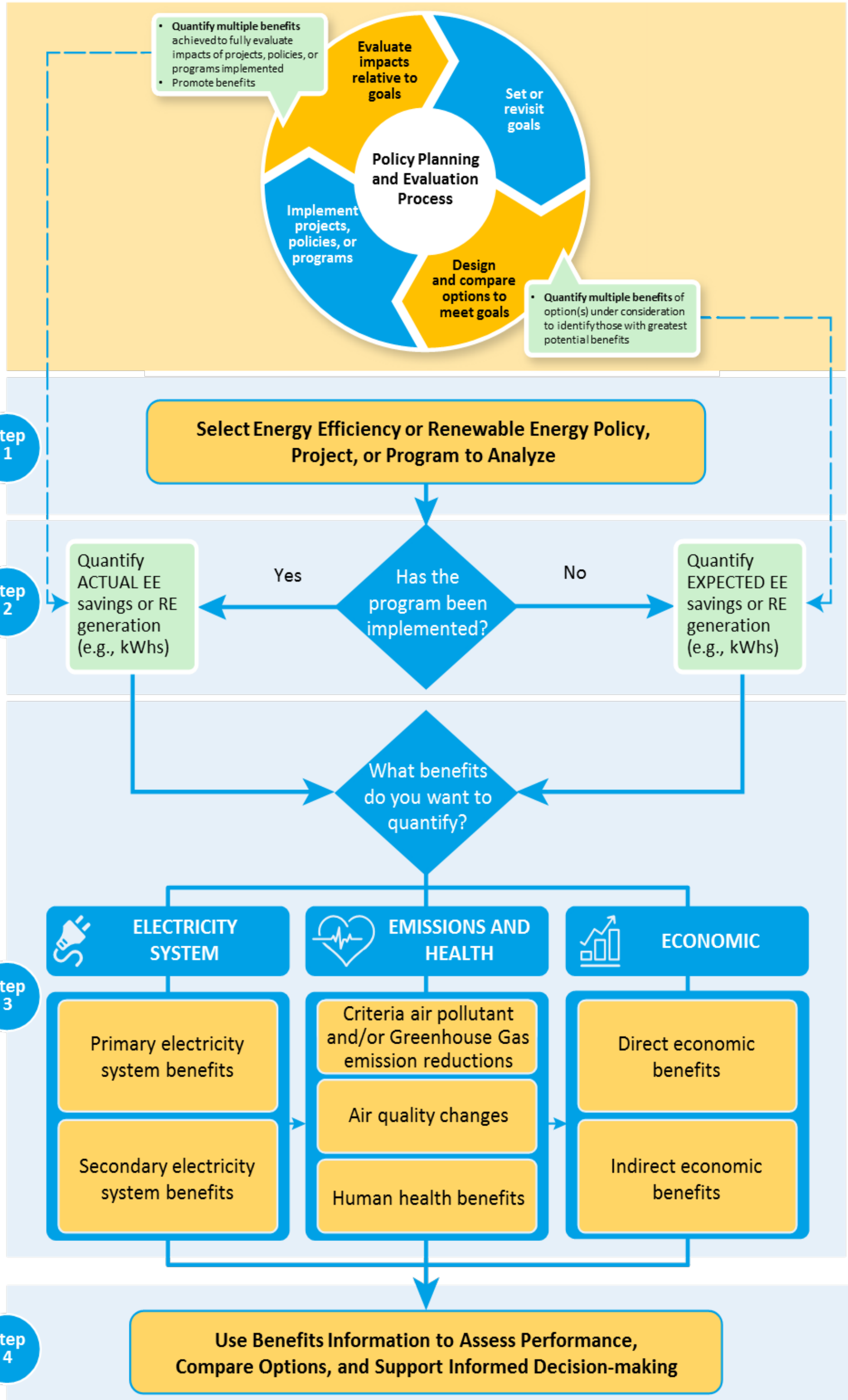
Identifying the Purpose, Priorities, and Constraints

When getting started, an analyst must decide which policies or programs to evaluate, which benefits to assess, the nature of the analysis and its level of rigor, and the constraints on the scope of the analysis imposed by available resources. Considering the questions below will help analysts design the analysis, determine its boundaries, and select the appropriate methods and/or tools.

- *Why is the analysis being conducted?* The answer to this question will determine the scope and goals of the analysis. For example, will the results of the analysis be used primarily for informational purposes (e.g., to assess how a proposed initiative could contribute to a jurisdiction's priorities), to support environmental or economic development planning and implementation decisions, or to inform regulatory reporting?
- *Which energy efficiency and renewable energy goals, policies, activities, and/or programs will be evaluated?*[1] Analysts can focus on the benefits of a single energy efficiency or renewable energy activity (e.g., retrofitting a single state or local government building) or an entire program (e.g., the state or locality's portfolio of energy efficiency activities, renewable portfolio standard [RPS], or green purchasing program). The activities chosen can be identified based on the jurisdiction's overall energy policy and planning goals, regulatory or legislative requirements, or findings from studies that indicate which activities are most likely to result in energy savings and other benefits.

