CHAPTER FIVE

Assessing the Economic Benefits of Clean Energy Initiatives

Given the strong link between economic performance and energy use, it is important for states to account for the macroeconomic effects of potential clean energy policies and programs during the process of selecting and designing these policies. Many studies have shown that when a state makes cost-effective investments in energy efficiency and renewable energy, the state's entire economy will benefit. For example, Wisconsin's Focus on Energy Program was created to manage rising energy costs, promote in-state economic development, protect the environment, and control the state's growing demand for electricity. An analysis conducted by the Wisconsin Department of Administration anticipates that it will meet these objectives while creating more than 60,000 job years, generating more than eight billion dollars in sales for Wisconsin businesses, increasing value added or gross state product by more than five billion dollars, and increasing disposable income for residents by more than four billion dollars between 2002 and 2026 (Wisconsin Department of Administration, 2007; see text box *States Quantifying the Economic Benefits of Clean Energy Policies*). These results demonstrate that positive results from clean energy investments have spread to the broader community.

States can estimate the potential economic benefits of clean energy policies and programs they are considering by projecting potential changes in the flow of goods, services, and income within a regional, state, or local economy. These changes can result in benefits to key macroeconomic indicators, including employment, gross state product, economic output, economic growth, and personal income/earnings. By assessing the benefits of clean energy on these indicators, states can:

- Demonstrate how clean energy can help achieve economic development goals;

DOCUMENT MAP

CHAPTER FIVE CONTENTS

STATES QUANTIFYING THE ECONOMIC BENEFITS OF CLEAN ENERGY POLICIES

Wisconsin's Focus on Energy Program advances cost effective energy efficiency and renewable energy projects in the state through information, training, energy audits, assistance and financial incentives. Its efforts are designed to help Wisconsin residents and businesses manage rising energy costs, promote in-state economic development, protect the environment and control the state's growing demand for electricity and natural gas over the short and long term.

The Wisconsin Department of Administration conducted an evaluation of the economic impacts of the Focus on Energy Program from its inception in 2002 through 2026. The analysis involved:

1. Documentation and extrapolation of the net direct effects of the program, such as program-related spending, energy cost savings and spending on new equipment;
2. Application of a regional economic model (in this case, the REMI model); and
3. Analysis of the implications.

The results indicate that the Focus on Energy Program provides net benefits to the State of Wisconsin. Specifically, the analysis estimates that between 2002 and 2026, the Focus on Energy Program is expected to:

- create more than 60,000 job-years (see the text box *Job Years Versus Jobs*);
- generate sales for Wisconsin businesses of more than eight billion dollars;
- increase value added or gross state product by more than five billion dollars; and
- increase disposable income for residents by more than four billion dollars.

Source: Wisconsin Department of Administration, 2007.

- Build support for their clean energy initiatives among state and local decision-makers; and
- Identify opportunities where meeting today's energy challenges can also serve as an economic development strategy.

This chapter helps states understand the issues and methods for assessing the economic benefits of clean energy options so that they may 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.

Section 5.1 explains how clean energy initiatives create direct, indirect, and induced macroeconomic effects on the economy and can achieve benefits. Section 5.2 presents steps, methods ranging from rule-of-thumb estimates to rigorous dynamic modeling, and issues states can consider using to conduct an analysis of the potential macroeconomic benefits of clean energy programs. Section 5.3 describes a sampling of state macroeconomic analyses as case studies.

5.1 HOW CLEAN ENERGY INITIATIVES CREATE MACROECONOMIC BENEFITS

Clean energy initiatives can result in macroeconomic benefits through *direct*, *indirect*, and *induced* economic effects. As implied by these terms, some of the macroeconomic benefits of clean energy investments accrue to those individuals, businesses, or institutions *directly* involved in the investment, while other benefits arise in related economic sectors and society as a whole via *indirect* and *induced* "ripple" (or "multiplier") effects.

- The design and scope of the clean energy initiative typically determine the *direct and indirect effects*.
- The structure and composition of the state's economy determine the resulting *indirect and induced effects*.

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 those that affect the supply of energy, such as renewable portfolio standards. The direct effects of these demand and supply programs are key inputs to macroeconomic analyses. The indirect and induced effects are determined once the direct effects interact with the overall state or regional economy. When exploring the direct, indirect, and induced costs and benefits of clean energy programs, it is useful to consider how the initiative affects other state economic policy objectives, such as distributional equity, and to ensure that it both affects the segments of the economy that were initially targeted and minimizes negative ramifications (e.g., a resulting loss in jobs in another sector, which would have distributional effects).

Direct, indirect, and induced effects are described in greater detail below.

WHAT ARE DIRECT, INDIRECT, AND INDUCED EFFECTS?

Most approaches for quantifying local economic impacts characterize economic impacts based on *direct, indirect,* and *induced* effects. The same terms are used in computable general equilibrium and hybrid macroeconomic models

Direct effects are changes in sales, income, or jobs associated with the on-site or immediate effects created by an expenditure or change in final demand; for example, the employment and wages for workers who assemble wind turbines at a manufacturing plant.

Indirect effects are changes in sales, income, or jobs in upstream-linked sectors within the region. These effects result from the changing input needs in directly affected sectors; for example, increased employment and wages for workers who supply materials to the turbine assemblers.

Induced effects are changes in sales, income, or jobs created by changes in household, business, or government spending patterns. These effects occur when the income generated from the direct and indirect effects is re-spent in the local economy; for example, increased employment and wages for workers at the local grocery store because turbine assemblers use their increased wages to buy groceries.

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.

CLEAN ENERGY INITIATIVES EXPAND LOCAL RENEWABLE ENERGY MARKETS AND REDUCE ENERGY COSTS

From 2001–2006, New Jersey's solar market experienced strong growth and saved solar owners an estimated $1.1 million annually in total electricity costs, spurred by the Customer On-Site Renewable Energy Program (CORE), which provides rebates for renewable technologies (NJ BPU, 2005).

5.1.1 WHAT ARE THE DIRECT EFFECTS OF DEMAND-SIDE INITIATIVES?

Clean energy initiatives that affect the demand 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 initiatives generally aim to increase the use of cost-effective energy efficiency technologies (e.g., including more efficient appliances and air conditioning systems, more efficient lighting devices, more efficient design and construction of new homes and businesses), and advance efficiency improvements in motor systems and other industrial processes. Demand-side initiatives can also directly reduce energy consumption, such as through programs encouraging changing the thermostat during the hours a building is unoccupied or motion-detecting room light switches.

The direct macroeconomic effects of demand-side energy efficiency initiatives arise from the expenditures for goods and services used to implement the initiatives as well as the energy and other cost savings generated by the initiatives. These costs and savings include:

- *Energy cost savings:* dollars saved by businesses and households resulting from reduced energy costs (including electricity, natural gas, and oil cost savings), potentially reduced repair and maintenance costs, deferred equipment replacement costs, and increased property values resulting from the new equipment.
- *Program administrative costs:* dollars spent operating the efficiency initiative, including labor, materials, and paying incentives to participants. It is important to determine how the costs of a program will be funded, such as through a surcharge on consumer electricity bills. If they are funded through general government revenues, it is helpful to consider the impact of diverting funds from other projects.
- *Household and business expenditures:* dollars spent by businesses and households for purchasing and installing more energy-efficient equipment. For policies supported by a surcharge on electric bills, the surcharge is a cost to be included.
- *Sector transfers:* increased flow of dollars to companies that design, manufacture, and install energy-efficient equipment, and 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 participants. For example, they affect the purchasing power of participating consumers, the profitability of participating businesses, and the profitability of conventional power generators. Together, the shifts caused by demand-side initiatives affect income, employment, and overall economic output by:

CLEAN ENERGY INITIATIVES EXPAND LOCAL ENERGY EFFICIENCY MARKETS AND ATTRACT BUSINESS INVESTMENT

For example, from 1999-2005, the number of energy service companies operating in New York State increased from fewer than 10 to over 180 companies, spurred by the New York Energy $mart Program (NYSERDA, 2006b).

- Decreasing residential energy costs, and thereby increasing the disposable income available for non-energy purchases.[1]
- Increasing income, employment, and output by reducing the outflow of resources that leave the state when it imports electricity.[2]
- Increasing income, employment, and output by stimulating the production and sale of energy-efficient equipment by existing businesses within the state.
- Increasing income, employment, and output by decreasing the cost of doing business and improving competitiveness.
- Increasing income, employment, and output by expanding the in-state market for energy efficiency and attracting new businesses and investment.
- Decreasing revenue for utilities due to the reduction in energy sales, unless the state's utility revenue structures allow for program cost recovery or financial incentives for energy efficiency programs.[3]

5.1.2 WHAT ARE THE DIRECT EFFECTS OF SUPPLY-SIDE INITIATIVES?

Supply-side clean energy policies and programs change the fuel/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 (RE) 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 RE or CHP equipment supported by the initiative, as well as the energy savings and possible reduced energy supply costs from fuel substitution among entities participating in the supply-side program and their customers. The direct costs and savings of RE/CHP/DG initiatives include:

- *Displacement savings:* dollars saved by utilities from the displacement of traditional generation, including reduced purchases (either local or imports) of fossil fuels and decreased operation and maintenance costs from existing generation resources.
- *Waste heat savings:* dollars saved by utilities or other commercial/industrial businesses using waste heat in CHP applications for both heating and cooling purposes.
- *Program administrative costs:* dollars spent operating the initiative, including labor, materials, and paying incentives to participants. As with demand-side initiatives, it is important to determine how the costs of a program will be funded, such as through a surcharge on consumer electricity bills.
- *Construction costs:* dollars spent to purchase the RE/CHP/DG equipment, installation costs, costs of grid connection, and on-site infrastructure construction costs such as buildings or roads.

JOB YEARS VERSUS JOBS

Studies present employment estimates in terms of jobs and job years, and it is important to understand the difference. For example, a study may predict the creation of 15 job years. This is not the same thing as saying 15 jobs. Fifteen job years can mean one job that lasts for 15 years or it can mean 15 jobs that last for one year. It is important to explain carefully or question what the study is showing for potential job impacts.

In addition, sometimes job results are presented as "net jobs" or even simply "jobs." If an analysis of a clean energy program refers to "net jobs," it means the study factored in any job losses that may have occurred in non-clean energy related sectors due to the policy (e.g., decrease in demand for coal) and presents the impacts on jobs after those losses have been subtracted from any increase. If the results are presented as "jobs," clarification may be needed to determine whether the jobs are gross or net jobs.

---

[1] *An increase in disposable income may be reduced by any program costs imposed upon them. Generally, however, the net effect to, for example, consumers of energy efficiency programs, is positive.*

[2] *The magnitude of this impact can be especially significant in states that import large fractions of their energy*

[3] *California, Massachusetts, Minnesota, New York, and Oregon 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 (SWEEP 2002). It is important to consider each individual state's utility revenue structure when exploring the effect of clean energy programs.*

WHAT ABOUT OTHER ECONOMIC BENEFITS, SUCH AS AVOIDED CAPACITY INVESTMENT AND LOWER PRICE VOLATILITY?

Clean energy initiatives, whether on the demand side or supply side of the energy system, can create other direct economic benefits to individual energy producers and society as a whole. These benefits—*which are economic in character but arise specifically in the energy sector* —include increased fuel diversity, transmission reliability, avoided future investment in fossil-fuel generating capacity, reduced wholesale electricity price volatility, reduced fossil-fuel prices, and reduced transmission congestion and losses.

Assessing these benefits requires different methods from those used to assess the benefit mechanisms described in this chapter. These benefits and their assessment are covered in Chapter 3.0, *Assessing the Electric System Benefits of Clean Energy*.

- *Operating costs:* dollars spent to operate and maintain the equipment during its operating lifetime and the cost of production surcharges applied to consumers.

The expenditures and savings associated with supply-side clean energy initiatives shift economic activity among purchases of fuels, business activity in RE/CHP/DG generation, and business activity in existing generation. Together, the shifts caused by supply-side initiatives increase income, employment, and economic output in the state through the:

- Construction and operation of new clean energy-based power facilities.
- Stimulation of economic activity in the state's existing renewable energy industry for both in-state and export markets.
- Expansion of the in-state market for renewable energy services and attraction of new businesses and investment.[4]
- Reduced outflow of dollars for fossil-fuel imports (or increased inflow of dollars for fossil-fuel exports if state is a net fossil-fuel exporter), enabling those dollars to remain within the state.
- Increased application of CHP, in particular, by reducing the cost of doing business and improving overall competitiveness for non-energy companies.

