State and Local Climate and Energy Program

Assessing the Multiple Benefits of Clean Energy

A RESOURCE FOR STATES

U.S. ENVIRONMENTAL PROTECTION AGENCY

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A RESOURCE FOR STATES

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Preface

State clean energy initiatives can produce significant savings in fuel and electricity costs, as well as other benefits to the electric system, the environment and public health, and the economy.

Assessing the Multiple Benefits of Clean Energy: A Resource for States helps state energy, environmental, and economic policy makers identify and quantify the many benefits of clean energy to support the development and implementation of cost-effective clean energy initiatives.

This *Resource* identifies the multiple benefits of clean energy and explains why they should be quantified and considered along with costs. It starts by presenting clear, easy-to-understand background information on each type of benefit to help non-specialists understand how the benefits are generated and what can be done to maximize them. Building on that foundation, the *Resource* describes analytic options that states can explore as they conduct and review analyses of clean energy initiatives. It provides a framework for assessing multiple benefits, presenting detailed information on basic and more sophisticated approaches along with descriptions of tools for quantifying each type of benefit. It also includes many examples of how states have used multiple benefits approaches, along with additional resources for more information.

This groundbreaking document is the first to organize and present a comprehensive review of the multiple benefits of clean energy, together with an analytical framework that states can use to assess those benefits during the development and implementation of clean energy policies and programs. *Please Note: While the* Resource *presents the most widely used methods and tools available to states for assessing the multiple benefits of policies, it is not exhaustive. The inclusion of a proprietary tool in this document does not imply endorsement by EPA.*

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CHAPTER ONE

Introduction

Across the nation, states are considering and implementing a variety of clean energy (CE) policies and programs using energy efficiency, renewable energy, combined heat and power (CHP) and clean distributed generation (DG) to meet energy goals such as providing affordable, clean, and reliable energy for their citizens. These policies and programs offer multiple benefits through their ability to:

- Reduce demand for energy;
- Decrease stress on the energy system;
- Mitigate climate change, environmental degradation, and related human health concerns; and
- Promote economic development.

By including the broader set of benefits in the cost-benefit analyses conducted during planning processes, states get more comprehensive assessments of their potential CE investments and are:

- Demonstrating how clean energy policies and programs can help achieve multiple state energy, environmental, and economic benefits in a cost-effective way;
- Designing or selecting clean energy options that offer greater energy, environmental, and economic benefits;
- Identifying opportunities where clean energy can be used to support energy system, environmental, and/or economic development planning strategies across the state; and
- Building support for clean energy policies and programs.

DOCUMENT MAP

CHAPTER ONE CONTENTS

WHAT IS CLEAN ENERGY?

Clean energy includes demand- and supply-side resources that meet energy demand with less pollution than that created by conventional, fossil-based generation. Clean energy resources include:

Energy efficiency (EE) – refers to using less energy to provide the same or improved level of service to the energy consumer in an economically efficient way. Energy efficiency measures include a wide variety of technologies and processes, can be implemented across all major energy-consuming sectors, and may affect all energy sources (e.g., natural gas, electricity, etc).

Renewable energy (RE) – 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. Renewable energy can be generated on site or at a central station.

Combined heat and power (CHP) – also known as cogeneration, CHP is a clean, efficient technology that 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. CHP systems typically achieve 60% to 80% efficiencies, which is significantly higher than those of conventional power plants and separate steam units (*http://www.epa.gov/chp/*).

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

For more information, visit the U.S. Environmental Protection Agency's (EPA's) State & Local Climate Web site (*www.epa.gov/statelocalclimate*) and the ENERGY STAR® Web site (*http://www.energystar.gov/*).

STATE CLEAN ENERGY POLICIES AND PROGRAMS

States implement many policies and programs to advance clean energy, including:

- "Lead By Example" programs where the state increases the use of clean energy in its own government operations, fleets, and facilities;
- Regulatory approaches such as renewable or energy efficiency portfolio standards, appliance standards, building codes, interconnection standards; and
- Funding and incentive programs such as public benefits funds, tax incentives, grants, and revolving loan funds.

For more information on clean energy polices and programs, go to:

- EPA State & Local Climate Web site. *www.epa.gov/statelocalclimate/*
- *Clean Energy-Environment Guide to Action: Policies, Best Practices, and Action Steps for States* (U.S. EPA, 2006). *www.epa.gov/statelocalclimate/resources/action-guide.html*
- *State Clean Energy Lead by Example Guide* (U.S. EPA, 2009). *www.epa.gov/statelocalclimate/resources/example.html*

Assessing the Multiple Benefits of Clean Energy: A Resource for States provides states with a framework for evaluating the potential costs and benefits of their clean energy goals, policies, and programs. It shows state analysts how the prospective costs and benefits are derived, enabling them to conduct and manage analyses, review cost and benefit estimates presented to them, and make recommendations about the clean energy options the state should explore or the appropriate evaluation approaches and tools to use. This *Resource*:

- Describes both simple and more sophisticated methods for assessing these benefits;
- Provides guidance on how to choose among methods;
- Presents examples of how states are conducting multiple benefits analysis and using it to promote clean energy within their states; and
- Offers a wealth of resources, including links to analytical tools, guidance, and studies.

While clean energy resources are broad in source and impact, this *Resource* focuses on guidance for estimating impacts on the electricity system from energy efficiency and other clean energy resources that affect the power system. This focus is not meant to diminish the importance of other clean energy resources—including energy efficiency that reduces demand for both electricity and fossil fuels, and energy supplies from renewables and more efficient use of fossil fuels—but reflects the more complex nature of the analysis required to estimate impacts on the electric system.

This chapter provides an introduction to assessing the multiple benefits of clean energy, including:

- A description of the multiple benefits of clean energy that are covered in this *Resource*, along with examples of the findings from studies that have estimated the actual and potential benefits of a variety of state and regional clean energy initiatives (Section 1.1).

- A discussion of why it is important for states to assess the multiple benefits of clean energy (Section 1.2).

- An overview of the process and approaches involved in prospectively assessing the multiple benefits of clean energy (Section 1.3).

The remainder of the document provides much more detail about estimating potential energy savings of clean energy (Chapter 2) and about assessing the future electric system (Chapter 3), environmental (Chapter 4), and economic (Chapter 5) benefits introduced in this chapter.

