PART ONE

The Multiple Benefits of Energy Efficiency and Renewable Energy

DOCUMENT MAP

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The Multiple Benefits of Energy Efficiency and Renewable Energy

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PART ONE CONTENTS

ABOUT THIS CHAPTER

This chapter provides an overview of the purpose of the overall *Guide.* It defines energy efficiency and renewable energy and describes why quantifying the multiple benefits of energy efficiency and renewable energy may be valuable to a decision maker or analyst. This chapter sets the context for the subsequent chapters that describe the framework, methods, and tools analysts can use to quantify the electricity system, emissions and health, and economic benefits of energy efficiency and renewable energy.

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PREFACE

State and local energy efficiency and renewable energy investments can produce significant benefits, including lower fuel and electricity costs, increased grid reliability, better air quality and public health, and more job opportunities. Analysts can quantify these benefits so that decision makers can comprehensively assess both the costs and the benefits of their energy policy and program choices.

The U.S. Environmental Protection Agency (EPA) State and Local Energy and Environment Program is pleased to release the 2018 edition of *Quantifying the Multiple Benefits of Energy Efficiency and Renewable Energy: A Guide for State and Local Governments.* The *Guide* is intended to help state and local energy, environmental, and economic policy makers and analysts identify and quantify the many benefits of energy efficiency and renewable energy to support the development and implementation of cost-effective energy efficiency and renewable energy initiatives.

This *Guide* starts by describing, in Part One, the multiple benefits of energy efficiency and renewable energy and explaining the value of quantifying these benefits so that they are considered along with costs. In Part Two, the *Guide* shows policy makers and analysts how they can quantify the direct electricity, electricity system, emissions, health, and economic benefits of energy efficiency and renewable energy. It provides detailed information about a range of basic-to-sophisticated methods analysts can use to quantify each of these benefits, with key considerations and helpful tips for choosing and using the methods. Part Two includes case studies and examples of how analysts have quantified the benefits of state or local energy efficiency and renewable energy policies, programs, and investments. The chapters in Part Two also describe tools and resources available for quantifying each type of benefit.

The original 2010 version, *Assessing the Multiple Benefits of Clean Energy: A Resource for States,* was the first to organize and present a comprehensive review of the multiple benefits of clean energy and the methods available to quantify them. It became a cornerstone resource for EPA's State and Local Energy and Environment Program.

This 2018 edition includes:

- The latest information about the methods analysts can use and the available tools that support them
- New graphics that clearly present steps to quantify benefits and make it easier to understand the process
- Recent real-life examples and case studies where benefits have been quantified

Analysts can use the new *Guide* to learn how to quantify the multiple benefits of energy efficiency and renewable energy initiatives.

Please Note: While the Guide *presents the most widely used methods and tools available to state and local governments for quantifying the multiple benefits of policies, it is not exhaustive. The inclusion of a proprietary tool in this document does not imply endorsement by EPA.*

1.1. OVERVIEW: ASSESSING THE MULTIPLE BENEFITS OF ENERGY EFFICIENCY AND RENEWABLE ENERGY

Across the nation, state and local governments are increasingly adopting and updating policies and programs that encourage energy efficiency and renewable energy to achieve their energy, environmental, and economic goals. As of 2018, more than half of the states are actively implementing:

- Policies and programs to save energy in public-sector buildings and fleets and to improve the operational efficiency and economic performance of states' assets
- Mandatory or voluntary energy efficiency resource standards or targets
- Energy efficiency programs for individuals or businesses
- Mandatory or voluntary renewable portfolio standards (RPSs)
- Financial incentives to individuals, businesses, and/or utilities to encourage renewable energy or energy efficiency (DSIRE, 2018; ACEEE, 2017)

These policies have helped states and localities reduce harmful air pollutants, improve public health, lower energy costs and the costs of compliance with national air quality standards, create jobs, and improve the reliability and security of the nation's energy system.

Although the multiple benefits of these policies are clear in hindsight, some state energy efficiency and renewable energy policies faced initial resistance because the benefits were not fully appreciated or factored into the quantitative comparison of costs and benefits that often drives decision-making. This *Guide* provides valuable information to help analysts and policy makers understand: a range of energy and non-energy benefits associated with energy efficiency and renewable energy, the methods they can use to quantify them credibly, and key considerations for their analyses. With this information, state and local agencies can evaluate options in a more accurate manner by assessing the comprehensive benefits of proposed policies and programs—not just the costs.

WHAT ARE ENERGY EFFICIENCY AND RENEWABLE ENERGY?

The methods described in this *Guide* can be used to assess the impacts of a range of policies, including demand- and supply-side strategies, which generally fall within the following categories:

Energy efficiency reduces the amount of energy needed to provide the same or improved level of service to the consumer in an economically efficient way. Common policies include resource and technology standards, codes, and incentives that can advance the deployment of energy efficient technologies, and practices across all sectors of the economy.

Combined heat and power (CHP), also known as cogeneration, improves the conversion efficiency of traditional energy systems by using waste heat from electricity generation to produce thermal energy for heating or cooling in commercial or industrial facilities.

Demand response measures aim to reduce customer energy demand at times of peak electricity demand to help address system reliability issues; reduce the need to dispatch higher-cost, less-efficient generating units to meet electricity demand; and delay the need to construct costly new generating or transmission and distribution capacity. Demand response programs can include dynamic pricing/tariffs, price-responsive demand bidding, contractually obligated and voluntary curtailment, and direct load control/cycling (FERC, 2017).