WHY QUANTIFY INDIRECT AND INDUCED EFFECTS?

Quantifying the full range—direct, indirect, and induced—of the macroeconomic benefits from clean energy initiatives will maximize the potential value of the policy analysis. For example, the University of Illinois' analysis in 2005 of the proposed Illinois Sustainable Energy Plan estimated that the *direct* outlays and savings for the plan would provide the following benefits to the state of Illinois by 2020:

- A $7 billion net increase in economic output,
- A $1.5 billion net increase in personal income, and
- 43,000 net new jobs.

While these benefits are certainly substantial, the study further estimated the following *combined* direct and indirect benefits by 2020:

- An $18 billion net increase in economic output,
- A $5.5 billion net increase in personal income, and
- 191,000 net new jobs

In this case, the more robust quantification of macroeconomic benefits, as opposed to simply quantifying direct benefits, led to a substantially different appreciation of the economic significance of the program to the State of Illinois. (Bournakis and Hewings et al., 2005.)

5.1.3 WHAT ARE THE INDIRECT AND INDUCED EFFECTS OF CLEAN ENERGY INITIATIVES?

The distinction between demand-side initiatives and supply-side initiatives is a key factor in understanding the *direct effects* of clean energy initiatives, but this distinction is not necessary to describe *indirect and induced effects*. The indirect and induced effects of clean energy initiatives arise, respectively, from changes in sectors that are economically linked to the directly affected sectors and from changes in the purchases of retail goods and services by the employees of the businesses in which the direct and indirect economic effects occur.

Indirect Effects

Indirect effects result from "upstream" changes in business activity among firms supplying goods and services to industries directly involved in the clean energy initiative. For example, the construction of roads and foundations for a wind farm requires purchases of asphalt and cement from other economic sectors. Each of those other industries must also make purchases to support its own operations, and so forth.

---

[4] *See also, MTC (2005) and Heavner and Del Chiaro (2003) for additional information on evaluating EE/RE market potential and fostering so-called "clean energy clusters."*

There also can be “downstream” indirect effects, as the regional economy responds to lower energy costs, a more dependable energy supply, and a better economic environment fostering expansion and attracting new business growth opportunities.

In a state-level macroeconomic impact analysis, the fraction of all of the inter-industry purchases that occur within the state comprises the indirect effects. These purchases, in turn, affect income, employment, and economic output in those intermediate sectors.

The ability of the state’s economy to provide the goods and services needed to implement the initiative is a key factor affecting the quantity of in-state indirect effects. In general, a larger, more diverse economy will keep a greater share of the indirect purchases within the state (i.e., the indirect multiplier effects would be larger). For example, a study of the economic benefits of clean energy in New England for the Regulatory Assistance Project noted that “if there were a substantial indigenous renewable generator manufacturing and maintenance industry in New England, then the projected impacts would be larger” (RAP, 2005).

Induced Effects

Induced effects result from the additional purchases of goods and services by households and governments that are affected directly and indirectly by the clean energy initiative as described above (e.g., increased wage income generated from direct and indirect effects is re-spent by individuals; taxes generated by direct and indirect effects are re-deployed by governments). These outlays, in turn, lead to changes in income, employment, and economic output in all economic sectors.

5.2 HOW CAN STATES ESTIMATE THE MACROECONOMIC BENEFITS OF CLEAN ENERGY INITIATIVES?

Assessing the state-level macroeconomic benefits of clean energy initiatives involves measuring changes in the flow of dollars to households and businesses at the state level. Changes in these flows can be estimated as gross impacts (changes without adjustment for what would have occurred anyway) or net impacts (changes over and above what would have occurred anyway). The macroeconomic impacts of clean energy initiatives can also be evaluated for cost-effectiveness. Cost-effectiveness refers to the benefits generated per dollar of program costs.

Quantifying the macroeconomic effects—whether on a gross, net, or cost-effective basis—provides an aggregate measure of the magnitude of the benefits achieved by the initiative. A state can follow several basic steps to analyze the macroeconomic benefits of clean energy initiatives:

1. Determine the method of analysis, the desired level of rigor, and the desired level of detail about geographic and industrial sectors.

2. Quantify the direct costs and savings associated with the initiative.

3. Apply the previously determined method to quantify the macroeconomic impacts created by those costs and savings.

Each of these steps is discussed in more detail below.

5.2.1 STEP 1: DETERMINE THE METHOD OF ANALYSIS AND LEVEL OF EFFORT

Several methods are available to states for quantifying the macroeconomic effects of their clean energy initiatives. They range in complexity from using basic approaches or tools for screening purposes to sophisticated modeling tools for more rigorous dynamic modeling approaches. All of these methods involve predictions, inherent uncertainties, and numerous assumptions. In selecting the most appropriate method, states can consider many different factors, including time constraints, cost, data requirements, internal staff expertise, and overall flexibility and applicability. For example, a state looking to quickly compare many policy options to get an approximate sense of their costs or benefits as part of a stakeholder process would select a different tool than a state tasked by its governor or legislature to determine the sector-specific impacts of a particular policy or strategy. The latter situation would likely require a more rigorous analysis.

Consequently, it is useful for state policy makers to understand the basic differences between the different models and approaches, their strengths and weakness, and their underlying assumptions. The following sections introduce the basic concepts associated with widely accepted screening tools and more advanced models for macroeconomic analysis of clean energy initiatives. Table 5.2.1 describes the advantages and disadvantages of each method and when it is appropriate to use.

TABLE 5.2.1 COMPARISON OF BASIC AND SOPHISTICATED APPROACHES FOR QUANTIFYING MACROECONOMIC EFFECTS OF CLEAN ENERGY INITIATIVES

Type of Method	Sample Tools or Resources	Advantages	Disadvantages	When to Use this Method
Basic Approaches: - Rule-of-thumb estimates and - Screening models	- Rule-of-thumb Factors - Job and Economic Development Impact (JEDI) Model - RMI Community Energy Opportunity Finder - Renewable Energy Policy Project Labor Calculator	- May be transparent - Requires minimal input data, time, technical expertise, and labor. - Inexpensive, often free.	- Overly simplified assumptions - Approximate results - May be inflexible.	- When time and resources are short - For high-level, preliminary, analyses - To get quick estimates of employment, output and price changes - When screening a large number of policy options to develop a short list of options for further analysis.
Sophisticated Approaches: - Input-Output; - Econometric; - Computable General Equilibrium; and - Hybrid Models	- IMPLAN, - RIMS II - RAND econometric model - BEAR - REMI Policy Insight	- More robust than basic modeling methods. - May be perceived as more credible than basic methods. - Provides detailed results - May model impacts over a long period of time - May account for dynamic interactions within the state/ regional economy.	- May be less transparent than spreadsheet methods. - May require extensive input data, time, technical expertise, and labor commitments. - Often high software licensing costs. - Requires detailed assumptions that can significantly influence results.	- When policy options are well defined - When a high degree of precision and analytic rigor is desired - When sufficient data, time and financial resources are available.

Basic Approaches for Macroeconomic Impact Analysis

At the simpler, less resource-intensive level, screening tools and approaches provide quick, low-cost analyses of policies and require less precise data than needed for a rigorous, advanced analysis. These screening methods provide rough estimates of impacts and give a sense of the direction (i.e., positive or negative) and magnitude of the impacts upon the economy. They provide a useful screening device when many options are under consideration and limited resources are available to conduct advanced analyses. For example, a state considering a lengthy list of climate change mitigation options can use a screening tool to help rank the candidates to create a short list of options that warrant further analyses with more sophisticated tools. Screening approaches, such as rule-of-thumb job factors and tools (e.g., NREL's JEDI model, the RMI Community Energy Opportunity Finder, and REPP's Labor Calculator), are described below.

Rule-of-Thumb Economic Factors

States can apply rules of thumb or generic economic factors to their program results to estimate the economic impacts of clean energy measures in their states. These rules of thumb are typically drawn from more rigorous analyses and can be used when time and resources are limited. However, they provide only rough approximations of clean energy program impacts and so are most applicable for use as screening-level tools for developing preliminary benefit estimates and for prioritizing potential clean energy activities. Table 5.2.2 lists several rules of thumb that states have used to estimate the income, output, and employment impacts of energy efficiency and renewable energy programs.

TABLE 5.2.2 RULES OF THUMB FOR ESTIMATING INCOME, OUTPUT, AND EMPLOYMENT IMPACTS OF CLEAN ENERGY ACTIVITIES

Rule of Thumb	Source
TYPE OF IMPACT: Income/Output	
1 MW of wind generated requires $1 billion investment in wind generator components.	REPP, 2005 *http://www.repp.org/articles/static/1/binaries/Ohio_Manufacturing_Report_2.pdf*
$1 spent on concentrated solar power in California produces $1.40 of additional GSP.	Stoddard et al., 2006 *http://www.nrel.gov/docs/fy06osti/39291.pdf*
$1 spent on energy efficiency in Iowa produces $1.50 of additional disposable income.	Weisbrod et al., 1995 *http://www.edrgroup.com/library/energy-environment/iowa-energy.html*
$1 million in energy savings in Oregon produces $1.5 million of additional output.	Grover, 2005 *http://www.oregon.gov/ENERGY/CONS/docs/EcoNW_Study.pdf*
TYPE OF IMPACT: Employment	
$1 million in energy savings in Oregon produces about $400,000 in additional wages per year.	Grover, 2005 *http://www.oregon.gov/ENERGY/CONS/docs/EcoNW_Study.pdf*
$1 billion investment in wind generator components creates 3,000 full-time equivalent (FTE) jobs.	REPP, 2005 *http://www.repp.org/articles/static/1/binaries/Ohio_Manufacturing_Report_2.pdf*
$1 million invested in energy efficiency in Iowa produces 25 job-years.	Weisbrod et al., 1995 *http://www.edrgroup.com/library/energy-environment/iowa-energy.html*
$1 million invested in wind in Iowa produces 2.5 job-years.	Weisbrod et al., 1995 *http://www.edrgroup.com/library/energy-environment/iowa-energy.html*
$1 million invested in wind or PV produces 5.7 job-years vs. 3.9 job-years for coal power.	Singh and Fehrs, 2001 *http://www.repp.org/articles/static/1/binaries/LABOR_FINAL_REV.pdf*
1 GWh of electricity saved through energy efficiency programs in New York yields 1.5 sustained jobs.	NYSERDA, 2008 *http://www.nyserda.org/pdfs/Combined Report.pdf*
$1 million of energy efficiency net benefits in Georgia produces 1.6-2.8 jobs.	Jensen and Lounsbury, 2005 *http://www.gefa.org/Modules/ShowDocument.aspx?documentid=46*

As shown in Table 5.2.2, for example, the Renewable Energy Policy Project (REPP) estimates that every $1 billion of investment in the components that make up wind generators creates 3,000 full-time equivalent (FTE) jobs. REPP also finds that every megawatt (MW) of wind requires a $1 billion investment in the generator components (REPP, 2005). If a state has estimated the amount of renewable (wind) electricity that will be generated from its clean energy programs, it can use these factors to determine the amount of jobs that could be created.

The New York State Energy Research and Development Authority (NYSERDA) has developed a similar jobs factor for energy efficiency programs. It estimates that every GWh of electricity saved through energy efficiency programs yields 1.5 sustained jobs.[5] This factor is derived from a more sophisticated analysis of the macroeconomic impacts of the New York Energy $mart Program through 2007. This analysis estimated that the program had created, on average, 4,700 net jobs each year between 1999 and 2007 while saving about 3,164 GWhs in electricity (NYSERDA, 2008). Dividing the

---

[5] *By sustained, it means that the job is expected to last 15 years.*

number of jobs by the number of GWhs saved through energy efficiency measures yields an average number of net sustained jobs, about 1.5, for each GWh saved. New York uses this number to generate rough estimates of the job impacts of new or expanded energy efficiency-related programs under consideration. For example, when New York announced its 15 by 15 initiative, which set a goal of reducing energy demand by 15 percent or 27,300 GWhs through energy efficiency, NYSERDA's rule of thumb was used to estimate that the initiative was expected to create about 41,000 jobs in the state.