1.1 WHAT ARE THE MULTIPLE BENEFITS OF CLEAN ENERGY?

Clean energy affects the demand for and supply of conventional energy and can result in positive effects on the energy system, the environment, and the economy. To quantify these benefits, it is first necessary to understand how they are produced through energy savings and renewable energy generation.

1.1.1 ENERGY SAVINGS AND RENEWABLE ENERGY GENERATION: THE FOUNDATION FOR BENEFITS

Clean energy initiatives reduce energy consumption from fossil fuel generation in two ways:

- Energy efficiency policies and programs lead to direct reductions in energy consumption, which in turn reduces generation requirements.

- Renewable energy and clean distributed supply resources increase the amount of energy from clean (and more efficient) rather than conventional sources.

> **Demand-side initiatives** usually change the end-use efficiency of energy consumption.
>
> **Supply-side initiatives** usually change the fuel/generation mix of energy supply resources.

States have significant experience quantifying the actual and potential energy impact of clean energy policies. For example:

- A program evaluation of the New York State Energy Research and Development Authority's (NYSERDA) New York Energy $mart[SM] Program estimated the cumulative annual electricity savings achieved through 2007 at 3,060 GWh from energy efficiency, distributed generation, and combined heat and power. The cumulative annual renewable energy generation through 2007 was 106 GWh (NYSERDA, 2008). Combined, these resources are equivalent to about 2 percent of the amount of electricity generated in New York in 2006.[1]

Energy savings and renewable energy generation are important results of state clean energy initiatives and the basis for estimating many of the other benefits of clean energy to the energy system, environment and public health, and the economy. For example:

- An energy efficiency assessment study of the opportunities in the Southwest showed that widespread adoption of cost-effective, commercially available energy efficiency measures in homes and businesses would reduce electricity consumption by 18 percent in 2010 and 33 percent in 2020 with a $9 billion investment. These energy savings would avoid $25 billion in annual electricity supply costs and $2.4 billion in annual natural gas costs (SWEEP, 2002).

This section briefly describes each type of benefit. It also provides examples from recent studies that offer estimates of the multiple benefits of state and regional clean energy programs. A full list of all studies mentioned is presented in Appendix A, *Clean Energy Studies: Summary of Benefits Analyses and Findings.* Additional information about the different types of clean energy options available to states is provided in Appendix A.

1.1.2 ENERGY SYSTEM BENEFITS

Clean energy initiatives—in combination with demand response measures[2] —can help protect electricity producers and consumers from the costs of adding

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[1] *Patterns and Trends: New York State Energy profiles: 1992-2006. New York State Energy Research Development Authority. January 2008.* ***http://www.nyserda.org/publications/Patterns%20&%20Trends%20Final%20-%20web.pdf****.*

[2] *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 (DRAM, 2005).*

CONNECTICUT INCORPORATES MULTIPLE BENEFITS IN EVALUATION CRITERIA FOR NEW CAPACITY ADDITIONS

In June 2005, Connecticut policymakers enacted Public Act 05-01, *An Act Concerning Energy Independence* (EIA), which authorized the Connecticut Department of Public Utility Control to launch a competitive procurement process geared toward motivating new supply-side and demand-side resources in order to reduce the impact of Federally Mandated Congestion Charges on Connecticut ratepayers.

As part of the bid evaluation process, each capacity project is scored based on a multiple benefits weighting system:

- A total of 85% of the evaluation score is based on a benefit-cost analysis of the project.
- A total of 15% of the evaluation score is determined through the assessment of five other criteria with their associated weights:
  - Reduced emissions of SO_2, NO_x, and CO_2 – 5%
  - Use of existing sites and infrastructure – 2.5%
  - Benefits of fuel diversity – 2.5%
  - Front-loading of costs – 2.5%
  - Other benefits (e.g., transmission reliability, employment effects, benefits of high level efficiency such as CHP) – 2.5%

For more information, visit Connecticut's RFP website: *http://www.connecticut2006rfp.com/index.php*

new capacity to the system and from energy supply disruptions, volatile energy prices, and other reliability and security risks. The following four energy system benefits are usually recognized as important ways for clean energy initiatives to reduce the overall cost of electric service over time.

- *Avoided energy generation or wholesale energy purchases*. Clean energy measures can displace energy, specifically electricity, generated from fossil fuels (e.g., natural gas, oil, and coal fired power plants). Savings include avoided fuel costs and reduced costs for purchased power or transmission service.
- *Avoided or reduced need for additional power plant capacity*. Clean energy measures can delay or avoid the need to build or upgrade power plants or reduce the size of needed additions.
- *Avoided or deferred transmission and distribution (T&D) investments*. Clean energy measures, such as customer-sited renewables and clean DG (including CHP), which are sited on or near a constrained portion of the T&D system can delay or avoid the need to build or upgrade T&D systems or reduce the size of needed additions.
- *Avoided energy loss during transmission and distribution (T&D)*. The delivery of electricity results in some losses due to the resistance of wires, transformers, and other equipment. For every unit of energy consumption that a clean energy resource avoids, it has the potential to reduce the associated energy loss during delivery of energy to consumers through the T&D system. Distributed resources also reduce these losses by virtue of being closer to the load.

Many state-level clean energy analyses currently do not quantify emission-related health effects—a clear gap in analysis and understanding.

This gap can be addressed using EPA tools such as COBRA and BenMAP, described in Chapter 4, Assessing the Air Pollution, Greenhouse Gas, Air Quality and Health Benefits of Clean Energy Initiatives.

Other energy system benefits that can accrue from clean energy programs include avoided ancillary service costs, reductions in wholesale market clearing prices, increased reliability and power quality, avoided risks (e.g., risks associated with the long lead-time investments for conventional generation and from deferring investments until environmental and climate change policies are known), and improved fuel and energy security.

Many state and regional studies have quantified these benefits. These studies include:

- A study of the Million Solar Roofs initiative in California estimated that the program resulted in avoided capacity investments of about $7.1 million from 2007–2016 (Cinnamon et al., 2005).
- A study of widespread energy efficiency deployment in the Southwest (introduced in the previous section), used the calculated potential energy savings to estimate avoided capacity investments of about $10.6 billion by 2020 (SWEEP, 2002).

Analyses also illustrate how clean energy programs can improve the security, diversity, and overall reliability of a state's energy system, which remains a critical energy policy objective in light of the vital link between electric reliability and economic security.