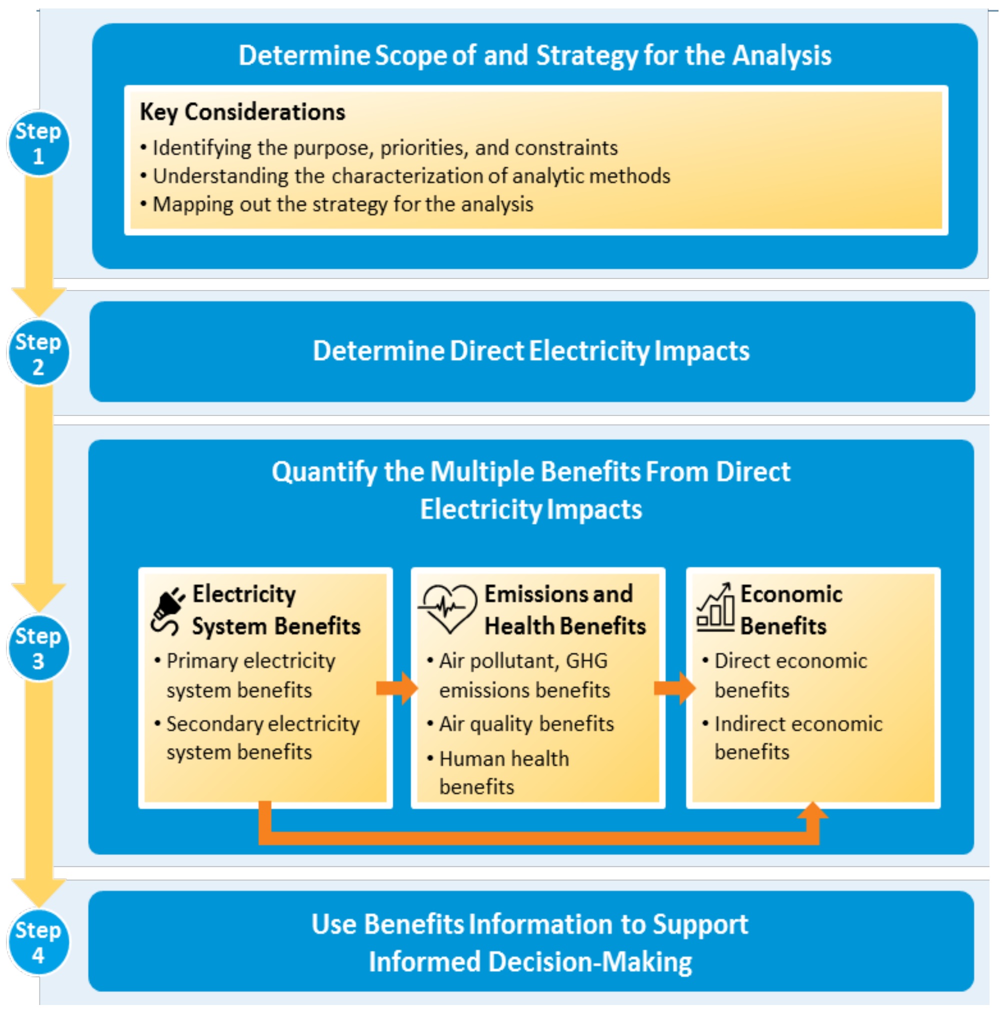
[1] *For information about best practices in designing and implementing energy efficiency and renewable energy policies, see U.S. EPA's* Energy and Environment Guide to Action: State Policies and Best Practices for Advancing Energy Efficiency, Renewable Energy, and Combined Heat and Power, 2015 Edition *at https://www.epa.gov/statelocalenergy/energy-and-environment-guide-action.*

Figure 1-1: How the Policy Planning and Evaluation Process Relates to the Process for Quantifying Multiple Benefits



- *Which benefits will be analyzed?* Analysts may concentrate on estimating some or all of the benefits, depending on the purpose and scope of the initiative. This decision will depend on the audience and its interests, available financial and staff resources, and the type and scope of the energy efficiency or renewable energy initiative(s) being assessed. For example, in a state where the governor has prioritized increasing renewables for the purposes of economic development and greenhouse gas (GHG) emissions reductions, an analyst with limited staff and resources would want to quantify, at a minimum, the macroeconomic (e.g., employment, gross state product, tax revenue) and emissions impacts for options under consideration. When developing a statewide energy or environmental plan, or assessing a new energy efficiency or renewable energy initiative that has broad goals and will be of interest to a large range of stakeholders, however, it may be more appropriate to assess a wider range of benefits.
- *What level of rigor is required?* Most benefits can be assessed using a range of basic to sophisticated methods. The rigor with which decision makers analyze benefits depends on factors such as the types of benefits being analyzed, the proposal's status in the development and design process, whether the proposal will be used to meet regulatory requirements, and the level of investment being considered.
- *What financial and staff resources, or external expertise, are available?* Financial, time, and staff resource constraints may limit the range of methods analysts can choose from, and will influence their approach for estimating benefits.
- *What kinds of data are available?* Sophisticated analytic methods can require an extensive amount of data (e.g., hourly electricity generation or emissions data), depending on the type and complexity of the analysis. Basic methods typically require less data and can often be used when data availability is a challenge.
- *Is the analysis retrospective or prospective?* Estimating actual benefits from an existing program retrospectively will involve different steps than estimating future benefits. Estimates of future benefits require more assumptions and involve more uncertainty