Renewable energy is energy generated partially or entirely from non-depleting energy sources for direct end use or electricity generation. Renewable energy definitions vary by state, but usually include wind, solar, and geothermal energy. Some states also consider low-impact or small hydro, biomass, biogas, and waste-to-energy to be renewable energy sources.

Clean **distributed generation** (DG) refers to small-scale renewable energy and CHP at the customer or end use site.

For in-depth information on more than a dozen policies and programs that state policy makers are using to meet their energy, environmental, and economic objectives, see EPA's publication, *Energy and Environment Guide to Action: State Policies and Best Practices for Advancing Energy Efficiency, Renewable Energy, and Combined Heat and Power* at https://www.epa.gov/statelocalenergy/energy-and-environment-guide-action.

1.1.1. Assessing Benefits with Costs

With typical policy analysis, the costs of an energy policy are tallied but the benefits may be underestimated or very limited in scope. A full accounting of costs is necessary, but it does not tell the complete story of how a new policy will affect a state, tribe, or community. Underrepresenting benefits—or not including them at all—in a final analysis hinders clear decision-making and can prevent environmental, energy, and/or economic policy makers from capturing all the potential gains associated with pursuing energy efficiency and renewable energy policies.

Consider a state utility commission that is evaluating whether it should approve a proposed energy efficiency program. The commission will typically require the program administrator to assess the cost-effectiveness of the program. Depending on the approach used by the administrator, the analysis may not include a balanced comparison of costs and benefits. For example, it may include all of the costs associated with the expanded program, along with the savings in electricity and resulting cost savings (i.e., benefits) to businesses and households that are likely to accrue from it, but exclude other benefits (such as health benefits) that arise from emissions reductions and economic benefits that derive from higher demand for energy-efficient equipment and services. Although such a limited analysis is somewhat informative, it overstates the net cost of the program. Quantifying these benefits would more accurately depict the broader value of energy efficiency or renewable energy programs.

In another example, suppose a state energy office is considering the expansion of a solar energy program primarily because the state is looking to diversify electricity generation. As part of its cost-benefit analysis, it may quantify only the additional cost to administer the expanded policy or program, the cost of additional investment in the solar panels, and the direct energy benefits (e.g., the renewable electricity generation). Suppose, however, that the governor has set a priority on job creation in the state and the state air agency is concerned about meeting national air quality goals. If the energy office were to expand its analysis to examine the potential impacts of the initiative on employment or emissions, it could demonstrate how the expanded solar program could help the state achieve other goals. Quantifying the program's multiple benefits, including the non-energy benefits, could facilitate integrated planning across government agencies, enabling states to maximize benefits across numerous priorities and implement fewer policies and programs to achieve their goals.

As these examples illustrate, understanding the full range of emissions reductions and resulting environmental, human health, and/or economic benefits from existing and proposed energy efficiency and renewable energy measures can help planners:

- Identify opportunities to improve the environment and public health, the energy system, and the economy.
- Reduce the compliance costs of meeting air quality standards.
- Demonstrate the broad value of energy efficiency and renewable energy initiatives, including the non-energy benefits, to state and local decision makers.
- Meet multiple goals more easily and at a lower cost than if addressed separately.

Figure I-1: When to Assess the Multiple Benefits of Energy Efficiency and Renewable Energy During the Policy Planning and Evaluation Process

Figure I-1 above depicts the policy, planning, and evaluation process and highlights when quantifying the multiple benefits of energy efficiency and renewable energy typically can be most helpful.

1.1.2. Filling Information Gaps

Why, then, isn't the complete range of benefits included as a standard component of benefit-cost analyses? Perhaps the most common reason is that many policy analysts and policy makers are simply unaware of the many benefits or, if they *are* aware, they don't know how to quantify them credibly.

This *Guide* aims to fill these information gaps for state and local decision makers. This segment, Part One, describes the electricity system, emissions, health, and economic benefits that can result from energy efficiency and renewable energy policies and programs. Part Two, "Quantifying the Benefits: Framework, Methods, and Tools," describes how analysts can quantify these benefits using a range of basic-to-sophisticated approaches. Part Two also includes information about specific tools and data that analysts can use to conduct benefit analyses, and provides case studies illustrating how these tools and data have been used.

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 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, although some of the analytic tools described can be applied more broadly. The *Guide* itself 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.