CLEAN ENERGY INITIATIVES CAN BENEFIT ECONOMIC DEVELOPMENT

A 2007 study by the American Solar Energy Society assessed the renewable energy and energy efficiency market and developed forecasts of the market's future economic growth. The study established a baseline of 2006 data describing the size and scope of the renewable energy and energy efficiency industry, and forecast the growth of the renewable energy and energy efficiency industry from this baseline to 2030 under three different scenarios.

Using this approach, the authors developed a case study for Ohio, an area hard hit by the loss of manufacturing jobs. In 2006 in Ohio, gross revenues for renewable energy totaled nearly $800 million and the renewable energy industry created more than 6,600 jobs, including increased employment among scientific, technical, professional, and skilled workers. The analysis concluded that the energy efficiency and renewable energy industries offer significant development opportunities in the state. In 2030, the renewable energy industry in Ohio could generate nearly $18 billion in revenues and 175,000 jobs annually, and the energy efficiency industry could generate more than $200 billion in revenues and more than 2 million jobs annually.

Source: Bezdek, 2007.

- The financial implications of the East Coast blackout in August 2003 help illustrate the importance of a reliable energy system: the blackout, which lasted a couple of days and affected about 20 percent of the U.S. population, was estimated to result in economic losses of $4.5 to $10 billion (Conaway, 2006).

- A study of the energy system benefits of energy efficiency and renewable energy in New England from Public Benefits Funds (PBFs) programs and Renewable Portfolio Standards (RPS) concluded that— based on 2004 forecasts from the Capacity, Energy, Load and Transmission (CELT) report from ISO-New England—regional demand-side management activities would reduce peak demand by 1,421 MW from a forecasted peak of 27,267 MW, a reduction of about 5 percent (RAP, 2005).

1.1.3 ENVIRONMENTAL AND HEALTH BENEFITS

Fossil fuel-based electricity generation is a major source of air pollutants that pose serious risks to public health, such as increased respiratory illness from fine-particle pollution and ground-level ozone. Fossil fuel-based generation is also a major source of greenhouse gases (GHGs), such as CO_2, which contribute to global climate change. States concerned about emissions are turning to clean energy technologies to limit pollution and improve air quality and public health. The air and health benefits of clean energy are summarized below.

- *Reduced criteria air pollutant and GHG emissions.* This *Resource* focuses on two categories of air emissions from the electricity sector: criteria air pollutant emissions, and GHG emissions. In the electricity sector, clean energy resources can reduce these emissions by displacing fossil fuel generation.[3] Reduced emissions of criteria air pollutants—ozone (O_3), carbon monoxide (CO), nitrogen oxides (NO_X), sulfur dioxide (SO_2), particulate matter (PM), and lead (Pb)—are linked directly to changes in air quality and public health effects.[4] State actions to reduce GHG emissions are tied to reducing the risk of global climate change and generally focus on reducing emissions of CO_2. Criteria and GHG emission reductions are usually measured in tons or as a percentage of some baseline level of emissions.

- *Improved air quality.*[5] Reduced emissions of criteria pollutants lead to fewer unhealthy air quality days and lower the incidence of public health effects associated with them. Ambient air concentrations of criteria pollutants are usually measured in "parts-per" units such as ppm (parts per million) or in

3 *It is important to note that estimating reductions in emissions from clean energy in the presence of market-based emissions programs, such as a cap and trade program, is more complicated. In the presence of an emissions cap and trade program (for example the SO_2 cap and trade program under Title IV of the Clean Air Act Amendments), sources affected by the cap scale back the amount of electricity they generate from affected sources and therefore reduce overall emissions as a result of clean energy. However, because the program allows these sources to emit up to the number of allowances they hold, they may adjust their compliance decisions in a way that allows them to generate these reduced levels of electricity at a higher emissions rate and reduce compliance costs. The allowance price would in theory be reduced. There are ways to capture the environmental benefits from clean energy for pollutants' affected market programs, such as retiring a portion of the allowance associated with the reduction. See Guidance on SIP Credits for Emissions Reductions from Electric Sector Energy Efficiency and Renewable Energy. U.S. EPA, Office of Atmospheric Programs, August 5, 2004.* ***http://www.epa.gov/ttncaaa1/t1/memoranda/ereseerem_gd.pdf***

4 *In addition to being a major source of criteria air pollutants and greenhouse gases, coal-burning power plants are the largest human-caused source of mercury emissions to the air in the United States, accounting for over 50% of all domestic human-caused mercury emissions (**http://cfpub.epa.gov/eroe/index.cfm?fuseaction=detail.viewInd&lv=list.listByAlpha&r=188199&subtop=341**). This Resource, however, does not address methods to assess hazardous air pollutants, like mercury.*

5 *Improved air quality represents only one of a broad set of environmental benefits that may accompany clean energy development. Other potential benefits include improved water quality and improved aquatic habitat. This* Resource *focuses on improved air quality and human health*

mass per volume units such as μg/m^3 (micrograms per cubic meter).[6]

- *Improved public health.* Improvements in air quality can reduce the adverse public health effects resulting from exposure to air pollution and reduce the costs of associated public health risks. Public health effects include premature mortality and exacerbation of health conditions such as asthma, respiratory disease, and heart disease.

Studies of the environmental benefits of clean energy initiatives tend to either focus on specific emission reduction objectives or analyze the overall emission reductions of multiple pollutants, including GHGs and criteria pollutants. Examples of these studies include:

- A Texas Emissions Reduction Plan (TERP) analysis in 2004 assessed the potential for clean energy to help meet NO_X air quality requirements as part of a State Implementation Plan (SIP) and found that NO_X emissions would be reduced by 824 tons per year in 2007 and 1,416 tons per year in 2012 (Haberl et al., 2004). Texas NO_X emissions from electricity generation were 140,676 tons in 2005, so these reductions represent 0.5 percent and 1 percent of 2005 emissions, respectively (USEPA, 2007).

- A 2007 Wisconsin study measured CO_2, SO_2, and NO_X emission reductions from the state's *Focus on Energy* program and found annual emission displacements of 1,365,755 tons of CO_2, 2,350 tons of SO_2, and 1,436 tons of NO_X from 2001 through 2007 (Wisconsin, 2007).[7] These reductions respectively represent about 2 percent, 1 percent, and 2.5 percent of Wisconsin emissions in 2005 (USEPA, 2007).