Figure 1-2: A Framework for Quantifying the Multiple Benefits of Energy Efficiency and Renewable Energy



than retrospective analyses. Note that this *Guide* focuses on forward-looking analyses, even though many of the same methods and tools can be used for retrospective analyses.

Understanding the Characterization of Analytic Methods Described in this *Guide*

The *Guide* distinguishes between "basic" methods that may require few resources and that a government agency's own staff may be able to easily implement and "intermediate" to more "sophisticated" modeling methods that may require significant financial and time commitments. This distinction is imprecise, as the sophistication of methods and models can be judged along a broad continuum, but it helps convey differences in complexity. For purposes of this *Guide*:

- *Basic methods* (e.g., spreadsheet analyses, trend extrapolations) are based on relatively simple formulations, such as the use of activity data (e.g., changes in generation levels) and factors (e.g., emission factors). In these methods, there is no attempt to represent the underlying system. Instead, they rely on factors or trends to capture what would be expected to result. These factors and other inputs require relatively little time or expense to develop, and are most appropriate for short-term analyses. Although simpler methods can provide a reasonable level of precision, users should decide whether the method and results are suitable for their intended purpose.
- *Intermediate methods* require some technical expertise but allow analysts flexibility to make adjustments and reflect different energy efficiency and renewable energy assumptions and savings. These methods typically have transparent assumptions, normally do not require software licensing fees, and are computationally simpler than sophisticated methods. Intermediate methods may be more credible than basic methods and tend to be most appropriate for short-term analyses.
- *Sophisticated methods* are characterized by extensive underlying data and relatively complex formulations that represent the fundamental engineering and economic decision-making (e.g., power sector system dispatch or capacity expansion modeling), or complex physical processes (such as in air dispersion modeling). Sophisticated models provide greater detail than the basic methods, and can capture the complex interactions within the electricity market and with other markets or systems. They are computationally intensive and may require considerable time and resources to operate. These methods are generally appropriate for short- or long-term analyses, or analyses where unique supply-and-demand forecasts are needed to incorporate the specific changes being considered.

UNDERSTANDING THE STRENGTHS AND LIMITATIONS OF MODELS AND ANALYTIC METHODS

Regardless of which analytic method or model is chosen, it is important to understand its strengths and limitations. Specifically, it is important to recognize:

- Models can provide a consistent framework for exploring how a system is likely to respond to different stimuli and for conveying the degree of uncertainty surrounding best estimates.
- Models are mathematical representations of physical or economic processes in the real world, and are only as good as our understanding of these processes. The results will be influenced by the model's design, flexibility, and complexity. For example, an optimization model is designed to show what *should be done* under assumed conditions, by identifying the most effective or least expensive approach. A simulation model, on the other hand, describes only what *might happen* under a range of scenarios. Simulation models offer insights into how a complex system responds to changing conditions under specific assumptions.
- Data inputs and assumptions have a significant effect on model outcomes, some more than others. Many of these inputs are uncertain. For example, drivers such as fuel prices, weather, unit availability, load levels and patterns, technology performance, future market structure, and regulatory requirements are all subject to uncertainty.