These rule-of-thumb factors can be handy when time and resources for more rigorous analysis are limited. As shown in Table 5.2.2, however, the range of values is wide. For this reason, it is very important to understand any biases that may be inherent in the rule of thumb before using them. For example, factors can be based on outdated information and would be affected by changes in construction and material costs that have occurred since the factor was derived. Alternatively, factors may not take into consideration that the funds are likely to have come from elsewhere in the economy and may result in negative impacts. For example, the REPP wind-related factor described above may not consider that the $1 billion investment could have been taken from another sector in the state or the United States as a whole, which may now experience job losses. There is an opportunity cost—the value of the next best alternative forgone—that states should consider when taking resources from one place in the economy and investing them in something different, in this case clean energy. In addition, it is not clear if the 3,000 jobs are net or gross. That is to say, it is not apparent whether the numbers reflect job losses that may occur in other sectors. It also is not obvious whether any additional price increases that the consumer would have to pay for renewable energy have been reflected in the analysis.

For energy efficiency programs, there are similar questions to consider when using a factor. When a state implements a program for energy efficiency through surcharges to rate payers, it is taking money away from the consumers that it would have spent on other goods, possibly creating job losses, and investing them into the energy efficiency program, possibly creating job increases.

Key questions to consider when using a rule-of-thumb estimate include:

- How recent are the construction and material costs used in the factor?
- Does it include the opportunity costs (lost jobs, reduced earnings, spending or GSP) that occur because the money for the clean energy program was taken from elsewhere in the economy?
- If the rule of thumb is related to employment, is the estimate it generates given in jobs or job years (for more information, see text box *Job Years Versus Jobs* earlier in this chapter).
- Does the rule of thumb reflect any price increases consumers may have to pay for the technology or program?

Typically, these are the types of issues addressed in more rigorous analysis but it is important to be aware of any limitations associated with rule-of-thumb factors. Because of these oversimplifications, rule-of-thumb factors are best recognized as screening-level tools that can provide preliminary estimates.

USING JEDI: THE CASE OF WIND POWER IN UTAH COUNTY, UTAH

Wind power has been proposed in Utah as a way to diversify the state's electricity generation. Utah State University used JEDI to inform decision makers about the likely impact of five wind capacity scenarios: 5 MW, 10 MW, 14.7 MW, 20 MW, and 25 MW.

Economic and demographic information was obtained from three sources: (1) the Economic Development Corporation of Utah (EDCU); (2) IMPLAN multipliers for Utah county supplied by NREL; and (3) two local wind developers. These data allowed the study to dictate cost and other inputs specific to their scenarios.

The results of the JEDI analysis indicated promising economic opportunities for wind power in Utah. For example, the proposed Spanish Fork project (14.7 MW) would produce 46 total new jobs, $1.2 million in wage earnings, and $4.2 million in economic output during the construction phase of the project (Mongha et al., 2006).

Screening Tools

Job and Economic Development Impact (JEDI) Model for Wind Projects

The U.S. Department of Energy/National Renewable Energy Laboratory (DOE/NREL) developed a spreadsheet-based model, *JEDI*, for estimating the local economic effects of the construction and operation of wind power plants. JEDI is designed to be user-friendly and does not require experience with spreadsheets or economic modeling. The model was originally developed with state-level parameters, but it can also be

THE IMPORTANCE OF ACCURATE ENERGY DATA

Accurate and complete state energy data are often missing or incomplete, but are a crucial input to any multiple benefit analysis. States do not always have dynamic energy sector representation and must rely on spreadsheet-level analysis.

used for county and regional analyses. Users enter basic information about the wind plant project (e.g., the project's state, county, or region; the year of construction; the size of the facility), and JEDI calculates the project cost as well as the jobs, income, and economic output that will accrue to the state, county, or region being analyzed. The project cost calculations are based on default expenditure patterns derived from numerous wind resource studies. The user can replace these default values with project-specific information, such as costs and expenditures, financing, taxes, and local share of spending (Goldberg et al., 2004).

JEDI uses input-output analysis to evaluate the direct, indirect, and induced macroeconomic effects from the project expenditures. This type of analysis quantifies relationships among industries in a state, regional, or national economy—i.e., showing how sales of goods and services in one industry lead to purchases or sales of goods and services in other industries. These relationships are depicted as state-specific multipliers that show how the effects of an investment multiply beyond the original transaction. The multipliers are adapted from year 2000 data used in the IMPLAN® Professional model, an input-output modeling tool described below in *Sophisticated Modeling Methods for Macroeconomic Impact Analysis*.

JEDI outputs should not be considered precise values, but rather an indication of the magnitude of potential economic development impacts. Structural characteristics that limit the accuracy of JEDI's results include the following:

- JEDI outputs are presented as aggregate impacts without sector specificity.
- JEDI is a static model and cannot account for future changes in wind power plant costs, changes in industry, or personal consumption patterns in the economy.
- Analyses are specific to wind power plants and therefore represent a gross analysis that does not reflect net impacts associated with alternative uses of the expenditures.
- Analyses do not account for changes in electricity prices or end-user electricity bills that could result from developing the wind power plant.
- Analyses assume that plant output generates sufficient revenues to accommodate the equity and debt repayment and annual operating expenditures.
- JEDI does not calculate "net jobs" or otherwise reflect the opportunity cost of alternative uses of investment.

  http://www.nrel.gov/applying_technologies/market_economic_mt.html

RMI Community Energy Opportunity Finder

The Rocky Mountain Institute (RMI) Community Energy Opportunity Finder is an interactive website tool that provides a preliminary analysis of the potential benefits of implementing energy efficiency or renewable energy in a particular community. This tool has the following characteristics:

- Is designed to perform an initial evaluation of the opportunities for energy efficiency and renewable energy projects in the community.
- Guides the user through the process of collecting energy use data for the local community and then calculates potential energy savings, dollar savings, and job creation that could be achieved through the energy efficiency or renewable energy project.
- Includes many calculations and assumptions based on published literature and substantial experience from dozens of energy experts.
- Can produce a reasonable estimated range of benefits from a small core of energy use data.
- Is limited by using largely default values and other information not necessarily specific to the project being analyzed.

Finder is intended to provide an overall sense of the potential benefits of energy efficiency and renewable energy options in a community, but should not serve in place of a detailed audit of each area or building where energy is used. A variety of cities, utilities, and education programs have used Finder as a screening tool. Examples of Finder applications are available at

USING REPP LABOR CALCULATOR: THE CASE OF NEVADA'S RPS

As part of its 1997 restructuring legislation, the Nevada legislature established an RPS that included a 5% renewable energy requirement in 2003 and a 15% requirement by 2013. The Nevada American Federation of Labor-Congress of Industrial Organizations (AFL-CIO) used the REPP Labor Calculator to estimate the job diversification effects of the RPS (IREC, 2005).

To use the calculator, AFL-CIO had to make a number of assumptions, including assumptions to estimate electricity sales by technology type, which were then used to estimate the installed capacity of each renewable technology.

The results of their analysis showed that, from 2003-2013, the RPS would create 27,229 total, direct full-time-equivalent (FTE) jobs. Of these jobs, 19,138 are estimated to be manufacturing jobs while 8,092 are installation and O&M jobs. These are direct jobs and do not account for any indirect or induced employment effects (AFL-CIO, 2002).

the RMI website. RMI is currently working on revising Finder and developing related web-based tools. *http://www.energyfinder.org/*

REPP Labor Calculator

The Renewable Energy Policy Project (REPP) has developed a tool that calculates the number of direct jobs resulting from state programs, such as an RPS program, that accelerate renewable energy development. The *Labor Calculator* is based on a survey of current industry practices related to manufacturing, installation, and operation and maintenance activities for renewable technologies. The spreadsheet-based format of the calculator provides a transparent framework that lays out all of the labor data and program assumptions.

The user specifies the required installed capacity to meet the renewable energy program requirements (e.g., an RPS), and the calculator determines the number and type of jobs in each renewable activity area by year per installed MW of capacity. The Labor Calculator estimates the total direct labor required to manufacture, install, operate, and service several types of clean energy projects, including wind power, distributed solar PV systems, biomass fuel production for use in biomass co-fired coal plants, and geothermal power plants. REPP is currently developing information to expand the Labor Calculator to include other biomass, geothermal, and solar thermal technologies.

MODELING ENERGY-ECONOMY INTERACTIONS: BOTTOM-UP VS. TOP-DOWN

Bottom-Up and *Top-Down* analyses are the two primary approaches for modeling energy-economy relationships. The major differences between these approaches are the emphases placed on a detailed technologically based representation of the energy system, and the representation of the general economy.

Bottom-up models include a detailed representation of the energy sector in the form of an energy technology matrix, where each technology is represented by engineering cost and performance characteristics. These models are capable of capturing substitution among labor, capital, and fuel inputs among technologies, and other structural changes in the energy sector in response to a given stimulus or policy constraint (Loschel, 2002). These models, however, generally do not assess how energy system changes spill over to other economic sectors and generate macroeconomic or general equilibrium effects. Bottom-up models are also limited in their ability to represent the influences of non-energy markets on cost and performance dynamics of the energy system technologies (Bohringer, 1998; Loschel, 2002).

Top-down models represent the energy sector in a more aggregate way and account for how the energy sector interacts with the rest of the economy. Rather than specifying energy technologies according to their engineering characteristics, top-down models usually represent technologies using aggregate production functions that capture substitution among technologies in response to price changes (i.e., substitution effects). In addition, top-down models usually employ an input-output (I-O) table to simulate supply-demand interactions and the reallocation of all goods and services across the economy. All of the sophisticated modeling methods described below are, fundamentally, top-down models.

The REPP tool is a job calculator, not an economic model. It shows direct gross job effects that could be captured by a state, but does not account for indirect or induced secondary effects. *http://www.repp.org/index.html*

Sophisticated Modeling Methods for Macroeconomic Impact Analysis

The screening tools described above provide relatively simple approximations of the economic feasibility and impact of clean energy initiatives. They are often easy to use, and results can be produced relatively quickly.

However, these tools do not typically provide a sufficient level of sophistication to evaluate substantial investments in clean energy initiatives. Development and implementation of clean energy initiatives at the state level generally require a more comprehensive analysis of the macroeconomic effects of alternative clean

TABLE 5.2.3 OVERVIEW OF SOPHISTICATED MODELING APPROACHES AND TOOLS FOR STATE ECONOMIC ANALYSIS

Example of State Tools	Advantages	Disadvantages	Considerations	When to Use
METHOD: Input-Output *(also called multiplier analysis)*				
IMPLAN	▪ Quantifies the total economic effects of a change in the demand for a given product or service. ▪ Can be inexpensive.	▪ Static; multipliers represent only a snapshot of the economy at a given point in time. ▪ Generally assumes fixed prices. ▪ Typically does not account for substitution effects, supply constraints, and changes in competitiveness or other demographic factors.	▪ Provides rich sectoral detail (NAICS-based). Could be appropriate if the need is to analyze detailed impacts by sector.	▪ Short-term analysis.
METHOD: *Econometric Models*				
RAND	▪ Usually dynamic, can estimate and/or track changes in policy impacts over time. ▪ Coefficients are based on historical data and relationships, and statistical methods can be used to assess model credibility.	▪ Historical patterns may not be best indicator or predictor of future relationships. ▪ Some econometric models do not allow foresight.	▪ Important to understand if model is myopic or has foresight.	▪ Short- and long-term analysis.
METHOD: Computable General Equilibrium (CGE) Models				
BEAR	▪ Account for substitution effects, supply constraints, and price adjustments.	▪ Not widely available at state level. ▪ Most CGE models available at state level are static, although a few are dynamic.	▪ Important to examine how the energy sector is treated within any specific CGE model.	▪ Long-term analysis.
METHOD: Hybrid				
REMI Policy Insight	▪ Most sophisticated, combining aspects of all of the above. ▪ Dynamic, can be used to analyze both short- and long -term impacts. ▪ Can be used to model regional interactions. ▪ Flexibility of looking at 2-, 3-, or 4-digit NAICS sectors.	▪ Can be expensive, especially if there is a need to analyze impacts on multiple sub-regions (e.g., counties within a state). ▪ Can require a fair amount of massaging inputs, especially with energy sector inputs.	▪ Important to examine how energy sector is treated. ▪ May need to update default data to account for most recent energy assumptions .	▪ Short- and long-term analysis.

energy initiatives. Several well established models have been developed to quantify the nature and magnitude of the macroeconomic effects of clean energy investments. These approaches include input-output models, econometric models, computable general equilibrium models, and hybrid models. Table 5.2.3 compares key characteristics among these four model types.