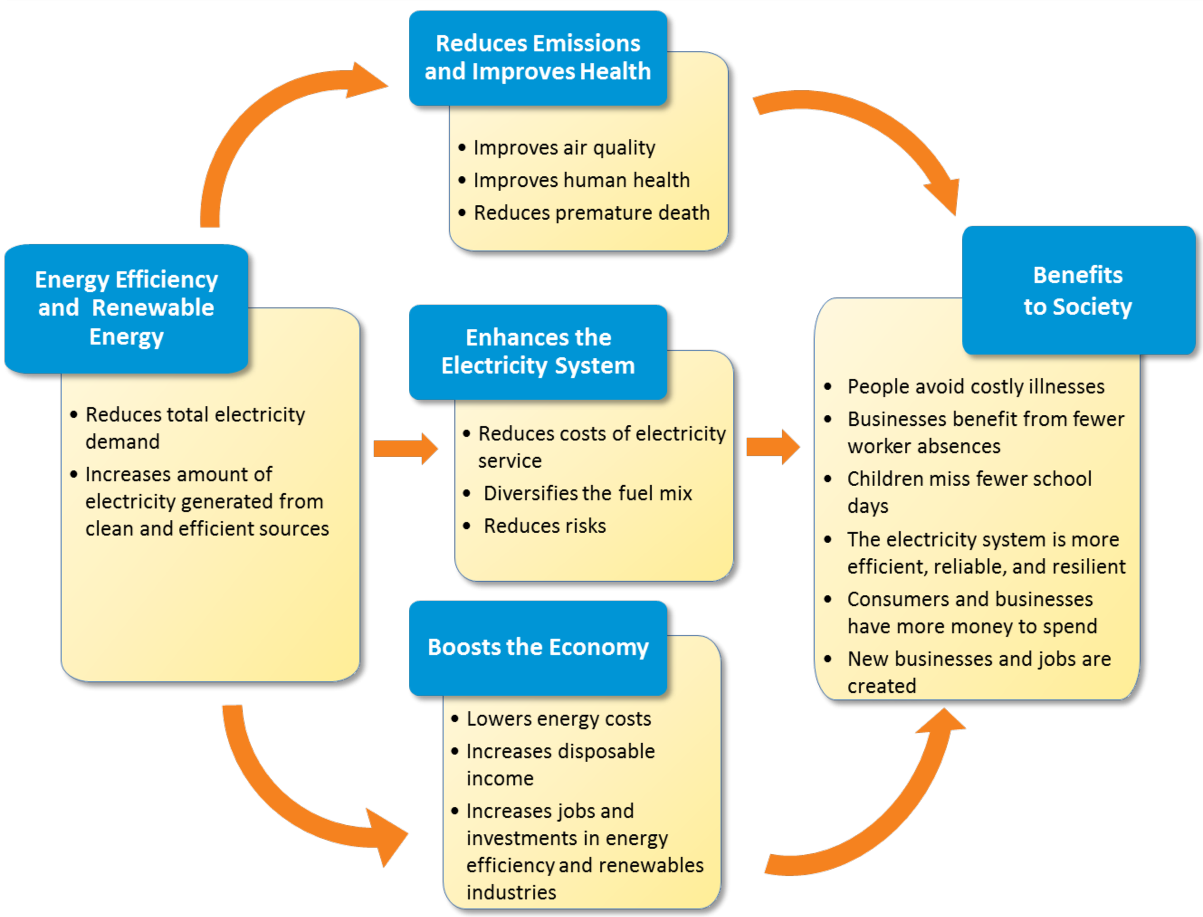
1.2. WHAT ARE THE BENEFITS OF ENERGY EFFICIENCY AND RENEWABLE ENERGY?

Energy efficiency and renewable energy policies can reduce the demand for and supply of energy generated from fossil fuels (e.g., natural gas, oil, and coal-fired power plants). Although this reduction in demand can lead to negative impacts (i.e., losses in revenue to the fossil fuel industry) that should be considered during policy analyses, it can also generate electricity system, emissions, health, and economic benefits for businesses, individuals, and society.

Electricity savings and renewable energy generation provide the basis for estimating the many benefits of energy efficiency and renewable energy to the electricity system, to emissions and public health, and to the economy, as depicted in Figure I-2 and described below.

- *Electricity system benefits*: Energy efficiency and renewable energy initiatives—in combination with demand-response measures—can help protect electricity producers and consumers from the costs of adding new capacity to the system and from energy supply disruptions, volatile energy prices, and other reliability and security risks.
- *Emissions and health benefits*: Fossil fuel-based electricity generation is a source of air pollution that poses risks to human health, including respiratory illness from fine-particle pollution and ground-level ozone (U.S. EPA, 2016a). The burning of fossil fuels for electricity is also the largest source of greenhouse gas (GHG) emissions from human activities in the United States, contributing to global climate change (U.S. EPA, 2017). Improving energy efficiency and increasing the use of renewable energy can reduce fossil fuel-based generation and its associated adverse health and environmental consequences.
- *Economic benefits:* Many of the electricity system, emissions, and health benefits yield overall economic benefits to the state. These benefits include savings in energy and fuel costs for consumers, businesses, and the government; new jobs in, profits for, and tax revenue from companies that support or use energy efficiency and renewable energy, such as construction, manufacturing, and services; and higher productivity from employees and students taking fewer sick days.