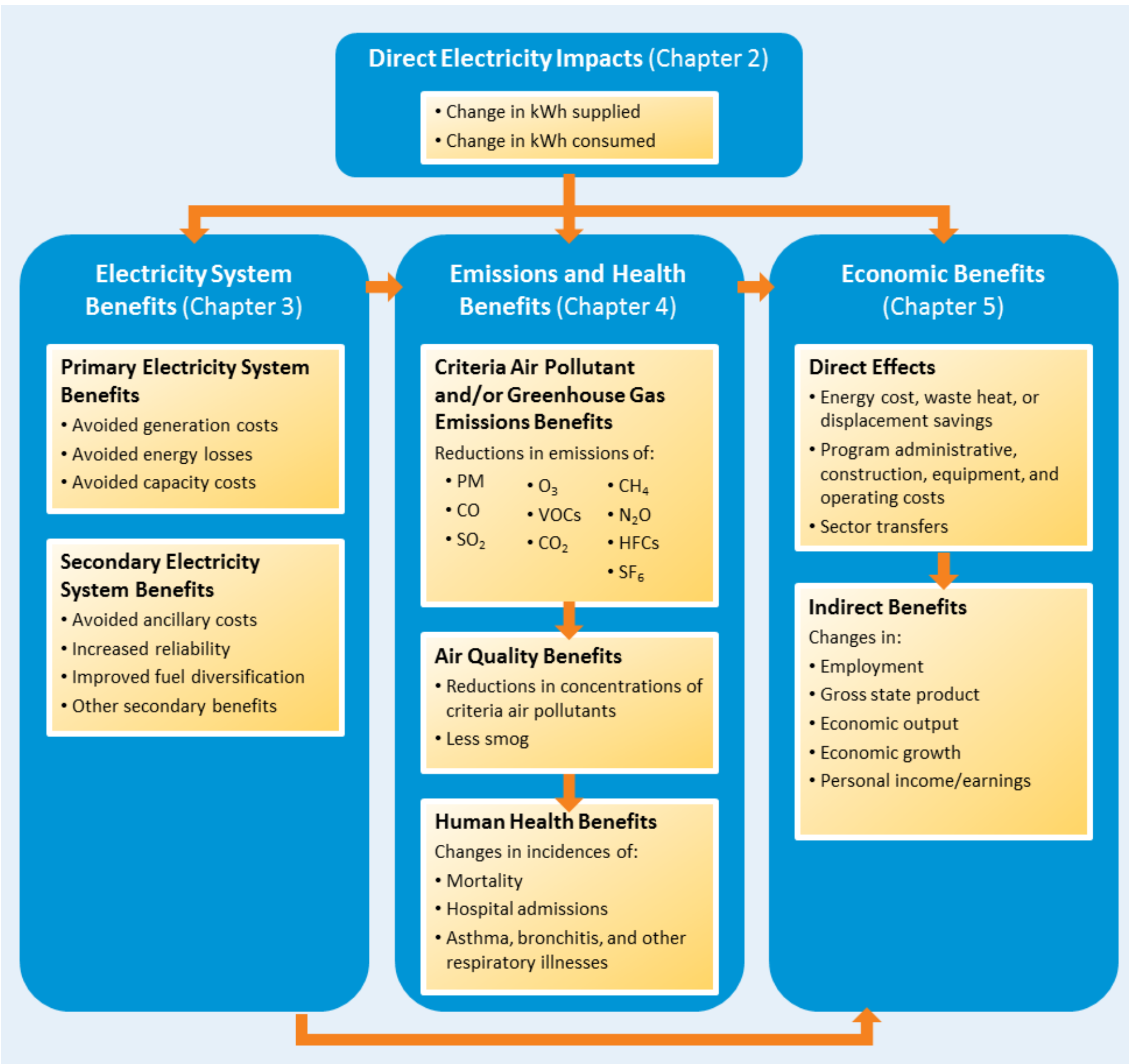
When selecting a method, it is helpful to understand the strengths and limitations of any approach. For more information, see the text box, "Understanding the Strengths and Limitations of Models and Analytic Methods." Many of these strengths and limitations are described in greater detail in the individual chapters that follow.

Mapping Out the Strategy for the Analysis

Once analysts have identified the purpose of the analysis, what benefits to quantify, and the level of rigor required, it is helpful to understand the interactions among and relationships between the various impacts and benefits. This will help them determine the order of analyses, the specific benefits they will need to quantify along the way, and the types of methods they will need to explore and use.

Figure 1-3 below, portrays the relationship between the direct electricity impacts quantified in "Step 2: Determine Direct Electricity Impacts," and the electricity system, emissions, health, and economic benefits quantified in "Step 3: Quantify the Multiple Benefits from Direct Electricity Impacts." It also identifies the chapter where the methods and tools to quantify direct electricity impacts and specific benefits can be found in the *Guide*. It can help analysts map out the necessary parts of the analysis upfront and steer them to the appropriate chapters for information about methods, data needs, available tools and data resources, and case studies.

Figure 1-3: Mapping Out the Relationships Between Direct Electricity Impacts and the Benefits of Energy Efficiency and Renewable Energy Initiatives



For example, consider analysts from a state or local agency with a small budget who are asked to do an informal analysis of the health benefits of a suite of energy efficiency programs. To measure health benefits, the analysts must first quantify the expected direct electricity impacts, in kilowatt-hours (kWh), using methods described in Chapter 2, "Estimating the Direct Electricity Impacts of Energy Efficiency and Renewable Energy." They will use the electricity impacts to estimate the quantity and type of emissions changes expected from the programs. Then the analysts can assess the related air quality changes anticipated at a local level. These air quality changes can then be used to estimate negative health effects that will be avoided due to the reduction in electricity demand. The analysts can calculate the monetary value associated with the negative health effects avoided to determine a comprehensive picture of the benefits. Methods for quantifying the emissions, air quality, and health impacts are described in Chapter 4, "Quantifying the Emissions and Health Benefits of Energy Efficiency and Renewable Energy." The analysts can use any of the relevant methods (e.g., basic to sophisticated) described in the *Guide* to quantify the electricity system, emissions, air quality, health, and economic impacts, but because the analysis is informal and the budget is low, the analysts may determine that the basic and intermediate approaches are the quickest and most economical to use for their purposes and start with them when they are exploring their options.