These and other studies demonstrate that clean energy initiatives can reduce emissions of both criteria air pollutants and GHGs. States may thus find it valuable to quantify the full range of emission benefits for policy support purposes.

Fewer studies have quantified the public health benefits of clean energy initiatives. Methods to translate emissions reductions into changes in air quality and associated health benefits can be complicated, and until recently they have not been as accessible to states as methods to assess emissions benefits. One study that did report health effects provides some indication of the magnitude of potential health benefits associated with policies targeting GHG emissions. This study analyzed how actions to reduce GHG emissions from fossil fuel use can also reduce conventional air pollutants in the United States. It found that NO_X-related morbidity and mortality benefits, per ton of carbon reduced, range from \$7.5–\$13.2 dollars under different carbon tax scenarios. In addition, the study reviewed 10 prior studies that estimated health and visibility benefits on a "per ton of carbon reduced" basis, finding these benefits to range from \$3–\$90 per ton of carbon emissions reduced (Burtraw et al., 2001).

1.1.4 ECONOMIC BENEFITS

Clean energy can create broad and diverse economic benefits that vary considerably across economic sectors and over time. Many of the energy system, environmental, and human health benefits of clean energy described above yield overall economic benefits to the state.

Key economic benefits include:

- *Energy Cost Savings.* Measures that reduce consumers' demand for energy result in energy cost savings to consumers.[8] Once energy savings are known, energy cost savings can be estimated by applying a cost factor (e.g., \$/kWh) to the energy savings estimate. Energy cost savings are typically reported in total dollars saved.

- *Human Health Benefits.* Clean energy policies that reduce criteria air pollutants may improve air quality and avoid illnesses and deaths as described above. Avoided illnesses result in reductions in sick days taken by employees, increases in productivity, and decreases in hospitalizations associated with upper and lower respiratory illnesses and cardiac arrest. Avoided deaths of workers can result in continued economic benefits to the state.

- *Employment***.** Clean energy initiatives create temporary, short-term jobs as well as long-term jobs—both directly from the clean energy activities and indirectly via economic multiplier effects. Employment effects of clean energy can be expressed by many different indicators, such as the full-time equivalent (FTE) number of jobs or job-years created. Because an initiative can generate

6 *For more information on the National Ambient Air Quality Standards (NAAQS), see http://www.epa.gov/ttn/naaqs/.*

7 *Emission reductions were presented in pounds in the Wisconsin report but converted to short tons to simplify comparisons in this document.*

8 *Measures that reduce energy demand may also result in lost revenues for energy suppliers, at least in the short term.*

OTHER ECONOMIC BENEFITS TO CONSIDER: REDUCING NATURAL GAS PRICES THROUGH INCREASED DEPLOYMENT OF RENEWABLE ENERGY AND ENERGY EFFICIENCY

A recent study by the Lawrence Berkeley National Laboratory (LBNL) examined several studies of the natural gas consumer benefits from clean energy programs, and analyzed their results in the context of economic theory. Most of the studies evaluated a national or state RPS, or a combined RPS and EE program.

Studies in the LBNL analysis consistently found that "RE and EE deployment will reduce natural gas demand, thereby putting downward pressure on gas prices" (Wiser et al., 2005). While the natural gas price reductions vary considerably from state to state, the analysis did offer some broad conclusions:

- Each 1% reduction in national gas demand is likely to lead to a long-term average reduction in wellhead gas prices of 0.8% to 2%.
- Most of the studies that were reviewed and that evaluated national RPS proposals, found the present value of natural gas bill savings from 2003-2020 within the range of $10 - $40 billion.
- Consumers' gas bill savings from development of RE and EE for electric power generation and consumption are estimated between $7.50 and $20 for each megawatt hour (MWh) of electricity produced by RE or saved with EE.

Source: Wiser et al., 2005

both employment gains and losses and because employment effects are likely to vary over time, it is important for a comprehensive analysis of clean energy initiatives to assess not only the quantity of jobs created (or eliminated), but also the type, duration, and distribution of jobs across the state's economic sectors.

- *Output.* Economic output is the dollar value of production, including all intermediate goods purchased, and all value added (the contribution of a sector to the economic output). Output depends upon consumption in the local economy, state government spending, investment, and exports of the industries in the state. Clean energy programs can increase output by stimulating new investments and spending within a state.
- *Gross State Product*. Gross state product (GSP) is the sum of value added from all industries in the state, and is analogous to the national concept of GDP. GSP is equal to the state's economic output less intermediate inputs acquired from beyond the state. Clean energy has the potential to result in GSP increases.
- *Income*. Income effects from clean energy investments can be measured using a variety of indicators. Most commonly, income effects are expressed as a change 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. In both cases, a net increase in income associated with clean energy initiatives can occur due to increased employment or wages.

Most economic analyses of clean energy initiatives report results in terms of effects on income, output, and employment. In several instances, benefit findings are summarized in terms of the expected benefit per dollar invested in a clean energy program or per dollar of energy savings. These values can vary significantly depending upon the type of value being estimated and upon the assumptions used to estimate them.[9] Examples of findings on the economic effects of energy efficiency and renewable energy programs include:

- Illustrative findings for income and output
  - Every $1 spent on concentrated solar power in California produces $1.40 of additional GSP (Stoddard et al., 2006).
  - Every $1 spent on energy efficiency in Iowa produces $1.50 of additional disposable income (Weisbrod et al., 1995).
  - Every $1 million in energy savings in Oregon produces $1.5 million of additional output and about $400,000 in additional wages per year (Grover, 2005).
- Illustrative findings for employment effects
  - Every $1 million of energy efficiency net benefits in Georgia produces 1.6–2.8 jobs (Jensen and Lounsbury, 2005).
  - Every $1 million invested in energy efficiency in Iowa produces 25 job-years, and every

[9] *It is important to understand how any benefit per dollar spent was generated. For example, some values—net values—consider the opportunity cost of how the investment in clean energy could have otherwise been spent. Others do not consider this cost and may depict a higher return per dollar invested. For another example, employment benefits may be measured in job-years, which can be short-lived, and are not the same as net jobs, which are permanent, longer term positions. For more information about how values are calculated and key questions to consider, see Chapter 5, Section 5.1.*

$1 million invested in wind produces 2.5 job-years (Weisbrod et al., 1995).[10]

- Every $1 million invested in wind or PV produces 5.7 job-years, versus 3.9 job-years for coal power (Singh and Fehrs, 2001).