Figure I-2: The Multiple Benefits of Energy Efficiency and Renewable Energy

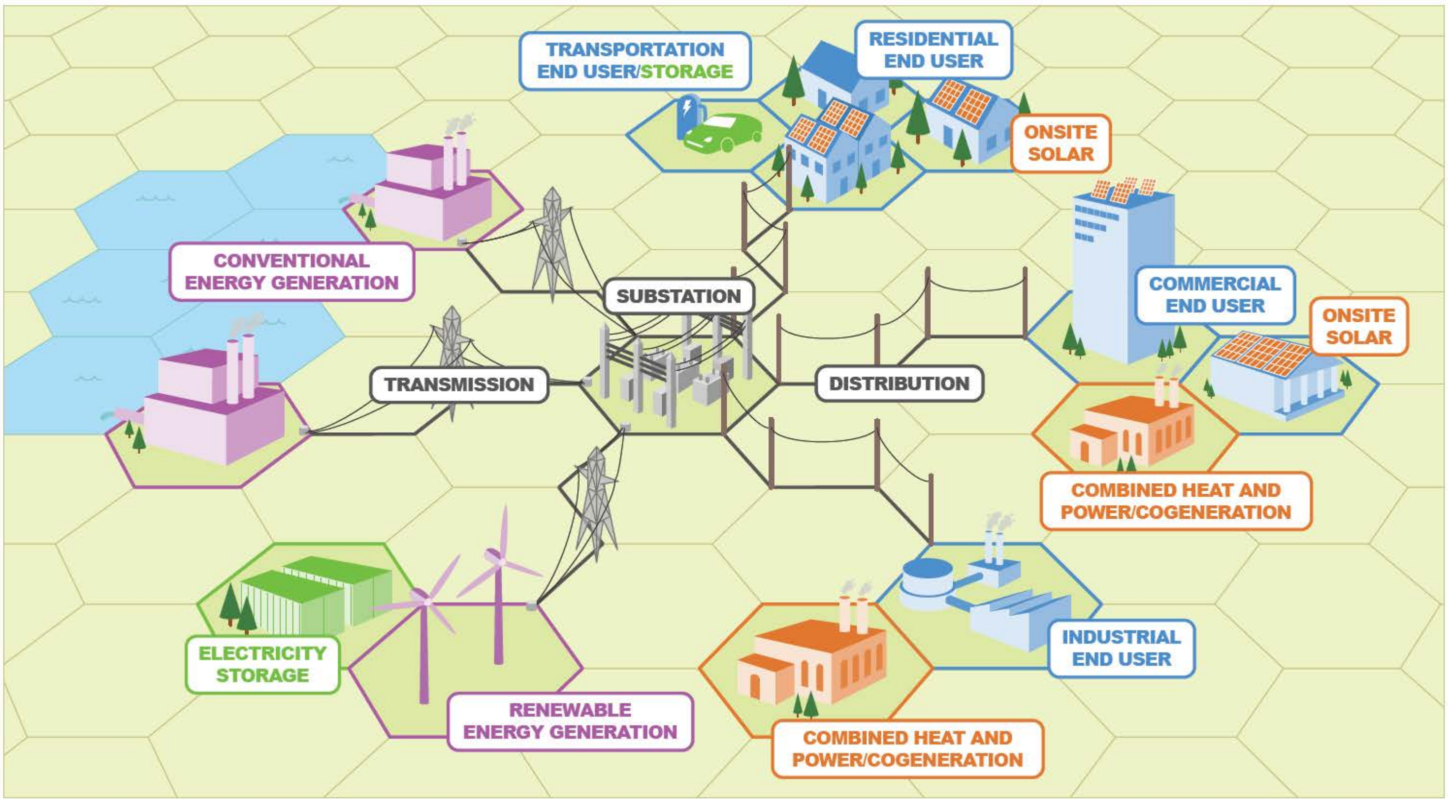


These three types of benefits are described in greater detail on the following pages. As mentioned earlier, descriptions of methods that analysts can use to quantify many of these impacts, as well as available tools, data, and case studies are found in Part Two, "Quantifying the Benefits: Framework, Methods, and Tools," of this *Guide*.

1.2.1. Electricity System Benefits

Energy efficiency and renewable energy initiatives can be cost competitive with other energy options and can provide benefits to the U.S. electricity system (illustrated in Figure I-3). For example, an analysis of 20 state energy efficiency programs found that these programs cost utilities on average 2.3 cents per kilowatt-hour, about one-half to one-third the cost of new resource options such as building power plants (LBNL, 2015; Lazard, 2017).

Figure I-3: The U.S. Electricity System



For more information on the U.S. electricity system, visit: https://www.epa.gov/energy/about-us-electricity-system-and-its-impact-environment.

Energy efficiency and renewable energy initiatives and investments produce both *primary* and *secondary* electricity system benefits.

- *Primary benefits* are those conventionally recognized for their ability to reduce the overall cost of electric service over time, such as the avoided costs of electricity generation or avoiding the need to build new power plants. These benefits can occur over the long run, the short run, or both. Some of these benefits are significant and most can be quantified.
- *Secondary benefits* indirectly reduce electricity system costs (such as deferred long-term investments), increase reliability, and improve energy security. Secondary benefits tend to be harder to quantify and, therefore, are less frequently assessed than primary benefits. Nevertheless, it is useful to identify these benefits and quantify them, when possible, to reflect both the costs and benefits of energy efficiency and renewable energy most accurately.

These benefits are described in greater detail below.