Now suppose an analyst needs to conduct a detailed, multi-sectoral, multi-year analysis of the direct and indirect macroeconomic (e.g., employment) impacts from a suite of energy efficiency programs for regulatory purposes and has a large budget for the analysis. The analyst would still start with the kWh saved, but would follow a different approach to the analysis, looking to Chapter 5, "Estimating the Economic Benefits of Energy Efficiency and Renewable Energy," to identify the most appropriate method(s) and tools to trace the expected flow of financial investments (rather than emissions) throughout the economy. Because a regulatory analysis demands a higher level of rigor, the analyst must explore more sophisticated, often costly, methods in addition to the basic and intermediate approaches.

KEY POINTS TO CONSIDER WHEN PLANNING AN ANALYSIS

- All methods involve predictions, inherent uncertainties, and many assumptions.
- The approach selected should match the question being asked. For example, simple tools should not be used to answer sophisticated, complex questions.
- The models, assumptions, and inputs used in the analysis should be transparent and well documented.
- Expert input and assumptions as well as expert peer review of the final results can enhance the credibility and usefulness of the analysis.

1.1.2. Step 2: Determine Direct Electricity Impacts

Step 2 involves estimating the potential electricity savings or renewable energy generation impacts of a program or policy. These electricity impacts (e.g., kWh avoided or generated) are critical because they serve as a key input for subsequent analyses of electricity system, air, health, and economic impacts. To determine the direct electricity impacts of policies and programs, an analyst typically develops or adopts business-as-usual projections of the electricity generation and consumption expected without them. The analyst then develops estimates of the electricity savings and renewable energy generation impacts expected from the energy efficiency and renewable energy programs (e.g., based on funding levels and assumptions about participation in the programs) to compare against their projections. Chapter 2, "Estimating the Direct Electricity Impacts of Energy Efficiency and Renewable Energy," describes in detail a range of methods, data, and tools available to estimate the electricity impacts that can then be used as a foundation for quantifying benefits.

1.1.3. Step 3: Quantify the Multiple Benefits From Direct Electricity Impacts

The impacts of an initiative do not end with their direct electricity impacts. The analyst can use the electricity impact estimates to assess the benefits of the programs to the overall electricity system and economy, as well as the environmental quality and public health benefits. For example, imagine an energy efficiency initiative where the electricity savings deliver a significant reduction in electricity demand. In this case, the energy efficiency programs could reduce electricity demand enough to delay or eliminate the need to construct a costly new power plant. This would be a benefit to the electricity system. Reducing generation of fossil fuel-based electricity will reduce emissions of criteria air pollutants and GHGs. Reducing criteria air pollution improves air quality in the near term and can lead to public health benefits. These benefits can be estimated and assigned an economic value. Consumers would enjoy reduced energy costs, which could lead to an increase in spending on other consumer goods and services. The economic benefits of the public health improvements (e.g., improved productivity from fewer sick days), energy cost and system savings, and investments in energy efficient equipment as well as non-energy products and services would likely stimulate the economy and create jobs.

In Step 3, the analyst quantifies the electricity system benefits, emissions and health benefits, and economic benefits, based on the estimates of direct electricity savings or renewable energy generation developed in Step 2. Chapters 3, 4, and 5 describe methods, data, and tools that can be used to perform these analyses. For any estimate of policy impacts, it is important to document clearly all the details of the analysis, including the scope of the analysis, the analytic approach used along with any limitations of the approach, and all of the underlying assumptions used in the analysis and their sources. Transparency about the approach and assumptions, as described in the box, "Being a Critical Reviewer of Analyses," will help to ensure that reviewers and decision makers can properly evaluate, interpret, and use the results.

BEING A CRITICAL CONSUMER OF ANALYSES

For anyone reviewing an analysis of policy impacts, it is helpful to identify any influences that might have affected the results. To help the reviewer do this, an analyst should clearly document the following elements:

- **Sponsor of the analysis**. In order to flag any potential biases, it is helpful to understand who sponsored or paid for an analysis.
- **Scope of the analysis**, including costs and benefits considered. While this *Guide* helps analysts quantify the potential benefits of policies to compare against the costs, some analyses consider only the costs or include estimates for only a very limited set of benefits. When reviewing results of an analysis that did not include benefits, it is helpful to recognize that the impacts presented are not comprehensive.
- **Analytic approach used and any limitations**. Taking time to understand the approach used in the analysis can help a decision maker or other reviewer judge whether the approach was appropriate for the purpose. If the purpose of the analysis is regulatory, for example, the level of rigor will likely be a more important consideration than in analyses used for simple screening purposes. A decision maker may have more confidence in a sophisticated analysis using known tools, or one that has gone through an independent technical peer review process, than a quick, back-of-the-envelope analysis. That said, a rough analysis may be more valuable in certain contexts where efficiency and speed are critical, such as a simple screening exercise.
- **Underlying assumptions**. Similarly, reviewing and understanding the assumptions made during the analysis, and the rationales behind those assumptions, can help a decision maker or other reviewer determine whether they are reasonable and objective. Typical questions include: Did the analysis use local data (e.g., economic, energy, fuel, technology) or rely on national data that may lack locally relevant detail? Does the analysis assume changes in prices and/or technology over time, and if so, how are they expected to change? Did the analysis include a sensitivity analysis for unknown variables that could vary significantly? Did the team conducting the analysis cite credible sources to clearly justify its assumptions and/or consult with experts or stakeholders to otherwise review the analysis?

1.1.4. Step 4: Use Benefits Information to Support Informed Decision-Making

This final step in the framework serves to ensure that information on the multiple benefits of energy efficiency and renewable energy is considered during the decision-making process. Incorporating this information into decisions can be facilitated by ensuring that a range of benefits are considered as criteria for selecting policy or program options, and by understanding the ways in which information on the benefits of energy efficiency and renewable energy can be used to support different types of planning.

Including a Variety of Benefits as Criteria for Policy Selection

Energy efficiency and renewable energy policies and programs are typically selected based on their potential to meet a specific goal (usually energy-related) set by a state or local government. When deciding which options to choose, however, it is helpful to expand the criteria to include other priorities—such as goals for air quality and economic growth—to which energy efficiency and renewable energy initiatives can contribute.

Developing these criteria involves balancing priorities and requirements specific to the state or locality's needs and circumstances. Typical assessment criteria include energy savings, economic costs and benefits, and feasibility-related criteria (such as political feasibility and the timeframe for implementation). By using methods described in this *Guide*, state and local decision makers can expand this set of criteria to include a broader range of quantified expected benefits from proposed energy efficiency and renewable energy programs, such as emissions and health-related criteria (e.g., changes in air pollutant emissions, health impacts), economic development-related criteria (e.g., jobs created or lost), and electricity system-related impacts (e.g., avoided costs of new generation or transmission and distribution [T&D] losses). Including these benefits increases the comprehensiveness and balance of the analysis and makes it easier to illuminate clearly the strategic trade-offs among options and across a range of priorities.

How States and Localities Have Used Energy Efficiency and Renewable Energy to Support Other Goals

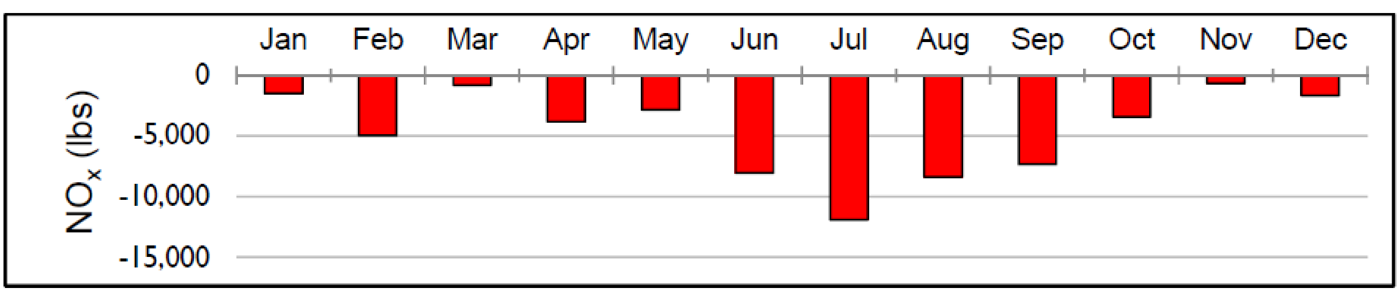
Many state and local governments have integrated their energy efficiency and renewable energy programs with other environmental, energy, and economic programs. This allows them to take full advantage of the multiple benefits generated by energy efficiency and renewable energy programs, strengthening the impact of other programs and meeting broader goals. Examples of this kind of integration are presented below.

Using Energy Efficiency and Renewable Energy to Achieve Environmental Goals

Many regions, states, and localities are incorporating energy efficiency and renewable energy into strategies to meet their air quality and/or climate change objectives (U.S. EPA, 2012; U.S. EPA, 2016). Quantifying the multiple benefits of energy efficiency and renewable energy programs can provide key data for use in developing state implementation plans (SIPs), GHG emissions reduction plans, and air pollution and/or GHG emissions cap-and-trade programs that include clean energy programs. (See Chapter 4, "Quantifying the Emissions and Health Benefits of Energy Efficiency and Renewable Energy," for more information.)