Input-Output Models

Input-output (I-O) models, also known as multiplier analysis models, are useful for quantifying macroeconomic impacts because they estimate relationships among industries in a state, regional, or national economy. Policy impacts in I-O models are driven by changes in demand for goods and services.

WHAT IS AN ECONOMIC MULTIPLIER (“RIPPLE EFFECT”)?

An economic multiplier, usually expressed as a ratio, captures how much additional economic activity is generated in each regional industry from a single expenditure (or change in final demand) in another industry.

In I-O models, multipliers estimate the size of sector-specific indirect and induced effects, as well as the economy-wide totals. Multipliers can be derived separately for employment, income, and economic output, and are interpreted differently depending on the form of the multiplier.

In California, for example, a study found that each $1 invested in new solar generation would result in an additional $0.50 of economic activity in California (this represents an output multiplier of 1.5). This study also found that 1MW of solar capacity would produce an additional 40 job-years. (Cinnamon and Beach et al., 2005)

At the core of any I-O model is an input-output table, which describes the flow of goods and services from producers to intermediate and final consumers. The I-O table in the most commonly used I-O models in the United States (e.g., IMPLAN, RIMS II) comes from national and regional public data sources such as the Bureau of Economic Analysis’ (BEA’s) national I-O table and regional economic accounts.

The strength of I-O based models is their ability to quantify the total economic effects of a change in the demand for a given product or service. In this context, “total” means the cumulative direct, indirect, and induced effects. The I-O model produces a set of multipliers that describe changes in employment, output, or income in one industry given a demand change in another industry. It is important to note, however, that the multipliers derived from I-O models only represent a snapshot of the economy at a given point in time. Due to their static nature, I-O models generally assume fixed prices and do not account for substitution effects and changes in competitiveness or other demographic factors; thus they are suitable for static or short-term analysis only (RAP, 2005).

In an analysis of the impacts of the Oregon Energy Tax Credits, the modelers determined that the I-O approach was most appropriate for a short-term analysis. With the IMPLAN model, they estimated that the net impacts of the tax credits in Oregon for the year 2006 were an increase in:

- Gross state product of more than $142 million.
- Jobs by 1,240.
- Tax revenue of nearly $10 million.

When it came to extrapolating the results into the future, however, they acknowledged that “estimating the long-term impacts taking into account regional changes in energy efficiency and the subsequent impact on economic output requires a much more extensive dynamic modeling exercise (Grover, 2007).” Additional studies that use input-output models are listed in the resource section at the end of this chapter.

Econometric Models

Econometric models are a set of related equations that use mathematical and statistical techniques to analyze economic conditions both in the present and in the future. Econometric models find relationships in the macro-economy and use those relationships to forecast how clean energy initiatives might affect income, employment, output, and other factors. For example, energy demand may be related to the price of fuel, the number of households, and/or the weather but not to individual income levels. These models examine historical data to identify those relationships and make predictions about the future.

Econometric models generally have an aggregate supply component with fixed prices, and an aggregate demand component. The models’ regression coefficients are similar to the multipliers produced by I-O models in the sense that they describe how one component of the economic system changes in response to a change in some other component of the economic system. Most econometric models use a combination of coefficients, some of which are estimated from historical data, and others that are coefficients obtained from other sources.

A key strength of econometric models is that they can estimate and/or track changes in policy impacts over time. Another strength is that consistency between the econometric model structure (developed for analysis) and the underlying economic theory can be evaluated using statistical methods. For example, because historical data are used to generate specific coefficients that reflect the observed relationships between variables, statistical methods can be used to test whether the observed historical data lend support to the (theoretically) hypothesized relationships between variables. This requires the structure of an econometric model to be formulated first based on economic theory and then the model’s coefficients estimated using historical data, rather than developing the structure of the econometric model itself based on the analysis of historical data (i.e., by developing the structure that best fits the observed data).

Econometric models can be used for both long- and short-term analyses. Because econometric models, in general, rely heavily upon historical data as the pattern for future behavior, the behavior projected is limited because it neglects changes in consumer and business conduct or investments that may occur when future policies and price changes are anticipated. For example, if a carbon standard were proposed today for implementation in five years, one might expect that firms would begin making decisions about investments in energy sources and carbon-efficient technology that would prepare them for when the mandatory provisions take effect. A myopic econometric model might predict that the actors will not alter their strategies until the mandatory provisions provide a "shock," even though they would be able to anticipate the effect. Unless the econometric model includes a mechanism for responding to anticipated policy changes it may not be able to reflect planning for implementation, thus missing investments in new types of fuels or technologies or planning to avoid last-minute capacity constraints and abandonment of recently purchased equipment. The predicted results of an unanticipated shock may be more negative in the short term than something that is anticipated. For this reason, users will need to be aware of the model limitations and strongly consider choosing a tool with foresight when conducting longer-term studies.

State-level econometric models are often developed by universities, private consulting firms, or nonprofit organizations. For example, RAND Science and Technology, a nonprofit institution, conducted an analysis for the Commonwealth of Massachusetts to retrospectively measure the economic benefit of energy efficiency improvements between 1977 and 1997. By looking at the historical data with their econometric model, they concluded that declines in energy intensity were associated with increases in gross state product and that declines in energy intensity can be an approximation of changes in energy efficiency. They also concluded that government investments in energy efficiency programs may lead to improvements in gross state product. Through statistical and mathematical equations, they could explore the relationship between different key variables, such as energy intensity, gross state product, and government investments, and determine which ones were statistically linked (Bernstein, 2002a). The list at the end of this chapter provides additional examples of state-level clean energy project analyses that have used econometric models.

Computable General Equilibrium Models

Computable general equilibrium (CGE) models use economic data to trace the flow of goods and services throughout an economy and solve for the levels of supply, demand, and price that satisfy the equilibrium constraints across a specified set of markets. Unlike econometric models, CGE models use a framework based on the tenets of microeconomic general equilibrium theory: market clearance and no excess profit. Market clearance refers to the notion that all economic output is fully consumed and that all labor and capital are fully employed. The no excess profit condition assumes that in perfect competition, firms will continue to enter any economic market until excess profits (i.e., profits exceeding a normal rate of return on capital) are diminished to zero. A result of this is that prices will equal the marginal cost of producing a product. When the baseline equilibrium is perturbed, for example, by a clean energy tax incentive, a new market equilibrium is created. Firms will enter and exit existing markets, and the economy will move to a new equilibrium, including adjusting prices and output throughout the economy. In this way, CGE models can be useful for assessing the economy-wide impacts of a clean energy policy.

Many CGE models are calibrated using data from a Social Accounting Matrix (SAM). A SAM is an extension of an I-O table, including additional information such as the distribution of income and the structure of production. Unlike I-O models, CGE models are able to account for substitution effects, supply constraints, and price adjustments in the economy snapshot. That is, CGE models *do not necessarily* use fixed coefficients and fixed prices to determine the relationships between a sector and its upstream and downstream sectors. Like I-O models, most CGE models are static, although some are dynamic.

CGE models are best used for long-term analyses because they may not accurately depict the economic impacts a state experiences on its way to the new equilibrium. The CGE analysis estimates what the economy will resemble in the new steady state. Particularly when compared with a static CGE model, econometric models are typically better at capturing those interim economic changes that will occur between the policy shock and the new equilibrium.

It is important to examine how the energy sector is treated within any specific CGE model. While it may allow for substitution effects, it may not include an option for consumers or firms to switch to renewable energy or

Analyzing Conservation Policies in Connecticut

In 2004, Connecticut analyzed the economic impact of oil and natural gas conservation policies in Connecticut. The state wanted to explore the impacts of fully funding a program between 2005 and 2020 to increase the efficiency of oil and natural gas for residential, commercial, and industrial users.

Connecticut used a hybrid model, the REMI Policy Insight model, for their analysis. REMI is a frequently used proprietary model in the US for analyzing state level policy initiatives. Because the model does not have a detailed energy sector module to fully capture the fuel-switching that would occur within the electricity sector, Connecticut used outputs from an energy analysis using an electricity dispatch model—ICF International's IPM—to estimate the energy changes used as inputs to Policy Insight. The direct costs included cost increases resulting from a 3% natural gas-use and oil-use surcharge on residential, commercial, and industrial users to pay for the program; the savings to residential, commercial, and industrial users due to reduced consumption of natural gas and oil; the consumption reallocation of other consumer goods due to an increase in personal income; the loss in sales to natural gas and oil firms due to reduced consumption; and the investment in new equipment, construction, research, and other sectors.

These direct effects were used as inputs to the REMI model to determine the indirect, induced, and overall effects of the program. The model was able to break down the results to determine the contribution the oil conservation efforts and the natural gas conservation efforts made to the overall economic impact. For example, as shown in the above table, the overall result of the analysis showed economic benefits to the state. The natural gas conservation efforts, however, contributed more than the oil programs to the overall benefits of the program. Because the model contains very detailed sector-specific information, the analysts were able to determine that "The disproportionate ratio between the oil and natural gas policies is due to the higher loss in demand for petroleum than for natural gas... the loss in demand of oil is almost 6 times higher than the loss in demand for natural gas" (REMI, 2004).

ECONOMIC GROWTH DUE TO CONSERVATION POLICIES IN CONNECTICUT (CUMULATIVE 2005-2020)

	Oil & Natural Gas	Oil	Natural Gas
Employment (Average Annual Increase)*	2,092	430	1,668
Output (Mil '96$)	3,094.90	82.80	3,020.64
GSP (Mil '96$)	2,033.01	266.21	1,773.82
Population	3,604	717	2,894
Real Disposable Personal Income (Mil '96$)	1,749.42	294.81	1,459.35
State Revenues (Mil '01$)	382.13	66.75	314.97

* *Employment is the average annual increase from the baseline. Employment is not cumulative and is based on output growth. Source: REMI, 2004.*

energy efficiency as a way to meet energy demand. Individual models will handle this differently depending upon the details (e.g., number of sectors) of the model.

CGE models are more readily available at the national level than at the state level, and most CGE models are highly aggregated. Some states, however, have developed and/or used state-specific CGE models to analyze the impacts of clean energy initiatives.[6] In California, for example, the University of California at Berkeley developed a dynamic CGE model, the Berkeley Energy and Resources (BEAR) model. In addition to the core CGE model, it includes extensive detail about the energy sector and also estimates greenhouse gas emissions. This model has been used to assess the potential impacts of state-level greenhouse gas mitigation policies in California. A recent analysis concluded that nearly 50 percent of California's 2020 goal of reducing emissions levels to 1990 levels could be achieved using just a handful of options under consideration, while increasing gross state product by 2.4 percent and creating more than 20,000 jobs (Roland-Holst, 2006).

Hybrid Models

Hybrid models incorporate aspects of two or more of the modeling approaches described above, with most models linking an I-O model to an econometric model. Most hybrid models used for energy-related analyses are described as regional economic-forecasting and policy-analysis models. These models are the most sophisticated—and expensive—of the four categories of models.

These models include five analytic elements: (1) output, (2) labor and capital demands, (3) population and

---

[6] *RTI International developed a CGE model (the* ***Applied Dynamic Analysis of the Global Economy (ADAGE) Model****) that can be used to explore dynamic effects of many types of energy, environmental, and trade policies, including climate change mitigation policies. For more information on CGE models and their application for macroeconomic impact analysis, see Sue Wing (2004).*

labor supply, (4) wages, prices, and profits, and (5) market shares. The integrated structure of these models allows them to capture everything from economic migration to changes in relative prices and the overall competitiveness of businesses in the economy. These models also include dynamic frameworks that support forecasting of both *what* will happen in response to an initiative and *when* it will happen.

Of the general approaches described in this section, the hybrid modeling approach offers the most flexibility and detail in tailoring an analysis to estimate the effect of a specific clean energy initiative on a state's economy. A user can specify and forecast numerous different model inputs, including: industry output, industry demand, government, investment and/or consumer spending, employment, factor productivity, labor supply, production costs, business taxes and credits, fuel and/or labor costs, wages, housing and consumer prices, and market shares. The results of the complex, dynamic simulations produced by hybrid models can be distilled into net impacts on key economic policy indicators, such as employment, income, and overall economic output. Hybrid models can be effective at estimating both the long- and short-term impacts of policies.