Primary Electricity System Benefits

Primary electricity system benefits of energy efficiency and renewable energy that can be included in a policy analysis include:

- *Avoided costs of electricity generation or wholesale electricity purchases:* Energy efficiency and renewable energy policies and programs can save money by lowering fuel costs and reducing costs for purchased power or transmission services associated with traditional generation.
- *Deferred or avoided costs of expanding power plant capacity:* Energy efficiency and renewable energy can play a critical role in meeting increased demand for electricity, in delaying or avoiding the need to build or upgrade power plants, or in reducing the size of needed additions.[1] This saves on capital investments and annual fixed costs (e.g., labor, maintenance, taxes, and insurance), which can translate into lower customer bills.
- *Avoided electricity loss in transmission and distribution (T&D):* Delivering electricity results in some losses due to the resistance of wires, transformers, and other equipment. For every unit of energy consumption that an energy efficiency initiative avoids or distributed renewable energy resource generates, it also avoids the associated energy loss during delivery of electricity to consumers through the T&D system and reduces waste in the system.[2]
- *Deferred or avoided costs of expanding T&D capacity:* Energy efficiency and renewable energy resources that are located close to where electricity is consumed can delay, reduce, or avoid the need to build or upgrade T&D systems or reduce the size of needed additions as electricity demand increases.[3] These savings can occur over the long run, the short run, or both.

WHOLESALE ELECTRICITY MARKETS AND FORWARD CAPACITY MARKETS

The **wholesale electricity market** operates through an auction system where electricity generators place bids, typically valued at their marginal operating costs (i.e., the operating cost required to produce each Megawatt-hour of electricity), to provide electricity during a specific time period in the near term. The grid operator then dispatches (i.e., assigns) generators, from lowest to highest cost, to meet electricity demand, and compensates all electricity generators at the price paid for the last and most expensive unit of electricity needed to meet demand.

Forward capacity markets—in which electricity system operators solicit bids to meet estimates of future peak electricity needs (typically a few years ahead)—signal future capacity needs. In these markets, energy efficiency and renewable energy resources can compete equally with conventional capacity providers, and thus may reduce the market signal to invest in conventional capacity.

Secondary Electricity System Benefits

Secondary electricity system benefits include:

- *Avoided ancillary service costs:* Ancillary services are electricity system functions that ensure reliability, rather than provide power.[4] Energy efficiency and renewable energy resources that reduce demand and are located close to where electricity is used—or support smooth operation of the power grid—can reduce some ancillary

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[1] Although electricity demand in the United States as a whole has been flat or decreasing for nearly 20 years, the accelerating use of electric vehicles is likely to increase electricity demand over the next five to 10 years. Furthermore, some states or regions may experience increasing demand from population growth.

[2] Renewable central-station generation incurs the same T&D losses as those from fossil fuel-based sources.

[3] In the long run, it is mostly energy efficiency and distributed renewable energy generation capacity that defers T&D costs. Grid-scale renewable energy resources' need for T&D infrastructure is similar to traditional generating units.

[4] Examples of ancillary services include operating reserves (e.g., responding to sudden gaps in supply and demand of electricity) and voltage support (e.g., maintaining voltage levels).

service costs, save fuel, and lower emissions by allowing some units to shut down, and may delay or avoid the need for investment in new generation to provide ancillary services.

- *Lower wholesale market clearing prices:* Energy efficiency and renewable energy policies and programs can lower the demand for electricity or increase the supply of electricity (renewable energy generators typically have little to no marginal operating costs), respectively, causing wholesale markets to clear at lower prices. This benefit can be dramatic during peak hours.
- *Better reliability and power quality:* The electric grid is more reliable if it is under less stress during peak hours, especially in regions where transmission is constrained. Integrating energy efficiency and onsite renewables can increase the reliability of the electricity system, because power outages are less likely to occur when the system is not strained; diversify the generation mix, making the system less vulnerable to outages; and potentially enhance power quality, which is important for the operation of some electrical equipment. For example, energy storage can be used to store excess renewable energy for later use; it can be installed close to where energy will be consumed, potentially alleviating congestion on T&D systems during peak periods. Storage technologies with rapid response capabilities can also be used to help manage fluctuations on the electricity grid caused by the intermittency of some renewable energy resources. Due to their flexibility and ability for rapid response, system operators are exploring automated demand response and storage for better integrating distributed renewable energy resource.
- *Avoided risks related to long lead-time investments:* Decisions to construct new electricity generating units are based on long-term projections of energy demand and electricity sale prices and it is expected that power plants will operate for long periods of time, often as long as 40 years, to fully recover construction and operating costs. Although energy efficiency and renewable energy resources certainly have some risk (e.g., underperformance compared with expectations), they can be attractive alternatives due to their modular nature and their relatively quick installation and disconnection time.
- *Reduced risk by deferring investment in traditional, centralized resources until environmental policies take shape*: Utilities prefer certainty around future legislative and regulatory policies before investing in large, traditional electricity resources. Uncertainty creates risks. As noted above, energy efficiency and renewable energy resources are typically developed at a smaller scale than traditional, centralized resources, and provide an incremental approach to deferring decisions on larger, more capital-intensive projects.
- *Improved fuel diversity:* Utilities that rely on a limited number of power sources can be vulnerable to price, availability, and other risks associated with any single fuel source. In contrast, the costs of energy efficiency and most renewable energy resources, such as solar or wind, are relatively unaffected by prices of other fuels and thus provide a hedge against price spikes. The greater the diversity in technology, the less likelihood of supply interruptions and overall reliability problems.
- *Strengthened energy security:* Due to its critical importance in providing power to the U.S. economy, the electricity system is vulnerable to attacks and natural disasters. Using diverse domestic energy efficiency and renewable energy resources bolsters energy security by reducing the vulnerability of the electricity system when attacks or natural disasters occur.