1.2 WHY ASSESS THE MULTIPLE BENEFITS OF CLEAN ENERGY?

States have historically evaluated clean energy policies based predominantly on their costs and impacts on energy demand. However, by considering the multiple energy system, environmental, and economic benefits of clean energy as they design and select clean energy policies and programs, states can more fully understand the range of costs and benefits of these potential actions. As stated earlier, with this multiple benefits information, states can:

- Demonstrate how clean energy policies and programs can help achieve multiple state energy, environmental, and economic benefits in a cost-effective way;
- Design or select clean energy options that maximize energy, environmental, and economic benefits.
- Identify opportunities where clean energy can be used to support energy system, environmental, and/or economic development planning strategies across the state; and
- Build support for clean energy policies and programs.

1.2.1 DEMONSTRATING THE MULTIPLE BENEFITS OF CLEAN ENERGY

Clean energy policies and programs typically reduce energy demand or increase generation from clean energy sources. Policies and programs are pursued based on an assessment of the costs of the program compared with the results, typically the energy savings or the new supply of clean electricity. For some options (e.g., low-cost energy efficiency measures), cost effectiveness can be easy to demonstrate because the direct, near-term benefits are recognized through less consumed energy and lower energy costs. However, other project types (e.g., renewable technologies, higher-cost energy efficiency measures) require higher initial capital costs, and may not result in net savings for many years. When evaluating these types of options on a cost basis alone, the savings may not exceed the costs during the short payback period defined by many investors and utilities (i.e., high discount rates), limiting interest in the higher investment options.

Most clean energy options, however, result in additional benefits that are frequently left out of the cost-benefit equation. This omission understates the benefits of the programs and can limit the use of clean energy to address multiple challenges. By developing and sharing information about the multiple benefits of clean energy, states can help build support for their programs and encourage other states to implement similar clean energy programs.

For example, the governor of a state may have set renewable energy goals that are to be achieved through the state's clean energy programs. The same state may also have economic development challenges, electricity congestion, or areas of nonattainment under National Ambient Air Quality Standards and not realize the extent to which the clean energy programs implemented to achieve the renewable energy goals also achieve these other goals by reducing stress upon the electricity system, reducing GHGs and air pollution, and achieving public health benefits. By evaluating the potential energy, economic, *and* environmental impacts of a clean energy program, a state can more fully appreciate the range of its benefits and better understand its cost-effectiveness. Demonstrating these findings both within and outside the state will help the state gain needed buy-in for its clean energy program from state officials, policy makers, and stakeholders, and encourage other states to implement similar clean energy programs.

1.2.2 DESIGNING OR SELECTING OPTIONS THAT ACHIEVE GREATER OR BROADER BENEFITS

Clean energy policies are typically recommended or implemented based on their potential to meet a specific goal—usually energy-related—as set by the state. When selecting among specific clean energy options, however, it is important to develop a set of more specific criteria for determining which options to include in the state clean energy portfolio. Developing these criteria

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[10] The difference in employment effects between energy efficiency and renewable wind power results primarily from the relatively low labor intensity of energy sectors—both renewable and fossil fuel—compared with the economy as a whole. Conserving energy reduces the energy bills paid by consumers and businesses, thereby enabling ongoing spending of those energy savings on non-energy goods, equipment, and services in sectors of the economy that employ more workers per dollar received.

How Many Jobs Can The Clean Energy Industry Generate?

The University of California-Berkeley reviewed 13 independent reports and developed a model to examine the job creation potential of the renewable energy industry. The study analyzed the employment implications of three national 20% RPS scenarios and two scenarios where the generation required by the RPS is produced instead by fossil-fuel generation.

The key finding is that the renewable energy industry generates more jobs than the fossil-fuel industries per unit of energy delivered and per dollar invested (Kammen et al., 2004). Renewable energy's employment advantage is driven primarily by the general shift from mining and related services to increased manufacturing, construction, and installation activity. The distinction between renewable technologies in terms of the number of jobs created in O&M and fuel processing is less clear and technology dependent. The graph summarizes these findings.*

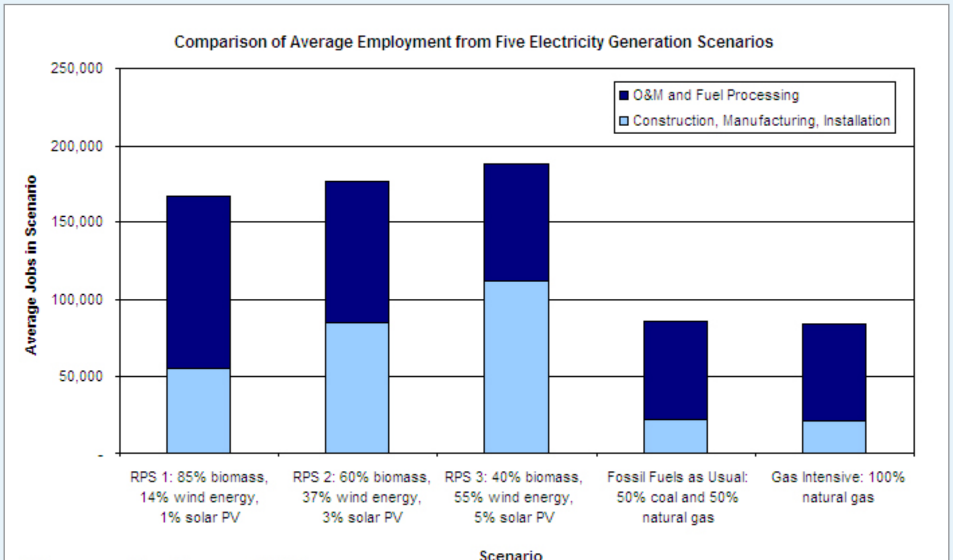


*Figure recreated from Kammen et al., 2004

involves balancing priorities and requirements specific to the state's needs and circumstances. Assessment criteria used by states can involve, for example, energy savings (e.g., in kWh or dollars), economic costs and benefits (e.g., as measured by payback periods, life-cycle costs), environmental impacts (e.g., changes in GHG and air pollutant emissions), economic development (e.g., jobs created or lost), and feasibility (e.g., political feasibility, time frame for implementation).