As with other models, it is useful to examine how the energy sector and technological change are treated within a hybrid model. Many states have found that detailed energy-related analyses require energy modeling to be done separately and used as inputs to a hybrid model. This can be a limitation of some hybrid models. In addition, these models can be very complex, time-consuming and expensive to run, and require significant input data.

Hybrid models used for policy analyses include REMI Policy Insight® (see text box *Analyzing Conservation Policies in Connecticut*), those developed by the Regional Economics Applications Laboratory (REAL, developed at the University of Illinois), the Illinois Regional Econometric Input-Output Model (ILREIM), and the Georgia Economic Modeling System (GEMS™, developed at the University of Georgia). A list of additional state-level analyses conducted using hybrid models is provided at the end of this chapter.

Comparison of Models Commonly Used by States to Analyze Clean Energy Initiatives

Table 5.2.4 summarizes key aspects of the four model types—input-output, econometric, CGE and hybrid—that have been frequently used for energy-related policy analyses. State analysts can consider this model information in deciding upon an appropriate model for analyzing the macroeconomic benefits of clean energy initiatives. No one model is perfect for any given analysis case, and the analyst may often choose a given model because it has been used previously for analyses within a state and certain individuals within the state analytic community are more familiar with run specification and interpretation of model outputs.

The direct, indirect, and induced macroeconomic benefits arise from the outlays, energy, and dollar savings generated by clean energy initiatives.

It is important for states to understand these outlays and savings because they are key inputs for quantifying changes in employment, income, and output.

5.2.2 STEP 2: QUANTIFY EXPENDITURES AND SAVINGS FROM THE CLEAN ENERGY INITIATIVE

The second step in analyzing macroeconomic effects is to quantify the direct expenditures and savings from implementing the clean energy initiative. The expenditures and savings are the primary inputs to the subsequent analysis of macroeconomic effects on income, employment, and output. As described in Sections 5.1.1 and 5.1.2, the specific expenditures and savings that states need to consider in this step are different for demand-side and supply-side initiatives. But generally speaking, these expenditures and savings include estimates of energy savings associated with the initiative and data on expenditures by participating entities and the costs of administering the program.

Key Considerations for Quantifying Expenditures and Savings

States have found it useful to design a strategy to quantify initiative expenditures and savings based on (1) the design and nature of the initiative, (2) the attributes of the state's economy, and (3) the expected behavior of the initiative participants. Several factors contribute to the challenge of developing such a strategy. The analyst can consider the following factors when establishing the necessary data to estimate expenditures and savings (DOA, 2001):

- *Expected energy savings or costs (e.g., oil, natural gas, electricity) to consumers over time.* To perform an economic impact analysis, it is often important

TABLE 5.2.4 COMPARISON OF MODELS FOR ESTIMATING MACROECONOMIC BENEFITS

General Model Category	Input-Output	Econometric	CGE	Hybrid
Example*	IMPLAN	RAND	BEAR	REMI Policy Insight
Model Characteristics				
I-O Component	Yes	Modified I-O	Social Accounting Matrix	Yes
CGE Component	No	Varies	Yes	Yes
Econometric Component	No	Varies	Limited	Yes
Open/Closed Economy	Both	Varies	Yes	Open
Dynamic Modeling Capability	No	Yes	Certain Models	Yes
State and County Level Modeling	Yes	Certain Models	Varies	Yes
Major Data Sources	BEA, BLS, CBP, and Census	Varies	Varies	BEA, BLS, CBP, EIA and Census
Industry Characteristics				
SIC/NAICS Classifications	Yes	Varies	Varies	Yes
Sector Aggregation Options	Yes	Yes	Yes	Yes
Other Features				
Trade Flows	Yes	Certain Models	Most	Yes
Substitution Effects	No	Varies	Yes	Yes
Price and Wage Determination	No	Yes	Yes	Yes
Feedbacks on Competitiveness	No	Yes	Yes	Yes
Migration, Demographic Changes	No	Varies	Varies	Yes
Impacts Measured				
Employment	Yes	Yes	Yes	Yes
Income	Yes	Yes	Yes	Yes
Output	Yes	Yes	Yes	Yes
Value Added	Yes	Yes	Yes	Yes
Proprietary	Yes	Some	Some	Yes
Overall Cost, Complexity, and Capability	Medium	High	High	High

* *Models names are included for illustrative purposes only, and do not imply an endorsement by EPA.*

to translate any energy savings into dollars. This monetization can be accomplished by applying projections of prices for different energy types (e.g., coal, oil, gas, electricity) to the profile of expected energy savings. For example, a policy that is funded by a surcharge on electricity bills imposes a cost on consumers but the energy efficiency investments will result in energy cost savings. Both will affect the economy. For more information on calculating energy savings, see Chapter 2, *Assessing the Potential Energy Impacts of Clean Energy Initiatives*.

- *Expected clean energy investment and realization rates in the short and long terms.* This factor is particularly important with regard to energy efficiency initiatives. In assessing the expected change in energy use from the proposed initiative, it is helpful to break down the most likely level of energy savings realization by participant group and/or equipment type. This "intention" information may be collected via a survey of potential participants or estimated using program analyses.[7] For example, a program might expect to achieve 30 percent penetration of a new technology in the residential sector in the short run, but 60 percent in the longer term. Both short- and long-term realization rates can significantly affect the overall magnitude and time profile of program effects. Therefore, states may find it useful to analyze the potential impacts of a program under different realization scenarios and then focus program efforts on achieving the optimal level of adoption over time.

- *The proportion of investment from individual participants versus program funding.* The energy savings from a program are partially reduced by any up-front outlays by program participants. It is important to account for participants' expected outlays because these outlays will affect the economic performance of the total program (including outlays and savings for participants). Participants' expenditures (and expected downstream savings) will also influence program participation. It is also an important factor to account for the amount and source of program funding. Program expenditures can affect the state economy; however, the nature and extent of those effects will depend on where the program funds come from (e.g., a system benefits charge applied to electricity bills) and the distribution of funds across different economic sectors. For example, a state might implement an energy-efficient water heater rebate program that is funded through a surcharge on all electricity bills. A portion of the amount paid will be returned to some consumers in the form of rebates. These rebates will cover some of the purchase cost of the new water heater. In this instance, the investment in the new water heaters is paid by program participants directly and electricity consumers through the surcharge.

- *The amount of initiative-related activity expected to occur locally.* For any type of spending/sales that originates within a state, part of the dollars will flow to businesses located in the state and part will flow to businesses outside of the state. Accounting for where those dollars flow is important because, to the extent that program-related flows replace flows that would have otherwise left the state, there is potential for in-state net economic gain. This effect is known as "import substitution," and is measured by factors called "regional purchase coefficients" (RPC). All four of the economic models shown in Table 5.2.4 use RPCs to account for this effect.[8]

- *The expected useful life of the clean energy investment.* Any estimation of program expenditures and savings requires information on the useful life of the products or services provided by the program. The costs and savings associated with program investments can be amortized over the expected useful life of the product or service. For example, a state program might promote the purchase of energy-efficient appliances but these appliances do not last indefinitely. It is important to consider life of the products when calculating potential long-term benefits of a program. If one expects the program to continue beyond the useful life of the initial investments, the analysis can also account for renewed investments when estimating the long-term character of program expenditures and savings.

- *The expected persistence of energy savings over time.* Estimation of expenditures and savings requires assumptions regarding the persistence of the energy savings over time. This may be, for example, an assumed annual loss of energy savings attributable to factors such as deterioration of equipment performance, removal of equipment, business closures, or other factors relevant to the persistence of demand- or supply-side energy saving effects. Note that the useful life of a clean energy investment is a key determinant in the ultimate long-term persistence of savings, but that the persistence of savings can also vary over time during the useful life.

- *The expected economic benefits associated with energy system, environmental, or public health benefits.* Potential energy system benefits, such as fuel

---

[7] *As a corollary, in estimating the energy savings to be achieved by a program, it is also important to account for, and net out, the baseline energy savings that would have occurred without the program.*

[8] *RPCs can be estimated for specific products or services based on analysis of, for example, the extent to which a state has a disproportionately large or small base of manufacturers providing the relevant types of energy-saving equipment (DOA 2001). Alternatively, many economic models contain default RPC values.*

cost savings and avoided capacity or transmission and distribution costs to the electricity generators and/or distributors, are economic benefits that can be estimated and included in an economic analysis in addition to the energy cost savings to consumers above. (For more information about energy system benefits, see Chapter 3, *Assessing the Electric System Benefits of Clean Energy.*) Likewise, environmental benefits such as reductions in criteria air pollutants can reduce the costs of complying with air quality standards and yield human health benefits such as avoided deaths, illnesses, and hospitalizations, and reductions in lost work days due to illnesses. As described in Chapter 4, an economic value can be estimated for many of these benefits, and they can be included in the economic analysis to ensure adequate representation of the overall benefits in the analysis.

In addition to these considerations, the appropriate method and data for quantifying costs and savings are influenced by the macroeconomic analysis method selected in Step 1 and its associated data requirements.

Methods for Quantifying Direct Expenditures and Savings

A wide range of methods can be used to quantify the direct expenditures and savings of a potential clean energy initiative (that go beyond those covered in this *Resource*), and states often develop a customized approach based on their specific needs and resources. For a prospective analysis of expenditures and savings, most methods involve projections using some modeling capability. Models available for prospective analyses range from relatively simple, spreadsheet-based models like Excelergy (see California example below) to more rigorous and data-intensive models such as the Long Term Industrial Energy Forecasting model (LIEF) and the Integrated Planning Model (IPM®), an electric power sector model (see Georgia and SWEEP examples). If an initiative has already been implemented, the modeling approach can be supplemented with actual expenditure and/or savings data from the program. In such instances, analysts can use already-collected program data on expenditures and savings as inputs to a retrospective analysis of macroeconomic effects, or as inputs to a prospective analysis of future expenditures and savings (or both, as is done in Massachusetts - described below). Including these actual expenditures and savings likely will require some type of "mapping" to defined economic sectors (e.g., by NAICS or SIC) before being entered into the models.

Examples of the methods that states have used to quantify expenditures and savings in prior analyses of clean energy initiatives are presented below. The first three examples (California, Georgia, and the Southwest) describe instances where the analysis was prospective and used modeling techniques to estimate the expenditures and savings of potential clean energy investments. The last example (Massachusetts) shows how a state might use actual clean energy initiative expenditures and savings to (1) estimate macroeconomic effects retrospectively and (2) project the future expenditures and savings from an initiative [also see Grover (2005), NYSERDA (2006b), and Sumi et al. (2003) for examples of using actual initiative data on expenditures and savings to estimate macroeconomic effects retrospectively]. More information on these studies can be found in the resource section at the end of the chapter.

California Concentrated Solar Power

A study of concentrated solar power (CSP) in California evaluated the potential benefits—in terms of direct and indirect effects on employment, earnings, and GSP—of the deployment of 2,100–4,000 MW of CSP from 2008–2020 (Stoddard et al., 2006). The outlay and savings data needed to quantify the direct and indirect effects of the project on employment, earnings, and GSP included the dollars spent by the project in California on materials, equipment, and wages.

The California study used data from the Excelergy Model, developed and maintained by NREL, to estimate the expenditures and savings generated in the CSP scenario. The data used by Excelergy to determine the expenditures and savings included the size of the plants to be built and the time periods for construction. Excelergy is an Excel spreadsheet-based model for solar parabolic trough systems that models annual plant performance and estimates capital and O&M costs. The data produced by Excelergy served as the input data for the macroeconomic analysis.

The study found that the "high CSP deployment" scenario would result in $13 billion in investment, of which an estimated $5.4 billion is estimated to be spent in California. Using RIMS II, the study found that this in-state investment would have a gross impact of $24 billion on California GSP.

Georgia Energy Efficiency Potential Study

To assess opportunities for energy efficiency investments in the state of Georgia, the Georgia Environmental Facilities Authority undertook a prospective analysis of the macroeconomic effects of varying levels of investment in energy efficiency in Georgia from 2005–2015 (Jensen and Lounsbury, 2005).

The expenditure and savings data required for the Georgia study included the costs of energy efficiency equipment, customer energy bill savings, and program administration and incentive costs. To quantify these inputs, the study used ICF International's Energy Efficiency Potential Model (EEPM) to estimate the potential for energy efficiency improvements through program and policy interventions, and the expenditures and savings associated with realizing that potential.