1.2.2. Emissions and Health Benefits

Energy efficiency and renewable energy can reduce air pollution and its negative consequences. For example, one analysis found that compliance with state RPSs in 2013 reduced national emissions from the power sector by 77,4000 metric tons of sulfur dioxide (SO_2), 43,900 metric tons of nitrogen oxides (NO_x), and 4,800 metric tons of fine particulates

($PM_{2.5}$) (NREL, 2016). Electricity generation is a major source of air pollution, including criteria air pollutants and GHGs. GHGs are also emitted during the refinement, processing, and transport of fossil fuels. These pollutants contribute to many environmental problems that can harm human health, including poor air quality and climate change, as described below.

Criteria Air Pollutants

Criteria air pollutants—such as particle pollution (often referred to as particulate matter or PM), ground-level ozone (O_3), carbon monoxide (CO), SO_2, NO_x, and lead (Pb)—lower air quality and can be harmful to human health.[5] Using fossil fuels to generate electricity increases levels of these pollutants in the atmosphere. Once emitted, some criteria air pollutants circulate widely, potentially for long distances.

Some "primary" air pollutants (e.g., PM, CO, SO_2, and NO_x), are directly harmful to people and the environment. Other "secondary" air pollutants form in the air when primary air pollutants and other precursor air pollutants, such as volatile organic compounds (VOCs), react or interact. For example, primary air pollutants such as NO_x and VOCs react under certain weather conditions to form O_3, a secondary air pollutant. O_3 is a principal component of photochemical smog that can cause coughing, throat irritation, difficulty breathing, lung damage, and can aggravate asthma (U.S. EPA, 2016c).[6] $PM_{2.5}$ is also a secondary air pollutant of particular concern because of its prevalence and links with many respiratory and cardiovascular illnesses and death (U.S. EPA, 2016b).[7]

Criteria air pollutants have local and regional effects and can dissipate in hours or days, so reducing them can have immediate positive benefits. Policies and programs that avoid or reduce the use of fossil fuel energy and criteria air pollutants, such as energy efficiency and renewable energy initiatives, can:

- *Improve air quality* by reducing or avoiding harmful criteria air pollutants, which yields direct and immediate health benefits to people, as described below. Air quality improvements can also strengthen ecosystems' health, increase crop and timber yields, and increase visibility.
- *Enhance public health* by reducing incidences of premature death, asthma attacks, and respiratory and heart disease; avoiding related health costs; and reducing the number of missed school and workdays due to illnesses.

Hazardous Air Pollutants

Hazardous air pollutants (HAPs), also known as toxic air pollutants or air toxics, are pollutants that are known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects. HAPs, such as mercury, can be by-products of fossil fuel-based electricity generation. For example, in the United States, power plants that burn coal to create electricity account for about 42 percent of all manmade mercury emissions (U.S. EPA, 2016a). Mercury exposure at high levels can harm the brain, heart, kidneys, lungs, and immune system of people of all ages.

Energy efficiency and renewable energy policies and programs that reduce emissions of mercury and other HAPs can help avoid the negative health impacts of exposure.

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[5] *The Clean Air Act requires EPA to set National Ambient Air Quality Standards for these air pollutants. EPA calls these pollutants "criteria" air pollutants because it regulates them by developing human health-based and/or environmentally based criteria (i.e., science-based guidelines) for setting permissible levels.*
[6] *Tropospheric O_3 also acts as a strong GHG.*
[7] *Different components of $PM_{2.5}$ have both cooling (e.g., sulfates) and warming (e.g., black carbon) effects on the climate system.*

Greenhouse Gases

GHGs—such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), and sulfur hexafluoride (SF_6)—trap heat in the atmosphere that would otherwise escape to space, and contribute to climate change. GHGs from natural sources help keep the Earth habitable, as the planet would be much colder without them. However, GHGs from human activities, such as from electricity generation, are building up in the atmosphere and contributing to climate change.[8] In the United States, the combustion of fossil fuels to generate electricity was the largest single source of CO_2 emissions in 2015, accounting for about 35 percent of total U.S. CO_2 emissions and 29 percent of total U.S. GHG emissions (U.S. EPA, 2017).

Increasing GHG emissions changes the climate system in ways that affect our health, environment, and economy. For example, climate change can influence crop yields, lead to more frequent extreme heat waves, and make air quality problems worse. CH_4, a potent GHG, also contributes to the formation of ground-level ozone, which is a harmful air pollutant and component of smog.

GHGs accumulate and can remain in the atmosphere for decades to centuries, affecting the global climate system for the long term. Because of this, measures like energy efficiency and renewable energy that immediately avoid or reduce GHGs can create long-lasting and positive benefits for the atmosphere and human health while also achieving short-term air quality and health benefits.

Regional Haze

When sunlight encounters tiny pollution particles in the air, haze forms and reduces the clarity and color of what humans see. PM pollution is the major cause of reduced visibility (haze) in parts of the United States, including many of our national parks.

Air pollutants that create haze come from a variety of natural sources, such as soot from wildfires, and manmade sources, such as motor vehicles, electric utility and industrial fuel burning, and manufacturing operations. Some of the pollutants that form haze have also been linked to serious health problems and environmental damage, as described earlier. In addition, particles such as nitrates and sulfates contribute to acid rain formation, which makes lakes, rivers, and streams unsuitable for many fish, and erodes buildings, historical monuments, and paint on cars.