For example, the Vermont State Agency Energy Plan for State Government stresses the importance of selecting and implementing its clean energy "lead by example" activities based on several criteria: reducing state operating costs through energy savings; reducing environmental impacts; sustaining existing and creating new Vermont businesses that develop, produce, or market environmentally preferable products; and demonstrating the economic benefits of clean energy activities to other states and the private sector (Vermont, 2005). By evaluating potential clean energy activities with criteria that cut across the multiple benefits, Vermont is able to select options that facilitate the achievement of multiple state goals and avoid options that may impede key priorities.

1.2.3 IDENTIFYING OPPORTUNITIES TO USE CLEAN ENERGY IN OTHER PLANNING PROCESSES

Many opportunities exist for states to integrate their clean energy programs with other state environmental, energy system, and economic programs. States can also use the multiple benefits from clean energy programs to help support and strengthen their environmental, energy planning, and economic development programs.

Using Clean Energy to Achieve Environmental Goals

Many states and regions are incorporating clean energy into their environmental strategies to meet their air quality and climate change objectives. Quantifying the multiple benefits of clean energy programs can provide key data for use in developing the SIPs, GHG emissions reduction plans, and air pollution and/or GHG emissions cap and trade programs that include clean energy programs. For example, in 2001, the 77th Texas Legislature established the Texas Emissions Reduction Plan (TERP) with the enactment of Senate Bill 5 (SB 5), and recognized that energy efficiency and renewable energy measures can make an important contribution to meeting National Ambient Air Quality Standards in the state. The 78th Legislature further enhanced the use of clean energy measures to meet the TERP goals by requiring the Texas Commission on Environmental Quality to promote energy efficiency and renewable energy to meet ambient air quality standards (for more information about the TERP, see Case Studies in Chapter 4, *Assessing the Air Pollution, Greenhouse Gas, Air Quality, and Health Benefits of Clean Energy Initiatives*).

States are relying heavily upon clean energy measures in their climate change action plans to reduce CO_2 emissions from the electric power sector. Other states or regions are using clean 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. Renewable energy and energy efficiency programs are also being used as offsets in cap and trade programs focused on reducing GHG emissions. For example, the Regional Greenhouse Gas Initiative (RGGI) has developed an offset program in which heating oil and natural gas efficiency improvements, landfill gas projects, and projects that reduce sulfur hexafluoride (SF_6) can be used as emission reductions. Additional renewable energy and energy efficiency programs are expected to qualify in the future.

Using Clean Energy to Achieve Energy Planning Goals

Many state and regional energy plans include clean energy activities and goals. States analyze the benefits of these goals to provide a basis for determining which clean energy initiatives to include in the plan. States can also require utilities to develop plans that are consistent with these state goals. Utilities are 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 regulated or deregulated electric system. These IRPs or portfolio management strategies often use multiple benefits analysis in the program evaluation criteria. For example, California requires consideration of environmental factors in determining cost-effectiveness of supply- and demand-side options. Beginning in 2003, California's Energy Action Plan has defined an environmentally friendly "loading order" of resource additions to meet the electricity needs: first, energy efficiency and demand response; second, renewable energy and distributed generation; and, third, clean fossil-fueled sources and infrastructure improvements (CPUC, 2003).

MULTIPLE BENEFITS ANALYSIS IS BEING USED IN REGIONAL PLANNING

The Conference of New England Governors and Eastern Canadian Premiers (NEG-ECP) seeks to cost-effectively coordinate regional policies that reflect and benefit U.S. states and Canadian provinces. In 2001, it developed a comprehensive Climate Change Action Plan with the long-term goal of reducing GHG emissions in the region by 75–85%. At the 30th annual conference held in May 2006, the Governors and Premiers enacted Policy Resolution 30-2 to promote energy efficiency and renewable energy in the region. Much of the resolution was based on a study that quantified the multiple benefits of existing and expected energy efficiency and renewable energy programs in New England.

The study, *Electric Energy Efficiency and Renewable Energy In New England: An Assessment of Existing Policies and Prospects for the Future*, estimates that by 2010, the combined effect of expected energy efficiency and renewable energy deployment will provide a wide range of benefits that go beyond direct energy savings, including:

Energy System Benefits: the report finds significant benefits to energy security including a stabilizing and reducing influence on the wholesale price of, and demand for, natural gas; reduced wholesale electricity prices in the regional market; reduced demand for new facilities in the electric market; and increased resiliency of the grid.

Environmental Benefits: estimated environmental benefits include savings of 31.6 million tons of CO_2 emissions, 22,000 tons of NO_x emissions, and 34,000 tons of SO_2 emissions between 2000 and 2010.

Economic Benefits: energy efficiency and renewable energy programs are estimated to produce a net positive $6.1 billion for the New England economy, more than 28,000 job-years, and $1 billion in wages.

Source: RAP, 2005.

Using Clean Energy to Achieve Economic Development Goals

Clean energy measures yield economic benefits that can affect businesses, industry, consumers, and households. Clean energy can create short-term jobs during the construction of clean energy facilities as well as permanent long-term employment. Sustained investment in clean energy can lead to local jobs in manufacturing, distribution, retail sales, installation, auditing and rating, and maintenance of equipment and technology. Cost-effective clean energy can increase regional economic output and reduce energy bills. As a result, many states are looking to measure and promote the employment and other economic development benefits of clean energy, and to incorporate these benefits into their economic development planning processes. In July 2008, for example, Pennsylvania Governor Rendell announced and signed The Alternative Energy Investment Fund. This fund was created to invest $665.9 million into alternative energy, including $237.5 million specifically targeted toward helping consumers conserve electricity and to manage higher energy prices, and $428.4 million to spur the development of alternative energy resources and to create at least 10,000 well-paying jobs in these industries (Pennsylvania, 2008; Wall Street Journal, 2008).

1.2.4 BUILDING SUPPORT FOR CLEAN ENERGY POLICIES AND PROGRAMS

By quantifying and promoting the multiple benefits of planned clean energy programs, states can address barriers by raising awareness and building support from key decision-makers and stakeholders by illuminating strategic tradeoffs among energy resources. For example, Connecticut's Climate Change Action Plan is aimed at reducing GHG levels to 1990 levels by the year 2010 and an additional 10% below that by 2020. The plan evaluated 55 action items, including a large number of clean energy activities. Connecticut found that demonstrating the anticipated multiple benefits early in the Action Plan development process, and involving numerous stakeholders in this process, were key to promoting the plan and obtaining the support of multiple stakeholders (see text box *Connecticut Incorporates Multiple Benefits in Evaluation Criteria for New Capacity Additions*) (CCC, 2005).