The EEPM model provided a detailed view of which sectors, subsectors, and end uses provide the greatest opportunity for energy efficiency improvements in Georgia's economy by using end-use forecast data along with industry data on the costs, applicability, and longevity of energy efficiency measures. Within the model, the extent to which energy efficiency measures are adopted over time depends on the costs of energy efficiency measures relative to supply-side options and the intensity of the projected policy interventions. This relationship allowed the analysis to account for the energy savings and expenditures associated with efficiency investments and program administration, as well as the cost and revenue reductions experienced by utilities from reduced demand for electricity or gas.

Since Georgia-specific data for end-use forecasts and utility avoided costs were not publicly available, the study used regional data from various sources, including the U.S. Department of Energy, the Energy Information Administration, and IPM model projections. Results from EEPM and IPM were used as inputs to the Georgia Economic Modeling System (GEMS), developed by the University of Georgia, to estimate macroeconomic development effects.

The results of the GEMS analysis demonstrated that investments in energy efficiency in Georgia would generate economic benefits. Specifically, the study explored three policy scenarios to capture the energy efficiency potential identified for Georgia: a minimally aggressive scenario, a moderately aggressive scenario, and a very aggressive scenario. The study concluded that each scenario would achieve long-term net economic benefits in Georgia including the creation of 1,500 to 4,200 new jobs and an increase in real disposable income of $48 million to $157 million by 2015 (Jensen and Lounsbury, 2005).

Southwest "High Efficiency" Study

The Southwest Energy Efficiency Project (SWEEP, 2002) analyzed the macroeconomic effects of investments in energy efficiency from 2003–2020 in southwestern states (including Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming). A "high efficiency" scenario was developed in the study by first establishing the expected level of energy savings and expenditures that would comprise this scenario.

In the residential and commercial sectors, SWEEP analyzed the energy savings and efficiency expenditures for the "high efficiency" scenario using the DOE-2.2 model, developed by James J. Hirsch & Associates in collaboration with the Lawrence Berkeley National Laboratory, accounting for specific building characteristics, energy use practices, state-by-state saturation and usage rates for end-uses, and other assumptions. This analysis included data from SWEEP, ACEEE, and EIA, among others.

In the industrial sector, SWEEP used the Long-Term Industrial Energy Forecasting (LIEF) model, along with U.S. Census and EIA data, to analyze the cost-effective electricity savings for the "high efficiency" scenario versus a base case scenario. LIEF is a model developed by the Argonne National Laboratory that uses three key factors to estimate the cost-effectiveness and adoption of energy efficiency measures in the industrial sector: (1) the assumed penetration rate, (2) the capital recovery factor, and (3) projected electricity prices. The LIEF model contains a number of cost assumptions for energy savings, and also has a number of parameters that the user can specify.

These analyses revealed, for example, that the "high efficiency" scenario would reduce average annual electricity demand growth from 2.6 percent in the base case to 0.7 percent, thereby reducing electricity consumption 33 percent by 2020 versus the base case. These and other savings would accrue with a total investment of $9 billion from 2003–2020. The macroeconomic effects of these expenditures and savings were then evaluated for their direct, indirect, and induced effects using the IMPLAN input-output model. Among the findings of the IMPLAN analysis were increased regional employment of 58,400 jobs and increased regional personal income of $1.34 billion per year by 2020 (SWEEP, 2002).

TABLE 5.2.5 SUMMARY OF ECONOMIC IMPACTS OF 2002 MASSACHUSETTS ENERGY EFFICIENCY PROGRAM ACTIVITIES

Electricity Bill Impacts	
Energy Savings	$21.5 million
Total Participant Annual Energy Savings	14 years
Average Life of Energy Efficiency Measures	$249 million
Total Participant Lifetime Energy Savings	$138 million
Total Program Costs	4.0 ¢/kWh
Average Cost for Conserved Energy	
Demand Savings	$1.2 million
Total Participant Annual Demand Savings	
Systems Impacts	
Savings to All Customers Due to Lower Wholesale Energy Clearing Prices	$19.4 million
Economic Impacts	
Number of New Jobs Created in 2002	2,093
Disposable Income from Net Employment in 2002	$79 million

Source: Division of Energy Resources, 2004.

Massachusetts Annual Report on Energy Efficiency

The Massachusetts Division of Energy Resources (DOER) produces an annual report analyzing the impacts of ratepayer-based energy efficiency programs in the state. The 2004 report is a retrospective analysis of the macroeconomic effects of investments in energy efficiency made in 2002 (DOER, 2004).

To perform the macroeconomic analysis, the DOER first determined the expenditures and savings for the 2002 investments. Program expenditures in 2002 included administration, marketing, program implementation, program evaluation, performance incentives paid to the distribution companies, and direct participant costs (2002 investments totaled $138 million). Program administrators collect these data on a continuous basis. Savings included direct participant energy savings and electricity bill reductions, which were estimated using a combination of data from Massachusetts distribution companies, including participation rates, average energy use per participant, and electricity rate impacts for each customer sector specific to each electric distribution company service territory. The detailed expenditure and savings data were then further disaggregated into industry-specific measures using Bill of Goods data developed by a contractor.

Using the expenditure and savings inputs, the DOER modeled the macroeconomic effects of 2002 program investments on employment, disposable income, and GSP using the REMI Policy Insight model. In addition, the DOER used those same expenditure and savings data in combination with the Energy 2020 model to project the lifetime energy savings of the 2002 program activities. Using these projected savings from Energy 2020 as inputs, the DOER used the Policy Insight model to estimate the future economic benefits reflected in Table 5.2.5.

5.2.3 STEP 3: APPLY THE METHOD TO QUANTIFY MACROECONOMIC EFFECTS

Once the direct expenditures and savings of a clean energy initiative have been quantified, the final step is to assess the aggregate macroeconomic effects of the initiative by applying the screening tool or modeling method selected in Step 1. With regard to policy implementation, many states have found the rigorous modeling methods outlined in Section 5.2.1 to be most effective in generating support for clean energy actions when a robust assessment of the full range of effects (i.e., direct, indirect, and induced) is required. The application of economic impact models to measure the effects of energy efficiency and renewable energy policies is widely used and accepted across the nation (Sumi et al., 2003).

Regardless of the method, the macroeconomic effects of a clean energy initiative are usually quantified in comparison to a projected baseline scenario of economic activity. Constructing a base case scenario, or updating a default base case that may be included in the model, is generally the first step in the process of applying the macroeconomic analysis method.

Comparing the effects of the initiative to a baseline enables quantification of the overall net impacts of the initiative because the base case reflects what would have occurred in the initiative's absence. Typically, the baseline scenario characterizes a business-as-usual forecast of energy use patterns and economic growth within the state assuming the funds for the initiative are reallocated to other government programs or BAU consumer spending levels. If states choose to pursue one or more of these methods, the base case should be developed according to specifications associated with that particular method of analysis. This *Resource* does not explicitly cover methods for economic base case scenario development.

The remaining steps in applying the method depend on the method chosen and the state's customized modeling scenarios for their slate of clean energy initiatives. These attributes will, in turn, influence how the results of the analysis should be interpreted for policy purposes. The steps taken by Connecticut in the analysis of their conservation program are described in the text box *Steps in a Macroeconomic Impact Analysis: Connecticut's Oil and Natural Gas Conservation Policies.*

5.3 CASE STUDIES

5.3.1 NEW YORK: ANALYZING MACROECONOMIC BENEFITS OF THE ENERGY $MART^{SM} PROGRAM

Benefits Assessed

- Net jobs and job years
- Personal income
- Total output
- Gross state product

STEPS IN A MACROECONOMIC IMPACT ANALYSIS: CONNECTICUT'S OIL AND NATURAL GAS CONSERVATION POLICIES

EPA and the State of Connecticut analyzed the impacts of Connecticut's proposed oil and natural gas conservation policies as part of the state's Climate Change Action Plan (CT GSC, 2004).

Step 1: Determine the method and level of effort

- Connecticut was interested in a *dynamic* analysis of both the *economic and demographic* impacts of these conservation policies over a 15-year time horizon.
- Connecticut contracted with Regional Economic Models, Inc. (REMI Policy Insight model) to model the policies because REMI's capabilities were consistent with its objectives and modeling needs.

Step 2: Quantify outlays and savings from the initiative

- The outlays and savings to be captured by the REMI Policy Insight model included oil and gas cost increases for users resulting from the surcharge on oil and natural gas; savings to oil and gas users due to reduced consumption of oil and natural gas; consumption reallocation of other consumer goods due to an increase in personal income; loss in sales to natural gas and oil firms due to reduced consumption; and investment in new equipment, construction, research, and other sectors.
- Data for the analysis were provided by an IPM study conducted for Connecticut, Northeast States for Coordinated Air Use Management (NESCAUM), Environment Northeast, Institute for Sustainable Energy, CT Department of Public Utility Control, CT Department of Environmental Protection, CT Clean Energy Fund, and United Technology Corporation.

Step 3: Apply the method to quantify macroeconomic benefits

- REMI developed a baseline forecast using a 53-sector model for Connecticut, along with three alternative conservation policy scenarios.
- The total macroeconomic effects of the policy scenarios were presented using the following indicators: employment, output, GSP, real disposable income, state revenues, and population changes.

The implementation of CT's proposed oil and natural gas conservation policy is pending legislative action.

Clean Energy Program Description

The New York Energy $mart public benefits program, created in 1998 and administered by the New York State Energy Research and Development Authority, promotes energy efficiency across the commercial, industrial, and residential sectors; advances renewable energy; provides energy services to low income residents of New York; and conducts research and development (NYSERDA, 2009). The program has four overarching goals related to improving the reliability of New York's energy system, reducing the energy costs for New Yorkers, mitigating environmental and health effects associated with energy use, and creating economic benefits for the state.

The Energy $mart Program (E$P) is funded by a System Benefits Charge (SBC) on the state's investor-owned utilities and, since 1998, New York has spent more than $1 billion to support it. The program's success and broad impact are products of a commitment to comprehensive evaluation, objective analysis, and collaboration in order "to ensure that the successes and failures of diverse programs are accurately and appropriately measured and reported" (NYSERDA, 2006b).

As part of that comprehensive evaluation process, NYSERDA produces an annual report detailing the multiple benefits of E$P on both a retrospective and prospective basis. NYSERDA recognizes that program expenditures "have substantial macroeconomic impacts that go beyond these direct benefits" because the "…purchase of goods and services through the Program set off a ripple effect of spending and re-spending that influences many sectors of the New York economy, and the level and distribution of employment and income in the State" (NYSERDA, 2009). NYSERDA therefore conducts a periodic macroeconomic impact analysis to quantify the full range of macroeconomic impacts, expressed in terms of net annual employment, labor income, total industrial output, and value added.

Method(s) Used

For the 2009 analysis, NYSERDA used the REMI Policy Insight model, a macroeconomic model that combines elements of input-output, econometric, and computable general equilibrium models, to conduct the analysis.

New York estimated the positive and negative direct effects of the program associated with the program's expenditures and associated energy savings. These effects include:

- an increase in demand for clean energy-related goods and services,
- an increase in disposable income for residential customers due to the energy savings,
- a reduction in productivity costs for business customers whose energy costs have been reduced as a result of the programs,
- a decrease in disposable income for residents from paying the SBC,
- an increase in production costs for businesses from paying the SBC charge, and
- an increase in costs to residents and businesses from purchasing the clean-energy-related goods and services.

The data necessary to determine these effects have been collected since E$P was implemented in 1999.

The analysis estimates historical macroeconomic impacts of the program from 1999 through 2008, and projects future impacts through 2022, assuming the program funding ends in 2008.

Results

The results of the macroeconomic impact analysis indicated that E$P has provided and will continue to provide net benefits in the form of increased employment, personal income, total output, and gross state product.

The model indicated that E$P initiatives implemented from 1999 through 2008 have already created 4,900 net jobs across the following sectors:

- 2,134 jobs in the Personal and Business Services sector,
- 841 in the Wholesale and Retail Trade sector,
- 794 in the Construction sector,
- 586 in the Transportation-related sector,
- 359 in State and Local Government, and
- 186 in Manufacturing.

During the same time period, the model showed that the program increased personal income by $293 million, gross state product by $644 million, and total output by $1 billion.

The model was used to estimate the cumulative results projected out to 2020, assuming that funding stops in 2008. During this 24-year period, E$P is expected to:

- Create 86,400 net job years,
- Increase personal income by $5.75 billion,
- Increase gross state product by $13.37 billion, and
- Increase total output by $20.59 billion (NYSERDA, 2009).