Policies and programs that avoid or decrease the PM pollution, like energy efficiency and renewable energy initiatives, can also reduce haze and acid rain, and lessen negative health impacts.

1.2.3. Economic Benefits

Energy efficiency and renewable energy initiatives can provide a number of important economic benefits for people, communities, and entire state economies. For example, a study conducted for Efficiency Vermont, the nation's first energy efficiency utility, found that every $1 million in efficiency program spending in Vermont creates a net gain of 43 job-years. Every $1 of program spending yields a net increase of nearly $5 in cumulative gross state product, an additional $2 in Vermonters' incomes over 20 years, and more than $6 in gross energy savings (Optimal Energy and Synapse Energy, 2011).

Energy efficiency and renewable energy initiatives affect the economy both *directly* and *indirectly*, by affecting individuals, businesses, or institutions directly involved in the investment as well as by having an effect on others who

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[8] The International Panel on Climate Change (IPCC) has concluded that human-caused GHG emissions are extremely likely—defined as having a greater than 95 percent probability of being true—to be responsible for more than half of the observed increase in global average temperatures since the mid-20th century (IPCC, 2014).

are less directly involved.[9] This section provides an overview of the direct and indirect economic effects of energy efficiency and renewable energy initiatives that are used to quantify the economic benefits. They are briefly summarized in Table I-1.

Table I-1: Summary of Economic Effects from Energy Efficiency and Renewable Energy Initiatives

<table>
<tr><th rowspan="2">Type of Policy or Program</th><th colspan="3">Economic Effects</th></tr>
<tr><th>Direct</th><th>Indirect</th><th>Both Direct and Indirect</th></tr>
<tr><td>Demand-side</td><td>▪ Household and business costs
▪ Program administrative costs
▪ Energy cost savings to households and businesses
▪ Sector transfers</td><td rowspan="2">▪ Increased disposable income
▪ Increased income, employment, and output in some industries
▪ Reduced cost of doing business
▪ Decreased income, employment, and output in some industries
▪ Expanded in-state market for some products and services, and attraction of new businesses and investment</td><td rowspan="2">▪ Health
▪ Employment
▪ Output
▪ Gross state product
▪ Income</td></tr>
<tr><td>Supply-side</td><td>▪ Construction costs
▪ Operating costs
▪ Program administrative costs
▪ Displacement savings
▪ Waste heat savings</td></tr>
</table>

Direct Economic Effects

Direct effects include changes in sales, income, or jobs associated with the immediate effects of an expenditure or change in demand. The direct effects of policies or programs that affect energy *demand*, such as those that stimulate investments in energy-efficient equipment by the commercial or residential sectors, will differ from the direct effects of initiatives that affect the *supply* of energy, such as RPSs.

Direct Economic Effects of Demand-Side Initiatives

Energy efficiency and renewable energy initiatives that affect the demand (or customer) side of energy services typically change the energy consumption patterns of business and residential consumers by reducing the quantity of energy required for a given level of production or service. Demand-side energy efficiency initiatives lead to direct costs and savings, including:

- *Household and business costs:* Costs for homeowners and businesses to purchase and install more energy-efficient equipment. For policies supported by a surcharge on electric bills, the surcharge is an included cost.
- *Program administrative costs:* Dollars spent operating the efficiency initiative—including labor, materials, and paying incentives to participants.
- *Energy cost savings:* The money saved by businesses, households, and industries resulting from reduced energy costs (including electricity, natural gas, and oil cost savings), reduced repair and maintenance costs, deferred equipment replacement costs, and increased property values. Energy cost savings are typically reported in total dollars saved.

[9] *Some analyses describe a third type of impact, induced effects. Induced effects result from the additional purchases of goods and services by consumers and governments that are affected directly or indirectly by the energy efficiency or renewable energy policy (e.g., increased wage income is spent on additional goods). These effects are typically called out by input-output modelers, while other analyses do not highlight them explicitly. In this chapter, induced effects are included under the indirect effects category unless indicated otherwise.*

- *Sector transfers:* Both the increased flow of money to companies that design, manufacture, and install energy-efficient equipment and the reduced flow of dollars to other energy companies, including electric utilities, as demand for electricity and less-efficient capital declines.

These direct costs and savings shift economic activity among different players in the economy. For example, households may increase spending on products that improve energy efficiency, such as foam insulation, as a result of a particular energy efficiency program, increasing revenue for the companies that produce and install foam insulation. To pay for the cost of the insulation, they may reduce spending on other goods and activities, lowering revenue for those businesses that would have otherwise received it. The stream of energy cost savings that results from the insulation may increase disposable income that households can spend on other goods and services. The reduced demand for electricity, however, may decrease revenue for utilities unless the state's utility revenue structures allow for program cost recovery or financial incentives for energy efficiency programs.[10] Together, the shifts caused by demand-side initiatives may result in economy-wide macroeconomic impacts, such as effects on income, employment, and overall economic output. An analysis of the magnitude and direction of the impacts can help policy makers design policies that provide the greatest overall benefit to a state or locality.