1.3 HOW DO STATES ASSESS THE MULTIPLE BENEFITS OF CLEAN ENERGY?

The preceding sections described how states are advancing clean energy policies and programs and the importance of assessing the multiple benefits of these policies and programs. This section provides an overview of how states conduct multiple benefits analyses and key issues for states to consider as part of the analyses.

Figure 1.3.1 illustrates the relationships among the multiple benefits of clean energy. As shown in the figure, while energy savings may be a primary goal of clean energy policies and programs, other benefits also accrue from these investments. These benefits are estimated based, in part, on the energy savings estimates, and in many cases may also be used as inputs for estimating one or more of the other benefits.

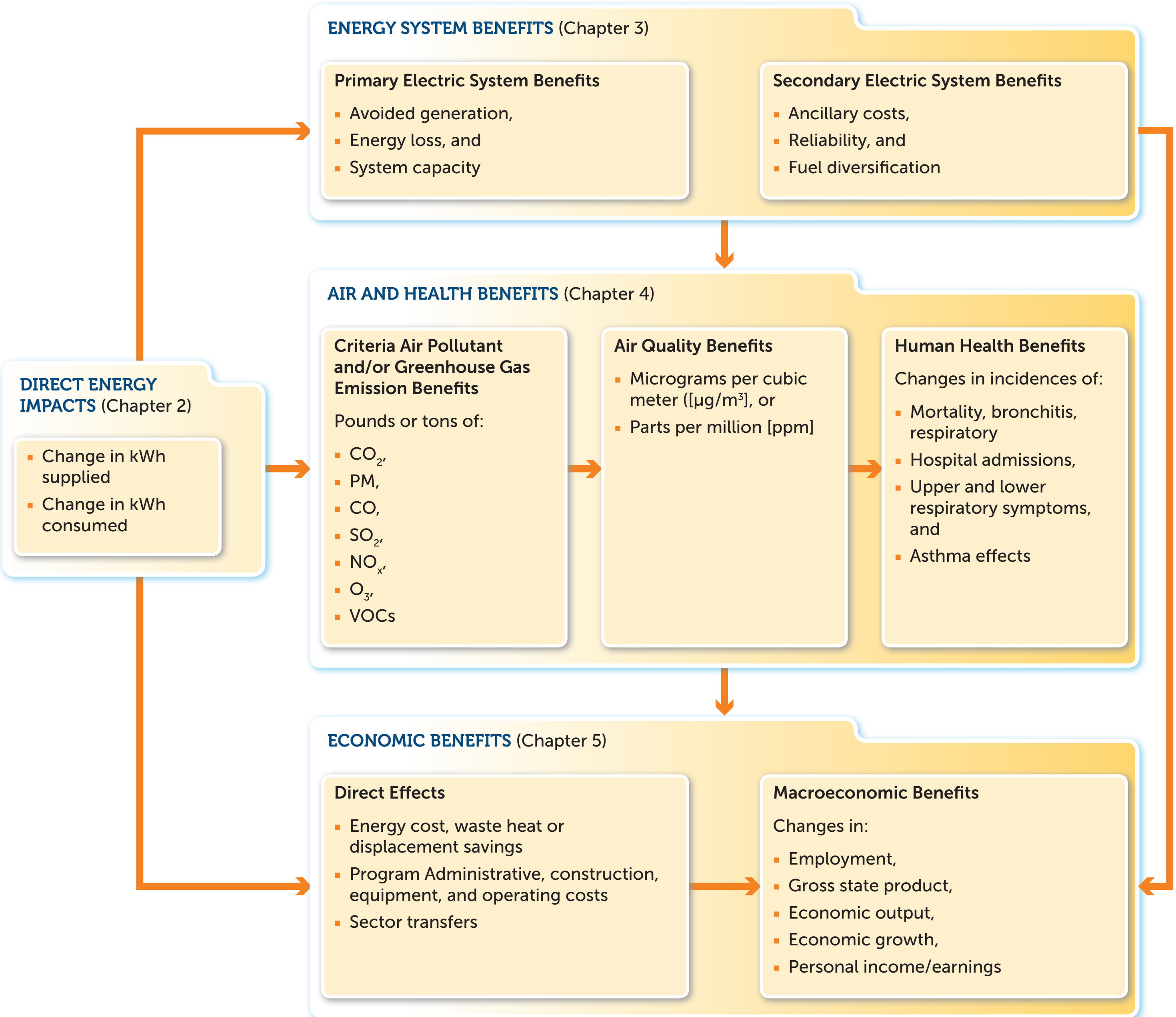
It is not necessary for a state to evaluate all of the multiple benefits of clean energy. Typically, a state's priorities and the purpose of its analysis influence which benefits are of most interest. Understanding the relationship between the benefits, however, can help states decide how to go about evaluating the benefits of interest.

As an example of how the different benefits of clean energy are related, consider a state that is contemplating a suite of energy efficiency programs. Based on funding levels and assumptions about participation in the programs, the state can estimate the direct energy savings likely to accrue from them. The benefits, however, do not end there. A state can use the energy savings estimates to evaluate the benefits of the programs on the state's energy system, economy, environment, and public health. For example, the energy demand reduction could be large enough to delay or eliminate the need to construct new conventional power plants, which can be quite costly. This would be a benefit to the energy system. The decrease in the generation of fossil-fuel-based electricity may result in a reduction in GHG emissions and/or criteria air pollutants. Criteria air pollutant reductions affect air quality and could 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 non-energy products and services. The economic benefits of the public health improvements (e.g., improved productivity from reduced sick days), energy cost and system savings, and investments in energy efficient equipment would likely stimulate the economy and create jobs.

States can take the following steps when planning and conducting an analysis of a clean energy policy, activity, or program that examines some or all of these clean energy benefits:

- *Determine which clean energy goals, policies, activities, and/or programs to evaluate.* When estimating the multiple benefits of their clean energy policies and programs, states can choose to focus on the benefits of a single clean energy activity (e.g., retrofitting a single state government building) or an entire program (e.g., the state's portfolio of energy efficiency activities, RPS, or green purchasing program). The clean energy activities selected for assessment can be identified, for example, based on the state's overall energy policy and planning goals,

FIGURE 1.3.1 RELATIONSHIP BETWEEN ENERGY SAVINGS & OTHER BENEFITS OF CLEAN ENERGY INITIATIVES



regulatory or legislative requirements, or findings from existing potential studies for energy efficiency and/or renewable energy that provide important information on which activities are most likely to result in energy savings and other benefits.