State and local governments are using innovative voluntary control measures, including energy efficiency and renewable energy, to help achieve or maintain attainment with national air quality standards. Clark County, Nevada, for example, estimated the emissions impacts of its renewable energy measures to identify whether and how they support attainment with the national ozone standard. The county found that renewables displaced 411,600 Megawatt-hours in 2015, leading to a reduction of 55,100 pounds (27.5 tons per year) of NO_x, an important ozone precursor, helping the county stay in attainment with the standard (Clark County, 2016). Figure 1-4 shows the monthly estimates of NO_x impacts from the county's renewables in 2015.

Figure 1-4: Monthly NO_x Reductions in 2015 from Renewables in Clark County, Nevada



State and local governments are also using energy efficiency and renewable energy to advance reductions under their SO_2 and NO_x cap-and-trade programs. For example, set-asides or carve-outs reserve a portion of the total capped allowances to be distributed to clean energy initiatives. In addition, state and local governments are using energy efficiency and renewable energy measures in their climate change action plans to reduce CO_2 emissions from the electric power sector (U.S. EPA, 2016). Quantifying the potential emissions benefits from implementing or expanding the use of energy efficiency and renewable energy helps demonstrate the value of these choices from an environmental perspective.

Using Energy Efficiency and Renewable Energy to Achieve Energy Planning Goals

Regional, state, and local energy plans often include energy efficiency and renewable energy activities and goals, such as RPSs or energy efficiency resources standards. By quantifying the electricity system benefits of proposed initiatives, state and local governments can identify the most effective approaches and develop realistic goals to include in their state or local energy plans.

In 2014, for example, the New York State Energy Research and Development Authority (NYSERDA) commissioned a study to assess the potential for increased adoption of energy efficiency and renewable energy technologies to help the state meet objectives outlined in the New York State Energy Plan (NYSERDA, 2014). The study found that the economic and achievable potential for energy efficiency translates into a 45 percent and 18 percent reduction, respectively, from energy sales forecasted for 2030. See Table 1-1, below.

Table 1-1. Potential Savings from Energy Efficiency Relative to New York State Energy Sales Forecast, 2030

	Energy Savings		
Scenario	Electric (GWh)	Natural Gas (TBtu)	Petroleum Fuels (TBtu)
Economic Potential	**91,856**	**321.1**	**120.0**
% of Forecast	***45%***	***32%***	***53%***
Residential	28,553	148.7	72.3
Commercial	58,550	136.8	45.1
Industrial	4,753	35.7	2.6
Achievable Potential	**36,328**	**107.9**	**43.0**
% of Forecast	***18%***	***11%***	***20%***
Residential	9,415	49.4	26.4
Commercial	25,407	47.0	15.4
Industrial	1,506	11.5	1.3
Savings from EEPS	**17,013**	**14.1**	**n/a**
% of Forecast	***8%***	***1%***	

Note: GWh is Gigawatt-hours and TBtu is trillion British thermal units. EEPS is the current New York State Energy Efficiency Portfolio Standard.
Source: NYSERDA, 2014.

The study also found that renewable resources have the technical potential to provide more than half of the state's energy for buildings and electric generation alone in 2030. These results fed into the final 2015 *New York State Energy Plan*, which requires 50 percent of all electricity to be generated with renewable energy sources and a 23 percent reduction in energy consumption from buildings, all while achieving a 40 percent reduction in GHG emissions from 1990 levels (New York State, 2015).

States can also require utilities to develop plans that are consistent with state energy goals. Utilities can be required to file either integrated resource plans (IRPs) or portfolio management strategies with the state public utility commission, depending upon whether the state has a vertically integrated or restructured electricity system.[2] These IRPs and

[2] *In some states, utilities are vertically integrated, meaning that one company is responsible for electricity generation, transmission, and distribution over a given service territory. State public utility regulators have authority over these utilities. In other states, where the electric power industry has been restructured, ownership of electric generation assets has been decoupled from T&D assets, and retail customers have their choice of electricity suppliers. In states where restructuring is active, state public utility regulators do not have authority to regulate the companies responsible for electricity generation, but they can regulate the electricity distribution utilities.*

portfolio management strategies often use some type of multiple benefits analysis in the program evaluation criteria (NESP, 2017).

Using Energy Efficiency and Renewable Energy to Achieve Economic Development Goals

Most states and localities are looking to stimulate economic growth, attract new businesses, and create new jobs. Analysts can quantify the potential economic benefits expected from energy efficiency and renewable energy programs to assess their economic value. For example, in 2015, Wisconsin commissioned a study to estimate actual economic impacts of the state's Focus on Energy program—a statewide energy efficiency and renewable energy initiative that provides information, technical support, and financial incentives to Wisconsin residents and businesses—over the 2011–2014 timeframe and project the cumulative impacts from 2015 to 2038. The study's estimated economic impacts include:

- A net increase of more than 19,000 job-years from 2011 to 2038 (6,235 from 2011 to 2014 and 13,056 from 2015 to 2038)
- More than $1.4 billion in disposable income for residents ($382 million from 2011 to 2014 and $1.053 billion from 2015 to 2038)
- $2.85 billion in increased value added to gross state product ($638 million from 2011 to 2014 and $2.216 billion from 2015 to 2038)
- More than $5.5 billion in sales for Wisconsin businesses ($1.424 billion from 2011 to 2014 and $4.078 billion from 2015 to 2038) (Cadmus, 2015)

Quantifying these benefits helps to demonstrate the economic value the incentives and support offerings provided by Focus on Energy can generate for the state. It allows decision makers to compare across options so that they can select, design, or adapt policies and programs that best align with their economic development priorities.