Direct Economic Effects of Supply-Side Initiatives

Supply-side energy efficiency and renewable energy policies and programs change the fuel and generation mix of energy resources or otherwise alter the operational characteristics of the energy supply system. Supply-side policy measures generally support the development of utility-scale renewable energy and combined heat and power (CHP) applications, and/or clean distributed generation (DG). The direct effects of supply-side initiatives arise from the costs of manufacturing, installing, and operating the renewable energy or CHP equipment supported by the initiative, as well as the energy savings and possible reduction of energy supply costs from fuel substitution among participants in the supply-side program and their customers. The direct costs and savings of renewable energy, CHP, and DG initiatives include:

- *Construction costs:* Money spent to purchase the renewable energy, CHP, and DG equipment; installation costs; costs of grid connection; and onsite infrastructure construction costs (such as buildings or roads)
- *Operating costs:* Money spent to operate and maintain the equipment during its operating lifetime and the cost of production surcharges applied to consumers
- *Program administrative costs:* Money spent operating the initiative—including labor, materials, and paying incentives to participants
- *Displacement savings:* Money saved by utilities from displacing traditional generation, including reducing purchases (either local or imports) of fossil fuels and lowering operation and maintenance costs from existing generation resources
- *Waste heat savings:* Savings accrued by utilities or other commercial/industrial businesses that use waste heat from CHP for both heating and cooling

Together, the shifts caused by supply-side initiatives may affect income, employment, and economic output in the state through the following factors:

- Increased economic activity in the renewable energy industry for both in-state and export markets

[10] At least 27 states have offered utilities the opportunity to benefit financially from operating effective energy efficiency programs. These financial incentives reward utilities based on the level of energy savings produced and/or cost-effectiveness of their energy efficiency programs (ACEEE, 2015). It is important to consider each individual state's utility revenue structure when exploring the effect of energy efficiency and renewable energy programs.

- Reduced spending on fossil fuel imports (or increased inflow of dollars for fossil fuel exports, if a state is a net fossil fuel exporter), allowing those dollars to remain within the state

Indirect Economic Effects

Indirect effects include "upstream" or "downstream" changes in sales, income, or jobs resulting from changing input needs in affected sectors. Indirect effects start to emerge once the direct effects interact with the overall state, local, or regional economy.

Upstream effects occur among businesses supplying goods and services to industries directly involved in the energy efficiency or renewable energy initiative. For example, the construction of roads and foundations for a wind farm requires purchases of asphalt and cement from other economic sectors, which in turn must make purchases to support operations. Downstream effects occur as the regional economy responds to lower energy costs, a more dependable energy supply, and a better economic environment that fosters expansion and attracts new business growth opportunities. Downstream indirect effects may include:

- Increased disposable income available for non-energy purchases[11]
- Increased income, employment, and output by stimulating production and sales of renewable energy and energy-efficient equipment by existing businesses within the state
- Reduced cost of doing business and improved overall competitiveness for non-energy companies
- Decreased income, employment, and output for fossil fuel producers and their suppliers within the state
- Expanded in-state market for renewable energy and/or energy efficiency products and services, and attraction of new businesses and investment[12]

Both Direct and Indirect Economic Effects

Some effects may be both direct and indirect, and apply to both demand and supply policies and programs. Examples of these types of benefits include:

- *Health*: Energy efficiency and renewable energy policies that reduce criteria air pollutants may improve air quality and avoid illnesses and deaths, as described above. Fewer illnesses mean fewer sick days taken by employees, better productivity, and fewer hospitalizations associated with respiratory illnesses and cardiac arrest. Fewer worker deaths can result in continued economic benefits to the state.
- *Employment*: Energy efficiency and renewable energy initiatives create jobs. These jobs can be temporary, short-term jobs as well as long-term jobs—created directly from the energy efficiency and renewable energy activities (e.g., in a company that expands due to increased demand for their products) and indirectly via economic multiplier effects (e.g., from restaurants and retail stores who get more customers because of new jobs).
- *Output*: Energy efficiency and renewable energy programs that stimulate new investments and spending within a state can increase output, which is defined as the total value of all goods and services produced in an economy, including all intermediate goods[13] purchased and all value added. Higher sales for energy-efficient or

[11] *An increase in disposable income may be reduced by any program costs imposed. Generally, however, the net effect to consumers of energy efficiency programs is positive (Browne, Bicknell, and Nystrom, 2015; IEA, 2014).*
[12] *See also MTC (2005) and Heavner and Del Chiaro (2003) for additional information on evaluating energy efficiency and renewable energy market potential and fostering so-called "clean energy clusters."*
[13] *Intermediate goods are products that are used as inputs in the production of other products, such as steel used to manufacture cars or bricks used to build houses.*

renewable energy goods in the local economy, increased government spending, bigger investment levels, and higher exports of energy efficiency or renewable energy products by state industries will enhance output.

- *Gross state product*: Expansion of energy efficiency and renewable energy-related investments and businesses can increase the total market value of the goods and services produced by labor and property in a state (i.e., gross state product). The gross state product is analogous to the national concept of gross domestic product and represents the state's economic output minus any intermediate inputs acquired from beyond the state.
- *Income*: A net increase in income associated with energy efficiency and renewable energy initiatives can occur due to increased employment or wages. Income effects from energy efficiency and renewable energy investments include changes in personal income or disposable income. Personal income is the sum of all income received. Disposable income is the income that is available for consumers to spend or save; that is, personal income minus taxes and social security contributions plus dividends, rents, and transfer payments.

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