- *Determine the goals and objectives of the multiple benefits analysis*. It is important to lay out the rationale for conducting a benefits analysis. Issues to consider include:

  - *Why is the analysis being conducted?* As described in Section 1.4, there are many reasons to analyze the benefits of a state's clean energy initiatives. For example, states can consider whether the information will be used primarily to gain support for their initiative; to help

Modeling Approaches

This *Resource* describes a broad range of modeling approaches that may be applied to estimating energy savings, costs, emissions and other impacts of clean energy resources. In an effort to guide decision-making, the *Resource* distinguishes between "sophisticated" modeling approaches that may require significant financial and time commitments, and "basic" approaches that require fewer resources and may more easily be implemented by the state's own staff. This distinction is somewhat imprecise, as model sophistication could actually be judged along a very broad continuum; nonetheless, the distinction helps convey in broad strokes how approaches to multiple benefit analyses can differ. For purposes of this discussion:

- **Basic approaches** (e.g., spreadsheet analyses, trend extrapolations) tend to be characterized by a relatively simple formulation, such as the use of activity data (e.g., changes in generation levels) and factors (e.g., emissions factors). In these approaches there is no attempt to represent the underlying system (generation dispatch), but instead they rely on factors or trends to capture what would be expected to result. In the example above, the emissions factor is meant to represent the average of what would actually be displaced by a clean energy resource that operates over a long period of time and under varying conditions. These factors and other inputs may be based on the results of more sophisticated modeling performed by others. Simpler approaches can provide a reasonable level of precision, depending on the nature and source of the parameter. Each user will have to assess whether the method and results are suitable for the intended purpose.
- **Sophisticated approaches** tend to be characterized by extensive underlying data and relatively complex formulation that represents the fundamental engineering and economic decision making of the entity (e.g., power sector system dispatch or capacity expansion modeling), or complex physical processes (such as in air dispersion modeling). Sophisticated models generally provide greater detail than the basic methods, and can capture the complex interactions within the electricity market and with other markets or systems. They can be used to inform discussions of what should happen (optimization) or what might happen given certain assumptions (simulation). These approaches are generally appropriate for short- or long-term analyses, or analyses in which unique demand and supply forecasts are needed to incorporate the specific changes being considered (e.g., implementation of a renewable portfolio standard).

Regardless of what approach is chosen, it is important to understand the strengths and limitations of the method or model. Specifically, it is important to recognize the following:

- Models are mathematical representations of physical or economic processes in the real world; therefore, these tools are only as good as our understanding of these processes. The results will be influenced by the model formulation. For example, an optimization model tells us what we should do under the assumed conditions and represents the "best" or least cost approach. A simulation model, potentially with logit functions or market share algorithms, will help us understand what might happen. Simulation models offer insights into how a complex system responds to changing conditions and specific assumed conditions.
- Data inputs and key driving assumptions have a fundamental effect on the outcomes, some more than others.
- What actually occurs (or has occurred) will depend on what values these key drivers ultimately take. For all, there is some degree of uncertainty: fuel prices, weather, unit availability, load levels and patterns, technology performance, future market structure and regulatory requirements, to name only a few, all have considerable uncertainties surrounding them. However, the strength of models, particularly those bottom-up models with engineering-economic detail, is that they provide a consistent framework for understanding how a system responds to different stimuli and to characterize the uncertainty surrounding our best estimates.

design a clean energy program and select the specific activities to include in the program, provide data for a regulatory purpose (e.g., a SIP or cap and trade program); or to support related environmental, planning, or economic development policy and program decisions.

- *Which benefits will be analyzed?* States can concentrate on estimating some or all of the multiple benefits of their clean energy activity or program, depending on the purpose and scope of the initiative. This decision will depend on the audience and their interests, available financial and staff resources, and the type and scope of the clean energy initiative(s) being assessed. For example, when deciding whether to conduct an energy efficiency retrofit of a single building, states may want to estimate the energy savings and GHG emission reductions of other building retrofit options and use this information to select the likely candidate for retrofitting. When developing a clean energy plan or assessing a more extensive clean energy initiative, it may be more appropriate to assess a broad range of benefits and use this information to help build widespread support for the program.

- *Determine how to conduct the analysis.* Multiple benefits analyses can employ a variety of approaches, ranging from basic screening estimates and spreadsheet analyses to more sophisticated modeling approaches. States will consider a variety of issues when determining the most appropriate approach for their needs and circumstances, and will balance competing factors as necessary—for example, the scope and rigor of the analysis may be balanced against the level of resources available. Key issues include:

- *What financial and staff resources are available?*
- *What other kinds of expertise (e.g., in-house staff and outside consultants) are available?*
- *Do data exist from similar analyses or for other states or regions? Or will a new analysis be required?*
- *Is the analysis retrospective (an historical assessment) or prospective (forward-looking)?*
- *What level of rigor is required? Is it for regulatory purposes or a preliminary screening of options?*
- *Will the analysis entail an iterative approach where the state explores a wide range of options using screening methods and then conducts a more comprehensive analysis of only the most promising options?*

More detailed information about how to estimate the potential benefits of clean energy initiatives is presented in the remaining chapters of the *Resource*, as follows:

- Chapter 2: Assessing the Potential Energy Impacts of Clean Energy Initiatives.
- Chapter 3: Assessing the Electric System Benefits of Clean Energy Initiatives.
- Chapter 4: Assessing the Air Pollution, Greenhouse Gas, Air Quality, and Health Benefits of Clean Energy Initiatives.
- Chapter 5: Assessing the Economic Benefits of Clean Energy Initiatives.

Each chapter describes approaches for calculating or estimating prospective benefits based on varying levels of rigor and provides examples of states' experiences using multiple benefits analysis to promote clean energy. The chapters provide general information on how to conduct and evaluate analyses of multiple benefits, rather than serving as a detailed workbook for quantifying benefits. Taken as a whole, these chapters provide a framework for states to use in determining the likely benefits of their clean energy goals, policies, and programs and using this information to support these initiatives.

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