Using Energy Efficiency and Renewable Energy to Achieve Multiple Goals Simultaneously

Rather than quantifying the environmental, energy, or economic benefits of energy efficiency and renewable energy in isolation, a more comprehensive and increasingly popular approach is for state and local government analysts to quantify the multiple environmental, energy, *and* economic benefits of their initiatives. This type of inclusive analysis enables states or local agencies to more fully understand the potential value of their energy efficiency and renewable energy policy choices across a wide range of impacts. The state of Maryland, for example, quantified the multiple energy, economic, and emissions benefits over the lifetime of the investments generated by EmPOWER Maryland, a program created by the legislature to meet the state's goal of reducing Maryland's per-capita electricity consumption and peak demand by 15 percent from to a 2007 baseline, by the end of 2015. The Maryland Energy Administration (MEA) and Maryland Public Service Commission (Maryland PSC) analyzed the impact as part of their annual reporting requirements and found that between 2007 and 2015, the program achieved cumulative savings of 5,394 Gigawatt-hours (99 percent of the target) and peak demand reductions of 2.1 Gigawatts (100 percent of the target).

MEA estimated that the total benefits of the EmPOWER Maryland program's energy efficiency upgrades and related investments, over their useful lifetimes, amount to:

- 38.9 billion kWh in lifetime energy savings
- $4.39 billion in lifetime energy bill savings
- 26 million metric tons of avoided carbon dioxide emissions (Maryland PSC, 2016)

The program also helped reduce energy burdens for nearly 21,000 low-income households in the state, decreasing their annual energy bills by $340 on average, or approximately 20 percent (U.S. EPA, 2017).

Based on these results, the Maryland PSC established an order in 2015 to continue EmPOWER Maryland past the end of the year, setting post-2015 annual incremental electric energy efficiency goals of 2 percent of a utility's weather-normalized gross retail sales, with a ramp-up rate of 0.2 percent per year. These goals are scheduled to take effect starting in 2018 (Maryland PSC, 2017).

1.2. PART TWO ROADMAP

The remaining chapters in this *Guide* are organized by type of benefit. Each chapter describes in detail the range of methods, data, and tools available to quantify the benefits and includes case studies showing how other analysts have applied the methods and/or tools.

- **Chapter 2, "Estimating the Direct Electricity Impacts of Energy Efficiency and Renewable Energy,"** discusses methods that can be used to estimate the future electricity savings of energy efficiency programs and future electricity production by renewable energy options. The chapter lays out the steps involved in developing these estimates, including:
  - Developing a business-as-usual energy forecast
  - Estimating potential direct electricity impacts
  - Creating an alternative policy forecast
- **Chapter 3, "Assessing the Electricity System Benefits of Energy Efficiency and Renewable Energy,"** describes the range of methods, data, available tools, and case studies for estimating primary and secondary electricity system benefits.
  - *Primary electricity system benefits* are quantified frequently using readily available methods and include:
    - Avoided cost of electricity generation or wholesale electricity purchases
    - Avoided cost of new generation
    - Avoided T&D losses
    - Deferred or avoided T&D capacity costs
  - *Secondary electricity system benefits* are often more difficult to quantify and include:
    - Avoided ancillary service costs
    - Reductions in wholesale market prices
    - Increased reliability and improved power quality
    - Avoided risks associated with long lead-time investments, such as the risk of overbuilding the electricity system
    - Reduced risks from deferring investments in power plants until future environmental policies take shape
    - Improved fuel diversity and energy security
- **Chapter 4, "Quantifying the Emissions and Health Benefits of Energy Efficiency and Renewable Energy,"** describes the range of methods, data, available tools, and case studies to help analysts:
  - Develop a baseline emissions inventory
  - Quantify emissions reductions from energy efficiency and/or renewable energy

    - Estimate air quality changes that occur from the emissions changes
    - Estimate the human health impacts, including avoided incidences of heart attacks, respiratory illnesses, asthma attacks, premature death, and lost work or school days
    - Monetize the economic value of the health impacts
- **Chapter 5, "Estimating the Economic Benefits of Energy Efficiency and Renewable Energy,"** describes the methods, available tools, and case studies analysts can use to estimate the economic benefits, including:
    - Employment
    - Economic output (i.e., total value of all goods and services produced in an economy)
    - Gross state product (i.e., combined value added from all of a state's industries)
    - Economic growth
    - Personal income/earnings

1.3. REFERENCES

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