NYSERDA evaluates E$P's macroeconomic impacts, as well as the energy system and environmental and health benefits, as part of its ongoing and comprehensive evaluation strategy. The E$P program analyses provide support for further development and implementation of clean energy initiatives. NYSERDA also collaborates with independent parties, partners with other government entities, and integrates its analyses into the public policy forum via a 24-member advisory group. NYSERDA's program underscores the importance of fully accounting for the multiple benefits of clean energy initiatives in establishing the basis for investment in energy efficiency and renewable energy.

For More Information

- *New York Energy $martSM Program Evaluation and Status Report*. NYSERDA. Report to the System Benefits Charge Advisory Group. May, 2006. *http://www.nyserda.org/Energy_Information/06sbcreport.asp*.

5.3.2 ILLINOIS: ANALYZING THE MACROECONOMIC BENEFITS OF CLEAN ENERGY DEVELOPMENT

Benefits Assessed

- Jobs
- Household income
- Business income

Clean Energy Program Description

In July 2005, the Illinois Commerce Commission voted to adopt a Sustainable Energy Plan, the culmination of years of work by the governor's *Special Task Force on the Condition and Future of the Illinois Energy Infrastructure*. The initial Sustainable Energy Plan (the "Plan") proposal included provisions for both renewable energy portfolio standards and energy efficiency portfolio standards, specifically:

- A Renewable Portfolio Standard (RPS) that required an increasing percentage of electricity sold to Illinois customers generated by renewable resources: 2 percent by 2006, and increasing annually by 1 percent until 2012.

  The RPS further stipulated, as determined by the study, that 75 percent of the renewable generation should come from wind resources.

- An Energy Efficiency Portfolio Standard (EEPS) that required electricity load growth to be reduced by the following amounts each year: 10 percent of projected load growth in 2006–2008, 15 percent in 2009–2011, 20 percent in 2012–2014, and 25 percent in 2015–2017.

The Illinois Commerce Commission's decision to adopt the Plan followed more than five months of public comment and deliberation among many stakeholders, including utility companies and public interest groups. Ultimately, the decision was largely guided by the proposed Plan's substantial benefits, which were quantified in a study released by the Energy Resources Center at the University of Illinois in June of 2005 (Bournakis and Hewings et al., 2005).

Method(s) Used

The direct and indirect macroeconomic impacts of the Plan's provisions were analyzed using the Illinois Regional Economic Input-Output Model (ILREIM).[9]

ILREIM includes two components, an input-output model and an econometric model. The model links the regional input-output component with macroeconomic and demographic variables in a dynamic framework that is able to examine the feedback effects of economic events with different sectors.

More specifically, this model is a system of linear equations formulated to predict the behavior of 151 endogenous variables, and consists of 123 behavioral equations, 28 accounting identities, and 68 exogenous variables. The model identifies 53 industries and three government sectors.

For each industry in the structure, the model projects output, employment, and earnings. The model also estimates GSP, personal consumption expenditures, investment, state and local government expenditures, exports, labor force, unemployment rate, personal income, net migration, population, and the consumer price index.

To run ILREIM, the researchers provided data describing the dollar value of energy savings, the actual electricity savings, and the various investments needed to support the RPS and EEPS described in the Plan. The scenarios that were run included large investments in ef-

---

[9] *Looking at the models described in Table 5.2.4, ILREIM is more like REMI than IMPLAN or RIMS II.*

ficiency equipment and large investments in renewable generation facilities relative to the baseline scenario.

Results

The University of Illinois analysis found, among other benefits, that by 2012 the Plan would:

- create 7,800 jobs and
- generate nearly $9 billion in additional household and business income.

In addition, the study also revealed other results:

- The state would experience an economic adjustment composed of the interplay between the reduced local production of fossil-fuel energy and the increased production of efficiency equipment (it is likely that some portions of the efficiency equipment will be manufactured in Illinois).
- Part of the saved energy will come from reduced energy imports.
- Non-local impacts will affect the economies of other states.

As indicated in the Illinois Commerce Commission's Resolution[10] to adopt the Plan, the realization (within the Commission and among interested stakeholders) that the Plan would "lead to rural economic development" and create other environmental benefits was a key factor in the Plan's final implementation. Furthermore, the transparent, detailed, and comprehensive nature of the benefits study assured that, even after an extensive review and comment period, the Plan ultimately adopted by the Commission was nearly identical to the governor's original proposal.

For More Information

- *The Economic and Environmental Impacts of Clean Energy Development in Illinois*. Bournakis, A., G. Hewings, J. Cuttica, and S. Mueller. Submitted to the Illinois Department of Commerce and Economic Opportunity. June, 2005. *http://www.erc.uic.edu/PDF/Clean_Energy_Development.pdf*.

---

[10] *ICC Resolution 05-0437, available at: http://www.dsireusa.org/documents/Incentives/IL04R.pdf*

Sampling of State Clean Energy Analyses by Type of Analytic Method

Reference	State/Region	URL Address
State-level Clean Energy Analyses that Used I-O Analyses		
Grover, S. 2007. Economic Impacts of Oregon Energy Tax Credit Programs (BETC/RETC). Prepared by ECONorthwest for the Oregon Department of Energy. May.	Oregon	*http://www.oregon.gov/ENERGY/CONS/docs/EcoNW_Study.pdf*
Nayak, N. 2005. Redirecting America's Energy: The Economic and Consumer Benefits of Clean Energy Policies. Prepared by the U.S. PIRG Education Fund. February.	U.S.	*http://newenergyfuture.com/newenergy.asp?id2=15905&id3=energy&#2*
Pletka, R. 2004. Economic Impact of Renewable Energy in Pennsylvania. Prepared by Black & Veatch for The Heinz Endowments and Community Foundation for the Alleghenies. March.	Pennsylvania	*http://www.bv.com/Downloads/Resources/Reports/PA_RPS_Final_Report.pdf*
RAP. 2005. Electric Energy Efficiency and Renewable Energy in New England: An Assessment of Existing Policies and Prospects for the Future. Prepared by The Regulatory Assistance Project and Synapse Energy Economics, Inc. May.	New England	*http://www.raponline.org/Pubs/RSWS-EEandREinNE.pdf*
Stoddard, L., J. Abiecunas, and R. O'Connell. 2006. Economic, Energy, and Environmental Benefits of Concentrating Solar Power in California. Prepared by Black & Veatch for U.S. DOE National Renewable Energy Laboratory. April.	California	*http://www.nrel.gov/docs/fy06osti/39291.pdf*
U.S. DOC. 2003. Developing a Renewable Energy Based Economy for South Texas – A Blueprint for Development. U.S. Department of Commerce, Economic Development Administration, and the University of Texas at San Antonio.	Texas	*http://www.solarsanantonio.org/pdf/EDAReport.pdf*

Sampling of State Clean Energy Analyses by Type of Analytic Method

Reference	State/Region	URL Address
SWEEP. 2002. The New Mother Lode: The Potential for More Efficient Electricity Use in the Southwest. Southwest Energy Efficiency Project, Report for the Hewlett Foundation Energy Series. November.	Southwest	*http://www.swenergy.org/nml*
State-Level Clean Energy Analysis that Used Econometric Models		
Bernstein, M., C. Pernin, S. Loeb, and M. Hanson. 2000. The Public Benefit of California's Investments in Energy Efficiency. Prepared by RAND Science and Technology for California Energy Commission. March.	California	*http://rand.org/pubs/monograph_reports/2005/MR1212.0.pdf*
Bernstein, M., R. Lempert, D. Loughram, and D. Ortiz. 2002a. The Public Benefit of Energy Efficiency to the State of Massachusetts. Prepared by RAND Science and Technology.	Massachusetts	*http://www.rand.org/pubs/monograph_reports/2005/MR1588.pdf*
Bernstein, M., R. Lempert, D. Loughram, and D. Ortiz. 2002b. The Public Benefit of Energy Efficiency to the State of Minnesota. Prepared by RAND Science and Technology.	Minnesota	*http://www.rand.org/pubs/monograph_reports/2005/MR1587.pdf*
Bernstein, M., R. Lempert, D. Loughram, and D. Ortiz. 2002c. The Public Benefit of Energy Efficiency to the State of Washington. Prepared by RAND Science and Technology for the Energy Foundation. February.	Washington	*http://www.rand.org/pubs/monograph_reports/2005/MR1589.pdf*
State-Level Clean Energy Analysis that Used Computable General Equilibrium Models		
Roland-Holst, D. University of California Berkeley. Economic Assessment of some California Greenhouse Gas Control Policies: Applications of the BEAR Model. No date given.	California	*http://calclimate.berkeley.edu/research/ghg/assets/2_Economic_Assessment.pdf*
State-Level Clean Energy Analysis that Used Hybrid Models		
Bournakis, A., G. Hewings, J. Cuttica, and S. Mueller. 2005. The Economic and Environmental Impacts of Clean Energy Development in Illinois. Submitted to the Illinois Department of Commerce and Economic Opportunity. June.	Illinois	*http://www.erc.uic.edu/PDF/Clean_Energy_Development.pdf*
CT GSC. 2004. 2005 Climate Change Action Plan, Appendix 9: Economic Impact of Oil and Natural Gas Conservation Policies. Connecticut Governor's Steering Committee, prepared by Regional Economic Models, Inc. November.	Connecticut	*http://www.ctclimatechange.com/documents/Appendix9_REMI_HeatingOilandNaturalGasConservationFunds_CCCAP_2005_000.pdf*
DOER. 2004. 2002 Energy Efficiency Activities. Massachusetts Division of Energy Resources.	Massachusetts	*http://www.mass.gov/Eoca/docs/doer/pub_info/ee02-long.pdf*
Hewings, G., and M. Yanai, 2002. Job Jolt: The Economic Impacts of Repowering the Midwest. Prepared by the Regional Economics Applications Laboratory.	Midwest	*http://www.issuelab.org/research/job_jolt_the_economic_impacts_of_repowering_the_midwest*
Jensen, V., and E. Lounsbury. 2005. Assessment of Energy Efficiency Potential in Georgia. Prepared for the Georgia Environmental Facilities Authority by ICF Consulting. May.	Georgia	*http://www.gefa.org/Modules/ShowDocument.aspx?documentid=46*
NYSERDA. 2009. New York Energy $mart Program Evaluation and Status Report; Year Ending December 31, 2008, Report to the Systems Benefit Charge Advisory Group, Final Report, March.	New York	*http://www.nyserda.org/publications/SBC%20March%202009%20Annual%20Report.pdf*

Sampling of State Clean Energy Analyses by Type of Analytic Method		
Reference	State/Region	URL Address
Sumi, D., G. Weisbrod, B. Ward, and M. Goldberg. 2003. An Approach to Quantifying Economic and Environmental Benefits for Wisconsin's Focus on Energy. Presented at International Energy Program Evaluation Conference. August.	Wisconsin	*http://edrgroup.com/pdf/sumi-weisbrod-wis-energy-iepec.pdf*
Weisbrod, G., K. Polenske, T. Lynch, and X. Lin. 1995. The Economic Impact of Energy Efficiency Programs and Renewable Power for Iowa: Final Report. Economic Development Research Group, Boston, MA. December.	Iowa	*http://www.edrgroup.com/library/energy-environment/iowa-energy.html*

Information Resources	URL Address
The American Council for an Energy Efficient Economy (ACEEE)	*http://www.aceee.org/*
Energy 2020 model	*http://www.energy2020.com/model_overview.htm*
ICF International Inc. IPM model	*http://www.icfi.com/Markets/Energy/energy-modeling.asp#2*
Minnesota IMPLAN Group, Inc. IMPLAN model	*http://www.implan.com/*
Regional Economic Modeling, Inc. REMI model	*http://www.remi.com/*
REPP Labor Calculator	*http://www.crest.org/*
Rocky Mountain Institute Community Energy Opportunity Finder tool	*http://www.energyfinder.org/*
RTI International Applied Dynamic Analysis of the Global Economy (ADAGE) model	*http://www.rti.org/page.cfm?objectid=DDC06637-7973-4B0F-AC46B3C69E09ADA9*
U.S. Bureau of Economic Analysis Regional Economic Accounts	*http://www.bea.gov/regional/index.htm*
U.S. Census Bureau	*http://www.census.gov/*
U.S. Department of Commerce RIMS II model	*https://www.bea.gov/regional/rims/*
U.S. DOE Argonne National Laboratory Long-Term Industrial Energy Forecasting (LIEF) model	*http://www.dis.anl.gov/projects/EnergyAnalysisTools.html#lief*
U.S. DOE Lawrence Berkeley National Laboratory DOE-2.2 model	*http://www.doe2.com/*
U.S. DOE National Renewable Energy Laboratory Excelergy model	*http://www.nrel.gov/*
U.S. DOE National Renewable Energy Laboratory Jobs and Economic Development Impact (JEDI) tool	*http://www.nrel.gov/analysis/jedi/*
U.S. Energy Information Administration	*http://www.eia.doe.gov/*
University of Georgia, Georgia Economic Modeling Systems (GEMS)	*http://www.cviog.uga.edu/*
University of Illinois, Regional Economics Applications Laboratory (REAL)	*http://www.real.uiuc.edu/*

References	URL Address
Bernstein, M., C. Pernin, S. Loeb, and M. Hanson. 2000. The Public Benefit of California's Investments in Energy Efficiency. Prepared by RAND Science and Technology for California Energy Commission. March.	*http://rand.org/pubs/monograph_reports/2005/MR1212.0.pdf*

References	URL Address
Bernstein, M., R. Lempert, D. Loughram, and D. Ortiz. 2002a. The Public Benefit of Energy Efficiency to the State of Massachusetts. Prepared by RAND Science and Technology.	*http://www.rand.org/pubs/monograph_reports/2005/MR1588.pdf*
Bernstein, M., R. Lempert, D. Loughram, and D. Ortiz. 2002b. The Public Benefit of Energy Efficiency to the State of Minnesota. Prepared by RAND Science and Technology.	*http://www.rand.org/pubs/monograph_reports/2005/MR1587.pdf*
Bernstein, M., R. Lempert, D. Loughram, and D. Ortiz. 2002c. The Public Benefit of Energy Efficiency to the State of Washington. Prepared by RAND Science and Technology for the Energy Foundation. February.	*http://www.rand.org/pubs/monograph_reports/2005/MR1589.pdf*
Bohringer, C. 1998. The Synthesis of Bottom-Up and Top-Down in Energy Policy Modeling. Energy Economics, v. 20, pg. 223-248.	*http://www.elsevier.com/wps/find/journaldescription.cws_home/30413/description#description*
Bournakis, A., G. Hewings, J. Cuttica, and S. Mueller. 2005. The Economic and Environmental Impacts of Clean Energy Development in Illinois. Submitted to the Illinois Department of Commerce and Economic Opportunity. June.	*http://www.erc.uic.edu/PDF/Clean_Energy_Development.pdf*
Cinnamon, B., T. Beach, M. Huskins, and M. McClintock. 2005. The Economics of Solar Power for California. August.	*http://akeena.net/Library/pdfs/Economics_of_Solar_Power_for_California_Aug2005.pdf*
CT GSC. 2004. 2005 Climate Change Action Plan, Appendix 9: Economic Impact of Oil and Natural Gas Conservation Policies. Connecticut Governor's Steering Committee, prepared by Regional Economic Models, Inc. November.	*http://www.ctclimatechange.com/documents/Appendix9_REMI_HeatingOilandNaturalGasConservationFunds_CCCAP_2005_000.pdf*
Department of Administration (DOA), State of Wisconsin. 2001. Focus on Energy Pilot Study: Demonstration of Economic Impact Analysis for Commercial & Industrial Programs. Prepared by Economic Development Research Group, Inc. September.	*http://www.edrgroup.com/pdf/Wis-Pilot-Report.pdf*
DOER. 2004. 2002 Energy Efficiency Activities. Massachusetts Division of Energy Resources.	*http://www.mass.gov/Eoca/docs/doer/pub_info/ee02-long.pdf*
Goldberg, M., K. Sinclair, and M. Milligan. 2004. Job and Economic Development Impact (JEDI) Model: A User-Friendly Tool to Calculate Economic Impacts from Wind Projects. Presented at the 2004 Global WINDPOWER Conference, Chicago, Illinois. March.	*http://www.nrel.gov/docs/fy04osti/35953.pdf*
Grover, S. 2007. Economic Impacts of Oregon Energy Tax Credit Programs in 2006 (BETC/RETC). Prepared by ECONorthwest for the Oregon Department of Energy. May.	*http://www.oregon.gov/ENERGY/CONS/docs/EcoNW_Study.pdf*
Heavner, B. and B. Del Chiaro. 2003. Renewable Energy and Jobs: Employment Impacts of Developing Markets for Renewables in California. Environment California Research and Policy Center. July.	*http://www.environmentcalifornia.org/uploads/OW/aa/OWaa2RaedlfHwQOWbxKd5w/Renewable_Energy_and_Jobs.pdf*
Hewings, G., and M. Yanai, 2002. Job Jolt: The Economic Impacts of Repowering the Midwest. Prepared by the Regional Economics Applications Laboratory.	*http://www.issuelab.org/research/job_jolt_the_economic_impacts_of_repowering_the_midwest*
IREC. 2005. Labor Forecasts and Job Trends for the Solar and Renewable Energy Industries. Interstate Renewable Energy Council Notebook, Version #5. January.	*http://www.irecusa.org/index.php?id=6*
Jensen, V., and E. Lounsbury. 2005. Assessment of Energy Efficiency Potential in Georgia. Prepared for the Georgia Environmental Facilities Authority by ICF Consulting. May.	*www.gefa.org/Modules/ShowDocument.aspx?documentid=46*

References	URL Address
Loschel, A. 2002. Technological Change in Economic Models of Environmental Policy: A Survey. Ecological Economics, v. 43	*http://www.elsevier.com/locate/ecolecon*
Mongha, N., E. Stafford, and C. Hartman. 2006. An Analysis of the Economic Impact on Utah County, Utah from the Development of Wind Power Plants. Renewable Energy for Rural Economic Development, Utah State University. DOE/GO-102006-2316. May.	*http://www.eere.energy.gov/windandhydro/windpoweringamerica/pdfs/wpa/econ_dev_jedi.pdf*
MTC. 2005. Energy Efficiency, Renewable Energy, and Jobs in Massachusetts. Massachusetts Technology Collaborative, Renewable Energy Trust. November.	*http://www.masstech.org/IS/reports/clusterreport11405.pdf*
Nayak, N. 2005. Redirecting America's Energy: The Economic and Consumer Benefits of Clean Energy Policies. Prepared by the U.S. PIRG Education Fund. February.	*http://newenergyfuture.com/newenergy.asp?id2=15905&id3=energy&#2*
Nevada AFL-CIO. Comments Submitted to the Nevada Public Service Commission: Procedural Order No. 3 and Request for Comments No. 2.	*http://www.repp.org/articles/static/1/binaries/Nevada_RPS.pdf*
New York Office of the Governor. 2003. Press Release: Governor Announces $14.5 Million for Clean Energy Projects. July 18, 2003.	*http://www.nyserda.org/Press_Releases/press_archives/2003/governor/govjuly18_03.asp*
NJ BPU. 2005. New Jersey's Clean Energy Program: 2005 Annual Report. New Jersey Board of Public Utilities, Office of Clean Energy.	*http://www.njcleanenergy.com/files/file/2005%20Annual%20Report.pdf*
NYSERDA. 2006a. Press Release: State Energy Authority Announces Partnership that will Lead to the Growth of Clean-Energy and Environmental Technologies in New York State. July 5.	*http://www.nyserda.org/Press_Releases/2006/PressRelease20060507.asp*
NYSERDA. 2006b. New York Energy $mart Program Evaluation and Status Report: Report to the Systems Benefits Charge Advisory Group. May.	*http://www.nyserda.org/Energy_Information/06sbcreport.asp*
NYSERDA. 2008. New York Energy $mart Program Evaluation and Status Report; Year Ending December 31, 2007, Report to the Systems Benefit Charge Advisory Group, Final Report, March.	*http://www.nyserda.org/pdfs/Combined%20Report.pdf*
NYSERDA. 2009. New York Energy $mart Program Evaluation and Status Report; Year Ending December 31, 2008, Report to the Systems Benefit Charge Advisory Group, Final Report, March.	*http://www.nyserda.org/publications/SBC%20March%202009%20Annual%20Report.pdf*
Pletka, R. 2004. Economic Impact of Renewable Energy in Pennsylvania. Prepared by Black & Veatch for The Heinz Endowments and Community Foundation for the Alleghenies. March.	*http://www.bv.com/Downloads/Resources/Reports/PA_RPS_Final_Report.pdf*
RAP. 2005. Electric Energy Efficiency and Renewable Energy in New England: An Assessment of Existing Policies and Prospects for the Future. Prepared by The Regulatory Assistance Project and Synapse Energy Economics, Inc. May.	*http://www.raponline.org/Pubs/RSWS-EEandREinNE.pdf*
REMI. 2004. Economic Impact of Oil and Natural Gas Conservation Policies. Prepared for U.S. Environmental Protection Agency and the State of Connecticut. November.	*http://ctclimatechange.com/documents/Appendix9_REMI_HeatingOilandNaturalGasConservationFunds_CCCAP_2005_000.pdf*
REPP. 2005. Component Manufacturing: Ohio's Future in the Renewable Energy Industry. Renewable Energy Policy Project. October.	*http://www.repp.org/articles/static/1/binaries/Ohio_Manufacturing_Report_2.pdf*
Roland-Holst, D. 2006. University of California Berkeley. Economic Assessment of some California Greenhouse Gas Control Policies: Applications of the BEAR Model. August.	*http://calclimate.berkeley.edu/research/ghg/assets/2_Economic_Assessment.pdf*

References	URL Address
Roland-Holst, D. Economic Growth and Greenhouse Gas Mitigation in California. August 2006. UC Berkeley	*http://utahcleanenergy.org/files/u1/d_GHG_Mitigation_in_CA_Exec_Summ_UC_Berkeley.pdf*
Spitzer, E. 2007. "15 by 15" A Clean Energy Strategy for New York. Speech by former Governor Spitzer, April 19.	*http://www.state.ny.us/governor/keydocs/0419071_speech.html*
Stoddard, L., J. Abiecunas, and R. O'Connell. 2006. Economic, Energy, and Environmental Benefits of Concentrating Solar Power in California. Prepared by Black & Veatch for U.S. DOE National Renewable Energy Laboratory. April.	*http://www.nrel.gov/docs/fy06osti/39291.pdf*
Sue Wing, I. 2004. Computable General Equilibrium Models and Their Use in Economy-Wide Policy Analysis: Everything You Ever Wanted to Know (But Were Afraid to Ask). MIT Joint Program on the Science and Policy of Global Change. Technical Note No. 6, September.	*http://mit.edu/globalchange/www/MITJPSPGC_TechNote6.pdf*
Sumi, D., G. Weisbrod, B. Ward, and M. Goldberg. 2003. An Approach to Quantifying Economic and Environmental Benefits for Wisconsin's Focus on Energy. Presented at International Energy Program Evaluation Conference. August.	*http://edrgroup.com/pdf/sumi-weisbrod-wis-energy-iepec.pdf*
SWEEP. 2002. The New Mother Lode: The Potential for More Efficient Electricity Use in the Southwest. Southwest Energy Efficiency Project, Report for the Hewlett Foundation Energy Series. November.	*http://www.swenergy.org/nml*
U.S. DOC. 2003. Developing a Renewable Energy Based Economy for South Texas – A Blueprint for Development. U.S. Department of Commerce, Economic Development Administration, and the University of Texas at San Antonio.	*http://www.solarsanantonio.org/pdf/EDAReport.pdf*
U.S. EPA. 2006. National Action Plan for Energy Efficiency. Office of Air and Radiation, Climate Protection Partnerships Division. July.	*http://www.epa.gov/cleanenergy/documents/napee/napee_report.pdf*
Weisbrod, G., K. Polenske, T. Lynch, and X. Lin. 1995. The Economic Impact of Energy Efficiency Programs and Renewable Power for Iowa: Final Report. Economic Development Research Group, Boston, MA. December.	*http://www.edrgroup.com/library/energy-environment/iowa-energy.html*
Wisconsin Department of Administration. 2007. Division of Energy. Focus on Energy Public Benefits Evaluation. Economic Development Benefits: FY07 Economic Impacts Report. Final: February 23, 2007.	*http://www.focusonenergy.com/data/common/dmsFiles/E_EC_RPTI_Econ_Dev_Benefits_FY07.pdf*